Bay Area Clean Water Agencies

Nutrient Reduction Study

Supplement to Evaluate Cost of Upgrades for the “No Net Load Increase (NNLI)” Scenario

February 15, 2019

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1. Introduction

In June 2018, the Bay Area Clean Water Agencies (BACWA) submitted the Nutrient Reduction Study to the San Francisco Regional Water Quality Control Board (Water Board)[1]. The Nutrient Reduction Study evaluated multiple strategies for nutrient load reduction for 37 wastewater treatment plants discharging to San Francisco Bay (Bay), including treatment optimization, sidestream treatment, plant upgrades, and nutrient load reduction by other means. The approach for the Nutrient Reduction Study, including the listed nutrient removal levels, was defined in the Scoping and Evaluation Plan[2], which was approved by the Water Board in February 2015.

This technical memorandum is intended to supplement the Study with an additional nutrient reduction scenario based on maintaining current nutrient discharge loads into the future. This scenario is referred to as the “No Net Load Increase” (NNLI) scenario. This scenario was requested by the BACWA Executive Board as a project amendment in 2015 to understand the potential costs of a future permit that included a no net load increase restriction. The analysis completed for this scenario was completed in parallel with the analyses conducted to prepare the 2018 Nutrient Reduction Study[1].

2. Methodology

The methods used for the NNLI analysis are similar to those of the Nutrient Reduction Study[1], in that all 37 participating wastewater treatment plants were evaluated individually. Similar to the Nutrient Reduction Study[1], the analysis for the NNLI scenario was conducted for both dry season (May 1 through September 30) and year round averaging periods and the technology selection is based on established technologies.

The discharge load targets for each plant are based on the average annual discharge loads to the Bay for ammonia, total nitrogen (TN), and total phosphorus (TP) as reported in the first submitted Group Annual Report in 2015[3].

The planning horizon for the NNLI analysis is based on a 25 year planning period. Facilities were sized based on projecting raw influent flows and loads by 25 percent (i.e., one percent year on average). Table 1 presents the total projected raw influent flows and loads used to size the NNLI facilities. The projected raw influent flows and loads for each plant are provided in Appendix A.

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[1] HDR (2018) Bay Area Clean Water Agencies: Nutrient Reduction Study. Potential Nutrient Reduction by Treatment Optimization, Sidestream Treatment, Treatment Upgrades, and Other Means. Submitted to the San Francisco Bay Regional Water Quality Control Board.
[2] HDR (2015) BACWA: Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades. Scoping and Evaluation Plan. Submitted to the San Francisco Bay Regional Water Quality Control Board.
[3] HDR (2015) Bay Area Clean Water Agencies Nutrient Reduction Study: Group Annual Report (Nutrient Watershed Permit Annual Report). Submitted to the San Francisco Bay Regional Water Quality Control Board.

Table 1. Total Projected Raw Influent Flows and Loads for NNLI Scenario

Criteria	Unit	Average Dry Weather Flow (ADWF)[1]	Average Annual	Dry Season Maximum Month (May 1 - Sept 30)[2]	Year Round Maximum Month[2]
Flow	mgd	602	638	642	1,072
BOD	lb/d	1,470,000	1,520,000	1,680,000	2,250,000
TSS	lb/d	1,560,000	1,620,000	1,800,000	2,480,000
Ammonia	lb N/d	165,000	171,000	176,000	244,000
Total Kjeldahl Nitrogen (TKN)	lb N/d	249,000	255,000	259,000	361,000
Total Phosphorus (TP)	lb P/d	35,800	36,200	41,600	53,200
Alkalinity[3]	lb $CaCO_3$/d	--	--	--	--
BOD	mg/L	290	290	310	250
TSS	mg/L	310	310	340	280
Ammonia	mg N/L	33	32	33	27
TKN	mg N/L	50	48	48	40
TP	mg P/L	7.0	7.0	8.0	6.0
Alkalinity[3]	mg $CaCO_3$/L	--	--	--	--

1. ADWF is calculated as the average flow for the months of July, August, and September.
2. The dry season maximum month values are used to size facilities to treat dry season loads that operate year round; the year round maximum month values are used to treat year round loads that operate year round.
3. There was little or no alkalinity data for the majority of participating agencies, so alkalinity loads are not included.

The treatment objective for the NNLI analysis was to not exceed the average annual discharge loads from the first Group Annual Report submitted in 2015[3] (based on average monthly data from July 2012 through June 2015). Table 2 presents the NNLI discharge loads that shall not be exceeded. It is anticipated that each treatment plant shall meet or outperform their allocated discharge loads under a NNLI scenario.

For more detailed information on the methods, such as basis of cost estimates, refer to Sections 1.3 and 3.1 in the Nutrient Reduction Study.[1]

Table 2. Projected Discharge Flows and Loads with NNLI Treatment Strategy

Plant Name[1]	Subembayment	Ammonia, lb N/d[2]	Total Nitrogen, lb N/d[2]	Total Phosphorus, lb P/d[2]
American Canyon	San Pablo Bay	8	157	56
Benicia	San Pablo Bay	409	498	59
Burlingame	South Bay	597	984	178
CCCSD	Suisun Bay	7,666	9,049	265
CMSA	Central Bay	1,581	2,101	198
Delta Diablo	Suisun Bay	1	-	-
DSRSD	South Bay	1,794	3,465	71
EBMUD	Central Bay	15,298	19,053	1,172
FSSD	Suisun Bay	18,269	23,188	1,839
Hayward	South Bay	4	2,817	437
Las Gallinas	San Pablo Bay	27	264	38
Livermore	South Bay	515	588	32
Millbrae	South Bay	4	278	38
Mt View	Suisun Bay	50	470	46
Napa	San Pablo Bay	26	357	35
Novato	San Pablo Bay	30	5,064	773
OLSD	South Bay	1	4	1
Palo Alto	Lower South Bay	10	92	61
Petaluma	San Pablo Bay	477	721	50
Pinole	San Pablo Bay	10	83	18
Richmond	Central Bay	499	11,717	657
Rodeo	San Pablo Bay	2,851	3,477	275
San Jose	Lower South Bay	101	492	97
San Leandro	South Bay	445	459	30
San Mateo	South Bay	18,617	21,267	299
SASM	Central Bay	106	309	44
SFO Airport	South Bay	3	53	22
SFPUC Southeast	South Bay	1,855	2,527	352
SMCSD	Central Bay	410	1,971	472
Sonoma SVCSD	San Pablo Bay	4,360	4,758	386
South SF	South Bay	105	145	18
Sunnyvale	Lower South Bay	7	33	6
SVCW	South Bay	1,330	2,136	279
Treasure Island	Central Bay	1,405	1,916	117
Union San	South Bay	8	157	56
Vallejo	San Pablo Bay	409	498	59
West Co WCSD	Central Bay	597	984	178
Total[3]		**78,870**	**120,500**	**8,420**

1. It is anticipated that the treatment plant performance shall meet or outperform the listed discharge loads.
2. Values rounded to the nearest whole number.
3. The total values might vary from the sum of the listed values by plant due to rounding.

3. Results

The following subsections present the results of the analysis for the NNLI scenario, including a general overview of recommended technologies for the NNLI scenario, anticipated nutrient load reduction, and planning level cost estimates.

3.1 Summary of Existing Nutrient Reduction Facilities

Figure 1 presents a visual depiction of the number of plants that currently perform TP and ammonia/TN load reduction strategies, respectively. TP load reduction is currently in place for 19 of the 37 agencies. The most common strategies for TP load reduction include chemical addition (typically a metal salt, such as alum or ferric) or use of an anaerobic selector in the activated sludge system as a means to enhance settleability and remove TP. For plants that add chemicals, the typical dosing locations include:

- Collection system (typically for odor control),
- Headworks (typically for odor control), and/or
- Primary clarifiers (typically for odor control and/or enhanced solids capture).

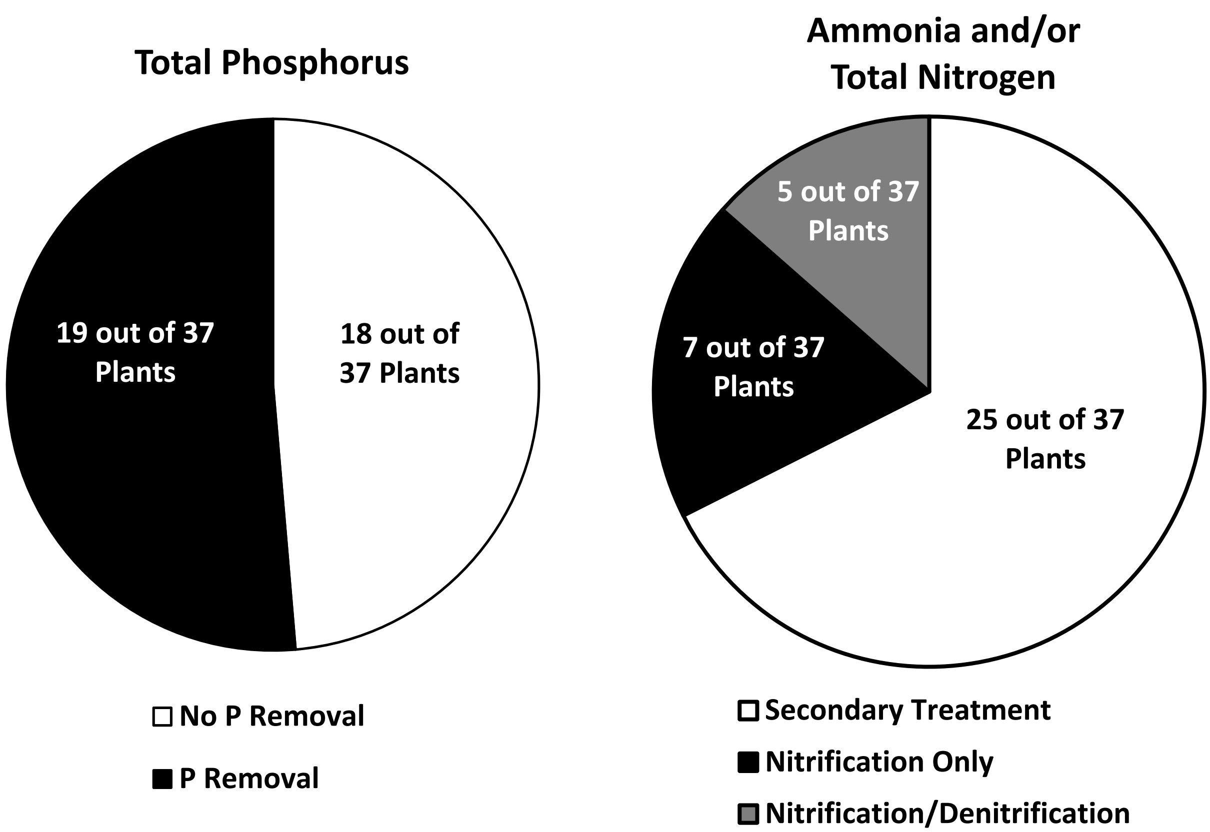

Figure 1. Summary of Existing Plants that Reduce TP (at left) and Reduce Ammonia/TN (at right)

Ammonia/TN load reduction treatment processes are currently in place for 12 of the 37 participating BACWA agencies. Of those, seven perform ammonia load reduction and the remaining five perform both ammonia and TN load reduction. There are several agencies that are in the design stages to upgrade their plants to reduce ammonia/TN loads (including, for example, Oro Loma Sanitary District, City of Palo Alto, and City of San Mateo).

3.2 Proposed NNLI Technologies for Nutrient Reduction

A general overview of the recommended facilities to meet NNLI nitrogen limits are presented in Figure 2. A detailed summary of facilities by agency is provided in Appendix B.

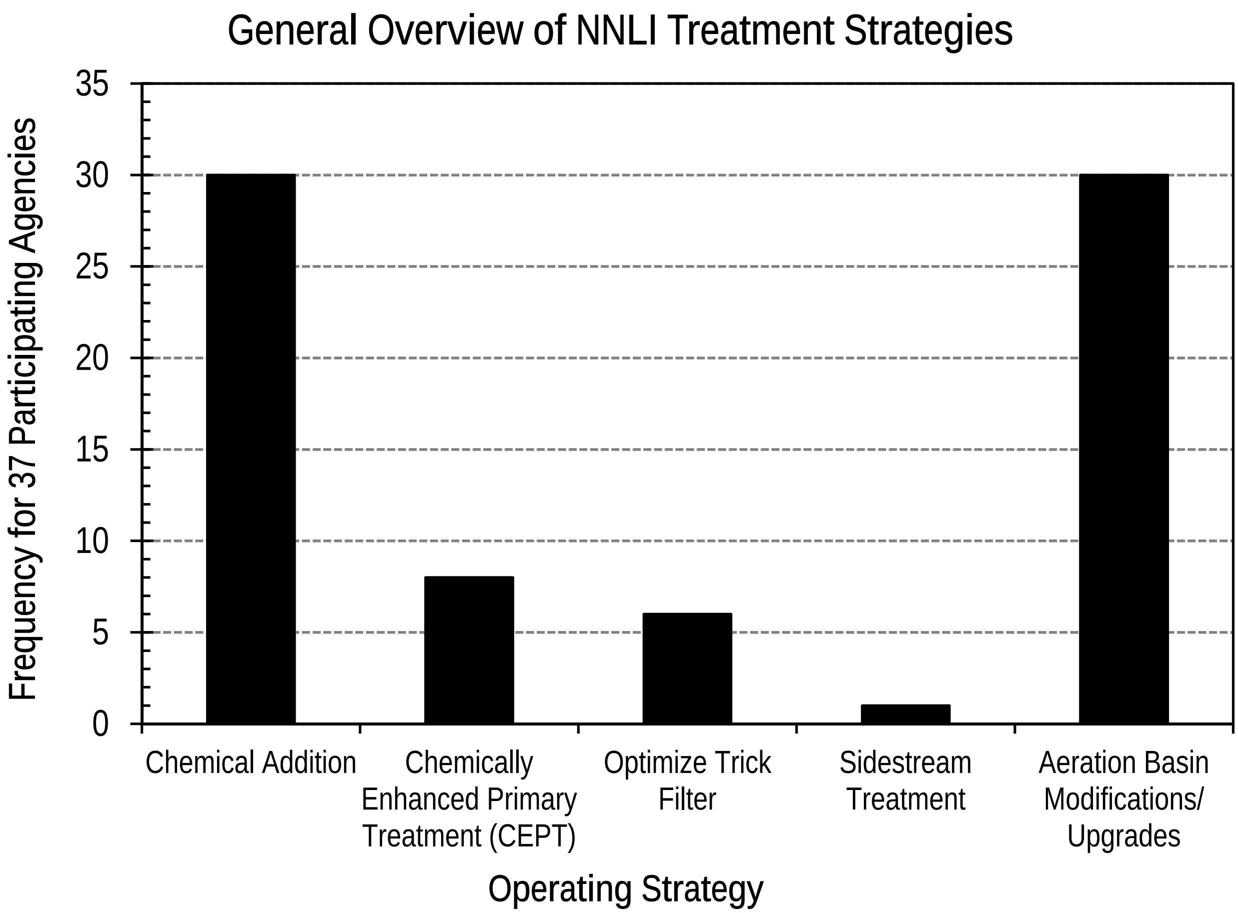

Figure 2. Recommended Plant Upgrade Strategies for NNLI Scenario (Average Annual Limits)

In most cases, facilities that currently remove ammonia, TN, and/or TP loads require less facility modifications and/or new facilities to meet NNLI limits in the future. This is attributed to those agencies already having the nutrient removal technologies and capabilities in place. Common improvement recommendations for such facilities include aeration basin modifications (e.g., adding anoxic zones) and increased return activated sludge (RAS) recycle rates.

Nutrient load reduction facilities for agencies that do not currently perform nutrient removal were typically more extensive than those already reducing nutrient loads.

Figure 3 and Figure 4 provide a more detailed breakdown of the frequency of aeration basin modifications and chemical addition for the NNLI scenario. Note: a single plant may have more than one recommendation in each category. Thus, the total number of modifications listed is greater than the number of participating agencies (37 in total).

The most common strategies in the activated sludge basin for NNLI include blower upgrades to satisfy the additional oxygen demand associated with ammonia/TN load reduction, increasing the return activated sludge (RAS) pumping rates to enhance TN load reduction (i.e., by returning more nitrate to the up-front denitrification zones), and adding anaerobic/anoxic zones to create environments for TP and TN load reduction.

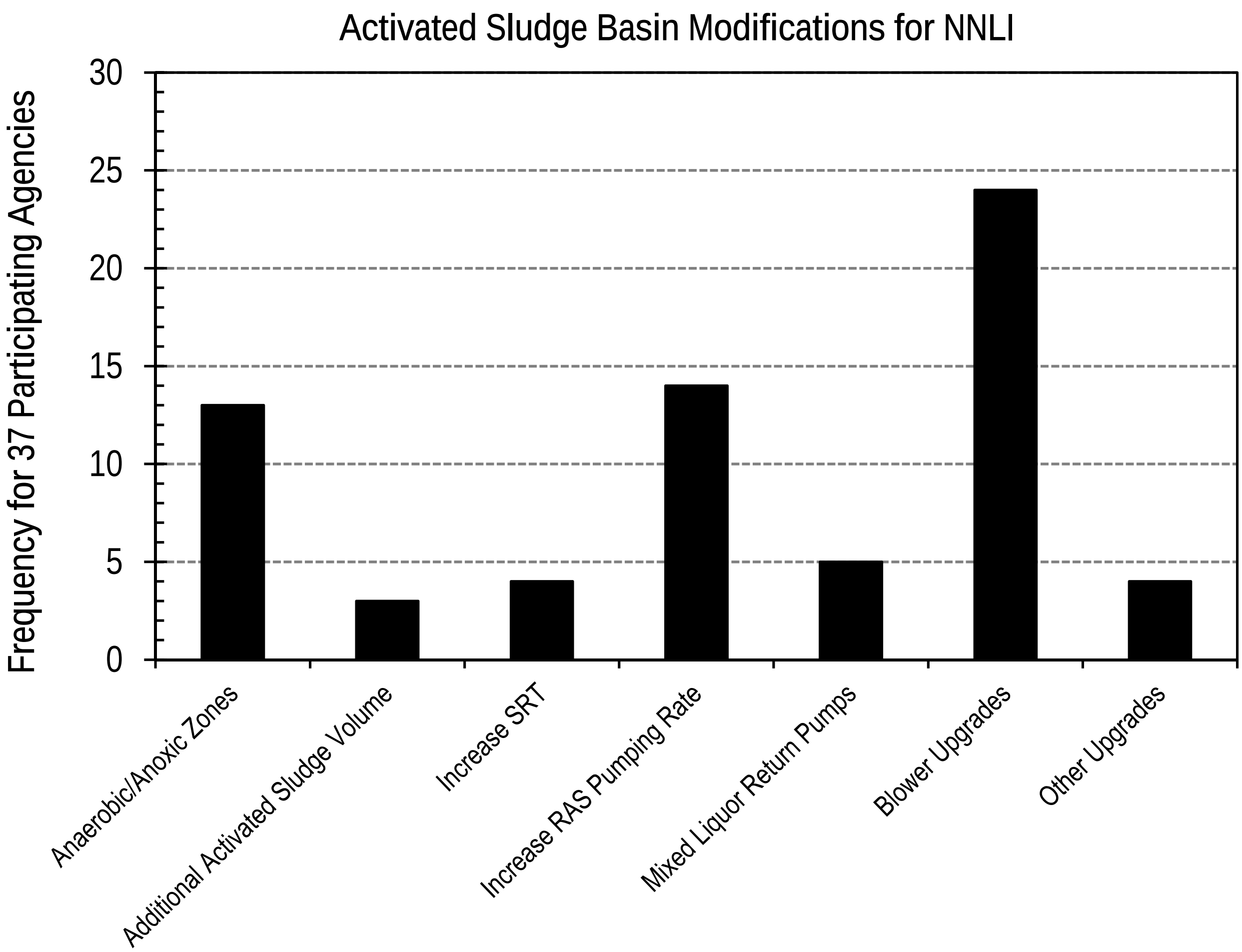

Figure 3. Recommended Upgrades for NNLI Scenario: Aeration Basin Modifications (Average Annual Limits)
Note: a single plant may have more than one recommendation in each category. Thus, the total number of modifications listed is greater than the number of participating agencies (37 in total).

The most common chemical strategies for NNLI include metal salt addition upstream of the activated sludge to reduce TP loads and increase downstream capacity in the activated sludge for ammonia/TN load reduction, followed by supplemental alkalinity addition required for nitrification and supplemental carbon addition for TN load reduction.

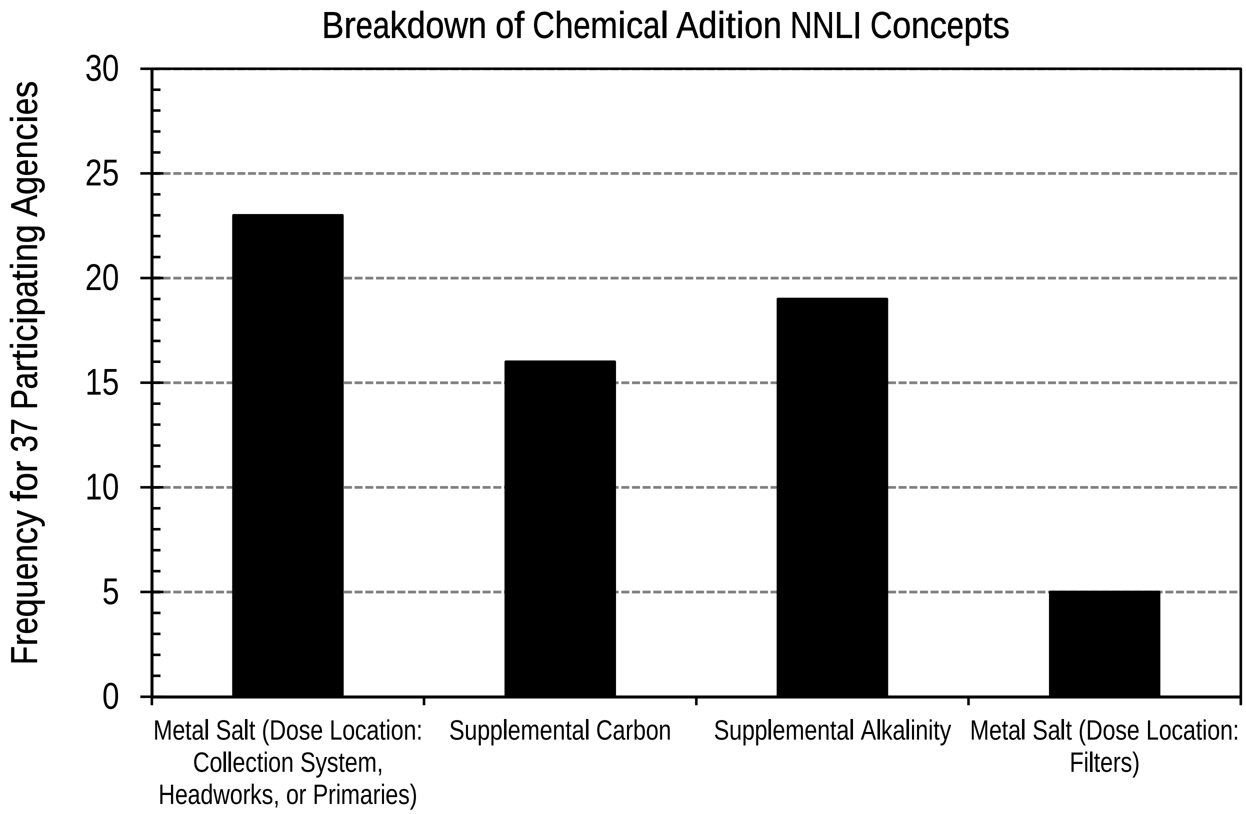

Figure 4. Recommended Upgrades for NNLI Scenario: Chemical Addition (Average Annual Limits)
Note: a single plant may have more than one recommendation in each category. Thus, the total number of modifications listed is greater than the number of participating agencies (37 in total).

3.3 Estimated Costs for the NNLI Scenario

The estimated costs for NNLI scenario are summarized in Table 3. The costs are separated into four scenarios based on dry season (May 1 through September 30) and year round nutrient limits, and whether TN or TN and TP are the nutrients of interest. Table 3 shows total estimated capital, operation and maintenance (O&M), and total present value costs.

The total present value cost for the NNLI scenario, for TN removal, is approximately $2.3 Billion for dry season and $2.6 Billion for year round design. The total present value cost for the NNLI scenario for both TN and TP increases by about $400 Million for both dry season and year round design. O&M costs account for between 30 and 40 percent of the total present value cost.

Table 3. Summary of Estimated Costs for the NNLI Scenario

	Total Nitrogen Removal Only			Total Nitrogen and Total Phosphorus Removal		
	Capital Cost, $M[1]	O&M PV Cost, $M[1,2]	Total PV Cost, $M[1,2]	Capital Cost, $M[1]	O&M PV Cost, $M[1,2]	Total PV Cost, $M[1,2]
Dry Season Total[3]	**1,566**	**769**	**2,334**	**1,606**	**999**	**2,605**
Year Round Total[4]	**1,856**	**847**	**2,703**	**1,904**	**1,103**	**3,007**

1. As described in the Nutrient Reduction Study, estimated costs are referenced to the Engineering News Record (ENR) San Francisco (SF) Construction Cost Index (CCI) for January 2018 at 12,015. Estimated costs do not account for changes in any other process, including solids handling or associated energy requirements.
2. The estimated present value is calculated based on a 2 percent discount rate for 25 years.
3. Facilities were sized for dry season loads and operated year round. Dry season loads are based on May 1 through September 30.
4. Facilities were sized for year round loads and operated year round.

4. Comparison of NNLI to Nutrient Reduction Study

Table 4 and Table 5 present the load reduction and estimated costs for the NNLI scenario in comparison to the results presented in the Nutrient Reduction Study[1] for the dry season and year round conditions, respectfully. The tables present the costs and load reductions for the NNLI scenario as well as the costs and load reductions associated with treatment optimization, sidestream treatment, and treatment upgrades to meet the Level 2 and Level 3 effluent quality benchmarks.

Table 4. Summary of Nutrient Load Reduction and Estimated Costs (Dry Season)

Parameter	Unit	Treatment Strategy[1]				
		Optimization[2]	Sidestream[2]	NNLI[2]	Level 2[2]	Level 3[2]
Design Flow	mgd	494	788	593	788	788
Ammonia	lb N/d	11,900	27,400	19,100	106,400	106,400
TN	lb N/d	7,000	32,000	29,400	90,300	110,800
TP	lb P/d	3,000	1,400	2,000	6,800	8,300
Ammonia	%	14%	24%	20%	93%	93%
TN	%	5%	19%	21%	54%	67%
TP	%	32%	12%	21%	58%	70%
Capital[1]	$M	107	391	1,606	6,544	7,866
O&M PV[1,2]	$M	134	345	999	2,226	2,945
Total PV[1,2]	$M	241	736	2,605	8,770	10,811
Per gpd[3]	$/gpd	0.5	0.9	5.1	11.1	13.7

1. Refer to Table 13 in the BACWA Nutrient Reduction Study (2018)[1]. Facilities are sized for the dry season and operated year round.
2. Costs are referenced to the ENR SF CCI for January 2018 at 12,015. Costs are not additive for scenarios (e.g., the Level 3 costs shown are inclusive of facilities needed to meet Level 2). Costs do not account for changes in any other process, including solids handling or associated energy requirements.
3. PV is calculated based on a 2 percent discount rate for 10 years (optimization), 25 years (NNLI), and 30 years (sidestream and upgrades).
4. Unit cost ($/gpd) was calculated by dividing the total present value by the design flow.

Table 5. Summary of Nutrient Load Reduction and Estimated Costs (Year Round)

Parameter	Unit	Treatment Strategy[1]				
		Optimization[2]	Sidestream[2]	NNLI[2]	Level 2[2]	Level 3[2]
Design Flow	mgd	546	869	658	869	869
Ammonia	lb N/d	12,300	27,400	19,100	106,900	106,900
TN	lb N/d	8,600	32,000	29,500	95,000	136,300
TP	lb P/d	3,100	1,400	2,000	7,000	10,500
Ammonia	%	14%	24%	20%	93%	93%
TN	%	7%	19%	21%	57%	82%
TP	%	34%	12%	21%	59%	88%
Capital[1]	$M	119	391	1,904	6,976	8,517
O&M PV[1,2]	$M	147	345	1,103	2,443	3,888
Total PV[1,2]	$M	266	736	3,007	9,420	12,405
Per gpd[3]	$/gpd	0.5	0.8	4.6	10.8	14.3

1. Refer to Table 13 in the BACWA Nutrient Reduction Study (2018)[1]. Facilities are sized for annual average condition and operated year round.
2. Costs are referenced to the ENR SF CCI for January 2018 at 12,015. Costs are not additive for scenarios (e.g., the Level 3 costs shown are inclusive of facilities needed to meet Level 2). Costs do not account for changes in any other process, including solids handling or associated energy requirements.
3. PV is calculated based on a 2 percent discount rate for 10 years (optimization), 25 years (NNLI), and 30 years (sidestream and upgrades).
4. Unit cost ($/gpd) was calculated by dividing the total present value by the design flow.

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Appendix A – Plant Influent Flows and Loads

The following tables present summaries of the raw influent projected flows and loads for the NNLI scenario for each of the 37 participating plants. Flows and loads were projected based on 25 growth with respect to current flows and loads (i.e., as described in the Nutrient Reduction Study).

Table A1. Projected Raw Influent Flows

Plant Name	Average Dry Weather Flow (mgd)	Average Annual (mgd)	Dry Season Maximum Month (mgd)	Year Round Maximum Month (mgd)
American Canyon	1.9	2.0	2.0	3.6
Benicia	2.6	2.8	2.9	4.4
Burlingame	3.5	3.8	5.4	9.3
CCCSD	44	48	48	73
CMSA	11	13	12	35
Delta Diablo	16	16	17	21
DSRSD	13	13	14	19
EBMUD	68	75	73	145
FSSD	15	17	17	29
Hayward	14	14	17	31
Las Gallinas	2.6	3.5	--	6.7
Livermore	8.5	8.5	8.8	11.1
Millbrae	1.9	1.9	1.9	3.4
Mt View	1.8	1.8	1.9	2.8
Napa	9	10	10	24
Novato	5.1	5.8	5.5	11.7
OLSD	15	16	17	27
Palo Alto	26	26	27	37
Petaluma	6	7	6	13
Pinole	3.5	3.6	3.8	5.9
Richmond	7	8	7	16
Rodeo	0.8	0.9	1.1	1.6
San Jose	133	133	136	173
San Leandro	6.0	6.3	6.6	10.0
San Mateo	14	14	15	25
SASM	2.8	3.3	3.1	7.5
SFO Airport	0.7	0.6	0.8	1.0
SFPUC Southeast	74	83	80	162
SMCSD	1.8	1.9	1.8	3.6
Sonoma SVCSD	3.0	3.8	3.5	10.2
South SF	11	11	11	18
Sunnyvale	17	17	17	22
SVCW	16	17	17	27
Treasure Island	0.4	0.4	0.5	0.6
Union San	28	28	29	37
Vallejo	12	12	12	23
West Co WCSD	10	11	11	21
Total	**602**	**638**	**642**	**1,072**

Table A2. Projected Raw Influent Ammonia Loads

Plant Name	ADWF (lb N/d)	Average Annual (lb N/d)	Dry Season Maximum Month (lb N/d)	Year Round Maximum Month (lb N/d)
American Canyon	480	500	530	690
Benicia	1,000	1,000	1,100	1,400
Burlingame	1,200	1,100	1,300	1,600
CCCSD	12,000	12,000	13,000	16,000
CMSA	3,400	3,300	3,600	4,700
Delta Diablo	4,400	4,800	4,800	6,400
DSRSD	3,600	4,300	3,600	6,300
EBMUD	18,000	19,000	18,000	24,000
FSSD	4,300	4,100	4,900	5,600
Hayward	3,800	3,800	4,000	5,600
Las Gallinas	--	550	--	980
Livermore	2,800	2,900	3,200	4,200
Millbrae	500	630	500	780
Mt View	600	700	700	2,400
Napa	2,400	2,400	2,500	3,800
Novato	1,500	1,500	1,600	2,900
OLSD	2,800	2,900	2,800	4,400
Palo Alto	7,400	7,400	7,800	10,000
Petaluma	1,600	1,800	2,000	3,000
Pinole	900	900	900	1,300
Richmond	2,600	2,300	3,100	3,600
Rodeo	130	250	130	310
San Jose	35,000	36,000	37,000	49,000
San Leandro	1,400	1,500	1,400	2,000
San Mateo	4,000	4,000	4,300	5,600
SASM	630	630	630	940
SFO Airport	700	640	810	1,020
SFPUC Southeast	22,000	24,000	24,000	37,000
SMCSD	380	380	380	470
Sonoma SVCSD	--	--	--	--
South SF	3,000	2,900	3,100	4,200
Sunnyvale	4,000	4,000	4,800	5,900
SVCW	5,300	5,400	5,700	7,500
Treasure Island	90	90	100	140
Union San	7,800	8,300	8,700	11,900
Vallejo	2,900	2,900	3,000	3,800
West Co WCSD	2,800	3,400	2,900	6,300
Total	**165,000**	**171,000**	**176,000**	**244,000**

Table A3. Projected Raw Influent TKN Loads

Plant Name	ADWF (lb N/d)	Average Annual (lb N/d)	Dry Season Maximum Month (lb N/d)	Year Round Maximum Month (lb N/d)
American Canyon	660	500	700	910
Benicia	1,200	1,200	1,300	1,800
Burlingame	1,500	1,600	1,600	2,300
CCCSD	18,000	17,000	19,000	24,000
CMSA	5,900	5,800	5,900	7,000
Delta Diablo	6,800	7,100	7,500	9,700
DSRSD	5,500	6,100	5,500	8,400
EBMUD	29,000	30,000	29,000	39,000
FSSD	7,000	6,000	7,400	9,500
Hayward	5,800	5,700	6,000	8,500
Las Gallinas	--	1,100	--	1,900
Livermore	3,600	3,600	4,000	5,300
Millbrae	900	900	900	1,400
Mt View	800	800	1,100	1,300
Napa	3,300	3,500	3,800	7,400
Novato	2,000	2,100	2,200	4,000
OLSD	5,300	5,600	5,500	8,100
Palo Alto	13,000	9,000	13,000	13,000
Petaluma	2,600	3,000	3,300	4,500
Pinole	1,300	1,300	1,300	1,900
Richmond	3,300	2,800	3,300	3,900
Rodeo	250	250	250	470
San Jose	53,000	57,000	53,000	78,000
San Leandro	2,600	2,900	2,600	3,900
San Mateo	5,400	5,400	5,800	7,500
SASM	1,000	1,100	1,000	1,600
SFO Airport	800	740	940	1,170
SFPUC Southeast	31,000	32,000	33,000	47,000
SMCSD	630	630	630	940
Sonoma SVCSD	--	--	--	--
South SF	4,900	4,900	5,200	7,000
Sunnyvale	6,000	6,100	6,000	7,800
SVCW	8,200	8,500	9,000	11,700
Treasure Island	100	110	130	170
Union San	10,000	11,000	11,000	15,000
Vallejo	4,300	4,100	4,500	6,100
West Co WCSD	4,500	5,300	4,500	8,900
Total	**249,000**	**255,000**	**259,000**	**361,000**

Table A4. Projected Raw Influent TP Loads

Plant Name	ADWF (lb P/d)	Average Annual (lb P/d)	Dry Season Maximum Month (lb P/d)	Year Round Maximum Month (lb P/d)
American Canyon	60	70	60	130
Benicia	120	130	140	190
Burlingame	440	430	530	1,020
CCCSD	2,200	2,300	2,400	3,300
CMSA	900	780	900	800
Delta Diablo	700	1,000	2,600	2,500
DSRSD	610	780	610	1,160
EBMUD	4,900	4,800	4,900	6,000
FSSD	1,000	1,000	1,100	1,900
Hayward	900	1,000	1,000	1,700
Las Gallinas	--	138	--	266
Livermore	460	460	530	690
Millbrae	100	140	100	230
Mt View	230	260	230	520
Napa	560	500	660	880
Novato	280	280	310	420
OLSD	610	690	660	940
Palo Alto	1,400	1,300	1,500	1,600
Petaluma	610	480	610	520
Pinole	150	140	160	170
Richmond	260	350	390	500
Rodeo	25	38	25	47
San Jose	9,000	8,900	10,600	12,400
San Leandro	350	390	350	530
San Mateo	510	510	550	720
SASM	280	180	280	200
SFO Airport	90	80	100	130
SFPUC Southeast	3,900	3,900	4,700	6,100
SMCSD	63	75	88	109
Sonoma SVCSD	--	--	--	--
South SF	760	750	810	1,090
Sunnyvale	810	800	810	1,000
SVCW	1,400	1,400	1,500	2,000
Treasure Island	13	13	13	16
Union San	1,100	1,200	1,200	1,700
Vallejo	490	510	530	840
West Co WCSD	590	610	590	920
Total	**35,800**	**36,200**	**41,600**	**53,200**

Appendix B – NNLI Results by Plant

Table B1 presents a summary of the results for each of the 37 participating agencies. The technology selection, and estimate capital, O&M, and total present value costs are presented for each plant.

Table B1. Summary of Selected Technologies and Estimated Costs for the NNLI Scenario

Plant Name	Technology Selection	Capital Cost, $M[1]	PV O&M Cost, $M[1,2]	Total PV Cost, $M[1,2]
American Canyon	• Alkalinity Addition • Anaerobic/Anoxic Zones (AB Mod) • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	2	1	3
Benicia	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod)	15	8	23
Burlingame	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod)	49	14	63
CCCSD	• Alum/Ferric - Headworks/Primaries • CEPT • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod)	9	93	102
CMSA	• Alum/Ferric - Headworks/Primaries • CEPT • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	20	43	63
Delta Diablo	• Alum/Ferric - Headworks/Primaries • CEPT • Optimize Trickling Filter • Alum/Ferric - Filters • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Split Treatment (AB Mod) • New Blowers (AB Mod)	20	14	34
DSRSD	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	5	17	22

Plant Name	Technology Selection	Capital Cost, $M[1]	PV O&M Cost, $M[1,2]	Total PV Cost, $M[1,2]
EBMUD	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	12	28	40
FSSD	• Alum/Ferric - Headworks/Primaries • Anaerobic/Anoxic Zones (AB Mod) • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod)	21	7	29
Hayward	• Alum/Ferric - Headworks/Primaries • Optimize Trickling Filter • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	89	34	123
Las Gallinas	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	58	6	64
Livermore	• Sidestream Treatment • Anaerobic/Anoxic Zones (AB Mod) • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	11	8	19
Millbrae	• Alum/Ferric - Headworks/Primaries • CEPT • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod)	7	5	12
Mt View	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	16	3	19
Napa	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	45	20	65
Novato	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • SBR (AB Mod)	5	4	8
OLSD	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Split Treatment (AB Mod)	24	8	32

HDR

Plant Name	Technology Selection	Capital Cost, $M[1]	PV O&M Cost, $M[1,2]	Total PV Cost, $M[1,2]
Palo Alto	• Optimize Trickling Filter • Alkalinity Addition • Anaerobic/Anoxic Zones (AB Mod) • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	59	26	86
Petaluma	• Optimize Trickling Filter • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	9	0	9
Pinole	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Split Treatment (AB Mod)	20	9	29
Richmond	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Step Feed (AB Mod)	17	22	39
Rodeo	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Step Feed (AB Mod) • Mixer Addition (AB Mod)	13	2	15
San Jose	• Alkalinity Addition • Anaerobic/Anoxic Zones (AB Mod) • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • SBR (AB Mod)	44	167	211
San Leandro	• Alum/Ferric - Headworks/Primaries • CEPT • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod) • Blower Setpoints (AB Mod)	85	57	142
San Mateo	• CEPT • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	327	126	453
SASM	• CEPT • Optimize Trickling Filter • Alkalinity Addition • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	33	6	39

Plant Name	Technology Selection	Capital Cost, $M[1]	PV O&M Cost, $M[1,2]	Total PV Cost, $M[1,2]
SFO Airport	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	12	7	19
SFPUC Southeast	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • SBR (AB Mod)	270	135	404
SMCSD	• Alum/Ferric - Headworks/Primaries • CEPT • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	3	3	6
Sonoma SVCSD	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod)	0	0	0
South SF	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • SBR (AB Mod)	40	47	87
Sunnyvale	• New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	212	19	231
SVCW	• Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	44	31	74
Treasure Island	• Alum/Ferric - Headworks/Primaries • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Step Feed (AB Mod) • Split Treatment (AB Mod)	39	19	57
Union San	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • IMLR (AB Mod) • Mixer Addition (AB Mod) • SBR (AB Mod)	145	55	200
Vallejo	• Alum/Ferric - Headworks/Primaries • Optimize Trickling Filter • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod)	72	27	99

Plant Name	Technology Selection	Capital Cost, $M[1]	PV O&M Cost, $M[1,2]	Total PV Cost, $M[1,2]
West Co WCSD	• Alum/Ferric - Headworks/Primaries • Alkalinity Addition • Sidestream Treatment • New AS Volume (AB Mod) • NDN by RAS MLE (AB Mod) • Mixer Addition (AB Mod)	54	31	85
Total		1,904	1,103	3,007

1. Costs are referenced to the ENR SF CCI for January 2018 at 12,015. Costs do not account for changes in any other process, including solids handling or associated energy requirements.
2. Present value cost is calculated based on a 2 percent discount rate for 25 years (NNLI).