UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Central Weber Sewer Improvement District

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COPIES: Central Weber Sewer Improvement District

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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 Central Weber Sewer Improvement District (CWSID) 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 CWSID fits in the Hybrid Process 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

CWSID has an average annual design flow of 52.1 million gallons per day (mgd) and currently receives an average annual flow of approximately 30.4 mgd. The existing facility operates a single-stage trickling filter treatment process with primary treatment and disinfection. Solids from the process are stabilized using conventional mesophilic anaerobic digestion, mechanically dewatered using belt filter presses, and either composted or land filled. The secondary treatment process is operated to meet the plant's seasonal ammonia limits. The plant is currently undergoing upgrades and expansion to meet the increasing demands for sewer services, and to satisfy the required discharge limits. The upgrades include addition of a new treatment train with headworks, primary clarifiers, an activated sludge basin with anoxic zones, chlorination and dechlorination system and improved solids handling. The influent flow to the facility will be split equally between the new activated sludge and the existing trickling filter processes. Trickling filter residuals will be co-settled in the primary clarifier of the trickling filter train. Primary solids from both trains and the thickened waste activated sludge (WAS) from the activated sludge train will be stabilized using conventional anaerobic digestion, dewatered, and either composted or disposed in a landfill. A process flow diagram for the POTW is presented in Figure 1. All unit processes represented in black indicate the existing facilities, while all processes in blue indicate the new facilities that are currently being added to the POTW. An aerial photo of the existing facility is shown in Figure 2 (note the new facilities are not yet constructed) and the major unit processes are summarized in Table 2.

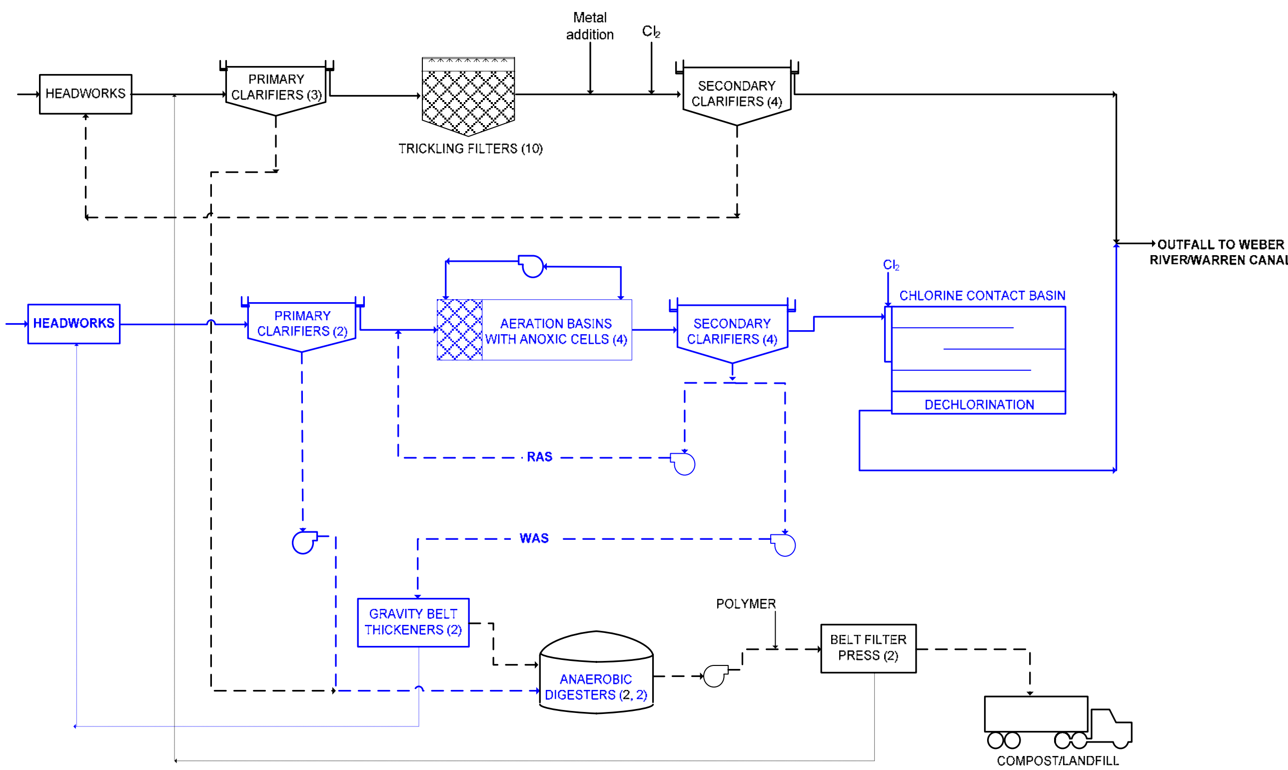

FIGURE 1
Process Flow Diagram of CWSID

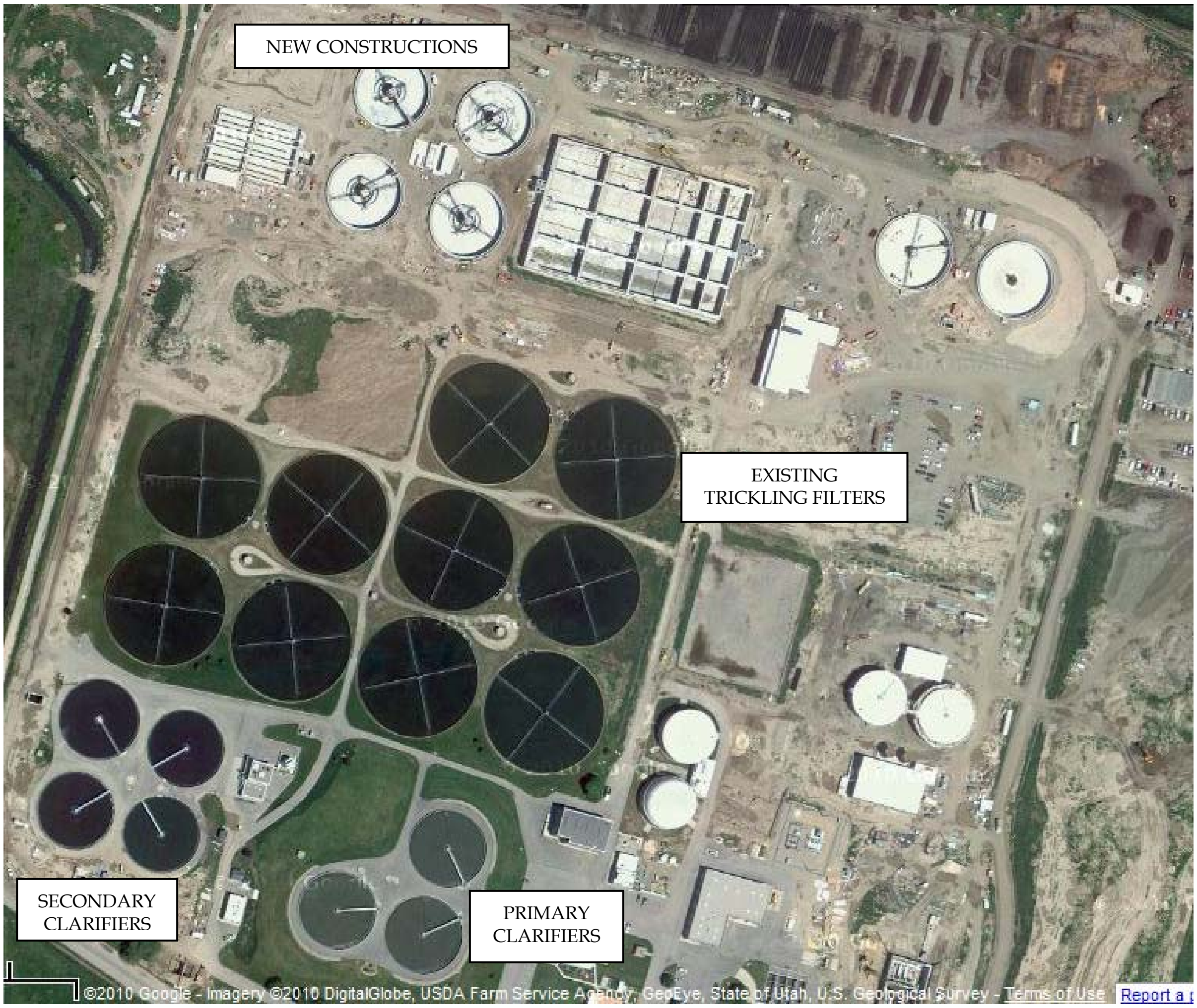

FIGURE 2
Aerial View of CWSID

TABLE 2
Summary of Major Unit Processes

Treatment step	Number of Units	Size, each	Details
Primary Clarifiers	5	3 clarifiers – 140-ft diameter, 7-ft SWD 2 clarifiers – 145-ft diameter, 12-ft SWD	3 existing and 2 new primary clarifiers
Trickling Filters	10	230-ft diameter, 5.25-ft media depth	Rock media
Aeration Basins with anoxic cells	4	2.9 MG	New process Total 22% anoxic volume Diffused aeration system for aeration basins
Blowers	3	Motor size – 700 hp	New equipment Single-stage centrifugal
Secondary Clarifiers	8	3 clarifiers – 140-ft diameter, 7-ft SWD and 1 clarifier – 160-ft diameter, 12-ft SWD at trickling filter train 4 clarifiers - 145-ft diameter, 16-ft SWD at the activated sludge train	4 existing and 4 new clarifiers Ferric chloride is added ahead of the existing secondary clarifiers in the trickling filter train
WAS Thickening	2	2 meter	New gravity belt thickeners
Anaerobic Digestion	3 Primary Digesters 1 Secondary Digester	Primary Digesters: 1.59 MG Secondary Digester: 1.43 MG	Anaerobic mesophilic 1 existing and 2 new primary digesters Existing secondary digester
Sludge Dewatering	2	2 meter	Existing belt filter presses

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.

CWSID will have two treatment trains after the upgrades, with significant investment in the recent infrastructure. This being the case, it was decided that a phased transition from the current process to an activated sludge treatment process only would make the most optimal use of the existing and the new facilities to meet 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 process) to Tier 2 phosphorus control, the new aeration basin was operated for enhanced biological phosphorus uptake by running the anoxic zones as anaerobic zones. Metal-salt was added at the secondary clarifiers of the trickling filters, while a new metal-salt addition system was provided at the secondary clarifiers of the activated sludge process as a back-up to biological phosphorus removal.

B. To go from Tier 2 to Tier 2N level of nutrient control, the aeration basins were converted to a biological nutrient removal (BNR) process with anaerobic, anoxic and aerobic zones. Metal-salt was added at the secondary clarifiers of the trickling filters for phosphorus removal, while the new metal salt addition system at the secondary clarifiers of the activated sludge process proposed for Tier 2 alternative was operated as a back-up for enhanced biological phosphorus removal.

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

D. To add nitrogen removal to Tier 1, the BNR process added in Tier 2N was expanded to treat 100% of the influent flow, while the trickling filter train was decommissioned. New secondary clarifiers were added after the BNR process to accommodate the entire plant flow. The deep bed granular media filters and intermediate pump stations described for Tier 1 were also included for this Tier with additional metal-salt feed point before the filters.

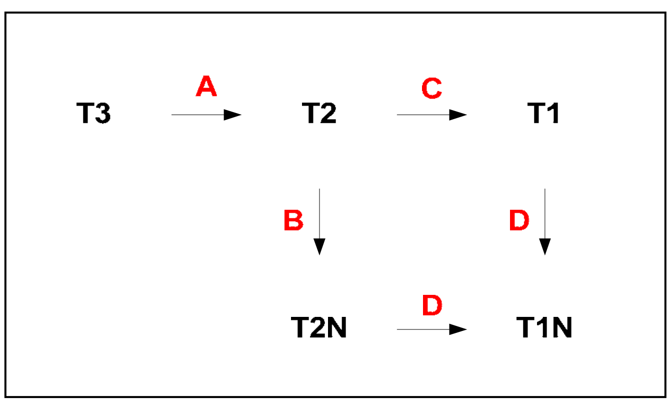

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for CWSID 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 CWSID 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	30.4	43.0	65.1
BOD, lb/day	31,605 (125 mg/L)	42,000 (117 mg/L)	69,000 (127 mg/L)
TSS, lb/day	36,806 (145 mg/L)	51,500 (145 mg/L)	78,400 (145 mg/L)
TKN, lb/day	4,878 (20 mg/L)	7,051[1] (20 mg/L)	10,675 (20 mg/L)
TP, lb/day	708 (3 mg/L)	1,030[1] (3 mg/L)	1,630[1] (3 mg/L)

[1] Historic conditions 2007-2008
[2] Projected by the POTW
[3] Design maximum month capacity of POTW

The main sizing and operating design criteria that are associated with the system upgrade for CWSID 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 (All Tiers)	14 days
Fraction of anaerobic volume in the BNR process (All Tiers)	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)	2 (3)
SVI (All Tiers)	180
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.

(2) Hydraulic loading rate at peak hourly flow

(3) SRT in the BNR process adjusted to maintain a nitrification safety factor of 2

3. Nutrient Upgrade Approaches

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

Tier 2 - Phosphorus (A)

The effluent limit for Tier 2 nutrient control alternative is 1.0 mg/L total phosphorus. To achieve this limit of phosphorus control, the anoxic zones in the aeration basins of the activated sludge train were operated as anaerobic zones for enhanced biological phosphorus removal. This was achieved by turning off the mixed liquor recycling pumps. A metal-salt addition system was implemented at the secondary clarifiers of the activated sludge train to be operated only as a back-up to biological phosphorus removal. The existing metal-salt addition system ahead of the secondary clarifiers of the trickling filter train was operated to chemically remove phosphorus from this train. A process flow diagram for this alternative is presented in Figure 4.

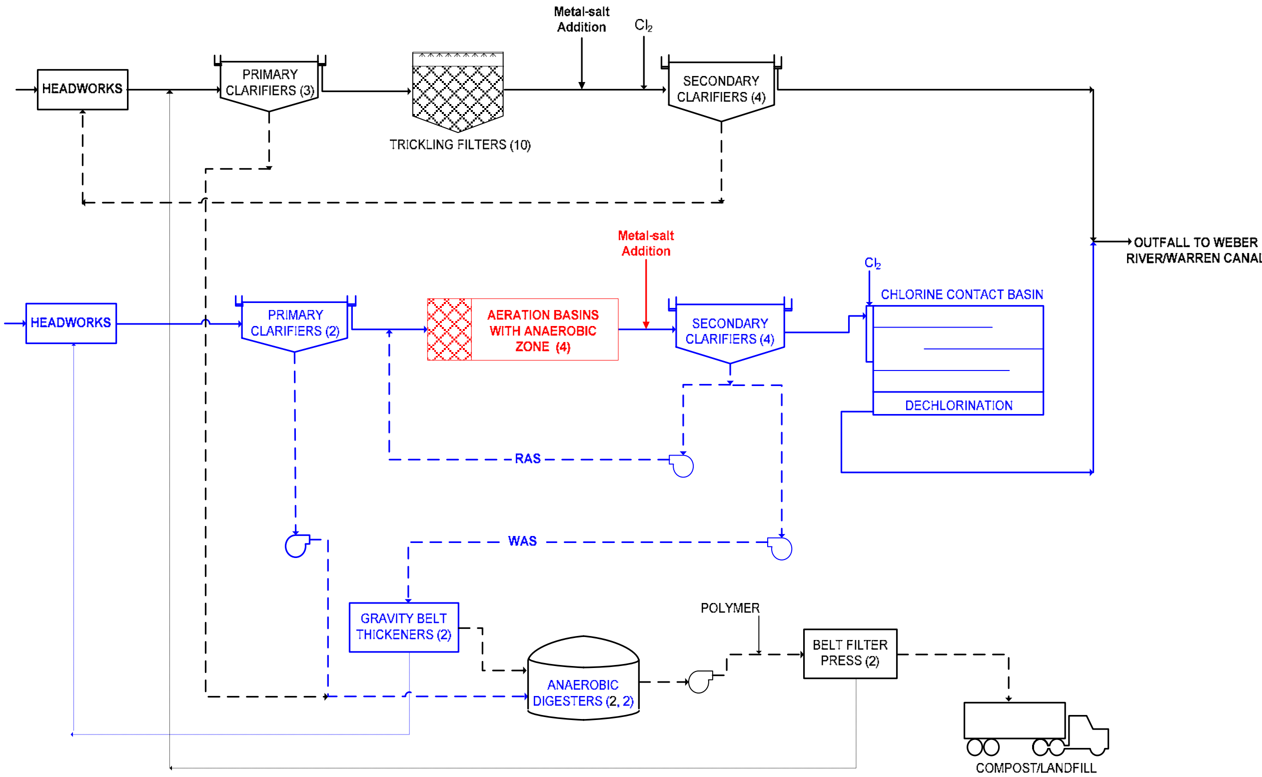

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N - Phosphorus & Nitrogen (B)

The effluent limit for this alternative is 1.0 mg/L total phosphorus and 20 mg/L total nitrogen. According to the process modeling for this scenario, CWSID was able to meet these limits by installing an anaerobic zone upstream of the anoxic zones in the new activated sludge process basins. This converted the anoxic-oxic process primarily designed for biological nitrogen removal to a combined BNR process. Metal-salt was added at the secondary clarifiers only as a back-up for biological phosphorus removal. Structural and mechanical additions and modifications were required to accommodate this to the existing facility. The trickling filter train remained unchanged. Because the influent TKN concentration to the plant is approximately 20 mg/L, CWSID can accomplish the total nitrogen limit without any upgrades to the trickling filter train. However, metal-salt was added ahead on the clarifiers to chemically remove phosphorus as described for the Tier 2 alternative. A process flow diagram for this alternative is presented in Figure 5.

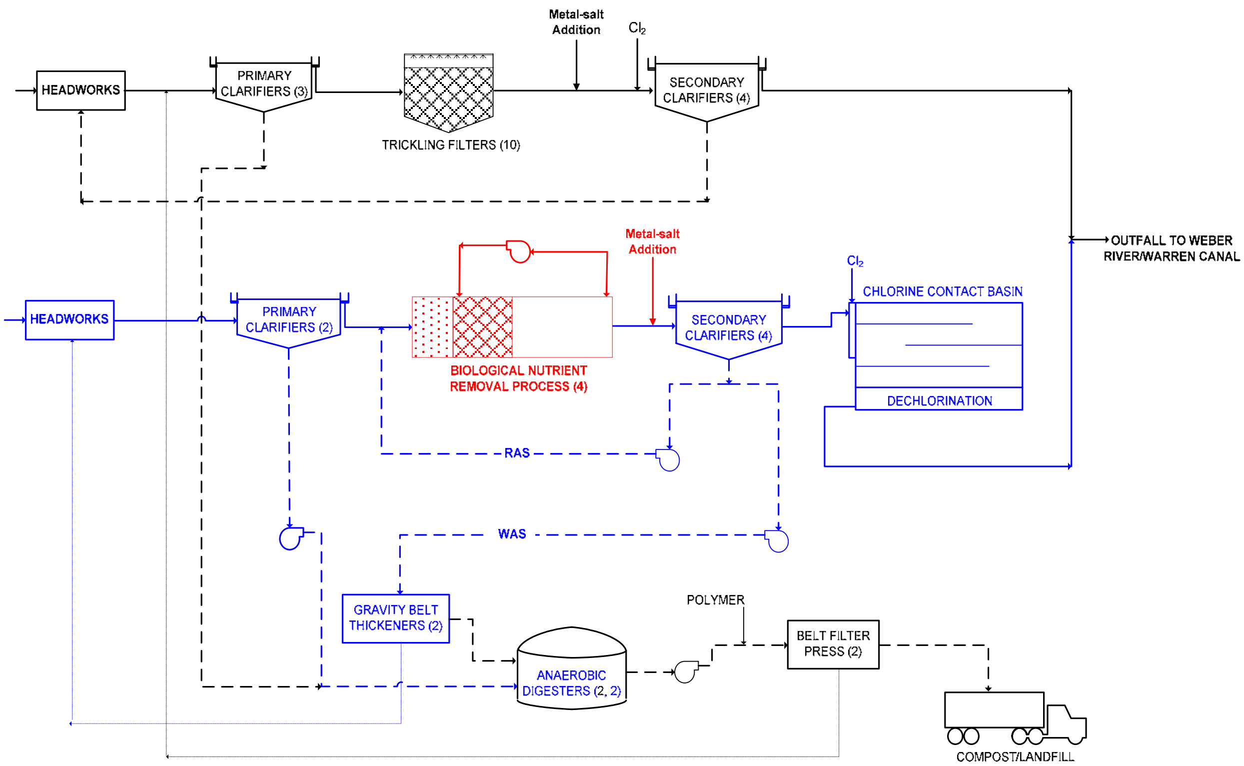

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Control

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 alternative that implements a biological phosphorus removal process by operating the anoxic zones in the activated sludge basins as anaerobic zones. Additionally, the secondary effluent from both treatment trains was pumped to deep bed granular media filters with a feed point for metal-salt addition just upstream. This achieved chemical phosphorus polishing. Figure 6 provides the process flow diagram of Tier 1.

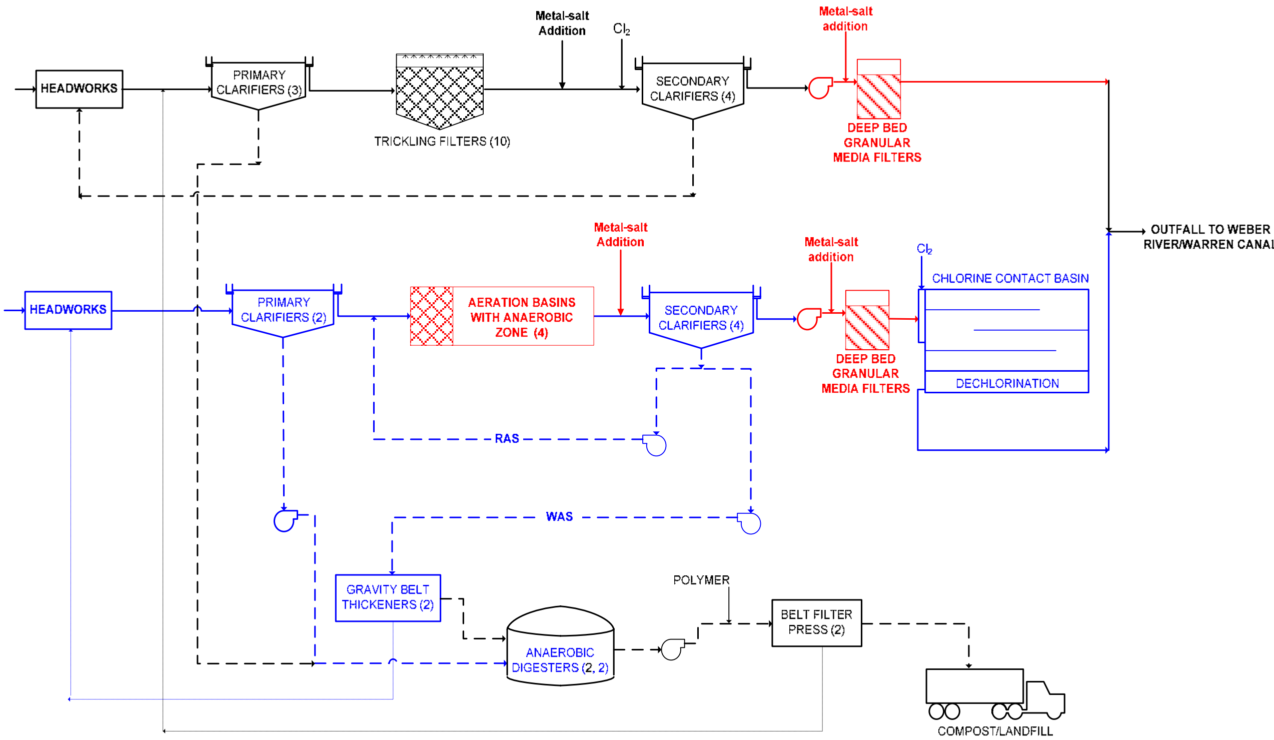

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N - Phosphorus & Nitrogen (D)

This approach builds on Tier 2N and Tier 1 by completely phasing out the trickling filter train and replacing it with an expanded BNR process sized to treat 100% of the plant influent. This required additional basin volume, with structural and mechanical upgrades and modifications. Additional primary and secondary clarifiers were needed to handle the entire flow of the plant. With a complete BNR process, metal-salt consumption at the secondary clarifiers was driven only as a backup to enhanced biological uptake of phosphorus. However, metal-salt was added upstream of the granular media filters for chemical phosphorus polishing. A process flow diagram for this alternative is presented in Figure 7.

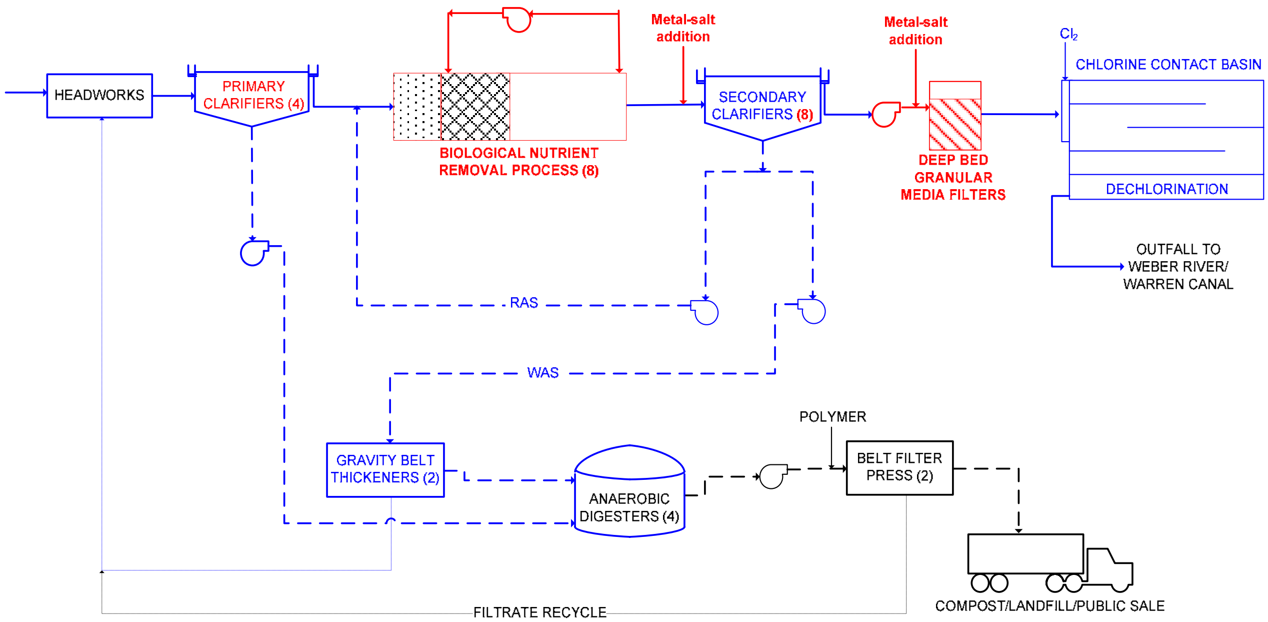

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Control

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, the existing metal-salt storage facility was augmented with additional storage and new feed pumps at the secondary clarifiers of the activated sludge train. For Tier 2N, the existing anoxic zone in the activated sludge basins were modified to accommodate the anaerobic zone. For Tier 1 phosphorus control, secondary effluent pump stations were needed, along with new deep bed granular media filters. For Tier 1N the BNR system identified for Tier 2N was expanded to treat the entire flow. This required additional tank volume, structural and mechanical modifications and primary and secondary clarifiers.

TABLE 5
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt storage and feed facility	X	X	X	X
Flow split structure and piping modifications		X		X
Anaerobic basins with mixers				X
Anoxic basins with mixers				X
Aerobic basins				X
Blower system and building expansion				X
RAS/WAS pumps				X
Primary clarifiers				X
Secondary clarifiers				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 storage and feed facility	$0.87	$0.87	$4.43	$4.43
Flow split structure and piping modifications	$0.00	$0.15	$0.00	$1.55
Anaerobic basins with mixers	$0.00	$0.00	$0.00	$6.58
Anoxic basins with mixers	$0.00	$0.00	$0.00	$9.89
Aerobic basins	$0.00	$0.00	$0.00	$9.43
Blower system and building expansion	$0.00	$0.00	$0.00	$3.26
RAS/WAS pumps	$0.00	$0.00	$0.00	$2.90
Primary clarifiers	$0.00	$0.00	$0.00	$9.58
Secondary clarifiers	$0.00	$0.00	$0.00	$19.15
Secondary effluent pump station	$0.00	$0.00	$13.50	$13.50
Deep bed granular media filters	$0.00	$0.00	$75.41	$75.41
TOTAL TIER COST	**$0.87**	**$1.02**	**$93.34**	**$155.68**

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 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, secondary effluent pumps and backwash pumps

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) CWSID composts all biosolids onsite

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	$0.47	$0.70	$0.45	$0.52	$1.20	$1.28	$0.83	$1.20
Polymer	$0.02	$0.03	$0.02	$0.04	$0.06	$0.07	$0.04	$0.04
Power	($0.02)	($0.02)	$0.14	$0.25	$0.25	$0.37	$0.75	$0.89
Total O&M	**$0.47**	**$0.72**	**$0.61**	**$0.81**	**$1.51**	**$1.72**	**$1.62**	**$2.13**

Note: $ Million (US) in December 2009

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

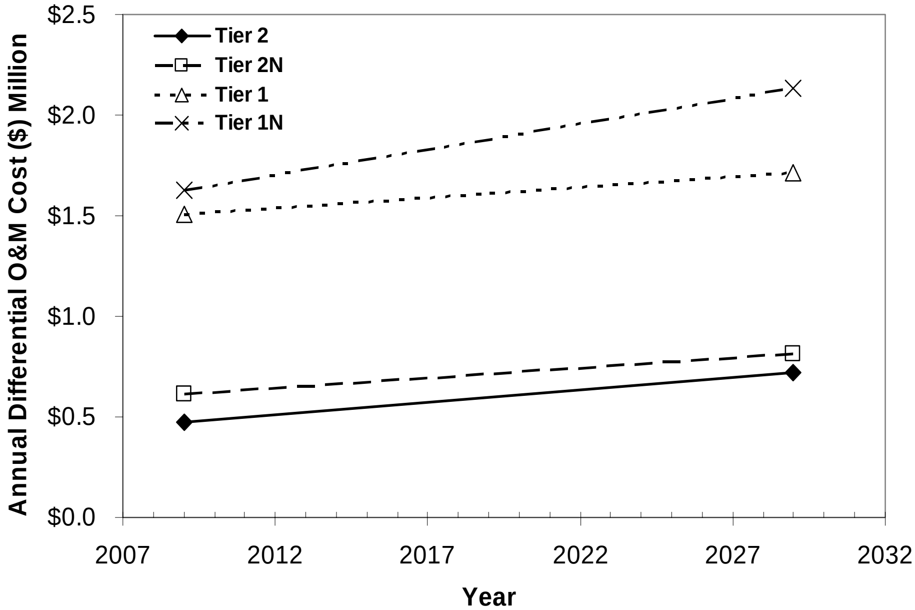

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

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

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	4,634,004	4,634,004	6,663,169	6,663,169
Nitrogen Removal (pounds)[2]	-	meets limit	-	22,546,281
Net Present Value of Removal Costs[3]	**$ 9,929,763**	**$ 11,852,688**	**$ 117,932,520**	**$ 184,280,149**
NPV: Phosphorus Allocation	9,929,763	9,929,763	117,932,520	117,932,520
NPV: Nitrogen Allocation[4]		1,922,924		66,347,629
TP Cost per Pound[5]	**$ 2.14**	**$ 2.14**	**$ 17.70**	**$ 17.70**
TN Cost per Pound[5]		**NA**		**$ 2.94**

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 CWSID 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	$ 1,016,000	$ 93,329,000	$ 155,677,000
Estimated Annual Debt Service[1]	$ 69,900	$ 81,500	$ 7,489,000	$ 12,491,900
Incremental Operating Cost[2]	486,700	622,400	1,518,300	1,649,600
Total Annual Cost Increase	$ 556,600	$ 703,900	$ 9,007,300	$ 14,141,500
Number of ERUs	47,500	47,500	47,500	47,500
Annual Cost Increase per ERU	$11.72	$14.82	$189.63	$297.72
Monthly Cost Increase per ERU[3]	**$0.98**	**$1.23**	**$15.80**	**$24.81**
Current Average Monthly Bill[4]	$15.50	$15.50	$15.50	$15.50
Projected Average Monthly Bill[5]	**$16.47**	**$16.73**	**$31.30**	**$40.31**
Percent Increase	**6.3%**	**8.0%**	**102.0%**	**160.1%**

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) 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 CWSID is shown in Table 11.

TABLE 11

CENTRAL WEBER				
Community Financial Impacts: Affordability of Treatment Alternatives				
	Tier 2	**Tier 2N**	**Tier 1**	**Tier 1N**
Median Annual Gross Income (MAGI)[1,2]	$ 39,400	$ 39,400	$ 39,400	$ 39,400
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$45.97**	**$45.97**	**$45.97**	**$45.97**
Projected Average Monthly Bill	$16.47	$16.73	$31.30	$40.31
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**36%**	**36%**	**68%**	**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 CWSID and per process modeling of the base condition (Tier 3), PCWID 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 CWSID 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	182,725	182,725	266,015	266,015
Total nitrogen removed, lb/year	----	0	----	925,405

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 CWSID 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**
CWSID	----	47.03	3.00	20.00	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Weber River	4920120	392.03	0.20	0.98	----	----	----	----	----	----	----	----
Combined Concentrations			**0.50**	**3.02**	**0.29**	**N/A**	**0.29**	**3.02**	**0.19**	**N/A**	**0.19**	**1.95**

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		942,190	905,565	2,400,422	1,668,868
Polymers, lb/year		22,954	24,215	56,411	35,903
Biosolids Management:					
Biosolids produced, ton/year		575	605	1,410	900
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	1,936,526	3,595,457	10,770,843
Air pollutant emissions, lb/year (5)					
	CO_2	0	1,746,747	3,243,102	9,715,300
	NOx	0	2,711	5,034	15,079
	SOx	0	2,324	4,315	12,925
	CO	0	127	236	707
	VOC	0	15	28	85
	PM_{10}	0	38	71	212
	$PM_{2.5}$	0	19	35	106

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

(1) CWSID composts all biosolids onsite. 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)*.