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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Unit</th>
<th>Average Dry Weather Flow (ADWF)(^1)</th>
<th>Average Annual</th>
<th>Dry Season Maximum Month (May 1 - Sept 30)(^2)</th>
<th>Year Round Maximum Month(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>mgd</td>
<td>602</td>
<td>638</td>
<td>642</td>
<td>1,072</td>
</tr>
<tr>
<td>BOD</td>
<td>lb/d</td>
<td>1,470,000</td>
<td>1,520,000</td>
<td>1,680,000</td>
<td>2,250,000</td>
</tr>
<tr>
<td>TSS</td>
<td>lb/d</td>
<td>1,560,000</td>
<td>1,620,000</td>
<td>1,800,000</td>
<td>2,480,000</td>
</tr>
<tr>
<td>Ammonia</td>
<td>lb N/d</td>
<td>165,000</td>
<td>171,000</td>
<td>176,000</td>
<td>244,000</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>lb N/d</td>
<td>249,000</td>
<td>255,000</td>
<td>259,000</td>
<td>361,000</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>lb P/d</td>
<td>35,800</td>
<td>36,200</td>
<td>41,600</td>
<td>53,200</td>
</tr>
<tr>
<td>Alkalinity(^3)</td>
<td>lb CaCO(_3)/d</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>290</td>
<td>290</td>
<td>310</td>
<td>250</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>310</td>
<td>310</td>
<td>340</td>
<td>280</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg N/L</td>
<td>33</td>
<td>32</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>TKN</td>
<td>mg N/L</td>
<td>50</td>
<td>48</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>TP</td>
<td>mg P/L</td>
<td>7.0</td>
<td>7.0</td>
<td>8.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Alkalinity(^3)</td>
<td>mg CaCO(_3)/L</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

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

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

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)](image-url)

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)](image)

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.

**Activated Sludge Basin Modifications for NNLI**

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.

![Activated Sludge Basin Modifications for NNLI](image)
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

<table>
<thead>
<tr>
<th></th>
<th>Total Nitrogen Removal Only</th>
<th>Total Nitrogen and Total Phosphorus Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Cost, $M¹</td>
<td>O&amp;M PV Cost, $M¹,²</td>
</tr>
<tr>
<td>Dry Season Total³</td>
<td>1,566</td>
<td>769</td>
</tr>
<tr>
<td>Year Round Total⁴</td>
<td>1,856</td>
<td>847</td>
</tr>
</tbody>
</table>

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 Study¹ 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>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Optimization²</th>
<th>Sidestream²</th>
<th>NNLI²</th>
<th>Level 2²</th>
<th>Level 3²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Flow</td>
<td>mgd</td>
<td>494</td>
<td>788</td>
<td>593</td>
<td>788</td>
<td>788</td>
</tr>
<tr>
<td>Ammonia</td>
<td>lb N/d</td>
<td>11,900</td>
<td>27,400</td>
<td>19,100</td>
<td>106,400</td>
<td>106,400</td>
</tr>
<tr>
<td>TN</td>
<td>lb N/d</td>
<td>7,000</td>
<td>32,000</td>
<td>29,400</td>
<td>90,300</td>
<td>110,800</td>
</tr>
<tr>
<td>TP</td>
<td>lb P/d</td>
<td>3,000</td>
<td>1,400</td>
<td>2,000</td>
<td>6,800</td>
<td>8,300</td>
</tr>
<tr>
<td>Ammonia</td>
<td>%</td>
<td>14%</td>
<td>24%</td>
<td>20%</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td>TN</td>
<td>%</td>
<td>5%</td>
<td>19%</td>
<td>21%</td>
<td>54%</td>
<td>67%</td>
</tr>
<tr>
<td>TP</td>
<td>%</td>
<td>32%</td>
<td>12%</td>
<td>21%</td>
<td>58%</td>
<td>70%</td>
</tr>
<tr>
<td>Capital¹</td>
<td>$M</td>
<td>107</td>
<td>391</td>
<td>1,606</td>
<td>6,544</td>
<td>7,866</td>
</tr>
<tr>
<td>O&amp;M PV¹,²</td>
<td>$M</td>
<td>134</td>
<td>345</td>
<td>999</td>
<td>2,226</td>
<td>2,945</td>
</tr>
<tr>
<td>Total PV¹,²</td>
<td>$M</td>
<td>241</td>
<td>736</td>
<td>2,605</td>
<td>8,770</td>
<td>10,811</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Treatment Strategy(^1)</th>
<th>(\text{Optimization}(^2))</th>
<th>Sidestream(^2)</th>
<th>(\text{NNLI}(^2))</th>
<th>Level 2(^2)</th>
<th>Level 3(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Flow</td>
<td>mgd</td>
<td>546</td>
<td>869</td>
<td>658</td>
<td>869</td>
<td>869</td>
<td>869</td>
</tr>
<tr>
<td>Ammonia</td>
<td>lb N/d</td>
<td>12,300</td>
<td>27,400</td>
<td>19,100</td>
<td>106,900</td>
<td>106,900</td>
<td>106,900</td>
</tr>
<tr>
<td>TN</td>
<td>lb N/d</td>
<td>8,600</td>
<td>32,000</td>
<td>29,500</td>
<td>95,000</td>
<td>136,300</td>
<td></td>
</tr>
<tr>
<td>TP</td>
<td>lb P/d</td>
<td>3,100</td>
<td>1,400</td>
<td>2,000</td>
<td>7,000</td>
<td>10,500</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>%</td>
<td>14%</td>
<td>24%</td>
<td>20%</td>
<td>93%</td>
<td>93%</td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>%</td>
<td>7%</td>
<td>19%</td>
<td>21%</td>
<td>57%</td>
<td>82%</td>
<td></td>
</tr>
<tr>
<td>TP</td>
<td>%</td>
<td>34%</td>
<td>12%</td>
<td>21%</td>
<td>59%</td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td>Capital(^1)</td>
<td>$M</td>
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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.
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

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Average Dry Weather Flow (mgd)</th>
<th>Average Annual (mgd)</th>
<th>Dry Season Maximum Month (mgd)</th>
<th>Year Round Maximum Month (mgd)</th>
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<td>2.6</td>
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<td>2.9</td>
<td>4.4</td>
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## Table A2. Projected Raw Influent Ammonia Loads

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<th>Year Round Maximum Month (lb N/d)</th>
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<td>1,100</td>
<td>1,300</td>
<td>1,600</td>
</tr>
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Table A3. Projected Raw Influent TKN Loads

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<th>Dry Season Maximum Month (lb N/d)</th>
<th>Year Round Maximum Month (lb N/d)</th>
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<td>Dry Season Maximum Month (lb P/d)</td>
<td>Year Round Maximum Month (lb P/d)</td>
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<td>1,700</td>
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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

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Technology Selection</th>
<th>Capital Cost, $M1</th>
<th>PV O&amp;M Cost, $M1,2</th>
<th>Total PV Cost, $M1,2</th>
</tr>
</thead>
</table>
| 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                  |
<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Technology Selection</th>
<th>Capital Cost, $M\textsuperscript{1}</th>
<th>PV O&amp;M Cost, $M\textsuperscript{1,2}</th>
<th>Total PV Cost, $M\textsuperscript{1,2}</th>
</tr>
</thead>
</table>
| 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 |
<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Technology Selection</th>
<th>Capital Cost, $M\textsuperscript{1}</th>
<th>PV O&amp;M Cost, $M\textsuperscript{1,2}</th>
<th>Total PV Cost, $M\textsuperscript{1,2}</th>
</tr>
</thead>
</table>
| 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 |
<table>
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<th>PV O&amp;M Cost, $M¹.²</th>
<th>Total PV Cost, $M¹.²</th>
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<td>7</td>
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<td>• Alkalinity Addition</td>
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<tr>
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<td>• Sidestream Treatment</td>
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<td></td>
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<td></td>
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<tr>
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<td>• Sidestream Treatment</td>
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<td>• New AS Volume (AB Mod)</td>
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<td>• NDN by RAS MLE (AB Mod)</td>
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<td>• IMLR (AB Mod)</td>
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<td>• SBR (AB Mod)</td>
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<td>• Split Treatment (AB Mod)</td>
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<tr>
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<td>• IMLR (AB Mod)</td>
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<td>• Mixer Addition (AB Mod)</td>
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<td>• SBR (AB Mod)</td>
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<td>• Optimize Trickling Filter</td>
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<td>Total PV Cost, $M\textsuperscript{1,2}</td>
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<td>----------------------------------</td>
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<td>• NDN by RAS MLE (AB Mod)</td>
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<td>• Mixer Addition (AB Mod)</td>
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<td><strong>3,007</strong></td>
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</tbody>
</table>

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).