BACWA Workshop #2: Nutrient Reduction by Treatment Optimization and Upgrades Update

7 June 2017
Agenda

1. Background
2. Case Studies
3. Draft Findings of Nutrient Removal Reports
   a) Optimization
   b) Sidestream
   c) Upgrades
   d) No Net Load Increase
4. Key Variables that Impact Results
5. Regulatory: N versus P
6. Results of Recycled Water/CIP Surveys
7. Sea Level Rise
8. Next Steps
Project Background
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></td>
<td></td>
<td>154 Marina Ct.</td>
<td></td>
</tr>
</tbody>
</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 (Submittal deadline is July 2018)
  - July 2018: Task 2 - Conduct treatment plant upgrades and analysis of removal by other means for nutrient load reductions (Submittal deadline is July 2018)
  - Annual Reporting (Annual submittal in October from 2015 through 2018)
37 Participating Agencies
Overview / Status of Study

Scoping Plan
Evaluation Plan
Data Collection & Analysis

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

Synthesis
Nutrient Reduction Plan

Completed
Drafts Completed
Upcoming
## 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>

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

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

- 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
Upgrades Approach

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

- **Concepts**
  - Sidestream Treatment
  - Design Facilities for Level 2 that could be further upgraded to meet Level 3 – no stranded assets
  - Technology Status: Established Technologies

<table>
<thead>
<tr>
<th>Level</th>
<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>
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<td>2 mg N/L</td>
<td>6 mg N/L</td>
<td>0.3 mg P/L</td>
</tr>
</tbody>
</table>
Case Studies
Pinole

Straight forward, in process of upgrading
## Pinole Optimization and Upgrade Concepts

<table>
<thead>
<tr>
<th>Process</th>
<th>Current</th>
<th>Optimization *</th>
<th>Sidestream</th>
<th>NNLJ</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primaries</td>
<td>Yes</td>
<td>--</td>
<td>-</td>
<td>Yes</td>
<td>CEPT</td>
<td>CEPT</td>
</tr>
<tr>
<td>Act Sludge</td>
<td>BOD</td>
<td>--</td>
<td>-</td>
<td>BNR (MLE)</td>
<td>BNR (MLE)</td>
<td>BNR (4-stage)</td>
</tr>
<tr>
<td>Sec Clarifier</td>
<td>Yes</td>
<td>--</td>
<td>-</td>
<td>Replace Existing</td>
<td>Replace Existing</td>
<td>Replace Existing</td>
</tr>
<tr>
<td>Peak Flow</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>Contact Stabilization</td>
<td>Contact Stabilization</td>
<td>Contact Stabilization</td>
</tr>
<tr>
<td>Filter</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Denite Filter</td>
</tr>
<tr>
<td>Carbon</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Fe/Al/Poly</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Fe/Pol</td>
</tr>
<tr>
<td>Sidestream Treatment</td>
<td>-</td>
<td>--</td>
<td>No for NH4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Plant is under construction for upgrades to meet Level 2
1. **CEPT:** use the recently implemented chemical feed facilities
2. **Nit/Denite:** expand the aeration basins to operate as nitrification/denitrification (ability to operate in contact stabilization mode during wet season)
3. **Secondary Clarifiers:** replace with new secondary clarifiers
1. **CEPT:** use the recently implemented chemical feed facilities

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3. **Secondary Clarifiers**: replace with new secondary clarifiers
4. **Denitrifying Filters**: add denitrifying filter complex
5. **Carbon**: add external carbon source
6. **Metal Salt**: add metal salt chemical feed facilities
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5. **Carbon:** add external carbon source
6. **Metal Salt:** add metal salt chemical feed facilities
Napa

Challenging due to ponds and seasonal flow variations
Challenges at Napa

- Split treatment and seasonal storage
- High ammonia in DAF clarifier effluent seasonally
- Not able to reliably meet Level 2 for TN during the winter
- Limited or no discharge in dry season (May through September)
## BACWA Upgrades

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<tr>
<th>Process</th>
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<th>Optimize</th>
<th>NNLJ</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primaries with Ferric Addition</td>
<td>Yes</td>
<td>Increase winter dose</td>
<td>Increase dose</td>
<td>Increase winter dose</td>
<td>Increase winter dose</td>
</tr>
<tr>
<td>Act Sludge</td>
<td>BNR (Step-feed)</td>
<td>BNR (Step-feed)</td>
<td>BNR (Step-feed)</td>
<td>BNR (Step-feed)</td>
<td>BNR (4-stage)</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ponds / DAF Clarifier</td>
<td>High Strength Ammonia (Seasonal)</td>
<td>High Strength Ammonia (Seasonal)</td>
<td>High Strength Ammonia (Seasonal)</td>
<td>High Strength Ammonia (Seasonal)</td>
<td>High Strength Ammonia (Seasonal)</td>
</tr>
<tr>
<td>Act Sludge for DAF Clarifier Effluent</td>
<td>-</td>
<td>-</td>
<td>BNR (4-stage / flexible)</td>
<td>BNR (4-stage / flexible)</td>
<td>BNR (4-stage)</td>
</tr>
<tr>
<td>Secondary Clarifier</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Filter</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
<td>Expand; add ferric chloride</td>
</tr>
<tr>
<td>Carbon</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
(1) **Ferric chloride.** Use existing chemical facilities (wet season).

(2) **Methanol.** Add methanol (or other carbon source) (wet season).

(3) **Aeration Basins.** Add two (flexible configuration with anoxic zones) for nitrification and denitrification of DAF clarifier effluent (wet season only),

(4) **Secondary Clarifier.** Add one (wet season only),
Level 2

- Aeration Basins
- Secondary Clarifier
- Methanol
(1) **Ferric chloride.** Use existing chemical facilities (wet season).

(2) **Methanol.** Add methanol (or other carbon source) (wet season).

(3) **Aeration Basins.** Convert to 4-stage BNR and add two basins

(4) **Aeration Basins.** Add two (flexible configuration with anoxic zones) for nitrification and denitrification of DAF clarifier effluent (wet season only),

(5) **Secondary Clarifier.** Add one (wet season only),

(6) **Ferric Chloride.** Before filters.

(7) **Filters.** Add media to sixth filter cell.
(1) Aeration Basins (Upgrade)
(2) Aeration Basins (New)
(3) Aeration Basins (New)
(4) Secondary Clarifier
(5) Filters with Chemical Addition
(6) Methanol
Draft Findings of Nutrient Removal Reports
Preliminary Optimization Results
DRAFT 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
  - $180M Dry and $223M Wet
  - Ranged from $0.4M to $28M per plant
- Unit Costs
  - Flow-weighted Total PV unit cost = ~$0.4/gpd
  - Flow-weighted Total PV/lb N rem = ~$1.4/lb N
  - Flow-weighted Total PV/lb P rem = ~$12/lb P
- Not all plants can reduce ammonia/TN loads for both dry and wet seasons:
  - 21 of 37 plants for dry season reduction
  - 19 of 37 plants for wet season reduction

Load Reduction w/Respect to Current Discharge:

- Ammonia load reduction is 18%
- TN load reduction is 10%
- Overall TP load reduction is 44%
Summary of DRAFT Optimization Findings

For Ammonia and TN Load Reduction

For TP Load Reduction
DRAFT Optimization Total PV Costs

Dry Flow-Weighted Ave = $12 Mil per Plant

*Draft Results are Sorted by Permitted Capacity
DRAFT Optimization Total PV Costs

Dry/Wet Flow-Weighted Ave = $12 Mil per Plant

*Draft Results are Sorted by Permitted Capacity
DRAFT Optimization Total PV Unit Costs

Dry Flow-Weighted Average = $0.4/gpd

*Draft Results are Sorted by Permitted Capacity
DRAFT Optimization Total PV Unit Costs

Dry and Wet Flow-Weighted Average = $0.4/gpd

*Draft Results are Sorted by Permitted Capacity
DRAFT Optimization Findings

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- TN load reduction is 10%
- Overall TP load reduction is 44%
Preliminary Sidestream Results
Sidestream Approach

• Basis of Evaluation
  - Identify upgrade strategies to reduce nutrients
  - Planning Period: 30 Years
  - Loading: Design Capacity
  - Design Criteria:
    • 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
## DRAFT Plants Eligible for Sidestream Treatment by Subembayment

<table>
<thead>
<tr>
<th>Subembayment</th>
<th>No. Plants Eligible for Ammonia Discharge Reduction to the Bay</th>
<th>No. Plants Eligible for Total Nitrogen Discharge Reduction to the Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suisun Bay</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>San Pablo Bay</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Central Bay</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>South Bay</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Lower South Bay</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>
DRAFT Total PV Costs for Sidestream

*Draft Results are Sorted by Permitted Capacity
Criteria used for screening:
- Year-round sidestream
- Year-round discharge
- Sufficient dewatering frequency (>4 days/week)

Number of candidate plants
- 16 out of 37 plants if ammonia reduction is the discharge objective
- 25 out of 37 plants if TN reduction is the discharge objective

Costs
- The Total PV costs is $660 Mil
- Flow-weighted average = $1.7/lb N removed

The overall Ammonia/TN load reduction from Current Discharge is 21 and 17 percent, respectively
Preliminary Upgrades Results
DRAFT 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 which includes filtration in Level 2

Number of Plants Already/Planning to Meet Targets:

- Level 2: 6
- Level 3: 1

* Excludes San Jose
** Excludes Sunnyvale

Costs

- Total PV Costs
  - Level 2 = $6,430M Dry and $8,050M Wet
  - Level 3 = $8,350M Dry and $10,370M Wet

- Total PV Cost Range per Plant
  - Level 2 = $3.8M to $2,240M per plant
  - Level 3 = $21M to $2,470M per plant

- Unit Costs
  - Level 2: $6/lb N Dry* and $8/lb N Wet
    $34/lb P Dry and $29/lb P Wet
  - Level 3: $12/lb N Dry** and $6/lb N Wet**
    >$60/lb P for Dry or Wet

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level 2 Load Reduction</th>
<th>Level 3 Load Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>&gt;88%</td>
<td>&gt;88%</td>
</tr>
<tr>
<td>Total N</td>
<td>&gt;61%</td>
<td>&gt;84%</td>
</tr>
<tr>
<td>Total P</td>
<td>&gt;63%</td>
<td>&gt;89%</td>
</tr>
</tbody>
</table>
Summary of DRAFT Upgrades Findings

Biological Process Selection for Ammonia/TN Load Reduction

Number of Plants out of 37

<table>
<thead>
<tr>
<th>Process</th>
<th>Existing</th>
<th>L-2 plant</th>
<th>L-3 plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>BODr</td>
<td>11</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>Nit Only</td>
<td>10</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>NDN</td>
<td>6</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>MBR</td>
<td>1</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Denite Filter</td>
<td>0</td>
<td>6</td>
<td>13</td>
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</table>
Summary of DRAFT Upgrades Findings

Filter Selection

<table>
<thead>
<tr>
<th>Filter</th>
<th>Existing</th>
<th>Existing + L-2</th>
<th>Existing + L-3</th>
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</thead>
<tbody>
<tr>
<td>MBR</td>
<td>1</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Filter</td>
<td>12</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Denit Filter</td>
<td>0</td>
<td>6</td>
<td>13</td>
</tr>
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</table>

Number of Plants out of 37
Summary of DRAFT Upgrades Findings

Chemical Usage

Number of Plants out of 37

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Existing</th>
<th>Existing + L-2</th>
<th>Existing + L-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEPT</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Fe/Al/Poly</td>
<td>16</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Carbon</td>
<td>0</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

EXISTING

EXISTING + L-2

EXISTING + L-3
DRAFT Total PV Costs for Upgrades

*Draft Results are Sorted by Permitted Capacity
DRAFT Total PV Costs for Upgrades

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dry Flow-Weighted Ave. ($ Mil/Plant)</th>
<th>Wet Flow-Weighted Ave. ($ Mil/Plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>480</td>
<td>610</td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Draft Results are Sorted by Permitted Capacity*
DRAFT Total PV Costs for Upgrades

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<tbody>
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<td>480</td>
<td>610</td>
</tr>
<tr>
<td>Level 3</td>
<td>620</td>
<td></td>
</tr>
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DRAFT Total PV Costs for Upgrades

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<tr>
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<tbody>
<tr>
<td>Level 2</td>
<td>480</td>
<td>610</td>
</tr>
<tr>
<td>Level 3</td>
<td>620</td>
<td>770</td>
</tr>
</tbody>
</table>

*Draft Results are Sorted by Permitted Capacity*
DRAFT Total PV Unit Costs for Upgrades

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dry Flow-Weighted Ave. ($/gpd)</th>
<th>Wet Flow-Weighted Ave. ($/gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Draft Results are Sorted by Permitted Capacity
Level 2 Wet

Level 3 Wet

Parameter | Dry Flow-Weighted Ave. ($/gpd) | Wet Flow-Weighted Ave. ($/gpd)
---|---|---
Level 2 | 8.0 | 9.0
Level 3 |  |  

*Draft Results are Sorted by Permitted Capacity
DRAFT Total PV Unit Costs for Upgrades

*Draft Results are Sorted by Permitted Capacity*
**DRAFT Total PV Unit Costs for Upgrades**

**Parameter** | **Dry ($/gpd)** | **Wet ($/gpd)**
--- | --- | ---
**Level 2** | 8.0 | 9.0
**Level 3** | 10.5 | 11.7

*Draft Results are Sorted by Permitted Capacity*
DRAFT Upgrade Findings

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</tr>
<tr>
<td>Total P</td>
<td>&gt;63%</td>
<td>&gt;89%</td>
</tr>
</tbody>
</table>
Preliminary No Net Load Increase (NNLI) Results
DRAFT NNLI Findings

Which nutrients are easiest to remove?
- Ammonia is the most difficult and expensive
  - Bigger basins due to increasing SRT for plants with act sludge
  - Expanded aeration system
  - Additional pumping
- TN load reduction requires ammonia removal
  - An external carbon source occasionally required
- TP load is the simplest and most straight forward to remove
  - Typically CEPT or Biological P removal
  - Tertiary filtration typically not required

PV Costs for 29 Plants
- Total PV = $1.4B Dry and $1.6B Wet
- Total PV ranged from $5.1M to $408M per plant

Unit Costs for 29 Plants:
- Flow-weighted Total PV unit cost = $4/gpd for both Dry and Wet
- TN: $42 lb N Dry and $17/lb N Wet
- TP: $88 lb P Dry and $72/lb P Wet

Load Reduction for 29 Plants:
- TN load reduction = 10,700 lb N/d
  (15% w/respect to 29 Plants Current Discharge)
- TP load reduction = 930 lb P/d
  (16% w/respect to 29 Plants Current Discharge)
DRAFT NNLI Total PV Costs

Dry Flow-Weighted Averages = $61 Mil per Plant

*Draft Results are Sorted by Permitted Capacity
DRAFT NNLI Total PV Costs

Dry and Wet Flow-Weighted Averages = $61 and 68 Mil per Plant, Respectively

*Draft Results are Sorted by Permitted Capacity
DRAFT NNLI Total PV Unit Costs

Dry Flow-Weighted Average = $4/gpd

*Draft Results are Sorted by Permitted Capacity
DRAFT NNLI Total PV Unit Costs

Dry and Wet Flow-Weighted Averages = $4/gpd

*Draft Results are Sorted by Permitted Capacity
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Summary of Results
DRAFT: Total N Discharge Load Reduction and Costs under Various Scenarios (Dry Season)

- Optimization = 10-yr planning horizon
- NNLI = 25-yr planning horizon (Projected to all 37 Plants)
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity
DRAFT: Total N Discharge Load Reduction and Costs under Various Scenarios (Wet Season)

- Optimization = 10-yr planning horizon
- NNLI = 25-yr planning horizon (Projected to all 37 Plants)
- Sidestream and Upgrades (Level 2 and 3) = 30-yr planning horizon using Permitted Capacity
Observations
Role of Averaging Periods
Importance of Averaging Periods

The graph illustrates the importance of averaging periods in determining the influent ammonia load. It shows the difference between:

- **Maximum Day Limit**
- **Maximum Month Limit**
- **Average Annual Limit**
- **Dry Season Seasonal Limit**

The data points represent the influent ammonia load (lb N/d) from January 2008 to July 2011, highlighting the variability and the impact of averaging periods on regulatory compliance.
Role of Averaging Periods on SRT and Basin Volume

Averaging Periods Govern the SRT and Overall Basin Volume

SRT for Various Ave Periods
Ave Annual SRT = 8.0 d
Max Month SRT = 10 d
Max Day SRT = 15 d
## Role of Averaging Periods on Cost: Oro Loma for Level 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Dry Season</th>
<th>Wet Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ave Annual</td>
<td>Max Month</td>
</tr>
<tr>
<td>Capital PV</td>
<td>$ Mil</td>
<td>60</td>
<td>68</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>$ Mil /yr</td>
<td>5.7</td>
<td>6.0</td>
</tr>
<tr>
<td>O&amp;M PV</td>
<td>$ Mil</td>
<td>130</td>
<td>134</td>
</tr>
<tr>
<td>Total PV</td>
<td>$ Mil</td>
<td>190</td>
<td>202</td>
</tr>
<tr>
<td>NH4 Load Reduction *</td>
<td>%</td>
<td>97</td>
<td>99</td>
</tr>
</tbody>
</table>

* Based on 6-years historical data from Hampton Roads Sanitation District VIP Plant
Treating all the Flow
Case Study: City of Millbrae

- 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 compact footprint technology due to peaks

(1) Optimize ferric addition, (2) add polymer, (3) convert act sludge to MBR, (4) expand the aeration basins to create a third train, (5) add alkalinity, (6) add external carbon, (7) decommission the chlorination disinfection system (use for additional aeration basin volume), and (8) add an ultraviolet disinfection system.
Space Constraints
Case Study: CMSA

- MBR selected since it’s the only option that could meet Level 3 (split treatment with existing facilities would work for Level 2)
- Plant surrounded by highway or steep hills
- 8 Plants were pushed to compact footprint technology due to space constraints

(1) Use existing ferric chloride for CEPT, (3) Add MBR facilities, (4) add an external carbon source, (5) add alkalinity, and (6) add ferric chloride
Role of Emerging Technologies
Technology Status

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

Emerging Status
- Conv Nit and/or Denite (SBR, conventional, etc.)
- Denitrifying Filter
- Sidestream Deammonification (DEMON®, CANON, AnitaMox®, Cleargreen, etc.)
- Zeolite/Anammox
- Nitritation/Denitritation (SHARON®)
- Mainstream Granular Sludge (e.g., Nereda)
- Ammonia Recovery Process (AMR)
- CANDO
- Membrane Aerated Biofilm Reactor (MABR)

Innovative Status
- Sidestream Seeding Liquid Stream (BAR, AT-3, MAUREEN, etc.)
- Sidestream Deammonification – Granular Growth (Paques®)

Established Status

Knowledge/Development and Number

Research Status

Time
Regulatory: Nitrogen versus Phosphorus
## Differences in N and P Removal

### Nitrogen Removal

- Challenging to remove with major operational changes
  - Activated Sludge (typical): with longer SRT and intensive mixed liquor returns
  - Biological Filters (to trim): requires large filter footprint plus an external carbon source
- More expensive to remove
- Requires a large footprint
- Energy and chemical intensive (at low targets)
- Can be recovered in the sidestream

### Phosphorus Removal

- Straightforward removal
  - Biological P (Act Sludge)
  - Chemical Precipitation: Primaries, Filters, or Sidestream
- Less expensive to remove
- Less additional footprint (extra zone or filters)
- Chemical intensive
- Can be recovered in the sidestream
Greenhouse Gas Emissions
Technology Status

GHG Emissions Distribution for a Nominal 10 mgd Plant at Various Treatment Targets (Adapted from Falk et al., 2013)
Recycled Water and CIP Surveys
Recycled Water Survey

### Recycled Water Survey 2015

<table>
<thead>
<tr>
<th>Type of RW (See Note A)</th>
<th>Current Future</th>
<th>Future Future</th>
<th>Future Future</th>
<th>Future Future</th>
</tr>
</thead>
</table>

#### 2015 Monthly Recycled Water Distribution Data by Use Category (in acre-feet)

<table>
<thead>
<tr>
<th>Month</th>
<th>Total</th>
<th>Golf Course</th>
<th>Landscape</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Agricultural</th>
<th>Environ. Enhance</th>
<th>Internal Use</th>
<th>GW Recharge</th>
<th>Direct Potable</th>
<th>Other Non-Potable</th>
<th>Other Return</th>
<th>Return Flows</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>January</td>
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</table>
Current Recycled Water Findings

- ~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 over Time

Year 2015 (58,000 AFY)

Year 2030 (117,000 AFY)

Year 2040 (131,000 AFY)

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

[Pie charts showing distribution of recycled water usage for different years.]
Produce up to 2,200 AFY (~2mgd) of Title 22 Recycled Water at the City’s WWTP for use as cooling tower makeup water at the Valero Benicia Refinery and irrigation water for City customers.
### Planned CIP Projects that may impact nutrient loads

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

- 22 out of 37 plants have either on-going or planned CIP projects for nutrient load reduction
- Total Capital Cost of CIPs = $1.5 Bil
- Example: San Mateo
  - Nutrient Removal and Wet Weather Flow Management Update and Expansion Project
  - New headworks, primary clarifiers, membrane bioreactor with nutrient removal, and disinfection
  - Estimated capital cost = $349-369 Mil
Sea Level Rise
Sea Level Rise Approach and DRAFT Findings

- Models used:
  - FEMA 100-yr flood hazard
  - USACE 2047 sea level rise (30-yr)
  - USACE 2067 sea level rise (50-yr)
  - USACE 2117 sea level rise (100-yr)

Preliminary Number of Plants (out of 37) that are Potentially at Risk

<table>
<thead>
<tr>
<th>Plants at Risk for FEMA 100-yr Storm</th>
<th>Plants at Risk for USACE 2047 (30-yr)</th>
<th>Plants at Risk for USACE 2067 (50-yr)</th>
<th>Plants at Risk for USACE 2117 (100-yr)</th>
<th>No Tidal Flooding Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>17</td>
<td>20</td>
<td>27</td>
<td>10</td>
</tr>
</tbody>
</table>
Southern Portion
Next Steps

- Draft Report Comments
- Group Annual Report
- Updated Reports
- Others
BACWA Workshop #2: Nutrient Reduction by Treatment Optimization and Upgrades Update

7 June 2017