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Donner Summit Public Utility District

Preliminary Investigation of Wastewater Management Options

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1. INTRODUCTION

All wastewater from the Donner Summit Public Utility District (DSPUD) and the Sierra Lakes County Water District (SLCWD) is currently treated at the DSPUD wastewater treatment plant (WWTP) and is discharged either to the South Yuba River (SYR) or used to irrigate the Soda Springs ski area. In accordance with the requirements of the National Pollution Discharge Elimination System (NPDES) permit issued by the State of California Regional Water Quality Control Board, Central Valley Region (RWQCB), DSPUD discharges its effluent to the ski area whenever weather and other conditions are suitable for irrigation, but at least during the months of August and September. Typically, the period during which irrigation is possible, referred to as the "dry season" in this document, begins in early to mid-July and continues through late October or early November. The remainder of the year, during which irrigation is not possible, is referred to as the "wet season".

In addition to many other requirements, DSPUD's previous NPDES permit that was adopted on June 6, 2002, contained effluent limitations on ammonia-nitrogen (ammonia-n) and nitrate-nitrogen (nitrate-n) that were applicable to discharges to the South Yuba River. The ammonia-n limit was dependent on the temperature and pH of the effluent, but was generally in the range of about 3 to 6 mg/L as a monthly average to protect aquatic life in the river. The nitrate-n limit was 10 mg/L as a monthly average to protect human infants that may drink water from the river (not related to algal growth). DSPUD was issued a Cease and Desist Order that required full compliance with these limits by April 1, 2007. The 2002 permit also included a prohibition against causing fungi, slimes, or other objectionable growths in the South Yuba River.

With the main objective of complying with the ammonia and nitrate limits, DSPUD made major WWTP improvements in the years 2002 through 2006. Unfortunately, those improvements were not successful in attaining reliable compliance (reasons for noncompliance are discussed later in this document).

In April 2009, DSPUD was issued a new NPDES permit with a more stringent limit on ammonia-n (monthly average = 2.1 mg/L) and the same limit as the previous permit for nitrate-n (monthly average = 10 mg/L). The 2009 permit also contains a prohibition against causing water in the South Yuba River to contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses. These ammonia, nitrate, and biostimulation provisions are perhaps the most onerous issues in the 2009 NPDES permit; however, there are many other provisions that must be met, and all of these taken together have the potential of requiring major revisions to DSPUD's treatment and/or disposal facilities that may cost many millions of dollars. Because of these concerns, DSPUD authorized preparation of this document to identify and evaluate on a conceptual level various wastewater management options that it may wish to consider to provide for cost-effective compliance with regulatory requirements. It is anticipated that this document will assist DSPUD to determine which wastewater management options should be considered in more detail, including specific cost evaluations, in a subsequent Facility Plan.

In the section that follows, the NPDES permit requirements are considered in more detail, including possible implications. In subsequent sections, wastewater disposal options are considered followed by treatment options to suit the disposal options. Then, combined disposal and treatment options are identified and subjectively evaluated, including a recommendation on whether or not there should be further study. Finally, additional issues that would impact many or all of the options are considered.

2. NPDES PERMIT REQUIREMENTS AND POSSIBLE IMPLICATIONS

Key effluent limitations for river discharge contained in the 2009 NPDES permit are summarized in Table 1. For each parameter, an assessment of the existing plant performance and compliance strategies are indicated.

In addition to effluent limitations, the permit contains receiving water limitations, most of which it is believed the existing plant can comply with. The one notable exception is the requirement that the discharge shall not cause the water in the South Yuba River to contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.

The permit requires DSPUD to complete a number of special studies and reports, one of which is a study to evaluate the impact of the discharge on aquatic growths in the South Yuba River. This required study is the direct result of substantial algal growths in the South Yuba River downstream from the point of the DSPUD discharge in the spring of 2008. If it is found that the discharge is causing or contributing to growths that violate the biostimulation provisions, the permit will be reopened to impose additional restrictions needed for compliance. These could include new and/or more stringent effluent limitations on nutrients and/or prohibition against discharge during certain periods.

Although the previous tentative permit had allowed for dilution credits that substantially relaxed the limitations on nitrate (1.8 times higher) and dichlorobromomethane (24.5 times higher), these were eliminated in the final adopted permit. However, the permit does allow for possible reopening if DSPUD can provide new information to justify dilution credits. To allow dilution credits to be considered, DSPUD would have to install a discharge diffuser and flow monitoring station in the South Yuba River and conduct a mixing zone study. Even then, because nitrate is regulated based on a monthly average concentration and there may be months with little or no flow in the South Yuba River at the point of discharge, it is highly questionable whether dilution credits would be allowed.

Table 1

Key NPDES Permit Requirements, Plant Performance and Compliance Strategy

Parameter	Units	Effluent Limits[a]	Existing Plant Performance[b]	Compliance Strategy
BOD	mg/L	10/15/30	Generally compliant.	Continue/improve biological treatment, coagulation and filtration.
pH	Units	6.5 to 8.0[c]	Generally compliant.	Automatic chemical addition for alkalinity and pH control.
TSS	mg/L	10/15/30	Generally compliant.	Continue/improve biological treatment, coagulation and filtration.
Aluminum	µg/L	71/--/143	Frequently noncompliant. (---, ---, 620, 1310, 38.4, 127)	Monitor acid soluble aluminum. Possible Water Effects Ratio (WER).
Ammonia-N	mg/L	2.1/--/5.6	Frequently noncompliant. (Frequent non-certified lab data over 25 mg/L)	Improved treatment required.
Copper	µg/L	1.5/--/3.1	Frequently noncompliant. (4, 4, 7.8, 4.2, 5.9, 6)	Increase effluent hardness by using lime instead of soda ash for required alkalinity addition. Consider increased potable water pH. Possible Water Effects Ratio (WER).
Cyanide	µg/L	4.3/--/8.5	Occasionally noncompliant. (23, <2, 33, <2, DNQ 4, <2)	Evaluate future monitoring results. Consider changing from chlorine to UV disinfection. Consider immediate on-site testing without sample preservation.
Aldrin	µg/L	ND(d)	Rare noncompliance. (<0.002, <0.002, <0.002, DNQ 0.005, <0.002, <0.0028)	Evaluate future monitoring. Public education, source control if needed.
Alpha BHC	µg/L	ND(d)	Rare noncompliance. (<0.005, <0.005, 0.044, <0.005, <0.005, <0.00034)	Evaluate future monitoring. Public education, source control if needed.
Dichlorobromomethane	µg/L	0.56/--/1.2	Uncertain (e). (<0.5, <0.5, <0.5, DNQ 0.3, 1.2, 0.2)	Violations of this chlorine disinfection byproduct will be more likely with complete nitrification. Consider dilution credit, chloramination, UV disinfection.
Nitrate-N	mg/L	10/--/--	Frequently noncompliant. (Frequent non-certified lab data over 15 mg/L. Would be worse with good nitrification.)	Improved treatment required.
Silver	µg/L	0.23[d]	Rare noncompliance. (<0.09, <0.08, 0.26, 0.18, < 0.1, <0.12)	Evaluate future monitoring. Public education, source control if needed.
Zinc	µg/L	15/--/30	Frequently noncompliant. (22, 33, 22, 23.6, 25.3, 30.8)	Increase effluent hardness by using lime instead of soda ash for required alkalinity addition. Consider increased potable water pH. Possible Water Effects Ratio (WER).

Parameter	Units	Effluent Limits[a]	Existing Plant Performance[b]	Compliance Strategy
Manganese	mg/L	50[f]	Possible noncompliance. (---, ---, 8.7, 8.3, 52.8, 88.4)	Evaluate future monitoring and consider manganese removal in treatment process evaluations.
Total Coliform	MPN/100 mL	2.2, 23, 240[g]	Generally compliant.	Continue/improve biological treatment, coagulation, filtration, and disinfection.
Turbidity	NTU	2, 5, 10[h]	Generally compliant.	Continue/improve biological treatment, coagulation and filtration.

[a] Unless indicated otherwise, limits are Average Monthly/Average Weekly/Maximum Daily.

[b] Where a series of six results are shown in parenthesis, they are from special California Toxics Rule and related grab samples taken in June 2001, April 2002, November 2003, February 2004, December 2005, and December 2006, respectively. "DNQ" indicates an estimated value that is below the method quantitation limit.

[c] Range is based on instantaneous minimum and instantaneous maximum.

[d] Instantaneous maximum.

[e] Dichlorobromomethane is a chlorine disinfection byproduct that is mitigated by the presence of ammonia. Ammonia concentrations at the time of historical sampling are unknown.

[f] Annual average.

[g] 2.2 weekly median, 23 once in 30 days, 240 at any time.

[h] 2 daily average, 5 more than 5% of time in 24 hours, 10 at any time.

Since human health concerns regarding dichlorobromomethane are based on long-term average conditions (lifetime exposure) and there is believed to be substantial dilution available during most of the wet season, it is believed to be much more likely that dilution credits would be allowed for this parameter.

The reader is referred to the permit itself for complete coverage of all permit provisions.

A Cease and Desist Order was adopted together with the 2009 NPDES permit. This order provides a compliance schedule and interim permit limits for the following parameters: Ammonia, Nitrate, Copper, Cyanide, Zinc, Aldrin, Alpha BHC, and Silver. In essence, the Cease and Desist Order allows DSPUD to continue discharging these pollutants at historical levels while it pursues improvements to assure full compliance with the limits indicated in Table 1 by April 2014 (see Section 6 of this document for schedule of activities needed to attain compliance). However, since the permit limit on nitrate is the same as it was in the 2002 permit, DSPUD is not protected against mandatory fines for violation of the 10 mg/L nitrate-n limit.

Out of all the requirements contained in the NPDES permit, those regarding effluent ammonia and nitrate concentrations and biostimulation in the South Yuba River are considered the most problematic, because compliance is likely to require major improvements to the DSPUD wastewater treatment and/or disposal systems. Possible options for addressing these issues are discussed in the remaining sections of this document.

3. EFFLUENT DISPOSAL OPTIONS

In the following paragraphs, various alternatives for wastewater effluent disposal are considered. The methods of disposal will govern the required levels of treatment, which are considered later in this document.

Wet Season Direct Discharge to SYR, Dry Season Spray Irrigation

These are the methods of effluent disposal currently used by DSPUD. Key issues are the need to upgrade the plant for compliance with existing ammonia, nitrate and disinfection byproducts limits. Additionally, the need to prevent biostimulation in the South Yuba River would undoubtedly result in much more stringent requirements on nitrate, plus possible new requirements on phosphorous and/or other biostimulatory substances, adding much more to the cost of improvements, if feasible at all. Even after such improvements, it is likely that algae growths could continue to occur downstream from the DSPUD discharge due to nutrients from other point and nonpoint sources. The degree to which the DSPUD discharge would contribute to such growths would be in question. Because of these issues and because long-term and costly studies would be required to determine appropriate nutrient limitations for river discharge in algae growth periods, continued use of this option is considered to be infeasible. At least some modification of current effluent disposal practices is believed to be needed.

Limited Wet Season Direct Discharge to SYR, Seasonal Storage, Dry Season Spray Irrigation

This option is similar to that above, with a major difference: seasonal storage facilities would be provided to allow curtailing direct discharge during periods in the wet season when flows, temperatures, solar exposure and other conditions would facilitate algal growths in the South Yuba River, regardless of the presence or absence of the DSPUD effluent. In other words, DSPUD would stop discharging effluent when the effluent would probably contribute to nuisance biostimulation in the river. An investigation is needed to determine the conditions and times of effluent storage. This topic will be addressed in the biostimulation study that DSPUD is currently proceeding with as required in the NPDES permit.

An analysis of historical springtime flows for the years 2002 through 2008 was completed to assess the magnitude of possible storage requirements. For each year, beginning with the day before irrigation was started in that year and extending backwards, the volume of storage that would have been required to contain all of the plant effluent was determined as a function of the number of days. The results are shown in Figure 1. It is currently estimated that springtime discharges to the South Yuba River would have to be ceased approximately 45 to 60 days prior to the start of spray irrigation disposal. Based on the results shown in Figure 1, storage requirements could be in the 15 to 20 million gallon range (approximately 45 to 60 acre-feet), not including any allowance for precipitation in the reservoir area, and not allowing for any growth or increase in spring occupancy within the service area.

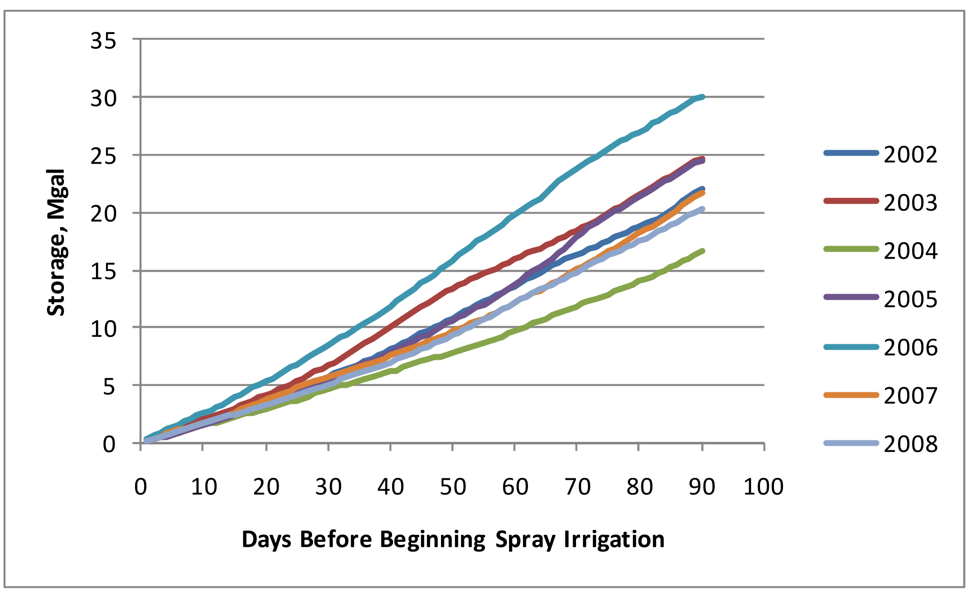

Figure 1
Seasonal Storage Requirements Based on Historical Flows

The effluent stored in the wet season would have to be disposed of by spray irrigation during the following dry season, greatly increasing the land area required for irrigation. Assuming a depth of two feet of water could be applied during the dry season, the land area required to dispose of the stored effluent could be in the range of 20 to 30 acres (to be verified and adjusted as needed), in addition to that required for dry season flows. Currently 45 acres are used to dispose of dry season flows. Thorough water balance calculations for a specific project would have to be performed to determine actual requirements.

Substantial questions exist regarding management of the reservoir and control of flows to and from it. Ideally, the reservoir would collect and store only wastewater effluent and limited precipitation during the time that the effluent is routed to storage and remains in storage in the spring and summer. To prevent accumulation and handling of precipitation during the remainder of the year, a reservoir outlet valve could be left open to allow natural runoff to flow from the reservoir to the river. However, unless specific steps are taken to mitigate the situation, dead algae and other debris accumulated in the reservoir as well as soil erosion from the reservoir area would be flushed into the river, which would be unacceptable. Two potential options to mitigate this problem are: 1) to line the reservoir, and 2) maintain a minimum pool for settling and have periodic discharges during times of high river flow. These options are discussed below.

If a suitable impermeable liner was used within the reservoir, the reservoir could be drained and then cleaned each summer. Effluent could be used to wash down the liner, and the used wash water, depending on quality, could be disposed of by irrigation or routed back through the treatment plant. Once the reservoir is cleaned, allowing precipitation to drain through the reservoir should not pose any significant water quality issues. The liner would protect the reservoir area from erosion. During the winter, snow would accumulate in the reservoir area, but most of this snow should melt away naturally before the reservoir outlet valve must be closed and springtime effluent storage initiated. If undesirable quantities of snow remained in late spring, some of the effluent otherwise being directly discharged to the river could potentially be sprayed over the remaining snow in the reservoir to melt it, with the combined effluent and snowmelt being allowed to flow to the river. There would be issues with handling effluent stored in the fall, if such storage is required after cessation of irrigation disposal to prevent biostimulation in the river at that time (to be determined in the biostimulation study). Hopefully the duration of storage would be short enough and temperatures cold enough to prevent significant deterioration in the quality of the stored effluent, which would have been previously treated to river discharge standards. In that case, the stored effluent could be gradually released to the river, once river discharge is possible. This potential issue will require further evaluation.

Under the minimum pool option, the reservoir would function as a settling basin for soils eroded from the reservoir catchment area and for dead algae or other debris that would accumulate in the reservoir. The reservoir water level would never be lowered below the minimum level required to provide this function. Therefore, the total volume of the reservoir would be this minimum pool volume plus the volume required for active storage. Each summer, the reservoir would be emptied down to the minimum pool elevation by spray irrigation at appropriate reuse sites. If any additional storage is required before river discharge can be started in the fall, the volume then stored would accumulate above the minimum pool, as would any precipitation occurring in the reservoir drainage area. At times of high river flows during the winter and spring, the reservoir would be rapidly emptied down to the minimum pool by direct discharge into the South Yuba River. It is hoped that permitting for the periodic reservoir discharge at times of high river flows and turbidity could be obtained. There is some precedence for a permit of this type.

If winter discharge from the reservoir under one of the options above or an alternative plan were not allowed, the reservoir would have to be sized to contain the 100-year frequency precipitation in the reservoir catchment area during the wet season, in addition to the required effluent storage volume. All of the stored water would have to be disposed of by irrigation in the dry season. As a result, this option would drastically increase the size requirements and costs for the storage reservoir and irrigation disposal areas.

Finding a suitable reservoir site and easements to and from it, acquiring the land, extending electrical service, and addressing environmental issues would be significant challenges in implementing this alternative. In the Treatment and Disposal Facilities Plan prepared for DSPUD in June 1984, reservoir sites for a seasonal storage reservoir of similar size requirements were investigated. The most promising site was in a ravine across the South Yuba River and approximately ½ mile northwest of the existing DSPUD discharge location.

Wet Season Storage, Dry Season Irrigation

Under this option, all wastewater effluent would be stored during the wet season and disposed of by irrigation in the relatively short dry season. This option, if feasible, would be preferred by the RWQCB because it would eliminate all direct impacts on the South Yuba River. Additionally, the level of treatment required for irrigation disposal would be lower than required for river discharge, resulting in lower treatment plant construction and operation costs.

The main problems associated with this option are the need for one or more extremely large storage reservoir(s) and the large land area required for irrigation. To properly determine the volume of storage required and the area needed for irrigation, detailed water balance calculations would have to be completed for a specific project. However, rough estimates can be developed. The estimates that follow are based on existing flows, without any allowance for additional growth or increased occupancy of existing units, which would increase the required storage volumes and irrigation areas. Reductions in infiltration and inflow volumes, if assured, would reduce the requirements.

If it is assumed that all of the DSPUD effluent is stored from November 1 through June 30 (actual storage duration would likely be longer for 100-year precipitation conditions), the volume of wastewater stored based on flows from 2002 through 2008 could be over 70 Mgal. Additional storage would have to be provided for 100-year return frequency precipitation in the catchment area of the storage reservoir(s), less evaporation from the reservoir(s). Depending on the configuration of the reservoir(s), the resultant total storage requirement could be more than 200 Mgal or 600 acre-feet (to be verified and adjusted as needed based on detailed water balance calculations).

Assuming a total applied water depth of about two feet in the subsequent dry season, and neglecting evaporation from the storage reservoir, approximately 300 acres of irrigation land would be required to dispose of the stored effluent (to be verified and adjusted as needed based on detailed water balance calculations). Additional irrigation land would be required for the dry season flows, but would be partly offset by evaporation from the storage reservoir. It is estimated that the total land requirement could be over 300 acres under irrigation, plus buffer areas.

As discussed for the seasonal storage alternative, finding a suitable reservoir site and spray irrigation disposal area and easements to and from them, acquiring the land, extending electrical service, and addressing environmental issues would be significant challenges in implementing this alternative. In this case, all of those challenges would be amplified due to the larger land areas and facility sizes involved. The total land requirement for storage and disposal plus buffer land could be around 500 acres for existing development and occupancy rates. In the Treatment and Disposal Facilities Plan prepared for DSPUD in June 1984, reservoir and irrigation disposal sites for a year-round land containment system such as described above were investigated. The most promising site for both storage and disposal was believed to be just west of Serene Lakes, which is an area currently being considered for development by Royal Gorge.

Because of the anticipated high costs (including land acquisition costs), large land requirements, environmental impacts, and anticipated public resistance, this alternative is not considered to be feasible.

Year-Round Direct Discharge to South Yuba River

This option is mentioned for completeness. However, it is recognized that there would be tremendous public and regulatory opposition to a year-round discharge. Even if it were to be allowed at all, it is expected that treatment requirements would be extreme and cost-prohibitive. This option should not be considered further.

Subsurface Disposal

Subsurface disposal via leach fields or percolation basins or similar systems, if feasible, could be considered for seasonal or year-round use. However, in the Donner Summit area, it is unlikely that a site with geologic and soil conditions that would allow the effluent to stay underground long enough to blend with natural groundwater and lose its identity as wastewater effluent could be identified. Rather, it is likely that, if adequate soil conditions could be found to allow the effluent to be disposed of below the ground surface initially, bedrock would be encountered below, causing the effluent to flow laterally and surface at some location down gradient from the point of discharge. Extensive soils, geological and hydrological investigations and modeling would have to be completed to determine the fate of the effluent. Under the best likely scenario, the effluent could exit the ground from the bed of a flowing surface water course, such as the South Yuba River. If flow to the surface water course was the clear fate of the effluent, discharge requirements needed to protect the beneficial uses of the surface water course (including prevention of biostimulation) would be imposed. However, it may be possible to attain some of the required treatment naturally as the effluent moves through the soil. It is noted that the Tahoe-Truckee Sanitation Agency (TTSA) wastewater treatment facility in Truckee disposes of its effluent into permeable soils along the Truckee River and that their discharge requirements are established to protect the beneficial uses of that river, with some credit given to incremental natural treatment during flow through the permeable soils.

A key issue with regard to subsurface disposal is groundwater degradation. Certainly, the discharge would not be allowed to cause the underlying groundwater to exceed applicable water quality criteria. For example, it would not be allowed to cause nitrate-n concentrations in excess of the 10 mg/L drinking water limit. This alone could necessitate a full nitrification and denitrification system similar to that required to meet existing NPDES permit requirements. Salinity and other issues would also exist. It would not be possible to have a subsurface discharge without increasing above background levels the groundwater concentrations of several constituents. The degree to which such increases may or may not be allowed would have to be determined by working with the Regional Board.

It is important to note that subsurface effluent disposal was the normal means of disposal in the Donner Summit area prior to the late-1980s. DSPUD’s effluent was discharged to a large leach field along the South Yuba River. However, the effluent did not stay underground; rather, much of it surfaced and flowed on top of the ground into the river. Even the effluent that did stay underground as it flowed into the river undoubtedly contributed to the unacceptable impacts that were obvious in the river, mainly attached algae growths on the river bottom during the summer and fall. In addition to DSPUD, all of the lodges, ski areas, businesses and residences in the Norden area had on-site subsurface disposal systems and many of those were known to fail with surfacing effluent. All of these subsurface disposal systems were abandoned with the Norden extension of the DSPUD sewage collection system in the late 1980s.

It was because of the failures of subsurface disposal systems and the lack of reasonably cost-effective alternatives for containment of all effluent on land that seasonal direct discharge to the South Yuba River was first permitted in the late-1980s.

Export Sewage to TTSA

Under this option, the DSPUD and SLCWD wastewater would be pumped over the summit and would connect with existing sewers in the Truckee area for flow to the TTSA wastewater treatment plant. The specific location for connection to existing sewage piping is currently unknown. According to Blake Tresan, District Engineer for the Truckee Sanitary District (TSD), it is unlikely that a connection would be made at the west end of Donner Lake, because sewage from this area flows through a series of six pumping stations, which are already near capacity, to get to the east end of Donner Lake. It is much more likely that the DSPUD wastewater would be piped through its own pressure pipe all the way to the east end of Donner Lake or all the way to the TTSA interceptor sewer. Assuming a pipeline from the DSPUD WWTP to the east end of Donner Lake, the total pipe length might be around 55,000 feet. Assuming an average cost of about $100 per lineal foot, the construction cost for the pipeline could be around $5.5 million.

The export pump station would be additional. With engineering, environmental, administrative and other related costs, plus a reasonable contingency allowance, the total cost of the export pump station and pipeline could be around $10 million.

The potential of DSPUD sewage going to the TTSA facility was discussed with Marcia Beals, General Manager for TTSA. Ms. Beals had the following concerns:

1. The TTSA plant was recently expanded from 7.4 to 9.6 Mgal/d. The 9.6 Mgal/d capacity was developed to serve projected buildout within the existing service area. Without a subsequent expansion (which is considered unlikely), the flow from DSPUD, if allowed, would effectively displace future development in the TTSA service area. This is unlikely to gain approval.
2. The recent TTSA expansion and increase in effluent flow to the Truckee River were very difficult to get approved through the environmental and regulatory processes (planning, design, and construction took approximately 10 years). The Truckee River is a water supply for the City of Reno and terminates at Pyramid Lake within the Paiute Indian Reservation. Accordingly, there are large and powerful interests that oppose any activity that would potentially degrade the quality of the Truckee River. TTSA was forced to upgrade their level of treatment, which includes nitrogen and phosphorous removal, contributing to a total capital cost (including engineering, administration, environmental, as well as construction) of approximately $70 million for the expansion project.
3. In order for DSPUD sewage to flow to TTSA, DSPUD would have to annex to TSD. Approval of both TSD and TTSA would be required.

Although the method of determination of DSPUD’s cost to buy capacity in the TTSA facility, if allowed at all, is not currently known, TTSA’s current connect fee for an equivalent dwelling unit (EDU) is $5,000. Using the current combined DSPUD/SLCWD peak week flow of about 600,000 gpd and assuming a flow of 300 gpd per EDU (not verified as an appropriate basis with TTSA), the existing DSPUD/SLCWD flows may be equivalent to approximately 2000 EDU. If the 2000 EDU were located within the current TTSA service area for which TTSA plant capacity has already been built, the total connection fee would be $10 million. However, for an annexation area that would require new capacity to be built, the buy-in cost would undoubtedly be much higher. The current TTSA service charge is $288 per year per EDU. However, TTSA also collects about 15 percent of their revenue from property taxes. Since properties within the DSPUD and SLCWD service areas would not be subject to the tax, the service charge would have to be increased accordingly. Additionally, service charges would have to be paid to TSD at the current rate of $19/month per EDU.

The discussion above is based on exporting raw sewage to TTSA. Consideration could also be given to exporting treated sewage; however, there is no apparent advantage to that. Unless the DSPUD effluent were piped all the way to the TTSA treatment facility, the effluent from DSPUD would get blended with raw sewage in Truckee and would still use up capacity in the TTSA WWTP. Perhaps there could be recognition of the lower loading of pollutants in establishing user fees, but that would be rather inconsequential to the other costs involved. All of the issues with regard to increased sewage effluent flows in the Truckee River would still exist and the costs for export facilities and buy-in to the TTSA system would remain nearly the same. Since DSPUD would also incur the cost of treatment at DSPUD, the total cost for exporting effluent would likely be substantially higher than for exporting raw sewage. If DSPUD treated to the same level as TTSA and piped the effluent to blend with the effluent of the TTSA facility for joint disposal, the costs for treatment at TTSA could potentially be avoided, but the costs for treatment at DSPUD undoubtedly would be at least as high as if the discharge were to the South Yuba River. When all costs associated with exporting the effluent are considered, this option would be much more costly than a South Yuba River discharge. Additionally, it is highly unlikely that TTSA would allow the DSPUD effluent to be combined in that manner, as TTSA would have responsibility for the combined effluent quality.

Based primarily on very difficult environmental and institutional issues that could delay a prospective project for many years, if it could be approved at all, it is considered unlikely that export of sewage to TTSA would be a viable option for DSPUD. Additionally, it does not seem as though there could be a significant cost incentive (if any) for pursuing this option. There are also potential water rights issues associated with moving the discharge from the South Yuba River to the Truckee River.

Summary of Disposal Options

All of the disposal options considered above and the pros and cons of each are summarized in Table 2. Recommendations on which options should be considered further are included in Section 5.

Table 2
Summary of Disposal Options

Option	Pros	Cons	Comments
Subsurface Disposal	❑ No direct river discharge	❑ Probable lack of suitable soils / geology ❑ Probable effluent surfacing ❑ Groundwater degradation	❑ This method of disposal was extensively used historically in the Donner Summit area, but failed.
Wet Season Storage, Dry Season Irrigation	❑ No direct river discharge ❑ Lowest treatment requirements	❑ Huge land area requirement ❑ High cost	❑ Finding and acquiring adequate suitable land would be very difficult.
Limited Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	❑ No direct river discharge when nuisance biostimulation could occur	❑ Cost and operational issues associated with seasonal storage	❑ A direct discharge from the seasonal storage reservoir to the SYR at times in the winter is needed to eliminate major storage and disposal issues associated with wet season precipitation in the reservoir area.

Option	Pros	Cons	Comments
Wet Season Discharge to SYR, Dry Season Irrigation	❑ No seasonal storage reservoir	❑ Undetermined extreme low-level nutrient requirements to mitigate biostimulation. ❑ Discharge may still be suspect for contributing to biostimulation	❑ This option is judged to be infeasible.
Year-Round Discharge to SYR	❑ No land disposal area or systems required	❑ Unacceptable to public and regulatory agencies	❑ Mentioned for completeness, but no further consideration recommended.
Export Raw Sewage to TTSA Sewers	❑ Eliminate discharge to SYR ❑ Eliminate DSPUD WWTP ❑ Eliminate land disposal on Donner Summit	❑ TTSA capacity committed to existing service area and difficult to expand further ❑ Difficult environmental issues associated with discharge to Truckee River ❑ Water rights issues	❑ Working through the political and environmental issues involved would undoubtedly take many years and would likely fail. ❑ It is unlikely that there would be a significant cost incentive that would justify pursuing this option.
Export Treated Effluent to TTSA Sewers	❑ Eliminate discharge to SYR ❑ Eliminate land disposal on Donner Summit	❑ Same as above, plus: ❑ DSPUD would still need capacity in TTSA plant, though pollutant load reduced. ❑ DSPUD continues to operate its own WWTP and thus must pay for two plants.	❑ No significant advantage and many disadvantages compared to exporting raw sewage.
Export Treated Effluent to TTSA Discharge Point or Other Truckee River Location	❑ Eliminate discharge to SYR ❑ Eliminate land disposal on Donner Summit ❑ Eliminate need to expand TTSA WWTP	❑ Environmental issues for Truckee River are even more difficult than for SYR. ❑ Required treatment would be at least as difficult and expensive as staying in the SYR. ❑ Water rights issues	❑ This is simply a relocation of the DSPUD discharge from the SYR to the Truckee River. ❑ The one benefit of this option compared to exporting raw sewage to TTSA sewers is that no TTSA plant expansion would be needed. However, the treatment system required at DSPUD would more than offset this advantage.

4. TREATMENT OPTIONS

The level of treatment to be provided will depend on the effluent disposal option. In this section, options for modifying the plant to meet the requirements in the existing NPDES permit are considered as a base case. This level of treatment would be appropriate for continued wet season discharge to the South Yuba River during times when biostimulation is not a threat. Subsequent to developing options for this base case, differences in treatment for other disposal options are discussed.

The existing wastewater treatment plant is intended to provide ammonia and nitrate removal by biological treatment. However, as previously indicated, the plant does not reliably meet requirements for these parameters. Most options for improving the plant are also based, at least partly, on biological treatment to remove ammonia and nitrate. Therefore, before beginning a discussion of specific options for improving the plant, it is helpful to discuss this type of biological treatment in general, and to discuss the existing wastewater treatment plant.

Biological Treatment to Remove Ammonia and Nitrate

Biological treatment to remove ammonia and nitrate is accomplished by the processes of nitrification and denitrification. Nitrification is the sequential oxidation of ammonia to nitrite and then nitrate by ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB). Collectively, the AOB and NOB are referred to as nitrifying bacteria or nitrifiers. Denitrification is the conversion of nitrate to nitrogen gas by bacteria that use organic substances in the wastewater (measured as BOD) or supplemental organic materials as their food and use the nitrate as a substitute for oxygen for their respiration. The bacteria that can use nitrate as a substitute for oxygen will do so only when oxygen is not available. Biological treatment to remove ammonia also results in removal of BOD.

Since nitrification must occur before denitrification can be accomplished, one option for a nitrification and denitrification system would be to have one or more aerobic basins for BOD removal and nitrification followed by an anoxic basin for denitrification. However, with this configuration, essentially all of the influent BOD would be consumed in the aerobic basins, leaving no external food for the bacteria that accomplish denitrification in the anoxic zone. Without an external food supply, denitrification would occur very slowly using decaying bacteria as the food source. To speed up the denitrification process, allowing smaller reactor basins, methanol or another suitable food could be added to the anoxic zone.

As an alternative to the aerobic-anoxic configuration mentioned above, the anoxic basin can be located upstream from the aerobic basin, if the nitrate formed in the aerobic basin is recycled back to the anoxic basin for denitrification. In this case, the incoming wastewater would be the food for the bacteria accomplishing denitrification, potentially eliminating the need for purchasing and feeding a supplemental food supply. This anoxic-aerobic configuration with a mixed liquor recycle stream from the aerobic basin to the anoxic basin (such as currently exists at DSPUD) is called a Modified Ludzack-Ettinger (MLE) system. The return activated sludge

(RAS) stream from the secondary clarifier serves as an additional nitrate supply to the anoxic zone. Unfortunately, the mixed liquor recycle stream (and perhaps the RAS) will contain a substantial amount of oxygen, and this oxygen must be consumed, using up valuable food, before denitrification can take place. Thus, the amount of denitrification that can be accomplished is limited by the food supply, the amount of nitrate that can be recycled, and the amount of oxygen that is recycled with the nitrate.

Nitrifying bacteria grow relatively slowly, particularly in cold conditions, which makes reliable nitrification at DSPUD difficult. At DSPUD, wastewater flows and loads during the fall months are much lower than those that occur in the winter. A sudden onset of high loads typically occurs around Christmas and high loading conditions occur sporadically throughout the winter in response to peak temporary occupancies in lodges and homes and peak usage of ski areas. The amount of nitrifying bacteria that can be grown from the wastewater in the fall is inadequate to handle the sudden onset of peak winter loads. When this is combined with the fact that nitrifying bacteria are particularly slow growers in the winter, it is considered necessary to feed ammonia in gradually increasing amounts during the fall months to build up the nitrifier population in preparation for winter loads. Intermittent ammonia addition between winter peak load events is also considered beneficial to maintain the nitrifier population. A more complete discussion of the influent loading patterns to the plant and the need for ammonia addition is included in the letter report from Jeff Hauser of ECO:LOGIC Engineering to Tom Skjelstad of DSPUD, dated January 15, 2009.

As discussed in the above-mentioned letter report, the required ammonia additions during low load and low flow conditions can result in very high influent TKN concentrations, perhaps as high as 200 mg/L at times. The supplemented influent TKN could be continuously over 125 mg/L for weeks in late November and early December. When starting from such high influent TKN concentrations, it may not be cost-effective to get down to the required effluent nitrate-n concentration of 10 mg/L using a two-stage MLE system, because this would require extremely high mixed liquor recycle flows, which would result in large amounts of oxygen delivered to the anoxic zone. The anoxic zone would have to be enlarged and methanol (or alternative carbon source) added to offset the oxygen supply. A better approach may be to add another anoxic basin downstream from the aeration basin or a second and separate nitrate removal system, such as a denitrification filter after the secondary clarifiers. In both cases, methanol or an alternative carbon source would be added to provide the food necessary for denitrification in this second location, but the total carbon addition requirements would be lower than for the original two-stage alternative, due to less oxygen impacts. Also, with two locations for nitrate removal, a higher reliability could be attained.

If a second anoxic basin is used after the aerobic basin, a final small aeration basin would then be added to strip out remaining nitrogen bubbles and to increase the effluent dissolved oxygen concentration. In this case, there would be four reactor basins in series (anoxic-aerobic-anoxic-aerobic). In this four-stage system, the mixed liquor recirculation stream from the first aerobic basin to the first anoxic basin, together with RAS flow, would be used to deliver that amount of nitrate that could be denitrified in the first anoxic zone using the food of the influent wastewater. The remaining nitrate would be removed in the second anoxic basin using the supplemental food source (methanol or other appropriate substance).

A potential alternative to feeding ammonia during low-load periods to build up a nitrifier population by growing the nitrifiers in the reactor basins is to purchase cultured nitrifiers grown off-site. There are several companies that can supply nitrifying bacteria in liquid suspensions, which can be dosed into the DSPUD treatment system. For this scheme to work, the nitrifiers would have to be added in the right amounts just as each high load event occurred and would have to begin removing ammonia immediately. If the nitrifiers were added before the peak loads actually occurred, supplemental ammonia would have to be added to support the added nitrifiers, in which case the benefit of adding the nitrifiers instead of growing them in the process would be largely eliminated. Unfortunately, when nitrifiers grown off-site in a "laboratory" are added to the process, there will undoubtedly be an acclimation period before the full ammonia removal potential would be realized. Also, loss of a substantial amount of the added nitrifiers due to predation would be possible. Several companies that can supply nitrifiers were contacted and none had experience or knew of applications similar to that considered here. At this time, the option of growing nitrifiers in the process appears to be more feasible than adding nitrifiers grown off-site.

Existing Wastewater Treatment Plant

The existing wastewater treatment plant includes flow equalization, screening, integrated fixed film activated sludge (IFAS) biological treatment, filtration, and chlorine disinfection. The biological treatment system is provided in two circular steel package plants that were originally designed as activated sludge systems without provisions for ammonia removal (nitrification) or nitrate removal (denitrification). During 2002 through 2006, both package plants were upgraded from activated sludge to IFAS by adding webbing material supported on stainless steel frames in the reactor basins to support attached biological growth in addition to the suspended growth already in the basins. Also, the reactor basins were subdivided into anoxic and aerobic compartments to provide an MLE configuration for nitrification and denitrification. The IFAS system was designed and provided by Brentwood Industries and is called the AccuWeb system.

The AccuWeb system was designed to meet monthly average effluent ammonia-n and nitrate-n concentrations of 5 and 10 mg/L, respectively. The first AccuWeb installation in a portion of Plant 2 (one of the steel package plants), constructed in 2002, was a demonstration project with a design capacity of 144,000 gpd. DSPUD proceeded with the subsequent installations to complete the retrofits of Plants 1 and 2 in 2005 and 2006, however, a firm capacity for these improvements has not been established.

As part of the plant upgrade to the AccuWeb system, chemical feed facilities were added to feed ammonia during low load periods to grow enough microorganisms to handle high ammonia loads before the high loads occurred. Additionally, a chemical feed system for alkalinity was provided, since the nitrification process consumes alkalinity and could produce unacceptably low pH values and inhibit proper treatment without the alkalinity addition.

It is believed that the existing plant was not able to meet the ammonia and nitrate requirements in the 2002 NPDES permit for some or all of the following possible reasons:

- Inadequate reactor volume and/or biological growth media surface area in the aeration basin for complete ammonia removal.
- Lack of automated controls and optimized strategies for ammonia addition, resulting in inadequate buildup of nitrifying bacteria populations in advance of peak load events.
- Inadequate anoxic reactor volume and/or biological growth media surface area for denitrification.
- Inadequate food supply to the anoxic zone for the amount of nitrate to be removed.
- Inadequate mixed liquor recycle flows.

Treatment Improvements to Meet Existing NPDES Permit Requirements

Options for modifying the existing wastewater treatment plant to meet existing NPDES permit requirements are considered in this section. The main focus is on meeting ammonia and nitrate limits, although all permit requirements are taken into consideration. Two general types of processes can be considered for meeting the ammonia and nitrate limits: 1) biological and 2) physical/chemical. Combined biological and physical/chemical systems are also considered.

Biological Treatment for Ammonia and Nitrate

Biological treatment can be provided using suspended growth (activated sludge), attached growth (bacteria growing on support media), and/or combinations of suspended and attached growth, such as occurs with the existing integrated fixed film activated sludge (IFAS) system. Many modifications of each type of system are possible. In the following paragraphs, several systems that are judged to be most applicable for application at DSPUD are considered, including:

- Upgrade the existing two-stage IFAS system.
- Upgrade the existing IFAS system, including conversion to a four-stage reactor configuration.
- Upgrade the existing two-stage IFAS system and add denitrification filters.
- Convert to a different IFAS system (two-stage with and without denitrification filters or four-stage).
- Convert to a submerged attached growth process.
- Build a new four-stage membrane bioreactor (MBR).

All of the systems listed above can have large populations of bacteria in relatively small reactor volumes, resulting in a small footprint. This is highly beneficial at DSPUD, due to limited site space and difficult topography. Also, a small footprint is beneficial if covering the basins to conserve heat is to be considered.

For all systems, ammonia feed and control systems would be included to build up and maintain the nitrifier population during low-load periods as previously discussed.

Upgrade the Existing Two-Stage IFAS System: Based on information provided by Brentwood Industries, manufacturer of the existing AccuWeb system, the existing reactors should be able to provide full nitrification (essentially complete removal of ammonia) for influent TKN loads up to about 230 lb/d. Since the required design capacities for influent TKN based on existing flows and loads are 156 and 234 lb/d for peak month and peak week conditions, respectively (from Technical Memorandum No. 1, Draft, May 12, 2008), it would seem that the existing aerobic volumes and media surface areas should be marginally adequate. However, in an analysis of actual plant performance in the winter of 2007/2008, full nitrification was never achieved when influent TKN loads exceeded 125 lb/d, and was not achieved reliably at lower loads. The reliable nitrification capacity that would be possible with new automated controls and process optimization is unknown. To obtain reliable compliance with the new ammonia-n limit of 2.1 mg/L, additional aerobic volume may be required for existing flows and loads; however, further analysis in cooperation with Brentwood Industries is warranted.

The denitrification capacity of the existing system is even more questionable than the nitrification capacity. In the fall of 2007, while relatively low effluent ammonia concentrations were being achieved, effluent nitrate-n concentrations were frequently in the 20 to 35 mg/L range. The degree to which these effluent nitrate-n concentrations could have been reduced by adding supplemental food (methanol or other) is not known. In the winter of 2007/2008, poor nitrification performance made it impossible to assess denitrification performance. Additional anoxic volume may be required for existing flows and loads; however, further analysis in cooperation with Brentwood Industries is warranted. To attain the high degree of denitrification required to meet permit nitrate limits, particularly with supplemental ammonia addition, high mixed liquor recycle rates and addition of methanol or an alternative carbon source will certainly be required.

Because this alternative may require only limited modifications to the existing treatment structures and does not include any new processes (like denitrification filters), this alternative has the potential of being the least-cost alternative.

Unfortunately, only limited data are available on the biological treatment capacity of the AccuWeb system. Including DSPUD, there are only three full-scale wastewater treatment plants in existence using the AccuWeb media. The other two are in Connecticut and Florida, and treatment issues and requirements are quite different from those at DSPUD. Since the DSPUD installation, Brentwood has switched from using the webs to using structured sheet media. Problems with red worms eating the biomass needed for treatment have been experienced with the webs. The structured sheet media results in a thinner and denser biomass that does not support the growth of red worms. Brentwood reportedly has developed good treatment performance models for the structured sheets, but not for the webs, which Brentwood no longer supplies.

The uncertainties and potential red worm problem associated with the AccuWeb media make assessment of a plant upgrade based on continued use of this system difficult. Based on preliminary discussions, Brentwood is willing to help with an assessment, but would not be able to provide a process performance warranty for an upgraded system.

Upgrade the Existing IFAS System, Four-Stage: This option has the same uncertainties and issues associated with the AccuWeb media as discussed above. Under this option, the existing aerobic reactors would be retained for nitrification in the second stage of a four-stage reactor system. As discussed previously for the two-stage alternative, additional aerobic volume may be required, depending on evaluations to be conducted in cooperation with Brentwood Industries. Similarly, it may be possible to retain the existing anoxic basins as the first stage of the four-stage system. However, depending on final volume requirements for all of the anoxic and aerobic zones, there are many possible ways to incorporate the existing reactor and clarifier volumes, together with new structures, into a four-stage system. The most cost-effective configuration would have to be determined.

The four-stage system should provide more reliable denitrification performance, using less methanol (or alternative carbon source) than a two-stage system. Mixed liquor recirculation rates from the first aerobic zone to the first anoxic zone could be tailored to use up the readily biodegradable substrate in the raw sewage, with little or no methanol addition and minimized dissolved oxygen interference. This would also minimize the size requirements for the first anoxic zone. Since the nitrate concentration at the downstream end of the second anoxic zone would be essentially the same as the effluent nitrate concentration, simple feedback controls based on the nitrate concentration could be used to supply the correct amount of methanol to reliably meet the effluent nitrate limit (controls for methanol feed in a two stage system would be more complicated and less precise).

In addition to modifying and/or adding reactor and/or clarifier structures, upgraded ammonia feed and control systems and new methanol (or alternative carbon source) storage and feed systems would be needed under this alternative.

Upgrade the Existing IFAS System, Two-Stage, Add Denitrification Filters: This option has the same uncertainties and issues associated with the AccuWeb media as the previous two alternatives. The main benefit of using a two-stage system with subsequent denitrification filters is that it has the potential of requiring the least modifications to the existing reactor basins and clarifiers. Compared to the two-stage option without denitrification filters, much lower mixed liquor recycle rates and smaller anoxic reactor basins would be required. Methanol usage and the reliability of the overall system in meeting ammonia and nitrate limits should be comparable to that of a four-stage system.

As discussed for the two-stage option without denitrification filters, additional aerobic volume (compared to the existing aerobic volume) may be required to obtain reliable nitrification with existing flows and loads. Although anoxic volume requirements would be minimized under this alternative, the adequacy of existing anoxic volumes and possible need for increased volumes would have to be investigated. Additionally, the following improvements would be required for existing flows and loads:

1. Build new denitrification filters downstream from the existing secondary clarifiers and upstream from the existing effluent granular media filters.
2. Upgrade existing ammonia feed and control system.
3. Build new facilities for storage and feed of methanol or alternative food.

Many different configurations of denitrification filters are available from various manufacturers. In all systems, the bacteria that remove nitrate are grown attached to the filter media and methanol (or an alternate substrate) is fed as the food to support denitrification. Periodic backwashing is required to scour away excess biological growth. The denitrification filters would be located in a new building to protect the equipment, provide access for operation and maintenance and to conserve heat.

Convert to a Different IFAS System: Several different IFAS systems can be considered. One option would be to use the new structured sheet media currently produced by Brentwood Industries. The structured sheet media consists of corrugated plastic sheets, layered together in blocks. Like the existing webs, the structured sheet media would be fixed in certain positions within the reactor basins. According the Brentwood, treatment results should be more predictable and reliable with the structured sheets. Since this is a new product, however, there are no reference installations with significant operating history.

Another option would be to use loose media retained in reactors with sieves or other suitable barriers. There are several manufactured systems of this type with many installations worldwide. The media are typically small plastic shapes that provide large amounts of surface area for biological growth. The new media are simply dumped into the reactor basin, with various degrees of fill being possible. Under the mixing and/or aeration conditions in the reactor basins, the media are suspended and move about freely. As the treated wastewater flows out of the reactor basins to the clarifiers, the media with attached growth are retained in the reactor basins. Systems can be operated with or without returning settled solids from the clarifiers to the reactor basins. If settled solids are returned, a substantial population of suspended bacteria can be developed in the reactor, so that treatment is accomplished both by attached and suspended growth. This is then an IFAS system. If solids are not returned from the clarifier to the reactor and essentially all treatment is accomplished by attached growth, the system is a moving bed bioreactor (MBBR). The IFAS configuration would be preferred at DSPUD for two primary reasons: (1) more treatment capacity could be provided in a smaller space, and (2) by including mixed liquor in the process, fine dispersed solids can be accumulated in biological flocs and removed in the secondary clarifier, leading to better reliability in meeting the effluent turbidity limit.

Two-stage systems with and without denitrification filters and four-stage systems can be investigated in accordance with previous discussions. These types of IFAS systems are designed based mostly on empirical data and models developed by the respective manufacturers, which would provide process performance warranties.

Convert to a Submerged Attached Growth System: The denitrification filter previously described is an example of a submerged attached growth system. Several manufacturers have developed submerged attached growth systems that can be used to provide complete biological wastewater treatment, including BOD removal, nitrification, and denitrification. Like the denitrification filter previously mentioned, attached biological growth occurs within a media bed that also provides for suspended solids removal. No secondary clarifier is needed. Excess biological solids are accumulated in the bed and removed periodically by backwashing. Both upflow and downflow systems are used. Media used in these systems include specifically sized fired clay and polystyrene beads. Proprietary process names include Biocarbone, Biofor, and Biostyr. There are hundreds of these systems in existence throughout the world. The TTSA wastewater treatment plant in Truckee converted to the Biostyr process in their recent plant upgrade and expansion. The plant is reportedly able to produce an effluent with typical ammonia-n and nitrate-n concentrations of around 0.5 and 1.5 mg/L, respectively.

For BOD removal, nitrification, and denitrification, three submerged attached growth systems would typically be used in series – one for each of these major functions. Because these are basically biologically active filter systems, they are limited by hydraulic loading rates per unit area. It is impractical to have the large recycle flows that would be associated with denitrification in an anoxic zone upstream from an aerobic zone such as occurs in the MLE configuration previously described. Therefore, it is not practical to use the influent wastewater as a food source for denitrification. Instead, all denitrification is accomplished using methanol or other suitable substrate after BOD removal and nitrification. Accordingly, the methanol usage for this system would be substantially greater than in the two-stage or four-stage IFAS systems previously discussed. The requirement for chemical alkalinity addition would also be much higher.

Submerged attached growth systems would have a very small footprint. These systems have been cost-effective mostly in larger plants, but can be considered for plants as small as DSPUD. These types of systems are proprietary treatment systems, the designs of which are based on empirical data and models developed by the respective manufacturers, which will provide process performance warranties.

The submerged attached growth systems alone would not be able to meet a 2 NTU effluent turbidity requirement. Therefore, the existing granular media filtration system at DSPUD would continue to be used after a new submerged attached growth system. It may be necessary to provide improved coagulation and flocculation ahead of these filters.

Build a New Four-Stage MBR: An MBR is a suspended growth (activated sludge) biological treatment system. In an MBR, clarifiers and effluent filters used in a conventional system are replaced with membrane filters submerged in the biological treatment system mixed liquor. Wastewater effluent is pulled through the membranes by pumping, leaving the solids in the reactor basins. The membranes would provide an absolute barrier to mixed liquor solids. The MBR effluent would typically have a turbidity under 0.2 NTU. By contrast, the existing biological treatment and granular media filtration system at DSPUD is designed to have an effluent turbidity under 2 NTU.

MBR systems have several distinct advantages, when compared to activated sludge and/or IFAS systems:

1. The need for clarifiers and granular media filters is eliminated as mentioned above.
2. Since solids settling in a clarifier is no longer required, mixed liquor solids can be increased to about 8,000 to 10,000 mg/L, compared to 3,000 to 4,000 mg/L in activated sludge and IFAS systems. This means that reactor basins can be 1/3 to 1/2 the size required for conventional activated sludge.
3. A much higher quality effluent is produced with high reliability.
4. Because membrane filters remove many colloidal solids that cannot be removed by clarification, there is frequently a benefit in further removals of heavy metals or other constituents of concern that have a particulate or colloidal fraction.
5. The MBR effluent is much easier to disinfect, leading to reliable effluent coliform compliance with lower chlorine doses. Additionally, if a switch is made to ultraviolet (UV) light disinfection, the required size of the UV facilities is substantially reduced as compared to systems without membrane filtration.
6. In general, MBRs are state-of-the-art treatment systems that produce the highest quality effluent, assuring more reliable compliance with current treatment standards and a better chance of meeting new and/or more stringent standards in the future.

The MBR system would include two concrete reactor basin trains, with each train including a pre-anoxic zone, an aeration zone, and a post-anoxic zone, each of which could be further staged. These would be followed by membrane basins that could be either concrete or prefabricated steel packaged units with the membranes installed. The membrane basins would include air scouring to keep the membranes clean and would therefore act as additional aerobic reactor volume. All reactor and membrane basins would be covered or inside a building. Permeate pumps for pulling the effluent through the membranes, blowers for air scour and for process aeration, mixed liquor recirculation pumps, chemical feed systems, and other ancillary facilities also would be inside a building.

Physical/Chemical Treatment for Ammonia or Nitrate

Ammonia and nitrate can be removed by various physical/chemical processes, including the following:

- Ammonia:
  - Air Stripping
  - Ion Exchange
  - Breakpoint Chlorination
  - Reverse Osmosis
- Nitrate:
  - Reverse Osmosis

Air stripping is considered impractical at DSPUD due to freezing of the stripping towers. Reverse osmosis would be prohibitively expensive and would produce a residual brine solution that would be extremely difficult and expensive to dispose of or eliminate. Therefore, these options are not considered further.

In general, physical/chemical treatment systems for nitrogen removal have been used only at a few municipal wastewater treatment plants throughout the country, dating back to the 1970s and 1980s. Most of these systems have since been abandoned in favor of biological treatment systems. The following are excerpts from the EPA Nitrogen Control Manual, dated September 1993:

> *"The physical/chemical processes for nitrogen control are at the opposite end of the spectrum from lower technology approaches. Although receiving only limited application, there is enough knowledge to determine that they have limited or no potential for most municipal applications."*
>
> *"The physical/chemical processes are briefly discussed in Section 2.5, more in the interest of completeness and to point out the problems of the past in order to avoid their repetition rather than to recommend their use."*
>
> *"Several physical/chemical nitrogen control treatment processes have been advanced and tried in municipal wastewater treatment applications. Only two remain in routine service. Physical/chemical treatment, except in highly specialized situations, is the process of last resort, especially at small plants."*

Ion Exchange for Ammonia Removal: Ammonia can be removed from filtered wastewater effluent by passing it through a packed bed ion exchange column (similar to a granular media filter) containing natural clinoptilolite media. In the clinoptilolite, the ammonium ion is removed by exchanging it for sodium ions, which are released into the wastewater. Other positive cations, most notably calcium, will compete with ammonium for the available exchange sites, reducing the capacity of the media to remove ammonia. When the clinoptilolite media has removed a certain amount of ammonium (and competing ions), the media is first backwashed and then regenerated by applying high concentration sodium chloride solutions in a stepwise process. The regenerant solutions are stored in different tanks, depending on previous uses and the accumulated ammonia concentrations. The regenerant solution with the highest accumulated ammonia concentration is circulated through the ion exchange column first, followed by regenerant that has been used less and has less accumulated ammonia. The final regenerant solution to be used during a regeneration cycle consists mostly of regenerant that has just been stripped of accumulated ammonia. During the regeneration process, the exchange sites are again occupied by sodium ions and the ammonium and competing cations are released into the regenerant solutions. After a regeneration cycle, the regenerant that was used first and contains the highest amount of accumulated ammonia is subjected to a stripping process to remove most of the accumulated ammonia. Caustic soda or lime is added to the spent regenerant to raise the pH and convert the ammonium ion into dissolved ammonia gas that can be removed by air stripping. However, the high pH also causes precipitation of magnesium hydroxide and calcium carbonate that must be removed by clarification before air stripping is accomplished. Once air stripping of ammonia is accomplished, the stripped regenerant is stored for use as the final step of the next regeneration cycle. The exhaust gas from the stripper is passed through an adsorption tower with sulfuric acid to take up the ammonia and form ammonium sulfate that can be sold as a fertilizer.

As described above, ammonia removal by ion exchange is a complex and mechanically intensive process. It has been used only in a couple full scale applications in the country. This was the method of nitrogen removal at TTSA for about 30 years, until the system was recently replaced with a submerged attached growth biological treatment system. The other full-scale application was at the Upper Occoquan Sewage Authority in Virginia. That facility has switched to suspended growth biological nitrification and denitrification. They have the ability to use breakpoint chlorination as a final polishing step for ammonia control.

According to Richard Svetich, a scientist who was responsible for running the ion exchange system at TTSA, the system was originally designed with the intent of producing an effluent total nitrogen level of 2 mg/L, but was unable to meet that objective. The TTSA ion exchange system was typically operated to produce an effluent ammonia-n concentration of about 5 to 6 mg/L. This was determined to be acceptable because further nitrogen removal from the effluent was found to occur by natural means after it was discharged underground and flowed through the soil to the Truckee River. According to Mr. Svetich, attaining an effluent concentration of 2 mg/L of ammonia-n in the ion exchange system would require a very conservative design with lightly loaded ion exchange columns, frequent regeneration and with very large chemical usage and expenses associated with regeneration and regenerant recovery. Pilot testing would be required to develop design criteria for use at DSPUD.

One possible option would be to design the ion exchange system to remove most of the ammonia (perhaps to around 5 mg/L) and then use breakpoint chlorination to remove the remainder of the ammonia down to the effluent limit. Breakpoint chlorination is discussed in the next sub-section of this document.

A significant issue associated with ammonia removal by ion exchange is that the biological process that is used for BOD removal should be operated to avoid nitrification. Otherwise ammonia would be converted to nitrate, which would not be removed in the ammonia ion exchange system and could cause violation of the effluent nitrate limit. Although obtaining complete nitrification at DSPUD is problematical as discussed elsewhere in this paper, operating to prevent nitrification altogether also would be difficult and may jeopardize other treatment objectives, particularly the final effluent turbidity limit of 2 NTU. To prevent nitrification altogether, the plant would have to be operated at a low mean cell residence time (MCRT of a few days, depending on temperature). Operation at a low MCRT requires more careful operator attention, produces more sludge, and would be less reliable in terms of meeting effluent BOD, TSS, and turbidity limits.

An option that might be most applicable for the conditions at DSPUD would be to use an ion exchange system after a nitrifying and denitrifying biological treatment process. In this way, the biological treatment system could remove as much ammonia as possible, without the need for supplemental ammonia addition to build up the nitrifier population. It is likely that the ion exchange system would have to be followed by breakpoint chlorination for further polishing of the effluent ammonia. However, considering the large difference between low fall loads and high winter loads at DSPUD, the amount of ammonia escaping the biological process upon the onset of winter loads would be such that the ion exchange system in this case would not be substantially different than if no biological ammonia removal was provided.

Because of the complexity, anticipated high costs, and other issues discussed above, it is considered unlikely that ion exchange would be a good option for DSPUD.

Breakpoint Chlorination for Ammonia Removal: Ammonia can be removed by adding chlorine in the form of chlorine gas or sodium hypochlorite in the process of breakpoint chlorination. As the chlorine is added, it combines with the ammonia first to form chloramines. The chloramines are measured as combined chlorine residual. Up to a weight ratio of about 5 parts of chlorine per part of ammonia nitrogen, the measured chlorine residual would increase as the chlorine is added. As more chlorine is added, the chloramines would be broken down, resulting in decreasing chlorine residual with increased chlorine dose, until a minimum residual is reached at a theoretical ratio of 7.6 parts of chlorine per part of ammonia nitrogen. This point of minimum chlorine residual is the breakpoint. Further addition of chlorine past the breakpoint would result in increasing chlorine residuals. The increasing residuals would be in the form of free chlorine (not chloramines). As the chloramines are being eliminated approaching the breakpoint, the chlorine is converted to the chloride ion and the nitrogen from the ammonia is converted into nitrogen gas, as well as some nitrous oxide and nitrogen trichloride.

In actual practice, it has been found that the amount of chlorine required to reach the breakpoint is greater than the theoretical requirement, perhaps around 10 parts of chlorine per part of ammonia nitrogen. Thus, to remove 30 mg/L of ammonia-n, around 300 mg/L of chlorine would be required.

When chlorine gas is used for breakpoint chlorination, there is a net consumption of 14.3 mg/L of alkalinity per mg/L of ammonia-n removed. This is double the consumption of alkalinity by biological nitrification. Therefore, lime or caustic soda would typically be added to offset the alkalinity loss in breakpoint chlorination. If sodium hypochlorite is used, alkalinity consumption is not a problem.

Because of the chlorine or sodium hypochlorite added, and because of the need to add alkalinity with chlorine, breakpoint chlorination results in a substantial increase in effluent salinity. When sodium hypochlorite is used, the total dissolved solids (TDS) added is 7.1 mg/L per mg/L of ammonia-n removed. When chlorine is used and alkalinity is replaced using caustic soda, the TDS added is 14.8 mg/L per mg/L of ammonia-n removed.

If a breakpoint chlorination process is used for ammonia removal, additional chlorine would be added beyond that required for ammonia removal to obtain a chlorine residual required for disinfection. As mentioned above, the residual would be in the form of free chlorine (not chloramines). The use of free chlorine for disinfection would also occur if the ammonia was removed biologically, unless some ammonia were added back in prior to disinfection. With free chlorine disinfection, there is a substantial risk of forming disinfection byproducts in amounts that would be above allowable limits. Although the chlorine added to reach the breakpoint does not result in free chlorine residual, the large amounts of chlorine involved in breakpoint chlorination would certainly cause concern regarding disinfection byproducts.

If chlorine gas were used for breakpoint chlorination, concerns regarding chlorine safety and public risk would be raised. At the minimum, chlorine containment and scrubbing systems would be required at the plant to mitigate the potential consequences of a leak within the plant. However, that would not address concerns regarding the safety issues involved in transporting chlorine gas to the plant and unloading it at the plant. Because of the safety concerns associated with chlorine gas, many communities discontinued its use in favor of using sodium hypochlorite. Now, with disinfection byproducts concerns, even the use of sodium hypochlorite is being discontinued in many plants in favor of using ultraviolet (UV) disinfection.

It is noted that chlorine gas is currently used for disinfection at DSPUD. However, only relatively small quantities are used and the chlorine is provided in 100 lb cylinders. Even with the 100 lb cylinders, the Uniform Fire Code requires containment and scrubbing systems, as well as other safety features that currently do not exist at the plant. Such systems should be provided with any plant upgrade. However, if breakpoint chlorination with chlorine gas is to be used, the plant will need to switch to ton cylinders of chlorine. In that case, the safety concerns and need for mitigation are greatly increased.

Breakpoint chlorination potentially could be used as the primary ammonia removal system or as a supplemental system to be used after biological treatment or ion exchange for ammonia removal. However, because of the large chlorine doses involved and related issues as discussed above, use as the primary ammonia removal method is not recommended.

The most likely application for breakpoint chlorination at DSPUD would be as a supplement to biological ammonia removal, particularly if that could eliminate the need for supplemental ammonia addition to build up the nitrifier population during the fall and during low-load periods in the winter. This would, in turn, eliminate a large amount of potential methanol usage and perhaps eliminate the need for a four-stage biological process. Unfortunately, however, the difference between the low load conditions of fall and the high-load conditions of winter are so extreme that this is not likely. As documented in the letter report from Jeff Hauser of

ECO:LOGIC Engineering to Tom Skjelstad of DSPUD, dated January 15, 2009, the influent TKN load during the weeks and months preceding the Christmas Holiday period are estimated to be only about 20 to 40 lb/d, compared to over 150 or 200 lb/d during peak winter periods. Therefore, without supplemental ammonia addition (and the associated additional methanol or other food addition), it would be expected that 70 percent or more of the TKN coming in during the initial peak loads could end up as ammonia in the effluent. With peak load influent TKN concentrations expected to be over 60 mg/L, effluent ammonia-n concentrations over 40 mg/L would be expected. Therefore, a chlorine dose of over 400 mg/L could be required for breakpoint chlorination. At a flow rate of 0.5 Mgal/d, that would require about 1700 lb/d of chlorine.

Based on the discussion above, breakpoint chlorination cannot be expected to eliminate the need for supplemental ammonia addition or a four-stage biological treatment process. Because of this and all of the concerns associated with breakpoint chlorination, it is suggested that means other than breakpoint chlorination should be planned to meet the 2 mg/L ammonia-n limit. Breakpoint chlorination should be considered only as a potential final polishing step in the event of minor excursions above the 2 mg/L ammonia-n limit.

The recommendation to consider breakpoint chlorination only as a final polishing option is in concert with the EPA Nitrogen Control Manual, dated September 1993. The following are excerpts from that manual:

> *"The only known operating facility where breakpoint chlorination is the principal nitrogen control strategy is at Sugarbush, Vermont. .. The utilities director's recommendation for others considering full nitrogen control by breakpoint chlorination can be summarized in one word – 'don't'."*
>
> *"It is recommended that breakpoint chlorination be routinely considered only for polishing applications, such as was used at the previously described North Tahoe Truckee Plant, where a low total or unoxidized nitrogen residual is mandatory."*

Upgraded Treatment to Prevent Biostimulation

If DSPUD were to continue discharging to the South Yuba River during times when nuisance algae growth could occur, it would have to remove biostimulatory substances to levels that would not cause or contribute to nuisance growths. At the present time, it is uncertain which substances would have to be removed and to what levels. It is believed that nitrogen and phosphorus, as primary nutrients for algae, would have to be removed to very low levels. Iron and other micronutrients might also be considered.

In the Treatment and Disposal Facilities Plan prepared for DSPUD in June 1984, the option of discharging to the river during times when algae growth could occur was investigated and discussed with the Central Valley Regional Water Quality Control Board. At that time, it was planned that such a discharge would have to meet background concentrations (concentrations in natural runoff without pollution from human activity) of total nitrogen and total phosphorus, which were estimated to be 0.3 and 0.02 mg/L, respectively. In establishing numerical discharge limits for storm water runoff in the Lake Tahoe basin, the Lahontan Regional Water Quality Control Board took a similar approach and established total nitrogen and total phosphorus limits of 0.5 and 0.1 mg/L, respectively. Although it may be feasible at substantial cost to meet these types of phosphorous limits, it is considered impractical to meet such low total nitrogen limits without going to such extreme treatment as reverse osmosis, which would be cost prohibitive.

Depending on the amount of dilution present below the DSPUD discharge, allowable effluent nutrient concentrations may be somewhat higher than the background levels mentioned above, but probably still at relatively infeasible levels. Because of this and because the studies that would be required to establish allowable nutrient concentrations would be expensive and time consuming, such studies are not recommended. Rather, the biostimulation study to be conducted by DSPUD should focus on defining times and conditions during which algae would not grow in nuisance amounts (such as cold winter and high-flow spring conditions), despite the presence of ample nutrients.

Based on the discussion above, it is believed that continued discharge to the river during times when algae can grow in nuisance amounts will be impractical.

Lower Levels of Treatment for Land Disposal

Two of the disposal options considered previously could potentially result in treatment requirements less stringent than those for meeting the numerical effluent limits contained in the existing NPDES permit. These are briefly discussed below.

Treatment for Subsurface Discharge

For subsurface disposal, treatment requirements are uncertain, due to questions regarding the ultimate fate of the effluent, possible impacts on surface water courses and groundwater degradation. It is possible, however, that treatment requirements could be somewhat less stringent than indicated by the numerical effluent limits contained in the existing NPDES permit. It is possible also that some natural treatment during underground flow could be attained.

Treatment for Storage and Irrigation Disposal

This disposal option is likely to result in the least stringent treatment requirements. For example, the existing discharge requirements for irrigation at the Soda Springs Ski Area allow average BOD and TSS concentrations of 30 mg/L (compared to 10 mg/L for river discharge) and total coliform organisms of 23 MPN/100 mL (compared to 2.2 for river discharge). There are no limits on ammonia, nitrate, metals, disinfection byproducts, or other parameters that are of concern for river discharge. In general, it is expected that a relatively simple secondary treatment plant would be adequate for this disposal option.

Summary of Treatment Options

The treatment options discussed above are summarized in Table 3. Recommendations on which options should be considered further are included in Section 5.

Table 3
Summary of Treatment Options

Option	Pros	Cons	Comments
Upgrade the Existing IFAS System, Two Stage	❑ Potentially the lowest cost alternative. ❑ Continue to use the existing AccuWeb modules. ❑ Fewer modifications to existing treatment system required, as compared to the four-stage option.	❑ Uncertainty on performance of AccuWeb. ❑ Potential red worm problems. ❑ Manufacturer has discontinued AccuWeb media in favor of structured sheet media. ❑ Lack of other AccuWeb installations to assess performance. ❑ Very high mixed liquor recirculation rates required. ❑ Higher methanol usage and more difficult control compared to the next two options. ❑ Less reliable than the next two options. ❑ Larger anoxic zone required, as compared to the option with denitrification filters.	❑ Cooperative effort with Brentwood Industries required to assess AccuWeb performance and improvement requirements.
Upgrade the Existing IFAS System, Four-Stage	❑ Continue to use the existing AccuWeb modules. ❑ Lower methanol usage and easier control compare to the two-stage option without denitrification filters. ❑ Higher reliability than two-stage without denitrification filters.	❑ Uncertainty on performance of AccuWeb. ❑ Potential red worm problems. ❑ Manufacturer has discontinued AccuWeb media in favor of structured sheet media. ❑ Lack of other AccuWeb installations to assess performance. ❑ Reconfiguration of existing basins and new basins required.	❑ Cooperative effort with Brentwood Industries required to assess AccuWeb performance and improvement requirements.
Upgrade the Existing IFAS System, Two-Stage, Add Denitrification Filters	❑ Continue to use the existing AccuWeb modules ❑ Fewest modifications to existing treatment system required as compared to both options above. ❑ Lower methanol usage and easier control compare to the two-stage option without denitrification filters. ❑ Higher reliability than two-stage without denitrification filters.	❑ Uncertainty on performance of AccuWeb. ❑ Potential red worm problems. ❑ Manufacturer has discontinued AccuWeb media in favor of structured sheet media. ❑ Lack of other AccuWeb installations to assess performance. ❑ New denitrification filter system must be added.	❑ Cooperative effort with Brentwood Industries required to assess AccuWeb performance and improvement requirements.

Option	Pros	Cons	Comments
Convert to a Different IFAS System	❑ IFAS systems with small plastic cylindrical biofilm carriers suspended in the reactor basins are well demonstrated with hundreds of installations worldwide. ❑ Better understanding of performance characteristics as compared to AccuWeb. ❑ Backed by large international wastewater process manufacturers. ❑ No red worm problems.	❑ No further use of the existing AccuWeb modules. ❑ High cost of conversion.	❑ Two-stage systems with and without denitrification filters and four-stage systems can be considered.
Convert to a Submerged Attached Growth System	❑ Hundreds of successful installations worldwide (including TTSA). ❑ Probable smallest footprint treatment system. ❑ Backed by large international wastewater process manufacturers.	❑ Completely new treatment plant structures required. Existing basins would be converted to alternative uses, perhaps equalization or sludge handling. ❑ No pre-anoxic treatment, so all nitrate must be removed with imported food (methanol or other).	❑ Most existing plants of this type are much larger than DSPUD. Cost effectiveness at small size is questionable.
MBR (Four-Stage)	❑ Hundreds of successful installations worldwide ❑ Membranes provide absolute barrier to solids and lowest turbidity effluent of any biological treatment system. ❑ Because many colloidal solids are removed, MBR may help to meet requirements for some metals and priority pollutants with a particulate component. ❑ No need for clarifiers or filters. ❑ High mixed liquor solids allow small footprint. ❑ Easiest effluent to disinfect.	❑ Completely new treatment plant structures required. Existing basins would be converted to alternative uses, perhaps equalization or sludge handling.	❑ Use of MBRs in recent years has grown exponentially. MBR would likely be the technology of choice for a new plant in situations similar to DSPUD.
Biological Treatment for BOD Removal Followed by Ion Exchange for Ammonia Removal	❑ Ion exchange is not a biological process, so no need to buildup nitrifier population in advance of peak loads. ❑ Not impaired by low temperature.	❑ Mechanically complex. ❑ May not be able to attain ammonia limit unless followed by breakpoint chlorination. ❑ Pilot testing required to establish design criteria. ❑ Must operate biological process to avoid nitrification, which is not desirable. Alternatively, must provide for nitrate removal.	❑ Only two full-scale municipal wastewater treatment plants known to have used ion exchange for ammonia removal (including TTSA). Both plants have abandoned these systems in favor of biological treatment for ammonia.

Option	Pros	Cons	Comments
Biological Nitrification and Denitrification Supplemented by Ion Exchange and Breakpoint Chlorination for Ammonia Removal	❑ No need to build up nitrifier population in advance of peak loads. ❑ Physical/chemical processes not impaired by low temperature.	❑ Same as above. ❑ This option would not allow substantial reduction in ion exchange system compared to above.	❑ Only two full-scale municipal wastewater treatment plants known to have used ion exchange for ammonia removal (including TTSA). Both plants have abandoned these systems in favor of biological treatment for ammonia.
Breakpoint Chlorination for Ammonia Removal	❑ Breakpoint chlorination is not a biological process, so no need to buildup nitrifier population in advance of peak loads. ❑ Not impaired by low temperature.	❑ Huge chlorine doses required (several hundred mg/L). ❑ Disinfection byproducts. ❑ Safety issues associated with gaseous chlorine transport and use (unless switch to sodium hypochlorite). ❑ Adds substantial salinity. ❑ Must operate biological process to avoid nitrification, which is not desirable. Alternatively, must provide for nitrate removal.	❑ EPA Manual on Nitrogen Control indicates this technology should be considered only for polishing small amounts of ammonia.
Treatment to Prevent Biostimulation	❑ Avoids need for seasonal storage	❑ Probably not feasible to meet nutrient limits needed to avoid biostimulation.	❑ Because of the anticipated infeasibility of this option and because it would be expensive and time consuming to determine appropriate nutrient concentrations to prevent biostimulation, it is recommended that determination of these concentrations should not be part of the DSPUD biostimulation study.

5. OVERALL WASTEWATER MANAGEMENT OPTIONS

In the previous sections, various disposal and treatment options are considered and evaluated on a conceptual level. In Table 4, disposal and treatment options are grouped into combined wastewater management options. For each option, a subjective rating is provided for each of four key evaluation factors: (1) anticipated costs, (2) reliability, (3) ease of implementation and (4) environmental impacts.

A three point rating system is used as follows:

- "+" indicates the option would likely be advantageous compared to other possible options based on this criterion.
- "0" indicates the option is neither favorable nor unfavorable based on this criterion. "0" can be considered an average or medium rating.
- "-" indicates the option would likely be disadvantaged compared to other possible options based on this criterion.

Anticipated costs represent the total life-cycle costs, including the initial capital cost and the ongoing operation and maintenance costs, such as labor, power and chemical costs. It must be recognized that the ratings given for cost are based on engineering judgment as to likely costs relative to other options, without the benefit of developing specific project sizes, layouts and actual cost estimates. Accordingly, there is a significant margin for error in making these assessments.

The reliability criterion reflects a preliminary assessment of the degree of certainty that the option can be designed with confidence to attain compliance with all regulatory requirements. A range of issues is lumped into the rating, including, but not limited to, such things as:

- the degree to which the technology is established, has been demonstrated successfully in other similar applications and reliable design criteria exist;
- the likelihood of operational problems or performance variability leading to occasional excursions beyond permitted limits; and
- the possibility of undesired side effects, such as disinfection byproducts or salinity issues.

Ease of implementation reflects the anticipated degree to which any legal, administrative, institutional, regulatory, land or right-of-way acquisition, or uncertain technical issues could delay the planning, design, and/or construction of the project.

Environmental impacts reflect the degree to which the option would result in the need to disrupt currently natural areas for the construction of wastewater facilities as well as any ongoing environmental impacts associated with the continued functioning of the option.

Table 4
Overall Wastewater Management Options

Disposal Option	Treatment Option	Cost	Reliability	Ease of Implementation	Environmental Impact	Further Consideration
Subsurface	Unknown	0	0	-	0	No
Wet Season Storage, Dry Season Irrigation	Secondary	-	+	-	-	No
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Upgrade Existing IFAS 2-Stage	+	-	+	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Upgrade Existing IFAS 4-Stage	+	-	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Upgrade Existing IFAS 2-Stage, Denitrification Filter	+	-	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	New IFAS 4-Stage	0	+	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	New IFAS 2-Stage, Denitrification Filter	0	+	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Submerged Attached Growth	0	+	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	MBR 4-Stage	0	+	0	-	Yes
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Non-Nitrifying Activated Sludge, Ion Exchange for Ammonia	0	-	-	-	No
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Non-Nitrifying Activated Sludge, Breakpoint Chlorination for Ammonia	+	-	0	-	No
Wet Season Discharge to SYR, Seasonal Storage, Dry Season Irrigation	Upgrade Existing IFAS 2-Stage, Ion Exchange and Breakpoint Chlorination for Supplemental Ammonia Removal, Denitrification Filter for Supplemental Nitrate Removal	-	-	-	-	No
Wet Season Discharge to SYR, Dry Season Irrigation, No Seasonal Storage	Undetermined Enhanced Nutrient Removal System	-	-	-	0	No
Year-Round Discharge to SYR	Undetermined Extreme Treatment	-	-	-	-	No
Export Raw Sewage to TTSA	None	0	+	-	-	No
Export Treated Effluent to TTSA	Undetermined Enhanced Nutrient Removal System	-	-	-	-	No

A final column in Table 4 is used to indicate a recommendation for further evaluation up to and including process analysis, unit sizing, and detailed life-cycle cost analysis. If during subsequent analyses, information is developed that would jeopardize the viability of an option, termination of further evaluation would be considered at that time.

6. ADDITIONAL CONSIDERATIONS

In this section, various issues that would affect many or all of the wastewater management options considered in this document are discussed, including:

- Infiltration and Inflow
- Equalization Storage
- Covering Basins to Conserve Heat
- Disinfection Alternatives
- Solids Handling
- Planning for Future Growth
- Schedule for Future Work

Infiltration and Inflow

At times during the year, infiltration and inflow (I/I) can constitute a significant portion of the total flow into the DSPUD WWTP. During the spring snowmelt, this is the primary flow component. However, flows that occur during peak occupancy periods in the winter (even without unusual I/I events) are frequently of the same general magnitude or larger than those in the spring.

I/I flows will have a significant impact on the sizing and cost of some treatment, storage, and disposal components, including influent equalization storage, filtration facilities, effluent storage, and effluent spray irrigation facilities (not a complete list). Additionally, since I/I can be much colder than wastewater from homes and businesses, the presence of I/I impacts the design temperature and sizing of biological treatment reactor basins (discussed later in this document). I/I flows also impact the ongoing operation and maintenance costs. Accordingly, it is highly important that both DSPUD and SLCWD have aggressive I/I mitigation programs. This is nothing new; both Districts have understood this and have sought to control I/I for many years. Although substantial progress has been made, more needs to be done. It is noted that some of the highest flows occurring since the year 2002 occurred in 2006 and 2007, after both Districts had made substantial I/I improvements. Although flows in 2008 and 2009 have been generally lower, this is probably due to less severe weather conditions that create I/I, rather than system improvements.

In planning and design of wastewater treatment, storage, and disposal facilities for the future, a key question is how much I/I to include in the flow projections. In general, the answer should be a conservative one. In many cases, projections of reduced I/I have not been realized. Therefore, it is suggested that, unless the specific causes of known I/I flows of the past have been identified and corrected and ample time and events have passed to prove a flow reduction, no reduction should be presumed. Sometimes, I/I flows eliminated at one location simply show up somewhere else.

The statement above does not mean DSPUD and SLCWD should accept the status quo. Just to hold the line at existing I/I amounts will require dedicated efforts from the two Districts. Furthermore, if substantive I/I reductions can be made over the years, that would have the benefit of lowering operating costs and potentially extending system capacity.

The two Districts may want to increase I/I reduction efforts and funding in advance of the design of the upcoming improvement project. However, it is doubtful that convincing results of permanent flow reductions could be realized in time to make a significant change in design based on recent historical flows.

Equalization Storage

Influent equalization storage will be considered for all wastewater treatment options. The existing plant includes an equalization storage tank with a volume of 0.2 Mgal, which, based on the design in 1985, was intended to equalize flows to over a peak 3-day weekend to 0.52 Mgal/d.

Based on the Draft Technical Memorandum No. 2, prepared for the current project in April 2009, and based on recent historical flows, the volume of 0.2 Mgal gallons would still be adequate to equalize influent flows to a maximum of about 0.5 Mgal/d, if the peak flow event that occurred from December 21, 2005 through January 2, 2006 is ignored. With that peak flow event included in the analysis, the theoretical storage requirement to equalize to 0.5 Mgal/d is increased to about 0.8 Mgal. To equalize to 0.4 Mgal/d, the volume requirements are about 0.4 and 1.8 Mgal, without and with consideration of the 2005/2006 peak flow event, respectively.

In the future design of treatment plant improvements, the most cost effective size of equalization storage will be determined. Consideration will be given to emergency peak flow handling should the equalization capacity be exhausted.

Covering Basins to Conserve Heat

As discussed previously in this document, cold winter temperatures are a particular concern for biological nitrification. For example, the net growth rate (growth minus decay) of nitrifying bacteria can about double with a temperature change from 5 °C to 10 °C, depending on the fraction of the time that the nitrifiers are under anoxic conditions (due to mixed liquor circulation through an anoxic zone). Doubling the growth rate would result in the need for about one-half the aerobic reactor volume to accomplish the same level of treatment.

Currently, temperatures in the biological reactors can get down to about 4 °C or 5 °C in the winter. Therefore, covering the basins to conserve heat may be of major benefit.

Heat is lost from wastewater treatment basins with exposed water surfaces by several methods, including: (1) net atmospheric radiation, (2) conduction and convection, and (3) evaporation. Heat is gained by: (1) solar radiation, (2) mechanical energy input due to mixing and/or aeration, and (3) the exothermic biological processes. In the coldest part of the winter, the most significant heat losses from exposed water surfaces are by atmospheric radiation and conduction and convection. The largest temperature changes due to these heat loss mechanisms occur with cold and windy conditions with lower wastewater flows.

Based on preliminary and approximate calculations, covering the basins to minimize atmospheric radiation and conduction and convection to the air above has the potential to increase the temperature in the reactor basins by 5 °C or more, depending on conditions. Therefore, covering the basins should be considered during planning and design.

Another option that could be considered to increase the temperature in the reactor basins is to generate electricity for use in the plant by using diesel driven generators and to cool the diesel engines using heat exchangers in the equalization basin. This option is currently employed at the Kirkwood Meadows Public Utility District. However, the main incentive for using on-site diesel generators at Kirkwood was the extremely high cost of power in that location.

Disinfection Alternatives

As previously noted, the current NPDES permit includes numerical limits on the chlorine disinfection byproduct dichlorobromomethane. There are other chlorine disinfection byproducts that can occur, but the reasonable potential analysis based on previous California Toxics Rule sampling indicated that only dichlorobromomethane had the reasonable potential to exceed water quality objectives. However, if the wastewater effluent was not fully nitrified to remove essentially all ammonia at the time of those previous samples, it is likely that disinfection byproduct formation was limited due to the presence of the ammonia. With ammonia present, chlorine forms chloramines and the disinfection process is referred to as chloramination, versus simply chlorination. Chloramination is known to substantially reduce disinfection byproducts compared to chlorination. It is currently unknown what level of disinfection byproducts would occur with complete nitrification and disinfection by chlorination. Certainly, there is reason to be concerned about disinfection byproducts if the nitrification system is improved and disinfection is by chlorination.

There are three possible methods by which disinfection byproducts can be mitigated:

- dilution in the receiving water
- practicing chloramination instead of chlorination
- switching to UV disinfection

As previously noted, dilution credits are not currently allowed in the NPDES permit. However, there are provisions to reopen the permit and reconsider the matter of dilution credits, if DSPUD installs a diffuser, conducts a mixing zone study, and meters the flow of the South Yuba River at the point of discharge. Obtaining dilution credits for dichlorobromomethane and any other disinfection byproducts that might occur in the future could be highly beneficial. The dilution credits would be based on long-term average flows in the South Yuba River and should be substantial. Therefore, DSPUD should pursue this option.

In a biological treatment process designed to remove ammonia, it is not practical to leave a little ammonia in the effluent for the purposes of chloramination. Instead, after removing essentially all ammonia, a little would be added back in. If the use of chlorine is to be continued or if sodium hypochlorite were to be used, adding some ammonia to mitigate disinfection byproducts should certainly be considered. At this time, it is not known whether chloramination would be fully successful in mitigating disinfection byproducts, particularly if dilution credits are not obtained.

By switching to UV disinfection, the chlorine disinfection byproducts could be eliminated. However, this would involve substantial capital and ongoing operation and maintenance costs.

As previously noted in this document, if chlorine disinfection is to be continued, the gaseous chlorine system should be upgraded to comply with Uniform Fire Code requirements. Alternatively, DSPUD could switch to using sodium hypochlorite.

Solids Handling

The previous discussions have been limited to the liquid stream treatment processes in the wastewater treatment plant. Solids handling must also be considered in any improvement or expansion project. This could include sludge digestion and mechanical dewatering facilities. The options for these improvements should be considered as part of a future Facility Plan.

Planning for Future Growth

As noted in previous communications with DSPUD, it is important for DSPUD and SLCWD to provide guidance on allowances for increased flows and loads due to projected new development in the service area. The detailed alternative analyses that must be started as the next step of project development must be based on certain flows and loads. Determination of what allowances should be made must be based on a plan for funding the incremental capacity. As previously noted, a viable option may be to proceed with detailed alternative analysis assuming minimal or no growth. Then, if appropriate, after the apparent best alternative is identified, a subsequent analysis could be completed to determine the changes required and increased costs for a somewhat larger capacity. To minimize rework, however, the initial growth and capacity determinations used for the alternative analysis should be as close as possible to the final determinations that will be used for project design.

In addition to projected new development, increased flows could occur as the result of increased occupancies of existing services. Historically, many second homes and lodgings have been vacant or lightly occupied and commercial activity has been relatively slow during the spring, summer, and fall. If any changes in the historical patterns are anticipated, these changes must be incorporated into wastewater flow and load projections, just like new growth.

In addition to determining growth and occupancy allowances for the upcoming improvement project, the Districts should also consider a “build-out” scenario. This would be useful in determining the possible ultimate capacity of treatment and disposal facilities, so that reasonable provisions for future staged expansion can be incorporated in the initial project.

Schedule for Future Work

As mentioned previously, full compliance with the new NPDES permit is required by April 2014. A schedule for key activities leading to compliance is shown in Figure 2.

As shown in the schedule, startup of plant improvements should occur in the late summer and fall of 2013 to assure compliance with the NPDES permit by the April 2014 deadline (a winter startup is not advisable). Allowing for two construction seasons, construction should start early in 2012. Preliminary design and detail design are expected to occur mostly throughout 2011. Therefore, facility planning and environmental analyses should be completed during the remainder of 2009 and 2010. Depending on the severity of environmental issues and any opposition to the proposed project, it may be difficult to meet this schedule. Accordingly, time is of the essence as DSPUD continues in the process of project development.

Two key decision points are shown in the schedule for DSPUD and SLCWD. First, soon after receiving this document, the Districts will need to determine which wastewater management alternatives considered herein (or others) should be evaluated in detail in a Facility Plan. At the same time, each District will need to decide how much future growth or change in occupancy rates, if any, should be assumed for the Facility Plan analyses, as discussed above. The final decision point regarding growth and capacity is shown near the end of the environmental process and before final definition of the recommended project, which will then be carried forward into preliminary design. Between the initial and final capacity determinations, the Districts will have some time to assess project funding options and the degree to which new growth will be able to participate in project funding.

Geotechnical investigations and surveys are shown at various times in the schedule. Initial preliminary work may be required to support facility planning. Subsequently, more detailed work will be needed to support preliminary design and detail design.

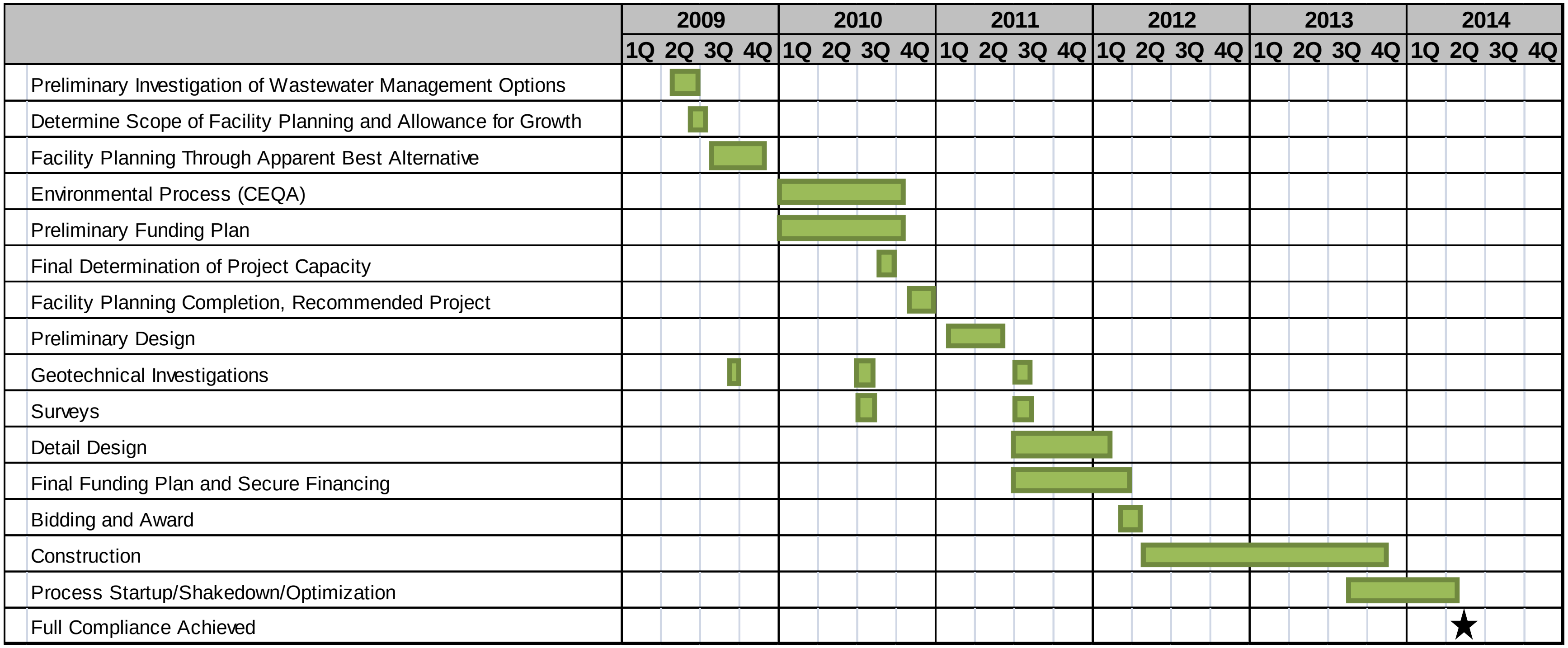

Figure 2
Project Development Schedule