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

PREPARED FOR: Utah Division of Water Quality

PREPARED BY: CH2M HILL

COPIES: Tremonton 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 Tremonton City Wastewater Treatment Plant (TCWTP) 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 TCWTP fits in the 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

TCWTP is designed for an annual average flow of 1.9 million gallons per day (mgd) and currently receives an average annual influent flow of approximately 1.4 mgd. The facility operates an aerated activated sludge process using two STM-Aerotor basins, with primary treatment, traveling bridge sand filtration and an UV disinfection system. The wastewater residuals from the primary and the secondary clarifiers are stabilized using conventional aerobic digestion, dewatered using Huber dewatering screw and composted. The STM-Aerotors are operated to meet the current BOD effluent limits of the POTW. A process flow diagram is presented in Figure 1 and an aerial photo of the POTW is shown in Figure 2. The major existing unit processes are summarized in Table 2.

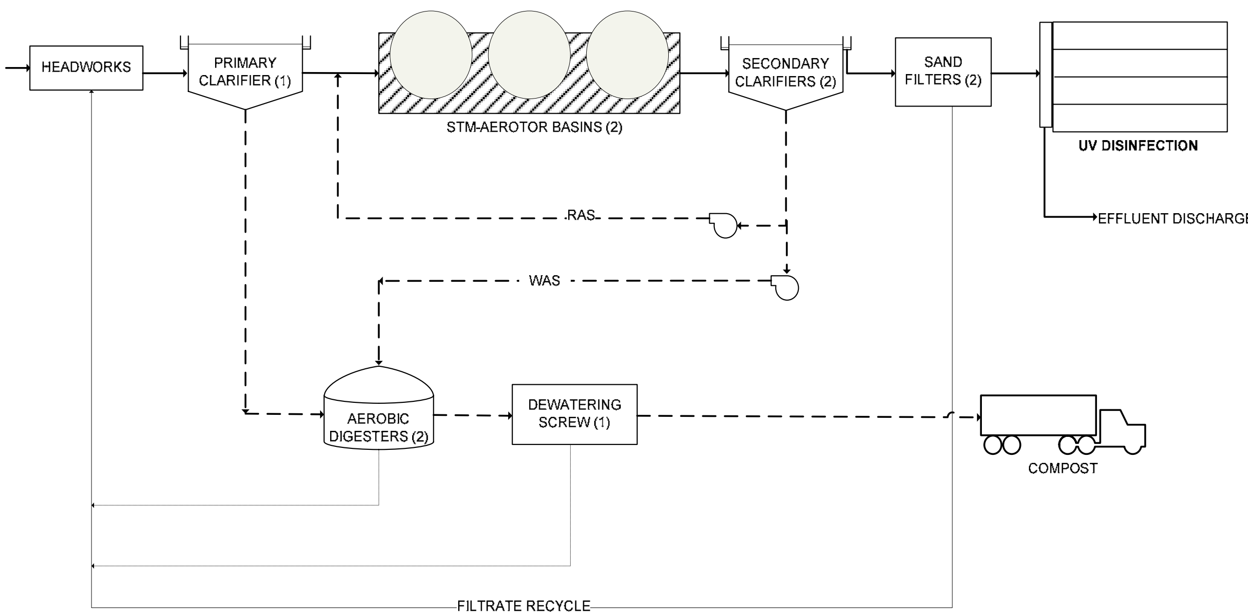

FIGURE 1
Process Flow Diagram

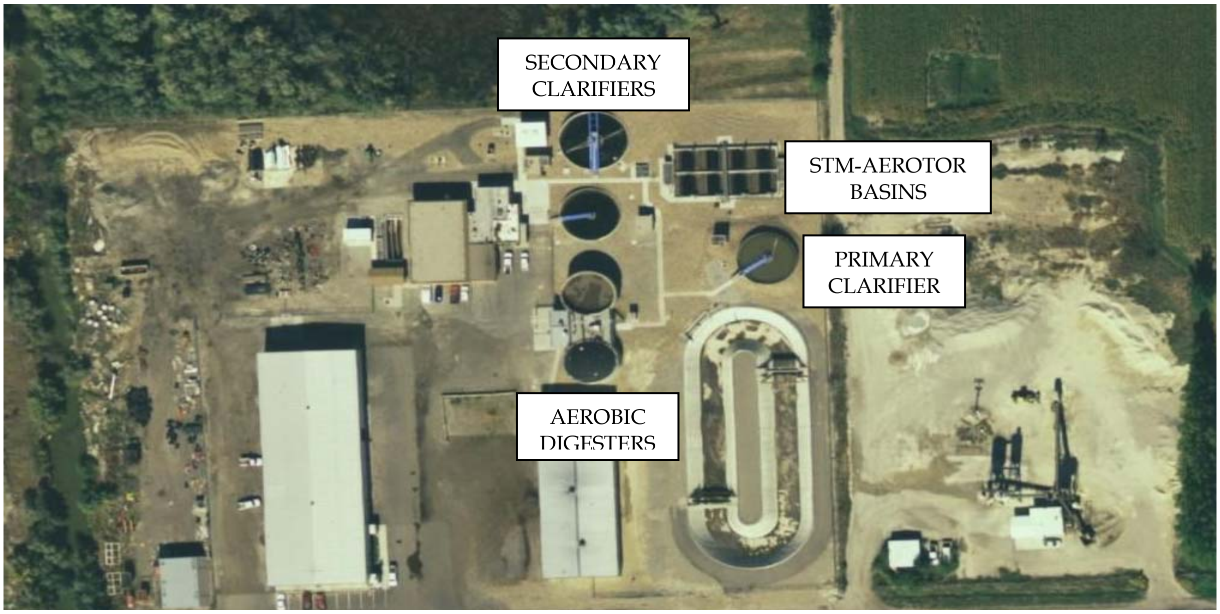

FIGURE 2
Aerial View of the Facility

TABLE 2
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifier	1	45-ft diameter, 10-ft SWD	Round
Activated Sludge basins	2	0.7 MG	STM-Aerotors
Secondary clarifiers	3	45-ft diameter, 10-ft SWD(1) 55-ft diameter, 10-ft SWD(1)	Round
Filtration	2	650-ft^2	Sand Filters/traveling bridge
Aerobic digestion	2	0.376 MG	----
Dewatering	1	----	Huber dewatering screw

2. Nutrient Removal Alternatives Development, Screening and Selection

A nutrient removal alternatives matrix was prepared to capture an array of viable approaches for the AS 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.

TCWTP has an aerated activated sludge process. 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, an anaerobic zone was added upstream of the existing STM-Aerotor basins to enable enhanced biological phosphorus removal. Metal-salt addition was provided as a back-up to the biological phosphorus uptake at the secondary clarifiers.

B. From Tier 2 to Tier 2N, no additional process modifications were required.

C. To go from Tier 2 to Tier 1 phosphorus control, the existing traveling bridge filters were replaced by deep bed granular media filters and a second metal-salt feed point was added upstream of the filters.

D. To add nitrogen control to Tier 1, an anoxic zone was added after the anaerobic zone described in A, for biological nutrient removal (BNR). These two zones were followed by the existing STM-Aerotor basins. Metal-salt dosing points at the secondary clarifiers and upstream of the deep bed granular media filters were retained as described in the previous upgrade steps.

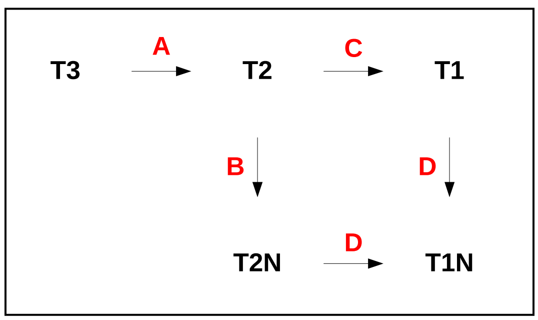

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for TCWTP 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 TCWTP 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	1.40	1.90	2.30
BOD, lb/day	4,087 (350 mg/L)	5,546 (350 mg/L)	6,983 (364 mg/L)
TSS, lb/day	3,036 (260 mg/L)	4,120 (260 mg/L)	3,836 (200 mg/L)
TKN, lb/day	385 (33 mg/L)	523 (33 mg/L)	633 (33 mg/L)
TP, lb/day	99 (8.5 mg/L)	135 (8.5 mg/L)	163 (8.5 mg/L)

(1) Historic conditions 2006-2008
(2) Projected by the POTW
(3) Design maximum month capacity of POTW. Assumed 1.2 times (peaking factor) the design average flow.

The main sizing and operating design criteria that are associated with the system upgrade for TCWTP 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 (All Tiers)	2:1, 7:1 (1)
Metal salt storage (T2 and T2N)	5 days
Metal salt storage (T1 and T1N)	14 days
Fraction of anaerobic volume in the BNR process (All Tiers)	15%
Fraction of anoxic volume in the BNR process (T1N)	30%
Mixed-Liquor return pumping ratio as a percent of influent Flow (T1N)	100%
Nitrification Safety Factor (T2N and T1N)	2(3)
Granular filter loading rate (T1 and T1N)	5 gpm/ft^2 (2)

(1) Target dosing ratio at the secondary clarifiers and upstream of polishing filter, respectively. Filter doses were for Tier 1 and 1N only
(2) Hydraulic loading rate at peak hourly flow
(3) SRT in the BNR process adjusted to maintain nitrification safety factor of 2

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. TCWTP can achieve this goal by introducing an anaerobic zone upstream of the existing STM-Aerotor basins. This converts the existing aerated activated sludge configuration to a more conventional biological phosphorus removal process. A metal-salt addition system was implemented at the secondary clarifiers to be used only as a back-up to the biological phosphorus removal. A process flow diagram for this alternative is presented in Figure 4.

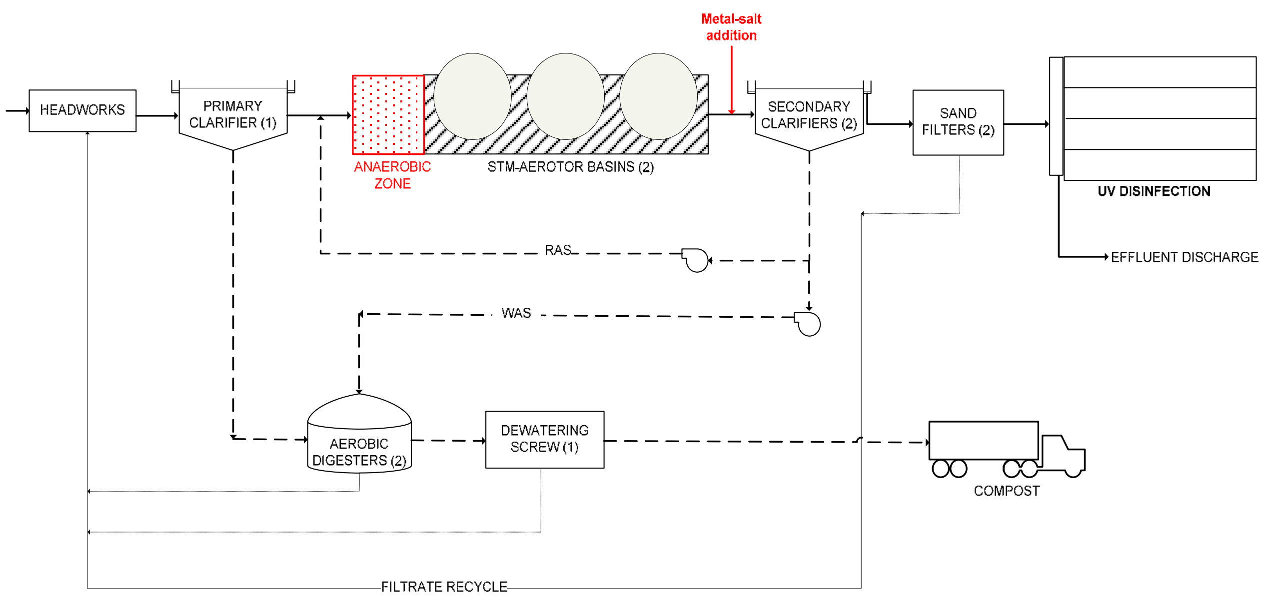

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

The addition of an anaerobic zone and the single metal-salt feed point at the secondary clarifier in Tier 2 would not require any adjustments for this Tier to achieve moderate levels of nitrogen control along with phosphorus control. The existing deep STM Aerotor system is already exhibiting sufficient biological nitrogen removal to meet this limit; therefore, the process flow diagram for this approach would be the same as presented in Figure 4.

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control; however, metal-salt addition at the secondary clarifiers would be mandatory to meet the 0.1 mg/L total phosphorus limit. The existing traveling bridge filters were replaced with new deep bed granular media filters and a second feed point for metal-salt addition was introduced upstream of the filters for chemical phosphorus polishing. A process flow diagram of this approach is provided in Figure 5.

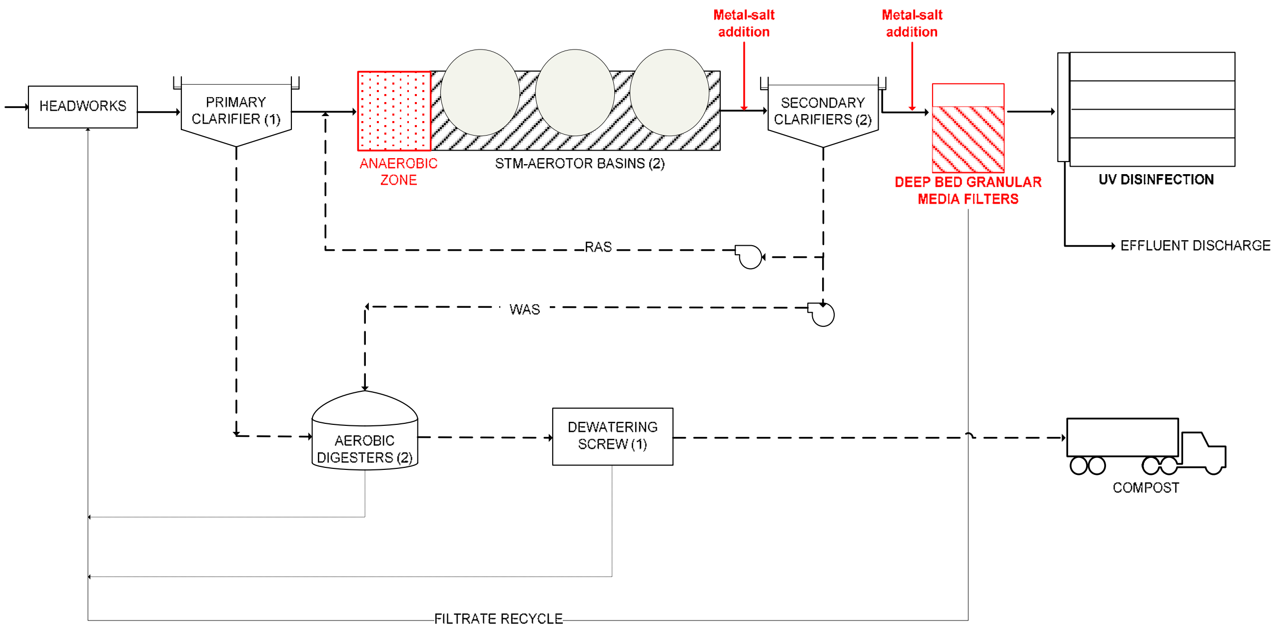

FIGURE 5
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach builds on Tier 2N and Tier 1 alternatives, by introducing an anoxic zone after the anaerobic zone to the existing process, for BNR. Additional basin volume was required to achieve the nutrient limits specified for this Tier and the existing mixed liquor recycling system was modified to recycle the nitrate-rich effluent from the STM-Aerotor basins to the new anoxic zone for denitrification. Metal-salt feed points at the secondary clarifiers and upstream of the filters was retained for chemical phosphorus polishing. A process flow diagram for this alternative is presented in Figure 6.

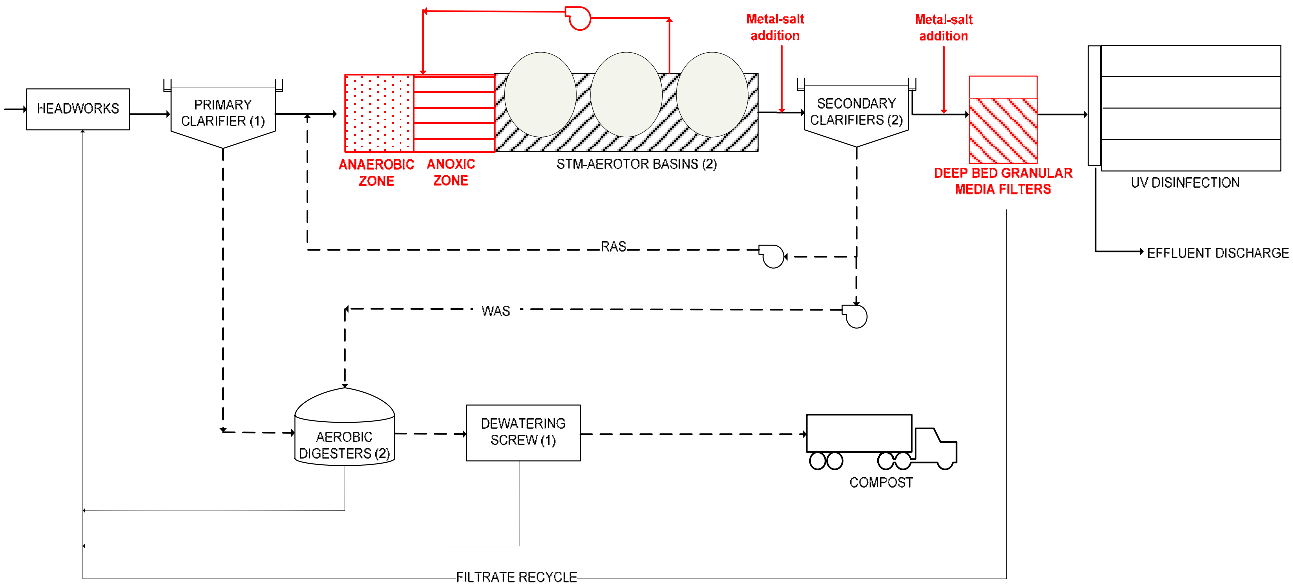

FIGURE 6
Modifications to POTW for Tier 1N Nutrient Control

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 and Tier 2N, an anaerobic basin with mixers, metal-salt storage facility and new metal-salt feed pumps were required. To go to Tier 1, the existing traveling bridge sand filters were replaced by new deep bed granular media filters with additional metal-salt storage facility and feed pumps upstream of the filters. A new pump station may be required to lift the secondary effluent flow to the granular media filters. For Tier 1N, an anoxic basin with mixers was needed with modifications to the existing mixed liquor recycling system, in addition to all the components identified in Tier 1.

TABLE 5
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt chemical feed and storage facility	X	X	X	X
Piping and flow structure modifications	X	X	X	X
Anaerobic basin with mixers	X	X	X	X
Anoxic basin with mixers				X
Mixed liquor recycle system modification				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 chemical feed and storage facility	$0.145	$0.145	$0.629	$0.629
Piping and flow structure modifications	$0.339	$0.339	$0.339	$0.387
Anaerobic basin with mixers	$1.040	$1.040	$1.040	$1.040
Anoxic basin with mixers	$0.000	$0.000	$0.000	$1.475
Mixed liquor recycle system modification	$0.000	$0.000	$0.000	$0.218
Secondary effluent pump station	$0.000	$0.000	$1.741	$1.741
Deep bed granular media filters	$0.000	$0.000	$6.989	$6.989
TOTAL TIER COST	**$1.524**	**$1.524**	**$10.738**	**$12.479**

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 either provided by the POTW or assumed based on the average cost 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 upgrades 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, mixing, intermediate pumping and mixed-liquor return pumping

TABLE 7
Operating and Maintainance Unit Costs

Parameter	Value
Biosolids hauling	$4.62/wet ton
Roundtrip hauling distance (1)	20 miles
Alum	$480/ton
Polymer	$0.99/lb
Power	$0.03/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	$0.001	$0.001	$0.001	$0.001	$0.001	$0.001	$0.001	$0.001
Metal-salt	$0.001	$0.001	$0.001	$0.001	$0.068	$0.090	$0.081	$0.108
Polymer	$0.001	$0.001	$0.001	$0.001	$0.001	$0.002	$0.001	$0.002
Power	$0.000	$0.003	$0.000	$0.003	$0.006	$0.011	$0.011	$0.016
Total O&M	**$0.003**	**$0.006**	**$0.003**	**$0.006**	**$0.076**	**$0.104**	**$0.094**	**$0.127**

Note: $ Million (US) in December 2009

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

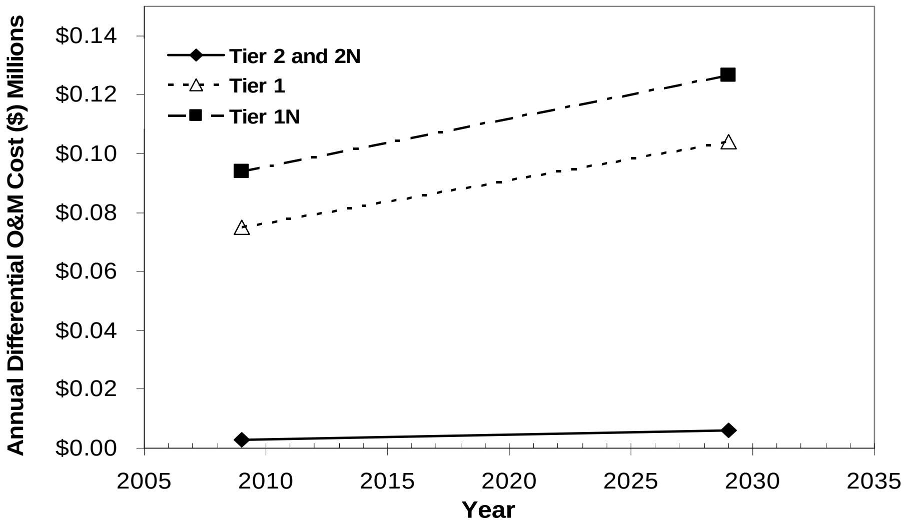

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

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

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	258,428	258,428	349,566	349,566
Nitrogen Removal (pounds)[2]	-	meets limit	-	1,012,649
Net Present Value of Removal Costs[3]	**$ 1,594,175**	**$ 1,594,175**	**$ 12,100,292**	**$ 14,159,247**
NPV: Phosphorus Allocation	1,594,175	1,594,175	12,100,292	12,100,292
NPV: Nitrogen Allocation[4]		-		2,058,955
TP Cost per Pound[5]	**$ 6.17**	**$ 6.17**	**$ 34.62**	**$ 34.62**
TN Cost per Pound[5]		**NA**		**$ 2.03**

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 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 TCWTP 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	$ 1,524,000	$ 1,524,000	$ 10,738,000	$ 12,479,000
Estimated Annual Debt Service[1]	$ 122,300	$ 122,300	$ 861,600	$ 1,001,300
Incremental Operating Cost[2]	3,200	3,200	76,600	95,900
Total Annual Cost Increase	$ 125,500	$ 125,500	$ 938,200	$ 1,097,200
Number of ERUs	3,990	3,990	3,990	3,990
Annual Cost Increase per ERU	$31.45	$31.45	$235.14	$274.99
Monthly Cost Increase per ERU[3]	**$2.62**	**$2.62**	**$19.59**	**$22.92**
Current Average Monthly Bill[4]	$22.44	$22.44	$22.44	$22.44
Projected Average Monthly Bill[5]	**$25.06**	**$25.06**	**$42.03**	**$45.35**
Percent Increase	**11.7%**	**11.7%**	**87.3%**	**102.1%**

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 TCWTP is shown in Table 11.

TABLE

Community Financial Impacts: Affordability of Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Median Annual Gross Income (MAGI)[1,2]	$ 41,900	$ 41,900	$ 41,900	$ 41,900
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$48.88**	**$48.88**	**$48.88**	**$48.88**
Projected Average Monthly Bill	$25.06	$25.06	$42.03	$45.35
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**51%**	**51%**	**86%**	**93%**

1 - Based on the average MAGI of customers within the service area of the facility

2 - MAGI statistics compiled from 2008 census data

11 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 TCWTP and per process modeling of the base condition (Tier 3), TCWTP 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 TCWTP 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	9,360	9,360	13,200	13,200
Total nitrogen removed, lb/year	----	0	----	42,620

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.

Currently TCWTP discharges to the Malad River, upstream to the Bear River. Table 13 shows the total phosphorus and total nitrogen concentration discharged by TCWTP to Malad River 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**
TCWTP	----	2.17	3.2	20.0	1.0	N/A	1.0	20.0	0.1	N/A	0.1	10.0
MALAD RIVER	4902720	705.73	0.18	1.99	----	----	----	----	----	----	----	----
Combined Concentration			**0.24**	**2.36**	**0.19**	**N/A**	**0.19**	**2.36**	**0.18**	**N/A**	**0.18**	**2.16**

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 below 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		5,000	5,000	281,100	330,800
Polymers, lb/year		50	50	1,100	1,100
Biosolids Management:					
Biosolids produced, ton/year		1	1	60	65
Average yearly hauling distance, miles(1)		0	0	55	60
Particulate emissions from hauling trucks, lb/year (2)		0	0	3	4
Tailpipe emissions from hauling trucks, lb/year(3)		0	0	7	8
CO_2 emissions from hauling trucks lb/year(4)		0	0	694	752
Energy Consumption:					
Annual energy consumption, kwh		3,650	3,650	193,500	377,775
Air pollutant emissions, lb/year (5)					
	CO_2	3,292	3,292	174,492	340,753
	NOx	5	5	271	529
	SOx	4	4	232	453
	CO	0	0	13	25
	VOC	0	0	2	3
	PM_{10}	0	0	4	7
	$PM_{2.5}$	0	0	2	4

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

(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)*.