BACWA Meeting with Regional Board: Review of the Nutrient Reduction Study

17 September 2018
Agenda

1. Watershed Permit Requirements
2. Scoping and Evaluation Report
3. Study Limitations
4. Nutrient Reduction Findings
5. Reduction by Other Means
6. Sea Level Rise
7. Key Observations
8. Summary
Watershed Permit Requirements
Watershed Permit

San Francisco Bay Regional Water Quality Control Board

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

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

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

Table 1. Discharger Information

<table>
<thead>
<tr>
<th>Discharger</th>
<th>Facility Name</th>
<th>Facility Address</th>
<th>Minor/Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>154 Magnolia Card</td>
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</table>

April 9, 2014
Watershed Permit Requirements

- Issued April 9, 2014 – Regional Water Board Order No. R2-2014-0014

- Requirements:
  - Scoping and Evaluation Plan (Accepted first quarter of 2015)
  - July 2018: Task 1 - Conduct treatment plant optimization and sidestream treatment evaluation for nutrient load reductions (Submitted before July 2018 deadline)
  - July 2018: Task 2 - Conduct treatment plant upgrades and analysis of removal by other means for nutrient load reductions (Submitted before July 2018 deadline)
  - Annual Reporting (Annual submittal in October from 2015 through 2018)
37 Participating Agencies
Scoping and Evaluation Report
Scoping and Evaluation Report (Accepted February 2015)

- Established nutrient levels
- Presented the approach for all 37 plants:
  - Data collection and prelim. assessment
  - Site visits
  - Site visit reports
  - Nutrient reduction report for each plant
  - GHG emissions
  - Removal by other means
  - Sea level rise
## Treatment Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Study</th>
<th>Ammonia</th>
<th>TN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 *</td>
<td>Optimization</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Level 2 *</td>
<td>Upgrades</td>
<td>2 mg N/L</td>
<td>15 mg N/L</td>
<td>1.0 mg P/L</td>
</tr>
<tr>
<td>Level 3 *</td>
<td>Upgrades</td>
<td>2 mg N/L</td>
<td>6 mg N/L</td>
<td>0.3 mg P/L</td>
</tr>
</tbody>
</table>

* Seasonal impacts considered for all three treatment levels:
  - Dry Season = May 1 to September 30
  - Wet Season = October 1 to April 30
Data Collection

Sent to Plants in Dec 2014 to Better Understand each Plant and Perform Pre-Engineering before each Site Visit
Site Visits

Objectives:

- Review data with lab staff
- Review permit requirements
- Develop treatment concepts to satisfy the permit requirements
- Walk the plant to confirm viability of developed concepts
- Produce a site visit report that confirms the concepts developed during the site visit
Data Review and Site Visits

Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades

### Facility Information
- **Facility Name**
- **Address**
- **Facility Contact**
- **Date of Visit**
- **Facility Attendees**
- **Consultant Mgmt Group Attendees**
- **Consultant Process Engineer**
- **Consultant Operations Expert**
- **Describe Existing Nutrient Limits (P any) Ammonia = 175 mg N/L AWE/L and 225 mg N/L MDEL**
- **Permitted Capacity** 19.5 mgd ADWF; 31.1 mgd PWWF

### Current Conditions

#### Flow
- **Annual Average Flow, mgd** 13.9
- **Peak Month, mgd** 13.7
- **Max Day, mgd** 14.2
- **Peak Hour Flow, mgd** 19

#### TSS Loads (Marginal seasonal impacts)
- **Annual Average, lb/d** 38,500
- **Peak Month, lb/d** 42,400
- **Max Day, lb/d** 58,500

#### BOD Loads (Marginal seasonal impacts)
- **Annual Average, lb/d** 35,700
- **Peak Month, lb/d** 37,400
- **Max Day, lb/d** 42,300

#### Ammonia Loads (Marginal seasonal impacts)
- **Summer** 80
- **Winter** 50

### TKN Loads (Marginal seasonal impacts)
- **Annual Average, lb/d** 3,800
- **Peak Month, lb/d** 4,100
- **Max Day, lb/d** 4,400

### Ortho-P Loads (Marginal seasonal impacts)
- **Annual Average, lb/d** 400
- **Peak Month, lb/d** 490
- **Max Day, lb/d** 610

### Total P Loads (Marginal seasonal impacts except for Max Day)
- **Annual Average, lb/d** 860
- **Peak Month, lb/d** 780
- **Max Day, lb/d** 1000

- **High due to solids from water recycling return streams**

- The current flows and loads are in-line with the Master Plan historical and projected flows and loads. The current flows and loads show marginal seasonal impacts on flows and loads.
- The annual summer total P loads are high due to phosphorus in the solids return stream from the Recycled Water Facility (RWF). Data Diablo adds ferric chloride (FeCl3) to their sewer at the Pittsburg and Antioch pump stations (FS) and alum at the Actiflo® process located at the RWF.

### Documentation (check all available documents)
- ☑ Current Master Plan
- ☑ PPD
- ☑ Facility Plan
- ☑ See Level Rice Report
Project Approach Summary

- **Scoping Plan**
- **Evaluation Plan**
- **Data Collection & Analysis**

- **Plant Optimization**
- **Sidestream Treatment**
- **By Other Means**
- **Facility Upgrades**

**Synthesis** → **Nutrient Reduction Plan**

- **Approved in Feb 2015**
- **Data Collection: Spring 2015**
- **Site Visits: Spring – Fall 2015**
- **Draft / Final Plant Reports: 2016-2018**
- **Summer 2018**
Study Limitations
Study Limitations

1. The Study’s treatment levels DID NOT consider water quality objectives. Rather, they were based on a tipping point in facilities needed to achieve Level 2 versus Level 3 (e.g., filters, chemicals, etc.).

2. Treatment levels were based on ammonia, TN and TP versus individual species (impacted technology selection)

3. Planning level effort that was limited to data exchange and a single site visit (i.e., not a detailed facilities planning report)

4. Projected flows/loads were typically not site specific

5. Used parametric cost estimating (excluded site specific constraints)

6. Findings (including costs and space requirements) were based on established, conventional technologies.
Nutrient Reduction Findings
Nutrient Reduction Findings (Submitted June 2018)

- Individual plant reports and sign-off letters for all 37 plants
- Optimization
- Sidestream treatment
- Plant upgrades
- Summary comparison of Opt./Sidestream/ Upgrades
February 12, 2018

Mr. Bruce Wolfe
Executive Officer
San Francisco Bay Regional Water Quality Control Board
1815 Clay Street, Suite 1400
Oakland, CA 94612

Subject: Acceptance of Plant-Specific Findings for the Nutrient Reduction Report

Dear Mr. Wolfe,

On behalf of Oro Loma Sanitary District, I have reviewed the individual plant report prepared for Oro Loma that is included as an appendix to the Potential Nutrient Reduction by Treatment Optimization, Biological Treatment, Treatment Upgrades, and Other Means Report (Nutrient Reduction Report). The plant report was prepared by the HDR consulting team under a contract with Bay Area Clean Water Agencies (BACWA). This report represents the Oro Loma facility in 2017 and outlines a methodology and costs to achieve advanced levels of nutrient treatment.

I agree that the recommended approach and cost estimates for reducing nutrients at our facility are reasonable with respect to the context of the overall report. Furthermore, in accordance with the Watershed Permit requirement for report certification, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. The Nutrient Reduction Report is, to the best of my knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Thank you.

[Signature]

Jason Warner
General Manager

Bay Area Clean Water Agencies
Nutrient Reduction Study
Oro Loma/Castro Valley
Wastewater Treatment Plant
San Lorenzo, CA

February 9, 2018
Final Report
Individual Plant Reports
(Appendix in the Main Report for each of the 37 Plants)

Each Report is 25-35 pages, which includes:

- Executive Summary
- Introduction
- Current Conditions
- Basis of Analysis
- Nutrient Load Reduction by Optimization
- Nutrient Load Reduction by Sidestream Treatment
- Nutrient Load Reduction by Upgrades (Levels 2 and 3)
- Nutrient Load Reduction By Other Means
- Greenhouse Gas Emissions
- Emerging Technologies
Optimization Results
Optimization Approach

- **Basis of Analysis**
  - Identify no / low cost strategies to reduce effluent nutrients
  - Planning Period: 2025 Horizon
  - Loading:
    - 0% Increase in Flows
    - 15% Increase in Loads
  - Design Criteria: Aggressive – no permit limits

- **Potential Optimization Concepts**
  - Use offline tankage
  - Operate in split treatment mode
  - Modify operational mode (e.g., raise SRT)
  - Add chemicals
  - Process control instrumentation
  - Add internal recycle for denitrification
Optimization Findings

Which nutrients are easiest to remove?
- Ammonia load reduction is most difficult
  - Increasing SRT for plants with act sludge
  - Operating Trickling Filter as a Nitrifying Trickling filter
- TN load reduction is possible if ammonia removal implemented
- TP load is easier to remove
  - Most plants already have metal salt chemical feed facilities
  - Some have anaerobic zones
  - Lose TP removal capability by forfeiting anaerobic zone

Costs
- Total PV
  - $241M Dry Permit and $266M Year-Round Permit
  - Ranged from $0.2M to $45M per plant
- Unit Costs
  - Flow-weighted Total PV unit cost = ~$0.5/gpd
  - Total PV/lb N rem = ~$6/lb N
  - Total PV/lb P rem = ~$8/lb P
- Plants identified for Ammonia/TN load reduction:
  - 15 of 37 plants for dry or year round reductions

Load Reduction w/Respect to Current Discharge:
- Ammonia load reduction is 14%
- TN load reduction is 7%
- Overall TP load reduction is 34%
Total PV Costs for Optimization

* Results are Sorted by Permitted Capacity

* Capital
  * O&M PV

* Present Value (M)
Sidestream Treatment Results
Sidestream Approach

- Basis of Analysis
  - Identify upgrade strategies to reduce nutrients
  - Planning Period: 30 Years
  - Loading: Plant Permitted Capacity
  - Requirements for Sidestream:
    - Anaerobic digestion
    - Year-round sidestream
    - Sufficient Dewatering Frequency (>4 days/week)
    - Water temperature governs technology selection

- Concepts
  - Ammonia/TN Removal:
    - Conventional nitrification technology
    - Deammonification technology
  - TP Removal: metal salt precipitation

- Acknowledgements
  - EPA Regional Grant led by EBMUD
  - Agencies that hosted pilots: EBMUD, SPFUC SEP, DD, OLSD, USD, CCCSD
Sidestream Findings

- Criteria for feasible sidestream implementation:
  - Anaerobic digestion
  - Year-round sidestream
  - Year-round discharge
  - Sufficient dewatering frequency (>4 days/week)

- Number of candidate plants
  - 15 out of 37 plants if ammonia reduction is the discharge objective
  - 23 out of 37 plants if TN reduction is the discharge objective
  - 15 out of 37 plants if TP reduction is the discharge objective

- Costs
  - The Total PV cost is $736 Mil for all the nutrients ($690 Mil for TN Load Reduction)
  - Removal Metric = $2.0/lb N removed; $2.8/lb P removed

- The overall Ammonia/TN/TP load reduction from Current Discharge is up to 24, 19, and 12 percent, respectively
Total PV Costs for Sidestream

* Results are Sorted by Permitted Capacity
Upgrades Results
Upgrades Approach

- **Basis of Analysis**
  - Identify upgrade strategies to meet effluent levels
  - Planning Period: 30 Years
  - Loading: Permitted Capacity
  - Design Criteria: Reliability – meet permit limits

- **Concepts**
  - Design Facilities for Level 2 that could be further upgraded to meet Level 3 – no stranded assets

**Treatment Levels**

<table>
<thead>
<tr>
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<th>Ammonia</th>
<th>TN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>--</td>
<td>Optimization</td>
<td>--</td>
</tr>
<tr>
<td>Level 2</td>
<td>2 mg N/L</td>
<td>15 mg N/L</td>
<td>1.0 mg P/L</td>
</tr>
<tr>
<td>Level 3</td>
<td>2 mg N/L</td>
<td>6 mg N/L</td>
<td>0.3 mg P/L</td>
</tr>
</tbody>
</table>
Upgrade Findings

Which nutrients are easiest to remove?

- Ammonia is the most difficult and expensive
  - Bigger basins due to increasing SRT for act sludge plants
  - Expanded aeration system
  - Additional pumping
- TN load reduction requires ammonia removal
  - Level 3 typically require an external carbon source
- TP load reduction is the simplest/most straightforward
  - Level 3 requires tertiary filtration
  - Upgrades use MBR (includes filtration in Level 2)

Number of Plants Already/Planning to Meet Levels:
- Level 2: 6
- Level 3: 1

Costs

- Total PV Costs
  - Level 2 = $8.8B Dry & $9.4B Year Round
  - Level 3 = $10.8B Dry & $12.4B Year Round
- Total PV Cost Range per Plant
  - Level 2 = $1.4M to $2,620M per plant
  - Level 3 = $9M to $2,870M per plant
- Unit Costs
  - Level 2: $8.5/lb N Dry & $8.7/lb N Year Round
    $44/lb P Dry & $44/lb P Year Round
  - Level 3: $8.4/lb N Dry & $7.7/lb N Year Round
    $66/lb P Dry & $59/lb P Year Round

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level 2 Load Reduction</th>
<th>Level 3 Load Reduction</th>
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<tbody>
<tr>
<td>Ammonia</td>
<td>&gt;93%</td>
<td>&gt;93%</td>
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<tr>
<td>Total N</td>
<td>&gt;57%</td>
<td>&gt;82%</td>
</tr>
<tr>
<td>Total P</td>
<td>&gt;59%</td>
<td>&gt;88%</td>
</tr>
</tbody>
</table>
Total PV Costs for Level 2 Upgrades

*Results are Sorted by Permitted Capacity*
* Results are Sorted by Permitted Capacity
Summary of Results
Box and Whisker Plots

- Used to Illustrate Data Distribution, Central Value, and Variability
- Box:
  - Median is horizontal line inside box
  - Box ends represent upper and lower quartiles (25th and 75th percentiles)
- Lines represent max and min values
Box and Whisker Plots for TN Load Reduction Metrics:
Unit Total PV, $/gpd (Left) and Removal Efficiency, $/lb (Right)

Notes:
1. The unit cost graphs are presented as box and whisker plots, where the boxes represent the range of costs falling within the 25th to 75th percentiles, the horizontal bar within the box represents the median cost, and the ends of the whiskers represent the minimum and maximum unit costs, respectively.
Total N Discharge Load Reduction and Costs under Various Scenarios (Dry Season Permit)

- Optimization = 10-yr planning horizon
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity
Total N Discharge Load Reduction and Costs under Various Scenarios (Year Round Permit)

Optimization = 10-yr planning horizon
Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity
Greenhouse Gas Emissions
Greenhouse Gas (GHG) Emissions

- Captures the impacts from additional energy and chemicals associated with nutrient load reduction
- Not intended to satisfy GHG emissions reporting requirements
- Nitrous oxide emissions not included but will likely increase with biological nitrogen removal processes

### Annual GHG Emissions (mt CO2 eq/yr) from Additional Energy/Chemicals for Nutrient Load Reduction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Optimization</th>
<th>Sidestream</th>
<th>Level 2 Upgrades</th>
<th>Level 3 Upgrades</th>
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<tr>
<td>Energy</td>
<td>mt CO2 eq/yr</td>
<td>14,400</td>
<td>4,500</td>
<td>119,000</td>
<td>138,500</td>
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<td>Chemicals</td>
<td>mt CO2 eq/yr</td>
<td>48,700</td>
<td>600</td>
<td>138,400</td>
<td>168,400</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>mt CO2 eq/yr</strong></td>
<td><strong>63,100</strong></td>
<td><strong>5,100</strong></td>
<td><strong>257,400</strong></td>
<td><strong>306,900</strong></td>
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</table>

| Increase in Bay Area GHG Emissions* | %          | 0.09%       | 0.007%     | 0.4%             | 0.5%             |

* WWTPs contribute ~3% to global GHG Emissions (IPCC, 2007)
Nutrient Reduction By Other Means
Current Recycled Water Quantities

- ~6% of Baywide plant effluent goes to recycled water
- Recycled water is expected to double by 2035
- The primary application is industrial (~40%)

6% Baywide Flow Reduction ≠ 6% Baywide Load Reduction
Recycled Water Distribution and Future Projection

Year 2015 (58,000 AFY)

- Golf Course Irrigation
- Landscape
- Commercial
- Agricultural
- GW Recharge
- Environ. Enhancement
- Internal Use
- Other Non-Potable Reuse
- Not Defined

Nutrient Reduction:
- 760 kg NH4/d
- 1,700 kg N/d

Year 2030 (117,000 AFY)

- Golf Course Irrigation
- Landscape
- Commercial
- Agricultural
- GW Recharge
- Environ. Enhancement
- Internal Use
- Other Non-Potable Reuse
- Not Defined

Nutrient Reduction:
- 2,200 kg NH4/d
- 3,500 kg N/d

Year 2040 (131,000 AFY)

- Golf Course Irrigation
- Landscape
- Commercial
- Agricultural
- GW Recharge
- Environ. Enhancement
- Internal Use
- Other Non-Potable Reuse
- Not Defined

Nutrient Reduction:
- 2,600 kg NH4/d
- 4,000 kg N/d
Sea Level Rise
Sea Level Rise Approach

Purpose: Identify plants vulnerable to impacts of future sea level rise (SLR)

- Information Sources: USACE and FEMA
- Considered high, intermediate, low rise rates
  - Low curve is based on historical rate of change
  - Intermediate – NRCS Curve 1
  - High – NRCS Curve 3
- Results
  - 16 plants are within 100-yr flood hazard
  - 2 plants are protected by FEMA accredited levees
  - 9 plants are not vulnerable to sea level rise under low, intermediate, or high projections
  - 10 plants are vulnerable under low, intermediate, or high rate of rise projections
Sea Level Rise Assessment, North Bay
Sea Level Rise Assessment, South Bay
Key Observations
Key Observations

1. Capital Costs are Substantial
2. There are Competing Needs for Resources:
   - Aging infrastructure, collection system upgrades, storm water, recycled water, etc.
   - SF Bay Area is resource limited; planning and prioritization would be key for implementation
   - SRF funding is limited. Plants using bond funding would have higher costs
3. Water Quality Objectives Influence Technology Selection
4. Averaging Periods Influence Footprint and Cost
5. Flexible Permit Structures Facilitate Innovation
6. Constrained Sites Influence Technology Selection
7. Technology Selection Influences Effluent Quality, Footprint, GHGs, and Costs
8. GHG Emissions Impacted By Water Quality Objectives
3. Water Quality Objectives
Influence Technology Selection
Water Quality Objectives Influence Facility Needs

- Lower limits dictate additional treatment
- Ammonia limits may preclude emerging technologies
  (See example below)

- Permitting uncertainty increases capital costs

Established Technology TN Removal

Example of Emerging Technology TN Removal
4. Averaging Periods Influence Footprint and Cost
Importance of Averaging Periods on Sizing Facilities

[Graph showing seasonal load variations with lines indicating Maximum Day Load, Maximum Month Load, Average Annual Load, and Dry Season Load.]
### Role of Averaging Periods on SRT and Basin Volume

<table>
<thead>
<tr>
<th>Averaging Periods Govern the SRT and Overall Basin Volume</th>
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</thead>
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<table>
<thead>
<tr>
<th>Aerobic SRT</th>
<th>Total PV</th>
<th>NH4 Load Reduction (%)</th>
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<tbody>
<tr>
<td>8 d</td>
<td>$200</td>
<td>&gt;95</td>
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## Role of Averaging Periods on SRT and Basin Volume

### Maximum Month

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<td>10 d</td>
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### Averaging Periods Govern the SRT and Overall Basin Volume
Role of Averaging Periods on SRT and Basin Volume

Averaging Periods Govern the SRT and Overall Basin Volume

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<td>10 d</td>
<td>$214</td>
<td>&gt;98</td>
</tr>
<tr>
<td>15 d</td>
<td>$260</td>
<td>&gt;99</td>
</tr>
</tbody>
</table>
5. Flexible Permit Structures Facilitate Innovation
Flexible Permit Structure for Nutrients

- Provides opportunities for creative and economical approaches.
- Traditional approaches (e.g., monthly and weekly limits on both a concentration and mass basis) may eliminate the most effective watershed solutions.
- Avoid disincentives to watershed management, nutrient trading and offsets, and other approaches to optimization.
- Adaptive Management is Recommended: when the relationship between nutrient loadings and water quality responses is not well defined, it is advisable to avoid overly restrictive effluent limits at the outset, which may result in over investment in advanced treatment.
6. Constrained Sites Influence Technology Selection
Millbrae Case Study

- Permitted Capacity = 3.0 mgd ADWF
- Peak = 9.0 mgd
- Key process:
  - Must be MBR
  - Must move blower building for a train
  - Must move disinfection for a train
  - Add new disinfection
- 8 Plants were pushed to MBR due to space constraints

Complexity of Upgrades in a Tight Space
7. Technology Selection Influences Effluent Quality, Footprint, GHGs, and Costs

Findings are based on Established Technologies; Emerging Technologies Should be Considered if Implementation Required
Emerging technologies

- Aerobic Granular Sludge
- FibrePlate Hybrid-membrane
- Membrane Aerated Biofilm Reactors (MABR)
- Dual Processes – Wet Weather/Dry Weather
  - CEPT, Micro-screens
- Cloth Media Filtration Primary Treatment
- Mainstream Deammonification
- Shortcut nitrogen removal
- HydroGrav
- Sidestream Deammonification
- AirPrex (Struvite)
- CalPrex (Brushite)
- Ammonia Recovery Processes
- Advanced Super Critical Water Technology
- Clean B Chlorine Dioxide Solids Stabilization

Gartner Hype Cycle

Source for Gartner Hype Curve:
http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp
8. GHG Emissions Impacted By Water Quality Objectives
Increase in GHG Emissions for Various Nutrient Targets based on a Nominal 10 mgd Plant

- Captures the impacts from additional energy and chemicals associated with nutrient load reduction
- Not intended to satisfy GHG emissions reporting requirements
- Nitrous oxide emissions not included but will likely increase with biological nitrogen removal processes

Summary
## Summary

1) Load reductions increase with more treatment.

2) Sidestream is cost-effective for both TN and TP ($/lb) but not feasible at all plants.

3) Upgrade costs are substantial.

4) Future limits would impact technology selection.

5) A basis of design report is recommended for any nutrient removal projects.

<table>
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<th>Unit</th>
<th>Treatment Strategy</th>
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<td>Load Reduction</td>
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<tr>
<td>TN</td>
<td>%</td>
<td>7%</td>
</tr>
<tr>
<td>TP</td>
<td>%</td>
<td>34%</td>
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<tr>
<td>Per gpd</td>
<td>$/gpd</td>
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</tr>
<tr>
<td>Per lb N</td>
<td>$/lb N</td>
<td>5.6</td>
</tr>
<tr>
<td>Per lb P</td>
<td>$/lb P</td>
<td>8.6</td>
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BACWA Meeting with Regional Board: Review of the Nutrient Reduction Study

17 September 2018