UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Salt Lake City Water Reclamation Facility

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COPIES: SLCWRF

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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 evaluation of the Salt Lake City Water Reclamation Facility (SLCWRF) 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 SLCWRF fits in the Hybrid Process (TF/AS) 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 (1)	Base condition (1)

Note: (1) Includes ammonia limits as per the current UPDES Permit

1. Facility Overview

This facility is designed for a maximum month capacity of 56 million gallons per day (mgd) and currently receives an average annual influent flow of 34 mgd. The facility operates a TF/AS process with primary treatment. Residual primary and secondary solids are co-settled in the primary clarifiers, thickened, stabilized using conventional mesophilic anaerobic digestion, and biosolids are either used for landfill cover or mine reclamation. Ferric chloride is added to the thickened sludge piping for biogas sulfide control and can also be added to the primary clarifiers. The TF/AS process is operated to achieve some nitrification. A process flow diagram is presented in Figure 1 and an aerial photo of the WRF is shown in Figure 2. The major unit processes are summarized in Table 2.

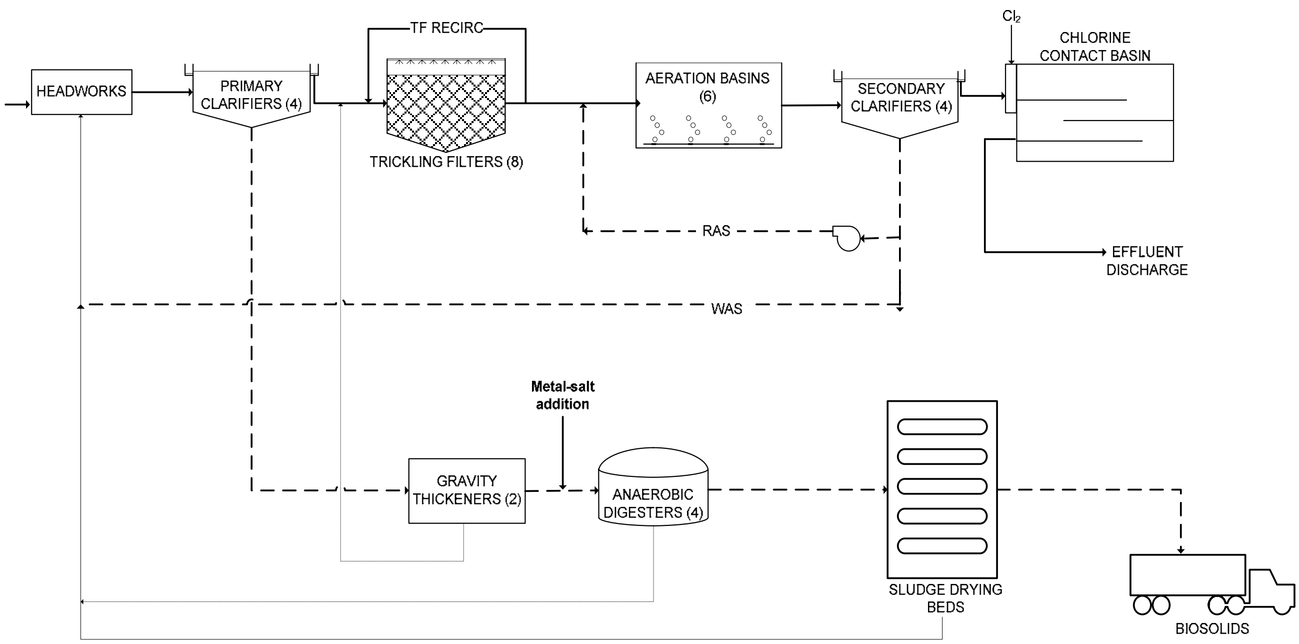

FIGURE 1
Process Flow Diagram

TABLE 2
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifiers	4	135-ft diameter, 8-ft SWD	
Trickling filters	4	173-ft diameter, 5.4-ft SWD	Rock Media
Trickling filters	4	173-ft diameter, 6.5-ft SWD	Plastic Media ($30ft^2/ft^3$)
Aeration basins	6	0.70 MG ea,20-ft SWD	100% diffused aeration
Secondary clarifiers	4	159-ft diameter, 12-ft SWD (2) 159-ft diameter, 14-ft SWD (2)	
PS/WAS thickening	2	60-ft diameter	Gravity Thickener
Anaerobic digestion	4	1.4 MG primary (3), 1.6 MG secondary (1)	Anaerobic Mesophilic Metal-salt added for sulfide control
Sludge drying	10	Total Area = 22 acres	85% DS

FIGURE 2
Aerial View of the Facility

On October 28th, 2009 SLCDPU, the Utah Division of Water Quality, and CH2M HILL met to review the proposed approach. In that meeting, it was decided by SLCWRF personnel that the best approach to address nutrient limits and best long-term plan for the WRF was to transition from TF/AS to activated sludge (AS). Hence, the group concluded that each of the modeling runs would include AS basins only. To accomplish this, CH2M HILL modeled the plant per design conditions described in Table 4 and in a configuration which meets Tier 3 (current) permit limits. This allows for the baseline definition of an AS facility which treats to a capacity and level equivalent to the existing plant. In order for the WRF to achieve the stated design capacity, the AS system would need to be expanded by adding four 0.7 MG aeration basins, an additional 159-ft diameter secondary clarifier, additional blower capacity and gravity belt thickeners. Figure 3 illustrates the WRF with the modifications and Table 3 includes the plant processes. The plant was modeled at a 2-day SRT. For the purposes of estimating the nutrient impact on the WRF, incremental differences in capital cost and O&M cost in addition to these modifications will be accounted for each of the 4 Tiers of nutrient removal.

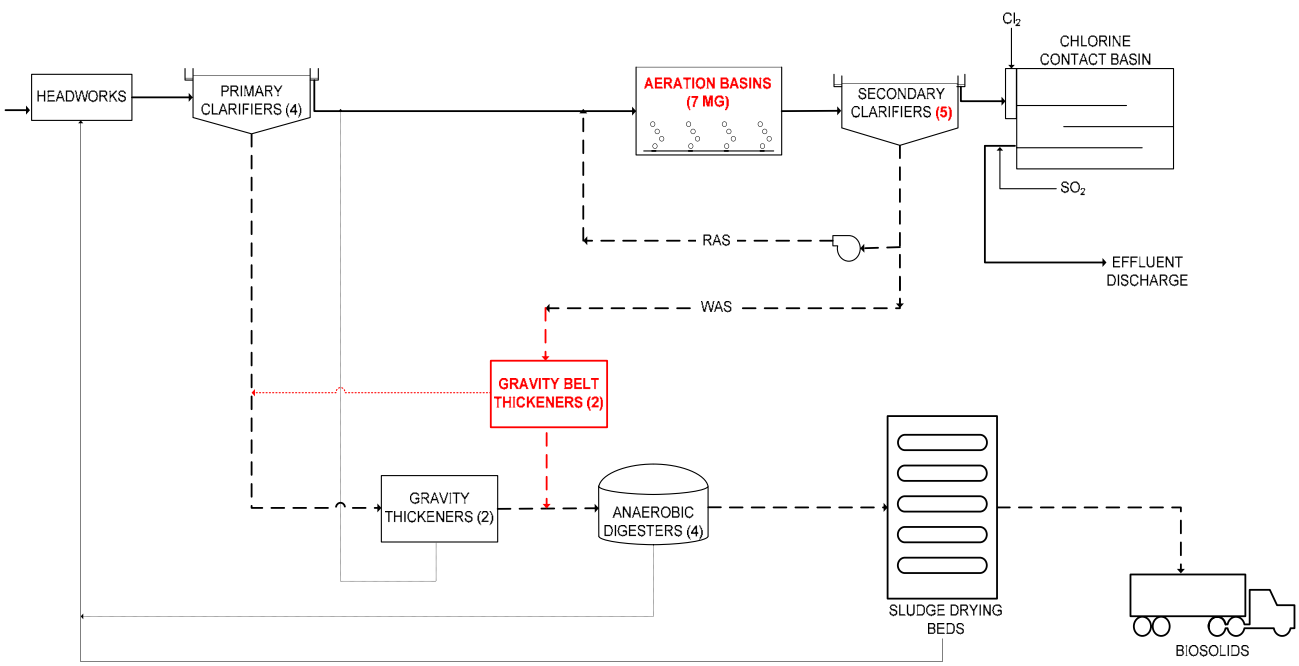

FIGURE 3
Process Flow Diagram

TABLE 3

Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifiers	5*	135-ft diameter, 8-ft SWD	
Aeration basins	10	0.70 MG ea,20-ft SWD	100% diffused aeration
Secondary clarifiers	5	159-ft diameter, 12-ft SWD (2) 159-ft diameter, 14-ft SWD (3)	
PS/WAS thickening	2	60-ft diameter	Gravity Thickener
Anaerobic digestion	4	1.4 MG primary (3), 1.6 MG secondary (1)	Anaerobic Mesophilic Metal-salt added for sulfide control
WAS Thickening	2	----	Gravity belt thickeners
Sludge drying	10	Total Area = 22 acres	85% DS

*SLCWRF plans on adding a 5th primary clarifier, so the system was modeled at design capacity with this primary clarifier in service.

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 activated sludge 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 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.

The SLCWRF is a relatively large POTW with an aged TF/AS process. SLCWRF recently converted the facility from TF/SC to TF/AS by decommissioning the solids contact basins and constructing new aeration basins and secondary clarifiers. The shallow rock media trickling filters are aged infrastructure and not as effective as the plastic media trickling filters. The plastic media trickling filters are shallow and have many operational issues. Based on this, it was decided to decommission the trickling filters and move the plant towards an activated sludge system. The discussion below proposes methods for modifying the existing process to achieve the different tiers of nutrient control. Figure 3 shows the selected upgrade approach used between each tier of nutrient control with the bullet points A through D below describing each upgrade step:

A. Tier 2: From Tier 3 (existing) to Tier 2 phosphorus control, an anaerobic zone was added to the activated sludge system to achieve enhanced biological phosphorus removal. New gravity belt thickeners (GBTs) were added to send thickened waste activated sludge (TWAS) directly to anaerobic digestion.

B. Tier 2N: To add nitrogen control to Tier 2, the activated sludge system was significantly increased and an anoxic zone and anaerobic zone was employed for biological nutrient removal. New GBTs were added to send TWAS directly to anaerobic digestion.

C. Tier 1: To go from Tier 2 to Tier 1 phosphorus control, granular media filters and an intermediate pump station were be added to the facility with metal-salt feed upstream of the secondary clarifiers and filters.

D. To achieve Tier 1N levels of control, the improvements in Tier 2N for BNR were employed with metal polishing and filtration used as in Tier 1.

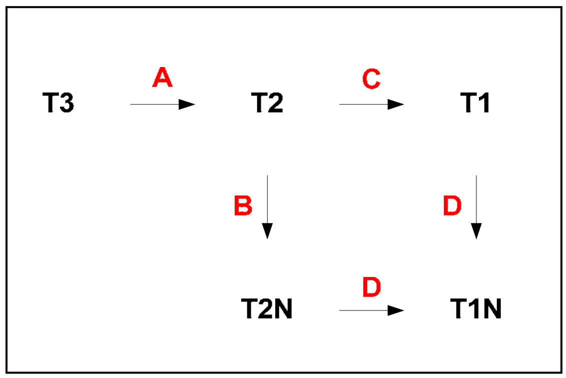

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for SLCWRF 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 by SLCWRF per the initial data request was evaluated to (a) develop, and validate the base process model, (b) size facilities to conserve the POTW's current rated capacity, and (c) project operating costs from 2009 through 2029. Table 3 provides a summary of the reported information used as the model input conditions. See process modeling protocol for additional information.

TABLE 4
Summary of Input Conditions

Input Parameter	2009	2029	Design
Flow, mgd	34[1]	38.1[2]	56[4]
BOD, lb/day	61,134 (218 mg/L) [1]	71,266 (224 mg/L) [2]	93,408 (224 mg/L) [4]
TSS, lb/day	62,996 (224 mg/L) [1]	72,890 (229 mg/L) [2]	93,408 (229 mg/L) [4]
TKN, lb/day	8,094 (28 mg/L) [4]	9,151 (28 mg/L) [4]	13,451 (28 mg/L) [5] [4]
TP, lb/day	1,687 (5 mg/L) [4]	1,908 (5 mg/L) [4]	2,804 (5mg/L) [5] [4]

(1) Historic conditions 2006-2007

(2) Per CH2M HILL 2008 Biosolids Master Plan

(3) Reported design maximum month capacity of POTW

(4) Per conversation with Dale Christensen, 10/1/09

(5) Assumed design maximum month capacity of POTW, per modeling and conversations with Facility Manager, Dale Christensen

The main sizing and operating design criteria that were important for capturing the costs associated with the system upgrade for SLCWRF are summarized in Table 5.

TABLE 5
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Target metal:PO_4-P molar Ratio to the secondary clarifier and filters (All Tiers)	2:1, 7:1
Metal-salt storage (T2 and T2N)	5 days
Metal-salt storage (T1 and T1N)	14 days
Fraction of aeration tank converted to anoxic volume (T2N and T1N)	26%
Mixed-Liquor return pumping ratio as a percent of influent Flow (T2N)	100% to 150%
Granular filter loading rate (T1 and T1N)	5 gpm/ft^2 [1]

(1) Hydraulic loading rate at peak hourly flow of 96 mgd

3. Nutrient Upgrade Approaches

The following paragraphs provide details of the upgrade approaches as presented previously in Figure 3.

Tier 2 Phosphorus (A)

The SLCWRF can achieve the 1.0 mg/L total phosphorus by modifying the aeration basin volume at 7.0 MG to include an anaerobic zone. WAS was thickened in gravity belt thickeners and primary solids was thickened and fermented in the existing gravity thickeners. The VFA rich supernatant of the gravity thickeners was combined with the primary clarifier effluent and fed to the anaerobic zone of the aeration basin to select for polyphosphate accumulating organisms. SLCWRF has the ability to feed ferric chloride to the primary clarifiers; however, it was difficult to control effluent total phosphorus from the primary clarifiers. Instead, a new metal-salt system was added upstream of the secondary clarifiers for back-up to EBPR process. A process flow diagram for this treatment approach is presented in Figure 5.

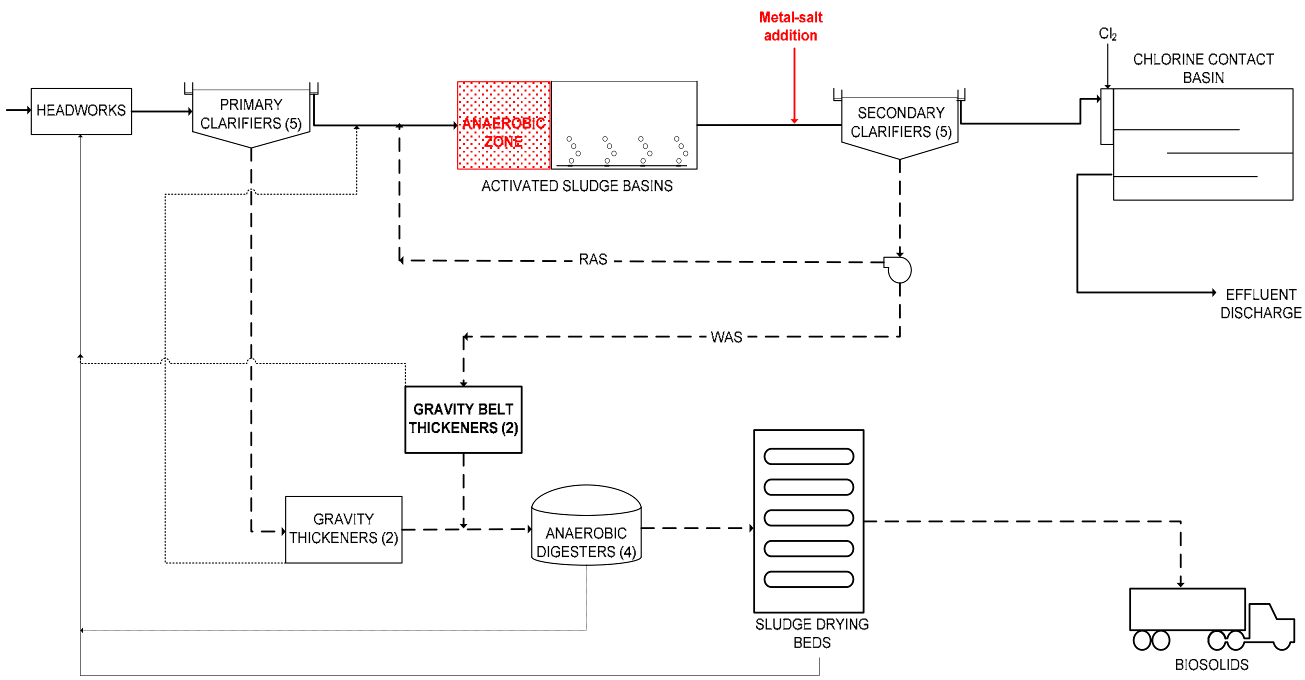

FIGURE 5
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

To accommodate the much higher SRTs, the aeration basin volume was increased to 25.2 MG and a 6th secondary clarifier was added. Anaerobic, anoxic, and aerobic zones were designed for biological nutrient removal. Internal mixed liquor recycles circulated nitrate and nitrite to the anoxic zone for denitrification. With a 2-day nitrification safety factor, the aeration basin was designed for a 15d SRT at design flow in order to nitrify at 14 °C. The primary solids was thickened and fermented in the gravity thickeners. The VFA rich supernatant of the gravity thickeners was combined with the primary clarifier effluent. The VFA rich gravity thickener supernatant and the primary clarifier effluent were fed to the anaerobic zone of the aeration basin to augment polyphosphate accumulating organism growth. As with Tier 1, a back-up metal-salt feed system was added upstream of the secondary clarifiers. A process flow diagram for this treatment approach is presented in Figure 6.

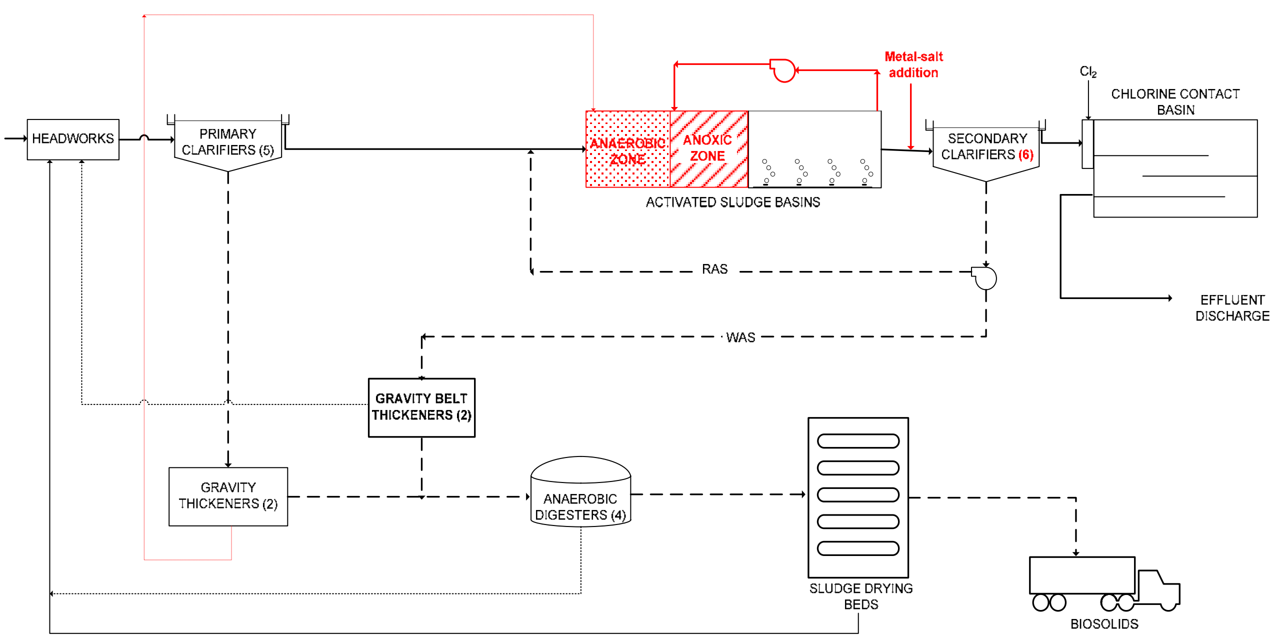

FIGURE 6
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. The approach removed phosphorus biologically down to below 1.0 mg/L, and then added metal-salt to the secondary clarifiers and the new deep bed granular media filters to achieve lower than 0.1 mg/L TP. Settled secondary effluent was pumped to the new granular media filters. Metal-salt was added to the only ahead of the granular media filters at a molar ratio of approximately 7:1. Metal salt could be added at the primary clarifiers and anaerobic digesters, also. A process schematic of this treatment approach is shown in Figure 7.

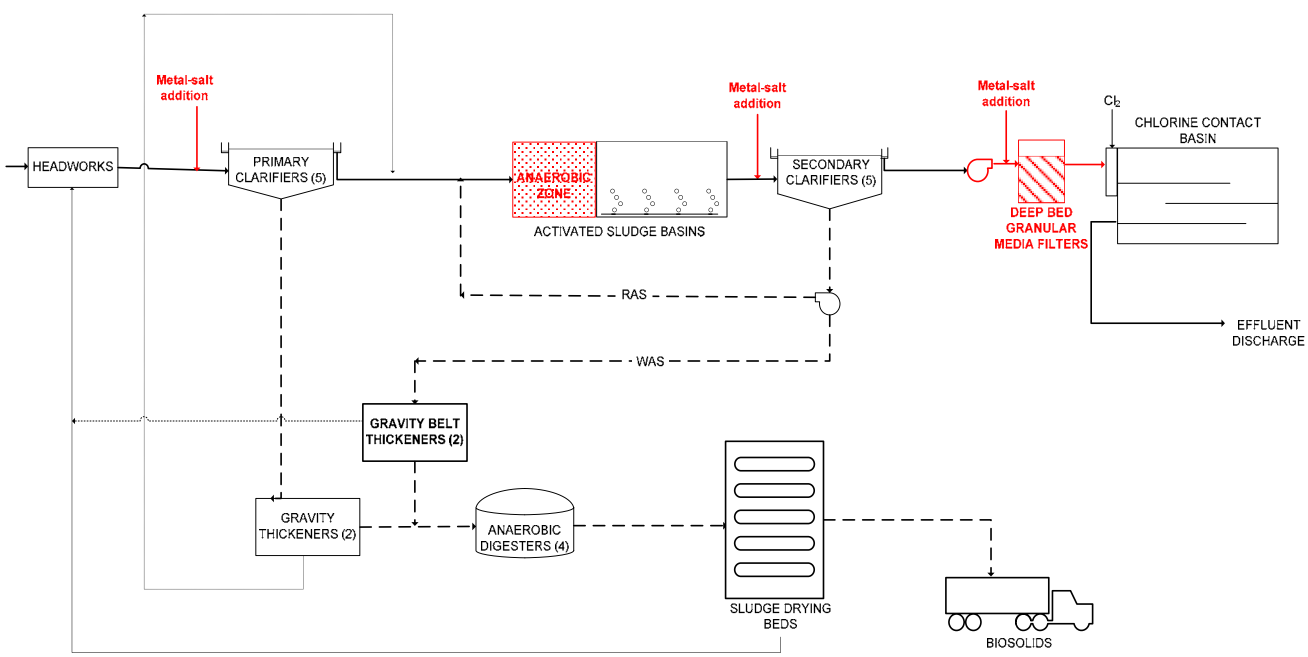

FIGURE 7
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach builds on a combination of the Tier 1 and Tier 2N. Nitrogen was removed biologically as in Tier 2N, and phosphorus was removed via the method described in Tier 1. A process schematic of this approach is presented in Figure 8.

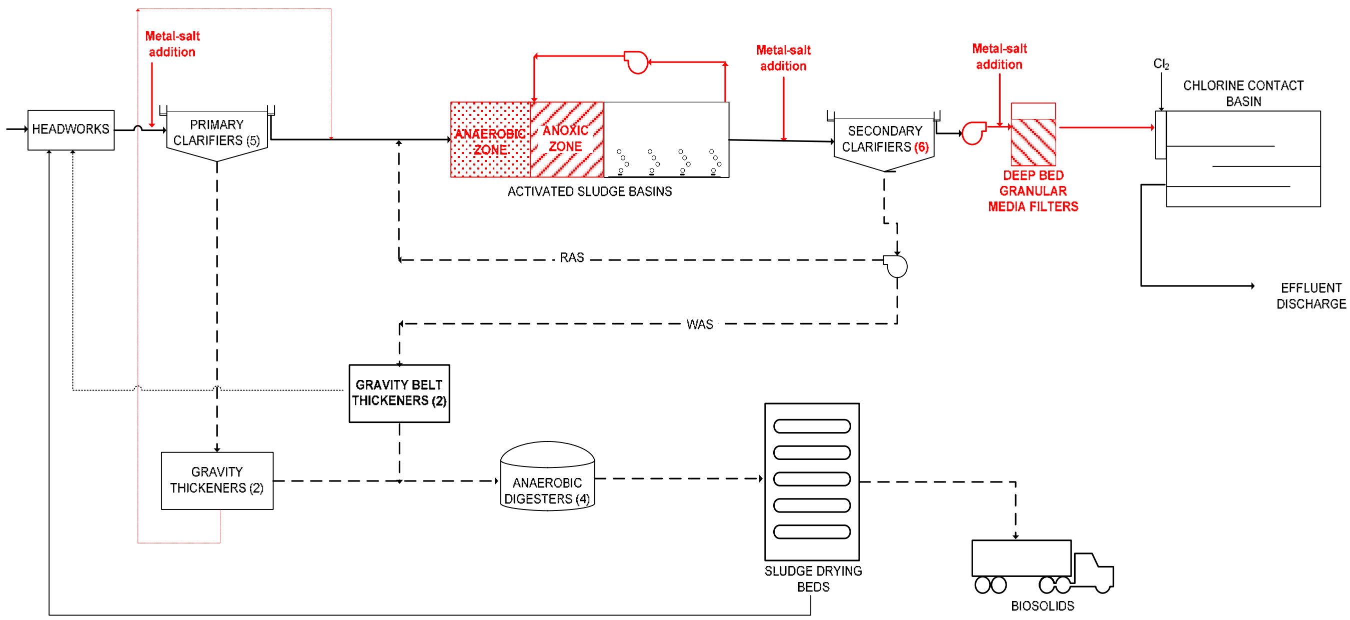

FIGURE 8
Modifications to POTW for Tier 1N Nutrient Control

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

Table 6 presents a summary of the major facility upgrade components identified for meeting each tier of nutrient control.

TABLE 6
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed and storage facility	X	X	X	X
Piping and flow distribution structure	X	X	X	X
Aeration basin modifications to include anaerobic zone	X		X	
New aeration basin volume with anaerobic and anoxic zones		X		X
New blower capacity and building		X		X
Mixed liquor recirculation system		X		X
Secondary effluent pump station			X	X
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 7 is -30%/+50%.

TABLE 7
Capital Cost Estimates ($ Million)

Unit Process Facility	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed and storage facility	$0.77	$0.77	$2.85	$2.85
Piping and flow distribution structure	$0.18	$0.31	$0.18	$0.31
Aeration basin modifications/expansion to include anaerobic zone	$0.60	$9.94	$0.60	$9.94
Aeration basin expansion to include anoxic zone	$0.00	$18.33	$0.00	$18.33
New aeration basin volume	$0.00	$6.89	$0.00	$6.89
New blower capacity and building	$0.00	$4.11	$0.00	$4.11
Mixed liquor recirculation system	$0.00	$1.52	$0.00	$1.52
Secondary effluent pump station	$0.00	$0.00	$14.46	$14.46
Granular media filters	$0.00	$0.00	$73.01	$73.01
TOTAL TIER COST	**$1.56**	**$41.89**	**$91.12**	**$131.45**

December 2009 US Dollars

Incremental O&M costs associated with meeting each tier of nutrient standard were generated for the years 2009 and 2029. The unit costs were either provided by the POTW or assumed based on the average costs in the State of Utah, and are presented in Table 8. A straight line interpolation was used to estimate the differential cost for the two years. O&M costs 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: aeration, secondary effluent pumps, backwash pumps and dewatering units.

TABLE 8
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$8/wet ton
Biosolids tipping fee	$6/wet ton
Biosolids roundtrip hauling distance(1)	25 miles
Ferric chloride	$1000/ton
Polymer	$1/lb
Power	$0.06/kwh

(1) Hauling distance between SLCWRF and Salt Lake Valley Landfill

Increased O&M relative to the current O&M cost (Tier 3) are presented in Table 9 and shown graphically in Figure 9.

TABLE 9
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	($0.03)	($0.02)	($0.07)	($0.04)	$0.06	$0.08	$0.14	$0.18
Metal-salt	$0.02	$0.02	$0.02	$0.02	$0.69	$1.06	$0.79	$1.01
Polymer	($0.01)	($0.01)	($0.04)	($0.02)	$0.04	$0.05	$0.08	$0.11
Power	$0.01	$0.04	$0.57	$0.53	$0.34	$0.38	$0.87	$0.87
Total O&M	**$0.01**	**$0.03**	**$0.47**	**$0.49**	**$1.13**	**$1.56**	**$1.88**	**$2.17**

Note: $ Million (US) in December 2009
Costs shown are the annual differential costs relative to the base line O&M cost of the POTW

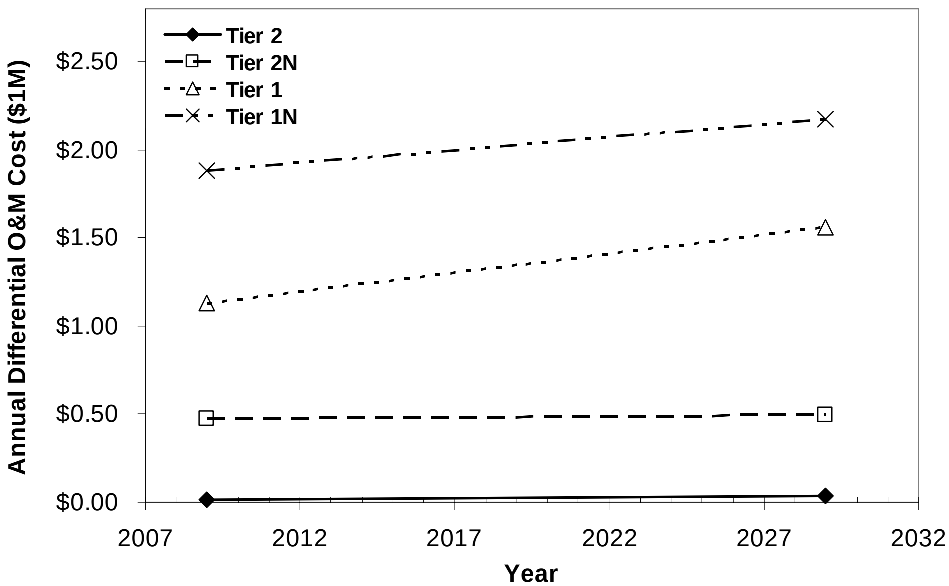

FIGURE 9
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

This section presents the estimated financial impacts that will result from the implementation of nutrient discharge standards for the State of Utah. 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 SLCWRF.

TABLE
10

Nutrient Removal: 20-Year Life Cycle Cost per Pound[1]

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	4,632,723	4,632,723	6,611,728	6,611,728
Nitrogen Removal (pounds)[2]	-	meets limit	-	21,988,943
Net Present Value of Removal Costs[3]	**$ 1,924,003**	**$ 49,291,416**	**$ 111,549,286**	**$ 162,169,260**
NPV: Phosphorus Allocation	1,924,003	1,924,003	111,549,286	111,549,286
NPV: Nitrogen Allocation[4]		47,367,413		50,619,974
TP Cost per Pound[5]	**$ 0.42**	**$ 0.42**	**$ 16.87**	**$ 16.87**
TN Cost per Pound[5]		**NA**		**$ 2.30**

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 those customers served by the POTW. The financial impact was 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 SLCWRF are presented in Table 11.

TABLE 11

Projected Monthly Bill Impact per Equivalent Residential Unit (ERU) for Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Initial Capital Expenditure	$ 1,560,000	$ 41,890,000	$ 91,116,000	$ 131,446,000
Estimated Annual Debt Service[1]	$ 125,200	$ 3,361,400	$ 7,311,400	$ 10,547,600
Incremental Operating Cost[2]	15,800	474,700	1,150,000	1,892,800
Total Annual Cost Increase	$ 141,000	$ 3,836,100	$ 8,461,400	$ 12,440,400
Number of ERUs	68,920	68,920	68,920	68,920
Annual Cost Increase per ERU	$2.05	$55.66	$122.77	$180.50
Monthly Cost Increase per ERU[3]	**$0.17**	**$4.64**	**$10.23**	**$15.04**
Current Average Monthly Bill[4]	$10.56	$10.56	$10.56	$10.56
Projected Average Monthly Bill[5]	**$10.73**	**$15.20**	**$20.79**	**$25.60**
Percent Increase	**1.6%**	**43.9%**	**96.9%**	**142.4%**

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 SLCWRF is shown in Table 12.

TABLE 12

Community Financial Impacts: Affordability of Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Median Annual Gross Income (MAGI)[1,2]	$ 32,600	$ 32,600	$ 32,600	$ 32,600
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$38.03**	**$38.03**	**$38.03**	**$38.03**
Projected Average Monthly Bill	$10.73	$15.20	$20.79	$25.60
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**28%**	**40%**	**55%**	**67%**

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 and disposal and energy consumption

As per the data received from SLCWRF and per process modeling of the base condition (Tier 3), SLCWRF is able to achieve some nutrient removal with its existing infrastructure, but not enough to meet the effluent limits of the specified Tiers of nutrient standards. Table 13 summarizes the annual reduction in nutrient loads in SLCWRF 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 13
Estimated Environmental Benefits of Nutrient Control

	Tier 2	Tier 2N	Tier 1	Tier 1N
Total phosphorus removed, lb/year	207,000	207,000	300,150	300,150
Total nitrogen removed, lb/year	----	0	----	1,035,000

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

Attempts were also made to summarize the nutrient content of POTWs' discharges and their receiving waters 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.

For SLCWRF, no STORET data was found upstream to the POTW discharge point. Thus, total phosphorus and total nitrogen concentration discharged by SLCWRF for baseline condition (Tier 3) and for each Tier of nutrient standard was not estimated.

The process upgrades established to meet the four tiers of nutrient standards require increased energy consumptions, chemical usage and biosolids production. Regular metal-salt addition would be required to meet the more stringent phosphorus limits. This would result in increased chemical sludge generation and consequently increased biosolids production. Process modifications to meet the total nitrogen limits would also result in increased energy consumption and biosolids productions. Table 14 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 a differential value relative to the base line condition.

TABLE 14
Estimated Environmental Impacts of Nutrient Control

		Tier 2	Tier 2N	Tier 1	Tier 1N
Chemical Use:					
Metal-salt use, lb/year		30,000	30,000	1,370,200	1,578,990
Polymers, lb/year		0	0	38,120	82,600
Biosolids Management:					
Biosolids produced, ton/year		0	0	550	730
Average yearly hauling distance(1)		0	0	630	830
Particulate emissions from hauling trucks, lb/year (2)		0	0	35	46
Tailpipe emissions from hauling trucks, lb/year(3)		0	0	80	105
CO_2 emissions from hauling trucks lb/year(4)		0	0	7995	10535
Energy Consumption:					
Annual energy consumption, kwh		137,076	7,757,955	4,523,175	12,071,053
Air pollutant emissions, lb/year (5)					
	CO_2	123,643	6,997,676	4,079,903	10,888,090
	NOx	192	10,861	6,332	15,243
	SOx	164	9,310	5,428	13,066
	CO	9	509	297	714
	VOC	1	61	36	86
	PM_{10}	3	153	89	214
	$PM_{2.5}$	1	76	45	107

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

(1) Based on the assumption of a 25 miles round trip hauling distance and, on the assumption that the facility uses 22 ton trucks for hauling biosolids to the landfill.

(2) Includes PM_{10} and $PM_{2.5}$ 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)*.

(3) 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+.

(4) CO_2 emission factor in pounds per year for hauling trucks were derived from *Rosso and Chau, 2009, WEF Residuals and Biosolids Conference Proceedings.*

(5) 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)*.