UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Central Valley Water Reclamation Facility

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DATE: September 2010

In partial fulfillment of the Utah Division of Water Quality *Publicly Owned Treatment Works (POTW) Nutrient Removal Cost Impacts Study,* this Technical Memorandum (TM) summarizes the process, financial and environmental evaluation of the Central Valley Water Reclamation Facility (CVWRF) 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 Ditches (OD)
- Activated Sludge (AS)
- Membrane Bioreactors (MBR)
- Trickling Filters (TF)
- Hybrid Processes (Trickling Filter/Solids Contact (TF/SC) or Trickling Filter/Activated Sludge (TF/AS))

The CVWRF 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

This facility is designed for a maximum month flow of 75 million gallons per day (mgd) and currently receives an average annual influent flow of 49 mgd. The facility operates a TF/SC process with primary treatment. Residual primary and secondary solids are thickened and stabilized using conventional mesophilic anaerobic digestion, mechanically dewatered, and either land applied or composted. Ferric chloride is added to the primary clarifiers for sulfide control. The TF/SC process is operated to achieve some nitrification in order to meet seasonal ammonia effluent limits. A process flow diagram is presented in Figure 1 and an aerial photo of the WRF is shown in Figure 2. The major unit processes are summarized in Table 2. The current practice to operate four of the six trickling filters year-round. Nitrification in the solids contact basin is reportedly largely dependent on seeding from the TFs and is affected during the winter season.

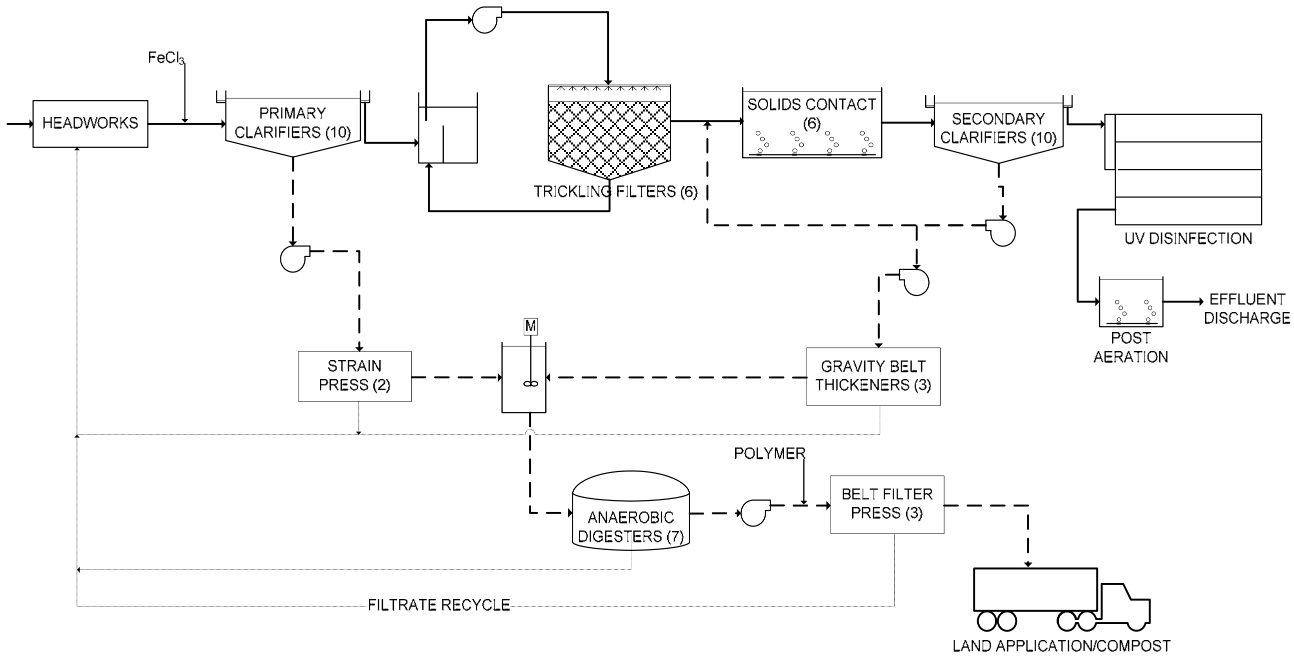

FIGURE 1
Process Flow Diagram

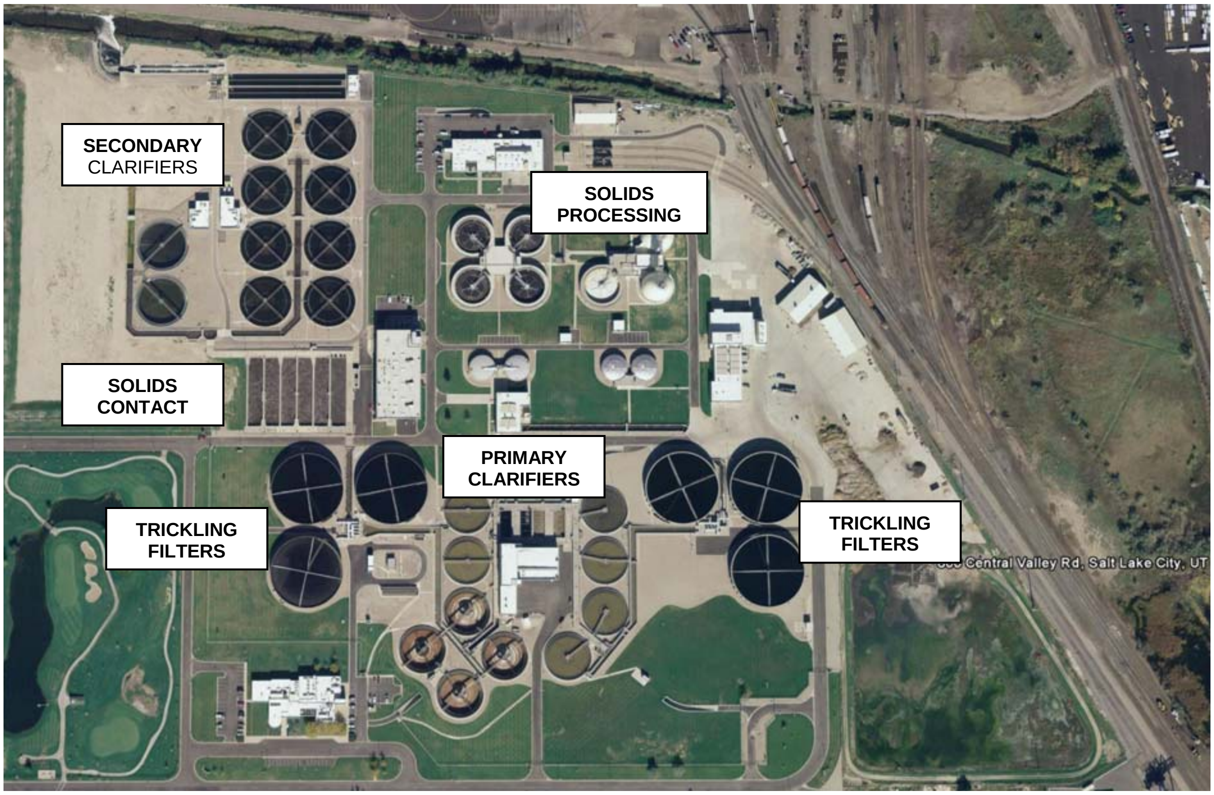

FIGURE 2
Aerial View of the Facility

TABLE 2
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifiers	10	110-ft diameter, 12-ft SWD	Metal-salt added for sulfide control
Trickling filters	6	170-ft diameter, 14-ft SWD	Plastic Media (30ft^2/ft^3), with distributor control
Solids contact basins[(1)]	8	0.76 MG,16-ft SWD	100% diffused aeration
Secondary clarifiers	10	125-ft diameter, 18-ft SWD (2), 125-ft diameter, 15-ft SWD (2)	Uni-tube suction header
Alum Storage and Feed Facilities	1	10,000 gallons with feed pumps	Typically not used
WAS thickening	3	2 meter	Gravity Belt Thickener
Anaerobic digestion	7	1.0 MG conventional (5), 1.65 MG egg-shaped (2)	Anaerobic Mesophilic
Sludge dewatering	3	2 meter	Belt Filter Press

[(1)] For Tier 3 (existing condition), the volume of the solids contact basins was increased from 4.56 MG to 6 MG in order to sustain adequate nitrification at the design condition, since this is a current discharge permit requirement.

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/SC or TF/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 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 CVWRF is a large POTW with a significant investment in the TF/SC process. Rather than demolish the TF/SC system, maximum use of existing infrastructure was implemented in the proposed approaches to meet nutrient limits. The existing process was modified to meet the different tiers of nutrient standards. 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, metal-salt addition was initiated at the primary and the secondary clarifiers.

B. To add nitrogen control to Tier 2, a portion of the primary effluent was bypassed around the existing trickling filters to the solids contact basins, while the solids contact basins were modified to include an anoxic zone and mixed liquor recirculation system. **It should be noted that for Tier 3 (existing condition) the volume of the solids contact basins was increased from 4.56 MG to 6 MG to sustain adequate nitrification capacity at the design-year condition, since this is a current permit requirement.**

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 control to Tier 1, the improvements proposed for Tier 2N was included, along with a post-denitrification moving bed bioreactor (MBBR) process to denitrify a portion of the settled secondary effluent.

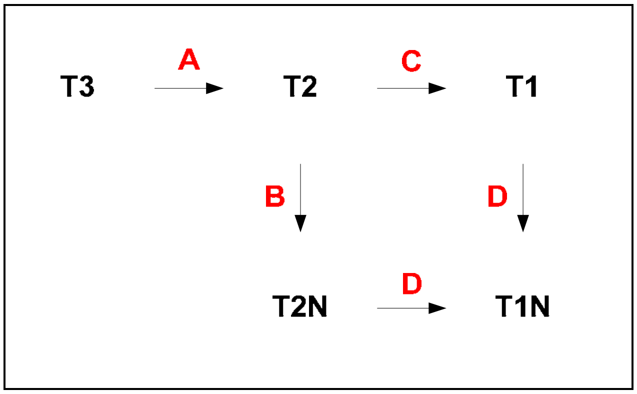

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

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

O&M costs for each tier were derived using straight-line interpolation between the 2009 (historic) and 2029 (projected) loadings. The design conditions were used for analyzing the current facility and sizing of additional unit processes as required to achieve each tier of nutrient control.

TABLE 3
Summary of Input Conditions

Input Parameter	2009[1]	2029[2]	Design[3]
Flow, mgd	49	68	75
BOD, lb/day	79,000 (193 mg/L)	113,724 (200 mg/L)	125,100 (200 mg/L)
TSS, lb/day	70,000 (171 mg/L)	95,528 (168 mg/L)	105,084 (168 mg/L)
TKN, lb/day	14,600 (36 mg/L)	22,725 (40 mg/L)	25,020 (40 mg/L)
TP, lb/day	2,452 (6 mg/L)	3,403 (6 mg/L)	3,753 (6 mg/L)

(1) Historic conditions of 2007-2008

(2) Projected by the POTW

(3) Reported maximum month design capacity of the POTW

The main sizing and operating design criteria that were important for capturing the costs associated with the system upgrade for CVWRF are summarized in Table 4.

TABLE 4
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Target metal:PO_4-P molar Ratio (T1 and T2)	1:1, 2:1, 7:1 [1]
Metal-salt storage (T1 and T2)	14 days
Portion of primary effluent bypassed around TFs (T2N)	50%
Fraction of aeration tank converted to anoxic volume (T2N)	33%
Mixed-Liquor return pumping ratio as a percent of influent Flow (T2N)	100% to 150%
Flow through post denitrification as a percent of influent Flow (T2N)	70%
Target methanol dose for post denitrification (T1N)	3.5 MeOH:NO_3-Neq
Denitrification MBBR loading rate (T1N)	1.5 g-N_{-eq}/m^2/d
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. Filter doses were for Tiers 1 and 1N only

(2) Hydraulic loading rate at peak hourly flow

3. Nutrient Upgrade Approaches

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

Tier 2 Phosphorus (A)

The CVWRF can achieve the 1.0 mg/L total phosphorus goal by adding a metal-salt feed system to the existing unit process facilities. The process modeling effort simulated a dual-feed strategy with metal-salt, at both the primary and the secondary clarifiers. A process flow diagram for this treatment approach is presented in Figure 4.

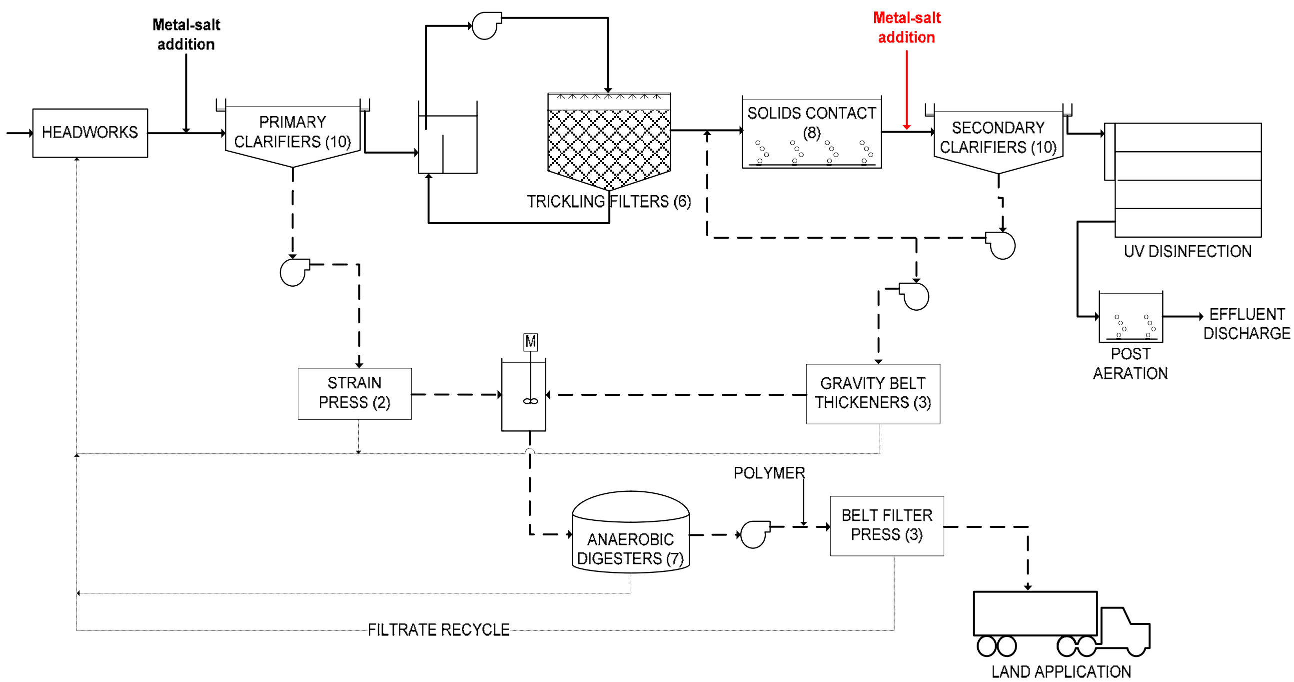

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

For this alternative, the dual-feed metal-salt addition for phosphorus control (described in Tier 2) was retained. However, to achieve moderate levels of nitrogen control (TN < 20 mg/L), the solids contact basins were modified to include anoxic zones and mixed-liquor recycle pumps were installed to recycle nitrified mixed liquor from the end of the aerobic zones to the anoxic zones. To facilitate partial denitrification by providing a carbon source, a portion of the primary effluent was bypassed around the trickling filters and mixed with TF effluent prior to entering the anoxic zones. In addition, covers and forced ventilation was installed on the TFs to eliminate heat loss on the units during winter season, thus preserving their "summertime" nitrification performance. A process flow diagram of this approach is provided in Figure 5.

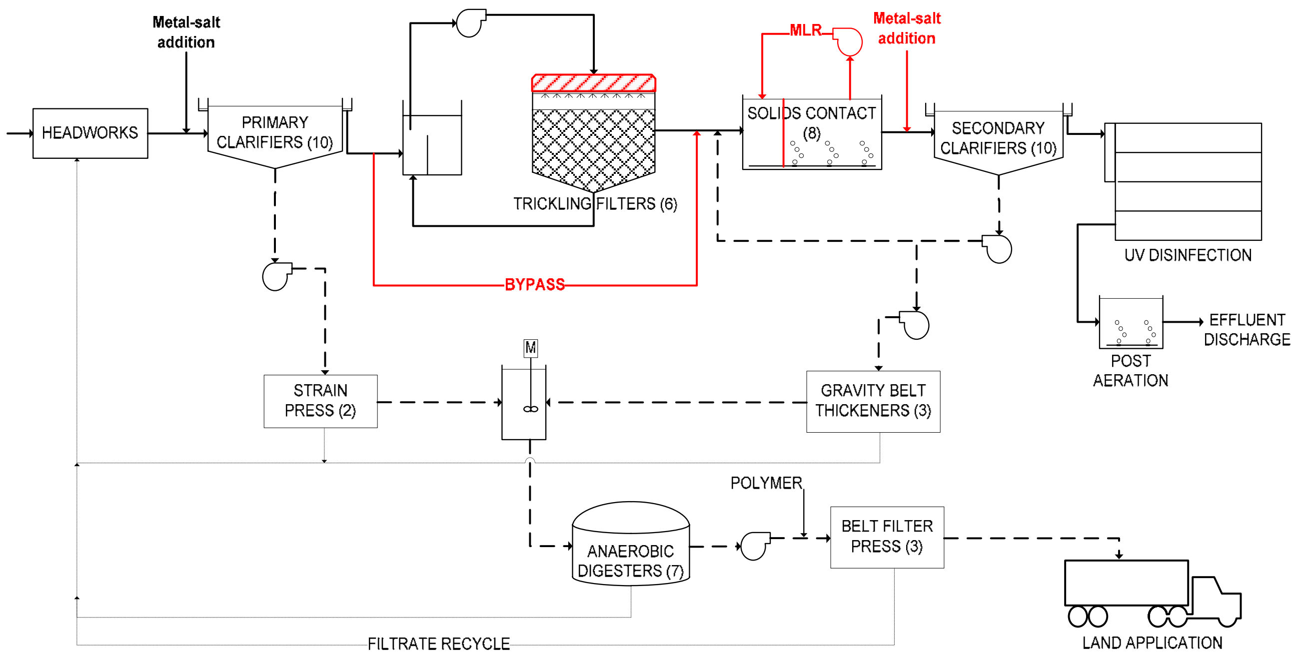

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. Settled secondary effluent was pumped to new deep bed granular media filters; with a third feed point for metal-salt addition upstream of the filters in order to achieve chemical phosphorus polishing. A process flow diagram of this approach is provided in Figure 6.

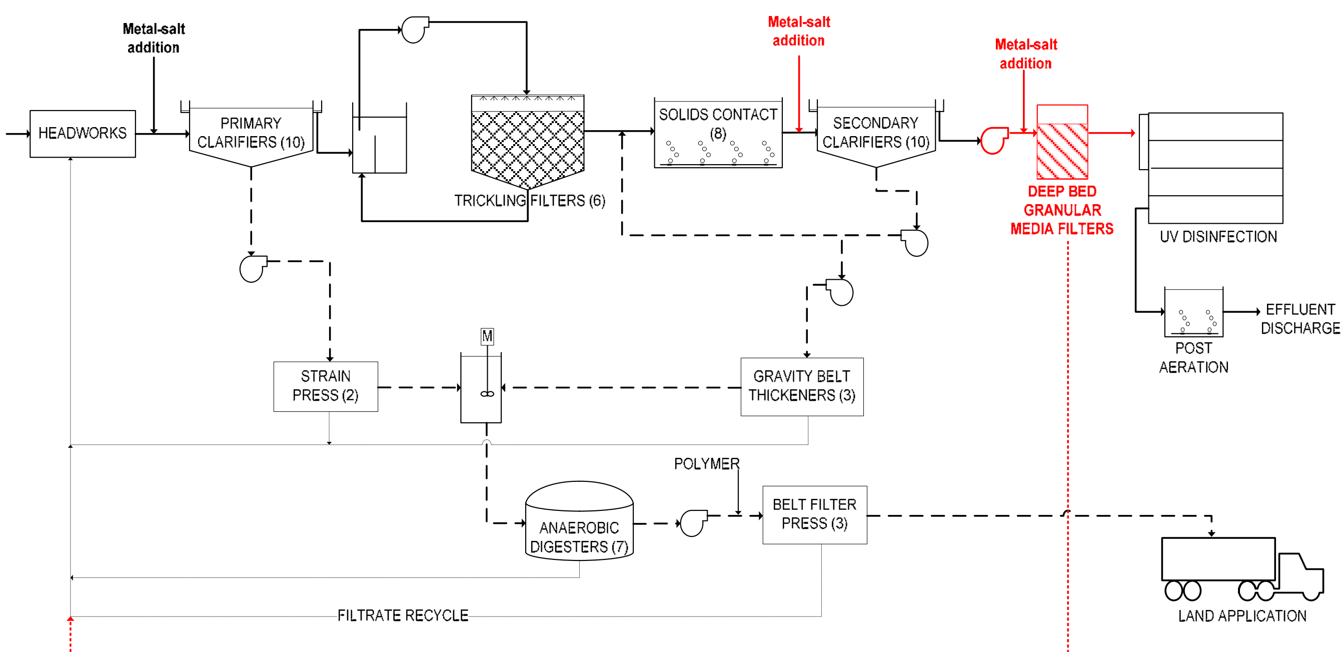

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach builds on a combination of the Tier 1 and Tier 2N upgrade schemes and adds a post-denitrification stage: moving bed biofilm reactors (MBBR) after secondary treatment and before chemical phosphorus polishing with the filters. The post-denitrification was sized to treat a portion (approximately 70%) of the settled secondary effluent flow. A supplemental carbon source was required for the denitrification process. A process schematic of this approach is presented in Figure 7.

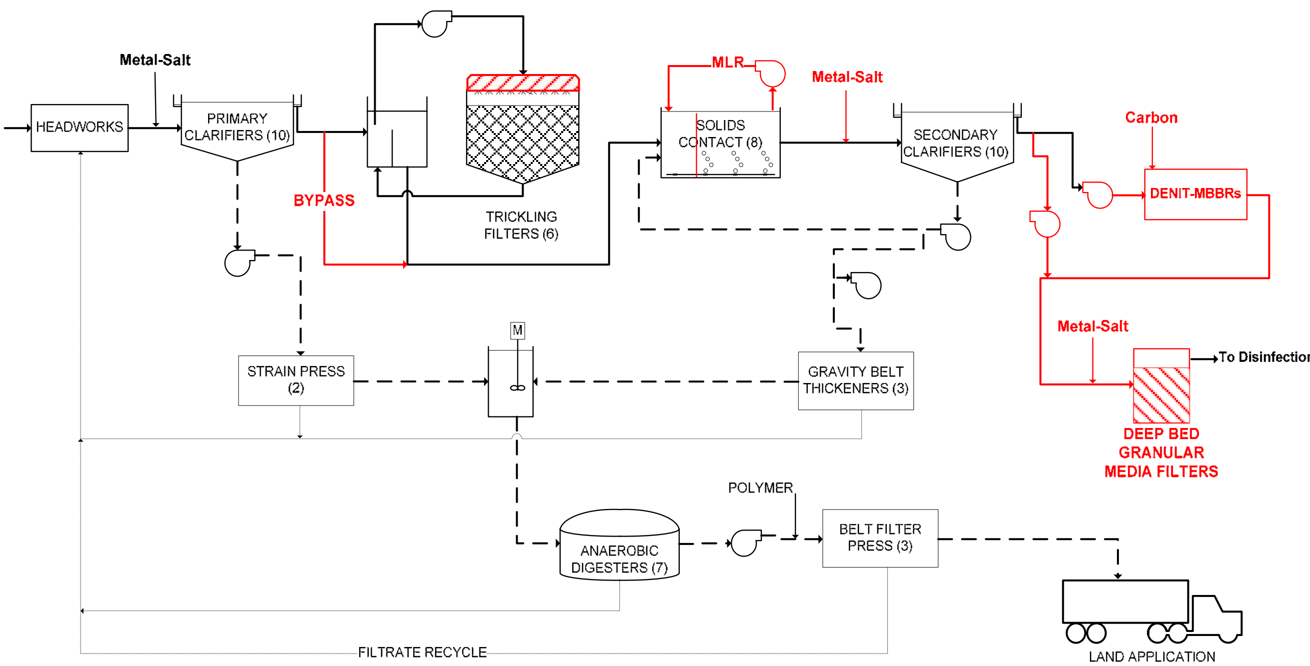

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Control

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 analyses included with this study.

Table 5 presents a summary of the major components identified for facility upgrades in order to meet the various Tiers of nutrient standards. It should be noted that the cost of increased solids contact basin volume that was assumed in order to sustain adequate nitrification capacity at the design-year condition, was not considered for estimation. For Tier 2, the existing metal-salt storage facility was augmented with additional storage and new metal-salt feed pumps were installed ahead of the secondary clarifiers. To go to Tier 2N, a bypass structure was required to bring a part of the primary effluent around the TFs, and, the existing solids contact basins were modified to achieve denitrification (e.g., anoxic zone mixers, modifications to the aeration grids, mixed liquor recycle pumping system). The TFs required covers and forced ventilation systems to enhance winter-time nitrification. Tier 1 phosphorus control alternative needed a secondary effluent pump station to lift the secondary effluent flow to the new deep bed granular media filters. With Tier 1N, a post-denitrification MBBR was installed between the secondary effluent pump station and the filters to denitrify a portion of the flow, along with supplemental carbon storage and feed facilities.

TABLE 5
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed pumps and storage facility	X	X	X	X
Bypass piping and flow distribution structure to anoxic zones		X		X
Covers and forced ventilation on TFs		X		X
Modifications to solids contact basins to include anoxic zones and mixed liquor recycle system		X		X
Secondary effluent pump station			X	X
Piping and flow distribution structure for MBBRs				X
Denitrification MBBRs				X
Deep bed granular media filters			X	X
Supplemental carbon feed facility for MBBRs				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	$1.69	$1.69	$4.88	$4.88
Flow split structure	$0	$0.63	$0	$0.92
Covers and forced ventilation on TFs	$0	$7.74	$0	$7.74

Solids contact basin modifications	$0	$1.33	$0	$1.33
Secondary effluent pump station	$0	$0	$15.76	$15.76
Granular media filtration system	$0	$0	$82.56	$82.56
Denitrification MBBR	$0	$0	$0	$30.37
Supplemental carbon feed facility	$0	$0	$0	$0.85
TOTAL TIER COST	**$1.69**	**$11.39**	**$103.22**	**$144.43**

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 costs for each alternative 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 Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$7.50/wet ton
Biosolids tipping fee	$6/wet ton
Roundtrip hauling distance (1)	120 miles
Alum	$480/ton
Polymer	$0.99/lb
Power	$0.05/kwh

(1) Assumed a roundtrip hauling distance between CVWRF and Skull Valley

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	$0.04	$0.10	$0.01	$0.01	$0.08	$0.14	$0.03	$0.08
Metal-salt	$0.90	$1.66	$0.91	$1.86	$1.64	$2.44	$1.41	$2.23

Carbon	$0	$0	$0	$0	$0	$0	$0.77	$1.60
Polymer	$0.02	$0.05	$0.01	$0.01	$0.04	$0.07	$0.01	$0.04
Power	$0.01	$0.03	$0.1	$0.19	$0.33	$0.41	$0.49	$0.76
Total O&M	**$0.97**	**$1.84**	**$1.03**	**$2.07**	**$2.09**	**$3.06**	**$2.71**	**$4.71**

Note: $ Million (US) in December 2009

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

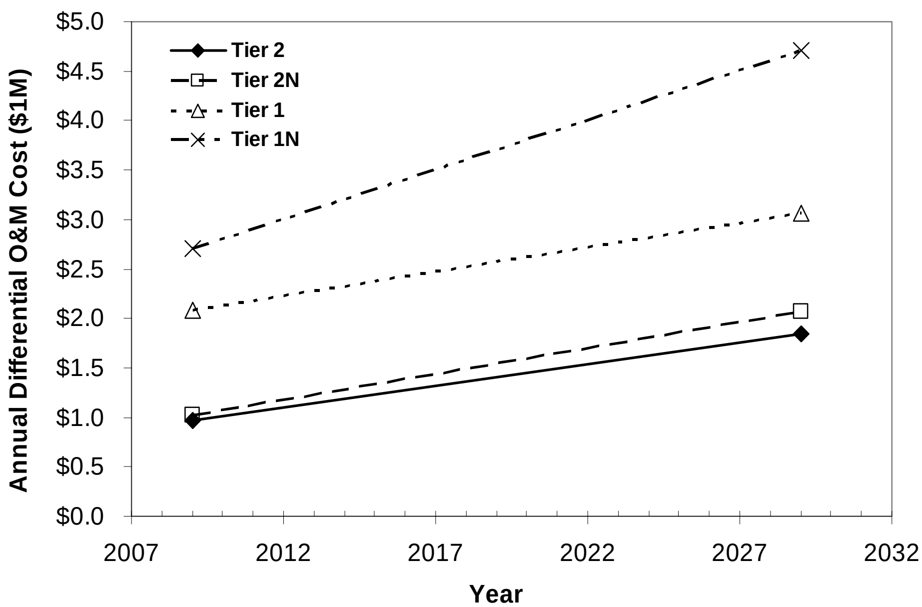

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

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

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	8,553,247	8,553,247	11,786,261	11,786,261
Nitrogen Removal (pounds)[2]	-	30,311,400	-	66,233,781
Net Present Value of Removal Costs[3]	**$ 22,917,427**	**$ 34,727,775**	**$ 142,275,399**	**$ 200,533,421**
NPV: Phosphorus Allocation	22,917,427	22,917,427	142,275,399	142,275,399
NPV: Nitrogen Allocation[4]		11,810,347		58,258,022
TP Cost per Pound[5]	**$ 2.68**	**$ 2.68**	**$ 12.07**	**$ 12.07**
TN Cost per Pound[5]		**$ 0.39**		**$ 0.88**

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 CVWRF 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	$ 1,693,000	$ 11,391,000	$ 103,220,000	$ 144,431,000
Estimated Annual Debt Service[1]	$ 135,900	$ 914,000	$ 8,282,600	$ 11,589,500
Incremental Operating Cost[2]	1,011,200	1,078,700	2,128,800	2,803,500
Total Annual Cost Increase	$ 1,147,100	$ 1,992,700	$ 10,411,400	$ 14,393,000
Number of ERUs	154,950	154,950	154,950	154,950
Annual Cost Increase per ERU	$7.40	$12.86	$67.19	$92.89
Monthly Cost Increase per ERU[3]	**$0.62**	**$1.07**	**$5.60**	**$7.74**
Current Average Monthly Bill[4]	$15.81	$15.81	$15.81	$15.81
Projected Average Monthly Bill[5]	**$16.43**	**$16.88**	**$21.41**	**$23.55**
Percent Increase	**3.9%**	**6.8%**	**35.4%**	**49.0%**

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 CVWRF 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]	$ 34,500	$ 34,500	$ 34,500	$ 34,500
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$40.25**	**$40.25**	**$40.25**	**$40.25**
Projected Average Monthly Bill	$16.43	$16.88	$21.41	$23.55
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**41%**	**42%**	**53%**	**59%**

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, disposal and energy consumption

As per the data received from CVWRF and per process modeling of the base condition (Tier 3), CVWRF 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 CVWRF 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 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	354,250	354,250	488,500	488,500
Total nitrogen removed, lb/year	----	1,118,700	----	2,610,320

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 CVWRF 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**
CVWRF	----	75.81	3.37	27.50	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Mill Creek	4992540	37.62	0.10	1.48	----	----	----	----	----	----	----	----
Combined Concentrations			**2.29**	**18.87**	**0.71**	**N/A**	**0.71**	**13.86**	**0.10**	**N/A**	**0.10**	**7.18**

The process upgrades established to meet the four tiers of nutrient standards would 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		2,957,690	2,982,455	5,376,970	4,610,630
Polymers, lb/year		21,000	5,000	38,000	14,400
Biosolids Management:					
Biosolids produced, ton/year		535	125	950	360
Average yearly hauling distance[1]		680,500	159,300	1,210,400	453,700
Particulate emissions from hauling trucks, lb/year [2]		38,100	9,000	67,800	20,700
Tailpipe emissions from hauling trucks, lb/year[3]		86,500	20,250	153,850	57,670
CO_2 emissions from hauling trucks lb/year[4]		8,654,770	2,026,150	15,395,800	5,770,850
Energy Consumption:					
Annual energy consumption, kwh		37,140	2,008,300	6,530,160	9,755,650
Air pollutant emissions, lb/year [5]					
	CO_2	33,500	1,811,490	5,890,200	8,799,600
	NOx	52	2,812	9,142	13,658
	SOx	45	2,410	7,836	11,707
	CO	2	132	428	640
	VOC	0	16	51	77
	PM_{10}	1	40	129	192
	$PM_{2.5}$	0	20	64	96

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 120 miles round trip hauling distance and, on the assumption that the facility uses 22 ton trucks for hauling biosolids to the landfill. Only 64% of the total biosolids in land filled.

[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)*.