UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Cedar City Wastewater Treatment Facility

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COPIES: Cedar City Wastewater Treatment Facility

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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 Cedar City Wastewater Treatment Facility (CCWWTF) 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 CCWWTF fits in the Trickling Filter 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	Base condition

1. Facility Overview

This facility is designed for 4.4 million gallons per day (mgd) and currently receives an average annual influent flow of 2.5 mgd. The facility operates a Trickling Filter process with primary treatment. Secondary solids are returned to plant headworks and settled in the primary clarifiers. Residual primary and secondary solids are stabilized using conventional mesophilic anaerobic digestion, dewatered with drying beds, and land applied for ultimate disposal. The trickling filter process is not operated to achieve nitrification as final effluent is land applied for irrigation. A process flow diagram is presented in Figure 1 and an aerial photo of the WWTF is shown in Figure 2. The major unit processes are summarized in Table 2.

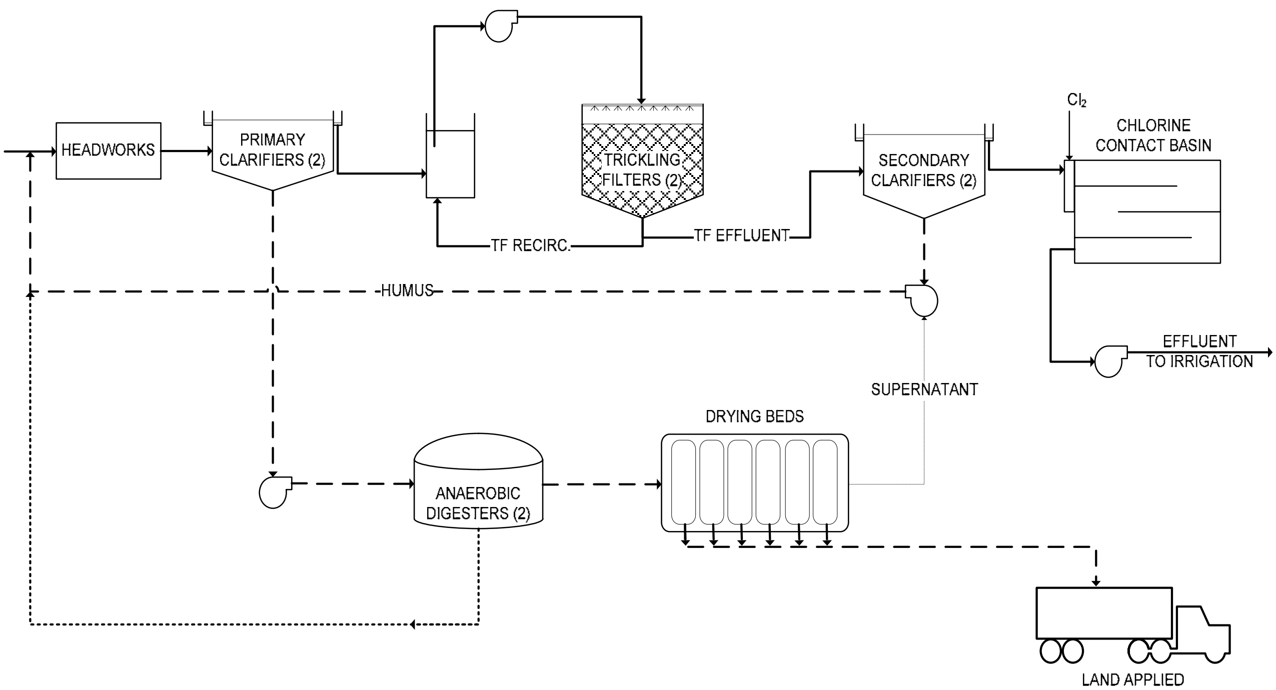

FIGURE 1
Process Flow Diagram

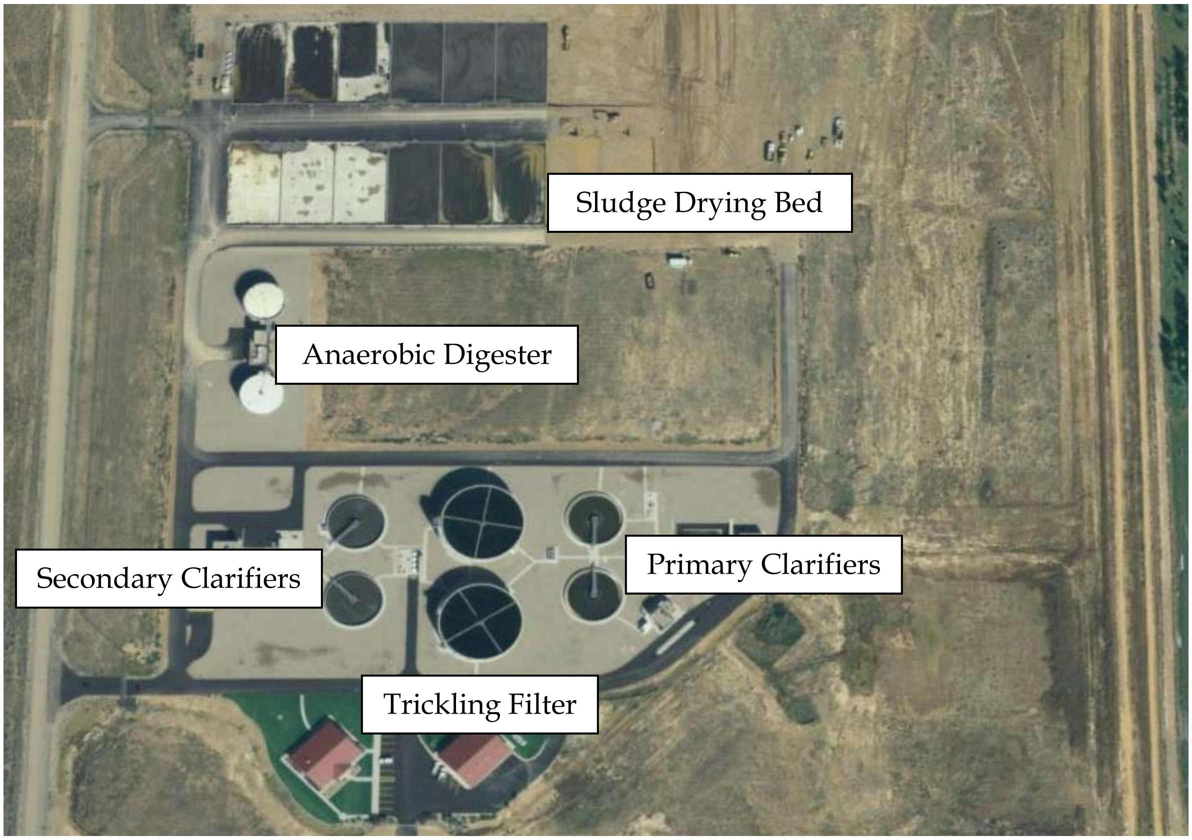

FIGURE 2
Aerial View of the Facility

TABLE 2
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifiers	2	70-ft diameter, 12-ft SWD	Primary solids typically 3%
Trickling filters	2	100-ft diameter, 16-ft SWD	Plastic Media (30ft^2/ft^3) w/ Natural Draft
Secondary clarifiers	2	70-ft diameter, 15-ft SWD	Center feed
Anaerobic digestion	2	385,000 gallons	Primary mixed & heated
Sludge drying beds	16	5,000 ft^2	Dried product ~ 90% solids

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 TF 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 CCWWTF has an investment in the TF process currently in operation. Rather than demolish the TF system, maximum use of the existing infrastructure was implemented in the proposed approaches to meet different nutrient limits. The existing process was modified 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. From Tier 3 (existing) to Tier 2 phosphorus control, multi-point feed metal-salt addition was initiated at the primary and secondary clarifiers.

B. To add nitrogen control to Tier 2, the primary effluent was distributed to both trickling filters and to the new biological nutrient removal (BNR) bioreactors. The TF effluent was then discharge to an aerobic zone within the bioreactor. Nutrients were removed from liquid stream primarily using biological processes. Multi-point metal-salt addition was retained from Tier 2.

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 upstream of the filters.

D. To achieve nitrogen control to Tier 1, the trickling filters were abandoned and the BNR bioreactors were expanded to accommodate the total flow. In addition, granular media filters were implemented with an additional metal-salt feed point for secondary effluent. Metal-salt addition upstream of the primary and secondary clarifiers was included to back-up the biological system.

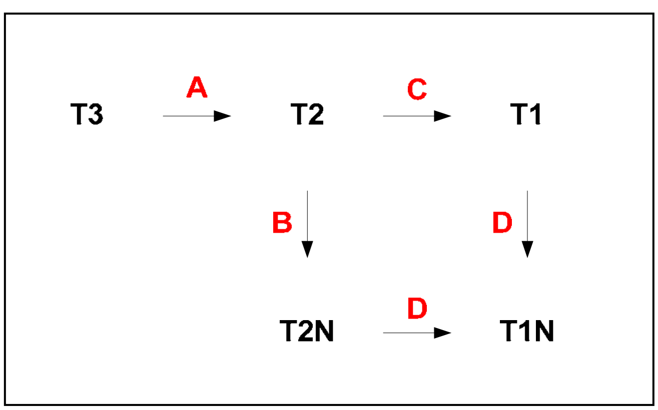

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for CCWWTF 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 CCWWTF 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. Table 3 provides a summary of the reported information used as the model input conditions. See process modeling protocol for additional information.

Projected 2029 influent flow and loading conditions provided by the utility exceed the facility's reported design capacity. Because this study is evaluating the cost impacts of nutrient removal and not capacity expansion, the 2029 average annual condition was modified to remain below plant capacity. This modification was made to maintain similarity between POTWs for the financial analysis.

TABLE 3
Summary of Input Conditions

Input Parameter	2009[(1)]	2029[(2)]	Design[(3)]
Flow, mgd	2.5	3.7	4.4
BOD, lb/day	5,796 (278 mg/L)	8,579 (278 mg/L)	9,614 (262 mg/L)
TSS, lb/day	6,000 (288 mg/L)	8,887 (288 mg/L)	9,284 (253 mg/L)
TKN, lb/day	876 (42 mg/L)	1,296 (42 mg/L)	1,835 (50 mg/L)
TP, lb/day	125 (6 mg/L)	185 (6 mg/L)	257 (7 mg/L)

(1) Historic conditions 2007-2008

(2) Reported 2029 flows and loading conditions exceed design condition. (reported 2029 Flow = 5.5 mgd), thus, assumed to be 3.7 mgd (1.2 (peaking factor) times less than the POTW design capacity)

(3) Reported design capacity of POTW

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

TABLE 4
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Influent design temperature (All Tiers)	14° C
Target metal:PO_4-P molar Ratio (All Tiers)	1:1, 2:1, 7:1 (1)
Metal salt storage (All Tiers)	14 days
Portion of primary effluent bypassed around TFs (T2N)	50%
Anoxic fraction of bioreactor (T2N, T1N)	44%
Anaerobic fraction of bioreactor (T2N, T1N)	10%
Mixed-Liquor return pumping ratio as a percent of influent Flow (T2N, T1N)	150%
Bioreactor SRT (T2N, T1N)	9 days
Granular filter loading rate (T1 and T1N)	5 gpm/ft^2 (2)

(1) Target dosing ratio at the primary clarifiers, secondary clarifiers and upstream of polishing filter, respectively. Note that polishing filters were implemented in T1 and T1N only.

(2) Hydraulic loading rate at peak hourly flow

3. Nutrient Upgrade Approaches

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

Tier 2 Phosphorus (A)

The CCWWTF can achieve the 1.0 mg/L total phosphorus goal of this Tier by adding a metal-salt addition system to the existing unit process facilities. The process modeling effort simulated a dual-feed strategy with metal-salt, at both the primary clarifiers and the secondary clarifiers. The expanded metal-salt addition concept included metal-salt addition to the recycle stream comprised of digester supernatant. This provided the utility with operational flexibility to add chemical upstream of the secondary clarifiers or at the recycle stream. A process flow diagram for this treatment approach is presented in Figure 4.

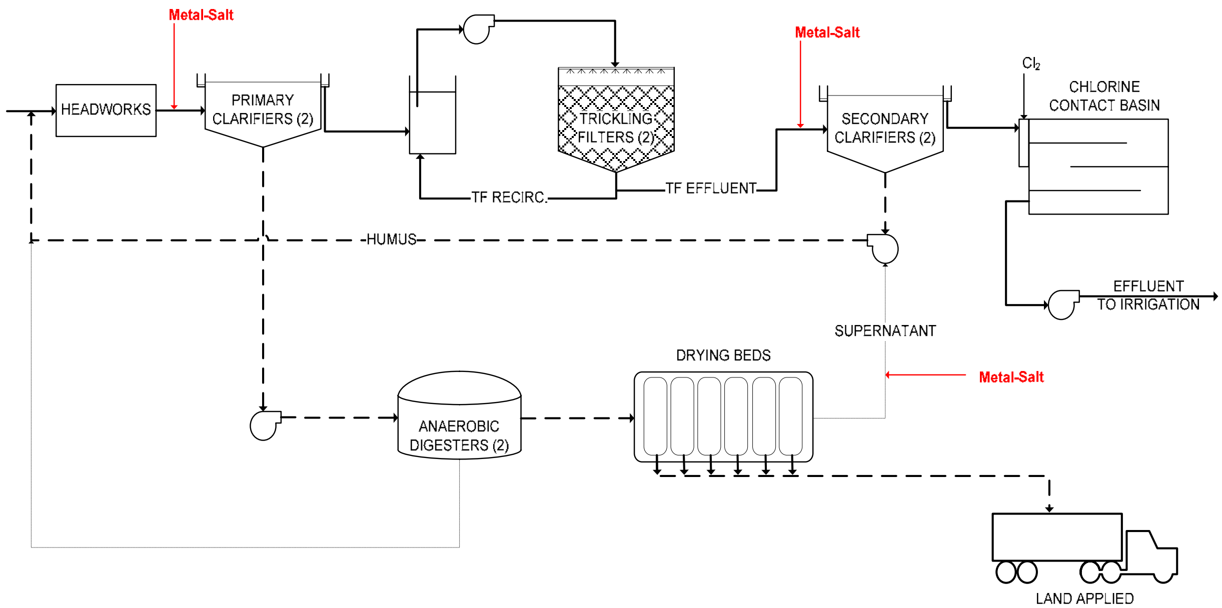

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

For this alternative, biological processes were the primary approach for removing nutrients from the liquid stream. The dual-feed metal-salt addition for phosphorus control (described in Tier 2) remained in place to back-up the biological processes. This approach split the primary effluent flow 50:50 to the tricking filters and to a new biological nutrient removal reactor system. The reduced loading to the trickling filters promoted nitrification. Trickling filter effluent was then discharged to an aerobic zone within the bioreactor to seed nitrifiers to the suspended growth system. The bioreactor included separate anaerobic, anoxic, and aerobic zones for BNR with an influent BOD: TP ratio of 29:1. New secondary clarifiers complete with RAS/WAS pumps and gravity belt thickeners were also required for the BNR system. A process flow diagram of this approach is provided in Figure 5.

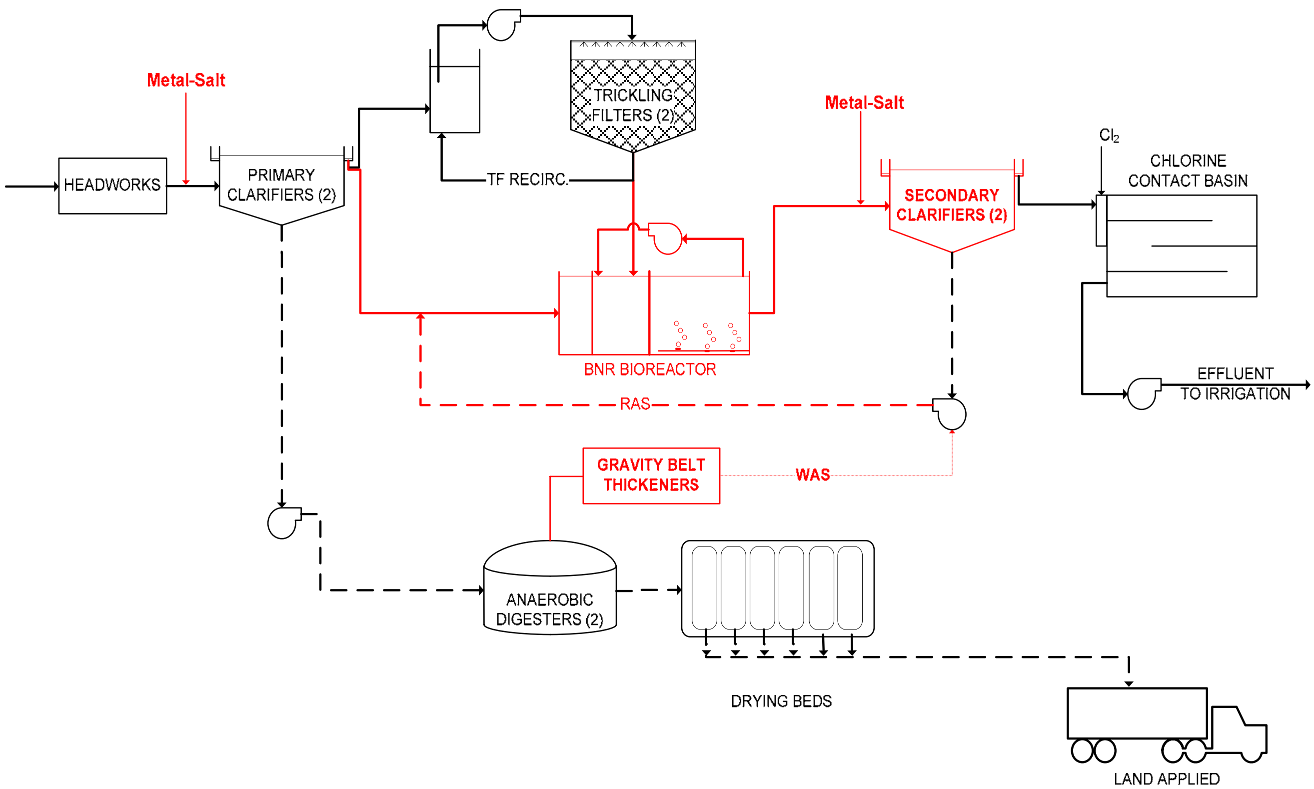

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. The trickling filter effluent was dosed with metal-salt and polymer and then flash-mixed prior to entering the secondary clarifiers. Settled secondary effluent was then pumped to deep bed granular media filters. An additional feed point for metal-salt addition was added just upstream of the filters. A process flow diagram of this approach is provided in Figure 6.

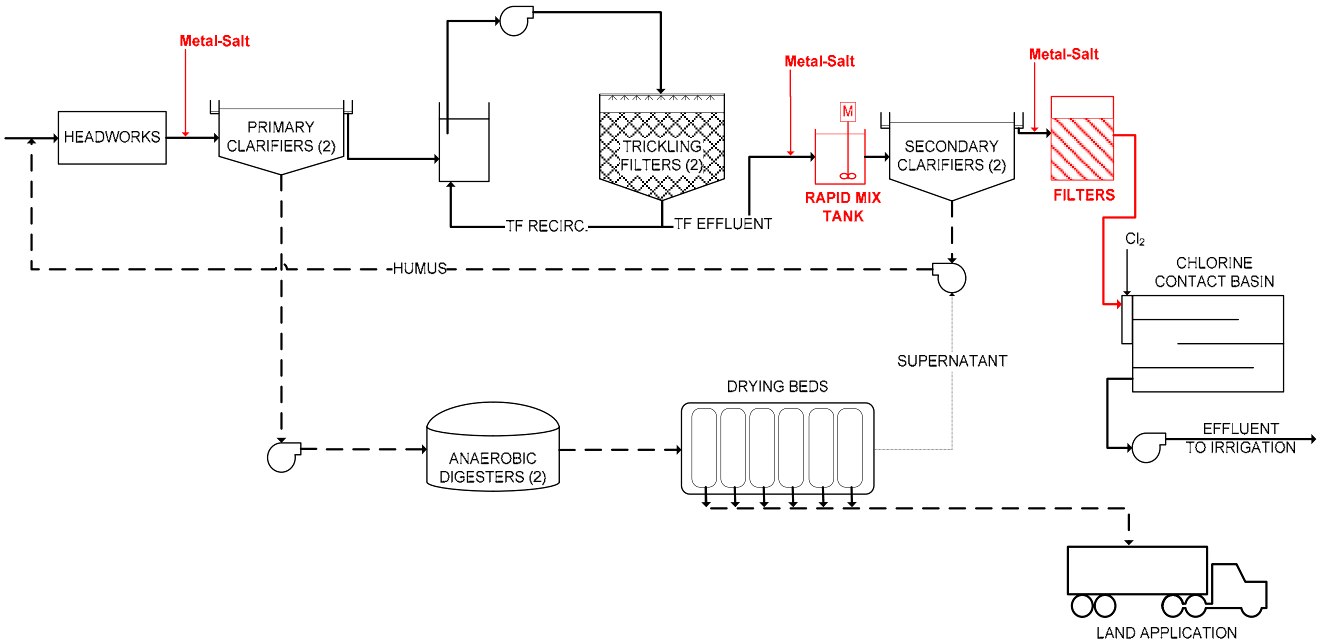

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach replaced the trickling filter process entirely by implementing new BNR bioreactors for 100% of the primary effluent flow. A metal-salt feed system was used remove the remaining phosphorus that the bioreactor does not remove. A granular media filter system was constructed to aid in the removal of particulate phosphorus. A process schematic of this approach is presented in Figure 7.

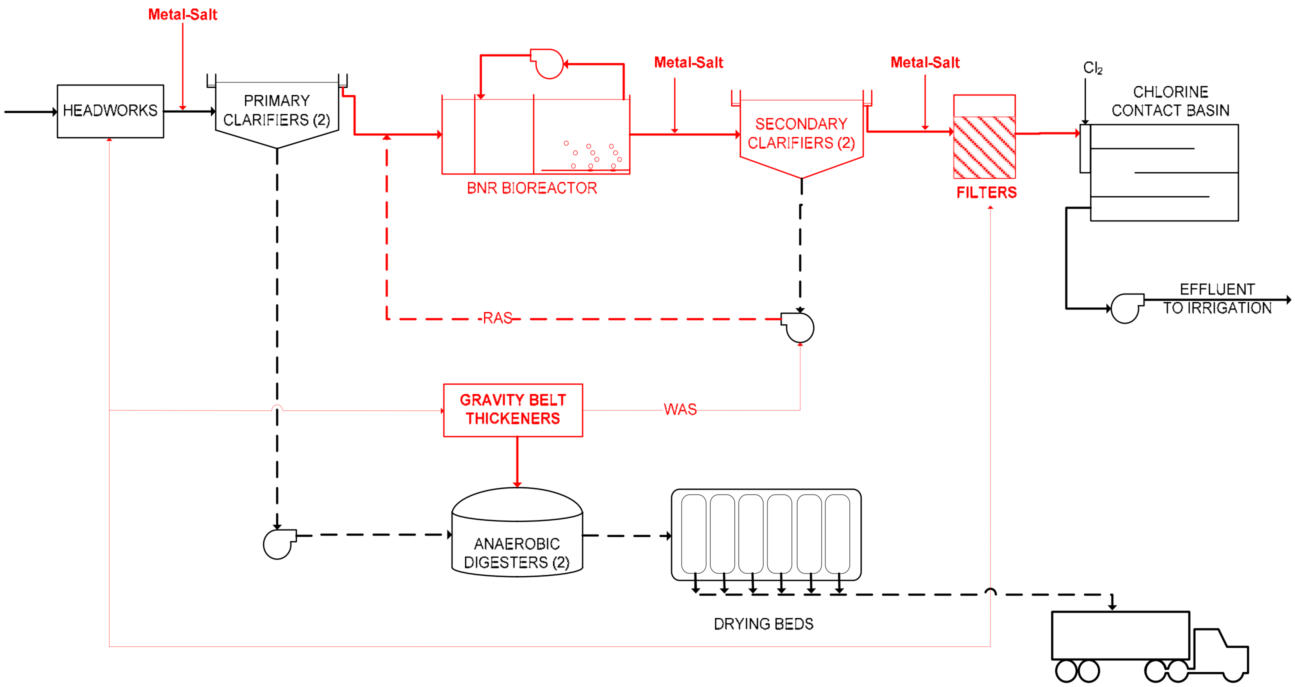

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Control

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 all Tiers, a new metal-salt feed and storage facility was required. For Tier 2N, a flow distribution structure would be required to split the primary effluent to the trickling filters and the new BNR bioreactor with anaerobic, anoxic and aerobic zones. The bioreactor included diffused aeration, blower building, mixed-liquor return pumps, and a series of mixers. Tier 1 alternative for phosphorus control required a secondary effluent pump station to lift the flow to new deep bed granular media filters. With Tier 1N, the BNR bioreactor was expanded to treat 100% of the flow.

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
Primary effluent distribution structure		X		
Bioreactors with anaerobic, anoxic and aerobic zones		X		X
Mixed liquor recirculation system		X		X
Secondary clarifiers		X		X
Gravity belt thickeners		X		X
Secondary effluent pump station			X	X
Rapid mix tank			X	X
Granular media filtration system			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 Facility	$0.678	$0.610	$0.822	$0.653
Anaerobic Basins with Mixers	$0.000	$1.161	$0.000	$1.838
Anoxic Basins with Mixers	$0.000	$1.620	$0.000	$2.442
Aerobic Basins with Mixers	$0.000	$2.007	$0.000	$3.216
NRCY Pumps	$0.000	$0.242	$0.000	$0.314
Flow Split Structure	$0.000	$0.460	$0.000	$0.290
Blower Building	$0.000	$1.330	$0.000	$2.201
Gravity Belt Thickener	$0.000	$0.435	$0.000	$0.435
Secondary Clarifiers	$0.000	$1.301	$0.000	$1.301
RAS+WAS Pumps	$0.000	$0.435	$0.000	$0.435
Rapid Mix Tank	$0.000	$0.000	$0.677	$0.000
Secondary Effluent Pumps	$0.000	$0.000	$2.370	$2.370
Deep Bed Granular media filters	$0.000	$0.000	$10.42	$10.42
TOTAL TIER COST	**$0.678**	**$9.596**	**$14.293**	**$25.921**

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 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, backwash pumps and dewatering units

TABLE 7
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$0/wet ton
Biosolids tipping fee	$0/wet ton
Roundtrip biosolids hauling distance (1)	None
Ferric chloride	$1000/ton
Polymer	$1/lb
Power	$0.07/kwh

(1) CCWWTF gives away the biosolids to the public or to farms, thus no hauling is required

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	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Metal-salt	$0.14	$0.17	$0.05	$0.05	$0.20	$0.23	$0.19	$0.30
Polymer	$0.01	$0.02	$0.00	$0.02	$0.02	$0.03	$0.00	$0.01
Power	$0.01	$0.00	$0.11	$0.16	$0.02	$0.03	$0.18	$0.27
Total O&M	**$0.15**	**$0.19**	**$0.16**	**$0.23**	**$0.24**	**$0.29**	**$0.37**	**$0.58**

Note: $ Million (US) in December 2009

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

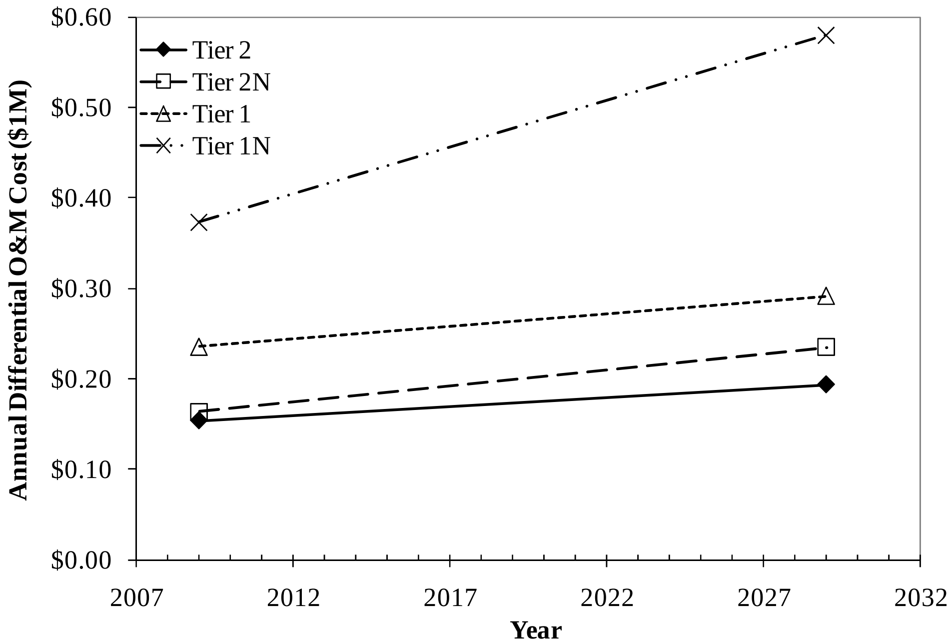

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

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

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	625,361	625,361	796,948	796,948
Nitrogen Removal (pounds)[2]	-	2,097,173	-	4,003,693
Net Present Value of Removal Costs[3]	**$ 3,325,021**	**$ 12,480,029**	**$ 18,310,285**	**$ 33,154,342**
NPV: Phosphorus Allocation	3,325,021	3,325,021	18,310,285	18,310,285
NPV: Nitrogen Allocation[4]		9,155,008		14,844,057
TP Cost per Pound[5]	**$ 5.32**	**$ 5.32**	**$ 22.98**	**$ 22.98**
TN Cost per Pound[5]		**$ 4.37**		**$ 3.71**

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 CCWWTF 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	$ 677,000	$ 9,596,000	$ 14,293,000	$ 25,921,000
Estimated Annual Debt Service[1]	$ 54,300	$ 770,000	$ 1,146,900	$ 2,080,000
Incremental Operating Cost[2]	155,900	166,300	238,700	383,900
Total Annual Cost Increase	$ 210,200	$ 936,300	$ 1,385,600	$ 2,463,900
Number of ERUs	9,990	9,990	9,990	9,990
Annual Cost Increase per ERU	$21.04	$93.72	$138.70	$246.64
Monthly Cost Increase per ERU[3]	**$1.75**	**$7.81**	**$11.56**	**$20.55**
Current Average Monthly Bill[4]	$23.61	$23.61	$23.61	$23.61
Projected Average Monthly Bill[5]	**$25.36**	**$31.42**	**$35.17**	**$44.16**
Percent Increase	**7.4%**	**33.1%**	**49.0%**	**87.1%**

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 CCWWTF 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]	$ 31,800	$ 31,800	$ 31,800	$ 31,800
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$37.10**	**$37.10**	**$37.10**	**$37.10**
Projected Average Monthly Bill	$25.36	$31.42	$35.17	$44.16
Meets State's Affordability Criterion?	Yes	Yes	Yes	No
Estimated Bill as % of State Criterion	**68%**	**85%**	**95%**	**119%**

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 CCWWTF and per process modeling of the base condition (Tier 3), CCWWTF 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 CCWWTF 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	24,555	24,555	31,405	31,405
Total nitrogen removed, lb/year	----	81,700	----	157,800

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 impact of effluent load reductions on receiving streams or 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 requirements. 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 CCWWTF, no STORET data was found upstream to the POTW discharge point. Thus, total phosphorus and total nitrogen concentration discharged by CCWWTF 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 13 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 13
Estimated Environmental Impacts of Nutrient Control

		Tier 2	Tier 2N	Tier 1	Tier 1N
Chemical Use:					
Metal-salt use, lb/year		279,550	91,250	390,686	372,092
Polymers, lb/year		7,226	1,830	8,726	1,611
Biosolids Management:					
Biosolids produced, ton/year		180	45	215	40
Average yearly hauling distance[(1)]		0	0	0	0
Particulate emissions from hauling trucks, lb/year [(2)]		0	0	0	0
Tailpipe emissions from hauling trucks, lb/year[(3)]		0	0	0	0
CO_2 emissions from hauling trucks lb/year[(4)]		0	0	0	0
Energy Consumption:					
Annual energy consumption, kwh		0	1,635,918	335,826	2,631,775
Air pollutant emissions, lb/year [(5)]					
	CO_2	0	1,475,598	302,915	2,373,861
	NOx	0	2,290	470	3,684
	SOx	0	1,963	403	3,158
	CO	0	107	22	173
	VOC	0	13	3	21
	PM_{10}	0	32	7	52
	$PM_{2.5}$	0	16	3	26

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

[(1)] CCWWTF gives away all its biosolids to public or to a farm. Thus no hauling is required

[(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)*.