Evaluation of Watershed Natural Treatment System for Source Water Protection

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DUDEK
HODGES RESERVOIR
NATURAL TREATMENT SYSTEM PROJECT

- Issues
  - Nutrient Loading
    - Algal Blooms
    - Taste & Odor
    - Treatment Costs
  - City of San Diego
    - Land Ownership
    - Drinking Water Reservoir – multiple users/partners
- Treatment Options
  - In Reservoir
  - NTS Alternatives
    - Distributed
    - Centralized
Distributed NTS Examples

Photo courtesy: ocean friendly gardens San Diego

Photo courtesy: semcog.org
Centralized NTS Examples

Project Brays Bayou
Stormwater Basin

The Project Brays stormwater detention basins will hold billions of gallons of water, reducing flood potential for thousands along the bayou.

South Los Angeles Wetland Park

Image courtesy: inhabitat
Natural Treatment System Alternatives

NATURAL TREATMENT SYSTEM
CONCEPTUAL PLAN

DISTRIBUTED NTS
CENTRALIZED NTS

OPTION 1
Main-stem

OPTION 2
Tributaries
<table>
<thead>
<tr>
<th></th>
<th>Effectiveness</th>
<th>Area</th>
<th>Capital Costs</th>
<th>Maintenance Costs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basins</td>
<td>37%</td>
<td>2-3%</td>
<td>$0.93/cf</td>
<td>&lt;1-6%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>49%</td>
<td>3-5%</td>
<td>$1.14/cf</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Swales</td>
<td>52%</td>
<td>10-20%</td>
<td>$0.62/cf</td>
<td>&lt;5-7%</td>
</tr>
</tbody>
</table>

* Maintenance costs as a percentage of construction costs
Exhibit 1. Life Cycle Costs for Stormwater BMPs in the Kit Carson Sub-Catchment
Model Development
- Watershed
- Land Use
- Nutrients
- SWMM

Hydrologic and Water Quality Analysis
- 2.5-Year Storm Event (2010-2011 Wet Year)
- Base Flow and Smaller Storm Events (2012-2013 Dry Year)
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Storm Water Management Model (SWMM)

Topography + Hydrology

Land Use + Nutrients

SWMM
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Hodges Watershed (300 mi²)

[Map of Hodges Watershed with locations of Felicita, Kit Carson, Cloverdale, and Green Valley.]
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Nutrient component based on land use coefficients developed throughout Southern California
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Watershed Specific Data
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Nutrient Loading based on Watershed Specific Data

Santa Ysabel Discharge to Hodges Reservoir and Nutrient Loading February 2011 - June 2011

Large Mixed-Use Watershed
Nutrient loading (lbs)
2/1/2011 to 6/1/2011
Total Nitrogen = 50,976
Total Phosphorus = 14,623

Discharge (cfs)

Nutrient Concentration (mg/l)

Santa Ysabel Stream Flow  City Discharge Measurements  Total Nitrogen  Total Phosphorus
Nutrient Loading based on Watershed Specific Data

Green Valley Discharge to Hodges Reservoir and Nutrient Loading February 2011 - June 2011

Small Urban Watershed
Nutrient loading (lbs)
2/1/2011 to 6/1/2011
Total Nitrogen = 1,429
Total Phosphorus = 612
Calibration for 2.5-year Storm Event

Upper Santa Ysabel Response to Storm Event on 02/26/2011 and Calibration

Runoff (cfs)

- Measured Discharge (USGS)
- Modeled Discharge (SWMM)

USGS Stream Gauge Data Missing
Calibration for Base Flow and Smaller Storm Events

Kit Carson Response to Storm Event on 02/08/2013 and Calibration

- Base Flow
- Smaller Storm Event

Runoff (cfs)

- Measured Discharge (Weston, Inc.)
- Modeled Discharge (SWMM)
Centralized NTS: Option 1

- **Detention Basins**
  - 50 Acres
  - 70 Acres

- **Constructed Wetland**
  - 500 Acres
Centralized NTS: Option 2

- Constructed Wetland 0.5 Acres
- Constructed Wetland 2 Acres
- Constructed Wetland 6 Acres
Centralized NTS: Option 1 Performance

Upper Santa Ysabel Detention Basin Inflow versus Outflow

Runoff (cfs)


Inflow  Outflow
Centralized NTS: Option 2 Performance

Kit Carson Constructed Wetland Inflow versus Outflow
**HODGES RESERVOIR**

**NATURAL TREATMENT SYSTEM PROJECT**

**Option 1 – Nutrient Removal**
*(Single 2.5-year Storm Event)*

<table>
<thead>
<tr>
<th>NTS</th>
<th>NTS Type</th>
<th>Nitrogen (lbs)</th>
<th>Phosphorus (lbs)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>$N_{\text{in}}$</td>
<td>$N_{\text{out}}$</td>
</tr>
<tr>
<td>Upper Santa Ysabel</td>
<td>Detention Basin</td>
<td>1,056</td>
<td>727</td>
</tr>
<tr>
<td>Santa Maria</td>
<td>Detention Basin</td>
<td>6,578</td>
<td>4,525</td>
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<tr>
<td>Santa Ysabel</td>
<td>Constructed Wetland</td>
<td>5,293</td>
<td>3,597</td>
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<tr>
<td><strong>Total Nutrient Removal</strong></td>
<td></td>
<td></td>
<td>4,078</td>
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**Option 2 – Nutrient Removal**
*(Annual Base Flow)*

<table>
<thead>
<tr>
<th>NTS</th>
<th>NTS Type</th>
<th>Nitrogen (lbs)</th>
<th>Phosphorus (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$N_{\text{in}}$</td>
<td>$N_{\text{out}}$</td>
</tr>
<tr>
<td>Kit Carson</td>
<td>Constructed Wetland</td>
<td>9,853</td>
<td>6,619</td>
</tr>
<tr>
<td>Green Valley</td>
<td>Constructed Wetland</td>
<td>2,643</td>
<td>1,770</td>
</tr>
<tr>
<td>Felicita</td>
<td>Constructed Wetland</td>
<td>3,967</td>
<td>2,654</td>
</tr>
<tr>
<td><strong>Total Nutrient Removal</strong></td>
<td></td>
<td></td>
<td>5,420</td>
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## HODGES RESERVOIR
### NATURAL TREATMENT SYSTEM PROJECT

<table>
<thead>
<tr>
<th>Evaluation Factors</th>
<th>Option 1 – NTS A</th>
<th>Option 2 – NTS B</th>
<th>Distributed NTS</th>
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<tbody>
<tr>
<td>Modeled Nutrient Load Reduction</td>
<td>High load reduction, but dependent on wet years.</td>
<td>High load reduction, but dependent on baseflow.</td>
<td>N/A</td>
</tr>
<tr>
<td>Land Availability</td>
<td>City of SD, PUD-owned</td>
<td>City of SD, PUD-owned</td>
<td>Dependent on private land &amp; ROWs</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Complex hydraulic engineering</td>
<td>Relatively simple – few sites, focused on low flows</td>
<td>High number of sites, difficult to coordinate and implement</td>
</tr>
<tr>
<td>Wetlands Regulations/ Habitat &amp; Species Benefits</td>
<td>Largest impact, moderate benefit</td>
<td>Moderate impact, largest benefit</td>
<td>Minimal impact and minimal benefit</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Largest impact</td>
<td>No impact</td>
<td>No impact</td>
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In-Reservoir Treatment Options

Vigorous Epilimnetic Mixing System

Hypolimnetic Oxygenation System

Prepared by Brown and Caldwell
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In-Reservoir Treatment Options

Prepared by Brown and Caldwell
QUESTIONS?