UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Spanish Fork City Wastewater Treatment Plant

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COPIES: Spanish Fork City Wastewater Treatment Plant

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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 Spanish Fork City Wastewater Treatment Plant (SFCWTP) 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 SFCWTP fits in the Hybrid Process Category with an activated sludge process and a trickling filter operating in parallel.

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

SFCWTP has an average annual design flow of 6 million gallons per day (mgd) and currently receives an average annual flow of approximately 3.4 mgd. The existing facility splits its flow between two treatment trains after primary clarification. One-third of the flow goes to a single-stage plastic media trickling filter process, while the rest goes to an activated sludge process with STM-Aerotor basins. The effluent from both the processes flows to a clarifier distribution box where it is distributed to the secondary clarifiers. The liquid effluent from the secondary clarifiers is chlorinated and dechlorinated before being discharged. The wasted secondary solids are thickened and stabilized using conventional mesophilic anaerobic digestion along with the primary residual solids. The digested solids are mechanically dewatered using belt filter press, dried by sludge drying beds, and the biosolids are disposed to a landfill. A process flow diagram for the POTW is presented in Figure 1 and an aerial photo of the existing facility is shown in Figure 2. All major unit processes are summarized in Table 2.

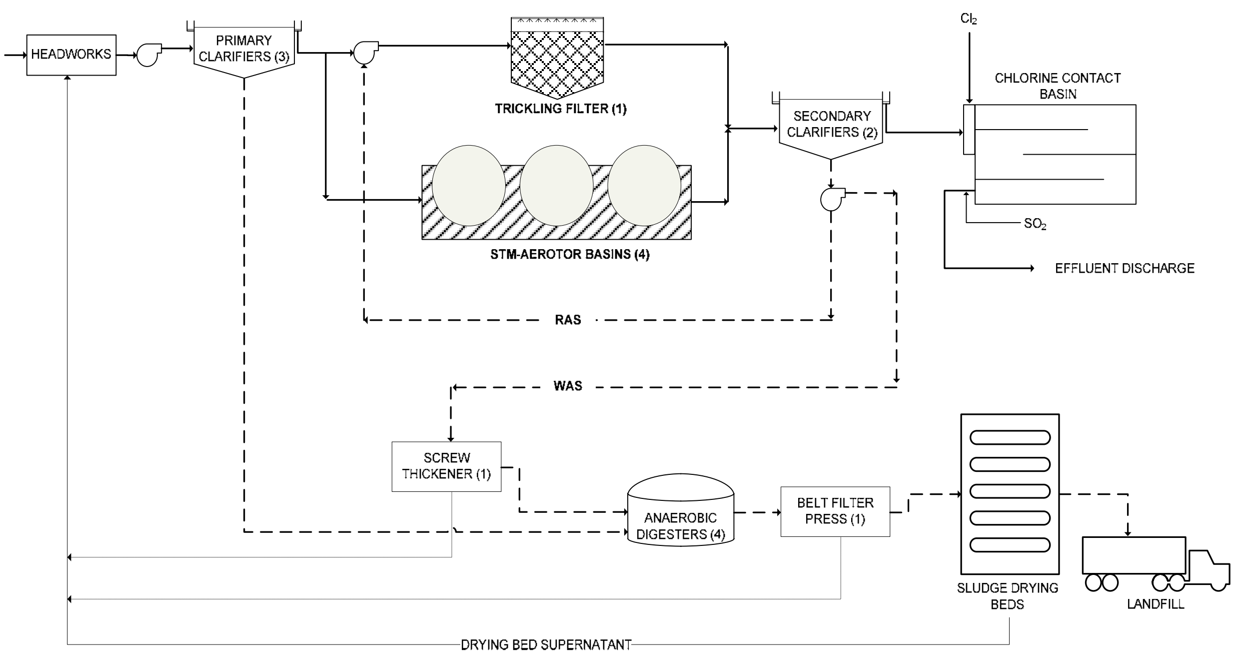

FIGURE 1
Process Flow Diagram of SFCWTP

FIGURE 2
Aerial View of SFCWTP

TABLE 2
Summary of Major Unit Processes

Treatment step	Number of Units	Size, each	Details
Primary Clarifiers	3	One @ 75-ft diameter, 12-ft SWD, Two @ 60-ft diameter, 7-ft SWD	Round
Trickling Filter	1	80-ft diameter, 16-ft media depth	Plastic-media
STM-Aerotor Basins	4	Two @ 266,475 gal, 15-ft SWD, Two @ 265,806 gal, 17.75-ft SWD	4 wheels in each basin
Secondary Clarifiers	2	90-ft diameter, 14-ft SWD	Round
Sludge Thickening	1	----	Screw thickener
Anaerobic Digestion	4	Two @ 0.38 MG, 26-ft SWD, Two @ 0.187 MG, 20-ft SWD	Conventional anaerobic mesophilic
Solids Dewatering	1	2 meter	Belt press
Biosolids Drying	9	----	Sludge drying beds

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 facilities with Hybrid Processes (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.

SFCWTP has a plastic media biotower and four STM Aerotor basins. 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 selected upgrade approach used between each tier of nutrient control with the following bullet points A through D describing each upgrade step:

A. From Tier 3 (existing process) to Tier 2 phosphorus control, metal-salt addition was implemented at the primary and the secondary clarifiers.

B. To add nitrogen removal to Tier 2, the STM-Aerotor basins were converted to a biological nutrient removal (BNR) process with an anaerobic and anoxic zone upstream of them. The unsettled effluent from the trickling filter train was combined with the mixed liquor of the BNR process at the STM-Aerotor basins for further nitrification, before final settling. Metal-salt addition was implemented at the primary and the secondary clarifiers as a back-up to biological phosphorus removal.

C. To go from Tier 2 to Tier 1 phosphorus control, deep bed granular media filters and an intermediate pump station was added to the facility with an additional metal-salt feed point before the filters.

D. To add nitrogen removal to Tier 1, the BNR process added in B was retained. The trickling filter effluent was combined with the BNR process at the Aerotor basins, and the secondary clarifiers were followed by intermediate pump station and deep bed granular media filters described for Tier 1 option, with an additional metal-salt feed point before the filters.

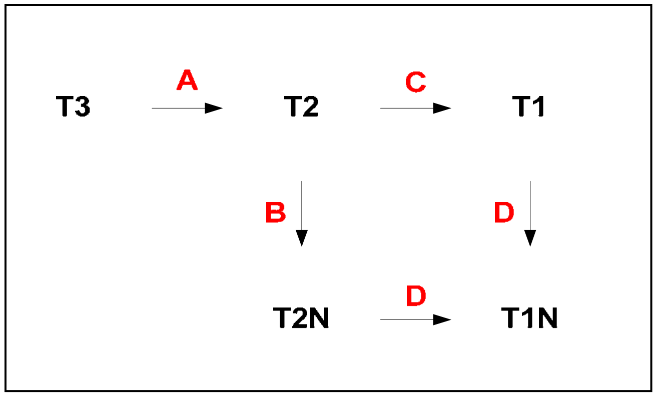

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for SFCWTP 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 SFCWTP per the initial data request 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[1]	2029[2]	Design[3]
Flow, mgd	3.40	6.0	7.20
BOD, lb/day	5,468 (195 mg/L)	9,758 (195 mg/L)	11,716 (195 mg/L)
TSS, lb/day	4,678 (165 mg/L)	8,257 (165 mg/L)	9,914 (165 mg/L)
TKN, lb/day	992 (35 mg/L)	1,752 (35 mg/L)	2,102 (35 mg/L)
TP, lb/day	175 (6 mg/L)	300 (6 mg/L)	361 (6 mg/L)

(1) Historic conditions for the year 2005-2007

(2) Assumed based on increase in population from Census Report

(3) Design maximum month capacity of the POTW. Assumed 1.2 times (peaking factor) the design average flow of the POTW.

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

TABLE 4
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Influent design temperature	10 deg C
Target metal:PO_4-P molar Ratio (T1 and T2)	1:1, 2:1, 7:1 [1]
Metal salt storage (All Tiers)	14 days
Fraction of anaerobic volume in the BNR process (T2N and T1N)	15%
Fraction of anoxic volume in the BNR process (T2N and T1N)	30%
Mixed-Liquor return pumping ratio as a percent of influent Flow (T2N)	100% to 150%
Nitrification Safety Factor (T2N and T1N)	1 [3]
SVI (All Tiers)	180
Granular filter loading rate (T1)	5 gpm/ft^2 [2]

(1)Target dosing ratio at the primary clarifier, secondary clarifiers and upstream of polishing filter, respectively.

(2)Hydraulic loading rate at peak hourly flow

(3) SRT in the BNR process adjusted to maintain nitrification safety factor of 1, since nitrifiers are seeded in the BNR process by the TF effluent

3. Nutrient Upgrade Approaches

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

Tier 2 - Phosphorus (A)

The effluent limit for Tier 2 alternative is 1.0 mg/L total phosphorus. SFCWTP can achieve this goal by adding metal-salts at the primary and the secondary clarifiers for chemical phosphorus removal. A process flow diagram for this alternative is presented in Figure 4.

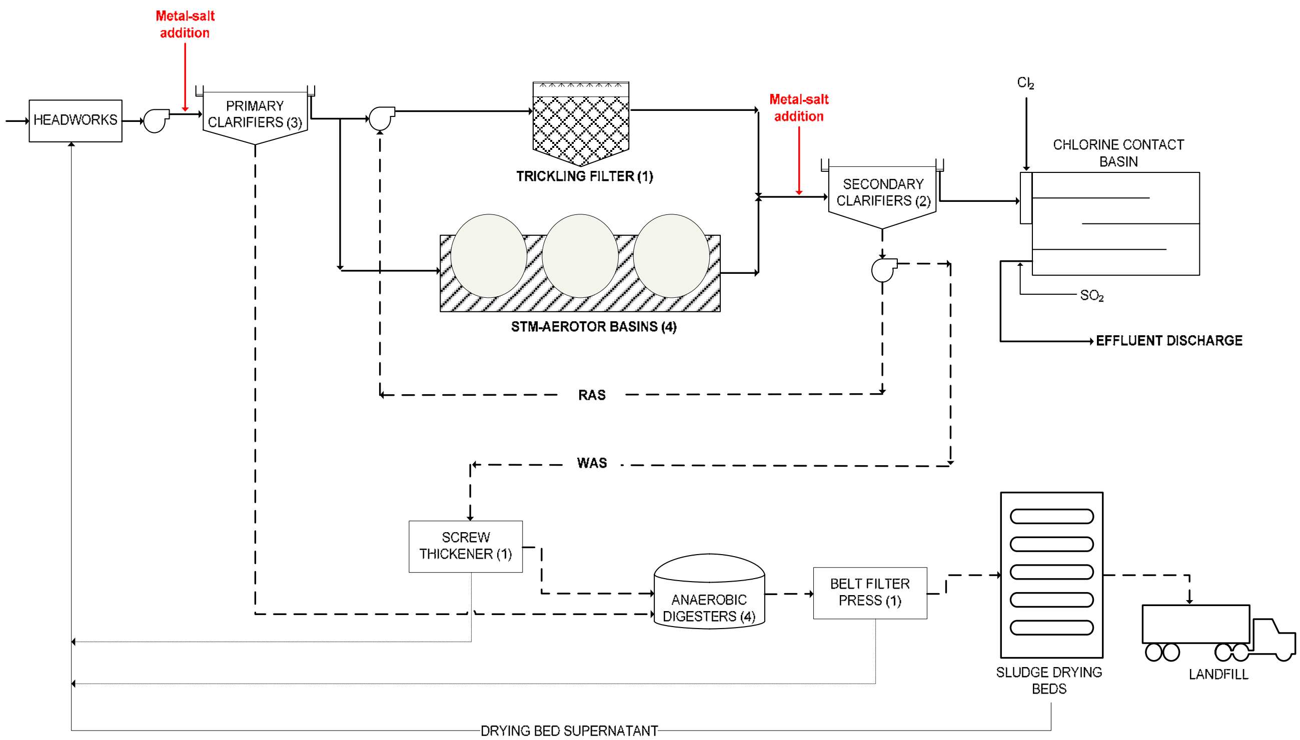

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N - Phosphorus & Nitrogen (B)

This Tier builds upon the upgrade approach for Tier 2 to incorporate nitrogen removal along with phosphorus removal. According to the process modeling for this scenario, the nutrient limits could be met by introducing an anaerobic and anoxic zone upstream of the STM-Aerotor basins. The existing mixed liquor recycling system was modified in order to recycle the effluent from the STM-Aerotor basins to the new anoxic zone. In addition, the unsettled effluent from the trickling filter process was combined with the BNR process in the aeration basins for further nitrification. This also helped seed nitrifiers to the aeration basins, thus allowing it to operate at lower solids retention time (SRT). Metal-salt feed points as mentioned in Tier 2 were retained; however, with a complete BNR process, metal-salt consumption was driven as a back-up to enhanced biological uptake of phosphorus. A process flow diagram for this alternative is presented in Figure 5.

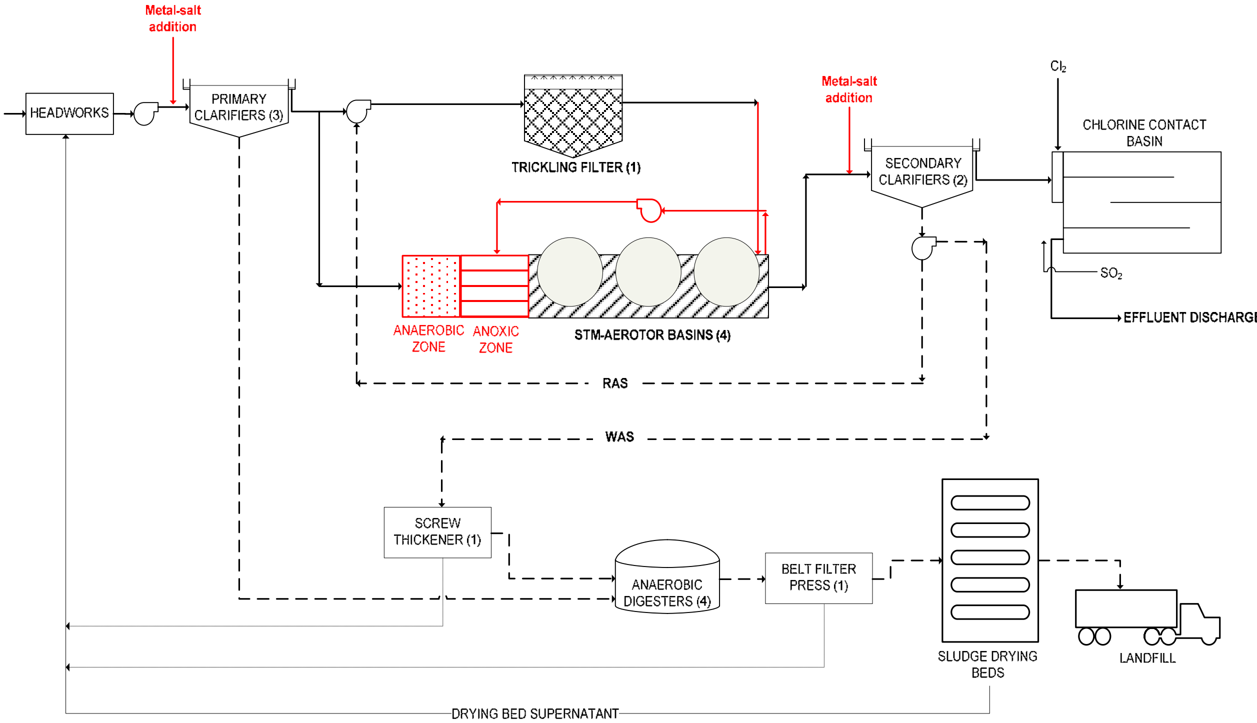

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 - Low Phosphorus (C)

The effluent limit for this alternative is 0.1 mg/L total phosphorus. This alternative builds upon the Tier 2 approach for phosphorus control; however, metal-salt use was mandatory to achieve the 0.1 mg/L total phosphorus. In addition to the metal-salt feed points mentioned in Tier 2, the secondary effluent was pumped to deep bed granular media filters with a feed point for metal-salt addition upstream. This achieved chemical phosphorus polishing. A process flow diagram of this approach is provided in Figure 6.

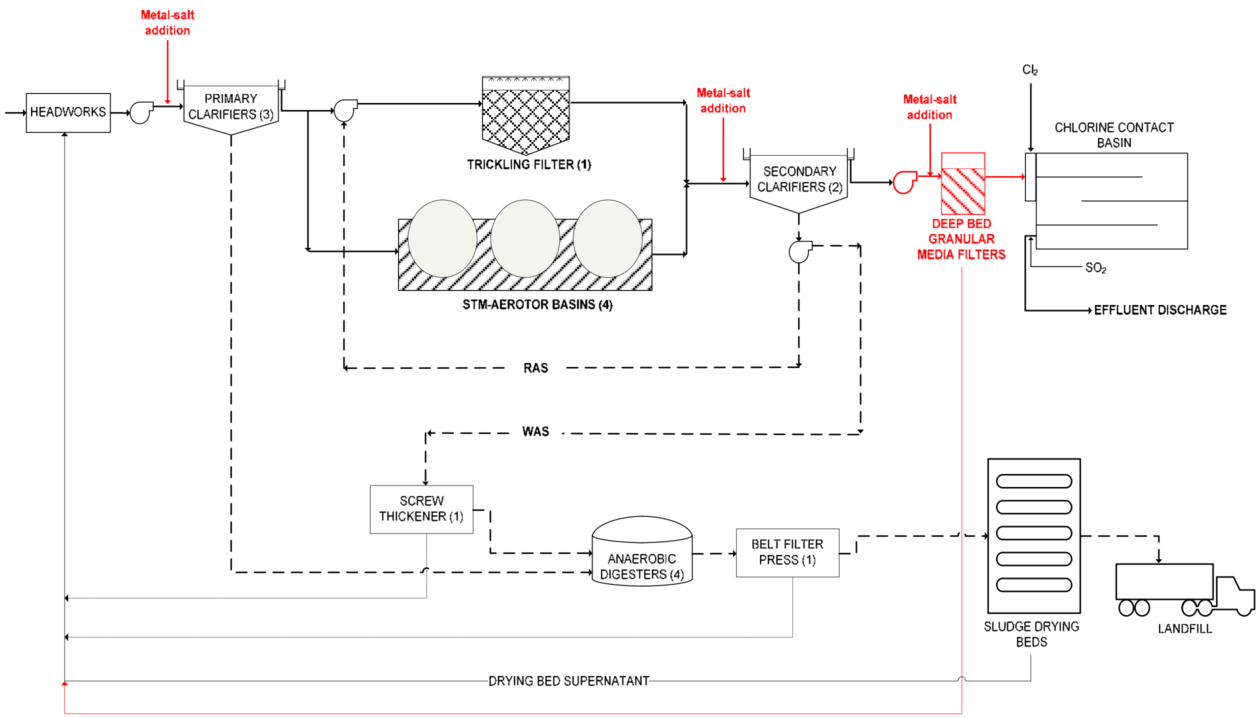

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N - Phosphorus & Nitrogen (D)

This approach is a combination of Tier 2N and Tier 1, where the existing STM-Aerotor basins were converted to a conventional BNR process by the addition of anaerobic and anoxic zones. The trickling filter effluent was combined with the activated sludge process at the aeration basins, and the secondary effluent was pumped to deep bed granular media filters with a feed point for metal-salt addition upstream. A process flow diagram for this alternative is presented in Figure 7.

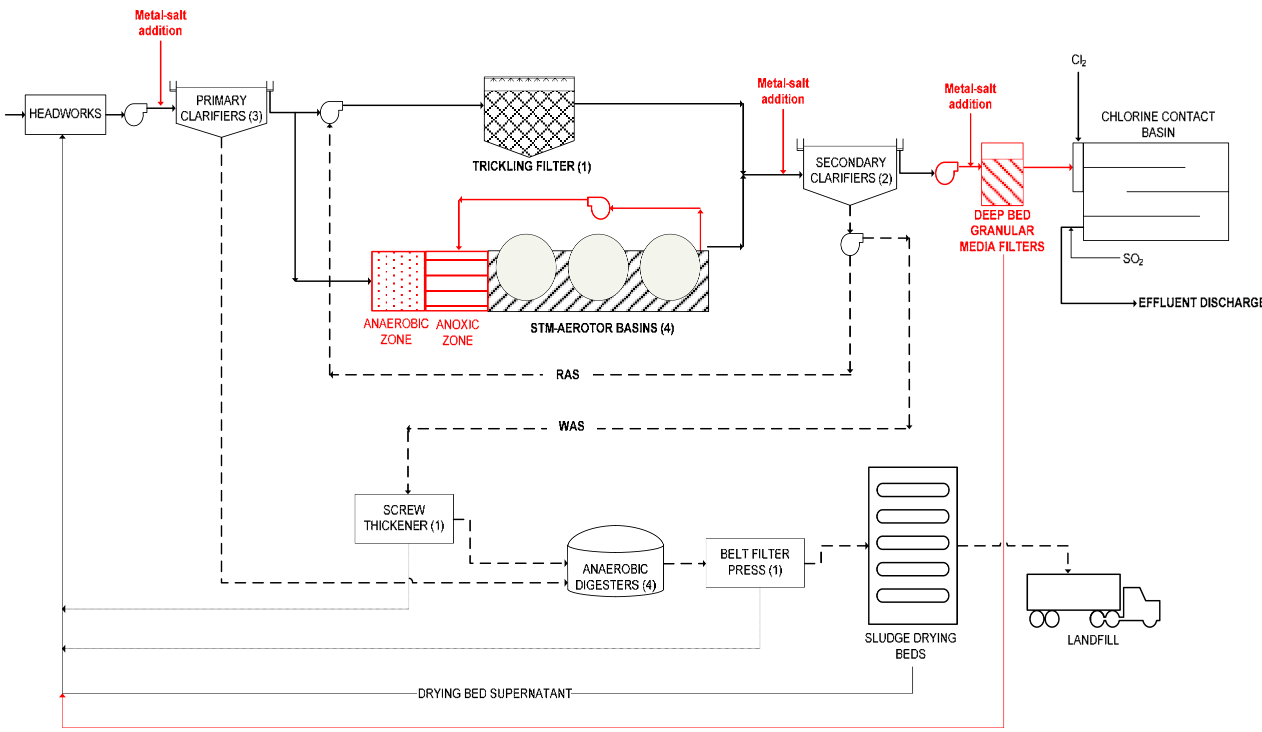

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Control

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 facility upgrade components identified for meeting each tier of nutrient control. For Tier 2, metal-salt storage facility was added along with new feed pumps at the primary and the secondary clarifiers for phosphorus removal. For Tier 2N, anaerobic and anoxic tanks complete with mixers were installed ahead of the STM-Aerotor basins for BNR, with modifications to the mixed liquor recycling system. Some structural and piping modifications were required to bring the trickling filter effluent to the existing STM-Aerotor basins. For Tier 1 phosphorus control, secondary effluent pump stations were needed to lift the secondary flow to the new deep bed granular media filters in addition to all the components identified for Tier 2. For Tier 1N, additional tank volume and deep bed granular media filters with a pump station were required.

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
Anaerobic basin with mixers		X		X
Anoxic basin with mixers		X		X
Mixed liquor recycle system		X		X
Modification to TF effluent piping and flow distribution structure		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 and storage facility	$0.87	$0.94	$1.21	$1.21
Anaerobic basin with mixers	$0	$0.91	$0	$1.16
Anoxic basin with mixers	$0	$1.62	$0	$2.20
Mixed liquor recycle system	$0	$0.29	$0	$0.29
Modification to TF effluent piping and flow distribution structure	$0	$0.51	$0	$0.60
Secondary effluent pump station	$0	$0	$2.93	$2.93
Deep bed granular media filters	$0	$0	$14.97	$14.97
TOTAL TIER COST	**$0.87**	**$4.27**	**$19.11**	**$23.36**

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 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 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 and backwash pumps

TABLE 7
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$8/wet ton
Biosolids tipping fee	$6/wet ton
Roundtrip hauling distance[(1)]	10 miles
Alum	$480/ton
Polymer	$1/lb
Power	$0.06/kwh

(1) Provided by the POTW

Increased O&M relative to the current O&M cost (Tier 3) are presented in Table 8 and shown graphically in Figure 8.

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	$0.02	$0.03	$0.01	$0.01	$0.02	$0.04	$0.01	$0.02
Metal-salt	$0.21	$0.35	$0.09	$0.17	$0.25	$0.43	$0.24	$0.43
Polymer	$0.01	$0.01	$0.01	$0.01	$0.01	$0.02	$0.00	$0.01
Power	$0.00	$0.00	$0.03	$0.03	$0.03	$0.06	$0.06	$0.09
Total O&M	**$0.23**	**$0.40**	**$0.13**	**$0.22**	**$0.32**	**$0.54**	**$0.31**	**$0.55**

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

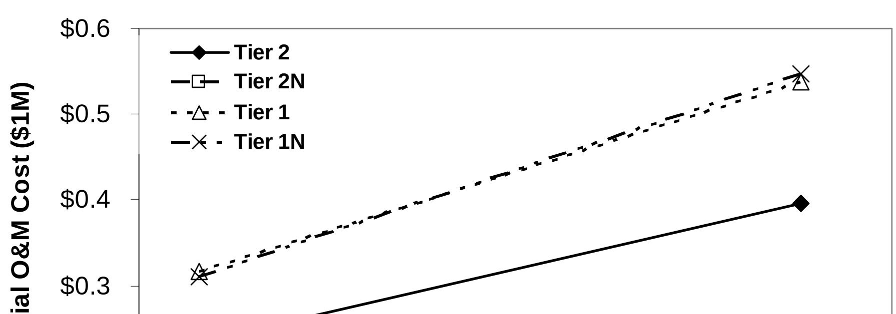

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

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

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	965,754	965,754	1,226,972	1,226,972
Nitrogen Removal (pounds)[2]	-	1,113,587	-	4,016,005
Net Present Value of Removal Costs[3]	**$ 5,645,102**	**$ 6,806,564**	**$ 25,519,146**	**$ 29,772,249**
NPV: Phosphorus Allocation	5,645,102	5,645,102	25,519,146	25,519,146
NPV: Nitrogen Allocation[4]		1,161,462		4,253,103
TP Cost per Pound[5]	**$ 5.85**	**$ 5.85**	**$ 20.80**	**$ 20.80**
TN Cost per Pound[5]		**$ 1.04**		**$ 1.06**

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 w as assumed that the nitrogen cost allocation w as the incremental difference betw een 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 SFCWTP are presented in Table 10.

TABLE 10

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Initial Capital Expenditure	$ 871,000	$ 4,111,000	$ 19,058,000	$ 23,290,000
Estimated Annual Debt Service[1]	$ 69,900	$ 329,900	$ 1,529,300	$ 1,868,800
Incremental Operating Cost[2]	242,300	136,600	327,200	321,300
Total Annual Cost Increase	$ 312,200	$ 466,500	$ 1,856,500	$ 2,190,100
Number of ERUs	6,720	6,720	6,720	6,720
Annual Cost Increase per ERU	$46.46	$69.42	$276.26	$325.91
Monthly Cost Increase per ERU[3]	**$3.87**	**$5.78**	**$23.02**	**$27.16**
Current Average Monthly Bill[4]	$20.52	$20.52	$20.52	$20.52
Projected Average Monthly Bill[5]	**$24.39**	**$26.30**	**$43.54**	**$47.67**
Percent Increase	**18.9%**	**28.2%**	**112.2%**	**132.4%**

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) w ithin 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 SFCWTP is shown in Table 11.

TABLE 11

Community Financial Impacts: Affordability of Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Median Annual Gross Income (MAGI)[1,2]	$ 46,300	$ 46,300	$ 46,300	$ 46,300
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$54.02**	**$54.02**	**$54.02**	**$54.02**
Projected Average Monthly Bill	$24.39	$26.30	$43.54	$47.67
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**45%**	**49%**	**81%**	**88%**

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 SFCWTP and per process modeling of the base condition (Tier 3), SFCWTP 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 12 summarizes the annual reduction in nutrient loads in SFCWTP 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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Total phosphorus removed, lb/year	35,905	35,905	45,220	45,220
Total nitrogen removed, lb/year	----	45,400	----	148,900

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 SFCWID to its receiving waters 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)

			Tier 3		Tier 2		Tier 2N		Tier 1		Tier 1N	
STORET LOCATION	**STORET ID**	**FLOW (cfs)**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**
SFCWTP	----	5.26	4.47	24.39	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Dry Creek	4996030	19.90	0.24	3.33	----	----	----	----	----	----	----	----
Combined Concentrations			**1.12**	**7.73**	**0.40**	**N/A**	**0.40**	**6.82**	**0.21**	**N/A**	**0.21**	**4.72**

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		411,888	174,814	504,080	477,904
Polymers, lb/year		8,504	5,894	10,349	4,689
Biosolids Management:					
Biosolids produced, ton/year		215	150	260	120
Average yearly hauling distance[(1)]		100	70	120	55
Particulate emissions from hauling trucks, lb/year [(2)]		5	4	7	3
Tailpipe emissions from hauling trucks, lb/year[(3)]		12	9	15	7
CO_2 emissions from hauling trucks lb/year[(4)]		1,230	850	1,500	680
Energy Consumption:					
Annual energy consumption, kwh		47,967	448,897	555,479	943,166
Air pollutant emissions, lb/year [(5)]					
	CO_2	43,266	404,905	501,042	850,735
	NOx	67	628	778	1,320
	SOx	58	539	667	1,132
	CO	3	29	36	62
	VOC	0	4	4	7
	PM_{10}	1	9	11	19
	$PM_{2.5}$	0	4	5	9

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 10 miles round trip hauling distance and, on the assumption that the facility uses 22 ton trucks for hauling biosolids to land application.

[(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)*.