BACWA

Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades

Scoping and Evaluation Plan

Submittal to San Francisco Regional Water Quality Control Board

November 26, 2014

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Scoping and Evaluation Plan

On April 9, 2014, the San Francisco Regional Water Quality Control Board (Water Board) issued Order No. R2-2014-0014, *Waste Discharge Requirements for Nutrients from Municipal Wastewater Discharges to San Francisco Bay* (Watershed Permit). The Watershed Permit sets forth a regional framework to facilitate collaboration on studies that will inform future management decisions and regulatory strategies. A component of the permit is to conduct treatment plant optimization and upgrade studies for nutrient removal. These studies will increase the understanding of external nutrient loads, improve the accuracy of the inputs used in load response models, and identify potential load reductions and costs for different dischargers to the Bay. Thirty seven plants (see Appendix A) will conduct the nutrient reduction studies collectively as members of Bay Area Clean Water Agencies (BACWA).

The Watershed Permit requires a Scoping and Evaluation Plan that describes the approach and schedule for completing the nutrient reduction studies by plant optimization and plant upgrade, as well as by other means. Nutrients of interest are ammonia, total nitrogen, and total phosphorus. The evaluation considers current flows for plant optimization/sidestream treatment but uses the permitted design capacity flows for plant upgrades. The effort comprises the following steps:

- Establish a range of nutrient removal levels
- Collect data for each plant and conduct a preliminary assessment based on this data
- Evaluate nutrient reductions achievable through plant optimization and sidestream treatment for each plant
- Evaluate nutrient reductions through plant upgrades for each plant
- Compile existing information to identify options for reducing nutrient loads by other means, such as water recycling, wetlands, etc.

The sections below describe the schedule and work necessary for completing the aforementioned steps.

Schedule

The optimization/sidestream treatment study and the plant upgrades study will be performed in parallel. The plants are required to submit a status report for each study by July 1, 2016 and again by July 1, 2017. The final reports are due for both studies the following year on July 1, 2018. In addition the Annual Group Nutrients Report showing trends in nutrient loadings will be submitted by October 1st of each year starting in 2015 and continuing until 2018.

A schedule is proposed that performs the two studies in parallel. An overview of the schedule along with descriptions for the tasks and completion dates is presented in Table 1. The project schedule has been designed to efficiently execute the study ahead of the deadlines specified in the Watershed Permit.

Table 1. Schedule by Tasks

Task	Description	Permit Deadline	BACWA End Date	Comment
1.) Project Management and QA/QC	Scheduled meetings, status updates, and QA/QC		12/2017	Manage the overall project and provide QA/QC of all deliverables
2.) Scoping and Evaluation Plans	Prepare documents for BACWA and RWQCB	12/1/2014 (Scoping) and 7/1/2015 (Evaluation)	12/2014	Documents that define the project approach and schedule
3.) Data Collection, Data Synthesis, and Site Visits	Disseminate questionnaire and compile data		10/2015	Collect plant data, compile data, and conduct site visits to produce site specific solutions
4.) Plant Optimization and Sidestream Treatment	Evaluate optimization and sidestream treatment strategies at each plant	7/1/2018	10/2015	Discuss the beneficial and adverse ancillary impacts for selected strategies; develop capital and operating costs
5.) Plant Upgrades	Evaluate plant upgrades for each plant	7/1/2018	10/2015	Discuss the beneficial and adverse ancillary impacts for each upgrade; develop capital and operating costs
6.) Nutrient Reduction By Other Means	Compile previous reports to identify attractive strategies	7/1/2018	10/2015	Discuss the beneficial and adverse ancillary impacts for any strategies; discuss institutional barriers to water recycling along with proposals for overcoming such barriers
7.) Group Annual Report	Assist BACWA with preparing the Annual Reports to RWQCB	10/1/2015, 10/1/2016, 10/1/2017, and 10/1/2018	10/1/2015, 10/1/2016, 10/1/2017, and 10/1/2018	
8.) Report Submittal	Submittal to RWQCB for the two studies	7/1/2018	6/2016	

Nutrient Removal Levels

The Watershed Permit does not explicitly state nutrient removal goals. As a result, nutrient removal levels for treatment plants were developed for the purposes of this study. As shown in Table 2, three seasonal nutrient levels were identified.

Table 2. Nutrient Removal Targets for Seasonal Averaging Periods*

Treatment Level	Study	Ammonia	Total Nitrogen	Total Phosphorus	Comment
Level 1	Optimization	--	--	--	Removal potential to be determined
Level 2	Upgrades	2 mg N/L	15 mg N/L	1.0 mg P/L	Without filters and external carbon **
Level 3	Upgrades	2 mg N/L	6 mg N/L	0.3 mg P/L	Filters and external carbon source required ***

*   The seasonal impacts will be considered for all three treatment levels.

** Achievable by conventional nutrient removal processes without effluent filtration and without adding an external carbon source. Certain participating plant configurations and technologies will require chemicals.

*** An external carbon source will not be required for certain plant configurations and technologies.

Level 1 consists of optimization efforts where nutrient loads are reduced as much as possible with little or no capital investment. As such, there are no defined numeric targets identified in Level 1. Capital investment(s) (e.g., excess tank volume) that were constructed with the intent to serve the projected growth in a facility's service area may be used in the near term to optimize nutrient removal, but may not be available in perpetuity as growth occurs in the service area. Thus, any strategies identified under Level 1 may not be viable in the long term if the facilities are needed to meet capacity requirements to accommodate planned growth.

The removal goals for plant upgrades are referred to as Levels 2 and 3. These levels were selected based on the typical tipping point for treatment technologies to achieve the respective effluent levels. For most plant configurations, the less stringent Level 2 can be achieved with conventional nutrient removal processes without adding an external carbon source (e.g., methanol) and without adding effluent filtration. The more stringent Level 3 requires an external carbon source for nitrogen removal and metal salt addition with filtration for most plant configurations. These factors contribute to a tipping point due to the well documented increase in cost, operational and safety burdens, energy demand, and greenhouse gas (GHG) emissions. Ammonia levels are selected to provide stable ammonia reduction (typically nitrification). The results for both Treatment Levels are beneficial for making informed future management decisions.

Nitrogen and phosphorus typically have seasonal impacts on receiving waters. Thus, targets for total nitrogen and phosphorus removal should be based on long averaging periods linked to the specific waterbody response to nutrient enrichment. Short averaging periods based on guidance applicable to toxics constituents[1] will would result in overly conservative designs for nutrient removal facilities in order to provide the required reliability to meet the targets, but would provide

[1] Brown and Caldwell (2014) Review of USEPA Methods for Setting Water Quality-Based Effluent Limits for Nutrients. Prepared for the National Association of Clean Water Agencies, Washington D.C.

little, or no, additional water quality benefit. As a result, seasonal averaging periods for total nitrogen and phosphorus discharges are proposed.

In order to capture seasonality variations, both wet season and dry season discharges will be evaluated. A dry season average was considered because it excludes sizing treatment facilities for peak wet weather events and low temperatures. Biological process kinetics are more rapid at warmer temperatures and thus result in a reduced footprint if sized for the dry season. During a significant precipitation event, plants are subjected to peak flows with subsequently less hydraulic residence time within the plant. Wet and dry season nutrient impacts on the estuary may differ as well.

The dry season, assumed to be from May 1 to September 30, will have different temperature and loading conditions. For example, the effluent temperature from a plant in Northern California is presented in Figure 1. For this facility, the design low temperature for a year round average monthly discharge is 15 degrees C, while the dry season low temperature is 21 degrees C. The design loads also will change by season.

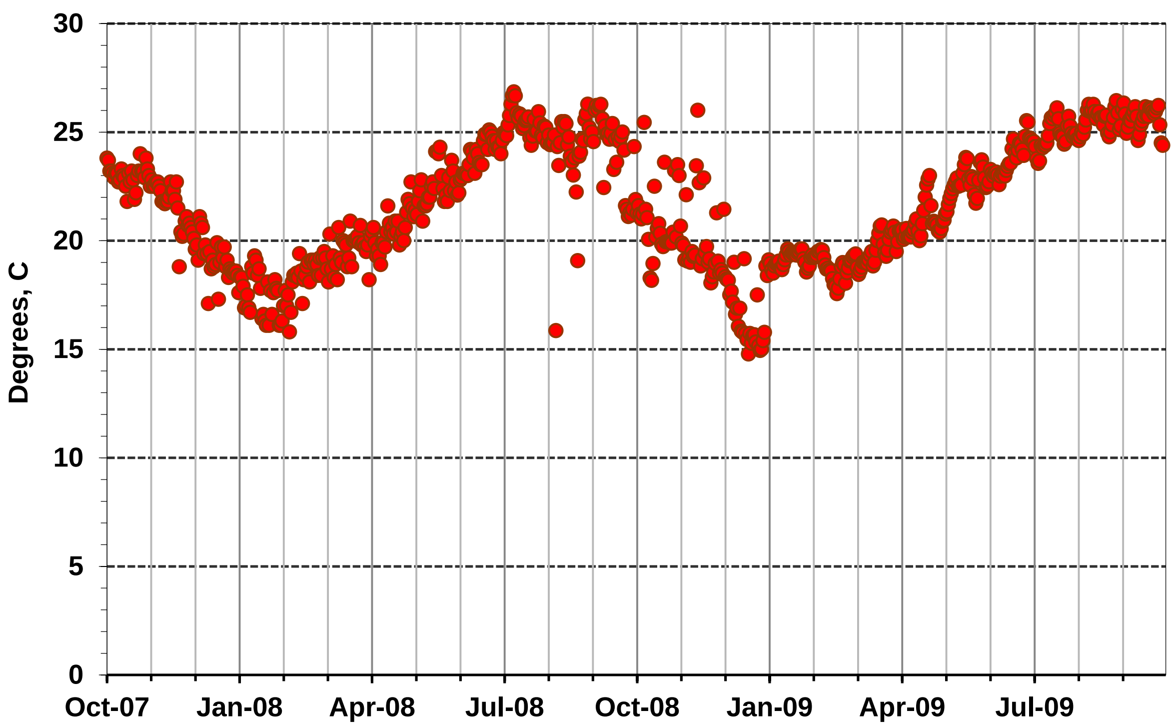

Figure 1. Effluent Temperature Data from a Plant

Data from each plant will be collected as flows and concentrations. The treatment levels are based on concentration. However, the potential nutrient reductions will be presented as load reductions. Using loads is beneficial because they are independent of the impact on flows (e.g., water conservation) while also providing nutrient removal credit for plants that divert flows (e.g., recycled water). The base case for identifying load reductions is the 2013 load calculated from the data set compiled in response to the 13267 Letter (March 2, 2012), which required the municipal dischargers listed in Appendix A to submit information on nutrients in wastewater discharges.

Data Collection and Preliminary Assessment

A questionnaire and site visit will be used to collect plant data. The questionnaire requests plant specific information, such as historical plant flows and loads, performance, treatment assets, etc. The questionnaire will provide an electronic workbook for each plant to submit its historical data. Based on the information received from the questionnaire, the team will perform a preliminary assessment to identify potential optimization strategies and plant upgrades for each plant. Following the preliminary assessment, a site visit of each plant will occur to confirm the preliminary assessment and identify additional nutrient reduction strategies.

A description of the questionnaire, preliminary assessment, and site visit is provided in the sub-sections below.

Data Collection

The questionnaire will be disseminated to each participating plant during the fall of 2014. This detailed request will create a high level understanding of how each plant operates. Plant performance data will be collected. A questionnaire most efficiently gathers data and collects the essential information needed for producing plant-specific results. The questionnaire will seek the following information:

- Plant process and service area description
- Site layout
- Major unit process dimensions and information on number of units in service
- Annual energy and chemical usage
- Future upgrade plans/expansion plans
- Identification of site constraints (e.g., space constraints, poor soils requiring piles, off-limits spaces, odor constraints, etc.)
- Prior reports and technical memoranda on existing facilities/nutrient removal plans
- Prior reports documenting nutrient reductions by other means. For example, plans for recycled water, wetlands treatment, etc.
- Background on regulatory drivers
- Others

The questionnaire responses will be broken out into two categories: data related to sidestream treatment and data related to the total plant performance. The first questionnaire will include influent, effluent, and sidestream data (if available). Information gathered from the responses pursuant to the first questionnaire will be used for the on-going United States Environmental Protection Agency (USEPA) sponsored Sidestream Treatment Grant being led by East Bay Municipal Utility District (EBMUD). The second questionnaire will include remaining information, including major unit process dimensions, site constraints, prior reports, historical plant data, etc. Both questionnaire responses will be due in early 2015.

Preliminary Assessment

Upon receiving all the questionnaire responses, the data will be organized and compiled for each participating plant. Any data gaps will be documented per plant and disseminated to each plant via email with a request for additional data and, if necessary, to perform additional sampling. The request will include:

- Constituents of interest (example BOD, TKN, TP, alkalinity)
- Sampling location (example: raw influent, primary effluent, secondary effluent)
- Sampling frequency (example: daily, weekly)
- Sample method (example: daily composite, hand composite, grab)
- Analytical methodology and laboratory reporting limits

The sampling campaigns will be short in duration by design (e.g., two weeks), designed to provide general guidance. In situations where additional sampling is not practical within the time-frame of the optimization effort, reasonable assumptions will be made for missing information.

The initial step in validating the dataset is to remove any outliers or questionable data. Such data will be removed with values noted.

Following the data screening, the organized data will be used to perform a preliminary assessment of each plant. The approach is to plot performance trends and calculate loading rates for the major unit processes (e.g., primary clarifiers). The values for each plant will be compared against typical design criteria to identify opportunities for optimization. For example, if a plant with activated sludge has historical data that suggests there is sufficient capacity to increase the solids residence time (SRT) and remove ammonia during the lowest flow summer months, then this will be documented.

The data questionnaire will also request information from each utility on planned future optimization/upgrades or expansion at their plant. The preliminary assessment will address how these optimization/upgrade projects will impact discharge nutrient loads. For example, a plant that plans to import organic waste would most likely increase its nutrient discharge load.

Site Visits

The third component is to visit each participating plant. Two-person teams that include a process engineer and an operations expert will visit each participating plant.

The site visits will confirm our understanding of how the plant operates, validate chemical use, and identify “no capital cost” and “low capital cost” optimization strategies. For example, they may look for any unused tanks for additional treatment, or examine operational practices such as the dissolved oxygen set-point. An example list of information that will be generated during the site visit is as follows:

- Validate and confirm facility mode of operation
- Validate and confirm whether the plant is a candidate for sidestream treatment

- Validate and confirm the historical performance trends, number of units in service, etc.
- Generate a list of optimization strategies and their implications, such as:
  - Flow routing
  - Chemical dosing strategy
  - Pumping strategy
  - Aeration strategy
  - Impact to plant capacity
  - Non-economic impacts (e.g., biosolids yield)
  - Impacts on sustainability (e.g., energy demand and GHG emissions)
- Confirm the on-going optimization/upgrade projects and summarize their potential impacts on nutrient discharge loads

A memo will be crafted for each plant that summarizes the site visit. Each plant will have the opportunity to review the memo and provide comments. The memo will include the following:

- Description of the plant and the current discharge requirements
- Description of the potential impact on nutrient discharge loads from on-going optimization/upgrade projects
- Check-list confirming the preliminary assessment findings
- List of potential optimization strategies
- Quantification of nutrient removal benefits
- Impacts on plant capacity, chemicals, biosolids yield, energy, GHG emissions, etc.
- Facility upgrade requirements
- Summary and conclusions

Nutrient Reduction through Plant Optimization

This first study focuses on plant optimization and sidestream treatment. The effort will generate a list of optimization strategies and sidestream treatment opportunities and develop costs for the most attractive option. Details for these two elements are provided in the sub-sections below.

Plant Optimization

Optimization of existing facilities is a potential first step toward nutrient reduction. Nutrient removal is possible at existing facilities due to operating below design load and thus unused available “capacity” might be devoted for nutrient reduction on an interim basis. It takes advantage of unused tankage, new process approaches, instrumentation improvements, and, without a permit limit with potential enforcement penalties, gets as much nutrient reductions as possible in the short term.

Any proposed optimization strategies are viewed as interim solutions as most strategies will take advantage of unused capacity (i.e., facilities not needed to meet the current load but may be required to treat the design load). In rare cases, facilities may be available that is not required to meet future loads and may be available for long term nutrient reduction. The unused capacity was typically constructed using fees to accommodate future growth so it may not be available for nutrient reduction in the future as that growth occurs or as stepping stones for either Level 2 or Level 3 technology changes in the plant. The plant optimization strategies are based on current flows and loads plus 15 percent to account for modest flow and loads growth. It is important to stress that implementing some of the strategies will likely impact overall treatment capacity and operational complexity in the long term. The plant might need to revert back to the prior mode of operation or add new facilities as flows and loads increase over time.

A list of the most common optimization strategies for each treatment category will be generated during the preliminary assessment effort. For example, a plant could implement chemically enhanced primary treatment (CEPT) as a means to remove total phosphorus and increase aeration basin capacity for ammonia removal. This list will serve as the starting point during each site visit. The strategies will be simple, low cost improvements that can be implemented quickly. The strategies will be grouped into “no capital cost” and “low capital cost” strategies. Examples are provided below:

- No Capital Cost Strategies:
  - Use offline tankage to provide additional treatment
  - Modify operational mode, such as raising the solids residence time
  - Modify blower operating set points
  - Operate in split treatment mode
  - Change to simultaneous nitrification/denitrification operation
  - Shut down aeration to create anoxic zones
- Low Capital Cost Strategies
  - Add instruments for nutrient removal in ammonia based aeration control mode
  - Add chemicals for phosphorus removal
  - Add chemicals to reduce load, unlock capacity
  - Add anoxic and/or anaerobic zones for biological nutrient removal
  - Add internal recycle for denitrification
  - Add mixers for unaerated zones

During the site visits, the optimization strategies from our preliminary assessment will be confirmed. Additionally, the two-person process and operations experts will walk the plant to identify additional optimization strategies. This two-person team will visit with operations staff to confirm the findings and ask for any additional input from operations.

Because the strategies are intended to reduce nutrient loads where possible, the solutions will be aggressive as the plant can always revert back to the prior mode of operation. However, the recommended strategies will be intended to maintain stable operation.

The optimization section under the memo produced for each site visit will consist of the following:

- Listing of optimization strategies

- Summary of adverse and ancillary impacts (e.g., greenhouse gas impacts)
- Capital and operations and maintenance (O&M) cost estimates per strategy (if pertinent). The O&M cost will discuss the impacts on energy, chemicals, and labor.
- Estimates of nutrient reduction and unit costs per optimization strategy (e.g., $/lb nutrient; lb GHG/lb nutrient)
- Discussion of seasonal nutrient reduction as some of the optimization strategies might only apply during the dry season and vice versa
- Discuss reduced capacity, process residuals, operational complexity and/or potential regulatory compliance issues that would be created as result of these modifications

Sidestream Treatment

The sidestream refers to the return streams from biosolids processing. Despite their small flows (typically <5 percent of raw plant flow), the sidestream represents about 15 to 40 percent of the discharge nutrient load as shown in Figure 2.

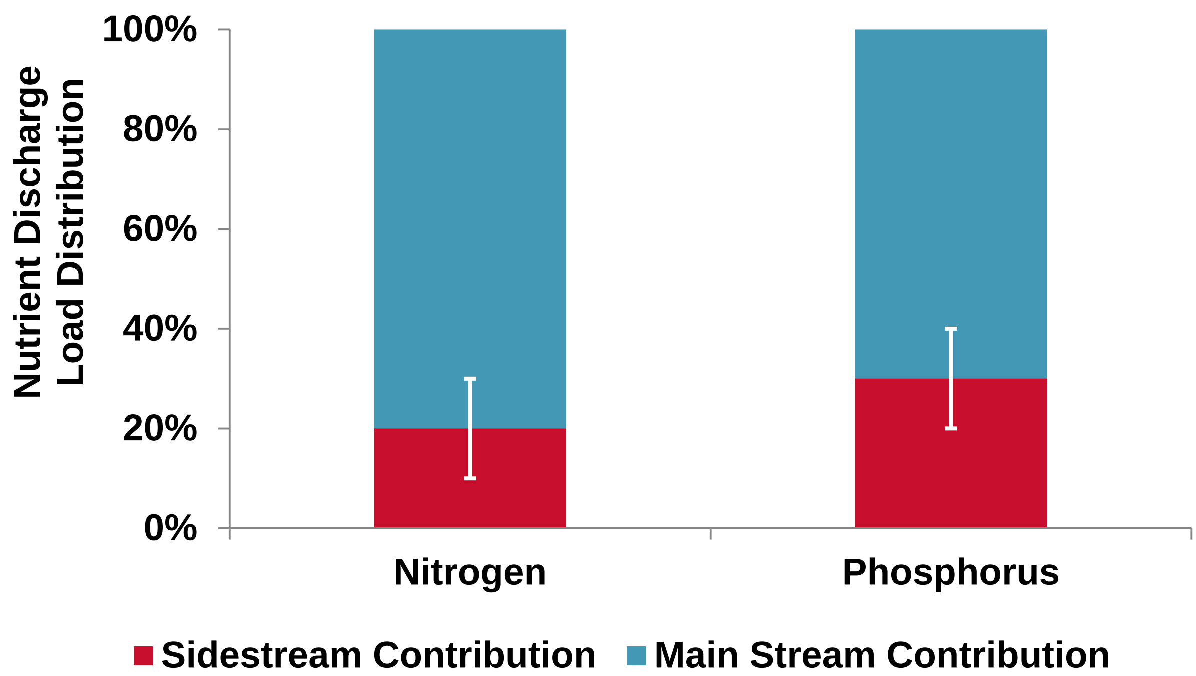

Figure 2. Nutrient Discharge Load Contribution

The benefits of removing nutrients in the sidestream are as follows:

- Warm water (favorable kinetics; small footprint)
- Concentrated nutrients (favorable kinetics; small footprint)
- Low flows (ability to equalize)
- More cost-effective as $/lb nutrient removed than complete liquid stream treatment conversion

- Less aeration and chemicals than liquid stream treatment (limited to nitrogen removal)
- Easier to phase construction than liquid stream treatment
- The sidestream process can remain operational to provide additional reliability and reduce the overall nutrient removal cost if Levels 2 and 3 are required in the future.

Not all plants are candidates for sidestream treatment. The approach for identifying candidate plants is described by the type of nutrient removal in the sub-sections below.

AMMONIA REMOVAL AND RECOVERY

Sidestream ammonia and total nitrogen removal technologies are more numerous that total phosphorus recovery choices. A graphic illustrating a decision tree to identify candidate plants for sidestream nitrogen removal is provided in Figure 3. The questionnaire will include the appropriate questions to identify candidate plants. For plants deemed non-candidates, the report will provide the basis for this decision.

There are dozens of technologies to consider. For candidate plants, the evaluation will consider either conventional nitrification or a deammonification technology, depending on the agency's questionnaire response.

PHOSPHORUS REMOVAL AND RECOVERY

The sidestream treatment of phosphorus typically relies on either chemical precipitation using metal salts or phosphorus recovery via struvite precipitation.

There are two commonly used phosphorus removal and recovery technologies for sidestream phosphorus reduction. For candidate plants, the evaluation will consider either conventional phosphorus removal by metal salts and settling, or phosphorus recovery (typically struvite precipitation technology) for plants using biological phosphorus removal.

SIDESTREAM TREATMENT DELIVERABLE

The memo for each plant will identify candidates for sidestream treatment. For candidate plants, the facilities and unit cost for removing ammonia or nitrogen and phosphorus will be presented. For plants deemed non-candidates, the report will provide the basis for this decision.

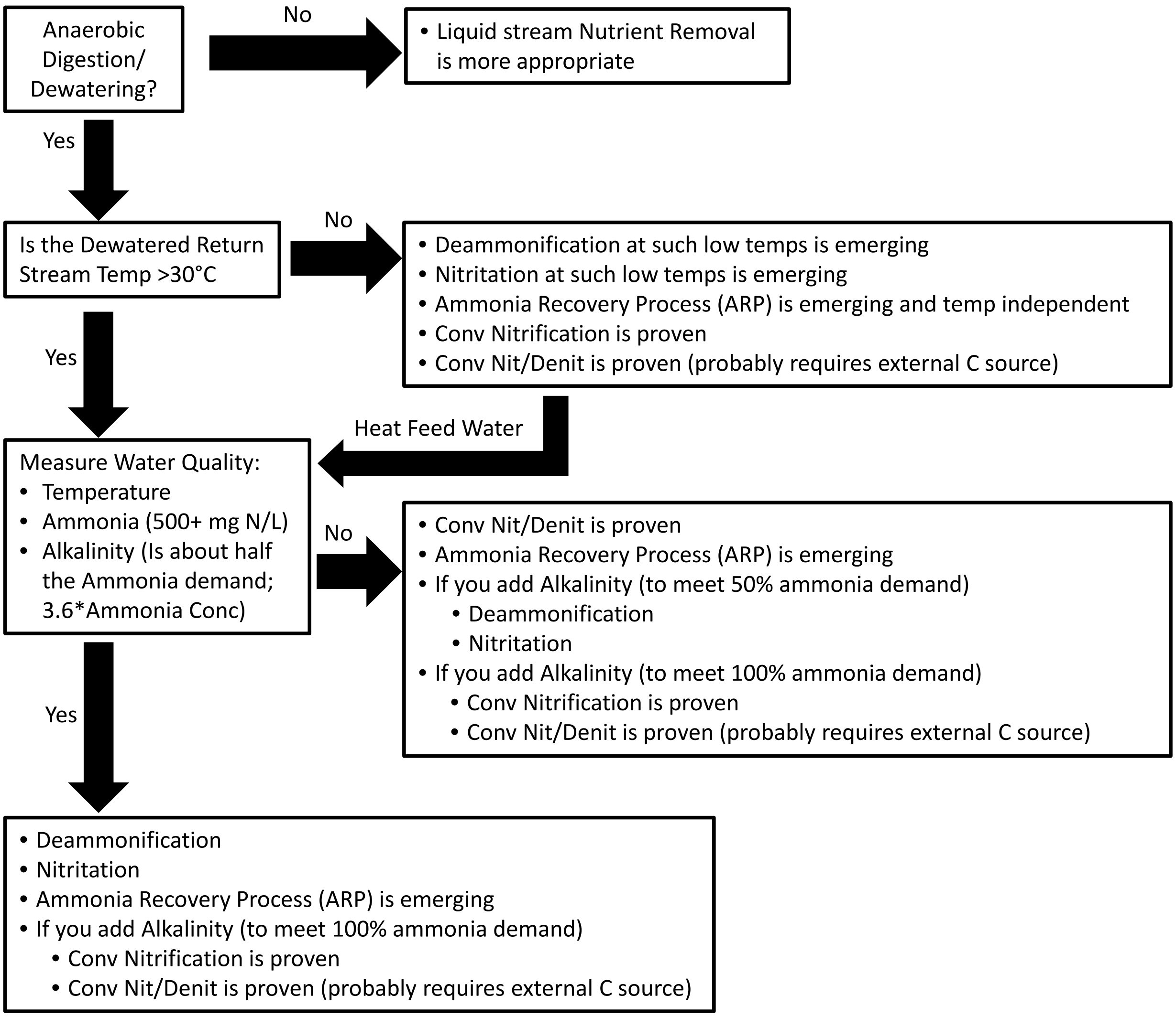

Figure 3. Decision Tree to Identify Candidates for Sidestream Nitrogen Removal

Nutrient Reduction with Plant Upgrades

Each facility will be evaluated to determine capital improvements necessary to provide nutrient removal to meet the Level 2 and Level 3 targets described in Table 2. Situations where dischargers have already upgraded existing treatment systems or implemented pilot studies for nutrient removal will be identified and incorporated into the analysis.

Established treatment technologies will be used to determine cost estimates (both capital and operating) and to determine site footprint requirements. However, innovative and/or emerging technologies will be identified for future consideration where they may be appropriate at individual facilities. As part of the evaluation, both beneficial and adverse ancillary impacts associated with plant upgrades will be identified for each facility and will be incorporated into the cost estimates.

Technology Plant Groupings

The first step in determining the plant upgrades necessary to meet the different nutrient removal levels is to classify each plant. Table 3 provides a list of all 37 plants and their classifications with respect to nutrient removal. Currently, none of these plants have been designed for deliberate phosphorus removal and some have nitrification or partial nitrogen removal.

Table 3. Summary of Current Secondary Processes for BACWA Facilities

Current Secondary Process	Discharger	Facility
Conventional Activated Sludge	Central Contra Costa Sanitary District	Central Contra Costa Sanitary District Wastewater Treatment Plant
	City of Burlingame	Burlingame Wastewater Treatment Plant
	Dublin San Ramon Services District	Dublin San Ramon Services District Wastewater Treatment Plant
	City of Livermore	City of Livermore Reclamation Plant
	City of Benicia	Wastewater Treatment Plant
	City of Millbrae	Water Pollution Control Plant
	Oro Loma/Castro Valley Sanitary District	Oro Loma/Castro Valley Sanitary Districts Water Pollution Control Plant
	City of Pinole	Pinole-Hercules Water Pollution Plant
	City of Richmond Municipal Sewer District	West County Agency Combined Outfall
	Rodeo Sanitary District	Rodeo Sanitary District Water Pollution Control Facility
	City of San Mateo	City of San Mateo Wastewater Treatment Plant
	City and County of San Francisco (San Francisco International Airport)	Mel Leong Treatment plant, Sanitary Plant
	Cities of South San Francisco and San Bruno	South San Francisco and San Bruno Water Quality Control Plant
	Union Sanitary District	Raymond A. Boege Alvarado Wastewater Treatment Plant
Activated Sludge with Seasonal Nitrification	Novato Sanitation District	Novato Sanitary District Wastewater Treatment Plant
Biological Nutrient Removal (BNR)	City of San Jose/Santa Clara	San Jose/Santa Clara Water Pollution Control Plant
	City of Petaluma	Ellis Creek Water Recycling Facility
High Purity Oxygen Activated Sludge	East Bay Municipal Utility District	East Bay Municipal Utility District, Special District No. 1 Wastewater Treatment Plant
	City and County of San Francisco (Southeast Plant)	Southeast Water Pollution Control Plant
Nitrifying Activated Sludge	Sonoma Valley County Sanitary District	Municipal Wastewater Treatment Plant
Nitrifying MBR	City of American Canyon	Wastewater Treatment and Reclamation Facility
Pond System and partial nitrifying activated sludge	Napa Sanitation District	Soscol Water Recycling Facility
Pond with nitrifying trickling filter	City of Sunnyvale	Sunnyvale Water Pollution Control Plant
Trickling Filter	Sausalito-Marin City Sanitary District	Sausalito-Marin City Sanitary District Wastewater Treatment Plant
	Sewage Agency of Southern Marin	Wastewater Treatment Plant
	U.S. Department of Navy (Treasure Island)	Wastewater Treatment Plant
Trickling filter and nitrifying trickling filter	Mt. View Sanitary District	Mt. View Sanitary District Wastewater Treatment Plant
	Las Gallinas Valley Sanitary District	Las Gallinas Valley Sanitary District Sewage Treatment Plant
Trickling Filter/Activated Sludge	Central Marin Sanitation Agency	Central Marin Sanitation Agency Wastewater Treatment Plant
	Silicon Valley Clean Water	Silicon Valley Clean Water Wastewater Treatment Plant
	City of San Leandro	San Leandro Water Pollution Control Plant
	West County Agency	West County Wastewater District Treatment Plant

Table 3. Summary of Current Secondary Processes for BACWA Facilities

Current Secondary Process	Discharger	Facility
	Vallejo Sanitation and Flood Control District	Vallejo Sanitation and Flood Control District Wastewater Treatment Plant
Trickling Filter/Solids Contact	Delta Diablo	Wastewater Treatment Plant
	City of Hayward	Hayward Water Pollution Control Facility
Trickling filters with nitrifying activated sludge	Fairfield-Suisun Sewer District	Fairfield-Suisun Wastewater Treatment Plant
	City of Palo Alto	Palo Alto Regional Water Quality Control Plant

Determining Upgrade Requirements

For nutrient removal upgrades, the general approach will be to consider Level 3 nutrient removal as a potential endpoint for all facilities. The intent is to avoid situations where a Level 2 scenario requires the construction of facilities that would be stranded in a Level 3 scenario.

In determining upgrade requirements, each facility will be evaluated based on existing infrastructure and space constraints. Existing infrastructure will be included in future upgrades as much as possible, especially if facilities are less than 10 years old. Space constraints will determine which technologies will be considered for implementation. For instance, a facility with limited footprint may consider membrane bioreactor and a facility with ample footprint could consider a 5-stage Bardenpho process for meeting Level 3 requirements. In cases of severely constrained sites, removal and replacement of existing facilities may be required.

Several technologies will be considered that represent well established technologies for cost and footprint estimates. Table 4 lists the established technologies that will be considered for upgrades.

There are other technologies that could be considered at this time, but they may be less established in the wastewater sector. Using less established technologies for cost estimation and determining footprint introduces an added level of risk that is not appropriate for planning. However, situations where innovative or emerging technologies may be appropriate in the future will be identified, but will not be included in the cost estimate or site layout. For instance, BioMag® represents an innovative technology that could be implemented, but the number of installations is currently less than 10 in North America.

Table 4. Established Technologies for Ammonia, Nitrogen and Phosphorus Removal

Level 2 Technologies	Level 3 Technologies[1]
Nitrifying Technologies	
Nitrifying air activated sludge Integrated fixed film activated sludge (IFAS) Membrane bioreactor (MBR) Nitrifying trickling filter (NTF) Biological aerated filter (BAF) Oxidation ditch	Level 2 meets Level 3 ammonia limits
Nitrogen Removal Technologies	
Modified Ludzack-Ettinger (MLE) Denitrification filter[2] Moving bed biofilm reactor (MBBR)[2] Step feed activated sludge Oxidation ditch	4-stage Bardenpho[2] Denitrification filter[2] MBBR[2] Oxidation ditch
Phosphorus Removal Technologies	
Oxidation ditch 2-stage Phoredox (P only) 3-stage Phoredox 5-stage Bardenpho (both N and P) Chemical[3] addition to primary clarifiers Chemical[3] addition to aeration basin Tertiary chemical[3] addition/solids removal	Direct filtration[3] Sedimentation/filtration[3] Membrane filtration[3]

Notes:

1. In addition to or expansion of Level 2
2. Carbon source may be required (e.g. methanol)
3. Metal salt or other chemical added

Facility Upgrades

The analysis will first determine plant upgrades that are necessary to meet the Level 3 requirements. For less stringent conditions, the unit processes will be removed to determine Level 2 and nitrification only scenarios. This approach avoids the situation where Level 2 upgrades would result in upgrades becoming obsolete for Level 3.

Figure 4 shows a progression of how technologies could be selected to meet nitrification requirements as well as Level 2 and Level 3 nitrogen removal requirements. This approach illustrates the progression of unit processes to meet Level 2 and later Level 3 requirements. For instance, Figure 4 shows that if a facility were upgraded to a membrane bioreactor (MBR) facility to meet Level 3 nitrogen limits, then a MBR process would also be used for Level 2 nitrogen removal and nitrification.

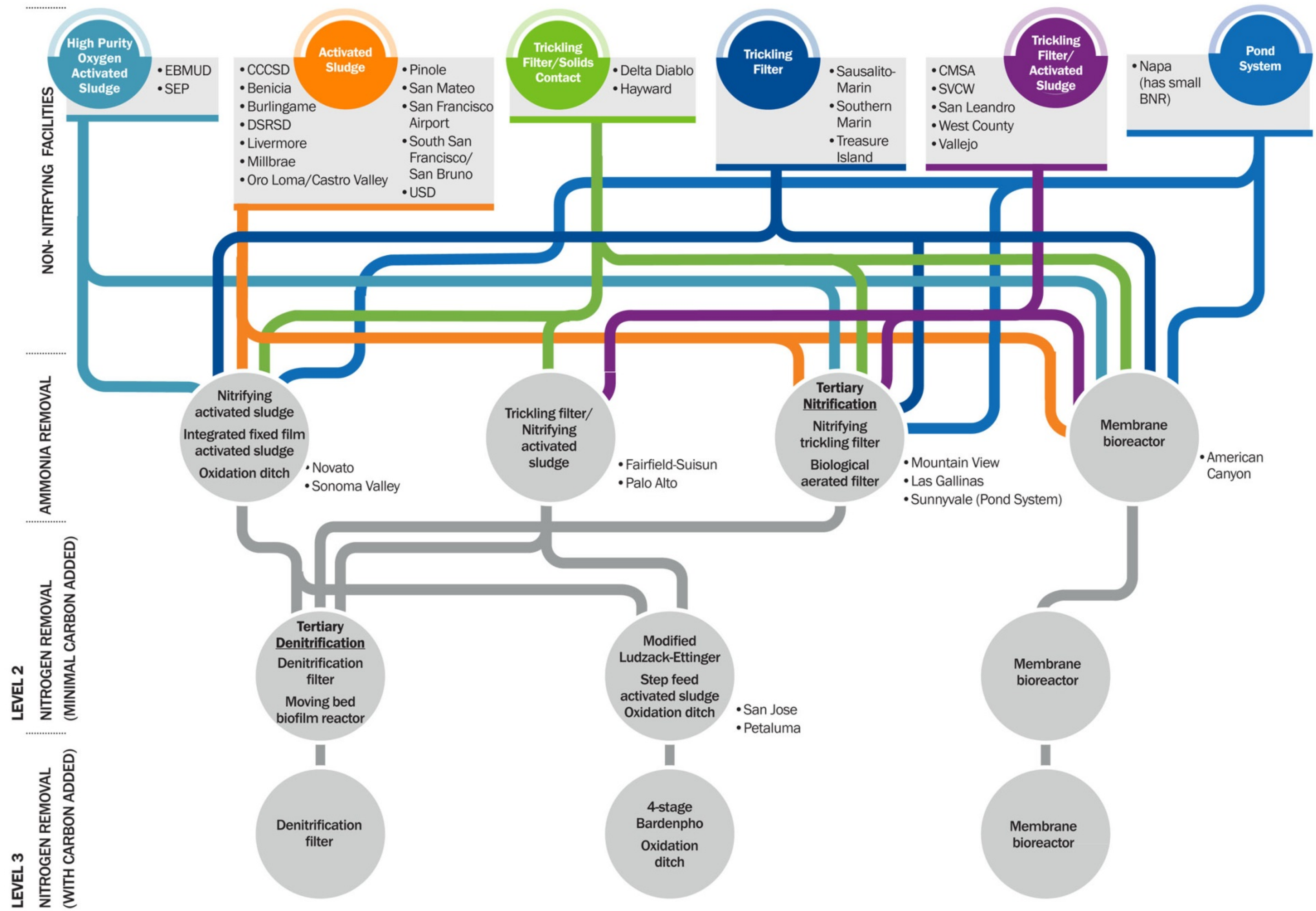

Figure 4. Existing Treatment Categories and the Nitrogen Removal Technologies Progression

Figure 5 shows a similar approach for phosphorus removal technologies. Certain facilities are well positioned to be upgraded to enhanced biological phosphorus removal (e.g. 5-stage Bardenpho or oxidation ditch) to meet Level 2 requirements. For all facilities, Level 3 phosphorus requirements would be met by chemical addition and filtration regardless of the technology implemented for Level 2 removal.

Figure 4 and Figure 5 provide guidance for the overall selection process for plant upgrades. However, the actual selection process will be driven by several factors including existing infrastructure, space constraints and existing solids processing technologies. Therefore, plant upgrades will be tailored to each facility based on these factors.

Once a representative technology that will comply with Level 3 nitrogen and phosphorus requirements has been selected for each facility, conceptual cost estimates will be prepared to determine capital and operating costs for the most attractive option. Operating costs will represent the change in cost due to nutrient removal. For instance, upgrading from a conventional activated sludge process to a membrane bioreactor will increase electrical, chemical, and labor costs and only that increase will be quantified. Cost estimates will be presented so that unit processes are line items that can be removed to evaluate other scenarios. For instance, change from a Level 2 nitrogen removal scenario to a nitrification-only scenario by eliminating anoxic zones.

Changes in GHG emissions from additional energy and chemical demands will be estimated. Expected changes in sludge production will be identified where appropriate. A qualitative estimate of changes in pharmaceuticals removal will be provided.

Impacts of Sea Level Rise

Participating agencies that are vulnerable to the impacts of sea level rise will be identified. The analysis will be based on publically available data from the United States Army Corps of Engineers, the Federal Emergency Management Agency, and publically available topography data. Participating agencies will provide key plant elevation data in the data collection template.

The impacts of sea level rise with respect to potential for inundation of facilities needed to achieve nutrient reduction will be determined for each of those identified agencies. Results will be presented in a map format, illustrating location of the participating plants and areas of inundation. The costs associated with sea level rise mitigation will not be determined as these additional costs are highly site specific.

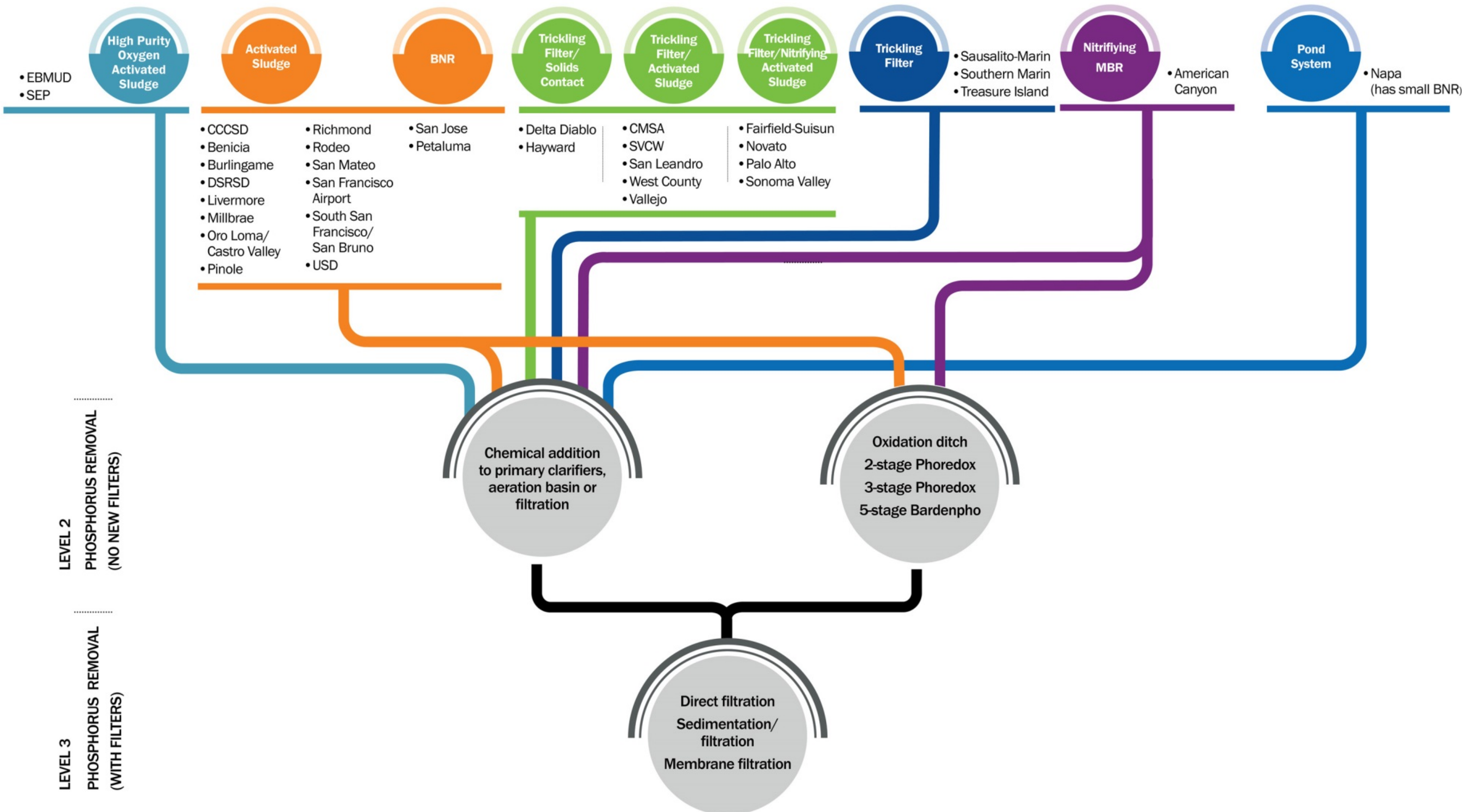

Figure 5. Existing Treatment Categories and the Phosphorus Removal Technologies Progression

Nutrient Reduction by Other Means

Strategies that reduce nutrient loadings to San Francisco Bay are not limited to options inside the plant fence. The optimization and plant upgrades sections focus on concepts that would be implemented inside the plant fence. This section serves as a first step in considering outside the plant fence concepts by compiling previous reports for each plant. Potential nutrient reduction by other means options are listed below:

- Effluent Management: Nutrient trading, water recycling and reuse
- Effluent Polishing: Wetlands treatment (e.g., Hayward Marsh)
- Solids Management: Biosolids export (un-stabilized) to a joint facility
- Source Control: Septic source abatement, urine separation, phosphorus dish detergent ban, etc.
- Non-Point Sources: Non-point source reduction program

The effort associated with this task is to compile any previous reports or documents prepared for each plant that addresses nutrient reduction by other means. Inclusion of such information into the evaluation might identify cost-effective and innovative solutions for nutrient load reductions. The ancillary benefits and adverse impacts for those identified strategies will be discussed. Additionally, the compiled report will identify institutional barriers to water recycling along with approaches for overcoming such barriers.

Economic Impacts Approach

The economic impacts for capital, operations and maintenance (O&M), and life-cycle analysis will be estimated for each plant. The O&M component includes the cost for energy, chemicals, and labor. The cost estimates will be based on best professional judgment of probable construction costs and not an official bid document. The estimates are considered planning level values. A more detailed analysis for each plant would be needed to refine these costs.

Approach

The capital cost estimates will be consistent with the American Association of Cost Engineers, Recommended Practice No. 17R-97, Class 4 and the American National Standards Institute definition of a “budget estimate.” The estimates will be accurate within a range of +40 percent to -20 percent. The life-cycle costs will be prepared using the Net Present Value (NPV) method.

The O&M cost estimates will be calculated using the HDR Water Cost Model. Energy and chemical costs will be confirmed based on preliminary process calculations.

Unit Cost

Unit costs will be developed in coordination with BACWA, such that they represent typical costs for the participating agencies in the San Francisco Bay Area. One set of unit costs will be used for all agencies, such that the results are directly comparable from one plant to another. An example of the unit cost parameters is presented in Table 5 (values will be developed at a later date).

Table 5. Unit Economics Sample Table

Parameter	Unit	Value
Engineering News and Review Cost Index		--
Construction Cost Index		--
Nominal Discount Rate	%	--
Inflation Rate:		
General	%	--
Energy	%	--
Chemicals	%	--
Base Year		--
Project Life	Years	--
Energy	$/kWh	--
Chemicals:		--
Ferric	$/ton	--
Alum	$/ton	--
Methanol	$/gal	--
Alkalinity	$/gal	--
Labor	$/FTE	--

Greenhouse Gas Emissions Accounting

The impact of process changes on GHG emissions will be included in the analysis for both studies. This includes increases in GHG emissions associated with recommended plant optimization and/or upgrade strategies. The analysis will not include the current GHG emissions at each plant.

The GHG emissions accounting will focus on the operating energy and chemical demand for any recommended plant optimization and/or upgrade strategies. The GHG emissions accounting will not include nitrous oxide emissions. The state of the science for nitrous oxide emissions is uncertain at this stage and thus difficult to confidently quantify.

The approach relies on the USEPA eGRID values[2] for each plant's regional energy production and the GHG emissions associated with chemical mining/fabrication. For example, converting energy demand to GHG emissions is based on an initial conversion to electrical demand, followed by a conversion to GHG emissions.

The plant questionnaire will include questions to determine fuel type and consumption at each plant, as well as chemical demands.

[2] http://www.epa.gov/cleanenergy/energy-resources/egrid/

Appendix A – Participating Facilities

Discharger	Facility Name	Facility Address
American Canyon, City of	Wastewater Treatment and Reclamation Facility	151 Mezzetta Court American Canyon, CA 94503 Napa County
Benicia, City of	Benicia Wastewater Treatment Plant	614 East Fifth Street Benicia, CA 94510 Solano County
Burlingame, City of	Burlingame Wastewater Treatment Plant	1103 Airport Boulevard Burlingame, CA 94010 San Mateo County
Central Contra Costa Sanitary District	Central Contra Costa Sanitary District Wastewater Treatment Plant	5019 Imhoff Place Martinez, CA 94553 Contra Costa County
Central Marin Sanitation Agency	Central Marin Sanitation Agency Wastewater Treatment Plant	1301 Andersen Drive San Rafael, CA 94901 Marin County
Delta Diablo	Wastewater Treatment Plant	2500 Pittsburg-Antioch Hwy Antioch, CA 94509 Contra Costa County
East Bay Dischargers Authority (EBDA), City of Hayward, City of San Leandro, Oro Loma Sanitary District, Castro Valley Sanitary District, Union Sanitary District, Livermore-Amador Valley Water Management Agency, Dublin San Ramon Services District, and City of Livermore	*EBDA Common Outfall*[A]	EBDA Common Outfall 14150 Monarch Bay Drive San Leandro, CA 94577 Alameda County
	Hayward Water Pollution Control Facility	
	San Leandro Water Pollution Control Plant	
	Oro Loma/Castro Valley Sanitary Districts Water Pollution Control Plant	
	Union Sanitary District, Raymond A. Boege Alvarado Wastewater Treatment Plant	
	Livermore-Amador Valley Water Management Agency Export and Storage Facilities[A]	
	Dublin San Ramon Services District Wastewater Treatment Plant (LAVMA)	
	City of Livermore Water Reclamation Plant (LAVMA)	

Discharger	Facility Name	Facility Address
East Bay Municipal Utility District	East Bay Municipal Utility District, Special District No. 1 Wastewater Treatment Plant	2020 Wake Avenue Oakland, CA 94607 Alameda County
Fairfield-Suisun Sewer District	Fairfield-Suisun Wastewater Treatment Plant	1010 Chadbourne Road Fairfield, CA 94534 Solano County
Las Gallinas Valley Sanitary District	Las Gallinas Valley Sanitary District Sewage Treatment Plant	300 Smith Ranch Road San Rafael, CA 94903 Marin County
Millbrae, City of	Water Pollution Control Plant	400 East Millbrae Avenue Millbrae, CA 94030 San Mateo County
Mt. View Sanitary District	Mt. View Sanitary District Wastewater Treatment Plant	3800 Arthur Road Martinez, CA 94553 Contra Costa County
Napa Sanitation District	Soscol Water Recycling Facility	1515 Soscol Ferry Road Napa, CA 94558 Napa County
Novato Sanitary District	Novato Sanitary District Wastewater Treatment Plant	500 Davidson Street Novato, CA 94945 Marin County
Palo Alto, City of	Palo Alto Regional Water Quality Control Plant	2501 Embarcadero Way Palo Alto, CA 94303 Santa Clara County
Petaluma, City of	Ellis Creek Water Recycling Facility	3890 Cypress Drive Petaluma, CA 94954 Sonoma County
Pinole, City of	Pinole-Hercules Water Pollution Control Plant	11 Tennent Avenue Pinole, CA, 94564 Contra Costa County
Rodeo Sanitary District	Rodeo Sanitary District Water Pollution Control Facility	800 San Pablo Avenue Rodeo, CA 94572 Contra Costa County
San Francisco (San Francisco International Airport), City and County of	Mel Leong Treatment Plant, Sanitary Plant	918 Clearwater Drive San Francisco International Airport San Francisco, CA 94128 San Mateo County
San Francisco (Southeast Plant), City and County of	Southeast Water Pollution Control Plant	750 Phelps Street San Francisco, CA 94124 San Francisco County
San Jose/Santa Clara Water Pollution Control Plant and Cities of San Jose and Santa Clara	San Jose/Santa Clara Water Pollution Control Plant	4245 Zanker Road San Jose, CA 95134 Santa Clara County
San Mateo, City of	City of San Mateo Wastewater Treatment Plant	2050 Detroit Drive San Mateo, CA 94404 San Mateo County
Sausalito-Marin City Sanitary District	Sausalito-Marin City Sanitary District Wastewater Treatment Plant	#1 Fort Baker Road Sausalito, CA 94965 Marin County
Sewerage Agency of Southern Marin	Wastewater Treatment Plant	450 Sycamore Avenue Mill Valley, CA 94941 Marin County
Silicon Valley Clean Water	Silicon Valley Clean Water Water Treatment Plant	1400 Radio Road Redwood City, CA 94065 San Mateo County
Sonoma Valley County Sanitary District	Municipal Wastewater Treatment Plant	22675 8th Street East Sonoma, CA 95476 Sonoma County
South San Francisco and San Bruno, Cities of	South San Francisco and San Bruno Water Quality Control Plant	195 Belle Air Road South San Francisco, CA 94080 San Mateo

Discharger	Facility Name	Facility Address
		County
Sunnyvale, City of	Sunnyvale Water Pollution Control Plant	1444 Borregas Avenue Sunnyvale, CA 94089 Santa Clara County
U.S. Department of Navy (Treasure Island)	Wastewater Treatment Plant	681 Avenue M, Treasure island San Francisco, CA 94130-1807 San Francisco County
Vallejo Sanitation and Flood Control District	Vallejo Sanitation and Flood Control District Wastewater Treatment Plant	450 Ryder Street Vallejo, CA 94590 Solano County
West County Agency (West County Wastewater District and City of Richmond Municipal Sewer District)	Richmond Municipal Sewer District No.1 (RMSD) Water Pollution Control Plant West County Wastewater District (WCWD) Treatment Plant West County Agency Combined Outfall	601 Canal Blvd. Richmond, CA 94804 Contra Costa County 2377 Garden Tract Road Richmond, CA 94801 Contra Costa County

Note:

A. Conveyance; not treatment facility.