

# UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of St. George Regional Wastewater Treatment Plant

PREPARED FOR: Utah Division of Water Quality  
 PREPARED BY: CH2M HILL  
 COPIES: St. George Regional Wastewater Treatment Plant  
 DATE: September 2010

In partial fulfillment of the Utah Division of Water Quality *Publicly Owned Treatment Works (POTW) Nutrient Removal Cost Impacts Study*, this Technical Memorandum (TM) summarizes the process, financial and environmental evaluations of St. George Regional Wastewater Treatment Plant (SGRWTP) to meet the four tiers of nutrient standards presented in Table 1.

The thirty mechanical POTWs in the State of Utah were categorized into five groups to simplify process alternatives development, evaluation, and cost estimation for a large number of facilities. Similar approaches to upgrading these facilities for nutrient removal were thus incorporated into the models developed for POTWs with related treatment processes. The five categories considered were as follows:

- Oxidation Ditch (OD)
- Activated Sludge (AS)
- Membrane Bioreactor (MBR)
- Trickling Filter (TF)
- Hybrid Process (Trickling Filter/Solids Contact (TF/SC) or Trickling Filter/Activated Sludge (TF/AS))

The SGRWTP fits in the Oxidation Ditch Category.

TABLE 1  
Nutrient Discharge Standards for Treated Effluent

Tier	Total Phosphorus, mg/L	Total Nitrogen, mg/L
1N	0.1	10
1	0.1	No limit
2N	1.0	20
2	1.0	No limit
3	Base condition <sup>(1)</sup>	Base condition <sup>(1)</sup>

Note: <sup>(1)</sup> Includes ammonia limits as per the current UPDES Permit

## 1. Facility Overview

This facility is permitted for an average annual flow of 17 million gallons per day (mgd) and currently receives an annual influent flow of approximately 8.9 mgd and an industrial influent flow of approximately 0.18 mgd. The facility operates an oxidation ditch process with anaerobic selectors. The selectors are used primarily to prevent the growth of filamentous organisms. Secondary effluent is partly discharged to the Virgin River after UV disinfection and partly reused after filtration using traveling bridge filters and disinfection. Residual secondary solids are gravity thickened and dewatered using centrifuges before being composted. The secondary treatment process is operated to meet the plant's BOS, TSS and ammonia limits. A process flow diagram of the existing facility is presented in Figure 1 and an aerial photo of the POTW is shown in Figure 2. The major unit processes are summarized in Table 2.

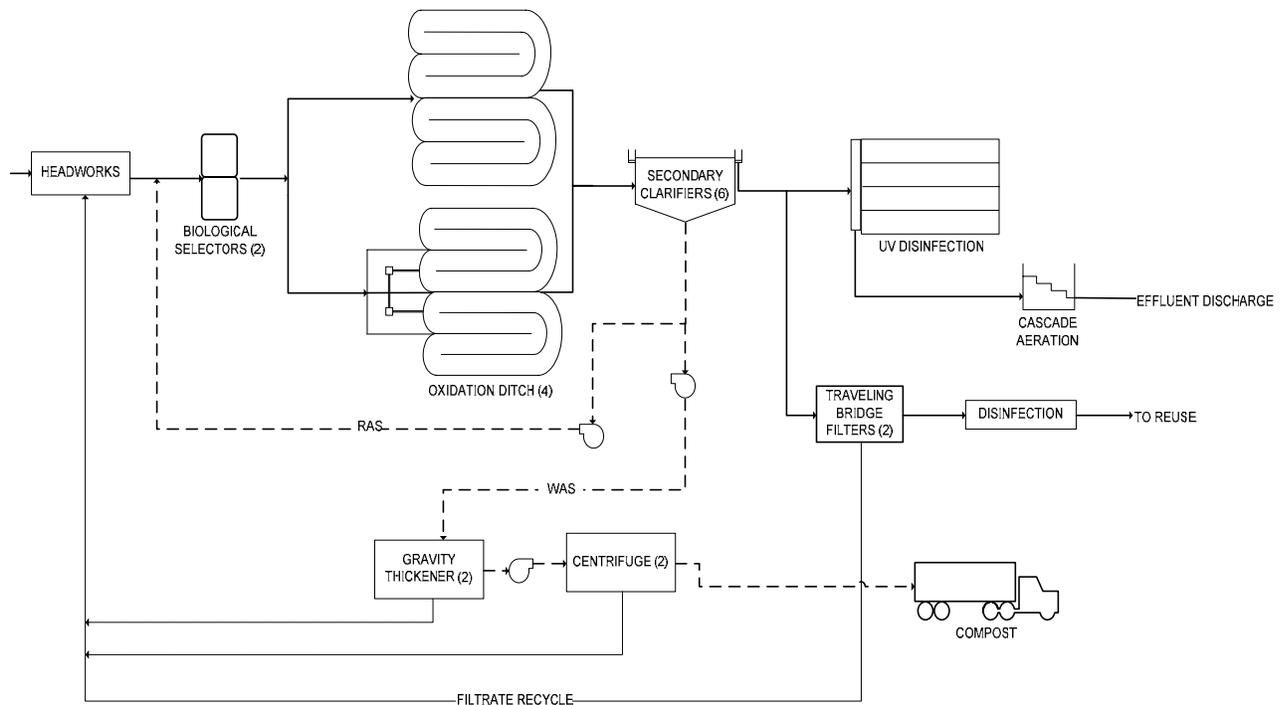
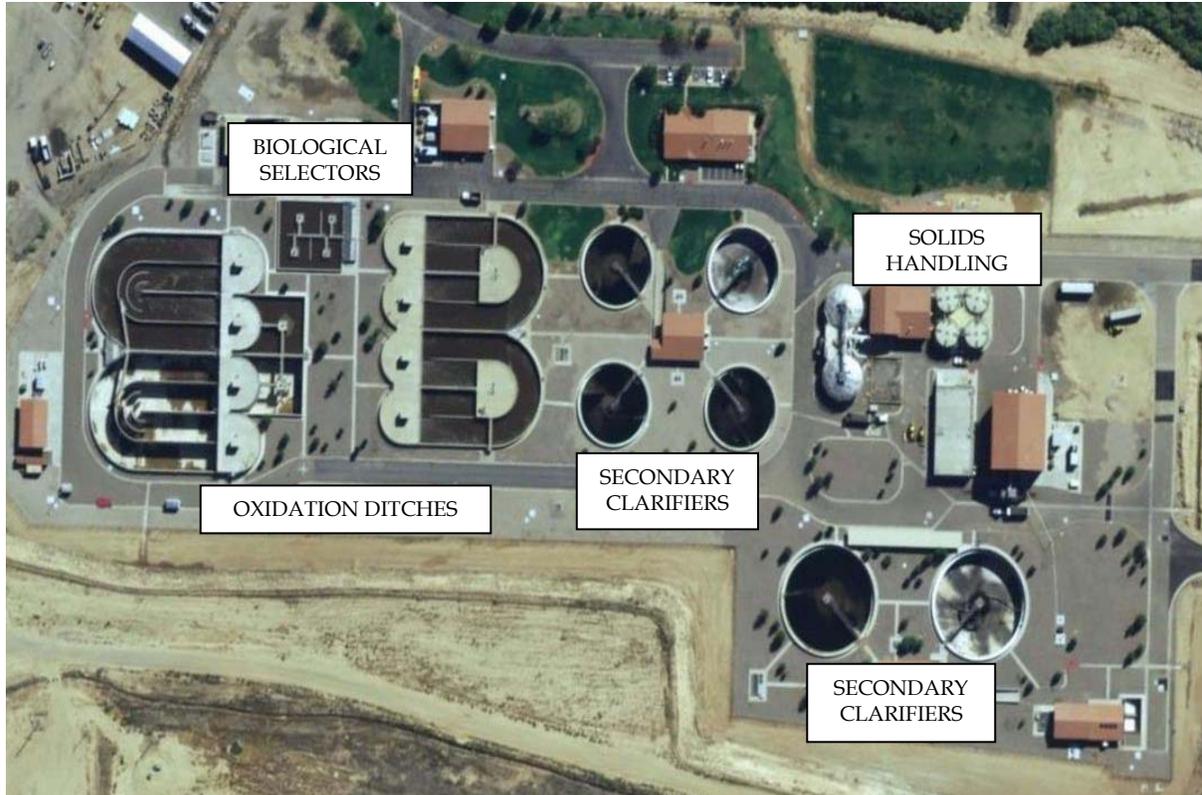


FIGURE 1  
Process Flow Diagram



**FIGURE 2**  
Aerial View of the Facility

**TABLE 2**  
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Biological selector	2	0.6 MG	Operated as anaerobic selectors
Oxidation ditch	4	2.5 MG, 18-ft SWD(2) 3.6 MG, 18-ft SWD (2)	Carrousel configuration
Secondary clarifiers	6	90-ft diameter, 15-ft SWD (4) 120-ft diameter, 15-ft SWD (2)	Round clarifiers
Filtration	2	1175-ft <sup>2</sup>	Traveling bridge filters. They are operated for the reuse water
WAS thickening	2	42-ft diameter, 150ft SWD	Gravity thickening
Sludge dewatering	2	----	Centrifuges

## 2. Nutrient Removal Alternatives Development, Screening and Selection

A nutrient removal alternatives matrix was prepared in order to capture an array of viable approaches for OD facilities (See Attachment A). This matrix considers biological and chemical phosphorus removal approaches as well as different activated sludge configurations for nitrogen control. The alternatives matrix illustrates that there are several strategies for controlling nutrient limits. The processes that were modeled and described in the subsequent sections are considered proven methods for meeting the nutrient limits. There may be other ways to further optimize to reduce capital and operation and maintenance (O&M) costs that are beyond the scope of this project. This TM can form the basis for an optimization study in the future should that be desired by the POTW.

SGRWTP has four (4) oxidation ditches with anaerobic bioselectors for biological nutrient removal and six (6) secondary clarifiers. A goal of this project was to make maximum use of existing infrastructure in the upgrade approaches selected for meeting the various tiers of nutrient limits. Upgrades were added to the system models added as required to meet increasingly stringent discharge limits. Figure 3 shows the basic upgrade approach used between each tier of nutrient control with the bullet points A through D below describing each upgrade step:

- A. From Tier 3 (existing) to Tier 2 phosphorus control, a metal-salt addition system was implemented at secondary clarifiers.
- B. To add nitrogen control to Tier 2, no additional process modification was required.
- C. To go from Tier 2 to Tier 1 phosphorus control, new deep bed granular media filters were installed with an intermediate pump station and an additional metal-salt feed point upstream for chemical phosphorus polishing.
- D. To add nitrogen control to Tier 1, no additional process modifications were required.

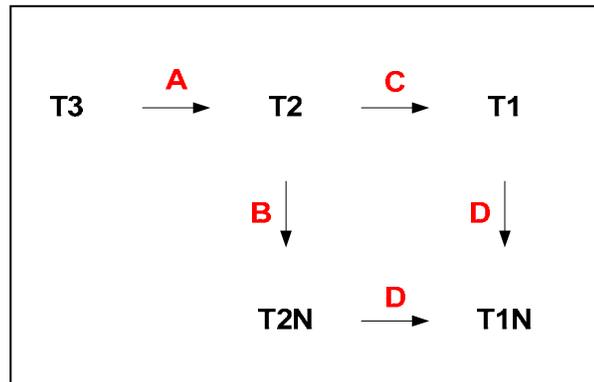


FIGURE 3  
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

## Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for SGRWTP was analyzed using the following four steps:

- Step 1. Review, compile, and summarize the process performance data submitted by the POTW;
- Step 2. Develop and calibrate a base model of the existing POTW using the summarized performance data;
- Step 3. Build upon the base model by sequentially modifying it to incorporate unit process additions or upgrades for the different tiers of nutrient control and use model outputs to establish unit process sizing and operating requirements;
- Step 4. Develop capital and O&M costs for each upgrade developed in Step 3.

The facility information and data received from SGRWTP per the initial data request and per phone conversation with Ben Ford was evaluated to (a) develop and validate the base process model, and (b) size facilities to conserve the POTW's current rated capacity. Table 3 provides a summary of the reported information used as the model input conditions. See Process Modeling Protocol (Attachment B) for additional information.

TABLE 3  
Summary of Input Conditions

Input Parameter	2009 <sup>(1)</sup>	2029 <sup>(2)</sup>	Design <sup>(3)</sup>
Flow, mgd	8.9	17.0	21.0
BOD, lb/day	14,849 (200 mg/L)	28,356 (200 mg/L)	35,058 (200 mg/L)
TSS, lb/day	16,401 (221 mg/L)	31,335 (221 mg/L)	52,542 (300 mg/L)
TKN, lb/day	2,348 (32 mg/L)	4,537 (32 mg/L)	5,604 (32 mg/L)
TP, lb/day	327 (4.5 mg/L)	638 (4.5 mg/L)	875 (5 mg/L)

<sup>(1)</sup> Historic conditions for the year 2007-2009

<sup>(2)</sup> Projected by the POTW

<sup>(3)</sup> Design maximum month capacity of POTW. Assumed 1.2 times (peaking factor) the design annual average flow of the POTW

The main sizing and operating design criteria that were associated with the system upgrade for SGRWTP are summarized in Table 4.

TABLE 4  
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Influent design temperature	14 deg C
Target metal:PO <sub>4</sub> -P molar Ratio (All tiers)	2:1, 7:1 <sup>(1)</sup>
Metal salt storage (T2 and T2N)	5 days
Metal salt storage (T1 and T1N)	14 days
Granular filter loading rate (T1 and T1N)	5 gpm/ft <sup>2</sup> <sup>(2)</sup>

<sup>(1)</sup>Target dosing ratio at the secondary clarifiers and upstream of the polishing filter, respectively.

<sup>(2)</sup>Hydraulic loading rate at peak hourly flow

### 3. Nutrient Upgrade Approaches

The following sections provide details of the upgrade approaches to meet the different Tiers of nutrient control as presented previously in Figure 3.

#### Tier 2 Phosphorus (A)

The effluent limit for Tier 2 alternative is 1.0 mg/L total phosphorus. SGRWTP can achieve this total phosphorus goal by introducing a metal-salt addition system to the existing unit process facilities. Process modeling effort simulated a single-feed strategy with metal-salt addition at the secondary clarifiers. The existing infrastructure can also be optimized to achieve this limit. In that case, the metal-salt addition system would be operated only as a backup to biological phosphorus uptake. A process flow diagram for this treatment approach is presented in Figure 4 with the upgrades indicated in red.

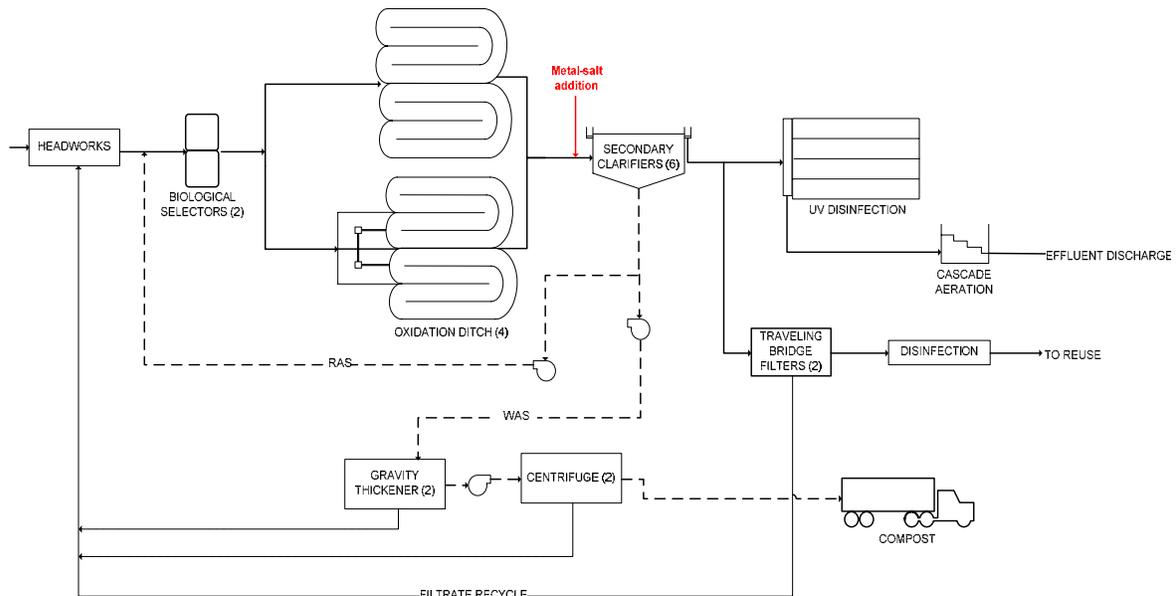


FIGURE 4  
Modifications to POTW for Tier 2 Nutrient Control

### Tier 2N – Phosphorus & Nitrogen (B)

The single metal-salt feed point approach taken for Tier 2 nutrient control alternative would not require any adjustment to achieve moderate levels of nitrogen control for this Tier along with phosphorus control. The existing oxidation ditch process at the POTW is already exhibiting sufficient biological nitrogen removal to meet this limit. Therefore, the process flow diagram for this approach would be to the same as presented in Figure 4.

### Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. The settled secondary effluent was pumped to new deep bed granular media filters with a second feed point for metal-salt addition upstream of the filters. This enabled secondary chemical phosphorus polishing to bring down the effluent phosphorus concentration to 0.1 mg/L. The existing traveling bridge filters could be used for treating the reuse water, however, the new filters would be sized to treat the entire flow of the plant. A process flow diagram of this approach is provided in Figure 5.

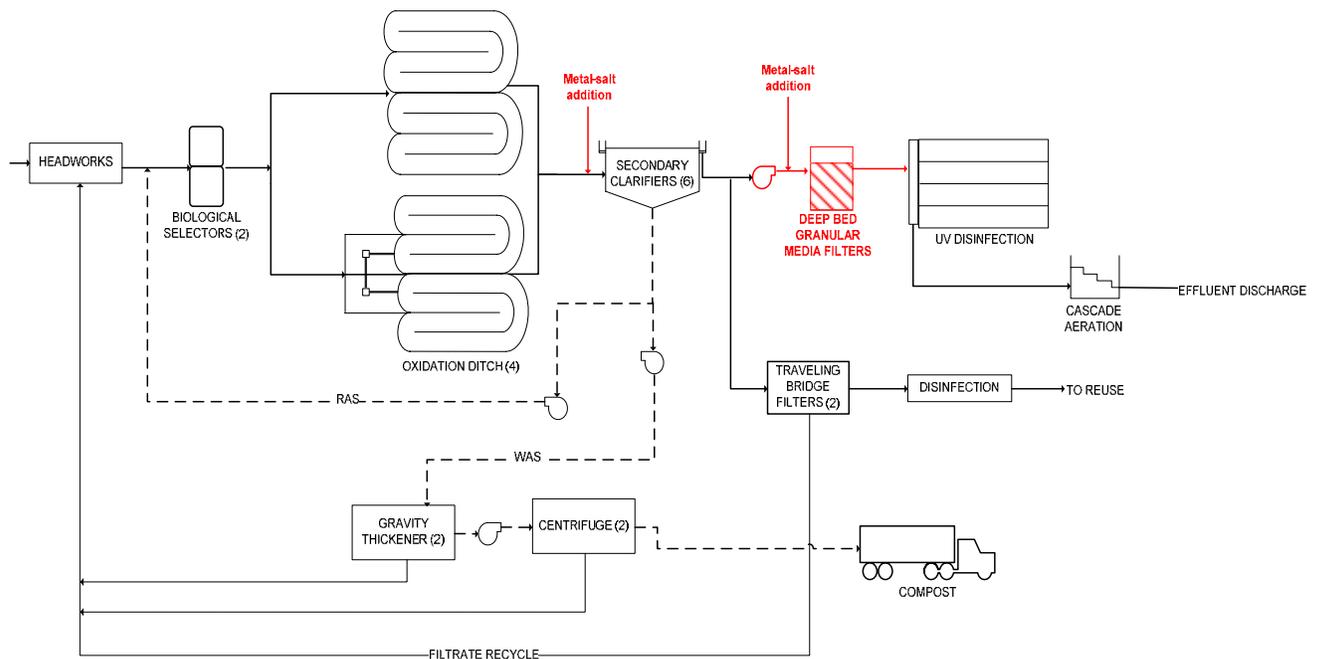


FIGURE 5  
Modifications to POTW for Tier 1 Nutrient Control

### Tier 1N Phosphorus & Nitrogen (D)

Process modeling efforts show that the addition of a new filtration system as proposed for Tier 1 would be sufficient for achieving the nutrient limits specified for this Tier. Therefore, this Tier would be identical to Tier 1 and the process flow diagram would be the same as presented in Figure 5.

#### 4. Capital and O&M Cost Estimates for Nutrient Control

This section summarizes the cost-impact results from this nutrient control analysis. These outputs were used in the financial cost model and subsequent financial analyses.

Table 5 presents a summary of the major components identified for the facility upgrade for meeting each tier of nutrient control. For Tier 2 and Tier 2N, a metal-salt storage facility and new metal-salt feed pumps were required to add metal-salt to the secondary clarifiers. For Tier 1 and 1N, a secondary effluent pump station was installed to lift the secondary flow to newly installed deep bed granular media filters with provisions for metal-salt addition using feed pumps upstream of the filters.

TABLE 5  
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed and storage facility	X	X	X	X
Secondary effluent pump station			X	X
Deep bed granular media filters			X	X

The capital cost estimates shown in Table 6 were generated for the facility upgrades summarized in Table 5. These estimates were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International and defined as a Class 4 estimate. The expected accuracy range for the estimates shown in Table 6 is -30%/+50%.

TABLE 6  
Capital Cost Estimates (\$ Million)

Unit Process Facility	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed pumps and storage facility	\$0.67	\$0.67	\$1.81	\$1.81
Secondary effluent pump station	\$0	\$0	\$9.21	\$9.21
Deep bed granular media filtration system	\$0	\$0	\$36.76	\$36.76
<b>TOTAL TIER COST</b>	<b>\$0.67</b>	<b>\$0.67</b>	<b>\$47.78</b>	<b>\$47.78</b>

December 2009 US Dollars

Incremental O&M costs associated with meeting each tier of nutrient standard were generated for the years 2009 and 2029. These costs were derived from the unit costs provided by the POTW. If unit costs were not provided, they were assumed based on the average costs in the State of Utah, and are presented in Table 7. A straight line interpolation was used to estimate the differential cost for the two years. O&M cost estimates for each upgrade included the following components:

- Biosolids management: hauling , use, and disposal
- Chemical consumption costs: metal-salt, and, polymer
- Power costs for the major mechanized process equipment: secondary effluent pumps, and backwash pumps

TABLE 7  
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	\$8/wet ton
Biosolids tipping fee	\$6/wet ton
Roundtrip biosolids hauling distance	40 miles
Alum	\$480/ton
Polymer	\$1.07/lb
Power	\$0.04/kwh

The estimated net impact of nutrient control on O&M relative to the current O&M cost (Tier 3) are presented in Table 8 and shown graphically in Figure 6.

TABLE 8  
Estimated Impact of Nutrient Control on O&M Costs

	Tier 2		Tier 2N		Tier 1		Tier 1N	
	2009	2029	2009	2029	2009	2029	2009	2029
Biosolids	\$0.01	\$0.03	\$0.01	\$0.03	\$0.05	\$0.07	\$0.05	\$0.07
Metal-salt	\$0.01	\$0.02	\$0.01	\$0.02	\$0.53	\$0.65	\$0.53	\$0.65
Polymer	\$0.00	\$0.00	\$0.00	\$0.00	\$0.01	\$0.01	\$0.01	\$0.01
Power	\$0.00	\$0.00	\$0.00	\$0.00	\$0.05	\$0.14	\$0.05	\$0.14
<b>Total O&amp;M</b>	<b>\$0.02</b>	<b>\$0.05</b>	<b>\$0.02</b>	<b>\$0.05</b>	<b>\$0.63</b>	<b>\$0.86</b>	<b>\$0.63</b>	<b>\$0.86</b>

**Note:** \$ Million (US) in December 2009.

Costs shown are the annual differential costs relative to the base line O&M cost of the POTW

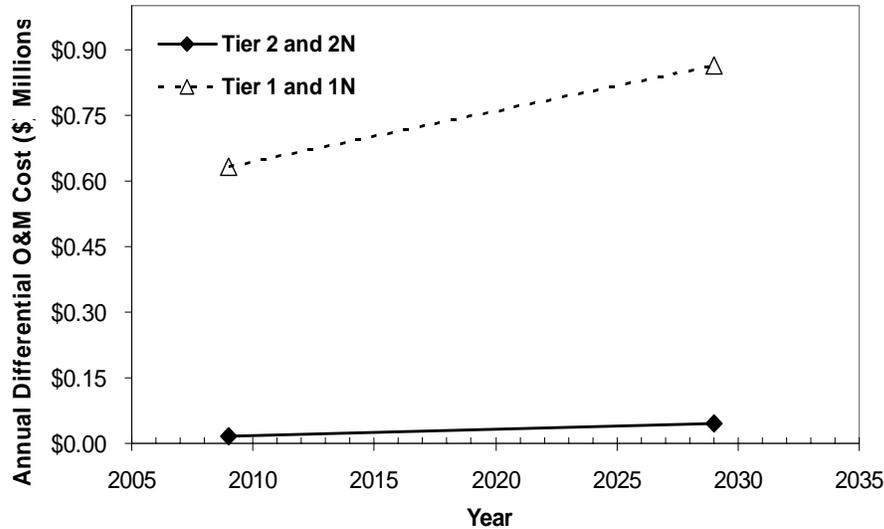


FIGURE 6  
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

## 5. Financial Impacts

This section presents the estimated financial impacts that will result from the implementation of nutrient discharge standards for SGRWTP. Financial impacts were summarized for each POTW on the basis of three primary economic parameters: 20-year life cycle costs, user charge impacts, and community financial impacts. The basis for the financial impact analysis is the estimated capital and incremental O&M costs established in the previous sections.

### Life Cycle Costs

Life cycle cost analysis refers to an assessment of the costs over the life of a project or asset, emphasizing the identification of cost requirements beyond the initial investment or capital expenditure.

For each treatment upgrade established to meet the studied nutrient limits (Tier 2, Tier 2N, Tier 1, and Tier 1N), a multi-year life cycle cost forecast was developed that is comprised of both capital and O&M costs. Cost forecasts are organized with initial capital expenditures in year 0 (2009), and incremental O&M forecasts from year 1 (2010) through year 20 (2029). The cost forecast for each treatment alternative was developed in current (2009) dollars, and discounted to yield the net present value (NPV).

The NPV was divided by the estimated 20-year nutrient discharge mass reduction for each tier, resulting in a cost per pound estimate for nutrient removal. This calculation represents an appropriate matching of costs with receiving stream load reduction over the same time period. Table 9 presents the results of the life cycle cost analysis for SGRWRF.

TABLE 9

<i>Nutrient Removal: 20-Year Life Cycle Cost per Pound<sup>1</sup></i>				
	<b>Tier 2</b>	<b>Tier 2N</b>	<b>Tier 1</b>	<b>Tier 1N</b>
Phosphorus Removal (pounds) <sup>2</sup>	65,577	65,577	1,016,842	1,016,842
Nitrogen Removal (pounds) <sup>2</sup>	-	meets limit	-	meets limit
<b>Net Present Value of Removal Costs<sup>3</sup></b>	<b>\$ 1,151,328</b>	<b>\$ 1,151,328</b>	<b>\$ 59,173,893</b>	<b>\$ 59,173,893</b>
NPV: Phosphorus Allocation	1,151,328	1,151,328	59,173,893	59,173,893
NPV: Nitrogen Allocation <sup>4</sup>		-		-
<b>TP Cost per Pound<sup>5</sup></b>	<b>\$ 17.56</b>	<b>\$ 17.56</b>	<b>\$ 58.19</b>	<b>\$ 58.19</b>
<b>TN Cost per Pound<sup>5</sup></b>		<b>NA</b>		<b>NA</b>
1 - For facilities that are already meeting one or more nutrient limits, "meets limit" is displayed for nutrient removal mass and "NA" is displayed for cost per pound metrics				
2 - Total nutrient removal over a 20-year period, from 2010 through 2029				
3 - Net present value of removal costs, including capital expenditures and incremental O&M over a 20-year period				
4 - For simplicity, it was assumed that the nitrogen cost allocation was the incremental difference between net present value costs across Tiers for the same phosphorus limit (i.e. Tier 2 to Tier 2N); differences in technology recommendations may result in different cost allocations for some facilities				
5 - Cost per pound metrics measured over a 20-year period are used to compare relative nutrient removal efficiencies among treatment alternatives and different facilities				

### Customer Financial Impacts

The second financial parameter measures the potential impact to user rates for customers served by the POTW. The financial impact is measured both in terms of potential rate increases for the POTW's associated service provider, and the resulting monthly bill impacts for the typical residential customer of the system.

Customer impacts were estimated by calculating annual increased revenue requirements for the POTW. Implementation of each treatment upgrade will increase the annual revenue requirements for debt service payments (related to initial capital cost) and incremental O&M costs.

The annual cost increase was then divided by the number of customers served by the POTW, as measured by equivalent residential units (ERUs), to establish a monthly rate increase per ERU. The monthly rate increase associated with each treatment alternative was estimated by adding the projected monthly rate increase to the customer's current average monthly bill. Estimated financial impacts for customers of the SGRWRF are presented in Table 10.

TABLE 10

<i>Projected Monthly Bill Impact per Equivalent Residential Unit (ERU) for Treatment Alternatives</i>				
	<b>Tier 2</b>	<b>Tier 2N</b>	<b>Tier 1</b>	<b>Tier 1N</b>
Initial Capital Expenditure	\$ 677,000	\$ 677,000	\$ 47,789,000	\$ 47,789,000
Estimated Annual Debt Service <sup>1</sup>	\$ 54,300	\$ 54,300	\$ 3,834,700	\$ 3,834,700
Incremental Operating Cost <sup>2</sup>	17,600	17,600	644,300	644,300
Total Annual Cost Increase	\$ 71,900	\$ 71,900	\$ 4,479,000	\$ 4,479,000
Number of ERUs	37,000	37,000	37,000	37,000
Annual Cost Increase per ERU	\$1.94	\$1.94	\$121.05	\$121.05
<b>Monthly Cost Increase per ERU<sup>3</sup></b>	<b>\$0.16</b>	<b>\$0.16</b>	<b>\$10.09</b>	<b>\$10.09</b>
Current Average Monthly Bill <sup>4</sup>	\$18.92	\$18.92	\$18.92	\$18.92
<b>Projected Average Monthly Bill<sup>5</sup></b>	<b>\$19.08</b>	<b>\$19.08</b>	<b>\$29.01</b>	<b>\$29.01</b>
<b>Percent Increase</b>	<b>0.9%</b>	<b>0.9%</b>	<b>53.3%</b>	<b>53.3%</b>
1 - Assumes a financing term of 20 years and an interest rate of 5.0 percent				
2 - Incremental annual increase in O&M for each upgrade, based on chosen treatment technology, estimated for first operational year				
3 - Projected monthly bill impact per ERU for each upgrade, based on estimated increase in annual operating costs				
4 - Estimated 2009 average monthly bill for a typical residential customer (ERU) within the service area of the facility				
5 - Projected average monthly bill for a typical residential customer (ERU) if treatment upgrade is implemented				

### Community Financial Impacts

The third and final parameter measures the financial impact of nutrient limits from a community perspective, and accounts for the varied purchasing power of customers throughout the state. The metric is the ratio of the projected monthly bill that would result from each treatment alternative to an affordable monthly bill, based on a parameter established by the State Water Quality Board to determine project affordability.

The Division employs an affordability criterion that is widely used to assess the affordability of projects. The affordability threshold is equal to 1.4 percent of the median annual gross household income (MAGI) for customers served by a POTW. The MAGI estimate for customers of each POTW is multiplied by the affordability threshold parameter, then divided by 12 (months) to determine the monthly 'affordable' wastewater bill for the typical customer. The projected monthly bill for each nutrient limit was then expressed as a percentage of the monthly affordable bill. The resulting affordability ratio for each nutrient limit for the SGRWTP is shown in Table 11.

TABLE 11

<i>Community Financial Impacts: Affordability of Treatment Alternatives</i>				
	<b>Tier 2</b>	<b>Tier 2N</b>	<b>Tier 1</b>	<b>Tier 1N</b>
Median Annual Gross Income (MAGI) <sup>1,2</sup>	\$ 33,900	\$ 33,900	\$ 33,900	\$ 33,900
Affordability Threshold (% of MAGI) <sup>3</sup>	1.4%	1.4%	1.4%	1.4%
<b>Monthly Affordability Criterion</b>	<b>\$39.55</b>	<b>\$39.55</b>	<b>\$39.55</b>	<b>\$39.55</b>
Projected Average Monthly Bill	\$19.08	\$19.08	\$29.01	\$29.01
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
<b>Estimated Bill as % of State Criterion</b>	<b>48%</b>	<b>48%</b>	<b>73%</b>	<b>73%</b>
1 - Based on the average MAGI of customers within the service area of the facility				
2 - MAGI statistics compiled from 2008 census data				
3 - Parameter established by the State Water Quality Board to determine project affordability for POTWs				

## 6. Environmental Impacts of Nutrient Control Analysis

This section summarizes the potential environmental benefits and impacts that would result from implementing the process upgrades established for the various tiers of nutrient control detailed in Section 3. The following aspects were considered for this evaluation:

- Reduction of nutrient loads from POTW to receiving water bodies
- Changes in chemical consumption
- Changes in biosolids production
- Changes in energy consumption
- Changes in emissions from biosolids hauling, disposal and energy consumption

As per the data received from SGRWTP and per process modeling of the base condition (Tier 3), SGRWTP is able to meet an effluent total nitrogen concentration of 10 mg/L and is very close on meeting Tier 2 level of phosphorus control with its existing infrastructure. Table 12 summarizes the annual reduction in nutrient loads in SGRWTP effluent discharge if the process upgrades were implemented. The values shown are for the current (2009) flow and load conditions. It should be noted that any increase in flow or load to the POTW will result in higher reductions.

TABLE 12

Estimated Environmental Benefits of Nutrient Control

	<b>Tier 2</b>	<b>Tier 2N</b>	<b>Tier 1</b>	<b>Tier 1N</b>
Total phosphorus removed, lb/year	1,350	1,350	25,740	25,740
Total nitrogen removed, lb/year	----	0	----	0

**Note:** Nutrient loads shown are the annual differential loads relative to the baseline (Tier 3) condition of the POTW for the year 2009.

The nutrient content of POTWs' discharges and their receiving waters were also summarized to examine the potential of various treatment alternatives for reducing nutrient loads to those water bodies. The POTW loads were paired with estimated loads in the upstream receiving waters to create estimated downstream combined loads. Those combined stream and POTW loads could then be examined for the potential effects of future POTW nutrient removal alternatives. The average total nitrogen and phosphorus concentrations discharged by each POTW were either provided by the POTW during the data collection process or obtained from process modeling efforts. Upstream receiving historical water quality data was obtained from STORET. Data from STORET was summarized in order to yield average total nitrogen and total phosphorus concentrations that could then be paired with the appropriate POTW records. It should be noted that the data obtained from STORET were not verified by sampling and possible anomalies and outliers could exist in historical data sets due to certain events or errors in measurement.

Table 13 shows the total phosphorus and total nitrogen concentration discharged by SGRWTP for baseline condition (Tier 3) and for each Tier of nutrient standard. The STORET ID from where historical water quality data were obtained is also presented in the Table.

TABLE 13  
Estimates of Average TN and TP Concentrations for Baseline and Cumulative Treatments to Receiving Waters (mg/L)

STORET LOCATION	STORET ID	FLOW (cfs)	Tier 3		Tier 2		Tier 2N		Tier 1		Tier 1N	
			TP	TN	TP	TN	TP	TN	TP	TN	TP	TN
SGRWTP	----	13.77	1.05	10.0	1.0	N/A	1.0	10.0	0.10	N/A	0.10	10
Virgin River	4950120	263.75	0.21	1.15	----	----	----	----	----	----	----	----
<b>Combined Concentration</b>			<b>0.25</b>	<b>1.59</b>	<b>0.25</b>	<b>N/A</b>	<b>0.25</b>	<b>1.59</b>	<b>0.21</b>	<b>N/A</b>	<b>0.21</b>	<b>1.59</b>

The process upgrades established to meet the four tiers of nutrient standards would require increased energy consumptions, chemical usage and biosolids production. Metal-salt would need to be added to meet the more stringent phosphorus limits. This would result in increased chemical sludge generation and consequently increased biosolids production. Table 10 summarizes these environmental impacts of implementing the process upgrades to achieve the various tiers of nutrient control. The values shown are on an annual basis, for the current (2009) flow and load conditions, and indicate the differential relative to the base line condition.

TABLE 10  
Estimated Environmental Impacts of Nutrient Control

	Tier 2	Tier 2N	Tier 1	Tier 1N
<b>Chemical Use:</b>				
Metal-salt use, lb/year	20,000	20,000	2,190,000	2,190,000
Polymers, lb/year	1100	1100	5110	5110
<b>Biosolids Management:</b>				
Biosolids produced, ton/year	3	3	515	515
Average daily hauling distance <sup>(1)</sup>	0	0	935	935
Particulate emissions from hauling trucks, lb/year <sup>(2)</sup>	0	0	52	52
Tailpipe emissions from hauling trucks, lb/year <sup>(3)</sup>	0	0	120	120
CO <sub>2</sub> emissions from hauling trucks lb/year <sup>(4)</sup>	0	0	11,890	11,890
<b>Energy Consumption:</b>				
Annual energy consumption, kwh	350	350	912,000	912,000
Air pollutant emissions, lb/year <sup>(5)</sup>				
CO <sub>2</sub>	307	307	823,075	823,075
NO <sub>x</sub>	0	0	1,278	1,278
SO <sub>x</sub>	0	0	1,095	1,095
CO	0	0	60	60
VOC	0	0	7	7
PM <sub>10</sub>	0	0	18	18
PM <sub>2.5</sub>	0	0	9	9

**Note:** Values shown are the annual differential values relative to the base line condition (Tier 3) of the POTW for the year 2009

<sup>(1)</sup> Based on a round trip hauling distance to the landfill of 40 miles and, assuming the facility uses 22 ton trucks for hauling biosolids.

<sup>(2)</sup> Includes PM<sub>10</sub> and PM<sub>2.5</sub> emissions in pounds per year. The emission factors to estimate particulate emissions were derived using the equations from *AP-42, Fifth Edition, Vol. I, Section 13.2.1.: Paved Roads (11/2006)*.

<sup>(3)</sup> Tailpipe emissions in pounds per year resulting from diesel combustion of hauling trucks were based on *Emission standards Reference guide for Heavy-Duty and Nonroad Engines, EPA420-F-97-014 September 1997*. It was assumed that the trucks would meet the emission standards for 1998+.

<sup>(4)</sup> CO<sub>2</sub> emission factor in pounds per year for hauling trucks were derived from *Rosso and Chau, 2009, WEF Residuals and Biosolids Conference Proceedings*.

<sup>(5)</sup> Emission factors for electricity are based on EPA Clean Energy Power Profiler (<http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html>) assuming PacifiCorp UT region commercial customer and *AP-42, Fifth Edition, Vol. I, Chapter 1, Section 1.1.: Bituminous and Sub bituminous coal Combustion (09/1998)*.