BACWA Workshop: Nutrient Reduction by Treatment Optimization and Upgrades Update

BACWA Workshop
27 June 2016

HDR
Brown AND Caldwell

BACWA
BAY AREA
CLEAN WATER
AGENCIES

Agenda

- Watershed Permit Background
- Project Approach/Status
- Assumptions
- Case Studies
- Report Feedback
- Summary of Preliminary Wave 1 Load Reductions and Cost Estimates
- Additional Data Requests
- Group Annual Report
- Next Steps
- Q/A

Watershed Permit Background

Watershed Permit

CALIFORNIA
Water Boards

Edmund G. Brown Jr.
Governor

Matthew Rodriquez
Secretary for
Environmental Protection

San Francisco Bay Regional Water Quality Control Board

ORDER No. R2-2014-0014
NPDES No. CA0038873

WASTE DISCHARGE REQUIREMENTS FOR NUTRIENTS FROM MUNICIPAL WASTEWATER DISCHARGES TO SAN FRANCISCO BAY

The following dischargers are subject to waste discharge requirements (WDRs) set forth in this Order, for the purpose of regulating nutrient discharges to San Francisco Bay and its contiguous bay segments:

Table 1. Discharger Information

Discharger	Facility Name	Facility Address	Minor/ Major
		151 Mezzetta Court	

Project Purpose

- Increase Understanding for each Plant and Subembayment
- Understand the Possible Cost and Load Reductions for:
  - o Optimization
  - o Sidestream Treatment
  - o Plant Upgrades
  - o Nutrient Load Reduction By Other Means
- Assist with making an informed decision for nutrient load reduction (if supported by sound science)

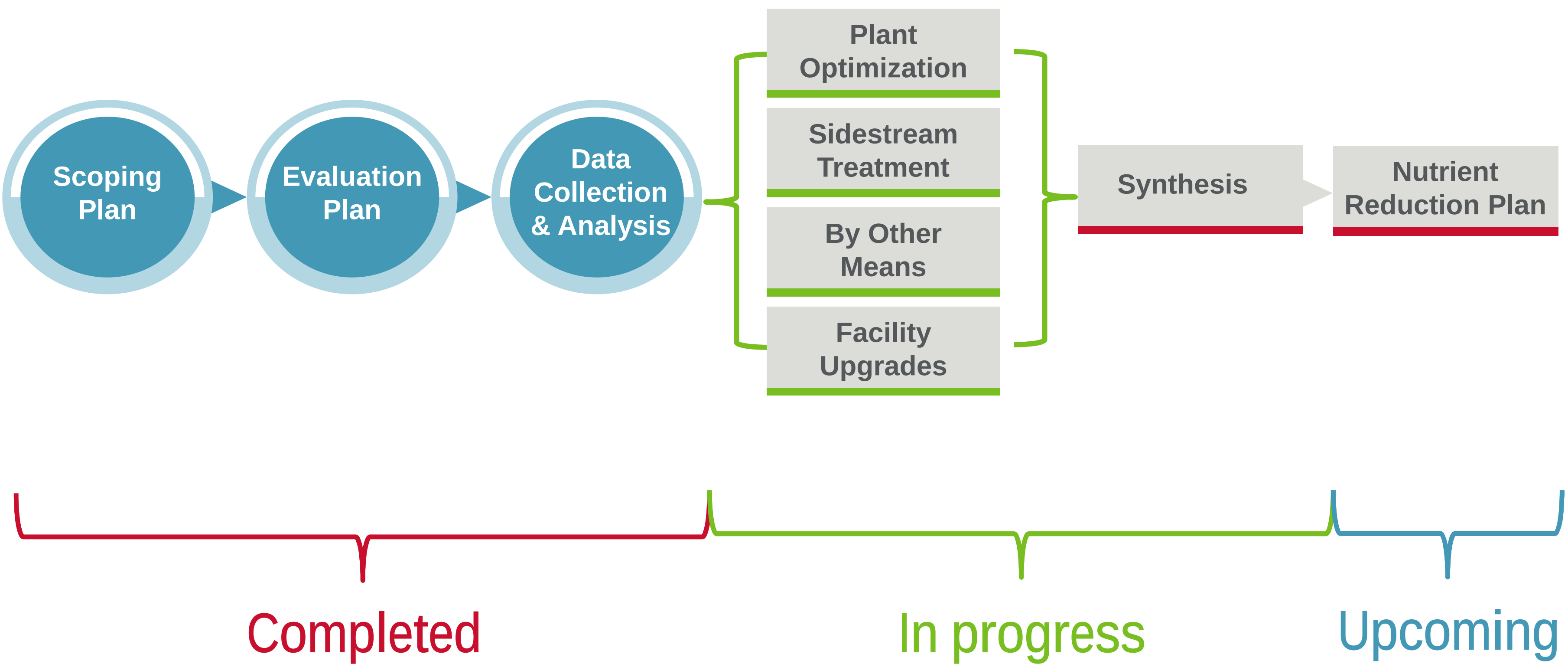
Watershed Permit Requirements

- Issued April 9, 2014 – Regional Water Board Order No. R2-2014-0014
- Requirements:
  - Scoping and Evaluation Plan (Accepted first quarter of 2015)
  - July 2018: Task 1 - Conduct treatment plant optimization and sidestream treatment evaluation for nutrient load reductions (Submittal deadline is July 2018)
  - July 2018: Task 2 - Conduct treatment plant upgrades and analysis of removal by other means for nutrient load reductions (Submittal deadline is July 2018)
  - Annual Reporting (Annual submittal in October from 2015 through 2018)

37 Participating Agencies

Project Approach and Status

Overview / Status of Study



Reports are being prepared in 4 Waves.
Draft Wave 1 reports are complete and results will be shared today.

Scoping and Evaluation Plan - Timeline

- Presented the approach to the Regional Board in December 2014
- Submitted in February 2015
- Accepted in February 2015

Treatment Levels

Level	Study	Ammonia	TN	TP
Level 1 *	Optimization	--	--	--
Level 2 *	Upgrades	2 mg N/L	15 mg N/L	1.0 mg P/L
Level 3 *	Upgrades	2 mg N/L	6 mg N/L	0.3 mg P/L

* The seasonal impacts will be considered for all three treatment levels:
  - Dry Season = May 1 to September 30
  - Wet Season = October 1 to April 30

Data Review and Site Visits

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Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades

Facility Information	
Facility Name	
Address	
Facility Contact	
Date of Visit	
Facility Attendees	
Consultant Mgmt Group Attendees	
Consultant Process Engineer	
Consultant Operations Expert	
Describe Existing Nutrient Limits *(if any)*	Ammonia = 170 mg N/L AMEL and 220 mg N/L MDEL
Permitted Capacity	19.5 mgd ADWF; 31.1 mgd PWWF

Current Conditions		
Flow	**Summer**	**Winter**
Annual Average Flow, mgd	13.0	13.1
Peak Month, mgd	13.3	13.7
Max Day, mgd	14.3	17.0
Peak Hour Flow, mgd	19	31.5
TSS Loads (Marginal seasonal impacts)		
Annual Average, lb/d	38,500	38,900
Peak Month, lb/d	42,500	43,400
Max Day, lb/d	58,500	60,500
BOD Loads (Marginal seasonal impacts)		
Annual Average, lb/d	35,700	37,400
Peak Month, lb/d	38,700	41,700
Max Day, lb/d	42,300	54,300
Ammonia Loads (Marginal seasonal impacts)	**Summer**	**Winter**

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Current Conditions		
Annual Average, lb/d	3,500	3,800
Peak Month, lb/d	3,800	4,100
Max Day, lb/d	3,800	4,400
TKN Loads (Marginal seasonal impacts)		
Annual Average, lb/d	5,400	5,700
Peak Month, lb/d	6,000	6,200
Max Day, lb/d	6,500	6,300
Ortho-P Loads (Marginal seasonal impacts)		
Annual Average, lb/d	360	370
Peak Month, lb/d	420	490
Max Day, lb/d	430	610
Total P Loads (Marginal seasonal impacts except for Max Day)		
Annual Average, lb/d	690	700
Peak Month, lb/d	760	780
Max Day, lb/d	2,100 High due to solids from water recycling return streams	900

- The current flows and loads are in-line with the Master Plan historical and projected flows and loads. The current flows and loads show marginal seasonal impacts on flows and loads.
- The max day summer total P loads are high due to phosphorus in the solids return stream from the Recycled Water Facility (RWF). Delta Diablo adds ferrous chloride (FeCl2) to their sewer at the Pittsburg and Antioch pump stations (PS) and alum at the ActiFlo® process located at the RWF.

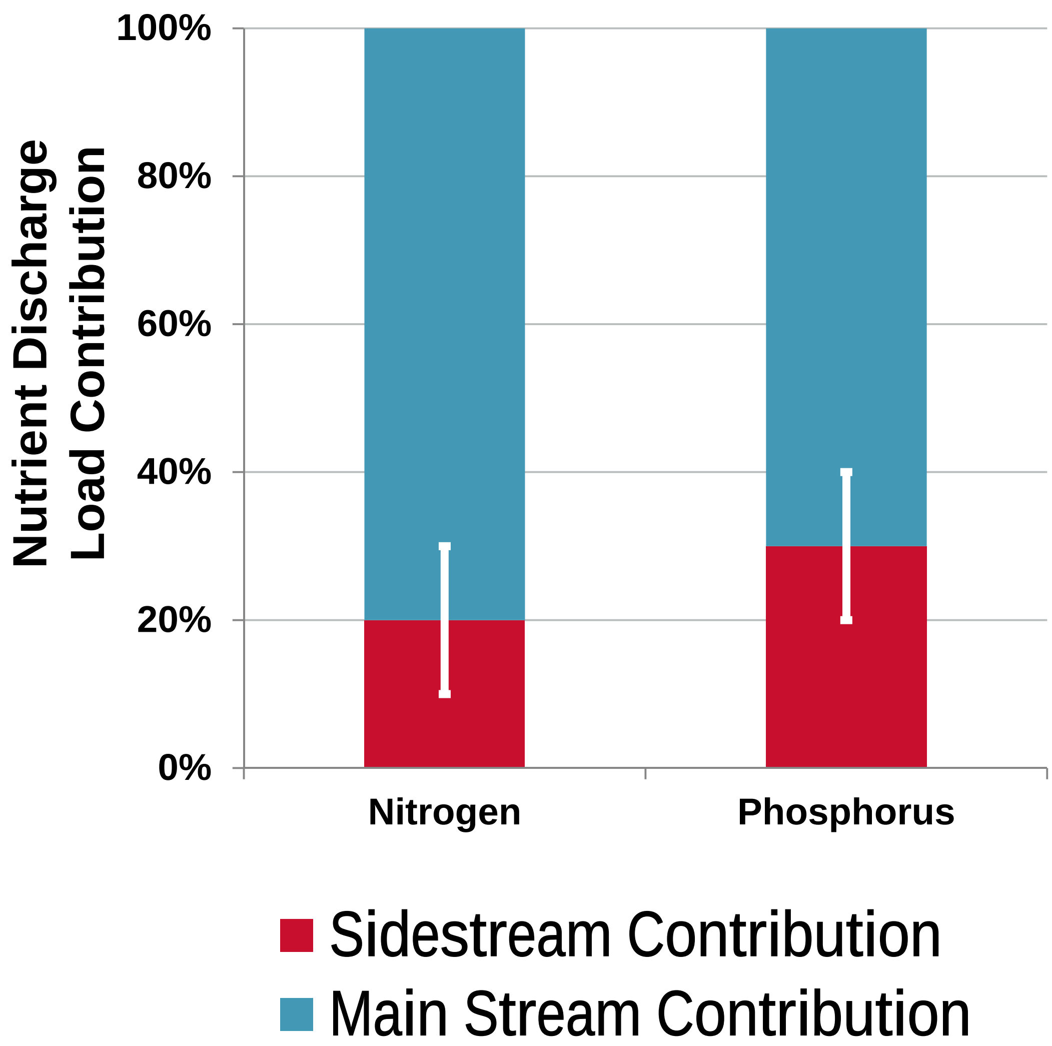
Documentation (check all available documents)	
☒	Current Master Plan
☒	PFD
☐	Facility Plan
☐	Sea Level Rise Report

Optimization Concepts

- Use offline tankage
- Operate in split treatment mode
- Modify operational mode (e.g., raise SRT)
- Modify blower set points
- Add chemicals
  - P removal
  - To unlock downstream capacity
- Shut down aeration to create anoxic zones
- Process control instrumentation
- Add internal recycle for denitrification

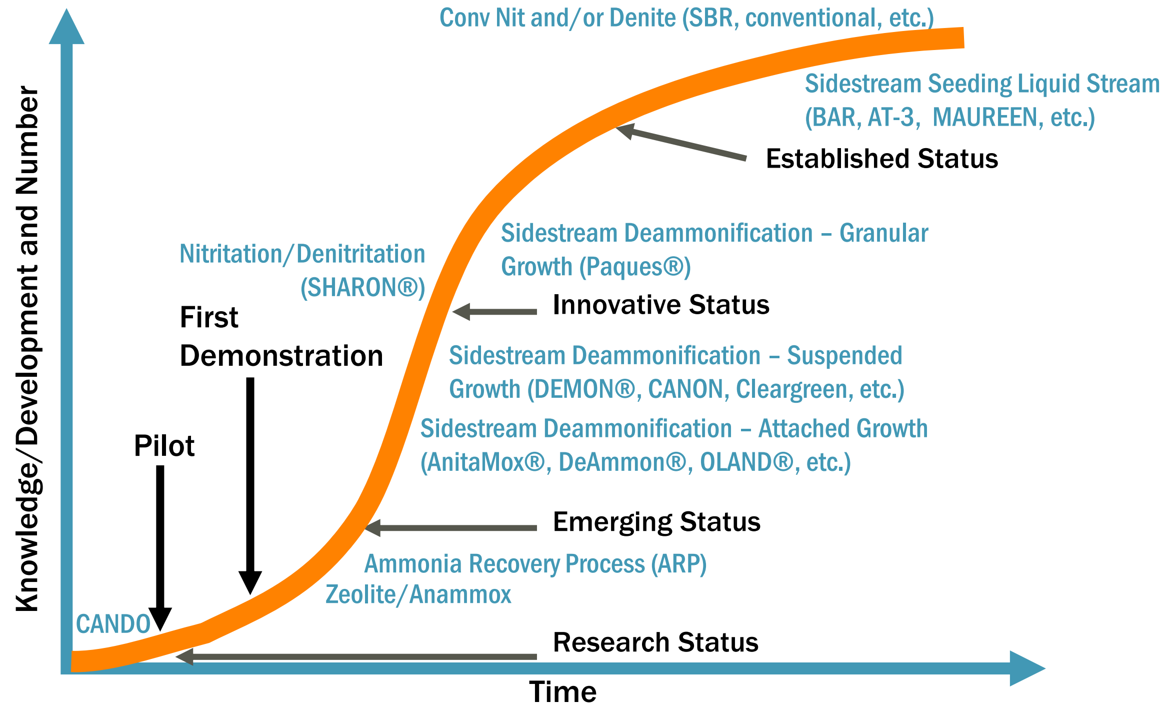
Sidestream Nutrient Load Contributions

- Are you a candidate?
- Which Technology?
  - Deammonification (i.e., Anammox)
  - Conventional Nitrification

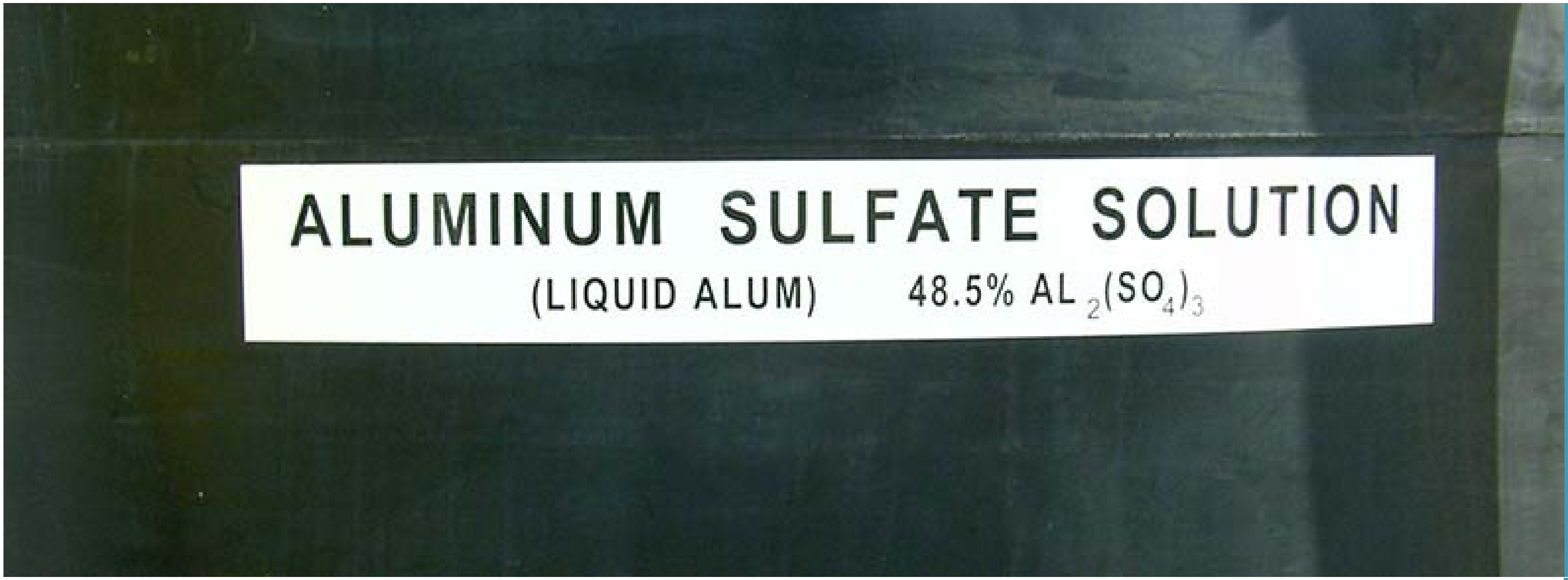


Overview of Plant Upgrades

- Evaluate Master Plan and CIP for future upgrades
- Identify strategies to meet Level 2 and Level 3
- Select appropriate technology
- Determine cost, implementation requirements & plant impacts
- Consider innovative technologies
- Discuss ideas with plant staff and get feedback



Adapted from Tetra Tech (2013) and Parker et al. (2011)



Basic Assumptions

Assumptions

- Planning Periods and Load Projections
  - Optimization: through year 2025
    (default: 0% change in flow; 15% increase in loads)
  - Upgrades/Sidestream: plant permitted capacity

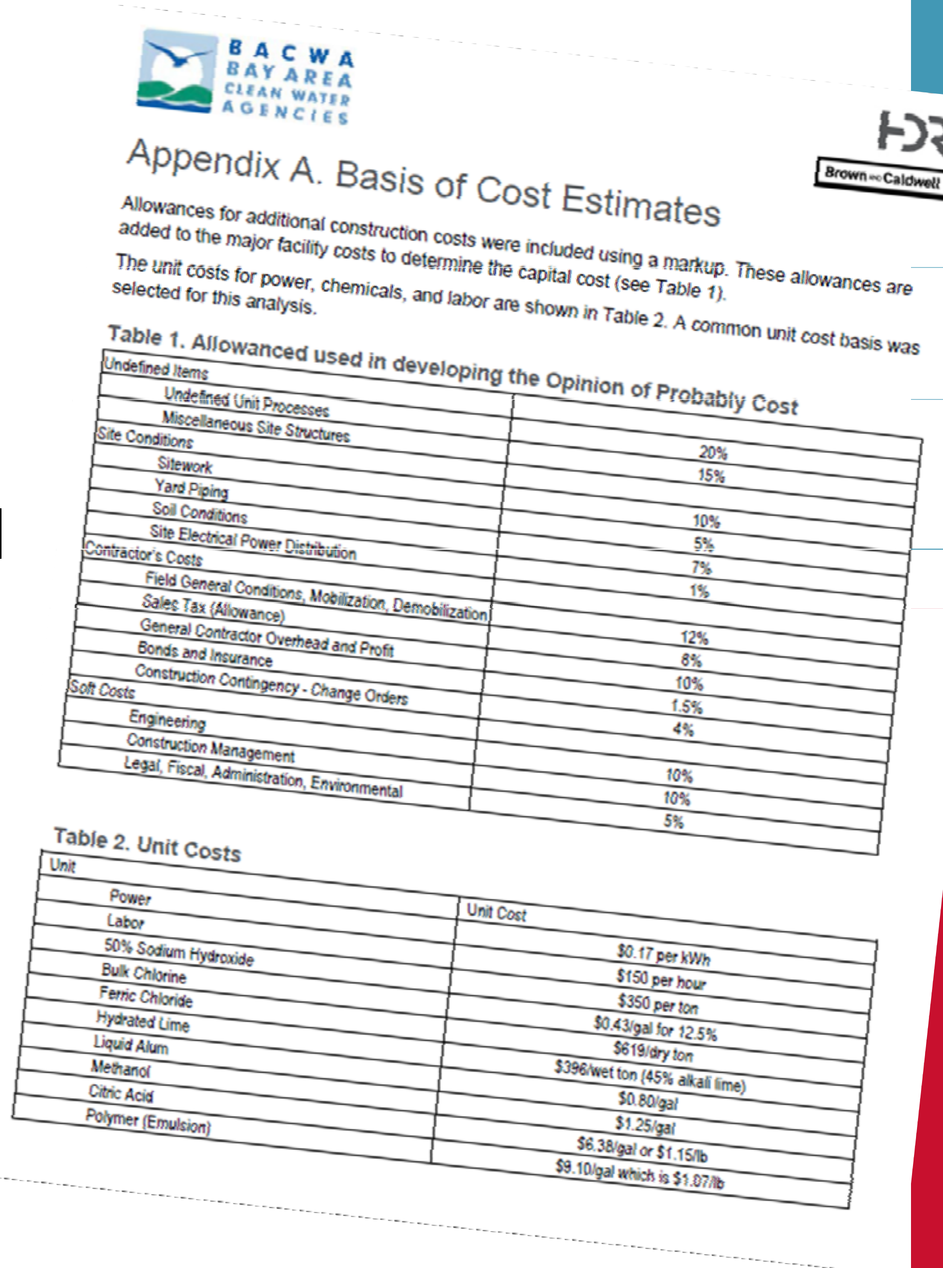
- Economic factors:

Table 3-4. Assumptions for Life Cycle Analysis

Scenario	Discount Rate	Period (yr)
Optimization	2%	10
Side Stream Treatment	2%	30
Level 2	2%	30
Level 3	2%	30

Assumptions

- Common Cost Estimating Factors
  - Energy: $0.17/kWh
  - Labor: $150/hr
  - Chemicals: Bay Area Chemical Consortium costs
- Greenhouse Gas Emissions
  - Energy: Bay Wide Assumption on Energy Type (eGrid EPA Value)
  - Chemicals: Unit Value for Mining/Manufacturing



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Appendix A. Basis of Cost Estimates

Allowances for additional construction costs were included using a markup. These allowances are added to the major facility costs to determine the capital cost (see Table 1).

The unit costs for power, chemicals, and labor are shown in Table 2. A common unit cost basis was selected for this analysis.

Table 1. Allowanced used in developing the Opinion of Probably Cost

Undefined Items	
Undefined Unit Processes	20%
Miscellaneous Site Structures	15%
Site Conditions	
Sitework	10%
Yard Piping	5%
Soil Conditions	7%
Site Electrical Power Distribution	1%
Contractor's Costs	
Field General Conditions, Mobilization, Demobilization	12%
Sales Tax (Allowance)	8%
General Contractor Overhead and Profit	10%
Bonds and Insurance	1.5%
Construction Contingency - Change Orders	4%
Soft Costs	
Engineering	10%
Construction Management	10%
Legal, Fiscal, Administration, Environmental	5%

Table 2. Unit Costs

Unit	Unit Cost
Power	$0.17 per kWh
Labor	$150 per hour
50% Sodium Hydroxide	$350 per ton
Bulk Chlorine	$0.43/gal for 12.5%
Ferric Chloride	$619/dry ton
Hydrated Lime	$396/wet ton (45% alkali lime)
Liquid Alum	$0.80/gal
Methanol	$1.25/gal
Citric Acid	$6.38/gal or $1.15/lb
Polymer (Emulsion)	$9.10/gal which is $1.07/lb

Cost Calculations

- Estimate Capital, O&M, and Net Present Value Costs
  - Dry and Wet Season
  - N&P, N, and P removal
  - Exclude current operating cost
- Compare results by plant for unit cost for nutrient removal
  - $/gpd capital
  - $ Net Present Value
  - $/lb N removed – cost for processes removing N
  - $/lb P removed – cost for processes removing P

Example Outcome

- Case 1
  - High unit capital cost
  - Modest unit removal cost
- Case 2
  - Tweak plant already removing nutrient
  - Low capital cost
  - Very high unit removal cost
- Case 3
  - Easy to convert (existing tankage)
  - Low operation cost
  - Efficient overall nutrient reduction

		Case 1	Case 2	Case 3
Flow	mgd	10	10	10
PV Cap	$mil	7.0	1.0	4.0
PV total	$mil	10.0	5.0	5.0
N removal	mil lb	5.0	0.5	3.0
Investment	$/gpd	0.7	0.1	0.4
Efficiency	$/lb N	2.0	10.0	0.6

Unit Capital Cost ($/gpd capital) → Investment required to implement

Unit Nutrient Reduction Cost ($/lb) → Efficiency of removal


Case Studies

Oro Loma Sanitary District
City of Benicia
Delta Diablo

Oro Loma

Optimization Details – Concepts Analysis

- Introduce each concept considered and rationale on whether to carry forward in the analysis

- **Optimization Strategy 1:** Optimize ferric chloride addition to the existing chemical feed facilities at the primary clarifiers. This effectively turns the primaries into chemically enhanced primary treatment (CEPT) to increase phosphorus, TSS, and BOD removal. OLSD does not currently add chemicals.
  - ***Is it feasible?*** Yes. The facilities already exist.
  - ***Potential impact on ability to reduce nutrient discharge loads?*** Increase P removal and reduce loading to the downstream activated sludge process. This could enhance the potential to remove ammonia in the downstream activated sludge.
  - ***Result from analysis:*** It will marginally increase P removal because the plant is already removing P in the downstream activated sludge. However, it will improve the day to day reliability for P removal, unlock downstream treatment capacity, and is thus deemed potentially viable.
  - ***Recommendation:*** Carry forward.

Optimization Details – Concepts Analysis

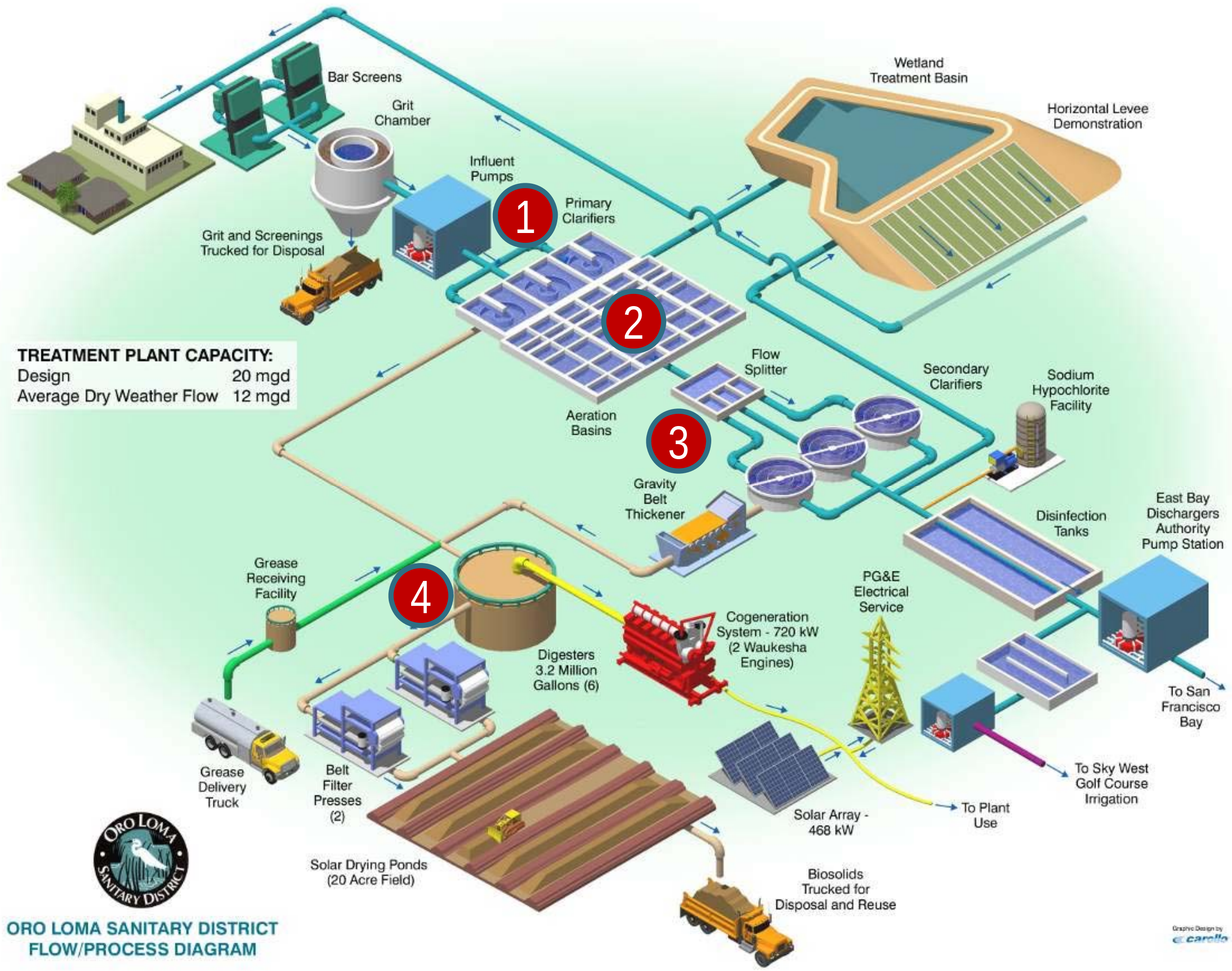
- Describe the capital and operating elements for concepts carried forward

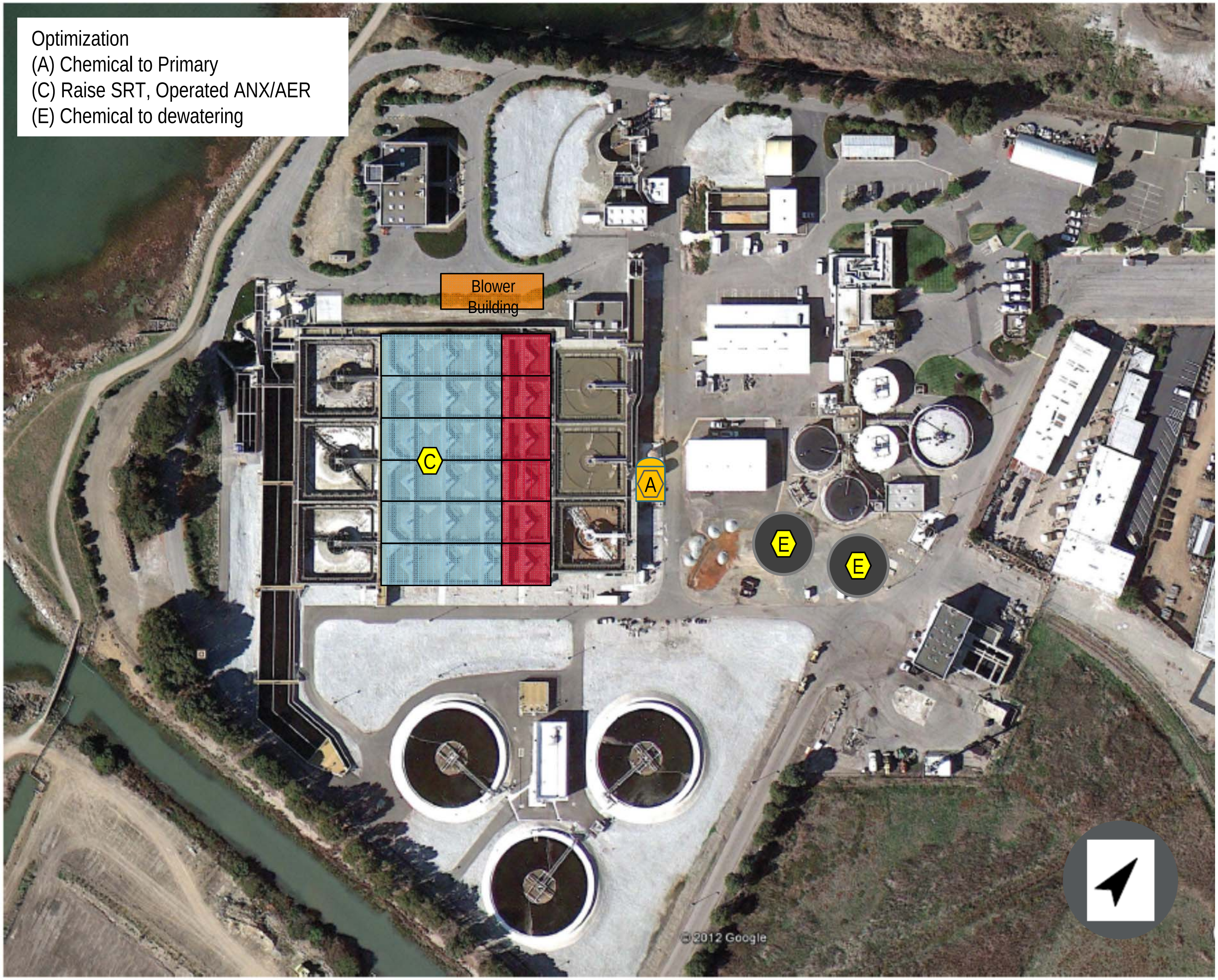
Table 4-1. Optimization Strategy Project Elements

Capital Elements	Operating Elements
CEPT for P Removal • No additional chemical facilities	• Optimize the existing facilities
Increase the SRT and Use Old Secondaries • No capital elements to increase the SRT • Modifications to the RAS piping/valving • Modifications to the Primary Effluent channel • New pumps to return mixed liquor from old secondaries to the aeration basins	• Decrease the WAS pumping rate to increase SRT sufficient for nitrification • Divert of portion or all of RAS to the old secondaries • Modify the level controls to divert a portion or all of primary effluent to the old secondaries • Pump mixed liquor from the old secondaries to the aeration basins
Increase the RAS Return Rate • No additional pumping capacity	• Optimize the existing facilities
Chemical Addition to Digested Biosolids • Metal salt and polymer facilities	• Metal salt and polymer addition to digested solids (upstream of dewatering)

Oro Loma - Optimization

1. Chemical to primaries
2. Raise SRT, extend aeration tank, operate in SNDN
3. Increase RAS return rate
4. Chemical to dewatering




Optimization
(A) Chemical to Primary
(C) Raise SRT, Operated ANX/AER
(E) Chemical to dewatering
Blower Building
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Optimization - Load Reduction

- Provide the projected ammonia, nitrogen and phosphorus discharge loads for the optimization concepts carried forward in the analysis

Table 4-2. Projected Discharge Nitrogen and Phosphorus Loads for Optimization

Parameter	Units	NH4-N Dry Season	NH4-N Wet Season	TN Dry Season	TN Wet Season	TP Dry Season	TP Wet Season
Current Discharge[1]	lb N or P/d	3,340	3,580	3,650	3,750	150	170
Discharge with Optimization Strategy[2]	lb N or P/d	570	660	2,040	2,350	30	30
Load Reduction[3]	lb N or P/d	2,770	2,920	1,610	1,400	120	140
Load Reduction[3]	%	83%	82%	44%	37%	81%	81%

1. Average for the period between 2016-2025 based on 2015 BACWA Group Annual Report, escalated based on influent load increases over the period.
2. Average for the period between 2016-2025 for optimized performance based on influent load increases over the period.
3. As compared to Current Discharge (Note 1).

Optimization - Costs

Table 4-3. Projected Costs and Nutrient Unit Costs for Optimization Strategy

Parameter	Units	Dry Season	Wet Season
Capital[1]	$ Mil	7.2	7.6
Annual O&M	$ Mil/yr	0.4	1.3
Present Value O&M	$ Mil	3.4	12.1
Present Value Total	$ Mil	10.6	19.7
Unit Capital Cost	$/gpd	0.6	0.6
NH4-N Cost[2,4]	$/lb NH4-N	1.1	1.9
TN Cost[2,4]	$/lb N	1.8	3.9
TP Cost[3,4]	$/lb P	5.9	5.9

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. Based on cost for nitrogen removal only
3. Based on cost for phosphorus removal only
4. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 10-year projection duration.

Optimization - Ancillary and Adverse Impacts

Table 4-5. Ancillary Benefits and Impacts for Optimization Strategy

Ancillary Benefits	Adverse Impacts
CEPT for P Removal • More organics and solids diverted to produce more biogas • Less oxygen demand on the downstream activated sludge • Phosphorus reliably removed under peak flow scenarios	• Dependency on chemicals • Chemical costs
Increase the SRT and Use Old Secondaries • Improved secondary clarifier settleability due to longer SRT • Increased TSS and BOD load reduction in the Secondary Clarifiers due to longer SRT • Reduced waste activated sludge yield • Improved contaminants of emerging concern removal	• Operating a more complex process • Additional energy demand • Foaming concerns • Might require alkalinity addition
Increase the RAS Return Rate • Ability to store RAS in the old secondaries during peak wet weather events (if necessary) • Alkalinity recovery from nitrogen reduction	• Additional energy demand by pumping more RAS
Chemical Addition to Digested Biosolids • Increased cake percentage • Assist with struvite related issues	• Dependency on chemicals • Chemical costs

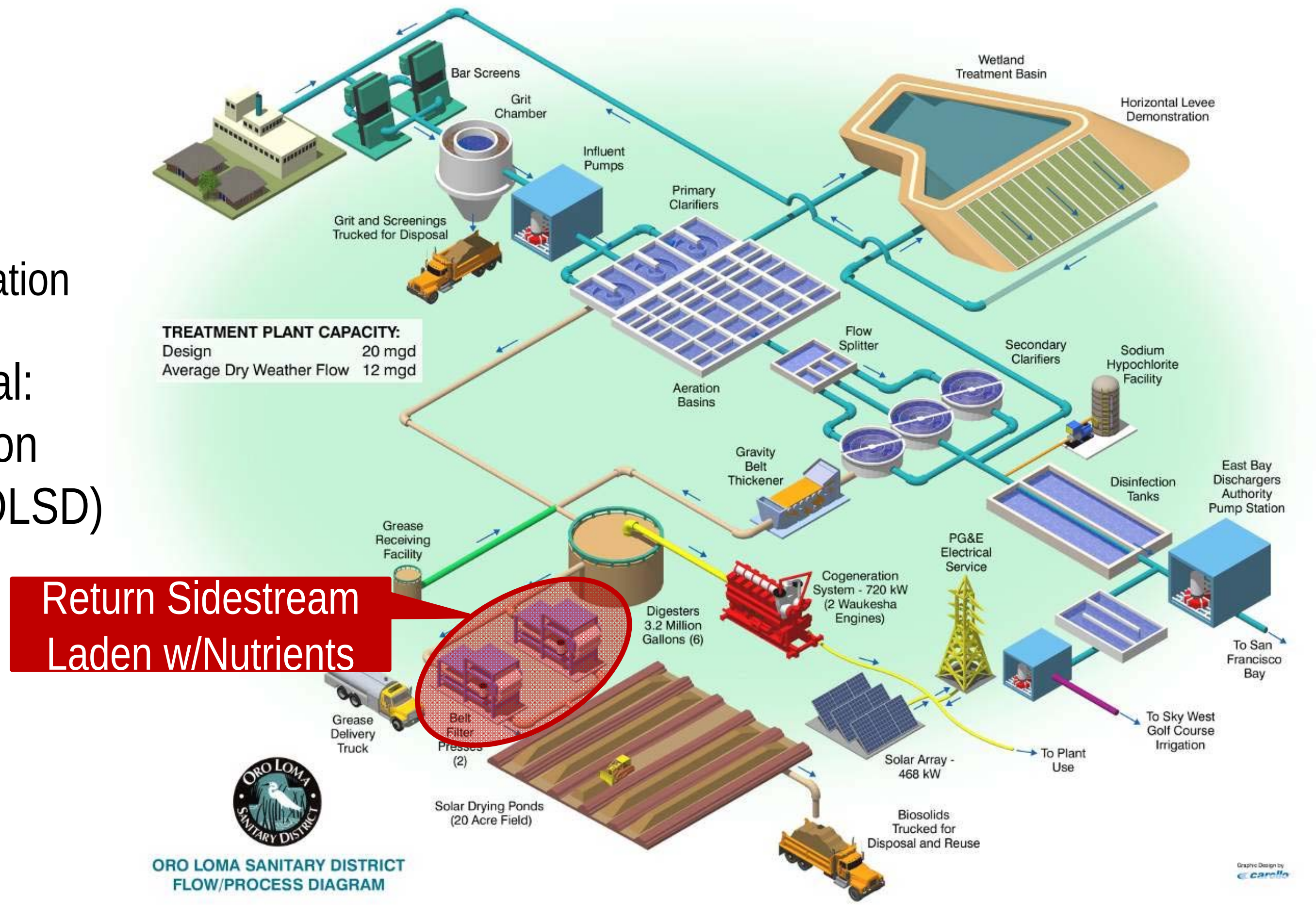
Oro Loma – Sidestream Treatment

1. Nitrogen Removal Options:

   a) Deammonification (i.e., anammox type) (default)

   b) Conventional nitrification

2. Phosphorus Removal: Chemical Precipitation (Not Applicable for OLSD)



Sidestream - Facilities

Report will provide a list of the key capital elements for Sidestream Treatment of Ammonia/TN and TP

Table 5–1. Sidestream Treatment Facility Needs for Ammonia/TN or TP Load Reduction

Ammonia/TN Load Reduction Elements	TP Load Reduction Elements*
Feed Pumping (if necessary)	--
Feed Flow Equalization	--
Pre-Treatment Screens	--
Biological Reactor	--
Aeration Supply Equipment	--
Effluent Pumping (if necessary)	--

* Sidestream treatment for TP discharge load reduction not recommended as previously discussed

Sidestream – Costs

Deammonification Technology Recommended (Anticipate a 21% TN Load Reduction)

Table 5-3. Projected Costs and Nutrient Unit Costs for Sidestream Treatment

Parameter	Units	Ammonia/TN	TP[5]
Capital	$1,000 [1]	16,000	--
Annual O&M	$1,000/yr	940	--
Total Present Value	$1,000 [2]	37,000	--
NH4-N Cost [2,4]	$/lb N	3.1	--
TN Cost [2,4]	$/lb N	3.1	--
TP Cost [3,4]	$/lb P		--

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. Based on cost for ammonia/nitrogen removal only.
3. Based on cost for phosphorus removal only.
4. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 30-year projection duration.
5. Sidestream treatment for TP discharge load reduction not recommended as previously discussed

Upgrade Details – Facilities

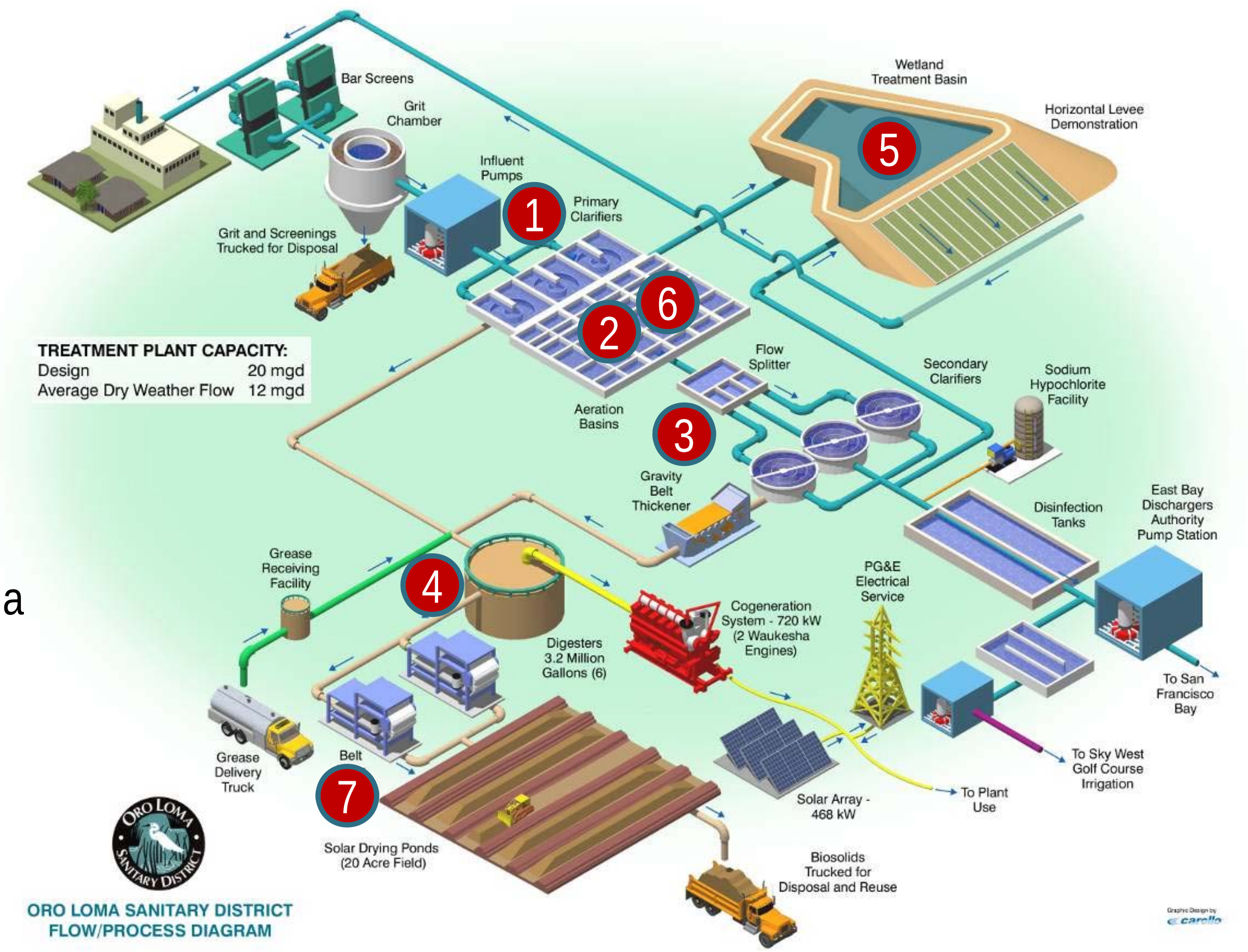
Report will provide a list of the key capital elements for throughout the plant for Levels 2 and 3

Table 6-1. Facility Needs Overview for Level 2 and 3 Plant Upgrades

Treatment	Level 2	Level 3
Primary	--	--
Flow Equalization	Expand the existing flow equalization basins (under the Ecotone Project)	Same as Level 2
Biological	• Modification to MLE (same as optimization) • Replace mechanical aeration with fine-bubble aeration system • Air Piping • Alkalinity • No new secondaries	Same as Level 2 plus: • Expansion of aeration basin volumes • External carbon source
Tertiary	--	• New Filters • Ferric Chloride and Polymer Chemical Feed • Rapid Mix and Flocculation Tanks
Biosolids or Sidestream	Deammonification Sidestream Treatment	Same as Level 2

Oro Loma – Level 2

1. Chemical to primaries
2. Raise SRT, extend aeration tank, operate in SNDN
3. Increase RAS return rate
4. Chemical to dewatering
5. Expand flow equalization
6. Replace mechanical aeration with fine-bubble diffusers and a blower building
7. Sidestream treatment (Deammonication)

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Level 2
(1) Chemical to primaries
(2) Raise SRT, extend aeration tank, operate as SNDN
(3) Increase RAS return rate
(4) Chemical to dewatering
(5) Expand flow equalization
(6) Replace mechanical aeration with fine-bubble diffusers and a blower building (shown)
(7) Sidestream treatment (Deammonication)
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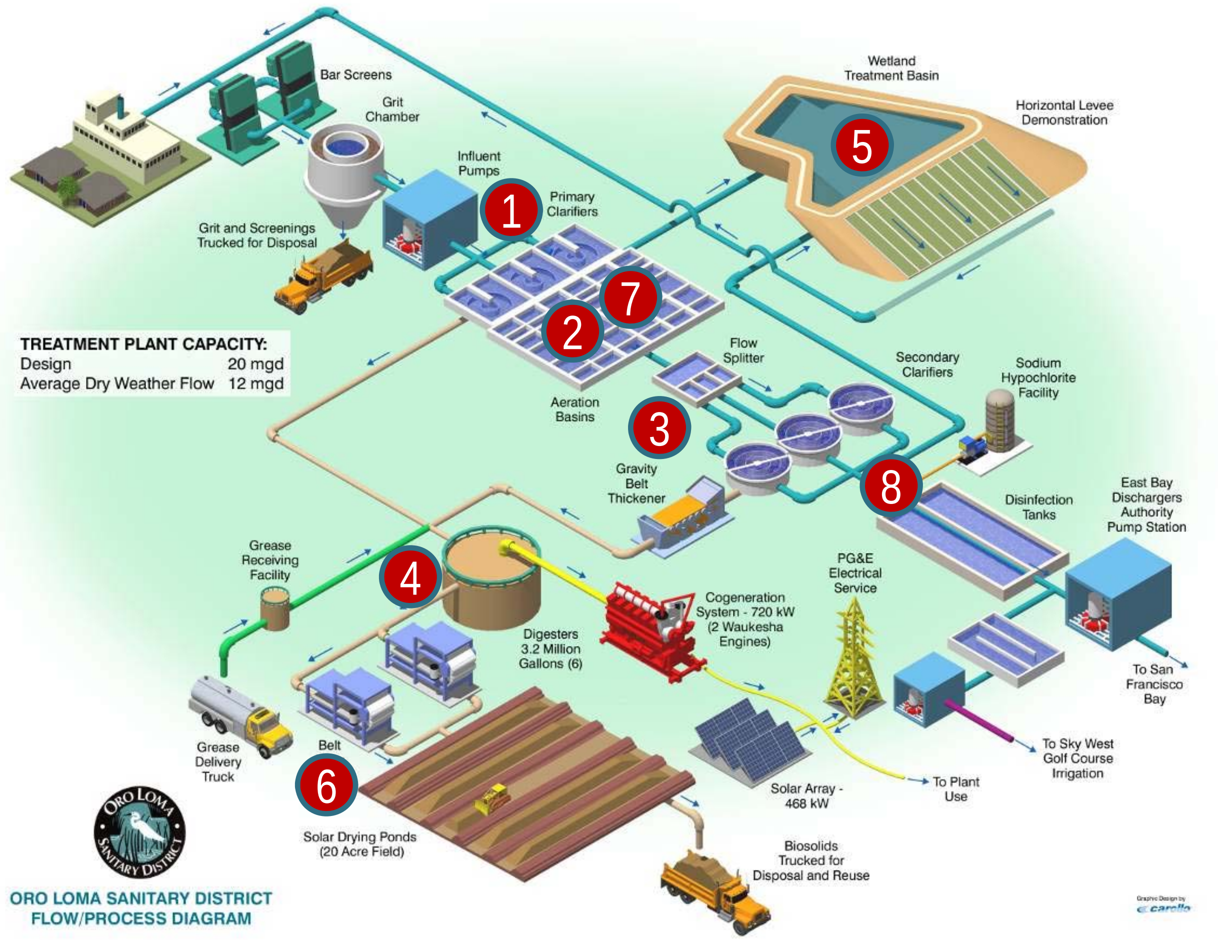
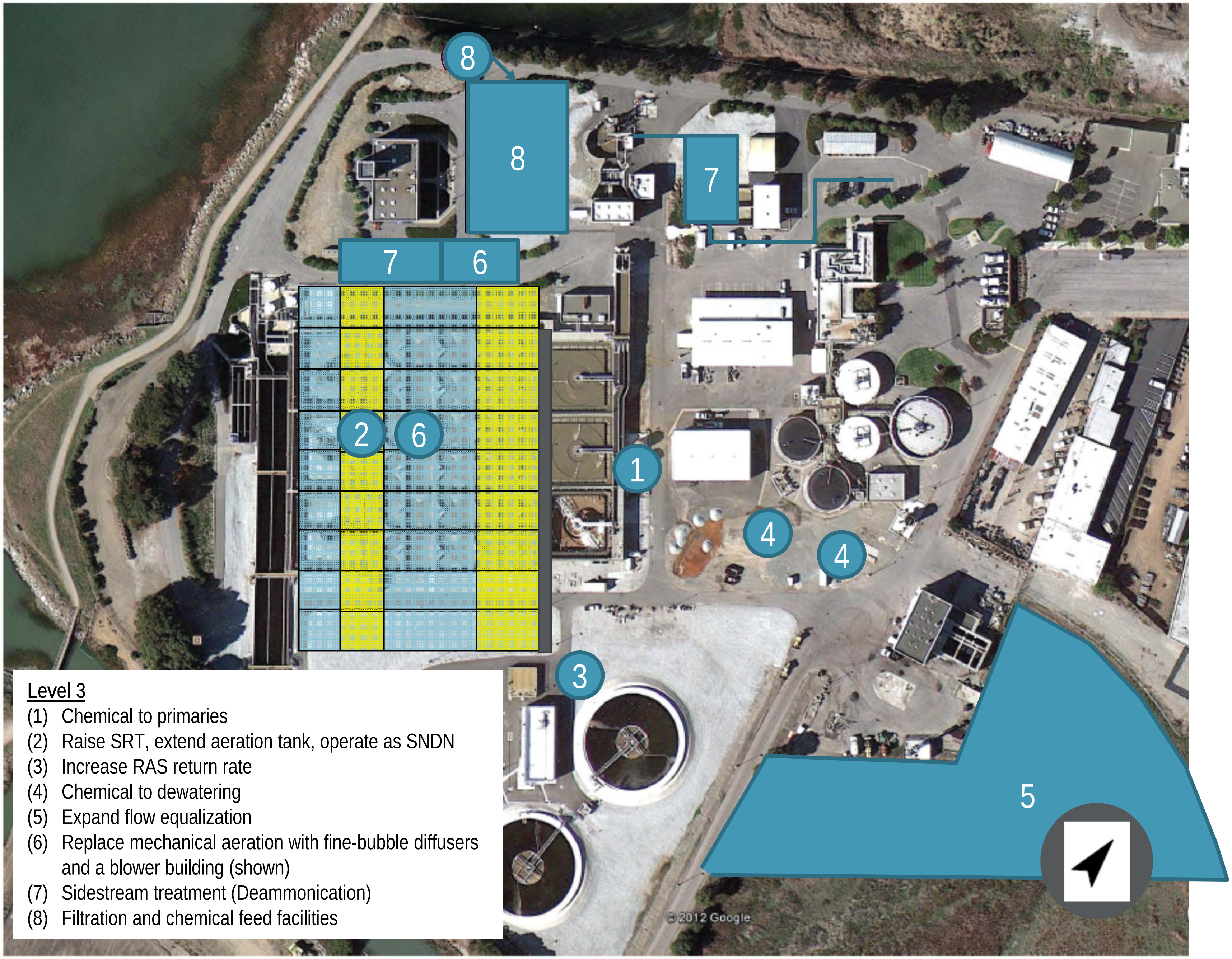
Oro Loma – Level 3

1. Chemical to primaries
2. Raise SRT, extend aeration tank, operate as SNDN
3. Increase RAS return rate
4. Chemical to dewatering
5. Expand flow equalization
6. Replace mechanical aeration with fine-bubble diffusers and a blower building
7. Sidestream treatment (Deammonication)
8. Filtration and chemical feed facilities

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Level 3
(1) Chemical to primaries
(2) Raise SRT, extend aeration tank, operate as SNDN
(3) Increase RAS return rate
(4) Chemical to dewatering
(5) Expand flow equalization
(6) Replace mechanical aeration with fine-bubble diffusers and a blower building (shown)
(7) Sidestream treatment (Deammonication)
(8) Filtration and chemical feed facilities
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Upgrade Details – Cost

Table 6-2. Estimated Capital and O&M Costs for Nitrogen and Phosphorus Plant Upgrades

Parameter	Unit	Level 2 Dry Season	Level 2 Wet Season	Level 3 Dry Season	Level 3 Wet Season
TN and TP Removal					
Capital[1]	$ Mil	28	38	52	74
Annual O&M	$Mil/yr	0.3	1.5	0.6	3.0
Total Present Value[2]	$ Mil	35	72	89	142
Unit Capital Cost	$/gpd	1.4	1.7	2.6	3.3
TN Removal					
Capital[1]	$ Mil	28	38	44	55
Annual O&M	$ Mil/yr	0.4	1.5	1.4	2.7
Total Present Value[2]	$ Mil	35	72	73	114
TN Cost[3]	$/lb N	1.3	2.8	1.8	2.8
TP Removal					
Capital[1]	$ Mil	0	0	8	18
Annual O&M	$ Mil/yr	0.4	0.4	0.6	0.8
Total Present Value[2]	$ Mil	8	9	23	35
TP Cost[3]	$/lb P	14	14	14	20

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. PV is calculated based on a 2 percent discount rate for 30 years.
3. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 30-year projection duration.

Upgrade Details – Ancillary and Adverse Impacts

Table 6-4. Ancillary Impacts for the Upgrades to Meet Levels 2 and 3

Strategy	Ancillary Benefits	Adverse Impacts
Level 2	• Leverage existing aeration basins and secondary clarifiers • Robust technology to absorb variability in flows and loads • Ability to reliably remove ammonia and TN • Reduced solids production • Reduced TSS and BOD discharge loading • Improved CEC removal compared to existing activated sludge	• New aeration system to learn, operate, and maintain • More complex to operate than existing activated sludge • New sidestream treatment facility to operate and maintain • More chemicals than current
Level 3	Same as Level 2 plus the following additional benefits: • Further enhanced CEC removal compared to Level 2 as any particulate bound CECs should be captured in the filters • Leverage and expand existing filter facility	Same as Level 2 plus the following additional adverse impacts: • More chemicals required than Level 2 • Safety from external carbon source (if methanol) • Additional unit process to operate (filters and sedimentation)

Upgrades – Emerging Technologies

- Introduce two technologies specific for each plant
- Advantages and disadvantages for each technology
- Potential next steps for each technology

The following two innovative technologies were specifically identified for future consideration at OLSD:

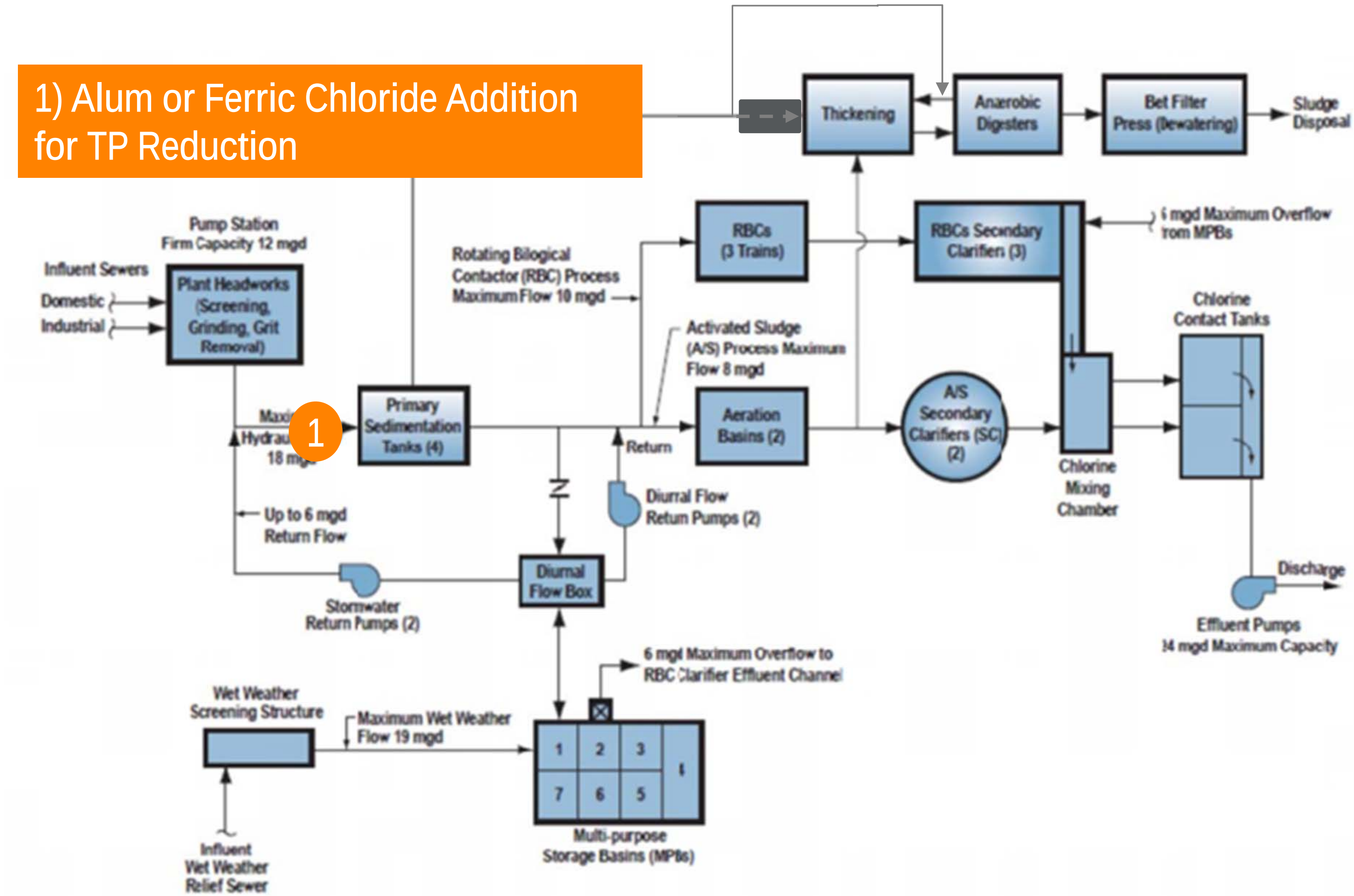
- Nutrient Removal using Granular Sludge – this could be used to phase out the biotower/activated sludge and/or MBR. The application of granular sludge means process tankage requirements are reduced which reduces overall costs. One supplier, Nereda, has large full-scale installations overseas in the Netherlands and South Africa; however, there are currently no full-scale installations in North America.
  - Advantages: Low footprint requirements, energy efficient, ability to remove ammonia, TN, and TP.
  - Disadvantages: No installations in North America.
  - Potential Next Steps: Determine footprint requirements and estimated cost of full-scale system and consider pilot or demonstration testing.
- Membrane Aerated Biofilm Reactor (MABR) – this aeration technology could replace the mechanical aeration system within the existing aeration basins. The membrane is used to deliver air (inside-out) and the activated sludge biology resides as a biofilm on the membrane. The biology takes up the air as it is delivered through the membrane. This configuration has been shown to use more or less all the provided air and thus results in a compact footprint. There are a few suppliers with several on-going piloting studies. However, there are currently no full-scale installations in North America.
  - Advantages: Low footprint requirements, energy efficient, ability to remove ammonia, TN, and TP.
  - Disadvantages: No installations in North America.
  - Potential Next Steps: Determine footprint requirements and cost of full-scale system and consider pilot or demonstration testing.

Table ES-1. Summary of Costs and Load Reductions

Parameter	Unit	Current Dry Season[1]	Current Wet Season[1]	Opt. Dry Season[2]	Opt. Wet Season[2]	Level 2 Dry Season[2]	Level 2 Wet Season[2]	Level 3 Dry Season[2]	Level 3 Wet Season[2]	Side-stream[2]
Flow to Bay	mgd	12.0	13.5	12.0	13.5	16.0	18.0	16.0	18.0	
Nutrients to Bay (Average)										
Ammonia	lb N/d	3,111	3,334	570	660	270	300	270	300	3,420
TN	lb N/d	3,391	3,493	2,040	2,350	2,000	2,250	800	900	3,920
TP	lb P/d	140	157	30	30	130	150	40	40	170
Costs [3]										
Capital	$ Mil	--	--	7.2	7.6	28	38	52	74	16
PV O&M	$ Mil	--	--	3.4	12.1	7	34	37	68	21
Total PV	$ Mil	--	--	10.6	19.7	35	72	89	142	37
Unit Costs										
Capital	$/gpd	--	--	0.6	0.6	1.4	1.7	2.6	3.3	--
TN Cost [4]	$/lb N	--	--	1.8	3.9	1.3	2.8	1.8	2.8	3.1
TP Cost [4]	$/lb P	--	--	5.9	5.9	14	14	14	20	--

Benicia

Optimization Strategy



Optimization Siting

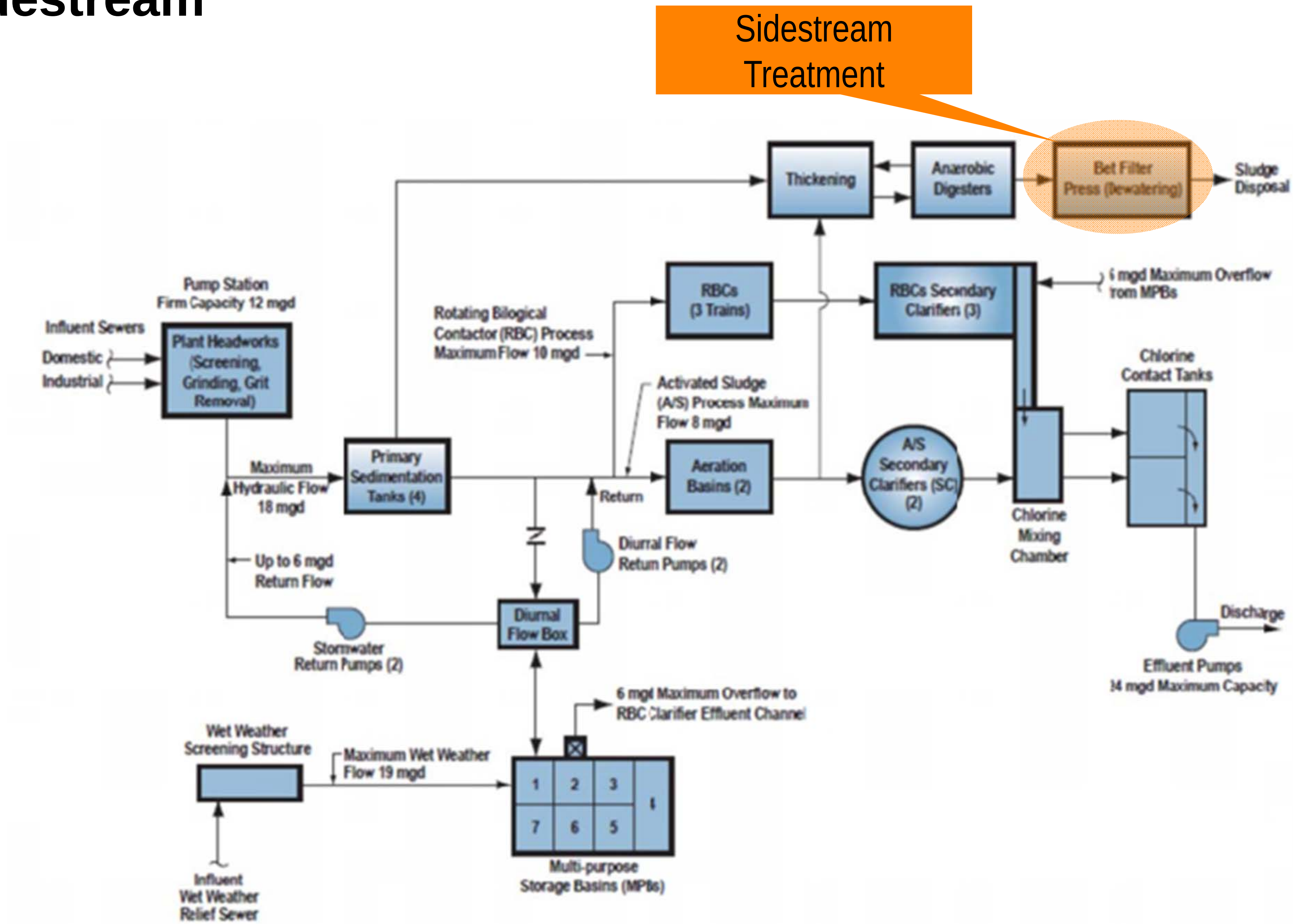
Optimization Costs

Table 4-3. Projected Costs and Nutrient Unit Costs for Optimization Strategy

Parameter	Units	Dry Season	Wet Season
Capital[1]	$ Mil	0.4	0.4
Annual O&M	$ Mil/yr	0.02	0.03
Present Value O&M	$ Mil	0.2	0.2
Present Value Total	$ Mil	0.6	0.7
Unit Capital Cost	$/gpd	0.2	0.2
NH4-N Cost[2,4]	$/lb NH4-N	0	0
TN Cost[2,4]	$/lb N	0	0
TP Cost[3,4]	$/lb P	4	4

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. The recommended optimization strategy does not address ammonia or total nitrogen removal.
3. Based on cost for P removal only.
4. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 10-year projection duration.

Sidestream



Sidestream Treatment
Thickening
Anaerobic Digesters
Belt Filter Press (Dewatering)
Sludge Disposal
Pump Station Firm Capacity 12 mgd
Influent Sewers
Domestic
Industrial
Plant Headworks (Screening, Grinding, Grit Removal)
Rotating Biological Contactor (RBC) Process Maximum Flow 10 mgd
RBCs (3 Trains)
RBCs Secondary Clarifiers (3)
6 mgd Maximum Overflow from MPBs
Activated Sludge (A/S) Process Maximum Flow 8 mgd
Chlorine Contact Tanks
Maximum Hydraulic Flow 18 mgd
Primary Sedimentation Tanks (4)
Return
Aeration Basins (2)
A/S Secondary Clarifiers (SC) (2)
Chlorine Mixing Chamber
Up to 6 mgd Return Flow
Diurnal Flow Return Pumps (2)
Diurnal Flow Box
Stormwater Return Pumps (2)
Discharge
Effluent Pumps
24 mgd Maximum Capacity
6 mgd Maximum Overflow to RBC Clarifier Effluent Channel
Wet Weather Screening Structure
Maximum Wet Weather Flow 19 mgd
1 2 3 4 7 6 5
Influent Wet Weather Relief Sewer
Multi-purpose Storage Basins (MPBs)

Sidestream – Costs

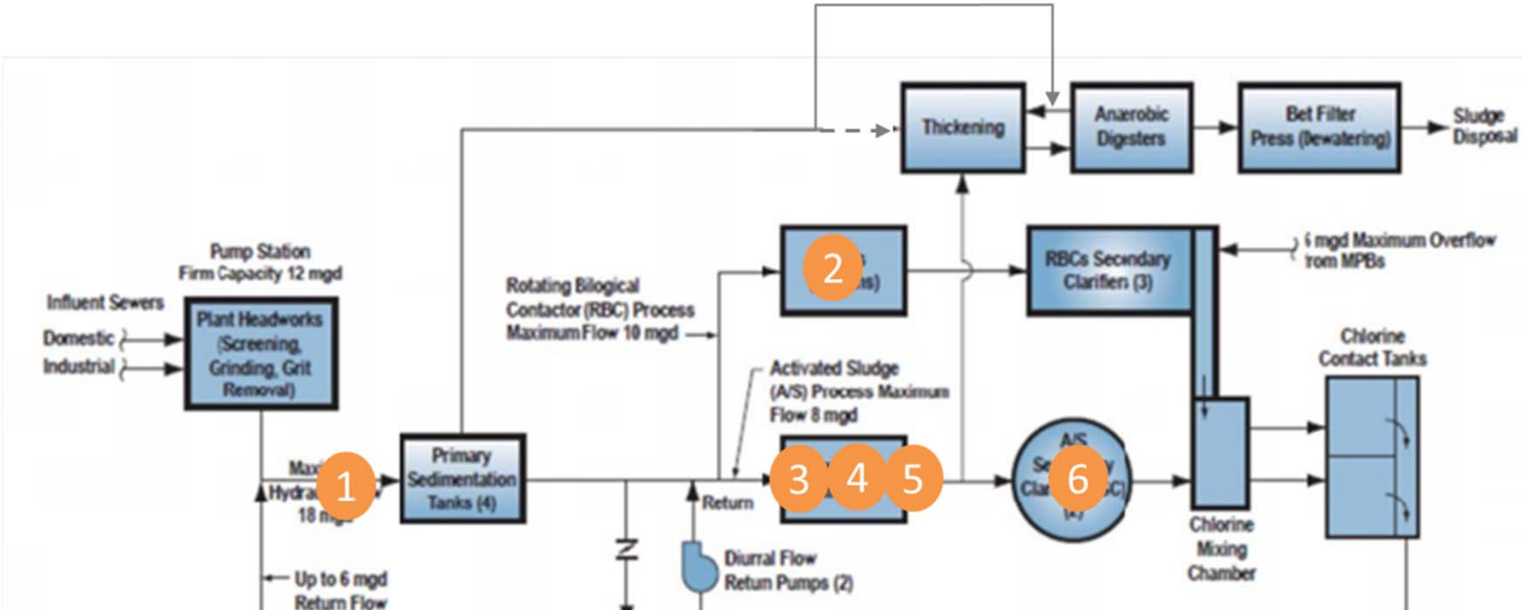
Deammonification Technology Recommended (Anticipate a 11% TN Load Reduction) plus Chemical Precipitation for TP Removal (Anticipate a 32% TP Load Reduction)

Table 5-3. Projected Costs and Nutrient Unit Costs for Sidestream Treatment

Parameter	Units	Ammonia/TN	TP
Capital	\$ Mil [1]	3.3	0.09
Annual O&M	\$ Mil/yr	0.08	0.02
Total Present Value	\$ Mil [2]	5.2	0.5
NH4-N Cost [2,4]	\$/lb N [3]	6.5	--
TN Cost [2,4]	\$/lb N [3]	6.5	--
TP Cost [3,4]	\$/lb P [3]	--	2.0

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. Based on cost for ammonia/nitrogen removal only
3. Based on cost for phosphorus removal only
3. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 30-year projection duration.

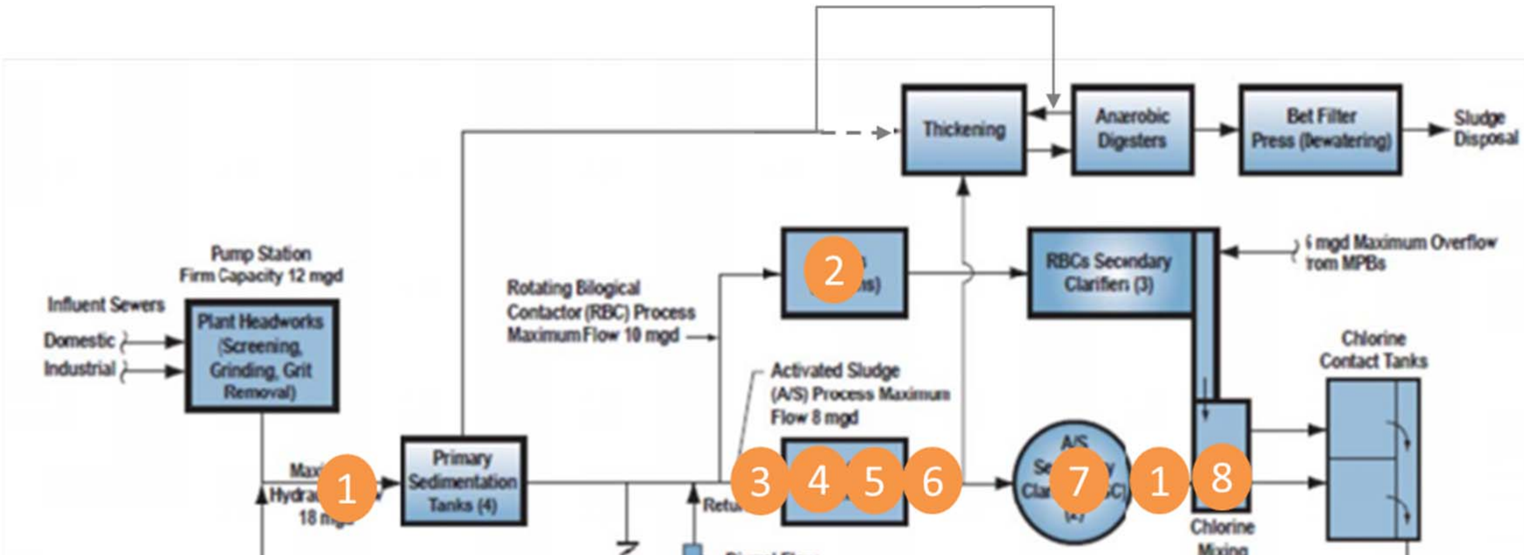
Level 2 Upgrades



1) Construct alum storage and dosing facility,
2) Demolition of existing RBC trains
3) Construct 2, new aeration basins in MLE configuration,
4) Retrofit existing aeration basins to a MLE configuration
5) Construct caustic soda storage and metering facilities,
6) Construct 1, new secondary clarifier.

Level 2 Siting

Level 3 Upgrades



1) Alum storage and metering facilities for P removal
2) Demolition of existing RBC trains
3) Construction of new aeration basins in 4-stage Bardenpho configuration,
4) Retrofit existing aeration basins to a 4-stage Bardenpho configuration
5) Construct caustic soda storage and metering facilities,
6) Construct methanol storage and metering facilities,
7) Construct 1, new secondary clarifier and
8) Construct tertiary filters

Level 3 Siting

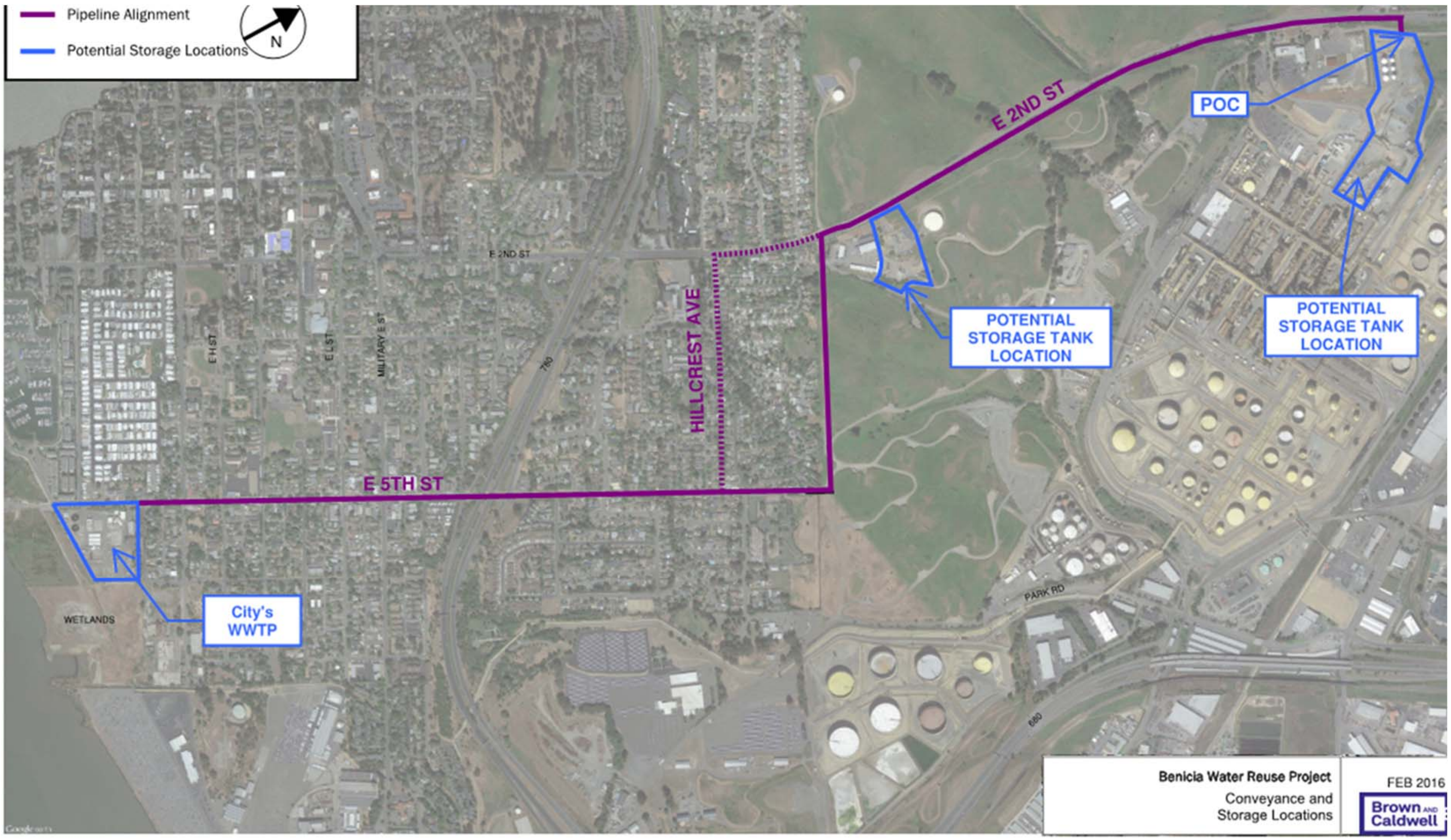
Level 2 and 3 Upgrade Costs

Table 6-2. Estimated Capital and O&M Costs for Nitrogen and Phosphorus Plant Upgrades

Parameter	Unit	Level 2 Dry Season	Level 2 Wet Season	Level 3 Dry Season	Level 3 Wet Season
TN and TP Removal					
Capital[1]	$ Mil	24.1	24.3	33.7	35.3
Annual O&M	$Mil/yr	0.14	0.17	0.41	0.46
Total Present Value[2]	$ Mil	27	28	43	46
Unit Capital Cost	$/gpd	5.4	4.8	7.5	6.9
TN Removal					
Capital[1]	$ Mil	23.6	23.8	27.3	27.5
Annual O&M	$ Mil/yr	0.10	0.12	0.26	0.30
Total Present Value[2]	$ Mil	26	27	33	34
TN Cost[3,4]	$/lb N	6.6	6.7	5.1	4.9
TP Removal					
Capital[1]	$ Mil	0.5	0.5	6.4	7.8
Annual O&M	$ Mil/yr	0.04	0.05	0.14	0.16
Total Present Value[2]	$ Mil	1.4	1.6	9.6	11.3
TP Cost[3]	$/lb P	2.2	2.1	11.1	11.6

Removal By Other Means

- Produce up to 2,200 AFY of Title 22 Recycled Water at the City of Benicia's WWTP for use as cooling tower makeup water at the Valero Benicia Refinery and for irrigation water for other City customers



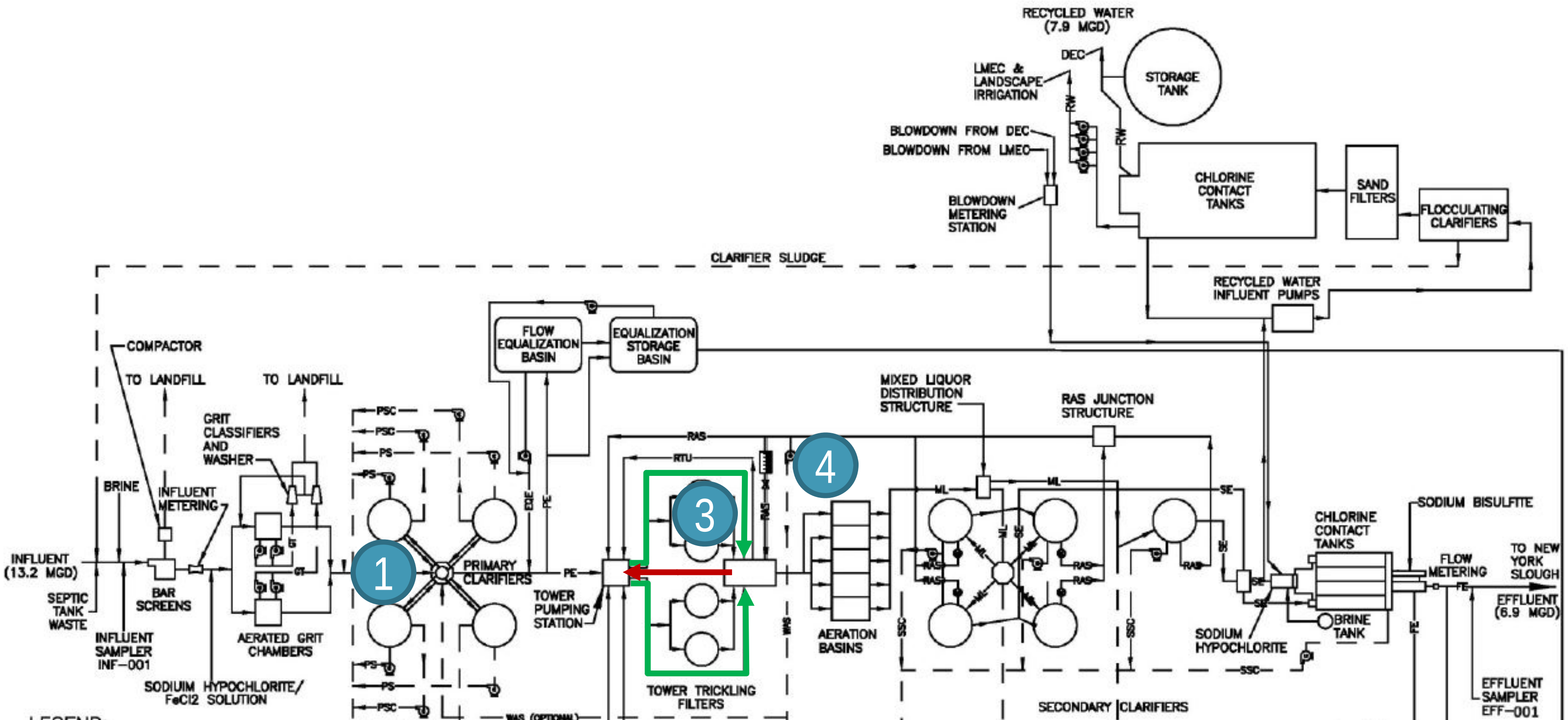
Executive Summary

Table ES-1. Summary of Costs and Load Reductions

Parameter	Unit	Current Dry Season[1]	Current Wet Season[1]	Opt. Dry Season	Opt. Wet Season	Level 2 Dry Season	Level 2 Wet Season	Level 3 Dry Season	Level 3 Wet Season	Side-stream
Flow to Bay	mgd	1.9	2.2	1.9	2.2	3.2	3.7	3.2	3.7	--
Nutrients to Bay (Average)										
Ammonia	lb N/d	389	420	419	452	53	61	53	61	560
TN[6]	lb N/d	475	513	511	551	400	457	160	183	700
TP	lb P/d	55	62	15	17	27	30	8	9	60
Costs [2]										
Capital	$ Mil	--	--	0.4	0.4	24	24.1	24.3	33.7	3.4
PV O&M	$ Mil	--	--	0.2	0.2	3	3.2	3.8	9.1	2.2
Total PV	$ Mil	--	--	0.6	0.7	27	27.3	28.1	42.8	5.7
Unit Costs										
Capital	$/gpd	--	--	0.2	0.2	5.4	4.8	7.5	6.9	6.5
TN Cost [3,7]	$/lb N	--	--	0	0	6.6	6.7	5.1	4.9	6.5
TP Cost [3]	$/lb P	--	--	4.4	4.1	2.2	2.1	11.1	11.6	2.0

Delta Diablo

Delta Diablo - Optimization



1) Optimize metal salt dosing to enhance existing P removal

3) Split treatment at the biotowers for ammonia removal

4) Add anoxic zone to aeration basin for total nitrogen removal (predicated on implementation of (3))

Optimization - Costs

Table 4-3. Projected Costs and Nutrient Unit Costs for Optimization Strategy

Parameter	Units	Dry Season	Wet Season
Total Capital[1]	$ Mil	5.6	6.0
Annual O&M	$ Mil/yr	0.02	1.1
Present Value O&M	$ Mil	0.2	10
Present Value Total	$ Mil	6	16
Unit Capital Cost	$/gpd	0.4	0.5
NH4-N Cost[2,4]	$/lb NH4-N	2.4	13.1
TN Cost[2,4]	$/lb N	1.4	3.6
TP Cost[3,4]	$/lb P	21	15

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. Based on cost for nitrogen removal only
3. Based on cost for phosphorus removal only
4. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 10-year projection duration.

Sidestream – Costs

Deammonification Technology Recommended (Anticipate a 17% TN Load Reduction)

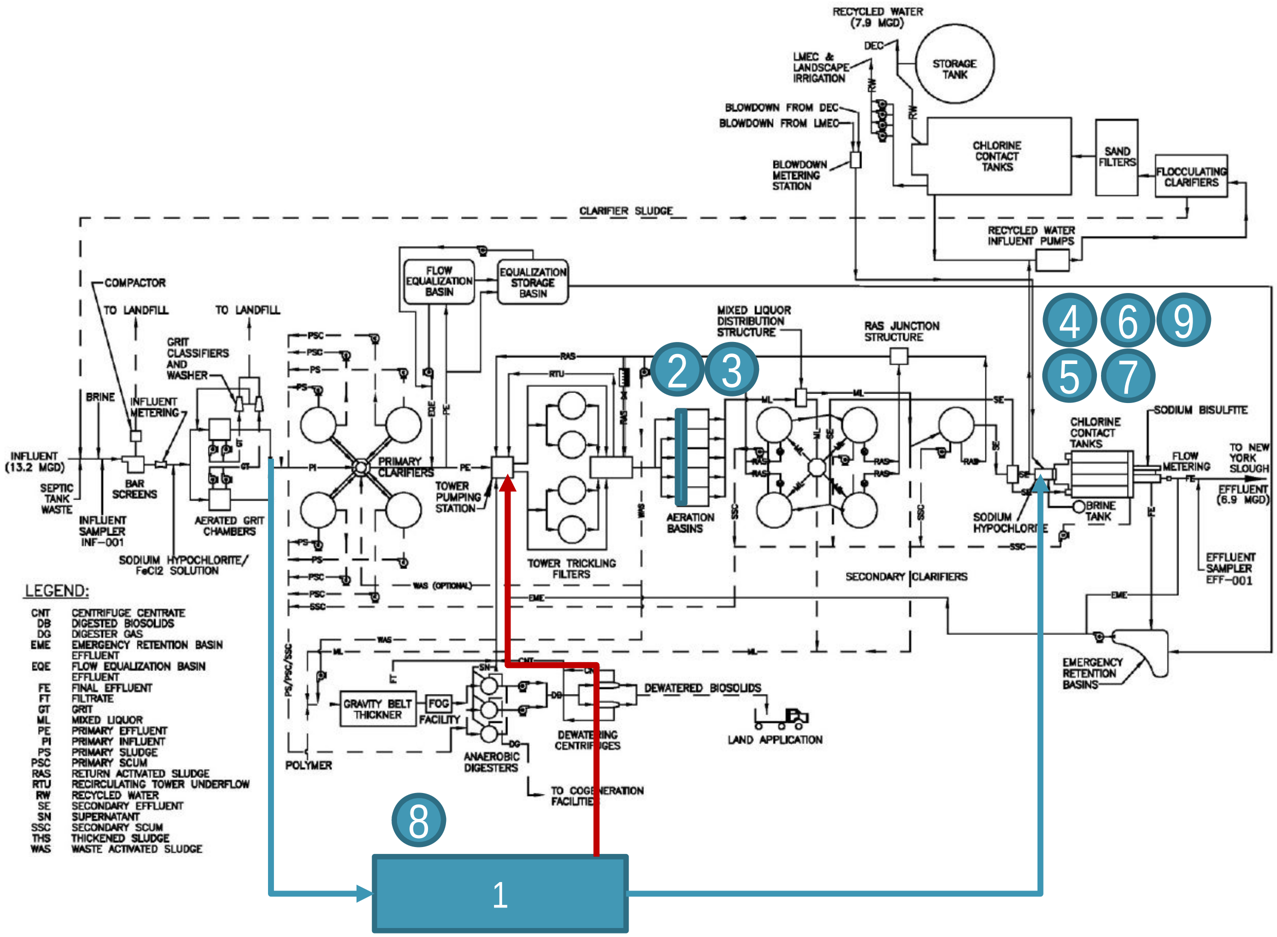
Table 5-3. Projected Costs and Nutrient Unit Costs for Sidestream Treatment

Parameter	Units	Ammonia/TN	TP[5]
Capital	$ 1,000 [1]	12,000	--
Annual O&M	$ 1,000/yr	610	--
Total Present Value	$ 1,000	26,000	--
NH4-N Cost [2,4]	$/lb N	3.3	--
TN Cost [2,4]	$/lb N	3.3	--
TP Cost [3,4]	$/lb P	--	--

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. Based on cost for ammonia/nitrogen removal only.
3. Based on cost for phosphorus removal only.
4. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 30-year projection duration.
5. Sidestream treatment for TP discharge load reduction not recommended as previously discussed

Delta Diablo – Level 2

1. New membrane bioreactor,
2. Convert aeration basin zone to anoxic zone
3. External carbon source facilities
4. Alkalinity facilities
5. New BAF facilities
6. External carbon source facilities
7. New denitrifying filters
8. External carbon source facilities
9. Metal salt/polymer chemical facilities

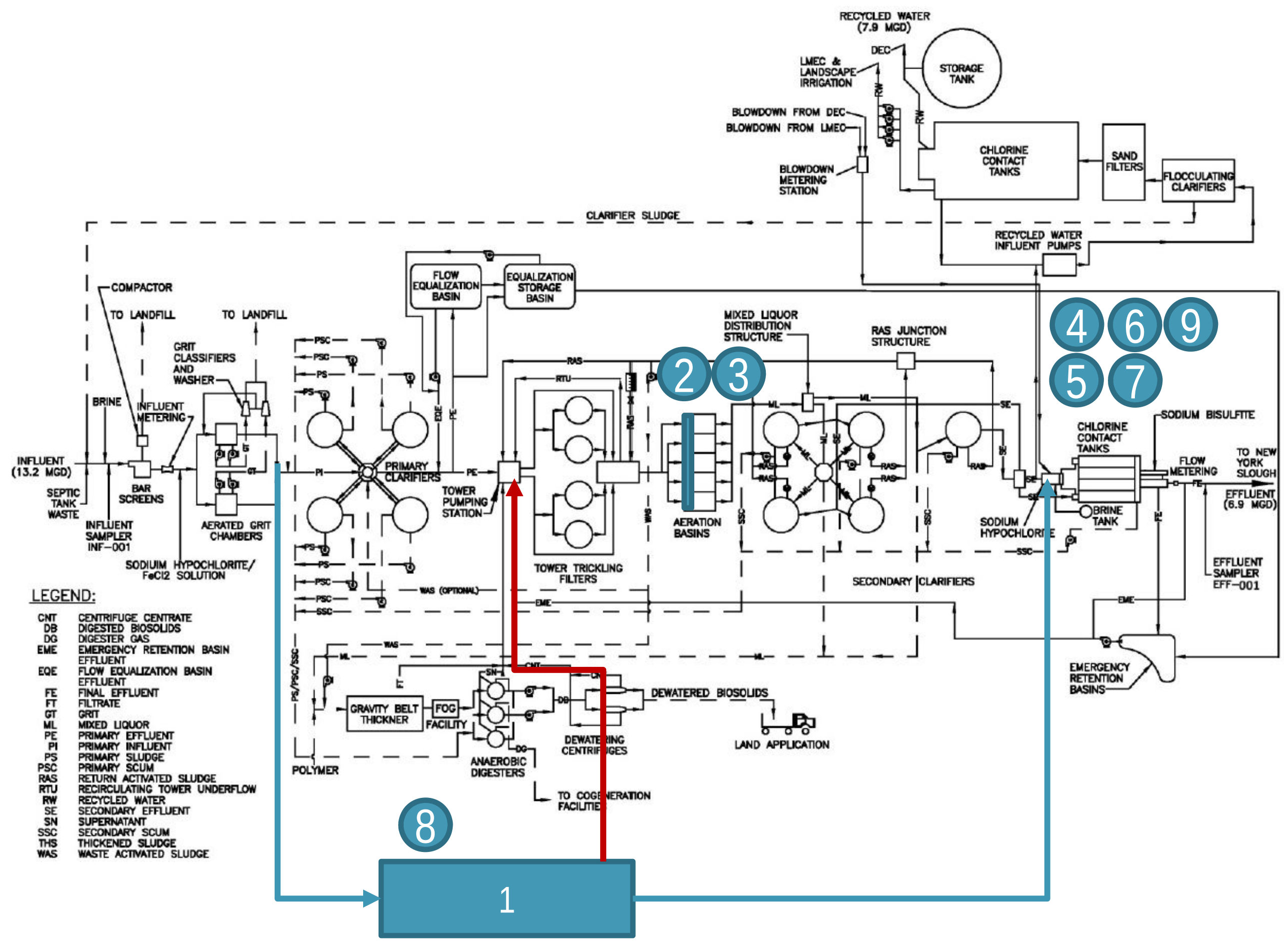


Level 2

Dry Season
Wet Season
4
5
6
7
3
2
1
2
Delta Diablo (fka Delta Diablo Sanitation District)

Delta Diablo – Level 3

1. New membrane bioreactor,
2. Convert aeration basin zone to anoxic zone
3. External carbon source facilities
4. Alkalinity facilities
5. New BAF facilities
6. External carbon source facilities
7. New denitrifying filters
8. External carbon source facilities
9. Metal salt/polymer chemical facilities
10. Rapid mix/flocculation tanks



Level 3

Dry Season
Wet Season
9
4
6
5
7
3
2
10
1
8
Delta Diablo (fka Delta Diablo Sanitation District)

Upgrade Details – Cost

Table 6-2. Estimated Capital and O&M Costs for Nitrogen and Phosphorus Plant Upgrades

Parameter	Unit	Level 2 Dry Season	Level 2 Wet Season	Level 3 Dry Season	Level 3 Wet Season
TN and TP Removal					
Capital[1]	$ Mil	110	140	120	150
Annual O&M	$Mil/yr	1.6	3.7	1.7	3.8
Total Present Value[2]	$ Mil	150	220	160	240
Unit Capital Cost	$/gpd	5.5	7.2	6.0	7.9
TN Removal					
Capital[1]	$ Mil	110	140	120	150
Annual O&M	$ Mil/yr	1.6	3.7	1.7	3.8
Total Present Value[2]	$ Mil	140	220	160	240
TN Cost[3]	$/lb N	4.3	5.9	4.0	5.2
TP Removal					
Capital[1]	$ Mil	13	14	20	22
Annual O&M	$ Mil/yr	0	0	0	0
Total Present Value[2]	$ Mil	13	14	20	22
TP Cost[3]	$/lb P	65	74	29	28

1. Costs are referenced to the ENR SF CCI for July 2015 at 11,155.
2. PV is calculated based on a 2 percent discount rate for 30 years.
3. The unit load reduction cost was calculated by dividing the total present value by the nutrient load reduction over the 30-year projection duration.

Executive Summary

Table ES-1. Summary of Costs and Load Reductions

Parameter	Unit	Current Dry Season[1]	Current Wet Season[1]	Opt. Dry Season[2]	Opt. Wet Season[2]	Level 2 Dry Season[2]	Level 2 Wet Season[2]	Level 3 Dry Season[2]	Level 3 Wet Season[2]	Side-stream[2]
Flow to Bay	mgd	6.0	7.4	6.0	7.5	7.5	9.4	7.5	9.4	
Nutrients to Bay (Average)										
Ammonia	lb N/d	1,565	1,957	1,140	1,790	130	160	130	160	1,510
TN	lb N/d	3,167	3,678	2,260	2,730	940	1,180	380	470	3,600
TP	lb P/d	65	76	50	50	60	80	20	20	--
Costs [3]										
Capital	$ Mil	--	--	5.6	6.0	110	140	120	150	12
PV O&M	$ Mil	--	--	0.2	10	40	80	40	90	14
Total PV	$ Mil	--	--	6	16	150	220	160	240	26
Unit Costs										
Capital	$/gpd	--	--	0.4	0.5	5.5	7.2	6.0	7.9	--
TN Cost [4]	$/lb N	--	--	1.4	3.6	4.3	5.9	4.0	5.2	3.3
TP Cost [4]	$/lb P	--	--	21	15	65	74	29	28	--

Report Feedback/Comments

We Need Your Feedback

- Are findings consistent with the site visit recommendations?
- Recommended process
- Site layouts
- Cost
- Special considerations
  - Recycled water
  - Site constraints
  - Greenhouse gas emissions constraints
  - Others

Summary of Preliminary Cost and Load Reductions for Wave 1 Plants

All information presented is preliminary and subject to change.

DRAFT Wave 1 Optimization Summary (Dry Season)

Facility	Permitted Capacity (ADWF) mgd	Capital Cost $ Mil	Total PV $ Mil	Capital $/gpd	TN Cost $/lb N	TN Load Reduction lb N/d	TP Cost $/lb P	TP Load Reduction lb P/d
American Canyon	2.5	0.4	0.6	0.3	N/A	N/A	3.8	45
Benicia	4.5	0.4	0.6	0.2	N/A	N/A	4.4	40
Burlingame	5.5	1.4	1.5	0.5	0.5	540	2.3	140
CCCSD	53.8	10.2	24.4	0.29	0.4	1,710	39	100
Delta Diablo	19.5	5.6	6	0.4	1.4	1,150	21	20
DSRSD	17	3.1	10.3	0.3	1.1	1,630	95	20
Hayward	18.5	0.7	3.1	0.06	N/A	N/A	1.6	530
Livermore	8.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Oro Loma	20	7.2	10.6	0.6	1.8	1,610	5.9	120
Total / Flow Weighted Average	**149.8**	**29**	**57.1**	**0.3**	**0.7**	**6,640**	**28.8**	**1,015**

*Load reductions are projected to the midpoint of analysis period.

DRAFT Wave 1 Summary of Level 2 Upgrades (Dry Season)

Facility	Level 2 Upgrades						
	Capital Cost $ Mil	Total PV $ Mil	Capital $/gpd	TN Cost $/lb N	TN Load Reduction lb N/d	TP Cost $/lb P	TP Load Reduction lb P/d
American Canyon	**16**	16	6.3	164	10	1.8	50
Benicia	**24.1**	27	5.4	6.6	360	2.2	60
Burlingame	**42.6**	65	7.7	7.5	670	14	180
CCCSD	**180**	248	3.4	3.4	5,600	N/A	N/A
Delta Diablo	**110**	150	5.5	4.3	3,000	65	20
DSRSD	**70**	120	3.9	3.8	2,200	760	10
Hayward	**174**	219	9.4	13	1,500	1.3	640
Livermore	**21**	23	2.2	1.9	1,100	N/A	N/A
Oro Loma	**28**	35	1.4	1.3	2,500	14	50
Total / FW Average	**666**	**904**	**4**	**7**	**16,940**	**97**	**1,010**

*Load reductions are projected to the midpoint of analysis period.

DRAFT Wave 1 Summary of Level 3 Upgrades (Dry Season)

Facility	Level 3 Upgrades						
	Capital Cost $ Mil	Total PV $ Mil	Capital $/gpd	TN Cost $/lb N	TN Load Reduction lb N/d	TP Cost $/lb P	TP Load Reduction lb P/d
American Canyon	**19**	55	7.6	39	120	9.4	60
Benicia	**34**	43	7.5	5.1	600	11	80
Burlingame	**56**	85	10	6.6	980	14	210
CCCSD	**251**	523	4.7	4.4	8,700	49	230
Delta Diablo	**120**	160	6	4	3,600	29	60
DSRSD	**80**	140	4.8	3.4	2,900	140	60
Hayward	**238**	310	13	11	2,400	26	710
Livermore	**26**	39	2.8	2.1	1,500	43	10
Oro Loma	**52**	89	2.6	1.8	3,700	14	150
Total / FW Average	**875**	**1,444**	**6**	**5**	**24,500**	**46**	**1,570**

*Load reductions are projected to the midpoint of analysis period.

Comparison of DRAFT Wave 1 Results (Dry Season)

Facility	Capacity (ADWF) mgd	Optimization		Level 2		Level 3	
		Capital Cost $ Mil	Capital $/gpd	Capital Cost $ Mil	Capital $/gpd	Capital Cost $ Mil	Capital $/gpd
American Canyon	2.5	0.4	0.3	16	6.3	19	7.6
Benicia	4.5	0.4	0.2	24	5.4	33	7.5
Burlingame	5.5	1.4	0.5	43	7.7	56	10
CCCSD	53.8	10.2	0.29	180	3.4	251	4.7
Delta Diablo	19.5	5.6	0.4	110	5.5	120	6
DSRSD	17	3.1	0.3	70	3.9	80	4.8
Hayward	18.5	0.7	0.06	174	9.4	238	13
Livermore	8.5	N/A	N/A	21	2.2	26	2.8
Oro Loma	20	7.2	0.6	28	1.4	52	2.6
Total / Flow Weighted Average	**149.8**	**29**	**0.3**	**666**	**4**	**875**	**6**

Comparison of DRAFT Wave 1 Results (Dry Season)

Facility	Capacity (ADWF) mgd	Optimization		Level 2		Level 3	
		TN Cost $/lb N	TN Load Reduction lb N/d	TN Cost $/lb N	TN Load Reduction lb N/d	TN Cost $/lb N	TN Load Reduction lb N/d
American Canyon	2.5	N/A	N/A	164	10	39	120
Benicia	4.5	N/A	N/A	6.6	360	5.1	600
Burlingame	5.5	0.5	540	7.5	670	6.6	980
CCCSD	53.8	0.44	1,710	3.4	5,600	4.4	8,700
Delta Diablo	19.5	1.4	1,150	4.3	3,000	4	3,600
DSRSD	17	1.1	1,630	3.8	2,200	3.4	2,900
Hayward	18.5	N/A	N/A	13	1,500	11	2,400
Livermore	8.5	N/A	N/A	1.9	1,100	2.1	1,500
Oro Loma	20	1.8	1,610	1.3	2,500	1.8	3,700
Total / Flow Weighted Average	**149.8**	**0.7**	**6,640**	**7**	**16,940**	**5**	**24,500**

Candidate Plants for Sidestream Treatment

Subembayment	Initial Screen: Eligible for Ammonia Reduction	Refined Estimate	
		Eligible for Ammonia Reduction	Eligible for Total Nitrogen Reduction
Suisun Bay	3	1	2
San Pablo Bay	8	2	6
Central Bay	6	6	6
South Bay	13	11	11
Lower South Bay	2	0	2
Total	32	20	27

Preliminary TN Discharge Load Reduction Potential with Sidestream Treatment (based on Current Dry Season)

Subembayment	Annual Average Daily Discharge, lb N/d*	Preliminary Discharge Reduction Potential with Sidestream Treatment, %**
Suisun Bay	6,620	5-10%
San Pablo Bay	1,670	15-20%
Central Bay	12,250	20-25%
South Bay	23,140	12-16%
Lower South Bay	7,570	20-25%
Total	51,250	15-20%

* Source: 2015 Group Annual Report

** Based on plants identified as candidates for sidestream treatment to further reduce ammonia discharge loads to the Bay

What Predictions Can We Make Based on Early Results?

Projecting Preliminary Wave 1 Total N Results for All Plants (Dry Season)

Parameter	Units	Current[a]	Optimization[b]	Sidestream[b]	Level 2[b]	Level 3[b]
Suisun Bay	kg N/d	6,622	5,600	6,200	2,900	1,100
San Pablo Bay	kg N/d	1,673	1,400	1,300	900	400
Central Bay	kg N/d	12,254	10,400	9,200	3,600	1,500
South Bay	kg N/d	23,135	19,700	19,200	8,100	3,200
Lower South Bay	kg N/d	7,567	6,400	5,400	6,200	2,500
Total	kg N/d	51,250	43,600	41,300	21,700	8,700
Load Reduction	kg N/d	--	7,700	10,000	29,500	42,600
Load Reduction	%	--	15%	19%	58%	83%

a) Group Annual Report 2015 dry season average values

b) Based on current loads

Projecting Preliminary Wave 1 Capital Cost Results for All Plants (Dry Season)

Parameter	Units	Optimization	Sidestream	Level 2	Level 3
Suisun Bay	$ Mil	20	20	400	600
San Pablo Bay	$ Mil	5	41	250	380
Central Bay	$ Mil	19	72	670	1,000
South Bay	$ Mil	43	123	1,050	1,570
Lower South Bay	$ Mil	33	36	940	1,410
Total	$ Mil	120	291	3,310	4,960

Additional Data Requests

Recycled Water

BACWA Recycled Water Survey 2015

Agency Name (Recycled Water Producer):

Recycled Water Distributors/Retailers:

CURRENT AND PROJECTED FUTURE AMOUNT OF RECYCLED WATER BY USE CATEGORY (in acre-feet)

	Total Distribute	Confidence (see Note B)	Golf Course Irrigation (See Note C)	Landscape (see Note D)	Commercial (see Note E)	Industrial (see Note F)	Agricultural (see Note G)	Environmental Enhancement (see Note H)	Internal Use (see Note I)	GW Recharge for Indirect Potable Reuse	Surface Water Augmentation	Direct Potable Reuse	Other Non-potable Reuse (See Note J)	RO concentrate or other return	Comments
Type of RW (See Note A):															
Current			0	0	0	0	0	0	0	0	0	0	0	0	
Future															
Future															
Future															
Future															
Future															
Future															

2015 MONTHLY RECYCLED WATER DISTRIBUTION DATA BY USE CATEGORY (in acre-feet)

	TOTAL		Golf Course	Landsca pe	Commer cial	Industria l	Agricult ural	Environ. Enhance	Internal Use	GW Recharg	Surface Water	Direct Potable	Other Non-	Return Flows	Comments
January															
February															
March															
April															
May															
June															
July															
August															
September															
October															
November															
December															
TOTAL															

Purpose: To provide information regarding recycled water projects that could have an impact on nutrient loads and/or concentrations.

Capital Improvement Project

Name of Re	<name>
Utility Name	<utility>
Phone Num	<phone>

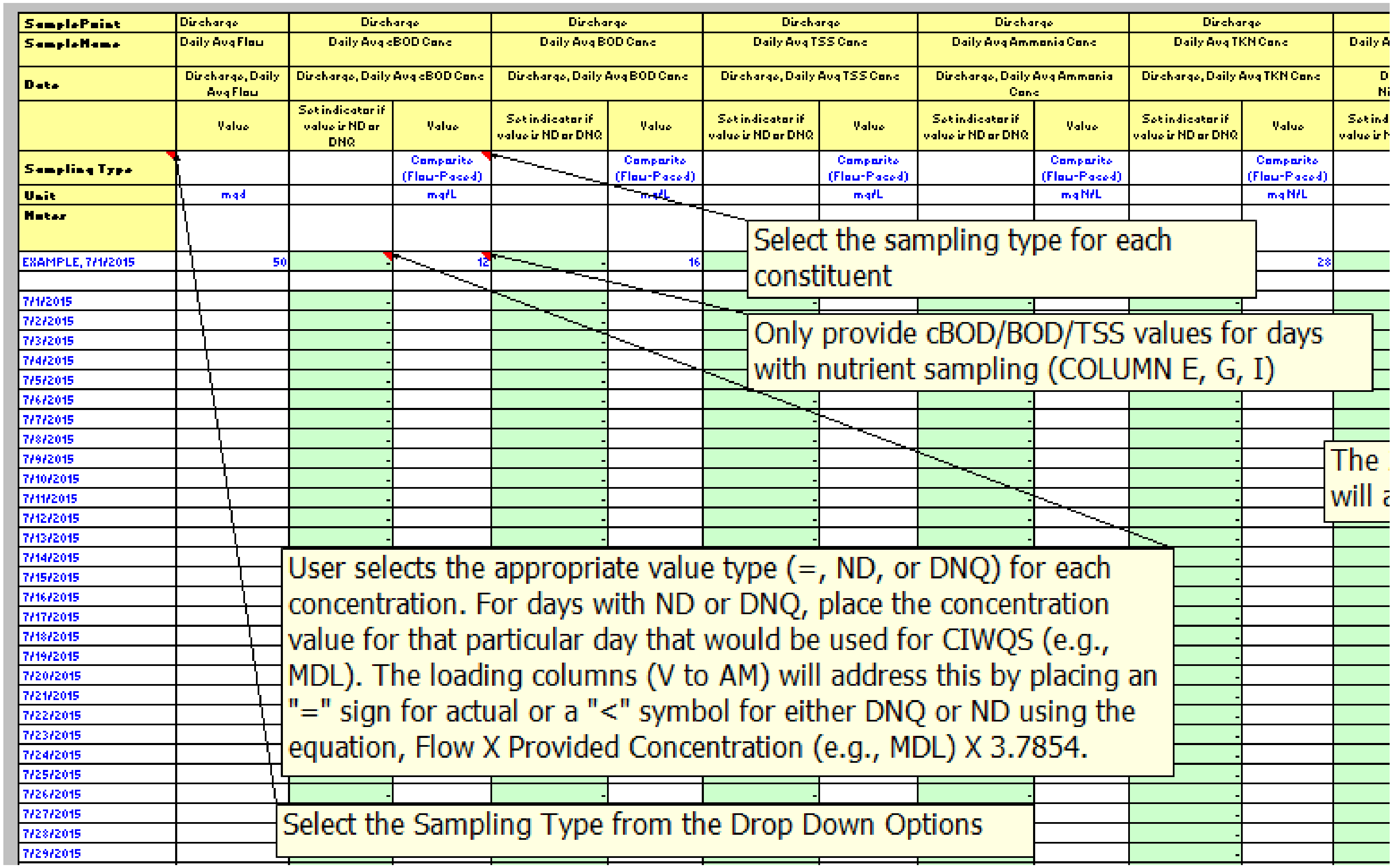
Planned CIP Projects that may impact nutrient loads

	Discharger	Permitted ADWDF Capacity (mgd)	Anticipated Year of Completion	Project Description	Estimated Effluent Total Nitrogen (mg N/L)	Estimated Effluent Total Phosphorus (mg P/L)	Capital Cost ($ Mil):	Estimated Annual O&M Cost (if available: $ Mil):	Level of Confidence	Comment
EXAMPLE	ABC	10	2018	1) Membrane Bioreactor (MBR); 2) Modify existing aeration basins to operate as Nit/Denite with anoxic zones and mixed liquor return pumps; 3) replace WAS pumps	6	N/A	$200	$100	100%	The MBR will perform reliable nitrogen removal to 6 mg N/L total nitrogen. The existing aeration basins will be modified to achieve what they can get with nitrogen removal. The anticipated average annual existing aeration basins effluent is 15 mg N/L total nitrogen.

Purpose: To provide information regarding other CIP projects that could have an impact on nutrient loads and/or concentrations.

Group Annual Report

Group Annual Report Workbook – Due on 7/31/2016



The workbook was updated to properly handle NDs and DNQs

Basis for Group Annual Report Input Workbook

- CIWQS limitations: problematic as a source of data for the Nutrient Annual Report.
  - Some agencies have different discharge points that are not accounted for in the CIWQS download query.
  - Recycled water flows and zero discharge periods are not consistently reported to CIWQS.
  - Agencies report different parameters for some analytes.
- Reduces Back and Forth QA/QC between HDR and Dischargers


Next Steps

Next Steps

- Release Wave 2 Reports (July 2016)
- Release Wave 3 Reports (late Summer 2016)
- Release Wave 4 Reports (Fall 2016)
- Submit Group Annual Report (October 1, 2016)
- Release Draft Report (Year End)

Q/A

BACWA Workshop: Nutrient Reduction by Treatment Optimization and Upgrades Update

BACWA Workshop
27 June 2016

HDR

Brown AND Caldwell

BACWA
BAY AREA CLEAN WATER AGENCIES