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April 4, 2008

Ms. Chris Tomasik
Assistant Director of Public Works
City of Benicia
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Benicia, CA 94510

Subject: Water Reuse Project – Administrative Preliminary Draft Design Report

Dear Ms. Tomasik:

CDM is pleased to submit the Administrative Preliminary Draft Design Report for the Benicia Water Reuse Project. The report summarizes the findings from the project's engineering studies, pilot-scale tests, and concentrate toxicity tests. Based upon this work, the report presents recommended design criteria, preliminary drawings, and cost estimates for a 2.0 million gallon per day Water Reuse facility.

We sincerely appreciate the assistance and support provided by you and your staff during this project. Thank you for the opportunity of working with the City on this important project.

Very truly yours,

T. Gerald Cole, P.E.
Senior Project Manager
Camp Dresser & McKee Inc.

Paul F. Meyerhofer
Senior Vice President
Camp Dresser & McKee Inc.

Contents

Section 1 Introduction 1-1

1.1 Project Background and Objectives 1-1
1.2 Project Authorization 1-1
1.3 Conceptual Design Report and Technical Memoranda 1-2
1.4 Purpose of the Preliminary Design Report 1-2
1.5 Project Team 1-2
1.6 Acknowledgements 1-3
1.7 List of Acronyms 1-3

Section 2 Basic Criteria for Project Development 2-1

2.1 Recycled Water Mineral Quality Objectives for Cooling Water 2-1
2.2 Title 22 Recycled Water Quality Requirements for Cooling Towers 2-1
2.3 Overview of Process Selection 2-2
2.4 Project Output Capacity and Flow Equalization 2-2
2.4.1 Project Design Output Capacity versus Available Secondary Effluent 2-3
2.5 Location of Project Facilities 2-4
2.6 System and Process Reliability Criteria 2-4
2.7 Planning Criteria Resulting from Environmental Review Process 2-5
2.8 Other Design Criteria 2-6

Section 3 Recycled Water Treatment Process Selection 3-1

3.1 Evaluation of Biological Nitrification Treatment Alternatives for Ammonia Removal 3-1
3.2 Advanced Treatment Systems 3-2
3.2.1 Evaluation of Partial Demineralization Systems 3-2
3.2.2 Pre-Treatment for Demineralization – Micro-filtration System 3-3
3.2.3 Partial Demineralization System – Reverse Osmosis 3-4
3.3 Evaluation of Alternative Disinfection Systems 3-4

Section 4 Regulatory Compliance for RO Concentrate Disposal 4-1

4.1 Overview 4-1
4.2 Conventional Water Quality Parameters 4-2
4.3 Trace Metals and Organics 4-3
4.4 Toxicity 4-3
4.4.1 Acute Toxicity 4-4
4.4.2 Chronic Toxicity 4-4
4.5 Conclusions 4-5

Section 5 Project Interface with Existing Facilities 5-1

5.1 Description of City's Existing WWTP 5-1

5.2 Overview of Interface Requirements 5-1
5.3 Diversion of Chlorinated Secondary Effluent 5-1
5.3.1 Utilize the Existing Effluent Pumps 5-2
5.3.2 Adding New Pumps to Existing Effluent Pump Station 5-2
5.3.3 Adding New Pump Station Adjacent to Effluent Pump Station 5-2
5.3.4 Adding New Pump Station East of Chlorine Contact Basin 5-3
5.4 Utilization of Multi-Purpose Basins 3, 4, & 5 for Equalization of Secondary Effluent Flow 5-3
5.4.1 Conveyance of Secondary Effluent from MPBs to NTFs 5-3
5.5 Equalization of Ammonia Return Flow from Existing Sludge Processing System 5-4
5.6 Micro-Filtration Backwash Flow Reprocessing 5-5
5.7 Storm Drainage 5-7
5.8 Electrical Power Supply 5-7
5.9 Rerouting of Existing Buried Facilities 5-7
5.9.1 Ductbank, Cable and Wiring to Wet Weather Control Structure 5-7
5.9.2 Sewer Serving the Administrative Building 5-7
5.9.3 Foul Air Duct Serving the Industrial Flow Monitoring Structure 5-8
5.9.4 Industrial Sewer Line 5-8
5.10 Disposal of RO Concentrate through the Existing Outfall 5-8

Section 6 Summary of Preliminary Design of Recycled Water Treatment Facilities 6-1

6.1 Process Schematic Diagram 6-1
6.2 Secondary Effluent Transfer and Equalization Systems 6-1
6.3 Nitrifying Trickling Filters 6-2
6.4 Micro-Filtration 6-4
6.5 Reverse Osmosis 6-5
6.6 UV Disinfection and Break Point Chlorination 6-6
6.6.1 UV Disinfection 6-6
6.6.2 Break Point Chlorination 6-7
6.7 Chemical Storage and Containment System Design Criteria 6-8
6.7.1 Applicable Codes 6-8
6.7.2 Chemicals Storage Requirements 6-8
6.7.3 Chemicals Stored Outside 6-8
6.8 Process Implications of Power Supply Interruption, Resultant Operating Procedures and Need for Standby Power 6-9

Section 7 Recycled Water Conveyance System 7-1

7.1 Introduction 7-1
7.1.1 Overview of Conveyance Pipeline Profile 7-1
7.2 Recycled Water Supply Pump Station 7-1
7.2.1 Instrumentation, Control, Monitoring and Sampling 7-2
7.3 Recycled Water Supply Pipeline 7-4

7.4 Impacts of Recycled Water Supply Interruptions at Valero Refinery 7-5

Section 8 Civil Design Criteria 8-1

8.1 Project Datum 8-1
8.2 Existing Surface and Subsurface Conditions 8-1
8.3 Pile Foundations 8-2
8.4 Disposal of Groundwater During Construction 8-2
8.5 Paving and Access Roads 8-3
8.6 Storm Drainage 8-3
8.7 Site Regrading 8-3
8.8 Landscaping 8-4
8.9 Recycled Water Pipelines 8-4

Section 9 Structural and Architectural Design Criteria 9-1

9.1 Structural Design Criteria 9-1
9.1.1 General 9-1
9.1.2 Dead Loads 9-1
9.1.3 Live Loads 9-1
9.1.4 Seismic Loads 9-1
9.1.5 Wind Loads 9-1
9.1.6 Foundation Design 9-1
9.1.7 Flood Conditions 9-2
9.2 Architectural Design Criteria 9-3
9.2.1 General 9-3
9.2.2 MF/RO Building 9-3
9.2.3 Nitrifying Trickling Filters 9-4

Section 10 Mechanical Design Criteria 10-1

10.1 Process Piping 10-1
10.2 Noise Criteria 10-2
10.3 HVAC Design Criteria 10-2
10.3.1 General 10-2
10.3.2 Air Conditioning Design of MF/RO Building 10-3
10.4 Fire Protection Design Criteria 10-3
10.5 Plumbing Design Criteria 10-4

Section 11 Electrical Power Supply and Design Criteria 11-1

11.1 General 11-1
11.2 Power Service 11-1
11.2.1 Existing PG&E Electrical Service 11-1
11.2.2 On-Site Emergency Electric Power Generation 11-1
11.2.3 History of Utility Power Outages 11-2
11.2.4 Electrical Service for Water Reuse Project 11-2
11.2.5 Required Additional Investigations 11-3

11.2.6 Preliminary Recommendation....11-3
11.3 Power Demands....11-3
11.3.1 Existing Plant Power Demands....11-3
11.3.2 Estimated Electrical Power Loads and Demands for the Water Reuse Project....11-4
11.4 Power Distribution for the New Water Reuse Treatment Facilities....11-4
11.5 Metering and Monitoring....11-5
11.6 Energy Efficiency....11-5
11.7 Branch Circuiting....11-5
11.8 Motors....11-6
11.9 Variable Speed Control....11-6
11.10 Lighting....11-6
11.11 Communications....11-6
11.12 Control Systems....11-6

Section 12 Estimated Project Costs....12-1
12.1 Bases for Cost Estimates....12-1
12.1.1 Construction Cost Estimates....12-1
12.1.2 Operating and Maintenance Cost Estimates....12-2
12.2 Estimated Construction and Capital Costs....12-2
12.3 Estimated Annual Operation and Maintenance Costs....12-3
12.4 Estimated Cost of Recycled Water Production....12-5

Section 13 Project Schedule....13-1
13.1 Project Schedule....13-1

Section 14 Remaining Major Decisions and Additional Studies....14-1
14.1 Remaining Major Decisions....14-1
14.2 Additional Studies Recommended During Final Design....14-1

Appendices

Appendix A Drawings
Appendix B City of Benicia Noise Ordinance and City General Plan, Chapter 4 Community Health and Safety, Paragraph D Noise
Appendix C Letter Report for the City of Benicia by CSA, dated 20 September 2006

Tables

2-1 Comparison of Key Secondary Effluent Quality Parameters and Recycled Water Quality Limits 2-1

3-1 Summary of Process Design Criteria for Tertiary Nitrifying Trickling Filters 3-1

3-2 Comparison of Key Secondary Effluent Quality Parameters and Recycled Water Quality Limits and Projected Recycled Water Quality 3-2

3-3 Summary of Micro-Filtration System Design Criteria 3-3

3-4 Summary of Reverse Osmosis Process Design Criteria 3-4

3-5 Summary of UV Disinfection System Process Design Criteria 3-5

4-1 Benicia WWTP NPDES Permit Discharge Limits 4-2

4-2 Benicia WWTP NPDES Toxic Substance Effluent Limits 4-3

4-3 Pilot Testing Trace Metal Results and NPDES Permit Limits 4-4

5-1 Summary of Economic Analysis – Flow Transfer Alternatives from MPBs to NTFs 5-4

6-1 Design Criteria for Secondary Effluent Transfer and Equalization Facilities 6-2

6-2 Nitrifying Trickling Filters Design Criteria and Mechanical Equipment 6-3

6-3 Micro-Filtration System Design Criteria and Mechanical Equipment 6-5

6-4 Reverse Osmosis Design Criteria and Mechanical Equipment 6-6

6-5 Design Criteria and Mechanical Equipment for UV and Break Point Chlorination 6-7

6-6 Estimated Chemical Storage Requirements 6-8

7-1 Recycled Water Supply Pump Station Preliminary Design Criteria 7-2

7-2 14-inch Recycled Water Supply Pipeline from Benicia WWTP to Valero Cooling Towers 7-4

9-1 Detailed Structural Design Criteria 9-2

10-1 Preliminary Pipe Material Schedule 10-1

10-2 General HVAC Design Criteria for Benicia, CA 10-2

11-1 New Water Reuse Treatment Facilities Summary of Estimated Electrical Power Demand 11-4

12-1 Summary of Estimated Capital Cost 2.0 mgd Water Reuse Project 12-3

12-2 Estimated Annual O&M Costs of 2.0 mgd Water Reuse Project 12-4

12-3 Cost of Producing Recycled Water 12-5

Figures

Page

1-1 City of Benicia Water Reuse Project Overall Site and Alignment Map ..... *follows* 1-1
2-1 Diurnal Storage Volume Required for 2.55 mgd Flow to MF ..... *follows* 2-3
3-1 Typical Nitrifying Trickling Filters 3-1
3-2 Process Schematic of the MF/RO System 3-2
3-3 Typical Micro-Filtration System 3-3
3-4 Typical RO System 3-4
3-5 Typical In-Channel UV Disinfection System 3-5
4-1 Typical Flow Balance for 2.0 mgd Water Reuse Plant 4-1
5-1 Existing Process Schematic Diagram ..... *follows* 5-1
5-2 Water Reuse Project Conceptual Site Plan ..... *follows* 5-1
5-3 Existing Stormwater Pump Station 5-4
6-1 Process Schematic Diagram ..... *follows* 6-1
7-1 Pipeline Route Map ..... *follows* 7-4
7-2 Hydraulic Profile of Recycled Water Supply Pipeline ..... *follows* 7-4
7-3 Example Photos of Existing, Valero Off-Site Dock Lines ..... *follows* 7-5
7-4 Example Photos of Cooling Towers & On-Site Pipelines at Valero Refinery ..... *follows* 7-5
9-1 Photo of Existing Equipment Building 9-3
12-1 Distribution of Estimated O&M Costs for 2.0 mgd Capacity Project 12-4
13-1 Preliminary Project Schedule ..... *follows* 13-1

Section 1
Introduction

1.1 Project Background and Objectives

The City of Benicia is located in the southeast corner of Solano County. The City and the nearby Valero Refinery have entered into a partnership to develop a project to supply water recycled from the City's wastewater treatment plant for use as cooling tower make-up water at the refinery. The proposed use of recycled water would offset a commensurate amount of raw water, thus increasing the reliability of the City's potable supply.

The City's wastewater facility provides secondary level treatment. Treatment processes consist of screening, grit removal, primary sedimentation, activated sludge, secondary clarification and disinfection. The plant has a design dry weather flow capacity of 4.5 million gallons per day (mgd) and currently treats an average dry weather flow of 2.36 mgd. Treated wastewater or effluent is discharged into the Carquinez Strait of the San Francisco Bay via a deep water outfall. Minimum standards of treatment or limits of pollutants discharged are regulated by the City's National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit is issued and administered by the San Francisco Bay Regional Water Quality Control Board.

The project is planned to deliver ~~up to 2 mgd of~~ recycled water to the refinery, which is approximately three miles north of the City's wastewater treatment plant (WWTP). Figure 1-1 presents a project location map. The minimum design capacity of the facilities would be 1.0 mgd and the maximum design capacity would be 2.0 mgd.

The overall project objectives as established by the City and Valero are as follows:

- Meet water quality and quantity requirements for the cooling towers.
- Meet discharge requirements for disposal of demineralized reject stream.
- Comply with State Title 22 requirements for recycled water for cooling towers.

1.2 Project Authorization

On July 7, 2004, in accordance with Task Order No. 1 to the Consultant Agreement between the City and Camp Dresser & McKee Inc. (CDM), the City of Benicia authorized CDM to provide Phase One Engineering Services for the development of the proposed Water Reuse Project. In June 2007, the City authorized CDM to proceed with preparation of the preliminary design for the proposed project.

1.3 Conceptual Design Report and Technical Memoranda

In October 2006, CDM submitted the Conceptual Design Report (CDR) for the Project to City staff. The CDR includes background information on process evaluations and selection, recommended processes and design criteria and estimated project construction costs. In the development of the conceptual design, CDM prepared five Technical Memoranda (TM) each for various components of the Project. The technical memoranda were prepared in draft form and were submitted to the City and its steering committee (described below) for review, comment and approval of CDM's recommendations. The technical memoranda produced in the development of the project concept are as follow:

- TM 1 – Evaluation of Alternative Reuse Treatment Systems and Ammonia Removal Options (Sept. 7, 2004)
- Supplement to TM 1 – Biological Nitrification Alternatives (Nov. 30, 2005)
- TM 2 – Evaluation of Alternative Disinfection Processes (Nov. 4, 2004)
- TM 3 – Recycled Water Conveyance System (Nov. 9, 2004)
- TM 4 – Analysis of Facilities Siting Alternatives (Feb. 2, 2005)

The CDR compiled and summarized these technical memoranda. The technical memoranda are included in the Appendix to the CDR.

1.4 Purpose of the Preliminary Design Report

The purpose of this Preliminary Design Report (PDR) is to refine and amplify the project components developed during the conceptual design phase and to serve as a road map for the development of the final design. The preliminary design builds on the background and criteria established in the conceptual design phase. The PDR is intended to be a stand alone document, providing brief summaries of decisions made during the conceptual design phase. Should the reader desire more information on process evaluations and other studies conducted during the CDR phase, the TMs referred to above will provide such information.

1.5 Project Team

The Project is being developed under the direction of Chris Tomasik, Assistant Director of Public Works for the City.

The City has an ad hoc steering committee for the Project, known as PURE (People Using Resources Efficiently). CDM is also very appreciative of the guidance, insight and direction provided from the committee as a whole and individually. The PURE committee is comprised of Benicia residents appointed by the City Council. The

members are: Robert Craft, Chair; Donald Basso; Dennis Lund; Brad MacLane; and Elizabeth Patterson, Council member. The Valero Refinery representative to PURE is Guy Young.

In addition to CDM, the City retained ~~EOA, Inc~~ Eisenberg, Olivieri and Associates Inc. (EOA) to provide consultation and direction for permitting and regulatory compliance issues. To ensure that the project meets the requirements of the California Environmental Quality Act (CEQA), the City retained Environmental Science Associates (ESA) to perform environmental assessment of the project and to develop a draft Initial Study/Mitigated Negative Declaration.

1.6 Acknowledgements

CDM wishes to acknowledge the valuable guidance and expert advice received from the City, and in particular, Chris Tomasik, John Bailey (retired WWTP Superintendent), Jerry Gall, WWTP Superintendent, and Jeff Gregory, WWTP Supervisor.

1.7 List of Acronyms

BFP	belt filter press
BOD	biochemical oxygen demand
$CaCO_3$	Calcium Carbonate
CDM	Camp Dresser & McKee Inc.
CDR	Conceptual Design Report
CEQA	California Environmental Quality Act
CIP	clean-in-place
CML	Cement Mortar Lined
CMLC	Cement Mortar Lined and Coated
CMUs	cement masonry units
Cn	cyanide
Cu	copper
DB	dry bulb
DIP	Ductile Iron Pipe Coated and Lined
DIPPL	Ductile Iron Pipe Polyethylene Fusion Lining
DOPH	State of California Department of Public Health
EDR	Electrodialysis Reversal
ft	foot
gal	gallons
GFD	gallons per square foot per day
gpm	gallons per minute
H2SO4	sulfuric acid
Harza	Harza Consulting Engineers and Scientists
HMI	Human Machine Interface
hp	horsepower
hr	hour

HVAC	Heating, Ventilation & Air Conditioning
Hz	Hertz
IS/MND	Initial Study/Mitigated Negative Declaration
kVA	KiloVolt Amperes
kW	KiloWatt (1000 Watts)
I/O	input/output
LPHI	Low Pressure, High Intensity
MBR	membrane bioreactor
MF	microfiltration
mg	milligram
mg/L	milligram per liter
mgd	million gallons per day
mL	milliliter
MPBs	Multi-Purpose Basins
MPN	Most Probable Number
MSDS	material safety data sheets
NaOCI	sodium hypochlorite
NaOH	caustic soda
NEC	National Electrical Code
NF	nanofiltration
Ni	nickel
NPDES	National Pollutant Discharge Elimination System
NTF	nitrifying trickling filters
NTU	Nephelometric Turbidity Unit
NWRI	National Water Research Institute
OSHA	Occupational Safety and Health Administration
PD	Project Description
PDR	Preliminary Design Report
PG&E	Pacific Gas & Electric Company
PLC	programmable logic controller
psi	pounds per square inch
PURE	People Using Resources Efficiently
PVC	polyvinyl chloride
pvdf	polyvinyldene fluoride
RBC	rotating biological contactors
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board – San Francisco Bay Region
RWSPS	recycled water supply pump station
SCH	schedule
SETPS	Secondary Effluent Transfer Pump Station
sf	square feet
SSTL	stainless steel
STL	steel
SWPS	stormwater pump station
TDS	Total Dissolved Solids

TEFC	totally enclosed fan cooled
Title 22	California Code of Regulations, Title 22 (Water Recycling Criteria)
TM	technical memorandum, technical memoranda
TRE	Toxicity Reduction Evaluation
TSS	Total Suspended Solids
TUc	chronic toxicity units
µg/L	micrograms per liter
UV	ultraviolet
VAC	volts alternating current
VFD	variable frequency drives
WWTP	Wastewater Treatment Plant

Section 2
Basic Criteria for Project Development

2.1 Recycled Water Mineral Quality Objectives for Cooling Water

For this project, strict water quality objectives have been established by Valero relating to ammonia, silica, chloride and total dissolved solids (TDS). The bases for setting strict limits for these constituents are as follows:

- Corrosion of admiralty metals, e.g., copper-zinc alloys from chloride and ammonia.
- Plating out of deposits, e.g., calcium carbonate ($CaCO_3$).
- Build-up of slimes in cooling towers.
- TDS build up affects the number of cycles of concentration, which directly affects operating costs.

Table 2-1 presents a listing of secondary effluent constituents of concern and the limits required for the recycled water to meet the water quality criteria.

Table 2-1
Comparison of Key Secondary Effluent Quality Parameters and Recycled Water Quality Limits

Parameter	*Units*	*Benicia Effluent Water Quality*	*Cooling Water Quality Limits*
ammonia	mg/L	30	<0.2
bicarbonate	mg/L	190	104
chloride	mg/L	120	20
phosphate	mg/L	2	3
silica	mg/L	22	17
hardness	mg/L	130	<200
TDS	mg/L	650	250

2.2 Title 22 Recycled Water Quality Requirements for Cooling Towers

Recycled water from the proposed Water Reuse Treatment System must meet disinfection requirements for tertiary recycled water, proposed for use as cooling water supply, as contained in Title 22, Division 4, Chapter 3 of the California Code of Regulations (Title 22).

For either chlorination or ultraviolet (UV) disinfection, Title 22 requires that the median concentration of total coliform bacteria measured in the disinfected effluent shall not exceed 2.2 per 100 milliliters (mL) over the prior seven-day test period, not

exceed 23 per 100 mL in more than one sample in any 30-day period, and never exceed 240 total coliform bacteria per 100 mL. Title 22 requires demonstration that alternative disinfection systems, such as UV, when combined with the filtration process, inactivate and/or remove 99.999 percent (5 log inactivation or removal) of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. In addition, the micro-filtration process must meet the Title 22 turbidity performance requirements for micro-filtration, which require that the filtered water does not exceed 0.2 Nephelometric Turbidity Unit (NTU) more than 5% of the time within a 24-hour period, and 0.5 NTU at any time.

The California Department of Public Health (DOPH) is responsible for approving UV disinfection systems. All UV disinfection systems proposed for water reuse in California must be validated under the 2003 NWRI/AWWARF Guidelines, which contain extensive design criteria.

2.3 Overview of Process Selection

Process evaluations and selections were made based on meeting Valero's water quality objectives shown in Table 2-1 and using Benicia secondary effluent quality as the feed water to the Water Reuse Treatment System. Benicia secondary effluent quality is also shown in Table 2-1. During the conceptual design phase, it was determined that biological nitrification using nitrifying trickling filters (NTF) would be the most cost-effective solution for ammonia reduction for the Benicia project.

In the application of secondary effluent to reverse osmosis (RO) membranes, pretreatment using microfiltration (MF) or ultra-filtration is typically used to prevent RO membrane fouling and to extend the lives of the membranes. Several recycled water projects employ MF for pretreatment to the RO process.

To meet the other mineral water quality objectives it was determined that RO would be required. For disinfection, UV was selected as the preferred method of disinfection to meet the Title 22 recycled water quality requirements for cooling towers.

After UV disinfection, breakpoint chlorination will be provided to reduce the ammonia level resulting from the NTF MF/RO processes to meet the strict product recycled water limit of < 0.2 mg/L.

Additional discussion of process selection is contained in Section 3.

2.4 Project Output Capacity and Flow Equalization

During dry weather periods, flow rates at the Benicia WWTP vary from about 1 mgd to peaks of nearly 4 mgd. During wet weather periods, peak flow rates can reach 24 mgd. The Water Reuse Project design must take these flow variations into account since one of the overall project objectives is to supply recycled water at a more or less constant rate of 2 mgd throughout the day.

To meet the design output capacity of the project, the input secondary effluent flow to the recycled water treatment system needs to be higher than 2.0 mgd to account for the reject (waste) flows from both the MF and the RO processes. The MF process will reject about 10% of its output and the RO will reject approximately 15% of its output flow. The MF reject will be recycled to the headworks of the plant for reprocessing; the RO concentrate will be sent to the outfall for disposal. Regulatory issues associated with RO concentrate disposal are discussed in Section 4.

Based on the preliminary flow balance performed by CDM, the input flow to a 2 mgd water reuse facility will need to be approximately 2.55 mgd to account for the reject flows. Hence, a constant flow of secondary effluent must be made available at the rate of 2.55 mgd, which would include approximately 0.25 mgd of MF backwash flow which is recycled to the headworks of the WWTP.

The MF and RO processes perform best when operated at nearly a constant flow rate. It is more cost-effective to equalize secondary effluent supply to the water reuse treatment system, than to equalize the product recycled water. Operating the water reuse treatment system at a constant flow rate also provides for stable operating conditions with less variation in process performance.

The secondary effluent will be equalized using a portion of the existing multi-purpose basins (MPBs) at the WWTP. These basins are generally used to equalize high, wet-weather flows to maintain the plant's performance during high flow periods. They are also used during dry periods to store wastewater when a process unit is taken out of service.

In 2004, City provided CDM with typical dry weather flow information including diurnal flow curves. Dry weather flow was approximately 2.7 mgd. This value was used in the development of the conceptual and preliminary designs. Figure 2-1 is based on average dry weather flow (ADWF) of 2.7 mgd. It graphically shows the variation in plant flow rate during dry weather periods and the estimated amount of equalization storage required to deliver approximately 2.55 mgd on a continuous basis. Approximately 400,000 gallons of storage is required, which is approximately the volume of MPBs Nos. 3, 4 & 5. During high wet weather flow periods, equalizing flow will not be necessary.

2.4.1 Project Design Output Capacity versus Available Secondary Effluent

Wastewater flow within the City's WWTP is metered at two locations. The first meter in the flow line is called the Influent Flow Meter (M-1) and is located just after the Influent Pump Station, which receives most of the in-plant returned flows. The second meter is called the Mid-Plant Flow Meter (M-2) and is located between the primary clarifiers and the activated sludge aeration basins. (The City also calls this meter its "Effluent Flow Meter.")

In conjunction with its review of the draft PDR, the City provided CDM with updated flow data for meter M-2 for total daily flow for year 2007. A review and brief analysis of the data set from April through October found that the mean (average) daily dry weather flow during this period was 2.38 mgd. Statistical analysis of the data set finds that the average dry weather flow (ADWF) can be expected to be 2.3 mgd at least 85% of the time.

Assuming that the ADWF to the plant is actually about 2.4 mgd, there is sufficient flow to meet a recycled water output design flow rate of 2.0 mgd during dry weather conditions, were it not for the in-plant water needs provided by the Number 3 Water System. This system pumps a continuous flow of approximately 450 gpm or 0.64 mgd. Some of this water is recycled within the plant downstream of the two flow meters, discussed above.

Also of concern would be the lack of secondary effluent remaining to provide dilution water for the RO concentrate prior to discharge during dry weather flow periods. Toxicity dilution studies (please refer to Section 4) were performed with a dilution ratio of 43%, based on a worst case scenario for very low ADWF of 2.7 mgd. Based on the latest data, there would be no secondary effluent dilution water available. The impact of such limitations on permit requirements would need to be evaluated.

For both of the reasons stated above, there currently is not sufficient dry weather flow to support a recycled water output of 2.0 mgd.

The City is in the process of conducting an in-plant flow study, which will recommend specific types of meters to be installed at appropriate locations to aid in plant operations and control. Until such study is completed and the new meters are installed and adequate flow data are collected, the revised maximum design capacity of the Water Reuse Project cannot be determined. Hence, this matter should be revisited in Final Design, when additional data are available.

2.5 Location of Project Facilities

During the conceptual design phase, it was determined that all project treatment facilities would be located at the City's WWTP.

2.6 System and Process Reliability Criteria

During development of the conceptual design, project reliability issues were discussed with the City, Valero, and the PURE Committee. It was agreed that providing 100% project reliability (24/7/365) would be too costly. Hence, interruption in the delivery of recycled water could be tolerated by Valero. A 500,000 gallon product water storage "break tank" will be provided at the refinery to supply water when there is a process upset that effects the recycled water quality, and also during limited power outage durations. The break tank storage would allow time to switch from recycled water to fresh water, and if necessary process the fresh water for

use as cooling water. The City agreed that fresh water backup would remain available.

Based on the decisions, cited above, the following criteria were developed:

- Early in the project concept development phase it was decided that standby power would not be provided. However, upon further analysis of this criteria during PDR development, it was determined by City staff that standby power will be required for some critical loads for process considerations and for building safety reasons. Please refer to discussions in Sections 6 and 11.
- All main line pump systems will have a standby pump.
- There will be two nitrifying trickling filters, each designed for one-half the total flow.
- MF system will be designed with multiple skids (minimum of 3).
- RO system will not be designed with a redundant skid, since there are no mechanical components associated with the system that are prone to fail.
- UV will be designed in compliance with the redundancy requirements of the DOPH.
- Recycled water will meet Title 22 requirements before leaving the City's WWTP site.

2.7 Planning Criteria Resulting from Environmental Review Process

The City retained environmental consulting firm, ESA, to prepare the appropriate environmental compliance document required under CEQA in order to implement the project. Using the CDR and Project Description (PD) prepared by CDM, ESA prepared a draft Benicia Water Reuse Project, Initial Study/Mitigated Negative Declaration, May 2007, *Preliminary-Subject to Revision* (IS/MND). In the draft IS/MND, ESA recommended several mitigation measures, most of which relate to issues associated with construction activities, such as noise, hours of operation, dust control, emissions from gas driven equipment, disruption to nesting birds, traffic control and the like. The reader is referred to the IS/MND for additional details. The primary mitigation measures that affect the preliminary design of the project facilities are presented below with discussion.

- Mitigation Measure GEO-1: Conduct a design level geotechnical investigation.

  A detailed geotechnical investigation was conducted by Harza in 1998 for the 1999 WWTP Improvements Project. The information contained in that report is

considered adequate for development of this PDR. During the final design phase, new borings will be taken at appropriate locations within the project site to confirm the soil conditions and geotechnical recommendations contained in the Harza report. More discussion of geotechnical design considerations is presented in Sections 8 and 9, herein.

- Mitigation Measure NOI-2: Include noise reduction features to ensure that operating noise levels associated with proposed pumping systems will conform to applicable City standards, codes and ordinances.

  Based on the City's Ordinance 8.20.140, no project equipment would be allowed to "…cause the noise level at the property line of any property to exceed the ambient base noise level by more than five decibels." (Refer to Appendix B.) Background noise levels should be taken under varying conditions (day time, night time, weekends, etc.) to determine background conditions.

  The motors that will drive the pumps of the Recycled Water Supply Pump Station that will pump the product water to the refinery will have special sound enclosures around them to meet the City's noise requirements. Similarly, the pump motors of the NTF Recycle Pump Station will also be fitted with sound enclosures.

  Other pump systems will either be submersible type, which have their motors submerged in a covered wetwell, or will be enclosed in the MF/RO Building.

2.8 Other Design Criteria

Other design criteria that emerged from planning and conceptual design efforts include:

- The facades of new buildings and structures should conform to those of the existing plant structures.

Section 3
Recycled Water Treatment Process Selection

3.1 Evaluation of Biological Nitrification Treatment Alternatives for Ammonia Removal

In order to meet the ammonia criterion set by Valero as stated in Section 2 above, six alternative biological nitrification alternatives were evaluated for cost-effectiveness and reliability. NTFs were selected as the best system for the City's Water Reuse Project. NTFs are attached growth biological treatment processes that allow the nitrifying bacteria to grow on the surface of solid media, as the wastewater flows over the media. The NTFs will oxidize the ammonia to nitrate, leaving approximately 2 mg/L remaining to be removed by the reverse osmosis process and finally by break point chlorination. (Details on the development and evaluation of nitrification alternatives can be found in Section 3 of the October 2006 CDR.)

There will be two NTFs units for Benicia and each will be 42-ft in diameter with 12 feet of media. Total height, not including the top of the distribution mechanism will be approximately 15-ft high. Overall design criteria are shown in Table 3-1.

Table 3-1
Summary of Process Design Criteria for Tertiary Nitrifying Trickling Filters

Item	*Description/Criteria*
Design Flow, mgd	2.55
Influent Ammonia Concentration, mg/L	30
NTF Effluent Ammonia Concentration, mg/L	2 to 3
Kinetic Temperature, degrees C	17
Recycle Ratio, %	50 to 100
Media Type	Polyvinyl chloride (PVC), Cross Flow
Nitrifying Trickling Filter Units (2)	42 ft diameter x 12 ft media depth
Feed pumps, including recycle, mgd	2.55 each (2 duty, 1 standby)

Figure 3-1 shows a typical dual set of trickling filters, similar to the ones proposed for the Water Reuse Project. As noted in the previous section, the NTFs for the Benicia project will be constructed of facades that match or blend with the architectural finishes of the existing plant's facilities.

Figure 3-1
Typical Nitrifying Trickling Filters

3.2 Advanced Treatment Systems

3.2.1 Evaluation of Partial Demineralization Systems

Computer simulation models of alternative partial demineralization schemes were run to determine the most cost-effective system that could process the City's effluent to meet the cooling water quality objectives. Technologies investigated in various combinations, included: granular media filtration, MF, nanofiltration (NF), RO and electrodialysis reversal (EDR). As input to the demineralization analysis, it was assumed that ammonia would be biologically removed by nitrification down to approximately 2 mg/L, as discussed earlier.

MF followed by RO was determined by computer simulations to meet all the requirements except for ammonia. The RO system will reduce the ammonia to approximately 0.2 mg/L. Approximately 15% of the plant flow after MF will be routed around the RO system and blended with the RO permeate. Providing a 15% blend around reduces the cost of the RO system, and also provides the benefit of producing a more stable, less corrosive product water than if 100% RO treatment is used. However, it will also raise the ammonia level in the blend to about 0.3 mg/L. Reducing the ammonia in the blended flow from about 0.3 mg/L to less than 0.2 mg/L will be met by breakpoint chlorination after UV disinfection. Figure 3-2 shows a process schematic of the MF/RO System.

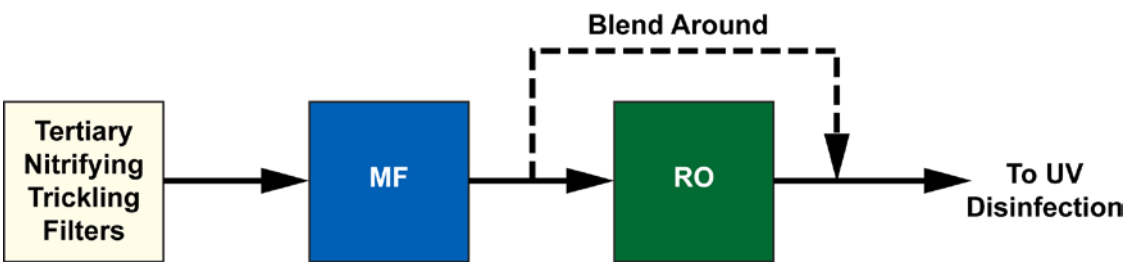

Figure 3-2
Process Schematic of the MF/RO System

Based on the above schematic the recycled water quality was projected to meet the water quality objectives as shown in Table 3-2.

Table 3-2
Comparison of Key Secondary Effluent Quality Parameters and Recycled Water Quality Limits and Projected Recycled Water Quality

Parameter	*Units*	*Benicia Secondary Effluent Water Quality*	*Cooling Water Quality Limits*	*Projected Recycled Water Quality*[1]
ammonia	mg/L	30	<0.2	<0.2
bicarbonate	mg/L	190	104	37
chloride	mg/L	120	20	<20
phosphate	mg/L	2	3	0.5
silica	mg/L	22	17	4
hardness	mg/L	130	<200	23
TDS	mg/L	650	250	120

[1] Based on 15 % blend around the RO system and breakpoint chlorination

3.2.2 Pre-Treatment for Demineralization - Micro-Filtration System

Micro-filtration will be provided before the RO membranes to reduce fouling and thus increase the cleaning interval. Typical MF systems processing secondary effluent will reject approximately 10% of the output flow, or filtrate. Hence, the output capacity of the MF system will be approximately 2.3 mgd. Motor operated strainers will be placed upstream of the MF's to protect them from residual particulates from the NTFs. MF systems are available in either the pressurized-type or the submerged, vacuum type. A pressurized MF system is recommended since it is more cost effective at the 2 mgd capacity. Table 3-3 presents a summary of the design criteria for the micro-filtration system. Figure 3-3 shows a typical pressure, micro-filtration system housed in a building.

Table 3-3
Summary of Micro-Filtration System Design Criteria

MF System Component	***Description/Criteria***
Design Output Flow Rate, mgd	2.3
Turbidity Process Performance, NTU	0.2 no > 5% in 24-hr
Membrane Type	Polyvinylidene fluoride (pvdf)
Reject Rate and Average Flow, %/mgd	10/0.25
Design Flux Rate, gallons per square foot per day (GFD)	25 to 40 (average)
MF Banks	Minimum of 3
MF Feed Pumps	3 at 900 gpm, 50 pounds per square inch (psi) & 35 horsepower (hp)

Figure 3-3
Typical Micro-Filtration System
(courtesy of Siemens Water Technologies Corp.)

3.2.3 Partial Demineralization System - Reverse Osmosis

The reverse osmosis system will be designed for an output capacity of 1.7 mgd. When the RO treated water (known as permeate) is combined with the 15% "blend around" flow from the MF process, the total output will be 2.0 mgd. The RO system is estimated to have a recovery rate of approximately 85% of the influent flow. Hence, the reject or concentrate stream will be approximately 300,000 gpd. The RO system will include cartridge filters to protect the RO membranes from any solids carry over from the MF process and would also allow short periods of MF bypass for emergency operation. The RO system will be fed by two horizontal, dry pit pumps. Flow is boosted in a recycle step, internal to the RO system, by two booster pumps. Table 3-4 below presents a summary of the RO System components. Figure 3-4 shows a photograph of a typical RO system.

Figure 3-4
Typical RO System

Table 3-4
Summary of Reverse Osmosis Process Design Criteria

RO System Component	*Description/Criteria*
Design Output Flow Rate, mgd	1.7
Membrane Type	Polyamide
Reject Rate and Flow, %/mgd	15/0.3
Reject Flow Disposition	Disposal to Existing Plant Outfall
Design Flux Rate, GFD	8 (average)
Cartridge Filters	40 inch
Low Pressure (35 psi) Supply Pumps (horizontal, dry-pit type)	2 at 35 hp each
High Pressure (125 psi) Booster Pumps (horizontal, dry-pit type)	2 at 125 hp each

3.3 Evaluation of Alternative Disinfection Systems

Alternative disinfection systems evaluated for the Benicia reuse project included chlorination using sodium hypochlorite and ultraviolet light disinfection. Recycled water from the proposed Water Reuse Treatment System must meet disinfection requirements for tertiary recycled water, proposed for use as cooling water supply, as contained in Title 22, Division 4, Chapter 3 of the California Code of Regulations (Title 22), as discussed in Section 2. In addition to chlorination, three types of UV systems were reviewed for applicability to the Benicia water reuse project. Low Pressure, High Intensity (LPHI) was selected owing to energy efficiency and applicability to the size of this project. Chlorination and LPHI UV were evaluated from economic and

reliability perspectives. Other qualitative factors, in particular water quality impacts, site impacts (owing to limited available space and allowances for future plant modifications) and ease of process control, favor UV over chlorination. Hence, UV was selected as the process alternative for disinfection.

Table 3-5 presents a summary of the process design criteria for the UV disinfection system for the project. Figure 3-5 shows a typical low pressure, high intensity UV module.

Figure 3-5
Typical In-Channel UV Disinfection System
(*Courtesy of Trojan Technologies)*

Table 3-5
Summary of UV Disinfection System Process Design Criteria

Item Description	***Criteria***
Title 22 Requirements for Cooling Tower Makeup Water	5 log poliovirus inactivation and 7-day median total coliform of 2.2 MPN/100 mL
Design UV Dose for MF Filtrate	80 mJ/cm^2
UV influent MF Filtrate Turbidity	0.2 ntu 95% of time, NTE 0.5 ntu
UV Transmittance	65% or greater at 254 nm
Reliability Requirements	Meet Design Dose with 1 Reactor Bank out of Service
Number of Trains (Channels)	One
Total Number of Banks, duty/standby	2/1
No. of Design Dose Lamps	80

Table 4-3 Pilot Testing Trace Metal Results and NPDES Permit Limits				
Pollutant	***Secondary Effluent (RO Feed)***	***RO Concentrate***	***Blended Effluent***	***NPDES Limit***
	ug/l	**ug/l**	**ug/l**	**ug/l**
Cadmium	0.015	0.10	**0.05**	5.7
Copper	2.8	17.7	**9.2**	32
Lead	0.20	1.0	**0.54**	17.3
Mercury	0.0051	0.021	**0.012**	0.087
Nickel	2.2	16.6	**8.3**	30.2
Selenium	0.36	1.6	**0.88**	31.0

4.4.1 Acute Toxicity

Acute toxicity describes the adverse effect that a substance has on a living organism, and which results either from a single exposure or from multiple exposures in a short space of time (usually less than 24 hours). Three sets of acute toxicity tests were performed using blends of the RO concentrate and effluent; one during the first round of pilot-scale testing and two during the third round. The acute toxicity tests consisted of parallel sets of static renewal tests, using the City's normal NPDES permit compliance test species: the freshwater Fathead Minnow, an estuarine fish species *Menidia beryllina* (Inland Silversides Minnow), and rainbow trout. The majority of tests showed 100% survival (i.e. no measurable toxicity). Survival results in the 43% RO concentrate blend were nearly identical to those in the 100% effluent for all three species tested. Based on these results, the blended discharge should meet all acute toxicity requirements.

4.4.2 Chronic Toxicity

Chronic toxicity describes the adverse effect that a substance has on a living organism, and which results when that organism is exposed to the substance continuously or repeatedly. ~~Two series of chronic toxicity tests were performed using blends of the RO concentrate and effluent.~~

The Benicia NPDES permit does not have enforceable effluent limits for chronic toxicity but instead has two "trigger values." Accelerated monitoring is required after exceeding either a three sample median trigger value of 10 chronic toxicity units (TUc) or a single sample maximum trigger of 20 TUc or greater. Further toxicity reduction evaluation (TRE) studies are required if the triggers continue to be exceeded during the accelerated monitoring.

Two series of chronic toxicity tests were performed using blends of the RO concentrate and effluent. The first round of pilot testing used the Benicia NPDES permit compliance test species, *Mytilus*. Three additional species (*Opossum Shrimp*, *Inland Silversides Minnow*, and *Giant Kelp*) were added in the third round of testing to

confirm the results and to determine whether other species might be more sensitive to the RO concentrate/effluent blend than *Mytilus*.

The majority of tests showed < 1 TUc results (i.e. no measurable chronic toxicity). Results in the 43% RO concentrate blend were nearly identical to those in the 100% effluent for all four species tested. Based on these results, the blended discharge should meet all chronic toxicity requirements.

4.5 Conclusions

Conventional pollutants such as BOD and TSS in the effluent discharged to the Carquinez Strait should remain at current levels and may even show improvement as the Nitrifying Trickling Filter and Micro Filtration components associated with the project could provide an overall reduction of conventional pollutants when the final RO concentrate is blended with the secondary effluent.

Based on the results of the toxicity tests performed and the analytical results of the minerals, metals and other priority pollutants analyzed, the projected maximum blend of 43% RO concentrate with 57% secondary effluent should not result in any exceedances of the City's current or likely future NPDES permit requirements.

Blended effluent trace metals concentrations will increase due to the addition of the RO concentrate; however, the total mass of metals (and organics) discharged to the Bay will remain the same. Blended effluent concentrations will typically be lower for most months of the year than shown by the mass balance calculations, given that effluent flows will be higher (i.e. more blending volume) than the conservative value used in the calculations.

It should be noted that the RO concentrate will be continuously discharged at a rate of approximately 0.3 mgd (for a project design output flow of 2.0 mgd with a WWTP average dry weather influent flow of 2.7 mgd). During all 24-hour periods the instantaneous blend ratio of concentrate to total flow will exhibit considerable variation due to the normal diurnal variation in WWTP flows. (Please refer to Figure 2.1 in Section 2, which shows the variation in total plant influent flow rate throughout the day.) The 24-hour composite samples collected for NPDES permit compliance analyses for conventional pollutants and metals will contain less than the conservatively projected 43% RO concentrate whenever WWTP average daily flows exceed 2.7 mgd.

Continuous, flow-through bioassays are currently required for acute toxicity monitoring. Given the diurnal variability in effluent/RO concentrate blends, it is recommended the City request a minor NPDES permit self-monitoring program modification, prior to RO project implementation, to allow it to use the 24-hour static renewal acute toxicity testing method in place of the flow-through method when operating in RO recycled water production mode.

Results of the pilot studies were presented to the Regional Water Quality Control Board – San Francisco Bay Region (RWQCB) staff. It is anticipated that only minor

Section 5
Project Interface with Existing Facilities

5.1 Description of City's Existing WWTP

To understand how the Water Reuse Project will interface with the City's existing WWTP, it is necessary to understand the existing facilities. The plant has two separate biological treatment systems. The conventional activated sludge system, which was added in the late 1990's, has a capacity of 4 mgd, but can handle up to 8 mgd peak flows during wet weather periods. It also has a rotating biological contactor (RBCs) system that was constructed in the 1970's. The RBC system is used during wet weather, when peak flows exceed 12 mgd. Flows above 12 mgd are stored in the multi-purpose basins for equalization up to 18 mgd. Waste activated sludge is thickened by dissolved air floatation and anaerobically digested. Digested sludge is dewatered on a belt filter press and the cake is hauled to a landfill. The filtrate is routed back to the headworks of the plant. Figure 5-1 presents a process block diagram of the liquid stream of the plant. Figure 5-2 shows the existing site plan of the City's WWTP with the major components of the Water Reuse Project superimposed on it.

5.2 Overview of Interface Requirements

Operation of the Water Reuse Plant is closely linked to the City's existing wastewater treatment plant. Chlorinated secondary effluent will be taken for the supply to the Water Reuse Plant, secondary effluent will be stored for equalization in three of the existing multipurpose basins, return flows (such as MF backwash water) will be returned to the plant headworks, RO reject (also called brine or concentrate) will be returned to the City's outfall, electrical supply will come through the plant's main electrical switchgear, as well as other points of interface. Hence, it is appropriate to describe these interface points and requirements and how they are proposed to jointly function.

5.3 Diversion of Chlorinated Secondary Effluent

Pumping will be required to transfer chlorinated secondary effluent to the multipurpose basins and take full advantage of the storage volume in the basins. The pumps utilized will need to operate at varying flows, responding to the average dry weather diurnal flow pattern and ensuring that sufficient flow is transferred to the recycled water treatment system on a daily basis. Figure 2-1 illustrates the diurnal flow pattern for the plant, and average daily flow rate that is required for the Water Reuse Treatment system (2.55 mgd).

Several options were investigated for pumping of chlorinated secondary effluent, including use of existing facilities and construction of a new transfer pump station. These options are discussed briefly below.

5.3.1 Utilize the Existing Effluent Pumps

The existing effluent pump station contains 4 variable speed pumps, two low range and two high range pumps. Pumps are utilized during high tide conditions to pump to the outfall, with secondary effluent flowing by gravity under low tide conditions. After review of the existing low range pumps, it was determined that the pump capacity is too large to be utilized effectively to transfer secondary effluent to the multipurpose basins, even when operating at reduced speeds. Utilizing the pumps would also add control complexity, as it would be required to split flows with modulating valves when it is required to pump simultaneously to both the outfall and the recycled water treatment system.

5.3.2 Adding New Pumps to Existing Effluent Pump Station

Review of design drawings reveals there is insufficient space in the effluent pump station wet well to add new pumps without potentially adversely impacting intake hydraulics to the existing pumps. Expansion of the wet well is also not considered feasible due to the proximity of existing facilities including the outfall pipeline, control valve and structure to the south; sodium bisulfite storage facilities to the south; the chlorine contact basin to the east; and existing duct banks and pull box to the west.

5.3.3 Adding New Pump Station Adjacent to Effluent Pump Station

Another possible location for siting a new pump station is west of the existing effluent pump station. A pump station at this location would require a new suction pipeline routed from the either the effluent pump station wet well, the sodium bisulfite mixing chamber, or further upstream in the chlorinated secondary effluent channel. Installation of the pipeline in the effluent pump station wet well is challenging as a location will need to be selected that would not adversely impact intake hydraulics to the existing pump bays. Installation and routing of the pipeline to the west from the wet well, sodium bisulfite mixing chamber or further upstream in the chlorinated secondary effluent channel is also challenging due to the proximity of existing facilities including the outfall pipeline, control valve and structure to the south; sodium bisulfite storage facilities to the south; chlorine contact basin to the east; existing duct bank and pull box to the west; and the existing primary effluent channel to the west. Also the volume of the effluent pump station wet well and sodium bisulfite mixing chamber is relatively small and a minimum volume will need to be maintained during low flow conditions to provide flows to the 3 water pumps (which draw suction from the effluent pump station wet well). This will require careful and precise control of both wet well level and rate of flow to the new pumps. Metering of flow upstream is recommended for control purposes, and it is considered difficult to install a flow meter in the existing chlorinated secondary effluent channel. Because of these reasons, it is not recommended that the pump station be installed in this location.

5.3.4 Adding New Pump Station East of Chlorine Contact Basin

There is space available to site a new pump station east of the chlorine contact basins. Suction pipelines for the pump station will be installed from the chlorine contact basins to a new wet well. This location is considered preferable to the other locations described above. Also, a large wet well volume is available for the pumps. A magnetic flow meter for control of the rate of flow of the pumps will be installed in the existing secondary effluent pipeline that feeds the existing chlorine mixing chamber. This new flow meter will be used to ensure that the secondary effluent transfer pumps are operated at the minimum flow rate that maintains sufficient flow to the No. 3 Water System under low average dry weather flow conditions. (The No. 3 water pumps draw suction from the effluent pump station wet well further downstream). This new pump station is called Secondary Effluent Transfer Pump Station (SETPS) No. 1, and its location is shown on Figure C-1 in Appendix A. The pump station will have 3 pumps (2 duty and 1 standby) to meet variable flow conditions. More details on the design of this pump station are presented in Section 6.

5.4 Utilization of Multi-Purpose Basins 3, 4 & 5 for Equalization of Secondary Effluent Flow

During dry weather periods, variable plant flow will be equalized in multi-purpose basins 3, 4 & 5. Secondary effluent will be pumped into the basins from SETPS No. 1. Basin volume will vary throughout the day as the basins are filling and also continuously drawing as feed water to the nitrifying trickling filters. In order to provide the required volume of approximately 400,000 gallons, the full depth of the basins must be available. Since the invert of the MPBs is at Elevation 92, a second pump station, SETPS No. 2, will be constructed to deliver water to the wetwell of the NTFs recycle pump station.

During wet weather periods when minimum flow is at or above 2 mgd, the diverted secondary effluent will by-pass the MPBs and will be conveyed directly to the NTFs recycle pump station. This will free all the MPBs to store wet weather flows that cannot be directly accommodated by the process systems of the plant.

5.4.1 Conveyance of Secondary Effluent from MPBs to NTFs

City staff expressed concerns regarding the additional operation and maintenance and energy requirements for SETPS No. 2. It was requested that CDM evaluate lowering the NTF Recycle Pump Station and flow by gravity from the MPBs to the NTF RPS wet well.

Construction costs as well as O&M costs were estimated for the two alternatives. The results of the analysis are presented below.

Alternative No. 1 – Use SETPS No. 2 to Convey Secondary Effluent at a constant rate to the NTFs Pump Station Wet Well.

- Advantages: Reliable flow control; makes full use of depth of MPBs.

- Disadvantages: Higher O&M cost, primarily from maintenance, and equipment replacement & repair.

Alternative No. 2 – Eliminate SETPS No. 2 and flow by Gravity to NTF Recycle Pump Station Wet Well. Lower the operating levels of the NTF RWPS Wet Well five (5) feet to accommodate gravity flow from the MPBs. Install a flow meter and flow control valve in a vault to control flow to constant rate. Lower the pipeline from the NTF Recycle Pump Station to the MF influent pump station and increase MF PS pumping head by 5 feet.

- Advantages: Less mechanical equipment to maintain, resulting in lower O&M costs.

- Disadvantages: Deeper piping; higher power consumption; not able to use full basin depth (storage).

Table 5-1 presents a summary of the cost analysis, which shows that the construction cost of Alternative No. 1 is estimated to be less expensive than Alternative No. 2. However, the total O&M costs for Alternative No. 1 are estimated to be more expensive that Alternative No. 2. Estimated annual power cost for Alternative No. 2 is approximately 40% more than Alternative No. 1, due to additional pumping at both the NTF Recycle PS and the MF Feed Water Pump Station. CDM recommends Alternative No. 1 be the method of conveyance, owing to better reliability and control. However, it is also recommended that the secondary transfer method should be re-evaluated in final design after the reliable project design capacity is determined and the amount of equalization storage is determined.

Table 5-1
Summary of Economic Analysis - Flow Transfer Alternatives from MPBs to NTFs

	Alt No. 1: SETPS#2	***Alt No. 2: Gravity Flow***
Estimated Construction Cost	$233,000	$253,000
Estimated Annual Operation & Maintenance Cost	$12,000	$1,000
Estimated Annual Power Cost	$3,300	$4,700

5.5 Equalization of Ammonia Return Flow from Existing Sludge Processing System

Sludge removed from the primary and secondary treatment processes is anaerobically digested and dewatered on a belt filter press (BFP). The City operates the BFP approximately 5 to 6 hours per day, 6 days per week. During this operational period the BFP filtrate is returned to the headworks of the plant for reprocessing. As a result of the anaerobic digestion process, this filtrate is very high in ammonia and causes large fluctuations in the ammonia load within the secondary processes, which makes for challenges in operating the secondary effluent chlorination system.

Large fluctuations in ammonia load will also pose operational problems for the NTFs, which will provide more consistent process performance if the ammonia loading is relatively consistent.

The filtrate flow rate is approximately 170 gallons per minute (gpm), which is estimated to be comprised of about 120 gpm of actual filtrate and about 50 gpm of washwater, which cleans the belt during processing.

The combined filtrate/washwater discharges into a sump in the Solids Treatment Building where it is combined with grit washer flow. Downstream these two flow streams are combined with surface drainage; from there they all flow to the headworks.

Plant staff report that the filtrate discharge pipe in the sump protrudes into the sump, so that a connection could be made to intercept the flow.

Nearby the sludge dewatering system is a sludge gravity thickener, which is no longer in use. It is covered and has an approximate capacity of 80,000 gallons. The amount of storage required to equalize the filtrate over a typical week is estimated to be approximately 50,000 gallons. Hence, this gravity thickener has sufficient capacity to store the filtrate for equalization. Filtrate flow would be metered back to the headworks at a constant flow rate ranging between 30 to 40 gpm. The filtrate would be pumped into the thickener and possibly could be gravity fed out of it. The details of making these modifications would be developed during final design.

5.6 Micro-Filtration Backwash Flow Reprocessing

City Operations staff expressed concern regarding CDM's recommended point of recycle of the MF backwash (MF BW or reject), that is to the Industrial Influent Sewer (IIS) and eventually to the headworks. The estimated flow rate of the MF BW is approximately 200,000 gpd, or about 140 gpm. CDM's understanding is that City's concerns relate to potential process impacts to the secondary treatment process and hydraulic impacts to the IIS.

Regarding hydraulic concerns, City provided an excerpt from a sewer study by Brown and Caldwell ("Benicia Business Park Sewer Collection System Analysis," prepared for City of Benicia, 16 Oct 06), which projects a build-out, peak wet-weather flow in the industrial influent sewer of approximately 7 mgd. B&C based its projections on certain flow factors that are documented in said report. Build out is projected over a 20 year period. Current Peak Wet Weather Flows (PWWF) were calculated at approximately 5 mgd. (Ref, Tables 8 & 9 from B&C report.)

CDM performed preliminary hydraulic calculations for the industrial influent sewer (IIS) within the plant boundary to determine flow capacity at maximum depth, while still maintaining open channel flow characteristics. Calculations indicate that the IIS has a maximum open-channel flow capacity of about 6.8 mgd. Flows above 6.8 mgd will cause the pipe to flow full with the resultant potential surcharging in the manholes.

Discharging the MF backwash flow (approximately 200,000 to 250,000 gpd) into the IIS during PWWF would cause the IIS to flow full and cause minor surcharging in the manholes. That is, there would be minor rises (approximately 3 to 6 inches) in the hydraulic grade line for these flow conditions. Given that this is a condition (i.e., PWWF) that would occur infrequently, it is believed that this surcharging condition should not cause hydraulic problems within the plant, and there would be no overflows from the in-plant manholes. It is unknown what effect, if any, this additional MF BW flow would have on backwater conditions in the upstream collection system. These hydraulic conditions will be fully evaluated during final design to ensure that there would not be any overflows.

Concerning process impacts, other plants (Orange County Water District's GWR Project and Dublin San Ramon Services District's [DSRSD] DERWA Project) discharge their MF backwash to their plant headworks. Memcor (formerly by U.S. Filter and now a Siemens Company) recommends MF BW be returned to the headworks for recycled water projects. Concerning the quality of the MF backwash, CDM contacted DSRSD regarding the quality of its MF BW. The BOD and suspended solids of the backwash were found to average about 30 and 50 mg/L, respectively for the two months (Nov/Dec 2007) when the MF system was in operation. It should be noted that for the larger DERWA sand filtration backwash plant, the filter backwash is also returned to the main plant headworks.

However, there are other approaches that could be taken in handling the MF backwash return flows. For example, the Carmel Area Wastewater District returns its MF backwash to a lamella plate settler. The clarified water is then returned to flow equalization for return to the MF process. (This system is under construction and not yet operating.)

A separate MF system could be included in the Water Reuse Project facilities to further concentrate the MF backwash. Under this process scheme, the MF filtrate (from the MF BW concentrator) would be returned to the MPBs, rather than the head works. The solids (a flow of approximately 40,000 gpd (approximately 30 gpm) could be pumped to the DAF for further thickening. This would save reprocessing of about 200,000 gpd through the secondary treatment system. The cost-effectiveness of this option would need to be determined during final design.

Operations staff suggested that the MF backwash could be sent directly to the DAF for concentrating of the solids. The MF BW flow rate (140-175 gpm) would be large in comparison to the WAS flow rate (40-50 gpm) and much more dilute (50 mg/L SS) compared with the WAS concentration (~5,000 mg/L SS). Hence, this excess, dilute flow may impair the performance of the DAF to adequately thicken the combined WAS and MF BW. Also, a separate pump system with 175 gpm capacity would be required to convey the MF BW to the DAF.

This issue of where to return the MF backwash will be more fully evaluated during final design to ensure that reprocessing the MF backwash does not disrupt or impair the operation of the City's wastewater treatment plant.

5.7 Storm Drainage

The area in which the Water Reuse Treatment Plant will be constructed currently has a pervious surface; therefore, the project will result in additional stormwater runoff. Rainfall collected from the MF/RO Building and other impervious services will be conveyed to the existing Storm Water Pump Station, discussed above and shown in Figure 5-3 and Figure C-1 in Appendix A.

Figure 5-3
Existing Stormwater Pump Station

5.8 Electrical Power Supply

Electrical power supply for the new Water Reuse facilities will be provided through the existing plant switchgear. Electrical power will be served from a new 2000 Amp frame power circuit breaker installed within the Plant's existing main switchboard, located in the Blower Building. New underground 480 volts alternating current (VAC) electrical feeders cable and conduit will exit the Blower Building and be routed easterly along the existing roadway to the new Water Reuse facilities. During final design the locations of existing underground piping and conduits along the proposed general alignment will be investigated to determine the exact conduit alignment.

5.9 Rerouting of Existing Buried Facilities

There are a few buried utilities that will have to be relocated in order to accommodate the Water Reuse Project. These utilities and the proposed relocations are described in the paragraphs below.

5.9.1 Ductbank, Cable and Wiring to Wet Weather Control Structure

There is a ductbank that traverses the area just east of the MPBs that will interfere with construction of the NTFs. This ductbank will be rerouted as shown on Figures C-1 & C-2 in Appendix A. A new pull box will be required as part of the relocation. The work should be done outside of wet weather periods.

5.9.2 Sewer Serving the Administrative Building

Similar to the electrical ductbank described above there is a 6-inch sewer line that runs north to south across about 40 feet east of the MPBs and that will interfere with construction of the NTFs. This sewer line will be rerouted as shown on Figure C-1.

5.9.3 Foul Air Duct Serving the Industrial Flow Monitoring Structure

A 12-inch FRP pipe (duct) traverses east to west on a slight northerly diagonal about 30 feet north of the access road. The duct will conflict with the UV channel. Hence, the western portion of this line will be rerouted closer to the existing 24-inch industrial sewer line as shown on Figure C-1.

5.9.4 Industrial Sewer Line

As shown on Figure C-1 in Appendix A, a 24-inch diameter sewer line traverses the project site area about 25 feet north of the access road. The project will not impact the alignment of this line, but recycle flows are proposed to be tied into this line as described above. Hence, one or two additional manholes may be constructed on this line to make the necessary connections. Flows in this line return by gravity to the plant headworks.

5.10 Disposal of RO Concentrate through the Existing Outfall

As discussed in Section 4, the RO concentrate will be discharged through the existing outfall. A 6-inch diameter pipe will be connected to the existing 30-inch diameter outfall at a location to be determined during final design. The most probable location will be south of the plant road. The connection will include a check valve and plug valve to prevent backflow of seawater and secondary effluent and to isolate the concentrate line, if necessary. Because the RO concentrate will have residual pressure of approximately 20 psi, pumping of it will not be required.

Since the nitrification process consumes about 7 mg of alkalinity per mg of ammonia converted to nitrate, sodium hydroxide will be fed at the inlet to the NTF's to maintain alkalinity at the proper level. Sodium hydroxide will be stored in a fiberglass tank, mounted on a concrete pad outside. Full secondary containment will be provided as discussed in Section 8.

ESA evaluated whether the NTFs would be a potential source of odor (*Benicia Water Reuse Project, Initial Study/Mitigated Negative Declaration, 2008*). ESA concluded that the NTFs would not be a significant source of odor:

> "In order to assess the potential for the proposed NTF units to result in odor impacts, an assessment of odor complaints and impacts associated with a facility that uses similar technology was conducted. The facility that uses similar filtration technology is the recycling facility at the City of Sunnyvale's water recycling plant. The BAAQMD has not received an odor complaint associated with the Sunnyvale plant in recent years (BAAQMD, 2006c); however, there are no residences in the immediate vicinity of the plant. In order to characterize the odor impact potential of the proposed filter system, the City of Sunnyvale was contacted regarding its filtration system. According to Sunnyvale's Senior Water Pollution Control Plant Operator, the Sunnyvale filtration devices do not release odors detectable at the plant and only a slight odor can be detected at the top of the open air filtration devices (Anima, 2006).
>
> Therefore, the filter system associated with the proposed project would not be expected to result in odors affecting a substantial number of people. Impacts related to odors would be less than significant."

Table 6-2 contains a summary of the design criteria for the NTFs including the mechanical equipment required for the process. Figure PD-2 in Appendix A contains a process block diagram for the NTF system.

Table 6-2
Nitrifying Trickling Filters Design Criteria and Mechanical Equipment

Biological Nitrification System	
Design Flow, mgd	2.55
Process Units	
Nitrifying Trickling Filters, number	2
Size, diameter x media depth, ft/ft	42/12
Media Type	Cross Flow
Media Specific Surface Area, sf/cf	45
Rotary Distributors	
Pneumatic Driven, variable speed	
Flow Range, gpm	900 to 1,800

Chemical feed pressurized piping will be corrosion-resistant, double containment type. Outdoor, exposed piping for caustic and hypochlorite will be heat traced to prevent "freezing" (crystallization). Heating tracing is provided for existing piping for these chemicals at the City's WWTP.

Flexible hoses as the chemical carrier pipes is an option to consider during final design. This approach, used at a few treatment plants, consists of installing flexible hose as the carrier pipe inside a rigid pipe that provides double containment. The flexible hose is pulled in/out of the containment pipes in a similar fashion to electrical wires inside conduits. Bends in this type of double contained piping system need to have a long radius so that the flexible hoses can be pulled. This type of piping system is generally simpler to install and maintain as there are no joints in the hose within a piping run. The ends of the flexible hose can be provided with compression-by-threaded fittings for connecting to the rest of the feed system.

6.8 Process Implications of Power Supply Interruption, Resultant Operating Procedures and Need for Standby Power

This issue was evaluated at the request of City staff. Should there be a power interruption resulting from PG&E failure and/or other causes, certain portions of the Water Reuse Facilities (WRF) could be negatively affected depending on the length of the outage. As noted in Paragraph 11.2.3, although infrequent, some outages have lasted several hours.

Initially, secondary effluent supply to the WRF will cease. The first system to be impacted would be the NTFs. If the NTFs are not functioning for several hours, the biological growth on the media will dry out and die, making for a long restart and recovery period for this unit process. Therefore, the media should be kept wet by recycling the water over the media at minimum flow. This will require that the NTF Recycle Pumps need to be operational during an outage lasting more than about 30 minutes. The ventilation fans would not need to be operational.

The next process potentially impacted by power outage would be the MF System. Upon power failure, MF systems are typically designed to go into backwash. Hence, the MF backwash pumps would need to be operational for one backwash sequence.

If feed water to the RO system sits static in the membranes too long, precipitates could form on the membranes, which, if severe enough, would require that they be replaced. To avoid this condition and cost, RO membranes are typically flushed upon power failure. Since antiscalants will be used in the feed water, such precipitation is not likely for durations of a couple of hours. However, to be safe, the RO membranes should be flushed. Supply water will be from the MF/RO Blend Tank.

Section 7
Recycled Water Conveyance System

7.1 Introduction

The conveyance system that will deliver recycled water from the Benicia WWTP site to the Valero Refinery will consist of a pump station at the WWTP, a pipeline approximately 14,000 feet in length and a "break tank" storage facility at the Refinery. Beginning at the WWTP the pipeline will travel from a new, high-lift recycled water supply pump station (RWSPS) to the Valero "off site" dock line right-of-way in the vicinity of East 7th Street and "H" Street. The pipeline will follow the abandoned Valero dock lines northerly for about 9,000 feet to the refinery property line. Within the refinery the pipeline will follow Avenue "E" South, then up a vertical rise (known as a "waterfall") to Avenue "F" to the cooling towers.

The existing Valero dock lines are attached to above-grade structural steel frames, known as "sleepers." An evaluation compared the cost of rehabilitating existing dock lines versus constructing new piping and it was determined that it was more cost-effective and reliable to install a new, 14-inch pipeline, rather than rehab portions of the existing dock lines. Within the refinery, new pipeline will be constructed on vertical extensions to the existing pipeline "sleepers" that parallel Avenues "E" and "F." The break tank would be located near the cooling towers. The capacity of the break tank is 500,000 gallons, which is equal to 6 hours of recycled water flow.

7.1.1 Overview of Conveyance Pipeline Profile

Valero provided CDM with copies of plan and profile drawings of the "off-site" dock lines as well as information about the pipe material, pressure class and wall thickness. Valero also provided information on the elevation of the existing pipeline sleepers within the refinery. Using this information, CDM developed a preliminary plan and profile of the pipeline from the City's WWTP to the cooling towers. The profile begins at the City's WWTP near elevation zero and reaches a high point approximately one mile northerly along the alignment at approximate elevation 201. The pump station at the WWTP will be located at approximate elevation zero. Hence the static lift will be about 200 ft. The terminal point of the pipeline will be at the break tank near the cooling water recirculation channel, which is located adjacent to the refinery cooling towers at elevation 95.

7.2 Recycled Water Supply Pump Station

The RWSPS will consist of three (2 duty/1 standby), vertical turbine pumps mounted over a clearwell. The clearwell will be constructed of reinforced concrete and the pumps will not be housed in a building but will have individual sound enclosures over each pump and motor. Table 7-1 presents the major components and design criteria for the pump station.

Table 7-1 ***Recycled Water Supply Pump Station*** ***Preliminary Design Criteria***		
Component	***Units***	***Criteria***
System Pumping Requirements		
Design Capacity	mgd	2.0
Design Capacity	gpm	1,400
Design Total Dynamic Head	ft	250
Static Head	ft	200
Pump Units		
Type		Vertical Turbine
Number, Total/Duty/Standby		3/2/1
Design Capacity per Pump		700
Design TDH per Pump	ft	255
Min. Efficiency at Design Point	%	82
Stages per Pump	No.	4
Pump Operation		Variable
Minimum Speed	rpm	TBD
Pump Motors		
Type		TEFC, w/ sound control enclosures
Size, each unit	hp	60
Drive Type		VFD
Synchronous Speed	rpm	1,800
Power Supply		480-V/3-phase/60Hz
Pump Discharge Piping		
Diameter	inch	8
Velocity at Design Flow	fps	4.43
Pumps Discharge Header Piping		
Diameter	inch	14
Velocity at Design Flow	fps	2.90
Discharge Flow Metering		
Type		Magnetic or Sonic
Size	inch	10
Velocity at Design Flow Rate	fps	5.67
Surge Tank for Hydraulic Transients		
Preliminary Tank Size	gallons	2,000

Based on a conceptual level review of the hydraulic profile, it is anticipated that a surge tank will be required on the discharge side of the pump station to control transient surge pressures in the transmission pipeline under power failure. The size of the tank will be confirmed during final design. This preliminary design assumes a nominal surge tank size volume of 2,000 gallons.

7.2.1 Instrumentation, Control, Monitoring and Sampling

7.2.1.1 Pump System Control

The RWSPS pumps will be automatically controlled by a programmable logic controller (PLC), based on water level in the clearwell. In that way, RWSPS will match the production rates of the water reuse treatment plant, which will be controlled to match daily demand. The pumps can also be controlled to pump at a selected flow

rate by setting a specific rate through a PLC. Manual pump start and stop and speed control will also be provided at the PLC.

Control interlocks with other systems will be as follows:

- All of the RWSPS pumps will be automatically stopped on high level in the break tank at Valero to avoid overfilling the tank.
- All of the RWSPS pumps will be automatically stopped on high micro-filtration effluent turbidity conditions.
- All of the RWSPS pumps will be automatically stopped on detection of critical alarm conditions at any of the upstream treatment processes.
- Under any of the hydraulic or process performance alarm conditions that would shut down the pumps, the recycled water would be routed to the City's outfall, or to the MPBs depending on water quality matters, until the alarm conditions have been addressed and cleared.

7.2.1.2 Monitoring

The following monitoring provisions will be incorporated into the pump station design:

- Water level in the clearwell will be continuously monitored using an ultrasonic level sensor, with separate float switches for high and low level alarms in the event of failure of the level sensor. The water level signal will be used for pump control as described above.
- A magnetic flow meter will be provided on the pump discharge header to measure pump flow rate. The flow signal will be used for regulatory and recycled water inventory recordkeeping, for RWSPS monitoring and for pump control as described above.
- A pressure transducer will be provided on the recycled water discharge header to continuously measure header pressure for the purposes of monitoring pump operation and head conditions in the transmission system.
- A locally indicating pressure gauge will be provided on the discharge header and on each pump discharge.

7.2.1.3 Sampling

A refrigerated automatic composite sampler may be required for regulatory sampling. The RWQCB may require the City to sample and report the quality of recycled water leaving the City's property. The sampler would draw from the recycled water discharge header and would be flow paced from the RWSPS flow meter. An on-line

ammonia analyzer will be provided to warn of ammonia concentrations exceeding the water quality requirements.

7.3 Recycled Water Supply Pipeline

Figure 7-1 presents a map of the recycled water transmission pipeline and Figure 7-2 show the preliminary hydraulic profile. Table 7-2 presents the details of the pipeline for each segment from the City's WWTP to the Valero Refinery. The pipe would be constructed of cement mortar lined steel pipe. Where the pipe is buried, it will be cement mortar coated and taped. The coating system for pipe installed on sleepers is to be determined. Joints will be welded.

Table 7-2
14-Inch Recycled Water Supply Pipeline from Benicia WWTP To Valero Cooling Towers

System Component	From Sta	To Sta	Estimated Quantities, ft
Segment No. 1: Sta 0+0 @ Benicia WWTP to Sta 14+24 @ connection to sleepers. Construct new buried pipeline	0	14+24	1775
Segment No. 2: Sta 7+92 @ start of sleepers to Sta 24+60 @ start of existing, buried 12-in lines. Construct new pipe on existing sleepers. Construct small stretch of buried pipeline near STA 11+00	11+45	24+60	1315
Remove Dock Line No. 3 from sleepers in Segment No. 2			1315
Segment No. 3: Sta 24+60 to Sta 30+00 end of existing, buried 12-in lines. Rehabilitate and connect to 2, existing 12-in lines	24+60	30+00	540
Segment No. 4: Sta 30+00 to Sta 32+20 at the "Y" plus additional 30 ft. Construct new, 14-in pipe on existing sleepers	30+00	32+20	220
Remove Dock Line No. 3 from sleepers in Segment No. 4			220
Segment No. 5: Sta 34+68 at the "Y" to Sta 42+15, end of where existing 12-in DL has been removed. Construct new, 14-in pipe on existing sleepers	34+68	42+15	747
Segment No. 6: Sta 42+15 to Sta 85+20, end of existing, abandoned 12-in DL. Construct new, 14-in pipe on existing sleepers. Bore and jack pipeline under Park road near STA 67+50.	42+15	85+20	4305
Remove abandoned pipe from sleepers in Segment No. 6			4305
Segment No. 7: Sta 85+20 to Sta 105+00, approximate Valero PL. Construct new, 14-in pipe on existing sleepers. Bore and jack pipeline under access roadway near STA 91+60.	85+20	105+00	1980
Segment No. 8: Sta 105+00 to Sta 140+00, approximate location of cooling towers. Construction new, 14-in pipe on extensions to existing sleepers.	105+00	140+00	3500
6-inch Air Inlet and Vacuum Release Valves Located at High Points			6
2-inch Air Inlet and Vacuum Release Valves			4
6-inch Blow Down Valves (BV's) Located at Low Points			7
In-Line Isolation Valves (BV's) Located at 2,000 ft intervals			7

Line isolation valves will be installed about every 2,000 feet to isolate sections for maintenance and/or repairs. Blow down valves will be located at low points to either drain the line or to "blow down" residual solids, which are unlikely to occur given the

high level of treatment. Air inlet and vacuum relief valves will be installed at critical high points to control the potential effects of high pressure and hydraulic transients.

Appendix A contains plan and profile drawings of the pipeline**.** Figures 7-3 and 7-4 provide example photos of Valero off-site dock lines and on-site pipelines, along with photos of the cooling towers.

7.4 Impacts of Recycled Water Supply Interruptions at Valero Refinery

There are four basic assumptions regarding the recycled water supply to Valero, as follows:

- City and Valero have agreed that recycled water will be an interruptible supply (refer to Paragraph 2.4)
- City has agreed to make available fresh water during interruptions.
- City has agreed to produce recycled water that meets the established water quality objectives (refer to Paragraph 2.1), which are similar to the quality of the fresh water currently being used.
- There will be break tank provided at the refinery that will have adequate capacity to allow switch over from recycled water to fresh water in the event of an interruption, resulting from power failure or out of spec water quality.

The time to make the switch over to fresh water may require treating the fresh water (at the refinery's on-site water treatment system) to meet water quality objectives. The time for this transition needs to be factored into the final sizing of the break tank.

In addition to automatic alarms sent to Valero (method and location to be determined), City should notify appropriate party(ies) at Valero via phone (or email) and provide an estimation of the duration of the outage. The projected duration could affect the steps that Valero chooses to implement. For instance, Valero might take a different course of action for a brief (10-15 minutes) power outage as compared to a severe process upset, which is likely to have an extended duration.

Section 8
Civil Design Criteria

8.1 Project Datum

In 1978, the WWTP datum was arbitrarily set at approximately 100 feet above the NGVD 29 (Mean Sea Level 1929) datum. The WWTP Bench Mark FC#3 is located on the concrete deck of the existing primary clarifiers. Recent survey by Cullen-Sherry & Associates (CSA, previously Cullen Engineering Associates [CES]) places FC#3 at 10.93 ft (NGVD29) and 110.26 ft (Plant Datum 1995). For the 1999 WWTP Improvements Project, Carollo directed CEA in 1995 to lower the datum by 0.70 feet "…to better match the 1978 datum." A detailed discussion of the history of adjustments to the plant datum can be found in the letter report prepared for the City of Benicia by CSA, dated 20 September 2006, and included in Appendix C.

Also in September 2006, CSA did topographic mapping of the area within the WWTP site dedicated to the Water Reuse Project. Referenced datum on the survey shows NVGD29 datum. Spot elevations taken by CSA on existing structures and shown on the Sept '06 topographic drawing were compared with elevations shown on Carollo's 1999 plans and 2003 Wet Weather Improvement Plans. In both cases the recent spot elevations based on the NGVD 29 datum were low by approximately 99.3 feet. In other words, the elevations were low by 99.3 feet (which was added back in 1978) and high by 0.7 feet (which was the lowering done in 1995).

For development of the preliminary design, CDM has used WWTP Datum and the elevations shown on the Carollo plans for work within the plant. The conveyance pipeline plan and profile drawings were based on GS Mean Sea Level for consistency with the existing plan and profile drawings of the Valero "off-site" dock lines which are based on this datum.

8.2 Existing Surface and Subsurface Conditions

A geotechnical investigation of the City's WWTP site was conducted by Harza Consulting Engineers and Scientists (Harza). The results of Harza's investigation were reported in its report, "Geotechnical Engineering and Environmental Services Benicia Wastewater Treatment Plant Benicia, California Project No. L592-G," dated 15 July 1997 and prepared for Carollo Engineers (Harza Geotech Report). The Harza Geotech Report contains site information obtained from several borings, and it makes recommended criteria for earth loads and foundation design. No exploratory borings were taken in the immediate vicinity of the proposed Water Reuse Project structures. However, two borings were taken by Harza at the eastern boundary of the site, just inside the flood wall. Harza reports three relevant borings taken by others in approximately 1977 along the eastern walls of the existing secondary clarifiers and multi-purpose basins.

The information contained in the Harza Geotech Report is determined adequate for preliminary design of the Water Reuse Project. For final design, 3 or 4 confirmatory borings may be required.

The elevation of the existing site allocated for the Water Reuse Project ranges from about Elevation 7.0 on the north to Elevation 5.0 at the southern boundary. There project site slopes downward from both north and south toward Storm Water Pump Station No. 2 (SWPS2) which is at about Elevation 0.0. (Refer to Drawing C-1 and C-2 in Appendix A).

Borings indicate the proposed area for the Water Reuse Project facilities is underlain by about 7 feet of fill, a few feet of sand, about 10 feet of peat and then clay generally described as "Bay Mud." Depth to bedrock varies from about 50 feet in the northern part of the project area to 100 feet in the southern portion. Groundwater could be anticipated at depths from 2 or 3 feet in the area around SWPS2, to 5 or 6 feet in other locations. Also, groundwater levels could vary based on tidal conditions, seasons and weather conditions. Hence, the need to provide dewatering of below-grade structures during construction should be anticipated.

Harza found very high soluble concentrations of sulfate and chloride ions at depths from 5 to 10 feet. Also, pH ranged between 5.4 and 7.1. These analyses indicate a corrosive environment for both concrete and steel materials. Special consideration will be given to corrosion control during final design. A licensed Corrosion Engineer will conduct an investigation and will make recommendations for protection of below grade structures. Such protection will include special type cement and concrete additives for concrete and a passive or active anode system for buried ferrous pipe and conduits. Poly-vinylchloride and other corrosion resistant material for pipe and conduits will be used to the greatest extent possible.

For structures deeper than five feet below grade, shoring will be required owing to OSHA standards as well as basically unstable near-surface soil conditions.

8.3 Pile Foundations

The deep soils described above are subject to seismic liquefaction, differential settlement and long-term settlement. For this reason, most of the existing structures are founded on piles. New structures should be supported on piles driven to bedrock as described in the Harza report. Piles will also require corrosion protection as described above.

8.4 Disposal of Groundwater During Construction

Groundwater, extracted during construction, will be discharged to the City's WWTP. This was the groundwater disposal method used for construction of the wet weather improvements in 2006.

8.5 Paving and Access Roads

No new access roads are required for the project. Existing access roads along the south, east and north of the site may be damaged during construction. The back access road to "G" Street also may be damaged from construction of the Recycled Water Pipeline to Valero Refinery. Road damage that occurs during the project will be repaired.

Pavement replacement over new pipe trenches and other disturbed paved areas will match existing thickness for AC pavement and aggregate base, except if those thicknesses would be insufficient to safely distribute the design wheel loads over the buried facilities. In such cases, pavement sections would need to be increased.

8.6 Storm Drainage

The area in which the Water Reuse Treatment Plant will be constructed currently has a pervious surface; therefore, the project will result in additional stormwater runoff. Currently, rainfall collected from buildings and other impervious services as well as surface run off is conveyed to Stormwater Pump Station No. 2 (SWPS2) located just south of the east-west access road. SWPS2, which has a two pumps (lead/lag) with name plate capacities of 800 gpm each for a pumping capacity of approximately 1,600 gpm, pumps collected stormwater into the existing 24-inch industrial line, which conveys the flow to the Industrial Diversion Structure. Depending on the amount of wastewater flow entering the WWTP headworks, water in the industrial line either flows by gravity to the headworks or is diverted into the Industrial Flow Box, from which it is pumped into the MPBs by the Storm Flow Return Pumps, which each have a reported capacity of approximately 350 gpm.

Rainfall collected from the roof of the new MF/RO Building and other new impervious surfaces, such as decking around the NTFs and new driveways, will be conveyed directly to the existing SWPS.

During final design a study should be undertaken to determine the most cost-effective means to handle both storm flows and the return flows from the Water Reuse Treatment System.

8.7 Site Regrading

Regrading of the site will be required to provide good drainage control, to set the elevation of new facilities to minimize visual impacts, and to avoid depressions of stormwater ponding. The deck surrounding the NTFs is proposed to be set at Elevation 101.0. Significant regarding of the site will be required on the north side, where the existing grade slopes from approximately El 106.5 down to about El 104. It is likely that the dirt removed for the NTF facilities will not be suitable for reuse on site and will need to be hauled off for disposal. Figure C-1 in Appendix A shows the location and existing contours in this area.

The finish floor for the MF/RO Building is proposed to be set at El 103.0. Some imported backfill may be required to bring the building pad up to grade because the existing grade at the northern area of the building site is at approximately El 101.5 to 102.0. Since the building will be supported on a pile foundation, perhaps some of the dirt from excavating for the NTFs can be used, since bearing capacity of the soil will not be a design issue.

8.8 Landscaping

There are no plants or vegetation within the allocated area for the proposed Project. Landscaping for the Project within the WWTP Property will blend with existing conditions. Tall trees and view-obstructing plants will not be included. Drought tolerant ground cover and low shrubs will be considered for unpaved areas, particularly on the north side of the NTF pad where the ground will be re-graded down to El 101.

Although not anticipated, existing landscaping disturbed as a result of the construction of the 14-inch, buried RW pipeline, constructed outside the fence from the WWTP to the Valero pipeline sleepers, will be replaced in kind.

8.9 Recycled Water Pipeline

The recycled water pipeline within the plant boundary will be buried and constructed of cement mortar-lined and coated steel pipe. It will be bedded with control density fill and buried with a minimum of four feet of cover. The pipe and trench will be designed for the largest wheel load of chemical transport trucks that deliver to the plant. For more detail on the recycled water pipeline outside the plant fence line, please refer to Section 7.

Section 9
Structural and Architectural Design Criteria

This section presents an outline of the structural and architectural design criteria. Code citations throughout this Section shall be the most recently adopted editions of each code.

9.1 Structural Design Criteria

9.1.1 General

General structural design criteria are discussed below. Detailed structural design criteria are provided in Table 9-1.

9.1.2 Dead Loads

Dead loads shall consist of gravity loads induced by all structural elements, equipment, piping, and contained liquids.

9.1.3 Live Loads

1. Roof Live Loads shall be as specified in California Building Code (CBC), including allowable reductions for area and shape.

2. Wind Loads shall be as specified in CBC.

3. Stairs, walkways and platforms shall be designed for a minimum live load of 100 psf.

4. Floor Loads in equipment rooms, shops areas, and platforms used for equipment removal shall conform to CBC, but shall be a minimum live load of 150 psf.

9.1.4 Seismic Loads

The design loads recommended in the California Building Code and importance factor 1 shall be used as a design minimum. Site specific response spectra and soil forces on buried structures and retaining walls shall be in accordance with the geotechnical study and report that should be conducted during final design. Preliminary values from the 1997 Harza Report are stated in Section 8.

9.1.5 Wind Loads

Wind loads shall be as specified in CBC.

9.1.6 Foundation Design

As noted in Section 8 there are poor soil conditions at the site and all structures of significant load will be founded on piles.

9.1.7 Flood Conditions

All hydraulic structures shall be designed to withstand the uplift resulting from the 100 year flood. EL 105 (plant datum).

Table 9-1 ***Detailed Structural Design Criteria***	
General	
GOVERNING CODE:	• California Building Code.
Concrete	
CODES:	• ACI 318-05, Building Code Requirements for Reinforced Concrete. • ACI 301-99, Specifications for Structural Concrete for Buildings. • ACI 350-01, Environmental Engineering Concrete Structures.
Concrete Masonry Units	
SPECIFICATIONS:	• National Concrete Masonry Association (NCMA) Specifications for the Design and Construction of Load Bearing Concrete Masonry, Publication No. TR75-B. • California Building Code
Structural Steel	
SPECIFICATIONS:	• AISC Allowable Stress Design Specifications for Structural Steel Building
Aluminum	
SPECIFICATIONS:	• Specifications for Aluminum Structures, Published by Aluminum Association, Current Edition.
Concrete	
Strength	• F'c = 4000 psi and psi for concrete fill pipe/conduit encasement.
Reinforcing	• ASTM A185
Prestressing Strand	• ASTM A416
Welded Steel Wire Fabric	• ASTM A185
Design	• Strength Design Method or Alternate Method
Detailing	• ACI SP-66(00) Manual of Standard Practice for Detailing Reinforced Concrete Structures
Reinforced Masonry	
Concrete Masonry Units	• ASTM C90, Grade N, Type I (Unit Compressive Strength F'm = 1,500 psi
Mortar for Unit Masonry	• ASTM C270, Type M or S
Reinforcing	• ASTM A615, Grade 60
Cold-Drawn Steel Wire	• ASTM A82
Mortar and Grout	• ASTM C476
Structural Steel	
Structural Shapes	• ASTM A36
Structural Tubing	• ASTM A500
Steel Pipes	• ASTM A53, Grade B
Welding	• AWS E70 Electrodes
High Strength Bolts	• ASTM A325F, Min. ¾ " Diameter
Other Bolts	• ASTM A307, Grade A
Anchor Bolts	• ASTM 307
Stainless Steel	
Structural Shapes	• AISI Type 316
Plates	• AISI Type 304, 316 or 317
Anchor Bolts	• AISI Type 316
Aluminum	
Structural Shapes and Pipes	• 6061-T6

Table 9-1 cont. ***Detailed Structural Design Criteria***	
Steel Decking (Non-Composite Roof Deck):	
Nominal Depth	• 1 ½ inches
Width of Rib	• Intermediate
Gage	• Minimum 20
Number of Spans	• Two (2)
Minimum Section Properties	• +S = 0.159 inch – Unit per ft. width • -S = 0.170 inch – Units per ft. width • I = 0.163 inch – Units per ft. width
Timber:	
Surface dry or surface green	• Used at 19% maximum moisture content
Douglas Fir-Larch - No. 1	• 2" to 4" thick, 5" and wider
Douglas Fir Larch – No. 2	• 2" to 4" thick, 2" to 4" wide
Douglas Fir Larch – Select Structural	• Beams and Stringer
Douglas Fir Plywood	• Structural Type I
Fiberglass Reinforced Plastic (FRP) for Grating and Miscellaneous Items	
Tensile Strength	14,000 psi, ASTM D636
Flexural Strength	25,000 psi, ASTM D790
Coefficient of Thermal Expansion	16 x 10^{-6} inch per inch per degree F
Water Absorption	0.02% in 24 hours

9.2 Architectural Design Criteria

9.2.1 General

The structures that require architectural treatment are the MF/RO Building and the Nitrifying Trickling Filters. Generally, architectural treatment will conform to the existing plant facilities. Figure 9-1 shows an example of existing building architectural treatment at the City's WWTP.

Figure 9-1
Photo of Existing Equipment Bldg

9.2.2 MF/RO Building

9.2.2.1 Structural Support System

The exterior walls and roof of the building will be supported by the steel ridged frames, roof purlins and girt system.

9.2.2.2 Wall and Roof Construction

The exterior walls will be constructed from ribbed-faced block (cement masonry units, CMUs), blanket insulation, and interior sheet rock liner.

The roof will be constructed from metal roof deck with interior liner, rigid insulation and prefinished metal standing seam roof panels. Insulation will be provided to meet Heating, Ventilation and Air Conditioning (HVAC) design criteria. Roof access hatches and ridge skylights will be provided for adequate access and natural light respectively. Exterior gutters and downspouts will be provided to collect and dispose of rain water.

9.2.2.3 Doors, Windows and Louvers

Steel hollow metal doors will be provided. Height of doors will be adequate for equipment installation. Minimum size of equipment doors shall be 6′-0 x 8′-0 high and main doors shall be 3′-0 x 7′-0 high. Louvers will be provided to meet HVAC design criteria. Windows will be provided as required.

9.2.2.4 Equipment Removal

Monorail cranes will be provided to remove pumps and motors, strainers and cartridge filters. MF and RO modules can be removed manually from their respective skids.

9.2.2.5 Floors

Floors shall have concrete monolithic trowel finish.

9.2.3 Nitrifying Trickling Filters

9.2.3.1 Structural Support System

As described in Section 6, the NTFs will be designed with an under-drain plenum, constructed of reinforced concrete. The plenum will have a clear space of approximately 3 feet under each filter. The floor of the plenum will be founded on piles.

9.2.3.2 Walls

The NTF walls will NOT be designed to be water bearing (or floodable). However, to meet the architectural requirements of the project, the walls of the two structural cylinders will be constructed of ribbed-face block to match existing structures. The filters will be open at the top and hence the walls must withstand the structural loads, discussed above in this section.

Section 10
Mechanical Design Criteria

This section contains schedules and design criteria covering piping, noise, HVAC, fire protection and plumbing.

10.1 Process Piping

Table 10-1 presents the preliminary Pipe Material Schedule for the tertiary treatment facilities.

Table 10-1
Preliminary Pipe Material Schedule

Pipe Service	*Symbol*	*Diameter (Inches)*	*A/U[a]*	*Material*
Air Supply	AS		A	Galv STL, Copper
Sodium Hypochlorite Solution	NaOCl		A U	CPVC (SCH 80) CPVC (SCH 80)
Citric Acid	CA			PVC (SCH 80)
Chlorinated Secondary Effluent	CLSE		A U	DIP PVC (C900). DIP
Sodium Hydroxide	NaOH			PVC (SCH 80)
MF Feed	MFFD		S	PVC (SCH 80)
MF Reject Water	MFR		S	SSTL 316, DIP, STL w/CML
MF Filtrate	MFFL		A	PVC (C900). DIP
Nitrifying Trickling Filter (NTF) Recycle	NTFR		A U	DIP PVC (C900). DIP
NTF Effluent	NTFE		A U	DIP PVC (C900). DIP
Floor Drain	FD		A U	DIP PVC, DIP
Overflow Return	OR		U	PVC (sewer), DIP
Potable Water	W		A U	Gal STL, Copper PVC (SCH 80)
Recycled Water	RW		A U	STL w/CML (200 psi), DIP (200 psi), STL w/CMLC (200 psi)
RO Feed	ROF		A	SSTL 316
RO Permeate	ROP		A	PVC (SCH 80)
RO Reject	ROR		A U	High Press-316 SSTL; Low Press-PVC PVC (SCH 80)
Roof Drain	RD		A	DIP, PVC
Sample	SP		A	PVC (SCH 80)

a A – Aboveground S – Submerged U – Underground
b STL – Steel PVC – Polyvinyl Chloride SCH – Schedule
DIP – Ductile Iron Pipe Coated and Lined DIPPL – Ductile Iron Pipe Polyethylene Fusion Lining
CML – Cement Mortar Lined CMLC – Cement Mortar Lined and Coated SSTL – Stainless Steel

10.2 Noise Criteria

Noise reducing enclosures and insulation will be used throughout the facilities to reduce equipment noise to less than 55 dB at the property line as required by City ordinance and General Plan criteria.

10.3 HVAC Design Criteria

10.3.1 General

HVAC systems will be designed in conformance with the most recently adopted editions of the following codes and regulations:

- California Building Code
- California Building Code Standards
- California Mechanical Code
- California Mechanical Code Standards
- California Plumbing Code
- California Plumbing Code Standards
- California Fire Code
- California Fire Code Standards
- California Building Energy Efficiency Standards For Non-Residential Buildings (Title 24)
- California Building Energy Efficiency Standards For Non-Residential Buildings (Title 24), Joint Appendix II, Reference Weather / Climate Data
- California Occupational Safety and Health Commission Orders
- National Fire Protection Associations Applicable Standards

General HVAC Design Criteria are presented in Table10-2**.**

Table 10-2
General HVAC Design Criteria for Benicia, CA

Criteria	***Design Parameter***	
Site elevation	55	Ft above sea level
Outdoor Summer Design Temperature(1)	ASHRAE 0.1%(2)	99°F DB 69°F MCWB
Outdoor Winter Design Temperature(1)	ASHRAE 0.2% (3)	33°F DB
Indoor Design Temperature Occupied Areas	Cooling: Heating:	78°F DB 72°F DB
Indoor Design Temperature Electrical Rooms	Cooling: Heating:	85°F DB 65°F DB
Indoor Design Temperature – Process Areas	Cooling: Heating:	85°F DB None

(1) California Building Energy Efficiency Standards For Non-Residential Buildings (Title 24), Joint Appendix II, Reference Weather / Climate Data.
(2) Based on average weather data, outdoor temperature will be above design basis 0.1% of the time. (9 hours/year).
(3) Based on average weather data, outdoor temperature will be below design basis 0.2% of the time. (18 hours/year).

10.3.2 Air Conditioning Design of MF/RO Building

The occupied portions of the MF and RO buildings will be provided with heating and cooling to maintain the design temperatures of 78°F dry bulb (DB) and 72°F DB. Heating units will be wall mounted heat pump units. Cooling units over 5 tons in size will be equipped with an economizer.

The electrical room will be provided with heating and cooling to maintain the design temperatures of 85°F DB and 65°F DB. Air conditioning unit(s) will be mounted on an external pad at grade; electric unit heater will be wall mounted electric unit heaters. The unit heaters will prevent condensation in the switchgear in case of extended shutdown.

The process areas will be provided with cooling only to maintain the design temperature of 85°F DB. The units will be roof mounted air conditioning units. Heating will not be provided, since freeze protection is not required.

10.4 Fire Protection Design Criteria

The fire protection system will be designed in conformance with the current adopted editions of the following codes and regulations:

- California Building Code
- California Building Code Standards
- California Mechanical Code
- California Mechanical Code Standards
- California Plumbing Code
- California Plumbing Code Standards
- California Fire Code
- California Fire Code Standards
- National Fire Protection Association 10, Standard for Portable Fire Extinguishers
- National Fire Protection Association 24, Standard for the Installation of Private Fire Service Mains and their Appurtenances
- National Fire Protection Association 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities
- California Occupational Safety and Health Commission Orders

The MF/RO Building is unclassified, as described by NFPA 820, Table 3-2, line 19. Hence, only fire hydrants for fire protection are required. No fire and explosion hazard, materials of construction and ventilation requirements are listed in NFPA 820 for the Buildings.

New hydrants, as required, will be located approximately 25 ft (minimum) from the MF/RO Building. Portable fire extinguishers will be mounted inside the building, near personal exit doors. Portable fire extinguishers will be ABC multipurpose dry chemical type UL-rated 20A:120B:C.

10.5 Plumbing Design Criteria

The plumbing system will be designed in conformance with the most current adopted editions of the following codes and regulations:

- California Plumbing Code
- California Plumbing Code Standards

The plumbing system will include rainwater scuppers, overflow scuppers and downspouts with spillout fittings to outside splash blocks for surface runoff, potable water emergency eyewash and shower stations, and plant No. 3 Water piping with wash-down hose bibs and connections for flushing of the chemical feed system.

Emergency eyewash and shower stations will be located in the immediate vicinity of the chemicals storage/feed area.

Wash down hose bibs will be provided at appropriate location requiring housekeeping (To be determined in final design).

Section 11
Electrical Power Supply and Design Criteria

11.1 General

The electrical design will conform to the most recent edition of the generally accepted electrical and building codes including:

- NFPA 70 – National Electrical Code (NEC)
- State of California – Division of Industrial Safety, Electrical Safety Orders
- State of California – Energy Commission, Energy Efficiency Standards
- Occupational Safety and Health Act (OSHA)

All electrical equipment will have Underwriters Laboratory approval where applicable. Areas of the electrical installation will be classified in accordance with the environment in which the equipment is installed. In general, the areas will be classified as unclassified (non-hazardous), hazardous (by Class, Division and Group), non-corrosive, corrosive, wet or dry.

11.2 Power Service

11.2.1 Existing PG&E Electrical Service

Electrical power is provided to the existing Benicia WWTP from the Pacific Gas & Electric Company (PG&E) overhead pole line which runs along East 5th Street at the west side of the treatment plant property. An underground conduit extends the PG&E primary cables from the riser pole to the single PG&E transformer located adjacent to the Blower Building. The transformer provides power at 480/277 VAC to the Main Switchboard located inside the Blower Building. A review of the record drawings for the Wastewater Treatment Plant Improvement Project (dated May 2001) and a preliminary site inspection indicate that the Main Switchboard is rated for a maximum of 4,000 amps, has two spare breakers (400 A and 800 A) and several spaces available for future expansion.

The PG&E pole line in East "G" Street, along the northern plant property line appears to be only a single phase circuit serving residential customers on the adjacent street. This line presently extends only part of the distance to the eastern property line of the WWTP.

11.2.2 On-Site Emergency Electric Power Generation

On-site backup power generation consists of a nominally-rated 1,000 kW, 480/277 VAC standby power generator set located near the Blower Building main switchboard. This natural gas powered generator installation includes a small on-site

propane storage tank, which can provide approximately 24 hours of operation, if the natural gas supply is interrupted. City staff advised that the generator was designed to operate several hours a day when required to remove the entire plant load from the PG&E service.

The PG&E service transformer and the standby generator are connected to the plant's main automatic transfer switch (located within the Main Switchboard) in a manner that allows any load within the plant to be connected to the electrical distribution system. Thus dual sources of power are provided to all components. The standby generator (1,000 kW) is connected to the emergency source side of the plant's automatic transfer switch. Preliminary discussions with plant staff indicate that the 1,000 kW generator has adequate capacity to allow full normal operation of the plant. The generator's 1,000 kW rating is equivalent to approximately 1,500 amps at 480 volts. Since the main switchboard has a full load capacity of 4,000 amps, the switchboard can supply more load through the normal PG&E transformer than can be served during a PG&E outage by the 1,000 kW generator.

11.2.3 History of Utility Power Outages

PG&E supplied CDM with its records of power outages over the three years from 2002 through 2004. PG&E reports five "momentary interruptions" and six sustained interruptions. Five of the sustained interruptions ranged between 50 and 80 minutes. One lasted nearly seven hours. Although the data set is too small for statistical analysis, still it appears that PG&E power supply to the WWTP has been highly reliable.

Regardless of high historical reliability or the potential capacity of the plant emergency power system to serve the new Water Reuse Project, it was determined, as noted in Section 2, that standby power will not be provided for the project. See Section 11.4 for a more detailed discussion of power distribution for the Water Reuse facilities during power outages.

11.2.4 Electrical Service for Water Reuse Project

The two alternatives for supplying power to the new Water Reuse Facilities were investigated, namely: provide power through the existing plant service; or, provide power though a new service dedicated to the Reuse Plant.

A preliminary calculation indicates that the existing 4,000 amp electrical service has adequate capacity to supply both the existing plant (approximately 960 connected load amps, including the 25% contingency/overload factor as required by the NEC) and the Water Reuse Facility (approximately 1,650 connected load amps also including a similar NEC 25% factor). Based on these conservative calculations, there would be approximately 1,390 amps (approximately 1,000 horsepower) of future expansion capacity through the existing service after the reuse facility is added.

PG&E indicated that either of the two alternatives (existing WWTP service or new service dedicated to the Reuse Plant would be feasible). The existing PG&E service

transformer, bus and switchgear is adequately sized for the new load additions. If the dedicated service approach is desired, an overhead pole line could be routed along East G Street to a service drop pole on the north side of the plant and then underground to a new transformer located in the vicinity of the Reclamation facilities.

Disadvantages:

- Requires convincing PG&E that a new (second) service is required at this location which already has an existing service with adequate capacity.
- May be higher in capital cost, depending on PG&E estimate.
- If PG&E requires that the new service must be overhead, visual impacts would become an issue.
- Potential design scheduling issues to coordinate with PG&E.

11.2.5 Required Additional Investigations

Before a final electrical service recommendation can be made, the following issue require additional investigation and resolution:

- Explore the viability and costs associated with a second PG&E service located on the northeast corner of the WWTP property and dedicated to the Water Reuse Plant. PG&E's preliminary estimate for this new (second) service was approximately $83,000 in 2005 dollars.

11.2.6 Preliminary Recommendation

At this stage of the project, it would appear that utilizing the existing plant service switchgear, installing a new 480 volt feeder circuit breaker and installing new underground conduit and wire would be the preferred approach to serving the new Reuse Facility.

11.3 Power Demands

11.3.1 Existing Plant Power Demands

City records indicate that the maximum electrical demand was 520 kiloWatt (kW) occurring in December 2003 and a low maximum demand of 420 kW occurring in June 2004. This maximum demand remained relatively constant over the period for which records were reviewed (January 2002 through October 2004).

Other than the power requirements of the proposed Water Reuse Project, it is anticipated that additional future demands on the plant's electrical service will be relatively low due to site constraint limitations.

11.3.2 Estimated Electrical Power Loads and Demands for the Water Reuse Project

Estimated electrical power demands were made based on preliminary process equipment selection and sizing. Table 11-1 contains a summary of estimated electrical power demands for the Water Reuse process equipment. This indicates that the new water reuse facility would add approximately 1,260 additional kilovolt Amperes (kVAs) (horsepower) of connected load to the existing plant. Although the actual demand load will be less (preliminary calculations indicate a normal operational load of approximately 845 horsepower would be anticipated), the connected load has been used to provide a conservative basis of analyzing the electrical service capacity at the Benicia WWTP.

Table 11-1
New Water Reuse Treatment Facilities
Summary of Estimated Electrical Power Demand

New Process Area	*Connected kVA*	*Demand kVA*
Secondary Effluent Transfer PS No. 1 Pumps	30	20
Secondary Effluent Transfer PS No. 2 Pumps	15	10
Trickling Filter Recirculation PS Pumps	90	65
Micro Filtration System	275	235
Reverse Osmosis System	450	235
Building Systems (lighting, HVAC, etc)	125	100
UV Systems	85	55
Chlorination System	10	5
Recycled Water Supply PS Pumps	180	120
Totals (kVA)	**1,260**	**845**

11.4 Power Distribution for the New Water Reuse Treatment Facilities

Electrical power for the new Water Reuse facilities will be served from a new 2000 Amp frame power circuit breaker installed within the existing Blower Building main switchboard. Further investigation will be required to determine whether the new circuit breaker will fit into one of the existing spare cubicles or whether a new cubicle and bussing would be required. If new cubicle and bussing are determined to be required, they would be located in the existing Blower Building electrical room. The new breaker would be located on the load side of the existing 4000 amp Automatic Transfer Switch, so the new Water Reuse facilities would have the option of being fed from the existing standby generator. As noted in Paragraph 2.6, the project design is not intended to have standby power for the entire Water Reuse Project. However, as discussed in Paragraph 6.8, certain critical loads will require standby power. PLCs and SCADA would be connected to Uninterruptible Power Supply Units (UPSs). During final design a load analysis should be performed to determine if the City's existing generator has adequate capacity to supply power to both the existing and new standby loads. If it is found not to have sufficient capacity, then alternative means of providing emergency power include: (a) load shedding of non-priority loads

of both the City's WWTP and the Water Reuse Project; (b) furnishing a separate standby generator for the critical equipment and loads of the Water Reuse Project.

New underground 480 VAC electrical feeder cable and conduit will exit the Blower Building and be routed easterly along the existing roadway to the new Water Reuse facilities. Due to extensive existing underground piping and conduits in the area, additional investigation will be required to determine the exact conduit alignment.

A new Motor Control Center (or switchboard) will be installed in a dedicated electrical room of the MF/RO Building. This MCC will include all motor starters, feeder circuit breakers and variable speed drives for the new Water Reuse facilities and process and related building equipment.

Figure E-1 in Appendix A shows a preliminary Single Line Diagram for the proposed project.

11.5 Metering and Monitoring

The new Water Reuse facilities will receive power through the existing plant PG&E revenue metering equipment. To account separately for the electrical operating cost of the project, separate City-owned, sub-metering devices will be installed to monitor and record the energy use of the Project.

11.6 Energy Efficiency

The City of Benicia is committed to reducing energy consumption and its carbon footprint while improving the community's air quality. These goals are a strategic plan priority and increasing energy efficiency is Benicia General Plan Goal 3.27. The City is currently a member of ICLEI, Local Governments for Sustainability, and is a partner in the Cities for Climate Protection campaign. As a campaign participant, the City will, amongst other things, establish a greenhouse gas emissions reduction target.

Electrical equipment will be selected to support these local goals and the national energy efficiency policies. Lighting and other systems will be designed to be energy efficient. Premium efficiency motors will be used to take advantage of PG&E's rebate program (currently called "Savings-by-Design") , that may be available during the final design period.

11.7 Branch Circuiting

Lighting will generally operate on 120 V, single phase circuits. 120 V, general purpose convenience receptacles will be located within the facility per the requirements of the National Electrical Code. Minimum conduit size will be ¾"and typically of galvanized steel for exposed locations, PVC for concrete encased locations and liquid tight type for flexible connections to motors and similar equipment. Wiring will be insulated copper for all power, control, lighting, and instrumentation circuits. Conduits in non-finished areas will be installed either on the surface of the structure

or concealed in concrete floor slabs or below grade. Conduits below grade will be non-metal (PVC) and encased with three inches of red dyed concrete. PVC coated rigid steel conduit will be provide for all exposed installation in corrosive areas. Spare conduits and wiring will be provided as appropriate.

11.8 Motors

Motors ½ Hp and larger will operate on 480 V, 3 phase. Smaller motors will be operated on 120 V, single phase. Motors will have cast iron housing, copper windings, 40° C ambient rating with a 1.15 service factor. Motors ½ Hp and larger will typically be premium efficiency type, NEMA Design B with Class F insulation. All AC motors will be squirrel-cage induction type. Motors will typically be provided with totally enclosed fan cooled (TEFC) enclosures unless otherwise dictated by the area in which they are located. Sound attenuation enclosures will be provided for selected motors located external to the MF/RO Building. Please refer to Section 8 for additional details regarding these enclosures.

11.9 Variable Speed Control

When pumps are required to be operated over an adjustable speed range by the process parameters, pumps will be provided with AC motors and VFD. The equipment, materials and installation will conform to IEEE 519 for harmonics generation and mitigation. Typically motors smaller than approximately 40 HP will utilize 6 pulse VFDs and larger motors will utilize 18 pulse drives or drives with active front end designs.

11.10 Lighting

Lighting will be installed as required to appropriately illuminate the new facilities. Lighting will be designed in accordance with the lighting efficiency Title 24 requirements. New fixtures will be similar to the existing to the extent possible. Low-profile, exterior lighting will be provided at the process units that are not enclosed, such as the NTF recycle pump station and UV system.

11.11 Communications

Raceways will be provided for extension of the plant communications system (telephone, intercom, etc.)

11.12 Control Systems

The Water Reuse facilities control system will be based on PLCs and personal computer running Human Machine Interface (HMI) software. The new system will be designed to run in a freestanding mode, but will be interfaced to the existing plant control system to the maximum extent possible. Additional investigation will be required to determine the most cost effective method of integrating the systems. To the extent feasible, new PLCs and HMI software will be of the same manufacturer as the existing plant systems.

Several of the new process systems will be provided with integral control systems by their manufacturer (UV, Reverse Osmosis, Micro Filtration, etc.). These systems will be connected via either data highway or individual hardwire input/output (I/O) to the main Water Reuse control system.

Because control system hardware and software is rapidly changing and since standard control approaches adopted by process system manufacturers vary, additional development of the control system hardware, operation strategy philosophies and physical connections will need to be developed as the project progresses.

12.1.2 Operating and Maintenance Cost Estimates

All the O&M cost estimates below are based on Year 2007 dollars.

- **Electrical Power Cost –** Electrical power costs used were $0.12/kWhr, which is based on the average unit price for power at the WWTP for one winter month and one summer month.

- **Labor Cost –** Labor cost was assumed at $50/hr, which includes City's normal general and administrative overhead. Administrative labor costs were estimated at 15% of the direct operations and maintenance costs for management and supervision.

- **Equipment Repair and Replacement –** An allowance of two percent (2%) per year of the estimated construction cost of major mechanical and electrical equipment was made to establish a sinking fund to repair and replace major items of equipment.

- **Chemicals –** Costs of sodium hypochlorite, sodium hydroxide and sodium bisulfite were obtained from City WWTP staff for actual cost paid for these chemicals. Cost for other chemicals (sulfuric acid, citric acid and antiscalants) were obtained from suppliers.

- **Other Consumables –** Cost of other consumables, such as replacement membranes, cartridge filters, UV lamps and ballasts were obtained from the respective equipment vendors. Those estimated costs are presented within the estimate of each system.

- **Special Maintenance –** Many WWTPs contract out for special maintenance services for electrical and instrumentation systems. An allowance for a special maintenance contract was made in the amount of $50,000, based on experience from a similar plant.

12.2 Estimated Construction and Capital Costs

~~Using~~ CDM developed construction cost estimates based on the cost assumptions described above and based upon ~~, construction costs were estimated for the various unit processes.~~ the construction costs of similar water reuse projects, including projects for the Carmel Area Wastewater District, City of Livermore, the Dublin San Ramon Services District, and East Bay Municipal Utility District/Chevron. Construction costs were updated from those presented in the October 2006 CDR using additional information developed during the preliminary design phase. Also, vendors were contacted for updated major equipment prices. Lastly, CDM reviewed the Engineering News Record Construction Cost Index (ENR CCI) for the San Francisco Area from October 2006 to September 2007, to determine if construction costs have escalated during that period. Although some small increase occurred in this index between October 2006 and September 2007, overall it actually dropped fractionally from 9099 to 9078. However, as was discussed with the City last November, the ENR CCI has not really tracked the significant cost increases that have been experienced in water-related,

public works projects. Hence, a modest inflation increase of 2.5% has been added to the October 2006 estimates.

The capital cost of a project includes both the initial construction cost plus all "soft costs" that are required to implement the project. These soft costs include: engineering, construction management, administration, environmental compliance, acquisition of permits and financing costs. Other assumptions used in developing the project capital cost estimates are:

- The cost for a "break tank" at Valero sized for 6 hrs of storage at the Water Reuse plant flowrate.
- 25% for engineering design and construction management and $1 million for the preliminary engineering, water quality testing, and environmental planning costs that will be completed prior to the start of engineering design.
- Contingency has been reduced from 25% in the CDR to 20% owing to the development of more detailed information from the preliminary design work upon which to base estimates.

~~Table 12-1 presents a summary of the estimated capital costs for project with production capacity of 2.0.~~ Tables 12-1, 12-2, and 12-3 present the estimated capital costs for projects with a production capacity of 2.0 mgd, 1.5 mgd, and 1.0 mgd, respectively.

Table 12-1
Summary of Estimated Capital Cost
2.0 mgd Water Reuse Project

Component	***Estimated Cost ($ millions)***
Microfiltration/Reverse Osmosis Systems	$11.3
Civil/Electrical Site Work	$1.0
UV Disinfection System	$1.2
Chemical Storage Tanks and Containment	$0.3
Recycled Water Pump Station	$0.57
Pipeline	$2.3
Nitrifying Trickling Filters	$3.1
Valero break tank, 0.5 MG	$0.51
Subtotal (rounded)	$20.3
Engineering and CM at 25%	$5.1
Subtotal	$25.4
Contingency at 20%	$5.1
Costs for preliminary engineering, water quality testing, and environmental planning	$1.0
Total Estimated Cost in September 2007 dollars	$31.5

Table 12-2 ***Summary of Estimated Capital Cost*** ***1.5 mgd Water Reuse Project***	
Component	***Estimated Cost ($ millions)***
Microfiltration/Reverse Osmosis Systems	$9.1
Civil/Electrical Site Work	$0.9
UV Disinfection System	$1.1
Chemical Storage Tanks and Containment	$0.3
Recycled Water Pump Station	$0.5
Pipeline	$2.1
Nitrifying Trickling Filters	$2.6
Valero break tank, 0.38 MG	$0.4
Subtotal (rounded)	$17.0
Engineering and CM at 25%	$4.3
Subtotal	$21.2
Contingency at 20%	$4.3
Costs for preliminary engineering, water quality testing, and environmental planning	$1.0
Total Estimated Cost in September 2007 dollars	26.6

Table 12-3 ***Summary of Estimated Capital Cost*** ***1.0 mgd Water Reuse Project***	
Component	***Estimated Cost ($ millions)***
Microfiltration/Reverse Osmosis Systems	$6.3
Civil/Electrical Site Work	$0.8
UV Disinfection System	$1.0
Chemical Storage Tanks and Containment	$0.3
Recycled Water Pump Station	$0.5
Pipeline	$2.1
Nitrifying Trickling Filters	$1.7
Valero break tank, 0.25 MG	$0.3
Subtotal (rounded)	$12.0
Engineering and CM at 25%	$3.3
Subtotal	$16.3
Contingency at 20%	$3.3
Costs for preliminary engineering, water quality testing, and environmental planning	$1.0
Total Estimated Cost in September 2007 dollars	$20.6

12.3 Estimated Annual Operation and Maintenance Costs

The annual O&M costs of the project include power, labor, chemicals, and replacement of consumables (e.g., membranes, UV lamps, etc). Labor estimates were based on experience with other operations at plants, available guidelines and discussions with existing Benicia Plant operations staff. The replacement costs for major consumables were based on manufacturers' recommendations and experience with other projects. Detailed estimates of O&M costs were developed and presented in the CDR. It was assumed that O&M costs have increased similar to construction costs and hence an inflation factor of 2.5% was added to the detailed estimates from the CDR. ~~A summary of estimated annual O&M costs is presented in Table 12-2. The amounts in the far right hand column are the updated O&M costs.~~

Tables 12-4, 12-5, and 12-6 present the estimated annual O&M costs for projects with a production capacity of 2.0 mgd, 1.5 mgd, and 1.0 mgd, respectively. The amounts in the far right hand column are the updated O&M costs.

Table 12-4~~2~~
Estimated Annual O&M Costs of 2.0 mgd Water Reuse Project

Item	NTF's	MF	RO	UV	Pumping	Admin	Totals Sept 2006	Totals Sept 07
Chemicals	$91,000	$56,300	$68,600	$19,600	$0	$35,300	$270,800	$277,600
Power	$26,700	$44,500	$151,000	$17,700	$108,300	$52,200	$400,400	$410,400
Consumables	$0	$63,500	$61,100	$16,700	$0	$21,200	$162,500	$166,600
Equipment R/R	$18,400	$20,100	$23,200	$15,600	$9,200	$13,000	$99,500	$102,000
Labor	$28,800	$68,800	$48,800	$38,000	$23,900	$31,200	$239,500	$245,500
E and I&C Maint.	$0	$20,000	$10,000	$11,000	$3,000	$6,000	$50,000	$51,300
Total	**$164,900**	**$273,200**	**$362,700**	**$118,600**	**$144,400**	**$158,900**	**$1,222,700**	**$1,253,400**

Table 12-5
Estimated Annual O&M Costs of 1.5 mgd Water Reuse Project

Item	NTF's	MF	RO	UV	Pumping	Admin	Totals Sept 2006	Totals Sept 07
Chemicals	$68,300	$42,200	$51,500	$14,700	$0	$26,500	$203,200	$208,300
Power	$20,000	$33,400	$113,300	$13,300	$81,200	$39,200	$300,400	$307,900
Consumables	$0	$47,600	$45,800	$12,500	$0	$15,900	$121,800	$124,800
Equipment R/R	$17,500	$20,100	$17,300	$14,300	$8,500	$11,600	$89,300	$91,500
Labor	$28,800	$68,800	$48,800	$38,000	$23,900	$31,200	$239,500	$245,500
E and I&C Maint.	$0	$20,000	$10,000	$11,000	$3,000	$6,000	$50,000	$51,300
Total	**$134,600**	**$232,100**	**$286,700**	**$103,800**	**$116,600**	**$130,400**	**$1,004,200**	**$1,029,300**

Table 12-6
Estimated Annual O&M Costs of 1.0 mgd Water Reuse Project

Item	NTF's	MF	RO	UV	Pumping	Admin	Totals Sept 2006	Totals Sept 07
Chemicals	$45,500	$28,200	$34,300	$9,800	$0	$17,700	$135,500	$138,900
Power	$13,400	$22,300	$75,500	$8,900	$54,200	$26,100	$200,400	$205,400
Consumables	$0	$31,800	$30,600	$8,400	$0	$10,600	$81,400	$83,400
Equipment R/R	$16,000	$20,100	$11,600	$12,700	$8,500	$10,300	$79,200	$81,200
Labor	$28,800	$68,800	$48,800	$38,000	$23,900	$31,200	$239,500	$245,500
E and I&C Maint.	$0	$20,000	$10,000	$11,000	$3,000	$6,000	$50,000	$51,300
Total	**$103,700**	**$191,200**	**$210,800**	**$88,800**	**$89,600**	**$101,900**	**$785,940**	**$805,700**

Figure 12-1 shows graphic distribution of the estimated annual O&M cost for a 2 mgd capacity plant. Labor costs, which include plant laboratory staff, make up approximately 33% of the estimated O&M costs and power and chemicals each make up about 25%.

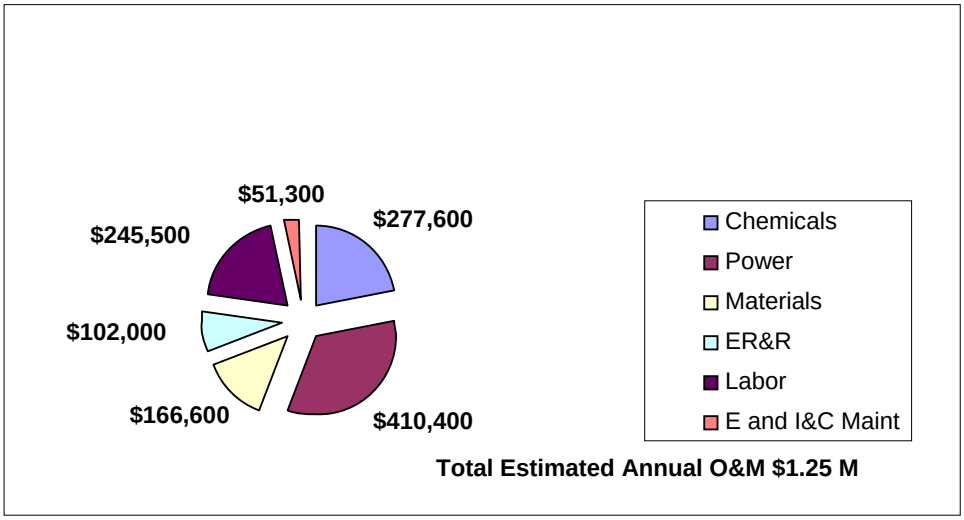

Figure 12-1
Distribution of Estimated O&M Costs for 2.0 mgd Capacity Project

12.4 Estimated Cost of Recycled Water Production

Based on the estimated O&M costs presented in Tables 12-~~2~~4, 12-5, and 12-6, the unit cost of producing and delivering recycled water to Valero was calculated for plant productivity ratios of 75% and 100%. Labor, materials, equipment repair/replacement and special electrical & instrumentation cost remain constant and independent of flow. Chemical and electrical power costs vary nearly directly proportional to flow. Based on those assumptions, the unit costs are shown in Table 12-~~3~~7. For example, the unit cost for a 2 mgd plant varies from about $560/acre foot (AF) at 100% productivity (basically, 24/7/365, which is unlikely given the reliability features designed into the project) up to $64~~5~~0/AF at 75% productivity. These estimates are based on operation and maintenance costs and do not include the amortization of capital costs.

Table 12-~~3~~ 7
Cost of Producing Recycled Water[1] ($/Acre ft)

Percent Productivity	***2.0 mgd Plant ~~Production Capacity~~***	***1.5 mgd Plant***	***1.0 mgd Plant***
100[2]	$560	$610	$720
75[3]	$64~~5~~0	$710	$860

[1] Do not include amortized capital costs.
[2] 24/7/365 operation at 100% productivity.
[3] For example, 24/7/365 at 75% productivity.

Section 13
Project Schedule

13.1 Project Schedule

Figure 13-1 contains an updated project milestone schedule. As shown therein, completion of the CEQA compliance process and final design will be needed before construction can begin.

As shown in Figure 13-1, the final design phase is projected to take approximately 10 months, bid phase 4 months and construction approximately 20 months, including start-up, testing and commissioning.

The preliminary schedule has been developed only for the treatment system. It is not known what contracting mechanism will be used to construct the off-site pipeline. Valero may build it with a separate contractor. Valero may want to have its engineering department design it, or a firm familiar with Valero's piping design requirements. No matter what the design arrangements are, CDM recommends that the pipeline should be built under a separate construction contract from the treatment system, since these types of construction are specialties, and generally pipeline contractors do not build treatment systems, and vice versa. CDM estimates that the pipeline could be constructed and tested in approximately 12 to 14 months or about 240 to 280 working days, within the estimated construction period for the treatment system.

Section 14
Remaining Major Decisions and Additional Studies

14.1 Remaining Major Decisions

Remaining technical decisions include the following:

- The design output capacity of the Project.
- The size of the break tank to be located near the Valero cooling towers.
- Whether to pre-purchase the MF and the UV equipment. Pre-purchase might save ten to fifteen percent on the cost of the equipment.

14.2 Additional Studies Recommended During Final Design

- Evaluate the capacity of the existing storm water pump station and industrial sewer to handle the combination of storm water flow within the site and return flows from the Water Reuse Project.
- Evaluate installing submerged membrane bioreactor (MBR) for combined nitrification and microfiltration in one or more RBC bays, as compared with separately stand alone NTFs and pressure MF. (This concept was introduced by plant staff.)
- Evaluate alternative methods of reprocessing the MF backwash water and the best location for return of this flow.
- Determine the best method of providing standby power for the critical loads of the Water Reuse Project.
- Conduct a corrosion study of soils, groundwater and sea air and recommend appropriate mitigation.
- Conduct background noise monitoring under varying conditions to obtain adequate data to support the efficiency and impact of project noise mitigation.
- Drill additional soil borings and update the Harza geotechnical report.
- There may be additional studies that result from the anticipated update of the draft IS/MND, prepared pursuant to CEQA compliance requirements.

Appendix A
Drawings

G-1	Title Sheet
PD-1	Process Block Diagram No. 1 Sec. Eff. Transfer Systems
PD-2	Process Block Diagram No. 2 Nitrifying Trickling Filters
PD-3	Process Block Diagram No. 3 Micro-Filtration System
PD-4	Process Block Diagram No. 4 Reverse Osmosis System
PD-5	Process Block Diagram No. 5 UV & RW Pump Station
PD-6	Process Block Diagram No. 6 Chemical Systems
HP-1	Preliminary Hydraulic Profile
C-1	Preliminary Site Plan Partial Area Plan III
C-2	Preliminary Site Plan Partial Area Plan IV
M-1	Recycled Water Pump Station Mechanical Plan & Section
E-1	Electrical Distribution Single Line
P-1	Plan and Profile Sta 1+00 to Sta 14+20
P-2	Plan and Profile Sta 7+92 to Sta 18+00
P-3	Plan and Profile Sta 18+00 to 32+00
P-4	Plan and Profile Sta 32+00 to Sta 46+00
P-5	Plan and Profile Sta 46+00 to Sta 60+00
P-6	Plan and Profile Sta 60+00 to 74+00
P-7	Plan and Profile Sta 74+00 to 88+00
P-8	Plan and Profile Sta 88+00 to 102+00
P-9	Plan and Profile Sta 102 to 116+90
P-10	Plan and Profile Sta 116+90 to 130+46
P-11	Plan and Profile Sta 130+46 to 146+50

THE CITY OF BENICIA CALIFORNIA

WATER REUSE PROJECT
PRELIMINARY DESIGN DRAWINGS
MARCH 2008

Drawing List

G-1	Title Sheet and Drawing List
PD-1	Process Block Diagram No. 1 Sec. Eff. Transfer System
PD-2	Process Block Diagram No. 2 Nitrifying Trickling Filters
PD-3	Process Block Diagram No. 3 Micro-Filtration System
PD-4	Process Block Diagram No. 4 Reverse Osmosis System
PD-5	Process Block Diagram No. 5 UV & RW Pump Station
PD-6	Process Block Diagram No. 6 Chemical Systems
HP-1	Preliminary Hydraulic Profile
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P-4	Plan and Profile Sta 32+00 to Sta 46+00
P-5	Plan and Profile Sta 46+00 to Sta 60+00
P-6	Plan and Profile Sta 60+00 to Sta 74+00
P-7	Plan and Profile Sta 74+00 to Sta 88+00
P-8	Plan and Profile Sta 88+00 to Sta 102+00
P-9	Plan and Profile Sta 102+00 to Sta 116+90
P-10	Plan and Profile Sta 116+90 to Sta 130+46
P-11	Plan and Profile Sta 130+46 to Sta 146+50

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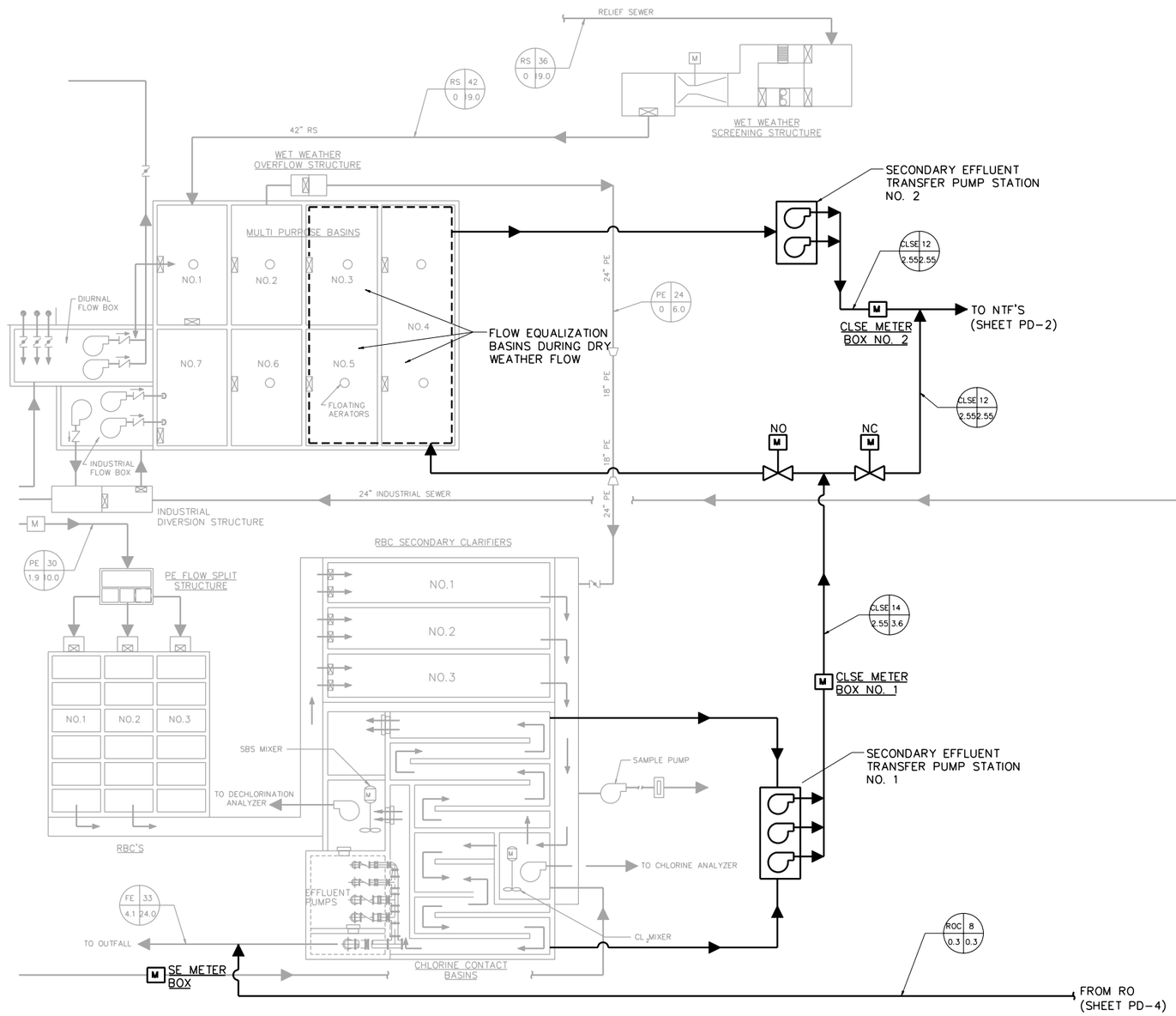
WATER REUSE PROJECT
PHASE 1

TITLE SHEET AND DRAWING LIST

SHEET
OF ___ SHEETS
SHEET ID
G-1

PROCESS BLOCK DIAGRAMS KEY	**SECONDARY EFFLUENT TRANSFER SYSTEMS SHEET PD-1**	NITRIFYING TRICKLING FILTER SYSTEM SHEET PD-2	MICRO-FILTRATION SYSTEM SHEET PD-3	REVERSE OSMOSIS SYSTEM SHEET PD-4	UV & RECYCLED WATER PUMP SYSTEMS SHEET PD-5	CHEMICAL SYSTEMS SHEET PD-6



LEGEND

- = EXISTING STRUCTURE
- = NEW STRUCTURE
- = FUTURE STRUCTURE
- = EXISTING PIPING
- = NEW PIPING
- = FUTURE PIPING

FE = FINAL EFFLUENT
MFR = MICRO-FILTRATION REJECT
PD = PROCESS BLOCK DIAGRAM
PE = PRIMARY EFFLUENT
RAS = RETURN ACTIVATED SLUDGE
RS = RAW SEWAGE
ROC = REVERSE OSMOSIS CONCENTRATE
SE = SECONDARY EFFLUENT
CLSE = CHLORINATED SECONDARY EFFLUENT
M = MOTOR OPERATED VALVE
NO = NORMALLY OPEN
NC = NORMALLY CLOSED

SERVICE — DIAMETER (INCHES) — AVERAGE FLOW (MGD) — PEAK FLOW (MGD)

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WATER REUSE PROJECT
PHASE 1

PROCESS BLOCK DIAGRAM NO. 1 SEC. EFF. TRANSFER SYSTEMS

SHEET 1 OF ___ SHEETS
SHEET ID
PD-1

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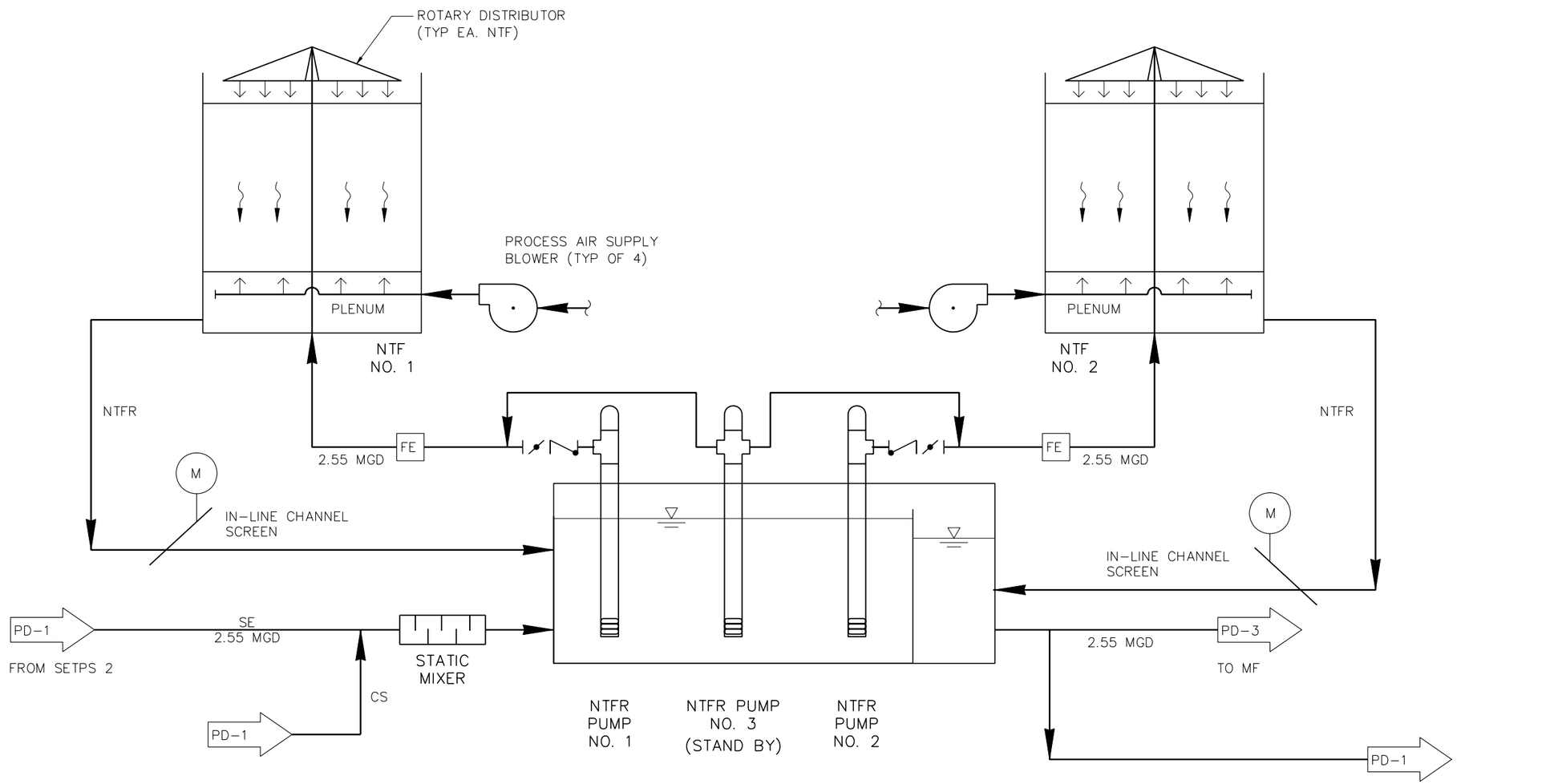

NTF	NITRIFYING TRICKLING FILTER
NTFR	NTF RECYCLE
SE	SECONDARY EFFLUENT
CS	CAUSTIC SODA
FE	FLOW METER
SETPS 2	SECONDARY EFFLUENT TRANSFER PUMP STATION NO.2
PD	PROCESS BLOCK DIAGRAM

NITRIFYING TRICKLING FILTER RECYCLE
PUMP STATION.

NITRIFYING TRICKLING FILTERS SYSTEM

REV. NO.	DATE	DRWN	CHKD	REMARKS

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WATER REUSE PROJECT
PHASE 1

PROCESS BLOCK DIAGRAM NO. 2
NITRIFYING TRICKLING FILTERS

SHEET
OF SHEETS
SHEET ID
PD-2

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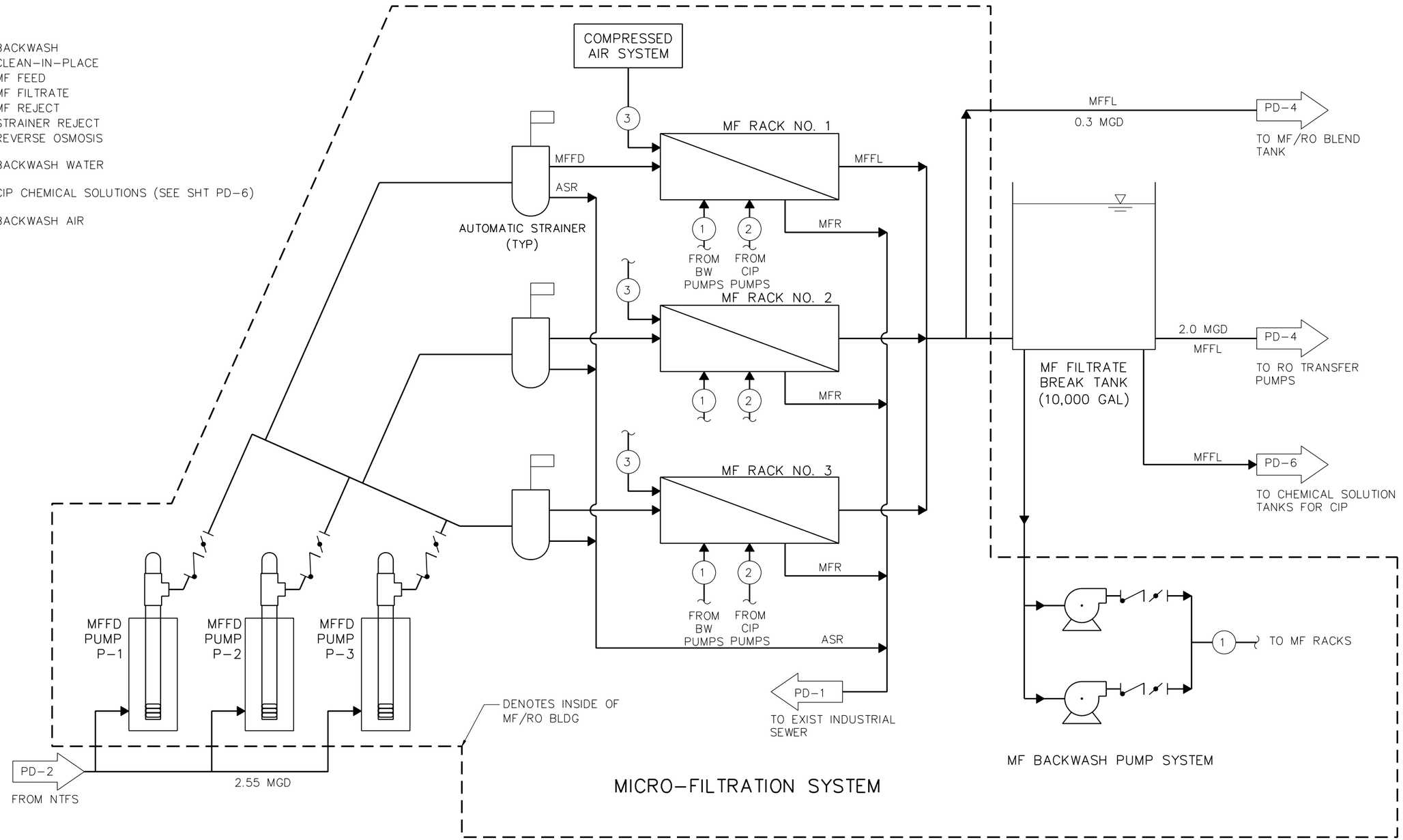
BW	BACKWASH
CIP	CLEAN–IN–PLACE
MFFD	MF FEED
MFFL	MF FILTRATE
MFR	MF REJECT
ASR	STRAINER REJECT
RO	REVERSE OSMOSIS
(1)	BACKWASH WATER
(2)	CIP CHEMICAL SOLUTIONS (SEE SHT PD–6)
(3)	BACKWASH AIR



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WATER REUSE PROJECT
PHASE 1

PROCESS BLOCK DIAGRAM NO. 3
MICRO-FILTRATION SYSTEM

SHEET
OF ___ SHEETS
SHEET ID
PD-3

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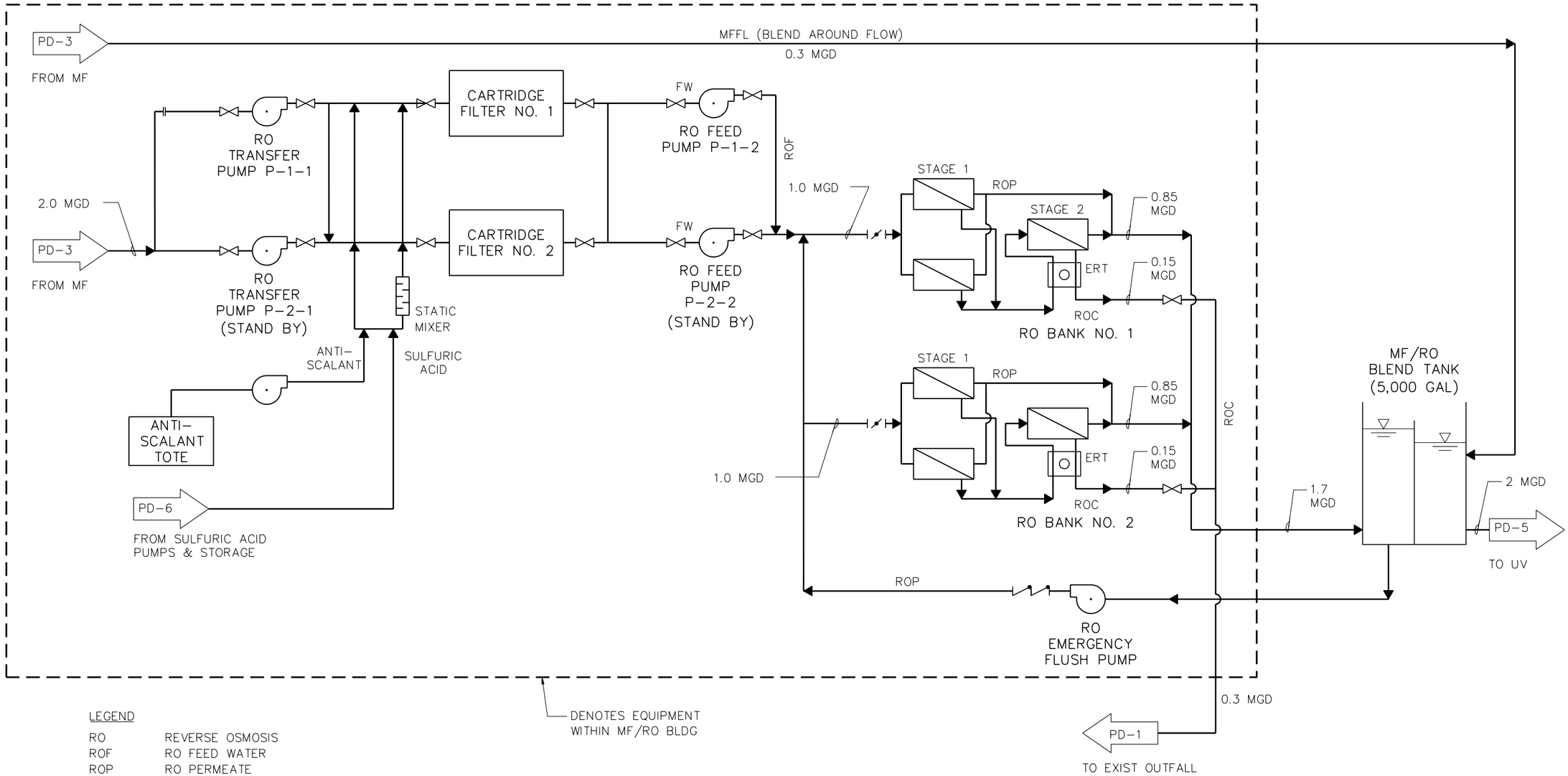

LEGEND

RO	REVERSE OSMOSIS
ROF	RO FEED WATER
ROP	RO PERMEATE
ROC	RO CONCENTRATE (REJECT)
ERT	ENERGY RECOVERY TURBINE

REVERSE OSMOSIS SYSTEM

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WATER REUSE PROJECT
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PROCESS BLOCK DIAGRAM NO. 4
REVERSE OSMOSIS SYSTEM

SHEET
OF SHEETS
SHEET ID
PD-4

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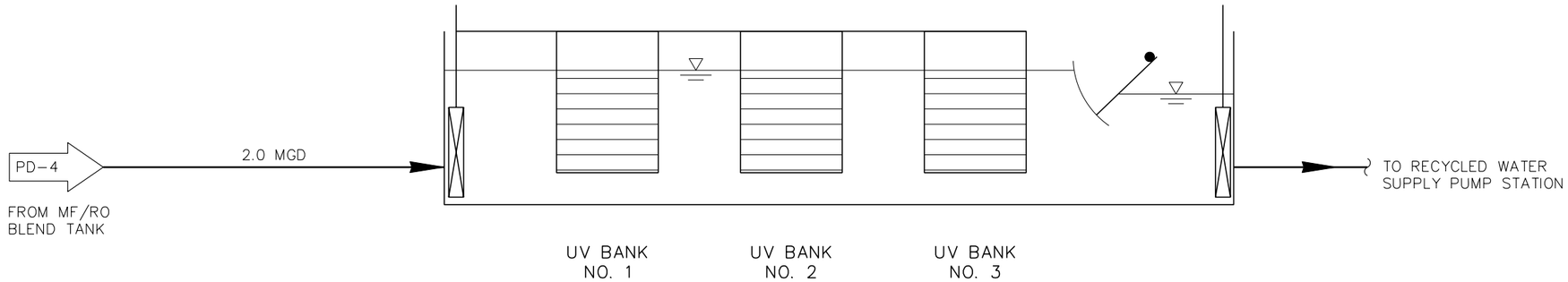
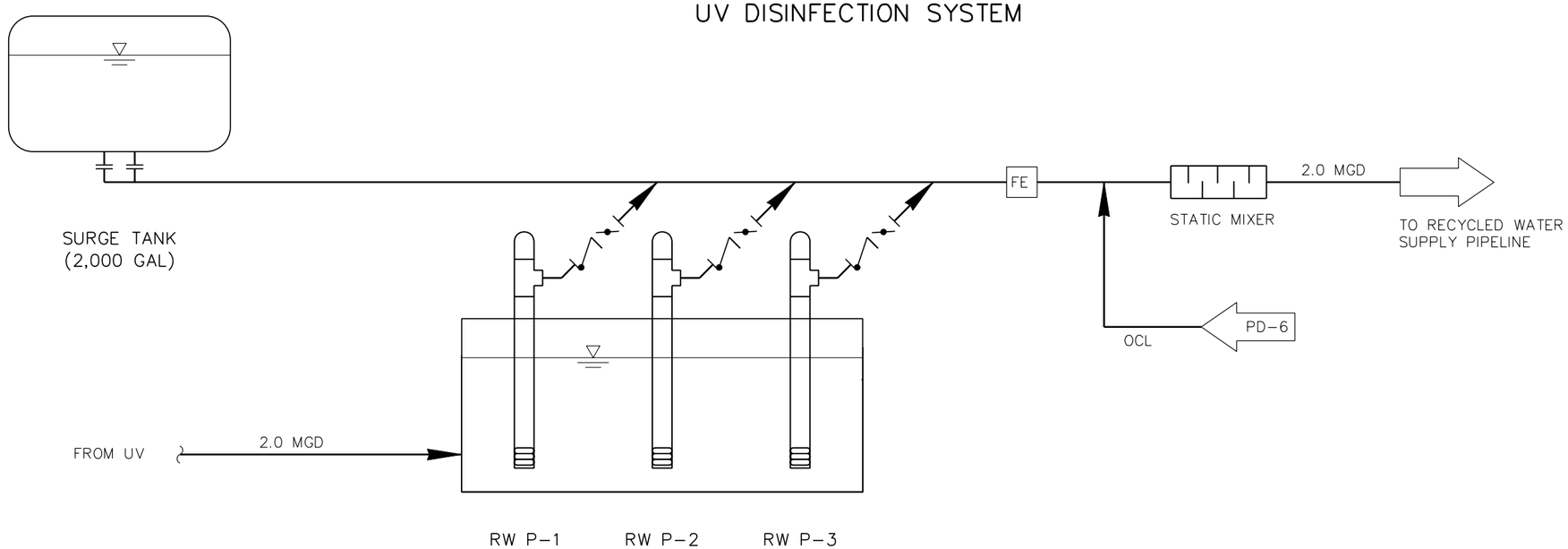


UV DISINFECTION SYSTEM



RECYCLED WATER SUPPLY PUMP STATION

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PROCESS BLOCK DIAGRAM NO. 5
UV & RW PUMP STATION

SHEET
OF SHEETS
SHEET ID
PD-5

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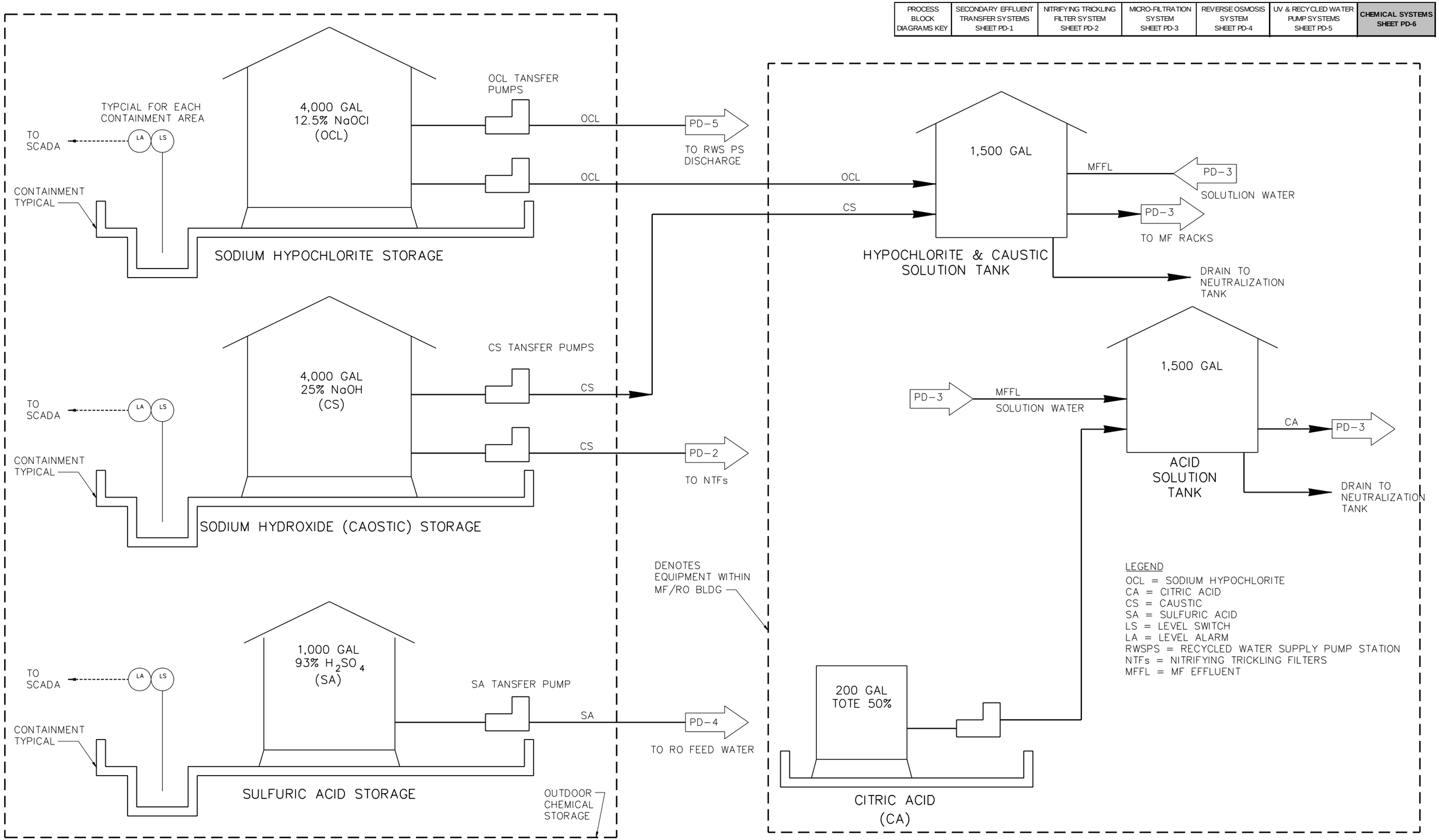

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WATER REUSE PROJECT
PHASE 1

PROCESS BLOCK DIAGRAM NO. 6
CHEMICAL SYSTEMS

SHEET
OF ___ SHEETS
SHEET ID
PD-6

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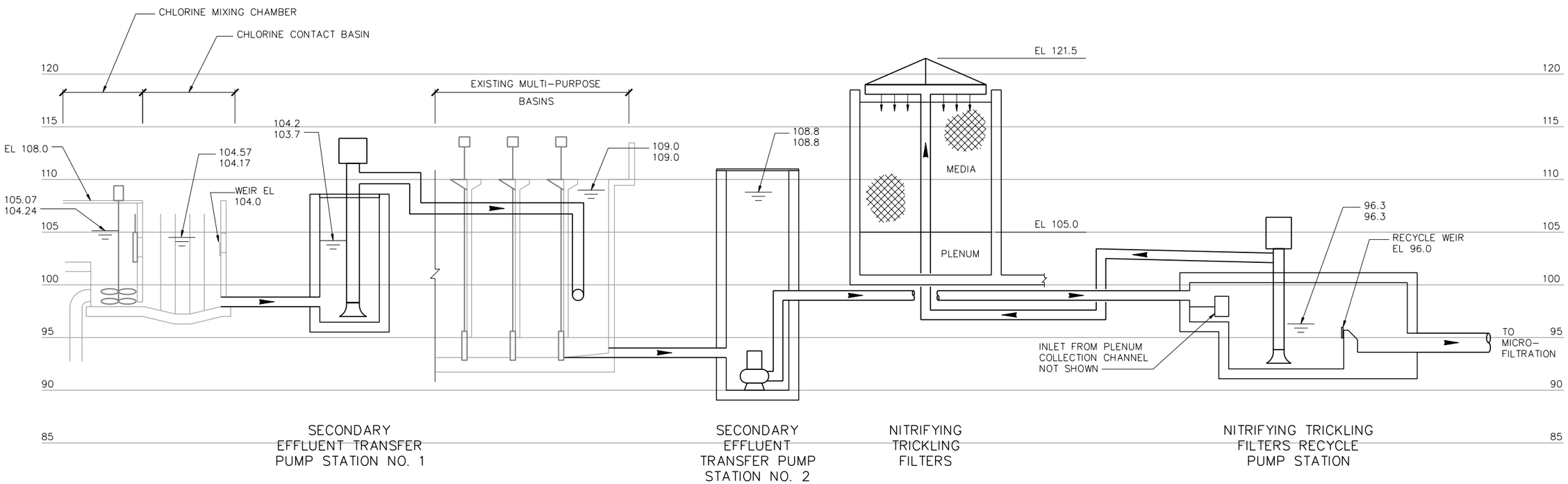

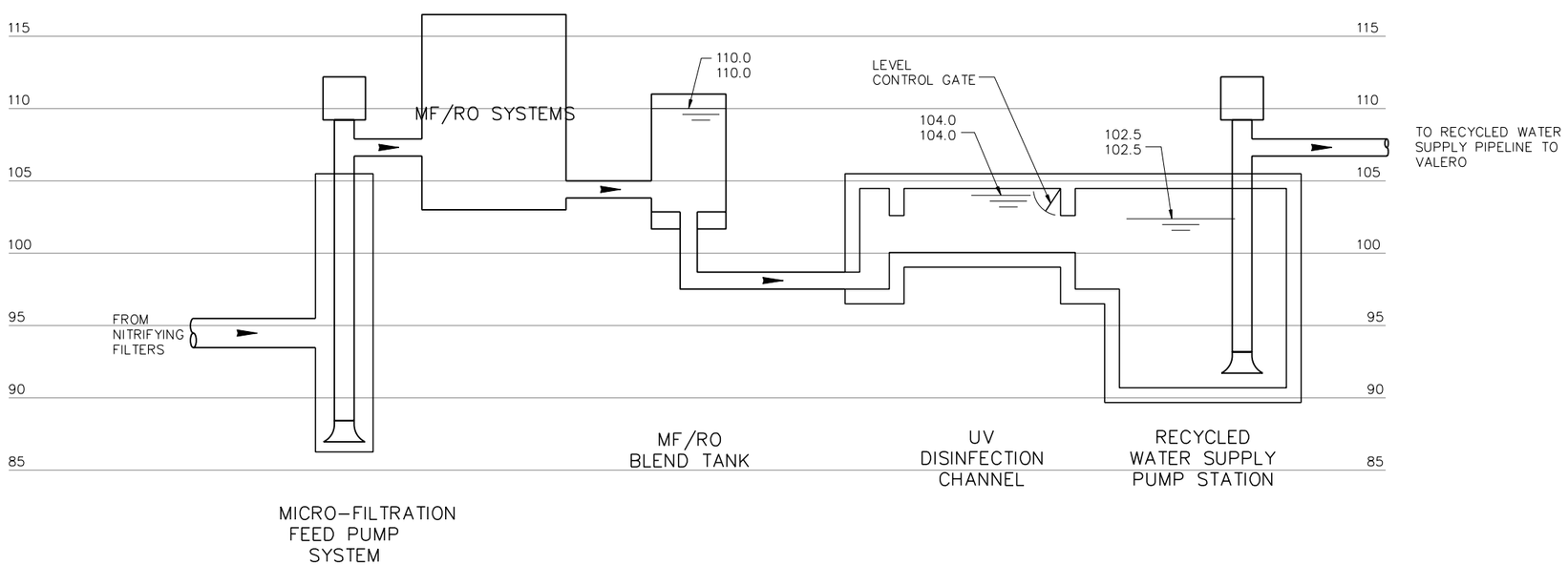

NOTES:

1. VERTICAL DATUM – PROJECT EL 100 EQUAL USC AND GS NORTH AMERICAN 1929 SEA LEVEL DATUM WITH SUPPLEMENTARY ADJUSTMENT OF JUNE 1959.

2. WATER SURFACE ELEVATIONS ARE TAKEN FROM THE WET WEATHER IMPROVEMENTS PROJECT HYDRAULIC PROFILE AND ARE FOR THE FOLLOWING CONDITIONS:
PLANT PEAK HYDRAULIC EFFLUENT FLOW = 24 MGD;
2 MGD RECYCLED WATER PRODUCTION
PLANT AVERAGE DAY MAXIMUM MONTH FLOW (YEAR 2005) = 4.06 MGD; 2 MGD RECYCLED WATER PRODUCTION

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PHASE 1

PRELIMINARY HYDRAULIC PROFILE

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OF ___ SHEETS
SHEET ID
HP-1

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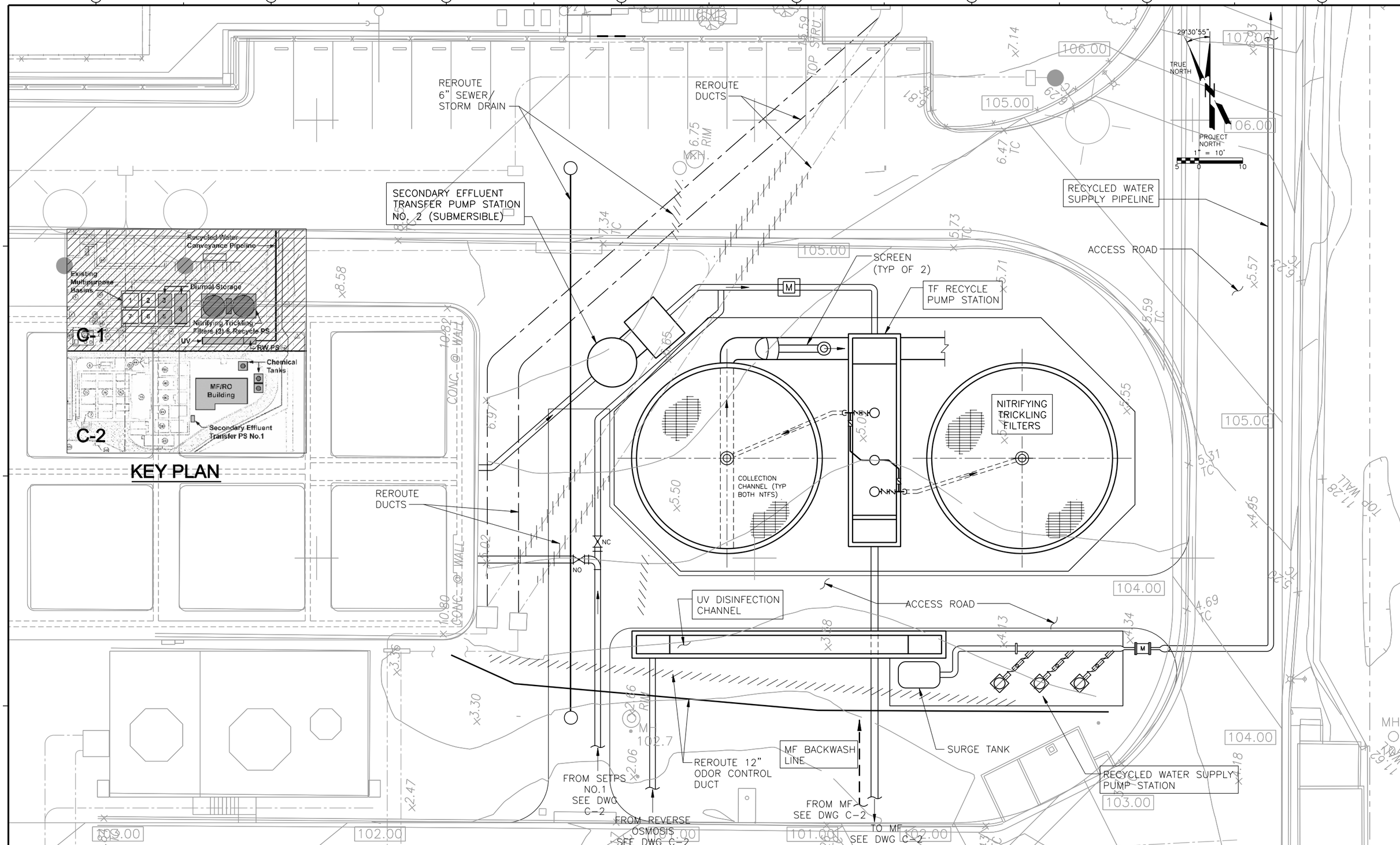

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WATER REUSE PROJECT
PHASE 1

PRELIMINARY SITE PLAN
PARTIAL AREA PLAN III

SHEET 1 OF --- SHEETS
SHEET ID C-1

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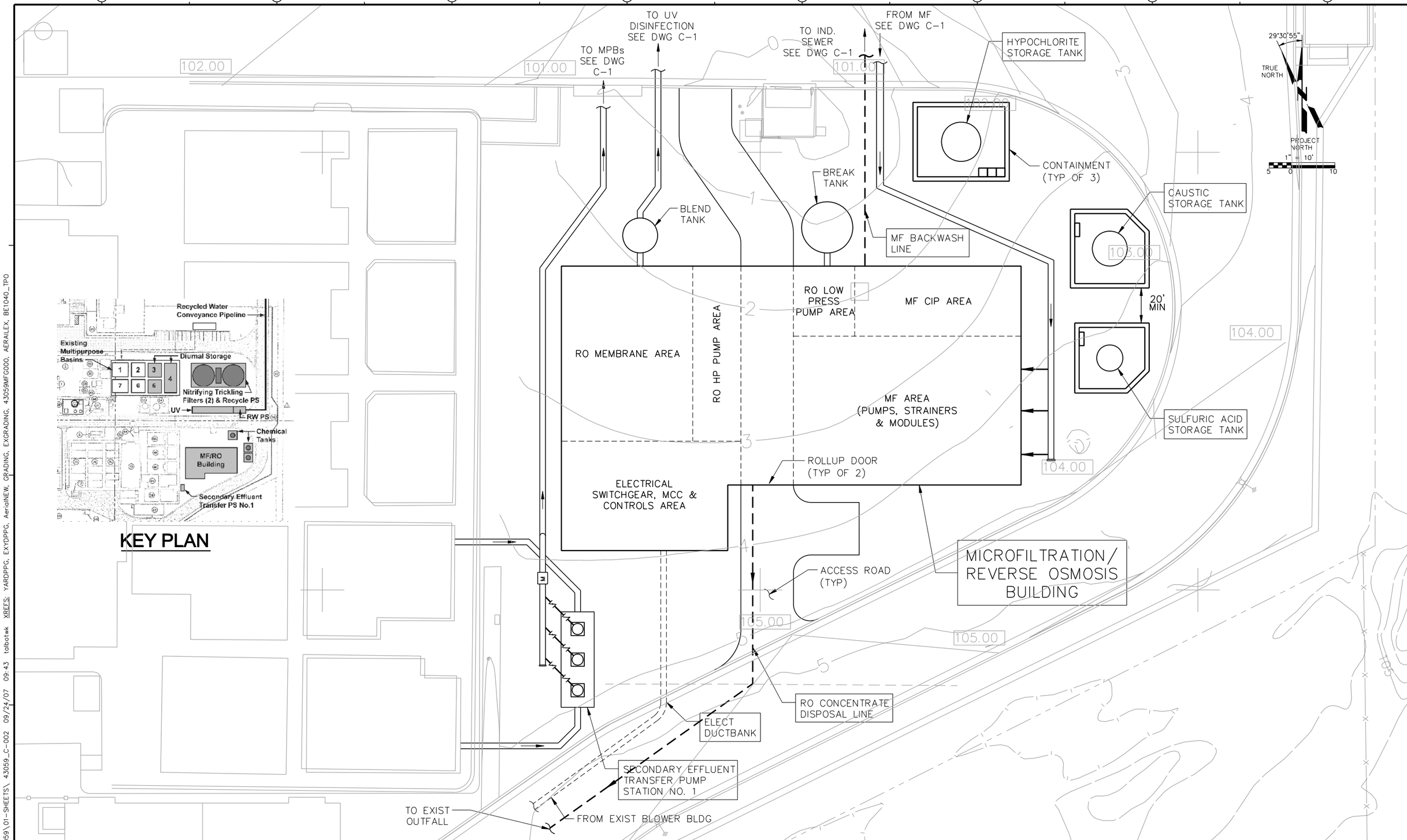

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WATER REUSE PROJECT
PHASE 1

PRELIMINARY SITE PLAN
PARTIAL AREA PLAN IV

SHEET 1 OF ___ SHEETS
SHEET ID
C-2

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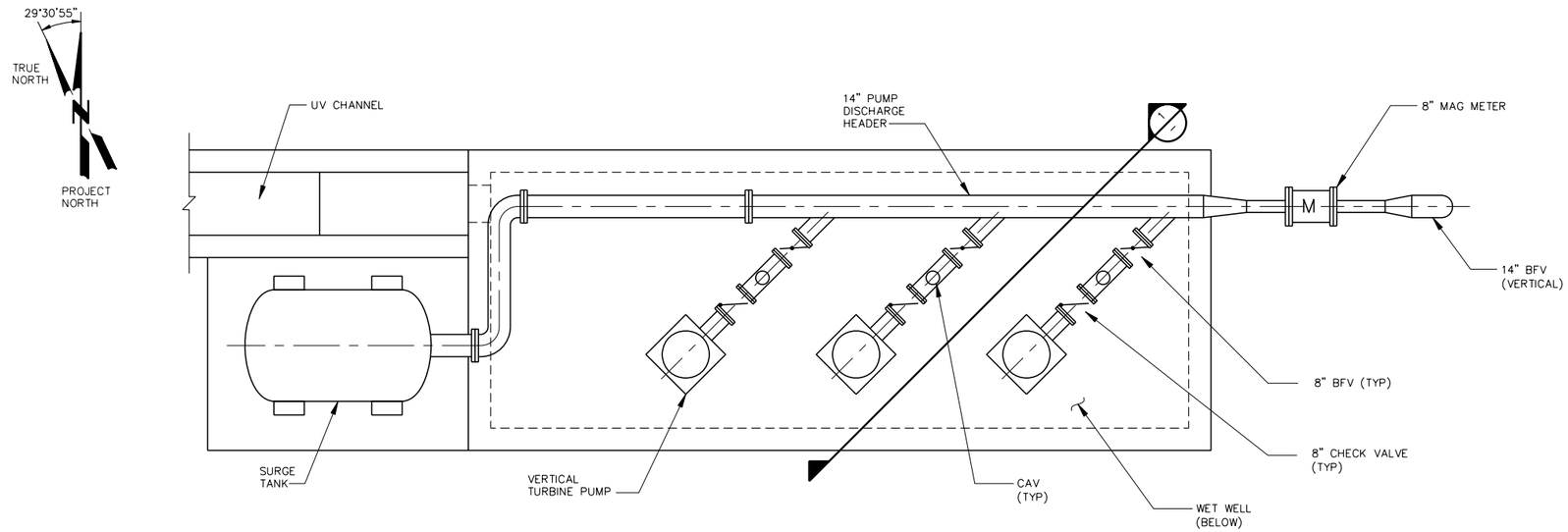
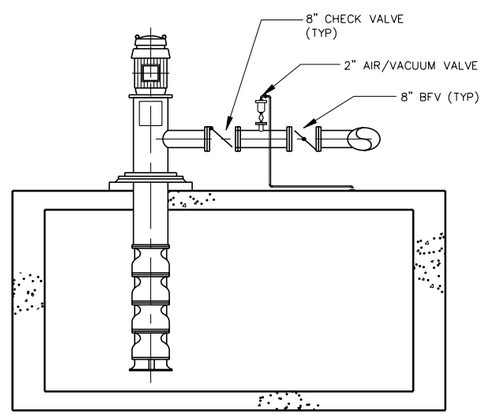


PLAN
1/4" = 1'-0"



SECTION 1
1/4" = 1'-0"

REV. NO.	DATE	DRWN	CHKD	REMARKS

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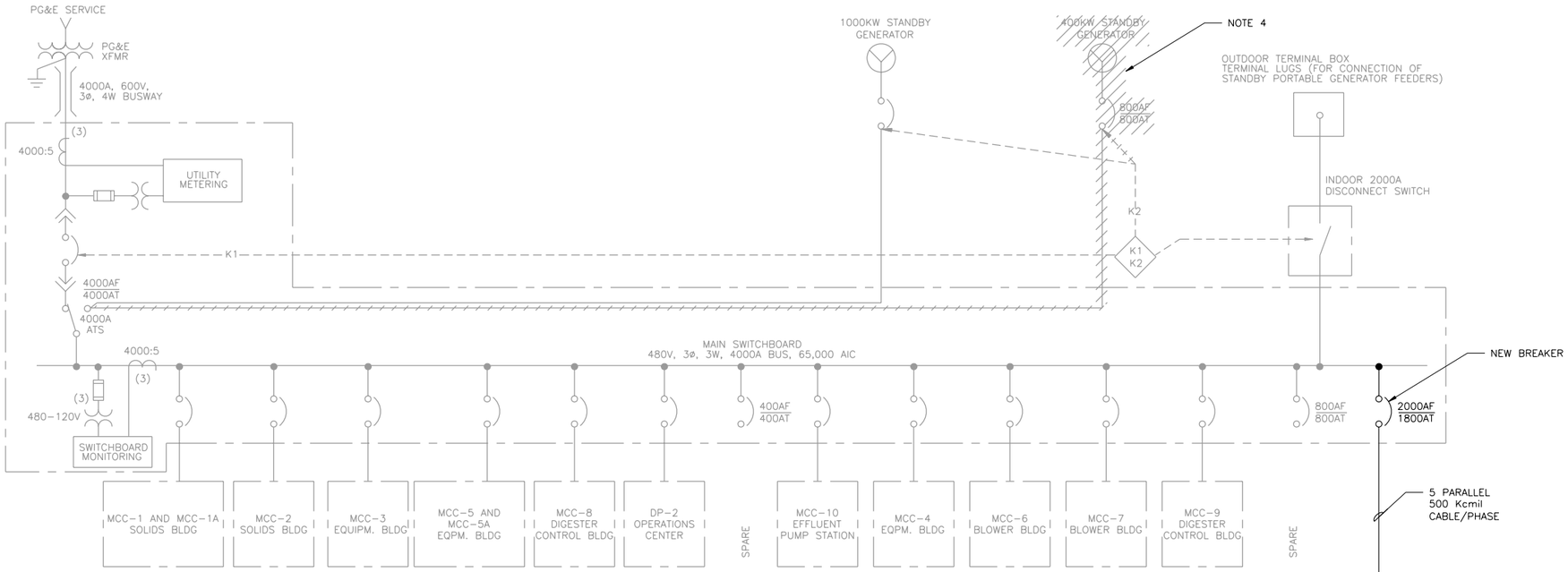
WATER REUSE PROJECT
PHASE 1

RECYCLED WATER PUMP STATION
MECHANICAL PLAN & SECTION

SHEET 1 OF ___ SHEETS
SHEET ID
M-1

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_M-001 09/19/07 10:10 nguyentv XREFS: 43059MFG000

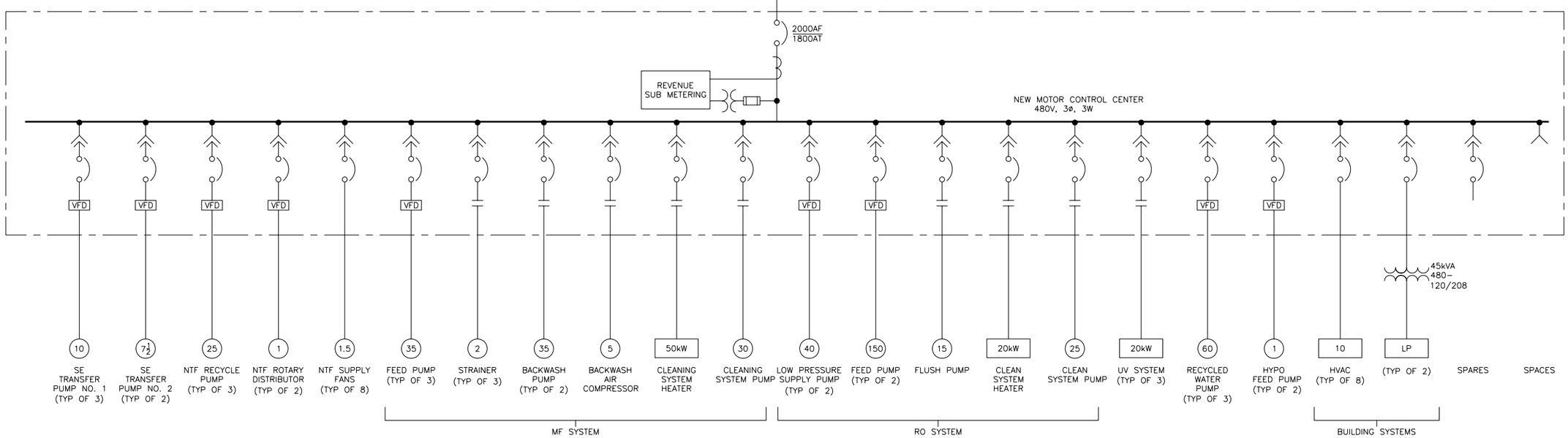


EXISTING PLANT SINGLE LINE

(NOTES 1 & 2)

NOTES:

1. NOT ALL EXISTING MCC AND LOADS ARE SHOWN.
2. EXISTING ELECTRICAL DISTRIBUTION SYSTEM DETAILS SHOWN HAVE BEEN TAKEN FROM CAROLLO RECORD DRAWINGS FOR BENICIA WWTP IMPROVEMENTS PROJECT (JUNE 1998). INFORMATION HAS NOT BEEN FIELD VERIFIED.
3. NEW EQUIPMENT SHOWN IN BOLD LINES & EXISTING EQUIPMENT SHOWN IN LIGHT LINES.
4. EXISTING GENERATOR, INDICATED BY PLANT STAFF TO BE REMOVED IN THE FUTURE.



NEW WATER REUSE SYSTEMS – SINGLE LINE

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
0 1/2 1"
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

CDM Camp Dresser & McKee Inc.
transiting engineering construction operations
100 PRINGLE AVENUE
WALNUT CREEK, California 94596
Tel (925) 933-2900
Fax (925) 933-4174

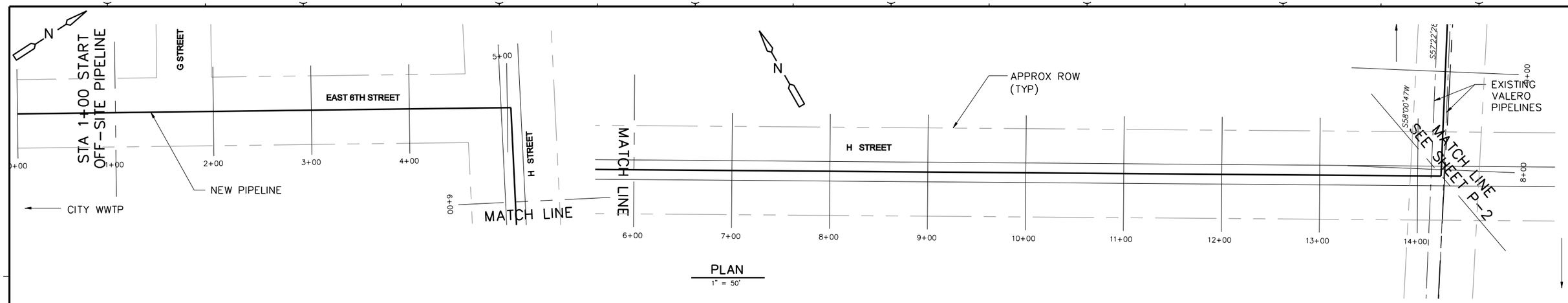
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

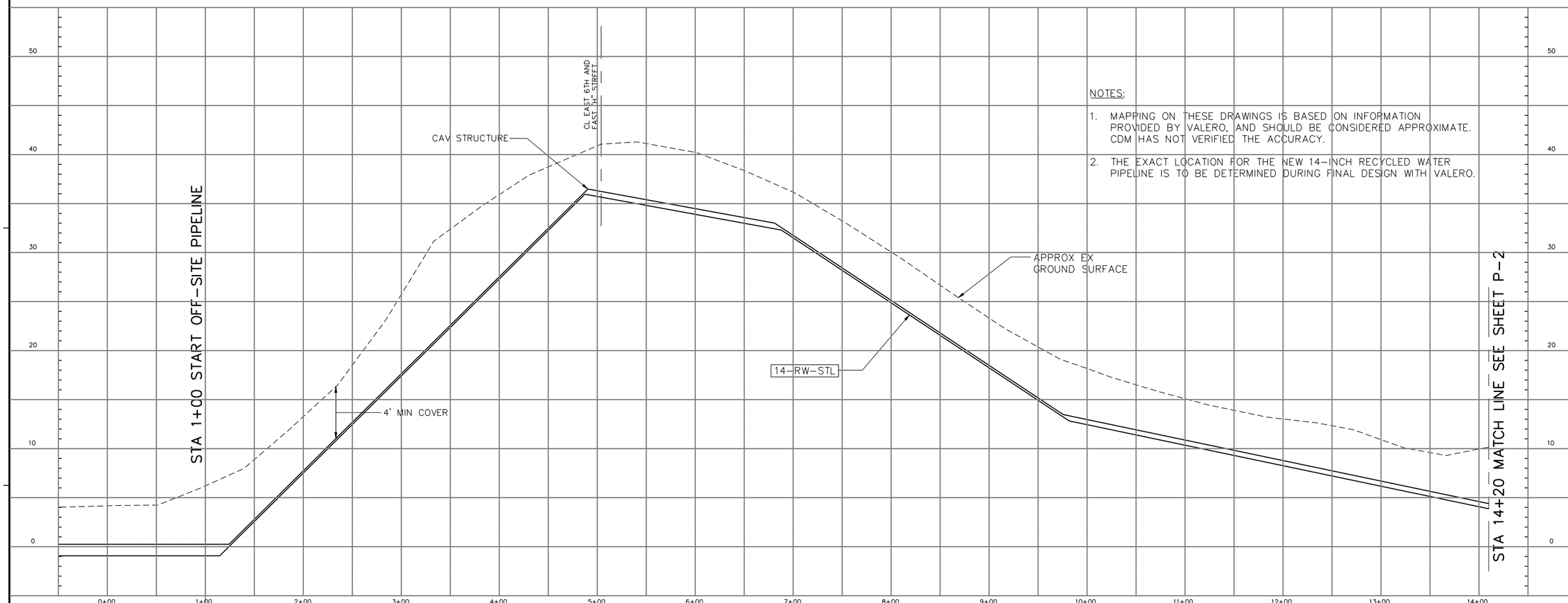
ELECTRICAL DISTIBUTION SINGLE LINE

SHEET 1 OF ___ SHEETS
SHEET ID
E-1

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_E-001 09/20/07 14:53 marshallkm XREFS: 43059MFG000



PLAN
1" = 50'



NOTES:

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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
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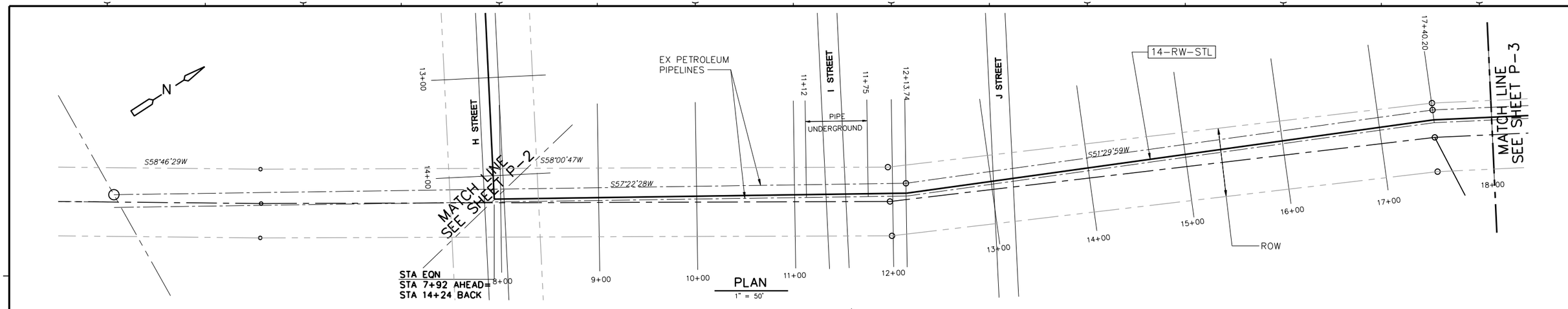
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

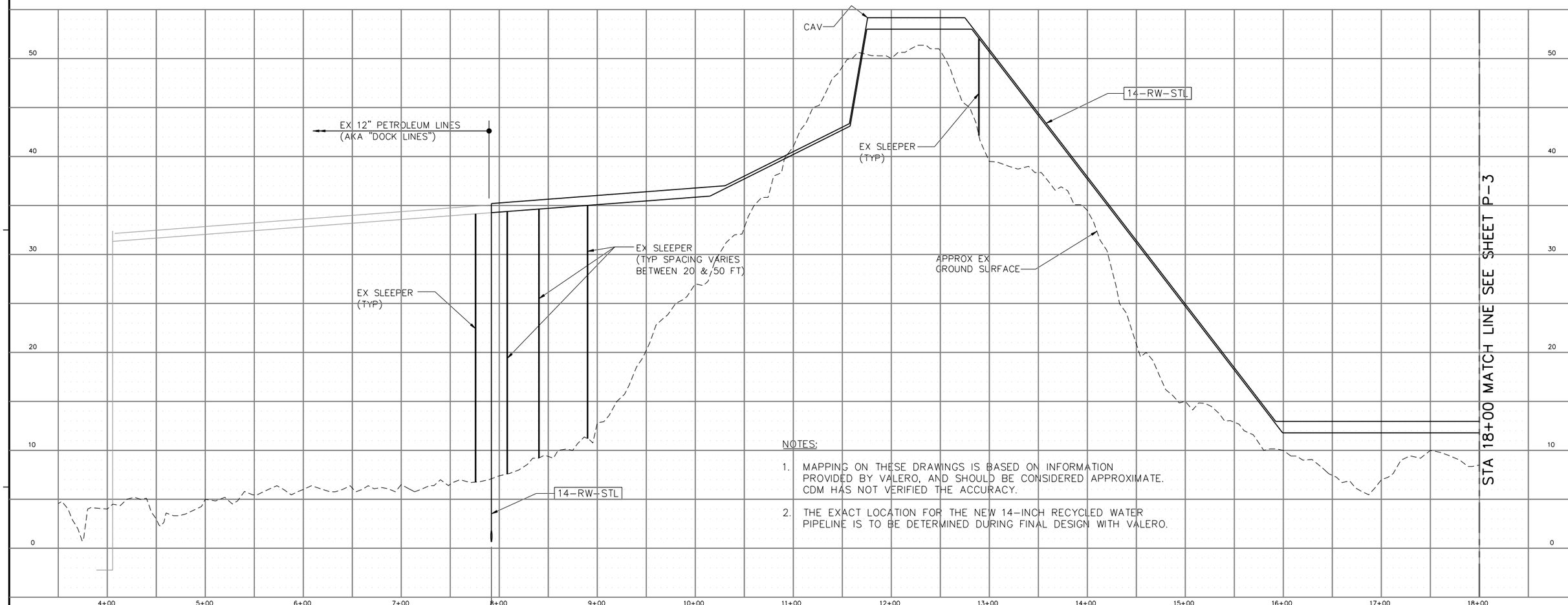
PLAN AND PROFILE
STA 1+00 TO STA 14+20

SHEET 1 OF ___ SHEETS
SHEET ID
P-1

N:\ACAD2000\2161\43059\01-SHEETS\43059_P-001 09/06/07 13:40 weiner.jo XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'



PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

NOTES:

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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
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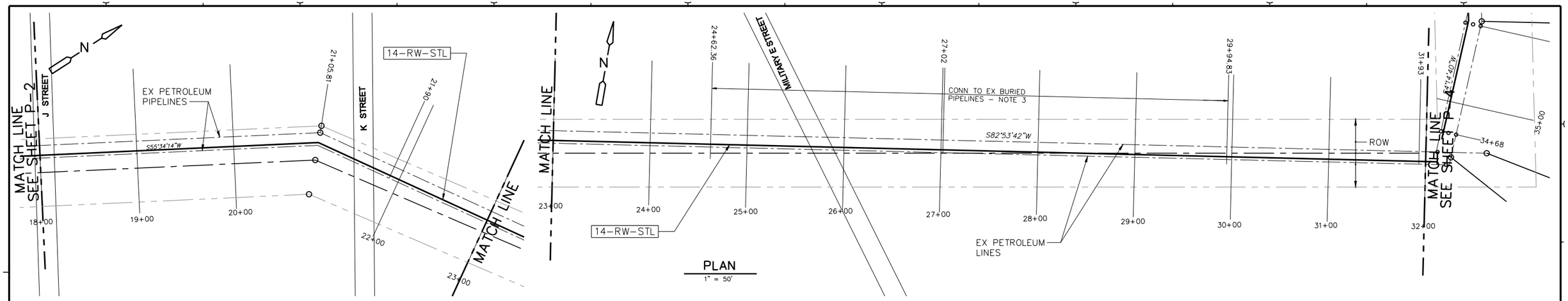
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

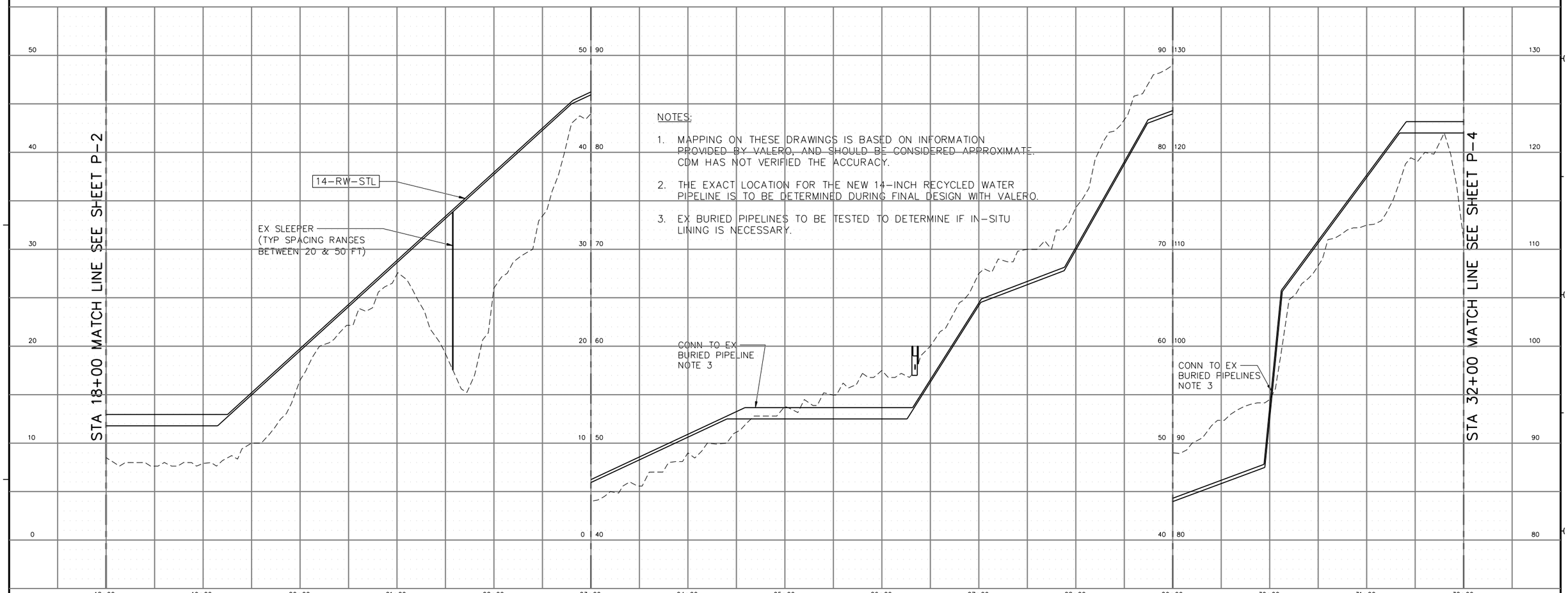
PLAN AND PROFILE
STA 7+92 TO STA 18+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-2

N:\ACAD2000\216\43059\01-SHEETS\ 43059_P-002 09/06/07 13:42 weiner.jp XREFS: 43059MFC000, PROFILE



PLAN
1" = 50'



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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.
3. EX BURIED PIPELINES TO BE TESTED TO DETERMINE IF IN-SITU LINING IS NECESSARY.

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

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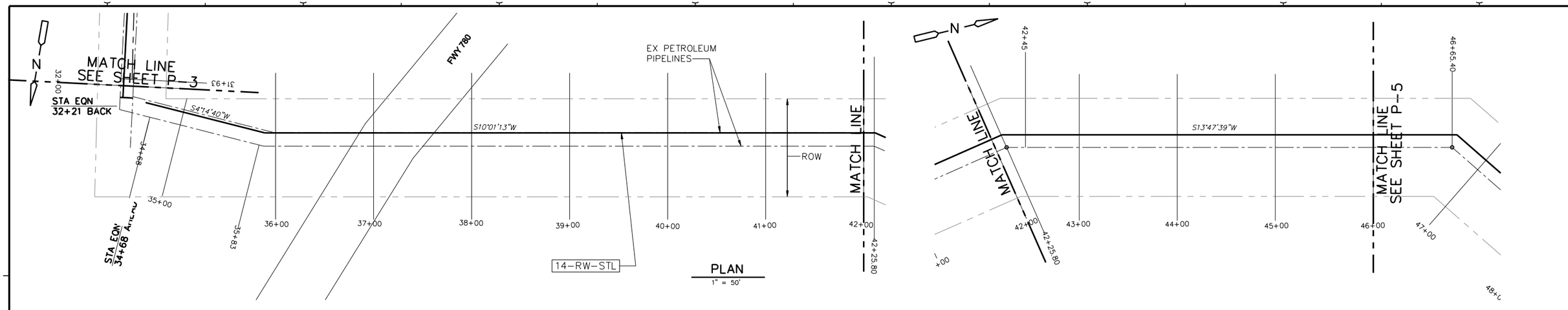
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

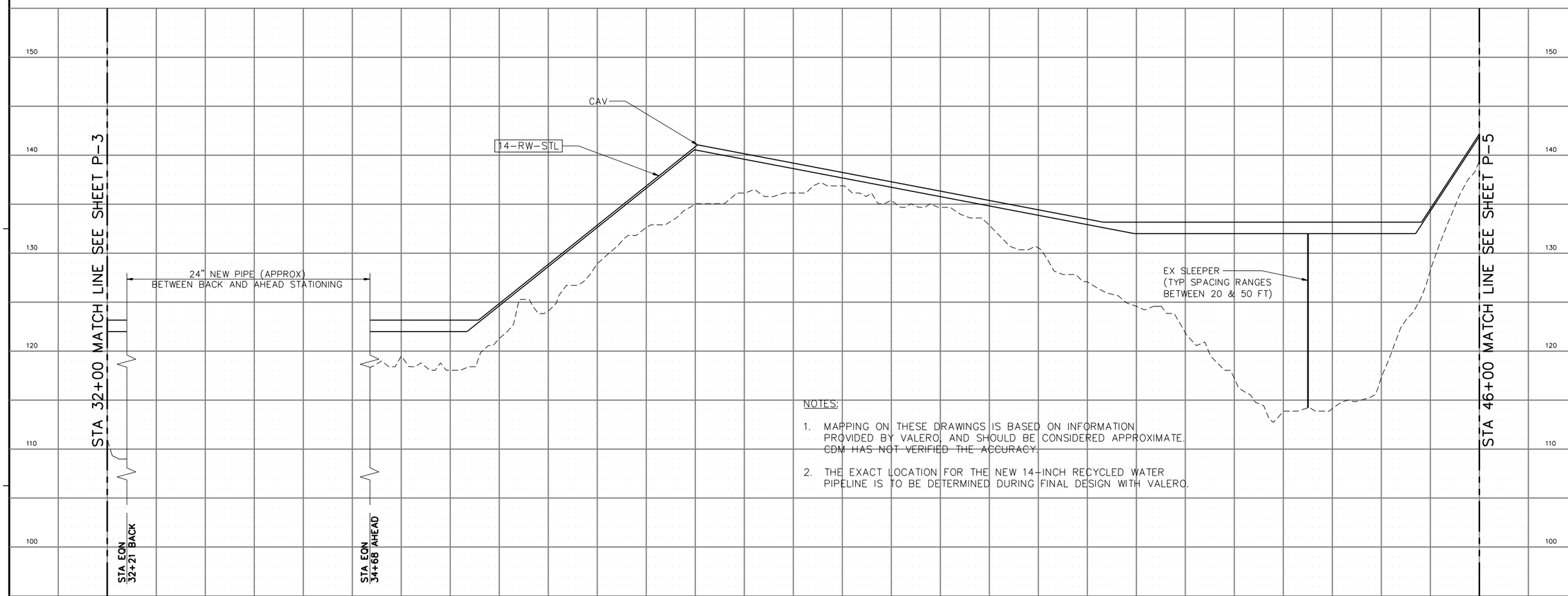
PLAN AND PROFILE
STA 18+00 TO STA 32+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-3

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_P-003 09/06/07 13:45 weiner.p XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'



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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
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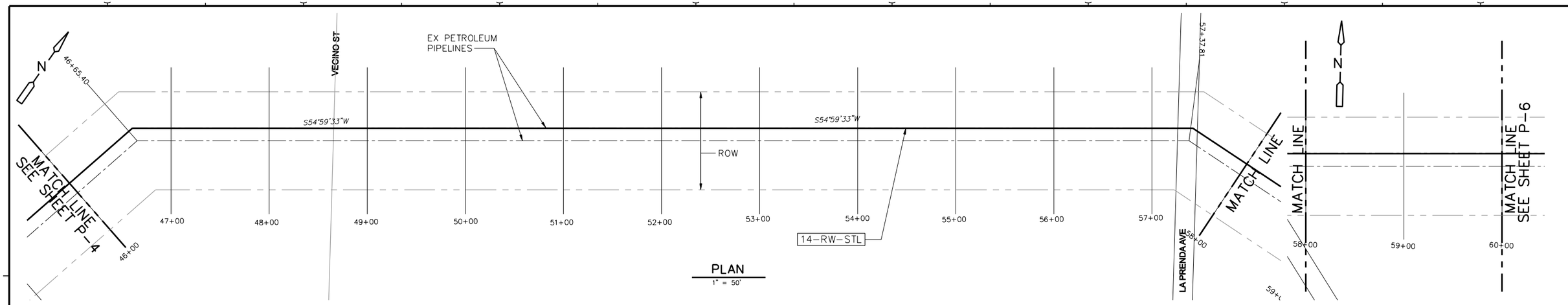
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

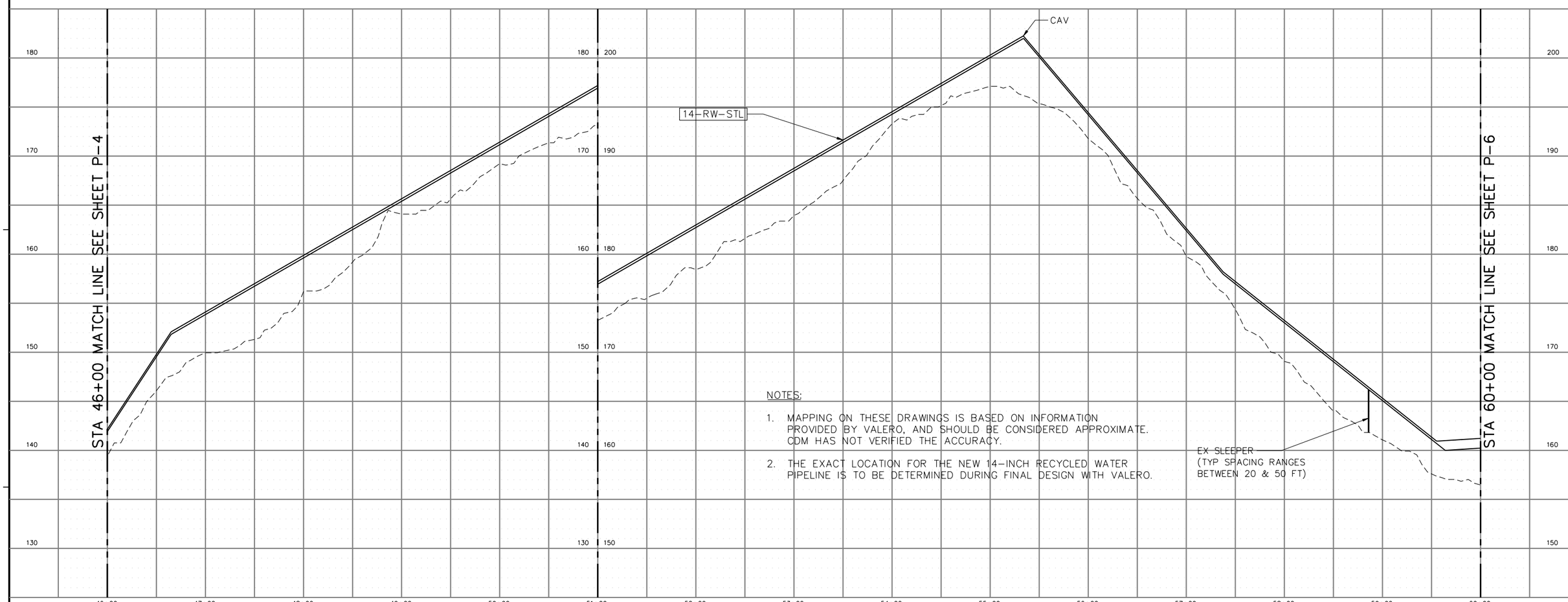
PLAN AND PROFILE
STA 32+00 TO STA 46+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-4

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_P-004 09/04/07 17:21 weinerja XREFS: 43059WFG000, PROFILE



PLAN
1" = 50'



NOTES:

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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

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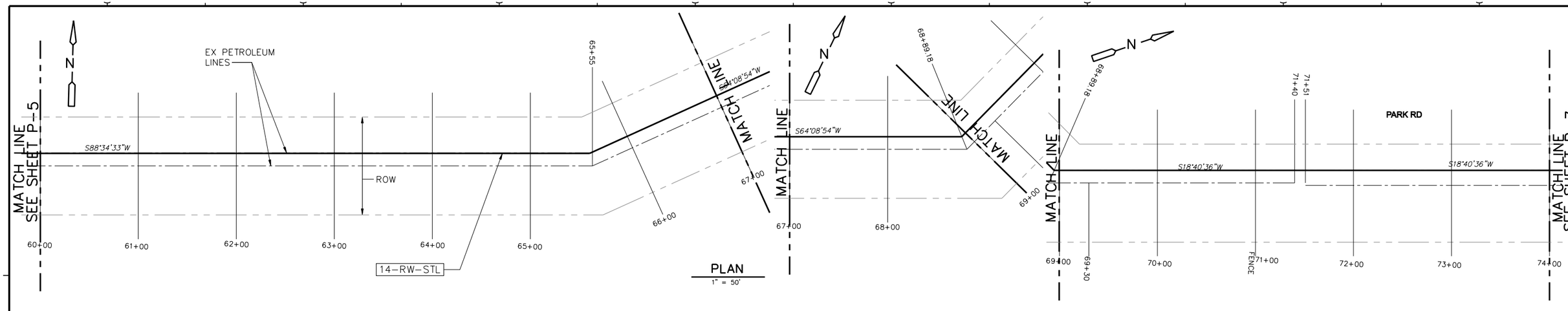
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

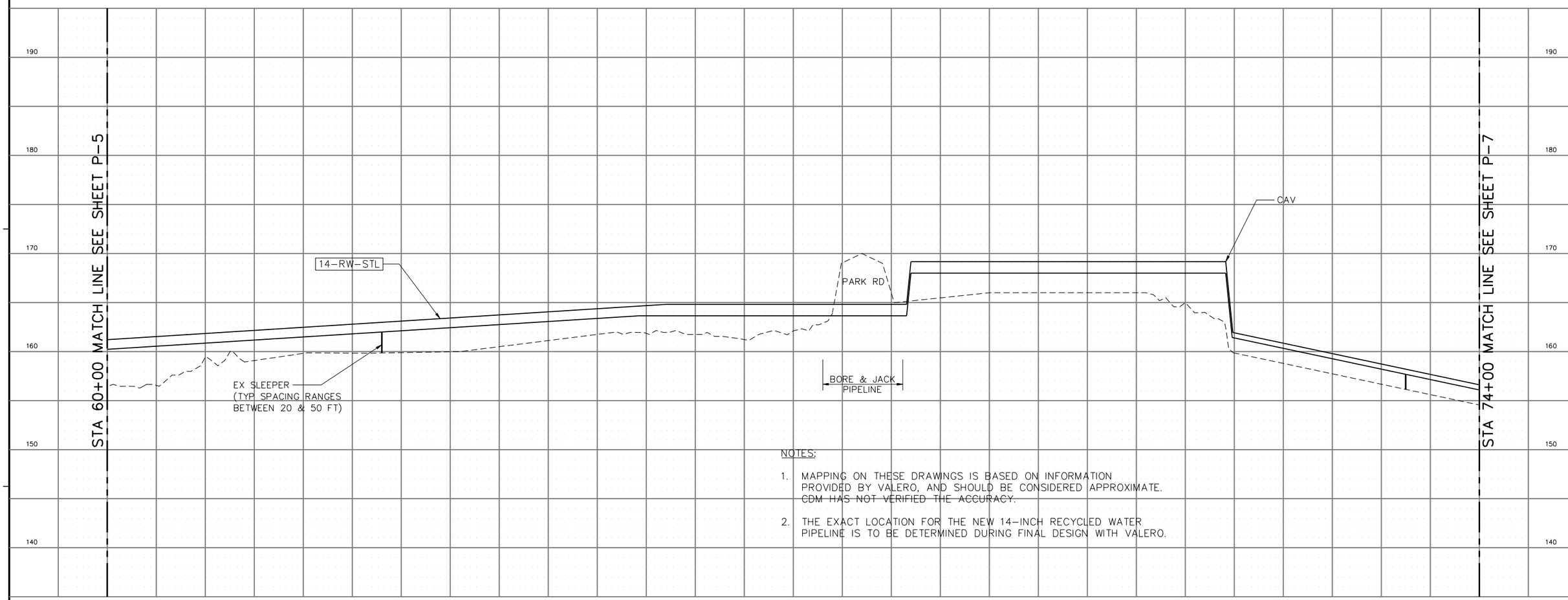
PLAN AND PROFILE
STA 46+00 TO STA 60+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-5

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_P-005 09/06/07 14:16 weinerjo XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'



NOTES:

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PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
0 1/2 1"
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consulting engineering construction operations
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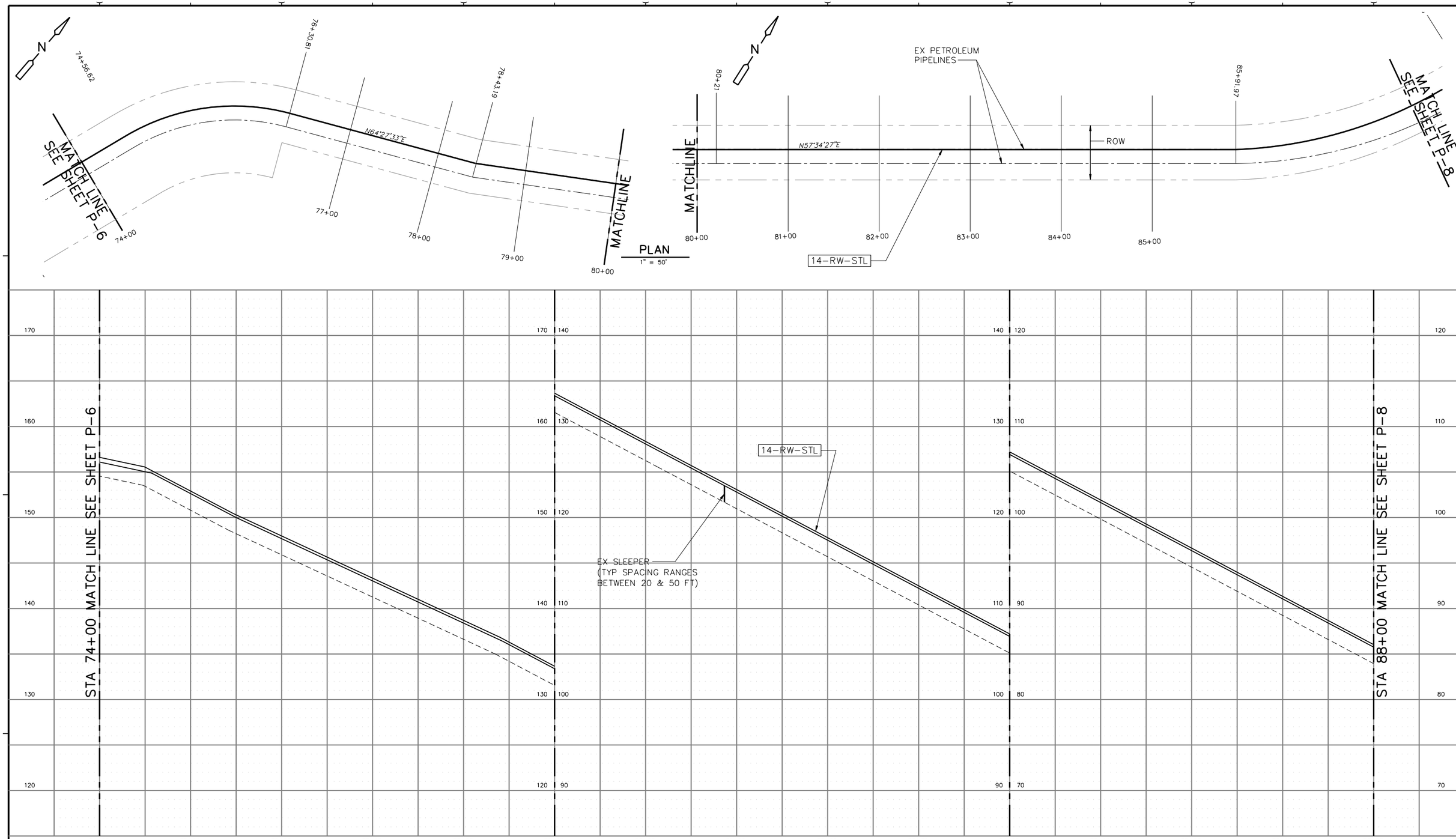
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

PLAN AND PROFILE
STA 60+00 TO STA 74+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-6

N:\ACAD2000\216\43059\01-SHEETS\ 43059_P-006 09/06/07 14:27 weiner.jo XREFS: 43059MFG000, PROFILE



REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
0 1/2 1"
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Fax (925) 933-4174

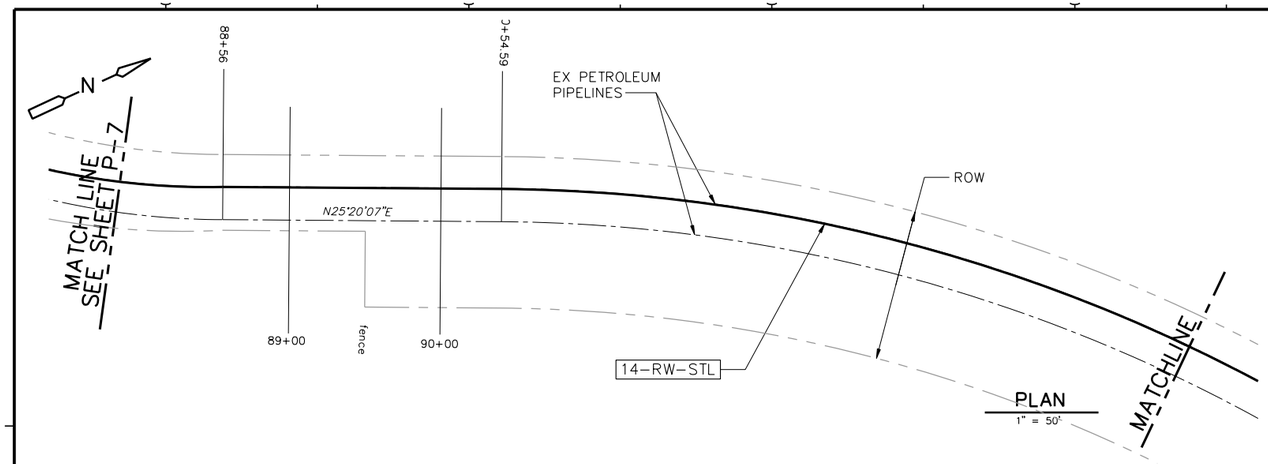
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

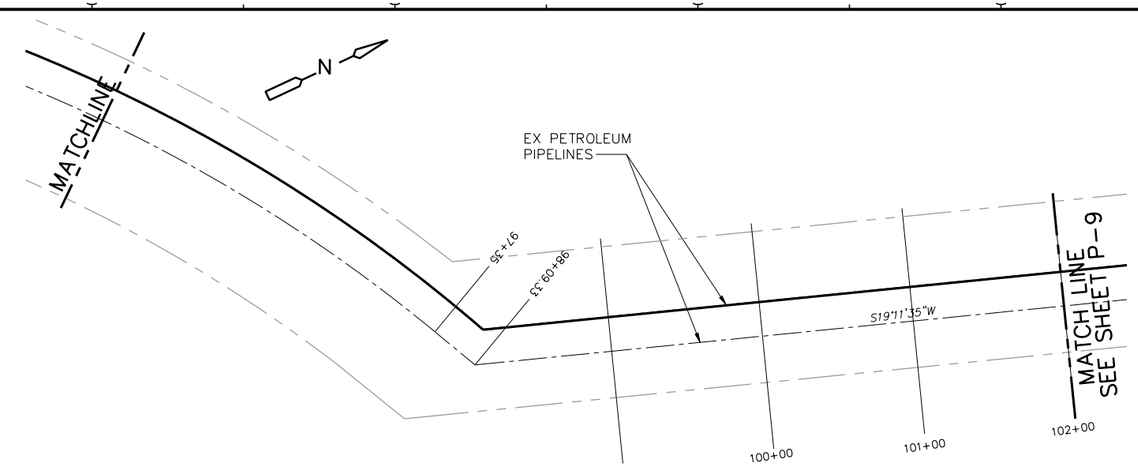
PLAN AND PROFILE
STA 74+00 TO STA 88+00

SHEET 1 OF ___ SHEETS
SHEET ID
P-7

N:\ACAD2000\216\43059\01-SHEETS\ 43059_P-007 09/06/07 14:35 weiner.jo XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'



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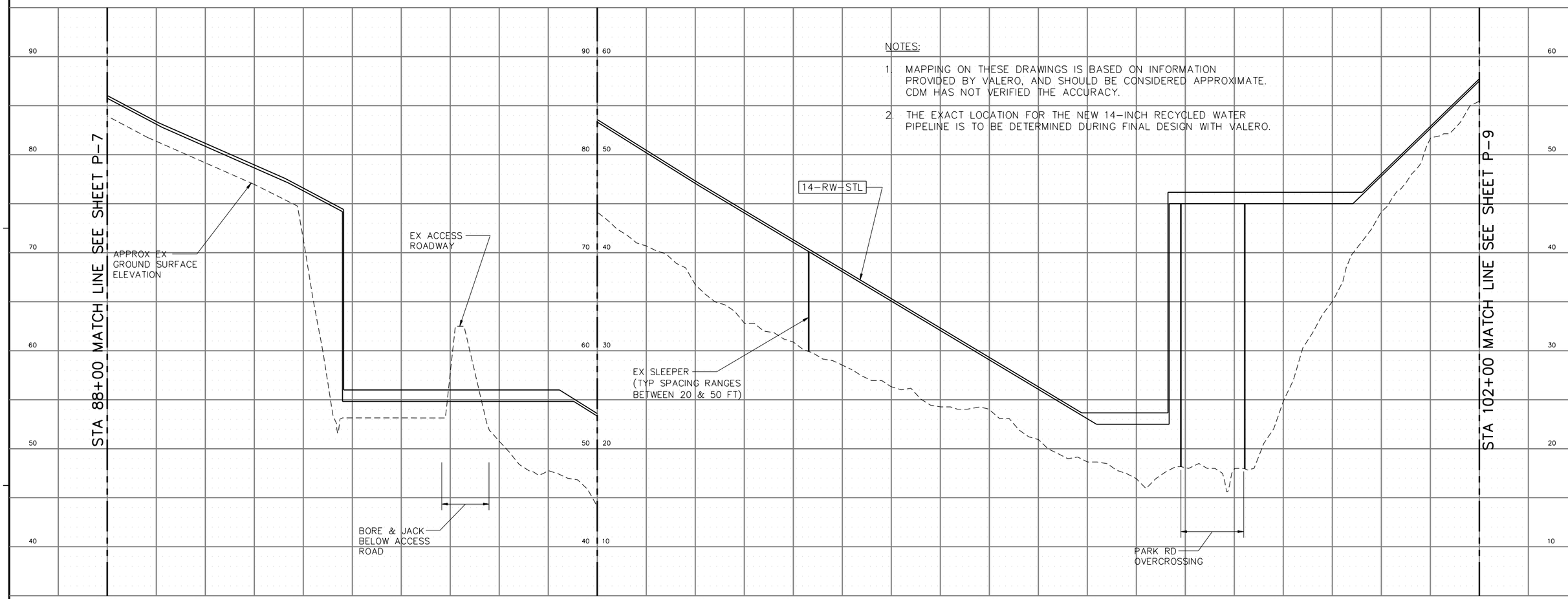

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

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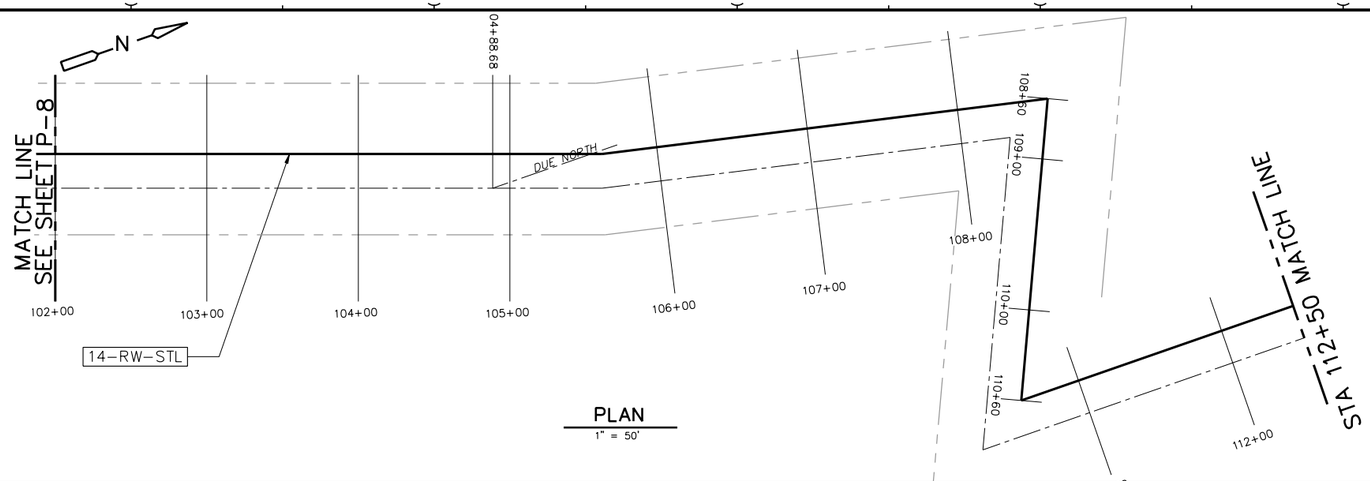
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

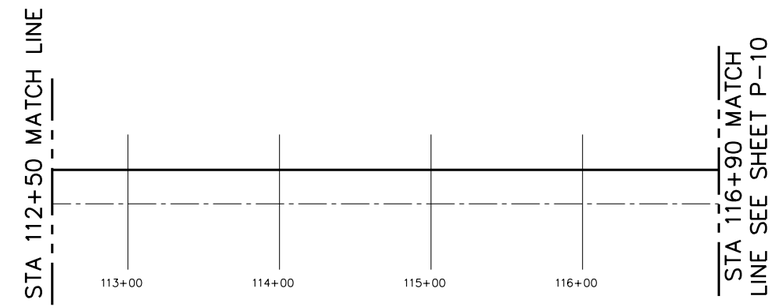
PLAN AND PROFILE
STA 88+00 TO STA 102+00

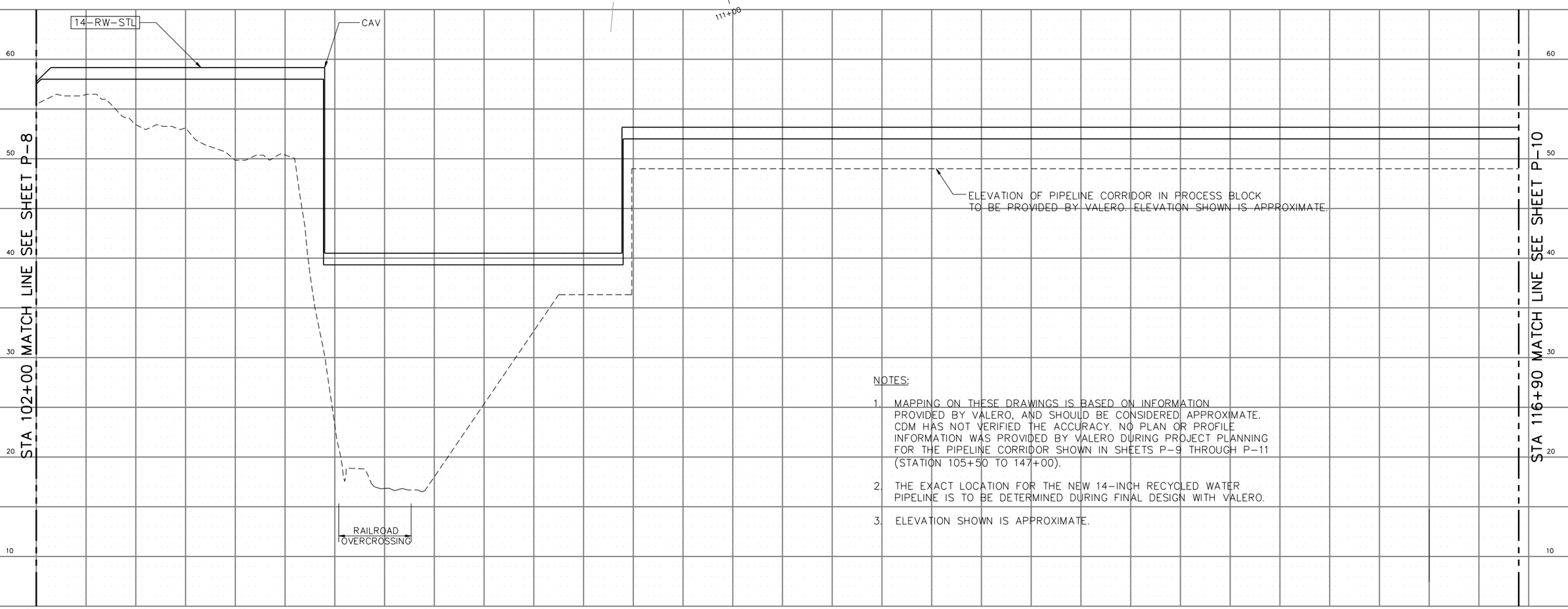
SHEET 1 OF ___ SHEETS
SHEET ID
P-8

N:\ACAD2000\2161\43059\01-SHEETS\ 43059_P-008 09/04/07 17:26 weiner.jo XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'





PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

NOTES:

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2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.
3. ELEVATION SHOWN IS APPROXIMATE.

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
0 1/2 1"
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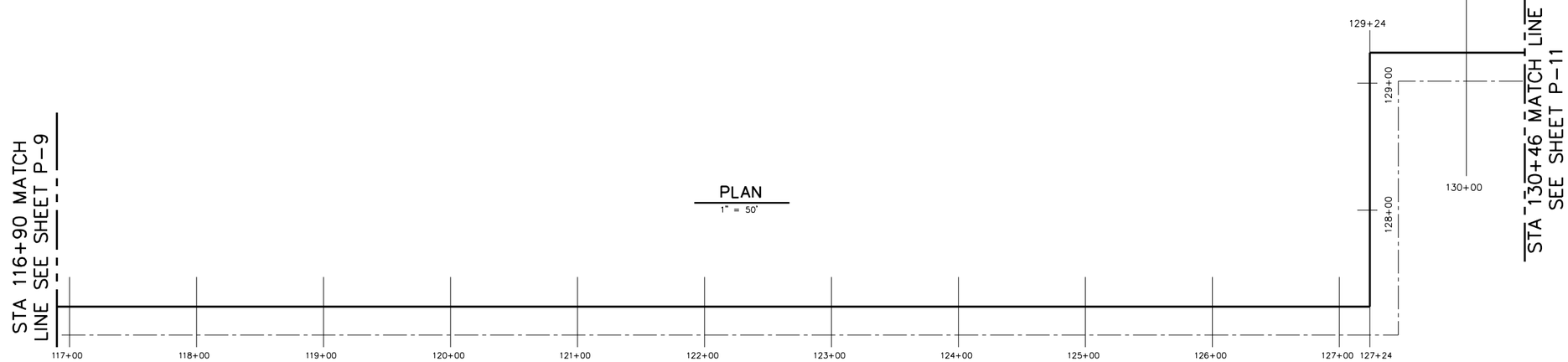
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

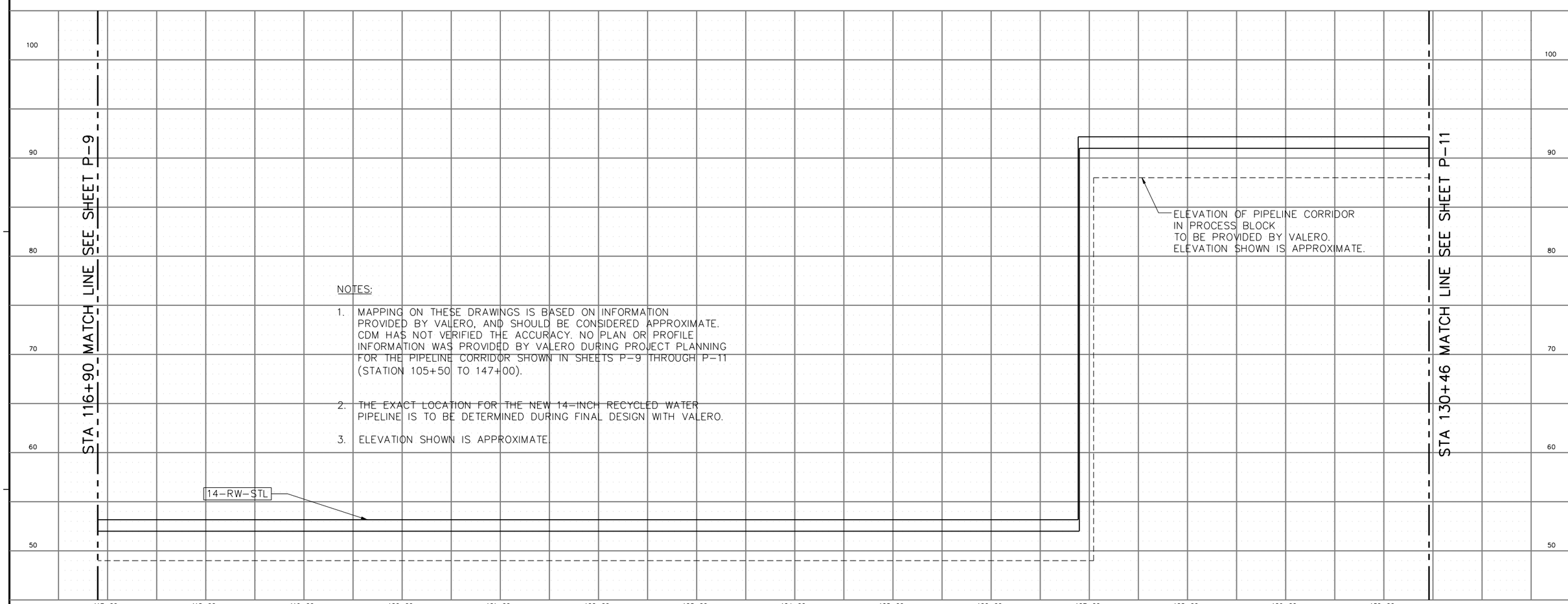
WATER REUSE PROJECT
PHASE 1

PLAN AND PROFILE
STA 102+00 TO STA 116+90

SHEET 1 OF ___ SHEETS
SHEET ID
P-9

N:\ACAD2000\216\43059\01-SHEETS\ 43059_P-009 09/20/07 17:15 talbotwk XREFS: 43059MFG000, PROFILE





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3. ELEVATION SHOWN IS APPROXIMATE.

PROFILE

SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

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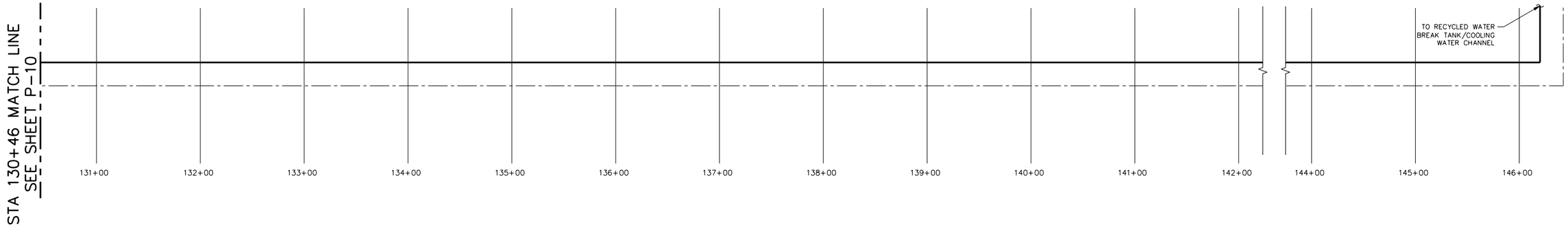
THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

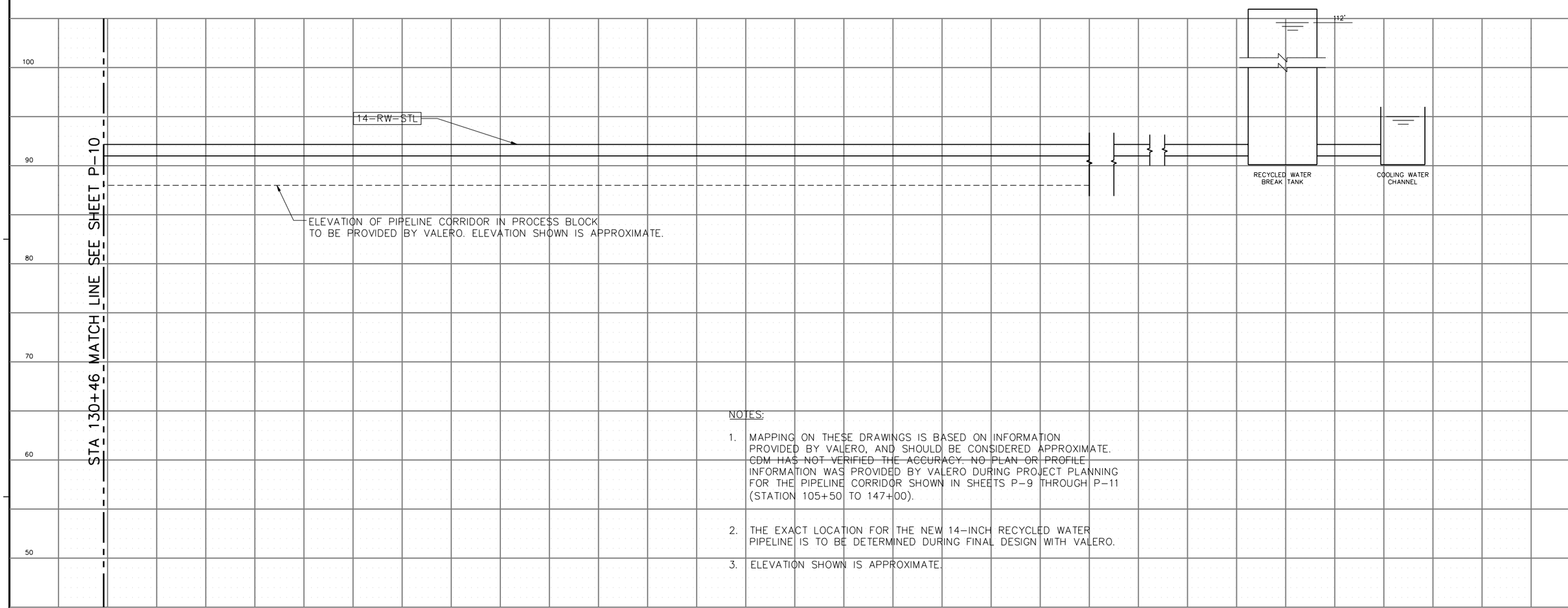
PLAN AND PROFILE
STA 116+90 TO STA 130+46

SHEET 1 OF ___ SHEETS
SHEET ID
P-10

N:\ACAD2000\216\43059\01-SHEETS\ 43059_P-010 09/20/07 16:43 talbotwk XREFS: 43059MFG000, PROFILE



PLAN
1" = 50'



NOTES:

1. MAPPING ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY VALERO, AND SHOULD BE CONSIDERED APPROXIMATE. CDM HAS NOT VERIFIED THE ACCURACY. NO PLAN OR PROFILE INFORMATION WAS PROVIDED BY VALERO DURING PROJECT PLANNING FOR THE PIPELINE CORRIDOR SHOWN IN SHEETS P-9 THROUGH P-11 (STATION 105+50 TO 147+00).
2. THE EXACT LOCATION FOR THE NEW 14-INCH RECYCLED WATER PIPELINE IS TO BE DETERMINED DURING FINAL DESIGN WITH VALERO.
3. ELEVATION SHOWN IS APPROXIMATE.

PROFILE
SCALE: HOR 1" = 50'
VRT 1" = 5'

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: JC
DRAWN BY: JAW
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: MAR 2008

WARNING
0 1/2 1"
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

CDM Camp Dresser & McKee Inc.
transulting engineering construction operations
100 PRINGLE AVENUE
WALNUT CREEK, California 94596
Tel (925) 933-2900
Fax (925) 933-4174

THE CITY OF BENICIA
250 EAST L STREET
BENICIA, CALIFORNIA 94510

WATER REUSE PROJECT
PHASE 1

PLAN AND PROFILE
STA 130+46 TO STA 146+20

SHEET 1 OF ___ SHEETS
SHEET ID
P-11

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Appendix B

City of Benicia Noise Ordinance and City General Plan, Chapter 4 Community Health and Safety, Paragraph D Noise

Chapter 8.20
NOISE REGULATIONS[1]

Sections:

8.20.010 Declaration of policy.
8.20.020 Definitions.
8.20.030 Sound-amplifying equipment – Purpose of provisions.
8.20.040 Sound-amplifying equipment – Registration – Required.
8.20.050 Sound-amplifying equipment – Registration – Statement filing and approval.
8.20.060 Sound-amplifying equipment – Registration – Fee.
8.20.070 Sound-amplifying equipment – Appeal from disapproval.
8.20.080 Sound-amplifying equipment – Use regulations.
8.20.090 Radios, television sets and similar devices.
8.20.100 Hawkers and peddlers.
8.20.110 Drums – Use restricted.
8.20.120 Schools, hospitals and churches.
8.20.130 Animals and fowl.
8.20.140 Machinery, equipment, fans and air conditioning.
8.20.150 Construction of buildings and projects.
8.20.160 Vehicle repairs.
8.20.170 Motor-driven vehicles.
8.20.180 Sound level measurement criteria.
8.20.190 Ambient base noise level.
8.20.200 Excessive noise prohibited.
8.20.210 Petition for temporary relief from regulations.
8.20.220 Repealed.
8.20.230 Violation – Additional remedy.

8.20.010 Declaration of policy.

It is declared to be the policy of the city to prohibit unnecessary, excessive and annoying noises from all sources subject to its police power. At certain levels noises are detrimental to the health and welfare of the citizenry and in the public interests shall be systematically proscribed. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-101).

8.20.020 Definitions.

As used in this chapter, unless the context otherwise clearly indicates, the words and phrases used in this chapter are defined as follows:

A. "Ambient noise" means the all-encompassing noise associated with a given environment, being usually a composite of sounds from any sources near and far. For the purpose of this chapter, ambient noise level is the level obtained when the noise level is averaged over a period of 15 minutes without inclusion of noise from isolated identifiable sources, at the location and time of day near that at which a comparison is to be made.

B. "Commercial purpose" means and includes the use, operation or maintenance of any sound-amplifying equipment for the purpose of advertising any business, or any goods, or any services, or for the purpose of attracting the attention of the public to, or advertising for, or soliciting patronage or customers to or for any performance, show, entertainment, exhibition, or event, or for the purpose of demonstrating such sound equipment.

C. "Decibel" means a unit of level when the base of the logarithm is the tenth root of 10 and the quantities concerned are proportional to power.

D. "Emergency work" means work made necessary to restore property to a safe condition following a public calamity, or work required to protect persons or property from an imminent exposure to danger, or work by private or public utilities when restoring utility service.

E. "Frequency" of a function periodic in time means the reciprocal of the primitive period. The unit is the hertz and shall be specified.

F. "Hertz" means the complete sequence of values of a periodic quantity which occurs during a period.

G. "Microbar" means a unit of pressure commonly used in acoustics and is equal to one dyne per square centimeter.

H. "Motor vehicles" includes, but is not limited to, mini-bikes and go-carts.

I. "Noncommercial purpose" means the use, operation or maintenance of any sound equipment for other than a commercial purpose. "Noncommercial purpose" means and includes, but is not limited to, philanthropic, political, patriotic and charitable purposes.

J. "Period" of a periodic quantity means the smallest increment of time for which the function repeats itself.

K. "Periodic quantity" means oscillating quantity, the values of which recur for equal increments of time.

L. "Person" means a person, firm, association, copartnership, joint venture, corporation, or any entity public or private in nature.

M. "Sound-amplifying equipment" means any machine or device for the amplification of the human voice, music, or any other sound. "Sound-amplifying equipment" shall not include standard automobile radios when used and heard only by the occupants of the vehicle in which the automobile radio is installed. "Sound-amplifying equipment," as used in this chapter, shall not include warning devices on authorized emergency vehicles or horns or other warning devices on any vehicle used only for traffic safety purposes.

N. "Sound level" or "noise level," in decibels (dB), is the sound measured with the "A" weighting and slow response by a sound level meter.

O. "Sound level meter" means an instrument including a microphone, an amplifier, an output meter, and frequency weighting networks for the measurement of sound levels which satisfies the pertinent requirements in American Standard Specifications for sound level meters S1.4-1971 or the most recent revision thereof.

P. "Sound truck" means any motor vehicle, or any other vehicle regardless of motive power, whether in motion or stationary, having mounted thereon or attached thereto any sound-amplifying equipment. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-102).

8.20.030 Sound-amplifying equipment – Purpose of provisions.

The council enacts this legislation for the sole purpose of securing and promoting the public health, comfort, safety and welfare of its citizenry. While recognizing that the use of sound-amplifying equipment is protected by the constitutional rights of freedom of speech and assembly, the council nevertheless feels obligated to reasonably regulate corrective constitutional rights of the citizens of this community to privacy and freedom from public nuisance of loud and unnecessary noise. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-501).

8.20.040 Sound-amplifying equipment – Registration – Required.

It is unlawful for any person, other than personnel of law enforcement or governmental agencies, to install, use or operate within the city a loudspeaker or sound-amplifying equipment in a fixed or movable position or mounted upon any sound truck for the purposes of giving instructions, directions, talks, addresses, lectures, or transmitting music to any person or assemblages of persons in or upon any street, alley, sidewalk, park, place or public property without first filing a registration statement and obtaining approval thereof as set forth in BMC 8.20.050 through 8.20.080. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-502).

8.20.050 Sound-amplifying equipment – Registration – Statement filing and approval.

A. Every user of sound-amplifying equipment shall file a registration statement with the city manager or his designee 15 days prior to the date on which the sound-amplifying equipment is intended to be used, which statement shall contain the following information:

1. The name, address and telephone number of both the owner and user of the sound-amplifying equipment;

2. The maximum sound-producing power of the sound-amplifying equipment which shall include the wattage to be used, the volume in decibels of sound which will be produced,

and the approximate distance for which sound will be audible from the sound-amplifying equipment;

3. The license and motor number if a sound truck is to be used;

4. A general description of the sound-amplifying equipment which is to be used; and

5. Whether the sound-amplifying equipment will be used for commercial or noncommercial purposes.

B. The city manager, or his designee, shall return to the applicant an approved certified copy of the registration statement unless he finds that:

1. The conditions of the motor vehicle movement are such that in the opinion of the city manager, use of the equipment would constitute a detriment to traffic safety; or

2. The conditions of pedestrian movement are such that use of the equipment would constitute a detriment to traffic safety; or

3. The registration statement required reveals that the applicant would violate the provisions set forth in BMC 8.20.080 or any other provisions of this code.

C. In the event the registration statement is disapproved, the city manager or his designee shall enforce upon the statement his reasons for disapproval and return it forthwith to the applicant. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-503).

8.20.060 Sound-amplifying equipment – Registration – Fee.

Prior to the issuance of the registration statement, a fee in the amount of $25.00 per day, or any portion thereof, shall be paid to the city, if the loudspeaker or sound-amplifying equipment is to be used for commercial purposes. No fee shall be required for the operation of a loudspeaker or sound-amplifying equipment for noncommercial purposes. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-505).

8.20.070 Sound-amplifying equipment – Appeal from disapproval.

Any person aggrieved by disapproval of a registration statement may appeal the disapproval to the city council within 10 days. The appeal shall be filed with the city clerk and placed on the next regular council meeting agenda for review. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-504).

8.20.080 Sound-amplifying equipment – Use regulations.

The commercial and noncommercial use of sound-amplifying equipment shall be subject to the following regulations:

A. The only sounds permitted shall be either music or human speech, or both.

B. The operation of sound-amplifying equipment shall only occur between the hours of 9:00 a.m. and 8:00 p.m. each day except on Sundays and legal holidays. No operation of sound-amplifying equipment for commercial purposes shall be permitted on Sundays or legal holidays. The operation of sound-amplifying equipment for noncommercial purposes on Sundays and legal holidays shall only occur between the hours of 9:00 a.m. and 9:00 p.m.

C. Sound levels emanating from sound-amplifying equipment shall not exceed 15 decibels above the ambient base noise level.

D. Notwithstanding the provisions of subsection (C) of this section, sound-amplifying equipment shall not be operated within 200 feet of churches, schools, hospitals, or city or county buildings unless specifically authorized by the city manager or his designee.

E. In any event, the volume of sound shall be so controlled that it will not be unreasonably loud, raucous, jarring, disturbing, or a nuisance to reasonable persons of normal sensitiveness within the area of audibility. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-506).

8.20.090 Radios, television sets and similar devices.

A. Use Restricted. It is unlawful for any person within any residential zone of the city to use or operate any radio receiving set, musical instrument, phonograph, television set, or other machine or device for the producing or reproducing of sound between the hours of 10:00 p.m. of one day and 7:00 a.m. of the following day in such a manner as to disturb the peace, quiet and comfort of neighboring residents or any reasonable person of normal sensitiveness residing in the area.

B. Prima Facie Violation. Any noise level exceeding the ambient base level at the property

line of any property or, if a condominium or apartment house, within any adjoining apartment, by more than five decibels shall be deemed to be prima facie evidence of a violation of the provisions of this section. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-201).

8.20.100 Hawkers and peddlers.
It is unlawful for any person within the city to sell anything by outcry within any area of the city zoned for residential uses. The provisions of this section shall not be construed to prohibit the selling by outcry of merchandise, food and beverages at licensed sporting events, parades, fairs, circuses and other similar licensed public entertainment events. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-202).

8.20.110 Drums – Use restricted.
It is unlawful for any person to use any drum or other instrument or device of any kind for the purpose of attracting attention by the creation of noise within the city. This section shall not apply to any person who is a participant in a school band or duly licensed parade or who has been otherwise duly authorized to engage in such conduct. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-203).

8.20.120 Schools, hospitals and churches.
It is unlawful for any person to create any noise on any street, sidewalk or public place adjacent to any school, institution of learning or church while the same is in use, or adjacent to any acute hospital, which noise unreasonably interferes with the workings of such institution or which disturbs or unduly annoys patients in the hospital, provided conspicuous signs are displayed in such street, sidewalk or public place indicating the presence of a school, church or hospital. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-204).

8.20.130 Animals and fowl.
No person shall keep or maintain, or permit the keeping of, upon any premises owned, occupied or controlled by such person any animal or fowl otherwise permitted to be kept which, by any sound, cry or behavior shall cause annoyance or discomfort to a reasonable person of normal sensitiveness in any residential neighborhood. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-205).

8.20.140 Machinery, equipment, fans and air conditioning.
It is unlawful for any person to operate any machinery, equipment, pump, fan, air conditioning apparatus, or similar mechanical device in any manner so as to create any noise which would cause the noise level at the property line of any property to exceed the ambient base noise level by more than five decibels. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-206).

8.20.150 Construction of buildings and projects.
It is unlawful for any person within a residential zone, or within a radius of 500 feet therefrom, to operate equipment or perform any outside construction or repair work on buildings, structures, or projects or to operate any pile driver, power shovel, pneumatic hammer, derrick, power hoist, or any other construction type device between the hours of 10:00 p.m. of any one day and 7:00 a.m. of the next day in such a manner that a reasonable person of normal sensitiveness residing in the area is caused discomfort or annoyance unless beforehand a permit therefor has been duly obtained from the city manager or his designee. No permit shall be required to perform emergency work as defined in BMC 8.20.020. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-301).

8.20.160 Vehicle repairs.
It is unlawful for any person within any residential area of the city to repair, rebuild, or test any motor vehicle between the hours of 10:00 p.m. of one day and 7:00 a.m. of the next day in such a manner that a reasonable person of normal sensitiveness residing in the area is caused discomfort or annoyance. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-401).

8.20.170 Motor-driven vehicles.

It is unlawful for any person to operate any motor-driven vehicle within the city in such a manner that a reasonable person of normal sensitiveness residing in the area is caused discomfort or annoyance; provided, however, any such vehicle which is operated upon any public highway, street, or right-of-way shall be excluded from the provisions of this section. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-402).

8.20.180 Sound level measurement criteria.

Any sound level measurement made pursuant to the provisions of this chapter shall be measured with a sound level meter using the "A" weighting. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-103).

8.20.190 Ambient base noise level.

Where the ambient noise level is less than designated in this section the respective noise level in this section shall govern.

		Sound Level A, decibels		
		Community Environment Classification		
Zone		Very Quiet (rural, suburban)	Quiet (suburban)	Slightly noisy (suburban, urban)
R1 and R2	10:00 p.m. to 7:00 a.m.	40	45	50
R1 and R2	7:00 p.m. to 10:00 p.m.	45	50	55
R1 and R2	7:00 a.m. to 7:00 p.m.	50	55	60
R3 and R4	10:00 p.m. to 7:00 a.m.	45	50	55
R3 and R4	7:00 a.m. to 10:00 p.m.	50	55	60
Commercial	10:00 p.m. to 7:00 a.m.	55	60	
Commercial	7:00 a.m. to 10:00 p.m.	60	65	
M1	anytime	70	70	
M2	anytime	75	75	

(Ord. 77-2 N.S. § 1, 1977; prior code § 12-104).

8.20.200 Excessive noise prohibited.

A. Notwithstanding any other provision of this chapter, and in addition thereto, it shall be unlawful for any person to wilfully make or continue, or cause to be made or continued, any loud, unnecessary, or unusual noise which disturbs the peace or quiet of any neighborhood or which causes discomfort or annoyance to any reasonable person of normal sensitiveness residing in the area.

B. The standards which shall be considered in determining whether a violation of the provisions of this section exists shall include, but not be limited to, the following:

1. The level of the noise;
2. The intensity of the noise;
3. Whether the nature of the noise is usual or unusual;
4. Whether the origin of the noise is natural or unnatural;
5. The level and intensity of the background noise, if any;
6. The proximity of the noise to residential sleeping facilities;

7. The nature and zoning of the area within which the noise emanates;
8. The density of the inhabitation of the area within which the noise emanates;
9. The time of day or night the noise occurs;
10. The duration of the noise;
11. Whether the noise is recurrent, intermittent, or constant; and
12. Whether the noise is produced by a commercial or noncommercial activity. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-601).

8.20.210 Petition for temporary relief from regulations.

Any person may petition the city council for temporary relief from provisions of this chapter by written request directed to the city clerk. The city council shall hear such petition at the next regular city council meeting not less than five days after the filing of said request. Upon hearing all the evidence, the city council may grant temporary relief from the provisions of this chapter upon such terms and conditions as the council may see fit if the council finds that the temporary relief does not endanger the health, welfare or safety of the residents of the city. The temporary relief may not exceed 30 days in duration. The applicant for relief may not exceed the provisions of this chapter until such time as the permit of the city has been issued. The decision of the city council shall be final. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-701).

8.20.220 Violation – Penalty.

Repealed by Ord. 03-9. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-105).

8.20.230 Violation – Additional remedy.

As an additional remedy, the operation or maintenance of any device, instrument, vehicle, or machinery in violation of any provision of this chapter, which operation or maintenance causes discomfort or annoyance to reasonable persons of normal sensitiveness or which endangers the comfort, repose, health or peace of residents in the area, shall be deemed and is declared to be, a public nuisance and may be subject to abatement summarily by a restraining order or injunction issued by a court of competent jurisdiction. (Ord. 77-2 N.S. § 1, 1977; prior code § 12-106).

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For statutory provisions on noise control, see Health and Safety Code § 46000 et seq.

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D. NOISE

The principal noise generator in Benicia is vehicular traffic. People are most sensitive to noise levels which disturb their comfort at home.

The Noise section describes the existing and projected future noise environments in Benicia so that harmful and annoying sound levels can be avoided or minimized. Major noise sources are identified, estimated noise levels throughout the community are reported, the effects of noise on the community are discussed, and ways to minimize unwanted noise are outlined.

1. Human Reaction to Noise

Three qualities characterize the subjective effect of noise on the listener: (1) the frequency of the noise, (2) the intensity of the noise, and (3) the time-varying character of the noise.

Researchers have grappled with how to translate objective measurements of sound into directly correlated measures of public reaction to noise.The descriptors of community noise in current use are the results of these efforts and represent simplified, practical measurement tools to gauge community response.

Table 4-1 shows the decibel levels of common noises.

Table 4-1. Decibel Levels of Common Noises

20	Soft whisper
40	Quiet office, living room, bedroom—away from traffic.
50	Light traffic at a distance, refrigerator, gentle breeze.
60	Average conversation, air conditioner at 20 feet, sewing machine.
65	Quiet typewriter.
70	Busy traffic, office tabulator, noisy restaurant. (This level may begin to affect hearing if one is constantly exposed.)
75	Vacuum cleaner.
80	Subway, heavy city traffic, ringing alarm clock at two feet, average factory noise. (Dangerous if exposure continues for more than eight hours.)
85	Truck traffic, noisy home appliances (washing machine, blender, food processor), power lawn mower. (Dangerous, even if exposure is less than eight hours.)
95	Noisy factory, shop tools.
100	Elevated train, chain saw, pneumatic drill. (Dangerous, even if exposure is less than two hours.)
120	Rock concert in front of speakers, sandblasting, thunderclap. (Danger is immediate.)
140	Jet airplane at 200 feet, gunshot blast. (Any length of exposure is extremely dangerous.)

The known effects of noise on people include hearing loss (not generally a factor with community noise), communication interference, sleep interference, physiological responses, and annoyance. Although the wide range of individual reactions to noise makes it extremely difficult to measure how noise affects individual health, medical studies suggest a correlation between noise and mental stress.

A decibel is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities.

COMMUNICATION INTERFERENCE

Communication interference is one of the primary environmental noise problems, and includes speech interference and interference of activities such as watching television. Normal conversational speech is in the range of 60 to 65 dB, and any noise in this range or louder may interfere with speech.

SLEEP INTERFERENCE

Sleep interference is a major noise concern. Noise can make it difficult to fall asleep, can create momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages, and can cause awakening.

Extensive research has been conducted on the effect of noise on sleep disturbance. Recommended values for desired sound levels in residential bedroom space range from 25 to 45 dB with 35 to 40 dB being the norm. The National Association of Noise Control Officials published data on the probability of sleep disturbance with various single event noise levels. Based on experimental sleep data related to noise exposure, a 75 dB interior noise level event will cause noise-induced awakening in 30 percent of all cases.

PHYSIOLOGICAL RESPONSES

Physiological responses are those measurable effects of noise on people which are realized as changes in pulse rate, blood pressure, *etc.* While such effects can be induced and observed, it is not known to what extent these physiological responses cause harm. Generally, physiological responses are a reaction to a loud, short-term noise such as a rifle shot or a very loud jet overflight.

ANNOYANCE

Annoyance is the most difficult of all noise responses to describe. Annoyance is a very individual characteristic and can vary widely from person to person. What one person considers tolerable can be quite unbearable to another. The level of annoyance

depends on the characteristics of the noise (*i.e.,* loudness, frequency, time, and duration), and how much activity interference (*e.g.,* speech interference and sleep interference) results from the noise. However, the level of annoyance is also a function of the attitude of the receiver. Personal sensitivity to noise varies widely. It has been estimated that 2 to 10 percent of the population is highly susceptible to noise not of their own making, while approximately 20 percent are unaffected by noise. Attitudes are affected by the relationship between the person and the noise source. (Is it our dog or the neighbor's?) Whether we believe that someone is trying to abate the noise will also affect our level of annoyance.

The following conclusions have been established through extensive study:

1. Except in carefully controlled laboratory experiments, an increase of only one dBA cannot be perceived by humans.
2. Outside of the laboratory, a three dBA increase is considered to be just noticeable.
3. A change of five dBA is required before any noticeable change in community reaction would be expected.
4. A 10 dBA increase is subjectively heard as a doubling of loudness and would most certainly cause community response.

2. Noise in the Community

EXISTING NOISE LEVELS

Once noise levels are computed or measured, they can be mapped. Noise levels are mapped as contours. Each contour line indicates an area on the inside of the line which has a higher noise level than the contour's value; the area on the outside of the line has a lower noise level than the contour's value. Because local topography, vegetation, or intervening structures may significantly affect noise exposure at a particular location, the noise contours should not be considered site-specific. Figure 4-6 shows existing noise contours in Benicia.

These noise contours were formulated based on a community noise survey conducted in October and November 1995. The results indicated that typical exterior noise levels in noise sensitive areas (*i.e.,* nursing homes, churches, theaters, residential uses, parks, libraries, and schools) are in the range of 51 dB to 63 dB L_{dn}. Traffic on local roadways and I-680 and I-780, industrial activities, and neighborhood activities are the contributing factors for background noise levels in the majority of the study area. Table 4-2 is a summary of the survey.

PROJECTED NOISE LEVELS

Traffic on I-680 and I-780 is expected to increase through the year 2015. The hourly traffic flow and mix of trucks and private automobiles during a typical 24-hour period is not expected to change. No major increase in railroad operation is expected to occur in the near future. Figure 4-7 indicates future noise contours.

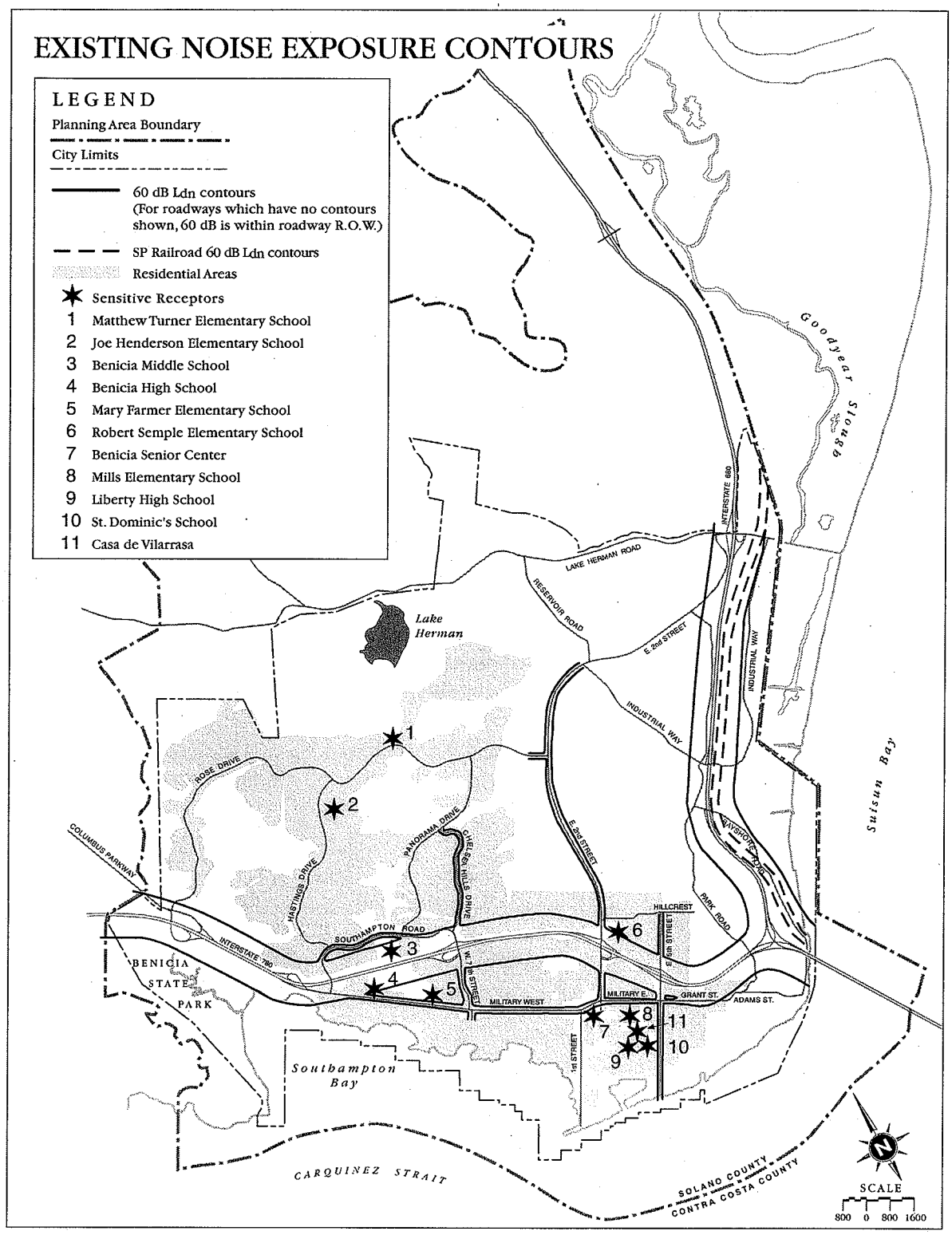

Figure 4-6. Existing Noise Contours

Table 4-2. Summary of Measured Exterior Noise Levels and Estimated Day-Night Average Levels (L_{dn}) in Areas Containing Noise-Sensitive Land Uses

Site	Location	Time/Period	Sound Level, dB				
			L_{eq}	L_{50}	L_{90}	L_{max}	Estimated L_{dn}
1*	329 Columbia Circle	—	—	—	—	—	54.2
2*	507 Bristol Court	—	—	—	—	—	54.0
3*	803 Elaine	—	—	—	—	—	50.8
4*	1781 Lindo Street	—	—	—	—	—	63.2
5	Corner of Reservoir Road and Lake Herman Road	Ld(1) Ld(2) Ln	51.5 55.5 41.0	39 48 35	32 37 30	66.0 70.5 60.0	53.1
6	Benicia Community Park	Ld(1) Ld(2) Ln	46.0 46.0 45.5	45 44 37	40 40 32	57.0 62.5 60.0	52.0
7	Southampton Park	Ld(1) Ld(2) Ln	56.5 53.5 47.0	53 47 40	46 39 36	72.0 68.5 59.0	56.0
8	Turnbull Park	Ld(1) Ld(2) Ln	48.5 53.5 43.0	45 48 39	43 44 37	63.0 70.5 57.5	52.2
9	City Park (Second St. & West K Street)	Ld(1) Ld(2) Ln	57.0 57.6 53.5	57 56 51	55 53 48	64.9 67.2 65.0	60.7
10	Bridgeview Park	Ld(1) Ld(2) Ln	51.9 49.8 42.8	45 45 40	41 43 38	67.8 60.7 58.0	51.6
11	Benicia Middle School Athletic Fields/ Bay View Villas	Ld(1) Ld(2) Ln	54.5 53.1 51.0	54 53 49	52 50 47	61.6 58.2 56.0	58.0
12	Matthew Turner Shipyard Park	Ld(1) Ld(2) Ln	58.4 53.1 47.3	58 51 45	54 48 42	63.1 63.1 58.0	56.8

* Continuous Monitoring Site

Ld = Measured noise level during daytime hours (7:00 am - 10:00 pm)

Ln = Measured noise level during nighttime hours (10:00 pm - 7:00 am)

L_{eq} = The average noise level during a given time period

$L_{50, 90}$ = The average noise level experienced 50 and 90 percent of a given time period

L_{max} = The maximum sound level recorded during a noise event

L_{dn} = The average noise level during a 24-hour day after 10 decibels has been added to the levels between 10 pm and 7 am.

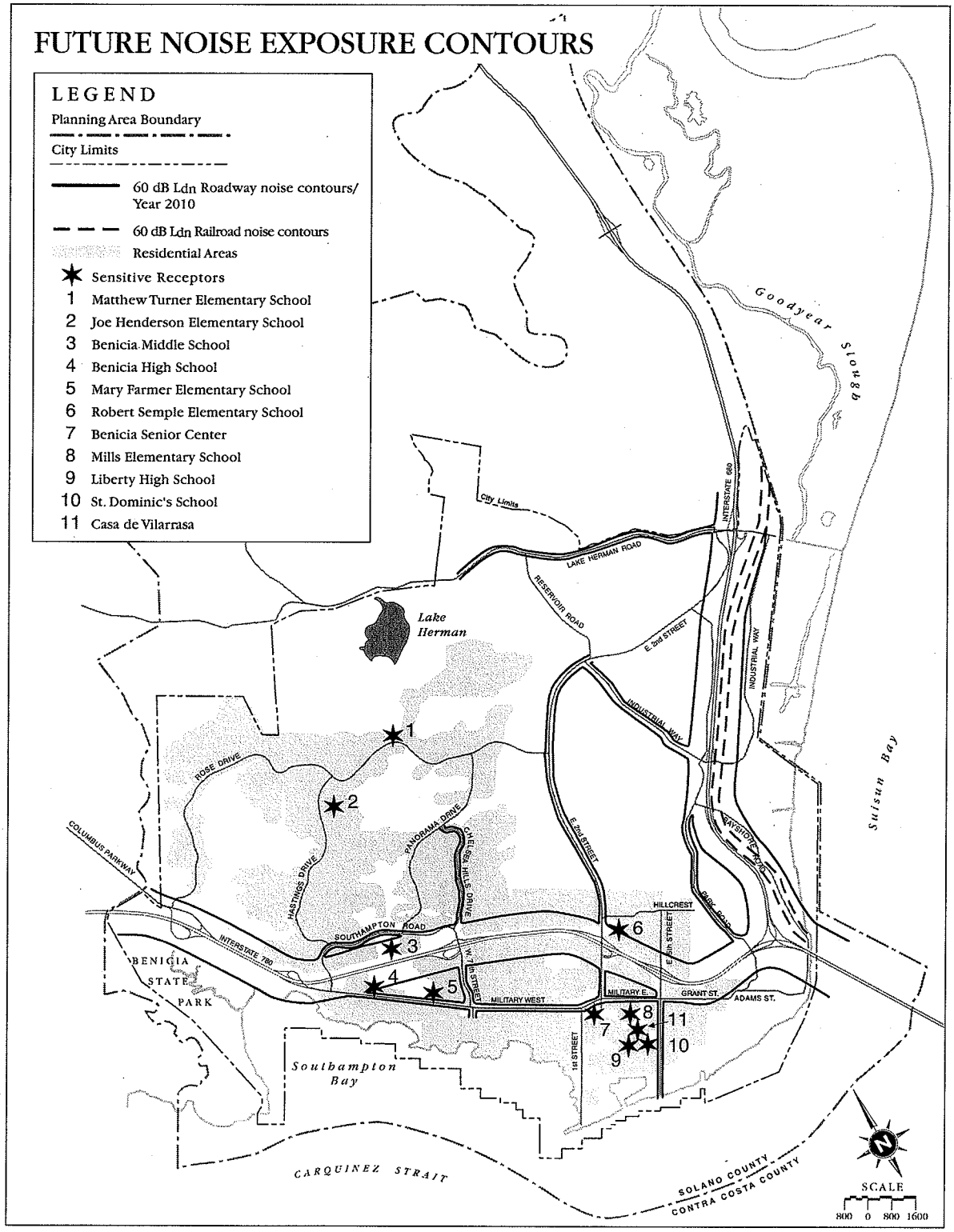

Figure 4-7. Future Noise Contours

3. Performance Standards for Noise Sensitive Uses

TRANSPORTATION NOISE SOURCES

Table 4-3 provides specific standards for determining the compatibility of proposed noise-sensitive land uses with transportation noise sources (refer to glossary for definition). Where noise-sensitive projects are proposed within areas which exceed the standards contained in Table 4-3, it is necessary to prepare a report that (a) performs an analysis of noise impacts, and (b) recommends mitigation measures to reduce noise levels on the site to comply with the standards in Table 4-3. This table is only to be used with proposed projects; the City's noise ordinance governs noise associated with existing uses.

Table 4-3. Maximum Allowable Noise Exposure for New Noise-Sensitive Uses From Transportation Noise Sources

Land Use	Outdoor Activity Areas[1]	Interior Spaces	
	L_{dn}/cnel, dB	L_{dn}/dB	L_{eq}, dB[2]
Residential	60[3]	45	—
Transient Lodging	65[4]	45	
Hospitals, Nursing Homes	60[3]	45	—
Theaters, Auditoriums, Music Halls	—	—	35
Churches, Meeting Halls	60[3]	—	40
Office Buildings, Commercial Uses, Industrial, Manufacturing, Utilities[5]	—	—	45
Schools, Libraries, Museums	60[3]	—	45
Playgrounds, Neighborhood Parks	65	—	—

[1] Where the location of outdoor activity areas is unknown; or does not exist, the exterior noise level standard will be applied to the property line of the receiving land use. Refer to glossary for definition of outdoor activity area.

[2] As determined for a typical worst-case hour during periods of use.

[3] Where it is not possible to reduce noise in outdoor activity areas to 60 dB L_{dn}/CNEL or less using a practical application of the best-available noise reduction measures, an exterior noise level of up to 65 dB L_{dn}/CNEL may be allowed provided that available exterior noise level reduction measures have been implemented and interior noise levels are in compliance with this table. If these noise levels cannot be complied with this will constitute a significant environmental impact.

[4] In the case of hotel/motel facilities or other transient lodging; with no proposed outdoor activity areas such as pool areas, only the interior noise level criterion will apply.

[5] Standards would only apply to areas requiring good speech intelligibility such as offices, conference rooms, etc.

STATIONARY NOISE SOURCES

Table 4-4 provides specific performance standards for determining the compatibility of proposed noise-sensitive land uses with stationary noise sources.The performance standards are for new noise-sensitive developments which may be affected by an existing stationary noise source.The performance standards also apply to new developments that include a stationary noise source which may affect an existing noise-sensitive development.

The intent of these performance standards is both to prevent new noise sources from encroaching on existing noise-sensitive developments and to prevent new noise-sensitive developments from encroaching on existing uses.

Noise sources evaluated relative to the performance standards in Table 4-4 should be considered with respect to their standard daily or weekly operating conditions. Noise sources may produce unusual noise levels due to temporary equipment malfunction, or unusual atmospheric conditions. Noise levels associated with these infrequent conditions are exempt from the performance standards contained in Table 4-4. In addition, the performance standards are not to be applied to safety signals or warning devices. In the event an acoustical study is required of an applicant, refer to Appendix I: "Requirements for an Acoustical Analysis."

Table 4-4. Noise Level Performance Standards for Noise-Sensitive Land Uses Which May Be Affected by Stationary Noise Sources

Land Use	Exterior Hourly L_{eq}, dB		Interior Hourly L_{eq}, dB	
	Daytime 7 a.m. to 10 p.m.	Nighttime 10 p.m. to 7 a.m.	Daytime 7 a.m. to 10 p.m.	Nighttime 10 p.m. to 7 a.m
Residential	55	50	40	35
Transient Lodging	55	50	40	35
Hospitals	—	—	40	35
Nursing Homes	55	50	40	35
Theaters, Auditoriums	—	—	35	35
Churches	55	50	40	40
Schools	55	50	45	45
Libraries	55	50	45	45

Stationary noise sources include industrial operations, outdoor recreation facilities, HVAC units, loading docks, etc.

The above standards may be adjusted upwards to allow for an increase in the existing ambient hourly L_{eq} caused by a proposed project. An increase of less than 3dB is permitted, even if the standards in Table 4-4 are exceeded; an increase of 3dB or greater constitutes a significant environmental impact, unless the increase does not cause the standards in Table 4-4 to be exceeded.

The noise level standards contained above shall be applied to a typical hour of operation. When a peak hour of operation is expected to occur consistently during daily or weekly operations, the standards shall also be applied to those operations.

Each of the noise standards specified above shall be lowered by five dB for tonal noises (humming, high-pitched tones, speech music, or recurring impulsive noises). This lowering of the standard does not apply to residential units established in conjunction with industrial or commercial caretaker dwellings. (See Glossary for definition of tonal noise).

The City may choose to apply the noise level performance standards at designated outdoor activity areas, in lieu of the property line.

The above standards do not apply to safety signals or warning devices.

For noise sources that occur on an infrequent basis and are considered to be safety equipment (such as flaring or pressure relief valves), a maximum noise level of 75 dB is acceptable, as measured from the receiver's property line. Noise levels which are projected to exceed this maximum are considered a significant environmental impact.

Where outdoor activity areas do not exist and/or are not expected to be affected, the City may choose to only apply the interior noise level criteria. For example, in the case of single family residences which do not have second story patios or outdoor activity areas, the City may choose to only apply an interior noise level standard at the second story interior spaces.

4. Community Noise Goals, Policies, and Programs

GOAL 4.23: **Reduce or eliminate the effects of excessive noise.**

Policy 4.23.1: Evaluate the compatibility of proposed projects with respect to existing and future transportation noise levels by utilizing Tables 4-3 and 4-4.

Program 4.23.A: Investigate and implement techniques to reduce traffic noise.

Policy 4.23.2: Use noise dampening building standards, site design, landscaping, and setbacks instead of sound walls, wherever possible.

Policy 4.23.3: Use available techniques such as building insulation, berms, building design and orientation, buffer yards, and staggered operating hours to minimize noise at the source.

Policy 4.23.4: Control development of noise-sensitive land uses in areas exposed to existing or projected noise which exceed the levels specified in Tables 4-3 and 4-4 unless the project includes specific, effective mitigation measures to reduce interior and exterior noise levels to those specified in Tables 4-3 and 4-4.

Program 4.23.B: Investigate conditioning construction of live/work units with a requirement to record a "notice of special restrictions" which would acknowledge the noisy nature of existing adjacent industrial uses.

Policy 4.23.5: Accommodate roadway improvement projects for build-out of the General Plan by recognizing that existing noise-sensitive uses may be exposed to increased noise levels from roadway repairs, increased traffic, and increased travel speeds. When it is not practical to reduce traffic noise levels to those in Table 4-4, the following criteria will be used as a test of significance for the environmental review of roadway improvement projects:

(a) Where existing noise levels are less than 60 dB L_{dn} at the outdoor activity area of a noise-sensitive use, a 5 dB L_{dn} increase in noise levels due to a roadway improvement project will be considered significant;

(b) Where existing noise levels range between 60 and 65 dB L_{dn} at the outdoor activity area of a noise-sensitive use, a 3 dB L_{dn} increase in noise levels due to a roadway improvement project will be considered significant; and

(c) Where existing noise levels are greater than 65 dB L_{dn} at the outdoor activity area of a noise-sensitive use, a 1.5 dB L_{dn}

increase in noise levels due to a roadway improvement project will be considered significant.

Program 4.23.C: If needed, revise the City's noise ordinance and consider incorporating the noise level performance standards in Table 4-4.

POLICY 4.23.6: Attempt to reduce noise in areas already highly impacted by excessive noise.

Program 4.23.D: Identify sources of noise in the community (such as flight patterns, construction noise, traffic, railroads, industrial, and amplified sound). Develop measures to reduce excessive noise to acceptable levels.

Appendix C

Letter Report for the City of Benicia by CSA,
dated 20 September 2006