Valero Crude by Rail Project
Public Comments received
April 4 -5, 2016

Commenter	Date Received
Association of Irritated Residents vs. Kern County Board of Supervisors ruling	4-Apr-16
Organizations	
League of Conservation Voters of the East Bay	4-Apr-16
Benicia Chamber of Commerce	4-Apr-16
Safe Fuel and Energy Resources California	4-Apr-16
Safe Fuel and Energy Resources California	5-Apr-16
Applicant	
Chris Howe	4-Apr-16
Individual Comments	
Russell Hands	4-Apr-16
Larnie Fox	4-Apr-16
Margaret Ericson	4-Apr-16
Jean Jackman	4-Apr-16
Charles Davidson	4-Apr-16
Michael D'Adamo	4-Apr-16
Madeline Koster	4-Apr-16
Greg Yuhas	4-Apr-16
California Senator Lois Wolk, Third Senate District	4-Apr-16
Frances Burke	4-Apr-16
Simone Cardona	4-Apr-16
Lynne Nittler	5-Apr-16
Identical Comments	
"Public Comment re Valero Crude by Rail Project - Appeal Application No. 16PLN-00009"	
10 Commenters (List and Sample Attached)	4/4-4/5/16
Identical Comments - With Modifications	
"Public Comment re Valero Crude by Rail Project - Appeal Application No. 16PLN-00009"	
Cate Leger	4-Apr-16
Identical Comments	
"I support the Valero Crude by Rail project"	
27 Commenters (List and Sample Attached)	4-Apr-16

Superior Court of California
County of Kern
Bakersfield Traffic Courtroom 2

Hearing Date: **April 01, 2016** **Time: 8:00 AM - 5:00 PM**

ASSOCIATION OF IRRITATED RESIDENTS VS KERN COUNTY BOARD OF SUPERVISORS

S1500CV283166

Honorable: J. Eric Bradshaw **Clerk:** Patrick Ogilvie

Court Reporter: N/A **Bailiff:** N/A
Interpreter: N/A **Language Of:** N/A

PARTIES:

ACE ATTORNEY SERVICE, Non-Party, not present	
ALON USA ENERGY, INC., Real Party Interest, not present	JOCELYN THOMPSON, Attorney, not present
ASSOCIATION OF IRRITATED RESIDENTS, Petitioner, not present	ANGELA MESZAROS, Attorney, not present
CENTER FOR BIOLOGICAL DIVERSITY, Petitioner, not present	ANGELA MESZAROS, Attorney, not present
KERN COUNTY BOARD OF SUPERVISORS, Respondent, not present	CHARLES COLLINS, Attorney, not present
KERN COUNTY PLANNING AND COMMUNITY DEVELOPMENT DEPARTMENT, Respondent, not present	CHARLES COLLINS, Attorney, not present
PARAMOUNT PETROLEUM CORPORATION, Real Party Interest, not present	JOCELYN THOMPSON, Attorney, not present
SIERRA CLUB, Petitioner, not present	ANGELA MESZAROS, Attorney, not present

NATURE OF PROCEEDINGS: RULING ON PETITION FOR WRIT OF MANDATE, HERETOFORE SUBMITTED

Hearing Start Time: 2:15 PM

* * * * *

DISPOSITION

The petition is **DENIED.** Respondents shall prepare a proposed judgment consistent with this ruling. Costs may be claimed in accordance with applicable statutes and rules of court.

BACKGROUND

This action arises from respondent Kern County Board of Supervisors' ("County's") approval of the Alon Bakersfield Refinery Crude Flexibility Project ("Project") in September 2014.

The refinery on the Project site was initially constructed in the early 1930's, and has expanded over the years. Historically, the refinery has processed primarily "heavy" crude oil produced in the San Joaquin Valley. The refinery's current crude processing capacity is 70,000 barrels per day. The purpose of the Project is to enhance the existing refinery's flexibility to receive and process a variety of crude oils, including "light sweet" crude oils produced in distant locations such as North Dakota, Colorado and Utah, while maintaining its ability to refine local heavy crude oil. To accomplish this, the Project would expand or modify on-site rail, transfer and storage facilities, including construction of a rail loop connected to the existing railway, and would add, modify, upgrade or repurpose various other refinery facilities. The rail terminal capacity would increase. The permitted crude processing capacity would not change.

Petitioners challenge the sufficiency of the EIR and County's findings under CEQA. Petitioners seek a "writ of mandate or peremptory writ," injunctive relief and declaratory relief to void the EIR and overturn County's approval of the Project.

STANDARD OF REVIEW

The parties do not agree on the appropriate standard of review. The standard of review in CEQA cases is governed generally by Public Resources Code §§ 21168 and 21168.5, and depends on the relief sought.

Section 21168 applies in cases seeking administrative mandamus, where a public agency's "determination, finding, or decision" is made as a result of a "proceeding in which by law a hearing is required to be given, evidence is required to be taken and discretion in the determination of facts is vested in a public agency," i.e., an "adjudicative" or "quasi-judicial" determination. *Pub. Res. Code § 21168*; *Laurel Heights Improvement Assn. v. Regents of University of California ("Laurel Heights") (1988) 47 Cal.3d 376, fn. 5; Vineyard Area Citizens v. City of Rancho Cordova ("Vineyard") (2007) 40 Cal.4th 412, fn. 4.* The court reviews an agency's determinations under Section 21168 to see if they are supported by substantial evidence in the light of the whole record. *Pub. Res. Code § 21168*.

Section 21168.5 applies in cases seeking traditional mandamus and cases other than those to which Section 21168 applies, such as cases where an agency has made a "legislative," "nonjudicial" or "nonadjudicative" determination or decision. *Pub. Res. Code § 21168.5*; *Laurel Heights, supra, 47 Cal.3d 376, fn. 5; Vineyard, supra, 40 Cal.4th 412, fn. 4; Center for Biological Diversity v. California Dept. of Fish & Wildlife ("Center") (2015) 62 Cal.4th 204, 214-215*. The court reviews an agency's determination or decision under Section 21168.5 to see if the agency committed a "prejudicial abuse of discretion." *Pub. Res. Code § 21168.5*. An "abuse of discretion" occurs under Section 21168.5 if: (1) "the agency has not proceeded in a manner required by law," or (2) "the [agency's] determination or decision is not supported by substantial evidence." *Pub. Res. Code § 21168.5*; *Vineyard, supra, at p. 435.* Judicial review of these two types of error differs significantly: the court determines de novo whether the agency has employed the correct procedures, "scrupulously enforc[ing] all legislatively mandated CEQA requirements," *Vineyard, supra, at p. 435 [quoting Citizens Golleta Valley v. Board of Supervisors (1990) 52 Cal.3d 553, 564]*; the court accords greater deference to the agency's substantive factual conclusions, and reviews them for substantial evidence. *Laurel Heights, supra, 47 Cal.3d at p. 393; Vineyard, supra, at p. 435.* Thus, in evaluating

an EIR for CEQA compliance under Section 21168.5, the court must adjust its scrutiny to the nature of the alleged defect, depending on whether the claim is predominantly one of improper procedure or a dispute over the facts. *Vineyard, supra, at p. 435; Center, supra, 62 Cal.4th 204, 214-215.*

In applying the "substantial evidence" standard to an agency's factual determinations under both Section 21168 and Section 21168.5, the court must resolve reasonable doubts in favor of the administrative finding and decision. *Topanga Association for a Scenic Community v. County of Los Angeles (1974) 11 Cal.3d 506, 514; Laurel Heights, supra, 47 Cal.3d at p. 393.* A court may not set aside an agency's approval of an EIR on the ground that an opposite conclusion would have been equally or more reasonable. Greenbaum v. City of Los Angeles (1984) 153 Cal.App.3d 401-402; *Laurel Heights, supra, 47 Cal.3d at p. 393.* The court does not pass upon the correctness of the EIR's environmental conclusions, but only upon its sufficiency as an informative document. *Laurel Heights, supra, 47 Cal.3d at p. 392.* The court must resolve reasonable doubts in favor of the administrative finding and decision. *Id. at p. 393.*

DISCUSSION

1. Description of Project and Baseline

The EIR describes baseline using environmental conditions as of the date the Notice of Preparation ("NOP") was published in 2013, adjusted to include the refinery's production in 2007. The former owner's 2008 bankruptcy resulted in a suspension of refinery operations. Some of those operations were restarted when real parties in interest purchased the refinery, but there was no crude oil processing in 2013. Petitioners argue that the EIR does not describe the true nature of the Project because it does not treat "restarting" the refinery as part of the Project, and baseline conditions should have been "zero crude processing," the refinery's production on the date the NOP was published.

CEQA Guideline 15125(a) states, in relevant part:

> An EIR must include a description of the physical environmental conditions in the vicinity of the project, as they exist *at the time the notice of preparation is published*,…This environmental setting *will normally constitute the baseline* physical conditions by which a lead agency determines whether an impact is significant. *14 CCR § 15125(a).* (Emphasis added.)

Neither CEQA nor the CEQA Guidelines mandates a uniform, inflexible rule for determination of the existing conditions baseline; rather, an agency enjoys the discretion to decide, in the first instance, exactly how the existing physical conditions without the project can most realistically be measured, subject to review, as with all CEQA factual determinations, for support by substantial evidence. *Communities for a Better Environment v. South Coast Air Quality Management Dist. (2010) 310, 328*. The date for establishing a baseline cannot be a rigid one; environmental conditions may vary from year to year and in some cases it is necessary to consider conditions over a range of time periods. *Save Our Peninsula Committee v. Monterey County Board of Supervisors (2001) 87 Cal.App.4th 99, 125*.

In the present case, County did not abuse its discretion in describing the Project or baseline conditions in a manner that recognized the refinery's 80-plus year production history. The EIR discusses at length the history of the refinery, environmental setting, and the specific components of baseline conditions, with supporting data. Substantial evidence shows that the refinery's pre-Project footprint and production capacity expanded over many years of operation to the currently-permitted 70,000 barrels per day, and included prior environmental reviews. The suspension of production at the refinery was temporary and artificial, due to the bankruptcy; "zero crude

production" in September 2013 was an anomalous deviation from the refinery's long history of operations. The Project is not a new refinery, and the existing refinery does not require an EIR to operate. Substantial evidence supports the EIR's use of the refinery's actual 2007 production as part of the baseline. Substantial evidence shows that 2007 production was consistent with average *actual* production for the 8-year period preceding the bankruptcy, the current owner's stated intentions upon acquiring the refinery, and the business realities of running a refinery. County proceeded in a manner permitted by law, based on substantial evidence, in describing the Project and how baseline conditions without the Project could most realistically be described and measured. There was no prejudicial abuse of discretion.

2. <u>Baseline GHG Emissions & Project Impacts</u>

Petitioners argue that "the EIR fabricates a [GHG] baseline of a hypothetical 'business-as-usual' project built between 2002-2004," and that this "hypothetical baseline violates CEQA's requirement that the baseline be based on 'real conditions on the ground.'" Petitioners argue, alternatively, that "even if [the] 'business as usual' baseline [is] valid under CEQA, the EIR does not properly apply the threshold." Petitioners argue that the EIR "makes no attempt to model a 'business as usual' project and compare the Project's emissions to business as usual."

County did not use a hypothetical "business as usual" model either to determine GHG baseline or to quantify Project impacts; "business as usual" was a factor in determining *significance* of the Project GHG emissions. The EIR evaluated Project GHG emissions as a cumulative impact, and compared estimated Project emissions in specified categories with emissions reductions expected from compliance with applicable regulations; this approach was permitted under the law. See *Center, supra, 62 Cal.4th 204, at p. 223.* The methodology and underlying data were disclosed in the EIR. There was no abuse of discretion in the manner in which County described and measured baseline conditions. County properly exercised discretion in assessing the significance of Project impacts with reference to the California Air Resources Board's "Scoping Plan" implementing AB32, and San Joaquin Valley Air Pollution Control District's "Guidance" for addressing GHG emissions impacts. County did not abuse its discretion by determining, based on substantial evidence, that GHG emissions from the Project would be less than significant through compliance with state regulations. Petitioner's argument that "the cap and trade program does not eliminate emissions" stands in contrast to the California Air Resources Board's determination on this global issue. County did not abuse its discretion in its methodology, determinations or decisions regarding baseline GHG emissions, Project impacts, or the significance of those impacts.

3. <u>Train Accidents & Operations</u>

Petitioners argue that due to a "math error," the EIR underestimates the risk of a train accident that would result in a release of hazardous materials "by a factor of five." Petitioners conclude that as a result, there is no substantial evidence to support the EIR's determination that the "hazards associated with rail transport are expected to be less than significant." Petitioners explain that the federal agency responsible for maintaining railroad accident statistics distinguishes between "accidents" and "incidents;" that all "events" along the railroad tracks that result in a hazmat release are reported in the "accidents" column of those statistics; and that in order to *correctly* calculate the "risk of an accident leading to a hazmat release," one must compare the "Number of accidents with a hazmat release" (numerator) to the "Number of accidents" (denominator). The result of this arithmetic, according to petitioners, is a train "accident" leading to a hazmat release once every 30 years (not once every 150 years).

There was no "math error." County did not prejudicially abuse its discretion in its calculations or determinations, and County's determinations are supported by substantial evidence. The fact that the Federal

Railroad Administration ("FRA") defines the terms "accident" and "incident" very particularly, or that it makes after-the-fact (or "after-the-accident") determinations to categorize all hazmat "events" in the "accidents" column of its statistics, does not mean County made a "math error" or prejudicially abused its discretion.

First, all the statistical information on which County and petitioners base their respective calculations, and their methods of calculation, were presented and part of the record. Neither the decision-makers nor the public were misled, and all interested parties were fully informed of petitioners' interpretation of the statistics before the EIR was approved.

Second, County was not compelled by the FRA statistical categories or "correct math" to limit its comparison of hazmat "events" to the FRA category for "accidents," only. The FRA term "accidents/incidents" (which County used for its 1-in-150 determination) includes all "reportable events." "Reportable events" are divided into three groups: (1) "Train accidents" – a safety-related event involving *on-track* rail equipment; (2) "Highway-rail grade crossing incidents" – any *impact between a rail and highway user at a designated crossing site*; and (3) "Other incidents" – any *death or injury of a railroad employee* that is not the result of a "train accident" or "highway-rail incident." Neither the FRA, nor the County, can know in advance whether a "reportable event," i.e., an "accident/incident," will involve a hazmat release until *after* the event has occurred. Yet, *any* "reportable event," i.e., "accident/incident" has the *potential* to result in a hazmat release. County chose to compare hazmat events to all "accidents/incidents," i.e., all events, rather than the narrower category of "on-track-plus-other-hazmat-events" chosen by petitioners. There was no math error.

Third, County's approach allows one to consider how many times a hazmat release occurs in relation to the total number of all accidents (generic definition) of *any* type. Petitioners approach looks at something else. Petitioners argue that "each individual in the denominator must be at risk of being in the numerator," and petitioners use an example of how to calculate "the proportion of football players that are injured in a game." Petitioners' approach, however, violates the very mathematical proposition they advance. Petitioners' calculation *excludes* two categories of "incident" (FRA definition) that involve impacts between trains and trucks, etc., at crossing sites, and death or injury to railroad employees. Some unknown number of hazmat release "reportable events" *would be* included in the FRA categories for "incidents" *but for* the FRA decision after-the-fact to insert them in the "accident" category. Some events in the FRA "accidents" category do not involve a hazmat release. Thus, if one is interested in knowing the number of hazmat events in relation to the total number of "reportable events," petitioners' calculation is not helpful. If one is interested in knowing the number of football players injured (i.e., hazmat release events) in relation to the total number of football players (i.e., the total number of "reportable events," meaning "accidents" and "incidents"), you would not *limit* the denominator to all *offensive* players, plus only the *injured* defensive and special teams players; the denominator must include *all players* on offense, defense and special teams, just as the County included all "reportable events" (i.e., all "accidents/incidents").

Independent of the fact there was no math error, the EIR specifically determined that the potential consequences of an oil spill along the BNSF mainline railroad tracks are a "significant and unavoidable impact," and a number of mitigation measures were imposed, to the extent legally permitted.

Petitioners argue that the EIR does not include a "thorough analysis of the impacts of the transport of crude to the Refinery by rail, on the mistaken assertion that this review was preempted by [the Interstate Commerce Commission Termination Act ("ICCTA")]." Petitioners argue, "At most, the Surface Transportation Board's exclusive jurisdiction over the economic regulation of rail carrier operations might impose some limits on the mitigation measures the County could require to address the rail transport risks of [the] Project."

The EIR properly considered and addressed, based on substantial evidence, the impacts of mainline railroad operations related to the Project, such as GHG emissions, risk of a mainline rail accident, biological impacts in the event of a spill, and various permissible mitigation measures. Respondents correctly observe, however, that the Surface Transportation Board's exclusive jurisdiction includes environmental regulation, and not merely *economic* regulations, thus preempting state environmental regulatory authority. *See, 49 U.S.C. §§ 10501(b), 10502(a); City of Auburn v. United States (9th Cir. 1998) 154 F. 3d 1025.* County did not prejudicially abuse its discretion in its analysis, disclosures or determinations related to railroad accidents or operations, and the determinations are supported by substantial evidence.

4. <u>Other Air Impacts</u>

Petitioners argue that the EIR does not fully disclose the Project's air impacts because it fails to analyze the emissions from the crude feedstocks (or "crude slate") to be processed at the refinery, it omits analysis of the emissions from flares, and it fails to disclose the "likely" increase in GHG emissions that will result from lower fuel costs and increased consumer demand caused by the Project.

The EIR discloses and analyzes the relevant crude oil types, and determines, based on substantial evidence, that no increases in flare emissions are expected. The EIR includes a projection that 61% of the crude delivered to the refinery will be light, sweet crude, with the remaining crude being local, heavy crude. The EIR anticipates and assesses the highest future emissions. The air quality and GHG emissions analyses make equipment-specific worst case assumptions related to crude oil types. The assessment anticipates the storage, processing, and utilization of 100 percent light crude as well as 100 percent heavy crude for equipment affected by the Project, and estimates the highest future emissions for each crude type. The EIR is not deficient by its omission of a speculative discussion regarding the economics of how this Project may or may not incrementally affect gasoline prices and consumer demand, and how that, in turn, may or may not affect GHG emissions. CEQA does not demand such speculation. The disclosures and sufficient analyses in the present EIR distinguish this case factually from the circumstances presented in *Communities for a Better Environment v. City of Richmond (2010) 184 Cal.App. 4th 70*. County did not prejudicially abuse its discretion, and the EIR's determinations are supported by substantial evidence.

5. <u>Mitigation Measures and Significance Analysis</u>

Petitioners argue that the EIR improperly uses GHG offsets as Project components and as inadequate mitigation measures. Petitioners also argue the EIR improperly relies on emission reduction credits to determine that the Project's emissions would be less than significant. The GHG offsets include the offset of emissions through state-mandated cap-and-trade, displacement of truck trips, and GHG emissions reductions resulting from the federal renewable fuels standards. Petitioners argue that these mitigation measures are inadequate and that the EIR's use of them as Project components was a prejudicial abuse of discretion, resulting in a failure to evaluate whether other measures should be considered. Petitioners also argue that the EIR erroneously concludes that emissions are not significant because the Project will offset these emissions by retiring emission reduction credits.

CEQA does not require a lead agency to ignore existing regulatory requirements that limit or avoid project impacts. The EIR assumes the Project will abide by existing laws, including state-mandated cap-and-trade measures as well as emission reduction credits, and considered them in assessing the significance of Project impacts. These laws and regulations are not optional; they are independently enforceable, and formed a logical and permissible part of the EIR's analysis of Project impacts. County did not prejudicially abuse its discretion.

Amy Million

From: Beth Gunston <bgunston@gmail.com>
Sent: Saturday, April 02, 2016 8:15 PM
To: Amy Million
Subject: Oppose: Crude by Rail

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Dear Benicia City Council & Planning Commission,

The League of Conservation Voters of the East Bay has taken a position of opposition to the proposal of Bakken crude oil movement through the City of Benicia. We join our voice with those of Benicians and citizens of nearby cities who are concerned about the environmental and public health threats that shipment of crude oil by train poses. Train derailments and spills are among major concerns associated with rail shipments, with the total volume of oil spilled by rail in 2013 alone totaling more than the combined amount between 1975-2012. Additionally, we oppose the procurement method of Bakken crude oil which is knowingly triggering environmental and social problems in North Dakota.

Not in Benicia! Not in the Bay Area! Not in communities uprail and downwind of Benicia!

Please convey my opposition to the City of Benicia and Valero.

Sincerely,

Beth Gunston
Board President, League of Conservation Voters of the East Bay

BENICIA CHAMBER OF COMMERCE & VISITORS CENTER
"Promoting Business For A Better Benicia"
601 First Street, Suite 100, Benicia CA 94510
707-745-2120 / Fax 707-745-2275
www.beniciachamber.com • info@beniciachamber.com

RECEIVED
APR 4 2016
CITY MANAGER'S OFFICE
CITY OF BENICIA

March 17, 2016

Mayor Patterson & Benicia City Council Members
CITY OF BENICIA
250 East L Street
Benicia, CA 94510

Dear Mayor Patterson & City Council Members:

For approximately three years, we as a community have been following Valero's Crude By Rail use permit application. Both advantages and concerns from both sides of the issue have been expressed, public hearings have taken place, EIR conducted, which resulted in a denial to certify the FEIR & use permit by the Planning Commission and an appeal to you, our elected officials, by the applicant.

As you are aware, Valero Benicia Refinery currently brings product in and out of its facility by marine vessel and rail. Together with Union Pacific, Valero is working to ensure they stay competitive in this commodity market while at the same time creating as little impact to Benicia residents and businesses as possible. Valero's Benicia Refinery is constantly monitored by multiple government agencies including Bay Area Air Quality Management and are required to meet or exceed criteria set forth by these numerous agencies. With the Valero Benicia Refinery, a VPP site, being one of the newest and most advanced refineries in the nation with a commendable safety record, they ask to continue doing what the refinery was designed to do, refine crude oil.

In keeping with the City's ongoing support of Economic Development, viability of Benicia's Industrial Park and the refinery's proven commitment to this community for more than 45 years, we respectfully request that you overturn the Planning Commission's decision to deny the Valero Crude By Rail permit and support and certify the Valero Crude By Rail Final Environmental Impact Report and the Use Permit application.

Sincerely,

Steve McClure, Chairman of the Board
Benicia Chamber of Commerce

ADAMS BROADWELL JOSEPH & CARDOZO
A PROFESSIONAL CORPORATION
ATTORNEYS AT LAW
601 GATEWAY BOULEVARD, SUITE 1000
SOUTH SAN FRANCISCO, CA 94080-7037

TEL: (650) 589-1660
FAX: (650) 589-5062
rkoss@adamsbroadwell.com

DANIEL L. CARDOZO
CHRISTINA M. CARO
THOMAS A. ENSLOW
TANYA A. GULESSERIAN
LAURA E. HORTON
MARC D. JOSEPH
RACHAEL E. KOSS
JAMIE L. MAULDIN
ELLEN L. WEHR

SACRAMENTO OFFICE
520 CAPITOL MALL, SUITE 350
SACRAMENTO, CA 95814-4721
TEL: (916) 444-6201
FAX: (916) 444-6209

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

April 4, 2016

BY EMAIL AND U.S. MAIL

Honorable Mayor Patterson
and City Council Members
City of Benicia
250 East L Street
Benicia, CA 94510

epatterson@ci.benicia.ca.us
mhughes@ci.benicia.ca.us
tcampbell@ci.benicia.ca.us
aschwartzman@ci.benicia.ca.us
cstrawbridge@ci.benicia.ca.us

Re: Valero's Crude by Rail Project (12PLN-00063)

Dear Honorable Mayor Patterson and City Council Members:

We are writing on behalf of Safe Fuel and Energy Resources California ("SAFER California") to urge the City Council to deny Valero's appeal of the Planning Commission's unanimous decision to deny certification of the Final Environmental Impact Report ("FEIR") and Use Permit Application for the Valero Crude by Rail Project. The following is a summary of our comments on the appeal:

- A Surface Transportation Board opinion regarding whether the Interstate Commerce Commission Termination Act of 1995 ("ICCTA") preempts local and state law is irrelevant because, in this case, the Project will result in significant, unmitigated impacts from Project operation *within the refinery boundary that is clearly outside the bounds of the ICCTA.*

- Construction of the Project's unloading rack, pipelines and other facilities within the refinery boundary would result in significant air quality and public health impacts from nitrogen oxides ("NOx") emissions from construction equipment, haul trucks and construction worker commute vehicles.[1]

- Project operation within the refinery boundary would result in a significant air quality impact from emissions of reactive organic gases

[1] P. Pless Comments on RDEIR, pp. 4-7; P. Pless Comments on FEIR, p. 11.

printed on recycled paper

("ROG") from numerous sources, including crude storage tanks, rail car unloading emissions and the liquid spill containment sump at the unloading facility.[2]

- Project operation would result in significant cancer risks from emissions of toxic air contaminants from crude storage tanks, railcar fugitive emissions and locomotive idling within the refinery boundary.[3]

- The Project's fugitive railcar ROG emissions from Project operation within the refinery boundary would result in a significant, unmitigated air quality impact.[4]

- The Project's change in service of the refinery's existing crude oil storage tanks alone would result in a significant, unmitigated air quality impact from ROG emissions.[5]

- An accident from Project operation within the refinery boundary would result in a significant, unmitigated impact to public health and safety from on-site hazards, including injury and death.[6]

- Project operation within the refinery boundary would result in a significant, unmitigated impact from flooding.[7]

- Installation of lighting above the unloading rack platform walkway would result in a significant, unmitigated impact to wildlife immediately adjacent in Sulphur Springs Creek.[8]

---

[2] P. Fox Comments on DEIR, pp. 21-30; P. Fox Comments on FEIR, pp. 8-11.
[3] P. Pless Comments on RDIER, pp. 33-36; P. Pless Comments on FEIR, pp. 72-75.
[4] P. Fox Comments on DEIR, pp. 30-31; P. Fox Comments on FEIR, p. 10; P. Fox Comments on Valero Appeal, pp. 3-5.
[5] P. Fox Comments on DEIR, pp. 21-24; P. Fox Comments on FEIR, pp. 8-9; P. Fox Comments on Valero Appeal, pp. 5-12.
[6] P. Fox Comments on Valero Appeal, pp. 12-50.
[7] P. Fox Comments on Valero Appeal, pp. 54-67.
[8] Letter from Scott Cashen to Rachael Koss re: Comments on the Valero Benicia Crude by Rail Project, March 28, 2016, pp. 3, 7.

printed on recycled paper

- Increased human activity at the unloading rack platform adjacent to the creek would result in a significant, unmitigated impact to wildlife by causing them to avoid using the creek as a movement corridor.[9]

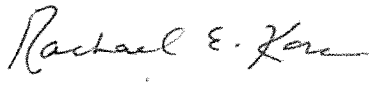
- The Project would substantially increase noise levels within the refinery boundary (e.g., from pumps, motors and train traffic), which would result in a significant, unmitigated impact to birds and other wildlife in the Sulphur Springs Creek riparian corridor.[10]

- The Project's impact on wildlife from chronic exposure to contaminants is significant and unmitigated.

- A crude spill or accident from Project operation within the refinery boundary would result in a significant, unmitigated impact to birds and other wildlife.

We urge the City Council to deny Valero's appeal of the Planning Commission's decision to deny the Project.

Sincerely,



Rachael E. Koss

REK:ric

cc: Donald Dean, Chair, Planning Commission ddean@ci.benicia.ca.us
Amy Million, Principal Planner amillion@ci.benicia.ca.us

---

[9] *Id.*, pp. 3-4, 7.
[10] *Id.*, pp. 4-5, 8-9; *see also* FEIR, Comment J3-24.

3111-019rc

printed on recycled paper

ADAMS BROADWELL JOSEPH & CARDOZO
A PROFESSIONAL CORPORATION
ATTORNEYS AT LAW
601 GATEWAY BOULEVARD, SUITE 1000
SOUTH SAN FRANCISCO, CA 94080-7037
TEL: (650) 589-1660
FAX: (650) 589-5062
rkoss@adamsbroadwell.com

DANIEL L. CARDOZO
CHRISTINA M. CARO
THOMAS A. ENSLOW
TANYA A. GULESSERIAN
LAURA E. HORTON
MARC D. JOSEPH
RACHAEL E. KOSS
JAMIE L. MAULDIN
ELLEN L. WEHR

SACRAMENTO OFFICE
520 CAPITOL MALL, SUITE 350
SACRAMENTO, CA 95814-4721
TEL: (916) 444-6201
FAX: (916) 444-6209

April 4, 2016

BY EMAIL AND OVERNIGHT MAIL

City of Benicia City Council
250 East L Street
Benicia, CA 94510
epatterson@ci.benicia.ca.us
mhughes@ci.benicia.ca.us
tcampbell@ci.benicia.ca.us
aschwartzman@ci.benicia.ca.us
cstrawbridge@ci.benicia.ca.us

Re: Valero's Appeal of the Planning Commission's Decision to Deny the Valero Crude by Rail Project

Dear Honorable Mayor Patterson and City Council Members:

We are writing on behalf of Safe Fuel and Energy Resources California ("SAFER California") to urge the City Council to deny Valero's appeal of the Planning Commission's unanimous decision to deny certification of the Final Environmental Impact Report ("FEIR") prepared for the Valero Crude by Rail Project ("Project") and to deny Use Permit Application 12PLN-00063 ("Use Permit") for the Project. We are also writing to provide additional information regarding the Project's significant impacts both within and outside the refinery boundary and the inapplicability of federal preemption in this case.

On September 15, 2014, SAFER California provided comments on the Draft EIR ("DEIR), identifying many fatal defects in the document. The City then revised and recirculated portions of the document with (1) new analyses of potential impacts that could occur uprail of Roseville, (2) an analysis of the amount of reactive organic gases emitted from railcars in air districts along the northern routes, and (3) supplemental analysis of the potential accidents involving crude trains based on new information that became available after the original DEIR was published. SAFER California provided comments on the Revised DEIR ("RDEIR")

printed on recycled paper

on October 30, 2015. Although the RDEIR addressed some of the errors and omissions we identified in our comments on the DEIR, most of the issues remained. The RDEIR still failed to adequately disclose, analyze and mitigate the Project's potentially significant impacts related to air quality, public health and hazards. The City released the FEIR on January 5, 2016. On February 8, 2016, we provided comments on the FEIR, showing that the FEIR failed to cure the defects we and other commenters identified in the DEIR and RDEIR, and dismissed hundreds of pages of expert, technical comments with a few pages of unsupported, conclusory responses. Our comments outlined the numerous defects in the City's analyses and urged the City to withdraw the FEIR and prepare a revised EIR which fully complies with the California Environmental Quality Act ("CEQA").[1]

On February 11, 2016, the Planning Commission unanimously denied certification of the FEIR and the Use Permit. The Planning Commission adopted Resolution No. 16-1 (PC), which contains 14 findings for denying certification of the FEIR. Resolution No. 16-1 (PC) also finds that the Project would be inconsistent with the City's General Plan.

On February 29, 2016, Valero appealed the Planning Commission's decision. Valero's appeal largely relies on its argument that the City Council must approve the Project because "[t]he City Council's hands are, in effect, tied by the law of federal preemption."[2] Valero also argues that the Planning Commission's findings are not supported by substantial evidence. As discussed below, Valero's arguments are unsupported by the law and facts. The City Council must deny Valero's appeal and uphold the Planning Commission's decision denying certification of the FEIR and the Use Permit.

We prepared these comments with the assistance of experts Scott Cashen and Phyllis Fox, Ph.D., P.E. These experts' technical comments are attached hereto and are incorporated by reference.

I. INTEREST OF COMMENTERS

SAFER California advocates for safe processes at California refineries to protect the health, safety, the standard of life and the economic interests of its

[1] Pub. Resources Code, §§ 21000 et seq.; We incorporate by reference our comments on the DEIR, RDEIR and FEIR.

[2] Valero's Appeal of Planning Commission Resolution No. 16-1, February 29, 2016, p. 2.

members. For this reason, SAFER California has a strong interest in enforcing environmental laws, such as CEQA, which require the disclosure of potential environmental impacts of, and ensure safe operations and processes for, California oil refineries. Failure to adequately address the environmental impacts of crude oil transport and refining processes poses a substantial threat to the environment, worker health, surrounding communities, and the local economy.

Refineries are uniquely dangerous and capable of generating significant fires and the emission of hazardous and toxic substances that adversely impact air quality, water quality, biological resources and public health and safety. These risks were recognized by the Legislature and Governor when enacting SB 54 (Hancock). Absent adequate disclosure and mitigation of hazardous materials and processes, refinery workers and surrounding communities may be subject to chronic health problems and the risk of bodily injury and death. Additionally, rail transport of crude oil has been involved in major explosions, causing vast economic damage, significant emissions of air contaminants and carcinogens and, in some cases, severe injuries and fatalities.

Poorly planned refinery projects also adversely impact the economic wellbeing of people who perform construction and maintenance work in the refinery and the surrounding communities. Plant shutdowns in the event of accidental release and infrastructure breakdown have caused prolonged work stoppages. Such nuisance conditions and catastrophic events impact local communities and can jeopardize future jobs by making it more difficult and more expensive for businesses to locate and people to live in the area. The participants in SAFER California are also concerned about projects that carry serious environmental risks and public service infrastructure demands without providing countervailing employment and economic benefits to local workers and communities.

The members represented by the participants in SAFER California live, work, recreate and raise their families in Solano County, including the City of Benicia. Accordingly, these people would be directly affected by the Project's adverse environmental impacts. The members of SAFER California's participating unions may also work on the Project itself. They will, therefore, be first in line to be exposed to any hazardous materials, air contaminants, and other health and safety hazards, that exist onsite.

These comments are also submitted on behalf of individuals who reside and work in the Project area, including, for example, Mark Sloan, who lives in the City of Benicia.

II. THE CITY COUNCIL MUST DENY VALERO'S APPEAL BECAUSE SUBSTANTIAL EVIDENCE SHOWS THAT PROJECT OPERATION WITHIN THE REFINERY BOUNDARY WOULD RESULT IN SIGNIFICANT, UNMITIGATED IMPACTS

CEQA Guidelines section 15090 provides that, before approving a project, a lead agency must certify that a final EIR complies with CEQA (among other findings).[3] Section 15091 provides that an agency cannot approve a project when the EIR "identifies one or more significant environmental effects of the project" unless the agency finds that changes have been required or incorporated into the project that reduce the adverse effect, such changes or alterations are within the jurisdiction of another agency, or mitigation measures are infeasible.[4] The agency's findings must be supported by substantial evidence.[5] CEQA prohibits an agency from approving a project that will have a significant effect on the environment, unless the agency has reduced the environmental effects with feasible mitigation measures or the agency determines that significant effects are unavoidable.[6]

Accordingly, the Planning Commission denied certification of the FEIR because the FEIR fails to comply with CEQA and substantial evidence shows that the Project would result in significant, unmitigated environmental impacts. For example, the Planning Commission found that "[t]he project is located in the 100-year floodplain, which would increase the hazards related to an accidental spill on the property."[7] Also, for example, the Planning Commission found that "[t]he project could potentially have negative biological impacts on Sulphur Springs Creek and the marsh area between the Benicia Industrial Park and the Carquinez Strait."[8] The Planning Commission also found the FEIR's air quality and greenhouse gas emissions analyses to be "insufficient."[9] Finally, for example, the

---

[3] 14 Cal. Code Regs., § 15090.
[4] *Id.*, § 15091(a).
[5] *Id.*, § 15091(b).
[6] *Id.* § 15092.
[7] Resolution No. 16-1 (PC), p. 2.
[8] *Id.*
[9] *Id.*

Planning Commission found that "[t]he EIR does not disclose all information necessary for complete evaluation of the air quality impacts of the project including the makeup of the crude oil associated with this project, which is based on an overly-broad interpretation of what constitutes trade secrets."[10] The Planning Commission's findings are well supported by substantial evidence in the record. Our comments (and many other comments from groups, agencies and individuals) on the DEIR, RDEIR and FEIR identified numerous fatal flaws in the FEIR's analyses and numerous undisclosed significant, unmitigated impacts from Project operation both within the refinery boundary and uprail. The comments below supplement our previous comments, and identify additional significant, unmitigated impacts from Project operation within the refinery boundary.

A. Substantial Evidence Shows that Project Operation Within the Refinery Boundary Would Result in Significant, Unmitigated Impacts to Biological Resources

The Project's proposed unloading rack and rail spur within the refinery boundary is located adjacent to Sulphur Springs Creek, which flows to Suisun Bay. In his attached comments, biologist Scott Cashen provides a list of special-status species with habitat in the Sulphur Springs Creek and its associated riparian corridor and marshes.[11] The species include the fully protected California black rail, California clapper rail and salt-marsh harvest mouse, among numerous other special-status species.[12] In Mr. Cashen's opinion, the Project's operation within the refinery boundary would result in significant, unmitigated impacts to these species as follows.

1. Project Lighting Within the Refinery Boundary Would Significantly Impact Wildlife Movement

Mr. Cashen explains in his comments that "Sulphur Springs Creek provides one of the last remaining corridors of aquatic and riparian habitat between Suisun Marsh (and Bay) and open space to the north."[13] Further, the City acknowledged

---

[10] *Id.*, p. 3.
[11] **Attachment A**: Letter from Scott Cashen to Rachael Koss re: Comments on the Valero Crude by Rail Project, March 28, 2016 ("Cashen Comments"), pp. 2-3.
[12] *Id.*
[13] *Id.*, p. 3.

that Sulphur Springs Creek is likely a movement corridor for wildlife, including the federally threatened California red-legged frog.[14]

The Project includes installation of 100 LED lights mounted 12 feet above the unloading rack platform walkway, located adjacent to Sulphur Springs Creek. According to the City, the effects of night lighting on wildlife movement "should"[15] or "would"[16] be less than significant due to "the downward orientation of Project lighting, away from the riparian corridor."[17] The City's conclusion is not supported by substantial evidence.

Mr. Cashen explains that, while "orienting lights downward reduces astronomical light pollution, it does not prevent ecological light pollution" or "the potential for Project lighting to significantly impact biota associated with Sulphur Springs Creek."[18] Mr. Cashen recommends that the City require Valero to implement a mitigation and monitoring program that ensures impacts to wildlife movement in the Sulphur Springs Creek corridor are mitigated to a less than significant level.[19] As it stands, the Project's impacts on wildlife movement from Project lighting at the unloading rack remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

2. Increased Human Activity from Project Operation Within the Refinery Boundary Would Significantly Impact Wildlife Movement

Increased human activity from Project operation within the refinery boundary would result in a significant, unmitigated impact on wildlife movement in the Sulphur Springs Creek corridor. While the City acknowledged that increased human activity could cause wildlife to avoid using Sulphur Springs Creek as a movement corridor, it concluded, without any support, that the impact to wildlife movement would be less than significant.[20] According to Mr. Cashen, the increased human activity from Project operation within the refinery boundary would, indeed,

---

[14] DEIR, pp. 4.2-6, 4.2-30.
[15] *Id.*, p. 4.2-30.
[16] RDEIR, p. 2-156.
[17] DEIR, p. 4.2-30; RDEIR, p. 2-156.
[18] Cashen Comments, p. 3.
[19] *Id.*, p. 7.
[20] RDEIR, p. 2-156.

cause wildlife to avoid using the Creek as a movement corridor, constitutes a significant, unmitigated impact to wildlife movement.[21] The City has not disclosed this significant impact. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

3. *Noise from Project Operation Within the Refinery Boundary Would Significantly Impact Birds and Other Wildlife*

The City concluded that "while the increase in train traffic may initially have a slight negative effect on nearby wildlife species, they are expected to soon habituate to the increased noise. The impact is less than significant, and no mitigation is required."[22] The City's conclusion is completely unsupported.

Mr. Cashen explains in his comments that noise pollution affects birds and other wildlife in several ways, including: (1) physical damage to ears; (2) stress responses; (3) fright–flight responses; (4) avoidance responses; (5) changes in other behavioral responses (such as foraging); (6) changes in reproductive success; (7) changes in vocal communication; (8) interference with the ability to hear predators and other important sounds; and (9) potential changes in populations.[23] Further, according to Mr. Cashen, two of the bird species that may occur within the Sulphur Springs Creek riparian corridor, yellow-headed blackbird and tricolored blackbird, "are especially susceptible to noise because when one bird reacts, many or all birds in the colony will react similarly, whether the group responds directly to the noise or to the first bird(s) that responded."[24]

Existing noise at the refinery averages 60 dBA during the day and 59 dBA during the evening and night.[25] The Project would generate significantly higher noise levels. According to the noise study prepared for the Project, the Project pumps and motors would produce a noise level of 87 dBA at five feet, and the trains would generate a maximum noise level of 81 dBA at 200 feet.[26] Mr. Cashen explains that "[n]oise at these levels is loud enough to have a significant impact on

---

[21] Cashen Comments, pp. 4, 7.
[22] DEIR, p. 4.2-32.
[23] Cashen Comments, p. 4.
[24] *Id.*
[25] Wilson Ihrig & Associates. 2013. Noise Study for Valero Crude-by-Rail Project, Table 1.
[26] *Id.*, p. 3.

birds and other wildlife that occur within the Sulphur Springs Creek riparian corridor."[27]

Mr. Cashen also provides scientific evidence that the City's conclusion that wildlife would habituate to a 20 dBA increase in the noise level is wrong. Scientific evidence shows that a 20 dBA increase in the noise level can have a significant negative effect on species occupancy, pairing success and other measures of fitness.[28] Moreover, "even those individuals that outwardly appear to habituate," may still have decreased fitness from an increased noise level.[29]

The impact on birds and other wildlife from Project noise generated within the refinery boundary remains significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

4. Project Operation Within the Refinery Boundary Would Significantly Impact Wildlife from Chronic Exposure to Contaminants

Mr. Cashen explains in his comments that environmental contaminants, such as petroleum products, "may adversely affect the survival, growth, reproduction, health, or behavior of species."[30] These contaminants can leach into waterways even without a spill or accident.[31] Indeed, free phase liquid hydrocarbons have been detected in monitoring wells at various locations within the refinery.[32] Yet, the City, without any supporting evidence, concluded that "[u]nder normal operating conditions," the Project would have "no impact" on water quality or hydrology.[33] The City's conclusion is contrary to scientific evidence.

For example, scientific evidence shows that:

Contamination of marsh sediments may impact clapper rails directly or indirectly. Potential direct effects include toxicity to adults, chicks, or

[27] Cashen Comments, p. 4.
[28] *Id.*, p. 5.
[29] *Id.*; *see also* FEIR, Comment J3-24.
[30] Cashen Comments, p. 5.
[31] *Id.*
[32] DEIR, p. 4.8-5.
[33] FEIR, Comment J3-19.

> embryos. Potential indirect effects include reduced prey quality, quantity, and availability, and altered vegetation structure/composition for nesting and sheltering.
> To date, most direct contaminant impacts to the [clapper] rail have likely been due to lifetime exposures at chronic, sub-lethal concentrations that alter individual fitness. Known contaminants of concern for rail recovery in the San Francisco Bay Estuary include mercury, selenium, PCBs, and petroleum hydrocarbons. The potential toxicological effects of long term chronic contaminant exposures can include reproductive impairment, compromised immune function, reduced growth, deformity, and altered behavior.[34]

The City's conclusion is unsupported. The Project's impact on species from chronic exposure to contaminants remains significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

5. *Project Operation Within the Refinery Boundary Would Significantly Impact Wildlife from an Accident or Spill*

An accident or spill at the Project site could expose wildlife to oil. According to the U.S. Fish and Wildlife Service, even relatively small exposures to oil can harm or kill birds and other wildlife.[35] Adverse effects to birds from exposure to petroleum hydrocarbons include loss of feather structure resulting in flightlessness, loss of water repellency of feathers resulting in hypothermia, chemical burns to the skin, and in extreme oilings, incapacitation.[36] Mr. Cashen explains that the "survival rate of oiled wildlife is low, even when considerable effort is devoted to cleaning and rehabilitating affected animals."[37] Moreover, some dispersants, when mixed with oil, can be quite toxic and can enhance the toxicity of oil if ingested by wildlife.[38] Also, trampling of oiled mudflats by cleanup crews pushes oil beneath the surface where benthic organisms reside. This results in reduced abundance of benthic prey for waterbirds, and an indirect hazard to waterbirds due to bioaccumulation of toxic chemicals in benthic prey.[39] Yet, the City never analyzed

---

[34] U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol I, pp. 114, 121.
[35] *Id.*. Vol I, p. 44.
[36] *Id.*, Vol II, p. 201.
[37] Cashen Comments, p. 6.
[38] *Id.*, pp. 6-7.
[39] *Id.*, p. 7.

the Project's impacts from on-site accidents on Sulphur Springs Creek or its riparian corridor, marshes and biota. The City's analysis of spill and accident impacts on biological resources was limited to "uprail" impacts.

In Mr. Cashen's opinion:

> any of the on-site accidents evaluated in the FEIR would result in significant mortality and substantially reduce the habitat of fish and wildlife species dependent on Sulfur Springs Creek." Sulphur Springs Creek is a federally protected waterway, and downstream coastal brackish marshes are federally protected wetlands. In the event of an accident at the loading rack, or anywhere along the pipeline, the impacts to the riparian corridor, in-stream marshes, and biota would be devastating due to their proximity.[40]

Mr. Cashen provides a list of feasible mitigation measures that would reduce adverse effects on biological resources from a spill or accident on Valero property including:

- Requiring Valero to demonstrate compliance with provisions of SB 861 (Oil Spill Contingency Plan);
- Requiring Valero to have the trained personal and equipment (e.g., booms and sorbent materials) needed to limit oil movement if a spill or accident occurs;
- Requiring Valero to provide funding, personnel, and other resources to oil cleanup response agencies;
- Requiring Valero to fund wetland restoration or other ecosystem improvement projects that benefit or protect water quality; and
- Requiring Valero to provide a financial security that guarantees the restoration or replacement of habitat affected by a spill or accident.[41]

As it stands, the Project's impacts on biological resources from a spill or accident at the Valero refinery remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

---

[40] *Id.*
[41] *Id.*, p. 9.

6. *Project Operation Within the Refinery Boundary Would Significantly Impact Nesting Birds*

The FEIR requires pre-construction surveys for nesting birds within the Project area, and all accessible areas within 500 feet, if Project construction activities would occur during the avian nesting season.[42] The FEIR indicates the pre-construction surveys should be conducted no sooner than 30 days prior to the start of any Project activity.[43] According to Mr. Cashen, this mitigation measure is insufficient to mitigate the Project's potentially significant impacts to nesting birds to a less than significant level.[44]

First, Mr. Cashen explains that some birds can build a nest and initiate egg-laying within 10 to 14 days.[45] Therefore, nesting bird surveys 30 days prior to construction activities would be insufficient to locate nests that could be affected by the Project.

Second, the FEIR does not establish minimum standards for the survey effort, including the need to adhere to scientific standards for nest site detection. According to Mr. Cashen, "nest finding is labor intensive and can be extremely difficult due to the tendency of many species to construct well-concealed or camouflaged nests."[46] As a result, most studies that involve locating bird nests employ a variety of search techniques, including flushing an adult from the nest, watching parental behavior (e.g., carrying nest material or food), systematically searching nesting substrates and broadcasting of bird calls.[47] In addition, Mr. Cashen explains that "breeding birds are known to be most active and detectable early in the morning, and there is a strong positive correlation between survey effort and abundance of nests detected."[48]

Finally, Mr. Cashen explains that "several of the bird species that have the potential to nest within 500 feet of the Project site are extremely difficult to detect."[49] For example, the California black rail is a secretive species that

---

[42] FEIR, p. H-7.
[43] *Id.*
[44] Cashen Comments, pp. 8-9.
[45] *Id.*, p. 8.
[46] *Id.*
[47] *Id.*
[48] *Id.*
[49] *Id.*

constructs its nest in dense wetland vegetation and the single pre-construction survey required by the FEIR is insufficient to detect rail nests that could be affected by the Project.[50]

Mr. Cashen states that any mitigation incorporated into the EIR must specify the techniques for nest surveys, the expected level of effort (i.e., hours per unit area), the search area, the time of day surveys will be permitted and the techniques that should be used to minimize human-induced disturbance.[51] As it stands, the Project's impacts on nesting birds from on-site operations remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

B. Substantial Evidence Shows the Project Would Result in Significant, Unmitigated Air Quality and Public Health Impacts from On-site Emissions

1. The Project Would Result in a Significant, Unmitigated Impact from On-site Railcar Fugitive Emissions

In Dr. Phyllis Fox's attached comments, she estimates fugitive reactive organic gas ("ROG") emissions from railcar positioning, connecting, disconnecting and unloading, all of which occur at the refinery. In her calculations, Dr. Fox used emission factors developed by the United States Environmental Protection Agency ("EPA") for marketing terminals, which are the same emissions factors used by Valero in its emission calculations. Dr. Fox's calculations show that the on-site ROG emissions per 50-car train are 412 pounds (lb) per visit, 824 lb/day and 150 ton/yr.[52]

Further, using emission factors developed by the EPA for oil and gas production, which are the emission factors used by San Luis Obispo County for the Phillips 66 Santa Maria Rail Spur project, the Project's on-site railcar fugitive emissions would rise to 1,350 lbs per 50-car train visit, or 2,700 lb/day.[53] Assuming

---

[50] *Id.*
[51] *Id.*, pp. 8-9.
[52] **Attachment B**: Phyllis Fox Comments on Valero Appeal, April 4, 2016 ("Fox Comments"), p. 7.
[53] *Id.*

two 50-car trains per day, the Project's on-site railcar fugitive emissions rise to 493 ton/yr.[54]

The CEQA significance thresholds for ROG emissions established by the Bay Area Air Quality Management District ("BAAQMD") are 54 lb/day and 10 ton/yr. Therefore, Dr. Fox's calculations show that the daily and annual on-site ROG railcar fugitive emissions exceed the BAAQMD significance thresholds. Dr. Fox provides a list of feasible measures to mitigate the Project's on-site railcar fugitive ROG emissions.[55] As it stands, the City has not disclosed or mitigated this significant impact. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

2. *The Project Would Result in a Significant, Unmitigated Public Health Impacts from On-site Fugitive Benzene Emissions*

Dr. Fox explained in her comments on the DEIR that ROG emissions contain substantial amounts of toxic air contaminants ("TAC"), including up to 7% benzene by weight.[56] The City completely failed to include on-site railcar fugitive benzene emissions in its revised health risk assessment ("HRA"). The HRA included only benzene emissions from other fugitive sources, such as valves, pumps and connectors. The HRA provides that these other fugitive sources would result in emissions of 0.062 lb/day and 0.01 ton/yr.

In her attached comments, Dr. Fox calculated the on-site fugitive railcar benzene emissions and found they could be up to 236 lb/day or 43 ton/yr.[57] Dr. Fox also calculated the Project's public health risk from on-site benzene emissions, including on-site fugitive railcar emissions, and found the Project would result in significant acute health impacts at the maximum exposed individual resident ("MEIR"), the maximum exposed individual worker ("MEIW") and at the nearest elementary school. Dr. Fox also found that the Project would result in significant chronic health impacts and cancer risk at the MEIW.[58] According to Dr. Fox, the Project's significant impact from benzene emissions could be mitigated by the

---

[54] *Id.*
[55] *Id.*, pp. 8-9.
[56] *See* FEIR, Comment B11-55; Fox Comments, p. 23.
[57] Fox Comments, p. 23.
[58] *Id.*, pp. 24-25.

feasible mitigation measures for on-site railcar fugitive ROG emissions. The City should require these measures. In addition, to mitigate the Project's benzene emissions, Dr. Fox recommends that the City limit the amount of benzene in crude allowed to be imported, to ensure cancer, chronic and acute health risks are less than significant.[59] The City has not disclosed or mitigated these significant public health impacts. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

3. The Project Would Result in a Significant, Unmitigated Impact from On-Site Crude Storage Tank Emissions

The Project would unload up to 70,000 barrels per day (bbl/day) of crude oil at the unloading rack and transport it through a new 4,000-foot long, 16-inch diameter pipeline, which connects with an existing pipeline to existing floating roof tanks that are currently permitted to store crude oil.[60] Dr. Fox provides a list of these eight tanks (1701 to 1708) in her comments and includes each tank's capacity and permit limit.[61] Dr. Fox explains that, historically, tanks 1701 through 1706 stored crudes delivered by ship and pipeline. Crudes delivered by pipeline originate in the San Joaquin Valley and have very low vapor pressures, typically less than 1 psi.[62] Crudes delivered by ship have vapor pressures less than 5 psi.[63] According to Dr. Fox, tanks 1707 and 1708 were recently constructed and were permitted under the federal Clean Air Act New Source Review program to store crude delivered by marine vessels and pipeline.[64]

Dr. Fox showed in her comments on the DEIR that the Project would increase ROG emissions from these tanks by increasing the vapor pressure of crude stored in them.[65] Dr. Fox calculated the increased ROG emissions and showed that the increase would result in a significant air quality impact.[66] The City ignored Dr. Fox's emissions calculations and stated in the FEIR, without any support, that the Project "would not increase emissions from storage tanks beyond existing

---

[59] *Id.*, p. 25.
[60] *Id.*, pp. 9.
[61] *Id.*, p. 10.
[62] *Id.*, p. 11.
[63] *Id.*
[64] *Id.*
[65] *See* FEIR, Comments B11-48, 52.
[66] *Id.*

levels...The tanks would not be modified, and would continue to be subject to the same throughput limits and permit conditions."[67] The FEIR's conclusion is not supported by the facts or the law.

First, CEQA requires the City to determine whether the Project would change the existing environment by increasing emissions as compared to actual existing emissions -- not whether the Project will change the environment by exceeding hypothetical emissions allowed under permit limits. This was precisely the issue before the California Supreme Court in *Communities for a Better Environment v. South Coast Air Quality Management District*.[68] The Court rejected the argument that "the analytical baseline for a project employing existing equipment should be the maximum permitted operating capacity of the equipment, even if the equipment is operating below those levels at the time the environmental analysis is begun."[69] The Court held that CEQA requires the baseline to reflect "established levels of a particular use," not the "merely hypothetical conditions allowable under the permits..."[70] Following the Supreme Court decision, the court in *Communities for a Better Environment v. City of Richmond*[71] similarly rejected the city's use of a hypothetical baseline, which failed to reflect actual operational conditions. "The [Supreme Court] stated that using hypothetical, allowable conditions as a baseline 'will not inform decision makers and the public of the project's significant environmental impacts, as CEQA mandates.'"[72] Thus, the City's argument in the FEIR has already been rejected by the California Supreme Court.

Second, the Title V permits that cover these tanks reveal that there are no vapor pressure or ROG limits for the tanks – there are only throughput limits.[73] Consequently, the Project can transfer Bakken and other similar light crudes into these tanks without violating any vapor pressure permit limits, but still significantly increasing ROG and TAC emissions.[74]

---

[67] FEIR, RTC B10-46.
[68] *Communities for a Better Environment v. South Coast Air Quality Management District* (2010) 48 Cal.4th 310.
[69] *Id.* at 316.
[70] *Id.* at 322.
[71] *Communities for a Better Environment v. City of Richmond* (2010) 184 Cal.App.4th 70.
[72] *Id.* at 89.
[73] Fox Comments, p. 13.
[74] *Id.*

Third, Dr. Fox explains that ROG emissions from crude oil storage tanks depend on the vapor pressure of the crude oil.[75] If the vapor pressure increases, so do the emissions. The City completely failed to take this into account. Moreover, the FEIR states that tank emission calculations and vapor pressure data are confidential business information, exempt from disclosure to the public. This is concerning given the direct correlation between vapor pressure and emissions (and the federal Clean Air Act's requirement that this information be disclosed).[76]

Finally, evidence shows that these tanks were permitted by the BAAQMD assuming vapor pressures far below the vapor pressures of the new crudes that will be stored in them.[77]

Dr. Fox calculated the Project's on-site tank ROG emissions. A detailed account of her calculations are included in her comments. Dr. Fox found that the Project's increase in tank ROG emissions would exceed the BAAQMD's significance thresholds for both annual and daily emissions.[78] Dr. Fox recommends feasible measures to mitigate the Project's significant air quality impact from storage tank ROG emissions, including retrofitting the tanks and using geodesic domes.[79]

As it stands, the Project's air quality impacts from on-site crude storage tank emissions remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

C. Substantial Evidence Shows the Project Would Result in Significant, Unmitigated Public Health and Safety Impacts from On-site Hazards

The RDEIR includes a quantitative risk assessment ("QRA") to evaluate the risks to the public from accidents at the Project site, including the following proposed new and modified facilities to support unloading 70,000 bbl/day of crude oil, shipped in two 50-unit trains per day: (1) proposed 8,880 feet of rail track between the proposed service road the crude oil tank farm, (2) the realigned 3,560-

---

[75] *Id.*
[76] 40 C.F.R. §§ 2.301, 71.5(c)(3).
[77] Fox Comments, p. 14.
[78] *Id.*, pp. 17- 20.
[79] *Id.*, p. 22.

foot rail track, (3) the proposed 1,900-foot long, 20-foot wide service road closer to the tank farm to the west, (4) the proposed 1,500-foot long unloading rack in the northeastern portion of the main refinery property, sandwiched between the eastern side of the lower tank farm and the fence adjacent to Sulphur Springs Creek, (5) a liquid spill containment sump with the capacity to contain the contents of one tank car, and (6) the proposed 4,000 feet of 16-ince diameter aboveground crude oil pipeline.[80]

Dr. Fox explains in her attached comments that the QRA is flawed for several reasons. These flaws, described below, result in a substantial underestimate of the significance of impacts from on-site accidents. Substantial evidence shows that, when the QRA's errors and omissions are corrected, the Project's on-site hazards risks would result in significant impacts that are not disclosed or mitigated in the FEIR.

1. The City's Significance Thresholds are Unsupported

Dr. Fox explains that the QRA significance thresholds are unsupported. The QRA uses public safety thresholds from Santa Barbara County's CEQA Guidelines ("SB Guidelines"). However, the City misapplies the SB Guidelines.

The SB Guidelines state that:

> ...these thresholds should not function as the sole determinants of significance for public safety impacts. Rather, they must be used in concert with applicable County policy, regulation, and guidelines to address other qualitative factors specific to the project which also help determine the significance of risk. For example, highly sensitive land uses (e.g., hospitals or schools) are generally given greater protection from hazardous situations overall. Also, long-term significant risks (e.g., natural gas production) generally are treated more conservatively than relatively short-term risks (e.g., natural gas exploration)."[81]

Yet, the QRA applied these thresholds as the "sole determinants of significance for public safety impacts" without considering any other factors specific to the Project

[80] RDEIR, p. 2-6.
[81] County of Santa Barbara Planning and Development, Environmental Thresholds and Guidelines Manual, October 2009 (SBPD 10/2008); available at https://www.countyofsb.org/ceo/asset.c/479.

that require greater protection. Dr. Fox explains that there are three major factors that must be considered in assigning the significance of hazards impacts for the Project.

First, the unloading facility presents a long-term significant risk to nearby businesses to the east. Many commercial properties, such as Conco, Praxair, Benicia Fabrication & Mach and Insight Glass, are within significant hazard zones.[82] Further, according to Dr. Fox, "one of the EIR's accident scenarios, a thermal tear, could result in injuries and fatalities at the nearest residence at Lansing Circle, approximately 2,000 feet northwest of the northern end of the Project site."[83] In addition, "[a]n accident at Tank S-1701 to S-1708, which would store the imported crude oil, could additionally result in injuries and fatalities in the Hillcrest neighborhood, about 1,000 feet from the nearest residence on Hillcrest Avenue."[84] The QRA completely failed to consider these scenarios.

Second, an on-site accident would result in significant impacts to plants and wildlife that rely on the adjacent Sulphur Springs Creek, just 50 to 60 feet away.[85] These significant biological impacts warrant more conservative treatment.

Finally, depending on the specific accident, on-site accidents at the new facilities could result in significant impacts at a local school. According to Dr. Fox, an accident involving the proposed storage tank would present significant risk of injuries and fatalities in the Hillcrest neighborhood and the Robert Semple School, about 3,000 feet from the nearest tank. Thus, more conservative treatment than the SB Guidelines risk spectrum is warranted.[86]

2. *The City's Use of Probability in the Risk Assessment Substantially Underestimates the Significance of Impacts*

The City evaluated the significance of an accident based on the "risk" that an accident would occur, determined as: risk = consequence x probability. Dr. Fox explains that,

---

[82] RDEIR, Figure 4.7-8.
[83] Fox Comments, p. 29.
[84] *Id.*
[85] *Id.*, p. 30.
[86] *Id.*

> [b]ecause probability is a number less than one, what this means is that the EIR has reduced the consequences, *e.g.*, the numbers of injuries and death, by multiplying them by a number less than one, thus reducing the apparent impact. However, probability is misleading because even if it is small, any given event can occur over the lifetime of the project, resulting in significant consequences.[87]

According to Dr. Fox, "the use of probability to estimate risk obscures the fact that accidents can be significant even if they occur infrequently."[88] Dr. Fox provides the example of the Lac-Megantic accident. If a Lac-Megantic-type accident occurs only once in 111 years, it would still be significant.[89] Indeed, "it is illustrative to mention that the 'once in 111 years' occurrence is as likely to happen next year as it is in 10, 30 or 111 years."[90]

3. *The QRA Risk Files are Unsupported*

Dr. Fox explains in her comments that a QRA is a process used to assign a numeric value to the probability of an impact, in this case, death and injuries resulting from an accident at the rail car loading facility.[91] A QRA requires information on the type of accidents, their probability of occurrence based on historical data from similar facilities, and consequence modeling of each accident scenario to determine impacts when the accident occurs.[92]

The RDEIR includes oil spill consequence analyses for several crude oil spill scenarios to evaluate worst-case thermal radiation hazards.[93] The RDEIR summarized the "worst-case thermal radiation hazard" distances based on these consequence analyses in RDEIR Table 4.7-8 and Figure 4.7-8 for two thermal radiation significance criteria: 5 kW/m^2 and 10 kW/m^2. The RDEIR explains that

> "[e]xposure to a thermal radiation level of 10 kW/m^2 could result in a serious injury (at least second-degree burns) if exposed for less than 1 minute, and it

---

[87] *Id.*, p. 31.
[88] *Id.*
[89] *Id.*
[90] *Id.*
[91] *Id.*, p. 32.
[92] *Id.*
[93] RDEIR, Appx. F, Attach. 3.

> was, therefore, assumed that all persons exposed to 10 kW/m^2 would suffer serious injuries. Serious injuries would start to be realized at and above 5 kW/m^2. Exposure to thermal radiation levels in excess of 10 kW/m^2 would likely begin to generate fatalities in less than 1 minute."[94]

Figure 4.7-8 contains thermal radiation isopleths overlaid on a Google map of the site, which indicates that the 5 and 10 kW/m^2 isopleths encompass Sulphur Springs Creek and commercial areas to the east of the unloading facility. Figure 4.7-8 shows that significant impacts will occur to habitat in the Creek and the encompassed commercial district. Based on this analysis, individuals along East Channel Road and Industrial Way within the thermal radiation 5 and 10 kW/m^2 circles would suffer serious injuries and fatalities.[95]

Oddly, rather than finding a significant impact from accidents at the rail unloading terminal, the RDEIR instead provides "risk profiles" which plot the frequency of an accident versus the number of injuries and fatalities.[96] The RDEIR's risk profile chart is divided into three areas: (1) insignificant, (2) potentially significant and (3) significant. According to the RDEIR, the unloading terminal falls into the insignificant category. The City's risk profile approach is completely unsupported.

There is zero evidence to support the City's transition from worst-case thermal radiation hazards in Figure 4.7-8 to the risk profiles in Figure 4.7-9. Dr. Fox explains that such a transition would require the following information: (1) an accident or failure frequency analysis to determine the probability of occurrence of each type of accident included in the consequence analysis at similar rail unloading terminals; (2) the annual chance of N or more injuries or fatalities; (3) population density information, *i.e.,* number of people per square mile; and (4) consequence area at each risk level (5 kW/m^2, 10 kW/m^2) to estimate the exposed population affected by injury or death. The EIR does not include this information for the unloading terminal.[97] Thus, the critical step in converting hazard zones to risk profiles is missing from the City's analysis and the City's conclusion is unsupported.

---

[94] RDEIR, Appx. F, Attach. 1, p. 16.
[95] Fox Comments, p. 34.
[96] *See* RDEIR, Figure 4.7-9.
[97] Fox Comments, p. 35.

4. *Substantial Evidence Shows that Off-site Impacts from On-Site Accidents are Significant*

Dr. Fox's analysis of the risk profiles shows that the City significantly underestimated the number of injuries and deaths from on-site accidents.

First, according to the RDEIR's risk profiles for injuries, the Project would result in 5.3 to 6.4 injuries from the worst-case on-site accident, which Table 4.7-8 reports would extend 1,585 feet from the accident site at a wind speed of 20 meters per second. The RDEIR contains no support for this injury estimate. Dr. Fox's analysis and calculations show that the correct number of off-site injuries is at least **108**, which would extend the risk profile into the potentially significant area.[98] If on-site workers are included, the number of injuries rises to at least **115**.[99] Dr. Fox points out that the actual number of injuries could be substantially higher because her calculations assume thermal radiation based on the *lowest* level reached in the zone.[100]

Second, according to the RDEIR's risk profile, the Project would result in 1.5 to 1.8 fatalities from the worst-case on-site accident, which would extend 1,109 feet from the accident site at a wind speed of 20 meters per second. The RDEIR contains no support for this fatality estimate. Dr. Fox's analysis and calculations show that the correct number of off-site fatalities is at least **11** fatalities, which would extend the risk profile into the potentially significant category.[101] Dr. Fox points out that the number of fatalities could be substantially higher due to exposure duration. According to Dr. Fox, if the exposure duration is 4.5 minutes or longer, which is plausible, the number of fatalities would be **18**.[102]

Dr. Fox's analysis shows that "the risk of off-site injuries and fatalities from the 'worst-case' on-site accident scenario is potentially significant to significant."[103] In her comments, Dr. Fox includes a long list of feasible mitigation measures that the City must require for the Project's significant public safety impacts from on-site accidents.[104]

---

[98] *Id.*, p. 38.
[99] *Id.*, p. 39.
[100] *Id.*
[101] *Id.*, p. 44.
[102] *Id.*
[103] *Id.*
[104] *Id.*, pp. 45-46.

5. *The City Failed to Evaluate Impacts from All Feasible Types of Accidents*

The City evaluated pool fires, which are contained to the area where spills occur, and a thermal tear, simulated as a Boiling Liquid Vapor Explosion ("BLEVE"). However, Dr. Fox explains that the release of a flammable material, like Bakken crude, "may result in a vapor cloud explosion, fireball and/or BLEVE, which could result in more significant consequences than the accident scenarios that were evaluated."[105]

According to Dr. Fox, "[a] vapor cloud explosion is the most dangerous and destructive explosion that could result."[106] A vapor cloud explosion results from the sudden release of a large quantity of flammable vapor, such as loss of tank containment or railcar contents. The vapor disperses and mixes with the air. If the mixture encounters an ignition source, a vapor cloud explosion occurs.[107] In Dr. Fox's opinion, vapor could explosions will likely occur as a result of the Project due to the volatility of Bakken crude and the proximity of many ignition sources and nearby tanks that could be engulfed by the vapors.[108] The City completely failed to consider vapor cloud explosions in its analysis.

6. *The City Failed to Evaluate Impacts from All Feasible On-site Accident Scenarios*

The City evaluated two classes of on-site accidents: (1) during train maneuvering at the rail unloading facility and (2) during line hookup and crude oil transfer.[109] The City analyzed accidents ranging from small releases from a tank car, from full release of tank car contents, and from full release of pipeline volume. Dr. Fox reviewed these consequence analyses and found that they contain errors and do not disclose the extent of Project impacts from all feasible on-site accidents.

First, the City estimated that a derailment while maneuvering onto the side-track unloading area would occur once every 100 years (a probability of 0.01). The City further concluded that a spill would be unlikely due to the low speed of on-site trains (3 mph) and tank car design. The City supposedly evaluated a "reasonable

---

[105] *Id.*, p. 47.
[106] *Id.*, p. 48.
[107] *Id.*
[108] *Id.*, p. 49.
[109] RDEIR, p. 2-106.

worst case scenario where one entire tank car contents spilled" and concluded the Project's spill containment system would hold this amount of crude, resulting in a less than significant impact.[110] However, the City provided no support for this conclusion. In Dr. Fox's opinion, the City's conclusion is unreasonable. Dr. Fox states:

> *First*, the spilled crude oil, which is very volatile, could rapidly form a fuel and air vapor cloud before the spilled crude reached containment. *Second*, the spill could occur in an area not controlled by containment/fire control. *Third*, even if the spill reached containment, vapors would be released from containment that could form a vapor cloud.
>
> The resulting vapor cloud could reach nearby tanks (only 50 to 80 feet away), loaded railcars, the loading rack or the Benicia Industrial Park. An ignition source would cause a fire, which could engulf waiting railcars, nearby tanks, or the Benicia Industrial Park (some of which store volatile and hazardous materials), leading to a BLEVE or thermal tear. Further, given the location of the loading rack and the density of nearby tanks, multiple tanks and railcars could be engulfed, resulting in a much larger thermal tear than evaluated in the EIR. A BLEVE at the northern end of the loading rack would result in significant off-site impacts at the nearest residences on Lansing Circle and significantly more injuries and fatalities than estimated in these comments as a higher population density area with 5,000 people per square mile is located to the northeast of the loading racks. Thus, ... accidents during on-site train maneuvering are significant.[111]

Second, the City evaluated accidents during line hookup and crude oil transfer from cars at the unloading facility. The City evaluated several crude oil spill scenarios to identify the "worst-case" thermal radiation hazards associated with a large crude oil fire, including three pool fire scenarios, a thermal tear (fireball or BLEVE) and an "unloading" scenario.[112] Dr. Fox explains that the City failed to disclose the extent of impacts from accidents during line hookup and crude oil transfer. According to Dr. Fox, the "worst-case" scenario is the explosion of rail cars and/or tanks (referred to in the RDEIR as a thermal tear and simulated as a

---

[110] *Id.*
[111] Fox Comments, p. 49.
[112] RDEIR, App. F, Att. 3, Oil Spill Consequence Modeling Results.

BLEVE).[113] Dr. Fox explains that "[a]ny of the evaluated pool fire scenarios, including the unloading scenarios, could generate enough energy to result in a thermal tear, which is the real worst case."[114] According to Dr. Fox, the injury hazard zone for a thermal tear could extend 2,339 feet from the accident site or 754 feet further than the worst-case pool fire.[115] An on-site thermal tear would result in very significant off-site impacts that have not been disclosed in the EIR and have not been mitigated.[116]

Third, the City failed to evaluate accidents along the pipeline. The Project includes the installation of 4,000 feet of pipeline and associated components between the unloading rack and the existing crude supply piping. Dr. Fox explains that pipeline leaks could occur from flange separation, corrosion, a lighting strike, flood or earthquake-induced failure.[117] According to Dr. Fox, natural disasters could not only damage the pipeline but also the Supervisory Control and Data Acquisition ("SCADA") system which detects pipeline failures and limits pipeline and pumping losses. As a result, an accident could cause a loss of the complete contents of a 50-car train (or 35,000 bbl).[118] "The air-vapor cloud formed as a result of such a pipeline leak could migrate into the adjacent tank farm and if an ignition source is encountered, result in a vapor cloud explosion, thermal tear, and/or BLEVE involving more than one tank."[119] Dr. Fox recommends several feasible measures for significant impacts from pipeline leak accidents, including:

- Cathodic protection and pipe coating to prevent corrosion;
- Check valves to limit size of spills;
- Visual pipeline inspection once per shift;
- An underground pipeline;
- SCADA systems to monitor for pipeline leaks;
- Check valves at the tie-in location;
- Regular maintenance and pipeline inspections; and
- An SPCC Plan.[120]

---

[113] Fox Comments, p. 50.
[114] *Id.*
[115] *Id.*
[116] *Id.*, pp. 50-51
[117] *Id.*, p. 54.
[118] *Id.*
[119] *Id.*
[120] *Id.*, p. 56.

Finally, the City failed to evaluate accidents at the crude tank farm. The proposed pipeline joins an existing pipeline that ends at the crude tank farm, which contains 8 existing crude oil tanks. The closest tank is 45 feet from the arriving tracks. The tanks are separated by the rail track by a 20-foot wide service road and the tank farm berm, which would be moved closer to the tanks to make room for the Project. According to Dr. Fox,

> [t]his location is problematic and greatly increases the risk and consequences of an accident, beyond that considered in the EIR. The location of a process, such as the unloading rack and new rail spur, in relation to other facilities, is a key consideration in locating processing equipment. Lees' seminal *Loss Prevention Handbook* notes: 'Storage is most likely to be put at risk by a process. It is necessary, therefore, for the two to be segregated.' This is the reason that the existing tank farm is separated from the refinery.[121]

Yet, Valero proposes to locate a loading operation that could move 70,000 bbl/day of highly flammable Bakken crude oil, adjacent to its tank farm, which also stores flammable material.

> An accident on the rail spur or at the unloading rack could generate a vapor cloud that would engulf one or more tanks in the adjacent tank farm, significantly increasing the impacts of an accident, or, alternatively, the vapor cloud from an accident in the tank farm could engulf the unloading facility, resulting in significant impacts. If the vapor clouds from these types of event encountered an ignition source, a vapor cloud explosion or BLEVE could result.[122]

Further, the unloading rack is 45 feet from the property line fence that separates the site from Sulphur Springs Creek. According to Dr. Fox, "[t]he location of the unloading rack and rail track is highly problematic due to its proximity to the refinery tank farm, Sulphur Springs Creek, and commercial properties along East Channel Road."[123] The Project location "increases the probability and consequences of an accident at the new facilities and virtually guarantees significant impacts in

---

[121] *Id.*, p. 64.
[122] *Id.*
[123] *Id.*, p. 60.

the immediately adjacent habitat."[124] The City completely failed to recognize the compounded risk created by the geographic location of the Project.

The southwestern tank is 725 feet from the nearest house in the Hillcrest neighborhood, and less than 2,000 feet from the Ironworkers headquarters at 3120 Bayshore Road and other local businesses. According to Dr. Fox, "if the worst-case accident scenario evaluated in the EIR were to occur in this area, it would cause significant injury and fatalities in the Hillcrest neighborhood, at the Ironworkers headquarters and at other local businesses."[125] The City completely failed to evaluate an accident scenario involving the tanks, arguing that there would be no change in tank service.[126] However, as Dr. Fox explains, "all crude oils and tank operations do not present the same risk of upset. The project would alter both the properties of the crude oils stored in the tanks and the operation of the tanks, which would alter the types of accidents that could occur and their consequences."[127] Indeed, the City admits that:

> [t]he consequences of a release of crude oil for a rail tank car depend on the properties of the crude oil and the area into which the crude oil is released. Relatively lighter crude oil has a lower flash point than relatively heavier crude oil. Therefore, relatively lighter crude oil is more likely to ignite upon release, causing a fire and/or explosion.[128]

Dr. Fox explains that this is also true of releases from the storage tanks. Many of the crude oils that will be imported are much more volatile than the crude oils currently stored in these tanks.[129] "The crude oils that have been stored in Tanks 1701 to 1708 are heavy crude oils that are much less flammable than Bakken and other light crudes available by rail. Thus, the Project will increase the probability and consequences of an accident relative to the baseline due to the higher volatility of the crudes."[130] In addition, the rail-imported crudes are not the only crudes that will be stored in these tanks. Crudes imported by pipeline and ship will continue to be stored in these tanks. Thus, "switch loading" (filling a tank, which previously

---

[124] *Id.*, p. 67.
[125] *Id.*, p. 55.
[126] RDEIR, p. 2-107.
[127] Fox Comments, p. 56.
[128] DEIR, p. 4.7-13.
[129] Fox Comments, p. 56.
[130] *Id.*, pp. 56-57.

contained a high or intermediate vapor pressure product, with a low vapor pressure product) will occur.[131] Dr. Fox explains that switch loading "is a very hazardous operation, much more hazardous than current tank operations."[132] The City completely failed to consider and address these hazards. The City must disclose significant safety impacts from tank accidents due to a switch in the type of crudes stored in the tanks. Dr. Fox provides several feasible mitigation measures for these impacts.[133]

In short, the City's analysis of health and safety impacts from on-site hazards is unsupported and substantially underestimates the extent and significance of impacts. The Project's impacts from public health and safety impacts from on-site hazards remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

D. Substantial Evidence Shows that Project Operation Within the Refinery Boundary Would Result in Significant, Unmitigated Impacts from Flooding

The Project site is located in the 100-year flood zone. Flooding occurs along Sulphur Springs Creek from the lack of channel capacity. There are no designated flood protection facilities on Sulphur Springs Creek. In the event of a major flood, the creek overflows its banks and floods adjacent areas, including the Project site.[134] The City failed to disclose the Project's potential to worsen flooding, the significant impacts from worsening floods on railcar accidents and releases of crude oil, and the resulting significant water quality impacts.

First, the Project could exacerbate flooding. The Project site, at any given time, could contain up to three 50-car trains, each with three locomotives, two buffer cars and 50 tank cars.[135] Dr. Fox states that:

> [a]n empty CPC-1232 jacketed railcar weighs 80,800 lbs or about 40.4 tons and the maximum weight per railcar including the weight of the empty car

---

[131] *Id.*, p. 57.
[132] *Id.*
[133] *Id.*, p. 59.
[134] *Id.*, p. 74.
[135] FEIR, Figure ES-3, cross-section B-B and Sec. 3.2.

> and its cargo is 143 tons; the weight of a buffer car is 45 tons; and a typical locomotive weighs about 216 tons. Thus, a 50-car train filled with crude oil would weight about 7,888 tons. In addition, 50 or more empty railcars, three additional locomotives, and two buffer cars could be present on the adjacent departure track, weighing an additional 2,758 tons. Thus, the total on-site railcar weight would be at least 10,646 tons.[136]

Dr. Fox explains that railcars would block the passage of flood flows, "acting like a dam and occupying volume that flood flows would otherwise use to dissipate. This would raise flood elevations and create new flooding impacts."[137]

Further, the railcars would physically displace flood waters. According to Dr. Fox, the railcars would displace 48% of the volume otherwise available for flood flows at the railyard and 29% at the loading racks.[138] Taking into consideration Valero's proposal to move the tank farm berm 12 feet west of the existing berm to make room for the loading racks and new track, Dr. Fox concludes that the net increase in flood elevation would be two feet at the loading racks and six feet at the yard.[139] In Dr. Fox's opinion, "[t]his is a significant impact as flood elevations will rise, aggravating flooding in adjacent areas."[140]

Second, substantial evidence shows that flooding could increase the hazards related to an on-site accidental spill. According to Dr. Fox, if unloading were underway when floodwaters arrived, multiple railcars could become disconnected from the force of the flows, spilling oil into floodways and Sulphur Springs Creek, and ultimately, into Suisun Marsh.[141] Further, if an ignition source were present, such as sparks created by floodwaters dislodging the unloading rack, the spilled crude could ignite and affect a large area.[142]

Third, substantial evidence shows that flooding could expose workers to drowning and other flood-related health and safety impacts. Dr. Fox explains that "as a simple matter of comment sense," a 100-year flood could expose on-site

---

[136] Fox Comments, p. 79.
[137] *Id.*
[138] *Id.*, pp. 80-81.
[139] *Id.*, p. 81.
[140] *Id.*
[141] *Id.*, p. 75.
[142] *Id.*

workers to injury or death.[143] Dr. Fox recommends that the City require the following mitigation measures for the significant impact to workers from site inundation, such as worker flood hazard training and a flood warning system.[144]

The City failed to disclose the Project's potential to worsen flooding, the significant impacts from worsening floods on railcar accidents and releases of crude oil, and the resulting significant water quality impacts. As it stands, the Project's impacts from flooding remain significant and unmitigated. Therefore, the City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

III. THE CITY COUNCIL MUST DENY VALERO'S APPEAL BECAUSE THE PROJECT IS INCONSISTENT WITH THE CITY'S GENERAL PLAN

Benicia Municipal Code section 17.104.060 prohibits the City from issuing a use permit if a project would be inconsistent with the City's General Plan. The Project conflicts with a number of the City's General Plan goals and policies. These goals and policies were adopted for the purpose of avoiding or mitigating environmental impacts.[145] Therefore, these inconsistencies are significant environmental impacts. These inconsistencies are also separate, non-CEQA, bases for requiring the City to deny the Use Permit. The following are examples of these inconsistencies:

A. The Project is Inconsistent with Goal 2.5 – Health, Safety and Quality of Life

The purpose of Goal 2.5 is to ensure new development maintains the "health, safety, and quality of life" of the City.[146] The Project is inconsistent with this goal because, as described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site health and safety impacts), the Project would result in significant, unmitigated impacts to public health and safety from emissions and hazards. Thus,

---

[143] *Id.*, pp. 75-76
[144] *Id.*, p. 76.
[145] CEQA Guidelines §X(b).
[146] City of Benicia General Plan, p. 41, Goal 2.5.

the City couldn't possibly approve the Project while maintaining the City's health, safety and quality of life.

B. The Project is Inconsistent with Goal 4.1 and Policy 4.1.1 – Community Health and Safety

The purpose of Goal 4.1 and Policy 4.1.1 is to prioritize the health and safety of the Benicia community when making planning and policy decisions.[147] The Project is inconsistent with this goal and policy because, as described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site health and safety impacts), the Project would result in significant, unmitigated impacts to air quality and public health and significant, unmitigated hazards impacts from accident risks. Should the City approve the Project, the City would threaten the community's public health and safety, not prioritize it.

C. The Project is Inconsistent with Goals 4.7, 4.8, 4.15 and 4.20 and Policy 4.8.1 – Hazards

The purpose of Goal 4.7 is to ensure that neighborhoods are safe from risks to public health that could result from exposure to hazardous materials.[148] The purpose of Goal 4.8 and Policy 4.8.1 is to protect sensitive receptors from hazards.[149] The purpose of Goal 4.15 is to reduce fire hazards.[150] The purpose of Goal 4.20 is to reduce health and safety hazards associated with hazardous materials and toxic air contaminants, among other health and safety hazards.[151]

The Project is inconsistent with these goals and policy because, as described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site hazards impacts), the Project would result in significant, unmitigated hazards impacts associated with accident risks from explosion, fire, spills and other accidents, and significant, unmitigated health risks from toxic air contaminant emissions. Thus, the City couldn't possibly approve the Project while protecting the public from

---

[147] *Id.*, p. 142, Goal 4.1 and Policy 4.1.1.
[148] *Id.*, p. 160, Goal 4.7.
[149] *Id.*, p. 162, Goal 4.8 and Policy 4.8.1.
[150] *Id.*, p. 165, Goal 4.15.
[151] *Id.*, p. 168, Goal 4.20.

health and safety hazards, including fire, toxic air contaminant emissions and hazardous materials.

D. The Project is Inconsistent with Goals 4.9 and 4.10 and Policy 4.9.1 – Air Quality

The purpose of Goal 4.9 and Policy 4.9.1 is to ensure clean air for Benicia residents.[152] The purpose of Goal 4.10 is to support improved air quality in the BAAQMD.[153] The Project is inconsistent with these goals and policy because, as described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site air quality impacts), the Project would result in significant, unmitigated air quality impacts in Benicia and the BAAQMD. Therefore, by approving the Project, the City would worsen air quality, not improve it.

IV. THE CITY COUNCIL MUST DENY VALERO'S APPEAL BECAUSE THE PROJECT VIOLATES THE BENICIA MUNICIPAL CODE

The Project site is located in a floodway, as defined by section 15.40.070 of the Benicia Municipal Code. Benicia Municipal Code section 15.48.050 provides that, because a floodway is an:

> extremely hazardous area due to the velocity of floodwaters which carry debris, potential projectiles and erosion potential, the following provisions apply:
>
> A. All encroachments, including fill, new construction, substantial improvements, and other development are prohibited within the floodway unless certification by a registered professional engineer or architect is provided demonstrating that encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge.

---

[152] *Id.*, Goal 4.9 and Policy 4.9.1.
[153] *Id.*, p. 163, Goal 4.10.

B. If subsection (A) of this section is satisfied, all new construction and substantial improvements shall comply with all other applicable flood hazard reduction provisions of this chapter. (Ord. 88-6 N.S. § 1, 1988).

There is no evidence, via a professional engineer certification or otherwise, that the Project will comply with section 15.48.050(A) since substantial evidence shows that the railcars will increase flood levels. Therefore, the Project violates the Benicia Municipal Code. The City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

V. THE CITY COUNCIL MUST DENY VALERO'S APPEAL BECAUSE THE PROJECT IS INCONSISTENT WITH THE BENICIA FLOODPLAIN MANAGEMENT POLICY

The Benicia Floodplain Management Policy 4.13.1 is to "[r]equire all potential developers in the Sulphur Springs Creek City of Benicia General Plan 165 floodplain to provide flood hazard mitigation measures that ensure the subject properties are not at risk of flooding during the FEMA-designated 100-year base flood." However, the City required no "flood hazard mitigation measures" for the Project. The EIR merely states that "Project components would be required to include in the design criteria flood hazard mitigation measures in accordance with the City of Benicia Floodplain Management Policy" which would "comply with construction standards established by the California Building Code."[154] The City failed to identify the "standards" that would be followed and, thus, failed to "provide flood hazard mitigation measures that ensure the subject properties are not at risk of flooding," as required by Policy 4.13.1.

The Project is inconsistent with the Benicia Floodplain Management Policy. The City Council must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

---

[154] DEIR, p. 4.8-19.

VI. THE CITY COUNCIL MUST DENY VALERO'S APPEAL BECAUSE THE PROJECT WOULD BE DETRIMENTAL TO THE PUBLIC'S HEALTH, SAFETY AND WELFARE

Benicia Municipal Code section 17.104.060 prohibits the City from issuing a use permit if a project would be "detrimental to the public health, safety, or welfare of persons residing or working in or adjacent to the neighborhood of such use," "detrimental to properties or improvements in the vicinity or to the general welfare of the city." As described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site public health and safety, air quality and hazards impacts), the Project would be extremely detrimental to the health, safety and welfare of the public, to properties in the vicinity and to the City's general welfare. Thus, the City cannot issue the Use Permit. The City must deny Valero's appeal and uphold the Planning Commission's decision to deny the Use Permit.

VII. THE PLANNING COMMISSION'S DECISION TO DENY CERTIFICATION OF THE FEIR AND THE USE PERMIT IS NOT PREEMPTED BY FEDERAL LAW

Valero argues that the Planning Commission's decision to deny certification of the FEIR and the Use Permit are preempted by federal law because the Interstate Commerce Commission Termination Act of 1995 ("ICCTA") "prohibits the City from denying a use permit application or any necessary environmental authorization on the basis of railroad impacts, whether such impacts are direct or indirect."[155] Valero's argument is not supported by the facts or the law.

First, substantial evidence in the record shows significant, unmitigated impacts *from Project operation within the refinery boundary* that is clearly outside the bounds of the ICCTA, including impacts from hazards and flooding and impacts to air quality, public health and safety, and biological resources. Under CEQA, when a project would have significant and unmitigated environmental effects, a lead agency has the authority to deny the project.[156] Further, Benicia Municipal Code section 17.104.060 prohibits the City from issuing a use permit if a project would be "detrimental to the public health, safety, or welfare of persons residing or

[155] Valero's Appeal of Planning Commission Resolution No. 16-1, February 29, 2016, p. 5.
[156] 14 Cal. Code Regs., §§ 15002(h)(5), 15042; *Native Sun/Lyon Communities v. City of Escondido* (1993) 15 Cal.App.4th 892.

working in or adjacent to the neighborhood of such use," or "detrimental to properties or improvements in the vicinity or to the general welfare of the city." The significant, unmitigated on-site impacts detailed in these comments alone provide sufficient grounds for the City Council to deny Valero's appeal and uphold the Planning Commission's unanimous decision to deny certification of the FEIR and the Use Permit.

Second, even if the Project would only result significant, unmitigated off-site impacts, the City can still deny certification of the FEIR and the Use Permit. Under the ICCTA, the STB has exclusive jurisdiction over "transportation by rail carriers."[157] However, the ICCTA does not preempt State and local laws of general application with a remote or incidental effect on rail transportation, and which do not unreasonably burden rail transportation.[158] Here, Valero, a non-rail carrier entity, seeks a permit from the City for its Project that is intended solely to benefit Valero's business and refinery operations. The Project entails the installation, operation and maintenance of new equipment, pipelines and associated infrastructure, and new and realigned segments of existing railroad track within the refinery boundary to allow Valero to receive crude oil by rail.[159] These Project activities are neither undertaken by Union Pacific Railroad ("UPRR"), nor are they integral to UPRR's interstate operations. Indeed, the City's counsel has repeatedly stated that UPRR will not own or operate the Project's unloading facility and Valero is not acting as an agent of UPRR. In other words, this is Valero's Project, not UPRR's. Therefore, the ICCTA does not grant the STB jurisdiction over the Project's permitting process.[160] Rather, under the exercise of traditional police powers under the Constitution, including State laws aimed at pollution prevention and environmental protection, like CEQA,[161] and local land use laws, like the City's Zoning Ordinance, the City has jurisdiction over the Project's permitting process.

In a preemption analysis, courts begin with the presumption that police powers to protect the health and safety of citizenry are not superseded by federal

---

[157] 49 U.S.C. § 10501(b).
[158] *Association of American Railroads* v. South Coast Air Quality Management District (9th Cir. 2010) 622 F.3d 1094, 1097.
[159] RDEIR, p. 2-3.
[160] *Florida East Coast Ry. Co. v. City of West Palm Beach* (11th Cir. 2001) 266 F.3d 1324.
[161] *Askew v. American Waterways Operators, Inc.* (1973) 411 U.S. 325, 328-29; *Exxon Mobil Corp. v. U.S. EPA* (9th Cir. 2000) 217 F.3d 1246, 1255.

law unless that is Congress' clear purpose.[162] The ICCTA's legislative history shows that Congress intended that the "States retain the police powers reserved by the Constitution."[163] Accordingly, courts have found that the ICCTA allows the exercise of local police power to protect the health and safety of the local community if the regulation does not unreasonably burden or discriminate against rail operations.[164] Here, denying certification of the FEIR and the Use Permit in no way burdens or discriminates against rail operations. If Valero doesn't get a permit, UPRR will go on business as usual. The Project is not part of UPRR's existing operations.

Further, CEQA requires the City to consider "[a]ll phases of a project...when evaluating its impact on the environment: planning, acquisition, development, and operation."[165] "Direct and indirect significant effects of the project on the environment shall be clearly identified and described, giving due consideration to both the short-term and long-term effects."[166] "Indirect or secondary effects" are those "which are caused by the project and are later in time or farther removed in distance, but are still reasonably foreseeable."[167] Thus, in reaching its decision, the City cannot ignore the Project's impacts from Valero's rail operations; it *must* consider *all* of the Project's impacts, including impacts from Valero's rail operations.

The City also has full authority to deny the Use Permit pursuant to its police powers under its Municipal Code. Benicia Municipal Code section 17.104.060 prohibits the City from issuing a use permit if the project would be "detrimental to the public health, safety, or welfare of persons residing or working in or adjacent to the neighborhood of such use," or "detrimental to properties or improvements in the vicinity or to the general welfare of the city." As described at length in our comments on the DEIR, RDEIR, FEIR, in the comments above and in the attached comments of Dr. Fox (which relate specifically to on-site public health and safety, air quality and hazards impacts), the Project would be extremely detrimental to the health, safety and welfare of the public. Thus, the City must deny Valero's appeal and uphold the Planning Commission's decision to deny the Use Permit.

---

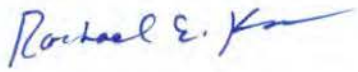
[162] *Rice v. Santa Fe Elevator Corp.* (1914) 331 U.S. 218, 230; *Oxygenated Fuels Assn. v. Davis* (9th Cir. 2003) 331 F.3d 665, 673; *Florida East Coast Ry. Co.*, 266 F.3d at 1327-29.
[163] *See* H.R. Rep. No. 104-311, p. 96, reprinted in 1995 U.S.C.C.A.N. 793, 808.
[164] *Norfolk Southern Ry. Co. v. City of Alexandria* (4th Cir. 2010) 608 F.3d 150, 160; *N.Y. Susquehanna & W. Ry. V. Jackson* (3d Cir. 2007) 500 F.3d 238, 254; *Florida East Coast Ry. Co.*, 266 F.3d at 1327-29.
[165] 14 Cal. Code Regs. § 15126.
[166] *Id.*, § 15126.2.
[167] *Id.*, §15358(a)(2).

In short, the Planning Commission's decision to deny certification of the FEIR and the Use Permit are not preempted by federal law because 1) the Project would result in significant, unmitigated impacts *from Project operations within the refinery boundary* that is clearly outside the bounds of the ICCTA and 2) it is the City's right and obligation to protect public health and safety and the environment from the adverse effects of the Project. Therefore, the City Council can and must deny Valero's appeal and uphold the Planning Commission's decision to deny certification of the FEIR and the Use Permit.

VIII. CONCLUSION

The Planning Commission's unanimous decision to deny certification of the FEIR and the Use Permit are supported by both the facts and the law. Thus, SAFER California urges the City Council to deny Valero's appeal.

Sincerely,



Rachael E. Koss

REK:ric
Attachments

cc: Donald Dean, Chair, Planning Commission ddean@ci.benicia.ca.us
Amy Million, Principal Planner amillion@ci.benicia.ca.us

Comments

on

Valero's Appeal

of Planning Commission's Denial

# of Valero Crude-by-Rail Project

Benicia, California

April 4, 2016

Prepared by
Phyllis Fox, Ph.D., PE
Consulting Engineer
745 White Pine Ave.
Rockledge, FL 32955

Table of Contents

I. SUMMARY AND CONCLUSIONS 1

II. ON-SITE ROG EMISSIONS ARE SIGNIFICANT 3

A. On-Site Fugitive Railcar ROG Emissions Are Significant 3

B. Feasible Mitigation For On-Site Fugitive Railcar ROG Emissions 5

C. Storage Tank ROG Emissions 7
1. Tanks Violate BAAQMD Rule 8-5 19
2. Feasible Tank Mitigation 20

III. ON-SITE TOXIC AIR CONTAMINANT EMISSIONS RESULT IN SIGNIFICANT OFF-SITE HEALTH RISKS 21

IV. PUBLIC SAFETY AND HAZARD IMPACTS ARE SIGNIFICANT 24

A. The EIR's Quantitative Significance Risk Assessment Is Incorrect and Unsupported 26
1. The Santa Barbara County CEQA Guidelines Are Misapplied 26
2. The Santa Barbara CEQA Guidelines Are Not Solely Applicable 29
3. The EIR's Quantitative Risk Assessment Is Unsupported 31

B. Off-Site Risks from On-Site Accidents Are Significant 37
1. Number of Injuries 37
2. Number of Fatalities 43
3. Feasible Mitigation 45

C. The EIR Fails to Evaluate All Feasible Types of Accidents 47

D. The EIR Fails to Evaluate All Feasible On-Site Accident Scenarios 49
1. Accidents During Train Maneuvering at Unloading Facility (Impact 4.7-3) 49
2. Accidents During Line Hookup And Crude Oil Transfer (Impact 4.7-4) 50
3. BLEVE (Thermal Tear) 52

E. Accidents at Other Project Facilities Were Excluded 54
1. Crude Oil Pipeline 54
2. Crude Tank Farm 57
3. Access Road 61

F. Factors Contributing to Hazard Impact Significance 62
1. The Location 62
2. Ignition Sources 69
3. External Events 71
4. Centroid Location 74
5. Other Rail Traffic 76

V. FLOODING IMPACTS ARE SIGNIFICANT 76

A. Flooding Could Increase Hazards 76

B. The Project Could Increase Flooding 79

C. Flood Mitigation 85

D. The EIR Fails to Address Benicia General Plan Requirements 88

I. SUMMARY AND CONCLUSIONS

I previously prepared comments on the City of Benicia's (City's) Initial Study/Mitigated Negative Declaration (IS/MND)[1] (Fox IS/MND Comments[2]); the Draft Environmental Impact Report (DEIR)[3] (Fox DEIR Comments[4]); the Recirculated Draft Environmental Impact Report (RDEIR)[5] (Fox RDEIR Comments[6]); and the Final Environmental Impact Report (FEIR)[7] (Fox FEIR Comments[8]) for Valero's Crude-by-Rail Project ("Project") at its Benicia Refinery ("Refinery"). The four CEQA documents

---

[1] City of Benicia, Valero Crude by Rail Project, Initial Study/Mitigated Negative Declaration, Use Permit Application 12PLN-00063, May 2013; Available at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Valero_Crude_by_Rail_IS-MND.pdf.

[2] Phyllis Fox, Comments on Initial Study/Mitigated Negative Declaration (IS/MND) for the Valero Crude by Rail Project, Benicia, California, Use Permit Application 12PLN-00063, July 1, 2013; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Report_by_Dr._Phyllis_Fox.pdf.

[3] City of Benicia, Valero Benicia Crude by Rail Project, Draft Environmental Impact Report, SCH # 2013052074, Use Permit Application 12PLN-00063, June 2014; Available at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Valero-Benecia-DEIR-CD.pdf.

[4] Phyllis Fox, Comments on the Draft Environmental Impact Report (DEIR) for the Valero Benicia Crude-by-Rail Project, September 15, 2014, Attachment A to SAFER Comments and Attachment 1 to NRDC Comments, Comment Letter B11 in FEIR, pp. 2.5-301/330; Available at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Attachment_A(2).pdf.

[5] City of Benicia, Valero Benicia Crude by Rail Project, Revised Draft Environmental Impact Report, SCH # 2013052074, Use Permit Application 12PLN-00063, August 2015; Available at : http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Valero_Benicia_Crude_by_Rail_RDEIR_Complete_Version.pdf.

[6] Letter from Phyllis Fox to Rachael Koss, Adams Broadwell Joseph & Cardozo, Re: Review of Revised Draft Environmental Impact Report for Valero Benicia Crude by Rail Project, October 30, 2015, Attachment B to SAFER Comments, Comment Letter J6 in FEIR, pp. 3.5-82/92; Available at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Attachment_B(2).pdf.

[7] City of Benicia, Valero Benicia Crude by Rail Project, Final Environmental Impact Report, SCH # 2013052074, Use Permit Application 12PLN-00063, January 2016; Available at: http://www.ci.benicia.ca.us/index.asp?SEC=B7EDC93A-FFF0-4A14-9B1A-1C8563BC256A&DE=26D88AB1-BB3F-4FF2-9924-D38F31BA0EA4&Type=B_BASIC.

[8] Phyllis Fox, Comments on the Final Environmental Impact Report for the Valero Crude by Rail Project, February 8, 2016, Attachment C to SAFER's February 8, 2016 Letter; Available at pdf 139–183 at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/Public_Comments_submitted_Jan_29-Feb_8_2016.pdf.

(IS/MND, DEIR, RDEIR, FEIR) are referred to collectively in these comments as "the EIR."

The Benicia Planning Commission held public hearings on the FEIR on February 8 - 11, 2016[9]. Based on these hearings and the EIR record, on February 11, 2016, the Planning Commission denied certification of the EIR and denied the use permit for reasons outlined in Resolution 16-1.[10] Valero appealed the Planning Commission decision on February 29, 2016.[11] Benicia Planning Commission staff (Staff) responded to these issues in a March 9, 2016 memorandum to the Benicia City Council.[12] The Community Development Director (CDD) concluded "the Project's on-site impacts are mitigated to a less than significant level and all the findings can be made to approve the Use Permit." Thus, Staff recommended that the City Council overturn the Planning Commission's denial, certify the FEIR, and approve the Use Permit (3/9/16 CDD Memo).[13]

SAFER requested that I review the CDD's conclusions, focusing on on-site impacts. My analysis of the record and additional analyses, documented below, indicate that the Project will result in significant on-site impacts that have not been disclosed in the EIR. These include:

- Significant on-site emissions of reactive organic gases (ROG) from railcar fugitives;

---

[9] City of Benicia, Planning Commission Minutes, Presentation & Miscellaneous Information; Available at: http://www.ci.benicia.ca.us/index.asp?SEC=B7EDC93A-FFF0-4A14-9B1A-1C8563BC256A&DE=3B2B9C15-AC66-4A93-9C22-8160CE702148&Type=B_BASIC.

[10] City of Benicia, Planning Commission Resolution No. 16-1, February 11, 2016 (2/11/16 BPC); Available at: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/6045/7-_PC_Resolution_No._16-1.pdf.

[11] Letter from John J. Flynn III, Nossaman LLP, to Lisa Wolfe, City Clerk, City of Benicia, February 29, 2016, Re: Appeal of Planning Commission Resolution No. 16-1, Denying Use Permit Application 12PLN-00063 and Declining to Certify Final Environmental Impact Report for the Valero Benicia Crude-by-Rail Project (SCH #2013052074); Available at: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/6044/6-_Valero_appeal_of_PC_denial_2-29-2016.pdf.

[12] Memorandum from Community Development Director to City Council, Re: Appeal of the Planning Commission's Decision to Not Certify the Final Environmental Impact Report (FEIR) and to Deny the Use Permit for the Valero Crude by Rail Project, March 9, 2016 (3/9/16 CDD Memo); Available at: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/6036/CBR_Appeal_CC_Staff_Report_FINAL.pdf.

[13] 3/9/16 CCD Memo, pdf. 18.

- Significant on-site ROG emissions from change in service of existing crude oil storage tanks;
- Significant cancer, chronic, and acute health impacts from benzene emitted from railcar fugitives;
- Significant off-site injury and fatality impacts from on-site accidents;
- Significant off-site flooding impacts from on-site infrastructure and railcars; and
- Significant off-site injury and fatality impacts from on-site accidents caused by seismic shaking.

Thus, the EIR must be revised to disclose these impacts, impose all feasible mitigation, and be recirculated.

II. ON-SITE ROG EMISSIONS ARE SIGNIFICANT

I previously commented that the EIR underestimated ROG emissions from ten on-site sources and that the revised on-site ROG emissions are significant.[14] The increase in ROG emissions from two of these sources is individually large enough to exceed CEQA significance thresholds. The EIR has failed to address these comments. The following sections expand my prior comments, demonstrating for the first time that (1) ROG emissions from on-site railcars are individually significant and cannot be offset by reductions in marine vessel calls, even if they were enforceable (which they are not) and (2) the increase in ROG emissions from storage tanks is significant.

A. On-Site Fugitive Railcar ROG Emissions Are Significant

In my comments on the Valero FEIR, I estimated fugitive ROG emissions from railcars from the California border to the Refinery, using the EIR's fugitive component method, but correcting its methodological errors.[15] These calculations did not include fugitive ROG emissions at the unloading facility. Thus, here, I have extended my railcar fugitive emission calculations to the Valero unloading facility. My calculations are presented in Exhibit 1. The methods I used are explained in my FEIR Comment III.E, as supplemented in my February 24, 2015 Comments on the Phillips 66 Santa Maria Rail Spur Project in San Luis Obispo County.[16]

---

[14] Comment B10-46 (Fox); Fox FEIR Comment III.

[15] Fox FEIR Comment III.E.

[16] Phyllis Fox, Comments on Final Environmental Impact Report for the Santa Maria Rail Spur Project, February 24, 2015 (Fox Santa Maria Rail Spur Comments), Comment II.H.1;. (Exhibit 4)

The unloading facility will receive two 50-car unit trains per day, 365 days per year.[17] The DEIR indicates that "[t]he duration of this unloading process, from entry of 50 loaded rail cars to refinery property, unloading of the 50 rail cars, to exit of 50 empty rail cars from refinery property, would be approximately 8 to 10 hours (16 to 20 hours for 100 rail cars)."[18] Elsewhere, the DEIR reports 12 hours to unload and prepare the empty train for the return trip.[19]

The EIR does not further breakdown this on-site time. The on-site ROG calculation requires an estimate of the amount of time full and empty railcars would be present on site. The FEIR for the Santa Maria Rail Spur Project indicates that it would take 1.7 hours to position the railcars and 460 minutes (7.7 hrs) to connect, disconnect, and unload an 80-car unit train.[20] The total amount of time full to partially full railcars would be on site is 9.4 hours for an 80-car unit train at Santa Maria. Thus, at Valero, full to partially full railcars would be present for about 6 hours or half of the upper bound estimate of 12 hours to unload and prepare the empty train for the return trip at Valero. In my calculations, I have assumed that full railcars will be present for 6 hours and empty railcars for 6 hours.

Using emission factors developed by EPA for marketing terminals, as assumed in Valero's railcar fugitive emission calculations but corrected as noted in my FEIR comments, the on-site, ROG emissions per 50-car unit-train are 412 pounds (lb) per visit,[21] 824 lb/day, and 150 ton/yr.[22] The CEQA significance thresholds for ROG emissions established by the Bay Area Air Quality Management District (BAAQMD) are 54 lb/day and 10 ton/yr.[23] Thus, both daily and annual on-site ROG railcar fugitive emissions are highly significant and must be mitigated.

---

[17] RDEIR, Appx. F, Attach 1, p. 1 ("Valero would operate the Project components 24 hours per day, 7 days per week, and 365 days per year.").

[18] DEIR, pdf 1157. *See* also Valero, Crude by Rail, Air Permit Application, Project Update Document # 1 (Nov. 2013 Valero Ap.), p. 6, *see* DEIR, Appx. E.4.

[19] DEIR, p. 3-22.

[20] San Luis Obispo County, Phillips 66 Company Rail Spur Extension and Crude Unloading Project, Final Environmental Impact Report and Vertical Coastal Access Project Assessment, December 2015, SCH #2013071028, (Santa Maria Rail Spur FEIR), Table 2.5; http://www.slocounty.ca.gov/planning/environmental/EnvironmentalNotices/railproject.htm#.

[21] Exhibit 1, cell: J31.

[22] Annual railcar ROG emissions for two 50-car unit trains per day, 365 days/year using marketing terminal emission factors = [(412 lb)/(50-car train) × (2 × 50-car trains/day) × (365 day/yr)]/(2000 lb/ton) = **150.4 ton/yr**.

[23] FEIR, Table 4.3-9.

The Santa Maria Rail Spur FEIR calculated railcar fugitive emissions using emission factors for oil and gas production developed by EPA. If oil and gas production emission factors are used for Valero, corrected as noted in my comments on the Santa Maria FEIR, the revised on-site railcar fugitive emissions are 1,350 lbs per 50-car unit train visit or 2,700 lb/day.[24] Assuming two 50-car unit train visits per day, 365 days per year, this works out to 493 ton/yr.[25] These emissions exceed the BAAQMD ROG CEQA significance thresholds of 54 lb/day and 10 ton/yr by huge amounts and are highly significant.

Thus, ROG emissions from on-site railcar fugitive component leaks are a significant, on-site unmitigated operational air quality impact that was not disclosed in the EIR. The EIR must require all feasible mitigation for this significant impact.

B. Feasible Mitigation for On-Site Fugitive Railcar ROG Emissions

The significant railcar fugitive ROG emissions can be mitigated by requiring the following:

- Emission Reduction Credits (ERCs);
- Actual reductions in emissions at the Valero Refinery, including at the Santa Maria Pump Station, tanker truck fleet, and storage tanks;
- Voluntary Emission Reduction Agreements (VERAs);
- Follow recommended industry practices to minimize railcar releases including pre-loading inspection of all railcar fugitive components, *e.g.*, PRVs, rupture discs, manway; adherence to change-out procedures; preventative maintenance; and tank car operator training;[26]
- Replace all non-closing pressure relief devices, such as rupture discs, rupture pins, or other one-time-use pressure relief device with standard PRVs;

---

[24] Exhibit 1, Tab: OnSite, Cell: G31.

[25] Annual railcar ROG emissions for two 50-car unit trains per day, 365 days/yr using oil & gas production emission factors = [1,350 lb/train × 2 trains/day × 365 days/yr]/(2000 lb/ton) = **492.8 ton/yr**.

[26] *See* Wright 2007, footnote 22; Tank Car Loading and Unloading, May 8, 2014; Available at: https://www.youtube.com/watch?v=1PzNbQlvgDw; and AAR/CMA North American Non-Accident Release Reduction Committee, Improving Securement in Hazardous Materials Tank Car Shipment. Recommended Industry Practices, October 1999; Available at: https://www.aar.org/Documents/NAR/Improving_Securement_in_Hazardous_Materials.pdf; Watco Compliance Services, Examination Before Shipping: Best Practices for Loading and Off-Loading Tank Cars Based on AAR Pamphlet 34; Available at https://www.fra.dot.gov/Elib/Document/3447.

- All tank car hatches should be closed and sealed during loading operations;[27]
- Require use of oxidation catalysts on existing heaters and boilers at the Valero Refinery to offset increases in ROG emissions;
- Require the use of pressure tank cars, such as the Tesoro DOT-120 design;[28]
- If pressure tank cars are not selected, require that railcars be operated with an inert gas headspace, such as nitrogen rather than ambient air;[29]
- Require the use of zero-leak fugitive components at the rail terminal and on the pipeline connecting the rail terminal and storage tanks;
- Implement LDAR program for all on-site railcars during railyard idling and unloading. This should include fugitive component monitoring of all fugitive components on all railcars during active transloading using a District-approved hand-held monitor on all full and empty railcars
- Annual source tests of all railcars to determine leak concentration of all fugitive components associated with railcar unloading, including railcar domes.
- Prohibit the use of any equipment that leaks liquid at a rate of greater than 3 drops per minute at a concentration greater than the applicable leak standard in Regulations 8-18-200, excluding disconnect losses. The leak concentration of railcar domes shall not exceed 100 ppm as methane. Disconnect losses shall not exceed 10 milliliters per disconnect. Disconnect losses shall be collect and stored in a closed container for disposal. Regulation 8-6-306.
- Under normal operating conditions, railcar domes shall be closed. When opening domes becomes necessary, the owner/operator shall record in a log book or electronic equivalent: (a) the date and time at which the dome was opened and (b) a description of why opening the domes was necessary.

These mitigation measures are not preempted because they do not manage or govern rail operations. Further, they control pollutants that are emitted from the railcars, which are owned (or leased) by Valero, who is not a rail carrier. And railcar ROG

---

[27] MBUAPCD Title V Operating Permit TV 34-01 Evaluation Report, ExxonMobil, March 9, 2005; Available at: http://yosemite.epa.gov/R9/air/EPSS.NSF/735056a63c1390e08825657e0075d180/e1e0cc5cd519261f88256fc0006c09f0/$FILE/TV34-01evl.pdf.

[28] The Tesoro DOT-120 design (with a shell thickness of 9/16") has a rated test pressure of 200 psi, but other DOT-120 and DOT-114 designs (with a shell thickness of 11/16") have rated test pressures of 300, 400, or 500 psi.

[29] The Valero RDEIR railcar fugitive ROG emissions assumed a 95% ROG control efficiency for using an ambient air headspace on the return-trip railcars. Valero RDEIR, Appx. A, pp. A-3 (5% dilution factor), p. A-14.

fugitive emissions, once released, are part of the ambient air and, thus, are part of the "commons" subject to regulation and control by local agencies.

In addition, ROG is twice removed from its source. The significance criteria for ROG are based on the fact that they are ozone precursors. Ozone is the pollutant of concern. Ozone is not emitted by railcars, but rather, it is formed in the atmosphere from precursor compounds, primarily NOx and ROG. The amount of ozone that forms depends on the level of other pollutants present in the air where it is emitted.[30]

C. Storage Tank ROG Emissions

The Project would unload up to 70,000 barrels per day (bbl/day) of crude oil at the unloading rack and transport it through a new 4,000-foot long, 16-inch diameter pipeline, which connects with an existing pipeline to storage tanks 1701 to 1708 in the Crude Tank Farm.[31] *See* Figures 1, 3, and 17 below.

The tanks that would receive the imported crude oil are existing external floating roof storage tanks that are currently permitted to store crude oil. The subject tanks and their capacities and permit limits are:

In the 2010 Nustar B5574 Title V Permit:

- S-57 Crude Oil Tank TK-1701, 6,300 kgal[32]
- S-58 Crude Oil Tank TK-1702, 18,900 kgal
- S-59 Crude Oil Tank TK-1703, 18,900 kgal
- S-60 Crude Oil Tank TK-1704, 6,300 kgal
- S-61 Crude Oil Tank TK-1705, 18,900 kgal
- S-62 Crude Oil Tank TK-1706, 18,900 kgal[33]

---

[30] D.J. Rasmussen, J. Hu and others, The Ozone-Climate Penalty: Past, Present, and Future, Environmental Science & Technology, v. 47, no. 24, 2013, pp. 14258–14266 (Exhibit 5).

[31] Nov. 2013 Valero Ap., p. 3; Slides, Valero Crude by Rail Project, City Council, p. 4, March 15, 2016; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/CBR_Appaeal_Presentation_March_15_2016.pdf.

[32] kgal = 1,000 gallons.

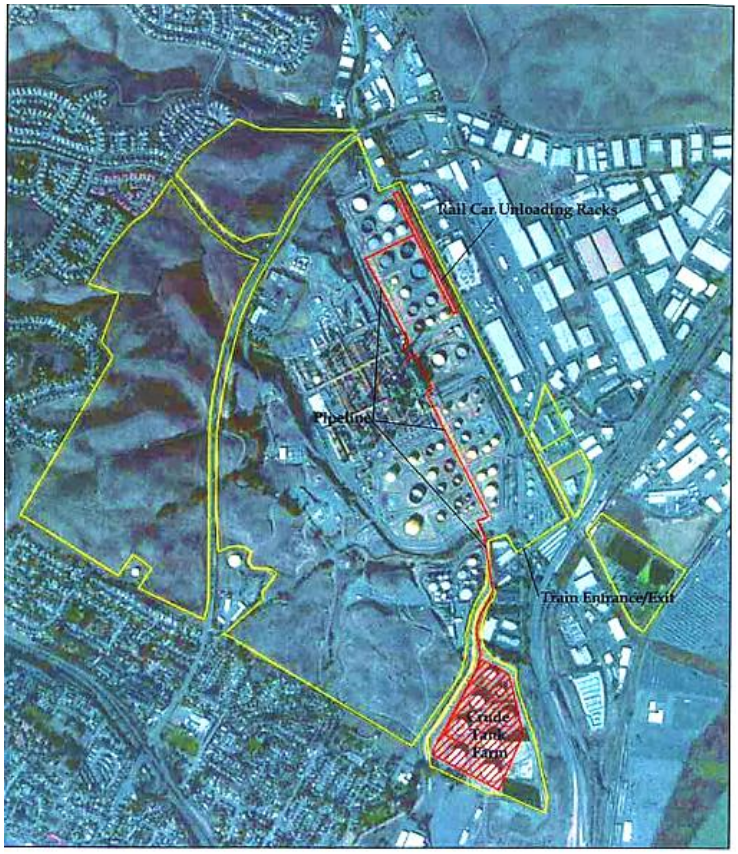
[33] BAAQMD, Final Major Facility Review Permit, Issued to: NuStar Logistics, L.P., Facility #B5574, December 20, 2010 (2010 Nustar B5574 Title V Permit); http://www.baaqmd.gov/~/media/files/engineering/title-v-permits/b5574/b5574_2010-12_final-permit_02.pdf?la=en.

In the 2015 Valero B2626 and 2010 Nustar B5574 Title V Permits:

- S-1047 Tank Crude Oil Tank TK-1707, 27,300 kgal; combined throughput limit of 62.6 MMbbl/yr with S-57 through S-62 at Nustar B5574 and S-1048 (based on 171.7 kBBL/day annual average)[34]
- S-1048 Tank, Crude Oil Tank TK-1708, 27,300 kgal; combined throughput limit of 62.6 MMbbl/yr with S-57 through S-62 at Nustar B5574 and S-1048 (based on 171.5 kBBL/day annual average)[35]

These eight tanks have a combined throughput limit of 62.6 million barrels per year (MMbbl/yr), which is adequate to process the rail-imported crude (25.6 MMbbl/yr), consuming 41% of their permitted throughput.

Figure 1: Valero Crude by Rail Project Location Map[36]



[34] MMbbl/yr = million barrels per year; kBBL/day = 1000 barrels per day.

[35] 2010 Nustar Title V Permit and BAAQMD, Final Major Facility Review Permit, Issued to: Valero Refining Co. – California, Facility #B2626, April 10, 2015 (2015 Valero B2626 Title V Permit); Available at: http://www.baaqmd.gov/~/media/files/engineering/title-v-permits/b2626/b2626-2015-04_aa-final-permit_02.pdf?la=en.

[36] Nov. 2013 Valero Ap., Figure 2-2.

Historically, Tanks 1701 through 1706 stored crude oil delivered by ships and pipeline. Crudes delivered by pipeline originate in the San Joaquin Valley and have very low vapor pressures, typical <1 psia. Crudes delivered by ship in the baseline have vapor pressures less than 5 psia. Tanks 1707 and 1708 were recently constructed and were permitted under the federal Clean Air Act New Source Review (NSR) program to store crude oil delivered by marine vessels and pipeline. Crude oil from marine vessels, pipeline, and the rail car unloading rack would be stored in these tanks after the Project is built out.[37]

The EIR did not include any increase in ROG emissions from these tanks as a result of the Project. Valero's Application for a Permit to Operate asserts that these tanks are not affected by the Project nor are they "altered" or "modified" sources and thus are not subject to Authority to Construct (ATC) and NSR requirements.[38] However, the record contains no demonstration that this is correct. This demonstration requires an analysis of the increase in ROG emissions resulting from the change in crude source, as clearly demonstrated by the 1/21/16 Bui E-mail to Valero, included above in Figure 2. The District clearly states:

> "In order for the District to determine that your grandfathered sources are altered rather than modified, the District will need:
>
> – The highest actual consecutive 24 hour throughput and its TVP or RVP and 12 month throughput and its TVP or RVP demonstrated and documented in owner records for each tank
>
> – Each grandfathered tank emissions using EPA Tank 4.09 program or Valero in house program based on the demonstrated throughput and vapor pressure."[39]

My calculations discussed below indicate that the Project would increase ROG emissions from these tanks sufficient to classify them as modified sources that triggers NSR review, requires offsets, and exceed BAAQMD CEQA significance thresholds.

I previously commented that the Project would increase the vapor pressure of crude oils stored in these tanks, thus increasing ROG emissions. I estimated the increase in ROG emissions due to the increase in vapor pressure and demonstrated that the increase is significant.[40] The BAAQMD made a similar comment:

---

[37] DEIR, pdf 1156.

[38] DEIR, Appendix E.4, Air Permit Application, Project Update Document #1 ("BAAQMD Application Update #1"), pdf 1158.

[39] Figure 2: E-mail from Thu Bui to Sue Gustofson, Re: Revised ATC Application 25242 – Crude by Rail (CBI), January 21, 2016, attached as Exhibit 7.

[40] FEIR, Comments B11-48/52 (Fox).

> "Change in Crude
> Valero plans to purchase and process a range of crudes but does not expect to increase the total crude oil throughput or increase production of existing products or by-products. Air District staff recommends that the RDEIR address the potential changes in emissions associated with handling lighter crude, which can have higher volatile organic compound (VOC) content than the existing crude being processed; this can lead to increased fugitive emissions during transport and storage which should be evaluated for air quality impacts."[41]

The FEIR responded to the BAAQMD by arguing that:

> "As explained in DEIR Section 3.5 and illustrated in DEIR Figure 3-11, the blended crude Valero processes is constrained by Valero's operational restrictions and BAAQMD permits and regulations. These same limitations constrain the individual crudes Valero procures and stores for processing. Therefore, it follows that the Project will not result in an increase in tank emissions. Further, the DEIR shows that certain crudes available by rail, such as Bakken, have already been processed at the Refinery. The Project does not propose any changes to its existing permitted levels, except to permit ROG emissions associated with unloading crude oil from tankers."[42]

In response to my comment, the FEIR asserted without any support that the Project "would not increase emissions from storage tanks beyond existing levels… The tanks would not be modified, and would continue to be subject to the same throughput limits and permit conditions." The FEIR ignored my ROG emission calculation.[43] These responses are incorrect, nonresponsive, and inconsistent with CEQA.

First, my review of the Title V permits that cover these tanks[44] indicates that they do not contain any vapor pressure or ROG limits, but rather only throughput limits. This means that the Project can transfer Bakken and other similar light crudes into these tanks without violating any permit limits, but while significantly increasing ROG and toxic air contaminants (TACs) emissions. Under CEQA, the emissions increase must be computed relative to the baseline. The EIR has failed to disclose the baseline vapor

---

[41] FEIR, Comment I12-10 (BAAQMD).

[42] FEIR, RTC I12-10 (BAAQMD).

[43] FEIR, RTC B10-46 (Fox).

[44] 2015 Valero B2626 and 2010 Nustar B5574 Title V Permits.

pressure and ROG emissions and the resulting increase from storing higher vapor pressure crudes in these tanks.

Second, all crude oils are not created equal. The ROG emissions from crude oil storage tanks depend upon the vapor pressure of the crude oil. The EIR's response does not address the fact that the vapor pressure of stored crude will increase compared to the CEQA baseline, increasing ROG emissions. The EIR and supporting documents claimed tank emission calculations and vapor pressure data as confidential business information (CBI). This information is routinely supplied as non-CBI information in support of air permit applications and CEQA documents. What does Valero have to hide?

A recent letter from Valero's outside counsel argues that "changes in crude slate, as already conclusively established, will have no impact on refinery emissions since any crudes imported by rail must be blended within the very same operational parameters that ***now*** constrain Valero's processing operations."[45] This is incorrect as I explained in my comments on the IS/MND and DEIR.[46] The responses to comments[47] do not address the issues I raised, which are relevant to the tank ROG and TAC emissions issue. In my comment B10-36, I explained that the majority of the ROG and TACs are emitted **before** blending occurs, so the argument that blended crudes will remain the same is irrelevant and incorrect. Further, crudes may be blended to the same API gravity and sulfur content, but these (and other blending parameters) are not related to constituents of concern that may be emitted, such as greenhouse gases, TACs, and ROG. Finally, the BAAQMD is not persuaded that this is correct as it has requested that Valero produce emissions data to support its claims. Figure 2. Our PRAs indicate that this data has not been produced.

Third, the baseline for estimating ROG emission increases from these tanks is actual ROG emissions in the baseline years, not "throughput limits and permit conditions," which are not even identified.

We filed public record act (PRA) requests with the BAAQMD to obtain tank emission calculations and vapor pressure data, but they were withheld by Valero as CBI. However, one non-CBI e-mail was produced which indicates these tanks were

---

[45] Letter from John J. Flynn III, Nossaman LLP, to Mayor Patterson and City Council, Re: Appeal of Planning Commission Resolution No. 16-1, Denying Use Permit Application 12PLN-00063 and Declining to Certify Final Environmental Impact Report for the Valero Benicia Crude-by-Rail Project (SCH#2013052074) (***emphasis*** in original), March 28, 2016 in April 4, 2016 City Council Agenda Package, at pdf 17-18; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/City_Council_Agenda_Packet_April_4_2016.pdf.

[46] FEIR, Comment B10-34 to B10-36 (Fox); Fox IS/MND Comments, pp. 2-35.

[47] RTC B10-34.

permitted assuming vapor pressures that are far below the vapor pressure of the new crudes that will be stored in them.

Figure 2: BAAQMD E-mail, Tank Vapor Pressure Data

From: Thu Bui
Sent: Thursday, January 21, 2016 11:30 AM
To: 'Gustofson, Sue'
Cc: Cuffel, Donald; Suhami, Iren
Subject: RE: Revised ATC Application 25242 - Crude by Rail (CBI)

Hi Sue,

As we have discussed several times in the past and recently last week, the District still needs more information on the crude storage tanks.

There are total 8 tanks in this project. According to A/N 2502, 3 grandfathered tanks (T-1701 to T-1703) are listed as "light" (3.5 psia TVP)crude tanks and 3 grandfathered tanks (TK-1704 to TK 1706) are listed as "heavy" (0.3 psia TVP) crude tanks. Two NSR new tanks are permitted at 4 psia TVP. At this time, Valero claimed that there will be no emission increases from storage tanks. In order for the District to determine that your grandfathered sources are altered rather than modified, the District will need:

- The highest actual consecutive 24 hour throughput and its TVP or RVP and 12 month throughput and its TVP or RVP demonstrated and documented in owner records for each tank
- Each grandfathered tank emissions using EPA Tank 4.09 program or Valero in house program based on the demonstrated throughput and vapor pressure

Based on this e-mail, the tanks that would receive the rail-imported crude oil historically stored crudes with very low vapor pressures, much lower than the crudes that would be stored in them under this Project, as summarized in Table 1.

Table 1:
Storage Tank Vapor Pressure Data

Tank	Baseline TVP[48] (psia)	Project TVP[49] (psia)
T-1701	3.5	13
T-1702	3.5	13
T-1703	3.5	13
T-1704	0.3	13
T-1705	0.3	13
T-1706	0.3	13
T-1707	4	13
T-1708	4	13

[48] E-mail from Thu Bui to Sue Gustofson, Re: Revised ATC Application 25242 – Crude by Rail (CBI), January 21, 2016 (Exhibit 7). We surmise that tanks permitted at 3.5 psi stored Alaska North Slope or similar, imported by ship, and tanks permitted at 0.3 psi stored San Joaquin Valley crude, imported by pipeline.

[49] RDEIR, Appx. F, pdf 326 and Table 5.1 (vapor pressure = (90 kPa)(0.145038 psi/kPa) = 13 psi.

The Project true vapor pressure (TVP) data for the eight tanks in Table 1 are based on Bakken crude, as reported in the RDEIR. The record contains ample evidence that the Project would import Bakken and other light crude oils, which have a much higher vapor pressure than crude oils historically stored in these tanks in the CEQA baseline. Thus, the Project would increase ROG emissions from these storage tanks. The evidence supporting Bakken and other similar light crudes is discussed below, followed by an estimate of the increase in ROG emissions due to storing these light crudes in tanks previously used to store much lower vapor pressure crude oils.

Valero has applied to the BAAQMD for a construction permit for the Crude by Rail Project. The Authority to Construct Application (ATC) is in the EIR.[50] Valero responded to questions by the BAAQMD in an April 11, 2013 letter. In this letter, Valero repeatedly describes the crudes that would be imported as light sweet crudes that will cause the current slate to become "sweeter," "lighter in gravity and lower in sulfur than the average Padd V or average Valero crude slate," and as "ANS look-alikes or sweeter."[51] Thus, Valero admitted that it is changing its crude slate to a lighter slate, *i.e.*, with a higher vapor pressure, in contradiction of its responses to comments.

> The DEIR reports that "[o]nce the Project is constructed and operational, Valero may well purchase large amounts of light sweet North American crudes. In fact, this is Valero's stated plan."[52] Elsewhere, the DEIR states "[s]ince Bakken is one of the available North American crudes that Valero might purchase and transport by rail to Benicia…"[53]

---

[50] DEIR, Appendices E.3 and E.4.

[51] Letter from Susan K. Gustofson, Valero to Thu Bui, BAAQMD, transmitting Crude by Rail Project, Response to BAAQMD 3/20/2013 Project Questions, April 11, 2013, Public Version (4/11/13 BAAQMD RTC), p. 5 ("North American sourced crudes are typically characterized as "sweet" meaning they contain less than 0.5 wt% sulfur. The North American sourced crudes currently available to the Valero Benicia refinery are expected to have sulfur below 0.5 wt% which is well below the typical crude slate average of 1.4 wt%. Therefore, these crudes directionally sweeten the crude slate and reduce the amount of refinery fuel gas sulfur treatment required."), p. 6 ("... the crude slate is expected to be sweeter with the introduction of North American sourced crudes."), p. 7 ("North American sourced crudes are expected to be sweeter than existing average crude slate", "North American sourced crudes are characterized as sweet and are expected to have sulfur content lower than current crude slate sulfur average"), p. 8 ("The crudes proposed to be brought in by rail are those that fall into the lower right corner of the graph, which would be lighter in gravity and lower in sulfur than the average Padd V or average Valero crude slate."), p. 8 … the proposed North American sourced crudes are expected to be ANS look-alikes or sweeter… there is not expected to be any difference in emissions… compared to existing operations."), p. 9 ("North American-sourced crudes proposed to be received by railcar are ANS look-alikes or sweeter..").

[52] DEIR, p. C.2-1.

[53] DEIR, p. 4.7-18.

The RDEIR confirms the crudes imported by rail will include Bakken crudes.[54] The hazard impact analyses are based on a "Bakken type crude" with a vapor pressure of 13 psia.[55] This vapor pressure is consistent with data reported elsewhere.[56] The oil spill consequence analyses in RDEIR Appendix F, Attachment 3 were used in the Santa Maria FEIR, where they were included without modification in a section called "Bakken Crude Oil" and each accident scenario was re-labeled as: "PROJECT: Bakken Rail".[57] Thus, as Bakken is clearly a proposed import and as the Project's consequence analyses were based on Bakken, the corresponding increase in ROG emissions from the storage tanks should also be based on Bakken.

The EIR asserts that the Refinery has processed Bakken crudes, imported by barge.[58] However, the EIR is silent on the amount of Bakken processed in the past, whether it occurred in the CEQA baseline, and the tank(s) that stored the crude. As it arrived by barge, it likely was stored in tanks that support the Marine Terminal, rather than the pipeline. Further, it is common for refineries to evaluate small quantities of crudes it is considering before committing to large shipments.[59] Thus, while small amounts of Bakken may have been processed as a litmus test for the Project, there is no evidence in the record that Bakken was a major source of crude feed for the Refinery. This Project proposes to import up to 70,000 bbl/day of Bakken, or 42%of the total crude throughput.[60]

Tank ROG emissions are routinely calculated with the EPA model TANKS 4.09d[61] or the underlying equations from EPA's Compilation of Air Pollutant Emission Factors (AP-42), Chapter 7.[62] The output from TANKS analyses are routinely included in appendices of air permit applications and CEQA documents. However,

---

[54] RDEIR, Appx. F, p. 41. ("The spill modeling was done using a multi-component crude with the properties provided below in Table 5.1. These crude properties were based upon a Bakken type crude due to its lighter properties and relatively higher volatility.")

[55] *Ibid* and RDEIR, Appx. F, Table 5.1 (vapor pressure = (90 kPa)(0.145038 psi/kPa) = 13 psi.

[56] Ryan Couture, NDPC Releases Bakken Crude Characterization Study, August 4, 2014, Table 1, showing Bakken crude vapor pressures ranging from 8.9 psi to 14.4 psi based on 152 samples; Available at: http://www.turnermason.com/index.php/ndpc-releases-bakken-crude/.

[57] Santa Maria FEIR, Appendix H.3, pp. H.3-19 to H.3-77. These analyses are identical to those found in the Valero RDEIR, Appendix F, Attachment 3.

[58] FEIR, p. 2.4-44, RTC A10-1.

[59] Garrett and others, 2016, p. 40.

[60] RDEIR, p. 2-20: Permitted Refinery throughput is an average of 165,000 bbl/day, so the Project would supply: 100(70,000/165,000) = **42.4**% of the total throughput.

[61] https://www3.epa.gov/ttnchie1/software/tanks/.

[62] EPA, AP 42, Fifth Edition, Volume I, Chapter 7: Liquid Storage Tanks; Available at: https://www3.epa.gov/ttnchie1/ap42/ch07/.

here, the inputs, tank construction information, and crude properties (vapor pressure, temperature, etc.) have been withheld as CBI. This is highly unusual as TANKS input and output do not include any CBI information and should not be withheld. Thus, the EIR has failed to support its claim that there will be no increase in ROG emissions from the tanks that would store the rail-imported crude.

An estimate can be made of the ROG emissions from storing 70,000 bbl/day of a crude oil with a vapor pressure of up to 13 psia in the subject eight storage tanks, using the TANKS 4.09 program.

The ROG emissions from these tanks between 2010 and 2015 are summarized in Table 2. The baseline years under CEQA are the two years prior to the issuance of the IS/MND in 2013. Thus, baseline ROG emissions from these tanks are the average ROG emissions in 2011 and 2012, as summarized below in Table 2.

Table 2: Historic ROG Emissions from Tanks (lb/day)[63]

	2010	2011	2012	2013	2014	2015	Avg. 2011-2012
NuStar							
TK-1701	14	14	14	14	14	15	**14.0**
TK-1702	4	4	3	3	3	3	**3.5**
TK-1703	4	4	3	3	3	3	**3.5**
TK-1704	2	2	2	1	1	3	**2.0**
TK-1705	3	3	2	2	2	2	**2.5**
TK-1706	4	4	2	2	2	2	**3.0**
Valero							
TK-1047	17	17	18	18	18	18	**17.5**
TK-1048	17	17	17	17	17	17	**17.0**

I ran EPA's TANKS model version 4.09d to demonstrate the impact of the proposed vapor pressure change on ROG emissions, *i.e.,* the increase in ROG emissions from storage tanks due to replacing the permitted baseline crude oils stored in these tanks with vapor pressures (TVP) ranging up to 0.3 to 4 psia with rail-imported crude oils with a project maximum vapor pressure (TVP) of 13 psia. For tank specifications, I relied on information contained in the permit application for the Valero Improvement Project and the most recent Valero and Nustar Permits to Operate for the respective tanks. Otherwise, I made conservative assumptions and relied on TANKS default values (*e.g.*, I assumed all deck fittings: gasketed; tank paint color/shade: white/white; paint condition: good; default numbers of deck fittings; etc.). TANKS calculated the

[63] Emissions data supplied by BAAQMD in response to: (1) Public Records Request No. 2016-03-0147 (NuStar Logistics), via March 21, 2016 e-mail from Rochelle Reed, BAAQMD, to Cody Elliott, Adams Broadwell Joseph & Cardozo, and Public Records Request No. 2016-03-0148 (Valero) from Rochelle Reed, BAAQMD, to Cody Elliott, Adams Broadwell Joseph & Cardozo.

annual turnover for each tank based on the tanks' respective volume and annual throughput (1,073,100,000 gal/year = 25,550,000 bbl/year=70,000 bbl/day). *See* Exhibit 3.

Table 3 summarizes ROG emissions associated with 70,000 bbl/day throughput of crude oils compared to both the CEQA baseline and the permitted vapor pressures, respectively, assuming only one tank would be in service to accommodate the crude oil storage for the Project. This table shows that if tanks 1702 to 1706 are used to store 70,000 bbl/day of rail-imported crudes with a TVP of 13 psia, the increase in ROG emissions relative to the CEQA baseline will exceed the annual (10 ton/yr) and daily (54 lb/day) BAAQMD CEQA significance for ROG. This table also shows that if the permitted TVP is used as the baseline, the increase in daily emissions at all tanks will exceed the BAAQMD daily CEQA significance threshold (54 lb/day). Thus, the increase in ROG emissions from storing higher vapor pressure crudes in the eight proposed tanks is a significant air quality impact that was not disclosed in the EIR and is not mitigated.

Table 3: Increase in ROG Emissions from Storing Rail-Imported Crude in Existing Tanks

Tank	Permitted TVP	TANKS VOC Emissions Based on Permitted TVP		Maximum Rail-Imported Crude TVP	TANKS VOC Emissions Based on TVP 13 psia		CEQA Baseline ROG Emissions	Net Increase in ROG Relative to CEQA Baseline		Net Increase in ROG Relative to Permitted TVP	
	(psia)	(lbs/yr)	(lb/day)	(psia)	(lb/yr)	(lb/day)	(lbs/day)	(ton/yr)	(lb/day)	(ton/yr)	(lb/day)
1701	3.5	7,759	21.3	13	27,629	75.7	14	8.5	46.6	7.9	**54.4**
1702	3.5	7,759	21.3	13	27,629	75.7	3.5	**10.4**	**57.1**	7.9	**54.4**
1703	3.5	7,759	21.3	13	27,629	75.7	3.5	**10.4**	**57.1**	7.9	**54.4**
1704	0.3	4,805	13.2	13	27,629	75.7	2	**10.7**	**58.6**	9.1	**62.5**
1705	0.3	4,805	13.2	13	27,629	75.7	2.5	**10.6**	**58.1**	9.1	**62.5**
1706	0.3	4,805	13.2	13	27,629	75.7	3	**10.5**	**57.6**	9.1	**62.5**
1707	4	8,022	22.0	13	27,629	75.7	17.5	7.9	43.1	7.8	**53.7**
1708	4	8,022	22.0	13	27,629	75.7	17	7.9	43.6	7.8	**53.7**
							Significance Threshold	**10**	**54**	**10**	**54**

The increase in ROG emissions from storing rail-imported crudes in these eight tanks would be even higher than shown in Table 3 because this table does not include emissions from roof landings, degassing, water draw, and tank cleaning, which are excluded from the TANKS 4.09d model.[64] I discussed these additional emission sources in my comments on the DEIR, but the FEIR failed to address the substance of my comments, instead asserting without any explanation or proof by calculation that "[t]he Project would not increase emissions from storage tanks beyond existing levels."[65] As this assertion is false, I present an estimate here based on the best available information.

The net increase in ROG emissions from changing the composition of the crude stored in these eight tanks plus other increases in ROG emissions not included in the EIR, cannot be offset by the decrease in marine vessel emissions, as shown in Table 4.

Table 4: Revised Annual and Daily Net Operational ROG Emissions

	ROG Emissions		
Emission Source	**lb/day**	**ton/yr**	**Source**
Unloading Rack & Pipeline Fugitives	10.3	1.88	DEIR, Table 4.15-5
Revised On-Site Locomotives	9.6	1.76	Pless FEIR Comments, Table 9a &9b
Tanks	58.6	10.7	*See* Table 3
Railcar Fugitives	824	150	Exhibit 1
Marine Vessels	-28.38	-5.18	DEIR, Table 4.15-5
TOTAL	**874**	**159**	
Significance Threshold	54	10	
Significant?	**YES**	**YES**	

In sum, the net increase in ROG emissions from the tanks, relative to the CEQA baseline, are significant taken alone. The net increase in ROG emissions from all Project sources, including the tanks, are highly significant and cannot be offset by the decrease in marine vessel emissions. Further, as explained in my comments on the DEIR, the reduction in emissions from reduced marine deliveries are not real or enforceable and thus cannot be relied on to offset emission increases.[66] The response to this comment does not offer an enforceable condition.[67]

[64] FEIR, Comments B10-48/50 (Fox).

[65] FEIR, RTC B10-48 referring to B10-46, pdf 417.

[66] FEIR Comment B10-45 (Fox), B11-47 (SAFER).

[67] FEIR, RTC B11-47 referring to B10-45.

1. Tanks Violate BAAQMD Rule 8-5

The BAAQMD Application asserts that these tanks "are in full compliance with Regulation 8, Rule 5…"[68] The 3/28/16 Flynn letter similarly asserts that "Valero ***already*** has the right to process and store" crudes delivered by rail. [69] These assertions are incorrect.

BAAQMD Regulation 8, Rule 5 and federal regulations prohibit storing crudes with a vapor pressure equal to or greater than 11 psia in external floating roof tanks, such as those proposed to be used by the Project (Table 1), without modification to include an approved emission control system.[70] The storage of crudes with vapor pressures of 11 psia or greater results in significant increases in ROG emissions, beyond those calculated by the TANKS model, and further present significant safety issues.

The types of crude that Valero proposes to import by rail will include crudes with vapor pressures equal to 11 psia or greater. The hazard analysis, for example, assumed that the maximum vapor pressure of the rail-imported crude would be 13 psia. Many Bakken and other light crudes have a true vapor pressure of 11 psia or higher.[71]

The permits to operate and Title V permits that cover these tanks (Table 1) do not include any vapor pressure limits or require any vapor pressure monitoring. Thus, Valero could store any crude in these tanks, in spite of the law, as there are no enforceable conditions.

Thus, the EIR must be modified to prohibit the storage of any crude with a vapor pressure equal to or greater than 11 psia in the subject tanks, unless the tanks are modified to include an approved emission control system. Otherwise, the EIR must

---

[68] DEIR, pdf 1157.

[69] 3/28/16 Flynn Letter, p. 1 (***emphasis*** in original).

[70] BAAQMD Rule 8-5, Section 8-5-301; 40 CFR 60.112B(b).

[71] FEIR, Comment B10-42 (Fox); Classification and Hazard Communication Provisions for Crude Oil – Bakken Crude Oil Data, June 13, 2014, Available at: http://www.unece.org/fileadmin/DAM/trans/doc/2014/dgac10c3/UN-SCETDG-45-INF26e.pdf; Dangerous Goods Transport Consulting, Inc., A Survey of Bakken Crude Oil Characteristics Assembled for the U.S. Department of Transportation, Submitted by American Fuel & Petrochemical Manufacturers, May 14, 2014, pp. 5, 19, Available for download from: https://www.afpm.org; North Dakota Petroleum Council, Bakken Crude Quality Assurance Study, Available at: http://www.ndoil.org/image/cache/Summary_2.pdf; Jeff Thompson, Public Crude Assay Websites, February 24, 2011. http://www.coqa-inc.org/docs/defaultsource/meeting-presentations/20110224_Thompson_Jeff.pdf; Russell Gold, Analysis of Crude From North Dakota Raises Further Questions About Rail Transportation, Wall Street Journal, February 23, 2014; Transportation Safety Board of Canada, TSB Laboratory Report LP148/2013 (TSBC 2013), Available at: http://www.bst-tsb.gc.ca/eng/lab/rail/2013/lp1482013/LP1482013.asp.

require storage of rail-imported crudes with a TVP >11 psia in pressure tanks. The mitigation for this impact must require certified true vapor pressure data for each railcar in each unit train shipment and monthly tank vapor pressure measurements to verify compliance.

2. Feasible Tank Mitigation

As discussed in Comment II.B, the increases in ROG emissions from storing rail-imported crudes in the eight tanks listed in Table 3 are significant. Even if the vapor pressure is limit to <11 psia, the increase in tank emissions coupled with other Project increases will remain significant. Thus, mitigation should be required for the increase in ROG emissions from the storage tanks.

These emissions can be reduced below the significance threshold by retrofitting the subject tanks with geodesic domes. These domes are feasible, satisfy best available control technology (BACT), and are widely used. Over 10,000 aluminum domes have been installed on petrochemical storage tanks in the United States.[72] The ExxonMobil Torrance Refinery: "completed the process of covering all floating roof tanks with geodesic domes to reduce volatile organic compound (VOCs) emissions from facility storage tanks in 2008. By installing domes on our storage tanks, we've reduced our VOC emissions from these tanks by 80 percent. These domes, installed on tanks that are used to store gasoline and other similar petroleum-derived materials, help reduce VOC emissions by blocking much of the wind that constantly flows across the tank roofs, thus decreasing evaporation from these tanks."[73]

A recently proposed crude storage project at the Phillips 66 Los Angeles Carson Refinery required external floating roof tanks with geodesic domes to store crude oil with an RVP of 11.[74] The Negative Declaration for this project assumed these tanks would store crude oil with a TVP <11 psi.[75] The ConocoPhillips Wilmington Refinery added a geodesic dome to an existing oil storage tank to satisfy BACT.[76] Similarly,

---

[72] M. Doxey and M. Trinidad, Aluminum Geodesic Dome Roof for Both New and Tank Retrofit Projects, Materials Forum, v. 30, 2006, Available at: http://www.materialsaustralia.com.au/lib/pdf/Mats.%20Forum%20page%20164_169.pdf.

[73] Torrance Refinery: An Overview of our Environmental and Social Programs, 2010, Available at: http://www.exxonmobil.com/NA-English/Files/About_Where_Ref_TorranceReport.pdf.

[74] See, e.g., Phillips 66 Los Angeles Refinery Carson Plant – Crude Oil Storage Capacity Project, September 6, 2013, Table 1-1, Draft Negative Declaration, Available at: https://www.aqmd.gov/CEQA/documents/2013/nonaqmd/Draft_ND_Phillips_66_Crude_Storage.pdf

[75] Carson Neg.Dec. Table 1-1.

[76] SCAQMD Letter to G. Rios, December 4, 2009, Available at: http://yosemite.epa.gov/r9/air/epss.nsf/e0c49a10c792e06f8825657e007654a3/e97e6a905737c9bd882576cd0064b56a/$FILE/ATTTOA6X.pdf/ID%20800363%20ConocoPhillips%20Wilmington%20-%20EPA%20Cover%20Letter%20%20-AN%20501727%20501735%20457557.pdf.

Chevron proposes[77] to use domes on several existing tanks to mitigate VOC emission increases at its Richmond Refinery.[78] The U.S. Department of Justice CITGO Consent Decree required a geodesic dome on a gasoline storage tank at the Lamont, Texas refinery.[79] Further, numerous vendors have provided geodesic domes for refinery tanks.[80]

These numerous applications of geodesic domes to control VOC emissions from refinery storage tanks demonstrate that geodesic domes are feasible for the subject tanks. Thus, geodesic domes must be required to mitigate significant air quality impacts of the Project.

III. ON-SITE TOXIC AIR CONTAMINANT EMISSIONS RESULT IN SIGNIFICANT OFF-SITE HEALTH RISKS

I also commented that these ROG emissions contain substantial amounts of toxic air contaminants (TACs), up to 7% benzene by weight (wt. %).[81] The FEIR did not respond to this comment. Assuming 7 wt. % benzene in fugitive volatile organic compound (VOC) emissions from railcars and that 80% of the VOCs is ROG, benzene emissions could be up to 236 lb/day or 43 ton/yr.[82] These revised benzene emissions are substantially higher than those included in the revised health risk assessment from conventional fugitive sources: 0.062 lb/day and 0.01 ton/yr.[83]

---

[77] City of Richmond, Chevron Refinery Modernization Project, Environmental Impact Report, Volume 1: Draft EIR, March 2014 (Chevron DEIR), Available at: http://chevronmodernization.com/project-documents/ .

[78] Chevron DEIR, Chapter 4.3.

[79] CITGO Petroleum Corp. Clean Air Act Settlement, Available at: http://www2.epa.gov/enforcement/citgo-petroleum-corporation-clean-air-act-settlement.

[80] See, *e.g.*, Aluminum Geodesic Dome, Available at: http://tankaluminumcover.com/Aluminum-Geodesic-Dome; Larco Storage Tank Equipments, Available at: http://www.larco.fr/aluminum_domes.html; Vacono Dome, Available at: http://www.easyfairs.com/uploads/tx_ef/VACONODOME_2014.pdf; Peksay Ltd., Available at: http://www.thomasnet.com/productsearch/item/10039789-13068-1008-1008/united-industries-group-inc/geodesic-aluminum-dome-roofs/; United Industries Group, Inc., Available at: http://www.thomasnet.com/productsearch/item/10039789-13068-1008-1008/united-industries-group-inc/geodesic-aluminum-dome-roofs/;

[81] Fox DEIR Comment II.E (FEIR, Comment B11-55).

[82] Benzene weight percent (7%) is reported based on VOC emissions. ROG emissions are a subset of VOC emissions. Conservatively assuming that 80% of VOC is ROG, the maximum benzene emissions = [(492.8 ton ROG/yr)/(0.8 ROG/VOC)] × (0.07 benzene/VOC)= **43.1 ton/yr** benzene; 43.1 ton/yr benzene × (2000 lb/ton) / (365 days/yr) = **236.3 lb/day**.

[83] Amy Million, City of Benicia, Email to Rachael Koss, Adams Broadwell Joseph & Cardozo, Re: Modeling Files for Valero CBR - Adams Broadwell Request, February 2, 2016, 1:24 pm. ("Some files have

The EIR assumed the benzene content of the crude oil would be 0.06 wt.%,[84] the default from the TANKS crude oil speciation profile, which is not representative of Bakken and other light crudes that will be imported. This yielded total benzene emissions from fugitive components of 30.3 lb/yr.[85] However, the revised HRA is based on even lower benzene emissions, just 22.5 lb/yr.[86] When benzene emissions from railcar fugitives are included, the total benzene emissions increase to 30.3 lb/yr + 86,249.5 lb/yr = **86,280 lb/yr.** Thus, my calculations of railcar fugitive emissions indicate that benzene emissions would be **2,852 times higher** than estimated in the EIR,[87] resulting in highly significant acute, chronic, and cancer health impacts.

We obtained the modeling files for the revised health risk assessment (HRA) from the City.[88] The acute, chronic, and cancer calculation details, taken directly from files provided by the City, are presented in Exhibit 2 in the tabs: (1) Acute; (2) Cancer; and (3) Chronic. The information in these tabs includes emission rates for each chemical included in the analysis and the resulting risk results by chemical for (1) acute hazard index; (2) chronic hazard index; and (3) cancer risk. This information is presented for four exposed populations: (1) maximum exposed individual resident (MEIR); (2) Maximum Exposed Individual Worker (MEIW); (3) and at two nearby sensitive receptors, a daycare facility and an elementary school.

I revised the risk calculations in Exhibit 2 to include benzene emissions from railcars. My calculations are summarized in Table 5 and documented in Exhibit 2, (Tab: Rev. Calcs). This table shows that benzene emissions from railcars alone (*see* Revised Health Risk Benzene) result in significant cancer risk at all receptors, *i.e.*, the MEIW, the MEIR, the Daycare facility, and the nearest elementary school; benzene emissions alone also result in significant acute health impacts at the MEIW, the MEIR, and the nearest elementary school as well as significant chronic health impacts at the MEIW. When emissions of all other TACs are included (*see* Modified Health Risks All TACs), health risks are even higher. Thus, the Project poses significant health risks for residents and workers in the vicinity.

---

been sent to you via the YouSendIt File Delivery Service. Download the file -... Updated Refinery HRA Calculation Jan 2016.xlsx...") (Exhibit 6.) *See* also summary in Exhibit 1, Tab Rev. Calcs.

[84] DEIR, pdf 469, 454 (Table 3-5).

[85] DEIR, pdf 460, Table 4-3.

[86] Exhibit 2.

[87] Increase in benzene emissions due to railcar fugitive emissions = [(43.2 ton/yr)(2000 lb/ton) + 30.3]/30.3 lb/yr = **2,852.**

[88] 2/2/16 Million E-Mail, Exhibit 6.

Table 5: Revised Health Risk Calculations for Emissions of Benzene and All TACs*

Receptor	Benzene Emissions (lb/day)	EIR Health Risks Benzene			Revised Benzene Emissions (lb/day)	Revised Health Risks Benzene		
		Chronic Hazard Index	Acute Hazard Index	Cancer Risk		Chronic Hazard Index	Acute Hazard Index	Cancer Risk
Resident	6.17E-02	0.00	0.00	9.42E-09	236.3	0.1	**14.1**	**3.61E-05**
Worker	6.17E-02	0.00	0.08	2.18E-08	236.3	**3.1**	**303.8**	**8.35E-05**
Daycare	6.17E-02	0.00	0.00	3.87E-09	236.3	0.1	0.4	**1.48E-05**
Elementary School	6.17E-02	0.00	0.00	3.87E-09	236.3	0.3	**1.8**	**1.48E-05**
Receptor		**EIR Health Risks All TACs**				**Modified Health Risks All TACs****		
		Chronic Hazard Index	Acute Hazard Index	Cancer Risk		Chronic Hazard Index	Acute Hazard Index	Cancer Risk
Resident		0.00	0.01	2.20E-06		0.1	**14.1**	**3.83E-05**
Worker		0.02	0.16	7.40E-06		**3.1**	**303.9**	**9.08E-05**
Daycare		0.00	0.00	2.52E-07		0.1	0.4	**1.50E-05**
Elementary School		0.00	0.00	2.23E-07		0.3	**1.8**	**1.50E-05**

* Valero provided revised results for the MEIW accounting for a "basemap shift" due to previously using an incorrect basemap; the "basemap shift" moved the MEIW by about 150 feet to the north northeast.[89,90] Given the magnitude of the revised health risks, this basemap shift does not materially affect my conclusions.

** Assumes all emissions are estimated correctly except benzene

Highlighted/bolded cells: significant health risks (acute and chronic hazard index equal to or greater than 1.0; cancer risk equal to or greater than 1.0E-05

These significant health impacts can be mitigated using the measures described for fugitive railcar ROG emissions in Comment II.B. In addition, a limit should be established on the amount of benzene in the crude, set to assure cancer, chronic, and acute health risks are less than significant. This limit should be enforced by requiring that benzene and other TACs that contribute significantly to health risks be measured in every batch of crude unloaded at the Refinery as the types of crude that will be imported by rail "are notorious for displaying significant variations in properties even when coming from the same field…"[91]

---

[89] Petra Pless, Pless Environmental, Inc., Letter to Rachael Koss, Re: Review Final Environmental Impact Report for Valero Benicia Crude by Rail Project, p. 66, Attachment D to SAFER's February 8, 2016 Letter; Available at pdf 165-255; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/Public_Comments_submitted_Jan_27-Feb_8_2016.pdf.

[90] *Ibid*, attached Letter from John Flynn, Nossaman LLP, to Bradley Hogin, Woodruff, Spradlin & Smart, Re: Comment on Risk Values presented in Appendix E.6 of the RDEIR, Valero Benicia Crude by Rail Project (SCH #2013052074); Use Permit Application 12PLN-00063, February 1, 2016.

[91] Thomas Garrett and others, The Challenges of Crude Blanding, Petroleum Technology Quarterly, Q2, 2016, p. 40 (Garrett and others 2016); Available at:

IV. PUBLIC SAFETY AND HAZARD IMPACTS ARE SIGNIFICANT

The RDEIR prepared a quantitative risk assessment (QRA) to evaluate the risks to the public from accidents at the Project site, which includes the following new and modified facilities to support unloading 70,000 bbl/day of crude oil, shipped in two 50-car unit trains per day:

(1) Installation of 8,880 track-feet of new rail track, some of which would replace the existing access road, between the new service road and Crude Oil Tank Farm;[92]

(2) Realignment of about 3,560 track-feet of rail track;

(3) Replacing a 4,000-foot long emergency access road with a new 1,900-foot long, 20-foot wide service road, moved closer to the tank farm to the west;[93]

(4) A 1,500-foot long unloading rack installed in the northeastern portion of the main Refinery property, sandwiched between the eastern side of the lower tank farm and the fence adjacent to Sulfur Springs Creek;[94]

(5) A liquid spill containment sump with the capacity to contain the contents of one tank car;[95] and

(6) 4,000 feet of new 16-inch diameter aboveground crude oil pipeline.[96]

These key features are shown in Figures 3 and 17.

---

http://www.digitalrefining.com/article/1001216,The_challenges_of_crude_blending.html#.VwKxqXrTCPV.

[92] RDEIR, p. 2-6.

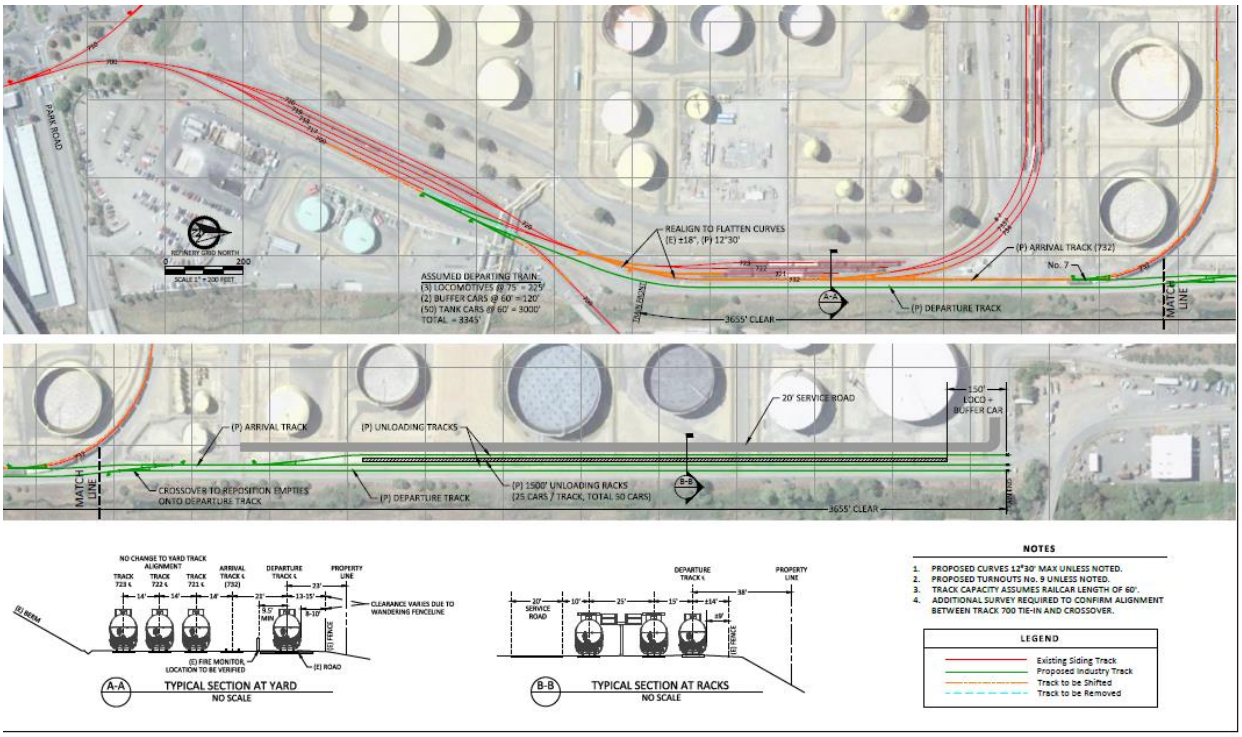
[93] RDEIR, Figure ES-3, p. 2-6.

[94] RDEIR, Figure ES-3.

[95] DEIR, p. 3-17; RDEIR, p. 42.

[96] RDEIR, p. 2-6.

Figure 3: Site Plan[97]



However, the EIR buries the supporting QRA analyses in dense appendices, presented in metric units, which are not accessible to the typical reviewer. The EIR fails to explain how to translate the results of these analyses into impact conclusions that can be understood by non-subject-matter experts, thus preventing meaningful public review of the impacts. The EIR fails to disclose the inputs to the analysis and equations and calculations used to arrive at impacts as do responses to our public records act requests (PRAs). The EIR further incorrectly summarizes the results of these analyses in the text as insignificant, when, in fact, they are highly significant. The QRA is also riddled with errors. The FEIR thus fails as an informational document.

The QRA is based on a large number of assumptions and equations, most hidden from view, which significantly underestimate the probability and consequences of on-site accidents. On-site accidents at the proposed new facilities, when these errors and omissions are remedied, result in highly significant off-site impacts arising from on-site accidents that are not mitigated in the EIR. The errors and omissions are discussed below.

[97] RDEIR, Figure ES-3; DEIR, Figure 3-3.

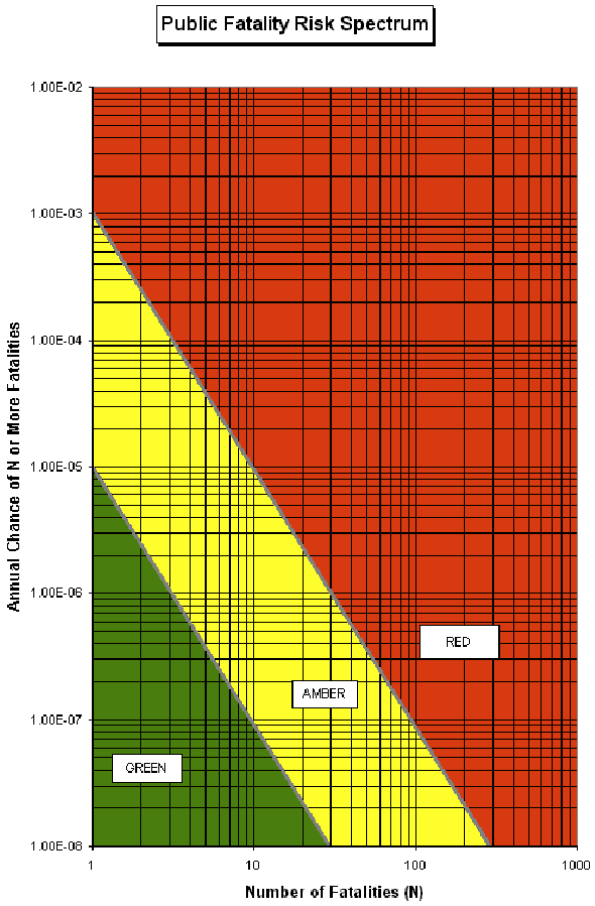
A. The EIR's Quantitative Significance Risk Assessment Is Incorrect and Unsupported

The RDEIR included a QRA for accidents at the unloading facility and evaluated the results using public safety thresholds in Santa Barbara County's CEQA Guidelines.[98,99] There are three major problems with the FEIR's reliance on these guidelines. They are misapplied and they are not applicable.

1. The Santa Barbara County CEQA Guidelines Are Misapplied

The Santa Barbara County CEQA Guidelines assign the significance of accidents based on the annual probability of the number of fatalities and injuries, as summarized in Figure 4 for fatalities.

Figure 4:
Santa Barbara Fatality Risk Thresholds



[98] RDEIR, Appx. F, Attach. 1, p. 38.

[99] County of Santa Barbara Planning and Development, Environmental Thresholds and Guidelines Manual, October 2009 (SBPD 10/2008); Available at: https://www.countyofsb.org/ceo/asset.c/479.

Impacts that fall within the green area are considered to be insignificant, in the amber zone to be "avoidable through application of feasible mitigation (*i.e.*, mitigation can render the impact to be insignificant)"; and in the red zone to constitute an unreasonable risk, requiring a statement of overriding considerations.[100]

The Santa Barbara guidelines explain that

> "…these thresholds should not function as the sole determinants of significance for public safety impacts. Rather, they must be used in concert with applicable County policy, regulation, and guidelines to address other qualitative factors specific to the project which also help determine the significance of risk. For example, highly sensitive land uses (e.g., hospitals or schools) are generally given greater protection from hazardous situations overall. Also, long-term significant risks (e.g., natural gas production) generally are treated more conservatively than relatively short-term risks (e.g., natural gas exploration)."[101]

The FEIR used these thresholds as the "sole determinants of significance for public safety impacts" without considering any other factors specific to the project that would require greater protection. There are two major factors that should have been considered in assigning the significance of the impacts.

First, the unloading facility presents a long-term significant risk to nearby businesses to the east of the loading facility. Many commercial properties (Conco, Praxair, Benicia Fabrication & Mach, Insight Glass) are within significant hazard zones.[102] Further, one of the EIR's accident scenarios, a thermal tear, could result in injuries and fatalities at the nearest residence at Lansing Circle, approximately 2,000 feet northwest of the northern end of the Project site.[103] An accident at Tanks S-1701 to S-1708, which would store the imported crude oil, could additionally result in injuries and fatalities in the Hillcrest neighborhood, about 1,000 feet from the nearest residence on Hillcrest Avenue. These scenarios were not evaluated, but should have been.

---

[100] SBPD 10/2008, pp. 123-124.

[101] SBPD 10/2008, p. 119.

[102] RDEIR, Figure 4.7-8.

[103] The EIR variously reports the distance from the unloading racks to the nearest off-site residence as 2,000 to 2,700 feet. *See*: DEIR pp. pdf 92 (>2000 ft), 245 (2,100 ft), 246, 251 (2,100 ft), 253 (unloading racks: 2,100 ft; unloading rack pumps: 2,250 ft), 256 (2,100 ft), 373 (2,700 ft), 410 (2,700 ft), 625 (2,700 ft), 860 (2,700 ft); RDEIR, pdf 40 (2,000 ft) .

Figure 5:
Nearest Residence to Crude Tank Farm
in Hillcrest Neighborhood

I note that the EIR is ambiguous as to the distance of the nearest residence, a key consideration for noise, hazard, and health impacts. The EIR variously reports distances of 2,000 feet to 2,700 feet, depending upon the impact area. A 700-foot discrepancy could result in life/death consequences for residents along Lansing Circle, the only residential neighborhood considered, as the EIR omitted all impacts at the Crude Tank Farm where the rail-imported oil would be store. This is yet more evidence that the City cannot rely on its consultant reviews to verify the accuracy of the EIR as asserted in its defense of the Valero appeal.[104]

Second, an on-site accident would result in highly significant impacts to animals and plants that rely on the adjacent Sulphur Springs Creek, just 50 to 60 feet away. These significant biological impacts warrant more conservative treatment under the Santa Barbara Guidelines.

Third, depending upon the specific accident (*see* Comment IV.D), on-site accidents at the new facilities could result in significant impacts at a local school. An

[104] 3/9/16 CCD Memo, p. 13 ("ESA conducted an independent analysis of those studies and all other studies prepared by other City consultants such as MRS and Dr. Barkan for the rail transportation risk analysis reports. City staff reviewed, commented and edited all documents. The Peer review of these studies by ESA and the City ensures that the City's independent analysis and judgment is maintained.").

accident involving the proposed storage tanks in the Crude Tank Farm (Figure 18 below), omitted from the EIR, but discussed below, would present significant risk of injuries and fatalities in the Hillcrest neighborhood (1,000 feet) and the Robert Semple School, about 3,000 feet from the nearest tank in the Crude Tank Farm. Thus, more conservative treatment than the Santa Barbara County risk spectrum is warranted.

Figure 6:
Nearest School to Crude Tank Farm

2. The Santa Barbara CEQA Guidelines Are Not Solely Applicable

Under CEQA, a project would result in a significant safety impact if it "create[s] a potential health hazard…" The FEIR evaluated the significance of an accident based on the "risk" that an accident would occur, determined as

Risk = consequence × probability.

Because probability is a number less than one, what this means is that the EIR has reduced the consequences, *e.g.*, the numbers of injuries and death, by multiplying them by a number less than one, thus reducing the apparent impact. However, probability is misleading because even if it is small, any given event can occur over the lifetime of the project, resulting in significant consequences.

Elsewhere, buried in an appendix, the EIR includes this caveat to its probability analysis:

> "The nature of risk analysis is that even if an event has a low likelihood of occurring, there is no guarantee that it will not. For example, even if the estimated probability of an event is 0.01, i.e., one in one hundred, corresponding to an expected interval between occurrences of 100 years, such an event could still happen in the near future, and in fact multiple

> events are possible within that time period. Such an occurrence would not mean that the risk analysis was incorrect, instead it may be due to two factors, the laws of chance, and uncertainty in the statistics. It is important that readers understand this and that statements to this effect be included in reports used to describe the results of analyses of this nature."[105]

Thus, the use of probability to estimate "risk" obscures the fact that accidents can be devastating and thus significant, even if they occur infrequently. A good example is a Lac-Megantic-type accident that would be devastatingly significant even if it its likelihood to happen is only once in 111 years. The inclusion of "probability" allows the EIR to dismiss as insignificant accidents that would result in significant injury, death, and property damage in the surrounding community because the EIR judges them to have a low probability of occurring. Here, it is illustrative to mention that the "once in 111 years" occurrence is as likely to happen next year as it is in 10, 30, or 111 years.

The CEQA Guidelines indicate that "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project" constitutes a significant effect on the environment.[106] The CEQA Guidelines do not include "probability" as a factor to consider in evaluating the significance of impacts. In response to similar comments on the RDEIR,[107] the FEIR's only response is "…the City exercised its discretion in determining an appropriate standard of significance by choosing to use public safety thresholds that were adopted by Santa Barbara County in August 1999…"[108] The City does not have the discretion to ignore CEQA and to misapply the Santa Barbara County guidelines (which are inconsistent with CEQA due to their reliance on probability).

The EIR itself admits low probability events that cause significant consequences are *per se* significant in response to comment A12-2: "… the consequences of a spill, upset, or accident could be significant regardless of how likely it is to occur."[109] However, the EIR fails to evaluate the significance of accident consequences taken alone. Many of the scenarios would result in serious injury and fatalities in surrounding areas. These are significant impacts that were not disclosed in the EIR.

---

[105] RDEIR, Appx. F, Attach. 1, p. 12 (pdf 373).

[106] CEQA Guidelines § 15382.

[107] FEIR, Comment B9-22 (CBE).

[108] FEIR, RTC B9-22 referring to RTC B9-20.

[109] FEIR, p. 2.4-64, RTC A12-2.

3. The EIR's Quantitative Risk Assessment Is Unsupported

A quantitative risk assessment is a process used to assign a numeric value to the probability of an impact, in this case, death and injuries resulting from an accident at the rail car loading facility. A QRA requires information on the type of accidents, their probability of occurrence based on historical data from similar facilities, and consequence modeling of each accident scenario to determine impacts when the accident occurs.

The RDEIR includes the results of oil spill consequence analyses for several crude oil spill scenarios used to evaluate worst-case thermal radiation hazards.[110] The RDEIR summarized the "worst-case thermal radiation hazard" distances based on these consequence analyses in RDEIR Table 4.7-8 and Figure 4.7-8 for two thermal radiation significance criteria: 5 kW/m^2 and 10 kW/m^2.[111] The RDEIR explains that

> "[e]xposure to a thermal radiation level of 10 kW/m^2 could result in a serious injury (at least second-degree burns) if exposed for less than 1 minute, and it was, therefore, assumed that all persons exposed to 10 kW/m^2 would suffer serious injuries. Serious injuries would start to be realized at and above 5 kW/m^2. Exposure to thermal radiation levels in excess of 10 kW/m^2 would likely begin to generate fatalities in less than 1 minute."[112]

Figure 4.7-8, reproduced here as Figure 7a, shows thermal radiation isopleths from Table 4.7-8 overlaid on a Google map of the site, which indicates that the 5 and 10 kW/m^2 isopleths encompass Sulphur Springs Creek and commercial areas to the east of the unloading facility, indicating significant impacts will occur to habitat in the Creek and the encompassed commercial district. Based on this analysis, individuals along East Channel Road and Industrial Way within the thermal radiation 5 and 10 kW/m^2 circles would suffer serious injuries and fatalities.

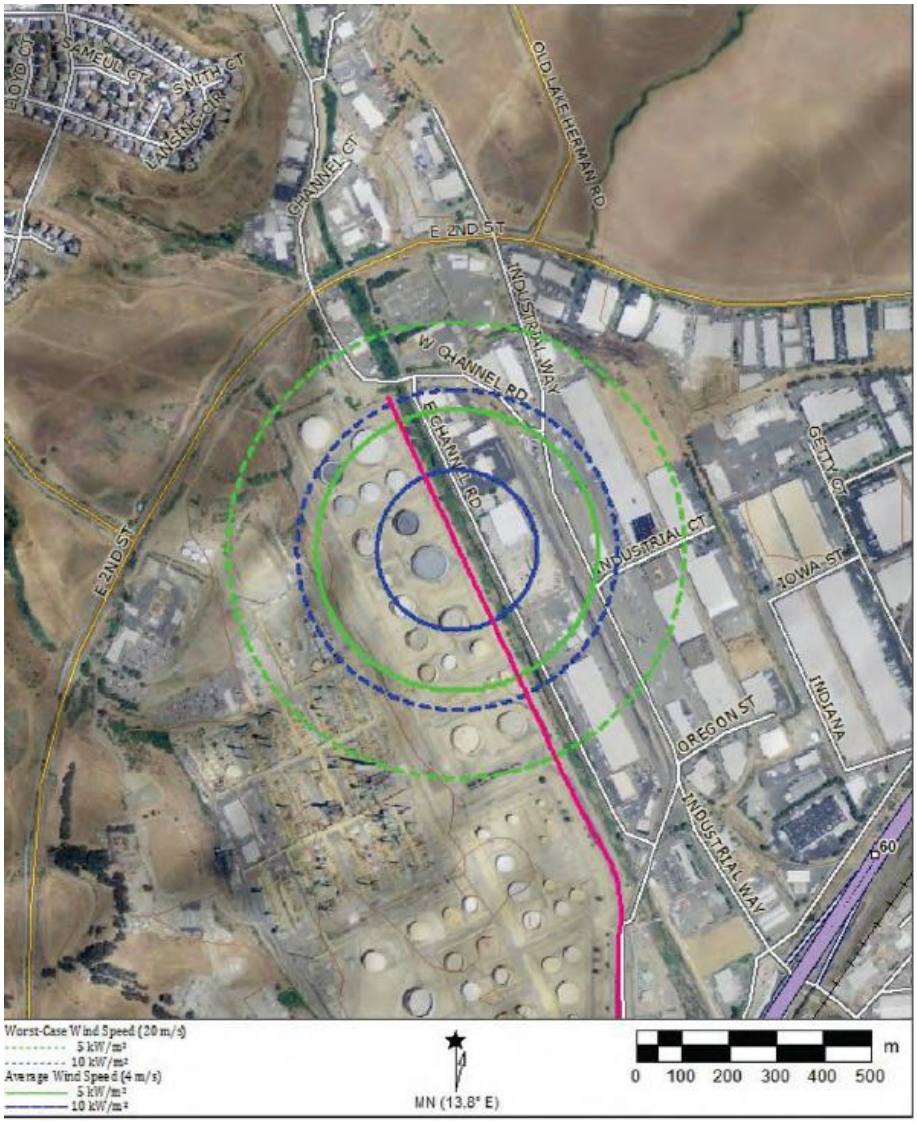
---

[110] RDEIR, Appx. F, Attach. 3.

[111] Thermal radiation intensity is a measure of the harm caused by heat from large-scale fires. It is measured in units of kilowatt per square meter (kW/m^2). See FEMA, Handbook of Chemical Hazard Analysis Procedures and CCPS, Chemical Process Quantitative Risk Analysis.

[112] RDEIR, Appx. F, Attach. 1, p. 16.

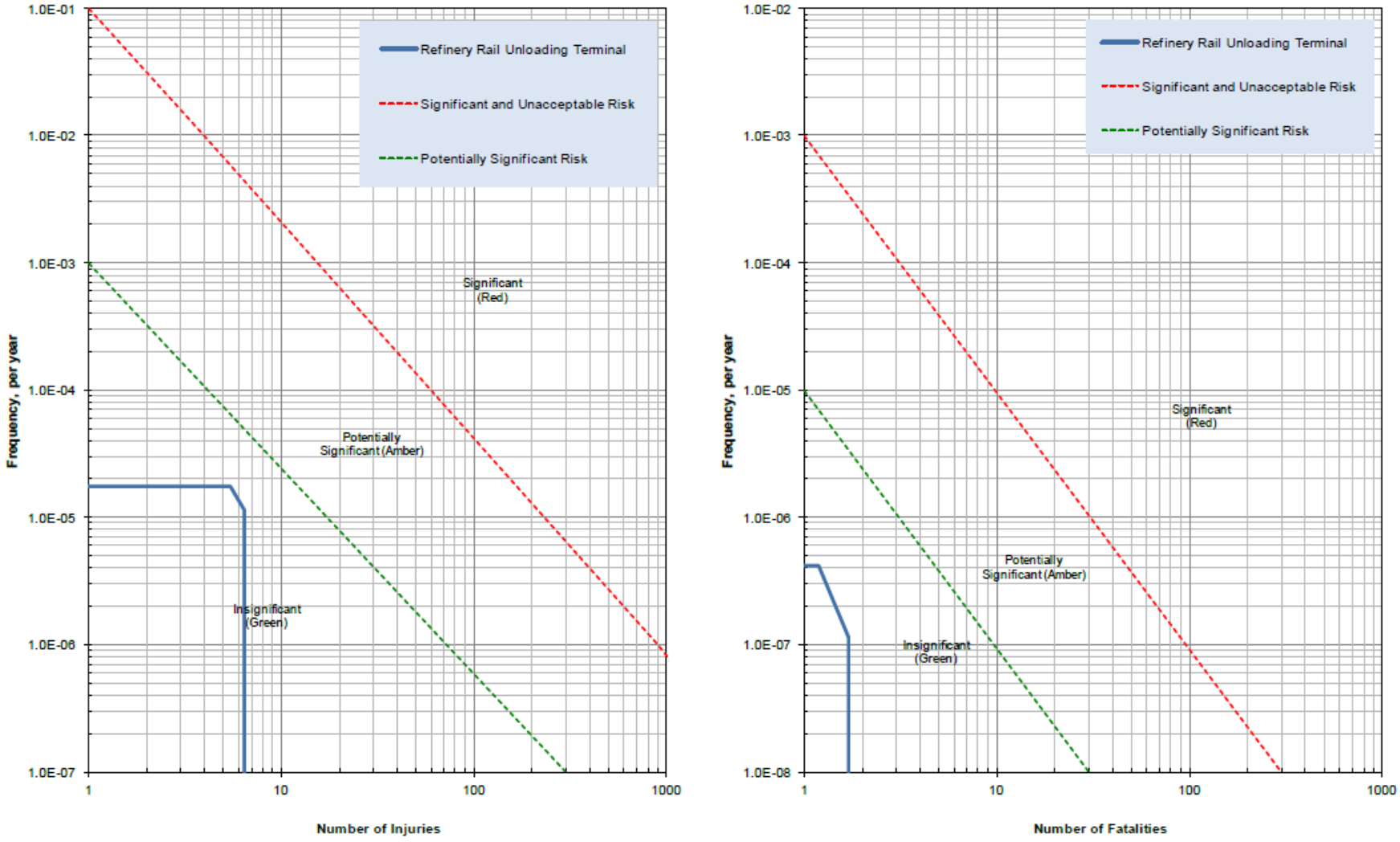
Figure 7a:
Worst-Case Facility Thermal Radiation Hazards[113]



Rather than finding a significant impact due to accidents at the rail unloading terminal, the RDEIR next points to Figure 4.7-9, which shows "risk profiles." A risk profile plots the frequency of an accident versus the number of injuries and fatalities. The chart is divided into three areas: (1) insignificant (green); (2) potentially significant (yellow); and (3) significant (red). The risk profiles for the unloading terminal fall in the insignificant yellow area and thus are deemed insignificant by the EIR. Figure 4.7-9 is reproduced here as Figure 7b. There are many problems with the EIR's analysis, discussed in the comments below.

[113] RDEIR, Figure 4.7-8.

Figure 7b:
Risk Profiles for Unloading Facility Crude Oil Spills and Fires[114]



[114] RDEIR, Figure 4.7-9.

The EIR contains no support for the transition from worst-case thermal radiation hazards shown on Figure 4.7-8 (Figure 7a) to the risk profiles shown in Figure 4.7-9 (Figure 7b). The risk profiles for the unloading terminal magically appear (while those for mainline accidents are documented in Appendix F, Attachment 1). The transition requires: (1) an accident or failure frequency analysis to determine the probability of occurrence of each type of accident included in the consequence analysis at similar rail unloading terminals; (2) the annual chance of N or more injuries or fatalities; (3) population density information, *i.e.*, number of people per square mile; and (4) consequence area at each risk level (5 kW/m^2, 10 kW/m^2) to estimate the exposed population affected by injury or death. The EIR does not include this information for the unloading terminal. Rather, the supporting appendix,[115] Risk Assessment Methodology, in the section where this information should be found asserts:

> "B. Failure Frequencies
> Once the scenarios have been identified, the analysis attempts to estimate the frequency of each scenario. The worst case hazard zones for the Santa Maria Refinery (SMR) did not extend off of the refinery property so it was not necessary to estimate failure frequencies of the events at the VBR. The remainder of this section focuses on the mainline rail failure events."[116]

The QRA for the Valero Rail Project was performed by the same consultants (Barkan/MRS) as the Phillips 66 Santa Maria Rail Spur Project. The Valero EIR apparently copied the risk assessment methodology section from the Santa Maria EIR and failed to update it. The worst-case hazard zone for Santa Maria did not extend off site and, thus, the Santa Maria EIR did not include a QRA for the rail spur and unloading terminal. However, this is not true for the Valero Rail Spur, where hazard zones do extend off site (Figure 7a), requiring a QRA. Thus, this critical step in converting hazard zones to risk profiles is missing from the Valero record.

There are other places that indicate the Valero risk assessment was copied from the Santa Maria Rail Spur EIR and incompletely updated.[117] The number of these errors, which were not subsequently corrected, suggests that the City cannot rely on its consultant reviews to verify the accuracy of the EIR as asserted in its defense of the

---

[115] RDEIR, Appx. F, Attach. 2, Risk Assessment Methodology.

[116] RDEIR, Appx. F, Attach. 2, p. 7.

[117] RDEIR, pdf 384 ("The crude transported to the SMR could be in Packing Group I."); pdf 392 ("The risk analysis was only done for the mainline rail since the hazard zones at the SMR did not extend off the refinery property.")

Valero appeal.[118] The risk assessment methodology sections of these two EIRs are nearly identical.[119]

Thus, the Valero EIR does not include any support for the transition from worst-case thermal hazard zones for the unloading terminal, as summarized in RDEIR Table 4.7-8 and Figure 4.7-8 (Figure 7a), to the risk profiles in RDEIR Figure 4.7-9 (Figure 7b). The risk profiles were used to determine the significance of on-site terminal unloading accidents, based on Santa Barbara County public safety thresholds. This represents a complete failure to support the critical step from the consequence analysis to the risk profiles.

In addition to this failure to support the on-site QRA assumptions, the EIR's consequence analyses in Appendix F were conducted with a proprietary model developed by Marine Research Specialists (MRS)[120] Further, the risk profiles were generated by another proprietary MRS model.[121,122] The use of undocumented proprietary models prevents meaningful public review.[123] Thus, we requested documentation for the QRA analysis.[124]

In response to our March 10, 2016 PRA for access to a functioning copy of the models used to generate risk profiles, which could have been provided under a confidentiality agreement, the City responded that "[t]he models used to generate the

---

[118] 3/9/16 CCD Memo, p. 13 ("ESA conducted an independent analysis of those studies and all other studies prepared by other City consultants such as MRS and Dr. Barkan for the rail transportation risk analysis reports. City staff reviewed, commented and edited all documents. The Peer review of these studies by ESA and the City ensures that the City's independent analysis and judgment is maintained.").

[119] Santa Maria FEIR, Appendix H.1 – Risk Assessment Methodology; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/FEIR+Phillips+Rail+Spur+Project+Dec+2015/Technical+Appendices/Appendix+H.1+-+Risk+Assessment+Methodology.pdf.

[121] RDEIR, pdf 378.

[122] Santa Maria FEIR, p. H.1-2.

[123] RDEIR, pdf 388 (SuperChems™ & IoMosaic SuperChems™). See also E-mail from Amy Million, City of Benicia to Cody Elliott, ABJC, March 17, 2016, Re: Valero Benicia Crude by rail Project Revised Draft Environmental Impact Report.

[124] Cody Elliott, Adams Broadwell Joseph & Cardozo, Letter to Brad Kilger, Lisa Wolfe and Amy Million re: Request for Immediate Access to Documents Referenced or Relied Upon the Valero Benicia Crude by Rail Project RDEIR, March 10, 2016.

risk profiles required are proprietary to the consultant, Marine Research Specialists (MRS)."[125] The City's QRA consultant, MRS, declined to provide a copy.[126]

In response to our March 10, 2016 PRA request for all "input and output data for the model [which is not confidential], all supporting calculations, live Excel spreadsheets, references supporting assumptions, and correspondence, we received a letter from MRS that "provided additional information…that should guide the requester to a better understanding of the information and assumptions that were used in the QRA."[127]

The additional information did not identify specific assumptions or calculations used to generate the Valero risk profiles, with the exception of new information on population densities. Rather, it provided a general description of the Project that summarized information already available in the EIR and partial summaries of some calculation results. The 3/30/16 Radis Letter, for example, admits numerous failure rates are required to estimate probabilities of a spill, ignition rates, and failure of the foam fire suppression system. However, it only presents the assumed failure rates without disclosing any of the assumed probabilities or supporting calculations. Similarly, as to determining consequences (death, injury), the 3/30/16 Radis Letter points to Appendix F, which omits on-site analyses due to the Santa Maria mixup. And as to risk estimates, the 3/30/16 Radis Letter asserts they are the same as for the mainline rail QRA, "where applicable" without explaining further.[128]

Finally, the 3/30/16 Radis Letter attached copies of some of the references cited in RDEIR Appendix F at pdf 357-359.[129] In many cases, just the title page and table of contents were provided, or a screen shot of an Amazon page listing the reference for sale. All of these references are general background information on the art of QRA analysis. They do not provide the specific methods, assumptions, and other inputs used for the Valero CBR project. As a subject-matter expert, I cannot use any of this information to determine the specific methods and assumptions that were used to generate the Valero risk profiles. The documents provided by MRS are not responsive to our PRA request and sheds no light on the specific assumptions and calculations used to convert the worst-case thermal radiation hazards shown on RDEIR Figure 4.7-8

---

[125] Amy Million, City of Benicia, Letter from to Cody Elliott, Adams Broadwell Joseph & Cardozo, Re: Public Records Act Request Dated March 10, 2016, March 10, 2016. (Exhibit 8)

[126] Letter from Steven R. Radis, MRS, to Amy Million, Benicia, Re: Public Records Act Request for the Valero Crude by Rail Project, March 30, 2016 (3/30/16 Radis Letter). (Exhibit 9)

[127] 3/30/16 Radis Letter, p. 4.

[128] 3/30/16 Radis Letter, p. 5.

[129] The provided documents did provide some new information, crude oil analyses and wind frequency distribution data, but no information as to how this information was used to generate risk profiles.

(Figure 7a) into the risk profiles shown in Figure 4.7-9 (Figure 7b), the key step in determining the significance of accidents.

In sum, the supporting calculations and assumptions used to generate the risk profiles on which the significance determination is based are unsupported in the record, preventing meaningful review. The EIR fails as an informational document. Thus, in the next section, I develop a method to estimate the number of injuries and fatalities resulting from the EIR's worst-case accident. It is important to realize that the EIR's worst-case accident is, in fact, not the worst-case accident.

B. Off-Site Risks from On-Site Accidents Are Significant

I attempted to reproduce the risk profiles in RDEIR Figure 4.7-9 (Figure 7b) using information from the EIR, as supplemented by PRAs. My analysis indicates that these profiles cannot be reproduced without access to proprietary models and the input data that generated them. Further, my analysis indicates they significantly underestimate consequences (number of injuries and deaths) of the modeled accidents. The EIR estimated significance for the number of injuries and fatalities.

1. Number of Injuries

The risk profiles for injuries in RDEIR Figure 4.7-9 indicates that 5.3 to 6.4 injuries[130] would result from the worst-case on-site accident, which RDEIR Table 4.7-8 reports would extend out from the accident site by 1,585 feet at a wind speed of 20 meters per second (m/s). The RDEIR does not disclose how this injury estimate was derived. My calculations indicate it is a substantial underestimate.

This section sets out a procedure to estimate the number of injuries using the thermal radiation contours on RDEIR Figure 4.7-8 by multiplying the occupied area within each contour by its population density. This figure is reproduced here as Figure 9. I developed this method as the EIR does not provide any support for this figure. The City also failed to provide supporting data required to make precise impacted area and affected population estimates in response to our PRAs.

The EIR uses a thermal radiation significance threshold of 5 kW/m^2, corresponding to 10% injuries among those exposed.[131] The worst-case affected area is encompassed within the outer green dashed circle in Figure 7a. Heat exposure is not uniform within the 5 kW/m^2 contour. It increases from very high levels near the source to 5 kW/m^2 at 1,585 feet away. To estimate the number of injured parties, I subdivided this area into two zones. Zone 1 is the area between the 5 and 10 kW/m^2 contours.

---

[130] Determined from the x axis, "number of injuries".

[131] RDEIR, pdf 393, Table 6.

I assume 100% of those in Zone 1 are exposed at 5 kW/m^2, resulting in 10% injury. Zone 2 is the area between the source and the 10 kW/m^2 contour. I assume 100% of those in Zone 2 are exposed at 10 kW/m^2, resulting in 100% injury. In fact, many individuals in these zones would be exposed to higher heat fluxes than the assumed 5 kW/m^2 and 10 kW/m^2, based on their closer proximity to the accident site. Thus, my estimates are conservatively low. The number of injuries in each zone is determined by multiplying the local population density by the sum of the area within each of these zones times the percent injuries at each heat flux level (10% & 100%):

Number of injuries = Population Density × [Area Zone 1 × 0.10 + Area Zone 2 × 1.0]

RDEIR Appendix F reports that the population density in the vicinity of the unloading facility is 1,000 people per square mile.[132] However, the 3/30/16 Radis Letter reports the population density in the Benicia Industrial Park is 1,400 workers per square mile. The Benicia Industrial Park is within the 5 kW/m^2 contour. Roughly half of the area encompassed by the 5 and 10 kW/m^2 isopleths falls within the Refinery or is vacant land.[133] The population density in these areas, except for the Project site, is assumed to be zero.

The area of the 5 kW/m^2 contour[134] is the area of a circle with a radius of 1,585 feet (RDEIR Figure 4.7-8, Figure 7a) or 0.28 square miles.[135] The area of the 10 kW/m^2 contour is the area of a circle with a radius of 1,109 feet (RDEIR Figure 4.7-8, Figure 7a) or 0.14 square miles.[136] Thus, the area of Zone 1 is 0.07 square miles and the area of Zone 2 is 0.07 square miles. Therefore, the off-site population in both Zones 1 and 2 is 98 in each zone or a total of 196 off-site people.[137]

The number of injuries among these 196 exposed parties, assuming 10% injury in Zone 1 and 100% injury in Zone 2 is 108.[138] The actual number of injuries could be higher as the thermal radiation is based on the lowest level reached in each zone. If on-site workers are included, 7 additional people would be in Zone 2 where 100% injury

---

[132] RDEIR, Appx. F, Tables 5.3 to 5.5. *See, e.g.*, pdf 336, Segment 1, Benicia Spur.

[133] RDEIR, Figure 4.7-8.

[134] RDEIR, pdf 393, Table 6.

[135] Impacted area based on 5 kW/m^2 = πr^2 = (3.1416)[(1,585 ft/5,280 ft/mi)]^2 = **0.28 mi^2**.

[136] Impacted area based on 10 kW/m^2 = πr^2 = (3.1416)[(1,109 ft/5,280 ft/mi)]^2 = **0.14 mi^2**.

[137] Population in Zone 1 = 0.07 mi^2 × 1,400 people/mi^2 = 98 people. Population in Zone 2 = 0.07 mi^2 × 1,400 people/mi^2 = 98 people. Total exposed people = 98 + 98 = **196.**

[138] Number of injuries = 0.1 × 98 + 1.0 × 98 = **107.8 injuries.**

occurs for a total of **115 injuries**.[139] The actual number could be larger as these calculations assume exposure at the lowest heat flux within each zone.

The 3/30/16 Radis Letter discloses for the first time that "[b]ased on the site reconnaissance study, it was estimated that approximately ten percent of the population would be outdoors and vulnerable at any given time. The remainder of the worker population would be effectively sheltered in place within their facilities." This information was not disclosed in the EIR, has not been subject to public review, and the supporting study is not in the record.

Elsewhere, the EIR makes a different claim. Rather than sheltering in place, it assumed that some of those exposed to a radiation intensity of 5 kW/m^2 would move away from the hazard. However, the EIR fails to support this assumption or disclose the fraction of exposed persons it assumed would move away.[140] As the time for significant injury is very short, 5 seconds for severe pain, 40 seconds for second-degree burns,[141] very few people could escape. Regardless of which adjustment was used, it does not represent a worst case and is not representative of the site.

First, if the accident occurs shortly before or after work shift changes, a very large number of workers would be at the parking lots or in their cars simultaneously on their way to/from surrounding businesses, rather than sheltered inside buildings. Further, traffic on local roads would be packed with commuters from outside of the affected area, increasing population density.

Second, many local businesses operate with outside workers, such as trucking operations. Further, many employees work outside on large fabrications. These include, for example, Valley Fine Foods bordering Park Rd; WR Meadows of Northern CA off Nevada Street; Allied Manufacturing with rail spur off Oregon St; Alfred Cohhagen Inc. of CA with access to rail spur off Oregon St.; Kermetico, Inc. off Oregon and Industrial Way; Bay Area Oil Products off Oregon and Industrial Way; Boltec Mannings next door to Bay Area Oil Products off Industrial Way; Ancon Services off Nevada St Location; Dunlap Manufacturing off Industrial Way; Calbody Steel Forming off West Channel; Santa Clara Warehouses off Industrial Way; Golden Gate Petroleum off West Channel Rd; Romak Iron Works off Industrial Ct.; National Tire Warehouse, off Stone Rd.; Coco-Cola Bottling off Getty Ct.; KemLite Sequentia off Iowa and Indiana Streets; Yandell Truckaway off Stone Rd. with rail spur; Emco East-Welder Repair off Stone Rd.; PEPSI Bottling Group off Park Rd.; Cork Supply USA off Stone Rd; Biagi

---

[139] The EIR estimates 20 Valero employees in four crews of 5 employees each plus Union Pacific Rail Road (UPRR) personnel to operate the locomotives, estimated to be one conductor and one engineer per train, for a total of 7 employees per shift. See: DEIR, pp. ES-4, 3-1, 4.11-1, 4.11-11, 5-2; RDEIR, p. 2-19, 2-143.

[140] RDEIR, pdf 391.

[141] RDEIR, pdf 391, Table 4.

Brothers with rail spurs off Stone Rd.; Bruno Glass Packaging Inc. next to Biagi off Stone Rd.; Delticom North America off Indiana St and Nevada St.; Ralphs-Pugh Co. off Oregon St. with rail spur.

Third, workers would be present around the clock at the Project site. None would be sheltered in place as no buildings are shown on site plans.

Fourth, as to sheltering in place, many of the businesses in the area are warehouses with large open areas for loading/unloading, thus exposing workers directly to thermal radiation. The buildings along East Channel Road and Industrial Way are mostly large manufacturing buildings that have big openings facing the street and unloading terminal, such as Trippany Steel Detailing, Inc. (*See* Figure 8)

Figure 8. Warehouses along East Channel Road Showing Open Bay Door (Trippany Steel Detailing

Fifth, due to the proximity of the riparian zone along Sulphur Springs Creek, the vegetation could ignite, spreading the fire and increasing the thermal radiation at short distances from occupied buildings.

Sixth, especially if the accident occurred on a hot summer day, many windows and doors would be open, offsetting benefits of sheltering in place.

Seventh, commercial/industrial operations such as those in the Benicia Industrial Park, often have major sources of heat and vapors/odors, such that windows and doors might be open for ventilation even when it is not a hot summer day. Also, aside from warehouses, these businesses would have shipments arriving and departing, such that doors might be open.

Eighth, the EIR failed to consider that those sheltered in place could experience injury and death from the impact of blast and flame penetration through windows, the possibility of gas ingress to buildings resulting in internal explosions, radiative heat transfer to occupants through windows, and the likelihood of external blast effects and flames penetrating building boundaries.[142]

Thus, in the absence of any support for 90% sheltered in place and given the conservative nature of my estimate of number of injuries,[143] the number of injuries should be based on the actual number of injuries, assuming the accident occurs during shift changes when workers are outside and commuters are on local roadways, estimated to be 115 to greater than 124, as discussed below.

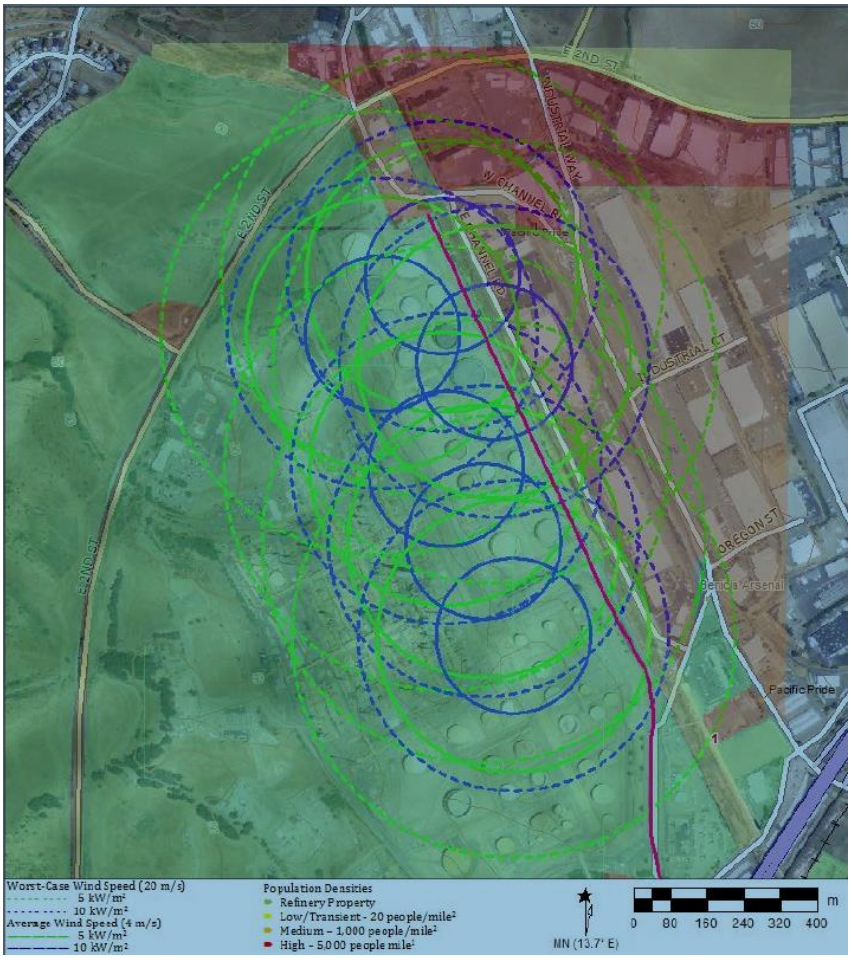
Finally, the 3/30/16 Radis Letter also discloses for the first time a map showing population densities around the Project site, reproduced here as Figure 9.

---

[142] B.S.W. Ashe and P.J. Rew, WS Atkins Consultants Ltd., Effects of Flashfires on Building Occupants, Research Report 084, 2003; Available at: http://www.frocc.org/pdf/building_eva/flashfires.pdf.

[143] My injury estimates are based on the outer radius of each zone. The actual number of injuries in each zone would be substantially higher as the thermal radiation levels are higher closer to the accident site.

Figure 9: Distribution of Hazards and Population Densities[144]



This figure shows that if the site of the accident were about 700 feet to the north, about one third of the 5 kW/m^2 contour would fall in the high population density area with 5,000 people per square mile. This would increase the number of injuries to more than 124.[145] Thus, the risk profile for injuries in RDEIR Figure 4.7-9 should show at least 124 injuries, not 5.3 to 6.4 injuries.

One hundred and twentyfour injuries extends the risk profile in Figure 7b into the potentially significant area,[146] as shown in Figure 10, assuming the accident frequencies presented by the EIR are correct. The number of injuries would be higher than the 124 estimated here, as the thermal radiation is higher throughout most of the

---

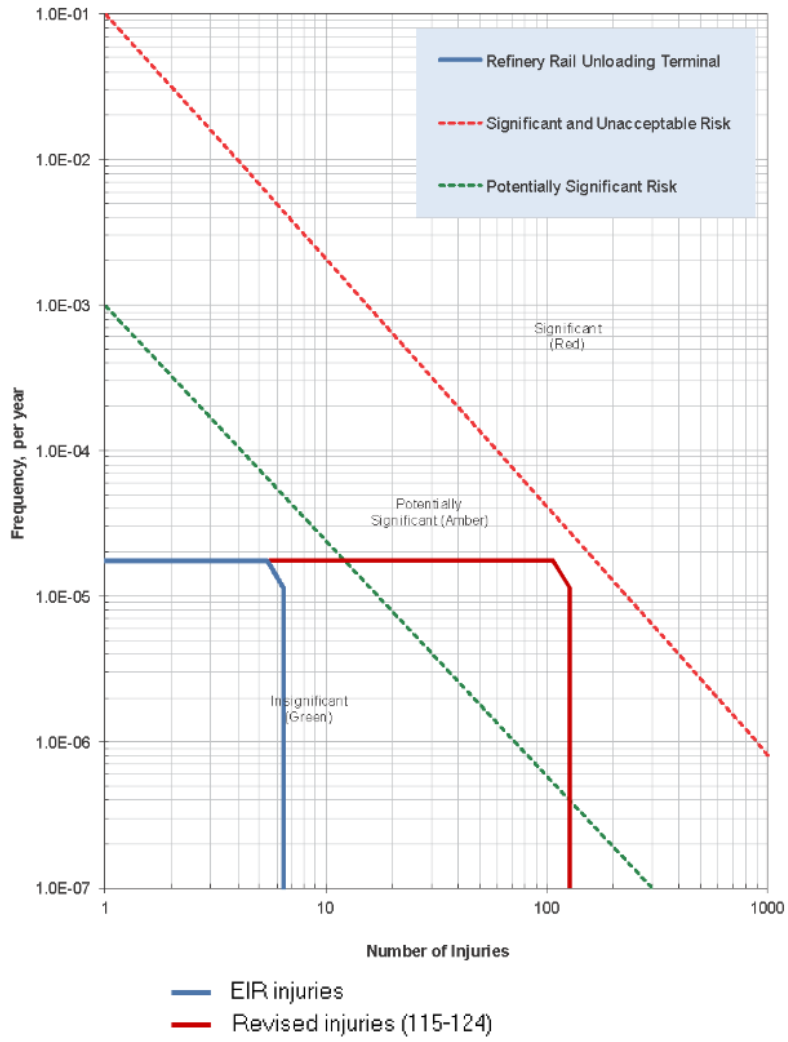
[144] 3/30/16 Radis Letter, Figure 1.

[145] Number of injuries if accident site is 700 feet north of the EIR location: (0.07 mi^2)(1/3)(5,000 people/m^2)(0.1) + (0.07 mi2)(0.7)(1,400 people/m^2)(0.1) + (0.07 m^2)(1,400 people/m^{i}2)(1.0) + 7 on-site workers =11,7 + 6.86 +98 + 7 = **123.56 injuries.**

[146] RDEIR, Figure 4.7-9.

two zones I used in my calculations than the assumed 5 kW/m² and 10 kW/m² significant levels. This is a significant impact that was not disclosed in the EIR.

Figure 10:
Modified Risk Profiles for Unloading Facility
Crude Oil Spills and Fires, Injuries[147]



2. Number of Fatalities

The risk profile for fatalities in RDEIR Figure 4.7-9 (Figure 7b) indicates that 1.5 to 1.8 fatalities[148] would result from the worst-case on-site accident, which RDEIR Table 4.7-8 reports would extend out from the accident site by 1,109 feet at a wind speed

[147] RDEIR, Figure 4.7-9.

[148] Determined from the x axis, "number of fatalities".

of 20 m/s. The RDEIR does not disclose how this fatality estimate was derived. My calculations indicate it is a substantial underestimate.

The significance threshold for fatalities used in the EIR is 10 kW/m^2, at which 11% fatalities occur, with 100% fatalities within the flame jet zone (which wasn't reported in the EIR).[149] The affected area within the 10 kW/m^2 isopleth is the area of a circle with a radius of 1,109 feet (Figure 7) or 0.14 square miles.[150] The 3/30/16 Radis Letter indicates that the population density in the off-site portion of this contour in the Benicia Industrial Park is 1,400 people per square mile. Roughly half of the area encompassed by the 10 kW/m^2 isopleth falls within the Refinery.[151] The off-site population exposed to 10 kW/m^2 (or greater, at distances less than 1,109 ft from the accident site) is 98 people.[152] Among these, 11% fatalities would occur or 98 × 0.11 = 11 fatalities.

Further, the RDEIR reports that after a 270-second exposure (4.5 minutes) at 10 kW/m^2, 100% fatality occurs. However, the EIR did not report exposure duration, so additional fatalities due to longer exposures cannot be estimated. However, if the exposure duration at 1,109 feet from the accident site was 4.5 minutes or longer, which is plausible, 100% fatalities could occur or 98 total. In addition, 7 on-site workers would be present in close proximity to the accident site. Thus a total of 11 + 7 = **18** to 98 + 7 = **105** fatalities could occur.

Therefore, the risk profile for fatalities should show at least 18 fatalities. It does not, but rather shows 1.5 to 1.8 fatalities. With 18 fatalities, the risk profile would extend into the potentially significant area,[153] while 105 fatalities would place it in the potentially significant zone. Figure 11. But the number of fatalities would be even higher than the lower bounds of 18 to 105 fatalities estimated here, as higher thermal radiation is present closer to the accident site, placing the number of fatalities in the significant zone.

---

[149] RDEIR, pdf 393, Table 6.

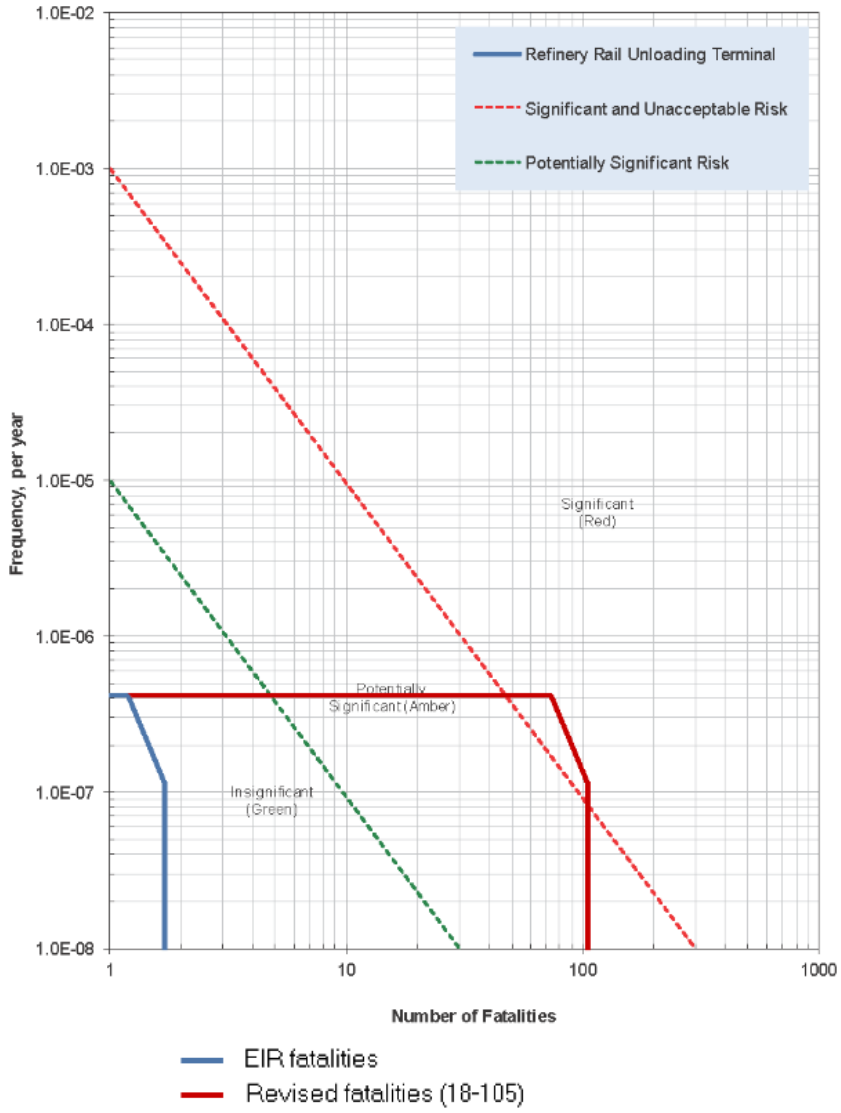
[150] Impacted area based on 10 kW/m^2 = πr^2 = (3.1416)[(1,109 ft/5280 ft/mi)]^2 = **0.14 mi^2**.

[151] RDEIR, Figure 4.7-8.

[152] Number of people exposed to 10 kW/m^2 = (0.14 mi^2/2) x 1,400 people/mi^2) = **98 people.**

[153] RDEIR, Figure 4.7-9.

Figure 11: Modified Risk Profiles for Unloading Facility Crude Oil Spills and Fires, Fatalities[154]



3. Feasible Mitigation

Based on the above corrections to the EIR's analysis, the risk of off-site injuries and fatalities from the "worst-case" on-site accident scenario is potentially significant to significant. Thus, all feasible mitigation must be required. The EIR does not include any mitigation for impacts of on-site accidents. The following are some feasible mitigation measures that should be required and would reduce the impact to a less than significant level:

[154] Based on modified RDEIR, Figure 4.7-9.

- Select an alternate site that is not adjacent to a tank farm and industrial area, loaded with flammable material and ignition sources;
- Require the use of pressure tank cars, such as the Tesoro DOT-120 design;[155]
- Use fail safe control valves and emergency cutoff switches at the loading rack to shut off the flow from transfer pumps;
- Provide a larger containment area, sufficient to contain the contents of at least 50 railcars;
- Use automatic fill shutoff switches, tied to an alarm, rather than the proposed manual gauge;
- Require mandatory Spill Prevention, Control, and Countermeasure (SPCC) training and annual refresher courses for all operators and other on-site employees;
- Require redundant backup pumps, pipes and tanks sufficient to transfer the entire contents of a 50-car train if needed in an emergency;
- Use self-contained, fixed foam fire protection system[156] using foam riser or foam ring around the unloading area;
- Design loading racks to withstand complete flooding (>10 feet), extreme temperatures, total loss of foundation due to liquefaction, and movement magnitude (Mw) 7.5 earthquake designed 25% stronger than current code;
- Maintain a nearby 24-hour firefighting crew;
- Eliminate ignition sources, including proper grounding to avoid static electricity buildup and lightning hazards, use of intrinsically safe electrical installation and non-sparking tools, implement permit system and formal procedures for conducting any hot work during maintenance;
- Design, construct, and operate loading racks according to international standards for prevention and control of fire and explosion hazards, including provisions for distances between tanks and adjacent facilities, *e.g.*, National Fire Protection Association (NFPA) Code 30 and American Petroleum Institute (API) Recommended Practice 2003.[157]

---

[155] The Tesoro DOT-120 design (with a shell thickness of 9/16") has a rated test pressure of 200 psi, but other DOT-120 and DOT-114 pressure tank car designs (with a shell thickness of 11/16") have rated test pressures of 300, 400, or 500 psi; *see* Fox FEIR Comment VI.B and C.

[156] ChemGuard, Fixed or Semi-Fixed Fire Protection Systems for Storage Tanks; Available at http://www.chemguard.com/pdf/design-manuals/D10D03192.pdf.

[157] International Finance Corporation, Environmental, Health, and Safety Guidelines for Crude Oil and Petroleum Product Terminals, April 30, 2007; Available at:

C. The EIR Fails to Evaluate All Feasible Types of Accidents

The EIR evaluated pool fires[158] (Figure 12) and a thermal tear, simulated as a Boiling Liquid Vapor Explosion (BLEVE). A pool fire is contained to the area where the spill occurs. They are essentially "tray fires" or "pan fires". These fires do not represent a worst case.[159]

Figure 12: Pool Fire

The release of a flammable material, such as Bakken crude, may result in a vapor cloud explosion, fireball and/or BLEVE, which could result in more significant consequences than the accident scenarios that were evaluated. In a vapor cloud explosion, the vapors from a crude oil spill could migrate off-site, into the adjacent, nearby tank farm or Benicia Industrial Park and ignite, presenting greater impacts than

---

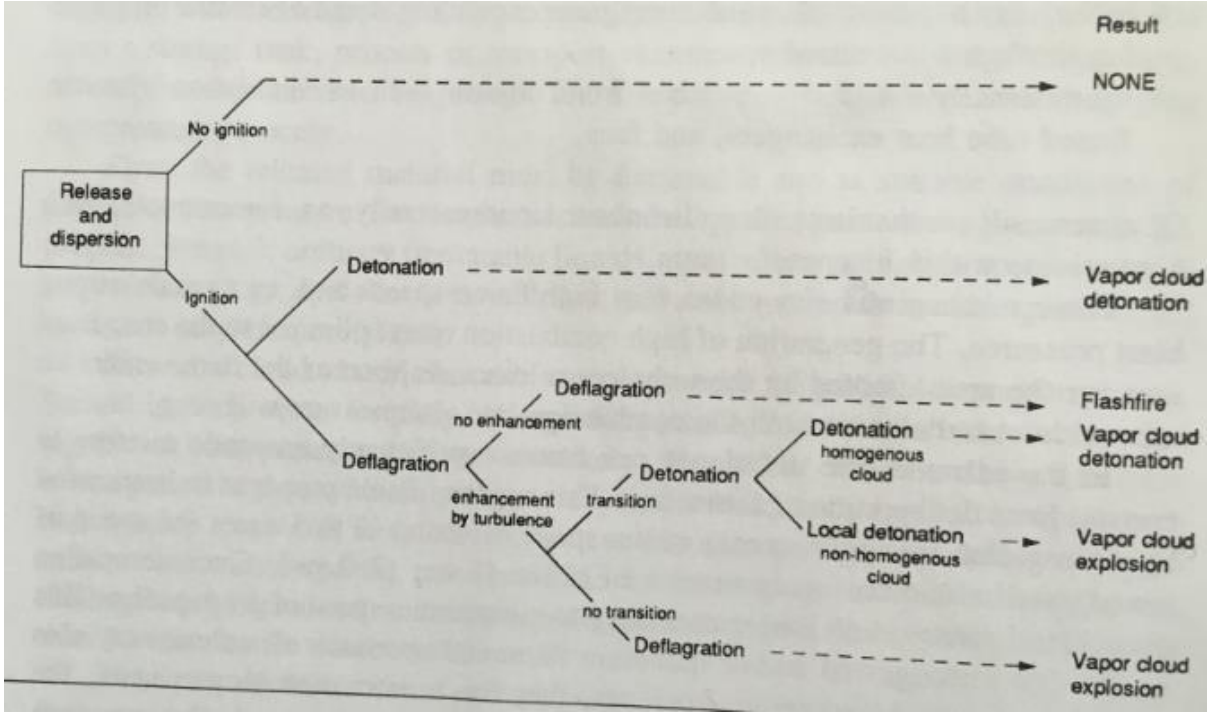
http://www.ifc.org/wps/wcm/connect/81def8804885543ab1fcf36a6515bb18/Final+-+Crude+Oil+and+Petroleum+Product+Terminals.pdf?MOD=AJPERES.

[158] A pool fire is a turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel where the fuel has zero or low initial momentum. *See*: http://www.iadclexicon.org/pool-fire/.

[159] Thomas Steinhaus and others, Large-Scale Pool Fires, Thermal Science Journal, v.11, no. 3, 2007; Available at: http://www.doiserbia.nb.rs/img/doi/0354-9836/2007/0354-98360702101S.pdf.

considered in the EIR.[160] The types of accidents that could occur when an ignition source is encountered are summarized in the event tree in Figure 13.

Figure 13:
Event Tree for Vapor Cloud Explosions and Flash Fires[161]



A vapor cloud explosion is the most dangerous and destructive explosion that could result. These events result from the sudden release of a large quantity of flammable vapor, such as loss of tank containment or multiple railcar contents. The resulting vapor is dispersed throughout the general area while mixing with air. If the mixture encounters an ignition source, a vapor cloud explosion occurs.. The resulting explosion could occur on site, in the adjacent tank farm, or in the Benicia Industrial Park, where consequences would be much more severe. An example of a vapor cloud explosion is shown in Figure 14. In this vapor cloud explosion, triggered by backfire from an idling diesel pickup truck, 15 were killed and 180 injured.[162] Many idling trucks are present in the Benicia Industrial Park, immediately adjacent to the Project site.

---

[160] *See* photographs of vapor cloud explosions at: https://www.google.com/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=photographs+of+vapor+cloud+explosions.

[161] Center for Chemical Process Safety, Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs, 1994, Figure 2.1.

[162] U.S. Chemical Safety and Hazard Investigation Board, Investigation Report, Refinery Explosion and Fire, BP Texas City, Texas, March 23, 2005, Report No. 2005-04-I-TX, March 2007; Available at: http://www.csb.gov/assets/1/19/csbfinalreportbp.pdf.

Figure 14: BP Texas City Vapor Cloud Explosion

Vapor cloud explosions are likely at the site due to the volatility of the Bakken crude and the proximity of many sources of ignition and nearby tanks that could be engulfed by the vapors. The EIR did not evaluate a vapor cloud explosion.

D. The EIR Fails to Evaluate All Feasible On-Site Accident Scenarios

The EIR separately evaluated two classes of on-site accidents: (1) during train maneuvering at the rail unloading facility (Impact 4.7-3) and (2) during line hookup and crude oil transfer (Impact 4.7-4).[163] The EIR analyzed accidents ranging from small releases from a tank car, full release of tank car contents, and full release of pipeline volume. The consequence analyses (thermal radiation as a function of distance from accident site) of each of these cases are found in Appendix F, Attachment 3 and summarized in RDEIR Table 4.7-8, which is captioned: "Worst Case Thermal Radiation Hazard Zones – Unloading Facility." As discussed below, this table contains errors and is not the worst case.

1. Accidents During Train Maneuvering at Unloading Facility (Impact 4.7-3)

The RDEIR estimated, based on Federal Railroad Administration (FRA) statistics, that a derailment while maneuvering onto the side-track unloading area would occur once every 100 years (a probability of 0.01). The RDEIR further concluded that a spill would be unlikely due to the low speed of on-site trains (3 mph) and tank car design.

[163] RDEIR, p. 2-106.

The FEIR then evaluated a "reasonable worst case scenario where one entire tank car contents spilled" but concluded the Project's spill containment system would hold this amount of crude, resulting in a less than significant impact.[164] The RDEIR does not point to any specific analysis in Appendix F that supports this conclusion, leaving the reviewer to guess which modeled scenario, if any, supports the assertion.

Further, this is an unreasonable conclusion. *First*, the spilled crude oil, which is very volatile, could rapidly form a fuel and air vapor cloud before the spilled crude reached containment. *Second*, the spill could occur in an area not controlled by containment/fire control. *Third*, even if the spill reached containment, vapors would be released from containment that could form a vapor cloud.

The resulting vapor cloud could reach nearby tanks (only 50 to 80 feet away), loaded railcars, the loading rack, or the Benicia Industrial Park.[165] An ignition source in these areas would cause a fire, which could engulf waiting railcars, nearby tanks, or businesses in the Benicia Industrial Park (some of which store volatile and hazardous materials), leading to a BLEVE or thermal tear. Further, given the location of the loading rack and the density of nearby tanks, multiple tanks and railcars could be engulfed, resulting in a much larger thermal tear than evaluated in the EIR. A BLEVE at the northern end of the loading rack would result in significant off-site impacts at the nearest residences on Lansing Circle and significantly more injuries and fatalities than estimated in these comments as a high population density area, with 5,000 people per square mile, is located to the northeast of the loading racks. Figure 9. Thus, as discussed in Comment IV.D.1, accidents during on-site train maneuvering are significant.

2. Accidents During Line Hookup and Crude Oil Transfer (Impact 4.7-4)

The RDEIR also evaluated accidents during line hookup and crude oil transfer from tank cars at the unloading facility and along the pipeline between the unloading facility and Tanks 1701 to 1708 (Impact 4.7-4). The RDEIR evaluated several crude oil spill scenarios to identify worst-case thermal radiation hazards associated with a large crude oil fire, as follows:[166]

- Pool Fire Scenario R1: 9,322 bbl at wind speeds of 1-20 m/s
- Pool Fire Scenario R2: 55,937 bbl at wind speeds of 1-20 m/s
- Pool Fire Scenario R3: 74,172 bbl at wind speeds of 1-20 m/s

---

[164] RDEIR, p. 2-106.

[165] The EIR does not contain a figure that locates the spill containment.

[166] RDEIR, Appendix F, Attachment 3: Oil Spill Consequence Modeling Results

- Thermal Tear (Fireball or BLEVE)
- Unloading: 22,706 gal at wind speeds of 1-20 m/s

The FEIR reports the "worst-case thermal radiation hazard distances – unloading facility"[167] in RDEIR Table 4.7-8, reproduced here as Table 6.

Table 6:
The EIR's Worst-Case Thermal Radiation Hazard Zones[168]

Wind Speed (meters/second)	Distance in feet to	
	5 kW/m²	10 kW/m²
1	518	282
2	558	308
3	581	324
4	974	554
5	994	571
10	1,053	620
20	1,585	1,109

NOTES:
kW/m²=kilowatts per square meter
See Attachment 3 of Revised DEIR Appendix F for the detailed consequence modeling results.
See Attachment 2 of Revised DEIR Appendix F for a description of the consequences associated with these hazards.

This table does not include the worst-case accident for either train maneuvering or the unloading facility. It combines (erroneously) two distinct scenarios, neither of which is the worst case. The entries (distance in feet to 5 kW/m² and 10 kW/m²) for wind speeds of 1 to 3 m/s are for the "unloading" scenario, while the entries for wind speeds of 4 to 20 m/s are for "pool fire" scenario R3, accounting for the dramatic jump up in distances between 3 and 4 m/s. The "unloading" scenario is just a pool fire in which 23,000 bbl of crude oil are released, *i.e.*, about one rail car's content. Many more railcars could be involved in an unloading accident.

The model runs in Appendix F indicate that neither of these scenarios is the worst case. The worst case is the explosion of (rail cars and/or tanks), referred to in the EIR as a "thermal tear" and simulated as a "Boiling Liquid Vapor Explosion" (BLEVE).[169] The thermal radiation hazard zones for the thermal tear are summarized in Table 7. Any of the evaluated pool fire scenarios, including the unloading scenarios,

[167] RDEIR, p. 2-107.

[168] RDEIR, Table 4.7-8.

[169] RDEIR, p. 2-94.

could generate enough energy to result in a thermal tear, which is the real worst case. This table shows that the injury hazard zone for a thermal tear extend out 2,339 feet from the site of the accident or 754 feet further than the worst-case pool fire (2,339 ft - 1,585 ft = 754 ft).

Table 7:
Thermal Radiation Hazard Zones,
Thermal Tear/BLEVE[170]

BLEVE Hazard Zones (feet)		
40 kJ/m^2	2,339	
150 kJ/m^2	1,158	
250 kJ/m^2	846	

The thermal tear is only considered under Impact 4.7-2, for off-site rail transport, which the EIR does not propose to mitigate due to "federal preemption." However, a thermal tear could also occur on site, resulting in significant off-site impacts that must be mitigated by requiring all feasible mitigation. The omission of an on-site thermal tear accident scenario in Impact 4.7-4 is clear error, as further discussed below. An on-site thermal tear would result in very significant off-site impacts that have not been disclosed in the EIR and have not been mitigated.

3. BLEVE (Thermal Tear)

A BLEVE is an explosion resulting from the failure of a vessel containing a liquid at a temperature significantly above its boiling point at normal atmospheric pressure. A BLEVE occurs when a vessel containing a superheated liquid catastrophically fails, usually as a result of external fire exposure (i.e., a pool fire under the vessel or a jet- or torch-type fire impinging on the vessel wall.[171] In contrast to a pool fire or a vapor cloud explosion, the liquid within a tank does not have to be flammable to cause a BLEVE. An external fire around a tank or rail car, for example, can heat the tank contents above its boiling point, resulting in an explosion.[172] The adjacent tank farm

---

[170] RDEIR, Table 4.7-7.

[171] Michael W. Roberts, Analysis of Boiling Liquid Expanding Vapor Explosion (BLEVE) Events at DOE Sites, 2000; Available at: http://efcog.org/wp-content/uploads/Wgs/Safety%20Working%20Group/_Nuclear%20and%20Facility%20Safety%20Subgroup/Documents/Analysis%20of%20Boiling%20Liquid%20Expanding%20Vapor%20Explosion%20(BLEVE)%20Events%20at%20DOE%20Sites.pdf.

[172] S. M. Tauseef, Tasneem Abbasi, S. A. Abbasi, Risks of Fire and Explosion Associated With the Increasing Use of Liquefied Petroleum Gas, Journal of Failure Analysis and Prevention, August 2010, Volume 10, Issue 4, pp 322-333; Available at http://link.springer.com/article/10.1007/s11668-010-9360-9#/page-2.

and 50-car unit trains full of crude oil present opportunities for a BLEVE. Examples of BLEVES involving railcars are shown in Figures 15 and 16.

Figure 15: Railcar BLEVE at Boomer, West Virginia[173]

Figure 16: Railcar BLEVE at Casselton, North Dakota

[173] Gordon Massingham, The Crudes – Part III, June 29, 2015 ("A Boiling Liquid Expanding Vapor Explosion (BLEVE) sends fire and debris 800 feet in the air near the small town of Boomer, WV following a train derailment and fire."); Available at: http://www.detricklawrence.com/the-crudes-iii/.

The EIR includes the explosion of tank cars, referred to as a "thermal tear" and simulated as a BLEVE.[174] This scenario could arise in the event that a pipeline or railcar spill exceeds the volume of the spill containment sump (which is designed to contain only the contents of a single rail car) and the spilled crude oil ignites.[175]

The EIR implies that it considered a thermal tear in determining the worst-case impacts. The RDEIR asserts: "The hazard zones associated with the fires and secondary thermal tears resulting in fireballs were incorporated into the QRA."[176] On the next page, the EIR states: "The worst case spill was assumed to be 240,000 gallons (about eight tank cars). An explosion of tank cars, referred to as a thermal tear and simulated as a Boiling Liquid Expanding Vapor Explosion (BLEVE), also was evaluated. The worst-case thermal radiation and explosion hazard distances are provided in Table 4.7-7. The modeling input data and results for these hazards are provided in Attachment 3 of the Revised DEIR, Appendix F."[177] However, my review of the model runs in Appendix F indicates that the results for the thermal tear are not included in Table 4.7-7, which is captioned: "Worst Case Thermal Radiation Hazard Zones."

E. Accidents at Other Project Facilities Were Excluded

The EIR only evaluated pool fires from leaks from railcars at the unloading facility. Accidents can also occur along the pipeline, at the Crude Tank Farm, and from train collisions with vehicles on the new access road.

1. Crude Oil Pipeline

The loading rack would be installed in the northeastern portion of the main Refinery property, between the eastern side of the lower tank farm and the fence adjacent to Sulfur Springs Creek.[178] Approximately 4,000 feet of primarily 16-inch-diameter piping and associated components and infrastructure would be installed as part of the proposed Project between the unloading racks to the existing crude supply piping. *See* Figure 17.

---

[174] RDEIR, p. 2-94.

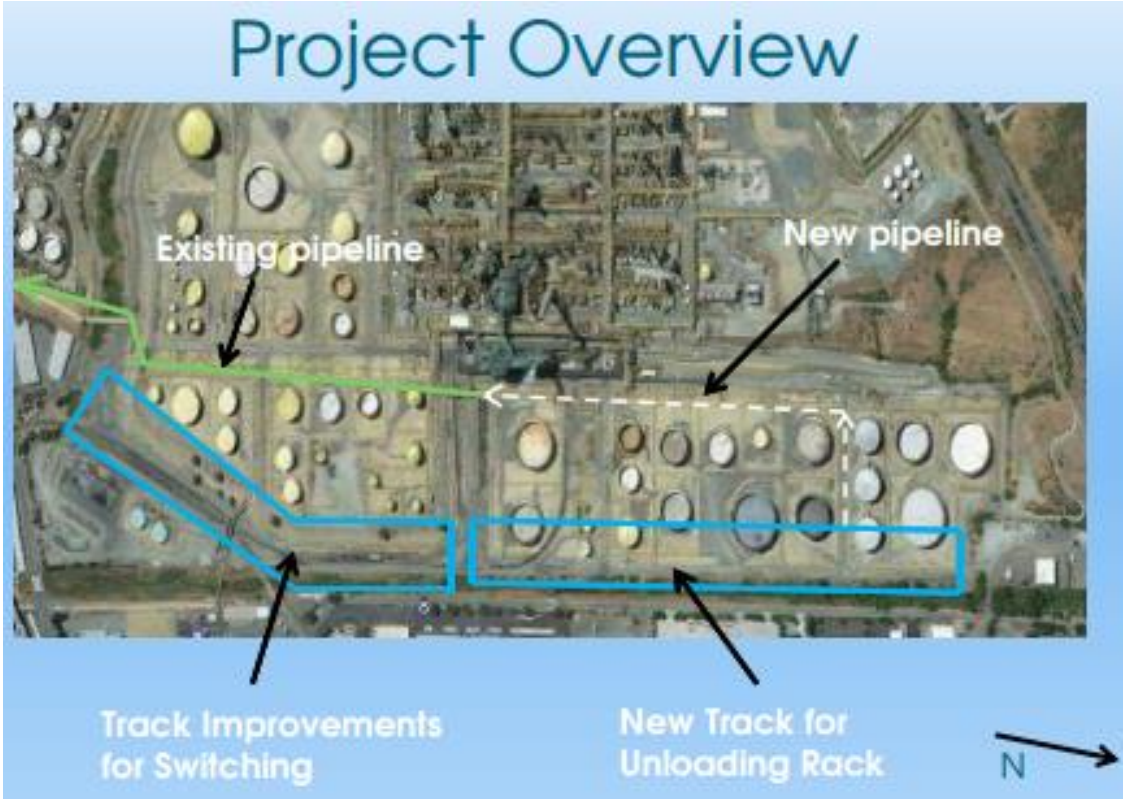
[175] RDEIR, Appx. F, Attach. 3, pdf 441–442.

[176] RDEIR, p. 2-93.

[177] RDEIR, p. 2-94.

[178] DEIR Figure 3-3 and pdf 354.

Figure 17[179]



The EIR did not evaluate a pipeline accident, presumably because it assumed the Supervisory Control and Data Acquisition (SCADA) system would detect a failure within 1 minute, limiting the pipeline and pumping loss. The worst-case spill from emptying the pipeline under this theory would be only about 73,000 gallons, which would occur where the pipeline connects with the unloading pumps and would drain into the area around the pipeline and unloading rack.[180]

However, this is not a worst case pipeline leak scenario. A leak could occur anywhere along the pipeline, distant from the containment sump, due to flange separation, corrosion, a lightning strike, flood, or earthquake-induced failure. The natural disasters could damage not only the pipeline but also the SCADA, resulting in minimal or no human intervention, leading to the loss of the contents of a 50-car unit train or 35,000 bbl. The air-vapor cloud formed as a result of such a pipeline leak could migrate into the adjacent tank farm and if an ignition source is encountered, result in a vapor cloud explosion, thermal tear, and/or BLEVE involving more than one tank.

---

[179] Valero, City Council Slides, March 15, 2015, p. 4.

[180] RDEIR, p. 2-107.

Further, the causes, probability, and consequences of a pipeline accident depend on where the pipeline is located. The record is not clear on pipeline location. The RDEIR states that the pipeline will be located "between the two rail spurs at slightly below ground level."[181] Elsewhere, the RDEIR states an "above ground pipeline would be routed along an existing internal road on the Valero property between the unloading facility and the Refinery"[182] and elsewhere, it is described as simply "aboveground."[183] The March 15, 2016 City Council slides (Figure 17) show the pipeline inside of the tank farm, rather than at the Project site between rail spurs. The probability of an accident depends on location, which is currently uncertain.

Thus, with these many locations to choose from, a pipeline spill could result from train accidents, collisions with on-road vehicles, pipeline mechanical or structural failure, corrosion, or human error anywhere between the unloading rack and along the pipeline connecting the unloading rack to the storage tanks. The condition of the existing segment of pipeline is not known and would likely be more vulnerable to accidents.

The Santa Maria EIR, which the Valero EIR relied on, evaluated a pool fire from a much larger pipeline release of a less flammable crude oil, 691,429 barrels.[184] The 5 kW/m^2 thermal flux extended 2,641 feet from the center of the release. The 10 kW/m^2 thermal flux, which would result in fatalities, extended 1,555 feet from the release center. These are much greater hazard zones than considered in any of the accident scenarios evaluated at Valero and are significant as discussed elsewhere in these comments. The EIR should require mitigation for pipeline leak accidents, including:

- Cathodic protection and pipe coating to prevent corrosion;
- Check valves to limit size of spills;
- Visual pipeline inspection once per shift;
- An underground pipeline;
- SCADA systems to monitor for pipeline leaks with solar and battery backup power supply;
- Check valves at the tie-in location;

---

[181] RDEIR, p. 2-20. Note that elsewhere, the pipeline is described as being "aboveground." *See* RDEIR, pp. 2-6, 2-107, 2-146; pdf 327.

[182] RDEIR, p. 2-107 and 3/30/16 Radis Letter, p. 3.

[183] RDEIR, p. 2-6, Table 5-1, p. 2-146.

[184] Santa Maria FEIR, Appx. H.3, p. H.3-16/17.

- Regular maintenance and pipeline inspections; and
- An SPCC Plan.

2. Crude Tank Farm

The new pipeline joins an existing pipeline that terminates at the "Crude Tank Farm" which contains 8 existing crude oil tanks that would store the rail-imported crude. The southwestern tank is only 725 feet from the nearest house in the Hillcrest neighborhood along McKinney Place. Further, it is less than 2,000 feet from the Ironworkers headquarters at 3120 Bayshore Road and local businesses. Thus, if the worst-case accident scenario evaluated in the EIR were to occur in this area, it would cause significant injury and fatalities in the Hillcrest neighborhood, at the Ironworkers headquarters and at other local businesses.

Figure 18:
Crude Tank Farm and Hillcrest Neighborhood

The EIR did not evaluate an accident scenario involving these eight tanks because it argued there would be no change in tank service.[185] However, all crude oils

[185] RDEIR, p. 2-107 (pdf 119) and pdf 327.

and tank operations do not present the same risk of upset. The Project would alter both the properties of the crude oils stored in the tanks and the operation of the tanks, which would alter the types of accidents that could occur and their consequences. The EIR admits as follows:

> "The consequences of a release of crude oil for a rail tank car depend on the properties of the crude oil and the area into which the crude oil is released. Relatively lighter crude oil has a lower flash point than relatively heavier crude oil. Therefore, relatively lighter crude oil is more likely to ignite upon release, causing a fire and/or explosion."[186]

This is also true of releases from the tanks. The changes in accident risk and consequences due to changes in the properties of crude stored in Tanks 1701 to 1708 must be evaluated relative to the CEQA baseline.

First, many of the crude oils that will be imported by rail are much more volatile than the crude oils currently stored in these tanks. *See* vapor pressure data in Table 2. The crude oils that have been stored in Tanks 1701 to 1708 are heavy crude oils that are much less flammable than Bakken and other light crudes available by rail. Thus, the Project will increase the probability and consequences of an accident relative to the baseline due to the higher volatility of the crudes.

Second, the rail-imported crudes are not the only crudes that will be stored in these tanks. Crudes imported by pipeline and ship will continue to be stored in these tanks. Thus, "switch loading" will most likely occur at these tanks. "Switch loading" refers to filling a tank, which previously contained a high or intermediate-vapor-pressure product, with a low-vapor-pressure product. Switch loading would occur, for example, if the tanks were alternated between heavy San Joaquin Valley crude and Bakken crude. Switch loading is a very hazardous operation,[187] much more hazardous than current tank operations. The NFPA and the API have specific guidelines for switching products in a tank.[188] The EIR is silent as to these hazards that would be created by storing Bakken crudes in Tanks 1701 to 1708. The EIR should be modified to prohibit switch loading at these tanks.

---

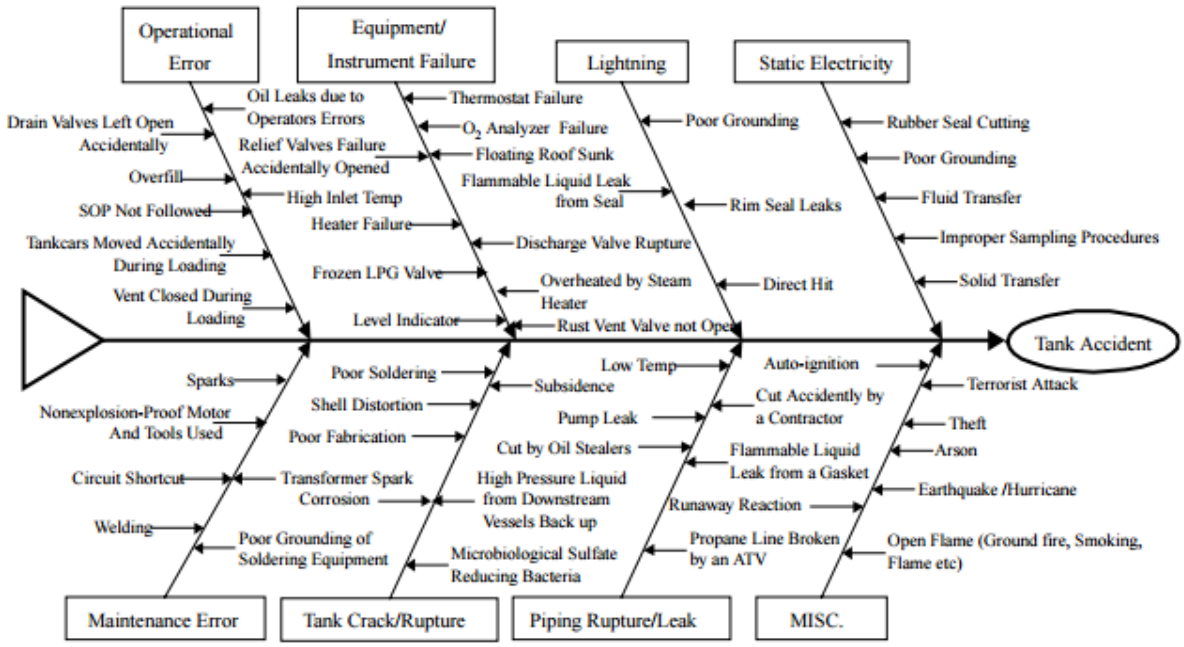
[186] DEIR, p. 4.7-13.

[187] National Transportation Safety Board, Storage Tank Explosion and Fire in Glenpool, Oklahoma, April 7, 2003, Pipeline Accident Report, NTSB/PAR-04/02, Adopted October 13, 2004; Available at: http://www.ntsb.gov/investigations/AccidentReports/Reports/PAR0402.pdf.

[188] NFPA 30: Flammable and Combustible Liquids Code; NFPA 77: Recommended Practice on Static Electricity; API Recommended Practice 2003: Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.

The EIR does not include any tank accident consequence analyses. Rather, it asserts that even if a pipeline spill occurred near the tank, the spill volume would be small as the tank is at the highest elevation along the pipeline and drainage would be in the area around the unloading racks.[189] However, tank accidents could be triggered by many other events besides pipeline leaks near the tank, as summarized in Figure 19.

Figure 19:
Fishbone Diagram of Accident Causes[190]



[189] RDEIR, pdf 327, 378.

[190] James I. Chang and Cheng-Chung Lin, A Study of Storage Tank Accidents, Journal of Loss Prevention, v. 19, pp. 51-59, 2006; Available at: http://www.technokontrol.com/pdf/storagetank-firesstudy.pdf.

These include operational errors,[191] maintenance errors,[192] equipment and instrument failures,[193] piping rupture/leaks,[194] tank crack or rupture,[195] lightening,[196] static electricity[197,198] and miscellaneous causes such as terrorist attacks, theft, arson, earthquakes/hurricanes, and open flames (ground fire, smoking).[199,200,201] Further, a vapor cloud from crude oil released elsewhere on the Project site could travel to the Crude Tank Farm and ignite. This could potentially involve up to eight tanks in an accident. The blast zone resulting from such an accident could destroy nearby houses in the Hillside neighborhood and buildings in surrounding industrial zones, including the Ironworkers Headquarters.

The EIR fails as in informational document as it did not include any analysis of tank accidents. The EIR must be revised to include tank accidents due to a switch in the type of crudes stored in these tanks and identify feasible mitigation. Feasible mitigation is identified in Figure 20.

---

[191] Operational errors that have caused tank accidents: drain valves left open, overfill, and SOP [standard operating procedure] not followed. Chang and Lin 2006.

[192] Maintenance errors that have caused tank accidents: sparks, nonexplosion-proof motor and tools, circuit shortcut, and welding. Chang and Lin 2006.

[193] Equipment/instrument failures that have caused tank accidents: thermostat failure, O_2 analyzer failure, floating roof sunk, discharge valve rupture, relief valve failure, rust vent valve not open, and level indicator failure. Chang and Lin 2006.

[194] Piping rupture/leak failures that have caused tank accidents: pump leak, cub by oil stealers. Chang and Lin 2006.

[195] Tank cracks/rupture scenarios that have caused tank accidents: poor soldering, shell distortion, poor fabrication, corrosion. Chang and Lin 2006.

[196] Contributing factors to lightning-induced accidents include: poor grounding, rim seal leaks, direct hits, flammable liquid leaks from a seal.

[197] Contributing factors to static electricity-inducted tank accident include: rubber seal cutting, poor grounding, fluid transfer, and improper sampling procedures. Chang and Lin 2006.

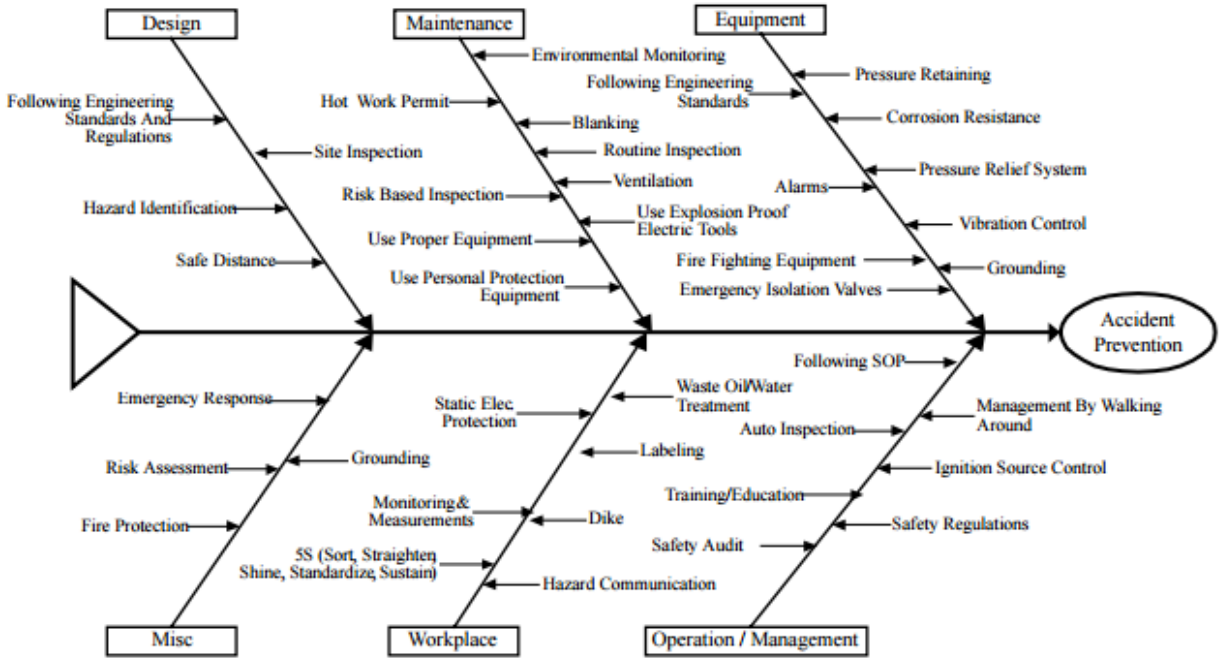
[198] First Live Video from Tank Farm Fire (Gasoline Tank, Bakken Crude is nearly as flammable as gasoline); Available at: https://www.youtube.com/watch?v=oAsBscxpKks.

[199] Chang and Lin 2006, Figure 1.

[200] W. Atherton and J.W. Ash, Review of Failures, Causes & Consequences in the Bulk Storage Industry, 2008, Journal of Technology and Environment; Available at: http://lightningsafety.com/nlsi_lls/Causes-of-Failures-in-Bulk-Storage.pdf.

[201] T. Davies and others, Bund Effectiveness in Preventing Escalation of Tank Farm Fires, ICHEME Symposium Series No. 139, October 1995; Available at: https://www.icheme.org/communities/subject_groups/safety%20and%20loss%20prevention/resources/hazards%20archive/~/media/Documents/Subject%20Groups/Safety_Loss_Prevention/Hazards%20Archive/S139%20-%20Major%20Hazards%20II/S139-17.pdf.

Figure 20:
Fishbone Diagram of Accident Prevention[202]



3. Access Road

The site currently includes a service road that runs along the length of the proposed arriving and departing tracks in roughly the same location. The Project includes a new service road in the vicinity of the loading racks, but is silent on the rest of the site. The site plan suggests that the balance of the service road would be replaced by rail track. However, several places in the EIR suggest that the existing service road will be retained.[203] If the full length of the service load is retained, traffic on this road, which would be sandwiched between an above ground pipeline and tracks, could lead to an accident involving full rail cars.

---

[202] Chang and Lin 2006, Figure 2.

[203] Various places in the RDEIR suggest the existing service road would not be replaced by track and would be retained. See: RDEIR, Appx. F, Attach. 1, p. 42 ("Downstream of the two unloading facility meter assemblies, a new 16-inch above ground pipeline would be routed along an existing internal road on the Valero property between the unloading facility and the refinery."); RDEIR p. 2-107 ("Downstream of the two unloading facility meter assemblies, a new 16-inch above ground pipeline would be routed along an existing internal road on the Valero property between the unloading facility and the Refinery."); RDEIR, Appx. F, QRA, p. 42, pdf 329 ("Downstream of the two unloading facility meter assemblies, a new 16-inch above ground pipeline would be routed along an existing internal road on the Valero property between the unloading facility and the refinery. This pipeline would connect with the existing refinery crude oil storage tanks. This road accommodates periodic on-site traffic only associated with refinery personnel traveling at low-speeds.").

F. Factors Contributing to Hazard Impact Significance

The impacts of an accident at the on-site facility are much greater than suggested by the analyses in Appendix F due to the EIR's failure to consider all relevant factors, including the unique location of the facilities and the omission of accidents involving the tanks and aboveground pipeline. The interaction among these components, *e.g.*, a train accident, perhaps triggered by an earthquake or flood, could damage the above-ground pipeline adjacent to the tracks or generate a vapor cloud that could ignite at the Crude Tank Farm. Alternatively, an unloading rack failure could release a vapor cloud that could engulf tanks in the adjacent refinery tank farm and ignite. These types of accidents, involving multiple components, would significantly increase the magnitude and consequences of an accident, compared to the scenarios evaluated in the EIR. Further, external factors, such as lightning strikes, floods, and earthquakes, could result in much greater accidents than evaluated in the EIR. Some of the factors that would contribute to much more severe accidents than were evaluated are discussed below.

1. The Location

The location of the unloading rack and rail track is highly problematic due to its proximity to the refinery tank farm, Sulphur Springs Creek, and commercial properties along East Channel Road. The new rail spur and unloading rack are parallel to the existing tank farm, sandwiched between the Valero Refinery tank farm on the west and Sulfur Springs Creek on the east.[204] The closest tank in the existing tank farm is only 45 feet away from the arriving tracks, separated from the tanks by only a 20-foot wide service road and the tank farm berm, which will be moved closer to the tanks to make room for the Project. The proximity of the tank farm, access road, rail lines, loading rack, and creek is certain to lead to much more significant impacts than disclosed in the EIR. Further, as discussed elsewhere, the site is a "regulatory floodway" and is located in an area of high earthquake-induced shaking. *See* Figures 28 to 31.

---

[204] RDEIR, Fig. 3-3. *See* also: (1) Project Plans at http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/Project_Plans_ONLINE_VERSION.pdf and (2) Valero Crude by Rail Project Description, March 2013 at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/ValeroCBR-ProjectDescription.pdf.

Figure 21: Project Site View NW, Tank Farm Avenue A[205]

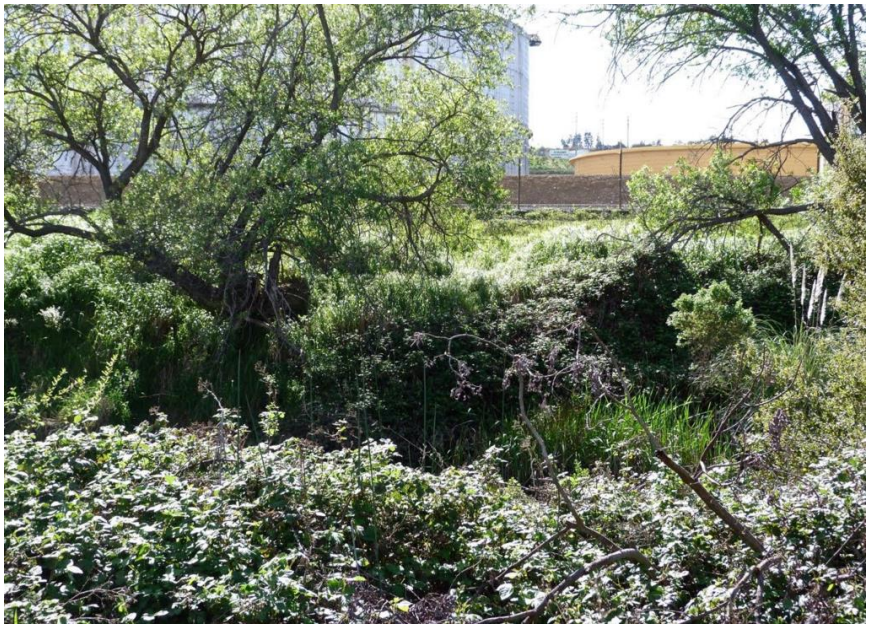
Figure 22: View SE along Avenue A,
Sulphur Springs Creek on Left, Lower Tank Farm on Right[206]

[205] Land Use Permit Application Crude by Rail Project, December 2012, Photograph 1; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/ValeroCBR-UsePermitApp.pdf.

[206] Land Use Application, Photograph 2.

Figure 23a: Northern End of Proposed Unloading Racks, Viewed from West Side Sulphur Springs Creek, Showing Tanks, Tank Berm, Service Road, Fence, Sulphur Springs Creek Riparian Zone.[207]

Figure 23b: Northern End of Proposed Unloading Racks, Viewed from West Side Sulphur Springs Creek, Showing Tanks, Tank Berm, Service Road, Fence, Sulphur Springs Creek Riparian Zone.[208]



[207] Photos taken by Marilyn Bardet, March 22, 2016.

[208] Photos taken by Marilyn Bardet, March 22, 2016.

Figure 24a: Southern End of Project Site Viewed from West Side of Sulphur Springs Creek[209]

Figure 24b: Southern End of Project Site Viewed from West Side of Sulphur Springs Creek[210]

[209] Photos taken by Marilyn Bardet, June 2013.

[210] Photos taken by Marilyn Bardet, June 2013.

This location is problematic and greatly increases the risk and consequences of an accident, beyond that considered in the EIR. The location of a process, such as the unloading rack and new rail spur, in relation to other facilities, is a key consideration in locating processing equipment. Lees' seminal *Loss Prevention Handbook* notes: "Storage is most likely to be put at risk by a process. It is necessary, therefore, for the two to be segregated."[211] This is the reason that the existing tank farm is separated from the refinery. I note that the EIR relied on the outdated revised second edition of Lees from 1996.[212]

However, here, Valero is proposing to locate a loading operation that will move 70,000 bbl/day of highly flammable Bakken crude oil, immediately adjacent to its existing tank farm, which also stores flammable material, creating a significant compound risk that was not considered in the EIR. Further, the EIR fails to disclose the contents of the adjacent tanks, which must be known to assess the hazards they pose to the unloading facility. An accident on the rail spur or at the unloading rack could generate a vapor cloud that would engulf one or more tanks in the adjacent tank farm, significantly increasing the impacts of an accident, or, alternatively, the vapor cloud from an accident in the tank farm could engulf the unloading facility, resulting in significant impacts. If the vapor clouds from these types of events encountered an ignition source, a vapor cloud explosion or BLEVE could result.

This perplexingly dangerous juxtaposition and absence of tank content data have been noted in comments by others.[213] The response to these comments asserts that the RDEIR "… provides a quantitative risk analysis of the Project… The risk analysis determined that the risk of injuries or fatalities associated with the unloading facility would be less than significant."[214] This is incorrect.

The QRA does not acknowledge the hazards associated with the adjacent tank farm nor disclose the tank contents, as requested in Comment B9-40. In fact, the response to Comment B9-40, seeking adjacent tank content data, refers to Response B9-32, which refers to Response B9-26, which does not address tank content data.

---

[211] Sam Mannan, Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Fourth Edition, 2012, p. 1891.

[212] RDEIR, pdf 358.

[213] DEIR Comments B9-39, B9-40, and H1-69 (Karras).

[214] RTC B9-39 (FEIR, p. 2.5-192). *See* also RTC H1-69 (asserting this issue is addressed in the QRA, which is incorrect).

The new 8-foot high tank farm berm would not prevent the interaction between the tank farm and unloading facility because vapor clouds would pass over the berm, from either the loading racks to the tank farm, and vice versa. Further, it is well known that berms are frequently damaged in tank accidents,[215] which could spread the consequences of a tank farm accident into the unloading area. Finally, some types of accidents could cause parts of the railcars to be thrown tens or hundreds of meters, which could result in chain reactions elsewhere.

The unloading rack is only 45 feet from the property line fence that separates the site from Sulfur Springs Creek.[216] The creek itself is directly adjacent (within 50 to 80 feet).[217]

Figure 25: Sulphur Springs Creek near Southern End[218]

[215] Davies and others, Bund Effectiveness in Preventing Escalation of Tank Farm Accidents, October 1995.

[216] RDEIR, Figure ES-3.

[217] RDEIR, Figure ES-3.

[218] Photo taken by Marilyn Bardet, June 2013.

Figure 26: Sulphur Springs Creek near Northern End[219]

This location increases the probability and consequences of an accident at the new facilities and virtually guarantees significant impacts in the immediately adjacent habitat. The EIR fails to factor these location issues into probability and consequence estimates used in the QRA.

Further, the EIR failed to identify or evaluate alternatives to the Project that would eliminate all of its direct impacts due to its location between a tank farm, a creek, and the Benicia Industrial Park.[220] These include crude import via currently operating and/or permitted crude-by-rail terminals elsewhere. There is currently an operating crude-by-rail terminal in the Bakersfield area (Plains) with untapped capacity as well as a proposed and permitted crude-by-rail terminal (Alon), each with direct connection to the Benicia Refinery via pipeline or via truck to pipeline. Further, there is another proposed terminal at nearby Stockton with access via marine barge.[221] In addition, there are three local operating terminals that could supply Valero, including the Kinder Morgan Terminal in Richmond and two terminals in Sacramento (Interstate and Carson) that could service the Valero Refinery by tanker truck.

---

[219] Photo taken by Marilyn Bardet, March 22, 2016.

[220] Fox Comments RDEIR and FEIR..

[221] EIR Comment J6-23 (Fox).

The EIR's response: "It is unclear how the Alon and Plains All American projects could serve as an alternative to the Project".[222] These terminals could deliver 70,000 bbl/day by rail into the local pipeline system and send it directly to Valero. Or, in the alternative, off-load it into tanker trucks for transport to the nearest pipeline, or for direct delivery to Valero by tanker truck from the Sacramento and Richmond terminals. The Tesoro Refinery is currently importing crude from these local terminals. These off-site terminals are feasible alternatives that would eliminate on-site impacts due to the location of the terminal to a less than significant level. They were not evaluated.

The proximity of the tank farm to the rail tracks and unloading racks result in many plausible accident scenarios that were not evaluated in the EIR. These include: (1) truck or car collision with a train, leading to a pool fire that engulfs storage tanks, LPG spheres, and/or unloading rack; (2) unloading rack pool fire that engulfs portions of the tank farm; (3) a train accident that engulfs the unloading rack and/or tank farm; (4) a thermal tear or BLEVE that impacts the tank farm; or (5) diesel engines on outdoors equipment at the Benicia Industrial Park (e.g., forklifts, trucks) could ignite vapors from an on-site accident.

In addition to large sources of flammable material immediately adjacent to the loading racks on the west, the Benicia Industrial Park immediately east of the site also stores and supplies large quantities of toxic and flammable gases that could ignite and release toxic gases in a fire. Praxair, for example, has on-site inventories of both flammable and toxic gases including acetylene, butane, hydrogen, ammonia, arsine, and carbon sulfide among others. Further, many of these adjacent businesses are ignition sources. Benicia Fabrication & Machine, Inc. (101 East Channel Road), does heavy machining and welding,[223] both ignition sources for vapor clouds originating at the Project site. Outdoor diesel equipment — forklifts, trucks — are concentrated along East Channel Road, with many outdoor workers.

2. Ignition Sources

Vapor clouds generated by spilled flammable liquids, such as the imported crude oil, have the potential to ignite anywhere within their flammable limits if there is an ignition source. The EIR indicates ignition data is required to estimate risks[224] and generally discusses "ignition probabilities."[225] The QRA also reports accident

---

[222] EIR, RTC J6-14.

[223] Benicia Fabrication & Machine, Inc.; http://beniciafab.com/ .

[224] RDEIR, Figure 5-1, pdf 325.

[225] RDEIR, pdf 396.

probabilities with and without ignition[226] and cites sources for ignition probabilities.[227] However, it fails to disclose the specific ignition probabilities used in the QRA and identify and discuss ignition sources at the site, at the adjacent tank farm, or in the adjacent Benicia Industrial Park. There are many.

Ignition sources at the site including locomotives for both crude and coke trains on the local rail lines, traffic on the access road, workers who smoke, hot surfaces, open flames as from welding, electric sparks from motors driving pumps and other equipment at the loading racks, suction of crude vapors into diesel engines and subsequent combustion, and friction sparks, as from trains on the tracks and railcars jamming into each other during stops and starts.

Ignition sources at the adjacent tank farm and refinery include welding and other maintenance activities, heaters and boilers, and flaring. See, for example, Figure 24b, which captures the proximity of the main Refinery to the Project site. The nearest refinery flare, for example, is about 1,350 ft west of the center of the unloading racks.

Ignition sources in the Benicia Industrial Park include several metal fabricators within 1,000 feet of the Terminal that cut, weld, grind, heat, etc. heavy metal on a daily basis, producing numerous ignition sources. Figure 27. The closest machine shop is less than 250 feet from the loading racks. The area also includes many businesses that use outdoor equipment, such as forklifts and that rely on trucks to receive and deliver product. All Points Petroleum, for example, distributes Valero's finished products, among many others.

[226] RDEIR, pdf 459 – 509.

[227] RDEIR, pdf 357-358.

Figure 27: Welding at Benicia Fabrication & Machine, Inc., 101 East Channel Rd, Benicia.[228]

The EIR also fails to explain and document in live Excel spreadsheets the methods it used to develop risk estimates involving ignition, the calculations to support accidents triggered by ignition, and the steps that will be taken to eliminate them. This was previously raised by others,[229] but the EIR sidestepped the issue by pointing to the QRA (which does not contain responsive information).[230]

3. External Events

The EIR recognizes external events, such as earthquakes, fog, floods, and sabotage as initiating and contributing causes of rail accidents[231] and though not explicitly recognized, accidents at the Project site. However, the EIR's on-site hazard analyses do not consider these events.

---

[228] Benicia Fabrication & Machine, Inc., Virtual Tour, Available at: http://beniciafab.com/machining.shtml.

[229] Comment B9-41, which is incorrectly labeled as B16-41.

[230] *See* Comment B9-41 (incorrectly labeled as B16-41), which refers to B9-32, which refers to B9-26, which cites the RDEIR as containing this information. Information on ignition sources is missing from the RDEIR.

[231] RDEIR, Tables 2.1 and 4.7-1.

Lightning

Lightning accounts for 61% of all accidents in storage and processing activities where natural events are identified as the root cause of the accident. In North America, 16 out of 20 accidents involving petroleum products storage tanks were caused by lightning strikes.[232] A lightning strike at one of the tanks east of the unloading facility could release a vapor cloud that could spread to the unloading rack and arriving or connected 50-car unit train, resulting in a much more significant accident than the on-site pool fires and thermal tear evaluated in the EIR.

Earthquakes

An earthquake is identified in the EIR as an external event that could initiate off-site rail accidents.[233] The EIR also admitted that the Project site "is likely to be subjected to at least one moderate to severe earthquake during the Project lifetime that will cause strong ground shaking."[234] However, earthquakes are not analyzed as an event that could initiate on-site accidents or increase the probability and consequences of an accident. If a 50-car unit train were being unloaded during an earthquake, many of the connecting hoses between the railcars and the unloading rack could be damaged or pulled away from the unloading rack, resulting in a much larger release of crude oil at the unloading rack (35,000 bbl) than evaluated in the EIR (22,692 bbl). Further, the railcars, which do not comply with building codes designed to protect against earthquakes, could be tipped over, resulting in loss of their contents distant from containment. These events could lead to a much larger pool fire or vapor cloud explosion than evaluated in the EIR.

The nearest active fault, the Concord-Green Valley fault, located 1.75 miles east of the Refinery, is capable of generating a maximum credible earthquake of Mw 7.1.[235] Seismic hazards include ground shaking, liquefaction, differential settlement, and lateral spreading.[236] The EIR failed to disclose that the Valero project site is known to be subject to high seismic ground motions and concluded, with no analysis or discussion, that impacts from exposing people or structures to "potential adverse effects involving strong seismic ground shaking" were less than significant and thus no mitigation was required.[237]

---

[232] Atherton and Ash, 2008, p. 2.

[233] RDEIR, Table 4.7-1 and p. 2-114.

[234] DEIR, p. 4.5-5.

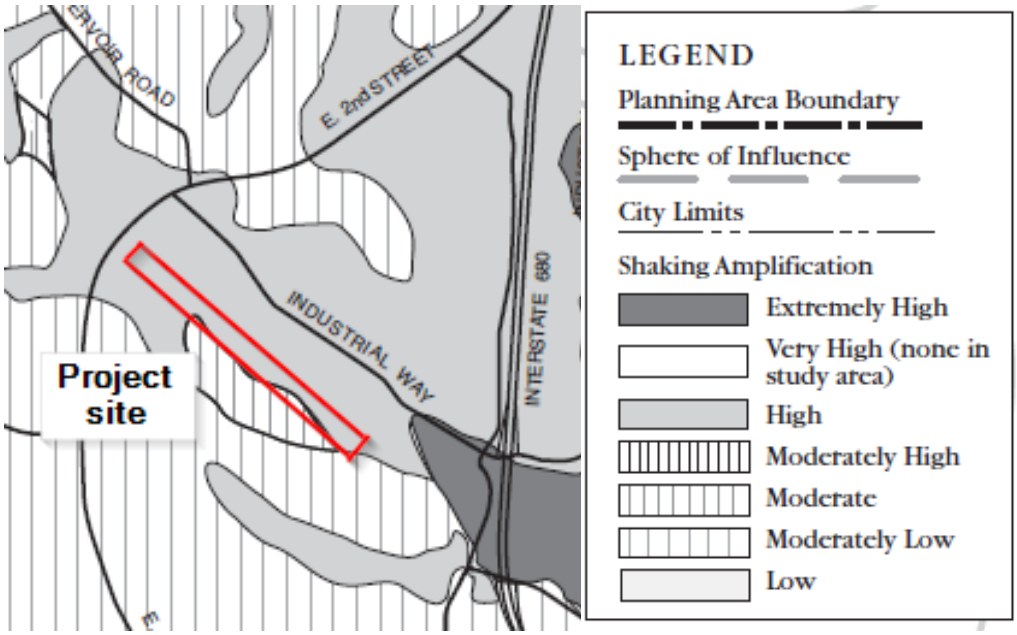
[235] DEIR, Figure 4.5-1 and p. 4.5-2/3.

[236] DEIR, pp. 4.5-2/5.

[237] DEIR, Table 2-1, p. 2-4, Impact 4.5-2.

A Caltrans study showed the site may be subject to a peak horizontal acceleration of 0.5 g from a 6.75 earthquake on the Concord-Green Valley fault, an event the EIR admits is likely to occur over the Project lifetime.[238] As a comparison, the maximum ground accelerations recorded in San Francisco and Oakland during the 1989 Loma Prieto earthquake were about 0.2 g.[239] Ground shaking could tip railcars off tracks and disconnect them from the unloading rack, events not addressed by structural design codes.[240] Further, the Benicia General Plan, Figure 28, shows that the Project site is in an area with "high" shaking amplification, which is distinct from "lateral spreading and settlement hazards".[241]

Figure 28:
Ground Shaking Amplification at Project Site[242]



[238] DEIR, p. 4.5-5.

[239] Valero Refining Company's Land Use Application for the Valero Improvement Project, DEIR, October 2002, pp. 4.6-5/6; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7B529090B4-087B-435C-9799-5C137730DD7F%7D.PDF.

[240] Valero Improvement Project, Addendum to VIP EIR, p. 2-100; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Valero_Improvement_Project_EIR_Addendum_ESA.PDF.

[241] Benicia General Plan, Adopted June 15, 1999, Part 2, Figures 4-1 and 4-2; Available at: http://www.ci.benicia.ca.us/index.asp?SEC=7EEEB29D-5DA5-43D4-8B01-B864248BCA1D&Type=B_BASIC.

[242] Benicia General Plan, 2009, Figure 4-1.

The impact of earthquake-induced ground shaking was raised in Comment B8-108, based on the Benicia General Plan.[243] The EIR's response to this comment only states geotechnical investigations "identified potential for lateral spreading and vertical displacement during seismic ground shaking, including within the 100-year flood plain where Project components are proposed." However, these are distinct consequences of an earthquake and do not encompass ground shaking.[244] RTC B8-108 then asserts mitigation measures MM 4.5-1 and 4.5-2 are required to reduce "impacts relating to liquefaction and other seismic-related ground failure."[245]

This is not responsive. Mitigation Measure 4.5-1 addresses civil engineering design standards to "overcome lateral displacement, horizontal ground separation, and vertical settlement," which are not "ground shaking." Mitigation Measure 4.5-2 is a post-earthquake track inspection program.[246] Neither of these mitigation measures addresses "shaking"-induced accidents, which was the subject of Comment B8-108. Shaking can occur without liquefaction, ground separation or vertical settlement, which are separate geologic hazards. Shaking is a concern because it can tip railcars off of the tracks, releasing crude oil, or disconnect the railcars from the unloading rack, resulting in large spills, too large to be contained by on-site containment. The EIR's QRA did not consider these risks.

Flood Hazards

The Project site is located within the 100-year flood zone and a regulatory floodway. This could cause accidents, increase the consequences of accidents, or aggravate flooding, which is prohibited in regulatory flood zones. Flood hazards are further discussed in Comment V.

4. Centroid Location

The EIR assumed that the worst case accident would occur in the southern one third of the loading rack, at location 1 on Figure 29. However, if the accident occurred elsewhere, such as at the northern end of the loading rack, at location 2 on Figure 29, the consequences would be greater. The EIR contains no justification for selecting the center of the loading rack as the location for the worst-case accident.

---

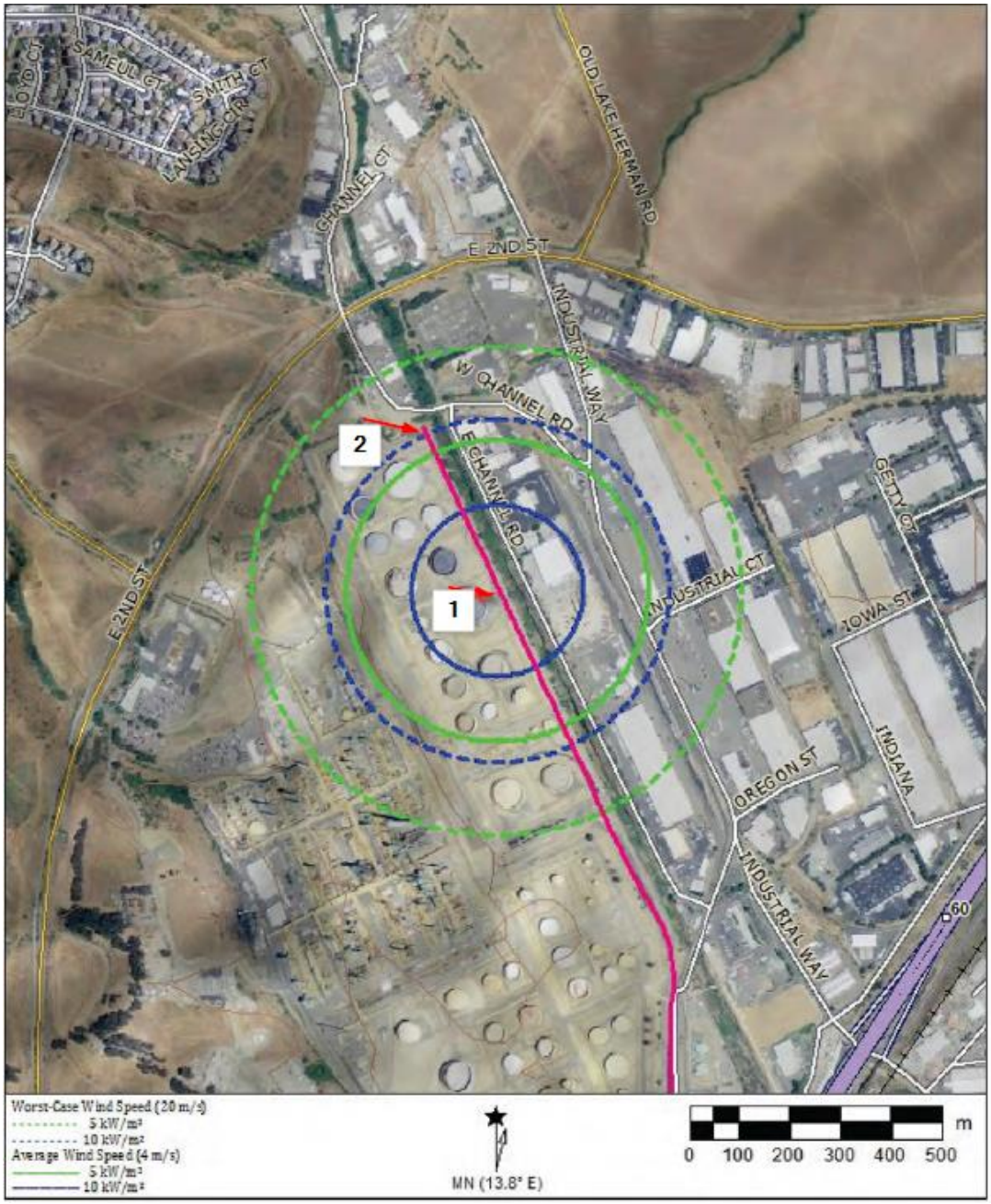
[243] FEIR, Comment B8-108, p. 2.5-99.

[244] *See*, for example, Benicia General Plant, Figure 4-1 ("Ground Shaking Amplification") and Figure 4-2 ("Geologic Hazards" including landslide and debris flow, liquefaction, lateral spreading and settlement hazards).

[245] FEIR, RTC B8-108, p. 2.5-144.

[246] DEIR, Table 2-1, pp. 2-4/5.

Figure 29:
Accident Locations (1 =EIR assumption)



If the accident occurred on the northern end of the loading rack (#2 in Figure 29), the 5 kW/m² thermal injury zone for a thermal tear would reach residential areas along Lansing Circle and would significantly extend into the high density zone with 5,000 people per square mile shown in red on Figure 9. Alternatively, if the worst-case accident occurred at the Crude Tank Farm, both the injury and fatality zones would extend significantly into the Hillside neighborhood.

5. Other Rail Traffic

The Refinery also exports an annual average of two railcars per day of LPG and sometimes imports LPG by rail.[247] It also exports coke. The EIR is silent on whether this existing rail traffic would share portions of the on-site rail tracks with the crude oil trains. If yes, the potential impacts resulting from the interaction of LPG and coke trains with crude trains should be evaluated.

V. FLOODING IMPACTS ARE SIGNIFICANT

Flooding results along Sulphur Springs Creek due to the lack of channel capacity and shallow flooding parallel to the channel. Further, there are no designated flood protection facilities on Sulphur Springs Creek. Lake Herman Reservoir is located upstream of the Project site, but it has no provisions for flood storage.[248] Thus, in the event of a major flood, the creek overflows its banks and floods adjacent areas, which include the Project site.

The EIR does not address the impact of floods on railcar releases of crude oil and resulting accidents and water quality impacts nor the impact of the railcars on the significance of flooding impacts, i.e., the volume occupied by railcars in the narrow floodway would displace flood volume, raising water elevations. These are discussed below.

A. Flooding Could Increase Hazards

In Resolution No. 16-1, the Planning Commission denied certification of the FEIR and a use permit for the Project based on 14 findings. In Finding 5, the Planning Commission concluded that "the Project is located in the 100-year floodplain, **which could increase the hazards related to an accidental spill on the property.**"[249]

The Staff response to Finding 5 cited to a paragraph from the Project's Environmental Check List[250] which discloses that the Project site is located in a "Special Hazard Flood Area" designated "Zone AE" within the 100-year flood zone. The cited section of the DEIR asserts with no analysis or other support that no flood damage to

---

[247] RDEIR, pdf 297.

[248] FEMA, Flood Insurance Study, Solano County, California and Incorporated Areas, Volume 1 of 3, pp. 18-19, 25, June 9, 2014.

[249] Benicia Planning Commission Resolution No. 16-1, Finding #5, February 11, 2016 (**emphasis added**); Available at: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/6045/7-_PC_Resolution_No._16-1.pdf.

[250] DEIR, pdf 402.

the Project's facilities would occur as the Project would comply the "Benicia Floodplain Management Policy" and the California Building Code. The DEIR further concluded that the new unloading facilities and rail track "would be unlikely to displace floodwaters, raise flood elevations, create new flooding impacts ( ), and/or exacerbate existing flooding problems (e.g., by increasing the severity or frequency of flooding relative to pre-Project conditions. Therefore, it is unlikely that the proposed Project would substantially displace or redirect flood flows. The impacts would be less than significant."[251]

The cited material from the DEIR in Staff's response to the Planning Commission Resolution fails to address the Planning Commission's point that flooding "could increase the hazards related to an accidental spill on the property."[252] In fact, flooding could increase the hazards related to an accidental spill, and the EIR failed to evaluate or even acknowledge them.

First, the DEIR asserts it would be "unlikely" that flooding impacts would occur. What does "unlikely" mean? The EIR contains no analysis whatsoever (which would require the use of a flood flow model, such as HEC-RAS) to determine the actual impacts of a 100-year flood on Project facilities, including railcars, and adjacent properties nor of the impact of the Project facilities on the flood itself, e.g., increases in flood elevation, increasing flooding. Thus, the claim that impacts would not be significant is unsupported. Merely stating that flooding impacts are "unlikely" does not constitute substantial evidence.

Second, if unloading were underway when floodwaters arrived, the force of the flows could disconnect and knock over multiple railcars during unloading, spilling oil into floodways, Sulphur Springs Creek, and ultimately into Suisun Marsh, rather than into on-site containment, as the loss of the content of multiple tank cars would exceed the capacity of on-site containment. The response to comments asserts that the "design of the proposed track/unloading rack includes flood hazard mitigation measures in accordance with the City of Benicia Flood Plain Management Policy."[253] However, these mitigation measures are not identified in the EIR or required as enforceable CEQA mitigation. The EIR mentions a "roadside curb" east of the track near the fence line.[254] Response to comment A10-3 also identifies a small curb at the fenceline. However, this

---

[251] DEIR, pdf 402. Similar language is also found in the DEIR at 4.8-19, pdf 227.

[252] Benicia Planning Commission Resolution No. 16-1, Finding #5, February 11, 2016 (2/11/16 BCR Resolution); Available at: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/6045/7-_PC_Resolution_No._16-1.pdf.

[253] RTC A10-4, FEIR, pdf 71.

[254] DEIR, p. 3-17 and pdf 354.

"curb" is not shown on any of the site plans in the EIR or required as part of the mitigation plan. Regardless, a small "curb" is unlikely to contain oil-laden floodwaters.

If spills exceeded the capacity of on-site containment or occurred outside of the sloped containment area, from railcars that had been knocked about by flood waters, the spill could reach Sulphur Springs Creek, causing adverse water quality impacts. If an ignition source were present, say sparks created by floodwaters dislodging the unloading rack, or railcars banging into each other, the spilled crude could ignite and the resulting explosion and burning mass would affect a large area.

Third, floods could lead to accidents not considered in the EIR, as well as exposing workers to drowning and other flood-related health impacts. The DEIR concluded that Impact 4.8-7, expose people or structure to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam, is less than significant.[255] However, the qualitative analysis in the DEIR only addresses the failure of Lake Herman Dam and not a flood involving only overflow of Sulphur Springs Creek, which is the much more likely event. A 100-year flood, regardless of its origin, could expose on-site workers to injury or death. This is a simple matter of common sense and requires no analysis. The EIR should find a significant impact to workers from site inundation and impose mitigation, which should include:

(1) worker flood hazard training;
(2) inclusion of elevated areas outside of the floodplain;
(3) on-site availability of emergency equipment such as inflatable rafts;
(4) flood warning system; and
(5) evacuation plans.

In addition to worker safety issues, floodwaters could overturn both full and empty rail cars, which could roll or float in the floodwaters, colliding with one another and the unloading rack, leaking oil that could result in vapor cloud explosions, thermal tears, BLEVEs, and other serious accidents due to the location of the facility, adjacent to a tank farm and Benicia Industrial Park, where numerous sources of ignition are located. Floodwaters could also cause erosion or disturbance of the gravel rail beds and tracks, which could cause on-site train accidents. These issues were raised in comments on the IS/MND[256] but were never addressed in the EIR.

Fourth, the EIR does not address the long-term effects of climate change on sea level rise and hence flooding-induced accidents at the site.[257] Rather, it asserts that an

---

[255] DEIR, p. 4.8-19.

[256] DEIR, pdf 623-624.

[257] RTC J2-3 (Bardet).

EIR need not consider sea level rise.[258] However, the cited CEQA case is not relevant to this situation. Rather, Guidelines section 15126.2(a) states in part: "The EIR shall also analyze any significant environmental effects the project might cause by bringing development and people into the area affected." Here, the Project would bring development and workers into a regulatory floodway that will be adversely affected by rising sea levels. Significant sea level rise (16 to 55 inches) is projected for the lower reaches of Sulphur Springs Creek,[259] which will increase flooding upstream, at the Project site. The Benicia General Plan notes that sea level rise "may mean that flooding could be exacerbated in low lying areas at high tides."[260]

B. The Project Could Increase Flooding

The Staff response to Commission Finding 5 also asserts that Project "facilities," the unloading rack and track, "would be unlikely to displace floodwaters, raise flood elevations, create new flooding impacts (), and/or exacerbate existing flooding problems. Therefore, it is unlikely that the proposed Project would substantially displace or redirect flood flows." This assertion is also not supported anywhere in the EIR with analyses. Similar assertions are made elsewhere in the EIR.[261] Unsupported assertions are not substantial evidence. Further, they are wrong.

The Federal Emergency Management Agency (FEMA) prepares Flood Insurance Rate Maps (FIRMs) that delineate flood hazard zones. The DEIR explains that the map for the portion of Benicia where the Project would be located shows that the entire project site is in an area classified as "Floodway Areas in Zone AE," where a floodway is defined as: "… the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachments so that the 1% annual chance flood can be carried without substantial increases in flood height."[262] *See* Figures 30 and 31.

---

[258] Ballona Wetlands Land Trust v. City of Los Angeles (2011) 201 Cal. App. 4th 455.

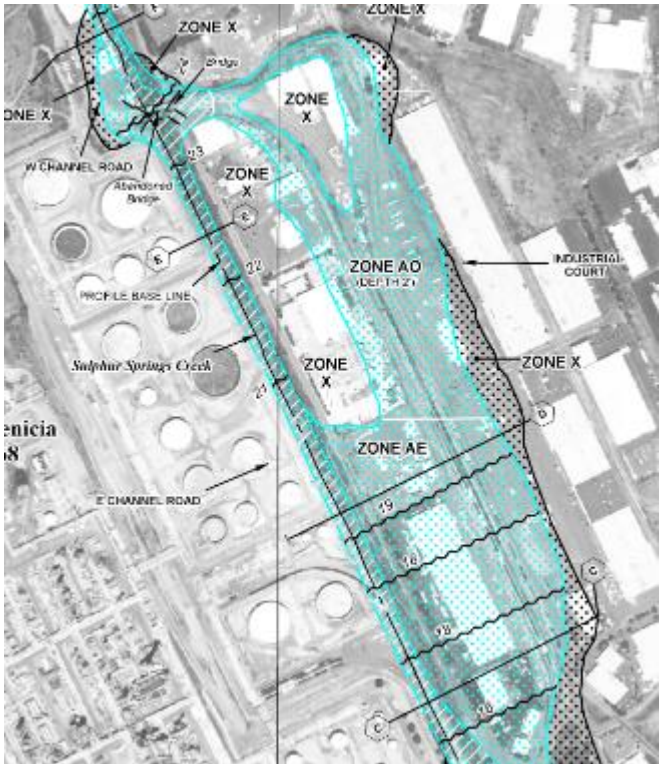
[259] San Francisco Bay Conservation and Development Commission, Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline, Approved October 6, 2011, Figure 1.15; Available at: http://bcdc.ca.gov/BPA/LivingWithRisingBay.pdf.

[260] Benicia General Plan, p. 151.

[261] *See, e.g.,* DEIR, Table 2-1 (Impacts 4.8-6, 4.8-7), pp. 4.8-18/20, 5-18; pdf 398, 401-403.

[262] DEIR, pdf 227.

Figure 30:
2009 Flood Insurance Map Panel 634[263]



FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

[263] FEMA, Flood Insurance Rate Map, Solano County, California and Incorporated Areas, Panel 634 of 730, May 4, 2009.

Figure 31:
2009 Flood Insurance Map Panel 634
Flooded Area Showing Project Site

The DEIR admits that "[c]onstruction of aboveground facilities within a flood hazard zone could potentially impede or redirect flood flows."[264] However, it goes on to argue that if the facilities in these zones are properly designed, they "would be unlikely to displace floodwaters, raise flood elevations, create new flooding impacts (e.g., by causing flooding of existing facilities or structures that previously would not have been inundated), and/or exacerbate existing flooding problems (e.g., by increasing the severity or frequency of flooding relative to pre-Project conditions). Therefore, it is unlikely that the Project would substantially displace or redirect flood flows. The impact would be less than significant."

However, this argument not only is not supported with engineering calculations, it also ignores the railcars and locomotives, which are not engineered "facilities" and thus will not be designed to meet flood codes. The Project site at any given time could contain up to three 50-car unit trains, each with three locomotives, two buffer cars, and 50 tank cars.[265] At the 1,500 foot long unloading racks, up to 50 railcars could be filled with crude oil.

---

[264] DEIR, p. 4.8-19.

[265] FEIR, Figure ES-3, cross section B-B and Sec. 3.2, pdf 368.

An empty CPC-1232 jacketed railcar weighs 80,800 lbs or about 40.4 tons[266] and the maximum weight per railcar including the weight of the empty car and its cargo is 143 tons;[267] the weight of a buffer car is 45 tons;[268] and a typical locomotive weighs about 216 tons.[269] Thus, a 50-car train filled with crude oil would weigh about **7,888 tons**.[270] In addition, 50 or more empty railcars, three additional locomotives, and two buffer cars could be present on the adjacent departure track, weighing an additional **2,758 tons**.[271]

Thus, the total on-site railcar weight would be at least **10,646 tons**.[272] Due to this weight, these railcars would not wash away but rather would block the passage of flood flows, acting like a dam and occupying volume that flood flows would otherwise use to dissipate. This would raise flood elevations and create new flooding impacts. *See* Figure 32.

---

[266] ICF, The Economic Impacts of Changes to the Specifications for the North American Rail Tank Car Fleet, December 9, 2014, Exhibit 7-3, (tare weight); Available at: http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Rail-Transportation/ICF-Rail-Study-12-9-14.pdf.

[267] 12/9/14 ICF, Exhibit 7-3 (weight limit).

[268] Union Pacific, Unit and Sweep Train Procedures; Available at: http://www.up.com/customers/ag-prod/ethanol/unit_train/index.htm.

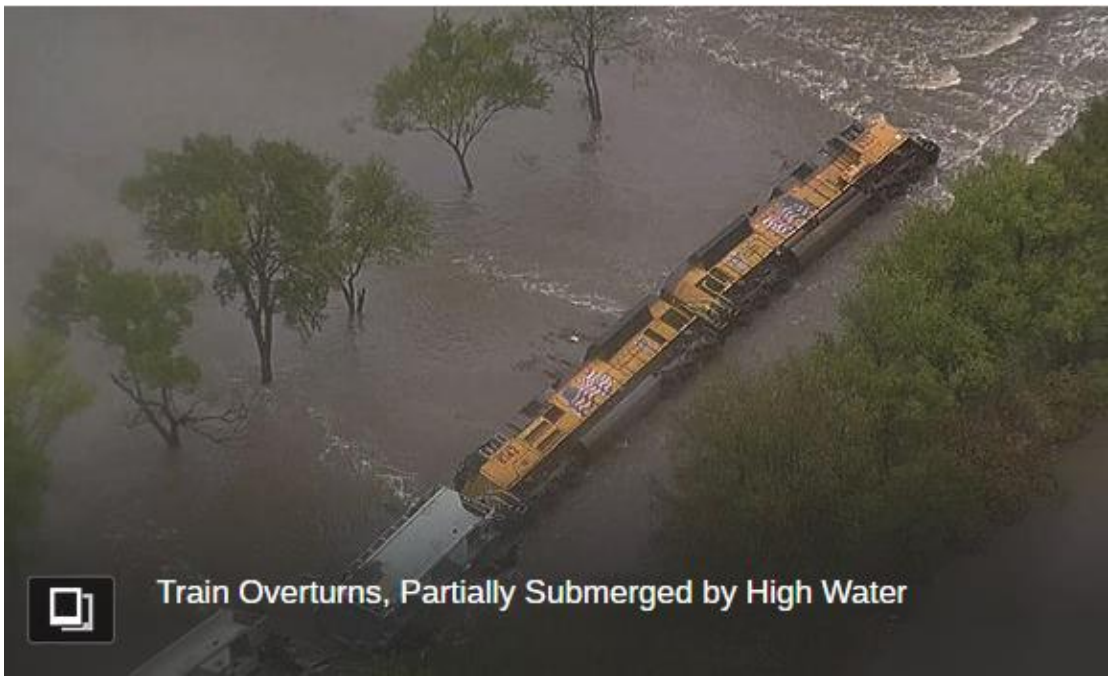
[269] Trains, Locomotive Weight? Available at: http://cs.trains.com/trn/f/111/t/74961.aspx.

[270] Weight of full 50-car unit train = weight of 50 full cars + 2 buffer cars + 3 locomotives = 50×143 + 2×45 + 3×216 = **7,888 tons.**

[271] Weight of empty 50-car unit train = weight of 50 empty cars + 2 buffer cars + 3 locomotives = 50×40.4 + 2×45 + 3×216 = **2,758 tons.**

[272] Total on-site unit train weight = weight of one full 50-car unit train + one empty 50-car unit train = 7,888 +2,758 = **10,646 tons**.

Figure 32:
Derailed Union Pacific Train in Heavy Rain and Flood[273]



At the yard, the railcars would occupy a volume of 500,714ft^3.[274] The volume contained by four 25-car long (about 1,500 feet)[275] unit trains,[276] the new 8-foot high

[273] Texas Flood Waters Cause Train to Derail, 2 Occupants Safe, ABC Channel 7 News, October 24, 2014; Available at: http://abc7news.com/weather/texas-flood-waters-cause-train-to-derail-2-occupants-safe/1049213/. *See* also (64-car train hauling cement) at: http://www.nbcdfw.com/weather/stories/Train-Partially-Submerged-After-Hitting-High-Water-Crew-Rescued-336590011.html.

[274] The volume of a 50-car unit train = train length × fraction occupied by railcars × cross sectional area of railcar = 3,345 ft × 0.9 × 3.1416(10.29 ft/2)^2 = **250,357 ft^3.** Unit train length from RDEIR, Fig. ES-3 (3,345 ft). Unit train diameter (10 ft 3.5 in) from: http://www.gbrx.com/media/1307/tank31800.pdf. Fraction occupied by railcars = length of railcar (54 ft 2 in) ÷ length over coupler (59 ft 9.5 in). Length of railcar from http://www.gbrx.com/media/1307/tank31800.pdf . Length over coupler from http://www.gbrx.com/products-services/railcar-manufacturing/31-800-gallon-tank-car/. RDEIR Figure ES-3, Section A-A, shows that at the yard, there will be two unit trains on four track segments. Thus, total volume occupied by two 50-car unit trains at the yard, a full train and an empty train = 2 × 250,357 ft^3 = **500,714 ft^3.**

[275] RDEIR, Figure ES-3, Section A-A.

[276] DEIR, p. 3-17.

concrete berm,[277] and the property boundary 86 feet to the west[278] is 1,032,000 ft^3.[279] Thus, the railcars would displace 48% of the volume otherwise available for flood flows at the yard.[280]

At the loading racks, the railcars would occupy a volume of 375,536 ft^3.[281] The volume (ignoring the volume occupied by the loading racks and pumps) contained by three 25-car long (about 1,500 feet)[282] unit trains,[283] the new 8-foot high concrete berm,[284] and the property boundary 108 feet to the west[285] is 1,296,000 ft^3.[286] Thus, the railcars would displace 29% of the volume otherwise available for flood flows at the yard.[287]

This would result in two impacts. *First,* it would cause an increase in elevation of the floodwaters upstream of the Project site. *Second*, it would cause the floodwaters to spread out to the east, penetrating further into the Benicia Industrial Park. The precise amount of rise and spread cannot be calculated with the information in the EIR and would require sophisticated flood routing modeling which should have been included in the EIR. However, the displaced volume calculations are sufficient evidence to confirm that the Project would aggravate flooding in adjacent areas, which is a significant impact. While the Project would increase the floodplain volume by 144,000 ft^3 [288] by moving the tank farm berm 12 feet west of the existing earthen berm to make room for the loading racks and new track,[289] this would not offset the increase in flooding created by locating railcars and loading racks in the floodplain (375,536 ft^3 at the loading racks and 500,714 ft^3 at the yard), which remove more floodplain volume

---

[277] DEIR, p. 3-30.

[278] DEIR, Figure 3-3, Section B-B: width between new berm and property line = (14 + 14 + 14 + 21 + 23) = **86 ft.**

[279] Volume in vicinity of yard = 1500 ft × 8 ft × 86 ft = **1,032,000 ft^3.**

[280] Percent volume in vicinity of yard occupied by railcars = (500,714 ft^3/1,032,000 ft^3) × 100 = **48.5%.**

[281] Volume occupied by railcars at loading racks = 1.5 × 250,357 ft^3 = **375,536 ft^3**. The factor of 1.5 is based on RDEIR Figure ES-3, Section B-B which shows only three unit trains in the cross section.

[282] RDEIR, Figure ES-3, Section B-B.

[283] DEIR, p. 3-17.

[284] DEIR, p. 3-30.

[285] DEIR, Figure 3-3, Section B-B: width between new berm and property line = (20 + 10 + 25 + 15 + 38) ft = **108 ft.**

[286] Volume in vicinity of yard = 1500 ft × 8 ft × 108 ft = **1,296,000 ft^3.**

[287] Percent volume in vicinity of loading racks occupied by railcars = (375,536 ft^3/1,296,000 ft^3) × 100 = **29%.**

[288] Increase in floodplain volume due to moving the tank farm berm 12 feet west of the existing berm (DEIR, p. 3-17) = 12 × 8 × 1,500 = **144,000 ft^3**.

[289] DEIR, p. 3-17.

than added by the relocated berm. The net effect is to worsen flooding, which is a significant impact. Thus, mitigation is required for flood-related impacts, including mitigation for accidents triggered by floods.

C. Flood Mitigation

The FEIR suggests that in the event of a 100-year flood, "it is possible that a delivery of crude could be rescheduled if the track became flooded to further avoid and minimize any flood related risks."[290] This does not address the impacts caused by or to railcars that are on site at the time of the flood and thus does not mitigate any of the impacts noted above. Further, this "possible" measure is not required as an enforceable mitigation and thus cannot mitigate any flood-related accident impacts.

The Benicia Flood Hazard Reduction Ordinance, Section 15.48.050, Floodways, require that "all encroachments, including fill, new construction, substantial improvements, and other development are prohibited within the floodway unless certification by a registered professional engineer or architect is provided demonstrating that encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge and, if satisfied, shall comply with all other applicable flood hazard reduction provisions of the City's Municipal Code."[291] The EIR fails to explain how the Project will comply with this provision and fails to demonstrate that compliance is feasible, given the presence of railcars that are not covered by design standards. The EIR should be modified to identify the design criteria and the certification by a registered professional engineer to satisfy this requirement.

Further, FEMA is currently in the process of completing the San Francisco Bay Area Coastal Study, a comprehensive coastal hazard analysis of San Francisco Bay coastal communities. Benicia is included in this study. The preliminary Flood Insurance Rating Map (FIRM) for the Project site continues to confirm that the entire project site is characterized as a "special flood hazard area" and is further specifically classified as a "regulatory floodway."[292] *See* Figure 33. The FEMA website indicates a "regulatory floodway" means:

> "…the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a

---

[290] RTC A10-4, FEIR, p. 2.4-46.

[291] DEIR, pdf 221.

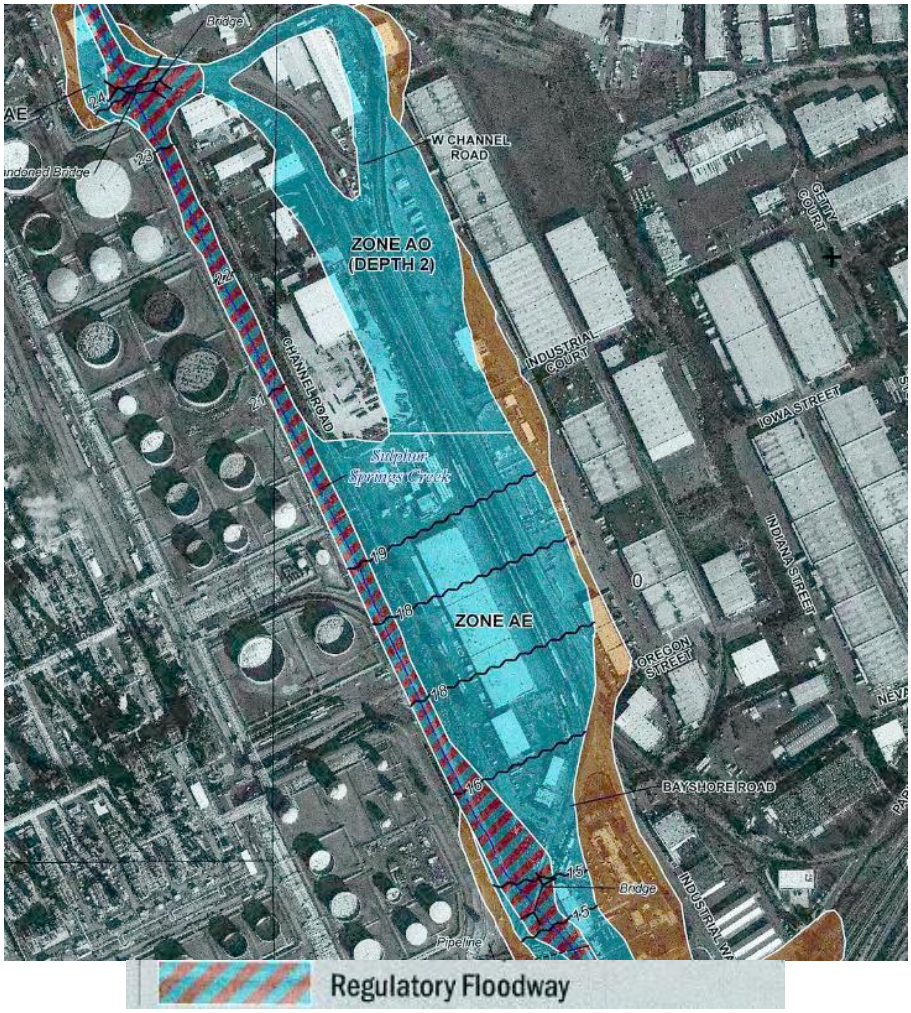
[292] National Flood Insurance Program, Flood Insurance Rate Map, Solano County, California, Panel 634 of 730, Preliminary, January 12, 2015; Available at: http://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/FloodMapPanel634.pdf.

> designated height. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations. For streams and other watercourses where FEMA has provided Base Flood Elevations (BFEs), but no floodway has been designated, the community must review floodplain development on a case-by-case basis to ensure that increases in water surface elevations do not occur, or identify the need to adopt a floodway if adequate information is available."[293]

The EIR does not disclose that the Project site is located in a "regulatory floodway" and does not explain how the Project site will comply with this definition. The EIR further fails to explain how the Project will be designed to assure no increase in water surface elevation, given the potential presence of up to 150 railcars at the site, plus the unloading facilities and new pipeline which will fill volume available in the baseline for floodwaters.

[293] FEMA, Definition of "Floodway"; Available at: https://www.fema.gov/floodway.

Figure 33:
2015 Flood Insurance Map Panel 634, Showing Project Site[294]



The EIR does not discuss design criteria to comply with FEMA regulations and the City of Benicia Floodplain Management Policy.[295] Further, the proposed infrastructure is inconsistent with the site's classification as a "regulatory floodway." Development is not allowed in a floodway if it would increase the water surface elevation. As demonstrated in Comment V.C, the Project would increase flood water surface elevation.

---

[294] FEMA, Flood Insurance Rate Map, Solano County, California and Incorporated Areas, Panel 634 of 730, May 4, 2009.

[295] *See* VIP DEIR, p. 4.9-24.

D. The EIR Fails to Address Benicia General Plan Requirements

The Project site is located in a floodway.[296] Benicia Municipal Code, Section 15.48.050, states that because a floodway is an "extremely hazardous area due to the velocity of floodwaters which carry debris, potential projectiles, and erosion potential, the following provisions apply:

> A. All encroachments, including fill, new construction, substantial improvements, and other development are prohibited within the floodway unless certification by a registered professional engineer or architect is provided demonstrating that encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge.
>
> B. If subsection (A) of this section is satisfied, all new construction and substantial improvements shall comply with all other applicable flood hazard reduction provisions of this chapter. (Ord. 88-6 N.S. § 1, 1988).

The EIR contains no evidence that subsection A can be satisfied as the railcars alone will increase flood levels. The EIR should be modified to include the subject registered professional engineer certification and to provide the public an opportunity to review it.

The Benicia Floodplain Management Policy further requires:

> GOAL 4.13: Prevent property damage caused by flooding.
>
> POLICY 4.13.1: Continue to implement the floodplain management policy currently followed by the City Program 4.13.A: Require all potential developers in the Sulphur Springs Creek City of Benicia General Plan 165 floodplain to provide flood hazard mitigation measures that ensure the subject properties are not at risk of flooding during the FEMA-designated 100-year base flood.

The EIR does not require any "flood hazard mitigation measures" and asserts that no mitigation is required for Impacts 4.8-6 (place structures in 100-year flood hazard area) and 4.8-7 (place people or structure within inundation area for flood) as the impacts are asserted, without support, to be less than significant.[297] Elsewhere, the EIR explains that "Project components would be required to include in the design criteria flood hazard mitigation measures in accordance with the City of Benicia

---

[296] BMC 15.40.070.

[297] DEIR, Table 2-1 and pp. 4.8-19.

Floodplain Management Policy" which would "comply with construction standards established by the California Building Code."[298] The EIR fails to identify the "standards" that would be followed and thus fails to identify flood mitigation.

Further, the EIR contains no evidence that proposed encroachments (which include the railcars) would not increase flood levels. My calculations presented elsewhere in these comments indicate that the railcars would increase flood levels by displacing a large volume of the flooded area. The EIR must present calculations to support its assertion that there would be no increase in flood levels or include mitigation for this impact.

[298] DEIR, p. 4.8-19.

ARRIVING RAIL CARS					Using Oil & Gas Production Emission Factors		Using Marketing Terminal Emission Factors	
Component	Service	Equipment Count per Railcar	Number of Railcars	Hours On-Site	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)
Pressure Relief Valve	Gas	2	50	6	0.8316	880	0.138	146
Valve	Light Crude Oil	1	50	6	0.0707	37	0.023	12
Valve	Gas	3	50	6	0.1386	220	0.023	37
Connectors	Gas	9	50	6	0.0259	123	0.034	162
Connectors	Light Crude Oil	2	50	6	0.0234	25	0.034	36
Total Arriving Rail Car Fugitive ROG Emissions						**1286**		**393**

DEPARTING RAIL CARS					Using Oil & Gas Production Emission Factors		Using Marketing Terminal Emission Factors	
Component	Service	Equipment Count per Railcar	Number of Railcars	Hours On-Site	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)
Pressure Relief Valve	Gas	2	50	6	0.8316	44	0.138	7.3
Valve	Light Crude Oil	1	50	6	0.0707	2	0.023	0.6
Valve	Gas	3	50	6	0.1386	11	0.023	1.8
Connectors	Gas	9	50	6	0.0259	6	0.034	8.1
Connectors	Light Crude Oil	2	50	6	0.0234	1	0.034	1.8
Total Departing Rail Car ROG Emissions						**64**		**19.6**

TOTAL		Using Oil & Gas Production Emission Factors		Using Marketing Terminal Emission Factors	
Component	Service	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)	Emission Factor (kg/hr/comp)	ROG Emissions (lb/visit)
Total On-site Railcar Fugitive ROG Emissions			**1350**		**412**

(1) Service, equipment count, and 5% dilution factor for empty cars based on Valero RDEIR, Appx. A, pp. A-11/14.

(2) Emission factors from CARB 1999, Table IV-2e for >/= 10,000 ppmv.

(3) Hours on site from Valero DEIR, p. 3-22, adjusted using Santa Maria FEIR, Table 2-5.

(4) Departing rail cars emissions calculated assuming 5% dilution factor, based on Valero RDEIR, Appx. A.

(5) Calculations assume 80% of VOCs are ROG.

	Benzene Emissions (lb/day)	Chronic Hazard Index	Acute Hazard Index	Cancer Risk	Revised Benzene Emissions (lb/day)	Chronic Hazard Index	Acute Hazard Index	Cancer Risk
	EIR Health Risks Benzene				**Revised Health Risks Benzene**			
Resident	6.17E-02	0.00	0.00	9.42E-09	236.3	0.1	**14.1**	**3.61E-05**
Worker	6.17E-02	0.00	0.08	2.18E-08	236.3	**3.1**	**303.8**	**8.35E-05**
Daycare	6.17E-02	0.00	0.00	3.87E-09	236.3	0.1	0.4	**1.48E-05**
Elementary School	6.17E-02	0.00	0.00	3.87E-09	236.3	0.3	**1.8**	**1.48E-05**
	EIR Health Risks All TACs				**Modified Health Risks All TACs***			
Resident		0.00	0.01	2.20E-06		0.1	**14.1**	**3.83E-05**
Worker		0.02	0.16	7.40E-06		**3.1**	**303.9**	**9.08E-05**
Daycare		0.00	0.00	2.52E-07		0.1	0.4	**1.50E-05**
Elementary School		0.00	0.00	2.23E-07		0.3	**1.8**	**1.50E-05**

* Assumes all emissions are estimated correctly except benzene

Highlighted cells: significant health risks (acute and chronic hazard index equal to or greater than 1.0; cancer risk equal to or greater than 1.0E-05

Tank	Permitted TVP (psia)	TANKS VOC Emissions Based on Permitted TVP (lbs/yr)	(lb/day)	Maximum Rail-Imported Crude TVP (psia)	TANKS VOC Emissions Based on TVP 13 psia (lb/yr)	(lb/day)	CEQA Baseline ROG Emissions (lbs/day)	Net Increase in ROG Relative to CEQA Baseline (ton/yr)	(lb/day)	Net Increase in ROG Relative to Permitted TVP (ton/yr)	(lb/day)
1701	3.5	7,759	21.3	13	27,629	75.7	14	8.5	46.6	7.9	54.4
1702	3.5	7,759	21.3	13	27,629	75.7	3.5	10.4	57.1	7.9	54.4
1703	3.5	7,759	21.3	13	27,629	75.7	3.5	10.4	57.1	7.9	54.4
1704	0.3	4,805	13.2	13	27,629	75.7	2	10.7	58.6	9.1	62.5
1705	0.3	4,805	13.2	13	27,629	75.7	2.5	10.6	58.1	9.1	62.5
1706	0.3	4,805	13.2	13	27,629	75.7	3	10.5	57.6	9.1	62.5
1707	4	8,022	22.0	13	27,629	75.7	17.5	7.9	43.1	7.8	53.7
1708	4	8,022	22.0	13	27,629	75.7	17	7.9	43.6	7.8	53.7
							Significance Threshold	10	54	10	54

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1702/17031
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 3.5)	All	59.20	54.43	63.97	57.12	3.5000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	1,475.0929
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.0676
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.5000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	1,722.3574
Value of Vapor Pressure Function:	0.0676
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	7,759.1814

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	2.1643
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	3.7875
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	76.3279
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	1,484.3470
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	0.8251
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	83.7235
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	71.1822

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1702/17031 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 3.5)	1,475.09	4,561.73	1,722.36	0.00	7,759.18

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1702/17031
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 11)	All	59.20	54.43	63.97	57.12	11.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations

Rim Seal Losses (lb):	7,191.8124
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.3297
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	11.0000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	8,397.3498
Value of Vapor Pressure Function:	0.3297
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	20,150.8933

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	10.5519
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	18.4659
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	372.1363
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	7,236.9307
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	4.0226
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	408.1939
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	347.0484

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1702/17031 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 11)	7,191.81	4,561.73	8,397.35	0.00	20,150.89

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1702/17031
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 13)	All	59.20	54.43	63.97	57.12	13.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1702/17031 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations

Rim Seal Losses (lb):	10,641.8875
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.4879
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	13.0000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	12,425.7484
Value of Vapor Pressure Function:	0.4879
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	27,629.3670

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	15.6140
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	27.3244
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	550.6585
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	10,708.6501
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	5.9524
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	604.0137
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	513.5354

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1702/17031 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 13)	10,641.89	4,561.73	12,425.75	0.00	27,629.37

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1705/1706
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 0.3)	All	59.20	54.43	63.97	57.12	0.3000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	112.0675
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.0051
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.3000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	130.8530
Value of Vapor Pressure Function:	0.0051
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	4,804.6515

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	0.1644
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	0.2877
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	5.7989
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	112.7706
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	0.0627
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	6.3607
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	5.4079

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1705/1706 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 0.3)	112.07	4,561.73	130.85	0.00	4,804.65

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1705/1706
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 11)	All	59.20	54.43	63.97	57.12	11.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	7,191.8124
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.3297
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	11.0000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	8,397.3498
Value of Vapor Pressure Function:	0.3297
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	20,150.8933

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	10.5519
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	18.4659
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	372.1363
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	7,236.9307
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	4.0226
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	408.1939
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	347.0484

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1705/1706 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 11)	7,191.81	4,561.73	8,397.35	0.00	20,150.89

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1705/1706
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	225.00
Volume (gallons):	18,900,000.00
Turnovers:	56.78

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 13)	All	59.20	54.43	63.97	57.12	13.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1705/1706 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	10,641.8875
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.4879
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	13.0000
Tank Diameter (ft):	225.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,561.7311
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	225.0000
Roof Fitting Losses (lb):	12,425.7484
Value of Vapor Pressure Function:	0.4879
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,273.2965
Average Wind Speed (mph):	10.6167
Total Losses (lb):	27,629.3670

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	15.6140
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	27.3244
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	550.6585
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	10,708.6501
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	5.9524
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	92	0.53	0.11	0.13	604.0137
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	33	1.30	0.08	0.65	513.5354

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1705/1706 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 13)	10,641.89	4,561.73	12,425.75	0.00	27,629.37

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1707/1708
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	255.00
Volume (gallons):	27,000,000.00
Turnovers:	39.74

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 4)	All	59.20	54.43	63.97	57.12	4.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	1,951.2837
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.0789
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	4.0000
Tank Diameter (ft):	255.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,025.0568
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	255.0000
Roof Fitting Losses (lb):	2,045.4968
Value of Vapor Pressure Function:	0.0789
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,295.5725
Average Wind Speed (mph):	10.6167
Total Losses (lb):	8,021.8373

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	2.5261
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	4.4207
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	89.0895
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	1,732.5222
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	0.9630
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118	0.53	0.11	0.13	125.3387
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36	1.30	0.08	0.65	90.6365

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1707/1708 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 4)	1,951.28	4,025.06	2,045.50	0.00	8,021.84

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1707/1708
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	255.00
Volume (gallons):	27,000,000.00
Turnovers:	39.74

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 11)	All	59.20	54.43	63.97	57.12	11.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations	
Rim Seal Losses (lb):	8,150.7207
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.3297
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	11.0000
Tank Diameter (ft):	255.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,025.0568
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	255.0000
Roof Fitting Losses (lb):	8,544.2588
Value of Vapor Pressure Function:	0.3297
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,295.5725
Average Wind Speed (mph):	10.6167
Total Losses (lb):	20,720.0364

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	10.5519
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	18.4659
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	372.1363
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	7,236.9307
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	4.0226
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118	0.53	0.11	0.13	523.5530
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36	1.30	0.08	0.65	378.5983

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1707/1708 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 11)	8,150.72	4,025.06	8,544.26	0.00	20,720.04

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	TK-1707/1708
City:	Benicia
State:	California
Company:	Valero Refining Co.
Type of Tank:	External Floating Roof Tank
Description:	

Tank Dimensions

Diameter (ft):	255.00
Volume (gallons):	27,000,000.00
Turnovers:	39.74

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good

Roof Characteristics

Type:	Pontoon
Fitting Category	Detail

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	Rim-mounted

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Bolted Cover, Gasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36

Meterological Data used in Emissions Calculations: San Francisco AP, California (Avg Atmospheric Pressure = 14.75 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Crude oil (TVP 13)	All	59.20	54.43	63.97	57.12	13.0000	N/A	N/A	50.0000			207.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-1707/1708 - External Floating Roof Tank
Benicia, California

Annual Emission Calcaulations

Rim Seal Losses (lb):	12,060.8059
Seal Factor A (lb-mole/ft-yr):	0.6000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.4000
Average Wind Speed (mph):	10.6167
Seal-related Wind Speed Exponent:	1.0000
Value of Vapor Pressure Function:	0.4879
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	13.0000
Tank Diameter (ft):	255.0000
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Withdrawal Losses (lb):	4,025.0568
Annual Net Throughput (gal/yr.):	1,073,100,000.0000
Shell Clingage Factor (bbl/1000 sqft):	0.0060
Average Organic Liquid Density (lb/gal):	7.1000
Tank Diameter (ft):	255.0000
Roof Fitting Losses (lb):	12,643.1330
Value of Vapor Pressure Function:	0.4879
Vapor Molecular Weight (lb/lb-mole):	50.0000
Product Factor:	0.4000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	1,295.5725
Average Wind Speed (mph):	10.6167
Total Losses (lb):	28,728.9957

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	15.6140
Automatic Gauge Float Well/Bolted Cover, Gasketed	1	2.80	0.00	0.00	27.3244
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	4	6.20	1.20	0.94	550.6585
Unslotted Guide-Pole Well/Gasketed Sliding Cover	1	25.00	13.00	2.20	10,708.6501
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	5.9524
Roof Leg (3-in. Diameter)/Adjustable, Center Area, Gasketed	118	0.53	0.11	0.13	774.7132
Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Gasketed	36	1.30	0.08	0.65	560.2204

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-1707/1708 - External Floating Roof Tank
Benicia, California

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Crude oil (TVP 13)	12,060.81	4,025.06	12,643.13	0.00	28,729.00

Comments

on

Final Environmental Impact Report

for the

Santa Maria Rail Spur Project

Nipomo, California

March 1, 2016

Prepared by:

Phyllis Fox, Ph.D., PE
Consulting Engineer

SUMMARY AND CONCLUSIONS

I previously filed comments on the Draft Environmental Impact Report (DEIR)[1] (Fox DEIR Comments[2]) and the Recirculated Draft Environmental Impact Report (RDEIR) [3] (Fox RDEIR Comments[4]) for the Phillips 66 ("Applicant") Rail Spur Extension and Crude Unloading Project ("Project" or "Rail Spur Project") at its Santa Maria Refinery (SMR) in Nipomo, California. These three documents (DEIR, RDEIR, FEIR) are referred to collectively in these comments as "the EIR".

I was asked by SAFER to review the Final Environmental Impact Report (FEIR or Rail Spur FEIR)[1], Responses to Comments (RTCs) on the RDEIR, and the Applicant's February 1, 2016 Letter to the County,[5] which proposes adoption of the Reduced Rail Deliveries Alternative, which was analyzed as one of the alternatives to the Project in the Final EIR. My review indicates that the Final EIR and the responses to my comments on the DEIR and the RDEIR have not resolved the issues that I raised in my comments, which stand unrebutted in the record. Thus, I reincorporate my prior comments on the DEIR and RDEIR, which are summarized below. My comments on

---

[1] San Luis Obispo County, Phillips 66 Company Rail Spur Extension and Crude Unloading Project Draft Environmental Impact Report and Vertical Coastal Access Project Assessment, October 2014 [Removed from SLOC's website as of February 23, 2016].

[2] Phyllis Fox, Comments on [Draft] Environmental Impact Report for the Phillips 66 Rail Spur Extension Project, Santa Maria, California, Prepared for Sierra Club, San Francisco, CA, January 27, 2014; Available at pdf 50 in: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/Comments+on+the+Draft+EIR/Organizations+and+Schools/Communities+For+A+Better+Environment-$!23+Comments+Only.pdf.

[3] San Luis Obispo County, Phillips 66 Company Rail Spur Extension and Crude Unloading Project Revised Public Draft Environmental Impact Report and Vertical Coastal Access Project Assessment, October 2014; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/Phillips+66+Company+Rail+Spur+Extension+Project+(Oct+2014)/Phillips+SMR+Rail+Project+Public+Draft+EIR.pdf.

[4] Phyllis Fox, Comments on Revised Draft Environmental Impact Report for the Phillips 66 Rail Spur Extension Project, Santa Maria, California, Prepared for CBE, et al; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/FEIR+Phillips+Rail+Spur+Project+Dec+2015/Response+To+Comments/3_Organizations+and+Schools/Communities+for+a+Better+Environment/Attachment+C1+Fox+Comments+and+Responses.pdf.

[5] Jocelyn Thompson, Allston & Bird, Letter to Members of the Planning Commission, San Luis Obispo County, Re: Phillips 66 Rail Spur Extension Project, February 1, 2016 (Exhibit 3A), with 22 attachments (Exhibit 3B).

the FEIR were prepared with assistance from Ian Goodman[6] on fugitive railcar reactive organic gases (ROG) emissions, hazards mitigation, and piecemealing.

First, the FEIR fails to evaluate all of the impacts of the Project. The Project involves replacing up to 97% of the Santa Maria Refinery's crude slate with tar sands crudes that have no history in the refining industry. These new crudes have higher levels of toxic heavy metals, higher levels of toxic and malodorous sulfur compounds, emit more greenhouse gases, and are more corrosive than conventionally refined crudes. These differences are hidden in the FEIR by cherry-picking two potential tar sands crudes and arguing they fall within the range of current crude sources, even though they exceed levels in the "typical crude blend."[7] This ignores increases in the average crude properties, or "creep", which has led to catastrophic accidents elsewhere. Thus, the EIR has failed to evaluate an entire class of impacts.

Second, the FEIR's estimate of railcar fugitive ROG emissions is significantly underestimated due to numerous errors and omissions. I revised the FEIR's analysis, correcting these errors and omissions. My revised analysis indicates that railcar fugitive ROG emissions exceed CEQA daily and annual ROG significance thresholds for on-site rail operations and in every air district through which the unit trains travel for both the 5 trains per week (the Project) and 3 train per week alternative, with the exception of Placer County APCD for daily emissions and San Luis Obispo County APCD for annual emissions (when on-site ROG emissions are excluded). The EIR does not include any mitigation for these significant impacts. Feasible mitigation is available and must be required.

Third, on-site accidents due to corrosion of refinery equipment could result in significant off-site impacts.

Fourth, the new facilities (unloading rack, new pipeline, extended rail spur with unit train full of crude oil) will result in increased risk of fire and explosion at the refinery that cause significant off-site impacts. The analyses demonstrating these significant impacts are buried in a highly technical appendix, while the EIR text argues

---

[6] Ian Goodman is President of The Goodman Group, Ltd. http://www.thegoodman.com/; his resume is available at: http://www.thegoodman.com/pdf/TGG20160122IanGoodmanCV.pdf.

[7] Rail Spur FEIR, Table 2.7.

that the impacts are not significant by relying on an accident scenario that is not supported in the FEIR.

Fifth, the FEIR concludes that the risk of unit train accidents is significant. The risk is primarily driven by the Los Angeles Area, Bay Area, and Sacramento areas, which have high population densities in close proximity to long stretches of track, which increase the risk of larger numbers of injuries and fatalities. But the FEIR declines to require any mitigation. Safer railcars are available and have been proposed for other projects. Tesoro, which is proposing a crude-by-rail terminal in Washington, has proposed to use DOT-120 pressure tank cars, which reduces the consequence of an accident and also fugitive ROG emissions. FEIR Mitigation Measure HM-2a should be amended to require higher standard DOT-120 or DOT-114 pressure tank cars that include the following safety features over and above those included on the Tesoro DOT-120 cars: (1) 11/16" minimum tank shell thickness; (2) minimum 300 psi test pressure; and (3) electronically controlled pneumatic brakes.

Sixth, the Rail Spur Project is just one of four related projects that were designed together and should have been evaluated as one project under CEQA. The responses to comments on piecemealing are inaccurate, misleading and fail to address my comments.

I. IMPACTS DUE TO CHANGES IN CRUDE SLATE WERE NOT EVALUATED

I previously commented that the Rail Spur Project would replace 97% of the baseline crude slate with up to 100% tar sands crudes. I noted that these new crudes have many chemical and physical properties that distinguish them from the baseline crude slate and that will result in impacts that were not evaluated in the Rail Spur Project RDEIR. I cited comments that I had previously made, which were attached to CBE's comments on the Rail Spur Project in Exhibits 2 and 3 (CBE-116). The responses to CBE-116 to CBE-120 assert that it examined changes in emissions associated with a change in crude slate as part of Impact AQ.2, assuming 100% tar sands crudes. My review of this analysis indicates that the FEIR did not evaluate changes in emissions associated with a change in crude slate, as I demonstrate below. The subject change in crude slate quality will result in significant on-site impacts that have not been disclosed to the public.

I.A Emission Changes Due to Changes in Flue Gas Composition

The tar sands dilbits proposed for import are rich in propane and butane. The RTC argues that any additional propane and butane in imported tar sands dilbits would be partitioned into the fuel gas due to their low boiling points.[8] In Comment CBE-117, I commented that if the increased amounts of propane and butane are partitioned into the refinery fuel gas, emissions would increase from heaters and boilers at the SMR.

First, I commented that the increased amount of propane and butane in the refinery fuel gas would increase combustion temperatures in all heaters and boilers because they burn with a hotter flame than natural gas. *Second*, I commented that propane and butane have higher GHG global warming potentials than other components in refinery fuel gas, which would result in elevated GHG emissions from all heaters and boilers. *Third*, I commented that increased propane and butane would increase the fuel gas heat content, potentially requiring modification or replacement of existing heater and boiler burners. None of these impacts were addressed in the RDEIR. None are addressed in the RTCs. Rather, these issues are sidestepped.

The response to Comment CBE-117directs to RTCs CBE-84, -85, and -111. These responses argue that the amount of propane and butane in "potential crude by rail sources" for two tar sands crudes (0.73% to 0.89%) are within the range of crudes currently refined at SMR (0% to 1.0%). This is misleading, as discussed elsewhere in these comments. *First*, the reported propane and butane in these two potential tar sands crudes are 5-year averages. Propane and butane in tar sands crudes vary depending on the season, increasing significantly in winter months. *Second*, maximum reported values for these two crudes are much higher the 5-year averages. Third, there are many other similar tar sands crudes with much higher propane and butane contents. *See* Table 7.

These responses also argue that most of the propane and butane is created during refining and that only 10% arrives in the crude oil. However, this is based on conventional crude oils, not tar sands dilbits, which are blends of bitumen and diluent. Diluents contain very high concentrations of propane and butane. Further, RTCs CBE-84 and CBE-85 address the Rodeo Refinery, not the Santa Maria Refinery; these two refineries operate on very different crude slates. If one assumes 10% is correct, tar sands dilbits could increase the amount of propane/butane arriving in the crude oil by factor of 2.5. If one-quarter of the refinery fuel gas were propane and butane, the

[8] RTC CBE-109.

impacts I identify in my comments would certainly be realized and would cause or contribute to significant air quality impacts.

I.A.1 Increased Combustion Emissions from Tar Sands Bitumens Not Evaluated

In Comment CBE-118, I commented that tar sands bitumens are composed of higher molecular weight chemicals and are deficient in hydrogen compared to conventional heavy crudes. This means more energy will be required and more combustion emissions (*e.g.*, NOx, ROG, GHG) will be produced to convert these crudes into the same slate of semi-refined and refined products as the current crude slate. More energy will be required to add hydrogen and break the bonds of the larger molecules. As the Rail Spur Project allows up to 97% of Santa Maria Refinery's crude slate to be replaced by tar sands crudes, emissions of criteria pollutants and greenhouse gases will increase from most fired sources as more heat will be required to break the bonds of these larger molecules.

The response to CBE-118 is not relevant at all. This response addresses the potential impact of increased amounts of propane and butane on fugitive emissions, *e.g.*, from pumps, valves, and connectors, not combustion sources. It does not even mention the impact of hydrogen deficiency and higher-molecular weight bitumen on emissions from fired sources. Thus, I reassert my original Comment CBE-118 and supporting information in attachments 2 and 3 to CBE's letter on the RDEIR.

In Comment CBE-119, I elaborated on the differences between the current crude slate and tar sands crudes, noting that Canadian tar sands bitumens are distinguished from conventional petroleum by the abundance of high-molecular weight polymeric material.[9] Canadian tar sands crudes have larger, more complex molecules such as asphaltenes and resins,[10] some with molecular weights above 15,000[11] that are not found in SMR's current crude slate. These heavy fractions have a marked effect on refining and result in the deposition of high amounts of coke during thermal processing in the

---

[9] O.P. Strausz, The Chemistry of the Alberta Oil Sand Bitumen, Available at: http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/22_3_MONTREAL_06-77_0171.pdf.

[10] Asphaltenes are nonvolatile fractions of petroleum that contain the highest proportions of heteroatoms, i.e., sulfur, nitrogen, oxygen. The asphalt fraction is that portion of material that is precipitated when a large excess of a low-boiling liquid hydrocarbon such as pentane is added. They are dark brown to black amorphous solids that do not melt prior to decomposition and are soluble in benzene and aromatic naphthas.

[11] O.P. Strausz, The Chemistry of the Alberta Oil Sand Bitumen, Available at: http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/22_3_MONTREAL_06-77_0171.pdf.

coker, which would occur at Santa Maria. They also require more intense processing in the coker to break them down into lighter products.

I further noted that these differences are not reflected in any of the lumper parameters (API gravity, vacuum residual ("resid") percentage, sulfur, TAN) presented in the FEIR and RDEIR.[12] These differences mean that the coker at Santa Maria will have to work harder to convert vacuum bottoms from distilling tar sand crude into gas oil, which will increase combustion emissions — NO_x, SO_x, CO, VOCs, PM10, PM2.5, and GHGs — as well as the amount of coke. These increases in emissions were not included in the emission inventory.

The response to CBE-119 concludes that "it is not anticipated that additional energy or coking requirements will be needed…" because the gravity and resid content of the crude is similar to the current crude slate, ignoring my comment that these lumper parameters do not address this issue.

First, the table comparing current and potential crude properties[13] does not include the resid content, one of the two factors the response relies upon.[14] Thus, there is no basis for half of RTC CBE-119's argument.

Second, the response cites an Argonne National Laboratory study as concluding "processing oil sands-derived crudes (syncrudes) does not impact the energy efficiencies of refineries." However, this study actually says:

> *Currently, Argonne's methodology pushes all the burden of oil sands processing to the upstream recovery steps. In the currently used methodology, processing oil sands-derived crudes (syncrudes) does not impact the energy efficiencies of refineries. Argonne will evaluate the existing arguments for separating the extra energy burdens of processing syncrudes between the oil sands recovery steps and the refinery processing.*[15]

In other words, this study didn't actually evaluate the impact of refining tar sands crudes on the energy efficiency of the refinery. Further, this study focused on SCO/syncrudes. A syncrude is the output from a bitumen/extra heavy oil upgrader

---

[12] Rail Spur RDEIR, Table 4.3-13 and p. 4.3-70; Rail Spur FEIR, Table 2.7 and p. 2-34.

[13] Rail Spur FEIR, Table 2.7.

[14] The RDEIR included "vacuum resid" information, but it was removed from the FEIR. (RDEIR, Table 4.3-13). The FEIR data appears not to be representative as it was based on "Vacuum Resid percentages based upon *available* distillation curves." [*emphasis* added].

[15] Ignasi Palou-Rivera, Jeongwoo Han, and Michael Wang, Updates to Petroleum Refining and Upstream Emissions, October 2011, p. 7. (Exhibit 8)

facility and is an upgraded crude. It does not contain diluent, the source of LPG in tar sands dilbits. Thus, the Argonne study is of questionable relevance. This study just assigned the reduced efficiency to upstream tar sands processing. There are other studies, published in referred journals, which demonstrate that refining tar sands requires more energy than refining conventional crudes.[16]

Third, although API gravity is widely used as an indicator of the performance of a refinery on a given crude, it is well known in the industry that API gravity is not a good indicator for the refining qualities of tar sands crudes at issue here.[17]

Fourth, the response quotes the following sentence from the Argonne report: "Refineries consume more energy when processing heavier crudes. Heavier crudes have a larger vacuum residue fraction that needs to be upgraded in order to maintain a commercially viable product slate." As noted in my first point above, the RTCs and the FEIR fail to report resid fractions for the currently refined crude slate and tar sands crudes.

Fifth, API gravity data are unsupported. The summary table reports a typical API gravity of 18.6° and a range for major crude sources of 12.2° to 21.0°.[18] Neither the responses nor the FEIR provide the supporting data for this information. The footnotes to the summary table disclose that the typical blend is based on a 3-year average and the range is for "major sources of current crudes" that "include a number of OCS and local offshore sources." However, this is not sufficient to evaluate the relevance of this data. The following information must be supplied to evaluate its relevance: (1) the identification of the three years to determine if they are part of the baseline; (2) the specific crudes and their fraction of the total slate; (3) the range in the crude slate blend charged to the refinery; (4) other chemical and physical data including vacuum resid

---

[16] G. Karras, Combustion Emissions from Refining Lower Quality Oil: What is the Global Warming Potential? *Environmental Science & Technology*, v. 44, no. 24, pp. 9584-9589, 2010 (Exhibit 19); Bredeson et al., Factors Driving Refinery CO2 Intensity, with Allocation into Products, *International Journal of Life Cycle Assessment*, v. 15, pp. 817-826, 2010 (Exhibit 20); J. J. P. Abella and J.A. Bergerson, Model to Investigate Energy and Greenhouse Gas Emissions Implications of Refining Petroleum: Impacts of Crude Quality and Refinery Configuration, Environmental Science & Technology, 2012 (Exhibit 21)

[17] Samuel A. Van Vactor, Pricing Royalty Crude Oil, Economic Insights, Inc., January 29, 2000, p. 8 ("Why are refiners willing to pay more for ANS than most California crude oils? In most instances it may simply be superior refining qualities (many of which are not explained by API gravity differences)."; p. 16 ("API gravity is a reasonable predictor of crude oil quality within a field, but not across fields."); Available at: http://econ.com/apijan00.pdf; Thomas Garrett and others, The Challenges of Crude Blending, Digital Refining Article 1001216, PTQ A1 2016 (Exhibit 4).

[18] Rail Spur FEIR, Table 2.7.

percentage, sulfur, and TAN. Further, a table must be supplied that lists each crude, the date sampled for all of the parameters reported in FEIR Table 2-7, the measured value, and the test method.

Finally, I commented that the differences between tar sands crudes and the current SMR crude slate are due to the nature of the high molecular fraction of the crudes. I specifically commented that these chemical differences are not reflected in any of the lumper parameters (API gravity, vacuum resid percentage, sulfur, TAN) reported in the Rail Spur RDEIR. In particular, I noted that these differences could result in more coke (and hence more coke trucks) and higher emissions of NOx, SOx, CO, ROG, PM10, PM2.5, and GHGs from fired sources. The response does not address this portion of my comment. Thus, I reassert it.

Therefore, I conclude that the Final EIR still fails to evaluate the impact of changes in crude slate chemistry on increases in emissions from refining tar sands bitumen.

I.B Emissions Changes Due to Increased Metals Content in Tar Sands Crudes

I commented in CBE-120 that tar sands crudes have higher metal content than the baseline crude slate, citing a U.S. Geological Survey ("USGS") report that found that "natural bitumen," the source of all Canadian tar sands-derived oils, contains 102 times more copper, 21 times more vanadium, 11 times more sulfur, six times more nitrogen, 11 times more nickel, and 5 times more lead than conventional heavy crude oil, such as those currently refined from local sources.[19]

The Rail Spur RDEIR[20] and FEIR[21] report vanadium and nickel concentrations in a current "typical crude blend" compared to two potential tar sands crudes. However, no information is reported for other heavy metals known to be enriched in tar sands crude, *e.g.*, mercury, copper, nickel, and lead. Further, no support is provided for the vanadium and nickel concentrations that are reported (*e.g.*, number of samples, dates collected, analytical reports, etc.).

---

[19] R.F. Meyer, E.D. Attanasi, and P.A. Freeman, Heavy Oil and Natural Bitumen Resources in Geological Basins of the World, U.S. Geological Survey Open-File Report 2007-1084, 2007, p. 14, Table 1, Available at http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf.

[20] Rail Spur RDEIR, Table 4.3-13.

[21] Rail Spur FEIR, Table 2.7.

I further commented that these metals end up in the coke and thus will be present in coke dust and coke pile runoff/seepage. The DEIR indicated that "[m]etals that are present in coke have been detected in groundwater at concentrations above the California Department of Health maximum contamination levels (MCL) in the area around the coke pile runoff area…" DEIR, p. 4.7-39/40. This statement vanished from the RDEIR after my comment with no explanation and is also not in the FEIR. A switch to tar sands crude could contribute to this existing significant impact from the coke pile as toxic heavy metals (*e.g.*, lead, mercury) may increase in the coke. This was not disclosed in the FEIR.

I also commented that the metal content of fugitive dust from the coke pile could increase to dangerous levels. The California Air Resources Board (CARB), for example, has classified lead as a pollutant with no safe threshold level of exposure below which there are no adverse health effects. Thus, just the increase in lead from switching to tar sands crude is a potentially significant on-site impact that is not disclosed in the FEIR and would not be mitigated by the three train alternative. Accordingly, accurate information on crude quality is critical for a thorough evaluation of the impacts of a crude switch, such as facilitated by rail import.

First, the response to CBE-120 incorrectly asserts that "… metals will remain in the coke and be transported by rail from the SMR for other uses."[22] I agree the metals will remain in the coke and that the coke will be transported by rail from the SMR. However, significant fugitive dust emissions occur between coke production in the cokers and rail transport from the facility. The coke is first dumped out of the bottom of two cokers into pits, transferred on a conveyor belt to a coke storage pile, and managed with front-end bucket loaders and bulldozers, which load the coke into trucks and railcars.[23] All of these operations generate significant amounts of coke dust, which is emitted into the air. The switch from local crudes to tar sands crudes may elevate the metal content of this dust, potentially resulting in significant public health and other impacts.

The new unloading facility and the railroad are located adjacent to the coke storage area on entering and leaving the Refinery. The proposed rail spur would traverse the coke fields.[24] In fact, the unloading facility would be located at the end of

---

[22] RTC CBE-120.

[23] Throughput Increase FEIR, p. 2-13.

[24] Rail Spur FEIR, Figure ES-2, 1-2, 2-3, 2-4.

the existing coke storage area.[25] Google Earth shows the coke handling area contains a large area covered with black coke. *See* Figure 1. Coke dust in these storage areas will be disturbed by passing unit trains, entering and leaving the facility. This would increase coke dust emissions compared to baseline conditions. This dust could also deposit on railcars, which would subsequently be released along the rail tracks on leaving the facility.

Figure 1: Santa Maria Refinery Coke Storage Area[26]

Coke dust emission problems are legendary in the refining industry and were not evaluated in the FEIR. I personally have worked on many. As a result, many coke storage piles are enclosed.[27] The Santa Maria coke piles are not enclosed. Dust is only controlled using water sprays, which allows significant coke dust emissions, especially

---

[25] Rail Spur FEIR, p. 1-1.

[26] Laurance Shinderman, Comments on Recirculated EIR, October 22, 2014; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/FEIR+Phillips+Rail+Spur+Project+Dec+2015/Response+To+Comments/4_General+Public/Shinderman+Laurance.pdf.

[27] Sarah Kramer, Extension Denied: Pet Coke Piles Must be Covered by June 2016, Medill Reports Chicago, February 17, 2015; Available at: http://news.medill.northwestern.edu/chicago/extension-denied-pet-coke-piles-must-be-covered-by-june-2016/; Sandra Murillo, Port of L.A. Covers Its Petroleum Coke, May 17, 2002, Los Angeles Times; Available at: http://articles.latimes.com/2002/may/17/local/me-coke17.

during the frequent high-wind events in the area. Thus, elevated levels of metals present in the tar sands crude will be present in emitted coke dusts, resulting in potentially significant environmental problems, as described in my comments on the RDEIR, but not addressed in the FEIR.

Second, the response to CBE-120 asserts that "emissions from the coke piles have not been found to contribute to dust emissions on the Mesa." However, the cited study only investigated a known high PM10 anomaly on the Nipomo Mesa, which is not near the coke pile. The affected receptors would include residential areas to the north and agricultural lands to the south of the coke handling operations. The FEIR did not evaluate the impacts of unit train traffic on coke dust emissions, increased metals in coke particulate matter on public health, or the impact of these metals on locally grown crops or their uptake through the food chain.

Third, as to the impacts of increased metals in coke dust on the groundwater contamination in the vicinity of the coke pile, the response to CBE-120 asserts that because the Regional Water Quality Control Board (RWQCB) was not concerned about this issue in Throughput EIR discussions, it is not an issue here either. However, the Throughput EIR is not relevant as it did not consider the existing groundwater contamination issue disclosed in the Rail Spur DEIR, which was inexplicably deleted in the Rail Spur RDEIR. Further, even if it had, any conclusions in that case would be irrelevant here as the Throughput FEIR did not involve a crude slate switch to tars sands crudes with elevated metals that are partitioned to the coke or a new rail spur and unit trains that could generate dust.

In sum, none of the issues I raised as to elevated levels of metals in coke were addressed in the RTC. I thus re-assert my prior comments.

II. RAILCAR FUGITIVE ROG EMISSIONS ARE SIGNIFICANT

I commented that railcars emit ROG and TACs from their point of origin through unloading as railcars are not vapor-tight. I presented an estimate of railcar fugitive ROG emissions based on the lower end of the reported crude shrinkage range (0.5% loss during transit). My estimate of ROG emissions within the SLOCAPCD (2,200 lb/day) exceeded the SLOCAPCD ROG+NOx significance threshold of 25 lb/day by two orders of magnitude, requiring additional mitigation.[28] The response to this comment asserts that the EIR included railcar fugitive emissions and that they are nominal, totaling only

[28] Comment CBE-122.

about 0.02 lbs per round trip within SLO County, based on fugitive leaks from tank car components.[29]

In response, I reviewed the FEIR's estimate of railcar fugitives. The FEIR substantially underestimated these emissions due to numerous errors and omissions in its calculations. When these errors and omissions are remedied, railcar fugitive ROG emissions from on-site operations and within all air districts through which the trains pass, are highly significant, exceeding both daily and annual CEQA significance thresholds, except Placer County APCD (for daily ROG) and SLOCAPCD (for annual ROG+NOx).

Railcar fugitive emissions arise from leaking valves, fittings, and closures on the railcars[30]. They were estimated in the FEIR using stationary source fugitive emission factors for oil and gas production facilities, in kilograms per hour per component (kg/hr/comp), assuming one flange per rail car; one pressure relief valve (PRV) on only one-quarter of the railcars (i.e., 20 on an 80 car unit train); and one open-ended line, open for only 5 minutes per tank car during unloading.[31]

There are many errors and omissions in the FEIR's calculations, summarized below. I recalculated railcar fugitive emissions, using the FEIR's fugitive component approach, but modified to correct errors and omissions. My calculations indicate railcar fugitive ROG emissions are 8.6 pounds per mile traveled per day (lb/mile-day) and 1.1 tons per mile traveled per day (ton/mile-yr), based on the FEIR's calculation method, but correcting errors and omissions.

Before starting, I note that the response to this comment stated that railcar fugitive emissions are 0.02 lb/round trip per train within SLO County.[32] However, the FEIR reports 0.14 lb/day for one train roundtrip.[33] The cited emissions of 0.02 lb/roundtrip appear to be only the emissions from the tank car top valve during unloading.

---

[29] RTC CBE-122.

[30] Watco Compliance Services, Securement of Hinged and Bolted Manway's and Service Equipment Inspection --Potential Leak Paths; Available at: https://www.fra.dot.gov/Elib/Document/3301.

[31] Rail Spur FEIR, p. B-17.

[32] RTC CBE-122.

[33] Rail Spur FEIR, p. B.1-7.

II.A Fugitive Emission Factors

The FEIR's railcar fugitive emission calculations are based on emission factors for fugitive components (valves, connectors, open-ended lines) in oil and gas production facilities, which are stationary sources.[34] These are not representative of railcar components (PRVs, pressure relief vents,[35] manways, bottom and top fittings) on unit trains travelling at up to 50 miles per hour (mph) over mountainous terrain and in terminal and switching operations.

In railcars, particularly when travelling in mountainous terrain or in railyard and switchyard operations in which impacts occur, the contents are sloshed about, outgassing ROG and creating pressure surges which can push headspace gases out of tiny openings in connectors, valves, vents, PRVs, and other fugitive components. These high-pressure surges created by sloshing are often great enough to exceed the pressure relief vent pressure, resulting in a release. Or if equipped with a disc, pressures are high enough to burst the disc, leaving the vent open for the remainder of the trip.

These are well known problems in rail transportation that have been studied but not eliminated.[36] Many tank cars are still equipped with these valves. Further, as the transported crude oil warms up, it expands, and the internal pressure of the tank car increases. Pressure relief valves are used to periodically relieve this pressure to ensure the internal pressure does not increase to dangerous levels, damaging the car shell. Sloshing and elevated temperature can result in direct releases to the environment of much larger amounts of ROG than would be released from a PRV at an oil and gas production facility. The emission factors that the FEIR used do not consider these enhanced leak mechanisms, as they are based on stationary sources.

II.B Number and Type of Fittings

The FEIR assumed each railcar is equipped with 1 flange and a top valve that is open for only 5 minutes, presumably during unloading. The FEIR also assumed that

---

[34] CARB, Mass Emissions of Fugitive Hydrocarbon Leaks at Petroleum Facilities, Table IV-2c, 1999; Available at: http://www.arb.ca.gov/fugitive/impl_doc.pdf.

[35] A pressure relief vent, designed to prevent or forestall over-pressuring the tank in event of exposure to fire, uses a frangible (breakable) disk that bursts at its rated pressure and remains open until replaced. They are distinguishable from pressure relief valves (PRVs), which self closes after a release.

[36] M.R. Saat, C.P.L. Barkan, and T.T. Treichel, Statistical Approach to Estimating Surge Pressure Reduction Devices' Performance, Railway Supply Institute Report R-974, November 2005; Available at: https://www.aar.org/Documents/NAR/RA_05-01_SPRD_Peformance_Saa_Nov_05.pdf.

one quarter of the railcars in a unit train, or 20 out of 80, also would have a PRV.[37] This is a gross underestimate of the number of components on railcars that routinely leak while in transit. Another recent EIR for a similar rail terminal, the Recirculated Draft Environmental Impact Report (RDEIR) and Final Environmental Impact Report (FEIR)[38] for the Valero Refinery[39] (referred to in these comments as the Valero RDEIR, as this is where the railcar fugitive emission calculations are found) assumed that each tank car would have 2 PRVs, 1 liquid valve, 3 gas valves, 9 gas connectors, and 2 liquid connectors.[40] The Santa Maria FEIR does not disclose any authority for the very small number of fugitive components on railcars assumed in its calculations. This small number is clearly wrong, as discussed below, thus substantially underestimating railcar fugitive ROG emissions. Further, assuming only one quarter of the railcars has a PRV is inconsistent with the description of the tank car models that may be used by the Project, which show that all are equipped with a "reclosing pressure relief device."[41]

Industry literature identifies many more sources of fugitive leaks from railcars that fall into the general classes of closures,[42] fittings,[43] and valves[44]. They include the fill hole cover, manway cover, stuffing box for bottom outlet valve, bottom outlet, loading/unloading valves, air inlet valve, vapor line, vacuum release valve, liquid line flange, gauging devices, sample lines, thermometer wells, heater coils, washout nozzle/plate and sump, leaks in liquid lines, and leaks at welds. Pressure relief devices, *i.e.*, rupture discs or safety vents, may also be present.[45] These remain open for

---

[37] Rail Spur FEIR, p. B.1-7.

[38] City of Benicia, Valero Benicia Crude by Rail Project, Final Environmental Impact Report, SCH # 2013052074, Use Permit Application 12PLN-00063, January 2016; Available at: http://www.ci.benicia.ca.us/index.asp?SEC=%7BFDE9A332-542E-44C1-BBD0-A94C288675FD%7D.

[39] City of Benicia, Valero Benicia Crude by Rail Project, Revised Draft Environmental Impact Report, SCH # 2013052074, Use Permit Application 12PLN-00063, August 2015; Available at : http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Valero_Benicia_Crude_by_Rail_RDEIR_Complete_Version.pdf.

[40] Valero RDEIR, pp. A-11/14.

[41] Rail Spur FEIR, Table 2.

[42] A closure is a device that closes an opening, such as blind flanges and pipe plugs.

[43] A fitting is a device that joins two or more devices or couplings.

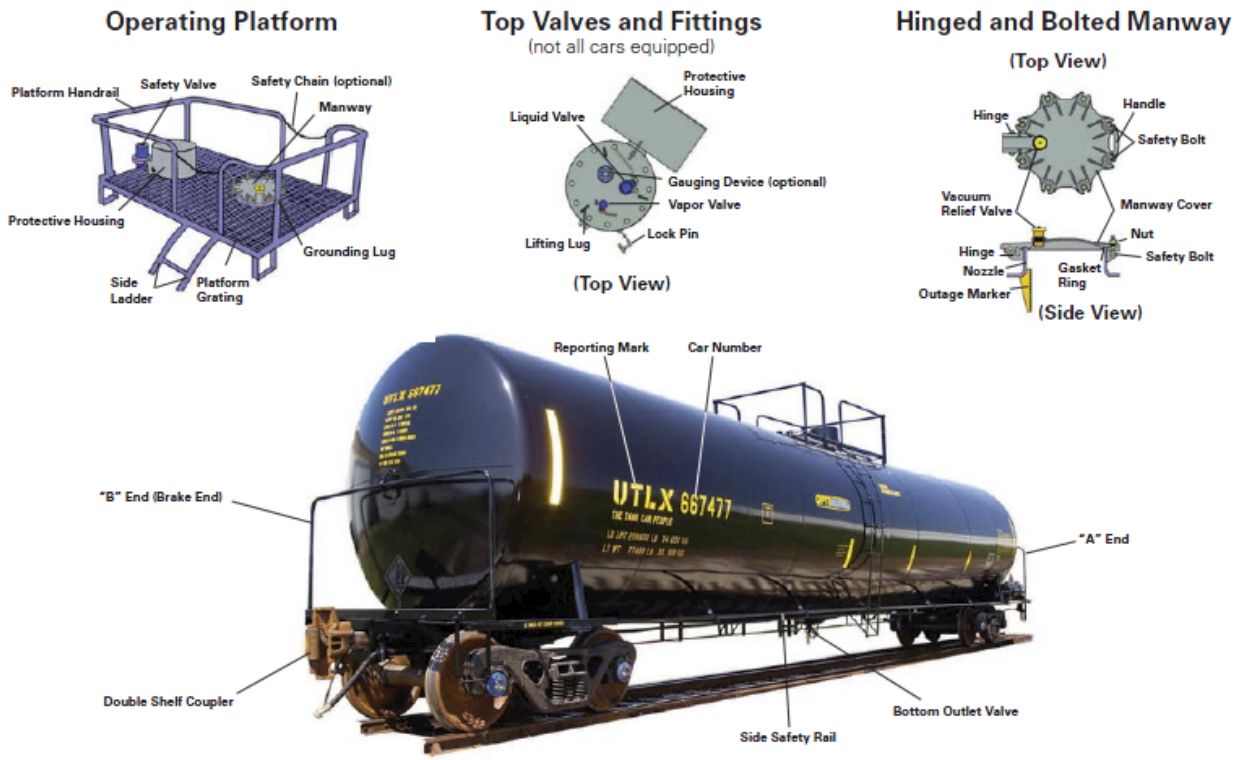
[44] A valve is a device designed to direct, start, stop, mix, or regulate the flow, pressure, or temperature of a process fluid.

[45] *See*, for example, Charles J. Wright, Assessing Tank Car Damage, Union Pacific Railroad, Participant's Manual: Tank Car Safety Course, July 2007; Available at: http://www.iafc.org/associations/4685/files/haz09_spkr410-assessingTankCarDamage.pdf; Association of American Railroads, Field Guide to Tank Cars, 2010; Available at: http://www.bnsfhazmat.com/wp-content/uploads/2015/06/4185_Field_Guide_To_Tank_Cars1-

(cont'd)

the duration of the trip if triggered by pressure surges, which are likely due to sloshing in the mountainous California terrain. In contrast, a pressure relief valve or PRV is spring-loaded and recloses after excessive pressure in the tank. Diagrams of some of these fitting are shown in Figure 2. Photographs of each can be found in the technical literature.[46] Each area of the railcar that includes leak points is further discussed below.

Figure 2: Tank Car Fittings[47]



opt.pdf; Tank Car Loading and Unloading, May 8, 2014; Available at: https://www.youtube.com/watch?v=1PzNbQlvgDw; TransQuip USA, General Service Car Fittings 101; Available at: www.fra.dot.gov/Elib/Document/3441; Watco Compliance Services, Securement of Hinged and Bolted Manway's and Service Equipment Inspection – Potential Leak Paths; Available at: https://www.fra.dot.gov/Elib/Document/3301.

[46] *See*: TransQuip USA, General Service Car Fittings 101; Available at: www.fra.dot.gov/Elib/Document/3441; Watco Compliance Services, Examination Before Shipping: Best Practices for Loading and Off-Loading Tank Cars Based on AAR Pamphlet 34; Available at https://www.fra.dot.gov/Elib/Document/3447.

[47] BP, General Purpose Tank Car, Available at: http://www.bp.com/content/dam/bp-bitumen/en_us/documents/bp-tank-car-poster.pdf.

Manway Seals and Top Fittings: The manway is typically an 18 inch or 20 inch cylinder with a hinged lid that allows access into the railcar from above for maintenance and cleaning. There are usually 6 to 8 eye bolts that secure the manway when not in use. The manway area may also include top fittings: loading/unloading vales, an air inlet valve, a vacuum release valve, and a gauging device. Each of these may emit fugitive ROG.

Bottom Fittings and Liquid Lines: The main railcar bottom fitting is generally a 4-inch valve located at the center bottom used to unload the car. Most of these valves have a handle located on the exterior of the tank, while some have a shaft running to the top of the tank to allow operation from the top. The bottom fitting may also include liquid lines required to fill or empty the railcar and washout nozzles used in car cleaning. Each of these may emit fugitive ROG.

Tank Shell and Safety Head: The railcar shell is a cylindrical tank and tank heads, curved at the ends. These tank car structures are joined by welding. Cracking due to fatigue or sudden impact is most likely to occur in the vicinity of welds. Any cracks would emit fugitive ROG.

Each of these components may release ROG into the atmosphere even if the components or associated gaskets are properly sealed. They release substantially more if not properly sealed. The major source of non-accident releases is the manway (*e.g.*, loose bolts, deteriorated gasket, misaligned gasket), followed by the liquid line (*e.g.*, threaded valve loose) and fill hole (*e.g.*, loose bolts, misaligned or deteriorate gasket, misaligned cover). These major leaking components were not included in the FEIR's railcar calculations.

Leak Detection and Repair (LDAR) programs at stationary sources use VOC detectors to find leaks so they can be repaired. LDAR programs are not used for railcars, allowing leaks to go undetected.

In my revised calculations, I used the number and type of fittings assumed in the Valero FEIR. The Valero fugitive component count is also an underestimate, based on industry literature. However, there is currently inadequate information in the record to support a different estimate. Applicants who propose rail terminals should be required by the lead agency to inventory fugitive components on the railcars they propose to use and the assumed number should be verified by an enforceable condition that requires post-project inventorying and reporting.

II.C Fugitive Component Leak Rate

The FEIR used the Screening Value Range Method (Leak/No Leak Method) from a 1999 CARB report[48] to estimate ROG emissions from railcar fugitive components. This method reports two sets of emissions factors. The first set, the "no leak" factors, is applied to components that are known to have a leak rate of less than (<) 10,000 parts per million (ppm), based on actual measurements. The second set, the "leak" factors, are applied to components that are known to leak at greater than or equal to (≥) 10,000 ppm. This method presumes the presence of a Leak Detection and Repair (LDAR)[49] program in which VOC emissions from fugitive components are regularly measured, so leak data are available that allow classification of the components into "leak" and "no leak" groups.[50] The FEIR relied on this leak/no leak method for oil and gas production facilities.[51] The FEIR's railcar fugitive emissions used the lower end of the range, for no-leak components, assuming all fugitive components leak at <10,000 ppm, without any data to support this choice.

I am not aware of any fugitive leak rate emission factors for railcars. However, the no leak factors are not applicable in this case and substantially underestimate ROG emissions for several reasons. *First*, railcars do not have to comply with a LDAR program, which keeps leak rates low by routinely measuring VOC emissions at the component face and fixing leaks as they occur. *Second*, the fugitive components are present on a mobile source, subject to acceleration, deceleration, and sloshing, which affect the integrity of the connections and increase leak rates. *Third*, the Federal Railroad Administration (FRA) has reported an increasing number of incidents involving damage to tank cars in crude oil service in the form of severe corrosion of the internal surface of the tank, manway covers, and valves and fittings.[52] This corrosion would significantly increase the leak rate. *Fourth*, PRVs can vent during transit, which is not considered at all in the CARB emission factors. Venting could result, for example, from high ambient temperatures. *Fifth*, on-site preparation of railcars for unloading

---

[48] CARB, California Implementation Guidelines for Estimating Mass Emissions of Fugitive Hydrocarbon Leaks at Petroleum Facilities, February 1999, Available at: http://www.arb.ca.gov/fugitive/impl_doc.pdf.

[49] A LDAR program identifies leaks using an Organic Vapor Analyzer (OVA). Any identified leaks are repaired on line within a time certain.

[50] CARB 1999, pp. 11-12.

[51] CARB 1999, Table IV-2c.

[52] Letter from Thomas J. Herrman, Acting Director, Office of Safety Assurance and Compliance, to Jack Gerard, American Petroleum Institute, July 29, 2013; Available at: https://www.fra.dot.gov/eLib/details/L04717.

releases emissions from many fugitive components that must be opened for access, including gauges, manways, top and bottom values, hatches, and connectors. *Sixth*, as noted elsewhere, railcars are typically underfilled, which results in significant sloshing in California's mountainous terrain and outgassing of vapors from the crude oil cargo, which create pressure that pushes headspace gases through openings in the fugitive components.

Thus, the higher leak rate emission factors should be used for railcars. The upper-bound leak-rate (≥10,000 ppm) emission factors are 3,700 (light crude oil valve) to 10,800 (light crude oil flange) times greater than the lower bound (<10,000 ppm) emission factors at oil and gas production facilities used in the FEIR. In my revised emission calculations, I used the upper bound oil and gas production emission factors.

II.D Service Type

The service type is the material in contact with the fugitive component. Where available, the CARB emission factors are reported for three "service types": (1) gas/light liquid; (2) light crude oil; and (3) heavy crude oil. Fugitive components at the bottom of railcars would be in crude oil service while those at the top would be in gas service. Components in gas service generally have the highest emission factors. The FEIR estimated fugitive emissions assuming all components were in light crude oil service.[53] This is a reasonable choice for components in contact with oil, at the bottom of the car, when the crude oil is tar sands dilbits,[54] as they have API gravities of 20°+ and given the limit of 30° API in mitigation measure HM-2d.[55]

However, rail cars are not topped off, so components at the top of the railcar would be in gas service. Regulations require that railcars be underfilled by 1% but railcars are typically underfilled by a much larger amount.[56] Thus, components on the

---

[53] Rail Spur FEIR, p. B.1-7.

[54] Rail Spur FEIR p. 4.3-47 ("The EPA AP-42 emission factor for light crude oil was used as a conservative estimate for crude oils that are medium API (over API20").

[55] Rail Spur FEIR, p. 4.7-88.

[56] U.S. Department of Transportation, Final Regulatory Analysis, Docket No. PHMSA-2012-0082, Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Final Rule, May 2015, pp 159-160 ("Surprisingly, most, if not all, shippers of crude oil do not know the unit weight of the lading in each tank car at a reference temperature (115°F) so they short load the tank. Based an audit of loading facilities in the Bakken, most offerors require a minimum of 3-5% outage after the tank has been loaded. Additionally, based on information obtained during Operation Classification, it was learned that the actual outage in tank car ranges from 3-9%. Short loading ensures a shipper that the tank car is in compliance with current regulations.")
(cont'd)

top of the car are in contact with vapors that outgas from the crude oil. Components in contact with gases generally have much higher leak rates than those in contact with oils. Further, the tar sands crudes are not a homogenous mixture. After several days of delivery time, layering occurs with water and sediment on the bottom and light products on top,[57] where they may outgas and leak at fugitive components. The 1999 CARB report does not include any emission factors for heavy crude oil for any facility type, with the exception of open-ended lines at oil and gas production facilities. The heavy crude oil emission factor in that case (7.11E-02 kg/hr/comp) is more than 3 times higher than the light crude oil factor (2.22E-02 kg/hr/comp).[58] Thus, in my revised fugitive emission calculations, I use the light crude oil factors for components in contact with oil and the gas/light liquid factors for components in contact with headspace gases, following the protocol used in the Valero EIR.[59]

II.E Valves

Each railcar has **at least** two valves – an inlet/outlet valve and a pressure relief valve (PRV). These valves are located either on the top center of the car or, less frequently, on the bottom center.[60]

II.E.1 Conventional Valves

The FEIR assumed each rail car would be equipped with a tank car top valve, represented by an open-ended line that would be open for only 5 minutes per tank car during unloading, resulting in ROG emissions of 0.0205 lb/day. I was unable to verify this calculation. Further, this value (0.0205 lb/day) was inserted as a value into the live spreadsheets provided by the County, without any supporting calculations. Thus, it is unsupported in the record.

The emission factor for an open-ended line at an oil and gas production facility for light crude oil is 1.8E-5 kg/hr/comp. Based on the footnote to the fugitive emission

---

http://www.regulations.gov/contentStreamer?documentId=PHMSA-2012-0082-3442&attachmentNumber=1&disposition=attachment&contentType=pdf.

[57] Gary Weimer, Irving Oil, Crude by Rail Quality Issues, June 6, 2013, pdf 16; Available at: http://www.coqa-inc.org/docs/default-source/meeting-presentations/20130606_weimer.pdf?sfvrsn=2.

[58] CARB 1999, Table IV-2c.

[59] Valero RDEIR, Appx. B.

[60] Greg Johnson, Where Valves Are Used: Tank Cars, Valve Magazine, April 17, 2014, Available at: http://www.valvemagazine.com/index.php/magazine/sections/where-valves-are-used/5827-tank-cars.

table in Appendix B.1[61], the ROG emissions should be 0.00635 lb/day.[62] Thus, there is either an error in the calculation, or a failure to explain the methodology.

In addition to its failure to support the open valve calculation, the FEIR also failed to include leakage when the valve is closed. Valves leak in the closed position, not just when open. The FEIR does not include any emissions from the valve in a closed position. In my revised emission calculations, I included emissions from the valve in its closed position, based on the oil and gas production upper bound valve emission factor for light crude oil.

II.E.2 Pressure Relief Valves

The FEIR estimated ROG emissions from pressure relief valves (PRVs) using a light crude oil generic conventional "valve" emission factor in oil and gas production, assuming a leak rate of <10,000 ppmv.[63] A conventional valve and a pressure relief valve emit different amounts of ROG, especially on railcars. Pressure relief valves would have much higher emissions than a conventional valve.

Other tables in the CARB report relied on in the FEIR indicate that emissions from PRVs are 6[64] to 75[65] times higher than from conventional valves at stationary sources and would be even higher for moving railcars, due to sloshing and periodic releases. In my revised railcar fugitive emission calculations, I used the lower end of this range (6 × normal valve) to adjust the "oil and gas" ≥ conventional valve emission factor to a PRV basis.[66]

Further, as noted above, the FEIR also assumed that only one-quarter of the railcars would have PRVs. This is wrong. Each railcar must have at least one PRV to meet regulations and a top or bottom unloading valve. Thus, in my revised calculations, I followed the procedure in the Valero FEIR, and assume two PRVs per railcar.

---

[61] Footnote: "Tank car top valve based on open ended lines for 5 minutes per tank car during unloading."

[62] Tank car top valve = (1.8E-5 kg/hr)(5 min/60min/hr)(2.204 lb/kg)(80 cars)(24 hr/day) = 6.35E-3 lb/day.

[63] The PRV emission factor reported in FEIR, p. B.1-7 is 1.90E-05 kg/hr/comp. CARB 1999, Table IV-2c indicates that this emission factor is for a light crude oil valve with a leak rate <10,000 ppm.

[64] CARB 1999, Table IV-2a (refinery screening: 1.691/0.2626 = 6.44).

[65] CARB 1999, p. 12 (3 refinery heaters: 4.47E-2/6.0E-4= 74.5).

[66] Adjusted PRV emission factor: (7.07E-2 kg/hr/comp)(6) = 0.42 kg/hr/comp.

II.F Flanges

The FEIR estimated emissions from flanges using a <10,000 ppmv emission factor of 2.4E-5 kg/hr/comp (light crude oil). The corresponding ≥10,000 ppmv emission factor is 2.6E-1 kg/hr/comp (gas),[67] or 10,800 times higher.[68] Measurements on threaded pipe connections and quick connect couplers on stationary railcars at a loading terminal indicate that ROG emission factors range from 0.0025 to 0.0097 kg/hr/comp[69], or factors of 104 to 404 times higher than the <10,000 ppm factor used in the FEIR's calculations. I used the ≥10,000 ppm emission factor for the oil and gas production section relied on in the FEIR in my revised calculations.

II.G Empty Railcars

The FEIR did not distinguish between full and empty railcars. Some crude oil would be present in the unloaded railcars as deposits on the railcar walls and within piping and fugitive components (referred to as "clingage"). This residual oil would outgas into the railcar interior and be emitted from the fugitive components, propelled by changes in temperature, wind shear across rail car surface, railcar movement, from open hatches, gaging losses, and connect and disconnect losses.

Unloaded railcar emissions presumably would be lower than loaded railcar emissions. Similar calculations in the Valero FEIR assumed a 5% "dilution factor," based on filling the empty railcars with air. Estimates by others suggest 5% underestimates these emissions.[70] I used the 5% dilution factor to assure a conservative estimate.

---

[67] CARB 1999, Table IV-2c and FEIR, p. B.1-7.

[68] ((2.4E-5 kg/hr/comp)/(2.1E-1 kg/hr/comp) = 10,833.3.

[69] Albert Hendler and others, Measurement of VOC Emissions f rom Pressurized Railcar Loading Arm Fittings, July 31, 2006; Available at: http://files.harc.edu/Projects/AirQuality/Projects/H051A/H51AFinalReport.pdf.

[70] An estimate made by Ohio EPA reported purging emissions from railcars that previously contained crude oil of 132 pounds per rail car during railcar cleaning. In addition, each unloaded railcar would have residual crude oil that clings to the inside of the railcar and fittings and can outgas ROG during transit, replenishing any lost vapors during transit. The Ohio permit evaluation estimated 0.1 bbl/1000 ft^2 based on AP-42, Table 7.1. An EPA study found that the volume removed in cleaning tank cars that transported petroleum and coal products averaged 128 gallons. *See, e.g.,* OhioEPA, Draft Air Pollution Permit-to-Install and Operate, January 16, 2014, pdf 5 - 6; Available at: http://wwwapp.epa.ohio.gov/dapc/permits_issued/1103115.pdf and EPA, Final Development Document for Effluent Limitations Guidelines and Standards for the Transportation Equipment Cleaning Category, Report EPA-821-R-00-012, June 2000, Table 4-3; Available at:
(cont'd)

II.H Revised Railcar Fugitive ROG Emissions

I corrected most of these errors and omissions and recalculated fugitive railcar ROG emissions, otherwise using the FEIR's method based on oil and gas production emission factors. I prepared calculations for two cases: (1) railcars on site and (2) for railcars in transit in air districts from the California border to the site. These calculations are in Exhibit 1 and summarized in Tables 1 and 2. I assumed the following in these calculations:

- Rail car service (gas or crude oil), equipment count, and 5% dilution factor for empty railcars were based on Valero RDEIR, Appx. A, pp. A-11/14;
- Emission factors from CARB 1999, Table IV-2e, for oil and gas production, upper bound screening factors (≥10,000 ppmv);
- Hours on site from FEIR, Table 2.5 (11.5 hours per unit train visit);
- PRV emission factor is 6 times that for a conventional valve;
- Departing rail car emissions calculated assuming 5% dilution factor;
- VOC emissions are assumed to be 100% ROG, based on crudemonitor.ca; and
- Average train speed of 26 mph.

II.H.1 On-Site Railcar Fugitive ROG Emissions

The revised on-site railcar fugitive emissions are 2,587 lbs per unit train visit, assuming oil and gas production emission factors.[71] Assuming 5 unit trains per week, this works out to 336 ton/yr.[72] Assuming 3 unit trains per week, this works out to 202 ton/yr.[73] These emissions exceed the SLOCAPCD ROG+NOx CEQA significance thresholds of 25 lb/day and 25 ton/yr.[74] Thus, ROG emission from on-site railcar

---

http://www.epa.gov/sites/production/files/2014-03/documents/tec_development_doc_final_2000.pdf.

[71] Exhibit 1, Tab: OnSite, Cell: G31.

[72] Annual railcar ROG emissions for 5 unit trains per week, using oil & gas production emission factors = [2,587 lb/train x 5 trains/week x 52 weeks/yr]/2000 lb/ton = 336 ton/yr.

[73] Annual railcar ROG emissions for 3 unit trains per week, using oil & gas production emission factors = [2,587 lb/train x 3 trains/week x 52 weeks/yr]/2000 lb/ton = 202 ton/yr.

[74] Rail Spur FEIR, Table 4.3-9.

fugitive leaks alone are a significant, on-site unmitigated operational air quality impact that was not disclosed in the FEIR.

If marketing terminal emission factors are used, as assumed in the Valero calculations, but otherwise using the assumptions above, the on-site, per-unit-train ROG emissions drop to 790 lb per unit train visit[75] or 45 ton/yr for the 5 unit train case[76] and to 62 ton/yr for the 3 unit train case.[77] The CEQA ROG+NOx significance thresholds for the SLOCAPCD are 25 lb/day and 25 ton/yr.[78] Thus, both daily and annual ROG emissions are significant for both the 5 and 3 train per week cases. Further, these emissions bound those I calculated in my Comment CBE-122 using the lower end of the crude shrinkage range, or 2,200 lb/day.

I also commented in CBE-122 that these ROG emissions contain substantial amounts of toxic air comments (TACs), up to 7% benzene by weight. The RTC did not respond to this comment. Assuming 7% benzene in the ROG emissions, benzene emissions could be up to 181 pounds per unit train visit to the SMR[79] or 24 ton/yr for the 5-car per week case[80] and 14 ton/yr for the 3-unit train per week case.

II.H.2 Off-Site Railcar Fugitive ROG Emissions

I next calculated railcar fugitive ROG emissions for each air district along the three routes that unit trains would take from the California border to the Project site: (1) northern route via Oakland; (2) northern route via Altamont; and (3) southern route. ROG emissions were estimated using emission factors in pounds of ROG emitted per mile traveled per day (lb/mi-day) and in tons of ROG emitted per mile traveled per day (ton/mi-yr), calculated using the procedure developed in the Valero RDEIR.[81] The average ROG emission factors are 8.6 lb/mi-day and 1.1 ton/mi-yr.[82]

---

[75] Exhibit 1, Tab: OnSite, cell: J31.

[76] Annual railcar ROG emissions for 5 unit trains per week, using marketing terminal emission factors = [790 lb/train × 5 trains/week x 52 weeks/yr]/2000 lb/ton = 103 ton/yr.

[77] Annual railcar ROG emissions for 3 unit trains per week, using marketing terminal emission factors = [790 lb/train × 3 trains/week x 52 weeks/yr]/2000 lb/ton = 62 ton/yr.

[78] Rail Spur FEIR, Table 4.3-9.

[79] Benzene in ROG emissions = 0.07(2587 lb ROG/visit) = **181.1 lb/visit**.

[80] Benzene emissions for 5 trains/wk = (336 ton/yr ROG/visit)(0.07) = **23.5 ton/yr** benzene; benzene emissions for 3 trains/wk = (202 ton/yr ROG/visit)(0.07) = **14.1 ton/yr** benzene.

[81] Valero RDEIR, Appx. A.

[82] Exhibit 1, Tab: LbMiDay, Cells: H15 & K15.

These calculations require the use of train speed in miles per hour (mph), a variable not used in the FEIR's railcar fugitive ROG emissions. However, in its locomotive calculations, the FEIR relies on a train speed of 40 mph with the exception of the distance between the San Luis Obispo County line to the SMR, over Cuesta Grade, where an average train speed of 20 mph is assumed.[83] These are very high for the terrain that will be traversed because:

a) some of the routing is mountainous where trains will move slower and pause to add/drop helper engines;

b) some of the routing is in urban areas where speeds may be lower, *e.g.*, Bay Area, Sacramento and Los Angeles;

c) crude unit trains are long and heavy; and

d) there may be congestion and delays, especially in areas with lots of rail traffic and passenger trains that have priority (such as Roseville-through the Bay Area and around Los Angeles).

The Surface Transportation Board (STB) requires weekly data collection, including average rail speed for various commodities. The Union Pacific reported a system-wide average train speed for crude shipments of 23 to 26 mph.[84]

Alternatively, in a recent DOT rulemaking, it was assumed that unit trains travel 220 miles per day and make 16 round trips per year.[85] Assuming a 3,000-mile roundtrip and 1 day loading and 1 day unloading yields 11.6 linehaul days, which works out to an average speed of 11 mph.[86] Thus, a more reasonable range for unit train speed is 11 to 26 mph. I used the upper end of this range, or 26 mph in my revised calculations to be conservative. However, a much lower speed is justified for much of the terrain the

---

[83] Rail Spur FEIR, p. B.1-9, 'Locomotive Emissions.' *See*: "Average Line Haul Speed, mph" and "SM to LO time (20 mph)".

[84] Calculated by dividing train-miles by total hours from origin to destination, less intermediate terminal time. Excludes the following train categories: yard, local, passenger, foreign, and maintenance of way. *See*: http://www.up.com/cs/groups/public/@uprr/@newsinfo/documents/up_pdf_nativedocs/ep724-stb-data-spreadsheet.pdf.pdf.

[85] Final Regulatory Impact Analysis, DOT Final Rule for High-Hazard Flammable Trains, May 2015, pp. 150, 153, 233; Available at: http://www.regulations.gov/contentStreamer?documentId=PHMSA-2012-0082-3442&attachmentNumber=1&disposition=attachment&contentType=pdf.

[86] The average speed, assuming a 3,000 mile roundtrip, 1 day loading, and 1 day unloading: (3000 mi/220 mi/day) - 1 day loading – 1 day unloading = 11.6 line haul days. The average speed then is: 3000/(11.6×24)=10.8 mph.

Santa Maria trains would traverse within California, which would significantly increase fugitive ROG emissions beyond the levels I estimated.

Regardless, high speeds may actually increase leakage from rail cars, beyond levels assumed in these calculations. This was not considered in these calculations. Thus, railcars either leak a lot per hour at lower speeds (including when parked at railyard and at the Santa Maria Refinery) or they leak even more per hour at the higher speeds assumed in the RDEIR's calculations.

The lb/mi-day and ton/mi-yr emission factors were then used with roundtrip distances traversed in each district as estimated in the FEIR[87] to calculate daily and annual railcar ROG emissions in each traversed air district from the stateline to the Roseville or Colton Railyard and from the railyards, to the Project site. These emissions were compared to CEQA ROG significance thresholds as summarized in the FEIR.[88] The Roseville/Colton to Project site daily analysis is summarized in Table 1 and shows that railcar fugitive ROG emissions are significant in every traversed air district for all routes, except Placer County APCD, when the methodological errors made in the FEIR are corrected. The stateline to Roseville/Colton analysis is reported in Exhibit 1, Tab: ByDistrict and also shows that daily ROG emissions are significant in every traversed air district for all routes, including Placer County APCD. The emissions in the Placer County APCD and SCAQMD are underestimated as they do not include emissions during the time the railcars spend at the Roseville and Colton Railyards. These results are consistent with those in my comments on the RDEIR, Comment CBE-122, calculated assuming 0.5% product loss.

[87] Rail Spur FEIR, p. B.1-2 and B.1-9 for Roseville to site and p. B.1-11 for stateline to Roseville.

[88] The CEQA significance thresholds are from FEIR, p. B.1-247.

Table 1:
Daily Railcar Fugitive ROG Emissions,
Roseville/Colton to Site

	Roundtrip (miles)	**Emissions** (lb/day)	**Significance Threshold** (lb/day)	**Significant?**
Northern Route via Oakland				
Placer County APCD	1.8	15	82	No
Sacramento Metro APCD	30.8	265	65	Yes
Yolo Solano APCD	64.2	552	-	-
Bay Area AQMD	276.9	2,381	80	Yes
Monterey Bay Unified AQMD	226.8	1,950	137	Yes
San Luis Obispo County APCD	134.1	1,153	25	Yes
Northern Route via Altamont				
Placer County APCD	1.8	15	25	No
Sacramento Metro APCD	75.8	652	65	Yes
San Joaquin Valley APCD	100.3	863	-	-
Bay Area AQMD	179.6	1,545	80	Yes
Monterey Bay Unified AQMD	226.8	1,950	137	Yes
San Luis Obispo County APCD	134.1	1,153	25	Yes
Southern Route				
San Luis Obispo County APCD	9.5	81	25	Yes
Santa Barbara County APCD	216.4	1,839	55	Yes
Ventura County APCD	115.6	983	25	Yes
South Coast AQMD	176.2	1,498	55	Yes

In addition to these exceedances of daily significance thresholds, several of the air districts through which the trains would pass have annual CEQA significance thresholds. The annual ROG emissions for Roseville to the site (Table 2) and the stateline to Roseville (Exhibit 1, Tab:ByDistrict) exceed the annual CEQA significance thresholds for all districts with annual thresholds, everywhere but in San Luis Obispo County APCD for both the Project (5 trains per week) and the 3 train per week alternative.

Table 2:
Annual Railcar Fugitive ROG Emissions
for 5 and 3 Trains Per Week,
Roseville/Colton to Site

	Roundtrip (miles)	**Emissions 5/3 Trains/wk** (ton/yr)	**Significance Threshold** (ton/yr)	**Significant?**
Northern Route via Oakland				
Placer County APCD	1.8	2	-	
Sacramento Metro APCD	30.8	34/20	-	
Yolo Solano APCD	64.2	71/43	10	Yes
Bay Area AQMD	276.9	305/183	15	Yes
Monterey Bay Unified AQMD	226.8	249/140	-	
San Luis Obispo County APCD	134.1	148/89	25	Yes
Northern Route via Altamont				
Placer County APCD	1.8	21.2	-	
Sacramento Metro APCD	75.8	83/50	-	
Yolo Solano APCD	100.3	110/66	10	Yes
Bay Area AQMD	179.6	198/119	15	Yes
Monterey Bay Unified AQMD	226.8	249/149	-	
San Luis Obispo County APCD	134.1	148/89	25	Yes
Southern Route				
San Luis Obispo County APCD	9.5	10/6	25	(1)
Santa Barbara County APCD	216.4	238/143	10	
Ventura County APCD	115.6	127/76	-	
South Coast AQMD	176.2	1,515/909	-	

(1) Significant when on-site emissions are included.

In sum, daily ROG emissions from railcar fugitive emissions are significant in every air district through which they pass, except Placer County, where emissions are underestimated due to failure to include Roseville operations. Further, annual ROG emissions are significant in every air district through which they pass that has an annual CEQA significance threshold. Thus, all feasible mitigation is required for railcar fugitive ROG emissions. I recommend several feasible air quality mitigation measures not identified in the FEIR below.

II.I Mitigation for Railcar Fugitive ROG Emissions

The significant railcar fugitive ROG emissions can be mitigated by requiring the following:

- Emission Reduction Credits (ERCs);
- Actual reductions in emissions at the Santa Maria Refinery, including at the Santa Maria Pump Station, tanker truck fleet, and storage tanks;
- Voluntary Emission Reduction Agreements (VERAs);
- Follow recommended industry practices to minimize railcar releases including pre-loading inspection of all railcar fugitive components, *e.g.*, PRVs, rupture discs, manway; adherence to change-out procedures; preventative maintenance; and tank car operator training;[89]
- Replace all non-closing pressure relief devices, such as rupture discs, rupture pins, or other one-time-use pressure relief device with standard PRVs;
- All tank car hatches should be closed and sealed during loading operations;[90]
- Require the use of oxidation catalysts on existing heaters and boilers at the Santa Maria Refinery to offset increases in ROG emissions;
- Require the use of pressure tank cars, such as the Tesoro DOT-120 design (*see* Comment IV.B);[91]

---

[89] *See* Wright 2007, footnote 22; Tank Car Loading and Unloading, May 8, 2014; Available at: https://www.youtube.com/watch?v=1PzNbQlvgDw; and AAR/CMA North American Non-Accident Release Reduction Committee, Improving Securement in Hazardous Materials Tank Car Shipment. Recommended Industry Practices, October 1999; Available at: https://www.aar.org/Documents/NAR/Improving_Securement_in_Hazardous_Materials.pdf; Watco Compliance Services, Examination Before Shipping: Best Practices for Loading and Off-Loading Tank Cars Based on AAR Pamphlet 34; Available at https://www.fra.dot.gov/Elib/Document/3447.

[90] MBUAPCD Title V Operating Permit TV 34-01 Evaluation Report, ExxonMobil, March 9, 2005; Available at: http://yosemite.epa.gov/R9/air/EPSS.NSF/735056a63c1390e08825657e0075d180/e1e0cc5cd519261f88256fc0006c09f0/$FILE/TV34-01evl.pdf.

[91] The Tesoro DOT-120 design (with a shell thickness of 9/16") has a rated test pressure of 200 psi, but other DOT-120 and DOT-114 designs (with a shell thickness of 11/16") have rated test pressures of 300, 400, or 500 psi.

- If pressure tank cars are not selected, require that railcars be operated with an inert gas headspace, such as nitrogen rather than ambient air;[92]
- Require the use of zero-leak fugitive components at the rail terminal and on the pipeline connecting the rail terminal and storage tanks;
- Implement LDAR program for all on-site railcars during railyard idling and unloading.

These mitigation measures are not preempted because they do not manage or govern rail operations. Further, they control pollutants that are emitted from the railcars, which are owned (or leased) by Phillips 66, who is not a rail carrier. And railcar ROG fugitive emissions, once released, are part of the ambient air and, thus, are part of the "commons" subject to regulation and control by local agencies.

In addition, ROG is twice removed from its source. The significance criteria for ROG are based on the fact that they are ozone precursors. Ozone is the pollutant of concern. Ozone is not emitted by railcars, but rather, it is formed in the atmosphere from precursor compounds, primarily NOx and ROG. The amount of ozone that forms depends on the level of other pollutants present in the air where it is emitted.[93] .

III. ON-SITE HAZARDS ARE SIGNIFICANT

Accidents caused by the change in crude slate and the new unloading facilities could endanger the refinery, refinery workers, and the surrounding community. These impacts were not evaluated in the FEIR.

III.A Hazards Due to Changes in Crude Slate at Existing Refinery

The FEIR includes a brief discussion of the impact of changes in crude slate on hazards at the Refinery, designated as Impact #HM.3.[94] This discussion touches on naphthenic acid corrosion, pointing to various inspection programs and ultimately dismissing corrosion-related accidents at the SMR from refining tar sands crudes because "… the expected range of sulfur and TAN [total acid number] would be within

---

[92] The Valero RDEIR railcar fugitive ROG emissions assumed a 95% ROG control efficiency for using an ambient air headspace on the return-trip railcars. Valero RDEIR, Appx. A, pp. A-3 (5% dilution factor), A-14.

[93] D.J. Rasmussen, J. Hu and others, The Ozone-Climate Penalty: Past, Present, and Future, Environmental Science & Technology, v. 47, no. 24, 2013, pp. 14258–14266 (Exhibit 5).

[94] Rail Spur FEIR pp. 4.7-92/94.

the range of the crudes that are currently being processed at the SMR. Therefore, the change in crude slate would not be expected to change the sulfur or TAN levels compared to the crude sources that are currently being processed at the SMR."[95] In Comment CBE-123, I explained why this is an inadequate discussion of corrosion-induced accidents and why the conclusion is wrong.

The response to Comment CBE-123 does not address any of the points that I raised, but rather simply restates the unsupported assertion that I challenged and expanded its discussion of various programs designed to protect against corrosion. The response to Comment CBE-123 states:

> "A review of the data in the RDEIR Table 4.7-14 [FEIR Table 2.7] shows that the expected range of sulfur and TAN would be within the range of the crudes that are currently being processed at the SMR. Therefore, the change in crude slate would not be expected to change the sulfur or TAN levels compared to the crude sources that are currently being processed at the SMR. It is possible that the TAN could increase when compared to the typical crude blend. However, with the program and management systems, discussed above, in place, this potential increase would not be expected to increase the hazards or likelihood of a release at the SMR. Therefore, the impact would be less than significant."[96]

This just repeats the unsupported assumption that I challenged in Comment CBE-123, without responding to any of my comments on corrosion-induced accidents.

First, to frame this issue, it is important to recognize that the Rail Spur Project is proposing to replace the **majority** of the current crude slate of 38,100 barrels per day (bbl/day) with up to 100% tar sands crudes. The Project proposes to import 37,142 bbl/day of cost-advantaged crudes by rail.[97] Thus, the Project would replace 97% of the baseline crude slate with up to 100% tar sands crude. The SMR Throughput Increase Project will increase the crude permit level to 48,950 bbl/day.[98] Thus, at full buildout, up to 76% of the crude slate could be different crude(s) than in the baseline, potentially 100% tar sands crudes. Therefore, the SMR is not tweaking its crude slate by blending tar sands crude, but embarking on a complete remake of its crude slate, using a crude or crudes that are new to the refinery and the refining industry. This wholesale

---

[95] Rail Spur FEIR, Table 4.7.18 and p. 4.7-94.

[96] RTC CBE-123.

[97] Rail Spur FEIR, p. 2-23.

[98] Rail Spur FEIR, p. 1-1.

remake requires more than asserting, without analytical support or mitigation for what are obvious significant impacts, that everything will be okay because the refinery would follow the formal Management of Feedstock Change Process.[99]

Second, the response assumes that if sulfur levels and TAN of the crude slate stay within the reported range, corrosion and hence corrosion-induced accidents are not an issue. This ignores the possibility of gradual creep in both sulfur and TAN levels, while remaining within the usual range, which could still be significant enough to cause an accident.

The SMR Rail Spur Project FEIR, for example, concedes that the new crude slate would increase sulfur levels by 0.8%.[100] From a corrosion standpoint, this is a significant increase. The SMR Rail Spur Project RDEIR did not discuss the impact of a 0.8% increase in sulfur on corrosion-induced accidents at the SMR.

The FEIR also relies on the Total Acid Number (TAN) to assure that corrosion will not result from the proposed crude slate switch. The TAN is a measure of total organic acids, some of which are corrosive, some not. This test does not disclose the specific acids that actually are present and thus can be misleading. The corrosivity of a given crude depends on the specific chemicals in the mix. Thus, TAN by itself is not an adequate indicator of whether a crude will cause corrosion.

As a rule-of-thumb, crude oils with a TAN number greater than 0.5 milligrams of potassium hydroxide per gram (mg KOH/g) are considered to be potentially corrosive and indicates a level of concern. A TAN number greater than 1.0 mg KOH/g is considered to be very high.[101] The "typical crude blend" at the SMR is reported as 1.0 mg KOH/g.[102]

Canadian tar sands crudes are very high TAN and sulfur crudes. The TAN of dilbits, for example, range from 0.98 to 2.42 mg KOH/g.[103] The Project is proposing to import crudes at the upper end of the sulfur range (5.0 vs. 5.2%) and TAN range (2.5 vs.

---

[99] Rail Spur FEIR, p. 2-35/36.

[100] Rail Spur FEIR, p. 4.3-49.

[101] Margaret Sheridan, California Crude Oil Production and Imports, Staff Paper, California Energy Commission, April 2006, p. 6; Available at: http://www.energy.ca.gov/2006publications/CEC-600-2006-006/CEC-600-2006-006.PDF.

[102] Rail Spur FEIR, Table 4.7-18.

[103] www.crudemonitor.ca.

4.0 mg KOH/g).[104] The upper end of the TAN range is far above the level of concern and far above the "typical crude blend" refined at SMR in the baseline.[105] As up to 97% of the current crude slate will be replaced by these tar sands dilbits, the TAN of the "typical crude blend" will increase above the current level of 1.0 mg/KOH/g.

For example, if 97% Peace Heavy River were refined, the typical TAN would increase to 2.5 mg KOH/g (0.03 × 1.0 + 2.5 × 0.97 = 2.45). Similarly, if 97% Peace Heavy River were refined, the typical sulfur content would increase from 4.2% to 4.98% (4.2 × 0.03 + 0.97 × 5.0 = 4.98). These are substantial increases when considering corrosion and indicate a very significant potential for catastrophic releases cause by corrosion-induced accidents. The RTC did not respond to my comments on this issue, instead asserting that various "accepted industry practices" would eliminate this risk and the new crudes would fall within the range of the current crudes. However, this does not address an alarming increase in the average.

In sum, the fact that the TAN and sulfur of the proposed tar sands dilbits falls within the range of crudes previously refined at SMR is irrelevant because the average will creep up. Thus, the RDEIR should have included a detailed analysis of the corrosion potential of the proposed crude slate, concluded it was significant and required mitigation, similar to that required in the Chevron EIR.

Sulfur and TAN creep are very important to consider because they are known to result in catastrophic accidents due to corrosion. A catastrophic blowout due to sulfur creep recently occurred at the Chevron Richmond Refinery. This refinery gradually changed crude slates, while staying within its established crude unit design basis for total weight percent sulfur of the blended feed to the crude unit,[106] the same reason used in the FEIR to justify that these impacts are not significant. This change increased the corrosion rate in the 4-sidecut line, which led to a catastrophic pipe failure in the #4 Crude Unit on August 6, 2012. This accident sent 15,000 people from the surrounding area for medical treatment due to the release and resulting fire that created huge black

---

[104] Rail Spur FEIR, Table 4.7.18.

[105] Rail Spur FEIR, Table 4.7-18.

[106] US Chemical Safety and Hazard Investigation Board, Chevron Richmond Refinery Pipe Rupture and Fire, August 6, 2012, p.34 ("While Chevron stayed under its established crude unit design basis for total wt. % sulfur of the blended feed to the crude unit, the sulfur composition significantly increased over time. This increase in sulfur composition likely increased corrosion rates in the 4-sidecut line.").

clouds of pollution billowing over the surrounding community and across the San Francisco Bay.[107]

The SMR has a similar crude unit, identified as the "crude tower" in the SMR Rail Spur Project FEIR Figure 2-10. These types of accidents can be reasonably expected to result from incorporating tar sands crudes into the SMR crude slate, even if the range of sulfur and TAN of the crudes remain the same, unless significant upgrades in metallurgy are required. This is the case as these crudes have significant concentrations of sulfur in the heavy components of the crude coupled with high total acid numbers (TAN) and high solids that aggravate corrosion. A crude slate change could result in corrosion from, for example, the particular suite of sulfur compounds or naphthenic acid content even if the crude slate is within the current design slate basis. This is the case due to chemical differences, not reflected in the lumper parameters of total sulfur and TAN, *e.g.*, different sulfur compounds and different corrosive acids. The gas oil and vacuum resid piping, for example, may not be able to withstand naphthenic acid or sulfidation corrosion from refining 76% to 97% tar sands crudes, potentially leading to catastrophic releases.[108]

Elevated levels of TAN and sulfur can cause accidents that result in catastrophic releases of air pollution. Such releases were not considered in the FEIR. Rather, the FEIR relies on the SMR's existing Process Safety Management program, including the Management of Change (MOC) and Mechanical Integrity (MI) programs, to prevent corrosion.[109] However, these programs were also in place at the Chevron Richmond Refinery (and many other similarly afflicted refineries) at the time of the August 2012 accident discussed above. They did not prevent a catastrophic accident caused by sulfur (or TAN) creep from changes in the crude slate that fell within the normal range. The recent Chevron Refinery Modernization Project FEIR incorporated many additional mitigation measures to improve these programs,[110] which should be required for the

---

[107] U.S. Chemical Safety and Hazard Investigation Board, Interim Investigation Report, Chevron Richmond Refinery Fire, Chevron Richmond Refinery, Richmond, California, August 6, 2012, Draft for Public Release, April 15, 2013, Available at; http://www.csb.gov/chevron-refinery-fire/.

[108] *See*, for example, K. Turini, J. Turner, A. Chu, and S. Vaidyanathan, Processing Heavy Crudes in Existing Refineries. In: Proceedings of the AIChE Spring Meeting, Chicago, IL, American Institute of Chemical Engineers; New York, NY, Available at: http://www.aiche-fpd.org/listing/112.pdf.

[109] Rail Spur FEIR, pp. 4.7-93/94.

[110] *See*, for example, Chevron Refinery Modernization Project, Revisions to Draft EIR Volumes 1 and 2, p. 4-40, Mitigation Measure 4.13-7h, Available at: http://chevronmodernization.com/project-documents/.

Santa Maria Refinery to mitigate the changes in amount and composition of sulfur and TAN in crudes imported by the Rail Spur Project.

Third, I commented that sulfidation corrosion (due to elevated sulfur levels) is an issue for the SMR because of the age of the facility, built in 1955. The response asserts that SMR follows industry guidelines to monitor, mitigate and prevent sulfidation corrosion.[111] However, following industry guidelines does not mitigate impacts if the piping is not adequate, as demonstrated by the Chevron accident. Refineries built before current American Petroleum Institute (API) standards were developed to control corrosion and before piping manufacturers began producing carbon steel in compliance with current metallurgical codes, are at significant risk of sulfidation corrosion induced accidents unless the piping is replaced to meet current metallurgical codes. The response to Comment CBE-123 does not disclose any information about the metallurgy of the SMR, which was built in 1955 before the codes were developed.

The early construction date suggests the metallurgy used throughout much of the SMR may not be adequate to handle the unique chemical composition of tar sands crudes without significant upgrades. There is no assurance that required metallurgical upgrades would occur if tar sands crudes dominate the crude slate, as they are very expensive and are not required by any regulatory framework. Experience with changes in crude slate at the Chevron Refinery in Richmond in the San Francisco Bay Area suggest required metallurgical upgrades are often ignored and may lead to catastrophic accidents.[112]

Sulfidation corrosion generally occurs above about 500°F for carbon steel pipe and above about 600°F for 5 Cr low-alloy steel. Some sulfide species are more corrosive than others, including mercaptans, hydrogen sulfide, and disulfides, all of which occur at elevated levels in tar sands crudes. Sulfidation corrosion manifests as uniform thinning and thus cannot be detected from visual inspections. Low silicon carbon steel can corrode 2 to 10 times faster than higher silicon carbon steel.[113]

---

[111] RTC CBE-123.

[112] U.S. Chemical Safety and Hazard Investigation Board, Interim Investigation Report, Chevron Richmond Refinery Fire, Chevron Richmond Refinery, Richmond, California, August 6, 2012, Draft for Public Release, April 15, 2013; Available at: http://www.csb.gov/chevron-refinery-fire/.

[113] E.H. Niccolls, J.M. Stankiewicz, J.E. McLaughlin, and K. Yamamoto, High Temperature Sulfidation Corrosion in Refining, September 2008, 17th International Corrosion Congress, Corrosion Control in the Service of Society, Vol. 1 of 5, as cited in: Interim Investigation Report, Chevron Richmond Refinery Fire, August 6, 2012; Available at: http://www.csb.gov/assets/1/19/Chevron_Interim_Report_Final_2013-04-17.pdf.

How much low silicon carbon steel piping is present at SMR? What impact will an admitted 0.8% increase in sulfur have on this piping? What sulfur compounds are present in the 0.8% increase in sulfur? Could sulfur increase more than 0.8%? The SMR Rail Spur Project FEIR and the response to Comment CBE-123 did not disclose either the specific suite of sulfur compounds in the proposed imports or the metallurgy and operating conditions in the units potentially susceptible to sulfidation corrosion, even though I raised both of these issues. Thus, the FEIR fails as an informational document under CEQA.

Refinery emissions released in upsets and malfunctions can, in some cases, be greater than total operational emissions recorded in formal inventories. For example, a recent investigation of 18 Texas oil refineries between 2003 and 2008 found that "upset events" were frequent, with some single upset events producing more toxic air pollution than what was reported to the federal Toxics Release Inventory database for the entire year.[114]

Catastrophic releases of air pollution from these types of corrosion-caused accidents were not considered in the FEIR and are significant. They could adversely impact on-site and off-site workers and other nearby sensitive receptors. Mitigation should be imposed, including at least the following:

- All mitigation measures required in the Chevron Refinery Modernization Project FEIR;
- 100% component inspection of all carbon steel piping systems susceptible to sulfidation corrosion; and
- Modification of work processes for review of damage mechanisms for processes covered by the Process Safety Management standard to conform with the American Petroleum Institute Recommended Practice 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry. The revised work processes shall require consideration of damage mechanism reviews as part of the Process Hazard Analysis process.[115]

---

[114] J. Ozymy and M.L. Jarrell, Upset over Air Pollution: Analyzing Upset Event Emissions at Petroleum Refineries, Review of Policy Research, v. 28, no. 4, 2011. (Exhibit 16)

[115] Terms and Conditions of Probation, People v. Chevron U.S.A. Inc., Superior Court of the State of California, County of Contra Costa, Case No. 1-162745-4. (Exhibit 17)

III.B Hazards Due to New Facilities

Section 4.7 of the DEIR contains the "hazards and hazardous materials" impact analyses, sometimes called the risk of upset analysis. This section evaluates the consequences of fire and explosion hazards from the new unloading facility, new aboveground pipeline, and the presence of railcars on the new rail spur. Two separate impacts were evaluated: (1) on-site accidents from crude oil unloading through pipeline transport to storage tanks at the SMR and (2) on-site train accidents. Impact HM.1 (Risk of Accidents at Unloading Facility) is designated as "less than significant"[116] or "Class III"[117] and no mitigation is proposed. The supporting material includes extensive discussion of the applicable regulatory framework and general methods used to analyze these types of impacts, but no discussion of how the impact conclusion was reached. It is simply stated.

The conclusion — that the maximum hazard zones are within the boundaries of the SMR and thus not significant — appears magically[118], without any support or explanation of how this conclusion was reached, beyond pointing at 75 pages of technical information in Appendix H.3. The supporting analyses in Appendix H.3 are impenetrable to all but subject area experts. Appendix H.3 indicates that the FEIR's analysis in Section 4.7 is misleading and fatally flawed. Offsite impacts from on-site accidents involving the unloading facility and on-site trains are highly significant and unmitigated.

The FEIR evaluated three types of on-site crude release accidents: (1) on-site crude railcar accident pool fires; (2) on-site crude railcar accident Boiling Liquid Expanding Vapor Explosions (BLEVES); and (3) on-site crude pipeline accident pool fires.[119] The FEIR asserts none of these accident scenarios result in significant impacts.

However, the FEIR buries the supporting analyses in dense appendices, presented in metric units, which are not accessible to the typical reviewer. The FEIR fails to explain how to translate the results of these analyses into impact conclusions that can be understood by non-subject-matter experts, thus preventing meaningful public review of the impacts. The FEIR further incorrectly summarizes the results of

---

[116] Rail Spur FEIR, p. IST-43.

[117] Rail Spur FEIR, p. 4.7-40.

[118] Rail Spur FEIR, Table 4.7.8 and Figure 4.7-4.

[119] Rail Spur FEIR, pp. H.3-2/17.

these analyses in the text as insignificant, when, in fact, they are highly significant. The FEIR thus fails as an informational document.

The FEIR explains that several crude oil spill scenarios were modeled to evaluate worst-case thermal radiation hazards associated with a large crude oil fire, ranging from small releases from a tank car, full tank car releases, and full pipeline releases, citing Appendix H.3. The FEIR then presents a table summarizing what it calls the "worst case onsite thermal radiation hazard zones."[120] This worst-case scenario is asserted to be a spill of nearly the entire pipeline, assumed to drain onto the ground in the area between the unloading facility and refinery storage tanks."[121] The summary table presents the distance from the accident site at various wind speeds to two thermal radiation intensities endpoints. These thermal radiation endpoints are the significance criteria used to evaluate impacts. The FEIR explains:

> "Exposure to a thermal radiation level of 10 kW/m^2 [kilowatt per square meter] could result in a serious injury (at least second-degree burns) if exposed for less than 1 minute, and it was, therefore, assumed that all persons exposed to 10 kW/m^2 would suffer serious injuries. Serious injuries would start to be realized at and above 5 kW/m^2. Exposure to thermal radiation levels in excess of 10 kW/m^2 would likely begin to generate fatalities in less than 1 minute. All persons exposed to thermal radiation within the flame area were assumed to suffer fatalities regardless of exposure duration."[122]

The FEIR then summarizes this information on a map of the site with the 5 and 10 kW/m^2 hazard zones superimposed.[123] This figure shows that none of the flammable hazard zones have the potential for off-site impacts. However, this analysis is inconsistent with the information in Appendix H.3, which includes several on-site accident scenarios that result in significant off-site impacts. The FEIR is silent on why these other accident scenarios are not discussed in Section 4.7. They are discussed below.

---

[120] Rail Spur FEIR, Table 4.7.8.

[121] Rail Spur FEIR, p. 4.7-44.

[122] Rail Spur FEIR, p. H.1-14. *See* also discussion on p. H.1-13.

[123] Rail Spur FEIR, Figure 4.7-4.

III.B.1 Worker Impacts Excluded

The FEIR fails to evaluate the impacts of accidents on workers, arguing in the odor impact section that "OSHA related worker issues are outside the scope of the EIR."[124] The FEIR specifically excludes workers from its risk of upset significance criteria, arguing they do not apply to occupational safety, *viz.*, "Occupational risk, which is governed by state and federal OSHAs is considered to be more voluntary and is generally judged according to more lenient standards of significance than those used for involuntary exposure".[125]

However, neither state nor federal OSHA nor other regulations cover the types of involuntary risks imposed by unit train accidents and exploding pipelines and tanks on workers in the vicinity of these facilities. A death is a death and it should not matter whether it is an on-site worker, off-site worker, or other member of the public. A worker is a member of society at large and is protected by CEQA. None of the federal and state laws reviewed in FEIR Section 4.7.2 include any measures to protect any workers, on-site or off-site, from train, pipeline, and tank farm accidents.

Regardless, CEQA is not a gap-filling regulatory program. CEQA covers all impacts to all media — the public, air, water, land, biological resources — regardless of how they may be classified, i.e., on-site workers, off-site workers, residents, threatened and endangered species, etc. These types of catastrophic events are entirely outside of the jurisdiction of OSHA or any other federal or state regulatory program and must be evaluated in the FEIR. The FEIR must be revised to address on-site worker impacts and be recirculated.

III.B.2 Coke Storage Area

The rail spur and unloading facility are adjacent to the coke storage area. Coke is a combustible material and could be engulfed in a major fire triggered by accidents within the unloading facility. A fire in the coke storage area would release metals associated with coke. Metals are present at elevated concentrations in all cokes[126] compared to crustal materials. Many are elevated even more compared to conventional crudes. This was not considered in any of the analyses and would result in far more significant impacts than disclosed in the FEIR.

---

[124] Rail Spur FEIR, p. 4.3-80.

[125] Rail Spur FEIR, p. 4.7-38.

[126] Table A-7 CFB Trace Compounds, Las Brisas Energy Center, LLC (Exhibit 18).

III.B.3 Tank Farm Accidents Are Significant

The FEIR states that imported crude would be sent through a 3,525-foot long pipeline to existing refinery storage tanks, concluding: "Therefore, crude oil storage would not result in any increase in fire and explosion risk at the refinery."[127] The FEIR does not contain any analysis to support this assertion. *See*, for example, Appendix H.3, which does not include a storage tank accident scenario, but rather only rail car and pipeline accident scenarios. The tank farm is important to evaluate as it is close to off-site receptors.[128] However, as noted below, one of the pipeline scenarios appears to engulf the tank farm.

This unsupported assertion is incorrect because it assumes no change in the properties of stored crude. The Project would change the composition of the crude slate. As noted elsewhere, up to 97% of the crude slate would transition from local heavy crude oils to much lighter and more corrosive tar sands dilbits. These crudes would increase the risk of fire and explosion, compared to the baseline crude slate, impacting not only workers, but also off-site parties. Further, tar sands crudes are more corrosive than the current crude slate and deposit large amounts of solids in storage tanks.

The FEIR only acknowledges the existing tank farm, but doesn't analyze hazard impacts resulting from storing a new crude oil. Rather, it concludes with no analysis at all:

> "Thermal radiation impacts from crude oil tank fires could cause injury 220 feet away. The closest population to the crude oil tanks at the Refinery is an industrial area 425 feet northeast of the crude oil storage facilities. The closest residence to the crude oil tanks, which is located within the industrial area, is 1,200 feet northeast of the tank storage area. The gas processing equipment and piping are at least 1,700 feet from the property fence line. Given the limited population and significant distance between these receptors and the SMR, there would not be a significant risk level"[129]

The FEIR does not contain any analysis for the tank farm. Thus, there is no support for the 220-foot impact distance.

---

[127] Rail Spur FEIR, p. 4.7-43.

[128] Rail Spur FEIR, Figure 2-3.

[129] Rail Spur FEIR, pp. 9-49, with similar language at pp. 4.7-15/97.

However, the analyses supporting the claimed 220-foot injury distance is not included in the FEIR and likely is based on the crude slate currently processed at the Santa Maria Refinery. Further, the nature of the "injury" is not disclosed. Regardless, a switch from current crude to tar sand dilbits or North American light crudes with an API gravity up to 30° would significantly increase the injury distance, likely far in excess of the 425-foot distance to the nearest receptor if the contents of the tanks were involved in a pool fire or a BLEVE. Thus, accidental releases from the tank farm were not analyzed in the FEIR and are likely highly significant.

III.B.4 Pipeline Accidents Are Significant

The FEIR includes a crude oil pipeline accident analysis for a pool fire, assuming a spill of 692,000 barrels of crude oil for wind speeds of 1 meter per second (m/s) (about 2 miles per hour (mi/hr) and 20 m/s (about 45 mi/hr).[130] The FEIR does not further describe this accident scenario. The volume spilled suggests it is the worst case accident that engulfs the entire tank farm[131] plus the full contents of a unit train. Regardless, the analysis is included in the FEIR as supporting the conclusion that pool fire accidents involving the pipeline would not result in significant off-site impacts.

The supporting analyses in Appendix H.3 are presented in a format that is not accessible to the average reviewer. Thus, they are extracted and summarized in Table 3.

Table 3:
Summary of
Crude Pipeline Accident Pool Fire[132]

	Heat Flux (kW/m²) **at Impact Distance** (ft)		
Wind Speed (m/s)	**5**	**10**	**12.5**
1	1,647	889	764
20	2,641	1,555	1,273

The impact metric in these analyses is "heat flux" expressed as kilowatts per square meters (kW/m²). Heat flux is thermal radiation intensity, the measure used in the FEIR to determine the resulting injury to exposed parties.

[130] Rail Spur FEIR, pp. H.3-14/16.
[131] Rail Spur FEIR, Table 2-6.
[132] Rail Spur FEIR, pp. H.3-14/17.

The interpretation of these data (and other similar data extracted from Appendix H.3 and summarized in these comments) requires a map that shows the location of potentially exposed populations relative to the accident sites (anywhere along the rail line within the Refinery boundary, at the unloading rack, along the new pipeline, at the new pipelines junction with existing storage tanks). It is common to include such a map in an EIR to locate the sensitive receptors. However, the FEIR fails to include a sensitive receptor map that locates all nearby residential and industrial properties and is thus deficient.

Any population located between the accident site(s) up to the reported impact distance, *e.g.*, as far away as 2,641 feet in Table 3, would experience significant impacts. At a heat flux of 5 kW/m^2, 10% injury would be experienced in the exposed population up to 2,641 feet from the accident if the wind were blowing at 20 m/s during the accident. Up to 1,555 feet from the accident, 100% of the exposed population would be injured, including second-degree burns in 14 seconds and 10% fatality at 60 seconds. And up to 1,273 feet from the accident, significant fatalities would occur. Significant impacts would also occur at a wind speed of 1 m/s up to 1,647 feet from the accident site.[133]

A pool fire pipeline accident could occur anywhere along the pipeline route, which could result in fires and BLEVES that would impact railcars and the tank farm. Assuming the pipeline accident modeled in the FEIR under calm wind conditions (1 m/s or about 2 mi/hr) engulfs the tank farm, significant impacts would occur up to 1,647 feet from the accident site under calm wind conditions (1 m/s). The impacted area includes an industrial area 425 feet northeast of the tank farm and a residence within the industrial area at 1,200 feet.[134] At a wind speed of 20 m/s (about 45 mi/hr), all persons up to 2,641 feet away would be seriously impacted and within a radius of 1,273 feet from the accident site, they would all be killed.

Thus, an accident along the new pipeline connecting the rail spur unloading facility and the existing tank farm that engulfs the tank farm has the potential to result in significant off-site (as well as even more significant on-site worker) impacts that were not disclosed in the text of the FEIR and incorrectly classified in Impact HM.1 as insignificant (Class III).[135] The actual modeling in Appendix H.3 indicates that off-site

---

[133] *See* Rail Spur FEIR, Appendix H.1, Table 3 for thermal radiation serious injury impact thresholds.

[134] Rail Spur FEIR, pp. 9-49, 4.7-97.

[135] Rail Spur FEIR, p. 4.7-40.

parties would be killed by on-site accidents. This is a significant impact that was not disclosed in the FEIR, but rather buried in an appendix that requires expert interpretation.

III.B.5 On-Site Train Accidents Are Significant

The FEIR also included on-site crude rail car accident scenarios, ranging from small releases from a railcar to the complete instantaneous loss of containment of a railcar contents, resulting in both pool fires and Boiling Liquid Expanding Vapor Explosions or "BLEVEs" for wind speeds ranging from 1 m/s to 20 m/s. Railcars can be exposed to pool fires and thermal tears with the initiating event being pipeline spills and fires as opposed to railcar accidents themselves, which are unlikely due to low speeds, except on entrance to the facility from the north.

The FEIR asserts, based on the analyses buried in Appendix H, that "potential hazards associated with the unloading facility are considered less than significant" and "[h]azards associated with the onsite portion of the Rail Spur Project would be less than significant since the worst case hazard zones do not extend outside of the boundaries of the SMR."[136]

However, my analysis of the railcar accident modeling in Appendix H.3 indicates that the risks from train accidents within the Refinery boundary result in significant on-site and off-site impacts for both pool fires and BLEVEs.

III.B.5.i Pool Fires

The FEIR analyzed pool fires resulting from an on-site crude railcar accident in which 54,440 barrels of crude (i.e., the entire contents of a unit train) are released for wind speeds ranging from 1 m/s to 20 m/s (2 mi/hr to 45 mi/hr).[137] These analyses report "heat flux" in kW/m^2 as a function of distance from the release, for distances of 100 to 1,000 meters (328 to 3,281 feet). An accident could occur anywhere within the Refinery boundary along the rail tracks shown on Figure 2-3. The results of the FEIR's railcar pool fire analyses are buried in Appendix H.3 in a format not accessible to the average reviewer. Thus, they are summarized in Table 4.

---

[136] Rail Spur FEIR, p. 4.7-44.

[137] Rail Spur FEIR, pp. H.3-2/9.

Table 4:
Summary of On-Site
Crude Railcar Accident Analysis[138]
of Pool Fires

Wind Speed (m/s)	**Heat Flux** (kW/m²) **at Impact Distance** (ft) **5**	**10**	**12.5**
1	775	407	331
5	876	495	410
10	928	541	446
20	1,404	958	810

The boundaries of the Refinery are shown in FEIR Figure 2-3. This figure and Google Earth maps indicate that the northeastern boundary of the Refinery where the rail line enters from north abuts industrial and residential property to the east and north and recreational areas in the Coastal Zone to the west. Sensitive receptors are located in these areas, for example, residences along Monadella Street and in areas to the north and south of Highway 1 (Willow Road) and users of the Oceano Dunes State Vehicular Recreation Area and Oso Flaco Lake and Dunes to the west.

The results of the railcar accident modeling summarized in Table 4 indicate that both on-site and off-site impacts are significant. When the wind speed is 20 m/s (45 mi/hr), the heat flux is 5 kW/m² at up to 1,404 feet from the accident site and 12.5 kW/m² at up to 810 feet from the accident site. FEIR Figure 2-3 indicates that if the accident occurred along the rail line near where it enters the refinery from the north, off-site sensitive receptors would be located within 1,404 feet of the accident site. Accidents are likely at this point due to the presence of various switches and a mix of trains.[139] Further, the maximally exposed individual resident (MEIR) in the cancer risk assessment is located in this area and is only about 1,300 feet from the rail line.[140] Thus, significant off-site impacts would occur from an accident within the Refinery boundary.

Further, refinery workers would be present throughout the Refinery and at the unloading facility. These workers would be the most highly exposed populations and would experience significant mortality.

---

[138] Rail Spur FEIR, pp. H.3-2/9.

[139] Rail Spur FEIR, p. 4.7-2 (Caselton ND CBR accident).

[140] Rail Spur FEIR, Figure 4.3-6.

Thus, railcar accidents within the Refinery boundary would result in significant impacts to both on-site and off-site populations. These impacts were not disclosed in the FEIR, but rather buried in a maze of tables that are not explained or analyzed.

III.B.5.ii Boiling Liquid Expanding Vapor Explosions (BLEVEs)

The FEIR also evaluated the radiant heat exposure and explosion over pressures resulting from an on-site railcar accident involving a Boiling Liquid Expanding Vapor Explosion or "BLEVEs." However, the FEIR fails to discuss the results of this analysis, which is buried in FEIR Appendix H.3 in a format not accessible to the average reviewer. Thus, they are summarized in Table 5.

Heat flux for the BLEVE analysis is reported in the FEIR in units of kilojoules per square meter (kJ/m^2), which is just another measure of heat density, similar to kW/m^2 used to evaluate pool fires, but just expressed in different units. The FEIR does not explain how to interpret heat flux. However, the DEIR did. At a heat of 40 kJ/m^2, 10% injury will result, at 150 kJ/m^2, 100% injury will result, and at 250 kJ/m^2, 1% fatalities will occur.[141]

Table 5:
Results of
Radiation Exposure Analysis from
On-Site Railcar Accident BLEVE[142]

Impact Distance (ft)	Radiant Heat Significance Threshold (kJ/m2)
1,690	40
1,194	80
1,066	100
859	150
830	160
643	250

Table 5 shows that significant impacts, 20% injury, will occur at up to 1,690 feet from the accident site. As discussed above, if the accident occurs, within the Refinery boundary, significant impacts will result outside of the Refinery, in industrial/residential areas to the east and in the Coastal Zone areas to the west.

[141] Rail Spur DEIR, Table 4.7.4.

[142] Rail Spur FEIR, pp. H.3-10/13.

Further, workers within 1,690 feet of the accident would also experience significant impacts, and those within 643 feet of the accident may die. These are significant impacts that were not disclosed in the FEIR.

III.B.6 The FEIR's Analysis Is Not Supported

The FEIR asserts that the "worst-case spill" would be about 90,800 gallons (2,162 bbl) of crude oil.[143] The information reviewed above from the supporting Appendix H.3 indicates that this is not correct. The FEIR identified much larger accidents. The accident that the FEIR claims is the worst case does not appear to be included in supporting Appendix H.3 or elsewhere in the record.

The FEIR then presents what it characterizes as the "worst-case thermal radiation hazards associated" with this worst case accident, summarized in Table 4.7-8 and Figure 4.7-4.[144] This information suggests that the significant impact zone remains fully contained on site, contrary to the accident scenarios in Appendix H.3. However, Figure 4.7-4 does not support this conclusion.

Figure 4.7-4 shows isopleths of flammable hazard zones. The center of these isopleths are at the location where the new pipeline turns 90 degrees, roughly midway between the unloading facility and the tank farm, compared with Figure 2-3. However, the FEIR states "The worst case spill occurs just north of the unloading facility where nearly the entire pipeline would drain onto the ground due to the slope of the area between the unloading facility and refinery storage tanks."[145]

Figure 2-3 shows that the unloading facility and storage tanks extend over a large distance to the east and south of the center of the circles in Figure 4.7-4. In a real worst case, such as where a pipeline fire would result in fire engulfing the unloading facility and adjacent storage tracks, as evaluated in scenarios in Appendix H.3, there would be chain events of fire and BLEVEs over a large area to the east and south. Some of this area is proximate to off-site receptors, such as along the refinery boundary southeast of the tank farm. Further, the eastern end of the storage tracks is proximate to Highway 1 on the eastern boundary of the refinery.

---

[143] Rail Spur FEIR, p. 4.7-43.

[144] Rail Spur FEIR, pp. 4.7-43/45.

[145] Rail Spur FEIR, p. 4.7-44.

IV. OFF-SITE HAZARDS: MAINLINE RAIL ACCIDENTS, SPILLS, FIRE, AND EXPLOSIONS

Mainline rail accidents, spills, fires, and explosions associated with the Project were found to have significant and unavoidable (Class I) impacts in regard to the following four issue areas:

- Hazards and Hazardous Materials (Impact HM.2),
- Public Services and Utilities (Impact PS.4),
- Water Resources (Impact WR.3), and
- Agricultural Resources (Impact AR.5).

In addition to the Project, a number of other crude by rail projects have been proposed or undertaken within California. The Project, together with other crude by rail projects, was found to have significant and unavoidable cumulative impacts from mainline rail accidents and spills, in regard to these same four issue areas.[146]

IV.A Hazards and Hazardous Materials (Significant Impact HM.2)

The main hazards associated with the Project are potential accidents along the Union Pacific Railroad (UPRR) mainline that could result in oil spills, fires, and explosions.[147] The FEIR used a Quantitative Risk Analysis (QRA) to determine the significance of mainline rail accidents and spills associated with the Project. Specifically, the QRA was used to determine the level of risk associated with the movement of trains from the SMR to the Roseville and Colton rail yards as well as to the California Border. The risk was found to be significant in the event of a release of crude oil that resulted in a fire or explosion in the vicinity of a populated area:

> "For the UPRR mainline tracks a quantitative risk assessment (QRA) was conducted to determine the level of risk associated with the movement of trains from the SMR to the Roseville and Colton rail yards as well as to the California Border. The risk for the full length of all three of the routes evaluated was found to be significant (Class I) in the event of a release of

[146] Hazards and Hazardous Materials, Public Services and Utilities, Water Resources, and Agricultural Resources.

[147] Rail Spur FEIR, p. ES-12.

crude oil that resulted in a fire or explosion in the vicinity of a populated area."[148]

[…]

"**The risk is primarily driven by the HTUA (Los Angeles Area, Bay Area, and Sacramento**)[149] […] **These are areas with high population densities in close proximity to long stretches of track, which increase the risk of larger numbers of injuries and facilities**."[150]

As confirmed by the QRA, mainline rail accidents, spills, fire, and explosions associated with the Project could result in large numbers of injuries and fatalities. Given the location of SMR, and the configuration of the rail network, crude trains would travel long distances through highly populated areas. These high populated areas include long stretches in the Los Angeles Area, Bay Area, and Sacramento, but they also include shorter stretches in cities throughout the state.[151]

Mainline rail accidents, spills, fire, and explosions associated with the Project were found to have impacts that were significant and unavoidable (Class I) in regard to Hazards and Hazardous Materials (Impact HM.2).

IV.B All Feasible Mitigation Not Required for Significant Impact HM.2

As more fully explained below, the FEIR does not adequately consider and recommend feasible options to mitigate hazards (Significant Impact HM.2). FEIR Mitigation Measure HM-2a should be amended to require higher standard DOT-120 or DOT-114 pressure tank cars.

Phillips 66 would own or lease all of the tank cars servicing the SMR as part of either a unit or manifest train. Phillips 66 proposes to use CPC-1232 tank cars, which are much less protective than other available tank cars.[152] Phillips 66 is not a rail carrier.

The FEIR recommends Mitigation Measure HM-2a requiring use of Option 1 tank cars in the Project:

---

[148] Rail Spur FEIR, p. ES-12.

[149] Rail Spur FEIR, p. 4.7-60, emphasis added; see FEIR Appendix H.6 for a list of High Threat Urban Areas (HTUAs).

[150] Rail Spur FEIR, p. 4.7-88, emphasis added.

[151] *See* Rail Spur FEIR, pp. 2-25, 4.7-16-4.7-17, 4.7-62-4.7-87.

[152] Rail Spur FEIR, p. 1-4, 2-22.

> "Only rail cars designed to FRA, July 23, 2014 Proposed Rulemaking Option 1: PHMSA and FRA Designed Tank Car as listed in Table 4.7.6, shall be allowed to unload crude oil at the Santa Maria Refinery." [153]

The FEIR concludes that use of Option 1 tank cars would result in substantially lower risk, but the hazards associated with the Project would still be significant:

> "Implementation of HM-2a would reduce the probability of a release from a rail car by about 74 percent over the rail car design that is currently proposed by the Applicant. […]
>
> Even with this reduction in release probability, the hazards associated with the Rail Spur Project risk along the UPRR right-of-way would still be potentially significant (Class I) in the event of a release of crude oil that resulted in a fire or explosion."[154]

The FEIR does not adequately consider and recommend feasible options to mitigate hazards. In terms of tank car designs, the FEIR has apparently only considered options from the DOT rulemaking.[155] Mitigation Measure HM-2a requires use of tank cars designed to Option 1, which is identified as "the safest tank car design that was part of the […] DOT […] rulemaking".[156]

As more fully explained below, Option 1 is <u>not</u> the safest tank car design that is available and permitted for transporting crude. There are higher standard pressure tank cars that would provide an additional safety benefit. These cars, which are designed to minimize leaks, would also provide feasible mitigation of one of the Project's significant air quality impacts, namely railcar fugitive ROG emissions along the entire route in California as well as on-site.

The tank car designs that were part of the recent DOT rulemaking are all general service (non-pressure) tank cars.[157] Crude oil has most commonly been transported in non-pressure tank cars, but DOT regulations specify that pressure tank cars can also be

---

[153] Rail Spur FEIR, p. 4.7-88; see FEIR, pp 4.7-24-4.7-27, for information on Option 1 tank cars.

[154] Rail Spur FEIR, p. 4.7-88. *See* also FEIR, p. ES-12-ES-13.

[155] Rail Spur FEIR, pp. 4.7-24-4.7-27 (USDOT Proposed Rulemaking for High-Hazard Flammable Trains (HHFT)).

[156] Rail Spur FEIR, p. ES-12.

[157] Rail Spur FEIR, pp. 4.7-24-4.7-27.

used for crude oil and other flammable liquids.[158] Pressure tank cars are used to transport higher hazard materials to minimize leaks and prevent releases when accidents occur.[159] They are designed to minimize leaks of toxic materials such as chlorine and can be retrofitted with enhanced fittings packages specifically designed to minimize leaks.[160]

Tesoro[161] has recently upgraded its crude by rail fleet with DOT-120 pressure tank cars that exceed the new DOT-117 non-pressure tank car standard.[162] Figure 3 provides the Tesoro Fact Sheet on the DOT-120 tank cars.

---

[158] Crude and other flammable liquids are permitted to be transported in pressure tank cars including DOT-105, 109, 112, 114, and 120. *See* USDOT Final Rule, Table 6 (80 FR 26653 (May 8, 2015)).

[159] Field Guide to Tank Cars, AAR Transportation Technology Center Bureau of Explosives, revised edition January 30, 2012, pp. 47-48 (Classes DOT-105, 109, 112, 114, and 120 are pressure tank cars used to transport liquefied compressed gases, poison/toxic inhalation hazard (PIH/TIH) materials, reactive materials, and/or corrosive materials requiring the additional protection afforded by a stronger car. Pressure tank cars are used to transport highly flammable LPG (liquefied petroleum gases, such as propane and butane), as well as very high hazard TIH chemicals such as chlorine gas and anhydrous ammonia.); Available at: https://drive.google.com/file/d/0B2FxPRhLGkEmTlZORm5YSVpTOGc/view?pref=2&pli=1.

[160] *See*: Midland Pressure Cars (Exhibit 6).

[161] Tesoro is a large independent refiner, with six refineries in the western US, including two in California. http://tsocorp.com/. Tesoro is extensively involved in crude by rail. *See* Rail Spur FEIR, p. 3-8; Valero RDEIR, p. 2-146; http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9NTcwOTEyfENoaWxkSUQ9MjcyMDYxfFR5cGU9MQ==&t=1;

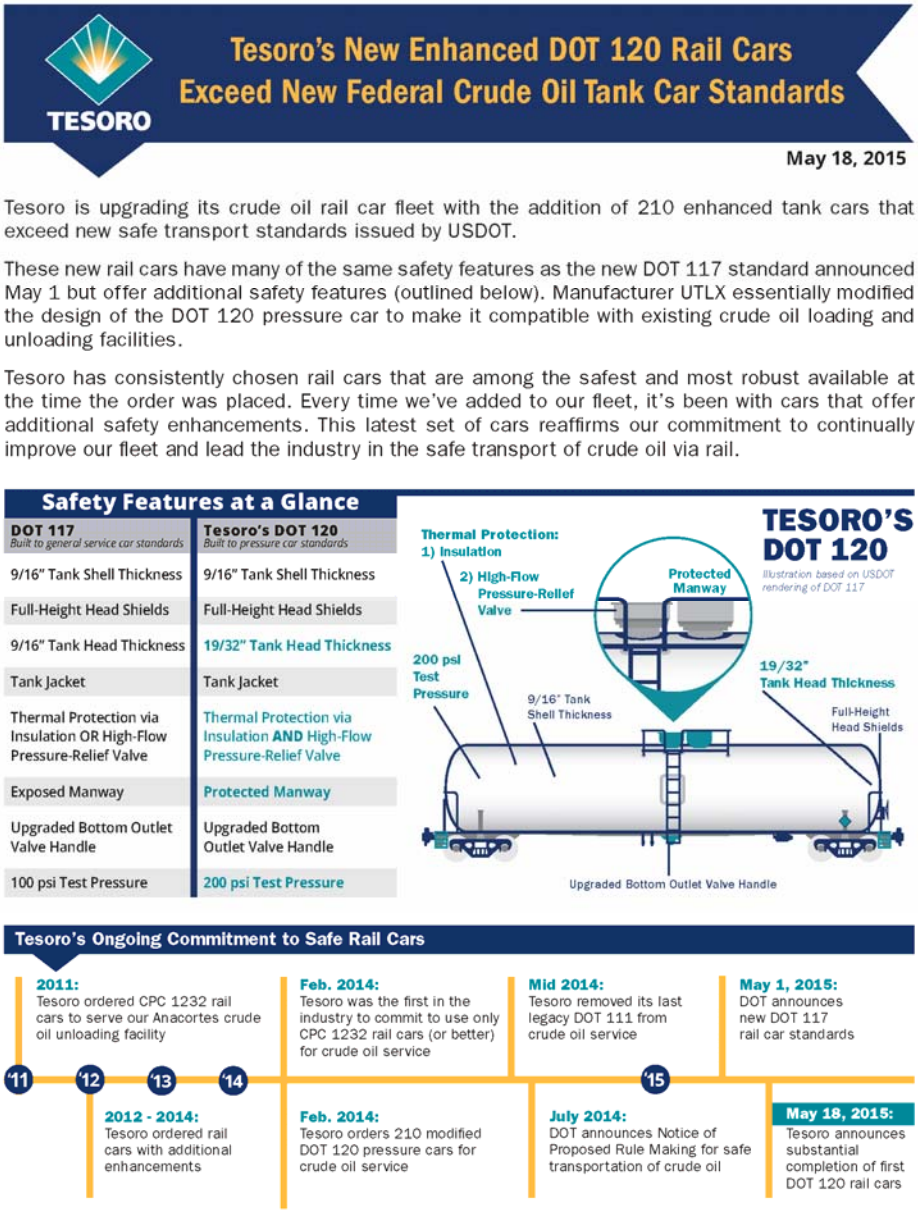
http://phx.corporate-ir.net/phoenix.zhtml?c=79122&p=irol-newsArticle&ID=2128049;

http://www.reuters.com/article/tesoro-rail-crude-idUSL2N0IS13N20131107.

http://www.efsec.wa.gov/Tesoro-Savage.shtml.

[162] Tesoro May 18, 2015 Press Release http://phx.corporate-ir.net/phoenix.zhtml?c=79122&p=irol-newsArticle&ID=2049329; for information regarding the new DOT-117 standard, see FEIR Section 4.7.5, USDOT Final for High-Hazard Flammable Trains (HHFT), and USDOT Final Rule: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains (80 FR 26644-26750 (May 8, 2015)).

Figure 3: Tesoro DOT-120 Tank



Cars[163]

The Tesoro DOT-120 tank cars exceed the DOT-117 standard and also exceed the Option 1 tank car design required in FEIR Mitigation Measure HM-2a. The DOT-120 cars have most of the same safety features as the Option 1 design, but also have some additional safety features:

- a thicker tank head (19/32" vs. 9/16"); and

[163] https://tsocorpsite.files.wordpress.com/2015/05/tesoro-dot-120-fact-sheet.pdf.

- two times the rated tank test pressure (200 psi [pounds per square inch] vs. 100 psi).[164]

Compared with the Option 1 design required in FEIR Mitigation Measure HM-2a, the Tesoro DOT-120 tank car design would improve safety.[165] But the Tesoro DOT-120 design is not the only available option for railcars safer than the Option 1 design; other higher standard tank car designs could provide significant additional mitigation of Significant Impact HM.2.

The Tesoro DOT-120 tank car design has a minimum tank shell thickness of 9/16", as does the Option 1 design.[166] Other DOT-120 and DOT-114 pressure tank car designs have a minimum tank shell thickness of 11/16".[167] Additional tank shell thickness can provide a substantial safety benefit.[168]

The DOT-120 and DOT-114 designs with additional shell thickness also have higher rated tank pressure (300-500 psi, vs. 200 psi for the Tesoro DOT-120 design).[169] This would provide an additional safety benefit, as well as mitigate one of the Project's significant air quality impacts, on-site and off-site railcar fugitive ROG emissions. Comment IV.B.

The railcars leak ROG emissions from numerous closures, fittings, and valves on the railcars, both while in transit to the site and while on-site. For the five train per week option, fugitive ROG emitted from on-site railcars are 2,587 lbs/day per unit train visit and 336 ton/yr. For the three train per week option, daily emissions are the same and annual emissions are 202 ton/yr. Both the annual and daily ROG emissions for both of these cases exceed the SLOCAPCD ROG+NOx CEQA significance thresholds of 25 lb/day and 25 ton/yr. Thus, ROG emissions from on-site railcar fugitive leaks are a

---

[164] Option 1 is similar to the new DOT-117 standard (Option 2 design in the DOT rulemaking), except that Option 1 incorporates a more damage-resistant top fittings design. The Tesoro DOT-120 cars include a protective housing for the manway. FEIR, p. 4.7-27; 4.7-96; Appendix H.2, p. 7.

[165] The QRA did not evaluate the Tesoro DOT-120 tank car design, and there do not now seem to be any publically available safety studies for this car design. Compared with Option 1, the Tesoro 120 tank car design has additional safety features, but it is uncertain how much this will improve safety. https://www.sightline.org/2015/12/15/tesoros-new-oil-train-cars-too-few-and-still-too-dangerous/

[166] The DOT-117 (Option 2) design also has a minimum tank shell thickness of 9/16". Other non-pressure tank car designs used for crude rail (including DOT-117R/Option 3, and some CPC-1232 and DOT-111) have a minimum tank shell thickness of 7/16".

[167] *See* footnote 169.

[168] *See* http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR1201.pdf pp. 58, 76-77.

[169] *See* footnote 169.

highly significant, unmitigated operational air quality impact that was not disclosed in the FEIR.

In addition, daily and annual railcar ROG emissions are significant in every air district through which they pass, except Placer County, where emissions are underestimated due to the failure to include Roseville Yard operations. Further, annual ROG emissions are significant in every air district through which they pass that has an annual CEQA significance threshold, except SLOCAPCD.

Absent additional mitigation, the Project will use non-pressure tank cars. Option 1, CPC-1232, and DOT-117 designs are non-pressure tank cars, with a rated test pressure of 100 psi. If the Project uses pressure tank cars, this may mitigate air quality impacts from fugitive railcar ROG. The Tesoro DOT-120 design (with a shell thickness of 9/16") has a rated test pressure of 200 psi, but other DOT-120 and DOT-114 designs (with a shell thickness of 11/16") have rated test pressures of 300, 400, or 500 psi. *See* footnote 169.

Therefore, the FEIR failed to incorporate all feasible mitigation measures to reduce significant impacts, as required under CEQA. FEIR Mitigation Measure HM-2a should be amended to require DOT 120 or DOT 114 pressure tank cars that include all of the following safety features: [170]

---

[170] DOT-114 and DOT-120 pressure tank car designs are permitted to have bottom outlets and can be configured to be compatible with crude by rail loading and unloading facilities. The Tesoro DOT-120 tank cars meet all the requirements of DOT Specification 120J200W, except that the manway area (cover thickness and insulation) has been modified to be compatible with crude by rail facilities. Tank cars similar to the Tesoro DOT-120 tank cars, but with a 11/16" minimum Tank Shell Thickness, would be modified versions of one of the following DOT Specifications:

- 120J300W (11/16" minimum Tank Shell Thickness, Jacketed, 300 psi Test Pressure),
- 120J400W (11/16" minimum Tank Shell Thickness, Jacketed, 400 psi Test Pressure),
- 120J500W (11/16" minimum Tank Shell Thickness, Jacketed, 500 psi Test Pressure).

Under the DOT specifications for DOT-114 tank cars, insulation is optional. Jacketed DOT-114 tank cars for crude service would have one of the following DOT Specifications:

- 114J340W (11/16" minimum Tank Shell Thickness, Jacketed, 340 psi Test Pressure),
- 114J400W (11/16" minimum Tank Shell Thickness, Jacketed, 400 psi Test Pressure).

See Figure 3, Tesoro DOT-120 Cars, in these Comments; Field Guild to Tank Car (footnote 158) pp. 5-10, 47-48; 49 CFR 79.101-1; 49 CFR 79.22; USDOT Final Rule, Table 6 (80 FR 26653 (May 8, 2015)); DOT Special Permit for Tesoro DOT 120 Tank Cars: 80 FR 9307 (February 20, 2015); DOT Special Permit DOT-SP 16188, January 7, 2015, pp. 1-2 www.phmsa.dot.gov/staticfiles/PHMSA/SPA_App/OfferDocuments/SP16188_2014060840.pdf.

> This special permit authorizes the manufacture […] of non-DOT specification tank cars […] for transportation of Class 3 flammable and combustible liquids […] meeting the

(cont'd)

- 11/16" minimum Tank Shell Thickness
- Full-Height Head Shields
- Tank Jacket
- Thermal Protection
- High-Flow Pressure-Relief Valve
- Protected Manway/TIH Top fittings protection system/nozzle
- Upgraded Bottom Outlet Valve Handle
- Minimum 300 psi Test Pressure
- Electronically controlled pneumatic (ECP) Brakes.

IV.C Hazard Impacts to Other Resource Areas

The Project was also found to have significant impacts from accidents, spills, fires, and explosions, in regard to:

- Public Services and Utilities (Significant Impact PS.4);
- Water Resources (Significant Impact WR.3);
- Agricultural Resources (Significant Impact (AR.5).

The impact to fire protection and emergency services along the UPRR mainline was found to be significant in the event of a fire or explosion.[171] Accidental oil spills along the UPRR mainline tracks were found to be significant in the event that a spill occurs where it could impact water resources,[172] and agricultural resources.[173]

---

requirements of […] DOT120J200W specification tank cars except that the hinged and bolted manway cover does not meet the minimum thickness required in §179.100-12(b), and the tank does not have insulation around the manway in accordance with the requirements of §179.100-4.

[171] Rail Spur FEIR, pp. ES-14 and 4.11-24-4.11-28.

[172] Rail Spur FEIR, pp. ES-15 and 4.13-25-4.13-27.

[173] Rail Spur FEIR, pp. ES-9, 4.2-38/39.

IV.C.1 All Feasible Mitigation Not Required for Significant Impacts PS.4, WR.3, and AR.5

Mainline rail accidents and spills associated with the Project were found to have impacts that were significant and unavoidable (Class I) in regard to public services and utilities (Impact PS.4),[174] water resources (Impact WR.3),[175] and agricultural resources (Impact AR.5).[176]

The FEIR recommends Mitigation Measure PS-4b, which is identical to Mitigation Measure HM.2a, requiring use of Option 1 tank cars in the Project:

> "Only rail cars designed to FRA, July 23, 2014 Proposed Rulemaking Option 1: PHMSA and FRA Designed Tank Car as listed in Table 4.7.6, shall be allowed to unload crude oil at the Santa Maria Refinery." [177]

Likewise, the FEIR recommends Mitigation Measures WR-3 and AR-5, which require implementation of Mitigation Measure PS-4b (which is identical to Mitigation Measure HM.2a):

> "Implement mitigation measures BIO-11 and PS-4a through PS-4c."[178]

The FEIR failed to incorporate all feasible mitigation measures to reduce the Project's significant impacts, as required under CEQA.

V. THE FEIR LACKS ENFORCEABLE CONDITIONS

The conclusion that the three-train alternative would not result in any significant on-site impacts is based on many tacit assumptions that affect emissions and hazard impacts that are not backed up by enforceable conditions. These include:

(1) The decrease in imported crude from reducing train trips from 5 per week to 3 per week would not be made up by importing an equivalent amount of non-local, North American crude oil by truck at the Santa Maria Pump Station;

(2) The imported crude would only be heated once per year;[179]

---

[174] Rail Spur FEIR, p. 4.11-29.

[175] Rail Spur FEIR, p. 4.13-27-4.13-28.

[176] Rail Spur FEIR, p. 4.2-39-4.2-40.

[177] Rail Spur FEIR, p. 4.11-28.

[178] Rail Spur FEIR, p. 4.7-88.

(3) The refinery will not accept or unload any crude oil with an API gravity of 30° or greater;[180]

(4) Rail spur access roads will be paved;[181]

(5) The corrosivity of imported crudes would not increase above the historic range;[182]

(6) The sulfur, benzene, toluene, ethylbenzene, and xylene (BTEX), and metal content of imported crudes would not increase above the historic range;[183]

(7) The locomotives will travel at an average speed of 40 mph with the exception of the distance between the San Luis Obispo County line to the SMR over the Cuesta Grade, where an average train speed of 20 mph is assumed[184] and an on-site switching speed of 3 mph;[185]

(8) The details of on-site locomotive operations, which determine on-site diesel particulate, NOx, ROG, and PM10 emissions[186]; and

(9) The new pipeline would be routed along an existing internal dirt road which "accommodates periodic on-site traffic only associated with refinery personnel travelling at low speed."[187]

Likewise, Mitigation Measure PS-4b (which is identical to Mitigation Measure HM.2), should be amended to require higher standard DOT-120 or DOT-114 pressure tank cars with additional safety features.

VI. THE PROJECT IS PIECEMEALED

The Phillips 66 San Francisco Refinery (SFR) consists of two facilities linked by a 200-mile pipeline. The Santa Maria Refinery (SMR) is located in Arroyo Grande in San Luis Obispo County, while the Rodeo Refinery is located in Rodeo in the San Francisco Bay Area. The Santa Maria Refinery mainly processes heavy, high sulfur

---

[179] Rail Spur FEIR, pp. 2-15, 2-30.

[180] Rail Spur FEIR, mitigation measure HM-2d, pp. IST-51, 4.7-88.

[181] Rail Spur FEIR, p. 2-17.

[182] Rail Spur FEIR, p. 2-34.

[183] Rail Spur FEIR, p. 2-34.

[184] Rail Spur FEIR, p. B.1-9.

[185] Rail Spur FEIR, Table 2.5, Note 5.

[186] Rail Spur FEIR, Table 2.5.

[187] Rail Spur FEIR, pp. 4.7-43/44.

crude oil and sends semi-refined liquid products, *e.g.,* gas oil and naphtha (pressure distillates),[188] to the Rodeo Refinery for converting into finished products. Propane and butane would be recovered from these semi-refined products during refining at the Rodeo refinery and sold as liquefied petroleum gas (LPG). As the two facilities are linked by a pipeline and have a formal name that subsumes both, it is a rebuttable presumption that changes at one will cause and/or contribute to changes at the other.

Phillips 66 is planning to replace a significant portion of its baseline crude slate with North American cost-advantaged crudes[189] delivered to its California refineries by rail and ship (Santa Maria, Rodeo, and Los Angeles). There are currently four related projects at the San Francisco Refinery (comprising the Santa Maria and Rodeo Refineries) that seek to facilitate a baseline crude switch that have recently been permitted or that are currently in the process of being permitted and that are inextricably linked and should have been evaluated as a single project under CEQA. Three of these are related to the Santa Maria Refinery and thus are discussed in these comments, one at the Rodeo end of the pipeline and two at the Santa Maria end of the pipeline. These projects are:

1. Rodeo Refinery Propane Recovery Project;[190]

2. Santa Maria Refinery Throughput Project;[191]

---

[188] The permits to operate for the Santa Maria Refinery and various pump stations along the pipeline indicate that the materials sent from Santa Maria to Rodeo are gas oil and "pressure distillates." The "pressure distillates" are referred to as "naphtha" in the subject RDEIRs. However, there are different types of naphtha, depending upon the boiling range. Full range naphtha, which is presumably what "pressure distillate" is intended to capture, is the fraction of hydrocarbons boiling between 30°C and 200°C. It consists of a complex mixture of hydrocarbons generally having between 5 and 12 carbon atoms and comprises 15% to 30% of the crude oil by weight. Light naphtha is the fraction boiling between 30°C and 90°C and consists of molecules with 5 to 6 carbon atoms. *See, e.g.,* http://en.wikipedia.org/wiki/Naphtha. The material sent from Santa Maria to Rodeo is not classically defined "naphtha" but rather "pressure distillate." To be consistent with the various EIRs, which refer to it incorrectly as "naphtha," I shall refer to it as "naphtha" in these comments, with the understanding that it is actually "pressure distillate" or "full range naphtha."

[189] Cost-advantaged crude is broadly defined in the McCabe declaration (2/1/16 Thompson Letter, Attach. 21) as any crude that costs less based on the "landed" price than the cost of the global benchmark crude, North Sea Brent.

[190] Contra Costa County, Phillips 66 Propane Recovery Project Recirculated Final Environmental Impact Report (RFEIR), January 2015; Available at: https://ca-contracostacounty2.civicplus.com/DocumentCenter/View/35130.

[191] Marine Research Specialists, Phillips 66 Santa Maria Refinery Throughput Increase Project, Final Environmental Impact Report, October 2012 (Throughput FEIR), Available at: http://slocleanair.org/phillips66feir.

3. Santa Maria Refinery Rail Spur Project.[192]

A timeline showing the interrelationship of these three projects is shown in Table 6. I previously commented on the relationship between the Santa Maria Refinery Throughput Project, the Santa Maria Refinery Rail Spur Project,[193] and the Rodeo Refinery Propane Recovery Project.[194] These comments are in the record.

The Santa Maria projects would increase the amount of propane and butane that is recoverable at Rodeo in two ways. First, the increase in crude throughput would increase the amount of gas oil and naphtha recovered at Santa Maria and sent to Rodeo in direct proportion to the increase in throughput, or by about 10% based on permit limits, assuming no change in crude slate. Second, the change in composition of the rail-imported crudes, compared to the baseline crude slate, would additionally increase the amount of propane and butane in the naphtha sent to Rodeo. These issues are discussed below in two sections: (1) Piecemealing of the Rail Spur and Propane Recovery Project and (2) Piecemealing of the Throughput Increase Project and Rail Spur Project.

VI.A Piecemealing: Rail Spur and Propane Recovery Project

In response to comments, the following sections demonstrate: (1) that there was not sufficient liquefied petroleum gas (LPG) in Rodeo's fuel gas to meet the Propane Recovery Project design basis of 14,500 bbl/day; (2) that the Throughput Increase Project would increase LPG in the semi-refined products sent to Rodeo; (3) that the Rail Spur Project would increase LPG in the semi-refined products sent to Rodeo; and (4) that vapor pressure limits on the Junction Station tanks would not limit the amount of LPG sent from Santa Maria to Rodeo.

---

[192] San Luis Obispo County, Phillips 66 Company Rail Spur Extension and Crude Unloading Project Revised Public Draft Environmental Impact Report and Vertical Coastal Access Project Assessment, October 2014, SCH # 2013071028; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/Phillips+66+Company+Rail+Spur+Extension+Project+(Oct+2014)/Phillips+SMR+Rail+Project+Public+Draft+EIR.pdf.

[193] Fox Comments, Rail Spur DEIR; Fox Comments, Rail Spur RDEIR.

[194] Phyllis Fox, Comments on Environmental Impact Report for the Phillips 66 Propane Recovery Project, Prepared for Shute, Mihaly & Weinberger LLP on behalf of Rodeo Citizens Association, November 15, 2013; Available at: http://crgna.org/blog/wp-content/uploads/2013/11/Fox-Report-FINAL.pdf and Phyllis Fox & Petra Pless, Comments on Recirculated Draft Environmental Impact Report for the Phillips 66 Propane Recovery Project, Rodeo California, Prepared for Adams Broadwell Joseph & Cardozo, February 2, 2015. (Exhibit 9A)

VI.A.1 Recoverable LPG in the Rodeo Baseline

The Propane Recovery Project at the Rodeo Refinery is designed to recover 14,500 barrel per day (bbl/day) of LPG from Rodeo fuel gas. The Propane Recovery FEIR asserts that there is adequate LPG available under Rodeo baseline conditions to recover this amount of LPG without any changes in the amount of LPG from Santa Maria.[195]

However, my analysis indicates that in order to reach this design target, day in and day out, the Rodeo Refinery requires additional amounts of LPG precursors from the Santa Maria Throughput and Rail Spur projects. The increased amounts of LPG precursors would come from semi-refined products from (1) increased crude throughput at the Santa Maria Refinery and (2) modifying the Santa Maria Refinery crude slate makeup by refining tar sands dilbits that include more naphtha, which is a source of LPG. These two projects, then, would provide additional LPG to make up the shortfall in LPG destined to be recovered by the Propane Recovery Project.

Response to comment ABJC-30 argues "The equipment design is a limiting factor on the amount of propane and butane that can be captured and stored, regardless of how much propane and butane can be produced by the SFR in the future or what type of crude oil is processed." The issue is not the upper bound, or design basis, but rather, the amount of LPG available to be recovered.

The equipment design is irrelevant for assessing piecemealing if the amount of propane and butane required to fill the design capacity is not available and must be supplied by other projects. The response to comment ABJC-30 is beside the point, and akin to arguing that a car can be driven 200 miles because it has an engine that gets 20 miles to a gallon and has a gas tank that can hold 10 gallons of gasoline, if the gas tank is only partially full. The impacts of supplying the additional LPG (or gasoline) required to reach the design basis of 14,500 bbl/day should be included with the project's direct impacts.

The amount of recoverable propane and butane in the baseline Rodeo Refinery fuel gas is overstated (<13,970 bbl/day).[196] As the supporting analytical data have never been produced, and the sampling point(s) have not been disclosed, the asserted amount does not constitute substantial evidence of recoverable butane/propane as

---

[195] Propane Recovery FEIR, p. 3.2-252. *See* also RTC ABJC 30 ("Data regarding actual LPG content of the RFG is consistent with the design basis for the project.").

[196] Fox/Pless Comments on Propane Recovery RDEIR, p. 12. (Exhibit 9A)

claimed in RTC ABJ-30. There are at least five reasons to question the asserted amount of baseline recoverable LPG.

First, Phillips 66 **adds** butane to the Rodeo fuel gas to control its specific gravity.[197] Butane levels must be high enough to assure efficient combustion in heaters, boilers, turbines, and other combustion sources. Thus, Phillips 66 cannot recover all of the butane it asserts is recoverable without compromising the performance of Rodeo combustion units.

Second, the Rodeo Refinery fuel gas system is very complex, comprising two separate fuel gas systems, which collect gases from a number of different refining units.[198] Some of these streams will be routed to the Propane Recovery Unit while others will not, *e.g.*, natural gas, U-240, D-301.[199] The "summary" data collected in 2011 and 2013 and reported as recoverable propane and butane[200] is for all gas streams lumped together, rather than just those from which propane and butane would be recovered. A major portion of the U-233 gas, on the other hand, is natural gas, which can contain significant amounts of propane and butane. This propane and butane would not be recovered, but is included in Phillips 66's "summary" measurements of propane and butane available for recovery. It is not possible to back out this contribution and figure out the actual recoverable amounts of LPG based on the record as the composition of the natural gas (and other sub-streams that would not be sent to the RFG Propane Recovery) are not in the record.

Third, the August 2011 sample suggests substantially less propane and butane are available for recovery at the Rodeo Refinery. The fuel gas sampling measured only 10,576 bbl/day from Refinery Fuel Gas systems U233 and A, which is 3,924 bbl/day shy of the 14,500 bbl/day design basis. The RDEIR then adds 4,898 bbl/day to this measured total, characterized as "butane currently recovered for sale."[201] However, the block flow diagram for the Rodeo Refinery shows that the butane that is currently recovered is not recovered from either sampled fuel gas system, but rather from the U-215 fuel gas treating system.[202] Thus, this added butane appears to have been double-counted. The August 2011 sample suggests there is a significant shortfall of

---

[197] Propane Recovery RDEIR, Appx. E, pdf 205: Flare Minimization Plan, Attach. M, p. 1.

[198] Propane Recovery RDEIR, Fig. 3-5.

[199] Compare Figures 3-4 and 3-5 in Propane Recovery RDEIR.

[200] Propane Recovery RDEIR, p. 3-33 & Figures 3-7 & 3-8.

[201] Propane Recovery RDEIR, Figure 3-7.

[202] Propane Recovery RDEIR Figure 3-5.

recoverable propane and butane. Thus, the fuel gas sampling in August 2011, while the Throughput Increase Project was being designed and permitted (Table 6), demonstrates that the Propane Recovery Project needed both the Throughput Increase Project and the Rail Spur Project to meet its design basis.

Fourth, supporting data for the 2011 sampling event were attached to the BAAQMD permit application. My analysis of these data indicate that Phillips 66 estimated recoverable butane/propane based on maximum flow rates, rather than average daily values, on a single day in August 2011.[203] Thus, recoverable propane/butane may be much less than claimed, and the Rail Spur and Throughput Increase Projects may supply a much larger portion of the shortfall.

Fifth, at the time the August 2011 sample was collected, the Rodeo refinery was apparently running a unique crude oil, a very light Russian Bakken-lookalike.[204] The record contains no information on the makeup of the crude slate at the time the 2013 samples were collected. It is possible, for example, that the refinery was also running a uniquely light crude slate to evaluate the recoverable LPG.

In sum, the Rail Spur Project, together with the predecessor Throughput Increase Project will increase the amount of recoverable propane and butane in the naphtha sent to Rodeo. As demonstrated below, it will contribute significantly to making up for the current shortfall in recoverable propane and butane at the Rodeo Refinery.

VI.A.2 Santa Maria Refinery Throughput Increase Project Would Increase Recoverable LPG at Rodeo Refinery

The Santa Maria Refinery Throughput Increase Project allows a 10% increase in crude throughput at Santa Maria, from 44,500 bbl/day[205] to 48,950 bbl/day.[206] Assuming no change in the typical crude slate[207], this increase would be refined at Santa Maria to produce roughly 10% more naphtha (pressure distillate) and gas oil. This 10% increase in naphtha and gas oil would be sent to Rodeo where it would be refined into gasoline, diesel, and jet fuel, producing up to 10% more propane and butane. This increase in propane and butane would be recovered by the Propane Recovery Project, thus making up part of the shortfall in feedstock for the Propane Recovery Project.[208] The CEQA findings for the Santa Maria Throughput Project explicitly recognize that the increase in throughput at the Santa Maria Refinery would result in "[a]n increased

[203] Fox/Pless Comments on Propane Recovery RDEIR, February 2, 2015, pp. 10-11. (Exhibit 9A)

[204] Karras Report, February 2, 2015 (Exhibit 7).

volume of products leaving the SMF for the Rodeo Refinery via pipeline."[209] This 10% increase is independent of other increases (due to changes in crude slate quality) discussed below.

VI.A.3 Santa Maria Refinery Rail Spur Project Would Increase Recoverable LPG at Rodeo Refinery

The Project proposes to import Canadian tar sands "dilbits," which are a mixture of tar sands bitumen and diluent. The bitumen is too viscous to be readily transported by pipeline or rail.[210] Thus, the bitumen is blended with 25% to 30% diluent to facilitate transport. The blended crude is known as a "dilbit." The diluent is typically natural gas condensate, pentanes, or naphtha.[211] Other materials can be blended with the bitumen, to produce dilsynbits and other mixtures.

The Rail Spur Project will increase the amount of LPG sent to Rodeo. These blended tar sands crudes contain more LPG than the baseline Santa Maria crude slate, and they yield more naphtha when refined.

VI.A.3.i Tar Sands Crudes Have More LPG than Baseline Crudes

The diluents used in these dilbits have high concentrations of propane/butane that can be partitioned into semi-refined products (naphtha) at SMR and recovered as propane and butane at Rodeo. The Rail Spur FEIR and RTC CBE-111 reported the five-year average "LPG Percentage" for two dilbits as 0.73% and 0.89%. These were compared to the current "typical crude blend" refined at the SMR of 0.9%, ranging from

---

[205] Throughput Increase FEIR, p. 2-24 (Department of Planning and Building permit limit).

[206] Throughput Increase FEIR, p. 2-24.

[207] Rail Spur FEIR, Table 2.7.

[208] *See* discussion in CBE-86 and -87.

[209] County of San Luis Obispo, Department of Planning and Building, Staff Report, December 13, 2012, Exhibit C – CEQA Findings, p. 2-24; Available at: http://slocounty.granicus.com/MetaViewer.php?view_id=10&clip_id=1401&meta_id=255988.

[210] Bitumen can be transported in heated pipelines and railcars. The Santa Maria facility would use a steam heating system once per year to facilitate unloading in cold weather. FEIR, p. 2-15.

[211] Rail Spur FEIR, p. 2-34. *See* also: Gary R. Brierley, Visnja A. Gembicki, and Tim M. Cowan, Changing Refinery Configurations for Heavy and Synthetic Crude Processing, Available at: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7BA07DE342-E9B1-402A-83F7-36B18DC3DD05%7D&documentTitle=5639138.

0% to 1.0%,[212] suggesting there would be no change in LPG content and thus no connection between the two projects. There are three problems with this comparison.

First, the supporting data for the Santa Maria crudes to demonstrate that these values represent the CEQA baseline crude composition are missing from the record. The footnotes to Rail Spur FEIR Table 2.7 indicate a "range of major crudes represent the major source of current crudes to the refinery and include a number of OCS, local onshore, and trucked crude sources" and "current SMR operations data from Phillips 66, 2015."[213] However, the period of record for these crudes, the specific crudes and the amounts of each, the number of samples, the analytical method(s) used to measure LPG, and the actual measured data used to calculate the average and range are critical to assess its accuracy and representativeness of the baseline crude slate. This information is missing from the record.

Second, the amount of diluent blended with the bitumen is adjusted by season and is higher in winter to control viscosity due to lower temperatures at the loading point and during transit. Thus, an annual average for dilbit and other tar sands mixtures will substantially understate peak values.

Third, the FEIR's comparison is selective and misleading. There are many other tar sands crudes with much higher LPG content that could be refined at Santa Maria and that would meet the new API gravity limit in mitigation measure HM-2d. The crudemonitor.ca site that the FEIR relied on for dilbit composition data for Access Western Blend and Peace River Heavy includes LPG data for eight similar blended tar sands crudes.[214] Four of these are compared with the typical SMR crude blend below in Table 7. Any dilbit (or other similar blended tar sands crude) could be selected as the FEIR does not limit the specific crudes that could be imported.

---

[212] Rail Spur FEIR, Table 2.7, "LPG Percentage".

[213] RTC CBE-111; Rail Spur FEIR, Table 2.7.

[214] Access Western Blend, Borealis Heavy, Christina Dilbit Blend, Cold Lake, Peace River Heavy, Albanian Heavy Synthetic (dilsynbit), Western Canadian Select (conventional & bitumen blends).

Table 7:
LPG Percentage (vol. %) in Tar Sands Crudes[215]
Compared to SMR Typical Crude Blend

Tar Sands Crude	Average	Maximum
Borealis Heavy	1.22	1.79
Cold Lake	1.08	1.85
Western Canadian Select	2.12	2.44
Albanian Heavy Synthetic	1.68	2.18
SMR Typical Crude Blend	**0.9**	**1.0**

This table shows that there are similar tar sands blended crudes that could be imported by rail that contain much more LPG than the Santa Maria typical blend, up to 2.4 times more. Further, even the two dilbits included in the FEIR's comparison can have more LPG than the 5-year averages reported in FEIR Table 2.7 (0.73% and 0.89%). A July 2015 sample of Access Western Blend contained 1.15% LPG[216] and a December 2012 sample of Peace River Heavy contained 1.06% LPG[217].

Thus, changing the crude slate at Santa Maria by refining tar sands blends could increase the amount of recoverable LPG at Rodeo, contributing to the Rodeo LPG shortfall. This is confirmed by three lines of evidence: (1) the reported distillation yield of naphtha[218] from tar sands dilbits, is higher than in typical SMR crude;[219] (2) the percentage of propane and butane in tar sands dilbits and other similar tar sands blends is higher than in a typical SMR crude (Table 7); and (3) vapor pressure limits on Junction Station tanks were increased.[220] The increase in LPG sent to Rodeo is in addition to the 10% increase due to the Throughput Increase Project. The ways in which this could occur are discussed in RDEIR Comments CBE-86 to -88 (Karras) and CBE-110 to -115 (Fox).

VI.A.3.ii Tar Sands Crudes Yield More Naphtha When Refined

The refining of these and other similar tar sands crudes at Santa Maria will increase the amount of LPG, mostly butane, sent to Rodeo in semi-refined products, thus reducing Rodeo's LPG shortfall. Dilbits and other similar blended tar sands crudes contain more LPG than Santa Maria's typical crude blend, as demonstrated below.

---

[215] http://www.crudemonitor.ca/home.php.

[216] http://www.crudemonitor.ca/crude.php?acr=AWB.

[217] http://www.crudemonitor.ca/crude.php?acr=PH.

[218] Naphtha is a light hydrocarbon mixture with a boiling point up to 190°C.

[219] Rail Spur FEIR, Table 2-11.

[220] Junction Station Tanks vapor pressure increase to 11 psia (Exhibit 22)

The RTC asserts that the FEIR's distillation yield figure "shows that the amount of naphtha, distillate, gas oil, and resid for the two dilbit crudes… are very similar to the typical composition of crude that is currently processed at the SMR."[221] This assertion is wrong for two reasons.

First, the distillation yield figure in the FEIR[222] shows a higher yield of naphtha (18%), where the propane and butane would be found, compared the "typical SMR" crude (11%). This is confirmed by similar distillation yield curves for tar sands crudes in my comments on the Rail Spur RDEIR, Figures 1 and 2 (CBE-111). And as demonstrated by the data in Table 7, the two tar sands crudes that the FEIR selected to make its case fall at the lower end of the propane/butane range. There are many tar sands crudes that yield much more LPG than Access Western Blend or Peace River Heavy, as seen in Table 7 above.[223]

Second, the distillation yield bar for "typical SMR" crude oil, footnoted as "Phillips 66-Average values for 2014 and part of 2015,"[224] is unsupported. The record does not disclose the number of samples included in the averages, the analytical method(s) used to develop the distillation yield curve, or the supporting laboratory reports, preventing review and confirmation of the reported distillation yields of naphtha and gas oil. Further, the County "has no records in its possession or control" that supports the "typical SMR" bar.[225] Finally, 2014 and 2015 are not the baseline years. The SMR was already refining 2% to 7% tar sands dilbits in these years.[226]

The FEIR includes a new mitigation measure (HM-2d) that prohibits the unloading of crudes with an API gravity of 30° or greater.[227] The FEIR is not otherwise proposing to limit the crudes that can be imported by rail. The proposed limit on API gravity would not prevent the unloading of most tar sands crudes and specifically, the four tar sands crudes I identified in Table 7, all of which have significantly more propane/butane than the typical Santa Maria crude. All of these crudes have

---

[221] RTC CBE-111.

[222] Rail Spur FEIR, Figure 2-11.

[223] *See* Fox Rail Spur RDEIR Comments, Figures 1, 2.

[224] RTC ABJC-32 and Rail Spur FEIR, Figure 2-11.

[225] Letter from Rita L. Neal, County Counsel, to Laura Horton, Adams Broadwell Joseph & Cardozo, Re: Public Records Act Requests Dated January 12 and 14, 2016, re: Phillips 66 Company Rail Spur Extension Project, January 21, 2016. (Exhibit 13)

[226] 2/1/16 Thompson Letter (Exhibit 3A), In the attachments to this letter (Exhibit 3B), see Exhibit 21, McCabe Declaration.

[227] RTC CBE-110 and FEIR, p. 4.7-88.

API gravities lower than 30°.[228] Further, there are many other tar sands crudes with elevated amounts of propane/butane and lower API gravities, such as Lloyd Blend (LPG = 3.05%)[229], Lloyd Kerrobert (LPG = 3.34%)[230], and Wabasca Heavy (LPG = 2.29%),[231] among many others. Thus, the proposed limit on API gravity does not prevent increased amounts of propane and butane from being present in the naphtha sent to Rodeo. Further, the FEIR is silent on how the API gravity limit would be enforced.

In sum, tar sands crudes could be selected to increase the amount LPG that is ultimately recoverable at Rodeo, reducing the Rodeo LPG shortfall. Thus, it is reasonable to expect that the Rail Spur Project will increase the amount of LPG in semi-refined products sent to Rodeo, consistent with Phillips 66's late 2012 increase in the Junction Station tank vapor pressure limits.

VI.A.3.iii Partitioning of Crude Oil LPG During Refining at SMR

In another line of argument against partitioning, the FEIR and RTCs assert that most of the propane and butane in Santa Maria crude ends up in the Santa Maria refinery fuel gas and thus would not be present in the semi-refined products sent to Rodeo.[232] This claim is only supported by a table that shows the "composition of refinery fuel gas at the SMR."[233] The table is unsupported. The sampling point(s), test method, underlying analytical data, number of samples, and period of record are not indicated, so the relevance of these data is unknown.

Regardless, the composition of refinery fuel gas, taken alone, does not prove that most of the propane and butane end up in the fuel gas. It says nothing about how much propane and butane goes elsewhere, such as into the naphtha. A refinery material balance is required to determine how propane and butane are partitioned within the refinery. The FEIR does not include a refinery material balance and thus fails to provide the public with information required to support the claim that all of the propane and butane ends up in the refinery fuel gas.

---

[228] http://www.crudemonitor.ca/crude.php?acr=PH.

[229] http://www.crudemonitor.ca/crude.php?acr=LLB.

[230] http://www.crudemonitor.ca/crude.php?acr=LLK.

[231] http://www.crudemonitor.ca/crude.php?acr=WH.

[232] Rail Spur FEIR, p. 2-31 and RTC CBE-84/85.

[233] RTC CBE-84/85.

The Rail Spur FEIR includes a block flow diagram for the Santa Maria Refinery.[234] This figure suggests that all of the propane and butane are partitioned into the naphtha at the front end of the refinery. The refinery fuel gas originates from the coker, at the tail end of the refinery.

The block flow diagram shows raw crude is first routed to the Pre-Flash Drum, where volatiles are separated. Propane and butane would be separated here due to their very low initial boiling points. The overheads from this unit, where the propane and butane would be found, are sent to the Crude Tower. The Crude Tower overheads are straight run naphtha, which would include the propane and butane. The block flow diagram does not show any fuel gas generated in these units where the crude is separated into various fractions based on boiling points. Rather, the block flow diagram shows that the refinery fuel gas originates from the coker, which is downstream from the Crude Tower.

As the block flow diagram indicates that no refinery fuel gas is produced at the front end of the refinery, the propane and butane arriving in the crude oil is distilled into naphtha which is sent to the Rodeo Refinery. The SMR block flow diagram does not support the RTC's claim that the propane and butane are partitioned into the fuel gas. Thus, the butane and other lighter components arriving in the tar sands dilbits would most likely be partitioned into the naphtha, accounting for the increased naphtha yield shown in the distillation figure (FEIR, Figure 2-11).

Very little, if any of the propane or butane in tar sands crudes would be partitioned into the gas oil at the SMR because gas oil is a much heavier material with a very low vapor pressure. This is confirmed by the distillation yield chart in the FEIR, Figure 2-11, which shows that the two candidate tar sands dilbits would produce more naphtha and about the same amount of gas oil as the current crude slate. The current crude slate yields about 11% naphtha, the light, butane-rich, semi-refined product sent to Rodeo, while the two tar sands dilbits yield about 18% naphtha,[235] consistent with the LPG information presented elsewhere.[236]

---

[234] Rail Spur FEIR, Figure 2-10. *See* also Throughput Increase DEIR, Figure 2-6 (*See* upper left, Unit D-1, Crude Tower, top arrow: "straight run naphtha". The only fuel gas line originates from the cokers.) This same figure is in the Throughput Increase DEIR, Figure 2-6.

[235] Rail Spur FEIR, Figure 2-11.

[236] Rail Spur FEIR, Table 2.7.

VI.A.4 Increased Amount of LPG in Santa Maria Naphtha and Gas Oil Would Not Exceed Santa Maria Refinery or Junction Station Tank Vapor Pressure Limits

The response to comments asserts that vapor pressure limits on various tanks, first at Santa Maria, then at the Junction Station, would prohibit an increase in the amount of LPG sent to Rodeo.

VI.A.4.i Santa Maria Refinery Tanks

In response to comments that the Rail Spur Project would increase the amount of LPG in semi-refined products sent to Rodeo in the DEIR, the RDEIR[237] asserted that permit limits on the vapor pressure of the "naphtha"[238] and gas oil tanks at the SMR restrict the amount of propane and butane that could be contained in the naphtha and gas oils sent to the Rodeo Refinery via pipeline. Thus, it claimed that more propane and butane in the naphtha and gas oil could not be sent to Rodeo without violating tank vapor pressure limits at the Santa Maria Refinery.

This claim was asserted without providing any supporting permits or vapor pressure measurements, information readily available to the applicant. I obtained the subject permits and vapor pressure data for the Santa Maria Refinery tanks. My review of this information indicated the RDEIR's claims are wrong as to vapor pressure constraints at the Santa Maria Refinery tanks. There are either no vapor pressure limits on the subject tanks, the stored naphtha and gas oil have vapor pressures far below the tank permit limits, or the naphtha tanks were covered and vented to a control device.[239]

The RTC on the Rail Spur RDEIR did not refute this information, and, in fact, conceded the Santa Maria Refinery vapor pressure issue[240] and changed the FEIR text to remove the alleged SMR tank vapor pressure constraint.[241]

However, the RTC shifted its vapor pressure constraint argument from tanks at the Santa Maria Refinery to tanks at the Junction Station, which is located in the San Joaquin Valley Air Pollution Control District (SJVAPCD), along the pipeline that connects the Santa Maria Refinery with the Rodeo Refinery.

---

[237] Rail Spur RDEIR, p. 2-31.

[238] The "naphtha" sent to Rodeo is actually "pressure distillate," which is the sum of naphtha and distillate and comprises about 31% of the whole crude.

[239] CBE-101 to -108 and RTC CBE-100 to -108.

[240] RTC CBE-100 to 108.

[241] Rail Spur FEIR, p. 2-31.

VI.A.4.ii Junction Station Tanks

The RTC on the Rail Spur RDEIR newly asserts that "[p]ermits issued by the San Joaquin Valley Air Pollution Control District effectively prevent a substantial increase in the LPG content of the material transported via the pipeline from the SMR to the SFR."[242] This claim is unsupported and wrong.

First, there is no evidence in the record that the semi-refined products are routinely off-loaded into tanks at the Junction Station. The normal practice when I worked at this facility was to push them straight through to Rodeo. These tanks are for emergencies and throughput management, not routine storage. Storage, when necessary, is provided by the tanks at the Santa Maria Refinery.

Second, the RTC asserts the semi-refined products are blended with crude oils. If true, this blending would reduce the vapor pressure of the mixture stored in the tank, as San Joaquin Valley crudes have very low vapor pressures. This would offset increases in vapor pressure due to increased LPG.

Third, information I gathered indicate that a substantial increase in LPG could occur if the naphtha were stored in Junction Station tanks, without exceeding vapor pressure limits.

The vapor pressure claim is followed by a table that lists the subject tanks at the Junction Station and their vapor pressure limits, reproduced below for reference:

Table 8:
SJVAPCD Permits for Junction Station Tanks (RTC CBE-100/108)

Tank #	Permit #[243]	Product	True Vapor Pressure Limit (psia)
40010	(S-1518-8-3)	Naphtha	11.00
80018	(S-1518-1-4)	Naphtha	10.99
110020	(S-1518-7-3)	Gas Oil	11.00
110022	(S-1518-2-2)	San Joaquin Valley Heavy Crude	11.00
110024	(S-1518-5-3)	Elk Hills Crude	11.00
1100026	(S-1518-31-2)	San Joaquin Valley Heavy Crude	11.00

[242] RTC CBE-86 and CBE-100 to -108.

[243] Junction Station Tank Permits (Exhibit 2).

The supporting permits and vapor pressure data again were not provided to support this table. Thus, we filed public records act requests to obtain the cited permits and vapor pressure data. This information indicates that the RTC's claims with respect to vapor pressure constraints limiting the amount of LPG sent to Rodeo are misleading and wrong for a second time for two reasons. First, the vapor pressure limits are not enforceable as a practical matter. Second, the increase in LPG from refining tar sands dilbits is not high enough to exceed the limits.

VI.A.4.ii.a The Junction Station Permits Would Not Limit the Amount of LPG in Santa Maria Semi-Refined Products

Response to Comment CBE-100/108 asserts that the Junction Station permits "prevent a substantial increase in the LPG content of the material transported via the pipeline from the SMR to the SFR." However, my review of these permits indicate the vapor pressure limits in these permits are not enforceable for three reasons.

First, these permits (Exhibit 2) do not require any vapor pressure monitoring or reporting, except when the materials stored in the tanks are changed:

> "Permittee shall conduct true vapor pressure (TVP) testing of the organic liquid whenever there is a change in the source or type of organic liquid stored in this tank. [District Rule 2520,9.3.2] Federally Enforceable Through Title V Permit."

These permits would allow 100% LPG to be stored in the Junction Station tanks, so long as there is no change in stored material. As long as the material stored in the tanks does not change, Phillips 66 is under no obligation to test or report the vapor pressure.

Second, all routine vapor pressure determinations in the Junction Station tank permits are made using standard industry nomograms, none of which apply to the gas oils and pressure distillates unique to the semi-refined products from tar sands crudes.[244] Thus, high vapor pressure material could be stored in these tanks, but not discovered as no measurements are required.

Third, the permits do not restrict the type of material that can be stored in the tanks. Thus, as a practical matter, the asserted vapor pressure constraints will not prevent higher vapor pressure material from being stored in tanks at the Junction Station than presently.

---

[244] SJVAPCD Permits S-1518-8-5; S-1518-1-6; S-1518-7-6; S-1518-2-5; S-1518-5-7; and S-1518-31-6. (Exhibit 2)

Therefore, the vapor pressure limits this comment relies on are not enforceable as a practical matter. They cannot be relied upon to restrict the amount of propane and butane in shipped gas oil and naphtha.

VI.A.4.ii.b The Junction Station Permits Anticipated More LPG in Santa Maria Semi-Refined Products

The RTC tank table reproduced above in Table 8 shows that the six tanks at the Junction Station have true vapor pressure (TVP) limits of 11 psia. These vapor pressure limits were increased during the time the Rail Spur Project was being planned to allow higher vapor pressure material, such as higher vapor pressure semi-refined products from Santa Maria, to be stored, which is consistent with fact that ConocoPhillips knew that higher vapor pressure material was planned for transport to Rodeo.

The vapor pressure limits for tanks 110022, 110024, and 110026 in Table 8 were raised[245] in late 2012,[246] around the time Phillips 66 was planning the Rail Spur Project, as evidenced by on-going paleontological, biological, and noise studies for the Rail Spur Project (Table 6).[247] While these three tanks are identified as storing various crude oils in the RTC, the permits indicate that they can store any organic liquid. If semi-refined products are offloaded into these tanks enroute to Rodeo and blended with semi-refined products, as suggested in RTC CBE-100/108, the vapor pressure would be significantly reduced.

Table 9:
True Vapor Pressure (psia)
Reported in RTC CBE-108/110
Compared to Cited Permit

	Tank 110022	**Tank 110024**	**Tank 1100026**
RTC CBE-100/108	11.00	11.00	11.00
Cited Permit	10	5.35	9.5

[245] The most recent version of these permits, which expire 5/31/2019, are: S-1518-2-5; S-1518-5-7; and S-1518-31-6. The last digit in these permit numbers is the version. These current permits are all two versions removed from the permits cited in the RTC and confirm the reported 11 psia vapor pressure limits.

[246] Notice of Preliminary Decision – ATC/Certificate of Conformity, Facility #S-1518, Project #S-1122222, November 9, 2012; Available at: https://www.valleyair.org/notices/Docs/2012/11-09-12%20(S-1122222)/Public%20Notice%20Packet.pdf.

[247] Phillips 66, Land Use Application, Santa Maria Refinery Rail Project, June 2013, Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/phillipslanduse.pdf.

Thus, given that Phillips 66 applied to raise the vapor pressure limits on three of these tanks while the Rail Spur Project was being planned, it is reasonable to assume that Phillips 66 anticipated an increase in the vapor pressure of material stored in these tanks.[248] This increase in tank vapor pressure limits is consistent with refining Bakken crude (which was to be imported via the Rail Spur Project as proposed in 2012), dilbits, and other similar tar sands crude blends at Santa Maria and sending more volatile semi-refined products with more LPG to Rodeo. As demonstrated below, these crudes contain more volatile components than present in the "typical crude blend" refined at Santa Maria in the baseline.[249] The increased amount of volatile material allowed by these vapor pressure limit increases would contribute to recoverable LPG at the Rodeo Refinery, making up for part of the LPG shortfall discussed below. The balance of the shortfall would be made up by the 10% increase in throughput allowed by the Throughput Increase Project.

VI.A.4.ii.c The Increase in Vapor Pressure of Semi-Refined Products Will Not Exceed 11 psia

Response to Comment CBE-100/108 asserts that "a very small amount of additional LPGs in the products coming from the SMR could cause a substantial increase in true vapor pressure of the material stored in the tanks at the Junction Station, resulting in an exceedance of the vapor pressure limit." This response goes on to claim: "LPGs are highly volatile compounds with a vapor pressure that ranges from 30 to 120 psi at 68 F and 50 to 190 psi at 100 F." An authority is not cited for these vapor pressure ranges, but they appear to be for various propane/butane mixtures varying from 100% butane to 100% propane at various temperatures. This response is misleading because it fails to disclose that the very high vapor pressures are for propane, which is a minor component of LPG in tar sands dilbits.

---

[248] From RTC-86: "Although these tanks were historically used to store heavy crudes, the RTC indicates: "all semi-refined products from the SMR are delivered into large above ground storage tanks until they can be sent in batches to the SFR. In addition, select materials from the SMR are blended with crude oil coming from oil production fields to the south, and the blending occurs in the above ground storage tanks at the Junction Station…" Further, the permits on these tanks allow any organic material to be stored.

[249] Rail Spur FEIR, Table 2.7.

Available data summarized in Table 10 indicate that baseline vapor pressures are much less than the permitted vapor pressure limits of 11 psia. Thus, the vapor pressure of gas oil and naphtha can increase considerably before exceeding the respective tank vapor pressure limits.

Table 10: True Vapor Pressure (psia)[250]
of Naphtha and Gas Oil in Junction Station Tanks

Year	2010	2011	2012	2013	2014	2015	Avg
Naphtha	5.54/6.16	6.84	5.76/5.79	6.68	-	5.26/4.08	**5.76**
Gas Oil	-	0.09	-	0.06	0.01	0.094	**0.06**

The very high vapor pressures cited in RTC CBE-100/108 are for propane. However, the majority of the LPG in tar sands dilbits is butane, which is much less volatile. Table 11 summarizes propane and butane (LPG) content of tar sands dilbits and other tar sands blends. This table shows that on average, a typical tar sands dilbit has about 95% butane and only 5% propane. Other types of tar sands crudes have even less propane, as they are not blended with diluent. Thus, a dilbit serves as a worst case for evaluating the hypothetical vapor pressure constraint.

Table 11: LPG Percentage (vol. %) in Tar Sands Crudes[251]
Compared to SMR Typical Crude Blend

Tar Sands Crude	Propane	Butane	% Butane
Access Western Blend	0.05	0.70	**93**
Peace River Heavy	0.06	0.83	**93**
Kearl Lake	0.02	0.88	**98**
Borealis Heavy	0.01	1.21	**99**
Cold Lake	0.05	0.78	**94**
Western Canadian Select	0.06	2.06	**97**
Albanian Heavy Synthetic	0.11	1.54	**93**
AVERAGE			**95**

A mixture of 5% propane and 95% butane at 100 F would have a true vapor pressure of 45 psia.[252] The same mixture at 70 F would have a true vapor pressure of

[250] The vapor pressure data for 2010 – 2012 is from Annual Inspection Reports and from 2013 – 2015 from analytical lab reports, based on measurements of samples. (Exhibit 14) The origin of the vapor pressure data in the Annual Inspection Reports is unknown and may be from various standard industry nomograms or default values from the EPA TANKS program.

[251] http://www.crudemonitor.ca/home.php.

[252] Vapor pressure of mixture of 5% propane and 95% butane at 100 F = (0.05)(177) + (0.95)(38) = 44.95 psia. *See*: http://www.engineeringtoolbox.com/propane-butane-mix-d_1043.html.

22 psia.[253] Thus, at 100 F, 12% of the naphtha could be LPG without exceeding a vapor pressure limit of 11 psia.[254] At 70 F, 23% of the naphtha could be LPG without exceeding a vapor pressure limit of psia.[255] The baseline LPG content in a typical crude blend is 0.9%[256] and 18% of the crude distills to naphtha.[257] Therefore, baseline naphtha contains about 5% LPG[258]. The actual amount is likely lower as the naphtha fraction includes some pressure distillate. Thus, the amount of LPG sent to Rodeo could increase by factors of two (12/5=2.4) to five (23/5=4.6) without exceeding the vapor pressure limit of 11 psia.

VI.A.5 Increase in Recoverable LPG at Rodeo from SMR Semi-Refined Products

Based on the analysis below, it is clear that the amount of LPG sent from Santa Maria to Rodeo would increase as a result of the Rail Spur Project. My calculations indicate that the increase in recoverable LPG at the Rodeo Refinery, as a result of the Santa Maria Rail Spur Project, would range from 275[259] to 900 bbl/day.[260] The Throughput Increase Project would further increase this by up to 10% relative to permitted throughput (302 to 990 bbl/day).

---

[253] Vapor pressure of mixture of 5% propane and 95% butane at 70 F = (0.05)(110) + (0.95)(17) = 21.65 psia *See*: http://www.engineeringtoolbox.com/propane-butane-mix-d_1043.html.

[254] Solving the equation, 5.76 + x(45) =11, for x, the fraction LPG, yields 12%.

[255] Solving the equation, 5.76 + x(22) =11, for x, the fraction LPG, yields 23%.

[256] Rail Spur FEIR, Table 2.7.

[257] Rail Spur FEIR, Figure 2-11.

[258] The amount of LPG in naphtha: (0.9/18)x100 = 5%.

[259] The Santa Maria Rail Spur Project would import 35,478 to 38,237 bbl/day of tar sands crude by rail. FEIR, p. ES-6. The increase in recoverable LPG, relative to the typical crude blend:
(1) assuming 35,478 bbl/day of tar sands crudes are delivered by unit trains (FEIR, p. ES-6) = (35,478 bbl/day)*(0.0244-0.01) = **511 bbl/day**; (2) assuming 38,237 bbl/day are delivered by unit trains: (38,237 bbl/day)(0.0244-0.01) = **551 bbl/day**. Average = [511+551]/2 = 275 bbl/day. The fraction LPG is the maximum reported LPG (Western Canadian Select) for tar sands blends from Table – minus the maximum in the baseline from FEIR Table 2.7.

[260] The increase in recoverable LPG, relative to the typical crude blend: (1) assuming 35,478 bbl/day of tar sands crudes are delivered by unit trains (FEIR, p. ES-6) = (35,478 bbl/day)*(0.0244) = **866 bbl/day**; (2) assuming 38,237 bbl/day are delivered by unit trains: (38,237 bbl/day)(0.0244) = **933 bbl/day**. Average = [866+933]/2 = **900 bbl/day.** The fraction LPG is the maximum reported LPG (Western Canadian Select) for sands blends from Table – minus the minimum (0%) in the baseline from FEIR Table 2.7.

The January to December 2013 fuel gas sampling at the Rodeo Refinery[261] measured an annual average daily value of 13,970 bbl/day[262] of LPG in the refinery fuel gas, compared to the design basis of 14,500 bbl/day[263], or a shortfall of an annual average daily value of **530 bbl/day**. As the daily recoverable LPG at Rodeo varies substantially from month to month, ranging from about 10,800 bbl/day to 16,800 bbl/day,[264] the shortfall on any given day could exceed 3,700 bbl/day (14,500 – 10,800 = 3,700), based on a monthly average.

Thus, increases allowed by both the Throughput Increase and Rail Spur projects are required to reach the design target of 14,500 bbl/day. This calculation reveals a deficit that could be filled by importing tar sands crudes with more LPG or importing light crudes, such as Bakken, by marine tanker under its existing operating permit. Significantly more LPG, for example, could be supplied to Rodeo by the Rail Spur Project than estimated here by importing tar sands crudes with a higher LPG content, such as Lloyd Kerrobert, which contains up to 1.6[265] times more LPG than assumed in this calculation.

VI.A.6 Increase in Recoverable LPG at Rodeo from Imports Via Santa Maria

The RTC asserts that "[n]o changes in the crude delivery system, type of crude or operations at the SMR are needed in order to fully utilize the propane recovery unit in Rodeo" with reference to the LPG samples collected in 2013.[266]

---

[261] The August 2011 sample is not a reasonable basis to estimate baseline propane/butane recovery because it is for a single month, based on limited sampling, and significant concerns have been documented about the accuracy and representativeness of this data that have not been addressed. *See* Fox/Pless Comments on Propane Recovery RDEIR, February 2, 2015, pp. 9-11 (Exhibit 9A) and Greg Karras Expert Report Re: Phillips 66 Propane Recovery Project RDEIR, December 5, 2014. (Exhibit 9B),

[262] Propane Recovery RDEIR, p. 3-33. This value may be higher than the true baseline because in 2013, the Santa Maria Refinery was refining 2% to 7% Kearl Lake dilbit. Rail Spur RDEIR, pp. ES-14, 4.13-27, 2-31, 2-33, 5-3. Further, the supporting data for the 2013 sampling has never been produced. My analysis of the 2011 supporting data, which was included in the BAAQMD application, indicates that recoverable LPG was based on maximum daily fuel gas flow rates, not the average, thus overstating recoverable amounts, which are based on daily averages. *See* Fox/Pless Comments on Propane Recovery RDEIR, February 2, 2015, pp. 10-11 (Exhibit 9A).

[263] Propane Recovery RFEIR, pp. 2-3, 2-6, 2-7, 3.1-28; BAAQMD, Authorities to Construct for Permit Application No. 25199, Plant No. 21359, Condition 2, March 18, 2015. (Exhibit 15)

[264] RTC ABJC-31, Exhibit A, Refinery Propane + Butane Production.

[265] The increment for WCS over typical SMR blend is 1.44% and for Lloyd Kerrobert over Typical Blend is 2.34%. Thus, Lloyd Kerrobert would yield 1.6 times more LPG than assumed in the above calculations.

[266] RTC CBE-84/85.

First, 2013 is not a baseline year. The only sample collected in the baseline years is the 2011 sample. From April through August 2011, when the 2011 LPG sample was collected, the Rodeo refinery received about 1.5 million barrels of 40° API gravity, 0.6% sulfur crude oil from Russia, with properties very similar to Bakken crude. The refinery did not normally run this highly volatile crude.[267] Thus, at the time of the August 2011 sample, the refinery was processing a lighter feedstock, similar to the then-proposed Bakken imports via the Rail Spur Project, which had more recoverable LPG than the baseline crude slate. This would have jacked up the amount of recoverable LPG in Rodeo fuel gas and thus biased the August 2011 sample high compared to the baseline.

Second, the record contains no data to support this claim. To support this claim, the FEIR would have to present complete crude slate composition data in the baseline and before and after the 2011 and 2013 LPG samples were collected.

VI.B PIECEMEALING: THROUGHPUT INCREASE PROJECT AND RAIL SPUR PROJECT

In response to comments, the following sections demonstrate that the Throughput Increase Project and the Rail Spur Project are inextricably linked for the following reasons:

- They were designed and planned together (Table 6);
- Local crude supplies were in serious decline and inadequate to satisfy the pre-Throughput Project permitted level (44,500 bbl/day), let alone the proposed increase;
- Local crude supplies were not cost competitive compared to North American cost-advantaged crudes available to ConocoPhillips;
- The truck unloading capacity at the SMPS was not adequate to accommodate both the increased throughput and making up for the throughput shortfall;
- The Throughput Increase Project could not be realized without a means to economically import the crude, which was fulfilled by the Rail Spur Project;

[267] Karras Report, February 2, 2015 (Exhibit 7).

- ConocoPhillips/Phillips 66 was actively developing North American cost-advantaged crude sources, which it planned to market to its existing refineries, including SMR, thus replacing higher priced local production.

VI.B.1 Designed and Planned Together

The Santa Maria Throughput Increase Project, the Santa Maria Rail Spur Project, and the Rodeo Propane Recovery Project were all on the drawing board at the same time (Table 6), planned to support each other. *See* Rail Spur RDEIR Comments ABJC-04 (Horton); ABJC-31 (Pless); CBE-100 (Fox); and Rail Spur DEIR Comments (Fox). The Rail Spur DEIR attempted to head off a piecemealing argument by pointing out that the Throughput Increase FEIR was certified about two months before the application for the Rail Spur Project was submitted to the County.

However, the timeline in Table 6 indicates that studies that became part of the application to the County were under way; design drawings had been prepared for the Rail Spur Project EIR well before the Throughput Increase FEIR was certified; and permit modifications had been filed to remove system vapor pressure constraints to facilitate these projects in early 2012. Thus, all three projects were being simultaneously planned. *See* Table 6. The FEIR attempts to downplay this connection by arguing the studies were not known to the County.[268] However, what was known to the County is not relevant, but rather, what was known to the applicant, who was obligated to disclose the full project.

The Rail Spur FEIR[269] and RTC[270] argue that the Throughput Increase and Rail Spur projects are not related because the Santa Maria Pump Station has sufficient capacity to unload crude oil from trucks and move it via pipeline to the Refinery. They further argue that they need only demonstrate that adequate infrastructure exists to deliver crude. However, crude and the infrastructure to deliver it are inextricably linked. The infrastructure/capacity to import sufficient crude to support the throughput increase does not prove that these projects are not dependent on one another. The missing "crucial element" is crude to supply the increase. Physical infrastructure with adequate capacity without sufficient crude oil to fill it does not demonstrate the projects are independent. An empty glass does not provide a drink of water. The RTC and FEIR also argue that cost is not a CEQA factor. But here, where

[268] Rail Spur FEIR, p. ES-27.

[269] Rail Spur FEIR, pp. ES-26/27.

[270] RTC ABJC-31.

slim operating margins and the high cost of local crudes renders an alternative infeasible, cost is an important factor to determine the interdependency of projects.

VI.B.2 Local Crude Supply in Decline

The Santa Maria Refinery was designed to refine local crudes. It is located in the middle of the Santa Maria Basin oil field and connected to production sites by a web of local pipelines. It is landlocked and has no access to marine deliveries. At the time that the Throughput Increase Project was first formally proposed, in 2007, there was not sufficient local competitively priced crude oil to supply either the refinery's permitted capacity (48,500 bbl/day) or the requested 10% increase in throughput to 48,950 bbl/day. Further, the applicant, ConocoPhillips, an integrated oil company with ownership of both production and refining, was aggressively developing North American, out-of-state, cost-advantaged sources of crude that it planned to deliver to its refineries in California, including Santa Maria.[271] Increasing the capacity of its refineries to accept more of these cost-advantaged crudes made good business sense.

The availability of crude oil is the "crucial element," *i.e.*, the "integral part" of the Throughput Increase Project that was not present in 2007[272]. The Project doesn't have "independent utility" without an adequate crude supply. Local supplies that had sustained the refinery for decades were in serious decline at the time the Throughput Increase Project was being planned. The decline has been well documented and admitted by Phillips 66 as a justification for the Rail Spur Project in its presentation to the San Luis Obispo Planning Commission on February 8, 2016:[273]

"California Crude Oil Production Decline

- The decline of California crude oils is very well documented
- Production along the Central Coast drastically reduced
- Competition for barrels"

---

[271] Phillips 66, Barclays CEO Energy-Power Conference, p. 11, September 3, 2014, New York; Available at: http://s1.q4cdn.com/175206842/files/doc_presentations/2014/BarclaysEnergyConf2014slides_ad.pdf.

[272] *National Parks & Conservation Ass'n v. County of Riverside* (1996) 42 Cal.App.4th 15505, 1519.

[273] Jocelyn Thompson, Phillips 66 Santa Maria Refinery Rail Spur Extension Project, Slides (Exhibit 12), pdf 25, Why This Project?, February 8, 2016; Available at: http://www.slocounty.ca.gov/Assets/PL/Santa+Maria+Refinery+Rail+Project/Phillips+66+Planning+Commission+Hearings/February+4$!2c+2016/Presentations+February+4$!2c+2016/Phillips+66+Applicant+Planning+Commission+Presentation.pdf.

Further, the locally available crudes were not cost-competitive with other crudes then flooding the market. ConocoPhillips had been developing out-of-state sources of North American cost-advantaged crudes that could not be cost effectively accessed with the local infrastructure. The access to crude oil required to supply the shortfall and 10% increase was supplied by the Rail Spur project, which was on the drawing board at the same time that the Throughput Increase Project was being permitted. The Rail Spur Project is a reasonably foreseeable consequence of the Throughput Increase Project because without available, cost-competitive crude oil, an increase in throughput would not be feasible. Further, the Throughput Increase DEIR identified increased rail transport as one of seven alternatives to the project, but did not evaluate it.[274] The impact of the two projects combined is much great that the impact of the Throughput Increase Project alone.[275]

The Rail Spur DEIR and FEIR admit these fundamental facts in their alternatives analysis when they explain: "The reduced rail delivery alternative would meet most of the objectives of the Rail Spur Project. However, it may not allow the SMR to operate at its permitted throughput capacity since less crude oil could be available to the refinery."[276] Further, the no project alternative analysis in the Rail Spur FEIR assumed 100% truck import from out-of-state,[277] confirming the intent to abandon local crude sources and import 100% of the crude from out-of-state sources owned by ConocoPhillips. Without the ability to import out-of-state sources, the refinery could not continue to operate at permitted levels in the future. The import of out-of-state sources requires the Rail Spur Project.

This was driven home recently by the May 19, 2015 Refugio pipeline rupture off the Santa Barbara County coast, which led to shutting down Exxon-Mobil Las Flores, PXP/Freeport McMoRan Point Arguello, and Venoco Ellwood off-shore production. The ruptured pipeline supplies connector pipelines that supply the Santa Maria Refinery.[278] The loss of this supply resulted in idling one of its two refining trains. The

---

[274] Throughput Increase DEIR, p. ES-6.

[275] Rail Spur FEIR, Table 3.1.

[276] Rail Spur DEIR, pp. ES-12 & 5-35; Rail Spur FEIR, pp. 5-3/4 and 5-69.

[277] Rail Spur FEIR, Sec. 5.1.1.

[278] Stillwater Associates, Bubble Map Update: How the Oil Spill Impacts the California Supply Chain, June 27, 2015; Available at: http://stillwaterassociates.com/bubble-map-update-how-the-oil-spill-impacts-the-california-supply-chain/; Freeport-McMoRan Reports Third-Quarter and Nine-Month 2015 Results, October 22, 2015, p. 17; Available at http://www.fcx.com/news/2015/10222015.pdf; Venoco, Inc. Temporary Crude Oil Trucking Project Description;, Revised August 6, 2015; http://www.cityofgoleta.org/home/showdocument?id=9903.

pipeline shutdown is long term, projected to take 5 years to get back on line.[279] Alternate crude supplies are so far not available at the Santa Maria Refinery to replace this lost production.[280] The Rail Spur Project is now being justified as required to replace this lost supply, demonstrating that local supplies are limited and not adequate to fill permitted limits.[281]

Finally, in February 1, 2016 comments submitted to the Planning Commission, Phillips 66 asserted that refining rates permitted in the Throughput Increase Project could be achieved without the Rail Spur Project because "the approved processing rates have been achieved already."[282] This was based on an expert declaration in attachments to this letter in which Mr. Schroll declared: "In March 2015, after the County conducted a full environmental review, the County provided Phillips 66 with Notice to Proceed on its prior-approved project to increase the throughput limit at the Refinery by 10%. Since then, the Refinery has achieved processing rates that reach that new throughput limit."[283] No further detail is provided.

New equipment and throughput limits are commonly tested on startup to identify operational issues and repair them before routine operation starts. A short-term test, for example, at maximum permitted daily throughput could be demonstrated by using crude stored in on-site tanks. Unless the maximum permitted throughput has been achieved over an extended period of time, a short-term, shake-down test would prove nothing.

Further, the Throughput Increase Project increased two crude throughput limits by 10%. The maximum daily limit was increased from 44,500 to 48,950 bbl/day, and the 12-month rolling average limit was increased from 16,220,600 to 17,866,750 bbl/day.[284] As the Notice to Proceed was not issued until March 2015, sufficient time has not elapsed to demonstrate that the 12-month rolling average limit in

---

[279] Alex Kacik, Refugio Oil Spill Pipeline Might Take Five Years to Get Back On Line, Pacific Coast Business Times, November 5, 2015; Available at: http://www.pacbiztimes.com/2015/11/05/refugio-oil-spill-pipeline-might-take-five-years-to-get-back-online/.

[280] Alex Kacik, Oil Company Wants to Expand Orcutt Drilling Despite Pipe Closures, September 4, 2015, Pacific Coast Business Times; Available at: http://www.pacbiztimes.com/2015/09/04/oil-company-wants-to-expand-orcutt-drilling-despite-pipe-closures/.

[281] 2/8/16 Thompson Slides (Exhibit 12), pdf 25.

[282] 2/1/16 Thompson Letter (Exhibit 3A), pp. 36-37.

[283] 2/1/16 Thompson Letter (Exhibit 3A), In the attachment to this letter (Exhibit 3B) see Attachment 31, Schroll Declaration, Parag. 13, pdf 353.

[284] Throughput Increase FEIR, p. 2-24.

the Throughput FEIR has been achieved. Further, the applicant has not provided any data to demonstrate that even the maximum daily limit can be achieved on a routine basis. A one-time test at the maximum daily limit would prove nothing as to crude supply over the long term as this amount of crude could be accumulated in on-site storage tanks in preparation for a shakedown test.

In addition, the application to SLOAPCD to increase the throughput limits to the levels evaluated in the FEIR was amended twice, each time lowering the 12-month rolling average limit, in recognition of the fact that "the refinery cannot realistically reach the maximum limit specified in the EIR." An amendment to the SLOAPCD application on November 12, 2014 lowered the 17,866,750 bbl/yr request to 17,340,000 bbl/yr. A December 18, 2014 amendment lowered the request to 16,860,000 bbl/yr due to inadequate offsets.[285]

Finally, over the period during which the Throughput Project was being permitted, the SMR throughput never reached the pre-Throughput Project permit limit (Table 12), indicating that the then-existing local crude supply was not adequate. The proposed increase under the Throughput Increase Project would have required an augmentation in crude supply.

Table 12:
Crude Throughput Compared to Permit Limits[286]

Year	**Annual Total** (MMbbl/yr)	**Daily Average** (bbl/day)
2009	13,081	35,838
2010	13,725	37,603
2011	14,126	38,701
2012	13,829	37,888
2013	15,197	41,636
Pre-Throughput Limit	**16,220**	**44,500**
Post-Throughput Limit	**16,860**	**48,950**

At the time the Throughput Increase Project was being planned (Table 6 shows that the application for the air permit was filed in 2007 and the Land Use Application in 2008), the Santa Maria Refinery received crude oil for processing from various sources,

[285] SLOAPCD, Authority to Construct Engineering Evaluation, Appl. No. 6015, January 29, 2014 (Exhibit 11).

[286] Email from D.G. Carlson to Phyllis Fox, November 20, 2014 (Exhibit 10).

including: (1) by pipeline from the Outer Continental Shelf (Exxon-Mobil Las Flores and PXP/Freeport McMoRan Point Arguello, 69%), Point Pedernales (18%), and the Orcutt Pump Station (6%) and (2) by truck deliveries to the Santa Maria Pump Station (7%).[287] Crude oil from some local onshore areas is delivered by truck to the Santa Maria Pump Station and then pumped into a dedicated pipeline that carries crude oil to the SMR.[288] Thus, most of Santa Maria Refinery's supply came from offshore Santa Barbara (69% + 18% = 87%) and most of this was federal Outer Continental Shelf. The Rail Spur FEIR explains:

> *"Production from offshore Santa Barbara County (OCS crude) has been in decline for a number of years. Oil production in Santa Barbara County (both onshore and offshore) peaked at about 188,000 barrels in 1995 (County of Santa Barbara Energy Division website) and currently production is around 61,000 barrels per day for both onshore and offshore oil fields (BOEM Pacific Region and Drilling Edge websites)."* [289]

Elsewhere, the FEIR explains:

> *"California production of crude oil per year has been in decline since 1986, when production peaked at slightly over 400 million barrels. The decline has averaged about 1.7% per year since 1995. More recently, the decline has averaged over 3% annually since the year 2000."* [290]

Santa Maria's main source of crude is Santa Barbara County, where oil production (including both onshore and offshore oil processed in the County) had dropped by 2/3, from 188,000 bbl/day in 1995 to 61,000 bbl/day by 2009.[291] The SMR would need to use most of this to meet its permitted throughput limit. However, SMR does not have ready access to all of the Santa Barbara production, as some is in the eastern part of the County, including offshore, and moves on pipelines into Ventura County.

SMR receives most of its crude supply via pipeline from three federal Outer Continental Shelf (OCS) projects: Exxon-Mobil Las Flores, PXP/Freeport McMoRan

---

[287] Throughput Increase DEIR & FEIR, p. 2-7.

[288] Throughput Increase DEIR & FEIR, Table 2-4.

[289] Rail Spur RDEIR, p. 2-36.

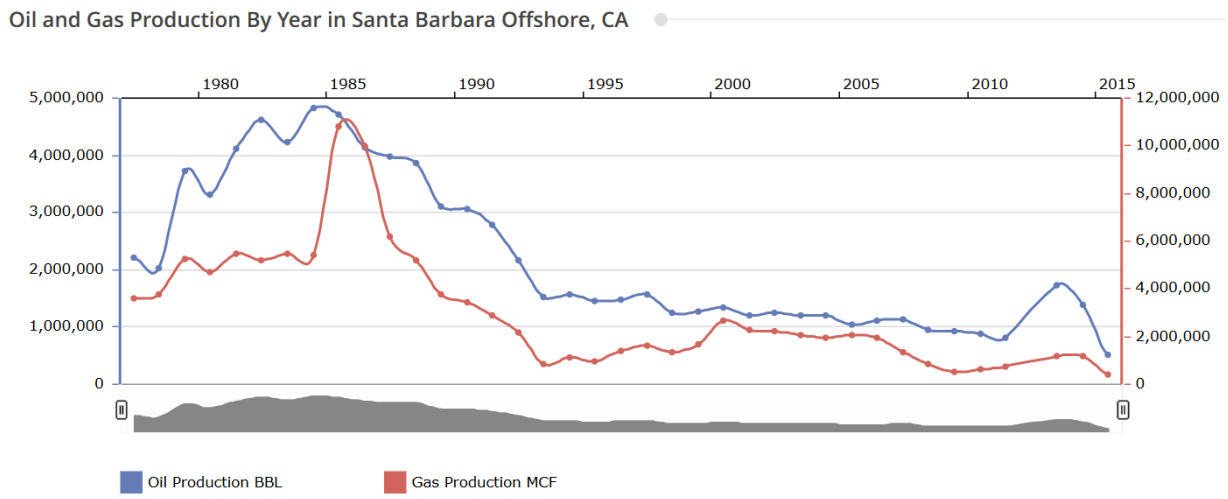
[290] Rail Spur FEIR, p. 6-3.

[291] http://www.sbcountyplanning.org/energy/information/oilGasProduction.asp; http://sbcountyplanning.org/energy/who/oil_gasMap.asp; DOGGR, Oil and Gas Statistics, pp. 58, 68-69, Offshore Oil And Gas Fields - 2009; Available at: ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf.

Point Arguello, and Point Pedernales. Production at these Federal OCS projects was over 166,000 bbl/day in 1995 and dropped to about 46,000 bbl/day by 2009 or by about three quarters.[292]

The decline in local sources of crude that the Santa Maria Refinery has relied upon is confirmed by other information, including as shown in Figures 4 and 5. Figure 4 shows the decline in Santa Barbara County in state water (but excludes federal OCS).

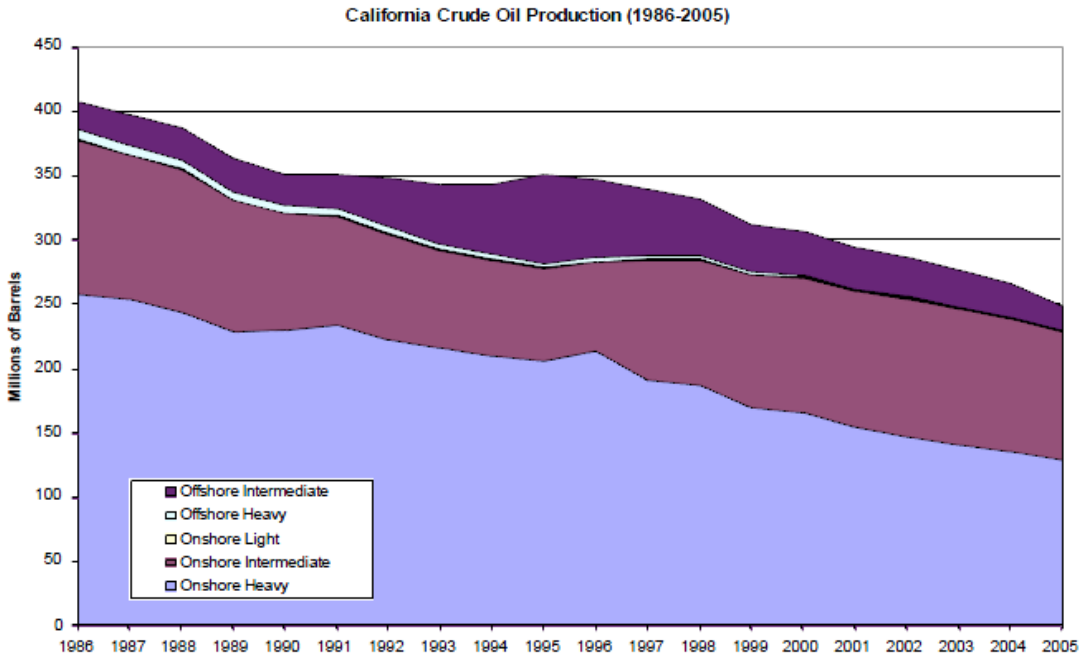
Figure 4:[293]



[292] *See* footnote 290.

[293] DrillingEdge, Oil & Gas Production in Santa Barbara Offshore, CA; Available at: http://www.drillingedge.com/california/santa-barbara-offshore.

Figure 5:[294]



Point Pedernales (part of the Offshore Heavy line in the above graph), supplied 18% of SMR's crude oil. It was ranked by DOGGR as one of ten oil fields in the entire state with the largest production decrease between 2006 and 2007.[295] Historical production from Point Pedernales peaked at close to 25,000 bbl/day of dry oil in 1987 and 1989 and declined to about 7,000 bbl/day by 2005.[296] As of 2008, production was projected to cease as soon as 2010 to 2012.[297] This oil could only go to the Santa Maria Refinery due to the pipeline configuration. Plains Exploration & Production Co. (PXP) proposed to increase offshore production from this field at Tranquillon Ridge prior to

[294] Margaret Sheridan, California Crude Oil Production and Imports, CEC Staff Paper, Report CEC-600-2006-006, April 2006, Available at: http://www.energy.ca.gov/2006publications/CEC-600-2006-006/CEC-600-2006-006.PDF.

[295] DOGGR, Oil and Gas Statistics, p. 65, Ten Oil Fields with Largest Production Decreases (bbl) – 2006 to 2007, 2007; Available at: ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2007/0102stats_07.pdf.

[296] Aspen, Final Environmental Impact Report, Tranquillon Ridge Oil and Gas Development Project, April 2008, p. 2-15, Available at: http://www.sbcountyplanning.org/energy/documents/projects/TranqRidgeFinalEIR/index.htm.

[297] Aspen 2008, p. 2-13.

2005,[298] which was justified to offset this production decline, but the project was rejected by the State Lands Commission in January 2009.[299]

Thus, ConocoPhillips certainly knew that it had a crude supply problem at Santa Maria.

Further, between 2007, when ConocoPhillips filed its permit application with SLOCAPCD, and the release of the Throughput DEIR in 2011, crude throughput at the Santa Maria Refinery declined from a high of 43,321 bbl/day to a low of 35,838 bbl/day in 2009.[300] The Throughput Increase FEIR estimated the increase in throughput relative to 2009 throughput of 35,838.[301] Thus, the refinery was operating at 8,712 bbl/day below its permitted capacity (44,500 - 35,838 = 8,712), at the same time it was asking for an increase in permitted throughput. The Throughput Increase FEIR assumed the shortfall and 10% increase could be supplied by local sources of crude, trucked into SMPA, mostly from Arroyo Grande and San Ardo,[302] in spite of significant declines in these fields at that time, prior to 2007. There is no evidence in the record that the identified local fields could supply the assumed increases.

Local crude trucked into SMPS actually declined from 4,090 bbl/day in 2007 to 3,036 bbl/day in 2009.[303] But the Throughput Increase FEIR assumed that supply from local crude sources could more than double to 8,219 bbl/day, an increase of 5,183 bb/day compared with actual 2009 supply. The Throughput FEIR assumed that local crude sources could supply almost triple what it actually supplied to SMR in 2009.[304]

Arroyo Grande was actually a small and declining crude source, with production down from 1,501 bbl/day in 2007 to 1,237 bbl/day in 2009, of which only 863 bbl/day

---

[298] County of Santa Barbara Planning and Development, Notice of Preparation of a Draft Environmental Impact Report, Tranquillon Ridge Development Project, February 8, 2006, pdf 47 citing a January 6, 2005 APCD letter under Sec. 7.0: Previous Environmental Documents; Available at: http://www.sbcountyplanning.org/energy/documents/projects/TranqRidgeFinalEIR/Vol2/App%20K.pdf.

[299] Sonia Fernandez, State Lands Commission Rejects Offshore Drilling Plant, NoozHawk, January 29, 2009; Available at: http://www.noozhawk.com/article/0129_state_lands_commission_rejects_offshore_drilling_plan.

[300] Rail Spur DEIR, Table 2.7.

[301] Throughput Increase FEIR, pp. A-5/6.

[302] Throughput Increase FEIR, pp. A-2/3.

[303] Throughput Increase FEIR, pp. 2-7, 9; A-2/3.

[304] (3036+5183)/3036 = 2.7.

went to SMR.[305] San Ardo is further away (96 miles from SMPS), and sends most of its crude elsewhere.[306] Most San Ardo production is by Exxon Mobil/Shell and is typically sent by unit train for refining in the Los Angeles area.[307] When Santa Maria trains use the southern route, this results in cumulative impacts with the San Ardo trains that was not considered in the FEIR.

Thus, ConocoPhillips knew competitively priced local crude could not supply the increase in throughput sought at the time of the Throughput Increase Project or continue to supply its original permitted throughput of 44,500 bbl/day. As noted in Comment ABJC-31, "[t]here would be no reason to apply for an increase in the face of declining local production without a plan to supply the increase and offset known anticipated declines."

As the refinery was operating below its permitted throughput, there would not be any need for a throughput increase unless there were plans to replace the then existing deficit with crudes from somewhere else. Instead, it is much more likely that ConocoPhillips' goal was to replace its local crude shortfall up to the throughput permit limit with North American cost-advantaged crudes that it was developing outside of California and that required rail to reach the refinery.

The current potential availability of new sources of local crude, as listed in RTC ABJC-31 to rebut the crude decline argument is immaterial because "the success and amount of additional production" are admittedly "speculative."[308] Further, these currently proposed projects were unknown and unknowable when the Throughput Increase Project was being permitted, so they are irrelevant as to what was known in the 2007 to 2012 timeframe.

---

[305] Throughput Increase FEIR, pp. 2-7; A-2/3; DOGGR, 2007 and 2009 Annual Oil and Gas Reports; Available at: http://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx.

[306] *See* footnote 304.

[307] Most San Ardo production is by Aera Energy, which is jointly owned by Exxon Mobil and Shell. The unit train is operated by Union Pacific for Exxon Mobil. The crude unit trains shuttling between San Ardo and the Los Angeles area use the UPRR line south through San Luis Obispo County and thus the routing of these unit trains coincide with the southern routing of unit trains from the Rail Spur Project. *See*: Rail Spur FEIR, p. 4.7-2; http://www.aeraenergy.com/; http://www.exxonmobil.com/Images/EMPCo/West_Coast2.pdf; http://www.up.com/customers/chemical/crude/origin_facilities/index.htm; and http://yosemite.epa.gov/R9/air/EPSS.NSF/735056a63c1390e08825657e0075d180/e1e0cc5cd519261f88256fc0006c09f0/$FILE/TV34-01evl.pdf.

[308] Rail Spur RDEIR, p. 2-36.

During the period these piecemealed projects were being developed, ConocoPhillips, an integrated oil company, was developing North American cost-advantaged crudes to market to its West Coast refineries to improve it profit margin. The production side and refining side of the company would have had access to the same information. More crude via the Throughput Increase Project means more profits.

In April 2012, Clayton Reasor, ConocoPhillip's Vice President, Corporate and Investor Relations, stated at an investor conference:

> *"We think that there's opportunities to capture more feed stock advantaged crudes. We can drive our clean product yields, increase our export capability. 1% improvement in clean product yield gives us about $100 million to $150 million of net income improvement. If we can capture $1 a barrel of WTI/Brent differential, it's worth about $90 million of net income. There is powerful economic incentives to capture these margin improvements….*
>
> *We think we have the ability to capture an advantaged feed stocks. It's a key part of our plan to improve margins in our R&M [refining and marketing] segment. I think having the system capability and the flexibility to capture crude advantage has helped us capitalize on the recent WTI [West Texas Intermediate] differentials we've seen. We plan to increase our exposure to heavy, to high acid, to WTI, WTS [West Texas Sour]. In 2012 we'll move that to over 60%. We think by 2015 we can move to over 65% without significant capital expenditure….*
>
> *We'll work to increase our infrastructure capability to get advantaged feeds into the refineries. We'll also work on export infrastructure around our West Coast and our Gulf Coast facilities.*
>
> *In the R&M segment, just look at the opportunities to add capacity. They don't seem to make a lot of sense to me at this point in time. We'll spend some incremental capital, that are going to be 25%- and 30%-type return projects around grabbing some of this advantaged crude, and pushing margins and yields*
>
> *Near term, we want to run more shale oil through our refineries. We have the kit today to run about 460,000 barrels a day of shale type crudes. As this new production comes online, as we debottleneck infrastructure, we'll work to bring that into the refineries. We also have some projects that we can pursue. At Billings we can go from 2% to 3% sulfur. We can go from 75% heavy to 100% heavy. This investment, it's less than $200 million. It will save us $3 to $4 a barrel. We'll work to increase our infrastructure*

capability to get advantaged feeds into the refineries. We'll also work on export infrastructure around our West Coast and our Gulf Coast facilities.[309]

In a September 2012 presentation, after Phillips 66 had split from Conoco Phillips (May 1, 2012), remarks by Greg Garland, CEO and Chairman of Phillips 66, continues the cost-advantaged crude theme:

"A big source of competitive advantage we think we can have in our business is the access to advantaged crudes. It's 75% of our cost structure, a lot of work going across the Company in accessing these advantaged crudes….

You will see us invest capital around infrastructure, to put advantaged crude to the front end of the refineries or export infrastructure to export product out of the back end of the refineries…

Talk about capturing advantaged feedstock. As I said, this is about 75% of the cost structure in our refining business. It's the single biggest lever that we have to create value in the base refining business. $1 a barrel across our system is worth about $500 million of net income to us. So it is significant. Today, PSX is the largest importer of Canadian heavy crude in the US. In July, we ran about 130,000 barrels a day of shale oils. We ultimately plan to take that to 460,000 barrels a day.

We think it'll take us a couple years to accomplish that. We announced the acquisition of about 2,000 railcars. That gets us about 120,000 barrels a day of additional capacity for shale. Probably that's going to go east and west to our refineries on the West Coast and East Coast. So far, we've had about a half a percent ROCE improvement with this. We think we can drive 2% to 3% ROCE [Return on Capital Employed] improvement with the shale crude…

We believe as we capture advantaged crude that we will drive margin improvement in our base.[310]

---

[309] Phillips 66 Investor Update, Thomson Reuters Streetevents Edited Transcript, COP – Phillips 66 Analyst Update, April 9, 2012, pp. 4, 6, 8; Available at: http://s1.q4cdn.com/175206842/files/events/2012/April%202012%20PSX%20Investor%20Update%20Transcript.pdf.

[310] Phillips 66 2012 Barclays CEO Energy-Power Conference, September 5, 2012, pp. 2, 4, 6; Available at: http://s1.q4cdn.com/175206842/files/events/2012/Phillips66_Barclays_CEO_Energy-Power_Conference_080512_FINAL.pdf.

In a September 2013 investor conference call, Clayton Reasor, Phillips 66's Senior Vice President of IR, Strategy and Corporate Affairs, discussed the role of Bakken and other light crude in Phillips 66's profit strategy:

> *"The positive $3.69 per barrel adjustment for feedstocks stems from running certain crudes and other feedstock that are priced lower than our benchmark crudes. For example, our feedstock advantage this quarter was primarily related to running foreign heavy sour crudes at our Gulf Coast refineries, and Canadian crudes in our refineries in the Central Corridor. In addition, our crude slate has increased to include more shale crudes, primarily Bakken and Eagle.*
>
> *Slide 12 shows the percentage of advantaged crude runs at our refineries, as well as clean product yields for 2011 and 2012. Many of our refineries have the complexity to run price-advantaged Canadian, Bakken and Eagle Ford crudes. Shale crudes are being run in all four of our refinery regions. And in addition, we have access to multiple transportation systems to reliably deliver these crudes to our US refineries, providing an overall competitive advantage….*
>
> *So as you think about this, it was originally envisioned as a Bakken play to go east and west, without question. Where we are investing in infrastructure is at our refineries for unloading, if you will. And we are using third-party access in the Bakken itself. I don't think we see the need to invest in terms of loading facilities in the Bakken at this point in time…*
>
> *And frankly, the nice thing about the railcars is they can move over time as the opportunity moves. But our view is that the next five-year window, Bakken crudes will probably move a lot of it by rail going east and west."*[311]

At the May 2013 Annual Meeting of Stockholders, the CEO of Phillips 66 stated:

> *"We increased our advantaged crude runs from 52% in 2011 to 62% in 2012. In the first quarter we announced that we are at 68% advantaged crude. Our plan is to get our refineries on a 100% advantaged crude. And we're going to do that by using trucks and rail and barges and ocean going vessels and pipelines. We're going to use every means available to us to put these advantaged crudes to the front of the refineries.*
>
> *The first and most significant lever that we have in creating value in refining is to capture advantaged crudes and put those crudes to the front of our refineries. We're well*

[311] Phillips 66 Fourth-Quarter Earnings Conference Call, January 1, 2013, pp. 5, 14; Available at: http://s1.q4cdn.com/175206842/files/events/2013/PSX_Transcript_2013_01_30T.pdf.

positioned. When you look at where the legacy assets are, where our refineries are, they're right around the emerging areas of production. Across our system $1 a barrel translates to $450 million of net income, so just $1 move and a $1 value capture is very significant for us. We increased our advantaged crude runs from 52% in 2011 to 62% in 2012. …"[312]

There are many similar investor and other presentations on the Phillips 66 website, under: "Investors", "Events and Presentations"[313] that make clear that ConocoPhillip's and Phillips 66's business strategy was to increase its profit margin by importing cost-advantaged crudes into its refineries, including those on California west coast and specifically, its Santa Maria Refinery.

VI.B.3 Alternate Sources of Crude

ConocoPhillips must have had a backup plan in 2007 when it submitted its application to SLOC (*see* Table 6) to replace the declining crude supplies and to meet the throughput increase. That backup plan was the Rail Spur Project to import North American cost-advantaged crudes that ConocoPhillips itself was actively developing. The timeline in Table 6 shows that planning for the Rail Spur Project, to replace declining crude supplies and to allow an increase in permitted throughput, started well before the Throughput Increase FEIR was certified.

ConocoPhillips was at this time an integrated oil company with both refining and crude production under common ownership. With local sources of crude in decline at the time the Throughput Increase Project was being permitted, available local sources were among the most expensive to produce.[314] Given increases in the supply of cost-advantaged crudes available outside of the local area, from ConocoPhillips' own reserves, it is obvious that ConocoPhillips was planning to import cost-advantages crudes from its own tar sand and light crude reserves.

---

[312] Phillips 66 Annual Meeting of Stockholders, May 8, 2013, p. 8; Available at: http://s1.q4cdn.com/175206842/files/events/2013/2013_PSX_Stockholder_MeetingTranscript.pdf.

[313] Phillips 66, Investors, Available at: http://investor.phillips66.com/investors/overview/default.aspx.

[314] As discussed in the previous section of these Comments ("Local Crude Supply in Decline"), crude production near Santa Maria and throughout California was in steep decline from 1995 onward. It was not feasible and profitable to expand local production, or even to maintain it at existing levels. Production costs in California tend to be high, due to the prevalence of mature fields and heavy crudes, which require widespread use of enhanced oil recovery. Further, off-shore drilling, which has been a major source of crude to SMR, is more expensive to produce than other crudes.

During this time, Conoco Phillips itself was very involved in developing various North American cost-advantaged crudes, including tar sands and light shale crudes.[315] It was a 50% owner (together with TransCanada) of the Keystone Pipeline (including KXL).[316] Further, by 2007, ConocoPhillips was also producing Bakken crudes and other light tight sands crudes including Barnett, Eagle Ford, Niobrara, and Permian.[317] And by 2014, it had become the tenth largest producer of Bakken crudes, in partnership with Burlington Resources Oil & Gas Company. Thus, ConocoPhillips was very interested in moving tar sands and light shale crudes to its refineries. These plans are evident in modifications that it made to tank vapor pressures in its pipeline system supplying the Rodeo and Santa Maria refineries.

In 2012, when ConocoPhillips was widely reporting its strong position in North American cost-advantaged light shale crude,[318] it applied to increase the vapor pressure on its Santa Maria Pump Station (SMPS) temporary storage tank from 7.5 to 11 psia. This is the pump station the RTC alleges could accommodate the proposed throughput. The 11 psia limit would allow ConocoPhillips to import light shale crudes, such as Bakken, by truck. This tank currently holds crudes transported by truck from local oil fields. The local oil fields that historically supplied crude to the Santa Maria Pump Station do not produce significant amounts of light crude oils with a vapor pressure of 11 psia, as witnessed by the vapor pressure limit on the Santa Maria Pump Station tank before it was raised (7.5 psia) in anticipated of importing Bakken crude. In fact, the Santa Maria Pump Station is equipped with two steam boilers and heat exchanges that are used to heat the heavy, high-viscosity crudes produced locally to lower their viscosity so they can be pumped via pipeline to the refinery.

So why increase the vapor pressure limit on the Santa Maria Pump Station tank that would be used to enable the proposed 10% increase in crude throughput, assumed to be local crudes in the Throughput Increase FEIR[319], when the refinery was operating below its then-permitted limit and local crudes have much lower vapor pressures, less than the then permit limit of 7.5 psia?

---

[316] 2007 Form 10-K, p. 25 ("In December 2007, we acquired a 50 percent equity interest in the Keystone Oil Pipeline (Keystone) to form a 50/50 joint venture with TransCanada Corporation.").

[317] http://www.conocophillipsuslower48.com/where-we-operate/Pages/bakken.aspx.

[318] http://investor.phillips66.com/investors/events-and-presentations/2012/default.aspx.

[319] Throughput Increase FEIR, pp. A-1, A-2.

Certainly not to handle the local heavy crudes that have traditionally been imported at SMPS. *First*, there is no reason to increase throughput when the local crude supply is inadequate to supply the permitted throughput before the increase. *Second*, there is no reason to increase the use of more expensive local crudes, even if they were available, when North American cost-advantaged crudes that ConocoPhillips was heavily invested in were available. It is most likely that ConocoPhillips was planning a crude switch, to cost-advantaged crudes that it was developing elsewhere. This crude switch was disclosed in the Rail Spur DEIR, but was not disclosed in the Throughput FEIR, even though it was on the drawing board. *See* Table 6.

This vapor pressure increase gave ConocoPhillips the option to truck in Bakken and other light crudes, while waiting for the new rail spur to come online. However, due to cost and environmental constraints, discussed below, trucks would not be used all the way from these alternate crude production sites. Instead, pending completion of the Rail Spur facility at the Santa Maria Refinery, light crudes could be temporarily railed to an existing terminal, most likely in the Bakersfield area, and trucked to the Santa Maria Pump Station, while securing the permits for its own on-site rail unloading facility. This arrangement was already used for heavy tar sands via the Paloma Terminal.[320] The Rail Spur FEIR identifies Bakersfield-area rail terminal-to-truck-to-SMPS as possible.[321] However, beyond this brief mention, neither FEIR evaluates this alternative. The Rail Spur FEIR only evaluated truck transport from distant, out-of-state locations rather than local terminals.

The rail-to-truck option would only be feasible on an interim basis due to its high cost, double that of rail import, while waiting for the Rail Spur Terminal to come on line. Thus, raising the vapor pressure on the SMPS tank presages the true intent, which was to import enough North American cost advantaged crude to the Santa Maria Refinery by rail to make up both the crude shortfall and the 10% throughput increase. In fact, Phillips 66 proposed this as the No Project Alternative for the Rail Spur Project, *viz.*, "Under the No Project Alternative it is likely that additional out of state crudes would be brought to various rail unloading terminals in California and transferred to trucks for delivery to the SMPS."[322]

---

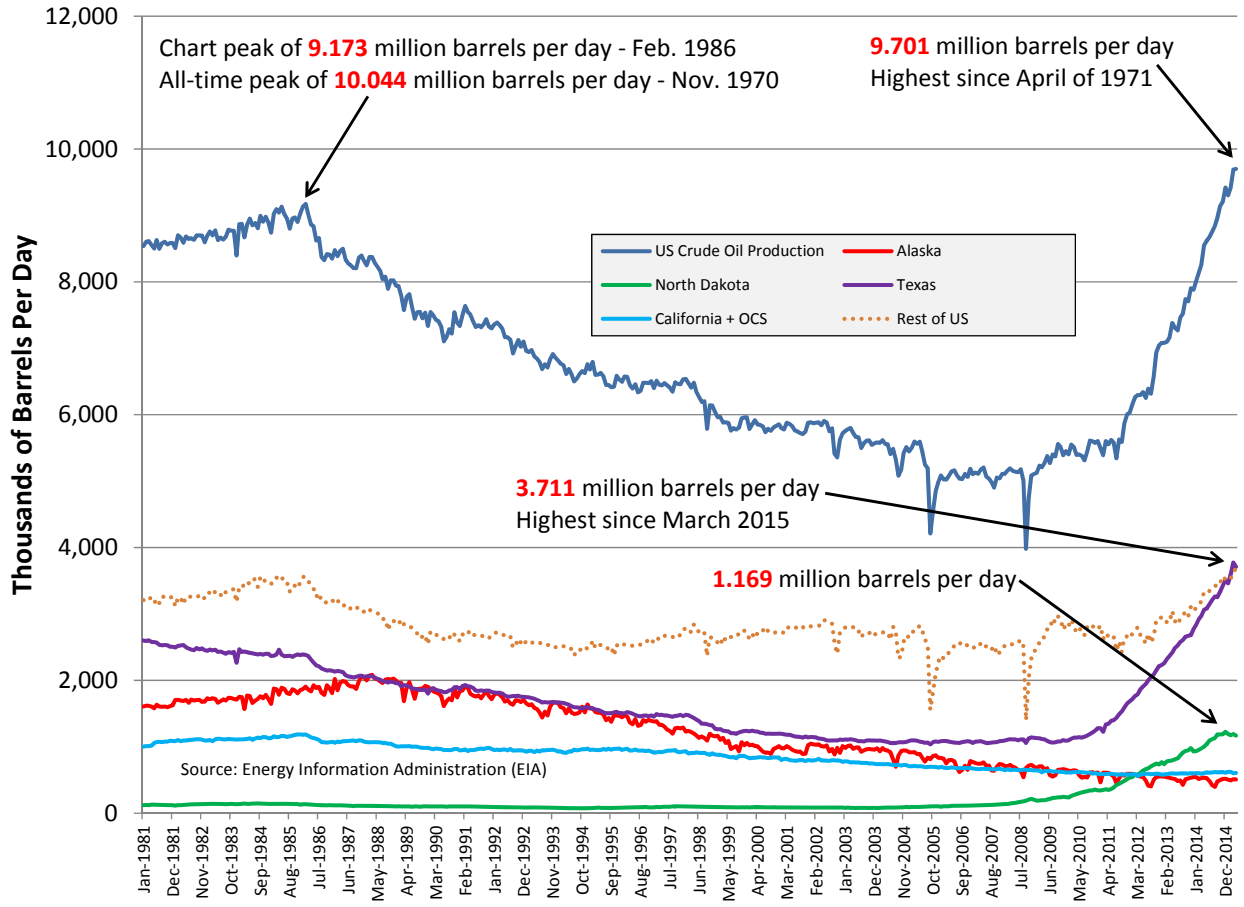
[320] Rail Spur FEIR, p. 5-3.

[321] Rail Spur FEIR, p. 5-4.

[322] Rail Spur FEIR, pp. 5-3/5.

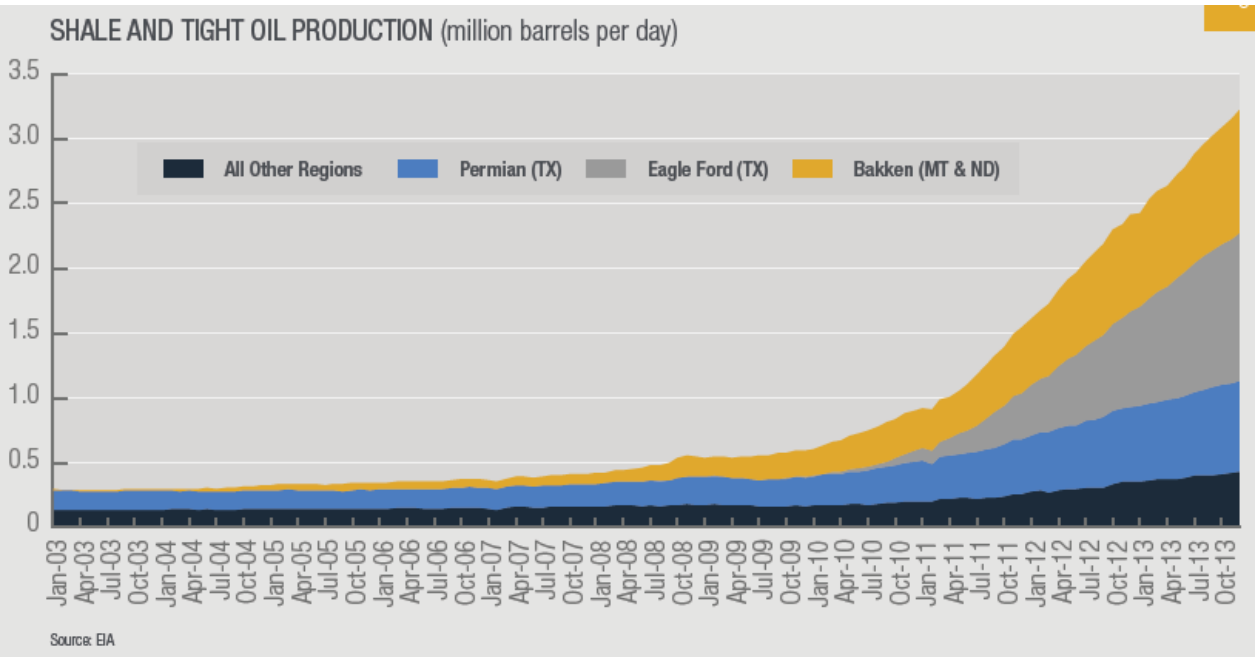
Thus, when the Throughput Increase Project was being permitted, ConocoPhillips was planning (i.e., it applied for permits) to make up its deficit and supply the throughput increase by importing Bakken and other similar light, domestic, cost-advantaged crudes that were flooding the market at the time and in which ConocoPhillips had a major stake. Figure 6 shows that at the time the Throughput Increase Project was being planned, between 2007 and 2012, California on-shore and off-shore crudes (light blue) were in decline while North Dakota (Bakken) crude (green) and other similar light crudes, not shown on this figure, were rapidly increasing.

Figure 6:[323]
Crude Oil Trends (1991-2014)



[323] Gordon Schremp, California Energy Commission, Crude Oil Overview & Changing Trends, Presentation at IEPR Commissioner Workshop − Trends in Crude Oil Market and Transportation, July 20, 2015, p. 16; Available at: http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-13/TN205401_20150720T084540_Crued_Oil_Overview__Changing_Trends.pptx.

Figure 7:[324]
Shale and Tight Oil Production



Further, ConocoPhillips, under its subsidiary name Burlington Resources, operated Conoco's Eagle Ford Shale and Bakken properties, where exploration and development were well under way by 2007,[325] when the Throughput Project was being planned. Bakken (and other light shale crude) production took off in 2007[326] and was likely the initial target of the Throughput Increase Project, as it was of the Rail Spur Project, because ConocoPhillips was aggressively developing its Bakken resources.[327]

---

[324] API. Understanding Crude Oil and Product Markets, pdf 9, 2008; Available at: http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Crude-Oil-Product-Markets/Crude-Oil-Primer/Understanding-Crude-Oil-and-Product-Markets-Primer-Low.pdf.

[325] Dale Wetzel, Bigger Plans in Store for Bakken, The Bismarck Tribune, June 20, 2007; Available at: http://bismarcktribune.com/news/state-and-regional/bigger-plans-in-store-for-bakken/article_1dafc6c3-722c-5e37-842f-7dfa2bc13821.html; ConocoPhillips-Burlington Resources; Available at: http://eaglefordshale.com/companies/conocophillips-burlington-resources/.

[326] The Bakken Formation: How Much Will It Help?, The Oil Drum, April 26, 2008, Available at: http://www.theoildrum.com/node/3868.

[327] R.T. Dukes, ConocoPhillips Increases Bakken Spending in its 2014 Budget, December 9, 2013, Available at: http://bakkenshale.com/news/conocophillips-increases-bakken-spending-2014-budget/; Top 50 North Dakota Bakken Oil Producers, March 2013; Available at:
(cont'd)

Figure 7 confirms the Bakken trend and shows that other light shale crudes were also entering the market around the time the Throughput Increase Project and Rail Spur projects were being planned.

The DEIR for the Rail Spur Project, for example, specifically identified Bakken crude as one of the crudes that would be imported. Tanks that store Bakken crudes are typically permitted at 11 psia. This plan to import Bakken crude is consistent with remarks made by the CEO of Phillips 66 at its December 2012 Annual Analyst Meeting:

> "*California is a challenging operating environment from a regulatory standpoint, we do not see that changing over the midterm. And so* ***our opportunity to improve performance in California is really around getting advantage crudes to the front end of the California refineries, it's rail****, it's ship, it's working on optimization of the cost structure and the export capabilities of those refineries. And we'll improve them to the extent that we can.*"[328]

Taken alone, the Throughput Increase Project could not access these distant North American cost-advantaged crudes, since there was no cost-effective way to get them to the refinery. The Santa Maria Pump Station was certainly considered, thus the change in vapor pressure. However, this would require significant, long-distance truck transport, which has many disadvantages over rail. The Rail Spur RDEIR admitted this, stating:

> "This declining production coupled with the lack of ability of the refinery to source competitively priced crude oil from outside the local area generates the need for the Rail Spur Project. The need for the project is not related to the permitted capacity of the refinery."[329]

This same statement was true in 2007, when ConocoPhillips started applying for permits for the Throughput Project. However, the Rail Spur FEIR eliminated this sentence and replaced it with:

---

http://www.petroleumnews.com/petroleumnewsbakken/charts/ND50_130602.pdf; ConocoPhillips, http://www.conocophillipsuslower48.com/where-we-operate/Pages/bakken.aspx.

[328] Thomson Reuters Streetevents, Edited Transcript, PSX - Phillips 66 First Annual Analyst Meeting, Event Date/Time: December 13, 2012; Available at: http://investor.phillips66.com/files/events/2012/PSX_Investor_Transcript_12_13.pdf.

[329] Rail Spur DEIR, p. 2-30.

> "In the long-term, the need for the SMR rail project could be driven by declines in local production of crude oil that can be delivered by pipeline."[330]

This change is misleading because it suggests that declining local production that would require the Rail Spur Project would only occur in the future. In fact, declining production was the status quo when the Throughput Increase Project was proposed. The Rail Spur Project provided the means to economically deliver the replacement crude, which otherwise was not available.

The fact that declining production in Santa Barbara County and offshore areas would affect the ability of the refinery to source competitively priced crudes cannot be erased by removing text from the RDEIR and FEIR. In fact, ConocoPhillips was planning to import tar sands and Bakken crudes to replace declining local production at the time the throughput Increase Project was proposed.

In April 2008, the Executive Vice President of ConocoPhillips for Exploration and Production explained to the Select Committee on Energy Independent and Global Warming of the U.S. House of Representatives in April 2008 that:

> "*The Canadian oil sands are projected to become an increasingly important source of oil for the United States, particularly considering recent declines in heavy oil production in* Mexico, Venezuela and *California*. The Canadian oil sands are projected to approach 20 percent of U.S. oil supplies by 2020."[331]

Further, as Mr. Lowe testified, ConocoPhillips had made significant investments in North American cost-advantaged tar sands crudes:

> *ConocoPhillips has a leading land position in the Canadian Athabasca oil sands and is actively investing to produce this oil, and then transport it to the United States for processing at our refineries. We have access to over 15 billion barrels of net potential oil resources, and plans are in place to increase our net production to about 400,000 barrels per day over the next decade. In 2008 alone, we are spending $900 million in development capital on the Canadian oil sands.*[332]

---

[330] Rail Spur FEIR, p. 2-38.

[331] Testimony of John E. Lowe, Executive Vice President, Exploration and Production, ConocoPhillips, Before the Select Committee on Energy Independence and Global Warming, U.S. House of Representatives on Tuesday, April 1, 2008, p. 15, *emphasis* added, internal citations omitted; http://www.phillips66.com/EN/newsroom/other_resources/Documents/Markey_Testimony_written.pdf.

[332] *Ibid.*

This tar sands crude supply was under development before permit applications were filed for the Throughput Increase Project.

A 2014 presentation made by Greg Garland, Chairman and Chief Executive Officer of Phillips 66, includes a figure showing Phillips 66's West Coast transportation plan, Figure 8, which shows tar sands crude going to Santa Maria. Mr. Garland testified: "We're disappointed in the progress to permit our Santa Maria rail rack 40,000 a day, but we have – we're optimistic that we'll get that done."[333] The cited rail unloading capacity is much greater than revealed in the Rail Spur FEIR, which reports a range of 35,478 to 38,237 bbl/day.[334]

Figure 8:
Phillips 66 Advantaged Crude
West Coast Transportation Plan[335]

[333] Barclays CEO Energy-Power Conference, p. 5, September 3, 2014, Transcript; Available at: http://s1.q4cdn.com/175206842/files/doc_presentations/2014/PSX-BarclaysCEOConfTransSept2014.pdf.

[334] Rail Spur FEIR, p. ES-6.

[335] Barclays CEO Energy-Power Conference, September 3, 2014, p. 10; Available at: http://s1.q4cdn.com/175206842/files/doc_presentations/2014/BarclaysEnergyConf2014slides_ad.pdf.

VI.B.4 Trucks Would Not Be a Long-Term Solution

The RTC argues that the increase in throughput could be delivered by truck to the Santa Maria Pump Station and then on to the Refinery by pipeline.[336] Crude oil is currently delivered by truck to the Santa Maria Pump Station, where it is off-loaded into a temporary storage tank and then shipped by dedicated pipeline to the Santa Maria Refinery. The RTC asserts that the current permitted limit on crude truck unloading at the SMPS is 26,000 bbl/day and the current truck unloading rate is about 6,800 bbl/day, leaving an untapped capacity of 19,200 bbl/day (26,000 - 6,800 = 19,200).[337] There are several problems with this line of reasoning.

First, the asserted "current" truck unloading rate of 6,800 bbl/day is not defined. What year is it? Is it the baseline? The record does not contain any historic truck delivery data, which is required to assess whether 6,800 bbl/day is a reasonable basis to estimate available future truck unloading capacity. Further, "current", assuming it is a recent year, is not a reasonable basis for determining available truck unloading capacity. The available unused truck unloading capacity should be based on the maximum truck unloading rate in the baseline years to demonstrate that sufficient excess capacity was available to accommodate changes in local supplies and upsets in downstream facilities. For example, the recent Refugio pipeline spill, which cut off a major oil supply to the Santa Maria Refinery, probably resulted in a significant increase in trucking crude to the Santa Maria Pump Station. The current 2015 truck unloading rate is not in the record, but is likely much greater than 6,800 bbl/day due to the Refugio pipeline spill.

Second, the untapped truck loading capacity is wrong. ConocoPhillips filed an application with the Santa Barbara County Air Pollution Control District (SBCAPCD) in June 2012 to increase the vapor pressure limit on the temporary storage tank at the Santa Maria Pump Station from 7.5 to 11 psia. To avoid increasing VOC emissions, tank throughput was reduced from 26,000 bbl/day to 21,859 bbl/day. This permit was granted in March 2013.[338] Thus, the RTC is wrong as to the amount of excess truck import capacity, which was 15,059 bbl/day (21,859 - 6,800 = 15,059). Further, it makes no sense to reduce the truck loading capacity while simultaneously applying for an increase in throughput if the increase in crude is coming by truck to the Santa Maria

---

[336] RTC ABJC-31.

[337] Rail Spur FEIR, p. ES-26.

[338] SLOCAPCD, Authority to Construct Engineering Evaluation, Appl. No. 6015, January 29, 2014 (Exhibit 11).

Pump Station, when the refinery is operating below its permitted throughput unless an alternative mode to supply crude is planned.

Third, at the time of the Throughput Increase Project, the Santa Maria Refinery was operating at up to **8,662 bbl/day** below its existing permit limit of 44,500 bbl/day.[339] The Throughput Project allowed a 10% increase in permitted maximum daily crude throughput, from 44,500 bbl/day[340] to 48,950 bbl/day or by **4,450 bbl/day**.[341] Thus, at the time that the Throughput Increase Project was proposed, the total shortfall in crude, assuming the refinery could operate at its then design throughput, was 4,450 + 8,662 = **13,112 bbl/day**.

In comparison, at the time the Throughput Increase Project was proposed, the available excess truck import capacity was 15,059 bbl/day. This leaves little margin (15,059 - 13,112 = 1,947 bbl/day) to accommodate changes in local crude supply, such as the 2015 Refugio Beach pipeline spill,[342] which reduced crude supply through the Santa Maria pump station by about 7,200 bbl/day.[343] As Phillips 66 indicated to the Planning Commission, this pipeline shutdown resulted in the "… pipeline from Las Flores Canyon to Sisquoc out of service indefinitely."[344] Phillips 66 President Tim Taylor stated that "until we get that pipe back in service, or an alternate, it's harder to get the full volume that we need."[345] In its 4th quarter earnings report, Greg Garland indicated

---

[339] Crude shortfall before Throughput Increase Project: 44,500-35,838 = **8,662 bbl/day**. The lowest reported crude throughput was 35,838 bbl/day (Rail Spur DEIR, Table 2.7).

[340] Throughput Increase FEIR, p. 2-24 (Department of Planning and Building permit limit).

[341] Throughput Increase FEIR, p. 2-24.

[342] InterAct, Emergency Permit Application for Emergency Trucking Activity to De-Inventory LFC Crude Storage Tanks – ExxonMobil Santa Ynez Unit Las Flores Canyon Facility, January 4, 2016 (1/4/16 ExxonMobil Application); Available at: http://www.sbcountyplanning.org/energy/projects/Exxon/ExxonMobil%20Emergency%20Temporary%20Trucking%20De-inventory%20Application.pdf.

[343] 1/4/16 ExxonMobil Application, pdf 61 ("P66 personnel stated that currently the P66 Station is operating at one-third of its capacity. Before the PAAPL shutdown, the Station handled about 100 trucks/day, currently they handle about 130 trucks/day. The facility is not limited by permits to a specific number of trucks it can receive. The single storage tank is limited to 21,859 bbls/day (approximately 145 truckloads/day) oil throughput by the Santa Barbara County Air Pollution District Permit to Operate (APCD PT"). Each truck carries about 21,859 bbl/day/145 trucks/day = 151 bbl/truck. Thus, before the spill, 100 trucks/day of crude were moving through the SMPS or about 100 × 151 = 15,100 bbl/day. After the spill, this decreased to 1/3(145) × 151 = 7,300 bbl/day. Thus, the spill reduced crude supply by 15,100 – 7,300 = **7,800 bbl/day.**

[344] Jocelyn Thompson, Phillips 66 Santa Maria Refinery Rail Spur Extension Project, Slides, February 4, 2016, pdf 25, Why This Project? (Exhibit 12).

[345] Kristen Hays, Phillips 66 Says California Rail Project Critical to Crude Supply, Reuters, February 4, 2016; Available at: http://www.reuters.com/article/us-phillips-66-crude-railways-idUSKCN0VD2P7.

that only about half of the loss could be made up by trucks: "We've probably cut that in half with trucks, and then we made up the volumetrics on process inputs at Rodeo.."[346]

Thus, as the excess truck unloading capacity was very close to the permitted truck throughput, within about 10%, there was very little margin to accommodate shifts in crude supply, such as the 2015 Refugio Beach pipeline spill.

Fourth, by the time the Notice to Proceed with the Throughput Increase Project was issued in March 2015, the available truck unloading capacity had declined significantly, from 15,059 bbl/day at the time the FEIR was issue, to 6,759 bbl/day.[347] Thus, at startup of the Throughput Increase Project, there was not adequate excess truck unloading capacity at the Santa Maria Pump Station to serve the project, confirming the need for an alternate delivery mode. The only alternate method in view is the Rail Spur Project.

Fifth, the calculation of untapped truck unloading capacity should be based on the maximum historic truck import. The record does not contain any historic truck import data, for years prior to 2007 when the application was submitted to SLOAPCD through the present, 2015.

Sixth, importing Bakken and other North American crudes by truck from their point of origin to the Santa Maria Pump Station would be neither economic nor environmentally feasible, as the Rail Spur FEIR itself concluded in its alternatives analysis.

Costs rise with distance for all modes of transport, but trucks cost more per ton-mile than rail. Thus, trucking becomes very expensive and non-competitive for long hauls. Trucking can be competitive for short hauls if there is no rail or pipeline access, as they are flexible and don't require lots of fixed costs. As noted by the CEO of the Canadian pipeline firm Enbridge, "You don't truck if you can rail and you don't rail if you can pipeline."[348] While cost-advantaged crudes could be railed to a local terminal and trucked from there to the Santa Maria Pump Station, this alternative was not

---

[346] Phillips 66 Q4 2015 Earnings Call Transcript, January 29, 2016; Available at: http://s1.q4cdn.com/175206842/files/doc_presentations/2016/feb/PSXtranscript2015Q4-2.pdf.

[347] Available truck unloading capacity at the Santa Maria Pump Station in 2015, based on 1/4/16 ExxonMobil Application, pdf 61: Permitted throughput – 2015 throughput prior to spill = 21,859 – (100 trucks/day)(151 bbl/truck)= **6,759 bbl/day.**

[348] David Sheppard and Bruce Nichols, Insight: Oil Convoy Blues: Trucking Game Foils Crude Traders, Reuters, October 14, 2011; Available at: http://www.reuters.com/article/2011/10/14/us-cushing-trucks-idUSTRE79D0OP20111014.

identified or evaluated in either the Throughput Increase FEIR or the Rail Spur FEIR's alternatives analysis and would not be cost effective on a long-term basis. As the Rail Spur FEIR purports to analyze "reasonable alternatives" and to be based on the "rule of reason,"[349] this option can be eliminated as unreasonable. Likewise, the Throughput FEIR's alternatives analysis, which was also based on the "rule of reason," did not include a rail terminal-to-truck-to-SMPS alternative.[350]

Trucks are the least preferred method of transporting oil in terms of safety, air quality, expense, and other factors.[351] The Rail Spur FEIR evaluated a truck import alternative and eliminated it on environmental grounds.[352] Trucks would not be the method of choice to deliver 13,112 bbl/day of crude oil to the Santa Maria Refinery from distant sources in North Dakota and other areas producing North American crudes, because trucks are the most expensive crude oil delivery method. As a general rule of thumb, it costs about $20 per barrel to move crude oil by truck, $10 per barrel by rail and $5 per barrel by pipeline, although the cost varies by geography.[353] Trucks are generally used in situations where it would be illogical or impossible to use railcars, pipelines, and tanker ships.[354] The Rail Spur Project is clear evidence that rail delivery is possible. Further, Figure 9 shows that at a cost of $20 per barrel, truck import would eliminate most to all of the crude oil discount from importing North American cost-advantaged crudes.

---

[349] Rail Spur FEIR, Sec. 5.1.

[350] Throughput Increase FEIR, Sec. 5.0; Available at: http://slocleanair.org/images/cms/upload/files/5_0_Alternatives.pdf.

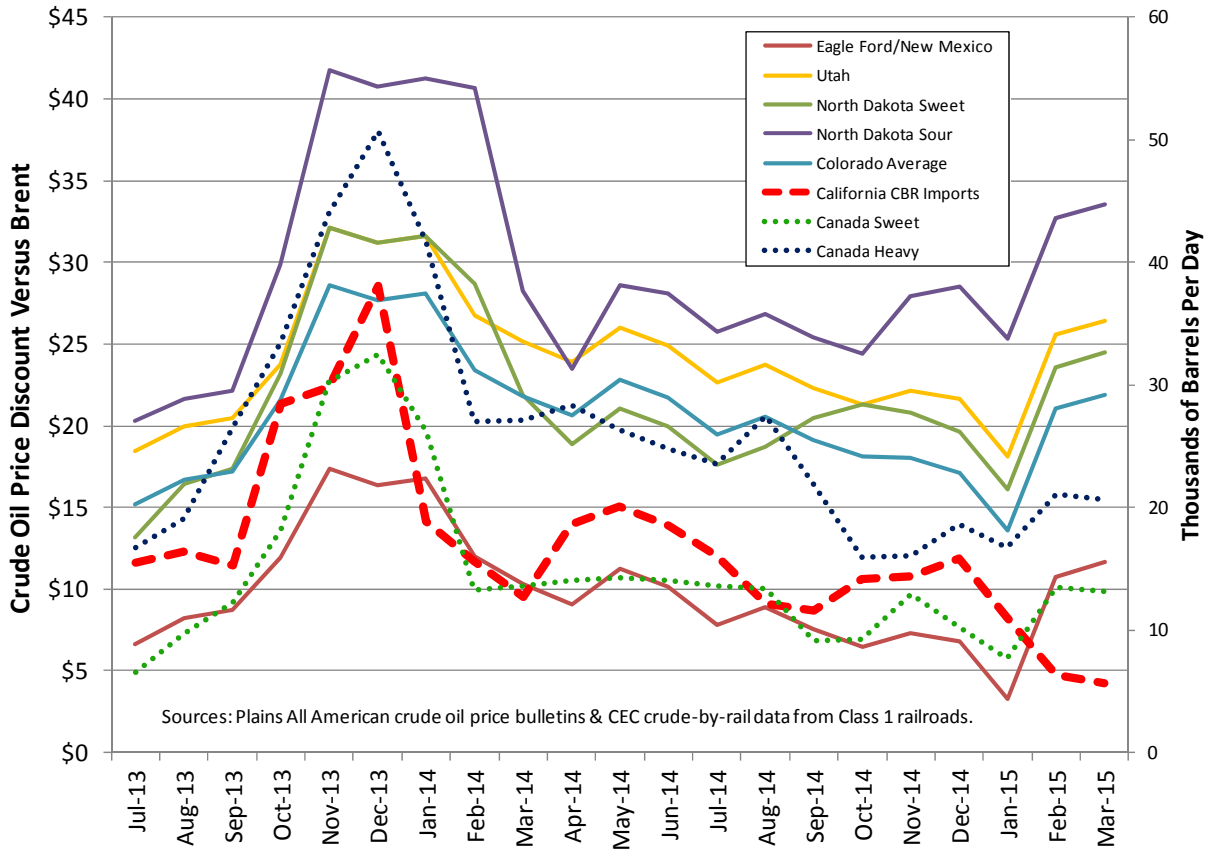
[351] How to Transport Oil More Safely, Wall Street Journal, September 23, 2015; Available at: http://www.wsj.com/articles/how-to-transport-oil-more-safely-1442197722.

[352] Rail Spur FEIR, Sec. 5.1.2.1 and 5.2.1.

[353] Brian Westenhaus, Trucks, Trains, or Pipelines – The Best Way to Transport Petroleum, OilPrice.com, August 13, 2013; Available at: http://oilprice.com/Energy/Energy-General/Trucks-Trains-or-Pipelines-The-Best-Way-to-Transport-Petroleum.html; Jennifer Hiller, Crude oil will continue rolling by train, July 28, 2013, Fuel Fix; Available at: http://fuelfix.com/blog/2013/07/28/crude-oil-will-continue-rolling-by-train/#14419101=0.

[354] Petroleum Transport, Wikipedia; Available at: https://en.wikipedia.org/wiki/Petroleum_transport.

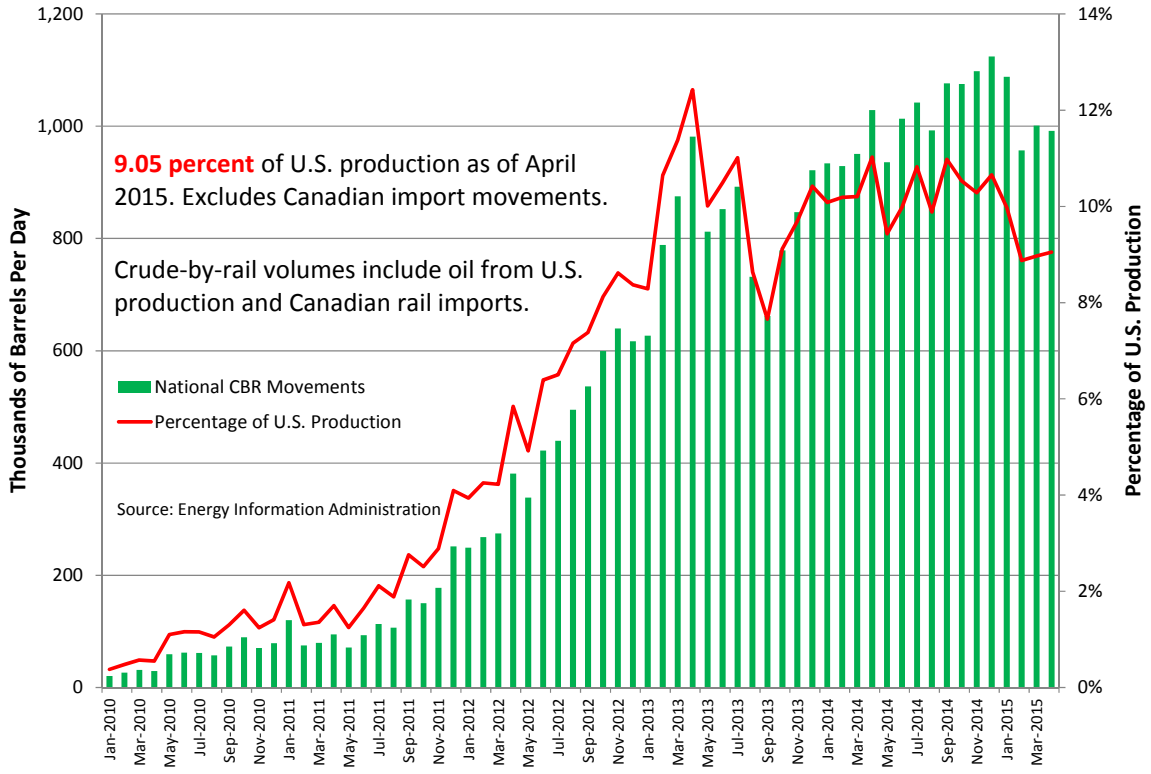
Figure 9:
Crude Oil Price Discount Versus Brent
[355]



Seventh, at the time the Throughput Increase Project was being planned, crude-by-rail was rapidly developing as the method of choice to deliver the cost-advantaged, mid-continent crudes, as shown in Figure 10.

[355] Schremp 2015, p. 34.

Figure 10:
Crude by Rail Trends (Jan 2010 – March 2015)[356]



In fact, the Throughput Increase DEIR identified seven alternatives to the Project, including increased rail transport, but failed to evaluate it.[357] Further, Phillips 66 announced its intent to purchase 2,000 new railcars in June 2012 to participate in this trend stating:

> *"The initial goal is to increase delivery of shale crudes to Phillips refineries by 100,000 to 150,000 bpd within two years using railroad unit trains, he [Garland] said"*[358]

Greg Garland, the CEO of Phillips 66, also told the Financial Times that:

> *"the company was planning to buy the cars for a total price of about $200m, to enable it to carry up to 120,000 barrels per day of cheaper crude available in the central US…*

---

[356] Schremp 2015, p. 29.

[357] Throughput Increase DEIR, p. ES-6.

[358] Phillips 66 to Buy 2,000 Rail Cars to Transport Oil, Reuters, June 8,; Available at: http://www.reuters.com/article/us-phillips-oil-rail-idUSBRE85713A20120608.

Phillips believes it will be more cost-effective for its refineries in California to transport oil more than 1,500 miles by rail than to buy it on international markets…

the financial performance of refineries in the central US with access to oil from North Dakota and Canada has been "just outstanding," Mr. Garland said, but refineries on the east and west coasts that use international crudes had been "struggling"…

Moving oil by rail is generally more expensive than using a pipeline, but Phillips thinks that for the foreseeable future there will be no pipes built to connect North Dakota to its refineries in California…and the crude price gap is likely to persist."[359]

In sum, the Throughput Increase Project and the Rail Spur Project are inextricably linked with each other and with the Propane Recovery Project for the following reasons:

- They were planned together (Table 6);
- Local crude supplies were in serious decline and inadequate to satisfy the pre-Throughput Project permit level (44,500 bbl/day), let alone the proposed increase;
- Local crude supplies were not cost-competitive compared to North American cost-advantaged crudes available to ConocoPhillips/Phillips 66;
- The truck unloading capacity at the SMPS was not adequate to accommodate both the increased throughput and the throughput shortfall;
- The Throughput Increase Project could not be realized without a means to economically import the crude, which was fulfilled by the Rail Spur Project;
- ConocoPhillips/Phillips 66 was actively developing North American cost-advantaged crude sources, which it planned to market to its existing refineries, including SMR, thus replacing higher priced local production; and
- The Throughput Project and the Rail Spur Project combined would supply the shortfall in LPG that would be recovered at the Rodeo Refinery.

[359] Ed Crooks, Phillips 66 to Boost Rail Capacity for Oil, Financial Times, June 7, 2012; Available at: http://www.ft.com/cms/s/0/9331b14e-b0b6-11e1-a2a6-00144feabdc0.html#axzz3y7qYdcE8.

Environmental Science & Technology

Article

pubs.acs.org/est

The Ozone–Climate Penalty: Past, Present, and Future

D. J. Rasmussen,[†,§] Jianlin Hu,[†] Abdullah Mahmud,[‡,§] and Michael J. Kleeman*[,†]

[†]Department of Civil and Environmental Engineering, University of California Davis, Davis, California 95616, Unites States

[‡]Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon 97207, Unites States

Supporting Information

ABSTRACT: Climate change is expected to increase global mean temperatures leading to higher tropospheric ozone (O_3) concentrations in already polluted regions, potentially eroding the benefits of expensive emission controls. The magnitude of the "O_3–climate penalty" has generally decreased over the past three decades, which makes future predictions for climate impacts on air quality uncertain. Researchers attribute historical reductions in the O_3–climate penalty to reductions in NO_x emissions but have so far not extended this theory into a quantitative prediction for future effects. Here, we show that a three-dimensional air quality model can be used to map the behavior of the O_3–climate penalty under varying NO_x and VOC emissions in both NO_x-limited and NO_x-saturated conditions in Central and Southern California, respectively. Simulations suggest that the planned emissions control program for O_3 precursors will not diminish the O_3–climate penalty to zero as some observational studies might imply. The results further demonstrate that in a NO_x-limited air basin, NO_x control strategies alone are sufficient to both decrease the O_3–climate penalty and mitigate O_3 pollution, while in a NO_x-saturated air basin, a modified emissions control plan that carefully chooses reductions in both NO_x and VOC emissions may be necessary to eliminate the O_3–climate penalty while simultaneously reducing base case O_3 concentrations to desired levels. Additional modeling is needed to determine the behavior of the O_3–climate penalty as NO_x and VOC emissions evolve in other regions.

INTRODUCTION

Surface ozone (O_3) is a secondary pollutant produced by the photochemical oxidation of CO and/or volatile organic compounds (VOCs) by the hydroxyl radical ($^{\bullet}HO$) in the presence of oxides of nitrogen ($NO_x \equiv NO_2 + NO$). Model perturbation studies have identified temperature as the most important weather variable affecting surface O_3 concentrations in polluted regions.[1−5] These findings have been validated against observations on multiple time scales that have shown strong correlations between temperature and O_3 concentrations in excess of about 60 ppb.[6−8] California is home to seven of the top ten most heavily O_3 polluted metropolitan areas in the United States ,[9] despite the dramatic reductions of NO_x and VOC precursor emissions over the past three decades.[3−6,10−12] A warming climate is expected to exacerbate surface O_3 in California's two major air basins: South Coast Air Basin (SoCAB) and San Joaquin Valley (SJV). Median surface temperatures during the O_3 season over western North America, including the SoCAB and SJV, are projected to warm between +1 to +5 K by the end of the 21st century.[13] These temperature increases may counter the benefits from pollution control strategies used in an effort to meet established air quality standards, resulting in a "climate penalty".[14,15]

In this study, the sensitivity of O_3 to temperature and NO_x and VOC emissions is calculated in both NO_x-saturated and NO_x-limited conditions with a reactive chemical transport model during two historical severe weekday pollution episodes in California: the SoCAB during September 7–9, 1993 (NO_x-saturated)[16,17] and the SJV during July 25–27, 2005 (NO_x-limited). Historical episodes are used for the base case analysis to enable the study of O_3-temperature relationships over a period spanning the past two decades to future conditions over which NO_x and VOC emissions have evolved. The results in this study are presented as an O_3 isopleth diagram that simultaneously describes the maximum concentration (ppb) and sensitivity to temperature (ppb K^{-1}) of surface O_3 under specified NO_x and VOC emissions.[18] This map of O_3–temperature relationships is compared to historical trends for validation and then projected forward to predict climate impacts on future O_3 pollution.

THE O_3–CLIMATE PENALTY

Varying definitions of the O_3–climate penalty have been presented in the literature. Wu et al. consider the climate penalty to represent either the additional decreases in NO_x emissions to counter any climate driven increase in O_3 (assuming NO_x is the limiting precursor) or the reduced benefits of emissions controls

Received: August 2, 2013
Revised: October 15, 2013
Accepted: November 4, 2013
Published: November 4, 2013

 © 2013 American Chemical Society

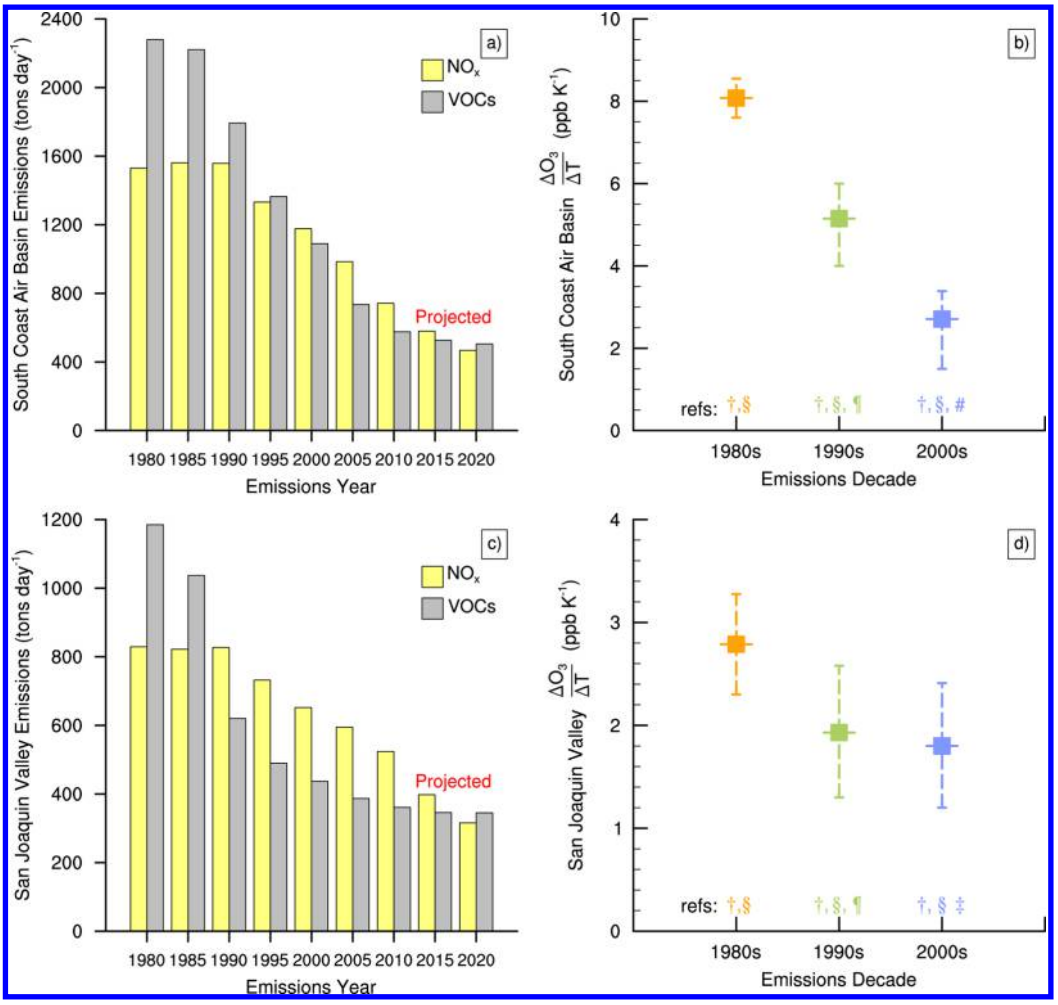


Figure 1. (a) Historical and projected average daily anthropogenic NO_x (yellow) and VOC (gray) emissions (tons day^{-1}) vs emissions year for the South Coast Air Basin and (b) the observed decadal trend in the O_3−climate penalty for the Southern California Air Basin attributed to emissions changes during the 1980s (orange), the 1990s (green), and the 2000s (blue). Dashed lines give the range of both observed and modeled O_3−climate penalty values in the South Coast Air Basin from the literature; solid squares are the mean O_3−climate penalty calculated from values given in the literature. Symbols beneath each range correspond to literature references: † is Mahmud et al.[6] (statistical down-scaling based on measured trends), § is Steiner et al.[8] (observations), ¶ is Kleeman[3] (model perturbation), # is Millstein and Harley[4] (model perturbation), and ‡ is Steiner et al.[5] (model perturbation); (c) as for (a) but for the San Joaquin Valley; (d) as for (b) but for the San Joaquin Valley.

due to the increase in O_3 due to a warmer climate.[15] Bloomer et al. calculate the "ozone−climate penalty factor" as the slope of the best fit line between long-term observational measurements of O_3 and temperature.[19] Other studies utilizing air quality models quantified the change in O_3 due to a prescribed temperature perturbation but did not refer to this sensitivity as a "climate penalty".[3,4,6] Here, we employ the temperature perturbation approach and refer to the direct increase in O_3 concentrations due to increasing temperatures (ppb K^{-1}) as the "O_3−climate penalty" or "climate penalty". Previous work has shown the past and present climate penalty to be highly varied in space and time due to differing chemical and meteorological environments that influence O_3 formation.[3,4,6,8,19] The aggregate effects that make up this relationship (the total derivative, $d[O_3]/dT$) are thought to include at least three components

$$\frac{d[O_3]}{dT} = \frac{\partial[O_3]}{\partial[\text{stagnation}]} \times \frac{d[\text{stagnation}]}{dT} + \frac{\partial[O_3]}{\partial[\text{reaction}]} \times \frac{d[\text{reaction}]}{dT} + \frac{\partial[O_3]}{\partial[\text{BVOC}]} \times \frac{d[\text{BVOC}]}{dT} + \ldots$$

The first term accounts for the association of warm temperatures with stagnant air masses that facilitate the accumulation of O_3 precursor species.[20] The second term accounts for the increase in chemical reaction rates for different species, including the thermal decomposition of alkyl nitrates (AN) and subspecies peroxyacetylnitrate (PAN), reservoirs for both NO_x and HO_x at low temperatures.[7] The third term accounts for temperature dependent variations in biogenic emissions of VOCs (BVOCs), which act as a significant source of precursors for O_3 formation under high-NO_x conditions and tend to increase with temperature for many species.[21,22] The ellipsis indicates several additional contributing temperature-dependent processes of varying sign that may not be dominant

under the assumptions of the current study, including wildfires in the western United States[23] and humidity in the Mid-Atlantic [24] (see Table 1 in ref 25 for a comprehensive list). Model perturbation studies resolve the climate penalty partial derivatives, while observations ascertain the total derivative. Extrapolation of present day O_3−temperature relationships to future climate to estimate changes in O_3 air quality assumes invariable emission rates and ignores complex chemistry−climate interactions.[14,25,26]

HISTORICAL TREND IN O_3−CLIMATE PENALTY IN CALIFORNIA

Figure 1 shows the trend in average daily NO_x and VOC emissions in the SoCAB and the SJV, along with the corresponding decadal trend in the climate penalty from previous model perturbation and observational studies. The climate penalty is strongly correlated with NO_x and VOC emissions in both the SoCAB and the SJV. From 1980 to 2010, average daily emissions of NO_x and VOCs in the SoCAB decreased roughly 2- and 4-fold, respectively; in the SJV, NO_x and VOC emissions decreased by a factor of 1.5- and 3-fold, respectively.[27] The dramatic decrease in these emissions reflects the success of California's statewide emission control programs. Over this same period, the mean value of climate penalty in the SoCAB decreased from +8.0 ppb K^{-1} in the 1980s to a present day value of +2.7 ppb K^{-1}, while the climate penalty in the SJV decreased from a value of +2.8 ppb K^{-1} in the 1980s to a current value of +1.8 ppb K^{-1}.[3,4,6,8,19] Similar NO_x−climate penalty trends have been observed elsewhere. In the eastern United States, a 43% reduction in power plant NO_x emissions between 1995 and 2002 was shown to correspond to a 1.0 ppb K^{-1} decrease in the O_3−climate penalty.[19,28] Over the next decade, emissions of NO_x and VOCs are expected to continue to decrease in both the SoCAB and the SJV raising the following question: Will the O_3−climate penalty effectively diminish to zero, or does a particular emissions strategy exist that minimizes the O_3−climate penalty?

METHODS

Model Description. The UC-Davis-California Institute of Technology (UCD-CIT) air quality model is a 3D Eulerian photochemical model that simulates reactive chemical transport in the atmosphere and predicts the concentration of both primary and secondary pollutants in the gas and particle phase. Relevant chemical reactions are modeled with the SAPRC11 mechanism.[29] A coupled online UV radiative extinction calculation accounts for the scattering and absorption of light due to high airborne particulate matter concentrations to give a more accurate representation of actinic flux. A more thorough description of the UCD-CIT airshed model and its evolution has been presented previously.[17,30−33]

Because of variations in the physical characteristics of each air basin, different model configurations were used to simulate each pollution episode. The horizontal resolution used in the SoCAB simulations was 5 km × 5 km. The vertical domain was divided into 5 levels (thicknesses of 38.5, 115.5, 154, 363, and 429 m), extending from the surface to 1.1 km above ground. This relatively shallow model depth is only appropriate in well-defined air basins, such as the SoCAB, where pollutants have a residence time of only a few days. The horizontal resolution in the SJV simulations was 8 km × 8 km, and the vertical distance from the surface to 5 km above ground was divided into 16 levels (the surface to 1.1 km above ground for the SJV simulations is comprised of 11 levels). In the SoCAB, hourly 2D and 3D meteorological fields (temperature, absolute humidity, wind speed and direction, and solar intensity) were interpolated from observations using the method described by refs 34 and 35, while the SJV simulations used hourly meteorological fields generated over California at 4 km × 4 km horizontal resolution with the Weather Research and Forecasting model (WRF) v3.4,[36] driven by the North American Regional Reanalysis (NARR).[37] Four-dimensional data assimilation (FDDA) is further used to nudge WRF model estimates closer to observed conditions. The WRF meteorological fields were averaged to 8 km × 8 km to reduce model simulation times. Previous studies have shown these configurations to well reproduce measured pollutant concentrations.[17,38]

The base case emission inventories for the SoCAB and SJV episodes were obtained from the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (ARB) and are summarized in refs 39 and 40, respectively. Boundary conditions at the western edge of each modeling domain were based on measured background concentrations of pollutants that are transported to California[41,42] and remained constant while emission perturbations were applied. Biogenic emissions were generated at 8 km × 8 km spatial resolution using the Biogenic Emission Inventory Geographic Information System (BEIGIS) model.[43] A year 2000 land-use pattern generated by the moderate-resolution imaging spectroradiometer (MODIS) satellite is used to determine vegetation types and leaf area indices. Hourly averaged surface air temperature and shortwave radiation from the meteorology are used to calculate emissions of isoprene, monoterpenes, and 2-methyl-3-buten-2-ol (MBO).[21,22] In the SJV, livestock feed VOC emissions were estimated using the method described by ref 44 and are mapped to the spatial distribution of livestock ammonia emissions. Predicted O_3 concentrations for both pollution episodes in this study had performance statistics that met U.S. Environmental Protection Agency (EPA) guidance for air quality models.[45]

Calculating the O_3−Climate Penalty. To generate an O_3 isopleth diagram, the episode base case emissions of NO_x and anthropogenic VOCs were uniformly scaled up (more emissions) or down (less emissions) to represent a hypothetical range of pollution control strategies in each air basin. Here, the air quality model explicitly simulates 121 and 64 NO_x and VOC emissions scenarios in the SoCAB and SJV, respectively. These simulations are then repeated after applying a temperature perturbation for a total of 370 model runs. In this study, a spatially uniform temperature perturbation was applied to every hour during both multi-day pollution events to calculate a value of the climate penalty at each NO_x and VOC emissions point. This technique explores the O_3−climate penalty under base case conditions to better understand important relationships between emissions and climate. Further work would be required to account for detailed future emissions trends and projected climate patterns if the effects of these secondary factors on future O_3−climate penalties are of interest.

The O_3−climate penalty was calculated as the difference between the O_3 concentrations predicted with the base case temperature profile and the base case temperature profile plus a −5 K perturbation divided by the magnitude of the temperature perturbation (ppb K^{-1}). The magnitude of the perturbation is arbitrary and is not intended to reflect a projection of future temperature change. Previous work has shown the O_3−climate penalty is not strongly sensitive to the absolute magnitude of the

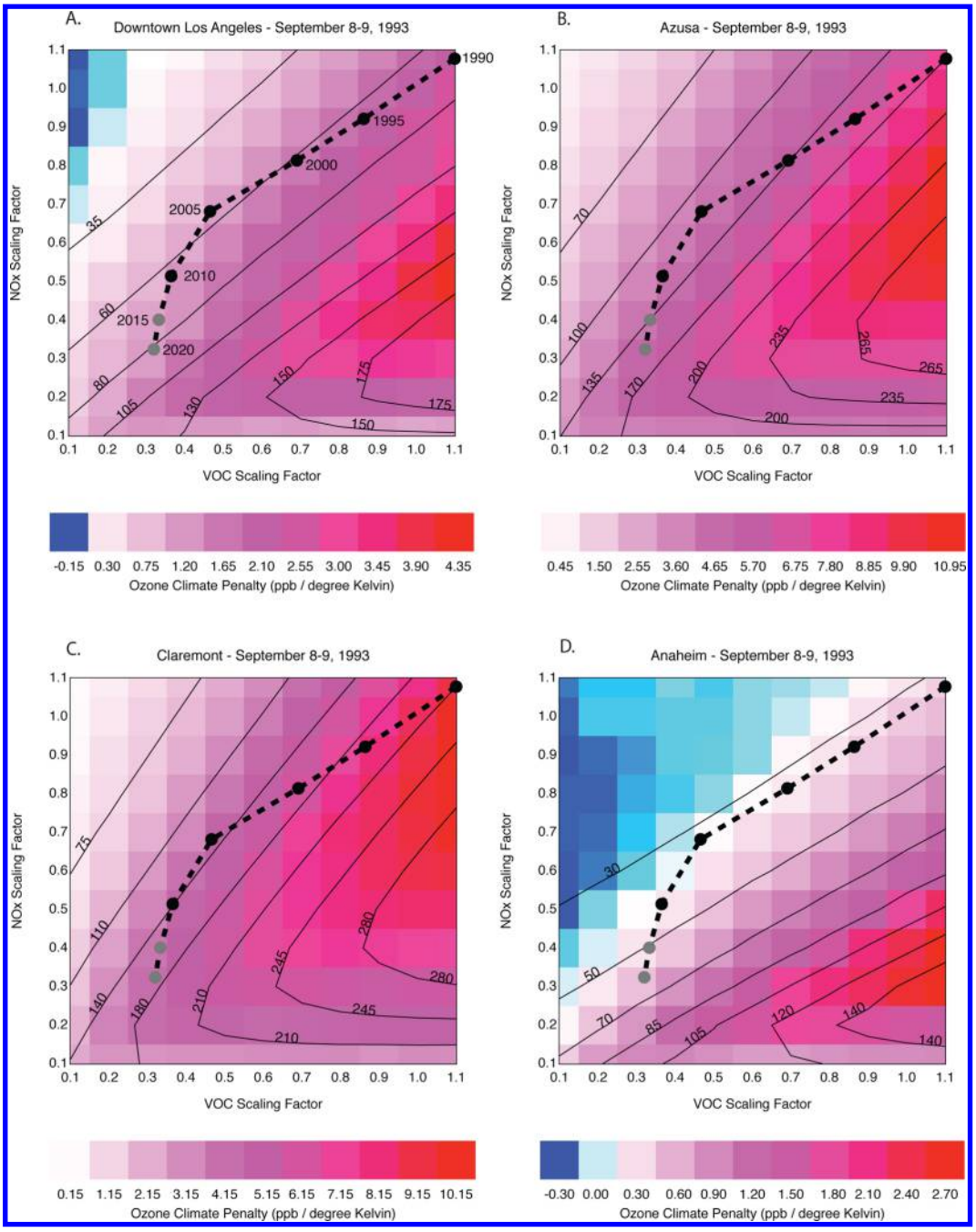


Figure 2. Isopleths of 8 h average O_3 (ppb)(solid black lines) and O_3−climate penalty (ppb K^{-1}) (colors) generated from a −5 K temperature perturbation for (a) Downtown Los Angeles, (b) Azusa, (c) Claremont, and (d) Anaheim. All calculations are for the conditions on September 8−9, 1993. Estimated anthropogenic emissions trend relative to the 1993 base year is shown as a dashed black line. A different color scale is used for each panel.

temperature perturbation used.[3] A negative (rather than positive) temperature perturbation was chosen in the present study because maximum daily temperatures from the base case episodes were greater than 40 °C and the contributions to $d[O_3]/dT$ from PAN decomposition and isoprene emissions have been shown to diminish at temperatures >39 °C.[8] Not fully accounting for these contributions could lead to an under prediction of the base case O_3 sensitivity to temperature. The negative perturbation produces temperatures that are more in line with historical temperature ranges and therefore yields values of $\partial[O_3]/\partial T$ that are more directly comparable to $d[O_3]/dT$ calculated from long-term measurements of O_3 and temperature.[6,8,19,46]

In this study, the temperature perturbation affects chemical kinetic reaction rates and biogenic emissions of isoprene, monoterpenes, and MBO.[21,22] The temperature perturbation does not alter the evaporation of anthropogenic VOCs [47] or the emission rate of soil NO_x and is uncoupled from temperature dependent meteorological variables such as mixed layer depth, solar insolation, wind speed and wind direction; model perturbation studies have shown that mixed layer depth has weak positive and negative effects on O_3 concentrations in polluted regions.[1,3] Temperature driven changes to atmospheric

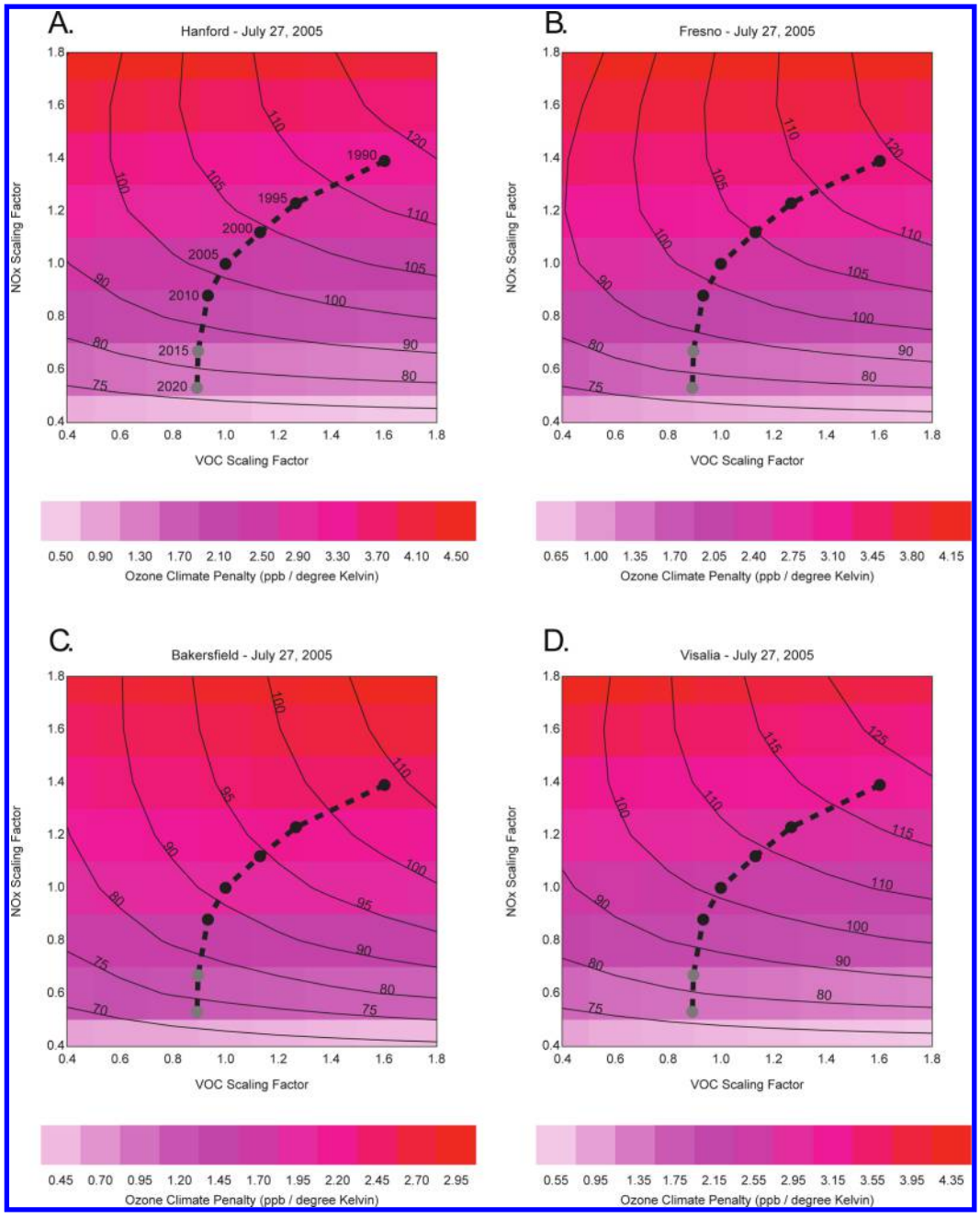


Figure 3. Isopleths of 8 h average O_3 (ppb)(solid black lines) and O_3−climate penalty (ppb K^{-1}) (colors) generated from a −5 K temperature perturbation for (a) Hanford, (b) Fresno, (c) Bakersfield, and (d) Visalia. All calculations are for the conditions on July 27, 2005. Estimated anthropogenic emissions trend relative to the 2005 base year is shown as a dashed black line. A different color scale is used for each panel.

circulation are not considered and could be important in defining the exact meteorological characteristics of peak O_3 episodes. Vegetation and land use data remain constant.

The Clausius−Clapeyron relation predicts exponential increases in the atmosphere's capacity to hold water vapor with increasing temperature. Increases in water vapor can lead to greater HO_x production that may affect O_3 formation differently depending on the region and the atmospheric conditions.[1,2,4,48] The temperature perturbations applied in the current study were coupled with different assumptions about humidity for each air basin depending on their geographical features. The majority of the SoCAB is close to the Pacific Ocean where an unlimited water reservoir maintains an approximately constant relative humidity (RH) with increasing temperature. The RH was therefore held constant in the SoCAB when temperature was perturbed. In the SJV, the supply of moisture is limited, and it was therefore assumed that absolute humidity would remain constant with increasing temperature, leading to a decrease in RH. Additional SJV modeling simulations that assumed constant RH resulted in O_3−climate penalty values nearly identical to those that fixed absolute humidity.

RESULTS AND DISCUSSION

Decreases in NO_x and VOC Emissions and the O_3−Climate Penalty Response. Isopleths of 8 h average O_3 (10:00−18:00 LDT) (ppb) and O_3−climate penalty (ppb K^{-1}) for NO_x and VOC emissions rates relative to conditions on September 8−9, 1993 are shown in Figure 2 at Downtown Los

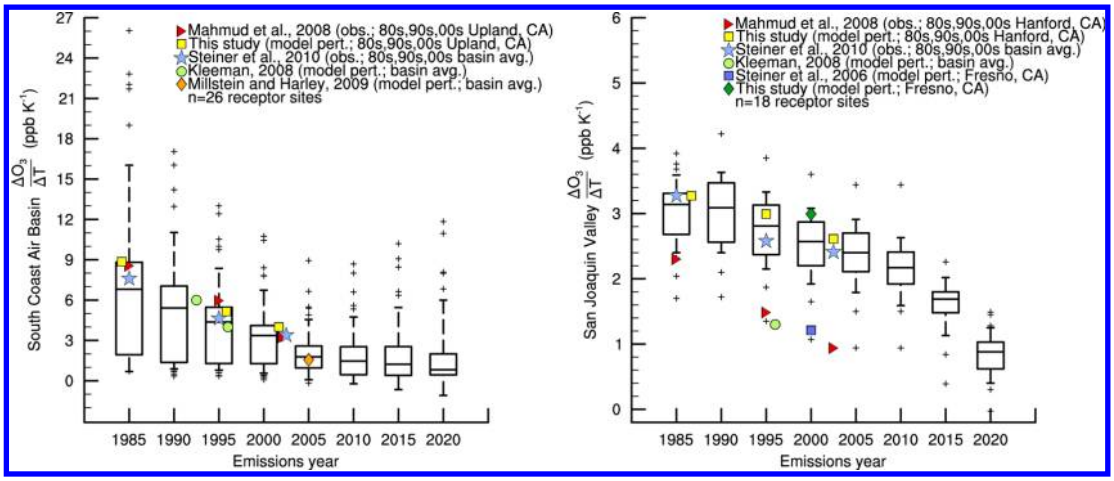


Figure 4. Historical (colored markers) and modeled O_3−climate penalty (ppb K^{-1}) for emissions years from 1985 to 2020 for the South Coast Air Basin (SoCAB) (left) and the San Joaquin Valley Air Basin (SJV) (right). The box-and-whisker plots (mean minus the standard deviation, 25th, 50th, 75th, and mean plus the standard deviation) give statistics of the modeled O_3−climate penalty at 26 urban receptors in the South Coast Air Basin and at 18 urban receptors in the San Joaquin Valley (Figure S1, Supporting Information). Values greater or less than the mean ± the standard deviation are shown as crosses. All modeled calculations are for the conditions on September 8−9, 1993 (SoCAB) and July 27, 2005 (SJV).

Angeles, Azusa, Claremont, and Anaheim in the SoCAB. Ozone isopleth diagrams generated for Visalia, Fresno, Hanford, and Bakersfield in the SJV for conditions on July 27, 2005 are shown in Figure 3. The SoCAB is an urban environment that is NO_x-saturated during weekdays,[49] while both the SJV and the eastern United States are predominantly NO_x-limited at all times.[50] Each isopleth shows the modeled base case O_3 concentration under a particular set of NO_x and VOC emissions rates with the same meteorology. In these simulations, NO_x is emitted from both soil and anthropogenic sources and VOC is emitted from anthropogenic and natural sources. For both air basins, NO_x and only anthropogenic VOC emissions are scaled. The scaling factors are the fraction of NO_x and VOC emissions relative to the base years. The base year for the SJV episode is 2005, and the base year for the SoCAB episode is 1993. Base years have a scaling factor of 1. The range of scaling factors was chosen to capture the range of both historical and projected emissions.

The colors overlaid on each O_3 isopleth diagram in Figures 2 and 3 show the magnitude of O_3−climate penalty (ppb K^{-1}). The maximum in the O_3−climate penalty occurs at a NO_x emission level slightly greater than that which produces the maximum O_3 under the base case temperature simulation and at the highest VOC emission rates. This is coincident with the "O_3 isopleth ridge", or the line of maximum O_3 formation. The minimum in O_3−climate penalty occurs in conditions that are appreciably NO_x-saturated. The simulations here suggest that when NO_x emissions are much greater than VOC emissions, the O_3−climate penalty may become strongly negative (i.e., a climate "benefit") at Downtown LA and Anaheim (−0.1 to −0.4 ppb K^{-1}) (O_3 decreases with increasing temperature), suggestive of O_3 titration by NO from further NO_x-saturation that results from the thermal decomposition of PAN at hotter temperatures.[7]

The historical and projected trend (1990—2020) in average daily anthropogenic NO_x and VOC emissions rates, relative to the respective base case inventory, is drawn on each isopleth diagram as black (historical) and gray (projected) dots connected by a dashed black line, taken together to constitute an emissions "trajectory". Receptors in each air basin are assumed to experience an equivalent rate of NO_x and VOC emissions reductions. The O_3 values along the NO_x−VOC emissions trajectory are an estimate of the maximum amount of O_3 pollution that could be formed during a severe pollution event with similar meteorology. Substantially NO_x-saturated conditions are not predicted by the emissions trajectory at any of the SoCAB or SJV receptors over the next decade (Figures 2 and 3).

In both air basins, the O_3 isopleth diagrams suggest that NO_x and VOC emission reductions between 1990 and 2010 have been effective at abating O_3 during weekday severe pollution events, especially in eastern LA and the SJV, confirming previous findings.[11,27] Reductions in O_3 in the SoCAB were accomplished through reductions in emissions of both NO_x and VOCs. Figure 2 shows that reductions in NO_x emissions alone over this 20-year period would have increased O_3 concentrations in the SoCAB. Little change in O_3 is seen at both Anaheim and Downtown LA (Figure 2a,d) because reductions in NO_x and VOC emissions produce a trajectory that stays within a zone of approximately constant O_3. In the SJV, reductions in O_3 have primarily occurred through reductions in NO_x emissions.

Over the next decade, the ARB projects that NO_x and VOC emissions will continue to decrease in both air basins, with NO_x emissions declining more rapidly. Projections for the SoCAB indicate that this emissions trajectory may not be optimal, with slight increases in O_3 concentrations (+20 to +30 ppb under the meteorological conditions studied). This result is consistent with findings from other investigators; Fujita et al. find that reductions in NO_x emissions without concurrent VOC emission reductions over the next decade will cause O_3 to increase in central portions of the SoCAB during weekdays.[10] No such effect is predicted for the SJV in the present study; the O_3 isopleths for the SJV predict continued decreases in O_3 over the next decade under meteorological conditions conducive to O_3 formation (Figure 3).

The historical and projected trend in the O_3−climate penalty can be inferred from the NO_x−VOC emission trajectory on the isopleths (Figures 2 and 3). Both NO_x and VOC emissions appear to play a role in determining the O_3−climate penalty in the SoCAB, contrary to previous findings that suggest NO_x emissions are the primary explanatory variable in the observed decreasing trend in the O_3−climate penalty.[19] Reducing NO_x emissions, primarily emitted as nitric oxide (NO), in a NO_x-saturated environment can exacerbate O_3 pollution by both decreasing O_3 loss by NO titration and increasing the ratio of VOCs to NO_x, favoring peroxy (HO_2) and alkylperoxy (RO_2)

formation, both of which propagate the chain reaction mechanism that produces O_3 in the troposphere.[51] While NO_x emission controls may be effective at decreasing the O_3−climate penalty in the NO_x-limited eastern United States and SJV,[19,50] the results of the current study suggest that further decreases in VOC emissions over the next decade in the SoCAB (NO_x-saturated) may be beneficial to reducing base case O_3 pollution and may additionally be effective at minimizing the O_3−climate penalty.

Future Trend in the O_3−Climate Penalty and Implications. The O_3 isopleth diagrams illustrate climate penalty−emissions relationships at individual receptor sites but do not readily facilitate an air basin-wide assessment of historical and projected trends in the O_3−climate penalty along the emissions trajectory. To characterize an air basin-wide climate penalty, we use 18 urban receptor sites in the SJV and 26 urban receptor sites in the SoCAB. The location of these receptors are shown in Figure S1 of the Supporting Information and are analogous to the receptor sites that are used by ref 8. Figure 4 shows the modeled historical (1985−2010) and projected (2015−2020) trend in O_3−climate penalty (ppb K^{-1}) at these receptor sites in the SoCAB (left) and the SJV (right). Modeled results are presented as box-and-whisker plots (25th, median, and 75th percentiles) where the whiskers are the mean (not shown) ± the standard deviation. Values outside of the whiskers are plotted as crosses. Historical values of the O_3−climate penalty from the literature (as both air basin averages and at individual receptors) are drawn as solid black symbols. Values given by ref 8 are decadal air basin averages constructed from long-term measurements and likely capture the full O_3−temperature relationship.

The observed trend of the O_3−climate penalty from all literature sources are generally well reproduced by the air quality model using the meteorology from severe pollution events that are characterized by very hot surface temperatures (r^2 = 0.98 in the SoCAB; r^2 = 0.69 in the SJV). The median model prediction is systematically lower than the measured climate penalty from ref 8 by at most 0.8 ppb K^{-1} in the SoCAB over the past three decades but is reproduced to within ±0.3 ppb K^{-1} in the SJV from the 1990s to the 2000s. In the SJV, site-by-site differences in the O_3−climate penalty are more pronounced (±1 ppb K^{-1}), including between the current and past model perturbation studies[3,5] and may reflect differing assumptions therein. Differences between modeled and observed values may reflect emissions sector changes (i.e., changes to VOC reactivity [52]) during the past three decades that are not captured using the uniform emissions scaling approach employed here or other contributions that are not captured with the simple temperature perturbation approach that only affects kinetic rate constants, biogenic emission rates, and water vapor concentrations in a representative episode. For example, calculation of the O_3−climate penalty from long-term modeled O_3 and surface temperature may yield different sensitivities than those derived from a single severe pollution event as some contributing components of the full O_3−temperature relationship may be driven by intraseasonal weather patterns and events. The choice of biogenic emissions models and chemical mechanisms may also influence the predicted climate penalty. The sensitivity of the results to these modeling options should be investigated in future work.

The range of climate penalties at receptors in the SoCAB in 1985 varies by about a factor of 30, +0.7 ppb K^{-1} to +26.2 ppb K^{-1}, a substantially wider range of variability compared to the SJV, +0.6 ppb K^{-1} to +3.9 ppb K^{-1}. Receptors east of Los Angeles that are adjacent to the San Gabriel Mountains (a large source of biogenic VOCs) have the largest climate penalties through out the simulation period (1985−2020) (Figure S2a, Supporting Information). These sites are likely sensitive to increased biogenic VOC emissions through rises in temperature. The central and coastal receptors in the SoCAB consistently have the lowest climate penalty as they may be saturated with fresh NO emissions that titrate O_3. While the future median O_3−climate penalty is projected to decrease steadily in both air basins, some receptors in the SoCAB near the San Gabriel Mountains (e.g., Azusa and Claremont, Figure 2b,c) are expected to experience a rise in the climate penalty due to the strengthening sensitivity of O_3 to strong biogenic emissions in a region where NO_x decreases much more rapidly than VOC emissions. The 2020 median O_3−climate penalty is projected to be +0.8 ppb K^{-1} in the SoCAB (basin-wide range of −0.8 ppb K^{-1} to +11.8 ppb K^{-1}) and +0.9 ppb K^{-1} in the SJV (basin-wide range of 0.0 ppb K^{-1} to +1.5 ppb K^{-1}), suggesting under the projected emissions pathway that increases in temperature due to climate change may continue to have deleterious effects on O_3 control programs. Although average daily NO_x and VOC emissions are projected to decrease 37% and 12%, respectively, over the next decade in the SoCAB,[27] potential concomitant anthropogenic VOC emissions reductions may be beneficial to reduce both base case O_3 and to further diminish the O_3−climate penalty.

In NO_x-limited regions such as the SJV and the eastern United States, continued decreases in NO_x emissions are anticipated and may continue to lower the O_3−climate penalty. The exact O_3−temperature relationship at other locations should be evaluated for a representative episode of interest (peak or average) using an appropriate reference year (historical or present day). Future studies should also account for climate-driven changes to atmospheric circulation, changes in land use, choice of boundary conditions that reflect changes to long-range transport of pollutants, and scaling individual emissions sectors to accurately reflect emission control targets.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Figures showing the location of the ozone receptors used in this study and model results for each air basin showing the spatial distribution of the ozone−climate penalty. This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: mjkleeman@ucdavis.edu. Phone: +1 (530) 752-8386. Fax: +1 (530) 752-7872.

Present Address

§ D.J.R. and A.M.: California Air Resources Board, Sacramento, California 95814, United States).

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

Research reported in this publication was partially supported by the National Institutes of Health under Award Number ES020237. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. We thank M. Hixson for data processing tools to prepare the model inputs. We acknowledge three anonymous reviewers and C. Anastasio, C. Cappa (UC-

Davis), J. Chen, and A. Kaduwela (CARB) for providing comments on earlier versions of the manuscript.

REFERENCES

(1) Aw, J.; Kleeman, M. J. Evaluating the first-order effect of intraannual temperature variability on urban air pollution. *J. Geophys. Res.-Atmos.* **2003**, *108*.

(2) Dawson, J. P.; Adams, P. J.; Pandis, S. N. Sensitivity of ozone to summertime climate in the eastern USA: A modeling case study. *Atmos. Environ.* **2007**, *41*, 1494−1511.

(3) Kleeman, M. J. A preliminary assessment of the sensitivity of air quality in California to global change. *Climatic Change* **2008**, *87*, S273−S292.

(4) Millstein, D. E.; Harley, R. A. Impact of climate change on photochemical air pollution in Southern California. *Atmos. Chem. Phys.* **2009**, *9*, 3745−3754.

(5) Steiner, A. L.; Tonse, S.; Cohen, R. C.; Goldstein, A. H.; Harley, R. A. Influence of future climate and emissions on regional air quality in California. *J. Geophys. Res.-Atmos.* **2006**, *111*, D18303.

(6) Mahmud, A.; Tyree, M.; Cayan, D.; Motallebi, N.; Kleeman, M. J. Statistical downscaling of climate change impacts on ozone concentrations in California. *J. Geophys. Res.-Atmos.* **2008**, *113*, D21103.

(7) Sillman, S.; Samson, F. J. Impact of temperature on oxidant photochemistry in urban, polluted rural and remote environments. *J. Geophys. Res.-Atmos.* **1995**, *100*, 11497−11508.

(8) Steiner, A. L.; Davis, A. J.; Sillman, S.; Owen, R. C.; Michalak, A. M.; Fiore, A. M. Observed suppression of ozone formation at extremely high temperatures due to chemical and biophysical feedbacks. *Proc. Natl. Acad. Sci. U.S.A.* **2010**, *107*, 19685−19690.

(9) State of the Air Report, 2013. American Lung Association. http://www.stateoftheair.org/2012/city-rankings/most-polluted-cities.html.

(10) Fujita, E. M.; Campbell, D. E.; Stockwell, W. R.; Lawson, D. R. Past and future ozone trends in California's South Coast air basin: Reconciliation of ambient measurements with past and projected emission inventories. *J. Air Waste Manage. Assoc.* **2013**, *63*, 54−69.

(11) Parrish, D. D.; Singh, H. B.; Molina, L.; Madronich, S. Air quality progress in North American megacities: A review. *Atmos. Environ.* **2011**, *45*, 7015−7025.

(12) Warneke, C.; de Gouw, J. A.; Holloway, J. S.; Peischl, J.; Ryerson, T. B.; Atlas, E.; Blake, D.; Trainer, M.; Parrish, D. D. Multiyear trends in volatile organic compounds in Los Angeles, California: Five decades of decreasing emissions. *J. Geophys. Res.-Atmos.* **2012**, *117*.

(13) Chistensen, J.et al. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Fyfe, J., Kwon, W.-T., Trenberth, K., Wratt, D., Eds.; Cambridge University Press: Cambridge, U.K., 2014.

(14) Jacob, D. J.; Winner, D. A. Effect of climate change on air quality. *Atmos. Environ.* **2009**, *43*, 51−63.

(15) Wu, S.; Mickley, L. J.; Leibensperger, E. M.; Jacob, D. J.; Rind, D.; Streets, D. G. Effects of 2000−2050 global change on ozone air quality in the United States. *J. Geophys. Res.-Atmos.* **2008**, *113*, D06302.

(16) Fraser, M. P.; Kleeman, M. J.; Schauer, J. J.; Cass, G. R. Modeling the atmospheric concentrations of individual gas-phase and particle-phase organic compounds. *Environ. Sci. Technol.* **2000**, *34*, 1302−1312.

(17) Ying, Q.; Fraser, M. P.; Griffin, R. J.; Chen, J.; Kleeman, M. J. Verification of a source-oriented externally mixed air quality model during a severe photochemical smog episode. *Atmos. Environ.* **2007**, *41*, 1521−1538.

(18) Sillman, S. The relation between ozone, NO_x and hydrocarbons in urban and polluted rural environments. *Atmos. Environ.* **1999**, *33*, 1821−1845.

(19) Bloomer, B. J.; Stehr, J. W.; Piety, C. A.; Salawitch, R. J.; Dickerson, R. R. Observed relationships of ozone air pollution with temperature and emissions. *Geophys. Res. Lett.* **2009**, *36*, L09803.

(20) Jacob, D. J.; Logan, J. A.; Yevich, R. M.; Gardner, G. M.; Spivakovsky, C. M.; Wofsy, S. C.; Munger, J. W.; Sillman, S.; Prather, M. J.; Rodgers, M. O.; Westberg, H.; Zimmerman, P. R. Simulation of summertime ozone over North America. *J. Geophys. Res.-Atmos.* **1993**, *98*, 14797−14816.

(21) Guenther, A. B.; Zimmerman, P. R.; Harley, P. C.; Monson, R. K.; Fall, R. Isoprene and monoterpene emission rate variability - model evaluations and sensitivity analyses. *J. Geophys. Res.-Atmos.* **1993**, *98*, 12609−12617.

(22) Harley, P.; Fridd-Stroud, V.; Greenberg, J.; Guenther, A.; Vasconcellos, P. Emission of 2-methyl-3-buten-2-ol by pines: A potentially large natural source of reactive carbon to the atmosphere. *J. Geophys. Res.-Atmos.* **1998**, *103*, 25479−25486.

(23) Pfister, G. G.; Wiedinmyer, C.; Emmons, L. K. Impacts of the fall 2007 California wildfires on surface ozone: Integrating local observations with global model simulations. *Geophys. Res. Lett.* **2008**, *35*.

(24) Camalier, L.; Cox, W.; Dolwick, P. The effects of meteorology on ozone in urban areas and their use in assessing ozone trends. *Atmos. Environ.* **2007**, *41*, 7127−7137.

(25) Fiore, A. M.; et al. Global air quality and climate. *Chem. Soc. Rev.* **2012**, *41*, 6663−6683.

(26) Weaver, C. P.; et al. A preliminary synthesis of modeled climate change impacts on U.S. regional ozone concentrations. *B. Am. Meteorol.* **2009**, *90*, 1843−1863.

(27) Cox, P.; Delao, A.; Komorniczak, A.; Weller, A. *The California Almanac of Emissions and Air Quality*, 2009 edition; California Evironmental Protection Agency: Sacramento, CA, 2009,

(28) Kim, S. W.; Heckel, A.; McKeen, S. A.; Frost, G. J.; Hsie, E. Y.; Trainer, M. K.; Richter, A.; Burrows, J. P.; Peckham, S. E.; Grell, G. A. Satellite-observed US power plant NO_x emission reductions and their impact on air quality. *Geophys. Res. Lett.* **2006**, *33*.

(29) Carter, W. P.; Heo, G. Development of revised *SAPRC* aromatics mechanisms. *Atmos. Environ.* **2013**, *77*, 404−414.

(30) Kleeman, M.; Cass, G. A 3D Eulerian source-oriented model for an externally mixed aerosol. *Environ. Sci. Technol.* **2001**, *35*, 4834−48.

(31) Kleeman, M. J.; Cass, G. R.; Eldering, A. Modeling the airborne particle complex as a source-oriented external mixture. *J. Geophys. Res.-Atmos.* **1997**, *102*, 21355−21372.

(32) McRae, G. J.; Goodin, W. R.; Seinfeld, J. H. Development of a second-generation mathematical model for Urban air pollution-I. Model formulation. *Atmos. Environ.* **1982**, *16*, 679−696.

(33) Mysliwiec, M. J.; Kleeman, M. J. Source apportionment of secondary airborne particulate matter in a polluted atmosphere. *Environ. Sci. Technol.* **2002**, *36*, 5376−5384.

(34) Goodin, W. R.; McRae, G. J.; Seinfeld, J. H. An objective analysis technique for constructing three-dimensional urban-scale wind fields. *J. Appl. Meteorol.* **1980**, *19*, 98−108.

(35) Goodin, W. R.; McRae, G. J.; Seinfeld, J. H. A comparison of interpolation methods for sparse data: Application to wind and concentration fields. *J. Appl. Meteorol.* **1979**, *18*, 761−771.

(36) Skamarock, W. C.; Klemp, J. B. A time-split nonhydrostatic atmospheric model for weather research and forecasting applications. *J. Comput. Phys.* **2008**, *227*, 3465−3485.

(37) Mesinger, F.; et al. North American regional reanalysis. *Bull. Am. Meteorol.* **2006**, *87*, 343−+.

(38) Hu, J.; Howard, C. J.; Mitloehner, F.; Green, P. G.; Kleeman, M. J. Mobile source and livestock feed contributions to regional ozone formation in Central California. *Environ. Sci. Technol.* **2012**, *46*, 2781−2789.

(39) Griffin, R. J.; Dabdub, D.; Kleeman, M. J.; Fraser, M. P.; Cass, G. R.; Seinfeld, J. H. Secondary organic aerosol. 3. Urban/regional scale model of size- and composition-resolved aerosols. *J. Geophys. Res.-Atmos.* **2002**, *107*.

(40) Ying, Q.; Lu, J.; Kaduwela, A.; Kleeman, M. J. Modeling air quality during the California Regional PM10/PM2.5 Air Quality Study (CPRAQS) using the UCD/CIT source oriented air quality model - part II. Regional source apportionment of primary airborne particulate matter. *Atmos. Environ.* **2008**, *42*, 8967−8978.

(41) Fraser, M. P.; Grosjean, D.; Grosjean, E.; Rasmussen, R. A.; Cass, G. R. Air quality model evaluation data for organics. 1. Bulk chemical composition and gas/particle distribution factors. *Environ. Sci. Technol.* **1996**, *30*, 1731−1743.

(42) Liang, J.; Horowitz, L. W.; Jacob, D. J.; Wang, Y.; Fiore, A. M.; Logan, J. A.; Gardner, G. M.; Munger, J. W. Seasonal budgets of reactive nitrogen species and ozone over the United States, and export fluxes to the global atmosphere. *J. Geophys. Res.-Atmos.* **1998**, *103*, 13435−13450.
(43) Scott, K. I.; Benjamin, M. T. Development of a biogenic volatile organic compounds emission inventory for the SCOS97-NARSTO domain. *Atmos. Environ.* **2003**, *37* (Supplement 2), 39−49.
(44) Howard, C. J.; Kumar, A.; Malkina, I.; Mitloehner, F.; Green, P. G.; Flocchini, R. G.; Kleeman, M. J. Reactive organic gas emissions from livestock feed contribute significantly to ozone production in central California. *Environ. Sci. Technol.* **2010**, *44*, 2309−14.
(45) *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze*; United States Environmental Protection Agency: Research Triangel Park, NC, 2007.
(46) Rasmussen, D. J.; Fiore, A. M.; Naik, V.; Horowitz, L. W.; McGinnis, S. J.; Schultz, M. G. Surface ozone-temperature relationships in the eastern US: A monthly climatology for evaluating chemistry-climate models. *Atmos. Environ.* **2012**, *47*, 142−153.
(47) Rubin, J. I.; Kean, A. J.; Harley, R. A.; Millet, D. B.; Goldstein, A. H. Temperature dependence of volatile organic compound evaporative emissions from motor vehicles. *J. Geophys. Res.-Atmos.* **2006**, *111*.
(48) Baertsch-Ritter, N.; Keller, J.; Dommen, J.; Prevot, A. S. H. Effects of various meteorological conditions and spatial emission resolutions on the ozone concentration and ROG/NO_x limitation in the Milan area (I). *Atmos. Chem. Phys.* **2004**, *4*, 423−438.
(49) Pollack, I. B.; et al. Airborne and ground-based observations of a weekend effect in ozone, precursors, and oxidation products in the California South Coast Air Basin. *J. Geophys. Res.-Atmos.* **2012**, *117*, 2156−2202.
(50) Duncan, B. N.; Yoshida, Y.; Olson, J. R.; Sillman, S.; Martin, R. V.; Lamsal, L.; Hu, Y.; Pickering, K. E.; Retscher, C.; Allen, D. J.; Crawford, J. H. Application of OMI observations to a space-based indicator of NO_x and VOC controls on surface ozone formation. *Atmos. Environ.* **2010**, *44*, 2213−2223.
(51) Seinfeld, J. H.; Pandis, S. N. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 2nd ed.; J. Wiley: Hoboken, N.J., 2006; p xxviii.
(52) Pusede, S. E.; Cohen, R. C. On the observed response of ozone to NO_x and VOC reactivity reductions in San Joaquin Valley California 1995 to present. *Atmos. Chem. Phys.* **2012**, *12*, 8323−8339.

Rachael E. Koss

From: Amy Million [AMillion@ci.benicia.ca.us]
Sent: Tuesday, February 02, 2016 1:24 PM
To: Rachael E. Koss
Cc: Heather McLaughlin
Subject: Modeling Files for Valero CBR - Adams Broadwell Request
Attachments: Valero Ltr 020116 Risk Values.pdf

Hi Rachael,
Per my previous email, below is a link to the AERMOD files you have requested. I have also attached a letter from Valero which provides clarification on the risk values presented in Appendix E.6 of the RDEIR. If you have any problems accessing the file, let me know.

Some files have been sent to you via the **YouSendIt** File Delivery Service.

Download the file - AerialNad27.tfw; AerialNad27.tif; RefineryNad27.tfw; RefineryNad27.tif; Updated Refinery HRA Calculation Jan 2016.xlsx; Valero ceqa chronic_5yrs_CAN_RISK.DTA; Valero ceqa chronic_5yrs_CAN_RISK.LST; Valero ceqa switching.dta; Valero ceqa switching.LST

Your files will expire after 7 days.

Attached are:

1. AerialNad27.tif and .tfw – "zoomed out" or long-range base map view
2. RefineryNad27.tif and .tfw – close-in base map view
3. Valero ceqa chronic 5 yrs CAN RISK.DTA and .LST – Input and output files for near-refinery line-haul locomotives and fugitives
4. Valero ceqa switching.dta and .lst – Input and output files for near-refinery switch engines
5. Updated Refinery HRA Calculation Jan 2016 – excel file version of the attachment in the memo showing the MEIW risk calculations.

Amy E. Million, Principal Planner
City of Benicia
250 East L Street
Benicia, CA 94510
phone 707. 746.4372 | fax 707.747.1637 | email amillion@benicia.org
www.ci.benicia.ca.us

From: Amy Million [mailto:AMillion@ci.benicia.ca.us]
Sent: Tuesday, February 02, 2016 1:24 PM
To: Rachael E. Koss
Cc: Heather McLaughlin
Subject: Modeling Files for Valero CBR - Adams Broadwell Request

Hi Rachael,

Per my previous email, below is a link to the AERMOD files you have requested. I have also attached a letter from Valero which provides clarification on the risk values presented in Appendix E.6 of the RDEIR. If you have any problems accessing the file, let me know.

Some files have been sent to you via the **YouSendIt** File Delivery Service.

Download the file - AerialNad27.tfw; AerialNad27.tif; RefineryNad27.tfw; RefineryNad27.tif; Updated Refinery HRA Calculation Jan 2016.xlsx; Valero ceqa chronic_5yrs_CAN_RISK.DTA; Valero ceqa chronic_5yrs_CAN_RISK.LST; Valero ceqa switching.dta; Valero ceqa switching.LST

Your files will expire after 7 days.

Attached are:

1. AerialNad27.tif and .tfw – “zoomed out” or long-range base map view
2. RefineryNad27.tif and .tfw – close-in base map view
3. Valero ceqa chronic 5 yrs CAN RISK.DTA and .LST – Input and output files for near-refinery line-haul locomotives and fugitives
4. Valero ceqa switching.dta and .lst – Input and output files for near-refinery switch engines
5. Updated Refinery HRA Calculation Jan 2016 – excel file version of the attachment in the memo showing the MEIW risk calculations.

Amy E. Million, Principal Planner
City of Benicia
250 East L Street
Benicia, CA 94510
phone 707. 746.4372 | fax 707.747.1637 | email amillion@benicia.org

www.ci.benicia.ca.us

Valero Ltr 020116 Risk Values.pdf
306K

Population	UTM X (m)	UTM Y (m)	Source	Chemical	Emission Rate (g/s)	Dispersion Factor	Concentration	Age bin	ED	DBR	EF	CF	FAH	ASF	AT	Cancer Potency Factor	Cancer Risk
Worker	576044	4214245	Line Haul	DPM	2.82E-03	1.77906	5.02E-03	16-70	40	230	0.68	0.000001	1	1	70	1.1	4.93E-07
Worker	576044	4214245	Switching	DPM	5.18E-03	8.08052	4.18E-02	16-70	40	230	0.68	0.000001	1	1	70	1.1	4.11E-06
Worker	576044	4214245	Idling	DPM	6.49E-04	46.872	3.04E-02	16-70	40	230	0.68	0.000001	1	1	70	1.1	2.99E-06
Worker	576044	4214245	Fugitive	Benzene	3.24E-04	7.33891	2.38E-03	16-70	40	230	0.68	0.000001	1	1	70	0.1	2.13E-08
Worker	576044	4214245	Fugitive	Ethylbenzene	2.16E-04	7.33891	1.59E-03	16-70	40	230	0.68	0.000001	1	1	70	0.0087	1.23E-09
Worker	Overall Cancer Risk																7.6E-06

Worker	576044	4214245	Line Haul	DPM	2.82E-03	1.77906	5.02E-03	5	0.001004
Worker	576044	4214245	Switching	DPM	5.18E-03	8.08052	4.18E-02	5	0.008365
Worker	576044	4214245	Idling	DPM	6.49E-04	46.872	3.04E-02	5	0.006081
Worker	576044	4214245	Fugitive	Benzene	3.24E-04	7.33891	2.38E-03	3	0.000793
Worker	576044	4214245	Fugitive	Ethylbenzene	2.16E-04	7.33891	1.59E-03	2000	7.93E-07
Worker	576044	4214245	Fugitive	Hexane	2.16E-04	7.33891	1.59E-03	7000	2.26E-07
Worker	576044	4214245	Fugitive	Hydrogen Sulfide	5.40E-04	7.33891	3.96E-03	10	0.000396
Worker	576044	4214245	Fugitive	Toluene	5.40E-04	7.33891	3.96E-03	300	1.32E-05
Worker	576044	4214245	Fugitive	Xylene	7.56E-04	7.33891	5.55E-03	700	7.93E-06
Worker	Chronic Hazard Index								0.017

Worker	576044	4214245	Line Haul	DPM	2.82E-03	1.77906	5.02E-03
Worker	576044	4214245	Switching	DPM	5.18E-03	8.08052	4.18E-02
Worker	576044	4214245	Idling	DPM	6.49E-04	46.872	3.04E-02
Worker	PM2.5 Concentration						7.7E-02

From: Thu Bui
Sent: Thursday, January 21, 2016 11:30 AM
To: 'Gustofson, Sue'
Cc: Cuffel, Donald; Suhami, Iren
Subject: RE: Revised ATC Application 25242 - Crude by Rail (CBI)

Hi Sue,

As we have discussed several times in the past and recently last week, the District still needs more information on the crude storage tanks.

There are total 8 tanks in this project. According to A/N 2502, 3 grandfathered tanks (T-1701 to T-1703) are listed as "light" (3.5 psia TVP)crude tanks and 3 grandfathered tanks (TK-1704 to TK 1706) are listed as "heavy" (0.3 psia TVP) crude tanks. Two NSR new tanks are permitted at 4 psia TVP. At this time, Valero claimed that there will be no emission increases from storage tanks. In order for the District to determine that your grandfathered sources are altered rather than modified, the District will need:

- The highest actual consecutive 24 hour throughput and its TVP or RVP and 12 month throughput and its TVP or RVP demonstrated and documented in owner records for each tank
- Each grandfathered tank emissions using EPA Tank 4.09 program or Valero in house program based on the demonstrated throughput and vapor pressure

For alteration, the District will impose permit conditions based upon the demonstrated daily and annual emissions.

Please submit the above information ASAP in order for the District to complete your application. Please let me know if you have any questions.

Regards,
Thu

From: Gustofson, Sue [mailto:Susan.Gustofson@valero.com]
Sent: Wednesday, November 13, 2013 9:34 AM
To: Thu Bui
Cc: Cuffel, Donald; Suhami, Iren; Penny, Stephen; Lam, Tom
Subject: Revised ATC Application - Crude by Rail (CBI)

Thu:

Attached is the revised ATC Application for Valero's Crude by Rail project. This revision excludes Tank 1776 from the project scope and reroutes the crude that would be received at the proposed rail car unloading rack to the existing crude storage tanks located in the crude tank farm. Emissions estimates have been updated to reflect these revisions.

Two copies – one entitled 'Confidential Business Information' and one 'Public Version' – have been sent to you via regular mail.

Please let me know if you have questions.

Susan Gustofson, P.E.
Staff Environmental Engineer
Valero Benicia Refinery
3400 East Second Street
Benicia, CA 94510
707.745.7203
susan.gustofson@valero.com

THE CITY OF BENICIA CALIFORNIA
A SESQUICENTENNIAL CITY 1847 ★ 1997

CITY HALL • 250 EAST L STREET • BENICIA, CA 94510 • (707) 746-4200 • FAX (707) 747-8120

March 30, 2016

VIA EMAIL celliott@adamsbroadwell.com

Cody Elliott
Adams Broadwell Joseph & Cardozo
601 Gateway Boulevard, Ste. 1000
South San Francisco, CA 94080

Re: Public Records Act Request Dated March 10, 2016

Dear Mr. Elliott:

This is in response to your request submitted pursuant to the California Public Records Act ("CPRA") dated March 10, 2016 and received by the City on March 10, 2016. In your letter, you request "immediate access to all documents considered and/or used to generate the risk profiles for the Valero Benicia Crude by Rail RDEIR ("RDEIR") for the Valero Benicia Crude by Rail Project ("Project"). Our request includes, but not limited to, a functioning copy of the model used to generated risk profiles for the Valero Crude by Rail RDEIR (see Figure 4.7-9), all input and output data for the model, supporting calculations, live Excel spreadsheets, references supporting assumptions, and correspondence."

The models used to generate the risk profiles requested are proprietary to the consultant, Marine Research Specialists (MRS). As stated in my March 17, 2016 email, you will find most, if not all, of the data you are looking for in the report which is Appendix F of the Revised DEIR. With that said, MRS reviewed your request and has provided the attached letter and reference documents.

This response is being provided in accordance with the requirements of the CPRA and the Open Government Ordinance of the City of Benicia contained in Title 4 of the Benicia Municipal Code.

Sincerely,

Amy Million
Principal Planner

Attachments:

cc: City Clerk
City Manager
City Attorney

ELIZABETH PATTERSON, *Mayor*
Members of the City Council
MARK C. HUGHES, *Vice Mayor* . ALAN M. SCHWARTZMAN . TOM CAMPBELL . CHRISTINA STRAWBRIDGE

BRAD KILGER, *City Manager*
KENNETH C. PAULK, *City Treasurer*
LISA WOLFE, *City Clerk*

Recycled Paper

March 30, 2016

Ms. Amy Million
Principal Planner
City of Benicia
250 East L Street
Benicia, CA
94510

Re: Public Records Act Request for the Valero Crude by Rail Project

Dear Amy:

Marine Research Specialists (MRS) has received the Public Records Act (PRA) request related to the quantitative risk analysis (QRA) that was prepared for the Valero Crude by Rail Project and used in the Revised Draft Environmental Impact Report. Our response to the request is summarized below:

A. Background

Adams Broadwell Joseph & Cardozo, on behalf of Safe Fuels and Energy Resources California, submitted a request for "…immediate access to all documents considered and/or used to generate the risk profiles for the Valero Crude by Rail RDEIR ("RDEIR") for the Valero Benicia Crude by Rail Project ("Project'). Our request includes, but is not limited to, a functioning copy of any model used to generate risk profiles for the Valero Crude by Rail RDEIR (see Figure 4.7-9), all input and output data for the model, all supporting calculations, live Excel spreadsheets, references supporting assumptions, and correspondence."

B. Quantitative Risk Analysis Approach and Software

Marine Research Specialists utilizes a suite of software tools to quantitatively evaluate the potential risks associated with activities that could result in a risk to the public. Our QRA models follow the specific methodologies and guidance outlined in numerous books that were published by the American Institute of Chemical Engineers, Center for Chemical Process Safety:

- Guidelines for Chemical Process Quantitative Risk Analysis.
- Guidelines for Chemical Transportation Risk Analysis.
- Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires and BLEVES.
- Guidelines for Process Equipment Reliability Data with Data Tables.
- Evaluating Process Plant buildings for External Explosions and Fires.
- Guidelines for Postrelease Mitigation Technology in the Chemical Process Industry.

Several staff members at Marine Research Specialists participated in the preparation of several of these guideline books while employed at Arthur D. Little, Inc. in Cambridge, MA. These books are all available at http://www.aiche.org/ccps/resources/publications.

The components that are evaluated in the preparation of a QRA were presented in our report as Figure 5-1 and involve the following steps:

- Identification of Release Scenarios
  - Review Site Specific Data
  - Develop Release Scenarios
- Development of Probability
  - Estimate Spill Probability
- Determination of Consequences
  - Assign Meteorological Conditions
  - Select Exposure Criteria
  - Conduct Consequence Modeling
- Development of Risk Estimates
  - Develop Population Data
  - Develop Ignition Data
  - Develop Injury and Fatality Rates
  - Construct Risk Profiles

The preparation of a QRA is computationally complex, involving a number of interrelated steps to estimate the probability of a given number of injuries and/or fatalities. In order to streamline the preparation of QRAs, Marine Research Specialists has developed a software package that includes all of the steps listed above and includes extensive databases that have been compiled over decades of preparing quantitative risk analyses for a wide variety of facilities and clients. The development of this software represents a significant effort and financial investment on our part that provides us with a streamlined method to cost effectively prepare QRAs and provides our firm with a significant competitive advantage for preparing QRAs. As such, we do not offer our software for sale and consider the software to be proprietary. In addition, our software package contains data that was obtained under confidentiality agreements with various clients and industry associations that we cannot release under any circumstances. Therefore, we decline to provide a copy of our QRA software in response to a PRA request.

In order to facilitate the PRA Request, we have provided additional information below that should guide the requester to a better understanding of the information and assumptions that were used in the QRA. Our report and attachments were included in the RDEIR as Appendix F, and contains most of the assumptions that were used in the QRA, including information on unloading facility release scenarios, potential worst-case consequences, exposure assumptions and risk profile development. The QRA that was provided for the unloading facility used the same basic assumptions as the QRA that was prepared for mainline rail risk estimates. Therefore,

the mainline rail QRA section of our report should be reviewed to obtain a better understanding of many of the assumptions that were used in the unloading facility QRA.

C. Identification of Release Scenarios

The physical attributes of the Valero Crude by Rail unloading facility were well described in the RDEIR. The tank car unloading rack would accommodate up to 25 tank cars on each side at one time (up to two, 50 tank car "switches" per day would be transported to the rack by train). The tank cars would be emptied into a single pipeline located between the two rail spurs at slightly below ground level. Each side of the rack would have 25 unloading stations, which would "bottom-unload" closed-dome tank cars using 4-inch-diameter hose, with dry disconnect couplings that would connect to a common header between the two sides of the rack (a check valve, connected to the top of each tank car via 2-inch-diameter hose would open to allow ambient air to enter during unloading and immediately close when unloading is finished). Three new pumps would be located on the western side of a new service road between Tanks 1720 and 1716. Two pumps operating in parallel would pump the crude oil from the unloading rack header via a new 16-inch pipeline; the third pump would be used as a spare.

The loading area also would be equipped with a fire protection system that complies with code requirements at the time of construction. System components could include, for example, fire detection equipment, hydrants, controls, and piping. The unloading rack would be equipped with a foam sprinkler deluge system and firewater monitors with foam generators at the unloading rack periphery. In the event of a spill that led to a fire, the sprinkler deluge system would activate and douse the area with foam. Any spilled oil would be directed away from the unloading area to the spill containment tanks, which would serve to keep any fire away from the tank cars.

Downstream of the two unloading facility meter assemblies, a new 16-inch above ground pipeline would be routed along an existing internal road on the Valero property between the unloading facility and the Refinery. This pipeline would connect with the existing Refinery crude oil storage tanks. This road accommodates periodic on-site traffic only associated with Refinery personnel traveling at low-speeds. The pipeline would be approximately 4,000 feet in length. The unloaded crude oil would be stored in the existing Refinery storage tanks.

Unloading hoses would be operated under suction, with potential failures resulting in very small spills that would be contained within the unloading facility sump system. Therefore, the main concern for large spills and potential offsite consequences is associated with the unloading pumps and pipeline between the pumps and storage tank.

The proposed unloading facility would have a maximum crude oil pumping rate of 4,000 gallons per minute. The unloading facility and 16-inch pipeline would be monitored using multiple Programmable Logic Controllers and controlled using the existing Refinery's Supervisory Control and Data Acquisition (SCADA) system. The SCADA would detect a catastrophic failure of the 16-inch pipeline within 1 minute, thus limiting pumping losses. However, the drainage of the pipeline would occur, and potentially result in a worst-case spill of about 73,000 gallons of

crude oil. This worst case spill would occur where the pipeline connects with unloading pumps since this is the lowest elevation of the pipeline. Further up the pipeline toward the storage tanks, the maximum spill volumes decrease, with the smallest spill volumes being near the storage tanks. In the event of a release from the pipeline, the oil would drain into the area around the pipeline and unloading racks, which could result in a pool fire. In each spill location along the pipeline, potential spills would be contained within diked or sump areas that are also protected by foam fire protection systems.

D. Development of Probability

The Marine Research Specialists QRA model contains information from numerous failure rate databases, including, but not limited to:

- Process Equipment Reliability Data, Centre for Chemical Process Safety, AICE, 1989, ISBN 0-8169-0422-7.
- Loss Prevention in the Process Industries, Second Edition (3 volumes).
- Shell International Petroleum Co. Ltd, Supply and Marketing Division, July 1993.
- WASH 1400 (NUREG-75/014) Appendix III to Reactor Safety Study, US Nuclear Regulatory Commission, October 1975.
- Reliability and Maintainability in Perspective, 3rd Edition, D.J. Smith, 1988 ISBN 0-333-46205-X.
- Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6.
- Hydrocarbon Leak and Ignition Database, Report N0. 11.4/180, May 1992, E&P Forum.
- California State Fire Marshal (CSFM). 1993. Hazardous Liquid Pipeline Risk Assessment Report.

The QRA utilized numerous failure rates to estimate the probability of a spill, ignition rates (see Section F) and the failure of the foam fire suppression system. All three are required to estimate the probability that an offsite consequence could occur. As such, the following failure rates were used in the QRA:

- Gathering Pipe Rupture, 1.5×10^{-7}/m-yr.
- 16” Main Pipe Rupture, 8.0×10^{-8}/m-yr.
- Catastrophic Pump Failure, 9.99×10^{-5}/yr.
- Foam System Valve Failure on Demand, 5.58×10^{-3}.

E. Determination of Consequences

Our report contained in Appendix F of the RDEIR contained a discussion of the consequence modeling and the model output files.

F. Development of Risk Estimates

The exposure assumptions and conditional probabilities that were used in the unloading facility QRA were the same as for the mainline rail QRA, where applicable. Additional site specific information for the unloading facility included assumptions for evaluating ignition probabilities,, population density and exposure assumptions as noted below.

Ignition Probabilities

Flammable vapor clouds have the potential to ignite anywhere within their flammable limits. Hence, it is necessary to identify potential ignition sources that a cloud may encounter, and to quantify the likelihood of ignition, if the cloud encompasses the sources. When determining ignition probabilities, there are two factors to take into account; first, source duration, the fraction of time that the source is present or in operation; and second, source intensity, the chance of the source actually causing ignition if contacted by a flammable cloud. For example, if a ground level flare is operating, it will almost always ignite a cloud, but it may only operate ten percent of the time. This would give an overall chance of ignition by the ground level flare of 0.1.

When a (virtually guaranteed) source of ignition is always in operation, a probability of greater than 0.95 is not generally assigned. There are two related reasons for this: one is the possibility that there may be a failure or unanticipated shut down of the system or item in question; the other reason is that to use a probability of less than 1 will allow some fraction of releases to pass over the source without ignition, to possibly ignite later when a larger area has been covered. This gives a more conservative result.

In general, when trying to identify ignition sources, the search is primarily for open flames, hot surfaces and electrical sparks, and, to a lesser extent, friction sparks from both continuous and intermittent activities. One extensive listing of potential ignition sources may be found in CCPS "Chemical Process Quantitative Risk Analysis". Estimates of the ignition probabilities of some of these sources are also provided. Typical ignition probabilities that were used in the analysis include:

- **Cars -** 0.06 per car; although many potential ignition sources within a car like faulty wiring or backfires are due to fuel rich mixtures in intake air, they are not always present nor guaranteed to cause ignition. This value was also applied to golf carts and other utility vehicles. (CCPS)
- **Structures -** 0.01 per structure; while there are many ignition sources within a structure, such as switches, doorbells, faulty wiring, pilot lights, HVAC systems and industrial equipment. The flammable vapors must first penetrate the structure before these ignition sources pose a hazard. Typical residence times of clouds are often brief enough that this is relatively unlikely; especially since the rail unloading facility will be equipped with a foam suppression system. (CCPS)

Population

The population surrounding the proposed rail unloading facility is characterized by Valero Refinery workers, and industrial and commercial workers at the adjacent Benicia Industrial Park. The Benicia Industrial has over 450 businesses and 6,500 employees (including the Valero Refinery workers). The average population density in the Benicia Industrial Park is 1,400 workers per square mile. A site reconnaissance study was conducted on April 14th and 15th 2015 to estimate population densities, commuter patterns and relative time the population is outdoors and vulnerable to exposure to an accident at the Valero rail unloading facility. Population densities that were used in the QRA model are presented in Figure 1, which also shows areas that could be exposed to thermal radiation hazards. Based on the site reconnaissance study, it was estimated that approximately ten percent of the population would be outdoors and vulnerable at any given time. The remainder of the worker population would be effectively sheltered in place within their facilities.

F. Conclusion

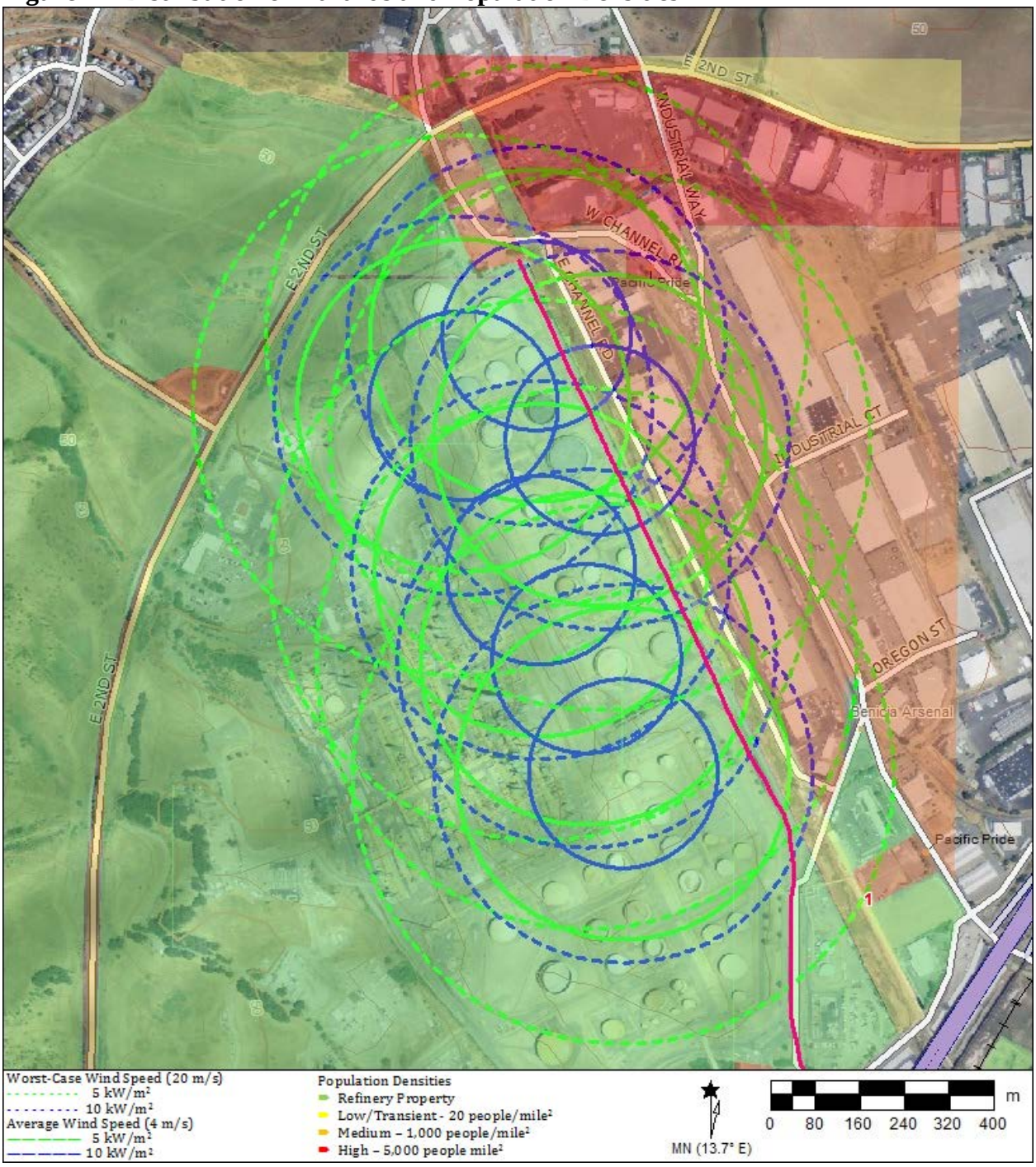
We have also provided the City with copies of the documents that we reference in our report. Since these documents were not referenced in the RDEIR, they were not provided as part of the EIR administrative record.

We believe the above should provide for a reasonable review QRA that was referenced in the Valero Benicia Crude by Rail Project RDEIR. Should you have any questions, or wish to discuss this information further, feel free to call me at (805.289.3927).

Best Regards,

Steven R. Radis
Principal

Figure 1 – Distribution of Hazards and Population Densities



March 28, 2016

Ms. Rachael E. Koss
Adams Broadwell Joseph & Cardozo
601 Gateway Boulevard, Suite 1000
South San Francisco, CA 94080

Subject: Comments on the Valero Benicia Crude by Rail Project

Dear Ms. Koss:

This letter contains my comments on the Valero Benicia Crude by Rail Project ("Project"), including an assessment of the Final Environmental Impact Report ("FEIR") prepared by the City of Benicia ("City") for the Project. The proposed Project would install a railcar unloading rack, repurpose an existing tank to include crude oil service, and construct associated infrastructure, including on-site rail lines, to allow the Refinery to receive crude oil by train.

I am an environmental biologist with 23 years of professional experience in wildlife ecology and natural resource management. Over the past 8 years I have served as a biological resources expert for over 100 projects. My experience and scope of work in this regard has included assisting various clients with evaluations of biological resource issues, reviewing environmental compliance documents prepared pursuant to the California Environmental Quality Act ("CEQA") and the National Environmental Policy Act ("NEPA"), and submitting written comments in response to CEQA and NEPA documents. My work has included the preparation of written and oral testimony for the California Energy Commission, California Public Utilities Commission, and U.S. district courts. In addition to my work as a biological resources expert, I have been involved in several scientific studies examining avian use of tidal marshlands in San Pablo, Suisun, and San Francisco Bays. This includes assisting the California Department of Fish and Wildlife ("CDFW") with bird surveys following the Kinder Morgan diesel fuel spill that occurred in Suisun Marsh in 2004. My educational background includes a B.S. in Resource Management from the University of California at Berkeley, and a M.S. in Wildlife and Fisheries Science from the Pennsylvania State University.

The comments herein are based on my review of the environmental documents prepared for the Project, a review of scientific literature pertaining to biological resources known to occur in the Project area, consultations with other biological resource experts, and the knowledge and experience I have acquired during more than 23 years of working in the field of natural resources management.

EXISTING CONDITIONS

Suisun Marsh encompasses more than 10% of California's remaining natural wetlands and serves as the resting and feeding ground for thousands of waterfowl migrating on the Pacific Flyway.[1] Additionally, Suisun Marsh provides essential habitat for more than 221 bird species, 45 animal species, 16 different reptile and amphibian species, and more than 40 fish species.[2] The Suisun Bay Area Recovery Unit, which borders the Valero refinery, is critical to conservation efforts because it provides a suitable pathway for habitat to shift up the estuary as anticipated climate change and sea level rise produce increasing salinities toward the east.[3]

Special-Status Species

The proposed rail line and railcar unloading rack would be located directly adjacent to Sulphur Springs Creek, which flows into Suisun Bay.[4] The brackish and salt marshes at the mouth of Sulphur Springs Creek provide habitat occupied by:

- California black rail - (*State listed as Threatened and Fully Protected*);
- California clapper rail - (*Federally listed as Endangered; State listed as Endangered and Fully Protected*); and
- salt-marsh harvest mouse - (*Federally listed as Endangered; State listed as Endangered and Fully Protected*).[5]

In addition, Sulphur Springs Creek and its associated riparian corridor and in-stream marshes provide suitable habitat for the following special-status species:

- California red-legged frog - (*Federally listed as Threatened*);
- western pond turtle - (*CA Species of Special Concern*);
- tricolored blackbird - (*State candidate for listing*);
- yellow-headed blackbird - (*CA Species of Special Concern*);
- Suisun song sparrow - (*CA Species of Special Concern*);
- Samuel's song sparrow - (*CA Species of Special Concern*);
- grasshopper sparrow - (*CA Species of Special Concern*);
- loggerhead shrike - (*CA Species of Special Concern*);
- yellow-breasted chat - (*CA Species of Special Concern*);
- San Francisco common yellowthroat - (*CA Species of Special Concern*); and

---

[1] DEIR, p. 4.2-2.

[2] *Ibid.*

[3] U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol I, p. 151.

[4] IS/MND, p. II-30.

[5] IS/MND, p. II-18 and DEIR, p. 4.2-28.

- short-eared owl - (*CA Species of Special Concern*).[6]

The Applicant did not conduct wildlife surveys to establish existing conditions in the Project Study Area. As a result, one must assume all of the species listed above occupy the Sulphur Springs Creek riparian corridor, and that they could be significantly impacted by the Project.

IMPACTS

Wildlife Movement Corridor

Sulphur Springs Creek provides one of the last remaining corridors of aquatic and riparian habitat between Suisun Marsh (and Bay) and open space to the north.[7] The Draft Environmental Impact Report ("DEIR") and Revised Draft Environmental Impact Report ("RDEIR") acknowledge the Sulphur Springs Creek riparian zone is a likely movement corridor for wildlife, including the federally threatened California red-legged frog.[8]

The Project includes installation of 100 LED lights mounted 12 feet above the unloading rack platform walkway, which would be immediately adjacent to Sulphur Springs Creek.[9] The DEIR and RDEIR do not identify the irradiance of the lights. However, they indicate the lights would constitute a significant increase in night lighting, which could potentially cause wildlife to avoid using Sulphur Springs Creek as a movement corridor.[10] According to the City, the effects of night lighting on wildlife movement "*should*" (DEIR, p. 4.2-30), or "*would*" (RDEIR, p. 2-156), be less than significant due to "the downward orientation of Project lighting, away from the riparian corridor."[11] This conclusion is not justified or supported by evidence. Whereas orienting lights downward reduces astronomical light pollution, it does not prevent ecological light pollution and the potential for Project lighting to significantly impact biota associated with Sulphur Springs Creek.[12]

In addition to night lighting, the RDEIR acknowledges the increase in human activity associated with the Project could cause wildlife to avoid using Sulphur Springs Creek as

---

[6] IS/MND, p. II-18 and DEIR, p. 4.2-27.

[7] James Associates, Inc. 2012. Benicia, Vine Hill, and Fairfield South 7.5-minute quadrangles [topographic maps]. MacTopos 3.0 georeferenced for MacGPS Pro.

[8] DEIR, pp. 4.2-6 and -30.

[9] IS/MND, p. II-6.

[10] RDEIR, p. 2-156.

[11] DEIR, p. 4.2-30. *See also* RDEIR, p. 2-156.

[12] Rich C, T Longcore. 2006. Ecological Consequences of Artificial Night Lighting. Island Press, Washington, DC. 458 pp. *See also* Perry G, BW Buchanan, RN Fisher, M Salmon, SE Wise. 2008. Effects of Artificial Night Lighting on Amphibians and Reptiles in Urban Environments. Chapter 16 *In:* Mitchell JC, RE Jung Brown, editors. Urban Herpetology. Herpetological Conservation 3:211-228.

a movement corridor.[13] This potentially significant impact was not analyzed in the environmental documents prepared for the Project, nor did the environmental documents provide evidence to support the finding that the impact to wildlife movement would be less than significant.

Noise

Noise pollution affects birds and other wildlife in myriad ways, including: (1) physical damage to ears; (2) stress responses; (3) fright–flight responses; (4) avoidance responses; (5) changes in other behavioral responses, such as foraging; (6) changes in reproductive success; (7) changes in vocal communication; (8) interference with the ability to hear predators and other important sounds; and (9) potential changes in populations.[14] Two of the bird species that may occur within the Sulphur Springs Creek riparian corridor are colonial species (i.e., yellow-headed blackbird and tricolored blackbird). Colonial birds are especially susceptible to noise because when one bird reacts, many or all birds in the colony will react similarly, whether the group responds directly to the noise or to the first bird(s) that responded.[15]

The environmental documents prepared for the Project did not analyze the effects of Project noise on wildlife. Instead, it jumped to the conclusion that "while the increase in train traffic may initially have a slight negative effect on nearby wildlife species, they are expected to soon habituate to the increased noise. The impact is less than significant, and no mitigation is required."[16] This conclusion ignores noise generated by the Project's pumps and motors, and it contradicts existing evidence.

First, the Valero Refinery is the primary contributor to the existing noise environment.[17] Existing noise at the refinery averages 60 dBA during the day, and 59 dBA during the evening and night.[18] The Project would generate significantly higher noise levels. Specifically, the pumps and motors associated with the Project would generate a noise level of 87 dBA at 5 feet, whereas the trains would generate a maximum noise level of 81 dBA at 200 feet.[19] Noise at these levels is loud enough to have a significant impact on birds and other wildlife that occur within the Sulphur Springs Creek riparian corridor.[20]

---

[13] RDEIR, p. 2-156.

[14] Ortega CP. 2012. Effects of Noise Pollution on Birds: A Brief Review of Our Knowledge. Ornithological Monographs 74:6-22.

[15] *Ibid.*

[16] DEIR, p. 4.2-32.

[17] Wilson Ihrig & Associates. 2013. Noise Study for Valero Crude-by-Rail Project. p. 2.

[18] *Ibid*, Table 1.

[19] *Ibid*, p. 3.

[20] Reijnen R, R Foppen, G Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and planning and managing road corridors. Biodiversity and Conservation 6:567-581. *See also* U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol I, p. 117.

Second, the environmental documents prepared for the Project provide no evidence that wildlife would habituate to an approximately 20 dBA increase in the noise level. To the contrary, Francis and Barber (2013) provided evidence that a 20 dBA increase in noise level can have a significant negative effect on species occupancy, pairing success, and potentially other measures of fitness.[21]

Third, as discussed in the comment letter submitted by the Natural Resources Defense Council ("NRDC"), the presence of a species in a disturbance zone does not equate to the absence of impacts.[22] Scientific evidence indicates that behavioral modifications among individuals confronted with noise – even those individuals that outwardly appear to habituate – can lead to decreased fitness.[23] The FEIR failed to respond to this issue.

The Project's impacts on birds and other wildlife from noise remain significant and unmitigated.

Contaminants

Chronic Exposure

Environmental contaminants may adversely affect the survival, growth, reproduction, health, or behavior of species.[24] Some contaminants may affect a narrow range of organisms while others, like petroleum products, can impact a broader range of organisms.[25]

Free phase liquid hydrocarbons have been observed in monitoring wells at various locations within the Refinery property.[26] Nevertheless, the analysis provided in the Project's environmental documents was limited to the effects of a spill or accident, ignoring the fact that contaminants may leach into waterways even without a spill or accident. NRDC's comment letter (dated October 30, 2015) raised this issue. It stated:

> [the Revised Draft EIR] fails to assess the fact that PAHs [polycyclic aromatic hydrocarbons], heavy metals, and other pollutants may deposit or leach into these waterways even without a spill or accident. Instead, the Revised Draft EIR summarily asserts that, "[u]nder normal operating conditions," Project-related

---

[21] Francis CD, JR Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Frontiers in Ecology and the Environment 11:305-313.

[22] FEIR, Comment J3-24.

[23] Francis CD, JR Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Frontiers in Ecology and the Environment 11:305-313. *See also* Ware HE, CJW McClure, JD Carlisle, JR Barber. 2015. A phantom road experiment reveals traffic noise is an invisible source of habitat degradation. PNAS 112:12105-12109.

[24] U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol I, p. 43.

[25] *Ibid*.

[26] DEIR, p. 4.8-5.

> crude oil transportation would have "no impact" on water quality or hydrology issues, with no explanation for reaching this conclusion. The City should acknowledge that rail operations can pollute water even under normal operating conditions, and it should identify and evaluate the Project's contribution to the problem.[27]

The FEIR failed to respond to this issue, which is potentially significant. For example, the federal *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* indicates:

> Contamination of marsh sediments may impact clapper rails directly or indirectly. Potential direct effects include toxicity to adults, chicks, or embryos. Potential indirect effects include reduced prey quality, quantity, and availability, and altered vegetation structure/composition for nesting and sheltering.[28]
>
> To date, most direct contaminant impacts to the [clapper] rail have likely been due to lifetime exposures at chronic, sub-lethal concentrations that alter individual fitness. Known contaminants of concern for rail recovery in the San Francisco Bay Estuary include mercury, selenium, PCBs, and petroleum hydrocarbons. The potential toxicological effects of long term chronic contaminant exposures can include reproductive impairment, compromised immune function, reduced growth, deformity, and altered behavior.[29]

The Project's impacts on species from chronic exposure to contaminants remain significant and unmitigated.

<u>Exposure Due to an Accident or Spill</u>

An accident or spill at the Project site could expose wildlife to oil. Even relatively small exposures to oil can harm or kill birds and other wildlife.[30] Adverse effects to birds due to external exposure to petroleum hydrocarbons include loss of feather structure resulting in flightlessness, loss of water repellency of feathers resulting in hypothermia, chemical burns to the skin, and in extreme oilings, incapacitation.[31] The survival rate of oiled wildlife is low, even when considerable effort is devoted to cleaning and rehabilitating affected animals.[32]

Some dispersants,[33] when mixed with oil, can be quite toxic and even enhance the

---

[27] FEIR, Comment J3-19.

[28] U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol I, p. 114.

[29] *Ibid*, p. 121.

[30] *Ibid*, p. 44.

[31] *Ibid*, Vol II, p. 201.

[32] De La Cruz et al. 2013. Post-release survival of surf scoters following an oil spill: An experimental approach to evaluating rehabilitation success. Marine Pollution Bulletin 67:100-106.

[33] Dispersants are chemicals that disperse the oil into the water column, so that much less stays at the surface, where it could affect beaches and tideflats.

toxicity of oil if ingested.[34] In addition, trampling of oiled mudflats by cleanup crews pushes oil beneath the surface where benthic organisms reside. This results in reduced abundance of benthic prey for waterbirds, and an indirect hazard to waterbirds due to bioaccumulation of toxic chemicals in benthic prey.[35]

Further, any of the on-site accidents evaluated in the FEIR would result in significant mortality and substantially reduce the habitat of fish and wildlife species dependent on Sulfur Springs Creek. Sulphur Springs Creek is a federally protected waterway, and downstream coastal brackish marshes are federally protected wetlands. In the event of an accident at the loading rack, or anywhere along the pipeline, the impacts to the riparian corridor, in-stream marshes, and biota would be devastating due to their proximity.

The FEIR did not specifically consider impacts of on-site accidents to Sulphur Springs Creek and its riparian corridor, marshes, and biota (although it concluded in Impact 4.7-6 that generically, biological impacts would be significant and unmitigable). Sulphur Springs Creek is within the significant hazard zone of every accident scenario that was evaluated. However, the FEIR did not identify this as a significant impact, but rather discussed only up-rail oil spills.[36] The impact of spills and other accidents to aquatic and biological resources at Sulfur Springs Creek should have been specifically recognized, analyzed, and mitigated. Mitigation is feasible and is not preempted by federal law because the accidents would occur at property, tracks, and an unloading facility owned by Valero.

MITIGATION

Wildlife Movement

The RDEIR concluded Project construction and operation could deter wildlife use of Sulphur Springs Creek as a movement corridor. However, it ultimately concluded impacts to wildlife movement would be less than significant. As discussed above, the RDEIR did not provide any evidence or analysis to support that conclusion. As a result, the Applicant should be required to implement a mitigation and monitoring program that ensures impacts to wildlife movement in the Sulphur Springs Creek corridor are mitigated to a less than significant level. As it stands, the Project's impacts on wildlife movement remain significant and unmitigated.

---

[34] U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Vol II, p. 201.

[35] *Ibid,* pp. 121 and 202.

[36] RDEIR, Appendix F, Attachment 3.

Nesting Birds

Most nesting bird species are protected by the Migratory Bird Treaty Act, and in some cases the State and federal government. The FEIR requires pre-construction surveys for nesting birds within the Project area, and all accessible areas within 500 feet, if Project construction activities would occur during the avian nesting season.[37] The FEIR indicates the pre-construction surveys should be conducted *no sooner than* 30 days prior to the start of any Project activity.[38] This mitigation measure is insufficient to avoid and minimize potentially significant impacts to nesting birds.

First, some birds can build a nest and initiate egg-laying within 10 to 14 days.[39] Therefore, nesting bird surveys 30 or more days prior to construction activities would be insufficient to locate nests that could be affected by the Project.

Second, the FEIR does not establish minimum standards for the survey effort, including the need to adhere to scientific standards for nest site detection. Nest finding is labor intensive and can be extremely difficult due to the tendency of many species to construct well-concealed or camouflaged nests.[40] As a result, most studies that involve locating bird nests employ a variety of search techniques. These include flushing an adult from the nest, watching parental behavior (e.g., carrying nest material or food), systematically searching nesting substrates, and broadcasting of bird calls.[41] In addition, breeding birds are known to be most active and detectable early in the morning, and there is a strong positive correlation between survey effort and abundance of nests detected.

Several of the bird species that have the potential to nest within 500 feet of the Project site are extremely difficult to detect. For example, the California black rail is a secretive species that constructs its nest in dense wetland vegetation. Conway et al. (2004) concluded as many as 15 replicate surveys may be needed to attain >90% detection probability of black rails within potential wetland habitat.[42] As a result, the single pre-construction survey required by the FEIR would be insufficient to detect rail nests that could be affected by the Project. Consequently, any mitigation incorporated into the EIR needs to specify the techniques that should be applied to nest surveys, the expected level of effort (i.e., hours per unit area), the search area, the time of day surveys will be permitted, and the techniques that should be used

---

[37] FEIR, p. H-7.

[38] *Ibid.*

[39] Baicich PJ, CJ Harrison. 1997. A guide to the nests, eggs, and nestlings of North American Birds. 2nd ed. London: Academic Press.

[40] DeSante DF, GR Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986. Condor. 89:636-653.

[41] Martin TE, GR Geupel. 1993. Nest-Monitoring Plots: Methods for Locating Nests and Monitoring Success. J. Field Ornithol. 64(4):507-519. *See also* Conway CJ, C Sulzman, BE Raulston. 2004. Factors Affecting Detection Probability of California Black Rails. Journal of Wildlife Management 68(2):360-370.

[42] Conway CJ, C Sulzman, BE Raulston. 2004. Factors Affecting Detection Probability of California Black Rails. Journal of Wildlife Management 68(2):360-370.

to minimize human-induced disturbance. As it stands the Project's impacts on nesting birds remain significant and unmitigated.

Contaminants

The RDEIR asserts that "[t]rain derailments and unloading accidents that lead to hazardous materials spills, fires, and explosions could result in substantial adverse secondary effects, including to Biological Resources, Cultural Resources, Geology and Soils, and Hydrology and Water Quality." The RDEIR acknowledges "the implementation of an approved California Oil Spill Contingency Plan could reduce impacts to marshes or other sensitive habitats within the State to less than significant."[43] However, it argues that compliance with SB 861, the Oil Spill Contingency Plan, is infeasible because it is preempted by federal law.[44] As a result, the RDEIR concluded an accident or spill would result in "significant and unavoidable" impacts to sensitive biological resources.[45] However, the RDEIR's analysis was limited to "uprail" impacts, ignoring impacts that could be mitigated if a spill or accident occurs on Valero's property, which is not preempted by federal law.

Feasible mitigation measures that would reduce adverse effects on biological resources from a spill or accident on Valero property include:

- Requiring Valero to demonstrate compliance with provisions of SB 861 (Oil Spill Contingency Plan);
- Requiring Valero to have the trained personal and equipment (e.g., booms and sorbent materials) needed to limit oil movement if a spill or accident occurs;
- Requiring Valero to provide funding, personnel, and other resources to oil cleanup response agencies;
- Requiring Valero to fund wetland restoration or other ecosystem improvement projects that benefit or protect water quality; and
- Requiring Valero to provide a financial security that guarantees the restoration or replacement of habitat affected by a spill or accident.

As it stands, the Project's impacts on biological resources from a spill or accident at the Valero refinery remain significant and unmitigated.

Sincerely,

Scott Cashen, M.S.
Senior Biologist

---

[43] RDEIR, p. 2-113.

[44] *Ibid.*

[45] *Ibid*, pp. 2-108 through -113.

Scott Cashen, M.S.
Senior Biologist / Forest Ecologist
3264 Hudson Avenue, Walnut Creek, CA 94597. (925) 256-9185. scottcashen@gmail.com

Scott Cashen has 20 years of professional experience in natural resources management. During that time he has worked as a field biologist, forester, environmental consultant, and instructor of Wildlife Management. Mr. Cashen currently operates an independent consulting business that focuses on CEQA/NEPA compliance issues, endangered species, scientific field studies, and other topics that require a high level of scientific expertise.

Mr. Cashen has knowledge and experience with many taxa, biological resource issues, and environmental regulations. This knowledge and experience has made him a highly sought after biological resources expert. To date, he has been retained as a biological resources expert for over 40 projects. Mr. Cashen's role in this capacity has encompassed all stages of the environmental review process, from initial document review through litigation support and expert witness testimony.

Mr. Cashen is a recognized expert on the environmental impacts of renewable energy development. He has been involved in the environmental review process for 28 renewable energy projects, and he has been a biological resources expert for more of California's solar energy projects than any other private consultant. In 2010, Mr. Cashen testified on 5 of the Department of the Interior's "Top 6 Fast-tracked Solar Projects" and his testimony influenced the outcome of each of these projects.

Mr. Cashen is a versatile scientist capable of addressing numerous aspects of natural resource management simultaneously. Because of Mr. Cashen's expertise in both forestry and biology, Calfire had him prepare the biological resource assessments for all of its fuels treatment projects in Riverside and San Diego Counties following the 2003 Cedar Fire. Mr. Cashen has led field studies on several special-status species, including plants, fish, reptiles, amphibians, birds, and mammals. Mr. Cashen has been the technical editor of several resource management documents, and his strong scientific writing skills have enabled him to secure grant funding for several clients.

AREAS OF EXPERTISE

- CEQA, NEPA, and Endangered Species Act compliance issues
- Comprehensive biological resource assessments
- Endangered species management
- Renewable energy
- Forest fuels reduction and timber harvesting
- Scientific field studies, grant writing and technical editing

EDUCATION

M.S. Wildlife and Fisheries Science - The Pennsylvania State University (1998)
B.S. Resource Management - The University of California, Berkeley (1992)

PROFESSIONAL EXPERIENCE

Litigation Support / Expert Witness

As a biological resources expert, Mr. Cashen reviews CEQA/NEPA documents and provides his client(s) with an assessment of biological resource issues. He then prepares written comments on the scientific and legal adequacy of the project's environmental documents (e.g., EIR). For projects requiring California Energy Commission (CEC) approval, Mr. Cashen has submitted written testimony (opening and rebuttal) in conjunction with oral testimony before the CEC.

Mr. Cashen can lead field studies to generate evidence for legal testimony, and he can incorporate testimony from his deep network of species-specific experts. Mr. Cashen's clients have included law firms, non-profit organizations, and citizen groups.

REPRESENTATIVE EXPERIENCE

Solar Energy Facilities

- Abengoa Mojave Solar Project
- Avenal Energy Power Plant
- Beacon Solar Energy Project
- Blythe Solar Power Project
- Calico Solar Project
- Calipatria Solar Farm II
- Carrizo Energy Solar Farm
- Catalina Renewable Energy Project
- Fink Road Solar Farm
- Genesis Solar Energy Project
- Heber Solar Energy Facility
- Imperial Valley Solar Project
- Ivanpah Solar Electric Generating
- Maricopa Sun Solar Complex
- Mt. Signal and Calexico Solar
- San Joaquin Solar I & II
- Solar Gen II Projects
- SR Solis Oro Loma
- Vestal Solar Facilities
- Victorville 2 Power Project

Geothermal Energy Facilities

- East Brawley Geothermal
- Mammoth Pacific 1 Replacement
- Western GeoPower Plant and

Wind Energy Facilities

- Catalina Renewable Energy Project
- Ocotillo Express Wind Energy
- San Diego County Wind Ordinance
- Tres Vaqueros Repowering Project
- Vasco Winds Relicensing Project

Biomass Facilities

- Tracy Green Energy Project

Development Projects

- Alves Ranch
- Aviano
- Chula Vista Bayfront Master Plan
- Columbus Salame
- Concord Naval Weapons Station
- Faria Annexation
- Live Oak Master Plan
- Napa Pipe
- Roddy Ranch
- Rollingwood
- Sprint-Nextel Tower

Project Management

Mr. Cashen has managed several large-scale wildlife, forestry, and natural resource management projects. Many of these projects have required hiring and training field crews, coordinating with other professionals, and communicating with project stakeholders. Mr. Cashen's experience in study design, data collection, and scientific writing make him an effective project manager, and his background in several different natural resource disciplines enable him to address the many facets of contemporary land management in a cost-effective manner.

REPRESENTATIVE EXPERIENCE

Wildlife Studies

- Peninsular Bighorn Sheep Resource Use and Behavior Study: (*CA State Parks*)
- "KV" Spotted Owl and Northern Goshawk Inventory: (*USFS, Plumas NF*)
- Amphibian Inventory Project: (*USFS, Plumas NF*)
- San Mateo Creek Steelhead Restoration Project: (*Trout Unlimited and CA Coastal Conservancy, Orange County*)
- Delta Meadows State Park Special-status Species Inventory: (*CA State Parks, Locke*)

Natural Resources Management

- Mather Lake Resource Management Study and Plan – (*Sacramento County*)
- Placer County Vernal Pool Study – (*Placer County*)
- Weidemann Ranch Mitigation Project – (*Toll Brothers, Inc., San Ramon*)
- Ion Communities Biological Resource Assessments – (*Ion Communities, Riverside and San Bernardino Counties*)
- Del Rio Hills Biological Resource Assessment – (*The Wyro Company, Rio Vista*)

Forestry

- Forest Health Improvement Projects – (*CalFire, SD and Riverside Counties*)
- San Diego Bark Beetle Tree Removal Project – (*SDG&E, San Diego Co.*)
- San Diego Bark Beetle Tree Removal Project – (*San Diego County/NRCS*)
- Hillslope Monitoring Project – (*CalFire, throughout California*)

Biological Resources

Mr. Cashen has a diverse background with biological resources. He has conducted comprehensive biological resource assessments, habitat evaluations, species inventories, and scientific peer review. Mr. Cashen has led investigations on several special-status species, including ones focusing on the foothill yellow-legged frog, mountain yellow-legged frog, desert tortoise, steelhead, burrowing owl, California spotted owl, northern goshawk, willow flycatcher, Peninsular bighorn sheep, red panda, and forest carnivores.

REPRESENTATIVE EXPERIENCE

Avian

- Study design and Lead Investigator - Delta Meadows State Park Special-Status Species Inventory *(CA State Parks: Locke)*
- Study design and lead bird surveyor - Placer County Vernal Pool Study *(Placer County: throughout Placer County)*
- Surveyor - Willow flycatcher habitat mapping *(USFS: Plumas NF)*
- Independent surveyor - Tolay Creek, Cullinan Ranch, and Guadacanal Village restoration projects *(Ducks Unlimited/USGS: San Pablo Bay)*
- Study design and Lead Investigator - Bird use of restored wetlands research *(Pennsylvania Game Commission: throughout Pennsylvania)*
- Study design and surveyor - Baseline inventory of bird species at a 400-acre site in Napa County *(HCV Associates: Napa)*
- Surveyor - Baseline inventory of bird abundance following diesel spill *(LFR Levine-Fricke: Suisun Bay)*
- Study design and lead bird surveyor - Green Valley Creek Riparian Restoration Site *(City of Fairfield: Fairfield, CA)*
- Surveyor - Burrowing owl relocation and monitoring *(US Navy: Dixon, CA)*
- Surveyor - Pre-construction raptor and burrowing owl surveys *(various clients and locations)*
- Surveyor - Backcountry bird inventory *(National Park Service: Eagle, Alaska)*
- Lead surveyor - Tidal salt marsh bird surveys (*Point Reyes Bird Observatory: throughout Bay Area*)
- Surveyor – Pre-construction surveys for nesting birds (*various clients and locations)*

Amphibian

- Crew Leader - Red-legged frog, foothill yellow-legged frog, and mountain yellow-legged frog surveys *(USFS: Plumas NF)*

- Surveyor - Foothill yellow-legged frog surveys *(PG&E: North Fork Feather River)*
- Surveyor - Mountain yellow-legged frog surveys *(El Dorado Irrigation District: Desolation Wilderness)*
- Crew Leader - Bullfrog eradication *(Trout Unlimited: Cleveland NF)*

Fish and Aquatic Resources

- Surveyor - Hardhead minnow and other fish surveys *(USFS: Plumas NF)*
- Surveyor - Weber Creek aquatic habitat mapping (*El Dorado Irrigation District: Placerville, CA*)
- Surveyor - Green Valley Creek aquatic habitat mapping *(City of Fairfield: Fairfield, CA)*
- GPS Specialist - Salmonid spawning habitat mapping *(CDFG: Sacramento River)*
- Surveyor - Fish composition and abundance study (*PG&E: Upper North Fork Feather River and Lake Almanor*)
- Crew Leader - Surveys of steelhead abundance and habitat use *(CA Coastal Conservancy: Gualala River estuary)*
- Crew Leader - Exotic species identification and eradication *(Trout Unlimited: Cleveland NF)*

Mammals

- Principal Investigator – Peninsular bighorn sheep resource use and behavior study (*California State Parks: Freeman Properties*)
- Scientific Advisor –Study on red panda occupancy and abundance in eastern Nepal *(The Red Panda Network: CA and Nepal)*
- Surveyor - Forest carnivore surveys *(University of CA: Tahoe NF)*
- Surveyor - Relocation and monitoring of salt marsh harvest mice and other small mammals *(US Navy: Skagg's Island, CA)*
- Surveyor – Surveys for Monterey dusky-footed woodrat. Relocation of woodrat houses (*Touré Associates: Prunedale*)

Natural Resource Investigations / Multiple Species Studies

- Scientific Review Team Member – Member of the science review team assessing the effectiveness of the US Forest Service's implementation of the Herger-Feinstein Quincy Library Group Act.
- Lead Consultant - Baseline biological resource assessments and habitat mapping for CDF management units *(CDF: San Diego, San Bernardino, and Riverside Counties)*

- Biological Resources Expert – Peer review of CEQA/NEPA documents (*Adams Broadwell Joseph & Cardoza: California)*
- Lead Consultant - Pre- and post-harvest biological resource assessments of tree removal sites *(SDG&E: San Diego County)*
- Crew Leader - T&E species habitat evaluations for Biological Assessment in support of a steelhead restoration plan *(Trout Unlimited: Cleveland NF)*
- Lead Investigator - Resource Management Study and Plan for Mather Lake Regional Park *(County of Sacramento: Sacramento, CA)*
- Lead Investigator - Biological Resources Assessment for 1,070-acre Alfaro Ranch property *(Yuba County, CA)*
- Lead Investigator - Wildlife Strike Hazard Management Plan *(HCV Associates: Napa)*
- Lead Investigator - Del Rio Hills Biological Resource Assessment *(The Wyro Company: Rio Vista, CA)*
- Lead Investigator – Ion Communities project sites (*Ion Communities: Riverside and San Bernardino Counties*)
- Surveyor – Tahoe Pilot Project: Validation of California's Wildlife Habitat Relationships (CWHR) Model *(University of California: Tahoe NF)*

Forestry

Mr. Cashen has five years of experience working as a consulting forester on projects throughout California. Mr. Cashen has consulted with landowners and timber operators on forest management practices; and he has worked on a variety of forestry tasks including selective tree marking, forest inventory, harvest layout, erosion control, and supervision of logging operations. Mr. Cashen's experience with many different natural resources enable him to provide a holistic approach to forest management, rather than just management of timber resources.

REPRESENTATIVE EXPERIENCE

- Lead Consultant - CalFire fuels treatment projects *(SD and Riverside Counties)*
- Lead Consultant and supervisor of harvest activities – San Diego Gas and Electric Bark Beetle Tree Removal Project *(San Diego)*
- Crew Leader - Hillslope Monitoring Program *(CalFire: throughout California)*
- Consulting Forester – Forest inventories and timber harvest projects *(various clients throughout California)*

Grant Writing and Technical Editing

Mr. Cashen has prepared and submitted over 50 proposals and grant applications. Many of the projects listed herein were acquired through proposals he wrote. Mr. Cashen's clients and colleagues have recognized his strong scientific writing skills and ability to generate technically superior proposal packages. Consequently, he routinely prepares funding applications and conducts technical editing for various clients.

PERMITS

U.S. Fish and Wildlife Service Section 10(a)(1)(A) Recovery Permit for the Peninsular bighorn sheep

CA Department of Fish and Game Scientific Collecting Permit

PROFESSIONAL ORGANIZATIONS / ASSOCIATIONS

The Wildlife Society (Conservation Affairs Committee member)

Cal Alumni Foresters

Mt. Diablo Audubon Society

OTHER AFFILIATIONS

Scientific Advisor and Grant Writer – *The Red Panda Network*

Scientific Advisor – *Mt. Diablo Audubon Society*

Grant Writer – *American Conservation Experience*

Scientific Advisor and Land Committee Member – *Save Mt. Diablo*

TEACHING EXPERIENCE

Instructor: Wildlife Management - The Pennsylvania State University, 1998

Teaching Assistant: Ornithology - The Pennsylvania State University, 1996-1997

U.S. Fish & Wildlife Service

Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

California clapper rail (Rallus longirostris obsoletus)

Suaeda californica (California sea-blite)

Cirsium hydrophilum var. hydrophilum (Suisun thistle)

Chloropyron molle ssp. molle (soft bird's-beak)

Salt marsh harvest mouse (Reithrodontomys raviventris)

Volume I

Tidal marsh at China Camp State Park.

Each recovery unit described below is necessary because each (1) protects one or more populations of the covered species found in it, (2) contributes to protection of populations throughout the geographic ranges of the covered species found in it, and (3) protects geographically distinct populations and thereby the natural range of morphological, physiological, environmental and/or genetic variation.

SUISUN BAY AREA RECOVERY UNIT

The Suisun Bay Area Recovery Unit (**Figure III-2**) includes suitable or restorable tideland habitats in the Suisun Bay area from Carquinez Strait to the edge of the Delta (legal Delta boundary), representing the eastern extent of the range of the covered species. It is separated from the San Pablo Bay recovery unit by gaps in habitat in the Carquinez Strait and intervening hills. Limited populations of *Cirsium hydrophilum* ssp. *hydrophilum* and *Chloropyron molle ssp. molle* and moderate numbers of salt marsh harvest mouse exist within the Suisun Bay Area Recovery Unit. Populations of California clapper rail in this recovery unit are sparser and more tenuous than in other recovery units, but are expected to strengthen with habitat restoration. Impacts of rising sea level are expected to result in increased salinity and will benefit clapper rails in Suisun, however, loss of high marsh refugia will outweigh the benefits of increased low marsh foraging habitat. In addition to being necessary for the reasons described above, this unit is necessary because it provides a suitable pathway for the species' habitat to shift up the estuary as anticipated climate change and sea level rise produce increasing salinities toward the east.

SAN PABLO BAY RECOVERY UNIT

The San Pablo Bay recovery unit (**Figure III-3**) encompasses San Pablo Bay populations and is separated from adjacent recovery units by gaps in populations and habitat for most covered species. The unit includes tideland habitats from Point San Pablo on the Contra Costa coast and Point San Pedro, Marin County, to the Carquinez Strait at the Carquinez (I-80) Bridge. Population dynamics of covered species in this unit are likely decoupled from adjacent units because of low dispersal relative to local recruitment. Limited populations of *Chloropyron molle ssp. molle*, California clapper rail, and salt marsh harvest mouse exist within the San Pablo Bay recovery unit. This recovery unit is less altered by development at higher elevations than the Central/South San Francisco Bay recovery unit and in many places has high sediment concentrations, so accommodation of rising sea level can be more readily achieved here. Accompanying increased salinity may enhance habitat conditions for the covered species. Although the Carquinez Strait presents a natural barrier to habitat connectivity between the San Pablo Bay and Suisun Bay Area Recovery Units, there may exist some degree of habitat and population connectivity between the San Pablo Bay and Central/South San Francisco Bay recovery units.

CENTRAL/SOUTH SAN FRANCISCO BAY RECOVERY UNIT

The Central/South San Francisco Bay recovery unit (**Figure III-4**) encompasses suitable or restorable tidelands from Point San Pablo on the Contra Costa coast and Point San Pedro, Marin County, to the extreme southern extent of the Bay. Limited populations of *Suaeda californica* and salt marsh harvest mouse exist within the Central/South San Francisco Bay recovery unit.

© 2008 by the Society for the Study of Amphibians and Reptiles
Urban Herpetology. Joseph C. Mitchell and Robin E. Jung Brown, editors
Herpetological Conservation 3:xx-xx.

CHAPTER 16

Effects of Artificial Night Lighting on Amphibians and Reptiles in Urban Environments

Gad Perry[1], Bryant W. Buchanan[2], Robert N. Fisher[3], Mike Salmon[4], and Sharon E. Wise[2]

Abstract — Amphibians and reptiles have evolved with natural lighting cycles. Consequently, alteration of natural variation in diurnal and nocturnal light intensities and spectral properties has the potential to disrupt their physiology, behavior, and ecology. We review the possible effects of night lighting on many species of amphibians and reptiles, noting that few studies of the consequences of artificial lights to amphibians and reptiles have been conducted to date. The one exception is the information available on the negative impacts of artificial lights on hatchling sea turtles, which has received considerable coverage in both scientific and popular media. In many studies that might be relevant, researchers have not recorded the illumination or irradiance at which experiments were conducted. We identify light pollution as a serious threat that should be considered as part of planning and management decisions in the maintenance or conservation of urban areas containing amphibians and reptiles. However, we consider it too early to precisely gauge the effects of artificial night lighting on other taxa found in light-polluted environments or provide specific management recommendations, beyond pointing out the urgent need for more information.

Key words — Activity Pattern, Amphibians, Behavior, Conservation, Ecology, Invasive Species, Light Pollution, Night Lighting, Photopollution, Physiology, Reptiles, Suburban, Urban

Conservation biologists have long been concerned about anthropogenic effects on species and environments. There is good reason for herpetologists to share this concern: both amphibians and reptiles are declining worldwide (e.g., Alford and Richards 1999; Gibbons et al. 2000). Much work has focused on habitat loss and the consequences of water and air pollution, particularly on amphibians. Other anthropogenic impacts, such as light pollution, remain poorly studied and are of concern for urban herpetofauna (defined here as those species that are present within or adjacent to urbanized areas). Light pollution is a by-product of anthropogenic outdoor illumination from sources such as street lighting, sports arenas, and porch lights (e.g., Dawson 1984). When discussed in the context of adverse effects on wildlife, light pollution is also known as photopollution (Verheijen 1985). Its effects on herpetofauna are the focus of this chapter.

Five decades ago, Verheijen (1958) documented illumination patterns produced by lighting devices in urban habitats. The abnormal lighting patterns from these artificial sources resulted in locally elevated contrast in brightness between lighted and background areas which attracted invertebrates, a phenomenon known as "light trapping" (Robinson and Robinson 1950). Artificial lighting has become much more pervasive since 1958, affecting most of the world's urban areas and adjacent habitats (Cinzano et al. 2001; Longcore and Rich 2004). Street and security lights can be more than one million times brighter than natural ambient illumination (S. Wise and B. Buchanan unpubl. data). Additionally, skyglow, caused by

[1]*Department of Natural Resources Management, Box 42125, Texas Tech University, Lubbock, TX 79409, USA*
[2]*Department of Biology, Utica College, 1600 Burrstone Rd., Utica, NY 13502, USA*
[3]*U.S. Geological Survey, Biological Resources Discipline, San Diego Field Station, 4165 Spruance Road, Suite 200, San Diego, CA 92101, USA*
[4]*Department of Biological Sciences, Florida Atlantic University, PO Box 1096, 777 Glades Rd., Boca Raton, FL 33431, USA*

reflection of artificial night lights from clouds, may increase nocturnal ambient illumination indirectly in less urban areas near cities (Cinzano et al. 2001). Sources of light pollution are often referred to as "night lighting," and the relatively new habitat created by the presence of artificial lights has sometimes been termed the "night-light niche" (Garber 1978).

With the exception of negative consequences for sea turtles, data on the effects of night lighting on amphibians and reptiles are uncommon. A recent book (Rich and Longcore 2006) focuses on many ecological aspects of light pollution. To avoid duplication, this review provides an updated synthesis of information we presented separately there (Buchanan 2006; Perry and Fisher 2006; Salmon 2006; Wise and Buchanan 2006). We focus on what little is known about the relationship between artificial lighting and urban herpetofauna and suggest areas that require further work. Special attention is paid to taxa that appear to be at greatest risk of being effected: species that are edificarian, feed at lights (or are simply positively phototactic), inhabit permanent and ephemeral ponds (parks, ditches), or are found in greenbelts or habitat reserves in or near city limits that are affected by skyglow or glare. Roads that connect urban areas, many of them illuminated by fixed lights in addition to vehicle headlights, may also have effects on species occurring nearby (Outen 2002; Spellerberg 2002), although few papers address this problem (e.g., Baker 1990; Mazerolle et al. 2005). In this chapter, we document the apparently positive (i.e., population-increasing) consequences of night lighting on some species and discuss effects that are clearly or possibly negative for others.

Taxonomic Preface

Information presented in the body of this chapter is arranged by habitat. However, some taxon-specific information pertains across habitats and is presented here. We use standard English names for large, well-recognized clades, but prefer scientific names when discussing specific species.

Salamanders — Salamanders are often nocturnal or crepuscular, with activity patterns regulated by photoperiod (reviewed in Wise and Buchanan 2006). Many species that have been studied are negatively phototropic or phototactic, although some species may show ontogenetic shifts in behavior, exhibiting positive phototaxis as larvae and negative phototaxis as adults (reviewed in Wise and Buchanan 2006). Artificial night lighting may affect physiology and behavior by (1) increasing ambient illumination, (2) lengthening photoperiod, and (3) varying the spectral properties of ambient light. Most studies of the effect of artificial light on salamanders have been conducted in the laboratory and focus on hormone levels or thermoregulation. These laboratory results, the basis for much of the information below, are important for generating field-testable hypotheses that may explain how artificial night lighting affects salamander populations in natural habitats.

Frogs — Frogs may be exposed to extreme changes in natural lighting patterns in urban environments. Few data exist that demonstrate direct effects of lighting on frogs, but many indirect effects are likely (Buchanan 2006). Adults of most taxa conduct the majority of their foraging and reproductive activities under twilight or nocturnal conditions. Eggs and larvae typically develop in aquatic environments, where they may be exposed to artificial illumination. Unfortunately, very few experimental data exist on the effects of artificial illumination on frogs in natural environments. Consequently, most of the data presented in this chapter have been extracted from papers dealing with the general effects of light on the physiology or behavior of frogs.

Caecilians — As with most subterranean taxa, relatively little is known about the biology of caecilians (Gower and Wilkinson 2005). Although many caecilians are of conservation concern, night lighting seems unlikely to be a significant cause of population decline, because these animals spend so little time above-ground and possess such poor eyesight. We have found no information to suggest otherwise and therefore do not discuss caecilians in the sections that follow.

Tuataras — The remaining range of this taxon is limited, and does not overlap major population centers. Thus, night lighting is an unlikely to affect populations. The current recovery plan (Gaze 2001) does not refer to lights as a source of concern, and as we have found no information to suggest otherwise, do not discuss tuataras in the sections that follow.

Crocodilians — Relatively few crocodilians occur in abundance in urban areas. When they do, as in parts of Florida, USA, and Darwin, Australia (Nichols and Lentic 2008), they are often considered a source of concern in terms of human safety, rather than a target for conservation efforts. Perhaps because of this bias, we have been unable to locate evidence of possible effects of night lighting on these organisms. Thus, no information on crocodilians is presented in this chapter. Given that most crocodilian species are under some degree of threat and that urban sprawl is likely to bring more of them into contact with humans and night lighting, we feel that studies to explore these effects are urgently needed.

Turtles — Marine turtles are diving specialists (Lutcavage and Lutz 1999) whose vision is adapted to finding food, locating mates, and avoiding predators underwater. Seawater differentially absorbs both the shorter (UV, violet) and longer (yellow to red) light wavelengths, while best transmitting wavelengths between 450–500 nm (blue-green to green). Some turtles have spectral sensitivities that are "tuned" (most sensitive) to the latter; sensitivity declines rapidly as wavelength increases (Witherington 1992a; Lohmann et al. 1997; J. Gocke, M. Salmon, and K. Horch unpubl. data). Negative influences of light pollution on sea turtles, especially those of artificial lights near beaches on the seaward locomotion of hatchlings,

have been well-studied (reviewed in Witherington and Martin 1996), and have led to the only attempts we are aware of to reduce such negative influences. However, the attention given to sea turtles has not resulted in investigations of other turtles. We suggest that field research on non-marine turtles is another area that needs to be addressed.

Lizards — Lizards are often terrestrial and can be either diurnal or nocturnal. More anecdotal information about the effects of night lighting on lizards is available than for any other group (Perry and Fisher 2006). Although this effort has identified some intriguing preliminary patterns (e.g., positive effects for invading species, discussed below), the lack of experimental or systematic observational data is a source of concern.

Snakes — Snakes can be either diurnal or nocturnal, and some species show an ontogenetic switch (Clarke et al. 1996). No studies directly link artificial light to positive or negative effects on snake populations. However, declines have been noted in snake populations in many populated regions, making such work very timely. Perry and Fisher (2006) discussed possible positive predator-prey interactions between snakes and their prey, such as geckos, that are attracted to artificial lights. They also reviewed the probable negative predator-prey interactions associated with prey, such as the apparent decline of heteromyid rodents due to artificial lights, and increased exposure to snake predators. Snakes generally elicit a negative response in the general public, placing them at a special disadvantage in urban areas.

Effects of light in urban habitats

Although irradiance (defined as the density of radiant flux on a surface and typically measured over 180 degrees in units of W/cm^2) is the more appropriate measure of light intensity to use when describing light levels, we often refer to illumination (lux, $lumen/m^2$), because it is more commonly reported in the literature, making for easier comparisons.

Urban Cores — In this section, we focus on species found within or near human dwellings (i.e., edificarian species). Taxa common in urban cores are often familiar to many; some of them have had a long history of co-residence with humans. Although the number of species capable of surviving close to humans is low, edificarian species can reach high densities in their adopted habitat. Responses of edificarian amphibians and reptiles to artificial lights are well documented (Tables 1, 2), but ecological consequences remain much less obvious.

Salamanders — Few salamanders are found in urban cores. However, Garden Slender Salamanders (*Batrachoseps major*), California Slender Salamanders (*B. attenuatus*), and Arboreal Salamanders (*Aneides lugubris*) often occur around houses or along rock walls in California, USA (Cunningham 1960; Petranka 1998). We have not been able to find any information on effects that night lighting might have on such species.

Frogs — Some species of frogs commonly associate with edificarian habitats, including several species that feed on insects at lights (Table 2). Such species are typically only active at night, normally foraging under low ambient illumination (Woolbright 1985; Buchanan 1992). Some nocturnal frogs, such as the widely introduced Cane Toads (*Bufo marinus*), regularly forage under enhanced illumination near buildings (Table 2). Many nocturnal frogs show positive phototaxis (Jaeger and Hailman 1973), and laboratory studies have demonstrated that enhanced lighting can facilitate foraging in edificarian species (Larsen and Pedersen 1982; Buchanan 1998). However, it is unclear whether frogs are attracted to the increased abundance of insects available at lights, the light itself, or a combination of the two. How much light or what illumination differential is necessary to elicit this effect also remains unknown.

Although additional foraging opportunities can be beneficial, frogs aggregating at lights may also experience increased mortality. For example, Baker (1990) suggested that frogs feeding under streetlights are particularly susceptible to being killed by automobiles. In addition, radical and rapid changes in illumination can reduce visual sensitivity and require hours for complete light adaptation (Cornell and Hailman 1984). The frog eye tends to adapt to the brightest available source of light (Fain et al. 2001). Once they are light-adapted, frogs moving through areas with different ambient illuminations may suffer reduced visual capabilities, particularly when moving into shadows cast by artificial lights (Cornell and Hailman 1984; Buchanan 1993; Fain et al. 2001).

Table 1. Non-nocturnal amphibians and reptiles reported to use the night-light niche.

Species	Location	Source
Lizards		
Geckos (Gekkonidae)		
Gonatodes humeralis	Peru	Dixon and Soini 1975
Gonatodes vittatus	Trinidad	Quesnel et al. 2002
Lygodactylus capensis	South Africa	V. Egan unpublished
Phelsuma laticauda	Hawaii	Perry and Fisher 2006
Phelsuma madagascariensis	Madagascar	García and Vences 2002

Table 1. Continued

Species	Location	Source
Sphaerodactylus cinereus	Florida, USA	J. Lazell unpublished
	Haiti	J. Lazell unpublished
Sphaerodactylus elegans	Florida, USA	Meshaka et al. 2004
Sphaerodactylus difficilis	Hispaniola	R. Powell unpublished
Sphaerodactylus macrolepis	Guana Island, BVI	Perry and Lazell 2000
Sphaerodactylus sputator	Anguilla	Howard et al. 2001
Anoles (Iguanidae)		
Anolis aeneus	Grenada	R. Powell unpublished
Anolis bimaculatus	St. Eustatius	R. Powell unpublished
Anolis brevirostris	Hispaniola	Bowersox et al. 1994
Anolis carolinensis	Hawaii	Perry and Fisher 2006
	Mississippi, USA	J. Lazell unpublished
	Texas, USA	McCoid and Hensley 1993
Anolis cristatellus	Dominican Republic	Schwartz and Henderson 1991
	Guana Island, BVI	Perry and Lazell 2000
	Puerto Rico	Garber 1978
Anolis cybotes	Hispaniola	Henderson and Powell 2001
Anolis distichus	Hispaniola	R. Powell unpublished
Anolis gingivinus	St. Maarten	Powell and Henderson 1992
	Anguilla	Hodge et al. 2003
Anolis leachii	Antigua	Schwartz and Henderson 1991
Anolis lineatopus	Jamaica	Rand, 1967
Anolis luteogularis	Cuba	J. Losos, unpublished
Anolis marmoratus	Guadeloupe	Powell and Henderson 1992
Anolis richardii	St. George's, Grenada	Perry and Fisher 2006
Anolis sabanus	Saba	Powell and Henderson 1992
Anolis sagrei	Bahamas	Schwartz and Henderson 1991
	Florida, USA	Meshaka et al. 2004
Anolis schwartzi	St. Eustatius	Powell et al. 2005
Anolis trinitatus	St. Vincent	R. Powell unpublished
	Young Island	R. Powell unpublished
Other iguanids (Iguanidae)		
Agama agama	Cameroon	Böhme 2005
	Gabon	Pauwels et al. 2004
Basiliscus basiliscus	Costa Rica	A. Vega unpublished
Leiocpehalus carinatus	Florida, USA	Meshaka, in preparation
Tropidurus plica (= Plica plica)	Trinidad	Werner and Werner 2001
Skinks (Scincidae)		
Cryptoblepharus poecilopleurus	Cocos Island, Guam	McCoid and Hensley 1993
Lamprolepis smaragdina	Pohnpei	Perry and Buden 1999
Snakes		
Racers (Colubridae)		
Alsophis portoricensis	Guana Island, BVI	Perry and Lazell 2000

Table 2. Nocturnal amphibians and reptiles reported to use the night-light niche.

Species	Location	Source
Frogs		
Toads (Bufonidae)		
Bufo americanus	Oklahoma, USA	J. Lazell unpublished
Bufo bufo	England	Baker 1990
Bufo cognanus	Texas, USA	S. Rideout unpublished
Bufo gutturalis	South Africa	V. Egan unpublished
Bufo maculatus	Cameroon	Böhme 2005
Bufo marinus	Costa Rica	A. Vega unpublished
	Florida, USA	Meshaka et al. 2004
	Guadeloupe	Henderson and Powell 2001
	Hawaii, Fiji, American Samoa	R. Fisher unpublished
Bufo melanostictus	China	Lazell 2002
Bufo terrestris	Florida, USA	W. Meshaka unpublished
Bufo woodhousii	Oklahoma, USA	J. Lazell unpublished
Bufo viridis	Europe	Balassina 1984
Schismaderma carens	Tanzania	V. Egan unpublished
Rain frogs (Leptodactylidae)		
Eleutherodactylus coqui	Puerto Rico	Henderson and Powell 2001
Eleutherodactylus johnstonei	Saba, Netherlands Antilles	Perry 2006
Treefrogs (Hylidae)		
Hyla cinerea	Florida, USA	Goin 1958
	Mississippi and Louisiana, USA	B. Buchanan unpublished
Hyla femoralis	Florida, USA	W. Meshaka unpublished
Hyla gratiosa	Florida, USA	W. Meshaka unpublished
Hyla squirella	Florida, USA	Goin and Goin 1957
	Mississippi and Louisiana, USA	B. Buchanan unpublished
Osteopilus septentrionalis	Anguilla	Henderson and Powell 2001
	Guana, British Virgin Islands	G. Perry, in MS
	Florida, USA	Carr 1940
Scinax eleochroa	Costa Rica	A. Vega unpublished
Old World treefrogs (Rhacophoridae)		
Chiromantis xerampelina	South Africa	V. Egan unpublished
Lizards		
Geckos (Gekkonidae)		
Afrogecko porphyreus	South Africa	E. Baard unpublished
Bunopus tuberculatus	United Arab Emirates	Perry and Fisher 2006
Cosymbotus platyurus	Southeast Asia	Case et al. 1994
Cyrtopodion scabrum	Jordan	Disi et al. 2001
Gekko chinensis	China	J. Lazell unpublished
Gekko gecko	China	J. Lazell unpublished
	Florida, USA	W. Meshaka unpublished
	Thailand	R. Fisher unpublished

Table 2. Continued

Species	Location	Source
Gekko subpalmatus	China	J. Lazell unpublished
	Philippines	J. Lazell unpublished
	Indonesia	J. Lazell unpublished
Gehyra mutilata	China	J. Lazell unpublished
	Hawaii	J. Lazell unpublished
	Sapwuahfik Atoll	Buden 2000
Gehyra oceanica	Sapwuahfik Atoll	Buden 2000
	Pacific Region	R. Fisher unpublished
Hemidactylus brookii	China	J. Lazell unpublished
Hemidactylus bowringi	China	J. Lazell unpublished
Hemidactylus flaviviridis	Egypt	Ibrahim and Ghobashy 2004
	United Arab Emirates	Perry and Fisher 2006
Hemidactylus frenatus	Australia	Cogger 1979:179
	Costa Rica	Savage 2002:484-485
	Florida, USA	W. Meshaka unpublished
	Guam	G. Perry unpublished
	Hawaii	Case et al. 1994
Hemidactylus garnotii	Costa Rica	Savage 2002:484-485
	China	J. Lazell unpublished
	Pacific Region	R. Fisher unpublished
	Florida, USA	Meshaka 2000
Hemidactylus haitianus (recently renamed *H. angulatus*)	Dominican Republic	Bowersox et al. 1994
Hemidactylus mabouia	Anguilla	Howard et al. 2001
	Brazil	Perry and Fisher 2006
	Cameroon	Böhme 2005
	Gabon	Pauwels et al. 2004
	Dutch Antilles	Powell and Henderson 1992
	Florida, USA	Meshaka 2000
	Guana Island, BVI	G. Perry unpublished
	Puerto Rico	R. Powell unpublished
	South Africa	V. Egan unpublished
	Venezuela	Fuenmayor et al. 2005
Hemidactylus persicus	United Arab Emirates	Perry and Fisher 2006
Hemidactylus turcicus	Israel	Werner 1966
	Egypt	A. Ibrahim unpublished
	Jordan	Disi et al. 2001
	United Arab Emirates	Perry and Fisher 2006
	USA: Alabama, Florida, and Mississippi	Nelson and Carey 1993
	Texas, USA	G. Perry unpublished
Hemiphyllodactylus typus	Pacific Region	R. Fisher unpublished
Homopholis wahlbergi	South Africa	V. Egan unpublished

Table 2. Continued

Species	Location	Source
Lepidodactylus lugubris	Costa Rica	Savage 2002:486
	Guam	G. Perry unpublished
	Hawaii	Case et al. 1994
	Sapwuahfik Atoll	Buden 2000
Nactus pelagicus	South Pacific	Perry and Fisher 2006
Pachydactylus bibronii	Namibia	Perry and Fisher 2006
	South Africa	E. Baard unpublished
Pachydactylus turneri	Namibia	Perry and Fisher 2006
	South Africa	V. Egan unpublished
Ptyodactylus guttatus	Israel	Werner 1965
Ptyodactylus hasselquistii	Israel	Y.L. Werner unpublished
	United Arab Emirates	Perry and Fisher 2006
Ptyodactylus puiseuxi	Israel	Y.L. Werner unpublished
Tarentola annularis	Egypt	Ibrahim 2004
Tarentola mauritanica	Egypt	A. Ibrahim unpublished
	Libya	Ibrahim and Ineich 2005
Thecadactylus rapicauda	Anguilla	R. Powell unpublished
	Dominica	J. Lazell unpublished
	Necker, BVI	J. Lazell unpublished
	Trinidad	Kaiser and Diaz 2001
Snakes		
Racers (Colubridae)		
Lamprophis fuliginosus	Namibia	Cunningham 2002
Boiga irregularis	Guam	Perry and Fisher 2006
	Papua New Guinea	Perry and Fisher 2006
	Solomon Islands	Perry and Fisher 2006

Turtles — Some terrestrial turtles, such as Box Turtles (genus *Terrapene*) are known to inhabit urban cores (Dodd 2001). Most of these species are diurnal and could conceivably be affected if night lighting extends their activity period or disturbs their nocturnal rest. Whether such an effect actually occurs remains unknown.

Lizards — Night lighting can benefit some urban lizards. Species that are not normally active after dark, especially anolis lizards members of the genus *Anolis*, have been observed foraging or being active near artificial lighting at night (Table 1), taking advantage of the "night-light niche" (Garber 1978). Normally nocturnal species, especially members of the family Gekkonidae, have also been documented around night lights (Table 2). At least some of these taxa are also known to occasionally be active during the day (McCoid and Hensley 1993; Teynié et al. 2004). Presumably, the attraction of invertebrates to artificial lights attracts lizards because of the greater quantity of food and the increased predictability of finding prey. Intriguingly, the work of Werner (1990) suggests that artificial lights can also provide basking sites, and thus a second important resource, for lizards (and possibly other amphibians and reptiles). Observations from Egypt (Ibrahim 2004; Ibrahim and Ghobashy 2004) suggest this may be a broad pattern, especially in winter, but additional studies are desirable.

Negative effects of lights on non-introduced urban lizards have not been documented, but some species are more likely to take advantage of the presence of lights, and asymmetric competition can cause locally negative effects for other taxa. The best-documented example is the interaction between two introduced geckos, the Common House Gecko *Hemidactylus frenatus* and the Mourning Gecko *Lepidodactylus lugubris*, in the Pacific. Although *H. frenatus* has negatively affected populations of *L. lugubris* and the Oceanic Gecko *Gehyra oceanica* in some lighted locations (Case et al. 1994), the two species appear to coexist in native and less-disturbed habitats (Case et al. 1994) and on other lighted structures (Perry and Fisher 2006).

Taxa that would not normally interact might nonetheless meet where artificial lights are available. Perry and Fisher (2006) reported a more extreme example from Hawaii.

Hemidactylus frenatus (nocturnal), the Gold Dust Day Gecko *Phelsuma laticauda* (a diurnal gecko), and the green anole *A. carolinesis* (also diurnal) sometimes forage together at the same light source, and may compete for food resources. Ironically, all three are not native to Hawaii, and their ranges do not naturally overlap anywhere. Observations conducted in 2007 indicate that *P. laticauda* was successful in competing for these habitats, at least in the area around Kona, Hawai'i, where it now dominates both the diurnal and nocturnal lizard communities (R. Fisher, unpub.). In a different example, Perry and Lazell (2000) reported that *Anolis cristatellus* forages at artificial lights in the British Virgin Islands. Its predator, the snake *Alsophis portoricensis* (Puerto-Rican Racer), was also observed at the same lights. These species would normally interact during the day, but such additional interactions are of interest for two reasons. First, if common enough, added interactions can exacerbate normal predation effects. Second, and more importantly, this example shows that night lighting can affect more than a single species at a time, perhaps allowing species to interact that would otherwise not do so and possibly creating novel food webs. More severe or pervasive consequences might occur when night lighting exposes native species to competition with or predation by native or introduced species with which they would not normally interact.

Snakes — The effects of night lighting are difficult to separate from other problems that snakes face in urban environments, such as persecution. Only two published reports have been found of nocturnal snakes foraging under lights (Table 2). Other nocturnal species, such as the Brahminy Blind Snake *Ramphotyphlops braminus*, are found near houses in tropical areas and in cities where they have become established, but what effect lights have on their populations is not known.

Urban Water Bodies and Greenbelts

Many cities and towns have areas of natural or semi-natural aquatic or terrestrial habitats, such as city parks and water runoff storage areas, within or just outside their limits. These are typically managed for aesthetics, recreation, and/or flood control. They may be connected to each other by corridors or isolated, and the intensity of management can range from heavy (e.g., channeled streams) to very low. In these areas, skyglow may chronically increase ambient illuminations to levels substantially greater than normal nocturnal light levels (Buchanan 2006; Cinzano et al. 2001). As a result, artificial illumination around urban ponds can be brighter than even the brightest natural nocturnal light levels. For example, nocturnal light intensity around Utica Marsh in Utica, New York was measured at 0.1–1 lux (S. Wise and B. Buchanan unpubl. data), equivalent to illuminations at dawn or dusk. High-density urban cores are typically surrounded by less developed areas (e.g., agriculture, waterways, and greenbelts). In such areas, human density gradually decreases with distance from the core and species absent from the city core are often present here. Despite greater diversity, however, these areas remain influenced by the urban matrix in which they are embedded and the resulting light pollution.

Salamanders — Salamanders, such those of the genera *Ambystoma* (Mole Salamanders) and *Notophthalmus* (Eastern Newts), are commonly found in ponds and surrounding terrestrial habitats within or near urban areas. Completely terrestrial taxa, such as those of the genus *Plethodon* (Woodland Salamanders), may be found in large wooded city parks and greenbelts. Where ponds are located near roadways, salamanders can be subject to very high probabilities of automobile impacts when crossing roads during nocturnal activity (Fahrig et al., 1995; Hels and Buchwald 2001; Mazerolle 2004). Most spotted salamanders (*Ambystoma maculatum*) and blue-spotted salamanders (*Ambysotoma laterale*) respond to disturbance and lights from approaching automobiles by halting their movements, perhaps further increasing the probability of automobile-induced mortality by increasing the time that salamanders spend on the roadway (Mazerolle et al. 2005).

The physiology and behavior of salamanders are influenced by a variety of biotic and abiotic factors, including ambient light. Introduction of artificial light during normally dark periods can disrupt the production of melatonin, a hormone responsible for many aspects of photoperiodic behavior and physiology (Vanecek 1998). Common Mudpuppy (*Necturus maculosus*) aquatic adults kept on a 12L:12D photoperiod exhibited higher plasma melatonin levels during the dark phase than during the light phase (Rawding and Hutchison 1992). When the photoperiod was reversed, melatonin production was also reversed. Aquatic adults of the Eastern Tiger Salamander *Ambystome tigrinum* also had significantly higher plasma levels of melatonin during scotophase (the dark period of a day-night cycle) than during photophase (the light period of a day-night cycle) (Gern and Norris 1979). Gern et al. (1983) found that *A. tigrinum* kept under constant light (a condition that can occur under bright point sources of artificial night lighting) did not show significant differences in plasma levels of melatonin during photophase and scotophase as they would under natural lighting conditions. Although not tested statistically, levels of melatonin during scotophase were similar to levels during photophase for salamanders kept on a regular 12L:12D photoperiod.

Melatonin has multiple effects in amphibians, including reducing tolerance to high temperatures and lowering body temperature (Erskine and Hutchison 1982; Hutchison et al. 1979). One prediction, therefore, is that decreased nocturnal plasma melatonin levels will cause higher metabolic rates. Whitford and Hutchison (1965) compared physiological functions of terrestrial adults of Spotted Salamander (*A. maculatum*) kept on a 16L:8D photoperiod to those kept on an 8L:16D photoperiod. As predicted, animals kept on a 16L:8D photoperiod had significantly higher pulmonary, cutaneous, and total rates of O_2 consumption and higher cutaneous and total rates of CO_2 production (Whitford and Hutchison

1965). Wise and Buchanan (2006) therefore hypothesized that artificially increasing the length of photophase through night lighting may disrupt normal cyclical changes in metabolic rates, changing the energy demands of salamanders. This effect could become problematic during periods of low food availability or when energetic demands are especially high, such as during egg production or periods of drought.

The diel pattern of vertical migration exhibited by larval salamanders (genus *Ambystoma*: *A. jeffersonianum* (Jefferson Salamander), *A. opacum, A. talpoideum* (Mole Salamander), and *A. tigrinum*) is influenced by ambient light, temperature, competition, and predation risk (Anderson and Graham 1967; Stangel and Semlitsch 1987). Anderson and Graham (1967) observed that *A. opacum* exhibited more activity on overcast days and less vertical migration on bright nights. Interruption of vertical migration may reduce size at metamorphosis or survival (Semlitsch 1987).

Changes in light intensity during scotophase as a result of artificial night lighting can also affect other behaviors, such as foraging. Buchanan (unpubl. data) tested adult Red-backed Salamanders (*Plethodon cinereus*) in the laboratory, in the absence of olfactory cues but under a range of illuminations (complete darkness, 10^{-5}, 10^{-4}, or 10^{-3} lux). Salamanders oriented toward prey sooner at higher ambient illuminations, indicating improved visually-based foraging ability with higher light levels. Although increased ambient light may allow salamanders to see prey better, it can also delay the nocturnal foraging activity of *P. cinereus*, which typically emerge from the leaf litter approximately 1–2 h after dark (B. Buchanan and S. Wise unpubl. data; Fig. 1). We conducted forest censuses 1–2 h after sunset in six dark (no artificial illumination; 10^{-4} lux) and six lighted (with white holiday lights; 10^{-2} lux, equivalent to bright moonlight) transects. Fewer salamanders were active in the lighted transects than in the unlighted transects during the census. B. Buchanan and S. Wise (unpubl. data) hypothesized that delayed emergence may reduce the length of time salamanders are able to forage, especially on dry nights, when reduced humidity decreases the amount of time spent foraging (Keen 1984).

Agonistic behavior is also affected by nocturnal ambient illumination. Adults of *P. cinereus* are territorial, guarding cover objects that provide access to food, moisture, and potentially mates (Mathis et al. 1995). In the laboratory, B. Buchanan (unpubl. data) examined the threat displays exhibited by territorial residents towards intruding salamanders under different levels of illumination (complete darkness, 10^{-4}, or 10^{-2} lux). Residents used more visual displays as light intensities increased. Presumably, visual threat displays are energetically costly to produce (Wise and Jaeger 1998); thus, increased use of visual displays with increased ambient illumination may negatively affect energy budgets. On the other hand, increased visibility may also allow individuals to assess better the outcome of agonistic interactions, thereby reducing the probability of contests escalating to overt aggression and injury (Jaeger 1981).

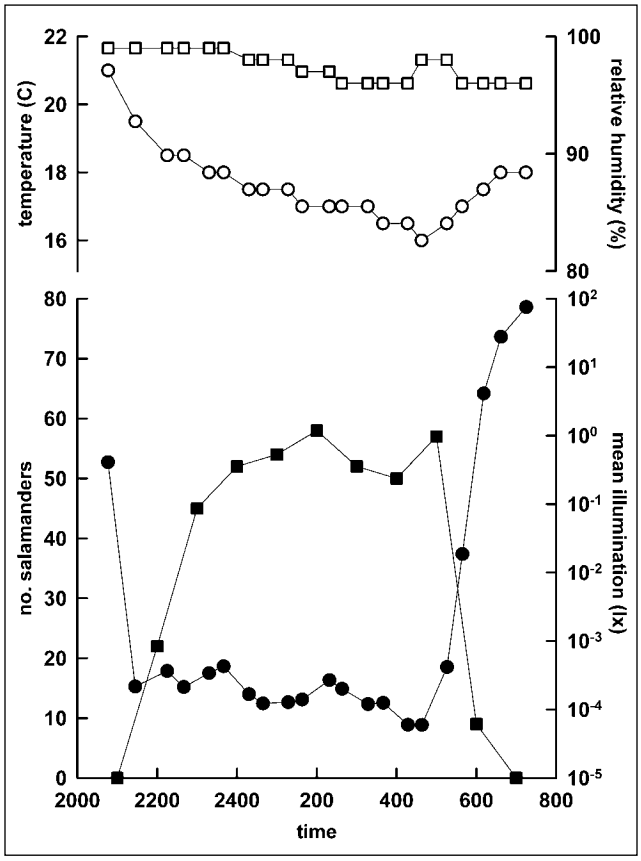


Fig. 1. Activity of *Plethodon cinereus* (Red-backed Salamander) during a representative night census (from dusk until dawn, 2100 – 0700 h, 1-2 July 2003) of two 50 x 1 m transects (Buchanan and Wise, unpubl. data). The study was conducted at Mountain Lake Biological Station, University of Virginia, Giles County, VA. Plotted are the numbers of salamanders detected on the leaf litter or vegetation (■), the mean illumination from the 4 cardinal directions (●), temperature ( ), and percent relative humidity ( ) for each sampling period.

Spectral properties of light may affect migration to and from ponds. Metamorphosed juvenile Red-spotted Newts (*Notophthalmus viridescens*) migrate from their natal ponds to nearby forests a few months after hatching and return to their natal ponds as adults. Adults also leave the ponds during periods of drought or when ponds freeze (Petranka 1998). These salamanders use a light-dependent magnetic compass (Phillips et al. 1995) involving extraocular photoreceptors (Adler 1970; Deutschlander et al. 1999) for navigation. Phillips and Borland (1992a,b,c, 1994) demonstrated experimentally that orientation and homing behavior were disrupted by monochromatic, long-wavelength light (yellow spectrum, especially 550–600 nm). Common outdoor lights emit light at 540–630 nm (Massey et al. 1990). Their use, therefore, could negatively affect the ability of *N. viridescens*, and perhaps other species of salamanders that use a similar light-dependent magnetic compass, to navigate to home ponds for breeding. Thus, spectral properties of artificial night lighting should be considered as

part of conservation or management efforts in urbanized habitats containing semi-aquatic salamanders.

Frogs — Frogs are typically aquatic breeders, and in urban settings they are likely to use both ephemeral breeding sites (e.g., ditches) and permanent sites (e.g., ponds or streams). Such sites are frequently exposed to increased light levels due to roadway lighting and skyglow (Buchanan 2006). Effects of altered lighting may be seen as early as during embryonic growth and larval development. Decreasing the duration of scotophase slowed growth in larval Painted Frogs *Discoglossus pictus* (Gutierrez et al. 1984) and African Clawed Frogs *Xenopus laevis*, causing the latter to metamorphose at a smaller size (Delgado et al. 1987; Edwards and Pivorun 1991). Conversely, constant lighting accelerated larval development in Northern Leopard Frogs, *Rana pipiens* (Eichler and Gray 1976). Thus, artificial night lighting has the potential to affect time to metamorphosis or size at metamorphosis.

The behavior and physiology of tadpoles may also be affected by night lighting. For example, larval American Toads (*Bufo americanus*) use photoperiodic cues to thermoregulate behaviorally (Beiswenger 1977) and vertical migration in *Xenopus laevis* larvae is dependent upon changes in illumination (Jamieson and Roberts 2000). Exposure at night to artificial light for as little as 1 min can disrupt production of precursors required for larval melatonin production (Lee et al. 1997), which may in turn have important effects on physiological performance (Vanecek 1998). For example, *X. laevis* larvae exposed to constant lighting did not experience normal diel patterns of color change (Binkley et al. 1988).

Adult frogs living in greenbelt or park areas, like those of many species, would traditionally be active at very low environmental illuminations (reviewed in Buchanan 2006), and may thus be affected by artificial night lighting. Species such as the Western Tailed Frog *Ascaphus truei*, normally active only at the darkest natural nocturnal illuminations (Hailman 1982), are likely to be influenced when environmental illuminations increase to levels at which the frogs typically seek refugia. Artificial night lighting can disrupt foraging, fat storage, and growth in adult frogs (e.g., in Fowler's Toad *B. fowleri*, Bush 1963). Reproductive behavior is also sensitive to changes in illumination. For example, calling males of Panamanian Cross-banded Treefrogs *Smilisca sila* exhibit illumination-dependent changes in anti-predator behavior under natural conditions (da Silva Nunes 1988). In another example, females of the Tungara Frog (*Physalaemus pustulosus*) become less likely to exhibit mate choice at higher ambient illuminations (Rand et al. 1997), and vary their oviposition behavior in response to changes in illumination (Tárano 1998). Other nocturnally breeding species, such as the Squirrel Treefrog *Hyla squirella* (Taylor et al. 2007) and the Sarayacu Treefrog *H. parviceps* (Amézquita and Hödl 2004), use visual cues in mate choice and male-male competition. Artificial lighting may allow these and other visually-based behaviors to occur at uncharacteristic times or intensities (Buchanan 2006).

Frogs moving across roadways while foraging or breeding have a high probability of being killed by automobiles (Fahrig et al., 1995; Hels and Buchwald 2001; Mazerolle 2004). Many frogs are primarily active at night, and the moving lights of oncoming cars create cycles of increasing and decreasing illumination that may make dark adaptation difficult. Buchanan (1993) found that rapid increases in illumination similar to that produced by oncoming traffic slow visual foraging in the Gray Treefrog (*H. chrysoscelis*). Mazerolle et al. (2005) similarly found that nocturnally active American toads (*B. americanus*), spring peepers (*P. crucifer*), green frogs (*R. clamitans*), and wood frogs (*R. sylvatica*) are more likely to become immobile on the road when approached by automobile-related stimuli than when left undisturbed. Although their experiment did not completely control for disturbance, making it impossible to separate out the effects of light and disturbance, their results are consistent with the idea that rapid shifts in illumination can alter the behavior of frogs at night.

Physiological consequences are also possible. For example, Leopard Forgs, *Rana pipiens* kept under constant lighting suffered from retinal irregularities (Bassinger and Matthes 1980) and Common Asian Toads *B. melanostictus* show reduced sperm production when maintained in constant light (Biswas et al. 1978). The expression of genes that, in turn, regulate other physiological processes can also be altered by constant illumination (Baggs and Green 2003; Green and Besharse 1996; Steenhard and Besharse 2000). The number of species that may be susceptible to these various effects and the magnitude of change in illumination intensity or duration that is necessary to elicit such responses remain unknown.

Turtles — A number of freshwater turtles survive within urban matrices, perhaps because of their unusual resistance to various pollutants (Gasith and Sidis 1984). Increasingly, species common in the pet trade, such as the Red-Eared Slider *Trachemys scripta elegans*, are also becoming widely established in urban settings (e.g., Lever 2003; Perry et al. 2007), presumably following their release or escape. Information about the ecology of such species in urban and near-urban environments, and on the influence of lights upon them, is lacking. The single exception involves a laboratory study in which Chinese Soft-Shelled Turtles (*Trionyx sinensis*) were shown to have lower food uptakes and growth rates at higher light intensities (Zhou et al. 1998). It is quite possible that species such as softshell turtles (Trionychidae) that sleep on shore at night would also be more exposed to predation due to increased visibility to predators in lighted landscapes.

Lizards — Many lizard species exist in urban peripheries. Nonetheless, we have not been able to find any studies showing effects of lights on these reptiles. Further study on the impacts of night lighting in these habitats is needed.

Snakes — Some aquatic snakes track the lunar cycle in their activity and foraging patterns (Andreadis 1997; Houston

and Shine 1994; Madsen and Osterkamp 1982). The issue of artificial lights disrupting the lunar cycle in natural areas (i.e. biodiversity reserves) adjacent to urban areas is of concern, but studies exploring this potential problem are absent. Increased lighting may affect snake foraging success. Predation success rates for some species that prey on snakes increase with increased illumination (Bouskila 1995), and some snake prey reduce their foraging activity in response to increased illumination (e.g., Bouskila 1995; Bowers 1988=).

Urban Beaches and Estuaries

Many of the world's largest cities originated as port towns. Other urban centers have more recently emerged around tourist destinations, and often feature heavily-developed beaches. In many cases, the same sandy beaches treasured by vacationers are also the traditional sites for sea turtle nesting. Sea turtles at such locations probably offer the best case studies of the effects of artificial lighting on any taxonomic group (e.g., Witherington 1992b). Other species, such as the diurnal Fringe-Toed Lizard (*Acanthodactylus scutellatus*) and the nocturnal Leaf-Nosed Snake (*Lytorhynchus diadema*) also inhabit those same dunes (e.g., Perry and Dmi'el 1995) and may be exposed to ambient light from nearby cities.

Frogs — Although no species of frog tolerates the high salinity associated with marine beaches per se, some (e.g., Marine Toads *Bufo marinus*, Crab-Eating Frogs *Rana cancrivora*) are known to breed in brackish water. One of them, *B. marinus*, has been widely introduced around the world (Lever 2003) and is commonly found near urban centers. In Hawaii, Guam, and elsewhere, large numbers will forage under lights, clearly taking advantage of the increased prey abundance (J. Lazell pers. comm.; G. Perry unpubl. data). However, the consequences of lights for amphibian populations inhabiting beaches and estuaries remain unstudied.

Turtles — McFarlane (1963) described how hatchling turtles in Florida, after emerging from their nests, were attracted to street lighting visible at the beach. Many crawled inland, crossed a coastal roadway *en route* to the lights, and were crushed on the road by passing cars. We now know that hatchlings worldwide are commonly attracted to light fixtures (Philibosian 1976; Peters and Verhoeven 1994), and that most turtles attracted to lights die from exhaustion, dehydration, and predation. Other sources of illumination (such as abandoned campfires on land) can also be deadly (Mortimer 1979). Artificial lighting also affects adult turtles by degrading the quality of their rookery sites. Nesting attempts (crawls of gravid females up the beach to nest) each night by Green Sea-Turtles (*Chelonia mydas*) and Loggerheads (*Caretta caretta*) were reduced to almost zero at historically important sites (Melbourne Beach, Florida; Tortuguero, Costa Rica) when these locations were experimentally exposed to lighting (Witherington 1992b). When the lights were turned off, nesting attempts each evening immediately increased. In Florida, the spatial pattern of artificial lighting probably accounts for the present distribution of the "preferred" rookery sites along the East Coast (approximately 75,000 loggerhead nests annually). About 90% of all nests are deposited at five beach sites characterized primarily by their lower exposure to artificial lighting (Salmon 2003). The same sites are also preferentially used by Leatherbacks (*Dermochelys coriacea*), *C. mydas*, and *C. caretta*, which elsewhere tend to nest at different locations. This suggests that the negative effects of coastal development and its associated lighting, rather than features that have traditionally promoted female reproductive success and hatchling survival, currently determine where marine turtles nest.

Lizards — Some species of lizards inhabit beaches, and a few, such as Black Iguanas (*Ctenosaura similes*), may occasionally be seen near human habitation. Slightly further from the beach proper, species such as the Fringe-Toed Lizards *Acanthodactylus scutellatus* and *A. schreiberi* inhabit dune formations nestled within seaside urban communities (Perry and Dmi'el 1995). However, such cases are uncommon, and we are unaware of any studies examining the influence of lights on such species.

Snakes — A number of snake species in the family Elapidae (some authors place them in the families Hydrophiidae and Laticaudidae) spend their lives in the sea and most can at times be found near land, if only briefly. Some of these (e.g. *Laticauda* species) can be quite common along beach-retaining walls in urban south-Pacific cities that are exposed to lights. Another group of snakes, the Homolopsines, primarily occur in mudflats and forage at night. Finally, terrestrial species such as the Sand Snake (*Psammophis schokari*) and *Lytorhynchus diadema* inhabit dune formations nestled within sea-side urban communities in Israel (Perry and Dmi'el 1995). However, we are unaware of studies examining the effects of lights on such species.

Remediation

All of the work conducted to date on light pollution remediation for herpetofauna involves sea turtles. Recent tests on hatchling orientation, conducted in an arena setting, indicated that natural cues and artificial lights "compete." This work offers hope of identifying a technological fix because it shows that a reduction in the perceived "attractiveness" of artificial lighting makes it more likely that hatchling orientation will be based upon natural cues (Tuxbury and Salmon 2005).

A number of studies have examined the feasibility of using alternative lighting methods that would reduce or eliminate the negative influence on sea turtles but that would also be acceptable to humans. Turtle-friendly lights generally emit wavelengths between 540 and 700 nm (amber to red) and can be produced either by designing lights that emit only the longer wavelengths (Fig. 2) or by using filters that exclude the

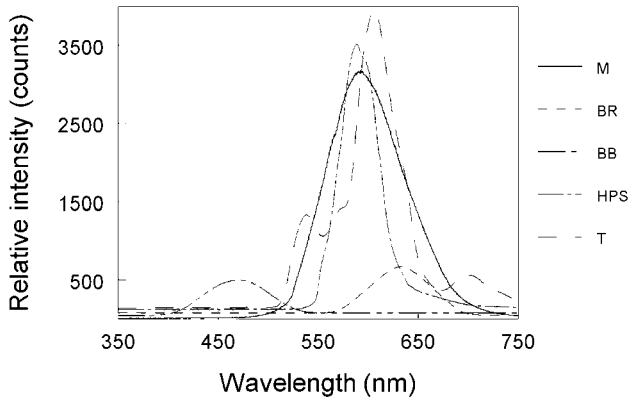


Fig. 2. Spectral energy distributions for four "turtle-friendly" lights (Magnaray, M; filtered High Pressure Sodium vapor, HPS; Twistee, T; and Beeman Red, BR). One short-wavelength light (Beeman Blue, BB) was used as a control. Filtered HPS lights are used on coastal roadway poled streetlights in Florida; the Twistee and Beeman red are lights designed for buildings (residential or commercial) that are visible at marine turtle nesting beaches.

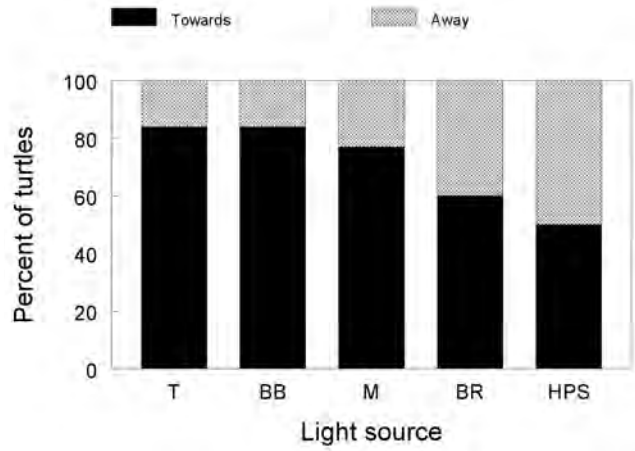


Fig. 3. Choices of hatchling sea turtles (Loggerheads, *Caretta caretta*) presented with various lights. A no-light control was used in each case. Differences among light sources in relative intensities were eliminated through the use of neutral density filters, so that responses shown by the turtles were based upon spectral differences alone. Results show that the turtles are statistically significantly attracted to the Twistee (T, n = 25 turtles), Beeman Blue (BB, n = 25), and Magnaray (M, n = 35) lights, but not to the Beeman Red (BR, n = 45) or Filtered HPS (HPS, N = 46).

shorter wavelengths of "broad-spectrum" lights. Salmon and his colleagues (Halager et al. in press) developed a bioassay that can be used to evaluate the efficacy of "turtle-friendly" lights by giving hatchlings choices between darkness and a light (single light experiments), or pairs of different lights. Using this bioassay, Halager et al. (in press) found that some lights are more attractive to turtles than others and that the strength of attraction declines as spectral energies become more concentrated in, and shifted toward, the longer wavelengths (Figs. 3, 4). Field experiments demonstrate that high-pressure sodium vapor lamps affect marine turtles, but passing such illumination through a filter that excludes wavelengths below 530 nm makes these lights far less attractive to hatchlings (Sella et al. 2006). In fact, when this filtered lighting is visible at nesting beaches, it no longer reduced nesting by adults (Pennell 2000).

The use of spectrally-modified outside lighting should increase the number of hatchlings that successfully locate the ocean, even at urban nesting beaches. Recently, lighting along a coastal roadway in the city of Boca Raton, Florida, was extensively modified. Streetlights placed on posts were turned off during sea turtle nesting season and replaced with light-emitting diodes installed in the pavement. These provided sufficient illumination for traffic safety, but none of the lighting was visible at the nesting beach. Behavioral tests at the beach demonstrated that the seaward orientation of hatchling Loggerheads was normal when the embedded lights were on, but disrupted when the elevated streetlights were on (Bertolotti and Salmon 2005). It remains to be seen to what extent use of similar technologies could help other taxonomic groups.

Discussion

Artificial light, long considered a problem for astronomers but of little concern to biologists, is increasingly viewed as a threat by conservation biologists. A recent volume (Rich and Longcore 2006) illustrated the pervasiveness of the problem of artificial lights, which affect a broad range of taxa. In this chapter, we focused on updating and summarizing the information for amphibians and reptiles, but emphasize that the problems associated with artificial night lighting likely do not stop with a particular group of organisms. It may impact entire communities, and we find it encouraging that solutions to this problem may also simultaneously benefit a broad range of taxa.

There are doubtlessly additional species and populations which use artificial lights and are not listed in Tables 1 and 2. For example, Outen (2002), Spellerberg (2002), identified lights associated with roads as a potential source of concern, but could find few studies directly evaluating this potentially widespread risk (but see Mazerolle 2004; Mazerolle et al. 2005). The reports collected by Rich and Longcore (2006) also stress the magnitude of the lack of information on effects of artificial night lighting for many taxonomic groups, including amphibians and reptiles (Buchanan 2006; Perry and Fisher 2006; Salmon 2006; Wise and Buchanan 2006). However, there is reason to be concerned about the effects of artificial light on amphibians and reptiles in general: many species are nocturnal and many populations are in serious decline (e.g., Alford and Richards 1999; Gibbons et al. 2000). Unfortunately, the literature demonstrates a lack of information for caecilians, tuataras, and crocodilians, which are primarily nocturnal and could therefore be at risk from changes in light levels.

Urban ecology is a rapidly growing discipline, but herpetological research in urban environments remains notably underrepresented. Studies typically focus on relatively undisturbed habitats, and even herpetofaunal surveys rarely

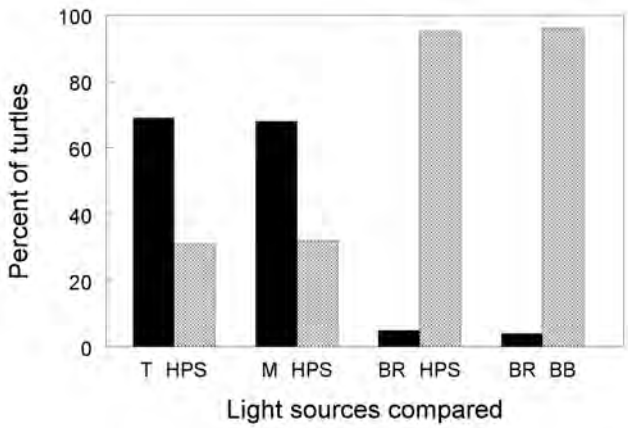


Fig. 4. Choices of hatchling sea turtles (Loggerheads, *Caretta caretta*) in tests in which paired light presentations were made. Turtles are significantly attracted to the Twistee (T) and Magnaray (M) lights when each is matched with a filtered HPS light (n = 29 and 60, respectively, for each test). However, turtles are significantly attracted to the filtered HPS light when it is paired with a Beeman Red light (BR, n = 40), which is also less attractive to the turtles than the Beeman Blue light (BB, n = 25).

explicitly address taxa found in or near human habitation. The biology of edificarian taxa is even more rarely reported (but see Powell and Henderson 2008). We hope that the increased interest in urban ecology will lead to more studies addressing light pollution and their effects on amphibians and reptiles. Although these influences are only beginning to be studied, a few general patterns appear to be emerging:

1) Species vary in their sensitivity to light pollution, which may have no effect, benefit, or negatively affect a particular taxon. Thus, it is important to consider the photobiology of all taxa found in a particular habitat. For example, sea turtle nesting problems may be reduced by shifting the spectra of lights to longer wavelengths. Shifting spectra to longer wavelengths can, however, disrupt migration in newts (which do not, fortunately, share the same habitat). Thus, there may not always be simple solutions to lighting problems other than the removal, reduction of use, or shielding of artificial night lighting.
2) Different aspects of a given species' biology can be affected differently by different lighting conditions at different life history stages.
3) There is a paucity of research available on the negative effects of lighting on herpetofauna. Negative effects of light pollution, such as the disruption of orientation in hatchling sea turtles (e.g., Witherington and Martin 1996) are well documented, but detailed studies for other taxa are not yet available.
4) There is a dearth of studies of the positive effects of lighting on herpetofauna. Positive influences, such as increased prey availability and thermoregulatory opportunities around artificial night lighting are better documented, if only anecdotally, in lizards (Tables 1, 2). We are not aware of studies that have elucidated population-level consequences are, what mechanisms are involved, and which species are most likely to be affected.
5) Indirect effects are likely to be common. Benefits to one species may negatively influence another, as demonstrated by Case et al. (1994). However, studies of this phenomenon that do not involve invasive species are only now starting to reach the literature (Rich and Longcore 2006).
6) The ability of artificial light to enhance the invasive potential of some species should be a source of broad concern. Some of the species listed in Table 1 and many of those in Table 2 were observed in areas outside their native range. The ability to use human habitats, which are often characterized by having additional lighting during the night, can be beneficial to invasive species, many of which first colonize urbanized areas. For species that are not only tolerant of such conditions but can also take advantage of the night-light niche, establishment of viable populations may be easier. Almost no information is available on the impacts of invaders such as geckos, which are generally perceived as innocuous, yet it seems likely that at least some native species (particularly invertebrate prey) must be negatively affected. Light-aided invasive species may also spread disease and exotic parasites to native species.

Is it possible to resolve such conflicts of interest between urban residents and urban amphibians and reptiles? New technology, briefly reviewed above, offers some promising options for providing illumination that satisfies human requirements while minimizing effects on other species. However, solving the light pollution problem necessitates light management, including protocols that eliminate the influence of artificial lighting on wildlife by, for example, turning off unnecessary lights, reducing wattage, shielding and lowering luminaires, or creating natural light barriers, such as dune or wooded areas, between light sources and wildlife habitats (Witherington and Martin 1996). However, humans often perceive lighted environments as more pleasing or safe. For example, lighting along roadways and in city parks is often considered necessary for pedestrian and vehicular safety. Thus, there may be resistance to reducing the amount of lighting at urban sites. There is much room for research on the human dimensions of the problem and such work can hopefully help identify technological solutions that benefit wildlife and are broadly acceptable to the public. We hope that such solutions can be incorporated rapidly not just where a particular species of sea turtle or gecko is found, but on a global scale commensurate with the scope of the artificial light problem.

Management Recommendations

The information presented in this chapter clearly indicates the potential for multiple types of effects on amphibians and reptiles resulting from artificial night lighting. Although

the most extensive work has been carried out on sea turtles at urban beaches, preliminary evidence indicates that many species are likely at risk. Although it is clear that much more research is needed in this area before firm conclusions can be drawn, work reviewed above has begun identifying potential problems and solutions to these problems, which we are hopeful can effectively be incorporated into standard practices. We recommend that managers adopt a precautionary approach and attempt to minimize consequences without waiting for researchers to confirm the impacts on a particular species or habitat. It is clear that the best approach for the conservation of native taxa involved is returning habitats as closely as possible to their natural lighting conditions, primarily through the removal of unnecessary lighting and shielding of necessary lighting. It is worth noting that several entities that have experimented with reducing lighting have also recouped their investment in reduced power costs (e.g., International Dark Sky Association: http://www.darksky.org/infoshts/pdf/is191.pdf; accessed May 2006).

Summary

Amphibians and reptiles have not evolved with artificial lighting at night. Thus, alteration of the natural variation in diurnal and nocturnal light intensities and spectral properties of lights has the potential to disrupt their physiology, behavior, and ecology. Our review documents identified possible effects of night lighting on many species of amphibians and reptiles. However, they also reveal that conclusive data are often lacking. Few studies on the consequences of artificial lights for amphibians and reptiles have been conducted to date, and in many that might be relevant, researchers have not recorded the illumination or irradiance at which experiments are conducted. Thus, it is currently impossible to precisely gauge the effects of artificial night lighting on taxa found in urban, light-polluted environments. The one exception is the information available on the negative impacts of artificial lights on hatchling sea turtles, which has received considerable coverage in both scientific and popular media. With that exception, we believe it is too early to draw sweeping conclusions and to provide broad management recommendations, beyond pointing out the urgent need for more information. However, we identify light pollution as a serious threat that should be considered as part of planning and management decisions in the maintenance or conservation of urban areas containing amphibians and reptiles.

Acknowledgments — We thank C. Rich and T. Longcore for first getting all of us together, and the many colleagues who have helped us locate obscure publications or graciously allowed us to use unpublished observations in this work. This is manuscript T-9-1047 of the College of Agricultural Sciences and Natural Resources, Texas Tech University.

Literature Cited

Adler, K. 1970. The role of extraoptic photoreceptors in amphibian rhythms and orientation: a review. Journal of Herpetology 4:99–112.

Alford, R.A., and S.J. Richards. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics 30:133–165.

Amézquita, A., and W. Hödl. 2004. How, when, and where to perform visual displays: the case of the Amazonian frog *Hyla parviceps*. Herpetologica 60:420–429.

Anderson, J.D., and R.E. Graham. 1967. Vertical migration and stratification of larval *Ambystoma*. Copeia 1967:371–374.

Andreadis, P.T. 1997. A lunar rhythm in the foraging activity of northern water snakes (Reptilia: Colubridae). *In* A.F. Scott, S.W. Hamilton, E.W. Chester, and D.S. White (eds.), *Proceedings of the Seventh Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys*. Pp. 13–23. The Center for Field Biology, Austin Peay State University, Clarksville, TN.

Baggs, J.E., and C.B. Green. 2003. Nocturnin, a deadenylase in *Xenopus laevis* retina: a mechanism for posttranscriptional control of circadian-related mRNA. Current Biology 13:189–198.

Baker, J. 1990. Toad aggregations under street lamps. British Herpetological Society Bulletin 31:26–27.

Balassina, D. 1984. *Amphibians of Europe: a Colour Field Guide*. David & Charles, Devon, UK. 132 pp.

Bassinger, S.F., and M.T. Matthes. 1980. The effect of long-term constant light on the frog pigment epithelium. Vision Research 20:1143–1149.

Bertolotti, L., and M. Salmon. 2005. Do embedded roadway lights protect sea turtles? Environmental Management 36:702–710.

Beiswenger, R.E. 1977. Diel patterns of aggregative behavior in tadpoles of *Bufo americanus*, in relation to light and temperature. Ecology 58:98–108.

Binkley, S., K. Mosher, F. Rubin, and B. White. 1988. *Xenopus* tadpole melanophores are controlled by dark and light and melatonin without influence of time of day. Journal of Pineal Research 5:87–97.

Biswas, N.M., J. Chakraborty, S. Chanda, and S. Sanyal. 1978. Effect of continuous light and darkness on the testicular histology of toad (*Bufo melanostictus*). Endocrinologia Japanica 25:177–180.

Böhme, W. 2005. *Agama agama* (Linnaeus, 1758), red-headed rock agama, nocturnal activity. African Herp News 38:20–21.

Bouskila, A. 1995. Interactions between predation risk and competition: a field study of kangaroo rats and snakes. Ecology 76:165–178.

Bowers, M.A. 1988. Seed removal experiments on desert rodents: the microhabitat by moonlight effect. Journal of Mammalogy 69:201–204.

Bowersox, S.R., S. Calderón, G. Cisper, R.S. Garcia, C. Hun-

tington, A. Lathrop, L. Lenhart, J.S. Parmerlee, Jr., R. Powell, A. Queral, D.D. Smith, S.P. Powell, and K.C. Zippel. 1994. Miscellaneous natural history notes on amphibians and reptiles from the Dominican Republic. Bulletin of the Chicago Herpetological Society 29:54–55.

Buchanan, B.W. 1992. Bimodal nocturnal activity pattern of *Hyla squirella*. Journal of Herpetology 26:521–523.

Buchanan, B.W. 1993. Effects of enhanced lighting on the behaviour of nocturnal frogs. Animal Behaviour 45:893–899.

Buchanan, B.W. 1998. Low-illumination prey detection by squirrel treefrogs. Journal of Herpetology 32:270–274.

Buchanan, B.W. 2006. Observed and potential effect of artificial night lighting on anuran amphibians. *In* C. Rich and T. Longcore (eds.), *Ecological Consequences of Artificial Night Lighting*. Pp. 192–220. Island Press, Washington, DC.

Buden, D.W. 2000. The reptiles of Sapwuahfik Atoll, Federated States of Micronesia. Micronesica 32:245–256.

Bush, F.M. 1963. Effects of light and temperature on the gross composition of the toad, *Bufo fowleri*. Journal of Experimental Zoology 153:1–13.

Carr, A.F., Jr. 1940. A contribution to the herpetology of Florida. University of Florida Miscellaneous Publications, Biological Science Series 3:1–118.

Case, T.J., D.T. Bolger, and K. Petren. 1994. Invasions and competitive displacement among house geckos in the tropical Pacific. Ecology 75:464–477.

Cinzano, P., F. Falchi, and C.D. Elvidge. 2001. The first World Atlas of the artificial night sky brightness. Monthly Notices of the Royal Astronomical Society 328:689–707.

Clarke, J.A., J.T. Chopko, and S.P. Mackessy. 1996. The effect of moonlight on activity patterns of adult and juvenile prairie rattlesnakes (*Crotalus viridis viridis*). Journal of Herpetology 30:192–197.

Cogger, H.G. 1979. *Reptiles and Amphibians of Australia* (1986 revised edition). Reed Books, Sydney, Australia. 808 pp.

Cornell, E.A., and J.P. Hailman. 1984. Pupillary responses of two *Rana pipiens*-complex anuran species. Herpetologica 40:356–366.

Cunningham, J.D. 1960. Aspects of the ecology of the Pacific slender salamander, *Batrachoseps pacificus*, in southern California. Ecology 41:88–99.

Cunningham, P.L. 2002. Colubridae: *Lamprophis fuliginosus*, brown house-snake. Foraging. African Herp News 34:28–29.

da Silva Nunes, V. 1988. Vocalizations of treefrogs (*Smilisca sila*) in response to bat predation. Herpetologica 44:8–10.

Dawson, D.W. 1984. Light pollution and its measurement. *In* R.C. Wolpert and R.M. Genet (eds.), *Advances in Photoelectric Photometry*, Vol. 2. Pp. 30–53. Fairborn Observatory, Fairborn, OH.

Delgado, M.J., P. Gutiérrez, and M. Alsonso-Bedate. 1987. Melatonin and photoperiod alter growth and larval development in *Xenopus laevis* tadpoles. Comparative Biochemistry and Physiology 86A:417–421.

Deutschlander, M.E., S.C. Borland, and J.B. Phillips. 1999. Extraocular magnetic compass in newts. Nature 400:324–325.

Disi, A.M., D. Modrý, P. Nečas, and L. Rifi. 2001. *Amphibians and Reptiles of the Hashemite Kingdom of Jordan An Atlas and Field Guide*. Chimaira, Frankfurt am Main, Germany. 408 pp.

Dixon, J.R., and P. Soini. 1975. The reptiles of the upper Amazon basin, Iquitos region, Peru. I. Lizards and amphisbaenians. Milwaukee Public Museum Contributions in Biology and Geology 4:1–58.

Dodd, C.K., Jr. 2001. *North American Box Turtles: a Natural History*. University of Oklahoma Press, Norman, OK. 231 pp.

Edwards, M.L.O., and E.B. Pivorun. 1991. The effects of photoperiod and different dosages of melatonin on metamorphic rate and weight gain in *Xenopus laevis* tadpoles. General and Comparative Endocrinology 81:28–38.

Eichler, V.B., and L.S. Gray. 1976. The influence of environmental lighting on the growth and prometamorphic development of larval *Rana pipiens*. Development, Growth and Differentiation 18:177–182.

Erskine, D.J., and V.H. Hutchison. 1982. Reduced thermal tolerance in an amphibian treated with melatonin. Journal of Thermal Biology 7:121–123.

Fain, G.L., H.R. Matthews, M.C. Cornwall, and Y. Koutalos. 2001. Adaptation in vertebrate photoreceptors. Physiological Reviews 81:117–151.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177–182.

Fuenmayor, G.R., G.N. Ugueto, A.M. Bauer, T. Barros, and J. Manzanilla. 2005. Expansion and natural history of a successful colonizing gecko in Venezuela (Reptilia: Gekkonidae: *Hemidactylus mabouia*) and the discovery of *H. frenatus* in Venezuela. Herpetological Review 36:121–125.

Garber, S.D. 1978. Opportunistic feeding behavior of *Anolis cristatellus* (Iguanidae: Reptilia) in Puerto Rico. Transactions of the Kansas Academy of Sciences 81:79–80.

García, G., and M. Vences. 2002. Natural history: *Phelsuma madagascariensis kochi* (Madagascar day gecko). Diet. Herpetological Review 33:53–54.

Gasith, A., and I. Sidis. 1984. Polluted water bodies, the main habitat of the Caspian terrapin (*Mauremys caspica rivulata*) in Israel. Copeia 1984:216–219.

Gaze, P. 2001. Tuatara Recovery Plan. Threatened Species Recovery Plan 47. Department of Conservation, Wellington, New Zealand. 36 p.

Gern, W.A., and D.O. Norris. 1979. Plasma melatonin in the neotenic tiger salamander (*Ambystoma tigrinum*): effects of photoperiod and pinealectomy. General and Comparative Endocrinology 38:393–398.

Gern, W.A., D.O. Norris, and D. Duvall. 1983. The effect of light and temperature on plasma melatonin in neotenic tiger salamanders (*Ambystoma tigrinum*). Journal of Herpetology 17:228–234.

Gibbons, J.W., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy, and C.T. Winne. 2000. The global decline of reptiles, dèjá vu amphibians. BioScience 50:653–666.

Goin, C.J., and O.B. Goin. 1957. Remarks on the behavior of the squirrel treefrog, *Hyla squirella*. Annals of the Carnegie Museum 35:27–36.

Goin, O.B. 1958. A comparison of nonbreeding habits of two treefrogs, *Hyla squirella* and *Hyla cinerea*. Quarterly Journal of the Florida Academy of Sciences 21:49–60.

Gower, D.J., and M. Wilkinson. 2005. Conservation biology of caecilian amphibians. Conservation Biology 19:45–55.

Green, C.B., and J.C. Besharse. 1996. Identification of a novel vertebrate circadian clock-regulated gene encoding the protein nocturnin. Proceedings of the National Academy of Sciences 93:14884–14888.

Gutierrez, P., M.J. Delgado, and M. Alonso-Bedate. 1984. Influence of photoperiod and melatonin administration on growth and metamorphosis in *Discoglossus pictus* larvae. Comparative Biochemistry and Physiology 79A:255–260.

Hailman, J.P. 1982. Extremely low ambient light levels of *Ascaphus truei*. Journal of Herpetology 16:83–84.

Halager, K., M. Denton, and M. Salmon. Turtle friendly lights: testing and assessment of efficacy. Proceedings of the Annual Symposium on Sea Turtle Biology and Conservation, National Marine Fisheries Service, in press.

Hels, T., and E. Buchwald. 2001. The effect of road kills on amphibian populations. Biological Conservation 99:331–340.

Henderson, R.W., and R. Powell. 2001. Responses by the West Indian herpetofauna to human-influenced resources. Caribbean Journal of Science 37:41–54.

Hodge, K.V.D., E.J. Cenksy, and R. Powell. 2003. The reptiles and amphibians of Anguilla, British West Indies. Anguilla National Trust, The Valley, Anguilla.

Houston, D., and R. Shine. 1994. Movements and activity patterns of arafura filesnakes (Serpentes: Acrochordidae) in tropical Australia. Herpetologica 50:349–357.

Howard, K.G., J.S. Parmerlee, Jr., and R. Powell. 2001. Natural history of the edificarian geckos *Hemidactylus mabouia*, *Thecadactylus rapicauda*, and *Sphaerodactylus sputator* on Anguilla. Caribbean Journal of Science 37:285–288.

Hutchison, V.H., J.J. Black, and D.J. Erskine. 1979. Melatonin and chlorpromazine: thermal selection in the mudpuppy, *Necturus maculosus*. Life Science 25:527–530.

Ibrahim, A. 2004. Ecology of the white-spotted gecko *Tarentola a. annularis* (Reptilia: Gekkonidae) in Ismailia City, Egypt. Zoology in the Middle East 31:23–38.

Ibrahim, A., and M. Ghobashy. 2004. Ecological and parasitological studies of the Indian leaf-toed gecko, *Hemidactylus flaviviridis* (Sauria: Gekkonidae) in the Ismailia Governorate, Egypt. Journal of the Egyptian German Society (Invertebrate Zoology and Parasitology) 45(D):277–294.

Ibrahim, A., and I. Ineich. 2005. Additional records to the herpetofauna of Nalup province, Libya. African Herp News 38:2–9.

Jaeger, R.G. 1981. Dear enemy recognition and the cost of aggression between salamanders. American Naturalist 117:962–974.

Jaeger, R.G., and J.P. Hailman. 1973. Effects of intensity on the phototactic responses or adult anuran amphibians: a comparative survey. Zeitschrift für Tierpsychologie 33:352–407.

Jamieson, D., and A. Roberts. 2000. Responses of young *Xenopus laevis* tadpoles to light dimming: possible roles for the pineal eye. The Journal of Experimental Biology 203:1857–1867.

Kaiser, H., and R.E. Diaz. 2001. Natural history: *Thecadactylus rapicauda* (turnip-tail gecko). Behavior. *Herpetological Review* 32:259.

Keen, W.H. 1984. Influence of moisture on the activity of a plethodontid salamander. Copeia 1984:684–688.

Larsen, L.O., and J.N. Pedersen. 1982. The snapping response of the toad, *Bufo bufo*, towards prey dummies at very low illuminations. Amphibia-Reptilia 2:321–327.

Lazell, J. 2002. The herpetofauna of Shek Kwu Chau, South China Sea, with descriptions of two new colubrid snakes. Memoirs of the Hong Kong Natural History Society 25:1–81.

Lee, J.H., C.F. Hung, C.C. Ho, S.H. Chang, Y.S. Lai, and J.G. Chung. 1997. Light-induced changes in frog pineal gland N-acetyltransferase activity. Neurochemistry International 31:533–540.

Lever, C. 2003. *Naturalized Reptiles and Amphibians of the World*. Oxford University Press, New York, NY. 318 pp.

Lohmann, K.J., B.E. Witherington, C.M.F. Lohmann, and M. Salmon. 1997. Orientation, navigation, and natal beach homing in sea turtles. *In* P.L. Lutz and J.A. Musick (eds.), *The Biology of Sea Turtles*. Pp. 107–135. CRC Press, Boca Raton, FL.

Longcore, T., and C. Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2:191–198.

Lutcavage, M.E., and P.L. Lutz. 1997. Diving physiology. *In* P.L. Lutz and J.A. Musick (eds.), *The Biology of Sea Turtles*. Pp. 277–296. CRC Press, Boca Raton, FL.

Madsen, T., and M. Osterkamp. 1982. Notes on the biology of the fish-eating snake *Lycodonomorphus bicolor* in Lake Tanganyika. Journal of Herpetology 16:185–188.

Massey, P., C. Cronwall, and C.A. Pilachowski. 1990. The spectrum of the Kitt Peak night sky. Publications of the Astronomical Society of the Pacific 102:1046–1051.

Mathis, A., R.G. Jaeger, W.H. Keen, P.K. Ducey, S.C. Walls, and B.W. Buchanan. 1995. Aggression and territoriality by salamanders and a comparison with the territorial behavior of frogs. *In* H. Heatwole and B.K. Sullivan (eds.), *Amphibian Biology. Vol. 2, Social Behaviour*. Pp. 634–676. Surrey Betty & Sons, Chipping Norton, New South Wales, Australia.

Mazerolle, M.J. 2004. Amphibian road mortality in response to nightly variations in traffic intensity. Herpetologica

60:45–53.

Mazerolle, M.J., M. Huot, and M. Gravel. 2005. Behavior of amphibians on the road in response to car traffic. Herpetologica 62:380–388.

McCoid, M.J., and R.A. Hensley. 1993. Shifts in activity patterns in lizards. Herpetological Review 24:87–88.

McFarlane, R.W. 1963. Disorientation of loggerhead hatchlings by artificial road lighting. Copeia 1963:153.

Meshaka, W.E., Jr. 2000. Colonization dynamics in two exotic geckos (*Hemidactylus garnotii* and *H. mabouia*) in Everglades National Park. Journal of Herpetology 34:163–168.

Meshaka, W.E., Jr., B.P. Butterfield, and J.B. Hauge. 2004. *The Exotic Amphibians and Reptiles of Florida*. Krieger, Malabar, FL. 166 pp.

Mortimer, J.A. 1979. Ascension Island: British jeopardize 45 years of conservation. Marine Turtle Newsletter 10:7–8.

Nelson, D.H., and S.D. Carey. 1993. Range extension of the Mediterranean gecko (*Hemidactylus turcicus*) along the northeastern gulf coast of the United States. Northeast Gulf Science 13:53–58.

Outen, A.R. 2002. The ecological effects of road lighting. *In* B. Sherwood, D. Cutler, and J.A. Burton (eds.), *Wildlife and Roads: the Ecological Impact*. Pp. 133–135. Imperial College Press, London, UK.

Pauwels, O.S.G., M. Burger, S. Guimondou, and W.R. Branch. 2004. Red-headed rock agama: nocturnal activity. African Herp News 37:20–21.

Pennell, J. 2000. The effect of filtered roadway lighting on the nesting behavior of loggerhead sea turtles. Master's Thesis, Florida Atlantic University, Boca Raton, FL. 33 pp.

Perry, G. 2006. *Eleutherodactylus johnstonei*. Habitat. Herpetological Review 37:443–444.

Perry, G., and D.W. Buden. 1999. Ecology, behavior and color variation of the green tree skink, *Lamprolepis smaragdina* (Lacertilia: Scincidae), in Micronesia. Micronesica 31:263–273.

Perry, G., and R. Dmi'el. 1995. Urbanization and sand dunes in Israel: direct and indirect effects. Israel Journal of Zoology 41:33–41.

Perry, G., and R.N. Fisher. 2006. Night lights and reptiles: observed and potential effects. *In* C. Rich and T. Longcore (eds.), *Ecological Consequences of Artificial Night Lighting*. Pp. 169–191. Island Press, Washington, DC.

Perry, G., and J. Lazell. 2000. Natural history: *Liophis portoricensis anegadae* (Puerto Rican racer), Night-light niche. Herpetological Review 31:247.

Perry, G., J.L. Owen, C. Petrovic, J. Lazell, and J. Egelhoff. 2007. The red-eared slider, *Trachemys scripta elegans*, in the British Virgin Islands. Applied Herpetology 4:88–89.

Peters, A., and K.J.F. Verhoeven. 1994. Impact of artificial lighting on the seaward orientation of hatchling loggerhead turtles. Journal of Herpetology 28:112–114.

Petranka, J.W. 1998. *Salamanders of the United States and Canada*. Smithsonian Institution Press, Washington, DC. 587 pp.

Philibosian, R. 1976. Disorientation of hawksbill turtle hatchlings, *Eretmochelys imbricata*, by stadium lights. Copeia 1976:824.

Phillips, J.B., and S.C. Borland. 1992a. Behavioural evidence for use of a light-dependent magnetoreception mechanism by a vertebrate. Nature 359:142–144.

Phillips, J.B., and S.C. Borland. 1992b. Magnetic compass orientation is eliminated under near-infrared light in the eastern red-spotted newt *Notophthalmus viridescens*. Animal Behaviour 44:796–797.

Phillips, J.B., and S.C. Borland. 1992c. Wavelength specific effects of light on magnetic compass orientation of the eastern red-spotted newt *Notophthalmus viridescens*. Journal of Experimental Biology 188:275–291.

Phillips, J.B., and S.C. Borland. 1994. Use of a specialized magnetoreception system for homing by the eastern red-spotted newt *Notophthalmus viridescens*. Journal of Experimental Biology 188:275–291.

Phillips, J.B., K. Adler, and S.C. Borland. 1995. True navigation by an amphibian. Animal Behaviour 50:855–858.

Powell R., and R.W. Henderson. 1992. Natural history: *Anolis gingivinus* (NCN) Nocturnal activity. Herpetological Review 23:117.

Powell, R., R.W. Henderson, and J.S. Parmerlee, Jr. 2005. *The Reptiles and Amphibians of the Dutch Caribbean; St. Eustacius, Saba, and St. Maarten*. St. Eustacius National Parks Foundation, St. Eustacius, Netherlands Antilles. 192 pp.

Quesnel, V.C., T. Seifan, N. Werner, and Y.L. Werner. 2002. Field and captivity observations on *Gonatodes vittatus* (Reptilia: Gekkonomorpha: Sphaerodactylini) in Trinidad and Tobago. Living World, Journal of the Trinidad and Tobago Field Naturalists' Club 2002:8–18.

Rand, S. 1967. Ecology and social organization in the iguanid lizard *Anolis lineatopus*. Proceedings of the US National Museum Smithsonian Institute 122(3595):1–77.

Rand, A.S., M.E. Bridarolli, L. Dries, and M.J. Ryan. 1997. Light levels influence female choice in Túngara frogs: predation risk assessment? Copeia 1997:447–450.

Rawding, R.S., and V.H. Hutchison. 1992. Influence of temperature and photoperiod on plasma melatonin in the mudpuppy, *Necturus maculosus*. General and Comparative Endocrinology 88:364–374.

Rich, C., and T. Longcore. 2006. *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington, DC. 458 pp.

Robinson, H.S., and P.J.M. Robinson. 1950. Some notes on the observed behaviour of Lepidoptera in flight in the vicinity of light-sources together with a description of a light-trap designed to take entomological samples. Entomologist's Gazette 1:3–20.

Salmon, M. 2003. Artificial night lighting and sea turtles. The Biologist 50:163–168.

Salmon, M. 2006. Protecting sea turtles from artificial night lighting at Florida's oceanic beaches. *In* C. Rich and T.

Longcore (eds.), *Ecological Consequences of Artificial Night Lighting*. Pp. 141–168. Island Press, Washington, DC.

Savage, J.M. 2002. *The Amphibians and Reptiles of Costa Rica: a Herpetofauna Between Two Continents, Between Two Seas*. University of Chicago Press, Chicago, IL. 954 pp.

Sella, K.A., M. Salmon, and B.E. Witherington. 2006. Does filtered lighting protect marine turtle hatchlings? Chelonian Conservation and Biology 5:255–261.

Schwartz, A., and R.W. Henderson. 1991. *Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History*. University of Florida Press, Gainesville, FL. 720 pp.

Semlitsch, R.D. 1987. Interactions between fish and salamander larvae: costs of predator avoidance or competition? Oecologica 72:481–486.

Spellerberg, I.F. 2002. *Ecological Effects of Roads. Land Reconstruction and Management*. Vol. 2 (M. J. Haigh, series editor). Science Publishers, Enfield, NH. 251 pp.

Stangel, P.W., and R.D. Semlitsch. 1987. Experimental analysis of predation on the diel vertical migrations of a larval salamander. Canadian Journal of Zoology 65:1554–1558.

Steenhard, B.M., and J.C. Besharse. 2000. Phase shifting the retinal circadian clock: *xPer2* mRNA induction by light and dopamine. Journal of Neuroscience 20:8572–8577.

Tárano, Z. 1998. Cover and ambient light influence nesting preferences of the Túngara frog *Physalaemus pustulosus*. Copeia 1998:250–251.

Taylor, R., B. Buchanan, and J. Doherty. 2007. Sexual selection in the Squirrel Treefrog, *Hyla squirella*: The role of multimodal cue assessment in female choice. Animal Behaviour 74:1753–1763.

Teynié, A., P. David, A. Ohler, and K. Luanglath. 2004. Notes on a collection of amphibians and reptiles from southern Laos, with a discussion on the occurrence of Indo-Malayan species. Hamadryad 29:33–62.

Tuxbury, S.M., and M. Salmon. 2005. Competitive interactions between artificial lighting and natural cues during seafinding by hatchling marine turtles. Biological Conservation 121:311–316.

Vanecek, J. 1998. Cellular mechanisms of melatonin action. Physiological Reviews 78:687–721.

Verheijen, F.J. 1958. The mechanisms of the trapping effect of artificial light sources upon animals. Les Archives Neerlandaises de Zoologie 13:1–107.

Verheijen, F.J. 1985. Photopollution: artificial light optic spatial control systems fail to cope with. Incidents, causation, remedies. Experimental Biology 44:1–18.

Werner, Y.L. 1965. Über die israelischen Geckos der Gattung *Ptyodactylus*und ihre Biologie. Salamandra 1:15–25.

Werner, Y.L. 1966. *The Reptiles of Israel*. Hebrew University Press, Jerusalem, Israel. 42 pp.

Werner, Y.L. 1990. Habitat dependent thermal regimes of two Hawaiian geckos (Reptilia: Gekkonidae). Journal of Thermal Biology 15:281–290.

Werner, Y.L., and N. Werner 2001. An iguanid lizard shamming a house gecko. Herpetological Bulletin 77: 28–30.

Whitford, W.G., and V.H. Hutchison. 1965. Effect of photoperiod on pulmonary and cutaneous respiration in the spotted salamander, *Ambystoma maculatum*. Copeia 1965:53–58.

Wise, S.E., and B.W. Buchanan. 2006. Influence of artificial illumination on the nocturnal behavior and physiology of salamanders. *In* C. Rich and T. Longcore (eds.), *Ecological Consequences of Artificial Night Lighting*. Pp. 221–251. Island Press, Washington, DC.

Wise, S.E., and R.G. Jaeger. 1998. The influence of tail autotomy on agonistic behaviour in a territorial salamander. Animal Behaviour 55:1707–1716.

Witherington, B.E. 1992a. Sea-finding behavior and the use of photic orientation cues by hatchling sea turtles. Ph.D. Thesis, University of Florida, Gainesville, FL. 241 pp.

Witherington, B.E. 1992b. Behavioral responses of nesting sea-turtles to artificial lighting. Herpetologica 48:31–39.

Witherington, B.E., and R.E. Martin. 1996. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Florida Marine Research Institute Technical Report TR-2, Florida Marine Research Institute, St. Petersburg, FL. 73 pp.

Woolbright, L.L. 1985. Patterns of nocturnal movement and calling by the tropical frog *Eleutherodactylus coqui*. Herpetologica 41:1–9.

Zhou, X.-Q., C.-J. Niu, Q.-F. Li, and H.-F. Ma. 1998. The effect of light intensity on daily food consumption and specific growth rate of the juvenile soft-shelled turtle, *Trionyx sinensis*. Acta Zoologica Sinica 44:157–161.

Ornithological Monographs
Volume (2012), No. 74, 6–22
© The American Ornithologists' Union, 2012.
Printed in USA.

CHAPTER 2

EFFECTS OF NOISE POLLUTION ON BIRDS: A BRIEF REVIEW OF OUR KNOWLEDGE

Catherine P. Ortega

Ecosphere Environmental Services, 776 E. Second Avenue, Durango, Colorado 81301, USA

Abstract.—Many avian species have long been exposed to loud natural sounds such as streams, waterfalls, and wind. However, anthropogenic noise pollution is a relatively recent phenomenon that birds now have to cope with throughout much of the world. Early investigations on bird responses to noise tended to focus on physical damage to ears, stress responses, flight or flushing responses, changes in foraging, and other behavioral reactions. These studies were often conducted under laboratory conditions because determining effects of noise on free-ranging birds is particularly difficult, in that we rarely have the opportunity to isolate noise as a single testable variable. By coupling introduced noise on the landscape (e.g., from gas well compressors) with ecologically similar controls, investigators have recently found additional responses, including avoidance of noisy areas, changes in reproductive success, and changes in vocal communication. Numerous investigators have compared urban birds with their rural counterparts in quieter surroundings and found that at least some birds can compensate for the masking effect of noise through shifts in vocal amplitude, song and call frequency, and song component redundancies, as well as temporal shifts to avoid noisy rush-hour traffic. Sounds have presumably always been part of the environment, but noise pollution has escalated over the past century, especially the past few decades, disturbing the integrity of natural ecosystems. This review provides general background information, updates on the most current literature, and suggestions for future research that will enhance our comprehensive knowledge and ability to mitigate negative effects of noise.

Key words: birds, communication, hearing, noise pollution, soundscape.

Efectos de la Polución Sonora en Aves: una Breve Revisión de Nuestro Conocimiento

Resumen.—Muchas especies de aves han sido expuestas prolongadamente a sonidos naturales fuertes, como arroyos, cascadas y viento. Sin embargo, la polución sonora antropogénica es un fenómeno relativamente reciente con el que las aves tienen que lidiar ahora en casi todo el mundo. Las primeras investigaciones sobre la respuesta de las aves al ruido tendían a enfocarse en el daño físico a los oídos, las repuestas de estrés, las respuestas de vuelo o huída, los cambios en el forrajeo y otras reacciones de comportamiento. Estos estudios fueron frecuentemente conducidos bajo condiciones de laboratorio porque determinar los efectos del ruido sobre aves libres es particularmente difícil, ya que rara vez se tiene la oportunidad de aislar el ruido como única variable que se pone a prueba. Al acoplar el ruido introducido en el paisaje, como el de los compresores de pozos de gas, con controles ecológicamente similares, los investigadores recientemente han encontrado respuestas adicionales, incluyendo la evasión de áreas ruidosas, cambios en el éxito reproductivo y cambios en la comunicación vocal. Numerosos investigadores han comparado

E-mail: ortega_cp@yahoo.com

Ornithological Monographs, Number 74, pages 6–22. ISBN: 978-0-943610-93-1. © 2012 by The American Ornithologists' Union. All rights reserved. Please direct all requests for permission to photocopy or reproduce article content through the University of California Press's Rights and Permissions website, http://www.ucpressjournals.com/reprintInfo.asp. DOI: 10.1525/om.2012.74.1.6.

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

aves urbanas con sus contrapartes rurales que ocupan áreas más silenciosas, y encontraron que al menos algunas aves pueden compensar el efecto de enmascaramiento del ruido por medio de cambios en la amplitud vocal, la frecuencia del canto y los llamados, y las redundancias en los componentes del canto. Las aves también exhiben cambios temporales para evitar el ruido de las horas pico del tráfico. Presumiblemente, los sonidos siempre han sido parte del ambiente, pero la polución sonora ha crecido a lo largo del siglo pasado y especialmente durante las últimas décadas, perturbando la integridad de los ecosistemas naturales. Esta revisión provee información general de base, información de la literatura más reciente y sugerencias para investigación futura que va a mejorar nuestro conocimiento y la habilidad para mitigar los efectos negativos del ruido.

The word *noise* dates back to the 13th century, and its etymology reveals the disdain that humans have long felt for noise. It originates from the Latin word *nausea* and is defined as unwanted sound or sound that interferes with hearing other sounds. *Sound* is typically defined as vibrations that move through the environment (e.g., air, water, or another medium) and provide an auditory sensation. Noise is a subjective perception with intra- and interspecific variation. One person may perceive a symphonic piece as glorious music while another perceives the same piece as disturbing noise. Similarly, important communication for one species may be perceived as noise by another species. For example, a loud chorus of frogs may interfere with the ability of owls to hear their prey, and cicadas (Slabbekoorn and Smith 2002) or colonies of seabirds (Feare et al. 2003) create a "deafening" experience to any other listener. The sounds of nature can be unwanted at times and can interfere with hearing or interpreting other sounds (Coates 2005), but the term "noise pollution" generally refers to unwanted sounds resulting from human activities.

Anthropogenic noise is related to human population density; therefore, we can assume that it has and will continue to increase as human populations increase. Cities have always been noisy (Rosen 1974), but noise pollution has dramatically increased since the industrial revolution. More recent technologies, especially recreational vehicles and modern conveniences, have exacerbated the problem. Although urban and suburban areas are noisier than less developed areas, natural areas are becoming increasingly noisy. No place on Earth is free from noise pollution because aircraft noise penetrates even the most remote locations. Noisy off-highway vehicles have also become common, even in formerly secluded areas (Barton and Holmes 2007).

Although noise has escalated over many decades, published studies on the effects of noise on birds have surged only in the past decade, possibly as a result of new instruments, song analysis programs, and opportunities to control noise. Most of this recent work has occurred in the field of vocal communication, often within the context of evolution of communication. Many papers have reviewed the effects of noise pollution on birds and other wildlife (Larkin et al. 1996, Warren et al. 2006, Dooling and Popper 2007, Slabbekoorn and Bouton 2008, Slabbekoorn and Ripmeester 2008, Brumm and Naguib 2009, Barber et al. 2010), but no recent review has covered the wide range of established and possible effects on birds. Therefore, the purpose of the present review is to (1) provide a general background for those unfamiliar with noise literature, (2) provide an update on the most current literature, and (3) suggest areas in need of future research that will enhance our comprehensive knowledge and ability to mitigate negative effects of noise.

How Sound Moves and Is Measured

Sound travels through air or other media in compression and expansion waves. The intensity of these waves produces a sound pressure level, which can be measured with a sound pressure meter. Sound pressure levels are typically measured over a period of time and expressed as a mean, which is most useful for studies of relatively continuous noise. For studies of intermittent noise, maximum sound levels may provide more meaningful measurements, as might other noise metrics that are reviewed in detail by Pater et al. (2009). The commonly used unit of measurement of sound pressure is the decibel (dB), a logarithmic measurement that can accommodate a wide range of frequencies. To put the dB scale in perspective, in the absence of environmental interference, an increase of 6 dB represents a doubling of loudness.

Not all sound pressures are perceived as equally loud because the ear (human or nonhuman) does not respond to all frequencies equally. For our convenience, we use a filter on sound level meters that respond to frequencies similarly to the human ear

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

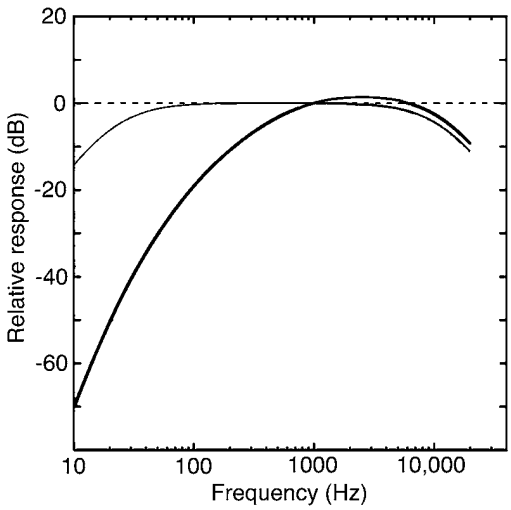


Fig. 1. A (thick line), C (thin line), and flat (black dashed line) decibel weighting systems.

(Fig. 1). This filter provides measurements on the "A scale," weighted for the range of human hearing. It is the most commonly used scale because much of our concern about noise is anthropocentric. In studies of potential effects of noise on nonhuman animals, especially those able to hear low frequencies, the C scale can be useful. For example, compared with humans, doves have ~40 dB more sensitivity at 1–10 Hz (Yodlowski et al. 1977, Kreithen and Quine 1979, Warchol and Dallos 1989, Schermuly and Klinke 1990); therefore, sounds in this range must be louder for us to hear them. The C scale used in conjunction with the A scale is useful to identify low-frequency sound because if the sound pressure levels consistently measure higher on the C scale than on the A scale, the difference might be explained by low-frequency noise. Alternatively, the distribution of acoustic energy can be assessed via analysis of recordings of the sound.

Degradation of sound structure differs with habitat as a result of differences in atmospheric spread, air turbulence, reflections, and scatter through materials such as vegetation (Brumm and Naguib 2009). This occurs through three main mechanisms: attenuation, reverberations, and irregular fluctuations in amplitude (Slabbekoorn et al. 2007). Attenuation is frequency dependent, with lower frequencies (sounds with longer wavelengths) being less affected by small objects (even molecules in the air) than higher frequencies; therefore, higher-frequency sounds usually attenuate faster, and lower frequencies travel farther. Reverberations, or echoes, reflect off surfaces in the environment numerous times and almost always arrive at the receiver later than the original signal, producing a variety of effects (Warren et al. 2006). Irregular fluctuations in amplitude are caused by air turbulence and accumulation of reverberations.

Under conditions without disruption of sound waves, sound levels decrease by 6 dB(A) with every doubling of distance from the sound source (Larkin et al. 1996). Therefore, if the study aims to identify effects of noise on birds, distance of a bird to the sound source must be considered. For a nest study, this involves measuring sound pressure level at the nest. For bird surveys, it requires taking Universal Transverse Mercator coordinates, compass bearing, and distance from the survey location to each bird detected; these values can be used with trigonometric functions to determine distance from each bird to the noise source. However, this method does not consider topography, vegetation, and other conditions that could alter noise attenuation. If it is practical, the investigator can also measure the sound level at the location of a bird after survey completion.

Effects of Noise on Birds

Many studies have focused on effects of landscape-scale conversions of visually differentiated habitat, but noise has received far less attention. Larkin et al. (1996:8) noted that

> Like other related fields such as effects of vehicles or recreation on wildlife…, effects of noise on wildlife often appear in the "gray literature" of conference proceedings and unpublished reports and manuscripts, rather than in the refereed scientific literature.

We have come some distance since 1996, but relatively few investigators currently work on this challenging new field of study.

Noise pollution affects birds in myriad ways, including (1) physical damage to ears; (2) stress responses; (3) fright–flight responses; (4) avoidance responses; (5) changes in other behavioral responses, such as foraging; (6) changes in reproductive success; (7) changes in vocal communication; (8) interference with the ability to hear predators and other important sounds; and (9) potential changes in populations. Reactions to noise depend on the type of noise produced, including frequency, loudness, consistency, and

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

duration. Some species react more negatively to noise than others. Colonial birds are highly susceptible to noise because when one bird reacts, many or all birds in a colony will react similarly (Burger 1998), whether the group responds directly to the noise or to the first bird(s) that responded.

Physical damage to ears.—Exposure to loud sounds damages sensory hair cells. In mammals, this results in permanent hearing loss. However, birds regenerate these hairs to some extent (Niemiec et al. 1994); therefore, damage is more temporary but with species-specific variation in recovery times (Ryals et al. 1999). Niemiec et al. (1994) reported increased recovery time with repeated exposure, which may have important implications for birds exposed to chronic or repeated noise. Physical damage to birds' ears occurs either with short-duration but very loud sounds (>140 dB[A] for single blasts or 125 dB[A] for multiple blasts; e.g., construction noise) or continuous (>72 h) exposure to noise >110 dB(A) (Dooling and Popper 2007). Some Federal agencies set noise standards within buffer zones for nests of high-priority species such as eagles, hawks, and owls; however, little else protects wild animals from noise.

Stress and fright–flight responses.—Chronic stress causes numerous physiological responses, including elevated heart rate, changes in hormone levels, and weight loss. Chronic stress also impairs the ability of birds to resist diseases and reduces their reproductive success (Blickley and Patricelli 2010). Some studies on noise and domesticated and laboratory animals have demonstrated fright–flight, avoidance, and agitation responses to noise (Environmental Protection Agency [EPA] 1980, Bowles 1995), yet these laboratory approaches to studying the effects of noise provide very little insight regarding how natural populations respond to noise. Much of the work conducted on stress and fright–flight responses under natural conditions focused on moving vehicles, such as aircraft (Brown 1990, Conomy et al. 1998, Trimper et al. 1998, Ward et al. 1999, Goudie 2006) and watercraft (Burger 1998, Rodgers and Schwikert 2002), which introduces confounding variables, especially visual disturbance.

Avoidance responses.—Avoidance appears to be the most common response to human disturbance, but some species are surprisingly tolerant and even seek out association with humans and disturbed habitats, including noisy habitats (e.g., House Finch [*Carpodacus mexicanus*] and Black-chinned Hummingbird [*Archilochus alexandri*]; Francis et al. 2009). Anthropogenic noise is almost always associated with other confounding disturbance variables (e.g., visual disturbances, vegetation, food resources, pollutants, concrete or asphalt effects on temperature, and perceived risks), which are difficult, if not impossible, to control.

Even though studies of road traffic noise are severely confounded by other variables, the effects of road-associated variables, including noise, measured by occupancy and densities, are consistently negative for most birds. Brotons and Herrando (2001), Forman and Deblinger (2000), and Fernández-Juricic (2001) found lower occupancy of birds near roads and attributed the lower numbers, in part, to traffic noise. In the Netherlands, Reijnen et al. (1995) controlled for visual aspects of the highway and found that noise was an important variable explaining lower occupancy near major roads. Although roads negatively affect a variety of taxa (Haskell 2000, Brotons and Herrando 2001, Reijnen and Foppen 2006), the overall effect of traffic noise on nesting birds, measured through lack of habitat occupancy, may extend >300 m on both sides of roadways (Forman and Deblinger 2000). From these and similar findings in the Netherlands (Reijnen et al. 1995), Forman (2000) and Forman and Alexander (1998) estimated that one-fifth of the United States is directly affected by traffic noise. Clearly, these studies have demonstrated that fragmentation and its associated variables, including noise, produce environmental and ecological impacts well beyond the edge of the physically altered habitat.

A few studies that controlled for noise as a single testable variable found species-specific avoidance of noisy areas. In New Mexico, Mourning Doves (*Zenaida macroura*) avoided gas-well-compressor noise, and several species nested significantly farther from well pads with noisy compressors than from gas well pads without compressors, including the Gray Flycatcher (*Empidonax wrightii*), Gray Vireo (*Vireo vicinior*), Black-throated Gray Warbler (*Setophaga nigrescens*), and Spotted Towhee (*Pipilo maculatus*) (Francis et al. 2009). During surveys, Western Scrub-Jays (*Aphelocoma californica*) and several other species were detected significantly more often on sites without compressors (Francis et al. 2009, Ortega and Francis 2012). In Canada, Bayne et al. (2008) found avoidance of noisy areas by Red-eyed Vireos (*V. olivaceus*), Yellow-rumped Warblers (*S. coronata*), and White-throated Sparrows (*Zonotrichia albicollis*); furthermore, they found 1.5× greater density of breeding birds near

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

noiseless energy facilities than near sites with noisy compressors.

Changes in foraging responses.—Results of a few studies have suggested negative effects of noise on foraging behavior. In Florida, Burger and Gochfeld (1998) observed significantly reduced foraging in five species with the presence of people compared with the absence of people, and the percentage of time spent foraging decreased with increased noise made by people. Similarly, but under laboratory conditions, Quinn et al. (2006) observed that Common Chaffinches (*Fringilla coelebs*) experienced reduced foraging with added white noise up to 68 dB(A). Canaday and Rivadeneyra (2001) found that machinery noise from petroleum exploration affected foraging guilds in Ecuador.

Changes in reproductive success.—Noise may affect egg production, incubation, brooding, predators, brood parasites, and abandonment, as well as the ability to find or attract a mate and the ability of parents to hear and respond to begging calls. Any species that regularly experience fright–flight responses (Southern and Southern 1979, Burger 1998) or an inability to attract mates and defend territories (Slabbekoorn and Ripmeester 2008) because of noise likely suffer reproductive loss. For some species, this may result in population declines.

Results of studies designed to determine effects of noise on reproductive success suggest species-specific variation. In Francis et al.'s (2009) study in northwest New Mexico, we found higher nest success near noisy gas well compressors than in quiet control sites because predators and cowbirds avoided noisy sites. However, as previously mentioned, many species avoided noisy areas and did not benefit from the lower level of predators and parasites. Black-chinned Hummingbirds preferred noisy sites, and House Finches often used gas-well-compressor equipment for nest sites where the sound pressure levels reached 85 dB(A) at the nest.

Noise may interfere with the ability to attract mates and maintain pair bonds. For example, in Alberta, Canada, male Ovenbirds (*Seiurus aurocapilla*) near gas well compressors experienced a 15% decrease in mate attraction (Habib et al. 2007). Additionally, Habib et al. (2007) found 18% more inexperienced (first-year) Ovenbirds at noisy compressor sites than at quieter control sites, which suggests that noise reduces the quality of habitat for these birds. Reproductive failure or reduced reproductive success can result in pair-bond degradation. In a laboratory experiment, Swaddle and Page (2007) reported that female Zebra Finches' (*Taeniopygia guttata*) preferences for their pair-bonded males decreased significantly with background noise. They suggested that in areas of high-amplitude environmental noise, birds may develop extra-pair behaviors because of weakened pair bonds.

Barton and Holmes (2007) reported reduced nest success close (<100 m) to trails with noisy off-highway vehicles compared with more distant locations in California. As in Francis et al.'s (2009) study, predators appeared to avoid the noisier sites. Barton and Holmes (2007) found 4× more nest abandonment near trails, whereas abandonment did not differ between noisy treatment sites and control sites in Francis et al.'s (2009) study (C. P. Ortega and C. D. Francis unpubl. data); the difference might be explained by chronic (24 h per day, 7 days per week) noise in the latter study compared with intermittent loud noise in the former. If birds select nest sites with chronic noise, to some degree they accept the conditions and may not abandon their nests in response to the noise. In areas with off-road vehicles, birds may select nest sites during the week when the immediate environment seems quiet compared with weekends, or they may select nest sites before the onset of the recreation season. In these cases, birds may not accept noisy conditions as part of the nest selection process, and this may result in nest abandonment.

Changes in vocal communication.—Across taxa, social relationships rely on communication, and vocal communication dominates much of the first-order contact in birds. Even though background noise can critically impair vocal communication, historically investigators did not focus on noise in studies of animal communication (Brumm and Slabbekoorn 2005). Over the past decade, many ornithological studies have focused on the effect of noise on communication.

Although we have a good understanding of a few species-specific responses—for example, in the Domestic Fowl (*Gallus gallus domesticus*; Brumm et al. 2009), Little Greenbul (*Andropadus virens*; Slabbekoorn and Smith 2002), Gray Flycatcher (*E. wrightii*) and Ash-throated Flycatcher (*Myiarchus cinerascens*; Francis et al. 2011), Great Tit (*Parus major*; Slabbekoorn and Peet 2003, Slabbekoorn and den Boer-Visser 2006, Pohl et al. 2009), Gray Shrike-thrush (*Colluricincla harmonica*; Parris and Schneider 2009), Gray Fantail (*Rhipidura*

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

fuliginosa; Parris and Schneider 2009), Common Nightingale (*Luscinia megarhynchos*; Brumm and Todt 2002; Brumm 2004, 2006), Eurasian Blackbird (*Turdus merula*; Nemeth and Brumm 2009, Ripmeester et al. 2010), Common Chaffinch (Brumm and Slater 2006), Song Sparrow (*Melospiza melodia*; Wood and Yezerinac 2006), Dark-eyed Junco (*Junco hyemalis*; Slabbekoorn et al. 2007), and House Finch (Badyaev et al. 2008)—we still have a great deal to learn about the responses of most species. However, many investigators have laid the groundwork for additional studies of noise.

Numerous studies have shown that environmental conditions constrain sound transmission. Vegetation affects the way that sound moves through different habitats (Ryan 1986, Slabbekoorn and Smith 2002, Hansen et al. 2005, Boncoraglio and Saino 2007, Simons et al. 2007, Pacifici et al. 2008) and different topographic environments (Brumm 2004, Warren et al. 2006, Slabbekoorn et al. 2007). Natural sounds (e.g., insect and other animal vocalizations, rain, wind, streams, and thunder) and anthropogenic noise can interfere with the detection and discrimination of vocal signals (often referred to as "masking"). Therefore, both natural sounds and anthropogenic noise play an essential role in determining the efficacy of vocal communication and also exert a selective pressure on the evolution of communication, often resulting in song frequencies that transmit most efficiently through a given environment (Morton 1975, Ryan and Brenowitz 1985).

Sound transmission differs with habitat (Slabbekoorn and Smith 2002, Slabbekoorn et al. 2007), but at least some birds compensate for these differences. For example, Slabbekoorn and Smith (2002) reported that song frequency of the Little Greenbul varies across habitat gradient in African rainforests. On an evolutionary scale, urban habitat is relatively novel, but some investigators pointed out that some urban settings are acoustically similar to cliffs, canyons, and other natural environments (Brumm 2004, Warren et al. 2006, Slabbekoorn et al. 2007). However, canyons and cliffs do not exist throughout all landscapes; therefore, many species are not adapted for the acoustics of canyons and cliffs. Furthermore, canyons and cliffs have not been well studied as selection pressures for communication in birds. Because urban areas are expanding on a global basis (Slabbekoorn et al. 2007), anthropogenic noise exerts an evolutionarily novel pressure on many birds worldwide.

In addition to environmental conditions, other selective pressures and constraints, such as body size (Morton 1975), vocal apparatus size (e.g., syrinx and bill characteristics; Ryan and Brenowitz 1985, Badyaev et al. 2008), and phylogeny (Ryan and Brenowitz 1985), influence evolution of bird song, with a trend of lower frequencies produced by larger birds (Ryan and Brenowitz 1985). When environmental conditions change, including background noise levels, natural selection will favor vocalizations that move effectively through the local habitat. Thus, changes in noise will affect both vocalizations and sensory drives (Ryan and Brenowitz 1985, Endler 1992). Other constraints, however, may preclude changes in vocalizations. For example, Badyaev et al. (2008) suggested that urban background noise should favor higher-frequency songs, but bill morphology, which is influenced by available food resources, may limit changes in song characteristics. In Arizona, they found that urban House Finches feed on larger, harder foods than their counterparts in the less disturbed Sonoran desert (e.g., sunflower seeds vs. cacti and grass seeds, respectively); they suggested that directional selection has favored larger bills in the urban population, resulting in a tradeoff between bill size and song characteristics important in courtship, particularly trills.

Noise can mask communication.—Masking occurs when sounds hide or interfere with the detection of a biologically relevant sound, such as vocal communication or sounds made by predators. Anthropogenic noise that masks vocal communication among birds can have serious consequences because birds use vocal communication to attract mates and defend territories (Slabbekoorn and Smith 2002, Wood and Yezerinac 2006, Barber et al. 2010); furthermore, noise can mask begging and alarm calls (Warren et al. 2006). Contact calls contribute to maintaining group cohesion, and if noise masks these calls, it can potentially result in lost individuals or breakdown of group cohesion. Exacerbating this problem, the "dawn chorus" temporally overlaps with one of the heaviest commuter-traffic rush hours. Therefore, noise may determine both habitat quality and reproductive success.

For effective communication, sounds transmitted by the sender must be detected by the receiver in forms with unaltered meaning. On the basis of data from 49 avian species tested both physiologically and behaviorally, Dooling and

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

Popper (2007) reported that birds hear, on average, best at frequencies between 1 and 5 kHz and hear well at the most sensitive frequencies of 2–4 kHz (Dooling 1982). In comparison, humans hear better over a broader frequency (20 Hz to 20 kHz, with most sensitivity 0.5–4.0 KHz; Dooling and Popper 2007); in other words, in general, birds must hear sounds at higher amplitudes than humans. Owls represent an exception and can hear much softer sounds than passerines and many nonpasserines (Dooling and Popper 2007), and some birds can hear in the ultrasonic range (Boncoraglio and Saino 2007). Dooling and Popper (2007) reported a general trend in which passerines and smaller birds also hear better at high frequencies whereas larger birds hear better at low frequencies. Long-distance communication ranges from 0.5 to ~6.0 kHz for typical birds; therefore, studies of masking communication should focus on this range (Dooling and Popper 2007). It may also be useful to provide a signal-to-noise ratio because detection and discrimination depend on both the signal and the background noise (Brumm and Todt 2002; Brumm 2004, 2006).

In Australia, Haff and Magrath (2010) investigated responses of nestling White-browed Scrubwrens (*Sericornis frontalis*) to various sounds; even though they responded (by ceasing begging calls) more strongly to natural predators than to white noise, they responded to broadband (both smooth and erratic) sounds more than to tonal sounds. Earlier, Maurer et al. (2003) had reported that nestling White-browed Scrubwrens begged to parental alarm calls, but they obtained their results under laboratory food-deprivation conditions. Magrath et al. (2007) also reported that adults emit a "food call" when they arrive with food, presumably to reduce the risk of erroneous begging. In Canada, Leonard and Horn (2008) found that nestling Tree Swallows (*Tachycineta bicolor*) responded to experimentally added white noise by emitting begging calls at higher minimum frequency and narrower frequency range, but added noise did not affect nestling growth. However, they used nest boxes, whereas Tree Swallows in natural conditions use cavities. Nestling–parent communication is likely muffled by wood, which differs between boxes and natural cavities. Little work has been done on responses of nestlings to various anthropogenic noise sources (but see Swaddle et al. 2012); however, the studies cited above suggest that noise pollution may affect communication between parents and nestlings.

Very little work has been conducted on birds' responses to what I would call "vocal communication interference levels." This has been extensively studied in humans and is referred to as "speech interference level" (Kryter 1994). It differs from the complete masking phenomenon that covers up or hides sounds; with speech interference, the sound (speech, song, call, etc.) can be heard (it may even be very loud), but the sounds are unintelligible. For example, one can hear people talking very loudly in a room next door yet not understand one word of the conversation. Habib et al. (2007) proposed "song distortion" as an alternative hypothesis to complete masking of vocalization to explain why 15% fewer Ovenbirds experienced successful pairing near noisy compressors compared with quieter control sites. The effects of, or responses to, these garbled sounds may or may not be similar to the effects of complete masking (sounds that cannot even be heard). Pohl et al. (2009) tested this with Great Tits under laboratory conditions and found that noise interfered with signal detection; interestingly, detections were worse during simulations of the dawn chorus compared with both urban and woodland noises.

Birds can change their vocalizations to compensate for the masking effect through (1) changes in song or call frequency, (2) changes in amplitude, (3) changes in song component redundancies, and (4) temporal shifts to avoid morning rush hour or other noise. Birds might also respond to masking by changing their position within the vegetation layer to maximize vocal transmission, but this has not, to my knowledge, been investigated. However, Patricelli et al. (2007, 2008) found that male Red-winged Blackbirds (*Agelaius phoeniceus*) orient themselves to maximize the intent or message of their vocalizations.

Changes in song frequency.—Patricelli and Blickley (2006) suggested two ways in which birds adjust frequency in response to low-frequency noise: (1) by increasing the lowest frequency with no change in the highest frequency, or (2) by shifting the entire vocalization to higher frequency. Slabbekoorn and Peet (2003), Slabbekoorn and den Boer-Visser (2006), and Mockford and Marshall (2009) discovered that Great Tits sing at a higher minimum frequency in noisy locations than in quieter locations. Great Tits apparently have plasticity in their vocal repertoires that enables them to breed successfully in locations with varying noise levels. Halfwerk and Slabbekoorn (2009)

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

also demonstrated that Great Tits responded to experimentally added low-frequency noise with songs consisting of higher minimum frequency, and they responded to experimentally added high-frequency noise with songs consisting of lower maximum frequency. At least some birds respond to noise with vocal repertoires consisting of songs that differ in frequency (Arcese et al. 2002) and by singing the songs least masked by background noise or by changing the frequency of particular songs in their repertoire (Wood and Yezerinac 2006, Halfwerk and Slabbekoorn 2009). Individuals may learn, during their own sensitive periods, particular songs least masked by noises around them (Wood and Yezerinac 2006).

Many species have shown the same pattern in different parts of the world. Wood and Yezerinac (2006) reported that Song Sparrows in urban areas in and near Portland, Oregon, sing higher-frequency low notes compared with their counterparts living in rural areas. Slabbekoorn et al. (2007) found that Dark-eyed Juncos in urban California sing at higher minimum frequency than populations living in forests. In Vienna, Austria, Nemeth and Brumm (2009) found higher song frequencies and shorter, albeit not statistically significant, intervals between singing bouts among urban Eurasian Blackbirds. Ripmeester et al. (2010) reported that city-dwelling Eurasian Blackbirds in the Netherlands sang at a higher peak frequency than their counterparts in forests. In Australia, Gray Shrike-thrushes increased the frequency of their songs in response to traffic noise (Parris and Schneider 2009). Individual Black-capped Chickadees (*Poecile atricapillus*) also shift the frequency of their song, but this has been reported in social contexts rather than in the context of background noise (Ratcliffe and Weisman 1985, Hill and Lein 1987). Nemeth and Brumm (2009) suggested, as an alternative to masking, that motivational states of higher arousal from higher urban bird densities may also explain the faster-paced, higher-frequency songs. Nemeth and Brumm (2010) further suggested that among urban Great Tits and Eurasian Blackbirds, vocal amplitude had a much larger effect on transmission distance than vocal pitch, and that song frequency shifts might be a side effect of singing at higher amplitudes.

Changes in amplitude.—Amplitude shifts, also referred to as the "Lombard effect" and first described as a human response (Brumm and Todt 2002, Warren et al. 2006; name derived from Lombard 1911), may allow birds to be heard in noisy areas. For example, Common Nightingales increase the volume of their singing with traffic noise (Brumm 2004) and white noise (Brumm and Todt 2002). This response has also been reported in Blue-throated Hummingbirds (*Lampornis clemenciae*), Zebra Finches and Budgerigars (*Melopsittacus undulatus*; reviewed in Warren et al. 2006), and Domestic Fowl (Brumm et al. 2009). Some birds may already produce songs or portions of songs at maximum levels; for example, although Brumm and Todt (2002) found that Common Nightingales sing at higher amplitudes in noisy environments, some elements or portions of their song did not increase in response to increased noise because, presumably, those elements were already at the highest possible amplitude.

Changes in song components and redundancies.—Brumm and Slater (2006) found that in naturally noisy areas, male Common Chaffinches sing some song components for longer bouts than their counterparts in quieter areas. However, they delivered fast trills in shorter bouts, which perhaps suggests a tradeoff between attracting females (attracted to trills) and reducing neuromuscular fatigue. Beyond this study, to my knowledge, very little work has been conducted in this area.

Temporal changes in singing.—We do not know much about species-specific reactions to noise that involve temporal shifts in singing. However, Brumm (2006) found that Common Nightingales can adjust the timing of their peak singing to avoid acoustic interference (in this case, playbacks of other species' songs), and Ficken et al. (1974) reported that Least Flycatchers (*Empidonax minimus*) and Red-eyed Vireos shifted their timing to avoid heterospecific overlap. Fuller et al. (2007) reported shifts from diurnal to nocturnal singing among European Robins (*Erithacus rubecula*). Similar temporal shifts have also been reported in frogs (Zelick and Narins 1982, 1983; Schwartz and Wells 1983; Narins 1995).

Interference with the ability to hear predators and other important sounds.—In addition to communication, hearing is critical for detecting predators and other dangers and opportunities in the environment (Quinn et al. 2006, Slabbekoorn and Ripmeester 2008, Barber et al. 2010). If sounds made by predators, such as footsteps, breathing, and rustling leaves, are masked by noise, the immediate situation becomes considerably more risky for potential prey. Also, even in the absence of noise made

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

by predators (e.g., aerial predators; Leavesley and Magrath 2005), if noise masks warning calls (by conspecifics or heterospecifics), the perception of danger may be underestimated, resulting in inappropriate, perhaps lethal responses. Conversely, from a predator's perspective, many birds and other animals find food resources through listening (Goerlitz et al. 2008). For example, American Robins (*Turdus migratorius*) listen for sounds of worms underground (Montgomerie and Weatherhead 1997), and many raptors depend on noises made by their prey (Knudsen and Konishi 1979, Rice 1982). This seems a relatively unexplored topic.

Sounds are also critical for an animal's ability to determine its orientation and move across a landscape. The contribution of sounds to the environment is referred to as a "soundscape," and the use of perceived sounds for general orientation within a landscape is referred to as "soundscape orientation" (Slabbekoorn and Bouton 2008). For example, animals use sounds to find water sources and protected areas. Soundscapes are particularly important for nocturnal animals and animals that move through caves or dense vegetation.

Challenges, Needs, and Opportunities

Isolating noise from confounding variables.—Determining effects of noise on free-ranging birds and other wildlife is particularly challenging because we rarely have the opportunity to isolate noise as a single testable variable. Numerous studies have suggested that human disturbances negatively affect birds and other wildlife species in a variety of ways. In many of these studies, noise is coupled with human disturbance, including snowmobiles (Creel et al. 2002, Seip et al. 2007), all-terrain vehicles (Barton and Holmes 2007), trails (Taylor and Knight 2003, Trulio and Sokale 2008), boating (Rodgers and Schwikert 2002, Peters and Otis 2006, Rojek et al. 2007), roads and traffic (Reijnen et al. 1995, Brotons and Herrando 2001), aircraft (Carney and Sydeman 1999, Giese and Riddle 1999, Goudie 2006, Rojek et al. 2007), and ski resorts (Ballenger and Ortega 2001).

However, none of these earlier studies separated noise from the effects of other disturbance. For example, studies on the effect of human noise (talking, laughing, etc.) are confounded with disturbance caused by physical presence of people (Burger and Gochfeld 1998) and with foraging opportunities provided by people (Fernández-Juricic 2001). Similarly, studies on the effects of road or highway noise (Brotons and Herrando 2001) are confounded with effects of habitat fragmentation caused by the roads themselves, the physical movement of traffic, perceived risks of traffic and increased predators, and vehicular exhaust. A few studies have demonstrated that birds and other wildlife can also be negatively affected by nonmotorized human recreational activities—for example, hiking with or without dogs on and off leash, horseback riding, cycling, and ski-slope activities—and some species are more disturbed by humans on foot than by motorized vehicles (Mallord et al. 2007, Patthey et al. 2008, Reed and Merenlender 2008, Stankowich 2008). The most definitive conclusion from most of these studies is that some aspect or several aspects of human disturbance negatively affect birds.

Our ability to detect birds with noise during surveys.—Ortega and Francis (2012) determined that sound pressure levels above 45 dB(A) significantly impaired our ability to detect birds; therefore, surveys in noisy areas likely underestimate bird occupancy. This is particularly relevant in studies aimed at comparing sites that differ in noise levels. For example, studies of fragmentation are often coupled with noisy activities, such as roads and other development. The effects of background noise clearly vary among observers' abilities to aurally detect birds, and species vary in their detectability. Pacifici et al. (2008) reported at 100 m, detection probabilities ranged from 0 to 1, and 3–99% of birdsongs were detected during a birdsong simulation experiment. They suggested that surveys focused on particular species might yield the best results. However, when the objective is to compare communities between or among sites, surveyors need to count all birds. In another simulated experiment, Simons et al. (2007) found that observers overcount within 50 m and undercount beyond that distance, and the mean number of birdsongs detected decreased by 41% with 10 dB(A) of added white noise.

Indirect effects that could change landscapes.—The indirect effects of noise, to my knowledge, have not been well studied, but at least one study has suggested potential effects on habitat because some birds that provide ecological services, such as pollination and seed dispersal, are affected either positively (e.g., Black-chinned Hummingbirds) or negatively (e.g., Western Scrub-Jays) by noise (Francis et al. 2009, 2012; Ortega and Francis 2012). Francis et al. (2009) reported on the potential of noise pollution from gas well compressors

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

to alter the future distribution of piñon–juniper (*Pinus edulis–Juniperus osteosperma*) forests because at least one of the main dispersers (Western Scrub-Jays) of piñons were notably absent from the noisy compressor sites. Currently, we do not know how noise indirectly affects other habitats.

Who regulates noise, where, and how?—The federal Office of Noise Abatement and Control (under the authority of the Environmental Protection Act) closed in 1981 because they concluded that noise issues would be better handled at the local level. Currently, states, counties, and municipalities regulate noise from an anthropocentric perspective with little or no consideration for wildlife species, although some federal land management agencies set their own noise tolerance levels for the benefit of wildlife, but usually for charismatic species sensitive to disturbance. Local regulations are often very lenient, with many loopholes, exclusions, and exemptions that promote special interests (for links to state regulations, see www.epa.gov/epahome/state.htm). For example, in Colorado, under Article 12, Noise abatement, section 25-12-103, Maximum permissible noise levels: "This article is not applicable to the use of property for the purpose of manufacturing, maintaining, or grooming machine-made snow." Other exclusions include athletic, entertainment, cultural, and patriotic events.

Sound pressure levels are also very lenient. For example, in Colorado, the limit set for motorized vehicles measured from 50 feet (15.2 m) from the center line of a road is 86 dB(A) and 90 dB(A) for speeds less than and exceeding, respectively, 35 mph (56.3 kph). Limits for off-road vehicles are almost as lenient, at 82 dB(A) and 86 dB(A) for below and above 35 mph (56.3 kph), respectively. Additionally, the same regulations state that

> In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurement.

This does not take into account the cumulative effects of noise pollution and makes for regulation with little or no teeth, set within a framework of ambiguity.

Without more stringent and enforceable regulations, reducing noise pollution will require citizen consciousness and compliance. With increasing urban sprawl and its associated noise pollution, louder and more frequent noises throughout the world, and bird population declines, the responsibility rests with researchers to provide useful information on the effects of noise pollution on birds and other wildlife and how noise can best be mitigated.

What kind of mitigation is possible?—In order to plan mitigation for noise, we need to understand the major sources of noise. Anthropogenic noise is nothing new, but the sounds of outdoor markets and horses clopping along cobblestone streets have been traded for more contemporary noises that now dominate our soundscape. Noise can conveniently be categorized as (1) long-term and relatively constant, such as noise from industry and business as well as housing (e.g., air conditioning and exhaust fans); (2) regular but intermittent, such as air and road traffic; and (3) temporary noise, such as military activities, special events, and domestic conveniences (e.g., lawn mowers, chainsaws, weed trimmers, leaf blowers, snow blowers, cell phones, car horns and alarms). Many temporary noises, however, collectively produce a constant urban hum.

Most noises can be muffled better; others are unnecessary (e.g., car horns to confirm activated alarms). Noise from industry can also be muffled, but unless regulations require it, industries may not volunteer to pay the high cost of current mitigation technology, such as noise reduction barriers. Bayne et al. (2008) estimated that retrofitting a compressor station with sound reduction equipment would cost $35,000–50,000. They also compared the estimated $175–250 million cost to reduce noise by 4 dB(A) throughout the energy sector in boreal Alberta with the $100 billion influx from the energy sector over the next 5 to 10 years (Habib et al. 2007, Bayne et al. 2008); they suggested that it would be a cost-effective best management practice.

Mitigation measures that have been suggested to reduce traffic noise include (1) using road surfaces that absorb more sound (Slabbekoorn and Ripmeester 2008, Blickley and Patricelli 2010); (2) reducing speed, especially during the breeding season (Makarewicz and Kokowski 2007, Parris and Schneider 2009, Slabbekoorn and Ripmeester 2008); (3) shuttle buses, especially in parks (Barber et al. 2010); and (4) seasonal road closures in important breeding areas to the extent feasible (Slabbekoorn and Ripmeester 2008). Parris and Schneider (2009) and Blickley and Patricelli (2010) pointed out that sound barriers for roads would reduce noise pollution but hinder wildlife movements. This is a management area in need of

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

further investigation. For many species, sound barriers make movement across roads difficult or impossible, but they may also prevent animal–vehicle collisions. Sound barriers do not necessarily have to extend to the ground and, coupled with wildlife overpasses, could be a potential solution, at least in some areas. Research on solutions as well as potential implementation might be funded by a noise tax (Sandberg 1991).

Mitigation measures will come with a financial burden; therefore, it is unlikely that industry will adopt them voluntarily or that citizens will willingly accept mitigation costs passed on by industry. As Blickley and Patricelli (2010) suggested, reduction of noise pollution will take policy action in terms of adjusted noise-level standards and mitigation measures to meet new standards. Before policy makers can make these important and perhaps controversial decisions, they will need compelling scientific evidence that noise negatively affects some species of birds and other wildlife, especially species of concern.

Although variation exists among species, the difference in masking threshold is ~6 dB(A) less in humans than in birds; in other words, humans can detect sounds with 6 dB(A) greater background noise compared with the typical bird (Dooling and Popper 2007). This has important implications for potential mitigation. Sound pressure levels decrease by ~6 dB(A) for every doubling of distance from the sound source. This implies that at least some birds can no longer detect a sound at half the distance from the noise source as a human can hear it. Therefore, humans are poor judges of what masks sounds for birds. In other words, compared with humans, birds may be less disturbed by noise closer to the source (e.g., highway noise, compressor noise, etc.), but the masking effects are greater.

Future research needs.—The EPA identified a need for research in three major areas involving the effects of noise on wildlife: (1) effects of long-term exposure to moderate noise levels, (2) whether wild animals experience the same adverse reactions to noise as laboratory animals, and (3) the ecological consequences of masking and altered behavioral patterns (EPA 1980). Thirty years have passed since the agency made these suggestions; however, relatively few research efforts since have addressed these three areas of need.

More recently, Warren et al. (2006) also suggested three, albeit different, areas in need of research: (1) the relationship between spatial distribution of noise and variation in communication, (2) potential relationship between timing of noise levels and the dawn chorus, and (3) the acoustics of canyons. They pointed out that, in addition to contributing to knowledge that benefits conservation and management planning strategies, these research topics would have the additional benefit of contributing to our overall knowledge of avian communication.

We are still on the forefront of our understanding of how at least some birds can adjust their vocalizations in response to noise pollution. But to my knowledge, in addition to the above research suggestions, we do not yet know the answers to many other critical questions (outlined below) and how all the information (known and unknown) interconnects.

(1) We know that some species change frequency or loudness of their songs in response to noise, but our knowledge comes from relatively few species. In order to generalize about common responses of birds to noise, we must increase our understanding of species-specific responses, covering at least the major taxonomic groups of birds. It may also be useful to know whether species within the major taxonomic groups of birds respond to noise in similar ways.

(2) Most research on effects of noise on bird communication has focused on song. However, other important vocalizations (e.g., alarm calls, contact calls, begging vocalizations, and invitation-to-copulation calls) have not been studied as much.

(3) We know little about how females respond to changes in vocalization or whether noise interferes with their ability to orient themselves in a spatially appropriate manner. Most of our knowledge comes from a few studies of frogs. For example, Bee and Swanson (2007; cited in Barber et al. 2010) reported that female Gray Treefrogs (*Hyla chrysoscelis*) take longer to orient themselves to male signals in the presence of traffic noise playbacks. Parris et al. (2009) pointed out a tradeoff between audibility and mate attraction in frogs that may apply to at least some bird species. They suggested that female Common Eastern Froglets (*Crinia signifera*) prefer lower-frequency songs because they indicate larger males, yet males call at a higher frequency in areas of traffic noise.

(4) In natural habitats, sound does not attenuate in a symmetrical spherical pattern because of permanent (e.g., topography) and temporary (e.g., atmospheric conditions) features. In general, lower frequencies degrade less in dense vegetation than

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

higher frequencies; however, lower frequencies attenuate more rapidly when emitted close to the ground (Boncoraglio and Saino 2007). Animals can spatially orient themselves to maximize hearing and vocalizing. For example, some birds directionally orient themselves in ways that maximize transmission of communication (Boncoraglio and Saino 2007, Patricelli et al. 2008). Therefore, one might expect that birds can change their position within the vegetation layers in addition to directional orientation to maximize their vocal transmissions.

(5) There may be an interesting relationship between abundance of certain species in noisy areas and their song frequency; birds with higher dominant song frequency may be more abundant near roads and other noisy areas (Rheindt 2003). Further investigation would help us predict effects of noise, particularly with new roads, industry, and energy extraction activities.

(6) Very little work has teased apart two major elements of noise masking: detection (signal not heard) and discrimination (signal heard but unintelligible). Distinction between these elements might be important if birds can still respond to certain components of a garbled song or call.

(7) We do not have an understanding of how noise has affected, or might affect in the future, birds at the population level. A necessary component of this would be to gain a better understanding of the effects of noise on the communication system between nestlings and their parents. Potential population changes will likely have to be modeled using soundscape information in geographic information systems (GIS). This will open up opportunities for interdisciplinary collaboration with GIS experts, planners, architects, acoustical physicists, agencies, and biologists in various disciplines. Many workgroups are already working on soundscape maps; for example, noise contours are regularly mapped for airports (Warren et al. 2006), and the National Park Service is developing a soundscape program. GIS maps with context options (e.g., time of day, seasons, and when particular events such as train trips or sporting events occur) should be invaluable tools for predicting bird population changes due to noise.

(8) We do not, to my knowledge, know how noise might affect competition for resources. For example, Ortega and Francis (2012) found that Violet-green Swallows (*Tachycineta thalassina*) are significantly more common on treatment sites (with noisy compressors) than on control sites (gas wells without compressors). One hypothesis is that the compressor noise eliminates bats that might overlap with swallows during the dawn and dusk hours, leaving more food resources for swallows.

(9) In order to determine the role of noise in predator–prey relationships, we need to better understand how noise affects the success of predators by masking sounds of their prey. Conversely, we need to understand how noise affects the ability of prey to detect predators.

(10) As mentioned above, noise is often difficult to study as a single testable variable. Several studies have used noise from gas well compressors because the noise can be turned off, and these sites can easily be compared with ecologically similar habitat adjacent to or surrounding gas wells without compressors. Conversely, adding noise is relatively easy but has both advantages and disadvantages of creating a situation that birds did not choose. It is easier to study human-created noise—at least in some situations, such as the energy sector—than to study the effects of noise in the natural world. However, it is not impossible to isolate naturally occurring noises. One opportunity to isolate naturally occurring noise as a single testable variable involves noise from flowing water. This may be logistically challenging but not impossible. Regulated streams can be "turned off" long enough to conduct bird surveys or experiments. These periods can be compared with times when streams flow and are noisy. Dam operators might be willing to cooperate as long as the requested times do not significantly interfere with water delivery. It could even be as simple as coordinating research activities with already scheduled dam operations.

(11) Many birds provide ecological services, such as seed dispersal, pollination, and pest control. At this point in time, we have a poor understanding of how noise affects these birds and how these effects may, in turn, affect the future distribution of certain habitats.

(12) Many birds incorporate songs of other species into their vocal repertoires. For example, David Attenborough hosted a revealing video of a Superb Lyrebird (*Menura novaehollandiae*) imitating sounds of camera shutters, car alarms, and chainsaws (www.youtube.com/watch?v=OFDdtRD5ED8). Similar accounts exist on the Internet of other birds, especially Northern Mockingbirds (*Mimus polyglottos*) and Eurasian Blackbirds (Stover 2009), imitating various cell phone rings and tones, ambulances, and other common urban noises. Presumably, incorporation of these anthropogenic

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

noises increases their overall repertoires, yet we do not know how females respond to these novel vocalizations.

The Future for Birds in a Noisier World

Noise is nothing new to many avian species, especially colonial species that collectively make deafening noises themselves. Some species have presumably lived with natural sound, such as streams, waterfalls, and wind, for a very long time. Anthropogenic noise pollution will continue to challenge many other species, and whether or not they can coexist with noise will depend on (1) the degree of sound spectrum overlap between anthropogenic noise and important acoustic cues in their world; (2) the degree to which other sensory forms can compensate for reduced hearing; (3) how other organisms (e.g., predators, competitors, parasites, seed dispersers, pollinators, and other organisms that provide ecological services) in the community respond to noise pollution; and (4) the extent to which males and females can coordinate their responses.

Sounds have always been an integral part of the environment, but changes by humans, resulting in noise pollution, have disturbed the integrity of natural ecosystems. Barber et al. (2010:8) suggested that "Taken collectively, the preponderance of evidence argues for immediate action to manage noise in protected natural areas." Management of noise will be necessary to maintain or restore the integrity of natural ecosystems. This will require numerous actions: (1) sound scientific research to better understand the complicated and sometimes seemingly underlying effects of noise pollution; (2) raising the collective consciousness of society about the harmful effects, including information on how citizens can reduce their contribution to noise pollution; and (3) working with policy makers to tighten regulations and enforcement of noise sources.

Literature Cited

Arcese, P., M. K. Sogge, A. B. Marr, and M. A. Patten. 2002. Song Sparrow (*Melospiza melodia*). *In* The Birds of North America, no. 704 (A. Poole and F. Gill, Eds.). Birds of North America, Philadelphia.

Badyaev, A. V., R. L. Young, K. P. Oh, and C. Addison. 2008. Evolution on a local scale: Developmental, functional, and genetic bases of divergence in bill form and associated changes in song structure between adjacent habitats. Evolution 62:1951–1964.

Ballenger, N., and C. P. Ortega. 2001. Effects of ski resort fragmentation on wintering birds in southwest Colorado. Journal of the Colorado Field Ornithologists 35:122–128.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology & Evolution 25:180–189.

Barton, D. C., and A. L. Holmes. 2007. Off-highway vehicle trail impacts on breeding songbirds in northeastern California. Journal of Wildlife Management 71:1617–1620.

Bayne, E. M., L. Habib, and S. Boutin. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. Conservation Biology 22:1186–1193.

Bee, M. A., and E. M. Swanson. 2007. Auditory masking of anuran advertisement calls by road traffic noise. Animal Behaviour 74:1765–1776.

Blickley, J. L., and G. L. Patricelli. 2010. Impacts of anthropogenic noise on wildlife: Research priorities for the development of standards and mitigation. Journal of International Wildlife Law and Policy 13:274–292.

Boncoraglio, G., and N. Saino. 2007. Habitat structure and the evolution of bird song: A meta-analysis of the evidence for the acoustic adaptation hypothesis. Functional Ecology 21:134–142.

Bowles, A. E. 1995. Responses of wildlife to noise. Pages 109–156 *in* Wildlife and Recreationists: Coexistence through Management and Research (R. L. Knight and K. J. Gutzwiller, Eds.). Island Press, Washington, D.C.

Brotons, L., and S. Herrando. 2001. Reduced bird occurrence in pine forest fragments associated with road proximity in a Mediterranean agricultural area. Landscape and Urban Planning 57:77–89.

Brown, A. L. 1990. Measuring the effect of aircraft noise on sea birds. Environment International 16:587–592.

Brumm, H. 2004. The impact of environmental noise on song amplitude in a territorial bird. Journal of Animal Ecology 73:434–440.

Brumm, H. 2006. Signalling through acoustic windows: Nightingales avoid interspecific competition by short-term adjustment of song timing. Journal of Comparative Physiology A 192:1279–1285.

Brumm, H., and M. Naguib. 2009. Environmental acoustics and the evolution of bird song. Advances in the Study of Behavior 40:1–33.

Brumm, H., R. Schmidt, and L. Schrader. 2009. Noise-dependent vocal plasticity in Domestic Fowl. Animal Behaviour 78:741–746.

Brumm, H., and H. Slabbekoorn. 2005. Acoustic communication in noise. Advances in the Study of Behavior 35:151–209.

Brumm, H., and P. J. B. Slater. 2006. Ambient noise, motor fatigue, and serial redundancy in chaffinch song. Behavioral Ecology and Sociobiology 60:475–481.

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

Brumm, H., and D. Todt. 2002. Noise-dependent song amplitude regulation in a territorial songbird. Animal Behaviour 63:891–897.

Burger, J. 1998. Effects of motorboats and personal watercraft on flight behavior over a colony of Common Terns. Condor 100:528–534.

Burger, J., and M. Gochfeld. 1998. Effects of ecotourists on bird behaviour at Loxahatchee National Wildlife Refuge, Florida. Environmental Conservation 25:13–21.

Canaday, C., and J. Rivadeneyra. 2001. Initial effects of a petroleum operation on Amazonian birds: Terrestrial insectivores retreat. Biodiversity and Conservation 10:567–595.

Carney, K. M., and W. J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68–79.

Coates, P. A. 2005. The strange stillness of the past: Toward an environmental history of sound and noise. Environmental History 10:636–665.

Conomy, J. T., J. A. Dubovsky, J. A. Collazo, and W. J. Fleming. 1998. Do Black Ducks and Wood Ducks habituate to aircraft disturbance? Journal of Wildlife Management 62:1135–1142.

Creel, S., J. E. Fox, A. Hardy, J. Sands, B. Garrott, and R. O. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. Conservation Biology 16:809–814.

Dooling, R. J. 1982. Auditory perception in birds. Pages 95–130 *in* Acoustic Communication in Birds, vol. 1 (D. E. Kroodsma and E. H. Miller, Eds.). Academic Press, New York.

Dooling, R. J., and A. N. Popper. 2007. The Effects of Highway Noise on Birds. [Report prepared for the California Department of Transportation, Sacramento; Jones and Stokes Associates.] [Online.] Available at www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf.

Endler, J. A. 1992. Signals, signal conditions, and the direction of evolution. American Naturalist 139 (Supplement):S125–S153.

Environmental Protection Agency. 1980. Effects of noise on wildlife and other animals: Review of research since 1971. EPA 550/9-80-100.

Feare, C. J., E. Henriette, and S. E. A. Feare. 2003. Variation in sound levels produced within a Sooty Tern colony. Waterbirds 26:424–428.

Fernández-Juricic, E. 2001. Avian spatial segregation at edges and interiors of urban parks in Madrid, Spain. Biodiversity and Conservation 10:1303–1316.

Ficken, R. W., M. S. Ficken, and J. P. Hailman. 1974. Temporal pattern shifts to avoid acoustic interference in singing birds. Science 183:762–763.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* 14:31–35.

Forman, R. T. T., and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology & Systematics 29:207–231.

Forman, R. T. T., and R. D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 14:36–46.

Francis, C. D., C. P. Ortega, and A. Cruz. 2009. Noise pollution changes avian communities and species interactions. Current Biology 19:1415–1419.

Francis, C. D., C. P. Ortega, and A. Cruz. 2011. Vocal frequency change reflects different responses to anthropogenic noise in two suboscine tyrant flycatchers. Proceedings of the Royal Society of London, Series B 278:2025–2031.

Francis, C. D., C. P. Ortega, R. I. Kennedy, and P. J. Nylander. 2012. Are nest predators absent from noisy areas or unable to locate nests? Pages 99–108 *in* The Influence of Anthropogenic Noise on Birds and Bird Studies (C. D. Francis and J. L. Blickley, Eds.). Ornithological Monographs, no. 74.

Fuller, R. A., P. H. Warren, and K. J. Gaston. 2007. Daytime noise predicts nocturnal singing in urban robins. Biology Letters 3:368–370.

Giese, M., and M. Riddle. 1999. Disturbance of Emperor Penguin *Aptenodytes forsteri* chicks by helicopters. Polar Biology 22:366–371.

Goerlitz, H. R., S. Greif, and B. M. Siemers. 2008. Cues for acoustic detection of prey: Insect rustling sounds and the influence of walking substrate. Journal of Experimental Biology 211:2799–2806.

Goudie, R. I. 2006. Multivariate behavioural response of Harlequin Ducks to aircraft disturbance in Labrador. Environmental Conservation 33:28–35.

Habib, L., E. M. Bayne, and S. Boutin. 2007. Chronic industrial noise affects pairing success and age structure of Ovenbirds *Seiurus aurocapilla*. Journal of Applied Ecology 44:176–184.

Haff, T. M., and R. D. Magrath. 2010. Vulnerable but not helpless: Nestlings are fine-tuned to cues of approaching danger. Animal Behaviour 79:487–496.

Halfwerk, W., and H. Slabbekoorn. 2009. A behavioural mechanism explaining noise-dependent frequency use in urban birdsong. Animal Behaviour 78:1301–1307.

Hansen, I. J. K., K. A. Otter, H. van Oort, and C. I. Holschuh. 2005. Communication breakdown? Habitat influences on Black-capped Chickadee dawn choruses. Acta Ethologica 8:111–120.

Haskell, D. G., 2000. Effects of forest roads on the macroinvertebrate soil fauna of the southern Appalachian mountains. *Conservation Biology* 14:57–63.

Hill, B. G., and M. R. Lein. 1987. Function of frequency-shifted songs of Black-capped Chickadees. Condor 89:914–915.

Knudsen, E. I., and M. Konishi. 1979. Mechanisms of sound localization in the Barn Owl (*Tyto alba*). Journal of Comparative Physiology A 133:13–21.

Kreithen, M. L., and D. Quine. 1979. Infrasound detection by the homing pigeon: A behavioral audiogram. Journal of Comparative Physiology A 129:1–4.

Kryter, K. D. 1994. The Handbook of Hearing and the Effects of Noise: Physiology, Psychology, and Public Health. Academic Press, San Diego, California.

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

Larkin, R. P., L. L. Pater, and D. J. Tazik. 1996. Effects of military noise on wildlife: A literature review. Technical Report 96/21. U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois.

Leavesley, A. J., and R. D. Magrath. 2005. Communicating about danger: Urgency alarm calling in a bird. Animal Behaviour 70:365–373.

Leonard, M. L., and A. G. Horn. 2008. Does ambient noise affect growth and begging call structure in nestling birds? Behavioral Ecology 19:502–507.

Lombard, É. 1911. Le signe de l'élévation de la voix. Annales des maladies de l'oreille et du larynx 37:101–119.

Magrath, R. D., B. J. Pitcher, and A. H. Dalziell. 2007. How to be fed but not eaten: Nestling responses to parental food calls and the sound of a predator's footsteps. Animal Behaviour 74:1117–1129.

Makarewicz, R., and P. Kokowski. 2007. Prediction of noise changes due to traffic speed control. Journal of the Acoustical Society of America 122:2074–2081.

Mallord, J. W., P. M. Dolman, A. F. Brown, and W. J. Sutherland. 2007. Linking recreational disturbance to population size in a ground-nesting passerine. Journal of Applied Ecology 44:185–195.

Maurer, G., R. D. Magrath, M. L. Leonard, A. G. Horn, and C. Donnelly. 2003. Begging to differ: Scrubwren nestlings beg to alarm calls and vocalize when parents are absent. Animal Behaviour 65:1045–1055.

Mockford, E. J., and R. C. Marshall. 2009. Effects of urban noise on song and response behaviour in Great Tits. Proceedings of the Royal Society of London, Series B 276:2979–2985.

Montgomerie, R., and P. J. Weatherhead. 1997. How robins find worms. Animal Behaviour 54:143–151.

Morton, E. S. 1975. Ecological sources of selection on avian sounds. American Naturalist 109:17–34.

Narins, P. M. 1995. Frog communication: In striving to be heard by rivals and mates, these amphibians have evolved a plethora of complex strategies. Scientific American 273(2):78–83.

Nemeth, E., and H. Brumm. 2009. Blackbirds sing higher-pitched songs in cities: Adaptation to habitat acoustics or side-effect of urbanization? Animal Behaviour 78:637–641.

Nemeth, E., and H. Brumm. 2010. Birds and anthropogenic noise: Are urban songs adaptive? American Naturalist 176:465–475.

Niemiec, A. J., Y. Raphael, and D. B. Moody. 1994. Return of auditory function following structural regeneration after acoustic trauma: Behavioral measures from quail. Hearing Research 75:209–224.

Ortega, C. P., and C. D. Francis. 2012. Effects of gas-well-compressor noise on the ability to detect birds during surveys in northwest New Mexico. Pages 78–88 *in* The Influence of Anthropogenic Noise on Birds and Bird Studies (C. D. Francis and J. L. Blickley, Eds.). Ornithological Monographs, no. 74.

Pacifici, K., T. R. Simons, and K. H. Pollock. 2008. Effects of vegetation and background noise on the detection process in auditory avian point-count surveys. Auk 125:600–607.

Parris, K. M., and A. Schneider. 2009. Impacts of traffic noise and traffic volume on birds of roadside habitats. Ecology and Society 14:29.

Parris, K. M., M. Velik-Lord, and J. M. A. North. 2009. Frogs call at a higher pitch in traffic noise. Ecology and Society 14:25.

Pater, L. L., T. G. Grubb, and D. K. Delaney. 2009. Recommendations for improved assessment of noise impacts on wildlife. Journal of Wildlife Management 73:788-795.

Patricelli, G. L., and J. L. Blickley. 2006. Avian communication in urban noise: Causes and consequences of vocal adjustment. Auk 123:639–649.

Patricelli, G. L., M. S. Dantzker, and J. W. Bradbury. 2007. Differences in acoustic directionality among vocalizations of the male Red-winged Blackbird (*Agelaius phoeniceus*) are related to function in communication. Behavioral Ecology and Sociobiology 61:1099–1110.

Patricelli, G. L., M. S. Dantzker, and J. W. Bradbury. 2008. Acoustic directionality of Red-winged Blackbird (*Agelaius phoeniceus*) song relates to amplitude and singing behaviours. Animal Behaviour 76:1389–1401.

Patthey, P., S. Wirthner, N. Signorell, and R. Arlettaz. 2008. Impact of outdoor winter sports on the abundance of a key indicator species of alpine ecosystems. Journal of Applied Ecology 45:1704–1711.

Peters, K. A., and D. L. Otis. 2006. Wading bird response to recreational boat traffic: Does flushing translate into avoidance? Wildlife Society Bulletin 34:1383–1391.

Pohl, N. U., H. Slabbekoorn, G. M. Klump, and U. Langemann. 2009. Effects of signal features and environmental noise on signal detection in the Great Tit, *Parus major*. Animal Behaviour 78:1293–1300.

Quinn, J. L., M. J. Whittingham, S. J. Butler, and W. Cresswell. 2006. Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*. Journal of Avian Biology 37:601–608.

Ratcliffe, L., and R. G. Weisman. 1985. Frequency shift in the fee bee song of the Black-capped Chickadee. Condor 87:555–556.

Reed, S. E., and A. M. Merenlender. 2008. Quiet, nonconsumptive recreation reduces protected area effectiveness. Conservation Letters 1:146–154.

Reijnen, R., and R. Foppen. 2006. Impact of road traffic on breeding bird populations. Pages 255–274 *in* The Ecology of Transportation: Managing Mobility for the Environment (J. Davenport and J. L. Davenport, Eds.). Springer-Verlag, Heidelberg, Germany.

Reijnen, R., R. Foppen, C. ter Braak, and J. Thissen. 1995. The effects of car traffic on breeding bird

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

populations in woodland. III. Reduction of density in relation to the proximity of main roads. Journal of Applied Ecology 32:187–202.

Rheindt, F. E. 2003. The impact of roads on birds: Does song frequency play a role in determining susceptibility to noise pollution? Journal für Ornithologie 144:295–306.

Rice, W. R. 1982. Acoustical location of prey by the Marsh Hawk: Adaptation to concealed prey. Auk 99:403–413.

Ripmeester, E. A. P., J. S. Kok, J. C. van Rijssel, and H. Slabbekoorn. 2010. Habitat-related birdsong divergence: A multi-level study on the influence of territory density and ambient noise in European blackbirds. Behavioral Ecology and Sociobiology 64:409–418.

Rodgers, J. A., Jr., and S. T. Schwikert. 2002. Buffer-zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats. Conservation Biology 16:216–224.

Rojek, N. A., M. W. Parker, H. R. Carter, and G. J. McChesney. 2007. Aircraft and vessel disturbances to Common Murres *Uria aalge* at breeding colonies in central California, 1997–1999. Marine Ornithology 35:61–69.

Rosen, G. 1974. A backward glance at noise pollution. American Journal of Public Health 64:514–517.

Ryals, B. M., R. J. Dooling, E. Westbrook, M. L. Dent, A. MacKenzie, and O. N. Larsen. 1999. Avian species differences in susceptibility to noise exposure. Hearing Research 131:71–88.

Ryan, M. J. 1986. Environmental bioacoustics: Evaluation of a commonly-used experimental design. Animal Behaviour 34:931–933.

Ryan, M. J., and E. A. Brenowitz. 1985. The role of body size, phylogeny, and ambient noise in the evolution of bird song. American Naturalist 126:87–100.

Sandberg, U. 1991. Abatement of traffic, vehicle and tire/road noise—A global perspective. Noise Control Engineering Journal 49:170–181.

Schermuly, L., and R. Klinke. 1990. Infrasound sensitive neurones in the pigeon cochlear ganglion. Journal of Comparative Physiology A 166:355–363.

Schwartz, J. J., and K. D. Wells. 1983. An experimental study of acoustic interference between two species of Neotropical treefrogs. Animal Behaviour 31:181–190.

Seip, D. R., C. J. Johnson, and G. S. Watts. 2007. Displacement of mountain caribou from winter habitat by snowmobiles. Journal of Wildlife Management 71:1539–1544.

Simons, T. R., M. W. Alldredge, K. H. Pollock, and J. M. Wettroth. 2007. Experimental analysis of the auditory detection process on avian point counts. Auk 124:986–999.

Slabbekoorn, H., and N. Bouton. 2008. Soundscape orientation: A new field in need of sound investigation. Animal Behaviour 76:e5–e8.

Slabbekoorn, H., and A. den Boer-Visser. 2006. Cities change the songs of birds. Current Biology 16:2326–2331.

Slabbekoorn, H., and M. Peet. 2003. Birds sing at a higher pitch in urban noise—Great Tits hit the high notes to ensure that their mating calls are heard above the city's din. Nature 424:267.

Slabbekoorn, H., and E. A. P. Ripmeester. 2008. Birdsong and anthropogenic noise: Implications and applications for conservation. Molecular Ecology 17:72–83.

Slabbekoorn, H., and T. B. Smith. 2002. Habitat-dependent song divergence in the Little Greenbul: An analysis of environmental selection pressures on acoustic signals. Evolution 56:1849–1858.

Slabbekoorn, H., P. Yeh, and K. Hunt. 2007. Sound transmission and song divergence: A comparison of urban and forest acoustics. Condor 109:67–78.

Southern, L. K., and W. E. Southern. 1979. Absence of nocturnal predator defense mechanisms in breeding gulls. Proceedings of the Colonial Waterbird Group 2:157–162.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. Biological Conservation 141:2159–2173.

Stover, D. 2009. Not so silent spring. Conservation Magazine 10 (1). [Online.] Available at www.conservationmagazine.org/articles/v8n2/not-so-silent-spring/.

Swaddle, J. P., C. R. Kight, S. Perera, E. Davila-Reyes, and S. Sikora. 2012. Constraints on acoustic signaling among birds breeding in secondary cavities: The effects of weather, cavity material, and noise on sound propagation. Pages 63–77 *in* The Influence of Anthropogenic Noise on Birds and Bird Studies (C. D. Francis and J. L. Blickley, Eds.). Ornithological Monographs, no. 74.

Swaddle, J. P., and L. C. Page. 2007. High levels of environmental noise erode pair preferences in Zebra Finches: Implications for noise pollution. Animal Behaviour 74:363–368.

Taylor, A. R., and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications 13:951–963.

Trimper, P. G., N. M. Standen, L. M. Lye, D. Lemon, T. E. Chubbs, and G. W. Humphries. 1998. Effects of low-level jet aircraft noise on the behaviour of nesting Osprey. Journal of Applied Ecology 35:122–130.

Trulio, L. A., and J. Sokale. 2008. Foraging shorebird response to trail use around San Francisco Bay. Journal of Wildlife Management 72: 1775–1780.

Warchol, M. E., and P. Dallos. 1989. Neural response to very low-frequency sound in the avian cochlear nucleus. Journal of Comparative Physiology A 166:83–95.

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

Ward, D. H., R. A. Stehn, W. P. Erickson, and D. V. Derksen. 1999. Response of fall-staging brant and Canada Geese to aircraft overflights in southwestern Alaska. Journal of Wildlife Management 63:373–381.

Warren, P. S., M. Katti, M. Ermann, and A. Brazel. 2006. Urban bioacoustics: It's not just noise. Animal Behaviour 71:491–502.

Wood, W. E., and S. M. Yezerinac. 2006. Song Sparrow (*Melospiza melodia*) song varies with urban noise. Auk 123:650–659.

Yodlowski, M. L., M. L. Kreithen, and W. T. Keeton. 1977. Detection of atmospheric infrasound by homing pigeons. Nature 265:725–726.

Zelick, R. D., and P. M. Narins. 1982. Analysis of acoustically evoked call suppression behaviour in a Neotropical treefrog. Animal Behaviour 30:728–733.

Zelick, R. D., and P. M. Narins. 1983. Intensity discrimination and the precision of call timing in two species of Neotropical treefrogs. Journal of Comparative Physiology A 153:403–412.

This content downloaded from 132.174.254.164 on Wed, 16 Mar 2016 03:00:19 UTC
All use subject to JSTOR Terms and Conditions

Synthesis of Noise Effects on Wildlife Populations

Paul A. Kaseloo (Phone: 804-524-6991, Email: pkaseloo@vsu.edu), Department of Biology, Virginia State University, Petersburg VA 23806

Abstract: This report contains a partial summary of a literature review dealing with the effect of noise on wildlife emphasizing the effects on birds. Beginning with studies in the Netherlands and, later, in the United States, a series of studies have indicated that road noise has a negative effect on bird populations (particularly during breeding) in a variety of species. These effects can be significant with 'effect distances' (i.e., those within which the density of birds is reduced) of two to three thousand meters from the road. In these reports, the effect distances increase with the density of traffic on the road being greatest near large, multilane highways with high densities. A similar effect has been reported for both grassland and woodland species. It is important to note that 1) not all species have shown this effect and 2) some species show the opposite response, increasing in numbers near roads or utilizing rights-of-way. It is important to determine the cause of this effect and to utilize additional or alternative methods beyond population densities as the sole measure of effect distance, because the latter is susceptible to variation due to changes in overall population density. Recommendations for further study are given, including alternative measures of disturbance in birds.

Introduction

This presentation summarizes part of a larger report that reviewed literature dealing with the effect of noise on wildlife on a wide variety of species (Kaseloo and Tyson 2004). Here, the responses reported for bird species are summarized, because they have been reported to show the most dramatic negative response to road noise of any group and this response appears proportionate to the level of traffic on the road. According to a recent estimate, 20% of the land area of the United States may be ecologically affected by public roads (Forman 2000). This estimate is based, in part, on findings of the effect of road noise on the density of bird populations. In these studies "effect distance" is defined as the distance from the road to the point at which reduced density was no longer recorded.

Effect of Road Noise on Bird Species

In an early study (a re-analysis of previous work), avoidance of roads was found for at least two species (lapwing and black-tailed godwit) of grassland birds (van der Zande et al. 1980). A subsequent study of grassland birds found seven of 12 species had reduced breeding densities near roads and that the effect distance increased from 20-1,700 m at 5,000 vehicles/day to 65-3,530 m at 50,000 vehicles/day (Reijnen et al. 1996). A longer-term (five-year) study near Boston found that, at least for two species of grassland birds studied (bobolinks and meadowlarks), the effect distances increased from no effect at 3,000-8,000 vehicles/day to 1,200 m at traffic densities of 30,000 vehicles/day or more (Forman et al. 2002).

In a study of woodland species, 26 of 43 (60%) were found to show a decrease in population densities with effect distances that also increased with the amount of traffic. The effect distances ranged from 50-1,500 m at 10,000 vehicles/day and increased to 70-2,800 m at 60,000 vehicles/day (Reijnen et al. 1995b). A further, multi-year study found that 17 of 23 species showed a reduction in breeding bird density in at least one year of the study (average 40,000-52,000 vehicles/day) (Reijnen and Foppen 1995a). This effect was reduced in years of high overall population density. The authors concluded that high overall population densities led to an underestimation of the quality of the habitat as the numbers of birds were forced into poorer-quality areas under these conditions (Reijnen and Foppen 1995a; see also Reijnen et al. 1997, figure 1).

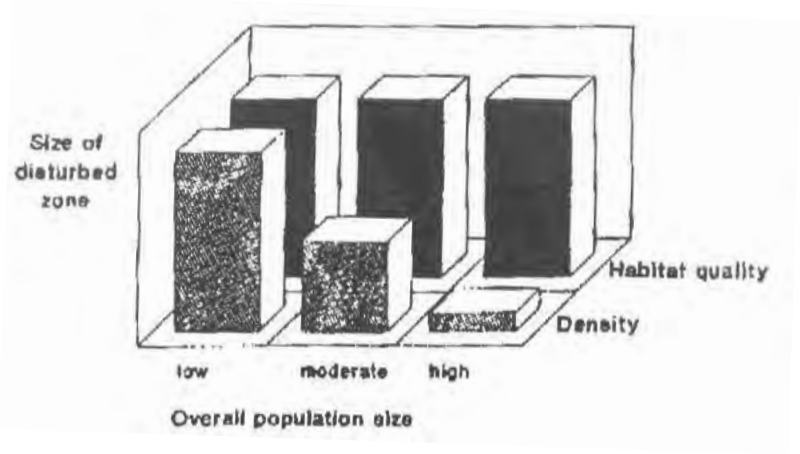


Figure 1. Schematic representation of the effect of disturbance by traffic on habitat quality (solid) and density (hatched) of breeding birds in relation to overall population size. (Reprinted with the kind permission of Springer Science and Business Media from Reijnen et al. 1997.)

Based on these results, sound levels above 50 dB(A) could be considered potentially deleterious, and the effect distance was estimated to be an average of 1,000 m (Reijnen et al. 1997). The existing model of the effect on birds assumes that noise is the presumptive major causative factor (see figure 2) because of the distances involved in the effect. However, it is important to consider that no multi-species study has found all species to be sensitive. In several studies that cover a wide range of habitat types it has been shown that while some species become less common near the road, others show the opposite effect, and the importance of these (ecotonal) species may also need to be considered in evaluating the impact of roads (Michael et al. 1976; Clark and Karr 1979; Ferris 1979; Adams and Geis 1981). It should be noted that noise was not the focus of these studies, but the fact that population densities vary dramatically between species merits consideration. Other species have been shown to breed in exceptionally noisy environments such as near roads and airports (e.g., Awbrey et al. 1995). Finally, a number of studies have found that rights-of-way can provide breeding habitat for some species and that management of this area can be important, particularly in areas where disturbance (e.g., from agricultural activity) farther from the road may preclude the use of alternative areas (Oetting and Cassel 1971; Voorhees and Cassel 1980; Laursen 1981; Warner and Joselyn 1986; Warner 1992). Again, it should be noted that noise was not the focus of these studies, but the close proximity of significant numbers of breeding birds of various types (pheasants, ducks, passerines) to the road (interstate highways) indicates that noise from the road is not an absolute barrier to breeding, particularly if alternative areas are not readily available.

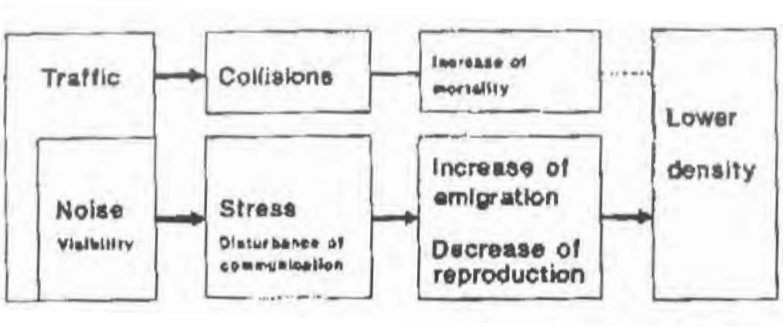


Figure 2. Probable relationship between traffic and density of breeding birds. (Reprinted with the kind permission of Springer Science and Business Media from Reijnen et al. 1997.)

The fact that the reduction in density of some species is proportional to traffic density supports the idea that noise is having a significant effect on these species. However, the effect is not universal and needs to be considered in terms of the surrounding habitat as well as species in question.

Recommendations for Future Study

Because the effect attributed to road noise can be extremely significant and has been shown to occur in a number of studies and across a wide variety of species, this effect must be investigated further. One central question that has yet to be resolved is whether noise in isolation is sufficient to cause this effect. To this point it has been assumed that noise is the cause because of the large effect distances and because other potential sources (e.g., visual disturbance, pollution, etc.) are unlikely to have an influence at such distances (Forman et al. 2002). If noise can be established as the cause of this effect, then mitigation efforts that are able to reduce noise alone can be expected to produce the desired response (i.e., may make habitat more attractive to species that had been avoiding these areas). In addition, the time for such a response to occur needs to be evaluated (i.e., over what time frame does a study need to be conducted to see a response). Because birds can be territorial it may take some time for them to reoccupy an area, even if acoustic conditions are more favorable.

The proximate effects of traffic noise on avian physiology have not been quantified. Since density alone can be a misleading indicator as to habitat quality (see also van Horne 1983), additional measures need to be employed to evaluate the stress the bird is experiencing. Such factors could include physiological measures of stress such as hormone levels or behavioral or activity measures that would indicate a bird is experiencing less or more favorable conditions. In breeding birds, the fecundity or fledging success might be useful indicators as well. Finally, areas of noise mitigation exist, and, although many of these may be near heavily populated regions, careful examination of these areas may reveal test sites that can be used for comparison to other (non-mitigated) areas so long as sufficient similarities (e.g., community composition, patch size, etc.) for comparison remain. These areas may present an opportunity for study without the need to construct or modify existing roads for such comparisons, although creation of controlled sites with high and low noise levels may ultimately prove necessary.

An accurate assessment of the impact of road noise will only be possible once the nature of the effect of road noise on birds is determined so that predictions as to the magnitude of the disturbance can be made.

Acknowledgments: The report summarized here was supported through the Federal Highway Administration through a cooperative agreement (DTFH61-03-H-00123).

Biographical Sketch: Dr. Paul Kaseloo is currently an assistant professor in the Biology Department at Virginia State University. He has a Ph.D. in zoology and physiology from the University of Wyoming, where his research involved the energy costs of diving and digestion in ducks. His broader research interests include the physiological ecology of vertebrates. He authored a review of the effects of noise on wildlife through the Federal Highway Administration Minority Institutions of Higher Education Competitive Assistance Program.

References

Adams, L. W. and A. D. Geis. 1981. Effects of highways on wildlife. Federal Highway Administration Technical Report No. FHWA/RD-81/067.

Awbrey, F .T., D. Hunsaker, and R. Church. 1995. Acoustical responses of California gnatcatchers to traffic noise. *Inter-noise* 65: 971-974.

Clark, W. D. and J. R. Karr. 1979. Effects of highways on red-winged blackbird and horned lark populations. *Wilson Bulletin* 91: 143-145.

Ferris, C. R. 1979. Effects of interstate 95 on breeding birds in northern Maine. *Journal of Wildlife Management*. 43: 421-427.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* 14: 31-35.

Forman, R. T. T., B. Reineking, and A. M. Hersperger. 2002. Road traffic and nearby grassland bird patterns in a suburbanizing landscape. *Environmental Management* 29: 782-800.

Kaseloo, P. A. and K. O. Tyson. 2004. Synthesis of Noise Effects on Wildlife Populations. FHWA Report.

Laurensen, K. 1981. Birds on roadside verges and the effect of mowing on frequency and distribution. *Biological Conservation* 20: 59-68.

Michael, E. D., C. R. Ferris, and E. G. Haverlack. 1976. Effects of highway rights of way on bird populations. Proceedings of the First National Symposium on Environmental Concern: 253-261.

Oetting, R. B. and J. F. Cassel. 1971. Waterfowl nesting on interstate right-of-way in North Dakota. *Journal of Wildlife Management* 35: 774-781.

Reijnen, R. and R. Foppen. 1995a. The effects of car traffic on breeding bird populations in woodland. IV. Influence of population size on the reduction of density close to the highway. *Journal of Applied Ecology* 32: 481-491.

Reijnen, R., R. Foppen, C. Ter Braak, and J. Thissen. 1995b. The effects of car traffic on breeding bird populations in woodland. III. Reduction in the density in relation to the proximity of main roads. *Journal of Applied Ecology* 32: 187-202.

Reijnen, R., R. Foppen, and H. Meeuwsen. 1996. The effects of car traffic on the density of breeding birds in Dutch Agricultural Grasslands. *Biological Conservation* 75: 255-260.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and planning and managing road corridors. *Biodiversity and Conservation* 6: 567-581.

van der Zande, A. N., W. J. ter Keurs, and W. J. Van der Weijden. 1980. The impact of roads on the densities of four bird species in an open field habitat–evidence of a long distance effect. *Biological Conservation* 18: 299-321.

van Horne, B. 1983. Density as a misleading indicator of habitat quality. *Journal of Wildlife Management* 47: 893-901.

Voorhees, L. D. and F. J. Cassel. 1980. Highway right-of-way: mowing versus succession as related to duck nesting. *Journal of Wildlife Management* 44: 155-163.

Warner, R. E. and G. B. Joselyn. 1986. Responses of Illinois ring-necked pheasant populations to block roadside management. *Journal of Wildlife Management* 50: 525-532.

Warner, R. E. 1992. Nest ecology of grassland passerines on road rights-of-way in central Illinois. *Biological Conservation* 59: 1-7.

Also, Albertson (1995) documented a rail abandoning its territory in Laumeister marsh, shortly after a repair crew worked on a nearby transmission tower.

Data on reproductive success of nests near heavily trafficked areas are lacking. Clapper rails nesting next to regularly disturbed areas are likely to be subject to higher rates of predation due to easy access provided by trails, levees, and roads. Disturbance of incubating or brooding adults may translate into reduced hatch or fledge success of young through increased nest predation if the adult vacates the nest, or through temperature stress (heat or cold) due to lack of thermoregulation by the adult. Reduced reproductive success results in reduced recruitment to an already unstable endangered population. In addition, continued disturbance may stress the adults and reduce survival through disruption of normal activities, such as reduced foraging or resting time or increased susceptibility to predators. Reduced survival of adult clapper rails, which has been identified as the most critical life stage in population models (M. Johnson unpubl. data; Foin *et al.* 1997), may also impact the long-term viability of the population.

The ramifications of disturbance related to human traffic during breeding season primarily include effects on eggs and chicks or the season's reproductive effort. In addition, anthropogenic noise may also impact survival of adults. Adults may be more responsive to noise during the breeding season, as their mating system is based primarily on auditory signals. Loud noises may elicit calling or prevent advertising calls from being heard, which could disrupt pair bonding and mating efforts. Studies of noise criteria suggest that noise levels above 80 to 85 decibels (dB) are disruptive to normal behavioral patterns in birds (Transportation Noise Control Center 1997). Clapper rails may be sensitive to noise throughout the year, as rails were heard calling in response to a nearby jackhammer in September (Evens *in litt*. 2009).

Clapper rail reactions to disturbance may vary with season; however, both breeding and non-breeding seasons are critical times. Disturbance during the nonbreeding season may primarily affect survival of adult and subadult rails. Adult clapper rail mortality is greatest during the winter (Eddleman 1989, Albertson 1995), primarily due to predation (Albertson 1995). Human-related disturbance of clapper rails in the winter, particularly during high tide and storm events, may increase vulnerability to predators. The presence of people and their pets in the high marsh plain or near upland areas during winter high tides may prevent rails from leaving the lower marsh plain (Evens and Page 1983). Rails that remain in the marsh plain during inundation are vulnerable to predation due to minimal vegetative cover available (Evens and Page 1986). This situation is exacerbated in small diked marshes with little to no high tide refugia or high marsh plain.

Although clapper rails may occur in areas with high levels of human-related disturbance, the effects of the disturbance on the rails is unknown and potentially significant. Many marshes only support very small clapper rail populations (*e.g.* only two rails detected at BSRA in 2005; Herzog *et. al*. 2005), which suggests that even minor incursions could disrupt and potentially extirpate vulnerable small populations or subpopulations. Because most clapper rail marshes are subjected to a variety of uses, the cumulative detrimental effects may be appreciable. Numerous routine human activities have the potential to adversely affect individual rails and overall population viability, for example, flood control; levee, dredge lock, pipeline, and powerline maintenance; recreational uses including bird watching and water sports; human and domestic

A framework for understanding noise impacts on wildlife: an urgent conservation priority

Clinton D Francis[1*†] and Jesse R Barber[2†]

Anthropogenic noise is an important environmental stressor that is rapidly gaining attention among biologists, resource managers, and policy makers. Here we review a substantial literature detailing the impacts of noise on wildlife and provide a conceptual framework to guide future research. We discuss how several likely impacts of noise exposure have yet to be rigorously studied and outline how behavioral responses to noise are linked to the nature of the noise stimulus. Chronic and frequent noise interferes with animals' abilities to detect important sounds, whereas intermittent and unpredictable noise is often perceived as a threat. Importantly, these effects can lead to fitness costs, either directly or indirectly. Future research should consider the range of behavioral and physiological responses to this burgeoning pollutant and pair measured responses with metrics that appropriately characterize noise stimuli. This will provide a greater understanding of the mechanisms that govern wildlife responses to noise and help in identifying practical noise limits to inform policy and regulation.

Front Ecol Environ 2013; doi:10.1890/120183

An emerging aim in applied ecology and conservation biology is to understand how human-generated noise affects taxonomically diverse organisms in both marine (eg Slabbekoorn *et al.* 2010; Ellison *et al.* 2012) and terrestrial (eg Patricelli and Blickley 2006; Barber *et al.* 2010; Kight and Swaddle 2011) environments. Noise is a spatially extensive pollutant and there is growing evidence to suggest that it may have highly detrimental impacts on natural communities; yet efforts to address this issue of emerging conservation concern lack a common framework for understanding the ecological consequences of noise. A conceptual scaffold is critical to scientific progress and to its ability to inform conservation policy. As more attention and resources are invested in understanding the full ecological effects of noise, it is important that investigators design research questions and protocols in light of the many possible costs associated with noise exposure and also that they properly link responses to several relevant features of noise, such as intensity, frequency, or timing, that could explain wildlife responses (Panel 1).

Here we introduce a framework using a mechanistic approach for how noise exposure can impact fitness at the level of the individual organism as a result of changes in behavior, and identify several acoustic characteristics that are relevant to noise exposure and ecological integrity. We provide representative examples of noise impacts, primarily from terrestrial systems; however, these issues are equally applicable to organisms in aquatic environments. We stress that various responses to noise exposure are less obvious than those that have typically been studied to date, such as signal modifications (eg changes in vocal frequency, amplitude, or vocalization timing) and decreases in site occupancy (eg Bayne *et al.* 2008; Francis *et al.* 2011b). Importantly, probable behavioral responses to noise that merit further scientific study might be detrimental to individual fitness and may have severe population-level consequences. As we show below, the presence of a species in a noisy area cannot be interpreted as an indication that it is not being impacted by elevated sound levels, because there are many potential costs associated with noise exposure that have not been rigorously studied.

In a nutshell:

- Noise is an intense, widespread pollutant, relevant to conservation efforts worldwide
- Using the number of animals present in environments exposed to anthropogenic noise as the sole metric of noise impacts can be deceiving because there are many hidden costs of noise exposure (eg compromising predator/prey detection or mating signals, altering temporal or movement patterns, increasing physiological stress)
- To ensure that conservation initiatives (and efforts to establish regulatory limits) are relevant, investigators must properly characterize a suite of noise features
- Reducing noise exposure and incorporating sound measurement into environmental planning will quickly benefit ecological systems

[1]*National Evolutionary Synthesis Center, Durham, NC; current address: Biological Sciences Department, California Polytechnic State University, San Luis Obispo, CA* [*]*(cdfranci@calpoly.edu);* [2]*Department of Biological Sciences, Boise State University, Boise, ID;* [†]*the authors contributed equally to this work*

Variation in responses to the same noise stimulus

Species differ in their sensitivities to noise exposure (Bayne *et al.* 2008; Francis *et al.* 2009, 2011a); however,

© The Ecological Society of America

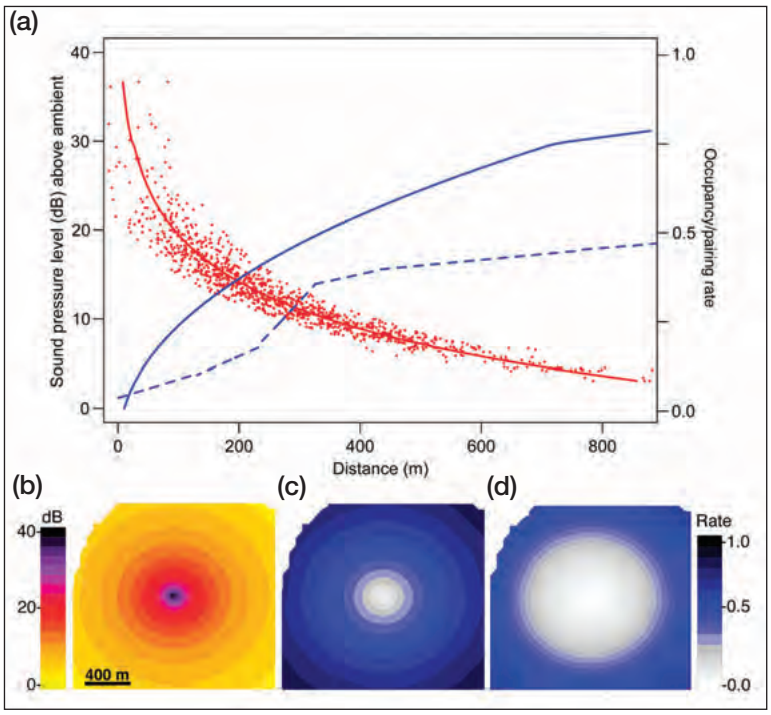


Figure 1. *Responses to the same noise stimulus can take a variety of shapes. (a) The sound pressure level (SPL) of noise (red) decreases with increasing distance from the source but may not reach "baseline" ambient levels until ~1 km away (this distance will vary depending on noise source and the environment). Response curves for species occupancy (blue solid line) and pairing rates (blue dashed line) in response to noise may have unique shapes, as might other measures of species responses to noise stimuli. The relationship between SPL and distance is from Francis* et al. *(2011c) and Francis (unpublished data) with noise generated from gas well compressors. Behavioral responses are hypothetical but based on responses in Francis* et al. *(2011c). (b) Spatial propagation of elevated noise levels from a point source (such as a single car or an oil/gas compressor station), which decays at a spreading loss of 6 dB or more per doubling of distance, due to the geometry of the spherical wave front. It is important to note that line sources (such as a busy highway; not shown) lose only 3 dB per doubling of distance due to their cylindrical wave front. Clearly, knowledge of the geometry of anthropogenic noise stimuli is essential to understanding the scale of exposure. (c and d) Spatial representation of (c) species occupancy and (d) pairing success surrounding a point source of noise.*

the degree to which individuals vary in sensitivity to noise during each life-history stage or due to behavioral context has been underappreciated. For example, ovenbird (*Seiurus aurocapilla*) habitat occupancy appears uninfluenced by noise exposure (Habib *et al.* 2007; Bayne *et al.* 2008; Goodwin and Shriver 2011), yet males defending noisy territories are less successful in attracting mates (Habib *et al.* 2007). Reed buntings (*Emberiza schoeniclus*) also show reduced pairing success in noisy areas (Gross *et al.* 2010). Such examples should serve as a warning to biologists, land managers, and policy makers: the same noise stimulus can affect various response metrics in different ways. An organism might show little to no response to noise in terms of habitat occupancy or foraging rate, for example, but may experience strong negative impacts in terms of pairing success, number of offspring, physiological stress, or other measures of fitness (Figure 1). Because the various responses may range from linear to threshold functions of noise exposure, investigators should take an integrative approach that incorporates several different metrics (eg density, pairing success, number of offspring), rather than using a single metric to describe how noise influences their study organism. But which alterations in behavior are most likely to occur and which are the most detrimental? These are important questions because funding and logistical constraints ensure that measuring all of the potential impacts of noise is impossible. Fortunately, the nature of sound stimuli can guide investigators toward likely behavioral changes that may influence fitness.

Characterizing noise and the disturbance–interference continuum

Determining whether a particular noise stimulus is within an organism's sensory capabilities is foremost in importance; if a sound consists of frequencies that are outside of an organism's hearing range, it will not have a direct effect (Panel 1; Figure 2). Provided that an organism can hear the noise stimulus, its acoustic energy could cause permanent or temporary hearing loss, but this might only occur when the animal is extremely close to the source of the noise (Dooling and Popper 2007).

Instead, sounds may have their greatest influence on behavior, which then translates into fitness costs, but how and why noise elicits a response can vary greatly (Figures 2 and 3). At one extreme, noise stimuli that startle animals are perceived as threats and generate self-preservation responses (eg fleeing, hiding), which are similar to responses to real predation risk or nonlethal human disturbance (ie the risk–disturbance hypothesis, which posits that animal responses to human activities are analogous to their responses to real predation risk; Frid and Dill 2002). Noise stimuli at this end of the continuum are often infrequent, but are abrupt and unpredictable. At the other end of the continuum, noise can impair sensory capabilities by masking biologically relevant sounds used for communication, detection of threats or prey, and spatial navigation. These noise stimuli tend to be frequent or chronic and their spectral (ie frequency) content overlaps with biologically relevant sounds. Increases in noise intensity (loudness or amplitude) will increase the severity of the impacts, regardless of whether it is perceived as a threat or masks biologically relevant sounds. An important supplement to this dichotomy is

 © The Ecological Society of America

that limited stimulus processing capacity could be responsible for some detrimental effects. Noise stimuli of various kinds might act as a distraction, drawing the animal's attention to a sound source and thereby impairing its ability to process information perceived through other sensory modalities (Chan *et al.* 2010). Alternatively, noise may reduce auditory awareness, trigger increased visual surveillance, and compromise visually mediated tasks. The mechanistic details and ecological importance of such distractions still need to be fully explored. Regardless, the conservation implications of understanding the importance of noise as a distractor are not trivial; if distraction is a fundamental route for noise impacts, our concern might spread beyond those frequencies that overlap with biologically relevant signals.

Behavioral changes

Although a limited number of laboratory studies have suggested that noise may affect gene expression, physiological stress, and immune function directly (Figure 3a; Kight and Swaddle 2011), most noise-related impacts appear to involve behavioral responses across four categories: (1) changes in temporal patterns, (2) alterations in spatial distributions or movements, (3) decreases in foraging or provisioning efficiency coupled with increased vigilance and anti-predator behavior, and (4) changes in mate attraction and territorial defense (Figure 3). As demonstrated below, these disturbance-, distraction-, and masking-mediated behavioral changes could directly impact individual survival and fitness or lead to physiological stress that may then compromise fitness.

Changes in temporal patterns

Sound stimuli that are perceived as threats can alter temporal patterns; for example, red foxes (*Vulpes vulpes*) cross busy roads when traffic rates are lower, suggesting noise cues might be affecting the timing of their movements (Figure 3b; Baker *et al.* 2007). Similarly, noise from boat traffic disrupts the timing of foraging by West Indian manatees (*Trichechus manatus*), potentially influencing foraging efficiency and energy budgets (Figure 3m; Miksis-Olds *et al.* 2007). Noise can also change behavior due to interference with cue detection. European robins (*Erithacus rubecula*) avoid acoustic interference from urban noise by singing at night, when noise levels are lower than during daylight hours (Figure 3c; Fuller *et al.* 2007). Although this example may appear to be an

Panel 1. Sound features relevant to noise-impact studies

In the main text we discuss how the spectral (frequency) composition of noise is related to an organism's hearing range and its ability to detect relevant sounds. For these reasons, it is critical that researchers collect sound-level data with an appropriate frequency-weighting filter. For instance, the "A" filter on many sound-level meters is based on equal loudness contours for human hearing; this filter provides a conservative estimate of bird hearing and is the best readily-available weighting for bird studies (Dooling and Popper 2007). However, whether working with birds or other taxa, it is best to simultaneously record and measure the noise using a "flat" frequency filter, then truncate the resulting spectral output to the most relevant frequency range for each species of interest (see below).

Investigators should also avoid the temptation to characterize a noise stimulus as a single decibel value, whether weighted or not, as other metrics that describe the noise are equally important (Figure 2). Time-averaged values, such as equivalent continuous sound level (L_{eq}), can be extremely informative to describe sounds that are chronic or frequent; however, these integration times do not properly characterize sounds that occur once, infrequently, or more regularly. Instead, measurements integrated over several hours will mischaracterize short, abrupt sounds that could be viewed as disturbances, such as noise events created by infrequent and loud military jet overflights that alter the behavior and time budgets of harlequin ducks (*Histrionicus histrionicus*; WebFigure 1; Goudie 2006). For disturbance sounds, exposure metrics that capture each sound event's maximum power (L_{max}; WebFigure 1a) and the rate at which power rises from the lowest detectable level to its maximum are important (ie onset; Figure 2). L_{max} values are often reported without stating the frequency weighting; in these cases, A-weighting (a human-centric curve) is assumed, which may be inappropriate for many animals.

In contrast, quantification of chronic noise can best be served with time-averaged values such as L_{eq} (WebFigure 1b). L_{eq} is typically calculated over 24 hours; however, many studies fail to report over what time period L_{eq} values were integrated and a 24-hr integration is assumed, which may not be appropriate for many ecological questions. For example, for a species that is sensitive to traffic noise, such as the white-breasted nuthatch (*Sitta carolinensis*; WebFigure 1b; Goodwin and Shriver 2011), it may be best to truncate the time interval to the hours of biological interest, such as during dawn chorus. Limiting frequency analyses to the hearing or vocal range of the target species or community may also be beneficial (eg Halfwerk *et al.* 2011b). Future studies should aim to use biologically relevant integration times and report these details.

Best practices will include simultaneous acquisition of high-quality audio recordings along with multiple sound level measurements to offer unconstrained opportunities to investigate alternative spectral filtering, time integration, and additional measurements, such as order statistics indicating the percentage of time above a certain decibel level or metrics reflective of the sound event's predictability (Figure 2). Carefully considering how these temporal, intensity, and frequency features (Figure 2b) interact will help investigators identify where along the disturbance–interference continuum (Figure 2a) the stimulus is most likely to fall and will help identify the most likely behavioral responses (Figure 3).

Above all, to maximize interpretability of results, facilitate comparisons among studies, and provide meaningful data for conservation measures, it is critical to explicitly report the acoustic metrics used in each study to describe species responses. Additional sound metric and terminology details can be found in Barber *et al.* (2011) and Pater *et al.* (2009).

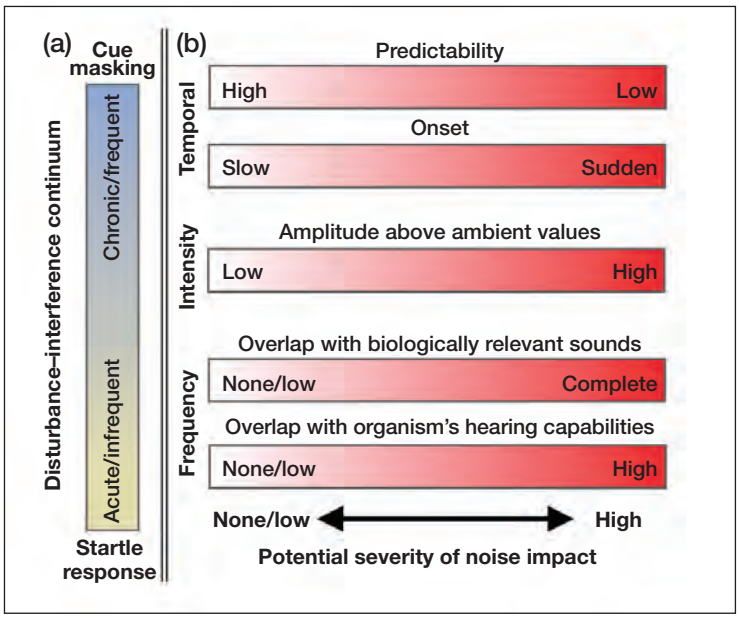


Figure 2. *(a) The disturbance–interference continuum can range from acute or infrequent noise stimuli that will likely trigger startle or hide responses to frequent or chronic noises that interfere with cue detection. (b) The severity of an impact from a noise stimulus will depend on the temporal, intensity, and frequency features of the stimulus.*

important behavioral adaptation that permits this species to overcome unfavorable acoustic conditions, the consequences of shifting the timing of song delivery are unknown. The effects of signal timing on mate attraction or territorial defense may be just as important to fitness as other signal features (eg frequency, syntax). Changes in the timing of song delivery of less than one hour can break down signaler–receiver coordination so that conspecific males do not recognize species-specific signals (Luther 2008). If signaler–receiver coordination is disrupted between singing males and responsive females, the behavioral flexibility that permits shifts in signal timing in response to noise may possibly be maladaptive.

Sleep is an important factor and follows a strong temporal profile. Although a substantial body of research has investigated the impact of noise on sleep in humans, scant information is available regarding its effects in other animals (reviewed in Kight and Swaddle 2011). Understanding the importance of sleep disruption on overall fitness is critical as we might expect detrimental influences even for species not typically described as dependent upon hearing (eg visually oriented predators such as raptors).

Alterations in spatial distributions or movements

Among the most obvious responses to noise are site abandonment and decreases in spatial abundance. These metrics may also be easiest and least costly to quantify, which perhaps explains why there are many such examples in the literature (eg Bayne *et al.* 2008; Eigenbrod *et al.* 2008; Francis *et al.* 2009). However, noise itself can affect an investigator's ability to measure responses to noise. For example, increases in continuous noise of 5–10 decibels (dB, A-weighted; Panel 1) above baseline can reduce bird numbers during standard bird surveys by one-half, greatly biasing measures of site occupancy and abundance (Ortega and Francis 2012). If not carefully considered, this detection problem could bias subsequent interpretations and management efforts.

Despite the known effects of noise on population sizes, there is still considerable evidence to suggest that animals may abandon areas when frequent or chronic noise stimuli interfere with cue detection or when more variable sounds are perceived as threats (Bayne *et al.* 2008; Goodwin and Shriver 2011; Blickley *et al.* 2012a). Birds with low-frequency vocalizations experience more acoustic interference from chronic low-frequency anthropogenic noise and therefore exhibit stronger negative responses to noise in their habitat use than birds with high-frequency vocalizations that experience less acoustic interference (Figure 3e; Francis *et al.* 2011a). These masking effects can be spatially extensive, potentially impairing communication at distances ranging from 0.5 to 1.0 km or farther from the noise source (Blickley and Patricelli 2012). Furthermore, changes in spatial distributions due to noise's effect on cue detection are not restricted to intraspecific communication; for instance, greater mouse-eared bats (*Myotis myotis*), which locate terrestrial prey based on sounds they generate when walking, also avoid hunting in noisy areas (Figure 3f; Schaub *et al.* 2008). In addition to disrupting cue detection at the intra- and interspecific level, ambient noise may also interfere with cue detection used for movement at larger spatial scales. Some frog species use conspecific calls to locate appropriate breeding habitat, while some newt species use heterospecific calls for the same purpose (reviewed in Slabbekoorn and Bouton 2008). Whether noise exposure impedes animals from using such acoustic beacons to locate critical resources (eg water, food, habitat) is unknown and should be a focus of future research.

Site abandonment or decreases in population numbers can also occur in response to unpredictable, erratic, or sudden sounds, which are perceived as threats (Figure 3d). For example, greater sage grouse (*Centrocercus urophasianus*) lek attendance declines at a higher rate in response to experimentally introduced intermittent road noise than to continuous noise (Blickley *et al.* 2012a), suggesting that sage grouse site occupancy may depend more on perceived risk than on masking of acoustic cues. Nevertheless, masking of communication may have other consequences (Figure 1).

Species undoubtedly differ in their sensitivities to disruptive sounds, but individuals within a population also show such differences (Bejder *et al.* 2006). Individuals can

 © The Ecological Society of America

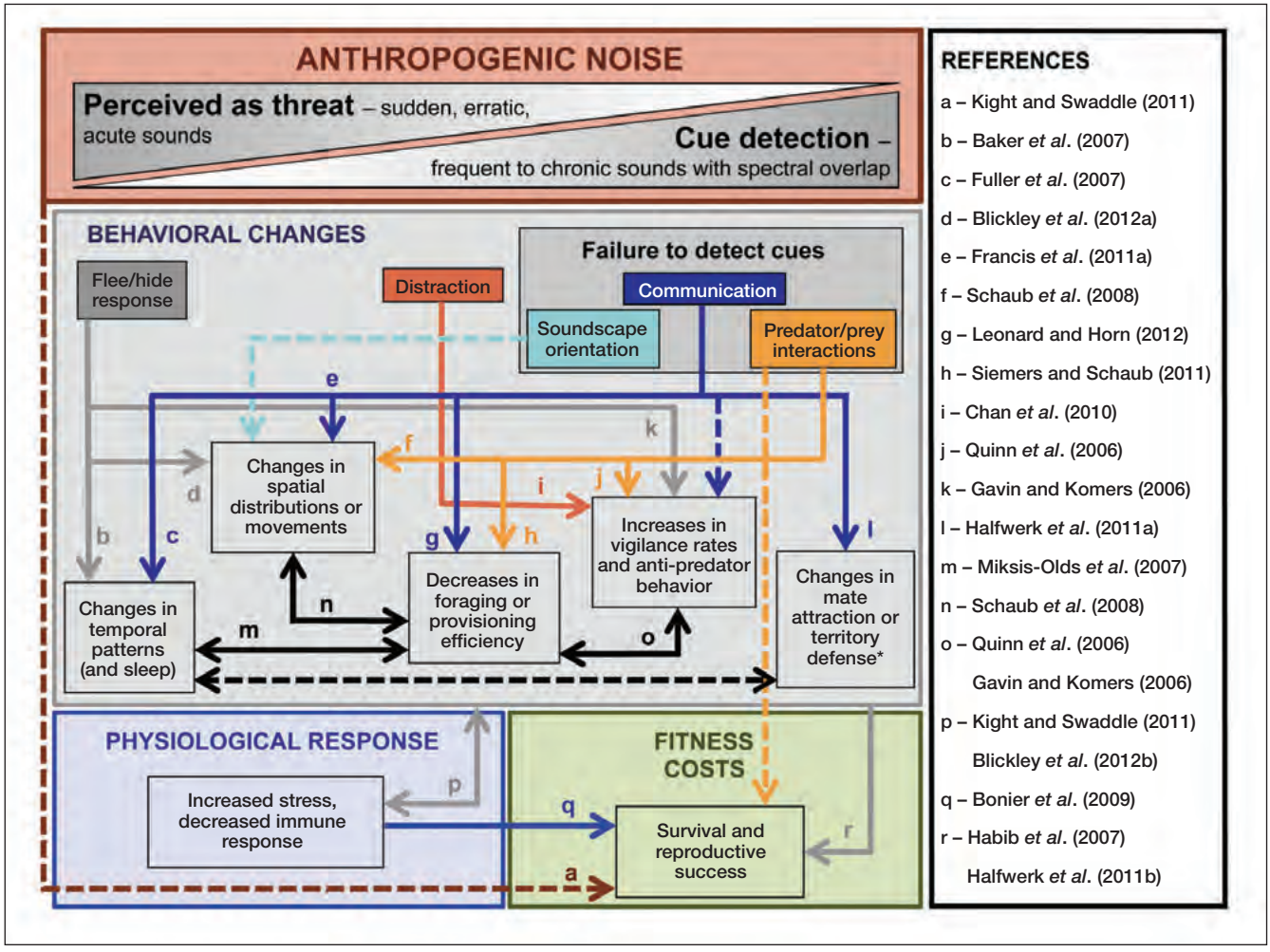


Figure 3. *Conceptual framework for understanding how noise stimuli – perceived as a threat or interfering with cue detection (the disturbance–interference continuum) – can elicit behavioral responses that have direct consequences for fitness or via a physiological stress response, which can also feed back to behavioral changes. Startle/hide responses are more likely to occur in response to noise stimuli that are perceived as a threat (acute, erratic, or sudden sounds). Problems arising from a failure to detect cues are more likely to occur when noise stimuli are chronic and overlap with biologically relevant cues used for communication, orientation, and predator/prey detection. Problems arising from distraction may occur as a result of sounds with features ranging from those that interfere with cue detection to those that are perceived as threats. Lowercase letters indicate studies (listed on the right) providing evidence for the link made for each arrow. Dashed arrows signify a link that we predict as important but for which no current evidence exists. The asterisk denotes that which could result from a change in behavior or a failure to change behavior in response to noise.*

vary greatly in their behavioral responses to stimuli, which may explain the variations in their ability to cope with environmental change (Sih *et al.* 2004). The redistribution of sensitive and tolerant individuals across the landscape may not appear to be a problem. However, in the case of social animals, where group living provides protection from predation, the loss of sensitive individuals from the group through site abandonment could increase predation risk for the group as a whole through the removal of the most vigilant group members. These sensitive individuals, who are now isolated from the group, lose the benefit of safety in numbers. Depending on population structure and the scale at which these individuals are displaced by noise, genetic diversity may be reduced because traits that govern risk-averse (shy/sensitive) and risk-prone (bold) behaviors can be heritable (Dingemanse *et al.* 2002).

Site abandonment and changes in abundance provide only a limited understanding of how noise can impact wildlife populations and communities. Importantly, abundance can also be misleading because areas where individuals are abundant do not always translate into high fitness for those individuals (eg Johnson and Temple 1986). Using such evidence to conclude that noise has no impact is problematic; individuals may not have alternative areas to occupy or other responses (survival, mating success, reproductive output) may be negatively affected by noise even when abundance is high (Figure 1a). These possibilities are especially likely when a noise stimulus is new and demographic processes

© The Ecological Society of America

have not had time to impact population size or when the population in an area that is exposed to noise is supplemented by individuals from elsewhere (ie source–sink dynamics).

Decreases in foraging or provisioning efficiency and increased vigilance and anti-predator behavior

Noise can impair foraging and provisioning rates directly (Figure 3, g and h) or indirectly as a consequence of increased vigilance and anti-predator behavior (Figure 3, i–k, o). When noise is perceived as a threat, an organism may miss foraging opportunities ("missed opportunity cost"; Brown 1999) while hiding or as a result of maintaining increased vigilance (Figure 3k; Gavin and Komers 2006). Missed opportunities can also occur when noise interferes with cue detection. For instance, nestling tree swallows (*Tachycineta bicolor*) exposed to noise beg less in response to recorded playbacks of parents arriving at nests (eg calls, movement, sounds) than nestlings in quiet conditions, presumably because the ambient noise masks parent-arrival sounds (Figure 3g; Leonard and Horn 2012). Unfortunately, this study did not determine whether missed provisioning opportunities translated into costs, such as reduced nestling mass or fledging success.

Noise that interferes with cue detection can also hamper predators' hunting abilities. For example, among greater mouse-eared bats, search time for prey was shown to increase and hunting success to decrease with exposure to experimental traffic noise (Figure 3h; Siemers and Schaub 2011). This decrease in foraging success may explain why some predators avoid noisy areas (Figure 3n; eg Schaub *et al.* 2008; Francis *et al.* 2009). Noise also impairs foraging in three-spined sticklebacks (*Gasterosteus aculeatus*), resulting in more unsuccessful hunting attempts (Purser and Radford 2011). Noise also possibly interferes with the ability of prey species to hear approaching predators, which could impact fitness directly. Although likely, elevated predation risk due to noise has yet to be demonstrated, but some evidence does suggest that animals exposed to noise behave as though they are at greater risk of predation. For example, in the chaffinch (*Fringilla coelebs*), continuous noise impairs auditory surveillance, triggering increased visual surveillance, as a result of which the birds spend less time foraging (Figure 3j; Quinn *et al.* 2006). Noise that serves as a distraction may also lead to an increased latency in predator-escape response (Figure 3i; Chan *et al.* 2010), potentially compromising survival. Both distraction and elevated vigilance could also cause a decrease in foraging rates and success (ie a trade-off; Figure 3o; Gavin and Komers 2006; Quinn *et al.* 2006). Collectively, these studies suggest that both interference noise and noise perceived as a threat decrease the rate and frequency at which organisms obtain food. Studies aimed at understanding the extent to which these behavioral shifts represent a metabolic expense (relevant to survival and reproductive success) will help to reveal the hidden costs of noise exposure.

Changes in mate attraction and territorial defense

The most direct way in which noise may alter an individual's ability to attract mates or defend its territory is through energetic masking, in which potential receivers are simply unable to hear another individual's acoustic signals through noise that is frequent or continuous during important temporal signaling windows. Changes made to acoustic signals appear to be an adaptive behavioral adjustment that permits individuals to communicate under noisy conditions (eg Fuller *et al.* 2007; Gross *et al.* 2010; Francis *et al.* 2011b), yet these shifts could also incur a cost. In noisy areas, female great tits (*Parus major*) more readily detect male songs sung at higher frequencies than females typically prefer (Halfwerk *et al.* 2011a). However, males who sing predominately at higher frequencies experience higher rates of cuckoldry (Figure 3l). Great tits breeding in noisy areas also have smaller clutches and fewer fledglings (Halfwerk *et al.* 2011b); similarly, eastern bluebirds (*Sialia sialis*) experience decreased productivity when nesting in areas with elevated noise levels (Kight *et al.* 2012). Paired with patterns of decreased pairing success in noisy areas (Habib *et al.* 2007; Gross *et al.* 2010), these studies suggest that short-term signal adjustments in response to anthropogenic noise might function as evolutionary traps (eg Schlaepfer *et al.* 2002) in which behavioral responses to novel acoustic stimuli could be maladaptive. That is, behavioral shifts to be heard in noisy areas may come with the cost of compromising the attractiveness of the signal to potential mates. This possibility remains to be tested against other potential explanations for declines in pairing or reproductive success, but emphasizes why investigators should measure aspects of fitness in noise-impact studies rather than simply documenting changes in site occupancy or abundance.

Finally, although the list of species known to shift their signals in response to noise is growing, there is at least one frog species and some bird species that do not alter their vocalizations in response to noise (eg Hu and Cardoso 2010; Love and Bee 2010; Francis *et al.* 2011b). More work is needed to provide a thorough understanding of the phylogenetic distribution of noise-dependent vocal change and researchers should strive to publish negative results, as knowledge of the apparent absence of these behavioral modifications is just as important as knowledge of their presence.

Linking behavioral changes, physiological responses, and fitness costs

The behavioral changes mentioned above can have direct consequences for fitness (Figure 3r), such as reduced pairing success (Habib *et al.* 2007) or reduced

 © The Ecological Society of America

reproductive success (Halfwerk *et al.* 2011b). However, behavior can influence, and be influenced by, physiological responses (Figure 3p; Kight and Swaddle 2011), which in turn can affect fitness (Figure 3q; Bonier *et al.* 2009). Kight and Swaddle (2011) reviewed many links between noise, physiological stress, and behavioral change, so we only briefly mention them here.

It is well known that increased physiological stress affects fitness (Figure 3q); yet, to our knowledge, a direct link between increased physiological stress due to noise and decreased survival or reproductive success has not been shown in wild animals. The best evidence for this potential link comes from two studies. In one, Blickley *et al.* (2012b) found that greater sage grouse on leks exposed to experimental playback of continuous natural gas drilling noise or intermittent road noise had higher fecal glucocorticoid metabolites (fGMs) than individuals on control leks. The authors suggested that masking of cues likely resulted in elevated stress levels, inhibiting social interactions or leading to a heightened perception of predation risk. In the other, Hayward *et al.* (2011) showed that experimental exposure to motorcycle traffic and motorcycle noise increased fGMs in northern spotted owls (*Strix occidentalis caurina*). In an observational component of the same study, spotted owls nesting in areas with higher levels of traffic noise fledged fewer offspring, even though they did not have elevated fGMs, suggesting that the effects of road noise may have been offset by greater prey availability in noisy areas. These two studies demonstrate that noise may lead to decreased fitness in sage grouse and spotted owls, and also clearly indicate that more research is needed to determine how noise exposure, physiological stress, and fitness are linked in wild populations.

Scaling up behavioral responses

Here, we have focused on effects of noise exposure at the level of the individual; however, studies that integrate individual behavior, population responses among multiple species, and species interactions are critical to understanding the cumulative, community-level consequences of noise. Measures of species richness are a good starting point, but may be misleading because species may respond negatively, positively, or not at all to sound stimuli (Bayne *et al.* 2008; Francis *et al.* 2009), individuals within a single species may respond differently to the same stimulus (Sih *et al.* 2004), and individuals that remain in noisy areas may suffer from one or more of the fitness costs discussed above. This variation within and among species in response to noise guarantees that communities in noisy areas will not always be subsets of the species that make up communities in comparable quiet areas. Researchers should couple standard measures of richness and alpha (local) diversity with beta-diversity metrics that reflect variations in the composition of species within communities and among sites. Nevertheless, additional investigations will be needed to understand why species respond to sound stimuli as they do. Settlement patterns may not hinge on the intensity of noise, but are perhaps due to the presence or absence of cues indicating the presence of predators and heterospecific competitors (Francis *et al.* 2009). These other species (ie predators or competitors) may have unique settlement patterns in response to noise and will complicate efforts to measure how noise directly affects the species of interest. Disentangling these interactions will also be essential to understanding the consequences of noise exposure for organisms that are not directly impacted by noise, such as plants that depend on noise-sensitive faunal taxa (Francis *et al.* 2012) or animals whose hearing range is not tuned to a particular frequency that makes up a sound stimulus.

Conclusions

Both policy and scientific literature have often oversimplified the effects of noise on wild animals, typically suggesting that species either are sensitive and abandon noisy areas or are not and remain. In our experience with stakeholders, habituation is an oft-cited reason for persistence and an absence of noise impacts, yet research on other stressors indicates that acclimation to a stressor might not release an organism from costs to fitness (Romero *et al.* 2009). Additionally, we have shown how behavioral modifications among individuals confronted with noise – even those individuals that outwardly appear to habituate – can lead to decreased fitness. Challenging the assumption that habituation to noise equals "no impact" will be difficult, but it will also be a critical component in revealing how a range of behavioral mechanisms link noise exposure to fitness costs. Ideally, we need to predict which combination of noise characteristics and behavioral contexts are most detrimental and under what circumstances behavioral changes affect fitness directly or indirectly. This will require an array of experimental and observational approaches and frameworks that complement the conceptual structure presented here (Figure 3). Other promising frameworks include the risk–disturbance hypothesis (Frid and Dill 2002), which provides an avenue for understanding energetic costs associated with wildlife responses to noise disturbances that are perceived as threats. Studies evaluating aspects of habitat selection and acoustic communication in response to noise may find it useful to frame questions in terms of ecological and evolutionary traps (Schlaepfer *et al.* 2002). Furthermore, investigators should strive to measure responses along a range of noise exposure levels to reveal the shape of response curves (eg threshold, linear) because these details will be indispensable to resource managers and policy makers when establishing and modifying regulatory limits that reflect the ecological effects of noise exposure.

An increase in anthropogenic noise levels is only one of many threats to biodiversity on which ecologists and policy makers should focus their attention. However, rel-

© The Ecological Society of America

ative to other conservation problems, noise may also offer readily available solutions, which, if implemented, could lead to major, measurable improvements for both wildlife and people. For example, use of noise-attenuating walls could reduce the area of a landscape exposed to elevated noise levels from natural gas extraction activities by as much as 70% (Francis *et al.* 2011c) and similar solutions exist for mitigating noise from roadways and cities (Code of Federal Regulations 2010). These mitigation efforts could come with drawbacks; for instance, noise-attenuating walls near roads could restrict the movement of wildlife and impede gene flow. Nevertheless, as we develop a better understanding of the ecological effects of noise, implementation of mitigation efforts can begin in many well-studied and high-priority systems (eg oil and gas developments in natural areas, transportation networks in national parks), where benefits outweigh the potential costs. In addition to protecting contiguous natural habitat, reducing noise exposure in and around developed areas will not only benefit wildlife populations and diversity, but will also provide adjacent human populations with the suite of physiological benefits afforded by living in a quieter community.

Acknowledgements

We thank J Bunkley, K Fristrup, A Keener, N Kleist, B Leavell, T Mason, C McClure, and H Ware for comments on earlier versions of this manuscript. CDF thanks the National Evolutionary Synthesis Center (NSF EF-0905606) for support and JRB acknowledges support from the Natural Sounds and Night Skies Division of the National Park Service (CESU H8R07060001).

References

Baker PJ, Dowding CV, Molony SE, *et al.* 2007. Activity patterns of urban red foxes (*Vulpes vulpes*) reduce the risk of traffic-induced mortality. *Behav Ecol* **18**: 716–24.

Barber JR, Crooks KR, and Fristrup KM. 2010. The costs of chronic noise exposure for terrestrial organisms. *Trends Ecol Evol* **25**: 180–89.

Barber J, Burdett C, Reed S, *et al.* 2011. Anthropogenic noise exposure in protected natural areas: estimating the scale of ecological consequences. *Landscape Ecol* **26**: 1281–95.

Bayne EM, Habib L, and Boutin S. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. *Conserv Biol* **22**: 1186–93.

Bejder L, Samuels A, Whitehead H, and Gales N. 2006. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Anim Behav* **72**: 1149–58.

Blickley JL and Patricelli GL. 2012. Potential acoustic masking of greater sage-grouse display components by chronic industrial noise. *Ornithol Monogr* **74**: 23–35.

Blickley JL, Blackwood D, and Patricelli GL. 2012a. Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at leks. *Conserv Biol* **26**: 461–71.

Blickley JL, Word KR, Krakauer AH, *et al.* 2012b. Experimental chronic noise is related to elevated fecal corticosteroid metabolites in lekking male greater sage-grouse (*Centrocercus urophasianus*). *PLoS ONE* **7**: e50462.

Bonier F, Moore IT, Martin PR, and Robertson RJ. 2009. The relationship between fitness and baseline glucocorticoids in a passerine bird. *Gen Comp Endocr* **163**: 208–13.

Brown JS. 1999. Vigilance, patch use and habitat selection: foraging under predation risk. *Evol Ecol Res* **1**: 49–71.

Chan AAYH, Stahlman WD, Garlick D, *et al.* 2010. Increased amplitude and duration of acoustic stimuli enhance distraction. *Anim Behav* **80**: 1075–79.

Code of Federal Regulations. 2010. Procedures for abatement of highway traffic noise and construction noise. Washington, DC: US Government Printing Office. 23 CFR §772.17. www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=cd313d7dd374014a6041944112b4456b&rgn=div5&view=text&node=23:1.0.1.8.44&idno=23#23:1.0.1.8.44.0.1.9. Viewed on 29 Mar 2013.

Dingemanse NJ, Both C, Drent PJ, *et al.* 2002. Repeatability and heritability of exploratory behaviour in great tits from the wild. *Anim Behav* **64**: 929–38.

Dooling RJ and Popper AN. 2007. The effects of highway noise on birds. Sacramento, CA: California Department of Transportation.

Eigenbrod F, Hecnar SJ, and Fahrig L. 2008. The relative effects of road traffic and forest cover on anuran populations. *Biol Conserv* **141**: 35–46.

Ellison WT, Southall BL, Clark CW, and Frankel AS. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conserv Biol* **26**: 21–28.

Francis CD, Kleist NJ, Ortega CP, and Cruz A. 2012. Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal. *P Roy Soc B–Biol Sci* **279**: 2727–35.

Francis CD, Ortega CP, and Cruz A. 2009. Noise pollution changes avian communities and species interactions. *Curr Biol* **19**: 1415–19.

Francis CD, Ortega CP, and Cruz A. 2011a. Noise pollution filters bird communities based on vocal frequency. *PLoS ONE* **6**: e27052.

Francis CD, Ortega CP, and Cruz A. 2011b. Vocal frequency change reflects different responses to anthropogenic noise in two suboscine tyrant flycatchers. *P Roy Soc B–Biol Sci* **278**: 2025–31.

Francis CD, Paritsis J, Ortega CP, and Cruz A. 2011c. Landscape patterns of avian habitat use and nest success are affected by chronic gas well compressor noise. *Landscape Ecol* **26**: 1269–80.

Frid A and Dill LM. 2002. Human-caused disturbance stimuli as a form of predation risk. *Conserv Ecol* **6**: 11.

Fuller RA, Warren PH, and Gaston KJ. 2007. Daytime noise predicts nocturnal singing in urban robins. *Biol Lett* **3**: 368–70.

Gavin SD and Komers PE. 2006. Do pronghorn (*Antilocapra americana*) perceive roads as a predation risk? *Can J Zool* **84**: 1775–80.

Goodwin SH and Shriver WG. 2011. Effects of traffic noise on occupancy patterns of forest birds. *Conserv Biol* **25**: 406–11.

Goudie RI. 2006. Multivariate behavioural response of harlequin ducks to aircraft disturbance in Labrador. *Environ Conserv* **33**: 28–35.

Gross K, Pasinelli G, and Kunc HP. 2010. Behavioral plasticity allows short-term adjustment to a novel environment. *Am Nat* **176**: 456–64.

Habib L, Bayne EM, and Boutin S. 2007. Chronic industrial noise affects pairing success and age structure of ovenbirds *Seiurus aurocapilla*. *J Appl Ecol* **44**: 176–84.

Halfwerk W, Bot S, Buikx J, *et al.* 2011a. Low-frequency songs lose their potency in noisy urban conditions. *P Natl Acad Sci USA* **108**: 14549–54.

Halfwerk W, Holleman LJM, Lessells CM, and Slabbekoorn H. 2011b. Negative impact of traffic noise on avian reproductive success. *J Appl Ecol* **48**: 210–19.

Hayward LS, Bowles AE, Ha JC, and Wasser SK. 2011. Impacts of

 © The Ecological Society of America

acute and long-term vehicle exposure on physiology and reproductive success of the northern spotted owl. *Ecosphere* **2**: 65.

Hu Y and Cardoso GC. 2010. Which birds adjust the frequency of vocalizations in urban noise? *Anim Behav* **79**: 863–67.

Johnson RG and Temple SA. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. In: Verner J, Morrison ML, and Ralph CJ (Eds). Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Madison, WI: University of Wisconsin Press.

Kight CR and Swaddle JP. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. *Ecol Lett* **14**: 1052–61.

Kight CR, Saha MS, and Swaddle JP. 2012. Anthropogenic noise is associated with reductions in the productivity of breeding eastern bluebirds (*Sialia sialis*). *Ecol Appl* **22**: 1989–96.

Leonard ML and Horn AG. 2012. Ambient noise increases missed detections in nestling birds. *Biol Lett* **8**: 530–32.

Love EK and Bee MA. 2010. An experimental test of noise-dependent voice amplitude regulation in Cope's grey treefrog, *Hyla chrysoscelis*. *Anim Behav* **80**: 509–15.

Luther DA. 2008. Signaller: receiver coordination and the timing of communication in Amazonian birds. *Biol Lett* **4**: 651–54.

Miksis-Olds JL, Donaghay PL, Miller JH, *et al.* 2007. Noise level correlates with manatee use of foraging habitats. *J Acoust Soc Am* **121**: 3011–20.

Ortega CP and Francis CD. 2012. Effects of gas well compressor noise on ability to detect birds during surveys in northwest New Mexico. *Ornithol Monogr* **74**: 78–90.

Pater LL, Grubb TG, and Delaney DK. 2009. Recommendations for improved assessment of noise impacts on wildlife. *J Wildlife Manage* **73**: 788–95.

Patricelli GL and Blickley JL. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. *Auk* **123**: 639–49.

Purser J and Radford AN. 2011. Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (*Gasterosteus aculeatus*). *PLoS ONE* **6**: e17478.

Quinn JL, Whittingham MJ, Butler SJ, and Cresswell W. 2006. Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*. *J Avian Biol* **37**: 601–08.

Romero LM, Dickens MJ, and Cyr NE. 2009. The reactive scope model – a new model integrating homeostasis, allostasis, and stress. *Horm Behav* **55**: 375–89.

Schaub A, Ostwald J, and Siemers BM. 2008. Foraging bats avoid noise. *J Exp Biol* **211**: 3174–80.

Schlaepfer MA, Runge MC, and Sherman PW. 2002. Ecological and evolutionary traps. *Trends Ecol Evol* **17**: 474–80.

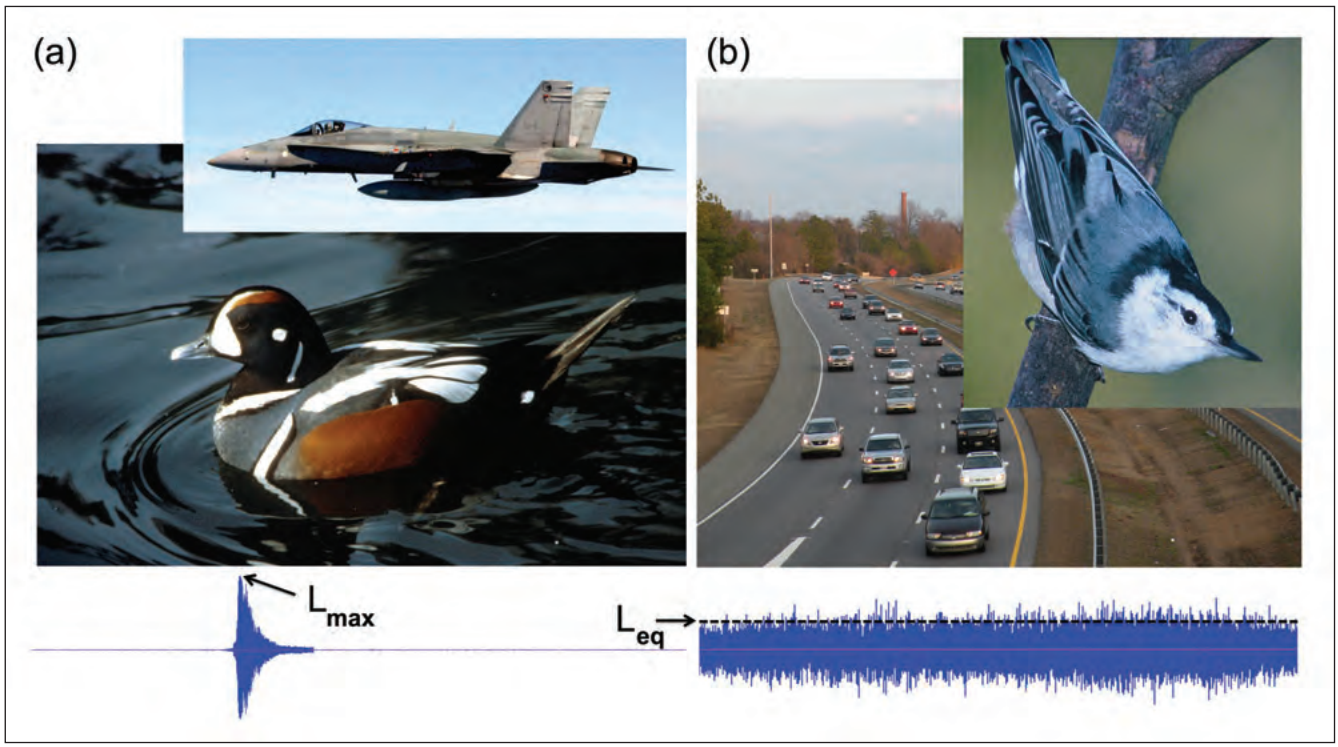
Siemers BM and Schaub A. 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. *P Roy Soc B–Biol Sci* **278**: 1646–52.

Sih A, Bell A, and Johnson JC. 2004. Behavioral syndromes: an ecological and evolutionary overview. *Trends Ecol Evol* **19**: 372–78.

Slabbekoorn H and Bouton N. 2008. Soundscape orientation: a new field in need of sound investigation. *Anim Behav* **76**: E5–E8.

Slabbekoorn H, Bouton N, van Opzeeland I, *et al.* 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends Ecol Evol* **25**: 419–27.

© The Ecological Society of America



(a) US Air Force and USFWS (b) USFWS and E Francis

WebFigure 1. *Example of two acoustic metrics that employ different time-weighting functions. (a) Infrequent noise events from aircraft alter harlequin duck behavior. These types of distinct noise disturbances should be quantified using L_{max}, which represents the loudest sound level occurring within a specified period (illustrated below photo in the waveform). (b) White-breasted nuthatches avoid chronic traffic noise. To characterize chronic noise it can be better to utilize L_{eq}, which represents a time-averaged value during a specified period (illustrated below photos as a dashed line in the waveform).*

© The Ecological Society of America

Callaway *et al*. (2007) noted that the intial impacts of climate change are likely to stem from these salinity changes, and that even relatively small salinity changes can cause shifts in dominant vegetation. Higher salinities in the summer and fall are expected to produce increased stress on tidal marsh plants, potentially leading to reduced productivity and mortality (Callaway *et al*. 2007). Furthermore, as overall salinity in the San Francisco Estuary increases and more salts accumulate in tidal marsh soils, larger pulses of freshwater of greater duration will be required to reduce soil salinities in the marsh and promote germination and recruitment (Callaway *et al*. 2007). Ultimately, species that prefer brackish conditions over tidal marshes would presumably suffer reduction in habitat, while tidal marsh species might expand into Suisun Bay and even the Delta. Closer study is needed of the potential amount and extent of salinity and habitat change, and the species-level effects of these changes.

Overall, threats from global climate change to tidal marsh habitats and species in California include: (1) habitat loss where landward migration of tidal marsh plant communities is prevented by artificial or geographic barriers, or where sea level rise or erosion exceeds sedimentation; (2) salinity gradients migrating up-estuary as tidal inundation increases; (3) greater extremes of heat and desiccation stress on wetland plants; (4) the loss and/or decreased *fecundity* of rare populations and species (Reid and Trexler 1991, Boorman 1992, Keldsen 1997); and (5) high mortality rates associated with extreme weather events (Downard *in litt.* 2009*b*).

Contaminants

Environmental contaminants may adversely affect the survival, growth, reproduction, health, or behavior of species. Some contaminants may affect a narrow range of organisms while others, like petroleum products, can impact a broader range of organisms. Known contaminants of concern in the San Francisco Bay Estuary include mercury, selenium, polychlorinated biphenyls (PCBs), organochlorine and organophosphate pesticides, dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and tributyltin from anti-fouling boat paints (see SWRCB 303d list, Region 2; Oros and Hunt 2005; Schwarzbach *et al*. 2006; Adelsbach and Maurer 2007). Ammonia and pyrethroid insecticides have become a recent concern. In addition, newly emerging contaminants which may act to disrupt endocrine systems, such as polybrominated diphenyl ethers (PBDEs) and phthalates, are being detected in the estuary's water, sediments, and biota (Oros *et al*. 2005, Oros and Hunt 2005) and are poorly understood. Unmonitored contaminants in San Francisco Bay include such chemicals as pharmaceuticals, plasticizers, flame retardants, and detergent additives (San Francisco Estuary Institute 2000). Toxic effects of many of these chemicals to rails and other estuary biota are not known. In other species, some of these chemicals have caused endocrine disruption and altered gender development through *in ovo* exposures (Colburn and Clement 1992). While the full impact of these emerging contaminants on species in the estuary remains to be determined, the increasing frequency at which they are being detected is cause for concern. All of the contaminants mentioned above have the potential to adversely impact biota in the estuary, depending on the extent and degree of contamination (Phillips 1987). Three of the primary known threats are described in further detail below.

Mercury: The estuary's aquatic and aquatic-dependent wildlife species are the most at risk from contamination by bioaccumulative pollutants such as mercury and selenium. Historically, the major source of mercury contamination in the San Francisco Bay-Delta was mine waste and

(7) Reduced habitat quality and increased attraction of predators from litter and debris.

(8) Contamination of marsh sediments, which may impact clapper rails directly or indirectly. Potential direct effects include toxicity to adults, chicks, or embryos. Potential indirect effects include reduced prey quality, quantity, and availability, and altered vegetation structure/composition for nesting and sheltering (see **Appendix E**).

Few of these causes of habitat degradation are independent of one another; they interact and mutually amplify. For example, construction and subsequent maintenance of a levee restricts tidal circulation, concentrates impacts of any fresh wastewater discharges, provides predator corridors and nest/den sites, compresses tidal refugial vegetation to a narrow strip, and promotes ruderal (weedy) vegetation. It may also mobilize contaminants buried in marsh sediments. Further, the presence of a levee may provide recreational access for people and their pets, which results in increased disturbance and potential litter problems. Rodents attracted to the litter, and provided access and nest sites by levees, will result in added predation pressure on clapper rails.

Fragmentation. As described above in Existing threats to California tidal marsh ecosystems (section 1), levees have led to widespread degradation and loss of rail habitat. Many of the tidal marshes in the bay are relatively small fragments, and the presence of levees facilitates predator access across the entire site. This is particularly true for the linear/strip marshes prevalent in the South Bay. Levees allow predators to travel miles out into baylands that would otherwise be naturally isolated from terrestrial predators. Mammalian predators, especially red foxes, rats, and domestic cats (American Bird Conservancy 2006) use levees as movement corridors and denning/nesting sites, as described below under Predation. Any clapper rail nests located close to levees are therefore subject to higher predation pressures. The red fox is a highly efficient predator of rail eggs, chicks, and adults in the South Bay. We speculate that red foxes do not typically travel far from the levees, which may result in lower rates of fox predation in large marshes that have more nesting habitat away from levees than small marshes.

Other threats result indirectly from levees due to the breakdown of tidal marsh habitat into relatively small, discontinuous, narrow fragments too small to develop the complex tidal drainage networks needed for productive rail habitats. Generally, extinction rates increase as habitat size decreases and distance from neighboring populations increases (MacArthur and Wilson 1967). As remaining habitat units decrease in size, edge effects become increasingly important. Smaller units have less space available to buffer adverse impacts from small populations and outside influences, such as predation, human disturbance, or chemical contamination (see Factor E below). Catastrophic mortality from chance environmental events, such as flooding, is a severe threat to the long-term survival of small, isolated populations (Schonewald-Cox *et al*. 1983). Isolation of small local populations increases chances of inbreeding. The breeding of closely related individuals can cause genetic problems in small populations, particularly the expression of deleterious genes (inbreeding depression). Individuals and populations possessing deleterious genetic material are less able to cope with environmental conditions and adapt to environmental change. Furthermore, small populations are subject to the effects of genetic drift (random loss of genetic variability). Populations that undergo extreme declines and rebound from a small number of survivors are particularly vulnerable to inbreeding depression. Clapper rails in San Francisco Bay suffer from both risks. Loss of genetic

tidal level, particularly in the South Bay (Atwater *et al.* 1979), are likely to be amplified by rising tidal levels.

Contaminants. Environmental contaminants may affect the health and vigor of clapper rails directly through toxic effects to individuals, or indirectly through effects to organisms upon which the rail depends. Acute poisoning associated with oil or toxic material spills could result in rail mortalities within affected habitat. A large oil spill in South Bay marshes could be catastrophic for the rail population. To date, most direct contaminant impacts to the rail have likely been due to lifetime exposures at chronic, sub-lethal concentrations that alter individual fitness. Known contaminants of concern for rail recovery in the San Francisco Bay Estuary include mercury, selenium, PCBs, and petroleum hydrocarbons. The potential toxicological effects of long term chronic contaminant exposures can include reproductive impairment, compromised immune function, reduced growth, deformity, and altered behavior (Schwarzbach *et al*. 2006). While few adult clapper rail mortalities have been directly attributed to contaminants, elevated mercury levels have been found in the tissues of some dead adults. Reproduction in clapper rails has been documented as poor, and contaminants, particularly mercury and perhaps PCBs, are the most likely contributors (Schwarzbach *et al*. 2006).

Contaminants could also indirectly impact rails by altering habitat features such as benthic prey density or nesting cover. Petroleum hydrocarbons and trace elements, such as arsenic, copper, silver, cadmium, and lead, may be an indirect hazard through toxicity to benthic prey. Although benthic organism densities and species composition are known to be altered within the bay by contaminants at some locations (San Francisco Estuary Institute 1999), the effect within rail habitat has not been systematically assessed.

Also of potential concern are newer environmental contaminants that are rarely monitored and poorly understood. Unmonitored contaminants in San Francisco Bay include such chemicals as pharmaceuticals, plasticizers, flame retardants, and detergent additives (San Francisco Estuary Institute 2000). Toxic effects of many of these chemicals to rails and other estuary biota are not known. In other species, some of these chemicals have caused endocrine disruption and altered gender development through in ovo exposures (Colburn and Clement 1992).

With the exception of the largest deepwater discharges of industry and some municipalities, much of the ongoing contamination of the bay enters at the margins, often through tidal marsh habitat. Many, if not most, tidal marsh sediments are more contaminated than open bay sediments (Collins and May 1997). As an omnivore inhabiting the margins of the bay, the clapper rail is exposed to sediment-born contamination of baylands, and may be particularly at risk of exposure to those chemicals that bioaccumulate in benthic prey. When comparing diving ducks with other species, the higher concentrations of selenium were found in benthic foragers (Ohlendorf *et al.* 1986). Contaminants that are toxic to vertebrates, persist in sediments, and transfer and accumulate in clapper rail prey, present the greatest contaminant hazards to clapper rail recovery.

For the past 75 years or more the greatest densities of breeding rails have been found in marshes of the South Bay (DeGroot 1927, Gill 1979, Harvey 1988). Freshwater inflows to the South Bay are substantially more limited than in the North Bay, which receives inflow from the Sacramento

drainage from Coast Range mercury mines and Sierra Nevada Range gold mines (San Francisco Estuary Regional Monitoring Program 1996). Substantial reservoirs of this toxic metal left over from mining activities remain in estuary *sediments*, as well as in *sediments* and soils associated with upstream tributary water bodies. Even today, mercury from these upstream sources continues to wash downstream into the estuary (California Regional Water Quality Control Board 2004). However, other significant sources of mercury have been identified as being of concern. Mercury released into the atmosphere through oil and coal combustion and through waste incineration can be re-deposited into aquatic ecosystems through precipitation, contaminating water bodies with no other known mercury inputs (Wiener *et al*. 2002). Once in the aquatic realm, certain conditions (*e.g.*, anoxia and sulfate-reducing bacteria) may allow for the transformation of inorganic mercury into methylmercury, an organic form that is highly toxic and much more bioavailable than the inorganic precursor. Under continuous exposure in a contaminated ecosystem, methylmercury is introduced into the body at a much faster rate than the body can eliminate it, and aquatic and aquatic-dependent organisms bioaccumulate it into various tissues. Methylmercury concentrations in aquatic ecosystems biomagnify in each successive trophic level, from primary producers to the top predators (Wiener *et al*. 2002). Tidal marshes often exhibit the conditions that promote methylation of mercury, and high mercury concentrations have been found in a variety of fish from the San Francisco Estuary (Greenfield *et al*. 2003).

Selenium: Selenium, another bioaccumulative element, can contaminate aquatic ecosystems through a variety of human activities, including fossil fuel combustion, mining and manufacturing processes, and irrigation of seleniferous soils (Maier and Knight 1994). All of these sources may be contributing to the selenium contamination observed in the estuary, with agricultural drainage of lands from the west side of the San Joaquin Valley and discharges from local oil refineries the two primary sources (Presser and Luoma 2007). A non-native clam (*Potamocorbula amurensis*) that is abundant in the estuary has been shown to bioaccumulate selenium at a higher rate than crustacean zooplankton, and several predators of these bivalves have tissue selenium concentrations above thresholds thought to be associated with *teratogenesis* and reproductive failure (Stewart *et al*. 2004). The selenium contamination of the estuary's bivalve food web may pose a threat to bottom-feeding animals, such as the white sturgeon (*Acipenser transmontanus*), surf scoter (*Melanitta perspicillata*), and Sacramento splittail (*Pogonichthys macrolepidotus*) (Presser and Luoma 2007, Linville *et al*. 2002, Stewart *et al*. 2004, Teh *et al*. 2004). In fact, deformities typical of selenium-induced teratogenesis have been observed in Sacramento splittail (Stewart *et al*. 2004).

Petroleum: The San Francisco Bay Estuary has many potential sources of petroleum and petroleum-byproduct (*e.g.*, PAHs) releases, due to a high degree of urbanization, with six oil refinery complexes, substantial ship and oil tanker traffic, and a large number of gasoline, diesel, or fuel oil-powered vehicles. PAHs are commonly detected in bay waters and sediments where tidal marsh species may be exposed to them (Ross and Oros 2004). Exposure of tidal marsh species to free petroleum products generally occurs as a result of vessel- or pipeline-related oil spills. As is known from numerous spill events, even relatively small exposures to oil can harm or kill birds and other wildlife (Gilardi and Mazet 1999).

Petroleum hydrocarbons:

San Francisco Estuary is highly urbanized, with six oil refineries, substantial ship and oil tanker traffic, and a large number of gas-powered vehicles. Petroleum hydrocarbons enter the San Francisco Estuary via petroleum spills, discharges from ships, runoff from roads and parking lots, discharges of industrial effluents, and atmospheric deposition. As a result, petroleum hydrocarbons are commonly detected in bay waters and sediment. Polycyclic aromatic hydrocarbons (PAHs) are among the most toxic hydrocarbons; many are carcinogenic (cancer causing) or mutagenic (mutation causing) (Eisler 1987). During the period 2002 to 2007, polycyclic aromatic hydrocarbons in sediment have been highest along the southwestern shoreline of the Central Bay (3.3 ppm), followed by South Bay (1.9 ppm), lower South Bay (1.6 ppm), San Pablo Bay (0.9 ppm), and Suisun Bay (0.4 ppm) (San Francisco Estuary Institute 2008). Rails may be exposed to petroleum hydrocarbons both internally and externally. Internal exposure for rails may occur through normal foraging. PAHs bioaccumulate in bivalves (Mix 1984), which are common prey items for rails.

External exposure generally results from an oil spill. Adverse effects of external exposure to petroleum hydrocarbons include loss of feather structure resulting in flightlessness, loss of water repellency of feathers resulting in hypothermia, chemical burns to the skin, and in extreme oilings, incapacitation (U.S. Fish and Wildlife Service 1997*b*). Oil exposure may not be immediately incapacitating and birds may remain vigorous enough to avoid capture for several days which may complicate rehabilitation efforts by increasing the secondary exposure of eggs and nestlings. Birds also ingest oil when preening oiled feathers. Ingestion of oil results in hemolytic anemia, liver damage, impaired reproduction, aspiration pneumonia and irritation of the intestines and is ultimately life threatening in even small doses (U.S. Fish and Wildlife Service 1997*b*). Some dispersants (substances added to a solution to improve separation of particles), when mixed with oil can also be quite toxic and even enhance the toxicity of oil if ingested.

Bromine-containing flame retardants:

Practically unheard of in the early 1990's, polybrominated diphenyl ethers (PBDEs, organobromine compounds that are used as flame retardants) increased rapidly over time and are now a pollutant of concern in the San Francisco Estuary. No regulatory guidelines exist yet for PBDEs. According to the Regional Monitoring Program for Water Quality, the highest average concentrations of PBDEs in water from 2002 to 2007 were found in Suisun Bay, suggesting the presence of PBDE inputs into the northern Estuary (San Francisco Estuary Institute 2008). In contrast to the results obtained from water monitoring, average concentrations of BDE 47 (one of the most abundant PBDEs and an index of PBDEs as a whole) in sediment from 2004 to 2007 were highest in the lower South Bay (0.81 ppb) and lowest in Suisun Bay (0.38 ppb). The cause of this disparity between water and sediment data for BDE 47 is not understood (San Francisco Estuary Institute 2008).

Marine Pollution Bulletin 67 (2013) 100–106

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Post-release survival of surf scoters following an oil spill: An experimental approach to evaluating rehabilitation success

Susan E.W. De La Cruz [a,*], John Y. Takekawa [a], Kyle A. Spragens [a,1], Julie Yee [b], Richard T. Golightly [c], Greg Massey [d,2], Laird A. Henkel [e], R. Scott Larsen [d,3], Michael Ziccardi [d]

[a] U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA 94592, United States
[b] U.S. Geological Survey, Western Ecological Research Center, Sacramento, CA 95819, United States
[c] Department of Wildlife, Humboldt State University, Arcata, CA 95521, United States
[d] Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA 95616, United States
[e] Office of Spill Prevention and Response, California Department of Fish and Game, Santa Cruz, CA 95060, United States

ARTICLE INFO

Keywords:
San Francisco Bay
Melanitta perspicillata
Sea duck
Wildlife rehabilitation
Oil exposure
Radio telemetry

ABSTRACT

Birds are often the most numerous vertebrates damaged and rehabilitated in marine oil spills; however, the efficacy of avian rehabilitation is frequently debated and rarely examined experimentally. We compared survival of three radio-marked treatment groups, oiled, rehabilitated (ORHB), un-oiled, rehabilitated (RHB), and un-oiled, non-rehabilitated (CON), in an experimental approach to examine post-release survival of surf scoters (*Melanitta perspicillata*) following the 2007 *M/V Cosco Busan* spill in San Francisco Bay. Live encounter-dead recovery modeling indicated that survival differed among treatment groups and over time since release. The survival estimate (±SE) for ORHB was 0.143 ± 0.107 compared to CON (0.498 ± 0.168) and RHB groups (0.772 ± 0.229), suggesting scoters tolerated the rehabilitation process itself well, but oiling resulted in markedly lower survival. Future efforts to understand the physiological effects of oil type and severity on scoters are needed to improve post-release survival of this species.

Published by Elsevier Ltd.

1. Introduction

Birds are often among the most affected vertebrate species in marine oil spills. For example, avian mortality rates after the 2010 *Deepwater Horizon* spill in the Gulf of Mexico showed the greatest increase compared to all other tetrapod vertebrate groups (Antonio et al., 2011). Such oil spill related mortality not only causes direct damage but can have profound impacts on marine bird population demographics (Votier et al., 2005; Henkel et al., 2012) including restricting survival and population recovery for many years afterwards, as was the case for sea ducks exposed to residual oil from the 1989 *Exxon Valdez* spill in Alaska (Esler et al., 2000, 2002). Given the large numbers influenced by oiling, marine birds have been frequent subjects of rehabilitation.

Wildlife rehabilitation plays a prominent public role and commands considerable resources during clean-up efforts after major marine oil spill events. While rehabilitation of oiled wildlife is common practice worldwide and mandated in California, its efficacy is often debated (Sharp, 1996; Estes, 1998; Jessup, 1998). Part of the controversy surrounding this practice centers on the survival of individuals released to the wild after treatment (Estes, 1998). Results of studies designed to evaluate avian post-release survival have been varied (Anderson et al., 1996; Sharp, 1996; Goldsworthy et al., 2000; Golightly et al., 2002; Altwegg et al., 2008), and several factors, including species, sex, body condition, degree of oiling, type of oil, and climatic conditions are known to play a role in survival outcomes (Goldsworthy et al., 2000). Recent advances in rehabilitative techniques (Mazet et al., 2002) have the potential to improve post-release survival, and continued experimental study is needed to evaluate their effects.

On 7 November 2007, the *M/V Cosco Busan* released 53,569 gallons of bunker oil into San Francisco Bay (SFB), California near the Oakland-San Francisco Bay Bridge. The surf scoter, (*Melanitta perspicillata*), a benthic-foraging sea duck, was the species most affected by the *Cosco Busan* spill (Hampton et al., 2008). Scoters are one of the most numerous waterfowl species wintering in this estuary, and SFB scoters comprise 39% of all those overwintering along the North American lower Pacific Flyway (1988–2009

* Corresponding author. Address: U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592, USA. Tel.: +1 707 562 2004; fax: +1 707 562 3001.
E-mail address: sdelacruz@usgs.gov (S.E.W. De La Cruz).
[1] Present address: Yukon Delta National Wildlife Refuge, State Highway Box 346, Bethel, AK 99559, United States.
[2] Present address: SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513, United States.
[3] Present address: Department of Veterinary Medicine, Denver Zoo, 2300 Steele Street, Denver, CO 80205, United States.

0025-326X/$ - see front matter Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.marpolbul.2012.11.027

average; Accurso, 1992; USFWS, 2009). Scoter species (including surf, white-winged *M. fusca,* and black *M. americana* scoters) in North America have declined by as much as 50% over the past 30 to 50 years (Hodges et al., 1996; Dickson and Gilchrist, 2002; Nysewander et al., 2005). Long-lived waterfowl species with low reproductive potential such as scoters are particularly sensitive to changes in adult survival (Goudie et al., 1994) and may have the most difficulty recovering from oil spills (Samuels and Ladino, 1983/1984). Additionally, many sea ducks show high winter site fidelity and pair on wintering areas; thus, factors that affect survival rates in SFB could have disproportionate effects on local subpopulations (Esler et al., 2000).

Following the *Cosco Busan* spill, more than one thousand oiled scoters were treated by the Oiled Wildlife Care Network (OWCN) using a standardized marine bird protocol (OWCN, 2001). Post-rehabilitation survival of scoters had not been previously studied but was of particular interest given that they comprise a significant component of birds oiled in Pacific coast wintertime spill events (Savard et al., 1998; Hampton et al., 2003). We used an experimental approach to design a marked-bird study that compared survival of scoters externally oiled and rehabilitated (ORHB) with two control treatment groups: un-oiled, rehabilitated (RHB) and un-oiled, non-rehabilitated (CON). We predicted that oiling and the rehabilitation process itself could have effects on survival such that CON birds would have highest survival followed by RHB and then ORHB birds.

2. Methods

2.1. Treatment, radio-marking and data collection

We captured beached, oiled scoters by hand from several locations (Fig. 1) around SFB during 8–21 November 2007. We used netguns (Coda Enterprises, Inc., Mesa, AZ) from a 4 m Boston Whaler to capture birds in Central and San Pablo Bays during 30 November–16 December 2007 (Fig. 1) for the RHB and CON treatment groups. Captured scoters were placed in holding cages and brought to a U.S. Geological Survey (USGS) research field station in Vallejo, California or to the OWCN rehabilitation center in Cordelia, California for processing. We banded, weighed, and measured each captured scoter. We used a combination of plumage characteristics and cloacal examination to determine sex and bursal depth measurements to determine age (Mather and Esler, 1999). Coelomic radio transmitters with external whip antennas (18–19 g, model A2310, Advanced Telemetry Systems, Insanti, MN, USA) were surgically implanted (Olsen et al., 1992; Korschgen et al., 1996; Mulcahy and Esler, 1999) by experienced veterinarians in juvenile and after-second-year (ASY) male and female scoters. Implant transmitters were used because they have been shown to be less disruptive and cause fewer behavioral modifications than external attachment methods for some wild waterfowl (Rotella et al., 1993; Hupp et al., 2003). Coelomic implant transmitters are preferred for scoters relative to other transmitter types when data are collected over a long period of time (Iverson et al., 2006).

Scoters in ORHB and RHB groups underwent treatment and surgery at the OWCN facility. Birds in both groups were treated following established rehabilitative protocols (OWCN, 2001; Mazet et al., 2002) that included administration of charcoal and isotonic fluids, oil removal (ORHB group) and cleaning, assistance with thermoregulation, diagnostic blood work, rehydration, and nutritional supplementation. After rehabilitative treatments were administered, scoters in both groups were radio-marked and kept post-surgery at the facility until their feathers were deemed fully waterproofed and they exhibited normal buoyancy. Marked scoters in ORHB and RHB that died before release were not included in the study ($N = 6$ ORHB, $N = 6$ RHB). At the USGS field station, we radio-marked CON scoters within 24 h of capture and kept them up to 2 h following implant surgeries prior to release. Subcutaneous fluids were administered to CON birds every 4–5 h throughout the period of captivity to minimize the risk of dehydration. Two CON birds died immediately after surgery and were not included in the survival analysis. Marked scoters were released in the northern reach of SFB at the Carquinez Strait in Vallejo (ORHB and RHB), and from the Hercules shoreline (ORHB, RHB, and CON; Fig. 1). One marked ORHB scoter that escaped from the rehabilitation facility after processing was subsequently heard in the survey area and included in our analyses.

We conducted aerial telemetry flights in a fixed-wing aircraft 2–3 times a week for a total of 34 flights between 16 December 2007 and 7 May 2008 to determine location and status of all marked birds. We used a left–right switch-box system to isolate signals on either side of the airplane and determine locations (Gilmer et al., 1981). Each transmitter was equipped with a mortality sensor that doubled the pulse rate of the transmitter when motionless for 8 h. For each survey, we recorded whether a scoter was detected or not, and whether or not detected scoters were alive or dead. Identified mortalities were confirmed by recovery of the carcass or transmitter. The area monitored included bays and the coastline to the north and south of SFB from Bodega Bay to Monterey Bay, including all SFB sub-bays (South, Central, San Pablo, and Suisun), and adjacent wetlands (Fig. 1 inset – see survey area). Transmitters could be heard from 24 km away at an average flight altitude of 460 m; therefore, we identified a 24 km buffer zone around the flight path within which we assumed all transmitters could be heard. California Department of Fish and Game also conducted three extended telemetry flights along the California coast during March 2008 to listen for marked birds that might have left the study area. Dates and areas covered on these flights were: 24 March, Ventura north to Pismo Beach; 25 March, Pismo Beach north to SFB; 27 March, Point Arena north to the Oregon border (Fig. 1 inset).

2.2. Data analyses

We used a live encounter – dead recovery model (Burnham, 1993; Cooch and White, 2005) in Program MARK (White and Burnham, 1999) to estimate winter fates of scoters. This joint model extends standard Cormack–Jolly–Seber models of live capture–recapture data and estimates additional parameters (Burnham, 1993). The four parameters included in live encounter-dead recovery models are: S (the probability of surviving the interval), r (the probability of being dead and reported), F (the probability of fidelity to the sampling region or remaining in the sample), and p (the probability of detection or recapture, conditional on being alive and in the sampling region) (Cooch and White, 2005). This model was most appropriate for our data as detection probability (p) was less than one for individuals across treatments (Murray and Patterson, 2006). Live encounter-dead recovery models allow for the assumption that a bird not detected during one time interval could be either dead or alive and not resighted and does not censor that individual from the interval (Cooch and White, 2005).

We constructed a series of 14 *a priori* candidate models which were designed to evaluate S given all possible combinations of group and time effects, and we included models with body mass and sex as covariates. We did not adjust mass for structural size of each bird, because recent studies have shown little or no improvement with adjustments over body mass alone to predict body condition (Schamber et al., 2009). In all models, we set $F = 0.986$, based on data from un-oiled, non-rehabilitated surf scoters radio-marked from 2003 to 2005 in which only 2 of 149 individuals permanently emigrated from the study area during winter (De La Cruz et al., unpublished data). In all models, we assumed r and p varied among treatment groups but not with respect

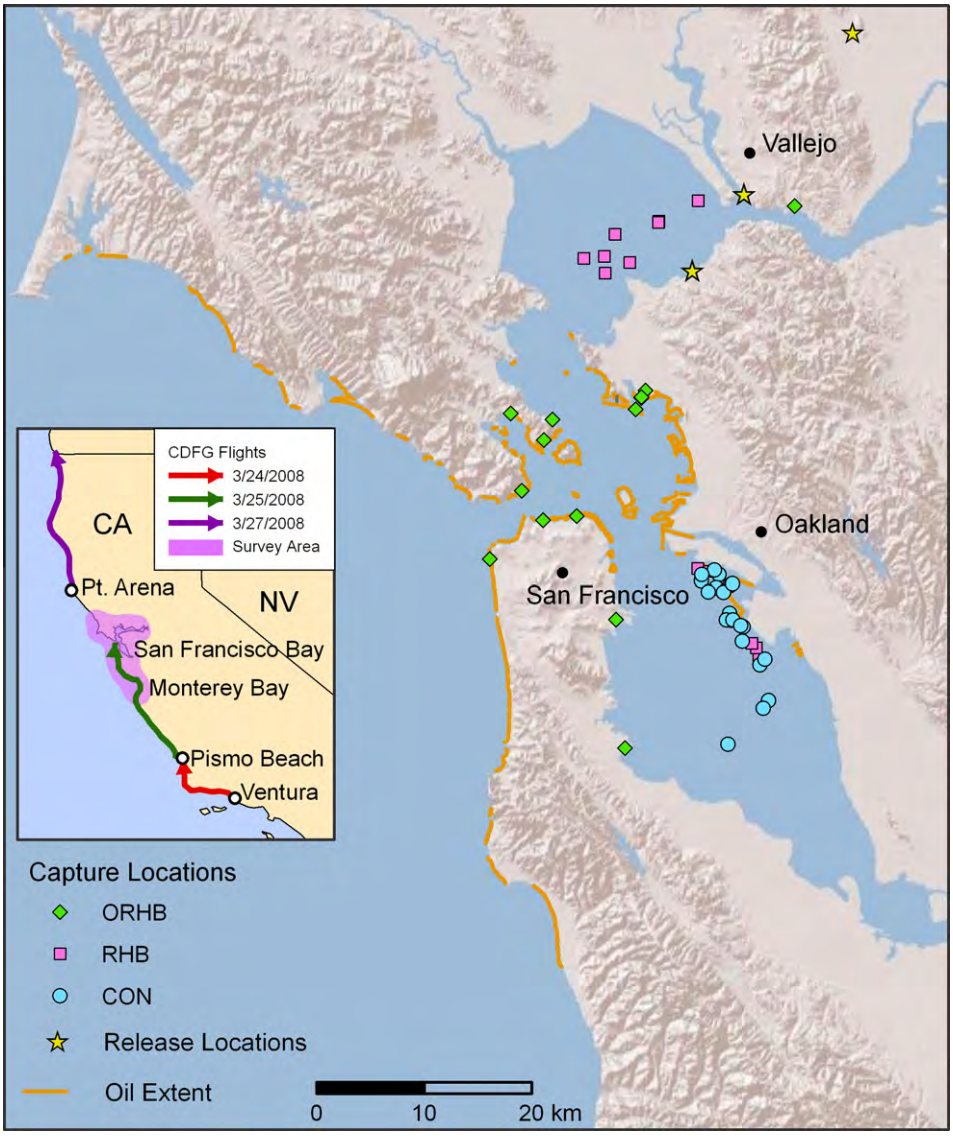


Fig. 1. Map of San Francisco Bay and surrounding coast showing capture locations and the extent of shoreline oiling due to the *M/V Cosco Busan* oil spill (taken from California Department of Fish and Game, Office of Spill Prevention and Response). The inset figure shows the survey area (shaded) flown during each of 31 telemetry flights over the survival study period. Lines along the coast show the starting points, extent and dates of three flights conducted in March to look for marked scoters that had left the study area.

to time, because neither mortality nor detection was variable across encounter occasions. We evaluated appropriate null models, including a no effects model, and models to test our assumptions about *r, p,* and *F*. Age was not included as a covariate in any model, since most of the marked individuals were adults (Table 1). We incorporated encounter data from 31 telemetry flights spanning 16 December 2007 to 7 April 2008 in our candidate models. Data obtained from three flights after 7 April were not included in our analyses, as earlier work showed the mean departure date of satellite-marked scoters for spring migration was 10 April (De La Cruz et al., 2009), and we assumed birds missing after that date could have begun migration. We chose to use the mean spring migration date as a more conservative cut-off date for our study as compared to the beginning of migration in early March (De La Cruz et al., 2009), because known mortalities occurred throughout March. We did not use a fixed post-surgical period for censoring birds (commonly 1–2 weeks for recovery in implant studies) because ORHB and RHB birds were held for an indefinite period until they regained their waterproofing, whereas CON birds were released within hours of surgery (Table 1). Due to lack of statistical power, we did not include post-surgery recovery time or total time in captivity as covariates in our models.

Within Program MARK, we constructed models with the design matrix tools and logit-link function and calculated parameter estimates and variances for each model. We assessed goodness-of-fit using the most general model having adequately estimated parameters by applying the median $\hat{c}$ approach in MARK, in which we simulated data with a range of overdispersion parameter (c) values, obtained a deviance $\hat{c}$ for each of the simulated data sets, and used logistic regression to identify the c which caused median deviance $\hat{c}$ to equal the observed $\hat{c}$. We used this estimated value ($\hat{c} = 1.13$, SE = 0.01) to compute quasi log-likelihood values (Burnham and Anderson, 2002). We used Quasi-Akaike's Information Criterion with a second-order bias correction ($QAIC_c$; Burnham and Anderson, 2002) to compare among models and estimated model fit based on values of $QAIC_c$, the number of parameters (K), and the deviance. Models were ranked and compared with $\Delta QAIC_c$ and $QAIC_c$ weights, where $\Delta QAIC_c$ estimated relative

Table 1
Sample size by sex and age, and means (SE) and ranges of mass, capture, surgery, and release dates for radio-marked surf scoters from each treatment group (ORHB = oiled, rehabilitated; RHB = un-oiled, rehabilitated; CON = un-oiled, non-rehabilitated). All dates are expressed as ordinal dates.

Treatment group	Sex/age[a]				Total *N*	Release mass (g)	Capture date	Surgery date	Release date	Recovery time[b]	Time in captivity[c]
	Male		Female								
	HY	AHY	HY	AHY							
ORHB	2	5	0	11	18	844.4 (14.8)	317.3 (0.8)	337 (0.6)	352 (1.3)	15 (1.0)	34.8 (1.9)
						695–975	312–325	334–343	345–365	9–24	20–51
RHB	1	7	0	7	15	861.3 (19.7)	342.5 (1.3)	348.9 (1.2)	357 (1.4)	8.1 (0.7)	14.5 (0.7)
						790–1020	334–347	340–353	347 – 365	5–12	11–18
CON	0	11	0	11	22	1003.8 (26.6)	348.8 (0.2)	350.2 (0.1)	350.6 (0.1)	0.3 (0.1)	1.7 (0.1)
						820–1280	348–350	349–351	350–351	0–1	1–2
OVERALL	3	22	0	29	55	912.8 (16.2)	337.8 (1.9)	345.6 (0.9)	352.7 (0.7)	7.2 (0.9)	15.3 (2.0)
						695–1280	312–350	334–353	345–365	0–24	1–51

[a] HY = Hatch year, designates a bird hatched during the summer prior to the study. AHY = After hatch year, designates a bird older than one year.
[b] Recovery time = mean (SE) and range of time in days between surgery and release.
[c] Time in captivity = mean (SE) and range of total time in days between intake and release.

differences between the top ranked model and each of the other models, and $QAIC_c$ weights indicated the support for a model relative to the others in the candidate set. Additionally, we calculated evidence ratios (w_1/w_j), where w_1 was the weight of the top ranked model and w_j was the weight of lower ranked models in the candidate set (Burnham and Anderson, 2002).

We also examined beta values (β), standard error (SE), and confidence intervals for variables of interest in the most parsimonious model that included those variables. Beta values are model-estimated slopes, interpreted on the basis of direction and their effect size relative to associated variation. Based on Esler and Iverson (2010), we used a criterion of SE $\beta_i < \beta_i$ to identify variables that had a potential biological relationship with survival. We used model averaging across the candidate model set to generate cumulative winter survival, detection, and recovery estimates for each treatment group. We used the variance–covariance matrix generated in MARK to calculate standard errors by the delta method (Williams et al., 2002; Powell, 2007), as well as confidence intervals in R (version 2.13.0; R Development Core Team, 2011).

3. Results

We released 55 radio-marked scoters in SFB between 11 and 31 December 2007 (Table 1). Capture dates for RHB and CON scoters overlapped each other but were later than those of ORHB scoters (Table 1). The range of surgery and release dates overlapped among all three treatment groups (Table 1). The average number of days between surgery and release (recovery time) and in captivity were longest for ORHB, versus RHB and CON birds (Table 1). We recorded 687 aerial telemetry locations during the survival study. Of these, 132 locations were from ORHB, 255 from RHB, and 300 from CON scoters. All locations were obtained within the surveyed study area (Fig. 1 and inset), and no marked scoters were detected during the three extended coastal flights conducted by California Department of Fish and Game in March (Fig. 1 inset).

Among the 14 candidate models we evaluated to explain variation in scoter survival, the best-supported model ($QAIC_c = 1119.47$, $w_i = 0.31$) indicated *S* varied as a function of treatment group and followed a consistent trend over encounter occasions, and that *p* and *r* also varied among groups (Table 2). The evidence for this model was only 1.17 times higher than the second highest ranking model ($QAIC_c = 1119.78$, $w_i = 0.27$), which specified *S* varied as a function of treatment group, and had no time trend. Weights for models ranked 3rd ($w_i = 0.17$) and 4th ($w_i = 0.12$) indicated weaker support for the additive effects of treatment group and body mass (1.87 times lower) or treatment group and sex (2.59 times lower). The beta estimates for release mass in model 3 (0.004, Table 2) and sex in model 4 (0.468, Table 2) were equal to or less than their associated standard errors (0.004 and 0.606, respectively) and their 95% confidence intervals both overlapped zero, indicating a lack of meaningful effects. We found little support for any of the remaining models ($w_i \leqslant 0.05$), including the no effects model (Table 2, model 7) which had an evidence ratio 25.15 times lower than the highest ranking model.

We averaged across all models (Burnham and Anderson, 2002) to determine cumulative winter estimates of *S*, *p*, and *r* for each of the three treatment groups. Cumulative survival curves plotted over all encounter occasions (Fig. 2) demonstrated low initial survival for ORHB scoters compared to other groups and a steep decline over encounter occasions, while survival for RHB and CON groups displayed a more gradual decline. The resulting estimates for *S* (± standard error, 95% confidence intervals) were 0.143 (±0.107, 0.032–0.636) for ORHB, 0.772 (±0.229, 0.427–1.000) for RHB, and 0.498 (±0.168, 0.254–0.977) for CON (Fig. 2). Model averaged estimates of *p* and *r* followed a similar trend among treatment groups. Estimates of *p* were 0.727 (±0.038, 0.646–0.795) for ORHB, 0.823 (±0.024, 0.770–0.866) for RHB, and 0.769 (±0.023, 0.721–0.811) for CON. Estimates for *r* were 0.205 (±0.112, 0.063–0.498) for ORHB, 0.843 (±0.379, 0.019–0.999) for RHB, and 0.603 (±0.230, 0.187–0.909) for CON.

4. Discussion

We used live-encounter dead-recovery models to evaluate survival (*S*) in light of detection (*p*), recovery (*r*), and site fidelity (*F*) rates of marked scoters in each of our three treatment groups. We found strong support for models that indicated winter survival of scoters differed among treatment groups in our study, and was lowest for ORHB birds. Contrary to our predictions, we found that survival was not negatively influenced by the rehabilitation process itself, as evidenced by the fact that RHB birds had higher survival than CON birds. In addition, the highest ranked model indicated that mortality was likely to occur early in the study for ORHB birds. Small sample sizes resulted in overlap of 95% confidence intervals among groups; however, the cumulative model averaged survival estimate for ORHB (0.143) was substantially lower than that of both RHB (0.772) and CON (0.498) scoters.

Likewise, estimates for reporting of dead scoters (*r*) and detection of live scoters (*p*) also differed among groups in our top models and were lowest for ORHB birds. In particular, the low estimate of *r* for ORHB scoters (0.205) reflects a large number of birds that either died and were not reported or disappeared early in the

Table 2
Ranking of models used to estimate winter fates of surf scoters in a live encounter – dead recovery analysis. The best-fitting model is that with the lowest $QAIC_c$ value and support for each model is indicated by difference in its $QAIC_c$ value from the best model ($\Delta QAIC_c$) and its $QAIC_c$ weight.

Model rank	Model Description [a]	$QAIC_c$	ΔQAICc	QAICc weight (w_i)	Evidence ratios	Model likelihood	Number of parameters (K)	QDeviance
1	{$S(g+T)p(g)r(g)F(0.986)$}	1119.47	0	0.31	–	1.00	10	1099.17
2	{$S(g)p(g)r(g)F(0.986)$}	1119.78	0.31	0.27	1.17	0.86	9	1101.53
3	{$S(g+\text{weight})p(g)r(g)F(0.986)$}	1120.73	1.26	0.17	1.87	0.53	10	1100.42
4	{$S(g+\text{sex})p(g)r(g)F(0.986)$}	1121.37	1.90	0.12	2.59	0.39	10	1101.07
5	{$S(g*T)p(g)r(g)F(0.986)$}	1123.41	3.93	0.04	7.14	0.14	12	1098.97
6	{$S(T)p(g)r(g)F(0.986)$}	1124.01	4.53	0.03	9.64	0.10	8	1107.81
7	{$S(.)p(.)r(.)F(.)$}	1124.41	4.93	0.03	11.78	0.08	4	1116.35
8	{$S(.)p(g)r(g)F(0.986)$}	1125.26	5.79	0.02	18.09	0.06	7	1111.11
9	{$S(.)p(.)r(.)F(0.986)$}	1125.92	6.45	0.01	25.15	0.04	3	1119.89
10	{$S(t)p(g)r(g)F(0.986)$}	1151.32	31.84	0	–	0	37	1073.28
11	{$S(g+t)p(g)r(g)F(0.986)$}	1180.96	61.48	0	–	0	39	1098.47
12	{$S(g*t)p(g)r(g)F(0.986)$}	1264.83	145.36	0	–	0	99	1035.65
13	{$S(g*t+\text{weight})p(g)r(g)F(0.986)$}	1267.14	147.67	0	–	0	100	1035.28
14	{$S(g*t+\text{sex})p(g)r(g)F(0.986)$}	1274.16	154.68	0	–	0	100	1042.30

[a] Key to Model Description notation: S = survival probability, p = detection probability, r = recovery probability, F = probability of fidelity to study area (set at 0.986 for all models). Tested effects are in parentheses for each parameter – g = treatment group effect, t = time effect over encounter occasions, T = time effect follows a trend over encounter occasions. "*" indicates an interactive effect, while "+" indicates an additive effect. In Models 3 and 13 release mass was considered as a covariate for survival and in Models 4 and 14 sex was a covariate of survival.

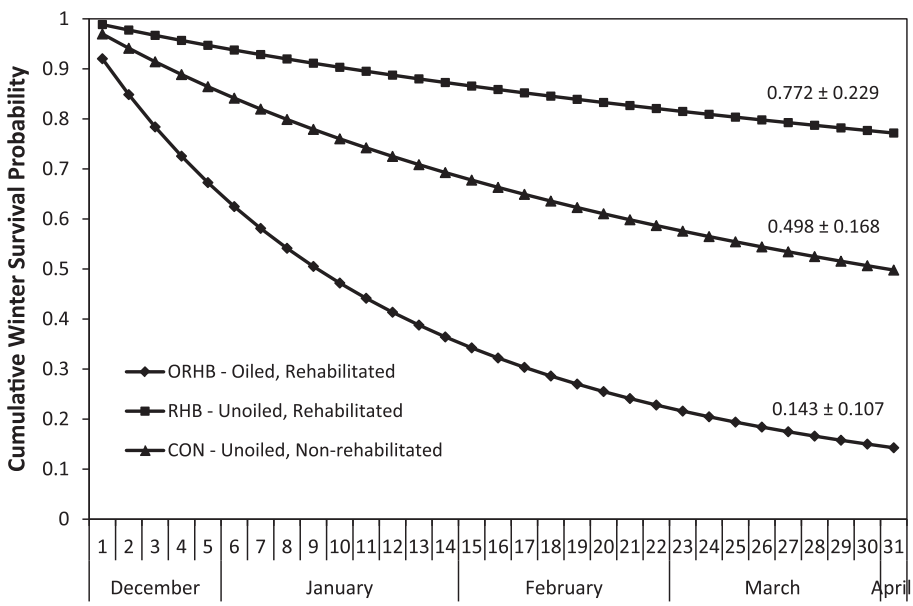


Fig. 2. Cumulative survival probability curves for 55 radio-marked San Francisco Bay surf scoters in treatment groups ORHB, RHB, and CON during winter 2007–2008. Curves are determined based on model-averaging across all candidate models. Numbers along the x-axis represent 31 telemetry flights taken over the course of the study period to collect encounter data on scoters.

study, and this parameter had a strong influence on cumulative estimates of S. High initial post-release mortality has been reported in marking studies of un-oiled scoters (Iverson et al., 2006) and in studies of other oiled and rehabilitated species such as common murres (*Uria aalge*; Newman et al., 2004). In these studies, early mortality was attributed to capture and handling stress. Given the much higher survival rate of RHB birds that underwent treatments similar to ORHB birds, this explanation seems less likely in our study; however, we did not directly evaluate capture and handling time as covariates in our models.

While differences among groups for estimates of p were smaller than for r, ORHB birds were detected less frequently. This may have occurred if ORHB behavior differed from other groups. For example, birds that spent more time near sheltered or covered areas or that were diving more frequently might have had a higher likelihood of being missed during aerial telemetry flights. Behavior results for these treatment groups (Golightly et al., 2011) indicated that ORHB scoters were found closer to shore than RHB and CON birds, but there were no differences in dive frequency or duration among the groups. On the basis of our previous work, we chose to hold the fourth parameter in our model, fidelity (F), constant at 0.986 for all groups. It is conceivable that this estimate was too conservative if prey or habitat conditions related to oiling in SFB caused birds to emigrate in higher numbers than in a typical year. However, we found no evidence for emigration from the study area based on coastal flights conducted in March prior to the onset of spring migration.

The covariates of sex and release mass (Models 3 and 4) had little influence on survival. This differs somewhat from the results of Goldsworthy et al. (2000), who found that both sex and release mass significantly affected post-release survival of little penguins (*Eudyptula minor*). Over a 20 month period, male little penguins

were more likely to survive than females, and the probability of survival increased by 10% with every 127 g increase in release mass (Goldsworthy et al., 2000). Incorporating a larger sample size to better examine the effect of these parameters may be valuable for scoters, especially since sea duck population dynamics are particularly sensitive to adult female survival (Goudie et al., 1994; Esler et al., 2000). Ranges for recovery time and total time in captivity were distinct among treatment groups; however, we lacked the statistical power to evaluate them as covariates in our survival models. Scoter species respond poorly to long periods of captivity (Rosenberg and Petrula, 2000; Richman and Lovvorn, 2008), so time spent in rehabilitation may negatively impact survival. However, RHB scoters had the highest survival of any group, yet they spent an intermediate time in recovery and total captivity compared to the other two treatment groups. This suggests that extended rehabilitation time itself may not have negatively influence ORHB survival; however, additional work focused on time in captivity is needed to fully understand its effect.

The cumulative winter survival estimate for RHB birds was similar to that of Harlequin ducks (*Histrionicus histrionicus*), another sea duck species, marked on un-oiled areas of Prince William Sound, Alaska (0.837, Esler et al., 2000; Esler and Iverson 2010), while CON scoter survival was markedly lower. Supplemental feeding and extended care of RHB birds could have had beneficial results, such as improving immune function or waterproofing, which resulted in higher survival for this group. In addition, CON scoters were marked in a separate facility by a different surgical team, which could have had some bearing on their differential survival. However, scoters in all groups were marked using a standard protocol (Olsen et al., 1992; Korschgen et al., 1996; Mulcahy and Esler, 1999) that has proven successful in several other studies of non-oiled surf scoters conducted by various teams across the Pacific coast (e.g. Iverson et al., 2006; Kirk et al., 2008; De La Cruz et al., 2009; Takekawa et al., 2011); therefore, the marking procedure itself is unlikely to be the source of differences among groups. Marking diving birds with transmitters can influence their descent speed and dive durations (Latty et al. 2010), and thus may also have an effect on their survival. In our study, birds from each group were marked with the same transmitter type to ensure transmitters effects were applied equally to all groups and were not likely to have caused the survival differences we detected among groups.

The cumulative survival rate of ORHB scoters was lower than those reported for other species in recent studies (Anderson et al., 2000; Golightly et al., 2002; Newman et al., 2004) that evaluated use of rehabilitation techniques instituted by OWCN in 1994 (Mazet et al., 2002). Anderson et al. (2000) found that oiled and rehabilitated American coots (*Fulica americana*) had a cumulative survival rate of 49%, while survival of a non-oiled, non-rehabilitated control group was one and a half times higher at 76%. Golightly et al. (2002) concluded that 100% of oiled and rehabilitated Western gulls (*Larus occidentalis*) treated in 1997 after the Torch/Platform Irene spill survived to 183 days after release, and that survival did not differ among this group and rehabilitated and non-rehabilitated control groups. Newman et al. (2004) studied survival of oiled and rehabilitated common murres and found that 68% survived at least 80 days after release; however, only 7% of common murres survived until 142 days. Reasons for the differences seen among these studies may be species-specific, as post-release survival is highly variable among species (Russell et al., 2003). For instance, penguins have higher post-rehabilitation survival (Morant et al., 1981; Underhill et al., 1999) than other species, including sea duck species like the white-winged scoter (Sharp, 1996).

Avian post-rehabilitation survival may also depend on several other factors, including degree of oiling, type of oil, and climatic conditions (Goldsworthy et al., 2000), that we did not evaluate in this study. Ingestion of petroleum hydrocarbons has a wide variety of documented physiological effects on birds, including anemia (Leighton et al., 1983), endocrine dysfunction (Peakall et al., 1981), poor condition (muscle and lipid catabolism – Oka and Okuyama, 2000) and immunosuppression (Rocke et al., 1984) that may be delayed or not apparent externally (Khan and Ryan, 1991). Blood health indices may help determine the extent of physiological damage a bird has sustained and guide treatment. Newman et al. (2004) showed that some of these indices, including lower total inorganic phosphorous concentration, higher creatine kinase activity, and higher fibrinogen concentrations, were associated with decreased survival in common murres. Inclusion of these parameters in more extensive survival analyses on rehabilitated scoters may help identify health parameters most important to this species.

Scoters spend three-quarters of their annual cycle migrating and wintering in estuaries and nearshore marine environments where the potential for them to experience acute mortality or long-term demographic effects (e.g. Henkel et al. 2012) due to oil spills is high. When scoters undergo rehabilitation as a result of an oil spill, post-release studies can provide information needed to improve treatments, make damage assessments, and ultimately weigh the costs and benefits of rehabilitation. It is difficult to determine the fate of oiled, wild birds that remain at sea and are not subject to treatment (Ford et al. 1987; Piatt et al. 1990); however if we assume that oiled, non-rehabilitated birds suffer 100% mortality, our data suggest that rehabilitation increased winter survival by 14.3%. Furthermore, our results demonstrate that unoiled scoters can tolerate modern rehabilitation techniques well. Given this, survival of rehabilitated oiled scoters, and perhaps many marine bird species, is likely dependent on several factors related to type of oil, severity of oiling, and species specific physiological effects. Identifying the most influential of these factors is the future challenge for rehabilitative programs.

Acknowledgements

This study was funded by the Oiled Wildlife Care Network (OWCN) at the University of California, Davis. OWCN personnel were directly involved in the rehabilitative care and radio-marking of scoters, but did not participate in data collection, analyses or interpretation. All capture, handling, and marking of scoters was carried out under the guidance and approval of the U.S. Geological Survey, Western Ecological Research Center, Animal Care and Use Committee with permits from California Department of Fish and Game (SC-004857 and SC-003855), U.S. Fish and Wildlife Service (MB-102896-0), and USGS Bird Banding Laboratory (BBL-22911). We are grateful for the comments of D. Esler, M. Ricca, and an anonymous reviewer, which helped to improve this manuscript. We thank E. Palm, M. Wilson, J. Shinn, S. Rhoades, L. Terrazas, A. Schultz, H. Robinson, and pilot B. Van Wagenen for assistance with scoter capture and marking, data collection, and data entry, as well as P. Gibbons, DVM, for his veterinary expertise. We acknowledge the assistance of Advanced Telemetry Systems for rapidly producing implant transmitters following the spill. Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. government.

References

Accurso, L.M., 1992. Distribution and Abundance of Wintering Waterfowl on San Francisco Bay, 1988-1990. Unpubl. Master Thesis. Humboldt State University, Arcata, CA, p. 252.

Altwegg, R., Crawford, R.J.M., Underhill, L.G., Williams, A.J., 2008. Long-term survival of de-oiled Cape gannets *Morus capensis* after the *Castillo de Bellver* oil spill of 1983. Biol. Conserv. 141, 1924–1929.

Anderson, D.W., Gress, F., Fry, D.M., 1996. Survival and dispersal of oiled brown pelicans after rehabilitation and release. Mar. Pollut. Bull. 32, 711–718.

Anderson, D.W., Newman, S.H., Kelly, P.R., Herzog, S.K., Lewis, K.P., 2000. An experimental soft-release of oil-spill rehabilitated American coots (*Fulica americana*): I. Lingering effects on survival, condition and behavior. Environ. Pollut. 107, 285–294.

Antonio, F.J., Mendes, R.S., Thomaz, S.M., 2011. Identifying and modeling patterns of tetrapod vertebrate mortality rates in the Gulf of Mexico oil spill. Aquat. Toxicol. 105, 177–179.

Burnham, K.P., 1993. A theory for combined analysis of ring recovery and recapture data. In: Lebreton, J.D., North, P.M. (Eds.), Marked Individuals in the Study of Bird Population. Birkhäuser Verlag, Basel, Switzerland, pp. 199–213.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference: A Practical Information–Theoretic Approach, second ed. Springer-Verlag, New York, New York, USA.

Cooch, E., White, G., 2005. Program Mark – A Gentle Introduction, version 4. Ithaca, NY. <http://www.phidot.org/software/mark/>.

De La Cruz, S.E.W., Takekawa, J.Y., Wilson, M.T., Nysewander, D.R., Evenson, J.R., Esler, D., Boyd, W.S., Ward, D.H., 2009. Surf scoter spring migration routes and chronology: a synthesis of Pacific coast studies. Can. J. Zool. 87, 1069–1086.

Dickson, D.L., Gilchrist, H.G., 2002. Status of marine birds of the southeastern beaufort sea. Arctic 55 (Suppl. 1), 46–58.

Esler, D., Iverson, S.A., 2010. Female harlequin duck winter survival 11–14 years after the *Exxon Valdez* oil spill. J. Wildlife Manage. 74, 471–478.

Esler, D., Schmutz, J.A., Jarvis, R.L., Mulcahy, D.M., 2000. Winter survival of adult female harlequin ducks in relation to history of contamination by the *Exxon Valdez* oil spill. J. Wildlife Manage. 64, 839–847.

Esler, D., Bowman, T.D., Trust, K., Ballachey, B.E., Dean, T.A., Jewett, S.C., O'Clair, C.E., 2002. Harlequin duck population recovery following the *Exxon Valdez* oil spill: progress, process, and constraints. Mar. Ecol. Prog. Ser. 241, 271–286.

Estes, J.A., 1998. Concerns about rehabilitation of oiled wildlife. Conserv. Biol. 12, 1156–1157.

Ford, R.G., Page, G.W., Carter, H.R., 1987. Estimating mortality of seabirds from oil spills. In: Proceedings of the 1987 Oil Spill Conference. American Petroleum Institute, Washington, DC.

Gilmer, D.S., Cowardin, L.M., Duval, R.L., Mechlin, L.M., Shaiffer, C.W., Kuechle, V.B., 1981. Procedures for the Use of Aircraft in Wildlife Biotelemetry Studies. U.S. Fish and Wildlife Service, Washington DC (Resources Publication No. 140).

Goldsworthy, S.D., Giese, M., Gales, R.P., Brothers, N., Hamill, J., 2000. Effects of the *iron baron* oil spill on little penguins (*Eudyptula minor*). II Post-release survival of rehabilitated oiled birds. Wildlife Res. 27, 573–582.

Golightly, R.T., Newman, S.H., Craig, E.N., Carter, H.R., Mazet, J.A., 2002. Survival and behavior of western gulls following exposure to oil and rehabilitation. Wildlife Soc. Bull. 30, 539–546.

Golightly, R.T., Gabriel, P.O., De La Cruz, S.E.W., Takekawa, J.Y., Lockerby, C.L., Henkel, L., Massey, G., Ziccardi, M., 2011. Behavior, movements, and dive activity of surf scoters oiled in the *Cosco Busan* spill. In Survival and Behavior of Surf Scoters Following Exposure to Oil and Rehabilitation. Final Report to Oiled Wildlife Care Network, Davis, California, pp. 4–31.

Goudie, R.I., Brault, S., Conant, B., Kondratyev, A.V., Petersen, M.R., Vermeer, K., 1994. The status of sea ducks in the North Pacific rim: toward their conservation and management. Trans. N. Am. Wildlife Nat. Res. Conf. 59, 2749.

Hampton, S.R., Ford, G., Carter, H.R., Abraham, C., Humple, D., 2003. Chronic oiling and bird mortality from the sunken vessel S.S. Jacob Luckenbach in Central California. Marine Ornithol. 31, 35–41.

Hampton, S., Baker, G., Donner, A., 2008. Natural resource damage assessment for the *Cosco Busan* oil spill: bird injury summary. California Department of Fish and Game, Office of Spill Prevention and Response, accessed 13.07.09. <http://www.dfg.ca.gov/ospr/spill/nrda/cosco-busan-nrda-bird-injury-factsheet-feb-2008.pdf>.

Henkel, J.R., Sigel, B.J., Taylor, C.M., 2012. Large-scale impacts of the *Deepwater Horizon* oil spill: can local disturbance affect distant ecosystems through migratory shorebirds? Bioscience 62, 676–685.

Hodges, J.I., King, J.G., Conant, B, Hanson, H.A., 1996. Aerial Surveys of waterbirds in Alaska 1957–94: Population Trends and Observer Variability. Information and Technology Report 4. USDOI, National Biological Service.

Hupp, J.W., Ruhl, G.A., Pearce, J.M., Mulcahy, D.M., Tomeo, M.A., 2003. Effects of implanted radio transmitters with percutaneous antennas on the behavior of Canada geese. J. Field Ornithol. 74, 250–256.

Iverson, S.A., Boyd, W.S., Esler, D., Mulcahy, D.M., Bowman, T.D., 2006. Comparison of the effects and performance of four radio transmitter types for use with scoters. Wildl. Soc. Bull. 34, 656–663.

Jessup, D.A., 1998. Rehabilitation of oiled wildlife. Conserv. Biol. 12, 1153–1155.

Khan, R.A., Ryan, P., 1991. Long term effects of crude oil on common murres (*Uria aalge*) following rehabilitation. B. Environ. Contam. Tox. 46, 216–222.

Kirk, M.K., Esler, D., Iverson, S.A., Boyd, W.S., 2008. Movements of wintering surf scoters: predator responses to different prey landscapes. Oecologia 155, 859–867.

Korschgen, C.E., Kenow, K.P., Gendron-Fitzpatrick, A., Green, W.L., Dein, F.J., 1996. Implanting intra-abdominal radio transmitters with external whip antennas in ducks. J. Wildlife Manage. 60, 132–137.

Latty, C.J., Hollmen, T.E., Petersen, M.R., Powell, A.N., Andrews, R.D., 2010. Abdominally implanted transmitters with percutaneous antennas affect the dive performance of common eiders. Condor 112, 314–322.

Leighton, F.A., Peakall, D.B., Butler, R.G., 1983. Heinz-body hemolytic anemia from the ingestion of crude oil: a primary toxic effect in marine birds. Science 220, 871–873.

Mather, D.D., Esler, D., 1999. Evaluation of bursal depth as an indicator of age class of harlequin ducks. J. Field Ornithol. 70, 200–205.

Mazet, J.A.K., Newman, S.H., Gilardi, K.V.K., Tseng, F.S., Holcomb, J.B., Jessup, D.A., Ziccardi, M.H., 2002. Advances in oiled bird emergency medicine and management. J. Avian Med. Surg. 16, 146–149.

Morant, P.D., Cooper, J., Randall, R.M., 1981. The rehabilitation of oiled jackass penguins *Spheniscus demersus*. In: Proceedings of a Symposium on Birds of Sea and Shore. African Seabird Group, Cape Town, pp. 286–302.

Mulcahy, D.M., Esler, D., 1999. Surgical and immediate post-release mortality of harlequin ducks (*Histrionicus histrionicus*) implanted with abdominal radio transmitters with percutaneous antennas. J. Zoo Wildlife Med. 30, 397–401.

Murray, D.L., Patterson, B.R., 2006. Wildlife survival estimation: recent advances and future directions. J. Wildlife Manage. 70, 1499–1503.

Newman, S.H., Golightly, R.T., Craig, E.N., Carter, H.R., Kreuder, C., 2004. The Effects of Petroleum Exposure and Rehabilitation on Post-Release Survival, Behavior, and Blood Health Indices: A Common Murre (*Uria aalge*) Case Study Following *The Stuyvesant* Petroleum Spill. Final Report. Oiled Wildlife Care Network, Wildlife Health Center, 1 Shields Avenue, School of Veterinary Medicine, University of California, Davis, CA 95616. pp. 1–46.

Evenson, J.R., Nysewander, D.R., Cyra, T.A., Murphie, B.L., 2005. Report of Marine Bird and Marine Mammal Component Puget Sound Ambient Monitoring Program for July 1992 to December 1999 Period. Washington Department of Fish and Wildlife, Olympia, WA.

Oiled Wildlife Care Network (OWCN), 2001. Protocols for the care of oil-affected birds. <http://ww.vetmed.ucdavis.edu/owcn/Participant.html#Protocols>.

Oka, N., Okuyama, M., 2000. Nutritional status of dead oiled rhinoceros auklets (*Cerorhinca monocerata*) in the southern Japan Sea. Mar. Pollut. Bull. 40, 340–347.

Olsen, G.H., Dein, F.J., Haramis, G.M., Jorde, D.G., 1992. Implanting radio transmitters in wintering canvasbacks. J. Wildlife Manage. 56, 325–328.

Peakall, D.B., Tremblay, J., Kinter, W.B., Miller, D.S., 1981. Endocrine dysfunction in seabirds caused by ingested petroleum. Environ. Res. 24, 6–14.

Piatt, J.F., Lensink, C.J., Butler, W., Kendziorek, M., Nysewander, D.R., 1990. Immediate impact of the 'Exxon Valdez' oil spill on marine birds. Auk 107, 387–397.

Powell, L.A., 2007. Approximating variance of demographic parameters using the delta method: a reference for avian biologists. Condor 109, 949–954.

R Development Core Team, 2011. R: A Language and Environment for Statistical Computing ISBN 3-900051-07-0. R Foundation for Statistical Computing, Vienna, Austria, <http://www.R-project.org/>.

Richman, S.E., Lovvorn, J.R., 2008. Costs of diving by wing and foot propulsion in a sea duck, the white-winged scoter. J. Comp. Physiol. B. 178, 321–332.

Rocke, T.E., Yuill, T.M., Hinsdill, R.D., 1984. Oil and related toxicant effects on mallard immune defenses. Environ. Res. 33, 343–352.

Rosenberg, D.H., Petrula, M.P., 2000. Scoter Life History and Ecology: Linking Satellite Technology with Traditional Knowledge. Exxon Valdez Oil Spill Restoration Project Annual Report (Rest. Proj. 98273). Alaska Dept. Fish and Game, Div. Wildl. Conser., Anchorage.

Rotella, J.J., Howerter, D.W., Sankowski, T.P., Devries, J.H., 1993. Nesting effort by wild mallards with three types of radio transmitters. J. Wildlife Manage. 57, 690–695.

Russell, M., Holcomb, J., Berkner, A., 2003. 30 years of oiled wildlife response statistics. In: Proceedings of the 7th International Effects of Oil on Wildlife Conference. International Bird Rescue Research Center (IBRRC), Hamburg, Germany (14–16 October 2003).

Samuels, W.B., Ladino, A., 1983/1984. Calculations of seabird population recovery from potential oil spills in the mid-Atlantic region of the United States. Ecol. Model. 21, 63–84.

Savard, J.P.L., Bordage, D., Reed, A., 1998. Surf scoter (*Melanitta perspicillata*). In: Poole, A., Gill, F. (Eds.), The Birds of North America, vol. 363. The Birds of North America, Inc., Philadelphia, PA.

Schamber, J.L., Esler, D., Flint, P.L., 2009. Evaluating the validity of using unverified indices of body condition. J. Avian Biol. 40, 49–56.

Sharp, B.E., 1996. Post-release survival of oiled, cleaned seabirds in North America. Ibis 138, 222–228.

Takekawa, J.Y., De La Cruz, S.E.W., Wilson, M.T., Palm, E.C., Yee, J., Nysewander, D.R., Evenson, J.R., Eadie, J.M., Esler, D., Boyd, W.S., Ward, D.H., 2011. Breeding synchrony, sympatry, and nesting areas of Pacific coast surf scoters (*Melanitta perspicillata*) in the Northern boreal forest. Stud. Avian Biol. 41, 41–63.

U.S. Fish and Wildlife Service (USFWS), 2009. Waterfowl Population Status, 2009. U.S. Department of the Interior, Washington, D.C., USA.

Underhill, L.G., Bartlett, P.A., Baumann, L., Crawford, R.J.M., Dyer, B.M., Gildenhuys, A., Nel, D.C., Oatley, T.B., Thornton, M., Upfold, L., Williams, A.J., Whittington, P.A., Wolfaardt, A.C., 1999. Mortality and survival of African penguins *Spheniscus demersus* involved in the *Apollo sea* oil spill: an evaluation of rehabilitation efforts. Ibis 141, 29–37.

Votier, S.C., Hatchwell, B.J., Beckerman, A., McCleery, R.H., Hunter, F.M., Pellatt, J., Trinder, M., Birkhead, T.R., 2005. Oil pollution and climate have wide-scale impacts on seabird demographics. Ecol. Lett. 8, 1157–1164.

White, G.C., Burnham, K.P., 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 (Supplement), 120–138.

Williams, B.K., Nichols, J.D., Conroy, M.J., 2002. Analysis and Management of Animal Populations: Modeling, Estimation, and Decision Making. Academic Press, San Diego, CA.

tidal level, particularly in the South Bay (Atwater *et al.* 1979), are likely to be amplified by rising tidal levels.

Contaminants. Environmental contaminants may affect the health and vigor of clapper rails directly through toxic effects to individuals, or indirectly through effects to organisms upon which the rail depends. Acute poisoning associated with oil or toxic material spills could result in rail mortalities within affected habitat. A large oil spill in South Bay marshes could be catastrophic for the rail population. To date, most direct contaminant impacts to the rail have likely been due to lifetime exposures at chronic, sub-lethal concentrations that alter individual fitness. Known contaminants of concern for rail recovery in the San Francisco Bay Estuary include mercury, selenium, PCBs, and petroleum hydrocarbons. The potential toxicological effects of long term chronic contaminant exposures can include reproductive impairment, compromised immune function, reduced growth, deformity, and altered behavior (Schwarzbach *et al*. 2006). While few adult clapper rail mortalities have been directly attributed to contaminants, elevated mercury levels have been found in the tissues of some dead adults. Reproduction in clapper rails has been documented as poor, and contaminants, particularly mercury and perhaps PCBs, are the most likely contributors (Schwarzbach *et al*. 2006).

Contaminants could also indirectly impact rails by altering habitat features such as benthic prey density or nesting cover. Petroleum hydrocarbons and trace elements, such as arsenic, copper, silver, cadmium, and lead, may be an indirect hazard through toxicity to benthic prey. Although benthic organism densities and species composition are known to be altered within the bay by contaminants at some locations (San Francisco Estuary Institute 1999), the effect within rail habitat has not been systematically assessed.

Also of potential concern are newer environmental contaminants that are rarely monitored and poorly understood. Unmonitored contaminants in San Francisco Bay include such chemicals as pharmaceuticals, plasticizers, flame retardants, and detergent additives (San Francisco Estuary Institute 2000). Toxic effects of many of these chemicals to rails and other estuary biota are not known. In other species, some of these chemicals have caused endocrine disruption and altered gender development through in ovo exposures (Colburn and Clement 1992).

With the exception of the largest deepwater discharges of industry and some municipalities, much of the ongoing contamination of the bay enters at the margins, often through tidal marsh habitat. Many, if not most, tidal marsh sediments are more contaminated than open bay sediments (Collins and May 1997). As an omnivore inhabiting the margins of the bay, the clapper rail is exposed to sediment-born contamination of baylands, and may be particularly at risk of exposure to those chemicals that bioaccumulate in benthic prey. When comparing diving ducks with other species, the higher concentrations of selenium were found in benthic foragers (Ohlendorf *et al.* 1986). Contaminants that are toxic to vertebrates, persist in sediments, and transfer and accumulate in clapper rail prey, present the greatest contaminant hazards to clapper rail recovery.

For the past 75 years or more the greatest densities of breeding rails have been found in marshes of the South Bay (DeGroot 1927, Gill 1979, Harvey 1988). Freshwater inflows to the South Bay are substantially more limited than in the North Bay, which receives inflow from the Sacramento

Oil Spills:

The threat of a major oil spill within the bay exists and contingency plans have been developed to cleanup and prevent distribution of oil to sensitive natural areas. To protect the clapper rail and salt marsh harvest mouse from such a catastrophe, one of the goals of any contingency plan for responding to a San Francisco Bay spill must be to effectively prevent and limit movement of oil into tidal marshes, particularly the more densely occupied marshes of the South Bay. The current oil spill contingency plan for San Francisco Bay ranks salt marshes and tidal flats as the two most sensitive shorelines to oiling (U.S. Fish and Wildlife Service 1997*b*). Both habitats are important to the rail and and the latter is important to the mouse. Barriers and berms are the preferred shoreline treatment method for these habitats; sufficient boom material should be kept available within the bay for prevention of oil movement into salt marsh habitat of the entire Estuary. Trampling of oiled mudflats by cleanup crews should be avoided because this pushes oil beneath the surface and prolongs its future availability to benthic prey of the rail.

There have been several major oil spills within San Francisco Bay in the last decades. These spills were due to a number of causes including shipping accidents, a pipeline rupture, an open valve at refineries, leaks from a sunken ship, etc. Many of the spills impacted the interior shoreline of the bay, with impacts to the Central Bay and Carquinez Strait. Numerous marshes in both areas support the rail and the mouse. Although no clapper rails were identified in salvage or cleanup operations, rails may have been oiled and escaped detection due to their normally secretive behavior. The effects of an oil spill depend on the degree of oiling and the nature and weathering of the oil. A large oil spill in the South Bay, where clapper rail populations are more densely concentrated, could have disasterous ramifications for the long-term survival of the species.

January 1971 - The collision of two tankers, the *Oregon Standard* and *Arizona Standard* released 27,600 barrels of bunker fuel oil at the Golden Gate Bridge. An estimated 4,000 seabirds were killed. Oil impacted the western shore of the Central Bay from the Tiburon Peninsula and Richardson Bay to 5 km (3.1 mi.) south of the Oakland Bay Bridge. The South Bay was unoiled due to northward moving surface flows. Most of the spilled oil was carried out to sea.

April 1988 - An open valve on a tank farm on the Shell Refinery in Martinez released 8,700 barrels of crude oil in the Carquinez Straits and contaminated 80.5 km (50 mi.) of shoreline habitat. The oil drained through Peyton Slough and Shell Marsh. Approximately 40.5 ha (100 acres) of tidal wetlands were contaminated by oil. While there is uncertainty about direct effects to rails because none were recovered, it is possible some rails were impacted (Page *et al.* 1989).

October 1996 - The *Cape Mohican* oil spill occurred when a valve on the ship's hull was opened during routine maintenance at the San Francisco Dry Dock. An estimated 96,000 gallons of fuel oil spilled into the dry dock and approximately 40,000 gallons of that oil

The Condor 89:636–653
© The Cooper Ornithological Society 1987

LANDBIRD PRODUCTIVITY IN CENTRAL COASTAL CALIFORNIA: THE RELATIONSHIP TO ANNUAL RAINFALL, AND A REPRODUCTIVE FAILURE IN 1986[1]

DAVID F. DESANTE AND GEOFFREY R. GEUPEL
Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970

Abstract. The avian productivity of 51 locally breeding species in coastal grassland, coastal scrub, and mixed evergreen forest habitats was estimated from 11 years of standardized mist-netting data collected between 10 May and 17 August at Point Reyes Bird Observatory's Palomarin Field Station. A relationship between the number of young birds banded per 100 net hr and the amount of annual (winter) rainfall during the previous season was apparent for the 10 years 1976 to 1985: productivity was low (19 to 32% below the 10-year mean) in years of extremely low rainfall, increased to a maximum (21 to 39% above the 10-year mean) in years of average or slightly above average rainfall, and decreased substantially (20% below the 10-year mean) in years of very heavy rainfall. The number of young birds banded per 100 net hr in 1986, however, was 62.3% below the previous 10-year mean and fell well outside the above relationship. This high level of reproductive failure occurred in most of the 51 locally breeding species and was independent of migratory behavior, habitat choice, and nest location. It was not independent of foraging behavior, however, as swallows and woodpeckers, species that feed their young on insects produced in decomposer- or detritus-based food chains rather than in primary production-based food chains, showed no significant reduction in productivity. Timing of the decrease in young birds suggests that the onset of reproductive failure occurred in mid-May, well after the nesting season began. Such a large-scale reproductive failure of virtually an entire landbird community has not been reported before and no obvious weather factors appear to explain it. Preliminary data indicate that the reproductive failure was not confined to the vicinity of Palomarin or to central coastal California but rather extended over much of northern California even to the west slope of the Sierra Nevada. It is interesting, but perhaps only coincidental, that several circumstances of this phenomenon, including its timing, appear to coincide remarkably well with the passage of a radioactive "cloud" from the Chernobyl nuclear power plant accident and associated rainfall.

Key words: Landbirds; productivity; reproductive failure; annual rainfall; community dynamics; California; mist-netting.

INTRODUCTION

Because the standard procedure for determining avian productivity, the monitoring of individual nests, is extremely time consuming and labor intensive for landbirds with widely dispersed and well hidden nests, little information exists concerning the long-term productivity of an entire landbird community. In fact, most of the existing data concerning the annual variations in landbird reproductive success have arisen from intensive single-species studies (e.g., Nice 1937, Perrins and Moss 1975, Nolan 1978, Pinkowski 1979, Petrinovitch and Patterson 1983, Tiainen 1983). The determination of reproductive success on a community-wide basis, however, must be a necessary and important component of the effort to understand what controls the dynamics and stability of avian communities, a question that continues to be the subject of ecological debate (Wiens 1983, 1984a; Noon et al. 1985; Dunning 1986). Information regarding annual variations in the reproductive success of various species or guilds of species within the community can provide additional insight toward understanding the dynamics of avian communities. Furthermore, long-term data on the extent and causes of natural fluctuations in the productivity of avian communities are necessary for a proper evaluation of the effects of human-caused environmental disturbances upon these communities. Wiens (1984b) provided convincing arguments for the importance of long-term studies of avian populations and communities.

Weather factors, including temperature, rainfall and snowpack, have been implicated as proximate causes of variations in avian productivity

[1] Received 27 October 1986. Final acceptance 31 March 1987.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

in a number of studies (Bryant 1975; Smith and Andersen 1982; Murphy 1983a,b; Tiainen 1983). Coastal central California typically experiences a Mediterranean climate characterized by mild wet winters and warm dry summers. Along the immediate coast, where the Point Reyes Bird Observatory's (PRBO's) Palomarin Field Station is located, the summer drought is ameliorated slightly by the occurrence of persistent fog. Nevertheless, nearly 83% of the annual precipitation falls as rain during the 5 months November to March while only 5% falls during the 5 months May to September. One might expect, therefore, that the amount of annual (essentially, winter) rainfall could affect subsequent reproductive success by affecting the quantity and quality of vegetative growth, which could, in turn, affect the food resources available for raising young as well as the amount of cover available for hiding nests.

For the past 11 years, PRBO personnel have monitored the productivity of 51 locally breeding bird species in coastal grassland, coastal scrub, and mixed evergreen forest habitats at the Palomarin Field Station by means of a standardized mist-netting program. Here, we present some of the results of this study. In particular, we describe the relationship between avian productivity during a given summer and the amount of rainfall during the previous winter, and document an unprecedented reproductive failure that occurred in 1986.

STUDY AREA AND METHODS

An array of 20 12-m nylon mist nets was established at 14 permanent locations at the Palomarin Field Station of the PRBO, just inside the southern end of the Point Reyes National Seashore in Marin County, California (37°56′N and 122°45′W). Fourteen of the 20 nets were located at eight sites along the western edge of the Arroyo Hondo in mixed evergreen forest habitat comprised primarily of coast live oak (*Quercus agrifolia*), California-bay (*Umbellularia californica*), Douglas-fir (*Pseudotsuga Menziesii*), blueblossom (*Ceanothus thyrsiflorus*), and California buckeye (*Aesculus californicus*). The bottom of the arroyo contained a narrow riparian growth of red alder (*Alnus oregona*). Six of these eight forest sites contained double nets stacked one over the other, while the other two forest sites contained single nets. The remaining six single nets were located at six sites in disturbed successional stage coastal scrub habitat adjacent to the arroyo. This habitat was comprised primarily of coyote bush (*Baccharis pilularis*), California sage (*Artemisia californica*), bush monkey flower (*Mimulus aurantiacus*), poison oak (*Rhus diversiloba*), California blackberry (*Rubus vitifolius*), and California coffeeberry (*Rhamnus californica*) interspersed with patches of introduced annual grasses (*Avena, Holcus, Phalaris*), thistles (*Cirseum*), and wild radish (*Raphanus sativa*). Thirty-mm mesh nets were used in the eight protected (from the wind) forest locations whereas 36-mm mesh nets were used in the six more exposed coastal scrub sites.

Disturbed successional stage coastal scrub habitat extended south and southwest for some 450 m from the general location of the nets to the bluffs immediately overlooking the Pacific Ocean. Both disturbed and undisturbed coastal scrub, interspersed with a number of small creeks and drainages, extended west and northwest from the study area for more than 20 km. A second-growth Douglas-fir forest bordered the study area on the north and extended for some 6 km up and over a forested ridge. The mixed evergreen forest of the Arroyo Hondo bordered the study area on the east and was variously 200 to 500 m wide. Moderately grazed coastal grassland and coastal scrub habitat extended for some 5 km to the southeast from the arroyo. Most of the coastal scrub habitat in the area, both to the northwest and to the southeast of the study area as well as that in the study area itself, was located on an old, relatively level marine terrace at about 60 m elevation.

Nets were run daily (weather permitting; i.e., not raining or excessively windy) from 10 May to 17 August during each of the 11 years 1976 to 1986. May 10 corresponds to the earliest date that a HY bird (excluding hummingbirds) was ever captured during the entire 11 years. Hummingbirds were excluded from this analysis because of the unavailability of hummingbird bands during several years of the study. August 17 is 100 days (ten 10-day periods) after 10 May and corresponds to the time after which substantial numbers of migrant birds begin to inundate the study area. There is no doubt that a few migrant individuals of several long-distance migrant species occurred each year prior to 17 August, particularly during the 20 days 29 July to 17 August. These data, however, are included in this analysis because substantial numbers of locally

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

TABLE 1. Birds banded at the Palomarin Field Station 10 May to 17 August. Comparison of 1986 with the previous 10 years.

Species	Behavioral class				Hatching-year birds						After-hatching-year birds					
					1976–1985			% 1986[7]/Mean	No. of SE[8]	CI[9] (%)	1976–1985			% 1986[7]/Mean	No. of SE[8]	CI[9] (%)
	M[1]	H[2]	N[3]	F[4]	Mean[5]	SE[6]	1986[5]				Mean[5]	SE[6]	1986[5]			
Band-tailed Pigeon	S	W	T	V	0.01	0.01	0.00	0.0	*[10]	*[10]	0.00	0.00	0.00	—	—	—
Mourning Dove	S	G	T	V	0.02	0.02	0.00	0.0	*	*	0.07	0.03	0.00	0.0	*[10]	*[10]
Downy Woodpecker	R	W	C	B	0.57	0.08	0.44	77.2	−1.63	80	0.13	0.05	0.00	0.0	*	*
Hairy Woodpecker	R	W	C	B	0.20	0.06	0.35	175.0	+2.50	95	0.12	0.04	0.00	0.0	*	*
Northern Flicker	S	W	C	B	0.22	0.06	0.53	240.9	+5.17	99.9	0.12	0.03	0.26	216.7	*	*
Olive-sided Flycatcher	L	W	T	S	0.29	0.06	0.09	31.0	−3.33	99	0.60	0.07	0.79	131.7	+2.71	95
Western Wood-Peewee	L	W	T	S	0.12	0.03	0.00	0.0	*	*	0.31	0.11	0.09	29.0	−2.00	90
Western Flycatcher	L	W	B	S	9.03	1.08	3.42	37.9	−5.19	99.9	1.81	0.21	1.40	77.3	−1.95	90
Ash-throated Flycatcher	L	W	C	S	0.02	0.01	0.00	0.0	*	*	0.23	0.06	0.00	0.0	−3.83	99
Tree Swallow	L	G	C	H	0.05	0.03	0.00	0.0	*	*	0.29	0.10	0.44	151.7	+1.50	80
Violet-green Swallow	L	W	C	H	0.10	0.04	0.00	0.0	*	*	0.40	0.11	0.44	110.0	+0.36	20
Northern Rough-winged Swallow	L	G	C	H	0.06	0.03	0.00	0.0	*	*	0.10	0.04	0.00	0.0	*	*
Cliff Swallow	L	S	B	H	0.07	0.03	0.18	257.1	*	*	0.55	0.09	0.00	0.0	−6.11	99.9
Barn Swallow	L	S	B	H	0.84	0.22	0.88	104.8	+0.18	10	0.32	0.08	0.61	190.6	+3.63	99
Steller's Jay	R	W	T	G	0.26	0.05	0.44	169.2	+3.60	99	0.18	0.08	0.35	194.4	*	*
Scrub Jay	R	S	S	G	0.09	0.03	0.00	0.0	*	*	0.09	0.02	0.00	0.0	*	*
Chestnut-backed Chickadee	R	W	C	F	4.76	0.46	1.49	31.3	−7.11	99.99	0.27	0.06	0.61	225.9	+5.67	99.9
Plain Titmouse	R	W	C	F	0.04	0.04	0.00	0.0	*	*	0.00	0.00	0.00	—	—	—
Bushtit	R	S	S	F	4.93	0.86	2.63	53.3	−2.67	95	0.70	0.18	0.53	75.7	−0.94	60
Red-breasted Nuthatch	S	W	C	B	0.11	0.06	0.09	81.8	*	*	0.01	0.01	0.00	0.0	*	*
Brown Creeper	R	W	B	B	2.11	0.25	0.70	33.2	−5.64	99.9	0.09	0.03	0.09	100.0	*	*
Bewick's Wren	R	S	C	F	6.67	0.57	1.76	26.4	−8.61	99.99	0.37	0.09	0.09	24.3	−3.11	98
Winter Wren	R	W	G	G	0.41	0.11	0.00	0.0	−3.73	99	0.06	0.03	0.09	150.0	*	*
Golden-crowned Kinglet	R	W	T	F	0.84	0.31	0.09	10.7	−2.42	95	0.07	0.02	0.00	0.0	*	*
Western Bluebird	R	G	C	G	0.04	0.02	0.00	0.0	*	*	0.16	0.06	0.00	0.0	*	*
Swainson's Thrush	L	W	S	G	2.44	0.34	0.53	21.7	−5.62	99.9	4.77	0.43	5.88	123.3	+2.58	95
Hermit Thrush	L	W	S	G	0.19	0.09	0.09	47.4	*	*	0.04	0.02	0.00	0.0	*	*
American Robin	S	G	T	G	0.20	0.09	0.00	0.0	−2.27	95	0.49	0.09	0.53	108.2	+0.44	30
Wrentit	R	S	S	F	6.81	0.40	3.34	49.0	−8.67	99.99	0.89	0.13	2.46	276.4	+12.08	99.99
European Starling	S	G	C	G	0.06	0.05	0.00	0.0	*	*	0.06	0.03	0.00	0.0	*	*
Hutton's Vireo	R	W	T	F	1.95	0.31	1.05	53.8	−2.90	98	0.15	0.04	0.09	60.0	*	*
Warbling Vireo	L	W	T	F	2.29	0.54	0.00	0.0	−4.24	99	1.83	0.25	1.58	86.3	−1.00	60

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

TABLE 1. Continued.

Species	Behavioral class				Hatching-year birds						After-hatching-year birds					
					1976–1985			% 1986[7] / Mean			1976–1985			% 1986[7] / Mean		
	M[1]	H[2]	N[3]	F[4]	Mean[5]	SE[6]	1986[5]		No. of SE[8]	CI[9] (%)	Mean[5]	SE[6]	1986[5]		No. of SE[8]	CI[9] (%)
Orange-crowned Warbler	L	W	G	F	4.36	0.45	1.23	28.2	−6.96	99.99	2.44	0.29	0.70	28.7	−6.00	99.9
MacGillivray's Warbler	L	W	G	F	0.28	0.08	0.00	0.0	−3.50	99	0.15	0.04	0.09	60.0	*	*
Wilson's Warbler	L	W	G	F	13.80	1.42	3.86	28.0	−7.00	99.99	2.42	0.17	2.19	90.5	−1.35	70
Black-headed Grosbeak	L	W	T	F	0.58	0.11	0.00	0.0	−5.27	99.9	0.74	0.13	0.70	94.6	−0.31	20
Rufous-sided Towhee	R	S	G	G	1.09	0.14	0.79	72.5	−2.14	90	0.51	0.07	1.05	205.9	+7.71	99.99
Brown Towhee	R	S	S	G	0.26	0.09	0.00	0.0	−2.89	98	0.10	0.02	0.18	180.0	+4.00	99
Rufous-crowned Sparrow	R	S	G	G	0.10	0.03	0.00	0.0	*	*	0.03	0.02	0.00	0.0	*	*
Black-chinned Sparrow	L	S	S	G	0.00	0.00	0.00	—	—	—	0.01	0.01	0.00	0.0	*	*
Savannah Sparrow	S	G	G	G	0.05	0.02	0.00	0.0	*	*	0.01	0.01	0.00	0.0	*	*
Grasshopper Sparrow	L	G	G	G	0.02	0.01	0.09	450.0	*	*	0.02	0.02	0.00	0.0	*	*
Song Sparrow	R	S	S	G	9.88	1.31	3.16	32.0	−5.13	99.9	0.81	0.11	0.79	97.5	−0.18	10
White-crowned Sparrow	R	S	S	G	3.90	0.51	3.51	90.0	−0.76	50	0.40	0.07	0.53	132.5	+1.86	90
Dark-eyed Junco	S	W	G	G	2.57	0.62	0.61	23.7	−3.16	98	0.16	0.04	0.35	218.7	*	*
Red-winged Blackbird	S	G	S	G	0.00	0.00	0.00	—	—	—	0.02	0.01	0.00	0.0	*	*
Brown-headed Cowbird	L	G	S	G	0.00	0.00	0.00	—	—	—	0.09	0.03	0.00	0.0	*	*
Purple Finch	S	W	T	V	2.66	0.64	0.79	29.7	−2.92	98	5.69	1.08	4.74	83.3	−0.88	60
House Finch	S	G	T	V	0.54	0.21	0.09	16.7	−2.14	90	0.76	0.18	0.44	57.9	−1.78	80
Pine Siskin	S	W	T	V	6.37	1.18	1.58	24.8	−4.06	99	4.49	0.78	3.34	74.4	−1.47	80
American Goldfinch	S	S	S	V	1.01	0.23	1.40	138.6	+1.70	80	1.43	0.19	1.14	79.7	−1.53	80
Total					93.26	6.13	35.20	37.7	−9.47	99.99	35.50	2.22	32.57	91.7	−1.32	70

[1] Migratory behavior: L = long-distance migrants, species in which individuals that breed in the neighborhood of the Palomarin Field Station winter primarily in the tropics, and never winter in numbers north of southern California; S = short-distance migrants, in which individuals that breed in the neighborhood of the Palomarin Field Station winter in substantial numbers at the latitude of Palomarin but not in the neighborhood of Palomarin; R = residents, in which individuals that breed in the neighborhood of Palomarin are permanent residents at Palomarin.

[2] Habitat preference: G = grassland species that prefer open, grazed, or mowed grassland habitat or the edges of grassland habitat for foraging when in the neighborhood of the Palomarin Field Station; S = scrubland species that prefer undisturbed or disturbed coastal scrub habitat for foraging when in the neighborhood of Palomarin; W = woodland species that prefer woodland habitat for foraging when in the neighborhood of Palomarin.

[3] Nest location: G = ground nesters; S = shrub nesters; T = tree nesters; C = cavity nesters; B = building or structure nesters. These classifications were made on the basis of observations of individuals nesting in the neighborhood of Palomarin. The four building or structure nesters place their open-cup or closed nests on a human-made structure, against a bank or a tree trunk, or behind the loose bark of a tree trunk.

[4] Foraging behavior during the breeding season: H = hawking; S = sallying; F = foliage gleaning; B = bark gleaning, including both probing and pecking; G = ground gleaning; V = vegetation regurgitating. This last group includes both pigeons and doves and the cardueline finches (Purple and House finches, Pine Siskin, and American Goldfinch), all of which forage, to some extent, during the breeding season on vegetable matter and regurgitate that food to their young.

[5] Birds banded per 1,000 net hr.

[6] Standard error of the mean.

[7] The percentage that the 1986 value was of the previous 10-year mean.

[8] The number of standard errors that the 1986 value was removed from the previous 10-year mean. Calculated as (1986 value − mean value for 1976 to 1985)/SE of the mean for 1976 to 1985.

[9] The largest confidence interval of the 1976 to 1985 mean that the 1986 value was outside of.

[10] Rare species, averaging less than two individuals per year. Sample size too small to allow a meaningful comparison of 1986 with the previous 10 years.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

fledged individuals of various resident and short-distance migrant species were still being captured in the nets during these 20 days, especially in years in which the breeding season was prolonged.

The nets were run for 6 hr per day beginning 15 min after local sunrise. The nets were always opened in a standardized order and were always closed in the same order. Thus, 120 net hr were accumulated in each full day of netting. This standardized program was faithfully adhered to from 1979 through 1986. Prior to 1979, the standardization was not quite so rigorous, but the total net hours and timing were quite similar to later years.

All birds captured were brought back to the on-site Field Station (10 to 300 m from the various nets) for processing, banding, weighing, and measuring. Age was determined by the degree of skull pneumatization and other morphological, mensural, and plumage characteristics as appropriate for the various species. Juvenile and immature birds in their first calendar year are referred to as hatching-year (HY) birds. Adult birds in their second or later calendar years are called after-hatching-year (AHY) birds. We were unable to age 0.26% of the birds encountered during the 11 years because of difficulty in determining the degree of skull pneumatization. These individuals were excluded from this analysis.

We used the number of HY birds (primarily dispersing juveniles but also, to a lesser extent, dispersing immatures) banded per 100 net hr of operation, and/or the ratio of HY/AHY birds banded during the same period as our measures of avian productivity. It should be noted that this method cannot be used directly to compare productivity between various species or species groups, either in terms of the number of young birds banded per 100 net hr or in terms of the young/adult ratio. This is because capture rates obtained from mist-netting procedures may be biased because of species-specific or age-specific differences in microhabitat preference, foraging height and behavior, flocking behavior, home range size, dispersal distance, and dispersal rate (Karr 1981, DeSante 1983). This method, however, can be used very effectively to compare the productivity of a given species or species group from year to year, and to compare various species and groups of species in terms of their annual variability in productivity. This is because juvenal and immature dispersal, for the most part, is assumed to be independent of local weather conditions.

This paper deals with data collected on 51 locally breeding species of birds (known to have bred at least once within 2 km of the netting operation) of which at least one individual was banded between 10 May and 17 August during the 11-year period 1976 to 1986 (Table 1; scientific names in Appendix). The 51 species were classified according to migratory behavior (three groups), habitat preference (three groups), nest location (five groups), and foraging behavior (six groups). These classifications were based upon the seasonalities of occurrence, habitat preferences, nest locations, and foraging behaviors of individual birds observed in the neighborhood of the Palomarin Field Station and thus are specific to that location. Additional information useful for migratory behavior and habitat preference classifications was obtained from Grinnell and Miller (1944), and for nest location classifications from Harrison (1979).

The comparisons of 1986 with the previous 10 years were based upon summary statistics (mean, standard error of the mean, confidence intervals for the mean, and range) for the years 1976 to 1985. Statistical significance was assumed if the 1986 value fell outside the 95% confidence interval for the mean for 1976 to 1985. The smoothed curve describing the relationship between annual productivity and annual rainfall, along with the 95% confidence interval of the smooth, was obtained by the B-spline adaptive regression technique (DeBoor 1978, Craven and Wahba 1979, O'Sullivan 1985, Silverman 1985).

RESULTS

The annual variability in the number of birds banded per 100 net hr (between 10 May and 17 August) over the 10-year period 1976 to 1985 was similar for HY (CV = 20.8%) and AHY (CV = 19.8%) birds (Fig. 1). Furthermore, for these same 10 years, the number of HY birds in any given year was positively correlated with the number of AHY birds in that same year (r = 0.849). In 1986, however, the number of HY birds banded per 100 net hr dropped dramatically while the number of AHY birds banded per 100 net hr was consistent with the previous 10 years. In fact, the number of HY birds banded per 100 net hr in 1986 was only 37.7% of the mean of the previous 10 years (Fig. 2a). Not only did the 1986 value fall well outside the 99% con-

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

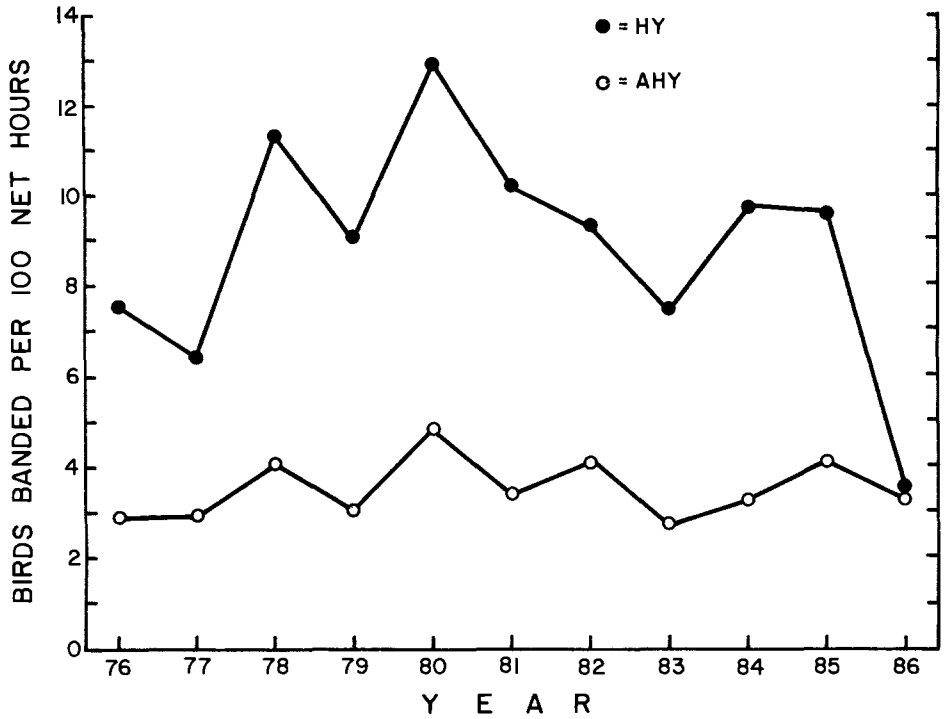


FIGURE 1. Number of birds of all species combined banded per 100 net hr during the period 10 May to 17 August for each of 11 years.

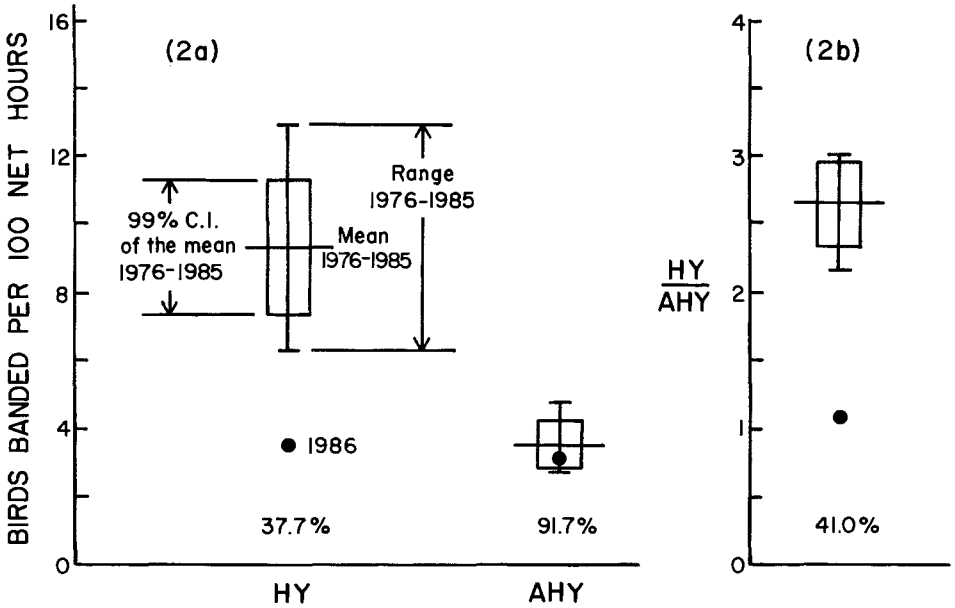


FIGURE 2. Comparison of 1986 with the previous 10 years with respect to banding data during the 100-day period 10 May to 17 August. (2a) Birds banded per 100 net hr. (2b) HY/AHY ratio. Shown in each case are the mean value for the 10 years 1976 to 1985 (long horizontal line), the 99% confidence interval of this 10-year mean (closed rectangle), the range of these 10 years (vertical line terminated by short horizontal lines), the 1986 value (filled circle), and the percentage that the 1986 value was of the previous 10-year mean.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

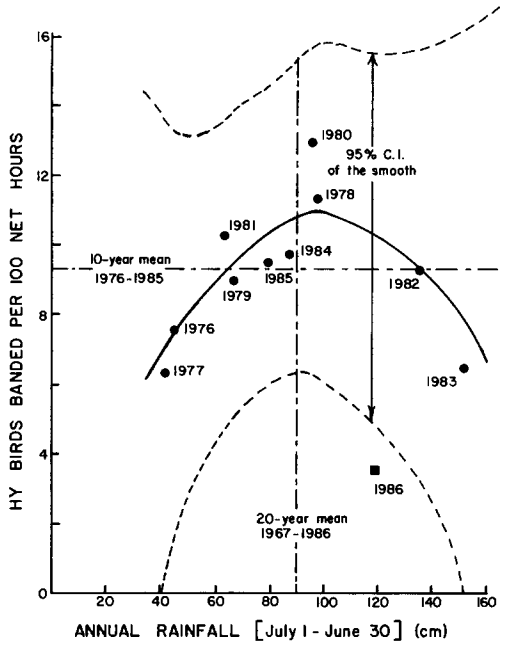


FIGURE 3. Number of HY birds banded per 100 net hr (during the period 10 May to 17 August) as a function of annual rainfall measured from 1 July to 30 June for the 11 years 1976 to 1986. Also shown are the smoothed curve for the 10 years 1976 to 1985 and the 95% confidence interval for the smooth as obtained by the B-spline adaptive regression technique.

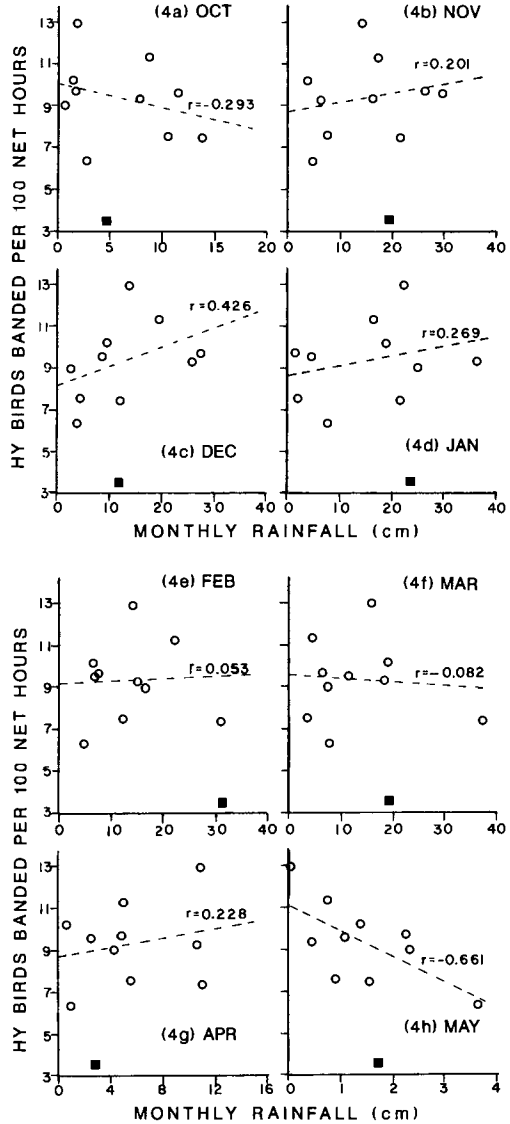


FIGURE 4. Number of HY birds banded per 100 net hr (during the period 10 May to 17 August) as a function of monthly rainfall totals for the 10 years 1976 to 1985 (○) and for 1986 (■). Also shown are the linear regression lines and correlation coefficients for the 10 years 1976 to 1985. (4a) October. (4b) November. (4c) December. (4d) January. (4e) February. (4f) March. (4g) April. (4h) May.

fidence interval of the previous 10-year mean (in fact, well outside the 99.99% confidence interval, being 9.47 standard errors from the mean), it also fell well outside the entire range of values for the previous 10 years. In contrast, the number of AHY birds banded per 100 net hr in 1986 was 91.7% of the previous 10-year mean and fell well within the 99% confidence interval of the previous 10-year mean (and within the 80% confidence interval as well, being only 1.32 standard errors from the mean). Thus, a highly significant decrease in the number of young birds occurred in 1986 without a concomitant decrease in the number of adults.

The annual variability in the HY/AHY ratio over the 10-year period 1976 to 1985 (CV = 11.4%) was considerably less than that for either the number of HY or AHY birds. This was because, during this period, the number of HY birds in any given year was directly related to the number of AHY birds in that same year. As a result, the 99% confidence interval of the 10-year mean for the HY/AHY ratio, as well as the 10-year range of the HY/AHY ratio, was quite narrow (Fig. 2b). The 1986 value of the HY/AHY ratio, however, was only 41.0% of the previous 10-year mean and fell far outside both the 99% confidence interval of the mean (in fact, far outside the 99.99% confidence interval, being 16.37 stan-

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

TABLE 2. Springtime temperatures (°C) during the period 20 April to 31 May for the past 5 years.

	1982	1983	1984	1985	1986
Minimum (range)	1–11	4–10	3–12	2–12	1–12
Minimum (mean)	5.6	7.2	7.6	6.4	6.2
Maximum (range)	11–26	15–28	16–26	15–25	13–27
Maximum (mean)	18.0	18.8	20.0	19.3	20.0

dard errors from the mean) and the range of the previous 10 years, a highly significant decrease.

THE RELATIONSHIP BETWEEN AVIAN PRODUCTIVITY AND WINTER RAINFALL

The relationship between annual productivity (the number of HY birds of all 51 locally breeding species banded per 100 net hr between 10 May and 17 August) and annual rainfall (measured from 1 July of the previous year to 30 June of the year in question) was consistent for the 10 years 1976 to 1985 (Fig. 3). Productivity appeared to be at a maximum (21 to 39% above the 10-year mean) at average or slightly above average rainfall levels and showed pronounced drops (19 to 32% below the 10-year mean) at both extremely low and extremely high levels of winter rainfall. The number of HY birds banded per 100 net hr in 1986, however, was 62.3% below the 10-year mean, and was well outside the 95% confidence limit of the smoothed curve for the previous 10 years. Certainly, variations in the total annual rainfall were not a cause for the drastically lowered productivity in 1986.

It may be suggested that the amount of rain that falls in a given, perhaps critical, month could influence reproductive success as strongly as the total annual rainfall. This, however, was not the case. Annual productivity (the number of HY birds banded per 100 net hr) over the 10-year period 1976 to 1985 showed no obvious relationship to monthly rainfall totals for any of the 8 months October to May (rainfall during the remaining 4 months was nearly negligible), with the possible exception of May when a weak negative correlation between productivity and rainfall occurred (Figs. 4a–h). While this latter case suggests that late spring storms might adversely affect reproductive success, the weak correlation could well be spurious, being driven primarily by the single extreme 1977 data point. It should not be surprising that no obvious relationships emerged between productivity and individual monthly rainfall totals because the monthly rainfall totals themselves were only weakly correlated with total annual rainfall. In fact, Spearman's rank correlation coefficients between monthly rainfall totals and total annual rainfall over the 10-year period 1976 to 1985 ranged from −0.491 to +0.770 for the 8 individual months October to May and averaged only +0.450. Indeed, as is obvious from Figure 4, monthly winter rainfall totals at Palomarin showed very high variabilities. The coefficients of variation over the 10 years 1976 to 1985 ranged from 60.6% to 82.2% for the 8 individual months October to May and averaged 71.3%. In contrast, the coefficient of variation for total annual rainfall over the same 10 years was 41.6%, quite high but considerably less than the average monthly variabilities. Such a situation is probably characteristic of Mediterranean climates.

It is also evident from these data that the 1985–1986 rainfall, while 38.0% above the previous 10-year mean, was extreme during only one month, February, when a record 31.55 cm occurred (Figs. 4a–h). It is unlikely, however, that this high total February rainfall could alone have been responsible for the 1986 reproductive failure because a similarly high total February rainfall (31.19 cm) occurred in 1983 and was followed by extremely heavy March and April total rainfalls as well (a record 37.59 cm in March and a record 11.05 cm in April). Yet, reproductive success in 1983 was reduced only 20.4% from the 10-year mean while reproductive success in 1986 was reduced 62.3% from the 10-year mean. Thus, the various total monthly rainfalls in 1985–1986 provide no obvious explanation for the 1986 reproductive failure.

Springtime temperatures did not provide an obvious explanation for the 1986 reproductive failure at Palomarin either (Table 2). Slightly clearer than usual weather during the period 20 April to 31 May produced nightly minimum temperatures that averaged 7.5% below the previous 4-year mean and daily maximum temperatures that averaged 5.1% above the previous

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

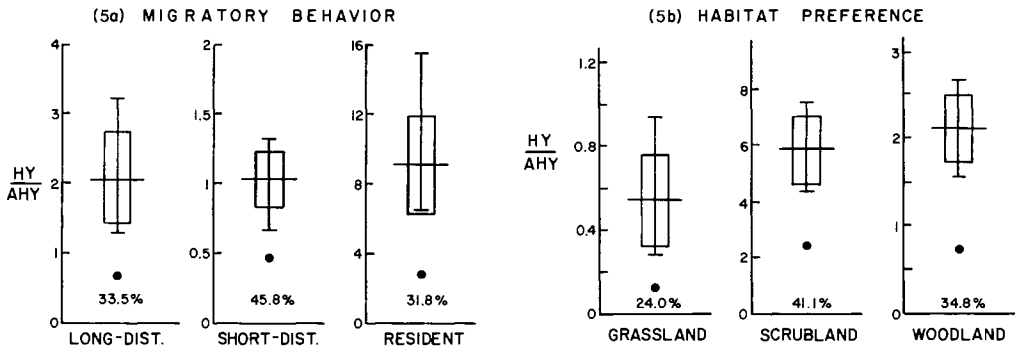


FIGURE 5. Comparison of 1986 with the previous 10 years for the HY/AHY ratio as determined from banding data during the 100-day period 10 May to 17 August for 51 species classified according to (5a) migratory behavior, (5b) habitat preference, (5c) nest location (next page), and (5d) foraging behavior (next page). Symbols and information presented are as in Figure 2.

4-year mean, but in neither case did the range of maximum or minimum temperatures fall outside the range of the previous 4 years.

Finally, no major habitat changes have occurred in the past 11 years within at least 2 km of the study area (which lies inside the Point Reyes National Seashore), other than the gradual continuing natural succession of a portion of the disturbed coastal scrub. Furthermore, no direct application of pesticides, herbicides, or other chemical contaminants were known to have occurred in the past 11 years within at least 2 km of the study area.

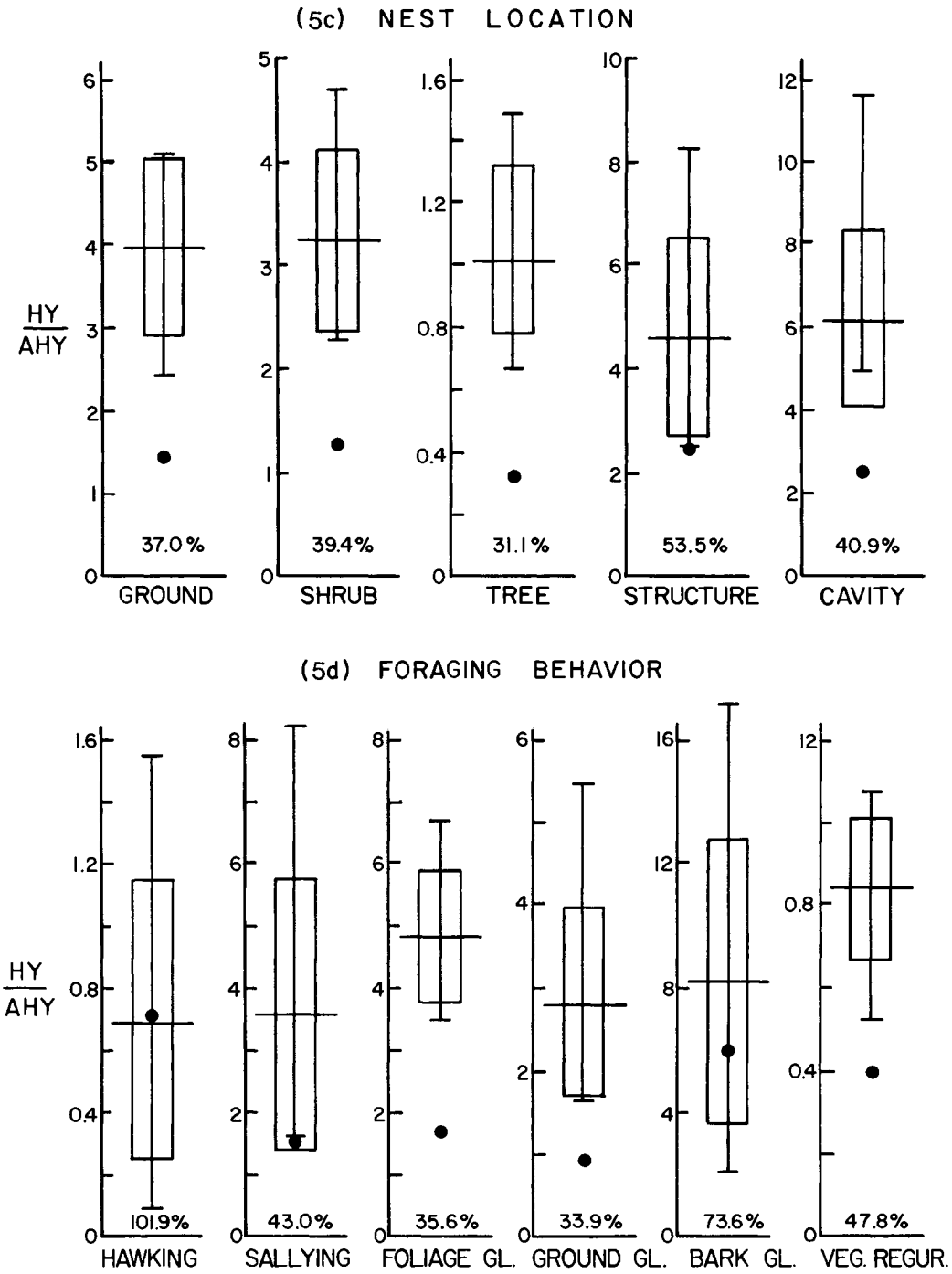
THE 1986 REPRODUCTIVE FAILURE: INDIVIDUAL SPECIES AND SPECIES GROUPS

During the 10-year period 1976 to 1985, HY individuals of 31 of the 51 locally breeding species were captured in large enough numbers to allow meaningful comparisions with 1986 (Table 1). Significant decreases in the number of HY birds banded occurred in 1986 for 22 of these 31 species. In contrast, significant increases in the number of HY birds banded occurred in 1986 for only three species (Hairy Woodpecker, Northern Flicker, and Steller's Jay), while nonsignificant changes (four decreases and two increases) occurred in 1986 for six species (Downy Woodpecker, Barn Swallow, Rufous-sided Towhee, White-crowned Sparrow, House Finch, and American Goldfinch). Furthermore, only four of the 20 rare species showed increases in 1986 in the number of HY birds banded. It appears, therefore, that the 1986 reproductive failure was characteristic of the great majority of individual species as well as being highly significant for all species combined.

For AHY birds, 26 of the 51 species had large enough sample sizes during the 1976 to 1985 period to permit meaningful comparisons with 1986 (Table 1). In striking contrast to the situation for HY birds, only four of these 26 species showed significant decreases in 1986 in the number of AHY birds banded, while seven species showed significant increases in 1986, and 15 species showed nonsignificant changes in 1986 (11 decreases and four increases). Thus, no consistent increasing or decreasing trends in the number of AHY birds banded in 1986 were characteristic of the various individual species. This is in agreement with the fact that the total number of AHY birds banded in 1986 for all species combined did not differ significantly from the previous 10-year mean.

In order to provide further possible insights into the 1986 reproductive failure, species were grouped according to migratory behavior, habitat preference, nest location, and foraging behavior and the HY/AHY ratios of these groups were examined. (See footnotes to Table 1 for definitions of each of the groups.) Highly significant decreases in the HY/AHY ratio occurred in 1986 for all three groups of species classified by migratory behavior (Fig. 5a; the 1986 value was 6.73 SE from the mean of the previous 10 years for the 19 long-distance migrant species, 9.44 SE from the mean for the 13 short-distance migrant species, and 7.33 SE for the 19 resident species). These results indicate that if the 1986 reproductive failure was related to factors operating during the previous winter on the wintering grounds of the various species, these factors were not confined either to the vicinity of the Palomarin Field Station or to the tropics but

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms



instead were very widely distributed. Alternatively, these results suggest that the factors involved were more likely operative during the breeding season at Palomarin.

Highly significant decreases in the HY/AHY ratio also occurred in 1986 for species characteristic of each of the major habitat types in the vicinity of the Palomarin Field Station (Fig. 5b;

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

the 1986 value was 6.20 SE from the mean of the previous 10 years for the 11 grassland species, 9.35 SE from the mean for the 13 scrubland species, and 11.58 SE for the 27 woodland species). The factors that contributed to the 1986 reproductive failure, therefore, were apparently not confined to any one habitat.

We created five nest location classifications in order to determine if the potential susceptibility to nest predators could have had an effect upon the severity of the 1986 reproductive failure. In particular, we felt that cavity nesters and, to a lesser extent, structure nesters should be less susceptible to nest predation than open-cup nesters that nest either on the ground or in shrubs or trees. Species in all five nest location groups, however, showed highly significant decreases in the HY/AHY ratio in 1986, although structure nesters (but not necessarily cavity nesters) were perhaps less severely affected (Fig. 5c; the 1986 value was 7.67 SE from the mean of the previous 10 years for the nine ground-nesting species, 7.32 SE from the mean for the 12 shrub-nesting species, 8.61 SE for the 13 tree-nesting species, 5.67 SE for the 13 cavity nesters, and 3.67 SE for the four structure nesters). This suggests that the factors causing the reduced reproductive success in 1986 were not primarily related to nest predation. The striking consistency across the various species groupings in the magnitude of the 1986 reproductive failure should be noted at this point. For all 11 groups of species classified according to migratory behavior, habitat preference, and nest location, 1986 produced, by far, the poorest HY/AHY ratio. For nine of these 11 groups, the 1986 HY/AHY ratio was only 24 to 41% of the previous 10-year mean.

Finally, we grouped the species according to their breeding season foraging behavior into six groups (Fig. 5d). These groups were developed not only to indicate the type of foraging behavior used by adult birds in the breeding season but also to reflect upon the type of food fed to nestlings. The 12 foliage-gleaning, 19 ground-gleaning, and 6 vegetation-regurgitating species showed highly significant decreases in the HY/AHY ratios in 1986 (being, respectively, 9.62, 5.37, and 8.23 SE from the mean of the previous 10 years). The 4 sallying species also showed a dramatic decrease in productivity in 1986, the HY/AHY ratio being 3.04 SE from the mean of the previous 10 years and thus falling well outside the 98% confidence interval, but barely inside the 99% confidence interval, of the mean. In sharp contrast to those four groups of species, two groups, the five hawking species (swallows) and five bark-gleaning species (woodpeckers, nuthatches, and creepers), showed no significant decreases in productivity in 1986, the HY/AHY ratio being, respectively, only 0.09 and 1.55 SE from the mean of the previous 10 years.

TIMING OF THE 1986 REPRODUCTIVE FAILURE

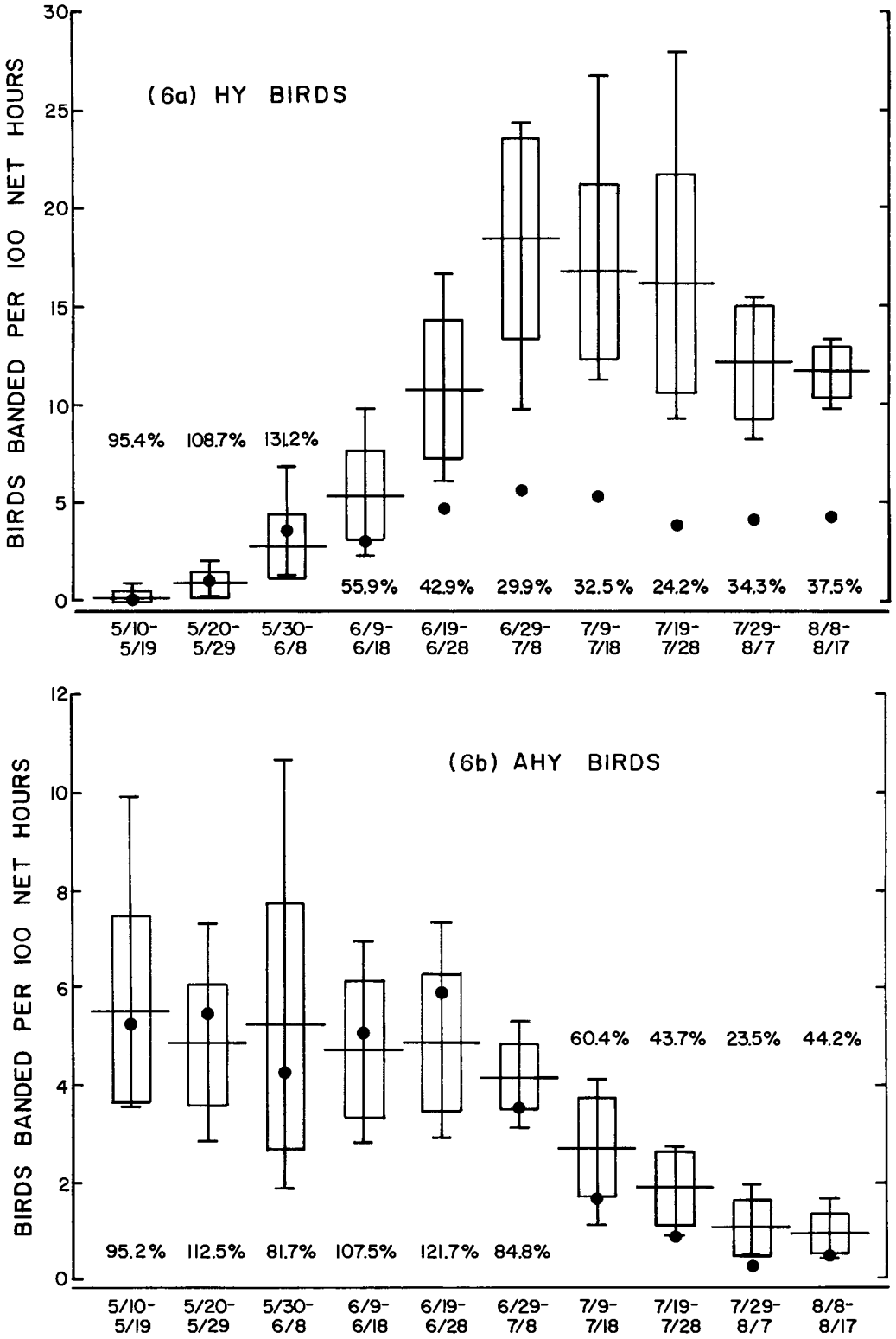
We next inquired when, during the season, the 1986 reproductive failure occurred. Was it evident from the very start of the season or did it occur sometime after the breeding season had begun? By comparing the 1986 HY capture rates during each of the ten 10-day periods between 10 May and 17 August with those of the previous 10 years, we found that 1986 started out as a perfectly normal year (Fig. 6a). Although the numbers of HY birds captured during the first three 10-day periods are always small, the numbers in 1986 were not significantly different from those in previous years, being some 95%, 109%, and 131%, respectively, of the previous 10-year mean. Beginning in the fourth 10-day period, however, highly significant decreases were detected in 1986 that increased in severity to a low of only 24% of average in the eighth 10-day period in late July. A slight recovery may have occurred in the ninth and tenth periods with decreases only to 34% and 37% of average, respectively. In summary, it was as if the peak of production that normally occurs from late June to mid-August simply never occurred at all in 1986, and numbers of HY birds remained roughly at early June levels.

It must be stressed here that the HY birds captured in our standardized battery of mist nets and shown in Figure 6a were, in the vast majority of cases, birds in juvenal plumage that were undergoing juvenal dispersal. They had fully grown tails and were independent of parental

→

FIGURE 6. Comparison of 1986 with the previous 10 years for the number of birds banded per 100 net hr during each of the ten 10-day periods between 10 May and 17 August. (6a) HY birds. (6b) AHY birds. Symbols and information presented are as in Figures 2 and 5.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms



This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

TABLE 3. Adult birds banded at the Palomarin Field Station 9 July to 17 August. Comparison of 1986 with the previous 10 years.

Classification	1976–1985 Mean[1]	1976–1985 SE[2]	1976–1985 Range	1986	% 1986[3]/Mean	No. of SE[4]	CI (%)[5]
Long-distance migrants	25.15	2.46	15.95–40.07	11.40	45.3	−5.59	99.9
Short-distance migrants	31.72	3.82	15.01–55.04	13.98	44.1	−4.64	99
Residents	9.84	1.71	3.34–20.03	6.15	62.5	−2.16	90

[1] Birds banded per 1,000 net hr.
[2] Standard error of the mean.
[3] The percentage that the 1986 value was of the previous 10-year mean.
[4] The number of standard errors that the 1986 value was removed from the previous 10-year mean. Calculated as (1986 value − mean value for 1976 to 1985)/SE of the mean for 1976 to 1985.
[5] The largest confidence interval of the 1976 to 1985 mean that the 1986 value was outside of.

care. In this respect, they had been out of their nests for at least 3 weeks and, in many cases, much longer. Thus, if the reproductive failure that we began to detect about 10 June was caused by an unusually high mortality of nestlings, this mortality must have begun to occur sometime between about 10 May and 20 May. If it was caused by the failure of eggs to hatch, this failure must have begun to occur somewhat earlier, about 25 April to 10 May. If it was caused by the failure of birds to breed or of females to lay eggs, it must have begun even earlier, roughly in mid-April.

We also compared 1986 with the previous 10 years for the number of AHY birds banded per 100 net hr during each of these same 10-day periods (Fig. 6b). We found no significant decreases in the number of adult birds during the first 60 days of 1986, but highly significant decreases during the last 40 days of 1986, at the time when the capture rate of adult birds normally begins to drop off. This significant decrease in 1986 could have been caused by an atypical mortality of adult birds. It could also have been caused by an unseasonably early termination of breeding activities in these birds that, in turn, was caused by their prior reproductive failures. Such an early termination of breeding activity would tend to bring about two related events: an early initiation of prebasic molt in adults, and an early initiation of fall migration in adult migrants. Both of these events would tend to lower the capture rates of adult birds because birds are less mobile and thus less likely to be captured during molt, and because adults of migrant species tend to migrate through interior California and are scarce on the coast where Palomarin is located (Stewart et al. 1974). It is of considerable interest, therefore, that the capture rate of adult birds during the last four 10-day periods of 1986 (9 July to 17 August) was significantly less than that for the previous 10 years for both long- and short-distance migrants but not for residents (Table 3). This provides a strong indication that the early termination of breeding and the consequent early initiation of molt and migration, rather than an abnormally high adult mortality, was the cause for the significantly low late season adult capture rate in 1986.

DISCUSSION

The relationship between landbird productivity in central coastal California and annual (winter) rainfall during the previous season appears to be that productivity is low in years of extremely low rainfall, increases to a maximum in years of average or slightly above average rainfall, and decreases substantially in years of very high rainfall. From an evolutionary standpoint, such a relationship may not be unexpected. It suggests that local breeding populations have become adapted to "average" levels of rainfall and produce fewer young during extreme conditions.

How might winter rainfall affect avian productivity? As winter rainfall increases from drought conditions it will bring about an increase in primary vegetative production. This, in turn, will bring about an increase in the food resources available for raising young as well as an increase in the amount of vegetative cover available for hiding nests from nest predators, at least for ground and shrub nesting species. In addition, in a Mediterranean climate, increased winter and spring rainfall will extend the time into the summer that the vegetation stays green and productive and will thus allow for additional broods or renesting attempts later in the season. All of these factors should tend to increase avian production.

Extremely high levels of winter rainfall, however, may tend to cause high winter mortality among both resident and short-distance migrant

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

species, thus decreasing the size of the breeding populations the following spring. Years of extremely high rainfall are often characterized by inclement spring weather (Figs. 4f, g) that can easily delay the onset of breeding and cause reproductive failures in first brood attempts. It is also conceivable that extremely high rainfall levels could directly impact food resources by negatively affecting the hatching, development, and growth of insects. All of these factors should tend to decrease avian production.

Landbird productivity in 1986, however, did not follow the pattern established over the previous 10 years. Rather, 1986 productivity was 62.3% below the mean for the previous 10 years. In this respect, it is interesting to note that the 1986 rainfall value of 118.97 cm predicts, according to the curve shown in Figure 3, a 1986 productivity value of 10.3 HY birds per 100 net hr, a value that is 110.4% of normal. The actual productivity value for the first 30 days of 1986 in fact averaged 111.7% of normal. Thus, the breeding season of 1986 started out in a perfectly predictable manner until something drastic happened a month or so into the season.

The severity of the factors that brought about the 1986 reproductive failure of landbirds at Palomarin can also be gauged by examination of Figure 3. The most severe drought that occurred in California this century occurred in 1976 and 1977. Accordingly, a drop in productivity of from 19.2% to 32.2% of the 10-year mean occurred during these years. Similarly, one of the highest winter rainfalls in California this century occurred during the Southern Oscillation/"El Niño" year of 1983 and corresponded to a drop in productivity of 20.4% from the 10-year mean. In sharp contrast, the 62.3% decrease in productivity that occurred in 1986 was two to three times as great as those caused by several of the most drastic climatic extremes experienced in California this century. The factors causing the 1986 failure must have been severe indeed.

What then did cause the dramatic decrease in productivity that occurred in most landbird species at Palomarin in 1986? Very simply, we don't know. Additional insight into the situation, however, may be obtained by investigating characteristics of the species that appeared *not* to be affected: the three species of woodpeckers, the swallows (at least the Barn Swallow), and a few other miscellaneous species. It is difficult, at first, to imagine what ecological characteristics swallows and woodpeckers could share that could have prevented them from suffering the reproductive failures that characterized most other species of landbirds in 1986. They both, however, feed their young largely on insects that are produced from detritus- or decomposer-based ecosystems, rather than from ecosystems based on primary production. Woodpeckers, for example, feed largely on grubs and beetles that feed on dying, dead, or decaying wood (Bent 1939). Swallows feed extensively on flying insects, especially Diptera, that often emerge from aquatic ecosystems (Bent 1942). In the neighborhood of the Palomarin Field Station, such aquatic ecosystems occur primarily in the flowing waters of several small, year-round or intermittent creeks, and are almost exclusively detritus-based ecosystems.

Along these same lines, the four flycatcher species partially depend upon flying insects that emerge from aquatic ecosystems. They also take substantial numbers of flying insects that emerge from terrestrial or arboreal primary production-based ecosystems. Nevertheless, their partial dependence upon nonprimary production-based ecosystems may account for their slightly less drastic productivity decline in 1986, as compared to foliage gleaners and ground gleaners (Fig. 5d). These same considerations tend to explain why structure nesters showed a less severe productivity decline in 1986 than species utilizing other nest locations (Fig. 5c): two of the four structure nesters are swallows while a third is a flycatcher.

Vegetation-regurgitating species may also have been slightly less severely affected in 1986 than most other species (Fig. 5d). It would appear that their ability to utilize primary production directly as a food supply for themselves and their young, rather than being entirely dependent upon consumers of primary production, may have helped these species to a small extent. Along these same lines, short-distance migrants seemed to have fared slightly less poorly in 1986 than either long-distance migrants or residents (Fig. 5a). This is readily explainable by the fact that fully 85% of the individual short-distance migrants banded during this study were of the six vegetation-regurgitating species.

Thus, it appears that the birds that were most severely impacted in 1986 were those species that forage and feed their young exclusively on insects that are produced within a primary pro-

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

duction-based ecosystem. If this were in fact the case, we might expect that species that forage and feed their young extensively on caterpillars or other large larvae that eat new plant growth might be the most severely affected. Indeed, this seems to be the case. We captured *no* HY Warbling Vireos or Black-headed Grosbeaks at Palomarin during the entire 100 days in 1986 and have no indication that any young of these species were produced anywhere in the vicinity of Palomarin. The previous 10-year means for these two species were 24 and six HY birds respectively.

The five miscellaneous species that showed no significant reproductive decline in 1986 warrant some discussion. The House Finch's 1986 reproductive success was only 16.7% of the previous 10-year mean. This drastic reproductive decline was not statistically significant only because in some years the species does not occur or breed at Palomarin at all. Regarding the Steller's Jay, we can offer no comment.

The three remaining species, Rufous-sided Towhee, White-crowned Sparrow, and American Goldfinch, are three of the four latest breeders at Palomarin and regularly fledge young well into August. (The fourth late breeder, interestingly, is the Barn Swallow which also regularly fledges young in August and occasionally even into early September.) The facts (1) that none of these four species showed significantly reduced productivities in 1986, (2) that for each of these species we banded substantial numbers of young during the final two 10-day periods of 1986, and (3) that the 1986 productivity decline during these final two 10-day periods was somewhat less than that of the three immediately preceding 10-day periods indicate that a recovery of reproductive success may have begun during these last two 10-day periods, but that it could only be detected in species whose breeding seasons regularly extend late into the season. If this were indeed the case, then the factors causing the reproductive failure may only have been operative for about 50 days.

The next obvious question is whether or not the phenomenon described here was limited to the immediate vicinity of Palomarin or extended over a greater area of California. Data from the Harvey Monroe Hall Research Natural Area in the subalpine Sierra Nevada suggests that, for Dark-eyed Juncos at least, a major reproductive failure occurred on the west slope of the central Sierra Nevada (D. DeSante, unpubl. data). Nine previous years of data have shown that numerous flocks of from 30 to 150 HY juncos normally move up the west slope of the Sierra into the subalpine in mid- to late summer. In 1986, the largest flock of dispersing juveniles recorded in the Hall Natural Area was only four individuals. Other workers on the west slope of the Sierra also reported extremely low numbers of juvenile juncos as well as a nearly complete absence of juvenile Warbling Vireos and Black-headed Grosbeaks (D. Gaines, pers. comm.).

An intensive study of the nesting of Mountain and Chestnut-backed chickadees at the Blodgett Forest Preserve on the west slope of the northern Sierra Nevada revealed that these species experienced nestling mortality during the last 2 weeks of May 1986 that was very much higher than that of any previous year (D. Dahlston, pers. comm.). Notably reduced reproductive success in 1986 as compared to 1984 and 1985 was reported for *pugetensis* White-crowned Sparrows at the Lamphere-Christensen Nature Preserve on the north coast of California (C. J. Ralph, pers. comm.). Furthermore, preliminary analysis of migrant *pugetensis* White-crowned Sparrows on Southeast Farallon Island indicates that the HY/AHY ratio for fall migrants in 1986 was 0.50 compared to the previous 5-year average of 2.71 (PRBO, unpubl. data). *Pugetensis* White-crowned Sparrows have a limited breeding range from extreme southwestern British Columbia south, west of the Cascade Range in Washington and Oregon, to northern coastal California (AOU 1957). Thus, it appears that the 1986 reproductive failure documented here for Palomarin was not limited to central coastal California but extended widely over northern California to and including the west slope of the Sierra Nevada, and perhaps north through western Oregon and Washington as well.

Interestingly, preliminary results indicate that the productivity of landbirds on the east side of the Sierra Nevada, both in the subalpine (D. DeSante, unpubl. data) and in the sagebrush shrubsteppe near Mono Lake (D. Gaines, pers. comm.), and specifically for Mountain Chickadees in Modoc County (D. Dahlston, pers. comm.), was at relatively normal levels. Similarly, preliminary data on landbirds from the Channel Islands off southern California indicate relatively normal, or even good, reproductive success (C. Collins, pers. comm.). Landbird re-

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

productive success, therefore, was not uniformly poor throughout all of California but varied geographically. We are currently following up these reports and investigating other reports in order to determine the full extent of the 1986 reproductive failure in western North America and elsewhere.

No obvious explanation, therefore, appears to exist for the unprecedented, drastic decline in the local production of landbirds at Palomarin and elsewhere in California in 1986. Given this situation, we surmise that the reproductive failure must have resulted from either a single very rare event or from a rare combination of not so uncommon events. One rare combination of events occurred during the period 13 to 16 February 1986, when a series of very heavy storms, in conjunction with unseasonably warm weather, deluged central California and caused widespread flooding. Night temperatures during the height of the storms were recorded in excess of 15°C. Nevertheless, it is not at all clear exactly how such a combination of events could have brought on the reproductive failure documented here, especially since the failure did not occur at the start of the breeding season but, rather, part way into it.

A second unprecedented rare combination of events occurred on 6 May 1986, when a rather cold rain coincided with the passage over coastal Washington, Oregon, and northern California of a radioactive "cloud" from the accident at the Chernobyl nuclear power plant in the U.S.S.R. We must stress at this point that there exists absolutely no direct evidence linking the reportedly very small amount of radiation dropped from the Chernobyl cloud to the reproductive failure documented here. Mere coincidence may be a possible explanation for the fact that the timing of the passage of the Chernobyl cloud coincided remarkably well with the timing of the onset of the reproductive failure at Palomarin, and that the geographical area over which substantial rainfall was coincident with the passage of the cloud appears, at first glance, to coincide with the geographical areas that experienced some reproductive failure. Furthermore, the species that tended to be unaffected by the reproductive failure were those that raise their young on insects that tend to be produced in detritus or decomposer, rather than primary production food chains. This suggests that the 1986 reproductive failure could have been caused by radioactivity precipitated from the Chernobyl cloud by rainfall, absorbed and incorporated into the primary production food chain by growing plants, concentrated in the food chain by insect consumers, and fed to nestling birds by their parents that foraged on these insects. Again, however, we must emphasize that this entire scenario is completely hypothetical, that the quantities of radioactivity that were reportedly released from Chernobyl are thought by some experts to be far too small to cause nestling mortalities (I. L. Brisbin, pers. comm.), and that the entire relationship of Chernobyl to the 1986 reproductive failure may be coincidental. Nevertheless, when such an unprecedented and drastic avian reproductive failure occurs without any obvious explanation, as we have documented here, any and all coincidences deserve further investigation.

ACKNOWLEDGMENTS

The detection of aberrant phenomena in natural processes, such as the 1986 reproductive failure documented here, depends upon the existence of long-term baseline data against which the aberrancy can be compared. It is with gratitude that we acknowledge the efforts of L. Richard Mewaldt, whose unswerving dedication to the importance of long-term biomonitoring played a major role in the establishment and continuation of the Palomarin Field Station. We are most indebted, however, to the members of the PRBO who, through their continuing financial assistance and numerous donations of time, energy, tools, and equipment, have made this long-term study possible. We especially thank Dorothy B. Hunt for her many generous financial contributions to the Palomarin banding program. We also thank the Chevron Corporation for timely financial assistance with the data analysis phase of this project, and the Point Reyes National Seashore for their cooperation.

The actual work of capturing, banding, processing, and releasing the more than 15,000 individual birds reported here was accomplished by the many volunteer field biologists of the Point Reyes Bird Observatory who each contributed several hundred hours of dedicated work. To each of the following persons who collected data for this study between 10 May and 17 August 1976 to 1986 we extend a personal message of appreciation: P. Abbott, M. Adams, B. Anderson, P. Ashman, D. Astilli, J. Atchley, B. Bainbridge, B. Batson, G. Beebe, C. Blake, N. Blank, G. Bletsch, S. Boehm, J. Boies, M. Bonoff, J. Booker, W. Bradley-Bray, D. Breese, B. Broad, A. Brody, C. Bukenroth, B. Bush, R. Campos, K. Chaffey, P. Christgau, F. Conan, L. Conpagno, V. Cotton, F. Cross, C. Cutler, D. Cutter, S. Dahlgren, O. Dakin, R. DelCarlo, C. Depkin, L. Elliot, A. Eneidi, S. Engel, G. Faigin, D. Farkas, A. Faulkner, B. Fearis, B. Fee, J. Feldman, M. Fenn, E. Fitzgerald, M. Flaherty, S. Flowers, D. Fortna, L. Friedman, M.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

Gartung, A. Godell, J. Goldberg, L. Goldenberg, S. Goldhaber, S. Guth, R. Halbeisen, F. Hall, S. Hamilton, K. Hansen, P. Hark, R. Harm, T. Hart, M. Heidt, M. Hetherington, J. Holmes, S. Hope, E. Horvath, M. Howard, S. Howell, L. Hug, S. Hull, J. Humphrey, I. Hunter, C. Isenhart, C. Isles, R. Ives, D. Jensen, S. Johnston, D. Judell, S. Karbowski, K. Keane, K. Keigwin, A. Keiserman, J. Kjelmyr, C. Kolb, C. Kramer, D. Kramer, D. Kremins, B. Lance, J. Lane, D. Lehner, J. Lewis, S. Lovi, D. Lowe, P. Lowery, R. MacDonald, R. Marlowe, G. Martinsen, K. McClaine, M. McClintock, J. McCormick, M. McDonald, L. McKean, K. Meyer, D. Miller, K. Moholt, B. Moon, D. Mooney, E. Moore, D. Morris, M. Morris, A. Morua, J. Murphy, J. Narwold, W. Ogle, J. Oppenheimer, L. Orman, M. Ormes, N. Ottam, L. Parrish, P. Paton, S. Patterson, S. Peaslee, N. Petersen, M. Piercy, C. Pierson, D. Plummer, T. Pogson, J. Poole, J. Price, M. Puente, K. Purcell, P. Pyle, D. Rainboth, S. Reeve, H. Reinke, C. Reittinger, J. Rider, L. Ring, J. Robbins, P. Sawyer, E. Scholz, J. Shipman, D. Shuford, D. Siemens, M. Simonds, S. Skykora, C. Sloan, E. Sorenson, S. Spon, K. Stacey, S. Stockton, R. Stone, T. Sullivan, J. Sundberg, P. Super, C. Swarth, J. Swenson, W. Sydeman, S. Tallen, D. Taylor, T. Theimer, K. Theodore, D. Thompson, I. Timossi, J. Trainer, M. Trocme, R. Tweit, J. Vindum, J. Walterman, S. Walters, K. Warheit, N. Warnock, D. Watcher, S. Webb, J. Weigand, B. Weissenborn, G. Welsh, E. West, F. Weyman, E. Whisler, L. Willimont, S. Wilson, J. Winter, C. Wolfe, K. Wong, and L. Young. Staff personnel in addition to the authors who banded birds during this time period include R. LeValley, J. Penniman, B. Sorrie, R. Stewart, and B. Yutzy. We apologize if we've forgotten anyone.

David Green helped with analysis and Lynne Stenzel assisted with statistical aspects and performed the B-spline adaptive regression analysis. Karen Hamilton helped prepare the figures. Earlier drafts of this manuscript were improved immeasurably by excellent and astute comments and suggestions from Malcolm Coulter, Jared Diamond, C. John Ralph, and an anonymous reviewer. We thank each of you for your generous help. This is PRBO contribution No. 359.

LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1957. Checklist of North American birds, 5th ed. American Ornithologists' Union, Washington, DC.

BENT, A. C. 1939. Life histories of North American woodpeckers. U.S. Natl. Mus. Bull. 174.

BENT, A. C. 1942. Life histories of North American flycatchers, larks, swallows and their allies. U.S. Natl. Mus. Bull. 179.

BRYANT, D. M. 1975. Breeding biology of House Martins *Delchion urbica* in relation to aerial insect abundance. Ibis 117:180–216.

CRAVEN, P., AND G. WAHBA. 1979. Smoothing noisy data with spline functions: estimating the correct degree of smoothing by the method of generalized cross validation. Numerical Math 31:377–403.

DEBOOR, C. 1978. A practical guide to B-splines. Applied Math. Sci. Springer, New York.

DESANTE, D. F. 1983. Annual variability in the abundance of migrant landbirds on Southeast Farallon Island, California. Auk 100:826–852.

DUNNING, J. B., JR. 1986. Shrub-steppe bird assemblages revisited: implications for community theory. Am. Nat. 128:82–98.

GRINNELL, J., AND A. H. MILLER. 1944. The distribution of the birds of California. Pacific Coast Avifauna 27.

HARRISON, H. H. 1979. A field guide to western birds' nests. Houghton Mifflin Co., Boston.

KARR, J. R. 1981. Surveying birds with mist nets. Stud. Avian Biology 6:62–77.

MURPHY, M. T. 1983a. Clutch size in the Eastern Kingbird: factors affecting nestling survival. Auk 100:326–334.

MURPHY, M. T. 1983b. Ecological aspects of the reproductive biology of Eastern Kingbirds: geographic comparisons. Ecology 64:914–928.

NICE, M. M. 1937. Studies in the life history of the Song Sparrow. Trans. Linn. Soc. N.Y. 4:1–247.

NOLAN, V., JR. 1978. The ecology and behavior of the Prairie Warbler *Dendroica discolor*. Ornithol. Monogr. No. 26, American Ornithologists' Union, Washington, DC.

NOON, B. R., D. K. DAWSON, AND J. P. KELLY. 1985. A search for stability gradients in North American breeding bird communities. Auk 102:64–81.

O'SULLIVAN, F. 1985. Contribution to the discussion of Silverman's paper. J. Royal Stat. Soc. Series B 47:4.

PERRINS, C. D., AND D. MOSS. 1975. Reproductive rates in the Great Tit. J. Anim. Ecol. 44:695–706.

PETRINOVITCH, L., AND T. L. PATTERSON. 1983. The White-crowned Sparrow: reproductive success (1975–1980). Auk 100:811–825.

PINKOWSKI, B. C. 1979. Annual productivity and its measurement in a multi-brooded passerine, the Eastern Bluebird. Auk 96:562–572.

SILVERMAN, B. W. 1985. Some aspects of the spline smoothing approach to nonparametric regression curve fitting. J. Royal Stat. Soc. Series B 47:4.

SMITH, K. G., AND D. C. ANDERSEN. 1982. Food, predation and reproductive ecology of the Dark-eyed Junco in northern Utah. Auk 99:650–661.

STEWART, R. M., L. R. MEWALDT, AND S. KAISER. 1974. Age ratios of coastal and inland fall migrant passerines in central California. Bird-Banding 45:46–57.

TIAINEN, J. 1983. Dynamics of a local population of the Willow Warbler *Phylloscopus trochilus* in southern Finland. Ornis. Scand. 14:1–15.

WIENS, J. A. 1983. Avian community ecology: an iconoclastic view, p. 355–403. *In* A. H. Brush and G. L. Clark [eds.], Perspectives in ornithology. Cambridge Univ. Press, Cambridge.

WIENS, J. A. 1984a. On understanding a non-equilibrium world: myth and reality in community patterns and processes, p. 439–457. *In* D. R. Strong, D. Simberloff, L. G. Abele, and A. B. Thistle [eds.], Ecological communities: conceptual issues and the evidence. Princeton Univ. Press, Princeton, NJ.

WIENS, J. A. 1984b. The place of long-term studies in ornithology. Auk 101:202–203.

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

APPENDIX

SCIENTIFIC NAMES OF THE SPECIES MENTIONED IN THE TEXT

Band-tailed Pigeon (*Columba fasciata*), Mourning Dove (*Zenaida macroura*), Downy Woodpecker (*Picoides pubescens*), Hairy Woodpecker (*Picoides villosus*), Northern Flicker (*Colaptes auratus*), Olive-sided Flycatcher (*Contopus borealis*), Western Wood-Peewee (*Contopus sordidulus*), Western Flycatcher (*Empidonax difficilis*), Ash-throated Flycatcher (*Myiarchus cinerascens*), Tree Swallow (*Tachycineta bicolor*), Violet-green Swallow (*Tachycineta thalassina*), Northern Rough-winged Swallow (*Stelgidopteryx serripennis*), Cliff Swallow (*Hirundo pyrrhonota*), Barn Swallow (*Hirundo rustica*), Steller's Jay (*Cyanocitta stelleri*), Scrub Jay (*Aphelocoma coerulescens*), Mountain Chickadee (*Parus gambeli*), Chestnut-backed Chickadee (*Parus rufescens*), Plain Titmouse (*Parus inornatus*), Bushtit (*Psaltriparus minimus*), Red-breasted Nuthatch (*Sitta canadensis*), Brown Creeper (*Certhia americana*), Bewick's Wren (*Thryomanes bewickii*), Winter Wren (*Troglodytes troglodytes*), Golden-crowned Kinglet (*Regulus satrapa*), Western Bluebird (*Sialia mexicana*), Swainson's Thrush (*Catharus ustulatus*), Hermit Thrush (*Catharus guttatus*), American Robin (*Turdus migratorius*), Wrentit (*Chamaea fasciata*), European Starling (*Sturnus vulgaris*), Hutton's Vireo (*Vireo huttoni*), Warbling Vireo (*Vireo gilvus*), Orange-crowned Warbler (*Vermivora celata*), MacGillivray's Warbler (*Oporornis tolmiei*), Wilson's Warbler (*Wilsonia pusilla*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Brown Towhee (*Pipilo fuscus*), Rufous-crowned Sparrow (*Aimophila ruficeps*), Black-chinned Sparrow (*Spizella atrogularis*), Savannah Sparrow (*Passerculus sandwichensis*), Grasshopper Sparrow (*Ammodramus savannarum*), Song Sparrow (*Melospiza melodia*), White-crowned Sparrow (*Zonotrichia leucophrys*), Dark-eyed Junco (*Junco hyemalis*), Red-winged Blackbird (*Agelaius phoeniceus*), Brown-headed Cowbird (*Molothrus ater*), Purple Finch (*Carpodacus purpureus*), House Finch (*Carpodacus mexicanus*), Pine Siskin (*Carduelis pinus*), American Goldfinch (*Carduelis tristis*).

This content downloaded from 132.174.254.164 on Mon, 28 Mar 2016 17:05:27 UTC
All use subject to http://about.jstor.org/terms

J. Field Ornithol., 64(4):507-519

NEST-MONITORING PLOTS: METHODS FOR LOCATING NESTS AND MONITORING SUCCESS

THOMAS E. MARTIN[1]
U.S. Fish and Wildlife Service
Arkansas Cooperative Fish and Wildlife Research Unit
University of Arkansas
Fayetteville, Arkansas 72701 USA

GEOFFREY R. GEUPEL
Point Reyes Bird Observatory
4990 Shoreline Highway
Stinson Beach, California 94924 USA

Abstract.—Attention to long-term declines in populations of Neotropical migratory birds has generated increased interest in how to monitor and manage them. Measurement of nesting success provides information on trends in recruitment, and measurement of vegetation associated with nests may identify habitat influences on breeding productivity. Examination of nests also allows collection of life history data (e.g., clutch size, numbers of broods, numbers of nesting attempts, nesting success), which provide important insight into vulnerability of species to decimation or perturbations. Comparisons of nesting success and habitat use across the geographic range of a species can determine local habitat effects on population recruitment and historical constraints on habitat use and species distributions. In this paper, standardized methods and cues are described that aid in locating and monitoring nests to allow comparisons across studies in space and time.

MÉTODOS PARA LOCALIZAR NIDOS Y MONITOREAR EL ÉXITO DE ESTOS

Sinopsis.—El decrecimiento progresivo de las poblaciones de aves que migran al neotrópico ha generado gran interés en cómo monitorear y manejar a éstos. El medir el éxito de anidamiento provee información en relación a las tendencias en el reclutamiento poblacional y las medidas de la vegetación asociada a nidos puede ser importante en identificar aspectos de ésta que influyan en la productividad. El examen de nidos también permite recopilar datos sobre ciclos de vida (ej. tamaño de la camada, número de camadas por año, número de intentos de anidamiento, y éxito de anidamiento) el cual provee información importate en referencia a la vulnerabilidad de la especie a perturbaciones. La comparación del éxito de anidamiento de una especie en diferentes habitats a lo largo de extensiones geográficas puede determinar el efecto de habitats locales en el reclutamiento poblacional y restricciones históricas en el uso de habitat y la distribución de la especie. En este trabajo, se describen métodos estandarizados y pistas que pueden ayudar a localizar y monitorear nidos de tal manera que se puedan hacer comparaciones entre estudios y lapsos de espacio y/o tiempo.

Habitat features that influence breeding productivity of birds are poorly known (Martin 1992). Measurement of nesting success and associated vegetation allows identification of such habitat features and also provides greater insight into evolution of habitat requirements and species coexistence than traditional metrics such as presence or abundance (Martin 1986, 1988a, 1992). Data on nest sites and mortality also improve understanding of ecological and evolutionary influences on life history traits

[1] *Current address: Montana Cooperative Wildlife Research Unit, Department of Biological Sciences, University of Montana, Missoula, Montana 59812 USA.*

(Lack 1968; Martin 1988b, 1993a, b; Martin and Li 1992), which can give insight into the abundance and vulnerability of species to population decimation (Martin 1993a, Pimm et al. 1988). Knowledge of life history traits taken together with data on breeding productivity can also provide information on demographic trends and warn of population problems before declines in density actually occur (Martin 1992, 1993a; Pienkowski 1991; Temple and Wiens 1989). Many life history traits, however, are unknown or poorly known for many species in North America; breeding biology studies are poorly represented among species and geographic locations (Martin 1992, 1993a; Ricklefs 1969). The paucity of studies exists in part from a misconception that nests are too difficult to find. Yet, cues and techniques for finding nests can be learned, as we describe here, thereby providing the vital information needed to curb long-term population declines of many species (see Robbins et al. 1989).

Nest record programs, where volunteers turn in records of nest attempts, have been in existence for years in both the United Kingdom (Ballie 1990) and United States (Bart 1977). These programs obtain data for broad geographic regions from volunteers who often locate nests incidental to other activities. Sample sizes for many geographic regions and habitat types are minimal and consistency in monitoring nests once they are found is poor. Thus, these programs suffer from several potential biases and require careful interpretation (Ballie 1990). In contrast, studies that focus on nest monitoring on long-term plots can provide data on breeding productivity for entire collections of species to allow comparisons within and among species in space and time (e.g., Martin 1992, 1993a; Martin and Li 1992; Sherry and Holmes 1992). Moreover, broad-scale deterioration of environmental conditions from habitat degradation or global warming can be detected if such studies are distributed across local microclimatic gradients and broad geographic regions (Martin 1992, Temple and Wiens 1989). Additionally, if vegetation is measured, habitat features that influence nesting success can be compared across the geographic ranges of species to provide insight into habitat requirements and distribution of species (see James et al. 1984, Knopf et al. 1990). Effective comparisons among species and locations, however, depend on standardization of sampling protocols.

In this paper we describe aids and standardized techniques for locating and monitoring success of nests. These methods are provided to standardize data collection to allow comparisons across investigators and in the hope of increasing both sample sizes and numbers of studies of breeding biology.

NEST LOCATION

Nest finding is labor intensive (DeSante and Geupel 1987), but most observers can improve their ability to locate nests in a matter of days with training and practice. The behavioral observations and clues described below work effectively for a variety of species. Our experience includes only a small subset of species and habitats available in North America,

however, and is largely restricted to wooded (scrub and forest) habitats. Other methods may be more effective in other habitats. For example, cable-dragging (Higgins et al. 1969) and rope-dragging (Labisky 1957) may be more effective methods for many grassland species. The patience and alertness of observers and their familiarity with the habitat and behavior of species are the most important influences on effectively locating nests.

We have successfully used these techniques to train individuals who even lack experience at bird identification. For example, a crew of four assistants initiated a study in Arkansas in 1991 where nesting behaviors of species were unstudied; this crew was provided only the general nest-finding guidelines given below. The crew included one experienced nest-finder, one person experienced at identifying birds and two people without experience at either. These workers found over 300 nests of open-nesting birds (Table 1). A crew of seven assistants that included two experienced nest-finders found more than 800 open-cup and cavity nests on Arizona sites in the same year (Table 1). In general, about 20 nests are needed for an adequate estimate of nesting success (Hensler and Nichols 1981), and such sample sizes were obtained for most species (Table 1). Moreover, species with small sample sizes can be compiled across years.

We recommend that two study plots be established for each person searching for nests and he or she should work on these two plots for the entire nesting season. Nest-searching should be alternated between plots between days. This schedule allows consistent monitoring and allows the person to become familiar with the plot and identify "hot spots." In general, eight plots, each 40 ha in size, should be established in forest habitat to find adequate numbers of nests for most species coexisting in any given forest, but smaller plots can be established if studying habitats with higher densities. This design fits in the national Breeding Biology Research and monitoring Database (BBIRD) administered by Martin.

Nest finding should begin early, as soon as territories are established. Non-migratory species generally are more variable than migrants and may initiate breeding considerably earlier in some years (e.g., Geupel and DeSante 1990). Visits prior to nesting are recommended to ensure early nests are not missed in 'unusual' years. Once general chronology of nest initiation is known (after the first year), a general description of this chronology helps assistants to know species on which to focus early in the season.

Nest location during nest construction.—Nests located during construction provide the best estimates of nest success. Permanent residents and many ground-nesting species often begin the earliest. Only the female constructs the nest and incubates for most small terrestrial bird species in North America (Kendeigh 1952, Silver et al. 1985). Exceptions include woodpeckers (Picidae), vireos (Vireonidae), and wrens (Troglodytidae). Thus, the most effective way of finding nests is by locating and following females, although males may provide some cues (see later), and some nests in the shrub layer can be found by random search. Ground nests

TABLE 1. List of species and numbers of nests found in a single field season in Arkansas and Arizona using teams of four and seven field assistants, respectively.

Arkansas		
Yellow-billed Cuckoo	*Coccyzus americanus*	13
Acadian Flycatcher	*Empidonax virescens*	51
Wood Thrush	*Hylocichla mustelina*	40
Red-eyed Vireo	*Vireo olivaceus*	51
Black-and-white Warbler	*Mniotilta varia*	19
Ovenbird	*Seiurus aurocapillus*	14
Worm-eating Warbler	*Helmitheros vermivorus*	16
Hooded Warbler	*Wilsonia citrina*	67
Indigo Bunting	*Passerina cyanea*	30
Arizona		
Acorn Woodpecker	*Melanerpes formicivorus*	8
Red-naped Sapsucker	*Sphyrapicus varius*	30
Williamson's Sapsucker	*Sphyrapicus thyroideus*	32
Hairy Woodpecker	*Dendrocopus villosus*	10
Downy Woodpecker	*Dendrocopos pubescens*	8
Northern Flicker	*Colaptes auratus*	26
Cordilleran Flycatcher	*Empidonax difficilis*	36
Mountain Chickadee	*Parus gambeli*	45
Pygmy Nuthatch	*Sitta pygmaea*	24
Red-breasted Nuthatch	*Sitta canadensis*	26
White-breasted Nuthatch	*Sitta carolinensis*	14
Brown Creeper	*Certhia familiaris*	22
House Wren	*Troglodytes aedon*	83
Hermit Thrush	*Catharus guttatus*	74
American Robin	*Turdus migratorius*	24
Ruby-crowned Kinglet	*Regulus calendula*	14
Warbling Vireo	*Vireo gilvus*	58
Orange-crowned Warbler	*Vermivora celata*	71
Virginia's Warbler	*Vermivora virginiae*	34
Yellow-rumped Warbler	*Dendroica coronata*	45
MacGillivray's Warbler	*Oporornis tolmiei*	9
Red-faced Warbler	*Cardellina rubrifrons*	21
Western Tanager	*Piranga ludoviciana*	39
Black-headed Grosbeak	*Pheucticus melanocephalus*	7
Green-tailed Towhee	*Pipilo chlorurus*	24
Dark-eyed Junco	*Junco hyemalis*	46

in forests are usually the most difficult to find and ground-nesting species are poorly studied (Martin 1992, 1993a). Yet, this group is thought to be particularly area-sensitive and good indicators of habitat disturbance (Martin 1993a, Whitcomb et al. 1981). Thus, special efforts should be made at locating and monitoring ground-nesting species.

Females tend to be extremely furtive during nest building. Mated females may be recognized by copulation events during latter stages of building or by observing that they move about the territory unharassed by the male. Any non-mated bird, especially an intruding male, is normally attacked immediately. Any female observed should be checked with

binoculars, especially after long flights across the territory, to determine whether nesting material is being carried. Nest material may not be obvious. For example, species such as Yellow-rumped Warblers (*Dendroica coronata*) and Wrentits (*Chamaea fasciata*) collect spider webbing, which is only observable as a small white spot after careful examination of the bill (Martin and Geupel, pers. obs.). Similarly, many birds carry fine materials for lining nests, and these materials are not obvious upon casual inspection.

Sitting near sources of nesting material (i.e., failed nests, thistles) or open areas with a good view of the territory can help detection of nest-building females. Different paths across plots should be used on each visit to increase the probability of randomly encountering females near undiscovered nests. Follow a bird carrying nesting material from a distance to avoid disturbance. Do not interrupt a long flight. If the bird disappears, begin to scan for potential nest sites. Be patient and wait for another visit, being careful not to interfere with her behavior. If the female disappeared near the nest, she will spend time in the area. Remain aware, however, that she may also move out of the back side of the patch to a different patch that contains the nest.

Some birds tolerate nearby observers and behave normally, but most are very wary of observers. If the observer is too close to the nest, the bird often will sit on a perch and eventually drop the nesting material if the observer does not move away. The observer should move quickly and quietly in the opposite direction from which the bird came. Obtain a new hiding position at least 15 m away and watch the female take nesting material several times and leave without it. Stay alert to the possibility that the female may enter one patch and then surreptitiously move among patches only to return the same way to give the appearance of nesting in the first patch. Some species such as MacGillivray's Warblers (*Oporornis tolmiei*), Hooded Warblers (*Wilsonia citrina*) and Sage Sparrows (*Amphispiza belli*) will walk on the ground for several meters to approach the nest secretly. Species that nest off the ground can often be detected as they move through a thick patch of vegetation by watching the vegetation move. Verify the nest status and location a few hours later, being careful to make sure the female is not present. Later visitation is recommended because usually the female has become aware of observers during their nest-finding activities.

Nest location during egg-laying.—The most difficult stage for finding nests is during egg-laying because the female may visit the nest only when she lays an egg and most songbirds lay one egg per day. In cold climates, the female will sometimes sit on the nest during egg-laying when weather is particularly harsh. Also, nest visitation becomes more frequent with increases in numbers of eggs laid (Kendeigh 1952, Zerba and Morton 1983). One means of finding nests during egg-laying is by carefully observing female and male behavior. When either parent gets near the nest, it will look at the nest. If an egg-laying female detects a predator in the area, such as an observer following her, she will sometimes check

the nest by looking down at it repeatedly. A good cue is a female staying in an area without actively feeding.

Finally, copulatory behavior can be used to detect nests during both nest-building and egg-laying. Copulation often occurs in the same tree above a nest, on the same branch, or in the next tree. Carefully examine the area immediately adjacent to any copulatory activity observed.

Nest location during incubation.—When females suddenly "vanish" and males increase the frequency of singing, females have probably initiated incubation. An increase in female foraging speed also indicates the onset of incubation. Females forage at slower speeds prior to incubation (during pre-construction, nest construction, and egg-laying) than during incubation and nestling stages. Females that are moving obviously fast (e.g., rapid hops, quick short flights, rapid wing flicks) should be carefully followed because they will return to the nest soon; on average, female passerines stay off the nest for 6–10 min and on for 20–30 min at a time across species (e.g., Nice 1937, Southern 1958, Zerba and Morton 1983).

Detection of incubating females can be accomplished in two ways. First, females can be encountered by constantly moving through the study plot, but constant alertness is imperative. Sometimes, sitting down in a spot for 20–30 min is useful because incubating females will leave the nest in that period. Second, females can be detected by call notes. Females of many taxa (e.g., Silviidae, Parulinae, Emberizinae) chip or call when they are off the nest. The female begins chipping just prior to leaving the nest or as soon as she is off it. Some taxa such as emberizid finches and icterines give a unique nest departure call when leaving the nest (McDonald and Greenberg 1991). If a vocalizing female is detected and then lost during the course of following her, immediately return to the point of original detection because it is often near the nest and the female can often be relocated before getting back on the nest.

Males can also be of some help. First, males often will respond to females when they leave the nest and either quietly guard the nest (e.g., Gray Catbird, *Dumetella carolinensis*; Slack 1976), or the female. Detection of a quiet male may indicate presence of a foraging female or a nest somewhere near him. Second, males will feed incubating females for a great array of species, particularly cavity-nesting birds, but for many open-nesting birds as well (Lyon and Montgomerie 1987, Silver et al. 1985, Martin and Geupel, unpubl. data). Any birds (male or female) observed should be checked for material in their bills because they potentially could be building nests, feeding females or feeding young. Finally, males of some species (e.g., Chestnut-sided Warbler, *Dendroica pensylvanica*) use favorite singing perches that are in direct view of the nest (Martin, pers. obs.). The nest can be located by following his line of sight.

Females are fairly tolerant of people following while they forage. The female is more cautious as she returns to the nest. A relatively long flight after foraging is probably a return to the nest and is often along the same route. Quickly running in her direction for about 25 m may often allow

resighting because the disturbance will keep her from returning to the nest. If she is near the nest, but cautious about approaching, she will display nervous displacement behavior. This "nest dance" involves bouncing back and forth between a few trees or substrates, and in some cases also includes very rapid foraging. Eventually, she will start to move down toward the nest and then suddenly fly back up. This behavior will be repeated several times in the course of a few minutes. If the observer is too close to the nest, the bird will continue to bounce back and forth between substrates and will sometimes fly off for a short time, only to return within a few minutes. The observer should back off and watch her with binoculars and she will then return to the nest. If the work is being conducted in cold conditions, do not keep her off the nest for more than 15 min because the eggs can chill to lethal levels. If the female has been followed for more than 30 min and has not disappeared or exhibited displacement behavior, then she probably does not have a nest. Of course this "30-min rule" does not apply to species where both sexes incubate.

If a female disappears into a tree or shrub, memorize the area where the female disappeared and choose potential nesting sites before approaching. Moving quietly, begin tapping potential nest shrubs in this area with a stick. Listen for the flush of the female off the nest. Watch for the female or the "nest dance." Note that spotting the female will confirm that the nest is nearby. If the nest is not found and the female is not observed leaving, then there is no confirmation that a nest is in the area. Because the nest is in a fixed location, the site can be revisited for careful searches in the future.

In many species, nest site preference seems to be an evolutionarily conservative trait (Martin 1988a, 1992, 1993c). Many birds prefer to nest in or under certain plant species or patch types that differ among bird species (Geupel 1993, Martin 1993c, Martin and Roper 1988). Familiarity with nest substrate and patch preferences can help in finding nests. Describe and visit nest locations from previous years to aid new observers in finding nests.

Nest location during the nestling stage.—Finding nests during the nestling period is easiest because both males and females commonly bring food to the nestlings and remove fecal sacs. Males are normally the easiest to follow because they are generally less cautious than females in approaching nests. Nests can usually be found from a greater distance using binoculars because of the constant activity of the parents.

Knowledge of the nesting cycle allows an observer to anticipate when to start looking for a new nest. Most species will renest following a nesting failure, although the number of nesting attempts or renesting intensity varies within and among species (Geupel and Desante 1990, Martin and Li 1992). Reconstruction begins almost always at a new site within 10 d and the new nest is likely to be farther away from the previous nest the earlier in the nesting cycle that failure occurred (citations in Martin 1992). Multi-brooded species may begin another nest in as little as 8 d

after fledging a prior nest. Sometimes the female will begin nesting while the male is still tending the fledglings of the previous brood (Burley 1980, Smith and Roff 1980).

Nest finding can be a difficult and frustrating task; patience is the most important asset. An observer should set a goal of trying to find at least one nest every day. More than one nest will be found on many days, but if at least one nest can be found each day the numbers of nests obtained over the season will accumulate and frustration will be minimized.

NEST MONITORING

Each nest found should be checked every 3–4 d to determine if it is still active (with eggs or young) or has failed. Except just after egg-laying and near hatching and fledging events, it is not necessary to check the nest contents. Instead, check the nest from a distance; if an adult is on the nest, do not flush it. Careful and highly conscientious attention to checking nests is critical for data quality because the number of days that nests are observed with eggs or young is used to calculate daily mortality rates, the most effective measure of nest success (Hensler and Nichols 1981; Mayfield 1961, 1975). Moreover, nesting outcome is difficult to determine with increasing length of time between nest checks and variation at this stage can bias estimates of nest success. The fledging date should be identified as the date of the last visit on which nestlings were observed in the nest. Do not extrapolate past the last date that young were observed except when the average nesting cycle duration is used to determine the fledging date from the known initiation date. Otherwise, an upward bias on Mayfield estimates occurs. Prior to the field season, a sheet of information that summarizes the general clutch size, length of the incubation period, and length of the nestling period for every species that occurs on the study sites should be prepared. This information aids anticipation of hatching and fledging events.

Flagging or other visible markers can increase risk of predation (Picozzi 1975) and, hence, should be used with caution. When possible, memorize the area and write a description of how to find the nest using compass bearings and distance estimates (paces) from obvious landmarks or flagging placed greater than 10 m from the nest. Another solution is to grid permanently all study plots with numbered stakes at 25 or 50 m intervals depending on the density of the vegetation; 25 m intervals are usually best (see Ralph et al. 1993 for information on establishing permanently marked plots). Nest location can be described from these permanent markers.

Nest cards are used to record data about the nest site and nest activity. The Cornell Laboratory of Ornithology (159 Sapsucker Woods Rd., Ithaca, New York 14850) maintains a national nest card database and, thus, their card or some similar variant should be used. All observations of nests should be recorded on the nest card, including visits when no activity was noted. Noting lack of adult activity is particularly critical for canopy or cavity-nests where nest contents cannot be checked. All this

information is needed for calculating nesting success (see also Bart and Robson 1982). Recorded information should include date, time, presence of adults and activity of adults (e.g., incubating, feeding young, flushed from nest). Also, any time the nest is approached close enough to see the contents, they should be noted on the nest cards (number of eggs, or number and age of nestlings). Age of the nestlings helps determination of nest fate in some cases by providing information on length of time that nests were active. Also, data should be summarized by success at each nesting stage (egg-laying, incubation and nestling) and, thus, accurate records of these stages are needed. When possible, data should include date of first egg, clutch completion date, hatching date, day of banding (if banded) and fledging date. Careful and detailed observations should be recorded if a nest predation event is observed in action. If the nest appears inactive based on observations from a distance, it should be approached to verify mortality. In the case of canopy nests, mirrors attached to telescoping poles (we use window-washing poles) can be used to check nest contents of nests up to 10 m off ground. If the nest appears depredated (eggs or young removed) then check the nest structure and immediate area around and under the nest for evidence of predation. Look for holes in the bottom of the nest cup. Any evidence (e.g., shell fragments, hole in nest, nest torn up) should be fastidiously noted on the card. When the young fledge, they commonly perch on the side of the nest thereby flattening the nest and they leave fecal droppings in the nest or on the edge or ground and such should be noted as possible evidence of successful fledging. When a nest is thought to have fledged, however, observers should try to verify by watching for fledglings or parents feeding fledglings or by hearing parents giving alarm or distress calls or young begging. This activity usually occurs near the nest site because fledglings often do not move very far in the first couple of days. Some species such as Rufous-sided Towhees (*Pipilo erythrophthalmus*), however, may move as far as 100 m in less than a few hours. Care must be exercised in classifying nest fate because some species or individuals may carry food up to 24 h or longer after predation of their nest. This behavior may be exacerbated by unrelated fledgings from neighboring territories. Descriptive confirmatory evidence of fledging should be noted on the nest cards.

PRECAUTIONS FOR MINIMIZING HUMAN-INDUCED MORTALITY

Locating and monitoring nests have the potential to reduce nest success (Gotmark 1992) but with proper precautions such biases can be eliminated or minimized (Martin and Roper 1988, Nichols et al. 1984, Willis 1973). Some investigators use camouflage netting over their heads or attached to camouflaged hats to reduce disturbance to birds. Initial location of the nest normally creates the most distress to adult birds and disturbance to the nest site because subsequent visits are brief. Some evidence suggests that predation rates are higher on the first or early visits than subsequent visits (Bart 1977, Nolan 1978, but see Bart and Robson 1982), perhaps caused by the disturbance during locating the nest. Therefore the following

guidelines are suggested when attempting to locate nests. (1) Distress calls by adults should be minimized and never allowed to continue for over 5 min. (2) Do not approach a nest when any potential nest predator, particularly a visually-oriented predator (e.g., corvid) is present. (3) Minimize disturbance to the area around the nest. (4) Do not get close to nests during nest building; birds will abandon if disturbed prior to egg-laying, particularly during the early part of a season.

To lower the probability of predation or brood parasitism during checks, we recommend the following precautions. (1) Check the nest from as great a distance as possible. Use binoculars to see the female or contents of the nest or get on logs and look from above into the nest when possible to minimize proximity and disturbance near the nest. (2) Disturb the birds and area as little as possible. Move to nests in different paths on subsequent visits and use a path that is quick, quiet and that minimizes disturbance to the vegetation; paths in the vegetation from broken stems or smashed grass/forbs can cue possible predators. Never leave a dead end trail to the nest. Do not return on the same path but continue walking in a different direction away from the nest. If avian predators are common, check other bushes without nests. Always assume a predator is watching. (3) Be quick and accurate during nest checks and nestling banding. If the nest must be approached, minimize the amount of time spent near the nest examining the contents because the more time spent at nest the more scent that is left for olfactory predators. (4) Minimize the number of observers visiting the nest (no photographers). (5) Use a pen or stick to check nests to prevent human scent from being left on or near a nest.

VEGETATION MEASUREMENT

As soon as a nesting attempt terminates (successful or unsuccessful), complete the nest card and then measure the vegetation associated with the nest. Be careful at the beginning of the season (May to early June), as an empty nest may not have had eggs laid yet; some species or individuals will delay as long as 8 d between completing nests and laying eggs. Do not bother nests at this stage, unless it is certain a nesting attempt was made and failed.

Vegetation should be measured for the nest substrate and surrounding patch. Vegetation in the patch surrounding the nest can provide information on microhabitat choices. Species that choose the same plant species as a nest substrate may choose different microhabitat types (Martin 1993c, unpubl. data). Moreover, vegetation in the habitat patch surrounding a nest may exert a strong influence on probability of mortality. For example, numbers of potential nest sites (stems of the same size and plant species as used for the nest) in the patch surrounding the nest may affect predation risk (Martin 1988c, 1992, 1993c; Martin and Roper 1988). Hence, determination of habitat patch preferences is important for developing land management guidelines and testing habitat selection theories. Comparisons of nest patch characteristics to unused patches or to patches used across the range of species may provide important insight into habitat

preferences (e.g., see James et al. 1984; Knopf et al. 1990; Martin 1988c, 1992, 1993c; Martin and Roper 1988). Standardized vegetation sampling methods should be used to allow comparisons among locations and investigators. Details of the vegetation sampling protocols used by the national BBIRD program are available from Martin upon request.

In conclusion, nest-monitoring plots can provide valuable data on the habitat influences on nesting productivity and possible causes underlying population trends. Constant-effort mist-netting schemes can provide an index of annual productivity (Ballie et al. 1986, DeSante and Geupel 1987) and also some information on adult and juvenile survivorship. These methods, however, do not necessarily provide information on the types of habitat conditions that facilitate increased nesting productivity. Nest-monitoring is more labor-intensive but provides direct information on both productivity and habitat conditions that facilitate maintenance of viable populations, thereby providing direct land management information. Moreover, nest-monitoring is the only way to ascertain the rate and consequences of cowbird parasitism. Finally, nest-monitoring provides badly needed data on life history traits of species, which allows identification of bottlenecks in the demography of species and, also, when taken together with nesting success may provide important insight into vulnerability of populations to disturbance (see Martin 1993a).

ACKNOWLEDGMENTS

We thank a large number of field assistants for help in learning how to teach people the art of finding and monitoring nests. L. Garner, S. Garner, J. D. Nichols. D. Petit, C. J. Ralph, C. S. Robbins and R. M. Mannan provided helpful comments on earlier drafts. Martin's work was supported by National Science Foundation (BSR-8614598, BSR-9006320) and the U.S. Fish and Wildlife Service. Geupel's work was supported by the members and board of the Point Reyes Bird Observatory, Chevron Corporation, and cooperation of the Point Reyes National Seashore. This is contribution Number 1 for the BBIRD program and Number 536 for PRBO.

LITERATURE CITED

BALLIE, S. R. 1990. Integated population monitoring of breeding birds in Britain and Ireland. Ibis 132:151–166.

———, R. E. GREEN, M. BRODY, AND S. T. BUCKLAND. 1986. An evaluation of the Constant Effort Sites Review Group to the Ringing Committee of the British Trust for Ornithology. BTO, Beech Grove, Tring, Herts, United Kingdom.

BART, J. 1977. Impact of human visitations on avian nesting success. Living Bird 16:187–192.

———, AND D. S. ROBSON. 1982. Estimating survivorship when the subjects are visited periodically. Ecology 63:1078–1090.

BURLEY, N. 1980. Clutch overlap and clutch size: alternative and complementary reproductive tactics. Am. Nat. 115:223–246.

DESANTE, D. F., AND G. R. GEUPEL. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986. Condor 89:636–653.

GEUPEL, G. R. 1993. Wrentit (species account). *In* D. Shurford, ed. Marin County breeding bird atlas: a natural history of Marin Co. breeding birds. Occidental Press, Bolinas, California, in press.

———, AND D. F. DESANTE. 1990. Incidence and determinants of double brooding in Wrentits. Condor 92:67–75.

GOTMARK, F. 1992. The effects of investigator disturbance on nesting birds. Current Ornithol. 9:63–104.

HENSLER, G. L., AND J. D. NICHOLS. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93:42–53.

HIGGINS, K. F., L. M. KIRSCH, AND I. J. BALL, JR. 1969. A cable-chain device for locating duck nests. J. Wildl. Manage. 33:1009–1011.

JAMES, F. C., R. F. JOHNSTON, N. O. WAMER, G. J. NIEMI, AND W. J. BOECKLEN. 1984. The Grinnellian niche of the Wood Thrush. Am. Nat. 124:17–47.

KENDEIGH, S. C. 1952. Parental care and its evolution in birds. Illinois Biol. Monogr. 22:1–357.

KNOPF, F. L., J. A. SEDGWICK, AND D. B. INKLEY. 1990. Regional correspondence among shrubsteppe bird habitats. Condor 92:45–53.

LABISKY, R. F. 1957. Relation of hay harvesting to duck nesting under a refuge-permittee system. J. Wildl. Manage. 21:194–200.

LACK, D. 1968. Ecological adaptations for breeding in birds. Methuen and Co., London, United Kingdom. 409 pp.

LYON, B. E., AND R. D. MONTGOMERIE. 1987. Ecological correlates of incubation feeding: a comparative study of high arctic finches. Ecology 68:713–722.

MARTIN, T. E. 1986. Competition in breeding birds: on the importance of considering processes at the level of the individual. Current Ornithol. 4:181–210.

———. 1988a. Processes organizing open-nesting bird assemblages: competition or nest predation? Evol. Ecol. 2:37–50.

———. 1988b. Nest placement: implications for selected life-history traits, with special reference to clutch size. Am. Nat. 132:900–910.

———. 1988c. On the advantage of being different: nest predation and the coexistence of bird species. Proc. Natl. Acad. Sci. USA 85:2196–2199.

———. 1992. Breeding productivity considerations: what are the appropriate habitat features for management? Pp. 455–473, *in* J. M. Hagan and D. W. Johnston, eds. Ecology and conservation of Neotropical migrant birds. Smithson. Inst. Press, Washington, D.C.

———. 1993a. Nest predation among vegetation layers and habitat types: revising the dogmas. Am. Nat. 141:897–913.

———. 1993b. Evolutionary determinants of clutch size in cavity-nesting birds: nest predation or limited breeding opportunities? Am. Nat., in press.

———. 1993c. Nest sites and nest predation: new perspectives on old patterns. BioScience 43:523–532.

———, AND P. LI. 1992. Life history traits of cavity- versus open-nesting birds. Ecology 73:579–592.

———, AND J. J. ROPER. 1988. Nest predation and nest site selection of a western population of the Hermit Thrush. Condor 90:51–57.

MAYFIELD, H. F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255–261.

———. 1975. Suggestions for calculating nesting success. Wilson Bull. 87:456–466.

MCDONALD, M. V., AND R. GREENBERG. 1991. Nest departure calls in female songbirds. Condor 93:365–373.

NICE, M. M. 1937. Studies in the life history of the Song Sparrow. I. Trans. Linn. Soc. New York 4:1–247.

NICHOLS, J. D., H. F. PERCIVAL, R. A. COON, M. J. CONROY, G. L. HENSLER, AND J. E. HINES. 1984. Observer frequency and success of mourning dove nests: a field experiment. Auk 101:398–402.

NOLAN, V. 1978. The ecology and behavior of the Prairie Warbler *Dendroica discolor*. Ornithol. Monogr. 26:1–595.

PICOZZI, N. 1975. Crow predation on marked nests. Journal of Wildlife Management 39:151–155.

PIENKOWSKI, M. W. 1991. Using long-term ornithological studies in setting targets for conservation in Britain. Ibis 133 suppl.:62–75.

PIMM, S. L., H. L. JONES, AND J. DIAMOND. 1988. On the risk of extinction. Am. Nat. 132:757–785.

RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service, General Technical Report, Pacific Southwest Res. Sta., Albany, California, in press.

RICKLEFS, R. E. 1969. An analysis of nesting mortality in birds. Smithson. Contr. Zool. 9:1–48.

ROBBINS, C. S., J. R. SAUER, R. S. GREENBERG, AND S. DROEGE. 1989. Population declines in North American birds that migrate to the Neotropics. Proc. Natl. Acad. Sci. USA 86:7658–7662.

SHERRY, T. W., AND R. T. HOLMES. 1992. Population fluctuations in a long-distance Neotropical migrant: demographic evidence for the importance of breeding season events in the American Redstart. Pp. 431–442, *in* J. M. Hagan and D. W. Johnston, eds. Ecology and conservation of Neotropical migrant birds. Smithson. Inst. Press, Washington, D.C.

SILVER, R., H. ANDREWS, AND G. F. BALL. 1985. Parental care in an ecological perspective: a quantitative analysis of avian subfamilies. Amer. Zool. 25:823–840.

SLACK, R. D. 1976. Nest guarding behavior by male Gray Catbirds. Auk 93:292–300.

SMITH, J. N. M., AND D. A. ROFF. 1980. Temporal spacing of broods, brood size, and parental care in Song Sparrows (*Melospiza melodia*). Can. J. Zool. 58:1007–1015.

SOUTHERN, W. E. 1958. Nesting of the Red-eyed Vireo in the Douglas Lake Region, Michigan. Jack-Pine Warbler 36:105–130.

TEMPLE, S. A., AND J. A. WIENS. 1989. Bird populations and environmental changes: can birds be bio-indicators? Amer. Birds 43:260–270.

WHITCOMB, R. F., C. S. ROBBINS, J. F. LYNCH, B. L. WHITCOMB, M. K. KLIMKIEWICZ, AND D. BYSTRAK. 1981. Effects of forest fragmentation on the avifauna of the eastern deciduous forest. Pp. 125–205, *in* R. L. Burgess and D. M. Sharpe, eds. Forest island dynamics in man-dominated landscapes. Springer-Verlag, New York, New York.

WILLIS, E. O. 1973. Survival rates for visited and unvisited nests of Bicolored Antbirds. Auk 90:263–267.

ZERBA, E., AND M. L. MORTON. 1983. The rhythm of incubation from egg-laying to hatching in Mountain White-crowned Sparrows. Ornis Scand. 14:188–197.

Received 17 Dec. 1992; accepted 25 Feb. 1993.

VALERO
Benicia Refinery

April 4, 2016

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Mayor Patterson and
Members of the City Council
City of Benicia
250 East L Street
Benicia, CA 94510

Re: Misinformation Campaign

Dear Mayor Patterson and Members of the City Council:

I am writing in response to the misinformation campaign that is underway by opponents of the Valero Crude-by-Rail Project. Recently the opponent's campaign included a mail piece that was delivered to residents of Benicia. The mail piece is highly misleading and intended to instill undue fear in members of our community. As further evidenced by the attached quotes, it is clear the opponents of our project are not interested in solutions, but rather eliminating the use of petroleum altogether.

The employees of the Valero Benicia Refinery are proud of the contribution we make every day to fuel our economy and improve the lives of all Californians, not just residents here in Benicia. You should know that the Valero Benicia Refinery produces approximately 10% of California's supply of the world's cleanest gasoline. California consumers demand 40 million gallons of gasoline every day to run more than 30 million cars and light trucks that are on the road in our state.

For whatever time our society continues to depend on fossil fuels, we must refine oil in an environmentally responsible way and that is exactly what we do at the Valero Benicia Refinery.

Very truly yours,

Chris Howe

Chris Howe
Director – Health, Safety, Environment &
Government Affairs

CWH:mto

Attachments

cc: Heather McLaughlin, City Attorney
Bradley R. Hogin, City Special Counsel

Valero Refining Company-California • 3400 East Second Street • Benicia, California 94510-1097
Telephone 707.745.7011 • Facsimile 707.745.7514

"For me it's not only about whether they were going to bring it by rail, but whether they were going to bring it at all."

Marilyn Bardet

http://www.facesoffracking.org/story/ed-ruszel-2/

"An intelligent global cooling plan to save our planet for future generations and all species requires the [sic] we leave the oil beneath the soil!"

Andrés Soto

http://beniciaindependent.com/andres-soto-letter-not-fooled-by-big-oil-and-big-rail/

"Earthjustice is fighting oil and gas drilling by stopping infrastructure investment.

We use the courts to cut carbon emissions and to force a shift from dirty to clean energy."

Earthjustice
http://earthjustice.org/climate-and-energy/oil-gas-drilling#
http://earthjustice.org/climate-and-energy

"The current consumption of fossil fuels is a way to global catastrophe."

Communities for a Better Environment
http://www.cbecal.org/issues/clean-energy/

"We also push for the cleaner, smarter energy solutions that will … make dirty fossil fuels obsolete. We fight dirty energy projects on all fronts."

Natural Resources Defense Council
https://www.nrdc.org/issues/dirty-energy

Amy Million

From: Russ Hands <russellhands@sbcglobal.net>
Sent: Monday, April 04, 2016 1:34 PM
To: Amy Million
Subject: Valero Crude shipments

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Amy --

I am writing you to express my opposition to Valero crude oil shipments to the Benicia refinery in the strongest terms. I think the plan to bring oil trains to Benicia is reckless and dangerous. I am a Solano County Trauma surgeon and Benicia resident for the last 28 years. I know the kind of injuries a rail accident and fire can cause. Let's protect the safety of Benicians.

Sincerely,

Russell Hands M.D.
Chief of Surgery
Kaiser Napa Solano

Sent from my iPhone

Amy Million

From: Larnie Fox <larniefox@gmail.com>
Sent: Monday, April 04, 2016 11:09 AM
To: Mark Hughes; Alan Schwatzman; Christina Strawbridge; Tom Campbell; Elizabeth Patterson
Cc: Nick Sestanovich; Amy Million
Subject: Oil by Rail

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Mayor Patterson, City Council Members,

You are now considering what is probably the most important decision you will make as a public servants to Benicia, a decision will affect the safety and economic well-being of Benicians for years to come, our precious environment and our neighbors in California. The nation is watching us.

Consider carefully.

Some are telling you that this decision is not yours to make. They are wrong. Even if they were correct, you should still vote against this proposal to do everything in your power to protect the health, safety and economic interests of those you represent.

If you vote for it, you will be putting us on the wrong side of history. When the military left Benicia, people forecast economic disaster for the town. It didn't happen. When the oil industry dwindles and leaves, as it will, new frontiers will open up for us. As businesses and people are being priced out of San Francisco and Oakland, they are looking towards our area. When they do, they see a charming, affordable, safe community with good schools. They see an affordable Industrial Park where innovative new businesses could flourish. They see a strong arts community which feeds creative thinkers and fuels economic growth. They also see a dangerous and dirty oil industry that threatens all of that and much more.

In our representative democracy, it is your job to represent us, the people. It is not your job to represent the interests of huge Texas-based corporations, even though it may be convenient and lucrative to do so.

If you decide to go ahead with this shortsighted project, not only will you be putting the health and safety of your community at risk, you will also be making us Benicians culpable for the harm that will come to communities uprail from us. You will be making us culpable for environmental damage in some of the most beautiful and sensitive areas in the state.

We, as a community, must take a stand against the powerful forces that would profit from our sacrifices. We will find that we have friends in many places if we do.

Yes, there will be a price to be paid.

Yes, it will take courage to stand up to Valero.

Sincerely,

Larnie Fox
415.407.4823
larniefox@gmail.com

Amy Million

From: Margaret Ericson <mcericson@pacbell.net>
Sent: Monday, April 04, 2016 2:30 PM
To: Amy Million
Subject: For the public record on Valero crude by rail."
Attachments: IMG_7325.JPG

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Hi Amy,
I am keeping my comment short. It **is irresponsible to approve** Valero's plan to receive two 50-tanker oil trains each day at the Benicia refinery is emblematic of broader industry efforts to ramp up transport of oil -- including dirty tar sands crude from Canada and explosive Bakken crude from North Dakota -- in mile-long trains to refineries along the West Coast . I saw first hand, while returning to Benicia on my bike, two derailed cars carrying toxic waste from a refinery in Martinez in February 2016. This refinery is not close to residential zones in Martinez, which is not the case of the Valero Refinery where residential zone is far to close to allow this type of transportation.
Please reflect and vote responsibly on behalf of your fellow Benicians.
Warm Regards,
Margaret C Ericson
805 Goettel Court
Benicia, CA 94510

Amy Million
Principal Planner,
Benicia Community Development Department
amillion@ci.benicia.ca.us

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Re: Public Comment delivered at Feb. 9, 2016 Planning Commission meeting. This is my written version of comments regarding the FEIR and the Valero Crude-by-Rail Project. Please note I have submitted letters to earlier drafts as well. I am resending this letter to the Benicia Council.

Good evening Council members. Thank you for you public service, dedication and endurance. My name is Jean Jackman and I am your neighbor from Davis.

I am terrified at the prospect of 1.5 million gallons of oil rolling through my town twice a day.

The people of Benicia should be terrified too. The air pollution will increase cancer deaths. There is noise pollution. Your water supply is at risk. Imagine the result of an oil spill in the Sacramento River, your water source. In 2010, a spill of crude from a pipeline into a small creek in Michigan that flowed into the Kalamazoo River resulted in such a mess that the river had to be closed for 25 miles and they are still cleaning up the mess six years later. The cost of cleanup was 1.2 billion and if the company would have filed bankruptcy, taxpayers would have paid.

The trains would go right through Davis, 50 feet from residents, one block from heart of Downtown Davis, through densely populated neighborhoods, past our UC Davis Mondavi Performing Arts Center. And yet we have a dangerous, higher than average chance for a derailment. Why? Because of a low speed crossover between the main lines. This crossover is right next to our Amtrak passenger depot. This crossover is so dangerous that it is rated at just 10 mph. And yet a railroad expert, has personally observed trains passing through the cross-over high speeds—one at 47 mph nearly having an accident, "tank cars whipping from side to side on their wheels."

I am certain that weak links, much like our 10 mph cross-over, can be found all along the routes if we did investigations.

I am a retired teacher. I taught for 14 years in the Vacaville School system in the town of Elmira. At one point, we had more than 1000 students. The building I taught in is right across the street from the railroad tracks. Now, the building houses a small, private school for special education students. But it makes me wonder, how many schools, hospitals and environmentally sensitive areas like the Suisun Marsh along the route are threatened by these bomb trains...accidents waiting to happen.

Your neighbors in San Luis Obispo County hit the nail on the head when their planning staff said they do not believe the economic benefits from the project outweigh the unavoidable negative environmental impacts the project would cause, in San Luis Obispo and elsewhere in California. Thanks to them for thinking of their neighbors.

Please go to Wikipedia and look at the increases in train accidents and derailments since 2010. Then imagine those trains were carrying 1.5 million gallons of highly flammable crude. Is that the future you want? The number of spills here is climbing: from 98 in 2010 to 182 in 2013, according to the California Office of Emergency Services (OES).

We don't have the emergency response capability. We don't have a nimble railroad agency ready to upgrade trains. We only have accidents waiting to happen and increasingly so

Please, consider the health of your town of Benicia. But also be good neighbors, moral people, and consider the health of hundreds of thousands of people up rail. Please do not approve this projects until all impacts are mitigated.

Thank you,

Jean Jackman
JeanJackman@gmail.com

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Resolution to Cap Bay Area Oil Refinery Emissions and to Severely Limit the Planned Bay Area Influx and Refining of Toxic Bitumen"

WHEREAS, tar sands, a nearly solid mined material from Northern Canada, is increasingly being used by U.S. and Bay Area petroleum refineries as an inexpensive substitute for liquid petroleum for making gasoline; and West Cost refineries are expected to increase the tar sands usage eight-fold by 2030, especially in the Bay Area, which has the U.S.'s highest percentage of heavy crude refining capacity; and importantly, tar sands contains far more noxious sulfur and toxic heavy metals than traditional crudes, containing 21, 11 and 5 times more vanadium, nickel and lead, respectively, according to a U.S. Geological Survey report;

WHEREAS, in order to refine tar sands into gasoline, vastly greater amounts of heat and energy-intensive hydrogen production are required to remove the sulfur which is at the greatest percentage level found in any worldwide crude, and to break the bonds in giant, heavy complex molecules that are not found in traditional liquid petroleum, and that the high amounts of sulfur and acidity found within tar sands will tend to accelerate the corrosion of pipe metal, which according to the conclusions of U.S. Chemical Safety Board led to the 2012 Chevron fire in Richmond CA that sent 15,000 residents to the ER, and moreover, peer-reviewed literature as well as a recent Carnegie Endowment study of a wide range of global crudes types, entitled "Know Your Oil: Towards a Global Climate-Oil Index" have determined that refining tar sands produces the most global warming greenhouse gasses, implicated as a central cause of climate change, and most critically, the refining of tar sands will invariably release more local toxic air pollutants into communities, which are principle causes of asthma and are implicated in cancer;

WHEREAS, tar sands must be diluted with lightweight and flammable hydrocarbon solvents simply in order flow into railroad tank cars, pipelines and refinery equipment, so is actually a diluted bitumen called "DilBit"; and when DilBit is delivered to California refineries, primarily by one mile-long trains of railroad tanker cars, it must transverse through delicate ecosystems and over vital water-source aquifers, such as the Feather River Canyon and the Delta; and a

DilBit spill penetrates deeply into the water and soil and tends to remain far underground and is always nearly impossible to adequately remediate, as observed in the 2010 Kalamazoo River Enbridge Pipeline spill that has cost over $1 billion to date; and a tar sands railroad derailment fire would release a dense and heavy metal-laden toxic cloud of smoke that would invariably be near homes and schools in the Bay Area; and currently, no mandated mitigation measures, at either the State or Federal level, adequately address the above mentioned public health and safety risks of DilBit railroad tanker transport or refining, beyond a mere small percentage of that risk;

THEREFORE, MAY IT BE RESOLVED, in light of the expected nearly ten-fold increase in Bay Area refining of tar sands and also for critical public health and safety reasons, I call on the board members of the Bay Area Air Quality Management District, i.e., the "Air Quality District", as an elected representative or political party official, to demand that Bay Area Air District executive staff institute an enforceable numerical cap or limit on each refineries total greenhouse gas and toxic co-emissions, in order to prevent an otherwise predictable increase in local disease-causing toxic air pollutants, an increase in railroad diesel pollution within communities from possibly several mile-long DilBit trains per day and an increased risk of a major refinery fire due to sulfur corrosion.

THEREFORE, MAY IT FURTHER BE RESOLVED, as an elected representative or party official, I call on jurisdictions to deny refinery project land-use permits for refinery tar sands DilBit projects and deliveries that will increase local toxic pollution, create the above stated non-mitigable public safety and environmental hazards and counter State, Federal and international efforts to control greenhouse gas emissions responsible for climate change.

- Charles Davidson. Hercules. Contra Costa County CA. 4/4/2016

Amy Million

From: Michael D'Adamo <mvdadamo12@gmail.com>
Sent: Monday, April 04, 2016 4:54 PM
To: Amy Million
Subject: Valero oil train proposal

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Dear Ms. Million: I am writing to register my opposition to the proposal to transport crude oil to the Valero refinery. The environmental and health risks are legion and well known to you. I am a county resident. Please act in behalf of the concerns of the citizens of Benicia. Thanks. Michael D'Adamo, Ph.D.

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

April 4, 2016

Dear Councilwoman Christina Strawbridge,

In the RDEIR of the Crude by Rail Project, as previously in the DEIR, it is stated that if the Crude by Rail Project is implemented there (quote) "would be significant and unavoidable impact associated with air quality and greenhouse gas emissions, hazards and hazardous materials and biological resources." City Staff, -as staff member Amy Million told me, believes that the "impact associated with air quality and greenhouse gas emissions" etc., would be less from the railroad trains than it is now from the tanker ships at sea. I do not know how they (the Staff) calculated this. However, my main concern about the Crude by Rail Project is about the "significant and unavoidable impact" here in Benicia, and specifically, where I live. My home is in the part of Benicia that was once called the Highlands, and I live within 500 feet of Valero property.

The types of crude oil that would be transported by rail cars are called Bakken crude and Tar Sands, or bitumen. Bakken crude is extracted with several hundred different types of toxic chemicals, many of which are known carcinogens. Bitumen, which is extracted from Alberta's Boreal Forest, has to be upgraded with many other partly refined petroleum products to make it flow into pipelines and in and out of railcars. Chemicals like benzene (a highly carcinogenic substance) and other toxic/carcinogenic chemicals are added and evaporate on contact with air. Currently, only one tank from a ship of crude is unloaded each week. If the Crude by Rail trains were allowed to unload in Benicia, 100 tanks could be opened each day or night. Many toxic/carcinogenic vapors, would be released into the air with the daily disconnect operations of the 100 huge (80 foot long) rail cars. These "fugitive emissions"- whether or not they came with an odor – would permeate my neighborhood just as the smell of the 5 Year Maintenance Turn Around permeated the neighborhood. It came into my open windows to awaken me at 6:30AM on February 8, 2016. If Crude by Rail trains were allowed to unload in Benicia, I wonder how long it would be before people in my neighborhood would become ill, possibly with cancer.

Then again, what about our property values? I may need to do a reverse mortgage some day. I am a retired teacher and I have worked most of my life to pay for my house. If and when people were to become aware that Crude by Rail was being unloaded in the nearby Valero Refinery, would they consider paying to live in this neighborhood?

Another important issue is the noise of 2 trains- 50 tanks each- every day or night. We all know the impact of sound. Just as music can be healing and rejuvenating, other noises can be extremely irritating and unhealthy. A Valero employee told me that before the train could leave the Yard, after unloading, every 80 foot long tank car would have to be knocked against the one next to it, so that the engineer would know that they are all connected. So- every day or night- we would hear 100 tank cars knocking together, in addition to the rumbling sound of trains arriving and moving through the Industrial Yard.

Last but not least, "Benicia Saving Water Starts with You! " I reiterate this because it seems likely to me that Valero has not reduced its use of water, while the rest of us have gone down by 20 to 30 percent. (So, would it be correct to say that Valero now uses 20% more water that the rest of all Benicia citizens combined?) As you know, refining the Bakken Crude and the Tar Sands Crude would require far more water that the crude oil that Valero now processes. If Valero were to go up another 20-50% on their water use- would the well run dry? How would this affect the people of Benicia?

Thank you so much for your time. If something is "significantly and unavoidably hazardous" – like Fire Crackers – or Street Drugs- JUST SAY NO! Make it illegal. Please!

Sincerely yours,

Madeline R. Koster
31 years in Benicia

Attn: Brad Kiger, City Manager

Monday, April 4, 2016

From: Greg Yuhas

790 West J Street

Benicia, CA

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Subject:Comments for Benicia City Council

April 4, 2016

Valero Crude by Rail Permit Appeal

The scene here today reminds me of the musical "Les Miserables" with folks cloaked in the green, waving the flag of mother earth, mounting the barricades, to fend off the locomotive of industrial pollution as it charges across the nation towards our little town. Hale to our hearty friends as they throw themselves across the tracks screaming with their last breath, NOT IN MY BACKYARD!!!

Well, perhaps this is a revolution, but not quite as pure as it may seem. The real revolt lies with the Planning Commission's decision to deny the rule of law in its refusal to approve the Valero Crude by Rail permit application.

The City staff, its consultants and lawyers diligently followed the law and regulations in completing the California Environmental Quality Act (CEQA) requirement to submit an Environmental Impact Report (EIR) that advised the decision makers of the risks associated with the requested application. They and Valero clearly pointed out that the rail transport of crude oil is regulated by the Federal government and that the scope of Benicia's control is limited to the actual oil unloading operation described in the application.

Never-the-less, the Planning Commission chose to fly in the face of preemption and deny the permit.

Today, I want to encourage you to delay the appeal process while Valero seeks a specific decision from the Surface Transportation Board asserting that U.S. C. Sec. 10501(b) clearly preempts Benicia from using the CEQA process for imposing requirements that, by their nature, could be used to deny a rail carrier's ability to conduct rail operations.

If you are so confident as to uphold the Planning Commission's decision, you should expect litigation. While the legacy of "Don Quixote" may sit well with some of you, I for one am appalled that you might choose to spend my tax dollars "tilting at windmills."

In summary, if we as a nation are to survive and do our part in saving the world we must do it according to the law. If you believe the law is unclear then you too should be seeking resolution before making your decision.

Thank You

G.P. Yuhas

CAPITOL OFFICE
STATE CAPITOL
SACRAMENTO, CA 95814
TEL (916) 651-4003
FAX (916) 323-2304

DISTRICT OFFICES
1040 MAIN STREET
SUITE 101
NAPA, CA 94559
TEL (707) 224-1990
FAX (707) 224-1992

555 MASON STREET
SUITE 275
VACAVILLE, CA 95688
TEL (707) 454-3808
FAX (707) 454-3811

985 WALNUT AVENUE
VALLEJO, CA 94591
TEL (707) 551-2389
FAX (707) 551-2390

1350 TREAT BLVD.
SUITE 240
WALNUT CREEK, CA 94597
TEL (925) 926-6148

SENATOR.WOLK@SENATE.CA.GOV
WWW.SEN.CA.GOV/WOLK

California State Senate

SENATOR
LOIS WOLK
THIRD SENATE DISTRICT

CHAIR
GOVERNANCE & FINANCE

COMMITTEES
AGRICULTURE
ENERGY, UTILITIES & COMMUNICATIONS
HEALTH
NATURAL RESOURCES & WATER

SUBCOMMITTEES
INVASIVE SPECIES
OLIVE OIL PRODUCTION & EMERGING PRODUCTS

SELECT COMMITTEES
AUTISM & RELATED DISORDERS
CALIFORNIA'S WINE INDUSTRY
EMERGING TECHNOLOGY: BIOTECHNOLOGY & GREEN ENERGY JOBS
EXCELLENCE, INNOVATION & ACCOUNTABILITY IN STATE GOVERNMENT
MENTAL HEALTH
THE SACRAMENTO-SAN JOAQUIN DELTA

JOINT COMMITTEES
FAIRS, ALLOCATION & CLASSIFICATION
LEGISLATIVE BUDGET

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

April 4, 2016

Mayor Elizabeth Patterson and
Benicia City Council
City of Benicia
250 East L Street
Benicia, Ca 94510

Dear Mayor Patterson and Benicia City Council:

My district goes from Yolo County through Solano County along the railroad and I continue to be concerned about the potential uprail impacts throughout my district by the proposed Valero Benicia Crude-By-Rail Project. The project proposes improvements to Valero's Benicia Refinery that, if approved, will allow Valero to receive and process up to 100 tank cars of crude oil by railway per day from North American sources.

The community was wise to demand a DEIR for this project. I seriously question whether the EIR has adequately evaluated the true risk of an accident or an uprail spill involved with this project. Recently, there have been several major incidents across North America where rail accidents resulted in millions of gallons of spilled crude oil. Yet the DEIR estimates the risk of oil train spills between Roseville and Benicia would be about only once per 111 years? That defies logic and is a risky assumption based on recent experience. It only takes one minor mishap to cause a major accident or spill and potentially catastrophic impacts to the heavily populated communities through which these trains will run.

The EIR also highlights that emissions from the increase in rail traffic in the area resulting from this project will have a significant but avoidable effect on the air quality in the Sacramento basin. Given the risk from possible spills and accidents involving this hazardous cargo and the project's anticipated effect on air quality, I urge the City of Benicia, Valero, and Union Pacific to work

PRINTED ON RECYCLED PAPER

with the community to implement extraordinary safety measures to guarantee public safety if this project moves forward. In that regard, at a minimum, the measures to protect our region should include the following:

- Advance notification to county and city emergency operations offices of all crude oil shipments (to facilitate more rapid and appropriate public safety responses);
- Limitations on storage of crude oil tank cars in urbanized areas of any size, and appropriate security for all shipments;
- Support, including full cost funding, for training and outfitting emergency response crews;
- Utilization of freight cars with electronically controlled pneumatic brakes, rollover protection, and other features that mitigate to the extent feasible the risks associated with crude oil shipments;
- Funding for rail safety projects (e.g., replacement/upgrade of existing tracks, grade separations, Positive Train Control, etc.);
- Utilization of best available inspection equipment and protocols;
- Implementation of Positive Train Control to prioritize areas with crude oil shipments; and
- Prohibition on shipments of unstabilized crude oil that has not been stripped of the most volatile elements, including flammable natural gas liquids.

I recognize that many of these measures will require actions by the federal, state or regional authorities. However, if these actions are not implemented or moving forward, then the City of Benicia should not approve the Valero Crude-By-Rail Project. It should be noted that there are many mitigation measures that will, indisputably, substantially reduce the impacts of shipping crude oil by rail. Many of these measures are similar to the measures recommended by the California Interagency Rail Safety Working Group in its report, *Oil by Rail Safety in California* (June 14, 2014). Specifically, that report concluded that the current regulatory environment does not address the risks of increased oil by rail transport. As a consequence, the report recommended the following actions to address those deficiencies:

- Expand the Oil Spill Prevention & Response Program to cover inland oil spills
- Review and update of local, state and federal emergency response plans
- Improve emergency response capabilities
- Request improved guidance from United States Fire Administration on resources needed to respond to oil by rail incidents
- Increase emergency response training
- Request improved identifiers on tank placards for first responders
- Request railroads to provide real-time shipment information to emergency responders
- Request railroads provide more information to affected communities
- Develop and post interactive oil by rail map
- Request DOT to expedite phase out of older, riskier tank cars
- Accelerate implementation of new accident prevention technology
- Electronically-controlled pneumatic brakes
- Update California Public Utilities Commission incident reporting requirements
- Request railroads provide the State of California with broader accident and injury data

- Ensure compliance with industry voluntary agreement including, increased track inspections, break systems inspections, use of rail traffic routing technology, using lower speeds, increased trackside safety technology and ensure state agencies have adequate data.

Finally, as your state representative I will continue to be your advocate to help ensure that the California Public Utilities Commission increases the number of rail inspectors, advocate for additional funding for local emergency responders and ensure that all trains are in compliance with the minimum crew requirements as outlined in SB730 (Wolk 2015). The safety of the citizens of the City of Benicia, my district and the citizens of the State of California is my highest priority and as such, I would respectfully request that the Benicia City Council strongly consider the concerns and proposals outline in this letter.

Sincerely,

Lois Wolk
Senator, 3rd District

LW: ap

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Benicia Planning Commission February 8, 2016
Re: Valero Refinery

Good Evening, My name is Frances Burke I am from the City of Davis in Yolo County. As has been brought to your attention, Davis is an uprail community . Oil mega trains headed to the Valero refinery will pass through our downtown and past my house.. I live in a UC Davis housing community , within 200 feet of the Union Pacific rail tracks and next to the Mondavi Preforming Arts Center. I can see and hear trains passing by all day and all night. With the Valero refinery and the crude oil trains it will bring, I will feel, smell, and taste the additional fumes and breath the additional particulate matter from the increased daily trains. I will hear and feel the increased train traffic every time they signal at a crossing, and I am a potential victim of a deadly accident, explosion or train derailment.

I have followed this project closely and at every point available, I have submitted my concerns and made comments . The FEIR still fails to address the uprail impacts of the project and the FEIR still fails to adequately respond to our questions. The FEIR has offered us no mitigation for impacts from the increased train traffic or answered the question of who is financially responsible for an accident. The accident at Lac Megantic in Quebec showed us the cost of an accident can be in the Billions. The railroads claim federal preemption and the FEIR simply advised us to contact our congressional representative. My only conclusion is that uprail communities are considered collateral damage . Your decision to approve or disapprove this project has consequences for millions of Californians putting our lives, property, and health at risk .

Fossil fuels are a dinosaur and I ask the Council not to build their city's future on a dying fossil fuel industry. Please vote NO on the FEIR and NO on the Valero Refinery project. It has failed to adequately address our concerns or offer mitigation for the project impacts to our communities and for everyone from the state line to the Benicia City limits.

Thank you for my time and your attention.
Frances Burke
Davis Ca

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

I urge you to carefully review and count findings by Greg Karras from Communities for a Better Environment (senior scientist). The most vital element of the proposed project is the change of refinery feedstock. The assertions made by Valero that its current refinery capacity and permit limits prevent change in its crude slate, processing, or emissions - is inaccurate. Karras details many more misrepresented and innaccurate data. The EIR obscures very crucial data including significant refinery emission and hazard impacts. Valero's appeal and its EIR obscure significant potential refining impacts of the project. This is unacceptable, and I strongly urge you to deny the proposal, the rail project, and vote in opposition.

Urgently and Respectfully,
Simone Cardona

April 5, 2016

RECEIVED
APR 05 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Amy Million
Principal Planner
Benicia community Development Department
amillion@ci.benicia.ca.us

Testimony for Benicia City Council Meeting on April 4, 2016
These comments accompany the powerpoint slideshow based on the Oil-by-Rail Safety in California Report published in June 10, 2014 by the Governor's Office. Please add these comments to the public record for the Valero Crude-by-rail Project.

Dear Mayor and Members of the City Coucil,

I have prepared a slideshow that I hope will be useful in providing a statewide perspective as I believe your decision here in Benicia to allow Valero to introduce the daily transport of crude oil – a hazardous substance - through northern California cannot be limited to the concerns of this city alone.

1. ***The Oil-by-Rail Safety in CA Report*** – released in June of 2014 – was timed for your draft EIR and is included in the Valero Crude-by-rail records. It includes a Map highlighting 4 "Crude-by-Rail Areas of Concern."

2. The report provides the final analysis of Governor Brown's Interagency Working Group on the dangers of introducing crude-by-rail transport into CA. You can see we have oil trains crossing the trestle bridge in the steep Feather River Canyon now bound for Kinder Morgan in Richmond or S. CA.

3. The interactive map of CA shows all rail lines. If you play with this map (my written testimony provides the link), select the hand symbol across the top of the screen and move around the screen with it. Zoom in and out. Give it time to come up.

4. The areas in red show that all routes into CA (here you see only the northern routes) have significant stretches of high hazard rail, often over or parallel to critical rivers.

5. There are three main routes where **unit trains of 100+ tank cars come into CA** from the north, and all end up in Roseville. There apparently UP has agreed to divide the unit trains into trains of only 50 cars for Valero in Benicia. Oregon and Washington states already have extensive oil trains, pipelines and ports, perhaps because CA was considered too dangerous and difficult until recently.

6. The first route is from Oregon south through Shasta, Dunsmuir and Redding to Roseville. In 1991 in the hazardous Dunsmuir area on this close-up (see the red), 15 tank cars derailed, spilling herbicides into the Sacramento River and killing everything for 20 miles. It took a decade to recover. Can we risk another derailment and toxic spill here?

The purple lines to the north are earthquake faults. Green areas are sensitive species or habitat occurrences, and blue indicates rivers or water crossings.

7. Skip. (Slide of key markings: colors mentioned in slide 6.)

8. Trains enter the second route – the Feather River Canyon - from Oregon or Nevada. In Nov. 2014, 12 grain cars tumbled down the steep slopes, spilling corn into the river. Imagine if they had been oil tank cars instead with their history of breaching, spilling oil, and bursting into flame?

The third route over the Sierra Nevada Mountains at Donner Pass requires 5 engines because of the elevation climb. So far no unit trains of crude oil have been spotted on this route. The preferred route so far is through the Feather River Canyon. The elevation may be lower, but look at the long stretch of hazardous area.

9. HazMat team locations. Pink dots are the best trained emergency teams, yellow are support teams with less training, and blue squares are non-certified teams, mostly volunteers in rural areas. **CA is unprepared to protect rural and wilderness areas in the north, and with our hot, dry summers, even one breached car can ignite a forest fire.** The more populated areas are perhaps better protected, though oil train fires in recent years have been left to burn themselves out.

10. The key for the map.

11. The Sacramento-Benicia area includes known fault lines at Fairfield and Martinez (who knows about unknown faults), species sensitivities, many water crossings including the Suisun Marsh, and urban hazmat team placements.

12. This map is enough reason to deny the project. It's simply too dangerous bringing crude oil into CA by rail. The regional concerns include:

a. Trains run right through neighborhoods & downtowns, putting infrastructure, and more importantly, lives at risk.
b. A derailment in more remote areas could spark a wild fire in our hot, dry fire season.
c. Tracks run beside and cross over critical water supplies where a spill could pollute drinking water.
d. Trains run through sensitive species and habitat occurrence areas.
e. Known geologic faults run close to Benicia and the tracks.

https://www.cooldavis.org/wp-content/uploads/Oil-by-Rail-Risk-and-Response_Map-haz-mat-team-locations-1.pdf

My Powerpoint presentation showing screen shots of the map can be found here:
https://www.cooldavis.org/wp-content/uploads/2016/03/Oil-by-Rail-Safety-in-CA-map-1.pptx

Thank you,

Lynne Nittler
Citizen of Davis, CA

Valero Crude by Rail Project
Public Comments received - Appeal

Identical Comments

"Public Comment re Valero Crude by Rail Project - Appeal Application No. 16PLN-00009"

Commenter	Date Received
Individuals	
Morena Dunn	4-Apr-16
Charles Richard	4-Apr-16
Sharon Budde	4-Apr-16
Mary Haley	4-Apr-16
Dave Seaborg	4-Apr-16
Jamie Rosenblood	4-Apr-16
Teri Snow	4-Apr-16
A D	4-Apr-16
Lyn Goodness	5-Apr-16
Marla Flores-Jauregui	5-Apr-16

SAMPLE

Amy Million

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

From: KnowWho Services <noreply@knowwho.services>
Sent: Friday, April 01, 2016 8:34 PM
To: Amy Million
Subject: Public Comment re Valero Crude by Rail Project - Appeal Application No. 16PLN-00009

Dear Benicia City Council,

I'm writing to urge the Benicia City Council to back the Planning Commission's unanimous decision to reject Valero's proposal to transport explosive crude oil by rail through California communities to its refinery in Benicia, and to reject Valero's attempts to delay a final decision on this project.

The Planning Commission rightfully rejected this dangerous project because it "would be detrimental to the public health, safety, or welfare" of Benicians and communities along the oil train routes. The project's impacts include increased air pollution from refinery emissions (which could disproportionately affect low-income communities and communities of color) and oil spills during the offloading process (which could harm the Sulphur Springs Creek riparian corridor).

Furthermore, increases in the transportation of crude by rail has corresponded with an alarming increase in the number of derailments, spills, and explosions. More than five million Californians live in the blast zones of oil train routes, and this project would significantly increase the number of unsafe oil trains rolling through our communities.

As Attorney General Kamala Harris pointed out, the U.S. Department of Transportation found that rail shipments of highly volatile crude oil represent an "'imminent hazard," such that a "substantial likelihood that death, serious illness, severe personal injury, or a substantial endangerment to health, property, or the environment may occur." I agree with regulators, elected officials, local residents, nurses, and the the many thousands of Californians who have sounded the alarm about the unacceptable risks posed by this project.

For these reasons, I again urge the City Council to reject Valero's oil train project, as well as its attempts to delay resolution of this issue.

Thank you for your consideration.

Sincerely,

Morena Dunn
1517 Sacramento St
Berkeley, CA 94702-
reenieberk@aol.com
(510) 527-6985

Amy Million

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

From: KnowWho Services <noreply@knowwho.services>
Sent: Monday, April 04, 2016 2:41 PM
To: Amy Million
Subject: Public Comment re Valero Crude by Rail Project - Appeal Application No. 16PLN-00009

Dear Benicia City Council,

I'm writing to urge the Benicia City Council to back the Planning Commission's unanimous decision to reject Valero's proposal to transport explosive crude oil by rail through California communities to its refinery in Benicia, and to reject Valero's attempts to delay a final decision on this project.

February 2016 was the warmest February on record. Temperatures in the Arctic we wildly above normal this winter following many years of above normal temperatures causing the polar ice sheet, the arctic permafrost and many snows and glaciers to thaw rapidly.

Sea level rise and climate change will be devastating to the health and well being of Benicians. The first step to reversing these future health outcomes is to stop burning fossil fuels. For this reasons, the City Council should uphold the Planning Commissions decision and reject the Valero's expansion program.

In addition, the Planning Commission rightfully rejected this dangerous project because it "would be detrimental to the public health, safety, or welfare" of Benicians and communities along the oil train routes. The project's impacts include increased air pollution from refinery emissions (which could disproportionately affect low-income communities and communities of color) and oil spills during the offloading process (which could harm the Sulphur Springs Creek riparian corridor).

Furthermore, increases in the transportation of crude by rail has corresponded with an alarming increase in the number of derailments, spills, and explosions. More than five million Californians live in the blast zones of oil train routes, and this project would significantly increase the number of unsafe oil trains rolling through our communities.

As Attorney General Kamala Harris pointed out, the U.S. Department of Transportation found that rail shipments of highly volatile crude oil represent an ""imminent hazard," such that a "substantial likelihood that death, serious illness, severe personal injury, or a substantial endangerment to health, property, or the environment may occur." I agree with regulators, elected officials, local residents, nurses, and the the many thousands of Californians who have sounded the alarm about the unacceptable risks posed by this project.

For these reasons, I again urge the City Council to reject Valero's oil train project, as well as its attempts to delay resolution of this issue.

Thank you for your consideration.

Sincerely,

Cate Leger
2320 McGee Ave
Berkeley, CA 94703-
cate@greendwellings.com
(510) 848-8908

Valero Crude by Rail Project
Identical Comments
"I support the Valero Crude by Rail project"

Commenter	Date Received
Individuals	
Curtis Eggleston	4-Apr-16
Faye Withers	4-Apr-16
Rick Dillon	4-Apr-16
Samuel T. Haines Sr.	4-Apr-16
Tom Rybarczyk	4-Apr-16
Charles Graham	4-Apr-16
Gary Goetz	4-Apr-16
Audrey Nieman	4-Apr-16
Joseph Rizzi	4-Apr-16
Mike Nieman	4-Apr-16
Paul Cushing III	4-Apr-16
Sam Boykin	4-Apr-16
Michael Miller	4-Apr-16
Duayne E Weiler	4-Apr-16
Linda Sanderson	4-Apr-16
Robert Hayward	4-Apr-16
Alfonso Aguilera	4-Apr-16
Paul Leimone	4-Apr-16
Kristine Passalacqua	4-Apr-16
Errol Bisutti	4-Apr-16
Paul Modjesky	4-Apr-16
Devin Versace	4-Apr-16
Walt Quillin	4-Apr-16
Josh Schmidt	4-Apr-16
Vicki Shidell	4-Apr-16
Alan Nadritch	4-Apr-16
George Maichel	4-Apr-16

SAMPLE

Amy Million

From: Curtis Eggleston <cegg712@gmail.com>
Sent: Friday, April 01, 2016 7:11 PM
To: Amy Million
Subject: I support the Valero Crude by Rail project

RECEIVED
APR 04 2016
CITY OF BENICIA
COMMUNITY DEVELOPMENT

Dear Ms. Million,

I write today urging City Council to stand with Benicians in support of Valero's Crude by Rail Project. Simple on-site infrastructure projects such as these create new jobs and generate millions of dollars in local tax revenues that help keep our community, economy and business running.
I am also writing to support the continuance for a Surface Transportation Board opinion.

An opinion from the STB should:

- provide City Councilmembers with clear legal guidance on federal railroad operation preemption laws.
- protect our City from potential, unnecessary, costly litigation.

The City of Benicia and independent experts have spent more than three years closely reviewing this project and developing a comprehensive Final Environmental Impact Report (FEIR). These analyses go well beyond California Environmental Quality Act (CEQA) requirements. Most of the analyses concerned rail activity which the railroad already has the legal authority to provide. In addition, the analyses illustrated the project's many benefits for Benicia.

According to the DEIR, RDEIR, FEIR and economic analyses, this project WILL:

- Create 20 permanent, local, well-paying jobs and require an additional 120 skilled craftsman jobs during construction;
- Improve air quality and help California and the Bay Area achieve its climate goals by reducing greenhouse gas emissions by 225,000 metric tons per year;
- Operate under current air permits with the Bay Area Air Quality Management District (BAAQMD);
- Protects home values. Benicia's median home value is higher than those of neighboring communities including Vallejo and Martinez; Benicia's home values increased by 6% last year and are projected to grow even further in 2016. The Refinery supports Benicia's higher median home value by providing significant funding for improved local services and facilities.

Importantly, according to these analyses this project:

- Will not create additional health risks associated with project emissions;
- Will not change the type or amount of crude that the refinery processes;
- Will not increase process emissions;
- Will not change refinery operations.

Projects like these are economic drivers that help to make our community the best it can possibly be, and I strongly urge City Councilmembers to stand with Benicians in supporting the well-being of our City.

Sincerely,

Curtis Eggleston
467 Lassen Dr
Martinez, CA 94553