MEMORANDUM

TO: Steve Tanner, Engineering Manager
Coeur d'Alene Regional Office

FROM: Jen Cole, Scientist II, Technical Services DEQ State Office
John Tindall, P.E., DEQ Coeur d'Alene Regional Office

SUBJECT: **Garfield Bay Sewer District, LA-000003-03**, Staff Analysis for Recycled Water Permit (Municipal Wastewater)

1.0. Purpose

The purpose of this memorandum is to satisfy the requirements of IDAPA 58.01.17.400.04 (Recycled Water Rules) for issuing wastewater recycled water permits. It states the principal facts and significant questions considered in preparing the draft permit conditions and a summary of the basis for approval with references to applicable requirements and supporting materials.

2.0. Project Description

The Garfield Bay Water & Sewer District (GBWSD) treatment facility and forested irrigation site are located near Garfield Bay on Lake Pend Oreille off the Garfield Bay Cut-Off Road. GBWSD serves about 220 homes and a few commercial establishments within the District boundaries. Many of the homes are seasonal residences. The wastewater is predominantly domestic and not industrial. There is a large contribution of infiltration/inflow into the collection system during the wet seasons and high ground water periods.

The GBWSD wastewater facilities are approximately 10 miles southeast of Sandpoint and about 5 miles east of Sagle (Figure 2.2). Raw wastewater from the Garfield Bay area is collected and delivered to the treatment lagoons located approximately one-half mile north of the Bay. Five lift stations deliver collected wastewater to the treatment lagoons. The system consists of two aerated lagoons, a sedimentation lagoon, and a storage lagoon. The east aerated lagoon is 0.4 acres, 0.80 MG (million gallons); and the west aerated lagoon is 0.5 acres, 0.94 MG. Effluent from the aerated lagoons is delivered to the settling lagoon (1.2 acres, 1.6 MG). All lagoons at the facility are lined with High Density Polyethylene (HDPE) liners. A schematic flow diagram of the treatment process is shown in Figure 2.1.

The facility is planning to seepage test the two (2) aerated lagoons and storage lagoon during the next growing season. Compliance activity CA-003-02 in the draft permit requires the facility to submit a testing plan for approval by DEQ and subsequently test each lagoon. The sedimentation lagoon was seepage tested in October 2010 and the Idaho Department of Environmental Quality (DEQ) accepted the test results in December 2010.

Effluent from the settling lagoon is pumped to a newly-constructed, 10.3 MG (3.1 acre) storage lagoon about 0.6 miles north of the settling lagoon. Effluent from the storage lagoon is disinfected with a liquid sodium hypochlorite solution and irrigated on a forested site adjacent to the storage lagoon. Currently, approximately 10 acres of the forested site are set up for irrigation (see MU-000301 in Fig. 4.10) although only 9.0 acres are permitted under the current permit[9]. The wastewater treatment facility and irrigation site are located approximately 1 mile north of Garfield Bay (Figure 2.2) on Lake Pend Oreille. GBWSD has about 25 forested acres available for irrigation and all of it is fenced.

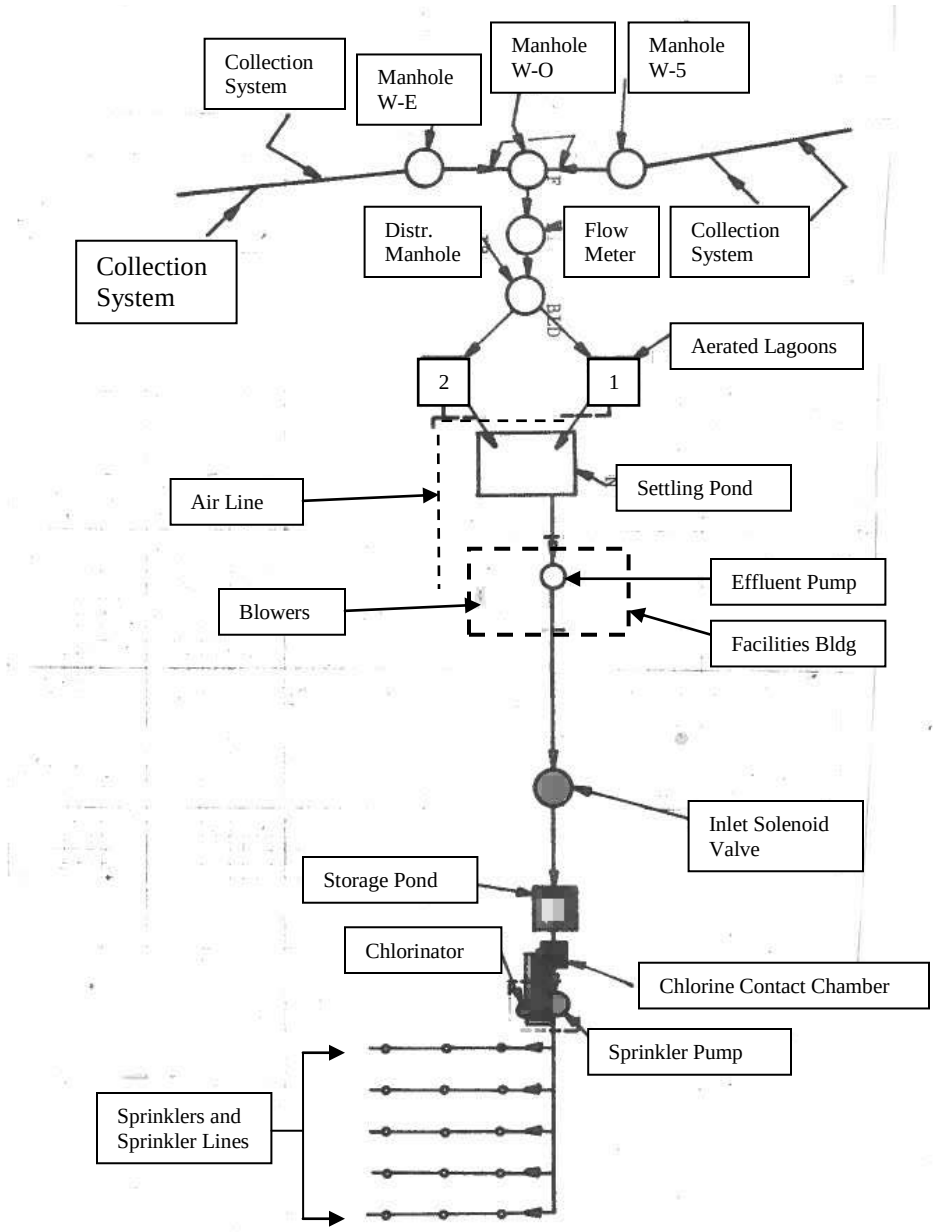

Figure 2.1. Schematic WW treatment flow diagram.

Figure 2.2. Vicinity map of the GBWSD treatment facility and irrigation site location.

3.0. Summary of Events

The GBWSD began operation of a seasonal reuse irrigation system in 1978. The Idaho Division of Environmental Quality issued a WLAP permit LA-000003 for Garfield Bay in 1989, which expired in March 1994. Permit LA-000003-02 was issued on May 19, 1994 by the Idaho Division of Environmental Quality and had an expiration date of May

1, 1999. The District continued to operate under the conditions permit LA-000003-02 until permit LA-000003-02 (same number) was issued by the Idaho Department of Environmental Quality (DEQ) on November 14, 2002. The second permit with the permit number of LA-000003-02 expired on November 17, 2007. In 2007-2008, GBWSD was completing construction of the new storage lagoon and conveyance structures and DEQ recommended delaying the reissuance of a reuse permit until the construction was complete. GBWSD submitted an application to renew their reuse permit on December 28, 2008.

In March 2011, the wastewater overflowed out of the south side of the storage lagoon (see Fig. 4.10). The operator was forced to irrigate disinfected water from the lagoon outside of the permitted irrigation season (May 1 to September 30) in MU-000301 (see Fig. 4.10) to prevent catastrophic failure of the lagoon dike. The operator also hauled some water from the storage lagoon back to the GBWSD aerated lagoons in an attempt to lower the storage lagoon level. Additional irrigation was also required in April 2011 which is also not allowed based on the current permit. A combination of factors has led to these permit violations including the following: excessive amount of infiltration and inflow (I/I) entering the collection system during the non-growing season; greater than average precipitation and lagoons; overland flow runoff into the storage lagoon; and lagoons that were fuller than normal going into the non-irrigation season because the sedimentation pond was being seepage tested. The GBWSD operator, Jeff Jordine, did contact DEQ about these problems and has provided reports to DEQ with data on the quality and quantity of the water irrigated outside the permitted irrigation season.

4.0. Discussion

The following is a discussion of: wastewater quality and monitoring, the plan of operation, surface water, ground water quality and monitoring, soils, hydraulic loading, constituent loading, buffer zones, hydraulic management unit configuration and compliance activities. Conclusions and recommendations are provided in section 5.0 below.

4.1. Wastewater Quality and Monitoring

Historic wastewater and nutrient loading rates are shown in Table 4.1. Total nitrogen concentrations in domestic wastewater typically range from 20 to 85 mg/L. [1] The average total nitrogen concentrations measured in Garfield Bay Sewer District wastewater effluent from 2004 through 2008 are low when compared to typical domestic wastewater. Total phosphorus concentrations in domestic wastewaters typically range from 2 to 20 mg/L. [1] The average total phosphorus concentrations in Garfield Bay Sewer District wastewater effluent from 2004 through 2008 are also low compared to typical domestic wastewater.

Table 4.1: Total nitrogen, total phosphorus and wastewater loading rates for 2004, 2005, 2006, 2007 and 2008. Loading calculations assume 9.0 acres are used for irrigation in each operating year shown.

Year	Nitrogen		Phosphorus		Wastewater Loading	
	lbs/acre-year	Average Concentrations mg/L	lbs/acre-year	Average Concentrations mg/L	Million gallons	inches/acre
2004	45	9.10	12	2.37	5.34	21.9
2005	29	5.72	12	2.48	5.88	24.1
2006	36	6.54	10	1.61	6.27	25.7
2007	44	8.82	12	2.31	6.39	26.1
2008	18	3.46	8	1.49	4.32	17.7

As a Class C facility, weekly monitoring of total coliform during periods of irrigation is required by IDAPA 58.01.17.601. It is recommended that additional wastewater monitoring requirements include the daily flow volume of effluent to the irrigation site compiled on a monthly basis. It is recommended that the Total Kjeldahl nitrogen, nitrate- + nitrite-nitrogen, pH, and total phosphorus be monitored monthly during irrigation.

4.2. Plan of Operation

It is understood that a Plan of Operation (also called an Operations and Maintenance Manual) is a living document and is modified as operations and regulatory requirements change. Section E, condition CA-003-01, as it appears in the draft permit, attached, requires the facility to submit for DEQ review and approval, an updated Plan of Operation. The Plan of Operation should include at a minimum all of the applicable information in the latest revision of the Plan of Operation Checklist found in section 1.9.3, page 1-72 of the Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater. [1]

An O&M Manual was submitted by the facility in 2008 reflecting the operational changes resulting from system upgrades. To supplement the O&M Manual submitted in 2008, CA-003-01 requires inclusion of a Quality Assurance Project Plan (QAPP), a Silvicultural Plan, an Odor Management Plan, a Waste Solids Management Plan, a Runoff Management Plan, a map of the irrigation system within each hydraulic management unit (MU) and any anticipated maintenance requirements during this permit cycle.

4.3. Surface Water

The nearest surface waters are Beaver Lake, located about 0.6 miles northeast of the irrigation site and Garfield Bay on Lake Pend Oreille, located about 1.0 mile south of the irrigation site.

Lake Pend Oreille is designated for cold-water aquatic life, salmonid spawning, primary contact recreation, domestic water supply, agricultural water supply, industrial water supply, wildlife habitat and aesthetics. Lake Pend Oreille is also a Special Resource Water, which means it is a special body of water recognized by the state as needing intensive protection. A Total Maximum Daily Load (TMDL) was developed for the near shore waters of Lake Pend Oreille to mitigate increasing eutrophication along the shoreline. [2] The target identified for the TMDL is an average total phosphorus concentration of 9 µg/L. The TMDL establishes an action threshold for an instantaneous concentration equal to 12 µg/L. The action target of 12 µg/L represents a value that is used in monitoring to evaluate attainment of standards based on individual sample concentrations.

The crop grown at the irrigation site consists of native forest comprised of various conifer species. [6] Common conifer species in the Coeur d'Alene region of Idaho include Ponderosa Pine and Douglas Fir which have typical root depths of 3.0 – 6.0 feet and 2.25 – 4.42 feet, respectively. [7] The typical loading rates during 2004 through 2008 for total phosphorus ranged from 8.0 to 12.0 lbs/acre-year. Typical uptake of phosphorus by mature non-grazed woodlands is estimated to be roughly 20 lbs/acre-year. [5]

Potential for surface water contamination via irrigation site runoff is minimal due to the 1.0 mile separation between the irrigation site and Garfield Bay in Lake Pend Oreille. Compliance Activity CA-003-01 of the draft permit attached requires the facility to submit an updated Plan of Operation which should include a Runoff Management Plan that addresses the best management practices for minimizing runoff and ponding on the reuse site.

4.4. Ground Water Quality and Monitoring

Ground water is assumed to flow generally to the south and southwest towards Garfield Bay on Lake Pend Oreille based on surface topography.

Ground water monitoring results for operating years 2004 through 2008 were compiled and analyzed in preparation of this draft permit. The monitoring parameters include spring and fall results for static water level, nitrate-nitrogen, total dissolved solids (TDS), chloride, and pH. Figures 4.1 through 4.4 graphically represent the historical monitoring trends in wells within close vicinity of the reuse irrigation site and treatment plant. Nitrate concentration monitoring results were all non-detect for each well in fall and spring from 2004 to 2008. Of the three wells sampled, the only domestic well within 500 feet of the proposed hydraulic management unit (MU-000302, see Fig. 4.10) is the Parnow Well (GW-000304, see Fig. 4.10).

In 2006, a DEQ evaluation process called a "Well Location Acceptability Analysis" was used to evaluate the vulnerability of the Parnow Well to contamination from the irrigation site. The conclusion of that evaluation was that a 250 foot buffer from the well to the irrigation site would provide adequate protection for the well. [8]

Figure 4.1 shows that during the historical period observed, the spring and fall static water levels show almost no variation (4 to 6 feet below ground surface) in the treatment plant well (GW-000301, see Fig. 4.10) located near the aerated lagoons. The only other well within 500 feet of the proposed irrigation site (MU-000302), the Parnow Well, showed a minimum depth-to-water of about 18 feet and the ground surface elevation of the well is about 20 feet higher than the ground in MU-000302.

In general, all three wells maintained fairly stable TDS, chloride, and pH levels between spring and fall sampling events. An exception is the spring chloride level in the Darley Well (GW 000302, see Fig. 4.10) during 2005. Since the elevated 2005 chloride level (5.3 mg/L) in the Darley Well occurred during spring sampling before irrigation started it can safely be assumed that irrigation did not contribute to the minor elevation of the chloride level.

The Wright Well (GW 000305, see Fig. 4.10) is a private well close to 500 feet from MU-000301. A "Well Location Acceptability Analysis" has not been completed for this well, as was completed for the Parnow Well in 2006, to determine the risks associated with this well being closer than 500 feet from the irrigation site. The GBWSD will be required to prepare a detailed map of the irrigation systems in each hydraulic management unit as part of the revised O&M Manual (see Sections 4.8 and 4.10 for more on this issue). This will be used to verify that no irrigation is occurring within 500 feet of the Wright Well.

Due to the historical monitoring data indicating that there are no elevated constituent levels in any of the wells, it is recommended that the requirement for ground water monitoring of nearby domestic wells not be included in the draft permit. It is recommended that soil monitoring be conducted annually to assess whether accumulation of constituents creates the possibility of ground water contamination. Due to the potential for high ground water at the irrigation site in the early spring, it is recommended that a piezometer (shallow monitoring well) be installed at each hydraulic management unit (MU, see Fig. 4.10) to determine when the ground water is at least below three (3) feet from the ground surface. Weekly monitoring in April, May and June is recommended. Irrigation could not occur in a MU until it is documented that the ground water is at least three (3) feet below the ground surface.

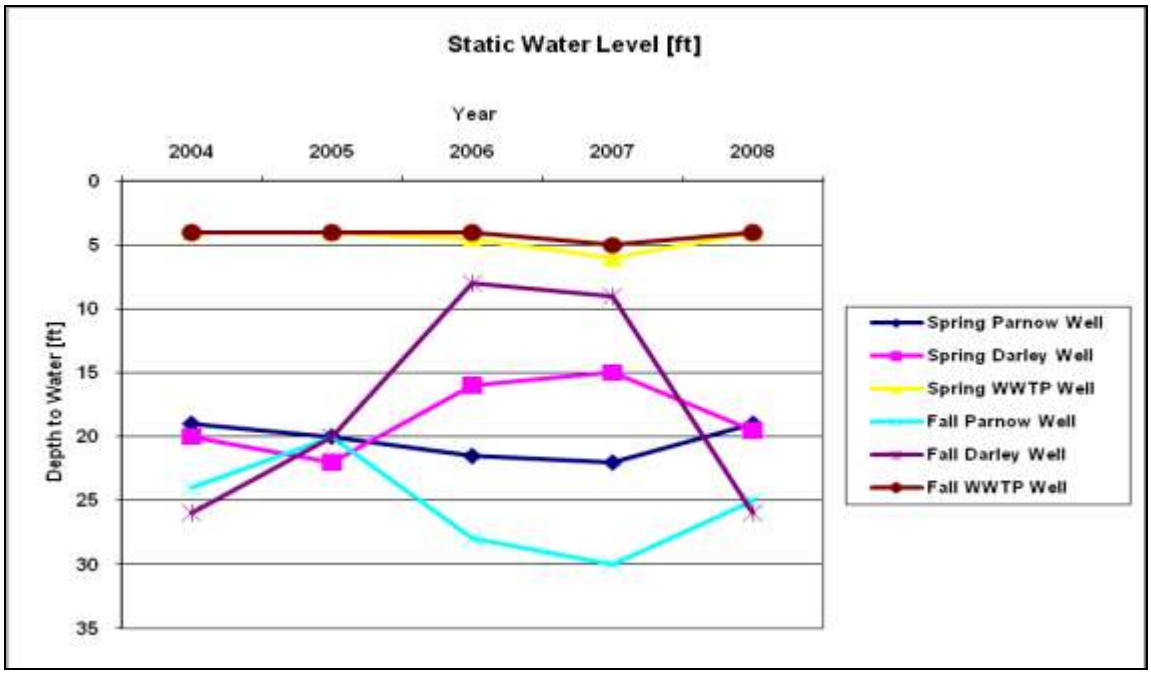

Figure 4.1. Historical well static water level monitoring data.

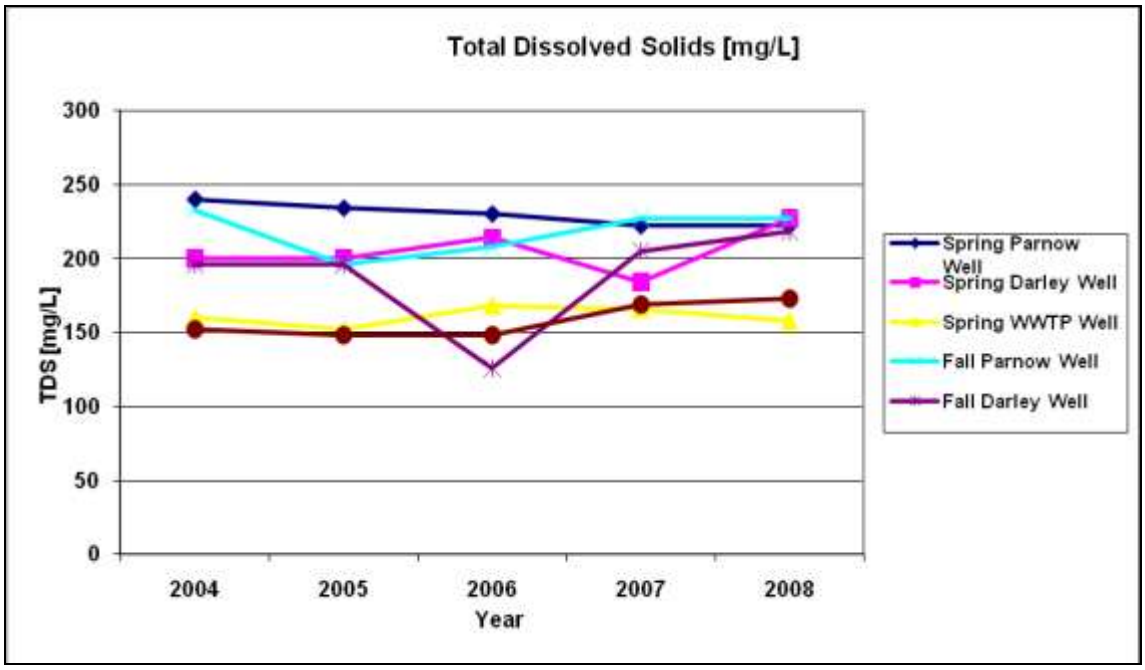

Figure 4.2. Historical well TDS monitoring data.

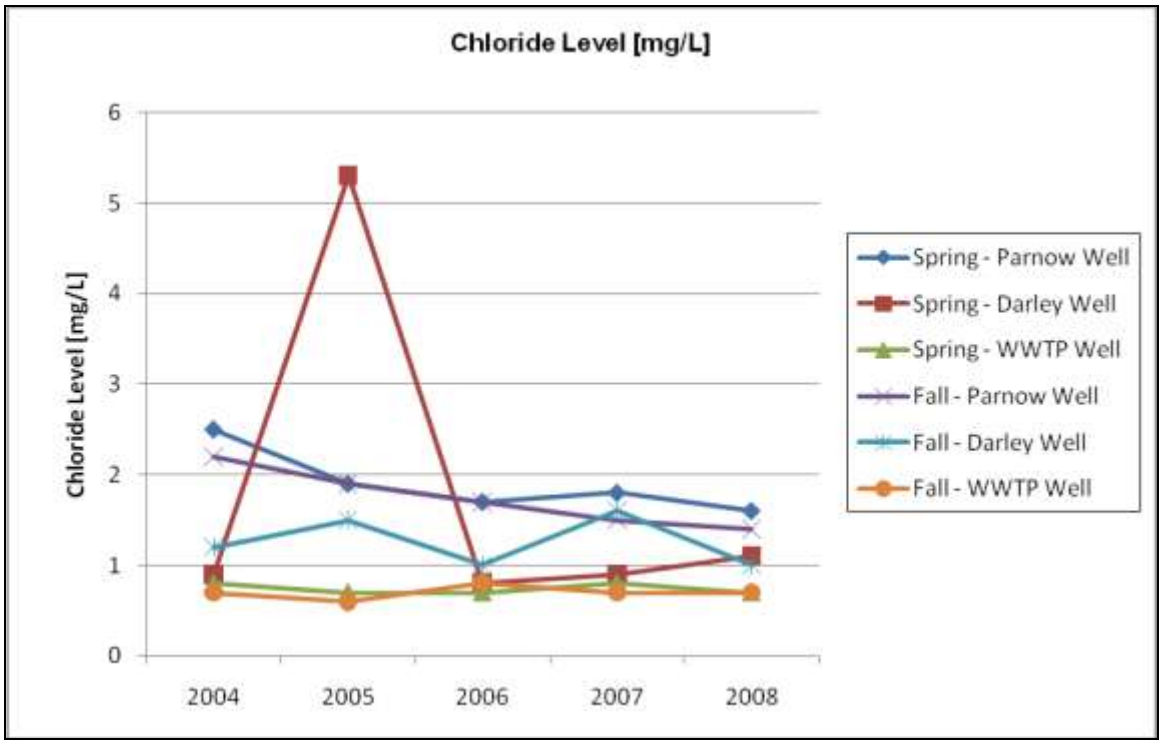

Figure 4.3. Historical well chloride monitoring data.

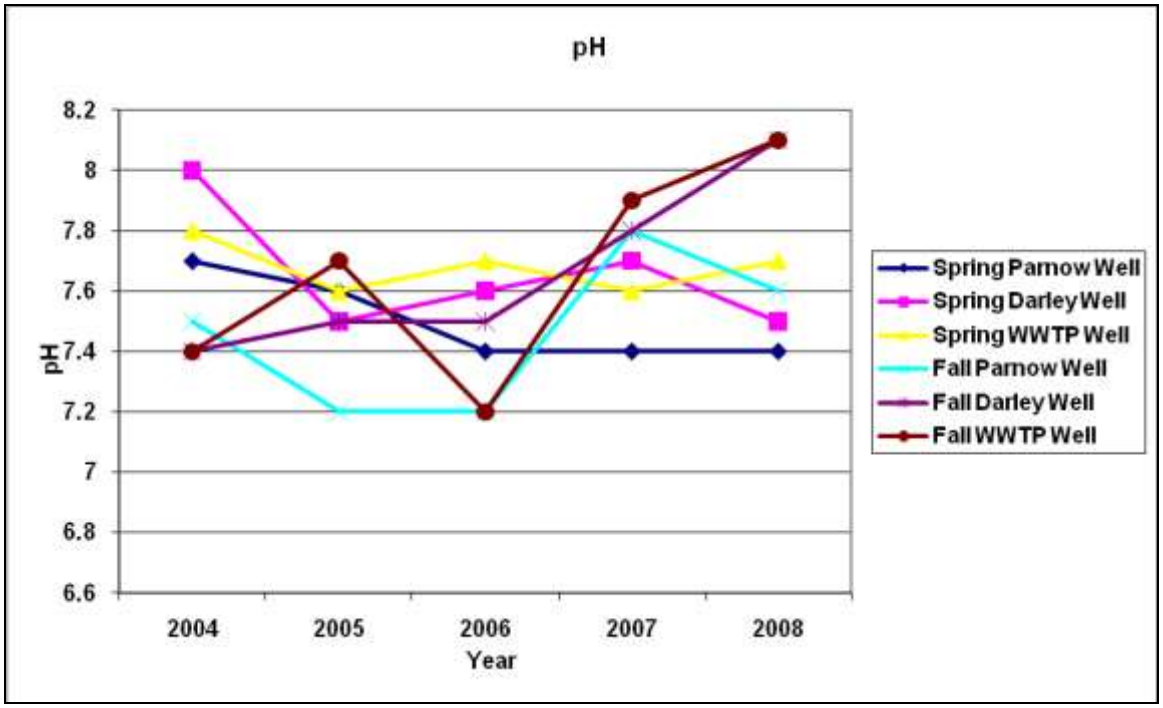

Figure 4.4. Historical well pH monitoring data.

4.5. Soils

The deep and well drained soils at the site are classified Pend Oreille silt loam with a water holding capacity of about 7 inches from 0 to 60 inches in depth[3]. Soil sampling was required annually in the fall during the last permit cycle. Soil samples from all sample depths had a pH range of 6.04 to 6.81 and showed nitrate, phosphorus and concentration values that are considered to be low for typical Idaho agricultural soils[1]. Figure 4.5 shows that even during the maximum hydraulic loading year, 2007, the ammonia-nitrogen and phosphorus levels in the soils did not reach unacceptable levels but were, in fact in the "medium" range for nitrogen and the "low" range for phosphorus[1].

Nitrate-nitrogen was not sampled during the last permitting period. Ammonia-nitrogen was only sampled during 2006 and 2007. The 2-year ammonia-nitrogen average was 15.5 mg/Kg at the 0-12 inch depth decreasing to 6.0 mg/Kg at the 12-24 inch sample depth. The plant-available phosphorus 5-year average was 5.24 mg/Kg at the 0-12 inch depth decreasing slightly to 5.10 mg/Kg as the 12-24 inch depth.

It is recommended that annual soil monitoring for electrical conductivity, nitrate-nitrogen, ammonia-nitrogen, pH, and plant-available phosphorus be required in the attached draft permit.

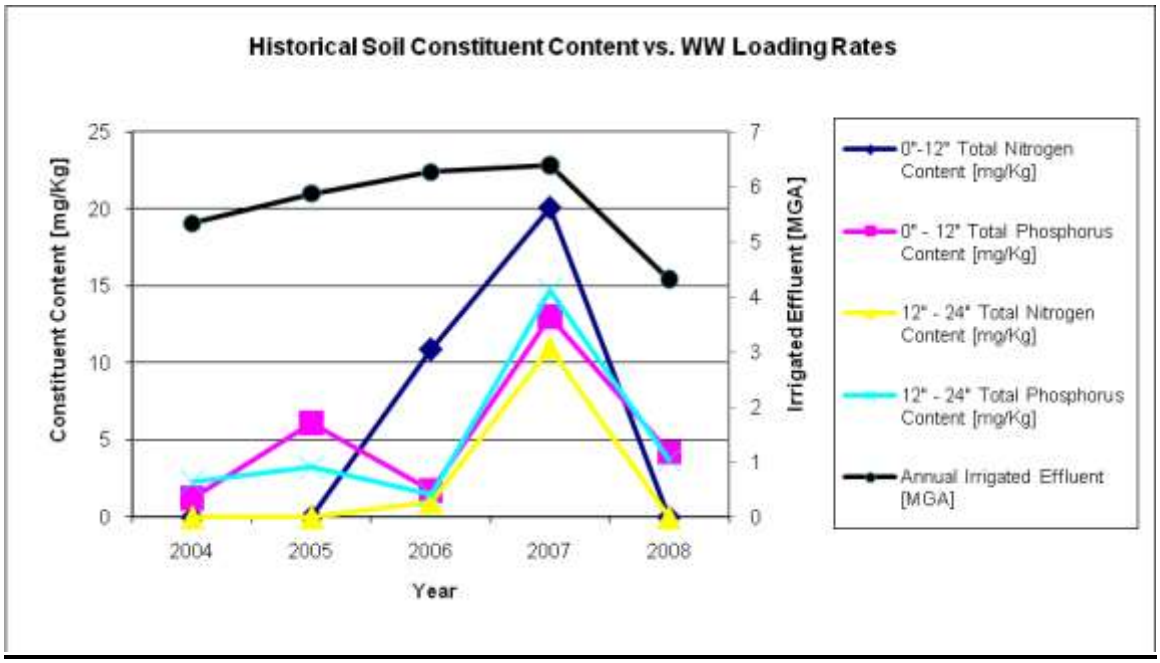

Figure 4.5. Historical soil monitoring data compared to historical hydraulic loading rate.

4.6. Hydraulic Loading

The facility irrigates native conifer forest acreage with a well-established full canopy using solid-set lateral sprinkler lines with an efficiency of 60-85%[1]. The current permit (LA-000003-02) allows up to 6.4 million gallons (26.1 inches/acre-year) of treated

wastewater to be irrigated between May and September onto a single 9.0-acre hydraulic management unit (MU-000301). Since issuance of LA-000003-02, the facility has expanded the MU-000301 acreage to 10.6 acres and has requested that two additional MUs be permitted for future use. The two additional proposed MUs are 9.25 and 5.29 acres (see Fig. 4.10).

As discussed in Section 3 of this report, irrigation occurred in March and April of 2011 outside of the permitted irrigation season of May 1 to September 30 to prevent the storage lagoon from overflowing. It is recommended that a compliance activity be included which will address this problem.

Table 4.2 below shows the estimated irrigation water requirement (IWR) to be used for all the MUs based on the precipitation deficit (P_{def}) estimated for Orchard with no cover at the Coeur d'Alene weather station number 101956[4]. See Appendix 1 for details on how the IWR was calculated. An irrigation efficiency of 65% was assumed for the solid-set lateral sprinkler lines with risers and impact sprinkler heads used to irrigate the site (the efficiency range (60-85%) for solid-set lateral lines in DEQ Guidance[1]).

Table 1.2 – Growing Season Calculated IWR for Irrigation System using 65% Irrigation Efficiency

Month	Calculated IWR*
April	0.48
May	2.34
June	5.27
July	8.34
August	5.78
September	2.96
October**	TBD
Total	**25.18**

* Expressed in inches per month
** To be determined (TBD). The Permittee may seek from DEQ approval to irrigate in October prior to irrigating if it can be demonstrated to DEQ the irrigation will be protective of public health and water quality.

The current permit stipulates a wastewater irrigation season starting on May 1 and continuing through September 30. The DEQ review indicates that extending the irrigation season to include the month of April is justified based on the estimated evapotranspiration rates of the forested site during April. However, based on the methods used to estimate irrigation water requirements, a maximum volume of 0.33 million gallons could be irrigated in April for all three MUs combined (see Table 4.3 below) provided that the depth to ground water is at least 3 feet below the ground surface.

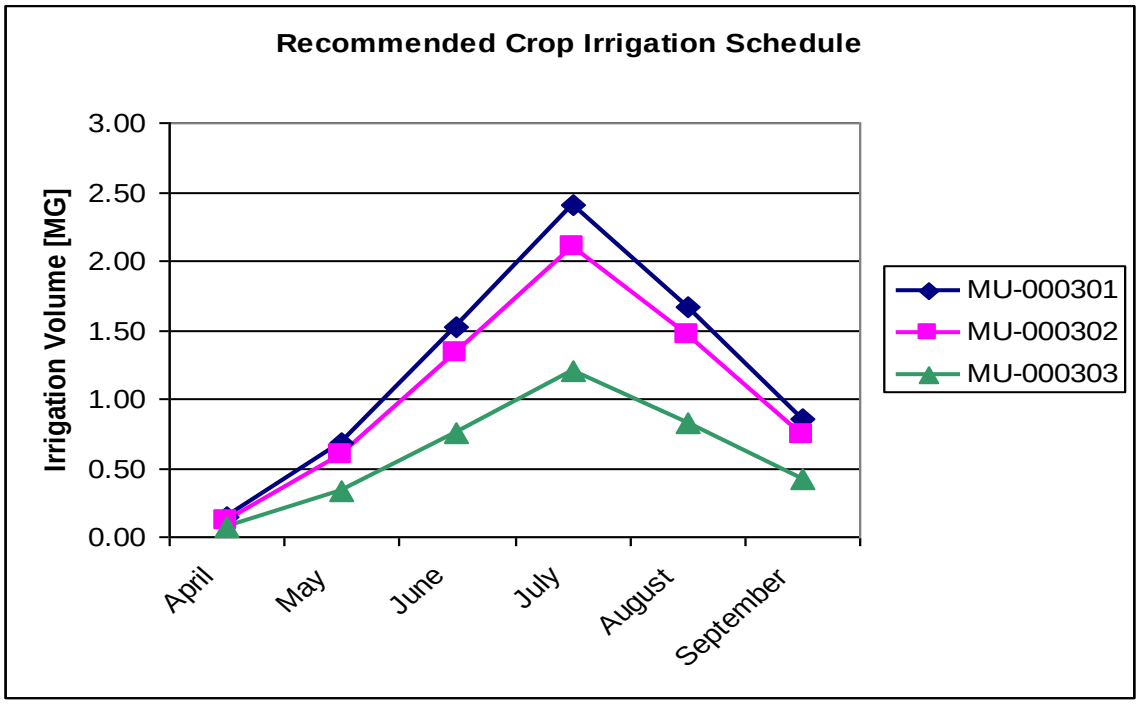

Figure 4.6. Estimated IWR and recommended monthly permit hydraulic loading limit for each HMU assuming 65% irrigation efficiency.

The estimated monthly IWR of the each HMU is shown in Table 4.3. It is recommended that the hydraulic loading proceed at the IWR which is consistent with estimated P_{def} rates at this site.

Table 4.3: Estimated monthly growing season irrigation water requirement (IWR) for forest and the proposed hydraulic loading rate at the Garfield Bay Water and Sewer District reuse site.*

Month	Max. HLR [MG**] for MU-000301 (10.6 acres)	Max. HLR [MG**] for MU-000302 (9.3 acres)	Max. HLR [MG**] for MU-000303 (5.3 acres)
April	0.14	0.12	0.07
May	0.67	0.59	0.34
June	1.52	1.33	0.76
July	2.40	2.11	1.20
August	1.66	1.46	0.83
September	0.85	0.75	0.43
Annual Total	**7.25**	**6.36**	**3.62**

*IWR based upon an irrigation efficiency of 65%.
**million gallons (MG)

4.7. Constituent Loading Rates Discussion

The sections below discuss proposed constituent loading rates for nitrogen and phosphorus. Figures 4.8 and 4.9 graphically represent historical loading rates at the site for nitrogen and phosphorus compared to estimated crop uptake and current permit limits.

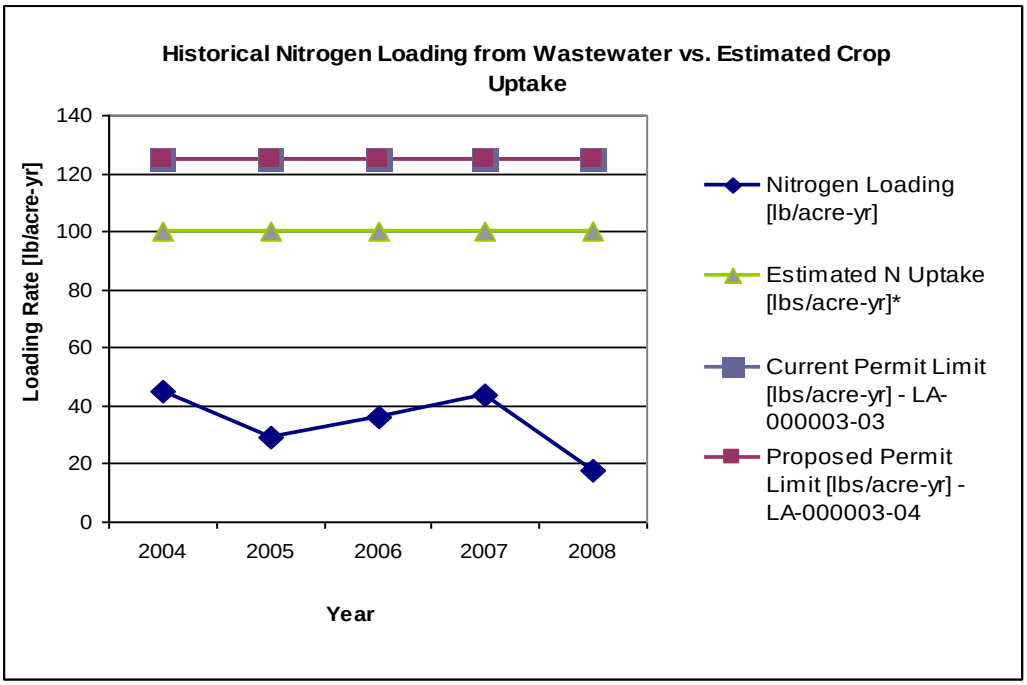

Figure 4.8. Historical loading rates for nitrogen compared to estimated nitrogen uptake, current and proposed permit limit of 125% of crop uptake.
*Estimates from NRCS. [5]

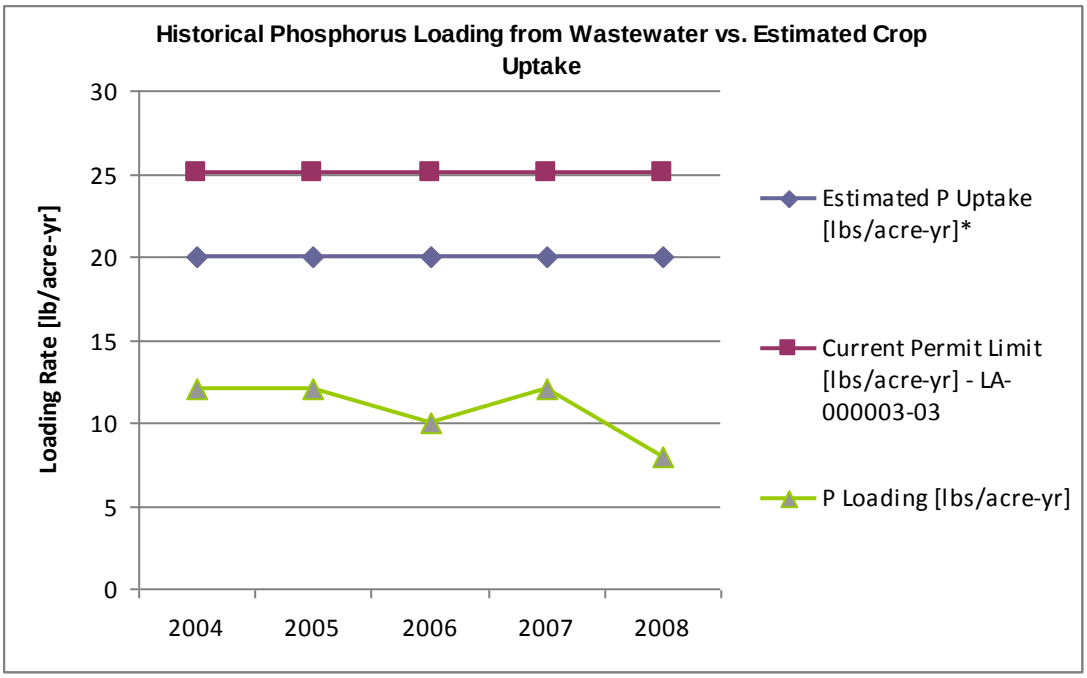

Figure 4.9. Historical loading rates for phosphorus compared to estimated phosphorus uptake, current permit limit of 125% of crop uptake and proposed permit limit of 150% of crop uptake.
*Estimate from NRCS. [5]

4.5.2.1 Nitrogen Management and Loading Rates

MU-000301, MU-000302 and MU-000303 consist of 10.58, 9.25, and 5.29 acres each, respectively, of native conifer forest. For non-grazed woodlands, 100 lbs/acre-yr of nitrogen uptake are estimated. [5] Draft DEQ guidance (see Appendix 2, Section 4.2.2.4.3) provides a method for calculating nitrogen loading rates presented in Equation 1.

Equation 1- Calculation of Nitrogen Loading Limit for Douglas Fir Forest (<25 years old)

$$\frac{C_{Pest} * N_{Pcan} + U_{est} * N_{under}}{V_{est}} = NL_{est}$$

Where:
C_{Pest} = estimated douglas fir canopy coverage (80%)
N_{Pcan} = nitrogen uptake by complete canopy, pine = 110 lb/acre-year
U_{est} = estimated understory coverage (20%)
N_{under} = nitrogen uptake by complete understory = 75 lb/acre-year
V_{est} = Available N after volatilization = 80%
NL_{est} = site estimated nitrogen loading limit

Solving for NL_{est}:

$$NL_{est} = \frac{C_{Pest} * N_{Pcan} + U_{est} * N_{under}}{V_{est}} = \frac{0.80\ (110) + 0.20\ (75)}{0.8} = \frac{88 + 15}{0.8}$$

NL_{est} = 129 lbs of N/acre-year

Historical loading rates for nitrogen (2004-2008) at this site have not exceeded 45 pounds/acre-year during the period considered in preparation of the draft permit number LA-000003-03. Figure 4.8 shows graphically that the maximum historical loading rate of 45 lbs/acre-yr is less than the estimated crop uptake (100-129 lbs/acre-yr) and just over a third of the current permit limit of 125% of crop uptake (125 lbs/acre-yr). It is recommended that the current permit limit of 125 lbs/acre-yr be used as the nitrogen loading rate limit in the draft permit.

4.5.2.2 Phosphorus Management and Loading Rates

Historical (2004-2008) loading rates for phosphorus at this site have not exceeded 12 lbs/acre-year during the period considered in preparation of the draft permit. Figure 4.9 shows graphically that the maximum loading rate of 12 lbs/acre-yr is significantly less than the estimated crop uptake (20 lbs/acre-yr) and current permit limit of 125% of crop uptake (25 lbs/acre-yr). [5] Based on the historical phosphorous loading rates and estimated uptake rates, it is recommended that no phosphorous loading rate limit be included in the draft permit. Soil and irrigation water should continue to be monitored for phosphorous to determine if any changes occur.

4.5.2.3 Chemical Oxygen Demand (COD) Loading Rates

Wastewater reuse permits typically include a chemical oxygen demand (COD) permit loading rate limit of 50 pounds/acre-day (lbs./ac-day). Based on an estimated COD concentration in the storage lagoon effluent of 100 mg/L, the estimated COD loading rates shown in Table 4.3 is about 3 lbs./acre-day over a six (6) month irrigation season

(this does not include October because irrigation will not normally occur in that month). The estimated COD loading rate is significantly less than 50 lb/acre-day typical limit. It is recommended that no COD loading limit be imposed in the draft permit and no monitoring is required.

4.8. Buffer Zones

It is recommended to use the buffer zone requirements of Scenario G of Table 6-4 (*Buffer Zone Guidance for Municipal Wastewater Treatment Sites*) of the DEQ Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater for Class C effluent:

- Secondary disinfected to less than 23 CFU/100 ml. total coliform based on the median of the last five (5) days of sample results with no samples greater than 230 CFU/100 ml.
- 300 feet between the irrigation site and inhabited dwellings
- 0 feet from the irrigation site to areas accessible by the public
- Maintain the existing three (3) strand barbed wire fence around the entire irrigation site
- Signage reading 'Warning: Recycled Water – Do Not Enter', or equivalent, every 500 feet and at each corner of the outer perimeter of the buffer zones of the site[1].

In addition to the above-mentioned buffer zone distances, buffer zones distances from the irrigation site to surface water, public water supply wells and private water supply wells are recommended as stated in section 6.5 of the *Guidance* [1]:

- 100 feet to surface waters (permanent or intermittent)
- 1,000 feet to public water supply wells
- 500 feet to private water supply wells except the Parnow Well (GW-000304, see Section 4.4 and Fig. 4.10)
- 250 feet to the Parnow Well (GW-000304, see Section 4.4 and Fig. 4.10)

MU-000301 (see Fig. 4.10) may currently have portions of the irrigation system within 500 feet of the private well called the Wright Well (GW-000305, see Fig. 4.10). A "Well Location Acceptability Analysis" has not been done for this well to determine the risks associated with this well being closer than 500 feet from the irrigation site. In the updated operation and maintenance (O&M) manual (see CA003-01 in Section 4.10), a revised map of the irrigation system laterals and sprinkler heads will need to be prepared to verify that the appropriate 500 foot buffer is maintained.

4.9. Hydraulic Management Unit Configuration

The existing permit includes a single 9.0-acre hydraulic management unit (essentially the same as MU-000301 in Fig. 4.10). Since issuance of the current permit in November 2002, the facility has undergone substantial upgrades, expanded wastewater storage capacity and proposed additional irrigation acreage. Figure 4.10 shows the positions of the three (3) proposed MUs relative to the recently constructed storage lagoon (LG-000304). The new acreages proposed for irrigation are included in MU-000302 and MU-000303.

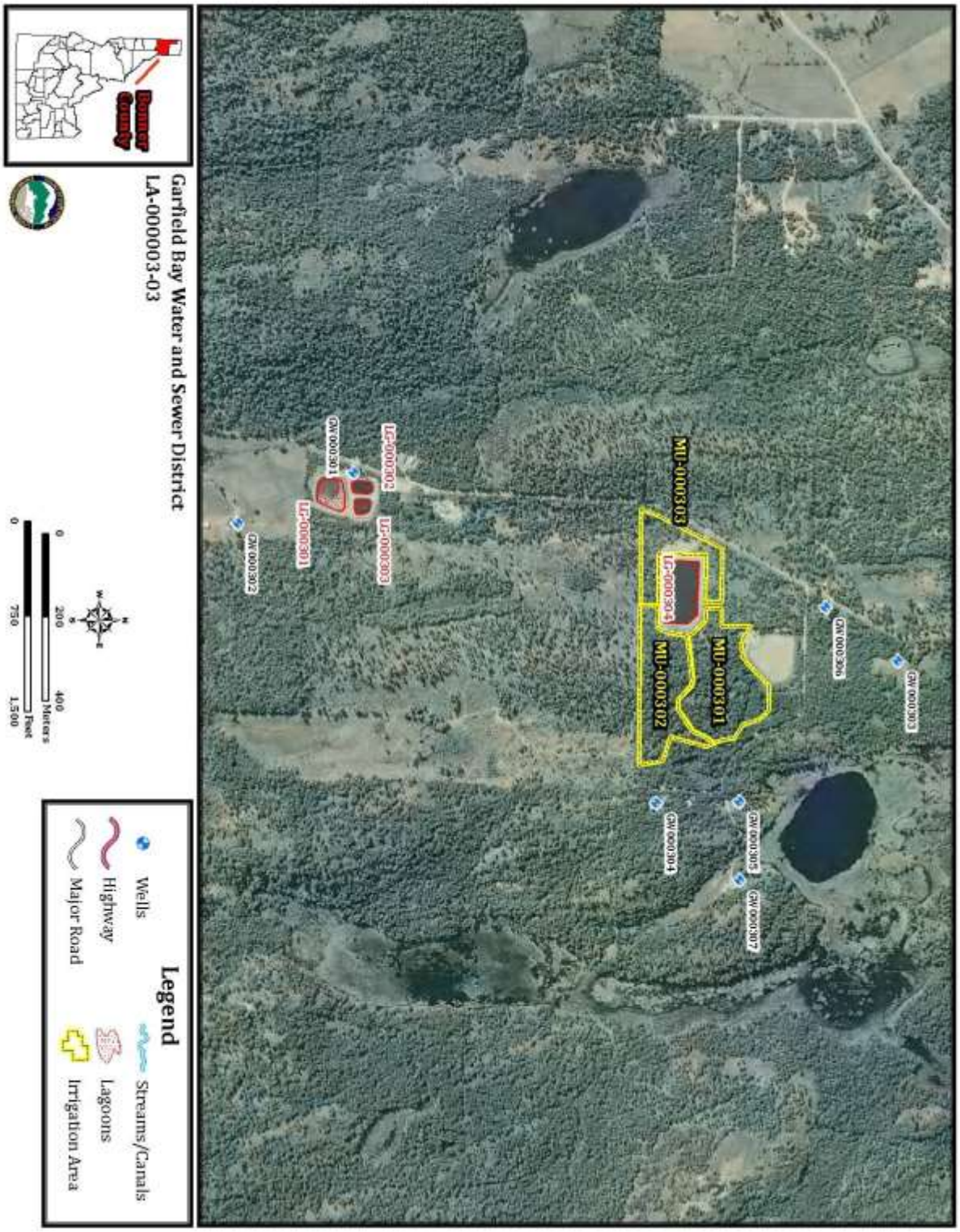

Figure 4.10. Satellite image of site showing relative positions of lagoons, each MU and private domestic wells in the vicinity of the irrigation site including the Treatment Site Well (GW-000301), Darley Well GW-000302), McGuken Well (GW-000303), Parnow Well (GW-000304), Wright Well (GW-000305), Storage Pond Well (GW-000306) and Engstrom Well (GW-000307)

4.10. Compliance Activities

Compliance activities include the following:

1. An updated Plan of Operation/O&M Manual (CA-003-01). As part of the O&M Manual update, a Quality Assurance Project Plan (QAPP), Runoff Management Plan, Odor Management Plan, Waste Solids Management Plan, updated Silviculture Management Plan and a map of the irrigation system within each hydraulic management unit (MU) will need to be submitted for review and approval;
2. Correction of the storage lagoon overflow (CA-0003-02). A report will need to be submitted detailing the proposed corrections to prevent a reoccurrence of the storage lagoon overflow in 2011. A schedule for implementing the corrections will need to be included in the report and this schedule will become enforceable as part of the permit.
3. Lagoon seepage testing (CA-003-03) of the aerated lagoons and storage lagoon;
4. Submittal of a permit renewal application at least 180 days prior to the permit expiration (CA-0003-04).

Section E, "Compliance Schedule for Required Activities" in the draft permit includes these compliance activities.

5.0. Conclusions

5.1. Loading Rates

1. It is recommended that the growing season hydraulic loading rates for each MU presented Table 4.2 be included as the permitted maximum monthly hydraulic loading rates in the draft permit.

2. It is recommended that the total nitrogen application rate limit be 125 pounds per acre-year.

3. It is recommended that no total phosphorus application rate limit be included in the draft permit as discussed in Section 4.5.2.2.

4. It is recommended that no COD loading limit be included in the draft permit, as discussed in Section 4.5.2.3.

5.2. Monitoring and Reporting

1. It is recommended that all wastewater effluent quality monitoring be conducted at the sample tap prior to the first irrigation sprinkler head after the chlorine contact chamber.

2. It is recommended that the wastewater monitoring be as follows:
    a. Daily influent wastewater flow rates;

b. Daily irrigation flowrates, when irrigating, with the acreage irrigated;
c. Daily total chlorine residual, when irrigating:
d. Weekly sampling of the irrigation water for total coliform, when irrigating;
e. Monthly sampling of the irrigation water for nitrate-nitrite as nitrogen, Total Kjeldahl Nitrogen, and total phosphorus.

3. It is recommended that monitoring of the nearby private domestic wells not be required as was required in the previous permit. It is recommended that piezometers (shallow ground water monitoring wells) be installed in representative locations in each hydraulic management unit (MU) to monitor the depth to ground water in the spring. Weekly monitoring of the piezometers in April, May and June is recommended. Irrigation could not occur in a MU until it is documented that the ground water is at least three (3) feet below the ground surface.

4. It is recommended that soil monitoring be conducted in each soil management unit for the following constituents in October of the first and fourth year of the draft permit:
   a. Electrical conductivity
   b. Nitrate-nitrogen
   c. Ammonia-nitrogen
   d. pH
   e. Plant-available phosphorus

5. It is recommended that all flow meters be calibrated annually.

5.3. Other

1. It is recommended that the Compliance Activities covered in Section 4.10 of this report be included in the draft permit.

2. It is recommended that the draft GBWSD Recycled Water Permit be issued for public comment.

References

[1] "Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater," Idaho Dept. of Environmental Quality, 2007

[2] "Near-shore Pend Oreille Nutrient TMDL," DEQ, December 2004

[3] "Web Soil Survey," Natural Resources Conservation Service (NRCS), United States Department of Agriculture Soil Survey Staff, 2008. Available at: http://websoilsurvey.nrcs.usda.gov. Accessed 2-13-2009.

[4] "ET_{Idaho} 2009: Evapotranspiration and Consumptive Irrigation Water Requirements for Idaho - Sandpoint KSPT (NWS --108137) for Willows, Precipitation Deficit," University of Idaho – Kimberly Research and Extension Center, 2010. Available at: http://www.kimberly.uidaho.edu/ETIdaho/stcvrstats.php?station=108137&cover=54&stats=Deficit

[5] "Nutrients Available from Livestock Manure Relative to Crop Growth Requirements. Appendix I: Nutrient Uptake and Removal-Part C, Non-Grazed Privately Owned Woodland. Natural Resource Conservation Service (NRCS), February 1998. Available at: http://www.nrcs.usda.gov/technical/NRI/pubs/nlapp1a.html

[6] WWRU Site Inspection Report, Dr. Xin Dai - DEQ, August 27, 2008

[7] USFS Agriculture Handbook, Vol. 1, 1990

[8] Letter from DEQ Employee, Roger Tinkey, to Chairman Moio of Garfield Bay W&S District, Parnow Well Buffer Zone, April 13, 2006

[9] 2010 Facility Annual Report, Garfield Bay Water and Sewer District, January 27, 2011 (Received by DEQ on February 3, 2011)

Appendix 1 – IWR Calculations

The irrigation water requirement (IWR) values for Garfield Bay W&S District (Table 4.2 in the Staff Analysis) were derived from monthly mean precipitation deficit (P_{def}) data available for "Orchards – Apples and Cherries no ground cover" and "Range Grasses – long season" from the ET_{Idaho} Coeur d'Alene 1E weather station (http://www.kimberly.uidaho.edu/ETIdaho/stninfo.php?station=101956). The data covers 79 years. This weather station was chosen for use in the IWR calculations instead of the closer ET_{Idaho} Sandpoint weather station (#108137) because the precipitation deficit estimates for the Sandpoint station are based on "non-irrigated" crops which underestimates the potential ET for a crop that is being irrigated. There is about 3 inches more precipitation on average during the growing season recorded at the Sandpoint station compared to the Coeur d'Alene station. This would translate to a lower P_{def} for a facility located near the Sandpoint station compared to a facility located near to the Coeur d'Alene station. The Garfield Bay irrigation site is a mature conifer forest which will have high evapotranspiration rates from the large amount of surface area available in the tree needles. The city of Spirit Lake has an 11 acre forested reuse irrigation site that is similar to Garfield Bay's and is located about 26 miles southwest of the Garfield Bay site. According the city of Spirit Lake's "2010 Reuse Annual Report", 48 inches were irrigated on the forested site over the growing season and soil moisture probes installed in the forested site showed that soils were never saturated. Considering these factors, it seems appropriate to use the higher P_{def} data from the Coeur d'Alene station with no adjustment for Garfield Bay irrigation site being close to Sandpoint.

The precipitation deficit (P_{def}) data for the Coeur d'Alene station assumes that the crops are irrigated. The draft "DEQ Guidance for Hydraulic and Nutrient Requirements for Forested/Poplar Sites - 3/13/09" recommends that the 80% exceedance data values of the monthly mean P_{def} be used for calculating native forest hydraulic loading limits when using irrigated weather station data (see Section 4.1.3.2.1 of the draft "DEQ Guidance for Hydraulic and Nutrient Requirements for Forested/Poplar Sites - 3/13/09" in Appendix 2). Table 1 summarizes the data taken from the ET_{Idaho} website for both crops.

Table 2 Precipitation Deficit (P_{def}) Data

	Orchards		Range Grasses	
	mm/day**	**in/month***	**mm/day****	**in/month***
January	-0.02	-0.02	-2	-2.44
February	-0.02	-0.02	-0.25	-0.31
March	0.07	0.09	-0.17	-0.21
April	0.32	0.38	0.13	0.16
May	1.38	1.68	1.21	1.48
June	3.41	4.03	1.83	2.23
July	5.16	6.30	3.19	3.89
August	3.69	4.50	1.68	2.05
September	2.06	2.43	0.36	0.44
October	0.16	0.20	-0.88	-1.07
November	-1.52	-1.80	-2.96	-3.61
December	-0.77	-0.94	-2.91	-3.55

* Calculated value (ET_{Idaho} data in mm/day / 25.4 in/mm ***** # days in month)
**80% Exceedance Data from ET_{Idaho} Coeur d'Alene 1E weather station #101956- "Orchards – Apples and Cherries no ground cover" and "Range Grasses – long season"

The facility is irrigating a native forest instead of a single-season crop such as alfalfa or hay. The forested site would not require irrigation to be productive. The additional water does promote growth as has been documented at the city of Spirit Lake's forested reuse site by Ralph Wheeler, forester, in the city of Spirit Lake's "2010 Annual Reuse Report". It will not be necessary for the permittee to irrigate according to the approximated IWR for an irrigated tree crop. Instead, the IWR will be used to set maximum monthly hydraulic application rates that are conservative and should prevent excessive irrigation even during wetter than normal growing seasons. Guidance specifically for forested sites is currently being developed by DEQ (DEQ, 2009). At this time, the Forest Guidance has not yet been approved for inclusion into the full Guidance Document (see Appendix 2 for the draft).

The irrigation site is mostly mature forest with a diverse tree population of different ages. For the purposes of the P_{def} calculations, the estimated composition of the management units is estimated to be about 80% trees and 20% brush and grasses. Another assumption is that where there are trees, the canopy covering the forest floor under the trees is estimated to be 90%. From Table 9 in Section 4.1.3.2.2 of the draft Forest Guidance, the corresponding forest cover factor is 0.95. Table 2 below shows the canopy-corrected values used for the growing season tree IWR as well as the contribution of the grasses. Negative values represent months where little or no growth takes place.

Table 3 Canopy-corrected P_{def} Values

Month	P_{def} Trees',[1, 2]
January	-0.02
February	-0.02
March	0.08
April	0.36
May	1.60
June	3.83
July	5.98
August	4.28
September	2.31
October	0.19
November	-1.71
December	-0.89

[1] Expressed in inches per month
[2] Table 1 value multiplied by a factor of 0.95

Accounting for the site composition, the tree values were multiplied by 80% and the grass values were multiplied by 20%. Table 3 shows the composited values for only the growing season at the Garfield Bay W&S District site. As shown in Table 3, October does not have any P_{def} using the 80% exceedance data (80% of the time the P_{def} will be greater than these values). There will be years when irrigating in October will be appropriate. DEQ may approve on a case-by-case basis, irrigation in October if the permittee can demonstrate that there is a positive $P_{def.}$

Table 4 - Composited Growing Season P_{def}

Months	Composited Irrigation Rates*
April	0.31
May	1.52
June	3.43
July	5.42
August	3.76
September	1.92
October	-0.03

* Expressed in inches per month

From Table 4-12 of the *Guidance* (DEQ, 2007), the system efficiency for solid set laterals utilizing risers and impact sprinkler heads was estimated to be 65% (the range is

60% to 85% in the DEQ Guidance). In order to represent the application system effectively, the values in Table 3 were divided by the assumed efficiency of the irrigation system and the resulting values are given in Table 4. The irrigation system is discussed in Sections 2.0, and 4.2.1.

Table 5 – Growing Season Calculated IWR for Irrigation System using 65% Irrigation Efficiency

Month	Calculated IWR*
April	0.48
May	2.34
June	5.27
July	8.34
August	5.78
September	2.96
October**	TBD
Total	**25.18**

* Expressed in inches per month
** To be determined (TBD). The Permittee may seek from DEQ approval to irrigate in October prior to irrigating if it can be demonstrated to DEQ the irrigation will be protective of public health and water quality.

Appendix 2

Draft Guidance

4.2.2.4.3 Forest and Poplar Plantation Nutrient Loading

Information regarding the nitrogen uptake of forested sites in the Pacific Northwest has largely been taken from Henry et al. (1999), *Managing Nitrogen from Biosolids*; and specifically from Chapter 6, "Using the Nitrogen Balance Approach for Forest Systems," Tables 6.1, 6.5 and 6.6. This is an important reference in that the authors have taken a vast and varied body of research, of which limited resources preclude an independent review here, and have distilled this research into waste land-treatment nutrient application recommendations for common Pacific Northwest tree species.

Nutrient Balance Assumptions

Henry et al. (1999) specifically discuss biosolids as a nutrient source. Biosolids by nature are residuals that are recalcitrant to some degree and when land-applied have various mineralization rates making nitrogen (N) available for plant uptake over a multi-year time frame. A simplifying assumption made for purposes of this guidance is that nitrogen in municipal wastewater effluent is readily available, resulting in mineralization reactions taking place relatively quickly. Therefore, a 100% mineralization rate is assumed. This assumption likely applies to many, but not all, food processing wastewater effluents also (Smith and Hayden, 1984).

A second simplifying and conservative assumption that *could* be made for regulatory expedience would be to disregard soil immobilization of N during first-time application. As shown in Henry et al. (1999) Table 6.2, first-year N immobilization values can be significant (175 pounds of nitrogen per acre [lb N/ac]). It may not be so important to consider first-year N immobilization in the event long-term N loadings are set at recommended annual uptake rates (Table 6, Table 7, and Table 8). This is typical permitting practice. Wastewater land treatment sites are typically used year after year for 10 to 30 years. Sites are typically owned by a sewer district or privately owned by a cooperator, and irrigation systems are usually installed for the long term. During wastewater reuse permitting and re-permitting, design loading rates are determined for at least the life of the permit, generally being five years.

It should be noted that documented decreases in forest productivity and increases in tree mortality have been observed in certain studies as a result of long-term N additions to forests (Aber and Magill, 2004). Given the potential for significant changes in forest health over time, there may be a need to re-assess the site at the end of a permit cycle, and revise nutrient loading rates if necessary.

Consulting Henry et al. (1999) Table 6.6, first-year loadings on a Douglas-fir plantation with understory and a 30:1 carbon to nitrogen ratio in the duff layer would allow 375 lb N/ac. For example, on a 40-acre site with nitrogen in treated wastewater applied at a rate of 3,600 lb nitrogen per year, the first year of operations could use just one parcel of approximately 10 acres, then the second, third and fourth 10-acre parcels could be used in successive years, for the first four years of the permit. Then from the fifth year on, loading rates could drop back to approximately 90 lb N/ac-yr over the entire 40 acres. Alternatively, one could design operations based on fifth and following year operations and apply approximately 90 lb N/ac over the entire 40 acres from the start of the permit operation. There may be some conservatism with respect to potential N losses built into the system by not inducing rapid decomposition of the duff layer by high initial N loadings.

Nutrient Uptake Values and Calculations

Nitrogen uptake values for hybrid cottonwood, Douglas-fir, pine (semi-arid conditions), and both herbaceous and woody understory are reproduced primarily from Henry et al. (1999) and appear in Tables 1, 2 and 3 below. These values represent the *net N uptake rate*, which is defined in Henry et al. (1999, p. 6-6) as the "gross" N uptake of the plant less the N contribution to uptake provided by N releases from litterfall decomposition and N cycling on the forest floor. The *net N uptake rate* can be modified to provide credit for N from other sources (e.g., residual soil N) to yield the *net N requirement*. If analysis of soil nutrient data shows little substantial change in available soil N concentrations (nitrate and ammonia) at benchmark seasons (every spring for example), there may be little need to make a correction for residual soil N.

The *net N requirement* should then be adjusted for denitrification/volatilization losses of applied wastewater. For wastewater effluent applications, these losses are mainly from denitrification and typically range from 15% to 25% (see EPA 1981, p. 4-4). Volatilization of ammonia would be expected to be low as pH in forest soils is typically neutral or slightly acidic, rendering cationic ammonium rather than the gaseous ammonia form as the dominant species. Denitrification losses ranging from 15% to 25% result in N uptake efficiency factors (e_f) of 0.85 and 0.75, respectively (see section 4.2.2.4.2, page 4-26). The e_f values of 0.85 and 0.75 amount to allowable N loading rates of 117% and 133% of the *net N requirement*, respectively. These calculations are summarized in Equation 1:

Equation 1. Calculation of the Net Nitrogen Requirement

$$N\ Loading\ Rate = \frac{(Net\ N\ Uptake - N\ Credits)}{(1 - Denitrification/Volatilization\ Rate)} = \frac{Net\ N\ requirement}{(1 - Denitrification/Volatilization\ Rate)}$$

Table 6, Table 7, and Table 8 show net N uptake values for hybrid cottonwood, Douglas-fir and white pine, and forest understory.

Table 6. Hybrid Cottonwood: Net N Uptake Rates

Year of Growth	Tree N Uptake; lb/ac-yr*	Understory N Uptake; lb/ac-yr	Total N Uptake; lb/ac-yr
Year 1	50	100	150
Year 2	120	50	170
Year 3	200	0	200
Year 4	220	0	220
Year 5-10	240	0	240

From Henry et al. (1999), Tables 6.1 and 6.6
* lb/ac-yr – pounds per acre year

Table 7: Douglas -fir and Pine: Net N Uptake Rates

Condition	Douglas-fir N Uptake; lb/ac-yr*	Pine (Semi-arid Environment) N Uptake; lb/ac-yr
Planted 1 year ago	0	0
Planted 2 years ago	0	0
Juvenile Plantations 3-25 years		
Canopy covers 100 % of site	110	80
Canopy covers 50 % of site	55	40
Older Stands		
Age over 25 years	45	30
Age over 40 years	25	30

From Henry et al. (1999), Tables 6.1 and 6.6
* lb/ac-yr – pounds per acre year

Table 8. Forest Understory: Net N Uptake Rates

Condition	Understory N Uptake; lb/ac-yr
Woody Vegetation	
Full Understory (covers 100 % of site)	40
Partial Understory (covers 50 % of site)	20
Thin Understory (covers 20 % of site)	10
Sparse Understory (covers 0 - 10% of site)	0
Herbaceous Vegetation	
Full Understory (covers 100 % of site)	751
Partial Understory (covers 50 % of site)	35
Thin Understory (covers 20 % of site)	15
Sparse Understory (covers 0 – 10 % of site)	0
New Plantation (see values for woody and herbaceous understory)	

From Henry et al. (1999), Tables 6.1 and 6.6.
Footnote: 1) Sally Brown. Personal communication to M. Cook August 29, 2008.

There are alternatives to nutrient uptake rates provided in Table 6, Table 7, and Table 8. In particular, the National Resource Conservation Service (NRCS) guidance "Nutrient Uptake and Removal – Nutrients Available from Livestock Manure Relative to Crop Growth Requirements" (NRCS 1998) (Appendix I, Part C) provides general recommendations for both N and P application rates for non-grazed privately owned

woodlands. Recommended rates are as follows: 100 lbs N/acre and 20 lbs P/acre. Also recommended is a 70% "nitrogen recovery factor" (i.e. e_f , the uptake efficiency factor; see section 4.2.2.4.2, page 4-26) to apply to recommended values. An e_f of 0.7 amounts to an allowable N loading of 143% of the *net N requirement*. The reciprocal of e_f (0.7) is 1.43, or as expressed as a percent, 143%. See the following NRCS website for more information:

http://www.nrcs.usda.gov/technical/land/pubs/nlapp1a.html

It should be noted that a commercial poplar plantation may require specific nitrogen application rates for profitable production. In the event the allowable volume of land applied wastewater does not supply the minimum N amount, supplemental fertilization may be necessary. On the other hand, forested sites used for land treatment in many cases would otherwise have no additional wastewater or nutrients so even in the case where the net N requirement cannot be met, there would be no need for supplemental fertilization.

Nutrient Loading Rate Calculation Example

In this example, Table 9 shows the values used to calculate the N loading rate for the scenario described in the table. The values are then substituted in Equation 1 to calculate the example nitrogen loading rate.

Table 9. Nutrient Uptake Calculation Example: Conditions

Condition	Value
Douglas-fir juvenile plantation, 8 years old; Forest Canopy covers 50% of the site	55 lb/ac N uptake (Table 2)
Partial herbaceous understory	35 lb/ac N uptake (Table 3)
Denitrification / volatilization rate	20%
Assume no appreciable change in soil storage from initial time of wastewater application to the end of permit cycle.	0 lb N/ac credit

$$N \quad Loading \quad Rate = \frac{[(55 + 35) - 0]}{(1 - 0.20)} = \frac{90}{0.80} = 112.5 \; lb \; N/ac - yr$$

1.2 References

Aber, J.D. and A.H. Magill. 2004. Chronic Nitrogen Additions at the Harvard Forest (USA): The First 15 Years of a Nitrogen Saturation Experiment. Forest Ecology and Management, Volume 196, pp. 1-5.

[EPA] Environmental Protection Agency. October 1981. Process Design Manual – Land Treatment of Municipal Wastewater. EPA 625/1-81-013. Center for Environmental Research Information, Cincinnati Ohio.

Henry, C., D. Sullivan, R. Rynk, K. Dorsey, and C. Cogger. 1999. Managing Nitrogen from Biosolids. Washington State Department of Ecology and Northwest Biosolids Management Association.

Smith, J.H., and C.W. Hayden. 1984. Nitrogen Availability from Potato-Processing Wastewater for Growing Corn. Journal of Environmental Quality Vol. 13, no.1, January-March.

[NRCS] Natural Resource Conservation Service. February 1998. Nutrients Available from Livestock Manure Relative to Crop Growth Requirements. Appendix I: Nutrient Uptake and Removal – Part C, Non-Grazed Privately Owned Woodland.
See the Web Site at: http://www.nrcs.usda.gov/technical/NRI/pubs/nlapp1a.html

4.1.3 Forest and Poplar Site Hydraulic Loading

Determining appropriate hydraulic loading rates is largely—but not solely—dependent upon site precipitation and evapotranspiration (ET) rates. In this section, where ET is referred to without qualifiers such as ET_{act}, ET_{pot} etc., it refers to the generalized concept. Where qualified, ET will have specific definitions important in the course of the discussion.

Idaho-specific consumptive irrigation requirements, as well as terminology definitions, are comprehensively discussed in Allen and Robison (2007). Idaho-specific ET data and other parameters related to consumptive irrigation requirements can be found at the following Web site, referred to in this document as "ETIdaho":

http://www.kimberly.uidaho.edu/ETIdaho/

The discussions in section 4.1.3.2 and section 4.1.3.3 provide methodologies for obtaining estimates of precipitation deficit (P_{def}) and actual evapotranspiration (ET_{act}) (as applicable) for a particular combination of "crop" (i.e. forest, poplar plantation, etc.) and weather station in both non-growing and growing seasons, respectively.

4.1.3.1 Non-Growing Season Hydraulic Loading – Forest and Poplar

There may be instances when non-growing season wastewater loading is allowed on forest and poplar sites. In Equation 2 below, the available water-holding capacity (AWC) of the soil plus the non-growing season ET_{act} values less the non-growing season precipitation (PPT_{ngs}) (not effective precipitation) yields an estimate of the non-growing season wastewater application capacity of the system, referred to as the hydraulic loading limit, non-growing season (HLL_{ngs}).

Equation 2. Non-growing Season Hydraulic Loading Limit

$$HLL_{ngs} = AWC + ET_{act} - PPT_{ngs}$$

The ETIdaho report provides rates for ET_{act} during wintertime for dormant vegetation, which is predominantly evaporation from soil following precipitation. Values for ET_{act}, defined in Allen and Robison (2007, page 43), should be obtained. Directions to obtain ET_{act} are in section 4.1.3.2.1.

This methodology makes no adjustment to non-growing season ET for tree canopy density (see section 4.1.3.2.2). In the case of non-growing season land application where the soil is wetted more frequently, the ET may be greater than stated. In frequently wetted scenarios, ET might be nearer to the potential ET (ET_{pot}) rates that are listed in

ETIdaho. However, non-growing season wastewater application is generally practiced sparingly if at all, on forested municipal land treatment sites, so ET_{act} should be used.

Calculation of non-growing season hydraulic loading rates is fully discussed in section 4.4.9. See also DEQ (2009), pages 7-10 for further explanation of calculating growing and non-growing season hydraulic balances. Examples that show how to calculate both forest and poplar non-growing season hydraulic loading rates are found in section 4.1.3.2.3 and section 4.1.3.3.3, respectively.

4.1.3.2 Forest ET and Irrigation Water Requirement Determinations

To determine wastewater loading rates for the growing season, values for the net irrigation requirement (IR_{net}), referred to here as precipitation deficit (P_{def}), first need to be determined. The P_{def} is then divided by the irrigation efficiency (E_i) of the irrigation system to yield the irrigation water requirement (IWR), as shown in Equation 3 below. Irrigation-related terms and calculations are discussed in detail in section 4.1.1.2.2.

Equation 3. Irrigation Water Requirement (IWR)

$$IWR = \frac{P_{def}}{E_i}$$

Where the relationship of P_{def} to ET is shown in Equation z. Precipitation Deficit:

$$P_{def} = ET - effective \quad precipitat \quad ion$$

It is obvious, yet it should be noted that native species living in native conditions are not irrigated. So terminology related to irrigated agriculture (IR_{net}/P_{def}, IWR, E_i etc.), has limited applicability.

The following sections provide instructions on how to determine ET_{act} and P_{def} for scenarios that are commonly encountered in wastewater reuse application on forested sites.

4.1.3.2.1 Weather Station and “Crop” Selection

Both a weather station and a “crop” must be selected in order to obtain P_{def} and ET_{act} data from ETIdaho that can be used to calculate allowable wastewater irrigation values. The

choice of weather station and crop will determine whether the P_{def} and ET_{act} data obtained are for an irrigated scenario or a non-irrigated scenario. This is because a weather station

may be designated (flagged) as non-irrigated or irrigated (see Table 5). In addition, a particular crop may be designated as always non-irrigated, always irrigated, or irrigated/non-irrigated depending on the weather station flag. So, in the case of wastewater reuse purposes, data for an irrigated scenario must be chosen, and care must be exercised to be sure that data for a non-irrigated scenario in not inadvertently selected. The following instructions serve to provide an example of the data selection process:

To obtain P_{def} and ET_{act} data from ETIdaho for forests irrigated with wastewater,

1) Select a weather station nearest to the site. As an example, the Sandpoint KSPT station is selected.

2) Next, consideration must be given to the weather station irrigation flags in Allen and Robison (2007), Appendix 5, Table 5.2 (page 161). First, determine whether the particular station that was initially selected has an irrigation flag of 1 or 0.

If the flag = 1, this indicates that "managed agricultural crops are typically irrigated" (see Table 5.2 footnote), and that P_{def} and ET_{act} values obtained for that station would be higher than for a water-limiting non-irrigated scenario because more water is available to evapotranspire in a "water sufficient" scenario.

If the station has an irrigation flag = 0 (or no value), this indicates the station has a rainfed (non-irrigated) scenario and P_{def} and ET_{act} values are less to reflect stress imposed by insufficient rainfall. Note that the Sandpoint KSPT station chosen for this example has an irrigation flag = 0.

3) After determining the weather station irrigation flag, then look up the crop number in Table 6 (pages 22-23) in Allen and Robison (2007). For forest sites, use *Orchards - no cover* (Allen 2008), crop no. 20. Then consult Table 7 (pages 24 and following) to determine the irrigation flag for the particular crop.

If the crop has an irrigation flag = 0 (defined on page 23), it will always be a non-irrigated crop and the associated P_{def} and ET_{act} values reflect non-irrigated conditions.

If the irrigation flag = 3, values are always for an irrigated scenario regardless of the weather station irrigation flag.

If the crop irrigation flag = 1 or 2, values are irrigated if the station irrigation flag = 1, and values are non-irrigated if the station flag = 0. In the example, crop no. 20 carries a flag = 1 as shown in Table 7.

4) This combination of flags for Sandpoint KSPT (flag = 0) and *Orchards - no cover* – crop no. 20 (flag = 1) indicates that the P_{def} and ET_{act} values obtained are for non-irrigated conditions.

If the effluent loadings are relatively small in relation to precipitation inputs, a crop with a flag = 1 would yield non-irrigated values which should be adequate (non-irrigated values are not available for all locations, but generally are available for northern Idaho).

If effluent loadings are substantial, and somewhat follow potential ET (ET_{pot} is defined in Allen and Robison 2007, page 43), then a crop with a flag = 1 would not yield appropriate values and an irrigated crop should be selected instead (Allen, 2008). In this example, we are limited to using crop no. 20 and must go to step 5).

5) In this forested site example, however, only Crop no. 20 can be used. So instead of selecting a different crop, select a different but nearby weather station, one which does not have a flag = 0, to obtain irrigated scenario P_{def} and ET_{act} values. In Appendix 5, Table 5.2, the Coeur d'Alene 1E station has an irrigation flag = 1, so *Orchards - no cover* P_{def} and ET_{act} data from this station should reflect irrigated conditions. The relationship between the combination of weather station irrigation flag and crop irrigation flag and the type of P_{def} and ET_{act} values obtained from ETIdaho is shown in Table 10.

Table 10. Weather Station and Crop Irrigation Flags and Type of P_{def} and ET_{act} Values Obtained.

Climate Station Irrigation Flag	Crop Irrigation Flag	Type of P_{def} and ET_{act} Values
Flag = 0 (rainfed or non-irrigated scenario)	Flag = 0 (always non-irrigated)	Non-irrigated
	Flag = 1 or 2 (depends on Station Flag)	Non-irrigated
	Flag = 3 (always irrigated)	Irrigated
Flag = 1 (managed agricultural crops typically irrigated)	Flag = 0 (always non-irrigated)	Non-irrigated
	Flag = 1 or 2 (depends on Station Flag)	Irrigated
	Flag = 3 (always irrigated)	Irrigated

For a "cropped" forested site such as a Christmas tree farm that will be managed as a commercial farm, wastewater reuse permits will likely require irrigation "substantially" according to irrigation water requirements (IWR). This presupposes that the site manager will take precipitation events and other meteorological conditions into account in the course of actively managing the irrigation needs of the crop. Monthly P_{def} average values should be used as a guide for irrigation management.

Considering the special case of native forested sites—which are not managed as commercial "crops"—wastewater reuse permits will likely not require the manager to account for precipitation events and other meteorological conditions. For the sake of simplicity, such sites would likely be required to apply wastewater at pre-determined monthly irrigation volumes not to exceed a certain fixed limit expressed as an "IWR." However, in order to minimize the occurrence of hydraulic overloading, the IWR in the case of the native forest would likely be based on a more conservative (i.e., lower) estimate of P_{def}—designated in ETIdaho as "P_{def} - 80% Exceedance". That is, a P_{def} that has an 80% chance of being exceeded in a given month, rather than the P_{def} – monthly average that has a 50% chance of being exceeded in a given month.

4.1.3.2.2 Canopy Density Correction

The growing season ET of forests will vary substantially depending on the density of the trees. A dense forest would be somewhat similar to an orchard (Allen 2008). For trees whose canopies are not fully covering the ground, the understory vegetation will influence the ET rate.

If there is no understory, then the ET (and thus the P_{def}) will be reduced in proportion of approximately the square root of the fraction of forest ground cover (Allen, 2008). For

example, if the canopy cover fraction is 0.8 (80%), then the canopy density factor would be 0.9 and the P_{def} would be adjusted as follows:

$$P_{def}\ (adjusted\ ) = \sqrt{0.8} * P_{def} = 0.9 * P_{def}$$

For convenience, Table 11 provides calculated factors to use with other canopy cover fractions. There may be significant changes in forest composition and canopy cover through time on sites used for wastewater land treatment. These changes may result in a need to re-assess canopy and understory cover at the end of a permit cycle, and re-calculate P_{def} if necessary.

If there is green understory, then the ET rate will likely be similar to that for full canopy cover, and the P_{def} would not be adjusted (i.e., 1.0 * P_{def}). The ET rate for conditions in which there is no understory, but the soil is nearly continuously wet by frequent effluent land application will also be similar to that for full canopy cover. However, continuously wet conditions from wastewater land treatment are seldom encountered. In cases of full cover or continuously wet conditions, ET will approach a maximum rate governed by energy available for evaporation (Allen, 2008).

Table 11. Canopy Density Correction Factors to Modify *Orchard – no cover* (no understory) in Estimating Forest P_{def}

Fraction of Forest Canopy Covering the Ground	Factor to Modify Orchard – no cover P_{def}
1.0	1.0
0.9	0.95
0.8	0.89
0.7	0.84
0.6	0.77
0.5	0.71
0.4	0.63
0.3	0.55

Allen and Robison (2007) documents the freeze-down (leaf fall) temperature used to mark the end of the growing season for orchards. In the case of conifers, they would tend to keep their crop coefficient (K_c) high into the winter, but probably will transpire less effectively due to cool temperatures and in some cases, frozen soil that impedes liquid movement to roots.

4.1.3.2.3 Example Calculation - Forest

The following is an example calculation to determine forest P_{def} and ET_{act} for the scenario described in Table 12:

Table 12. P_{def}, IWR, and ET_{act} Calculation Example: Conditions

Example Conditions
Vegetation:
- Douglas-fir juvenile plantation, 8 years old;
- Forest Canopy covers 50% of the site
- Sparse herbaceous understory; <10%
Location:
- Sandpoint, ID
Operations:
- Wastewater irrigations approach actual ET (ET_{act}) values during the growing season, albeit soils are not continually wet.
- The "growing season" defined by the wastewater reuse permit is May through September.
- Wastewater irrigations in the non-growing season are infrequent to none, and soils are not continually wet.
- Irrigation efficiency of handline system: E_i = 0.75
- Soil AWC = 4.3 inches

For the non-growing season, the HLL_{ngs} equation in section 4.1.3.1 is used. ET_{act} values from ETIdaho for the Coeur d'Alene 1E station *Orchards - no cover*, are reproduced below. In ETIdaho, values are expressed in millimeters per day (mm/day) and are then typically converted to inches per month as shown in Table 13. This conversion is done on all succeeding calculation examples in this section. The shading of growing season months in Table 13 is done to emphasize the fact that ET_{act} values have application for the non-growing season. PPT results from ETIdaho, Sandpoint KSPT station (not the Coeur d'Alene station), are reproduced below, as this is the closest station and would likely have the best estimates of PPT values.

Table 13. Example ET_{act} and PPT calculations for a Forested Site.

Month	ET_{act} (mm/day)	ET_{act} (in/month)	Precipitation PPT (mm/day)	Precipitation PPT (in/month)
Jan	0.28	0.34	3.35	4.09
Feb	0.76	0.84	2.80	3.09
Mar	1.27	1.55	2.25	2.75
Apr	1.83	2.16	1.9	2.24
May				
Jun				
Jul				
Aug				
Sep				
Oct	2.22	2.71	2.04	2.49
Nov	0.75	0.89	4.11	4.85
Dec	0.22	0.27	3.86	4.71
NGS Totals		8.76		24.22

The HLL_{ngs} in this example would be considered zero since the result is negative, as shown in the following calculation:

$$HLL_{ngs} = AWC + ET_{act} - PPT_{ngs} = 4.3 + 8.76 - 24.22 = -11.16 \quad in$$

For the growing season, P_{def} (80% Exceedance) values obtained from ETIdaho for the Coeur d'Alene 1E station for *Orchards - no cover* are reproduced in Table 9. A canopy cover density correction factor of 0.71 was used to adjust P_{def} for 50% canopy cover (Table 11). The shading of non-growing season months in Table 14 is done to emphasize the fact that P_{def} values have application during growing season months. Shading conventions in Table 8 and Table 9 are followed throughout the rest of this section.

Table 14. Example P_{def} and IWR Calculations for a Forested Site.

Month	P_{def} (mm/day)	P_{def} (in/month)	Canopy Density Factor (from Table 1) (unitless)	Adjusted P_{def} (in/month)	Irrigation Water "Requirement" (in/month)
Jan					
Feb					
Mar					
Apr					
May	1.26	1.54	0.71	1.09	1.46
Jun	3.23	3.81	0.71	2.71	3.61
Jul	5.03	6.14	0.71	4.36	5.81
Aug	3.67	4.48	0.71	3.18	4.24
Sep	2.13	2.52	0.71	1.79	2.38
Oct					
Nov					
Dec					

4.1.3.3 Poplar ET and Irrigation Requirement Determinations

The following sections discuss determination of P_{def} and ET_{act} in mature and maturing poplar stands, as well as in juvenile stands. Example calculations are also provided.

4.1.3.3.1 Mature and Maturing Poplar Stands

ETIdaho has a selection for *Poplar Trees – third year and older*. This is described as having trees planted relatively densely, and ground cover that is kept mostly bare through tillage for weed control. If this is not the case, other options, which are discussed below, should be considered.

For the growing seasons, determining poplar P_{def} on wastewater land treatment sites should be done as follows: For poplar plantations that are three years and older, use the P_{def} provided in ETIdaho for corresponding conditions. Use this value only after consulting Tables 6 and 7 and Appendix 5 Table 5.2 of Allen and Robison (2007), as described in section 4.1.3.2.1, to see whether values obtained are for an irrigated scenario. It should be noted that for certain weather stations on ETIdaho, the poplar crop may be assumed to be rainfed, and will have P_{def} values considerably lower than for irrigated poplar. This is because, for a rainfed crop, ET will not include the evaporation stemming from irrigation events. The ET_{act} will be similar to ET_{pot} if the plantation is irrigated in an amount approaching the irrigation water requirement. If the plantation is rainfed only, ET_{act} will generally be less than potential ET_{pot}, and ET_{act} values will be similar to precipitation. If P_{def} values obtained are for a rainfed scenario, do as described in section 4.1.3.2.1 for forests (orchards) to obtain irrigated scenario P_{def} values from another station.

For the non-growing season, determine poplar ET_{act} on wastewater land treatment sites as follows: For poplar plantations that are three years and older, use the ET_{act} value from the ETIdaho website for corresponding conditions. As with the growing season, use this value only after consulting Tables 6 and 7 and Appendix 5 Table 5.2 of Allen and Robison (2007), as described in section 4.1.3.2.1 above, to see whether values obtained are for an irrigated scenario. If ET_{act} values are for a rainfed scenario, do as described in section 4.1.3.2.1 for forests (orchards) to obtain irrigated scenario ET_{act} values for a different weather station.

4.1.3.3.2 Juvenile Poplar Stands

For recently planted poplar plantations (less than three years) with ground cover, then the P_{def} and ET_{act} for the ground cover surrounding the young trees should be used, especially if the young poplars do not have appreciable canopy cover on the field. The P_{def} and ET_{act} can be estimated by selecting *Grass Pasture - high management*.

In the case where the poplars are starting to grow, but are not as large as a stand of 3 year old poplars, or where poplars are more than three years old but are sparse and not dominant, then compute an acreage-weighted average of P_{def} and ET_{act} for both the *Poplar Trees – third year and older* category and the ground-cover type (e.g., *Grass Pasture - high management*).

An alternative means to find appropriate hydraulic loading rates is to obtain crop coefficients in the Agrimet Web site, and use these to modify reference ET (ET_r) values as described in the "All About Crop Coefficients" text file on the Agrimet Web site. There are values for first-, second-, third-year, and etc., poplar growth stages. Then calculate Pdef values. For the crop coefficients see this Website:

http://www.usbr.gov/pn/agrimet/cropcurves/crop_curves.html

4.1.3.3.3 Example Calculation - Poplar

In the following example, poplar P_{def} and ET_{act} are calculated, for the scenario provided in Table 15:

Table 15. P_{def}, IWR, and ET_{act} Calculation Example: Conditions

Vegetation:
- Poplar plantation, 4 years old; commercially managed
- Sparse poplar canopy; canopy covers 40% of the site
- partial grass understory; ~60% cover
Location:
- Sandpoint, Idaho
Operations:
- Wastewater irrigations approach actual ET (ETact) values during the growing season, albeit soils are not continually wet.
- The "growing season" defined by the wastewater reuse permit is May through September.
- Wastewater irrigations in the non-growing season are infrequent to none, and soils are not continually wet.
- Irrigation efficiency of handline system: Ei = 0.75
- Soil AWC = 4.3 inches

For the growing season, P_{def} values for this poplar-understory scenario were determined by selecting both *Poplar Trees – third year and older* P_{def} and *Grass Pasture – high management* P_{def} from ETIdaho for the Sandpoint KSPT station. According to Allen and Robison (2007), Appendix 5 Table 5.2 (page 161), this particular station has an irrigation flag = 0 (blank). This indicates a rainfed (non-irrigated) scenario at this station, with ET reduced to reflect stress imposed by insufficient rainfall. This station should not be used for this example scenario.

The crop numbers in Allen and Robison (2007), Table 6 (pages 22-23), *Poplar Trees – third year and older* and *Grass Pasture – high management* are crop nos. 34 and 15, respectively. In Table 7 (pages 24 and following), the crop irrigation flags are 1 and 2, respectively, indicating that values are for non-irrigated conditions at the Sandpoint station, which has a flag = 0. As discussed above for forests (*Orchards – no cover*), Appendix 5 Table 5.2 (Allen and Robison 2007) shows that the Coeur d'Alene 1E station has an irrigation flag = 1, so values for both of these crops should reflect irrigated conditions. This station should be used for this example scenario (see Table 10 for summary of the relationship between weather station irrigation flag and crop irrigation flag and the type of P_{def} and ET_{act} values obtained).

Values obtained from ETIdaho are reproduced in Table 16. Both *Poplar - third year and older* and *Grass Pasture - high management* were used. As stated in section 4.1.3, P_{def} is divided by irrigation efficiency to obtain the irrigation water requirement. Since this is a commercially managed plantation, monthly P_{def} rather than P_{def} (80% Exceedance) should be used, and permit requirements should reflect a hydraulic loading limit "substantially" equal to the IWR.

Table 16. Example Poplar P_{def} and IWR Calculations

	Poplar 3 yr & Older (40%)		Pasture - High Mgmnt (60%)		Weighted Average P_{def} (in/month)	Irrigation Water "Requirement" (in/month)
Month	P_{def} (mm/day)	P_{def} (in/month)	P_{def} (mm/day)	P_{def} (in/month)		
Jan						
Feb						
Mar						
Apr						
May	2.08	2.54	4.84	5.91	4.56	6.08
Jun	4.87	5.75	5.62	6.64	6.28	8.37
Jul	6.99	8.53	6.36	7.76	8.07	10.76
Aug	6.06	7.40	5.82	7.10	7.22	9.63
Sep	3.73	4.41	3.81	4.50	4.46	5.95
Oct						
Nov						
Dec						

For the non-growing season, ET_{act} values were obtained for this poplar-understory scenario by selecting both *Poplar Trees – third year and older* ET_{act} and *Grass Pasture – high management* ET_{act} from ETIdaho for the Coeur d'Alene 1E station (as was done for the growing season).

ET_{act} values for both *Poplar - third year and older* and *Grass Pasture - high management* from ETIdaho are reproduced in Table 17.

Table 17. Example Poplar ET_{act} Calculation.

	Poplar 3 yr & Older (40%)		Pasture = High Mgmnt (60%)		Weighted
Month	ET_{act} (mm/day)	ET_{act} (in/month)	ET_{act} (mm/day)	ET_{act} (in/month)	Average ET_{act} (in/month)
Jan	0.19	0.23	0.14	0.17	0.20
Feb	0.52	0.57	0.41	0.45	0.50
Mar	0.91	1.11	0.85	1.04	1.07
Apr	1.18	1.39	2.45	2.89	2.29
May					
Jun					
Jul					
Aug					
Sep					
Oct	2.54	3.10	1.97	2.40	2.68
Nov	0.66	0.78	0.54	0.64	0.69
Dec	0.16	0.20	0.12	0.15	0.17
NGS Totals		7.38		7.74	7.60

The HLL_{ngs} in this case would be zero since the result is negative, as shown in the following calculation:

$$HLL_{ngs} = AWC + ET_{act} - PPT_{ngs} = 4.3 + 7.60 - 24.22 = -12.32 \quad in/ac$$

1.3 4.1.3.3.4 References

Allen, R.G. and C. Robison. April 2007. Evapotranspiration and Consumptive Irrigation Water requirements for Idaho. University of Idaho. 246 pages plus appendices.

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