MEMORANDUM

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FROM: Chris Westerman, E.I.T. – Coeur d'Alene Regional Office

DATE: **February 9, 2016**

SUBJECT: **M-219-02 Granite Reeder Water and Sewer District, Staff Analysis supporting reuse permit issuance.**

Executive Summary

The Granite-Reeder municipal wastewater system consists of sewer collection pipes, a wastewater treatment facility (aerated lagoons and disinfection) and a Class C recycled water irrigation system. The Granite Reeder Water and Sewer District (District) owns and operates these wastewater facilities. The District serves full time and seasonal residences as well as commercial customers near the west central shore of Priest Lake in Bonner County, Idaho. Currently there are 235 equivalent residential units (ERUs) and 125 commercial ERUs connected to the existing wastewater system (Cordes 2014). The Idaho Department of Environmental Quality (DEQ) issued the first reuse permit (LA-000219-01) on March 15, 2010 with an expiration date of March 15, 2015. DEQ allowed the District to continue operating the reuse site under the terms and conditions of the expired permit for 2015 growing season (May 1st through September 30th – 153 days).

Raw wastewater effluent is discharged and stored in two (2) lined, aerated lagoons. After biological treatment, the wastewater is disinfected with sodium hypochlorite prior to irrigation. The treated and disinfected effluent (recycled water) is then irrigated over twenty (20) individual hydraulic management units with a total area of 41.5 acres of natural forest during the growing season. The total annual irrigation volumes have varied from 4.18 to 8.72 million gallons between 2012 and 2014.

Based on the annual report reviews and on-site inspections, the facility has demonstrated substantial compliance with the requirements of the reuse permit. The wastewater system (i.e. collection, treatment and disposal facilities) is fairly new construction and has only been in operation for the previous three (3) years (2012-2015). Staff recommends that the District be reissued a new recycled water permit and that the draft reuse permit is written with a ten (10) year term.

1 Introduction

The purpose of this memorandum is to satisfy the requirements of IDAPA 58.01.17.400 for issuing recycled water reuse permits. It briefly states the principal facts and significant questions considered in preparing the draft permit and provides a summary of the basis for the draft permit conditions.

Construction of the wastewater treatment facility and reuse site was completed in 2009 and DEQ issued a reuse permit on March 15, 2010 (LA-000219-01) with a term of five (5) years, expiring on March 15, 2015. The District began irrigating the reuse site with recycled water during the 2012 growing season. On April 23, 2014, staff with the Idaho Department of Environmental Quality (DEQ) met with the District's representatives for a permit renewal workshop in which the required contents for a substantially complete permit application were discussed. The renewal application and technical report were submitted to DEQ on September 16, 2014; a revised version of the technical report was submitted on December 30, 2014. The documents included with the application submittal are listed below:

- Recycled Water Reuse Permit Application Form
- A technical report supporting the reuse permit application renewal;
- An updated lagoon water balance; and
- Form A: Designation of Authorized Representative

2 Site Location and Ownership

Granite Reeder's treatment facility and reuse site are located near the west central shore of Priest Lake; approximately 30 miles north of the City of Priest River, Idaho (see Figure 1). The reuse site is located adjacent to the lagoons and is approximately 346 feet north of Granite Creek at the closest point and 1,994 feet west of Priest Lake. The legal description for the site is T61N, R4W, Section 17, E ½ NE ¼, Boise Meridian, Bonner County, Idaho. The District purchased approximately 80 acres from the United States Forestry Service (USFS) in 2007. Sixty (60) acres of this land on the west side of Reeder Bay Road was developed as the current facility and reuse site (see Figure 2). The remaining twenty (20) acres located on the east side of Reeder Bay Road, adjacent to the reuse site, is currently undeveloped and provides an additional horizontal buffer to the nearby residents.

The District owns and is responsible for the continued operation and maintenance (O&M) of the sewage collection system, wastewater treatment facility, and the reuse system. Vincent Aguirre is the current responsible official (RO) for the District and Travis Clemenson (the current responsible charge operator) has been designated as the authorized representative.

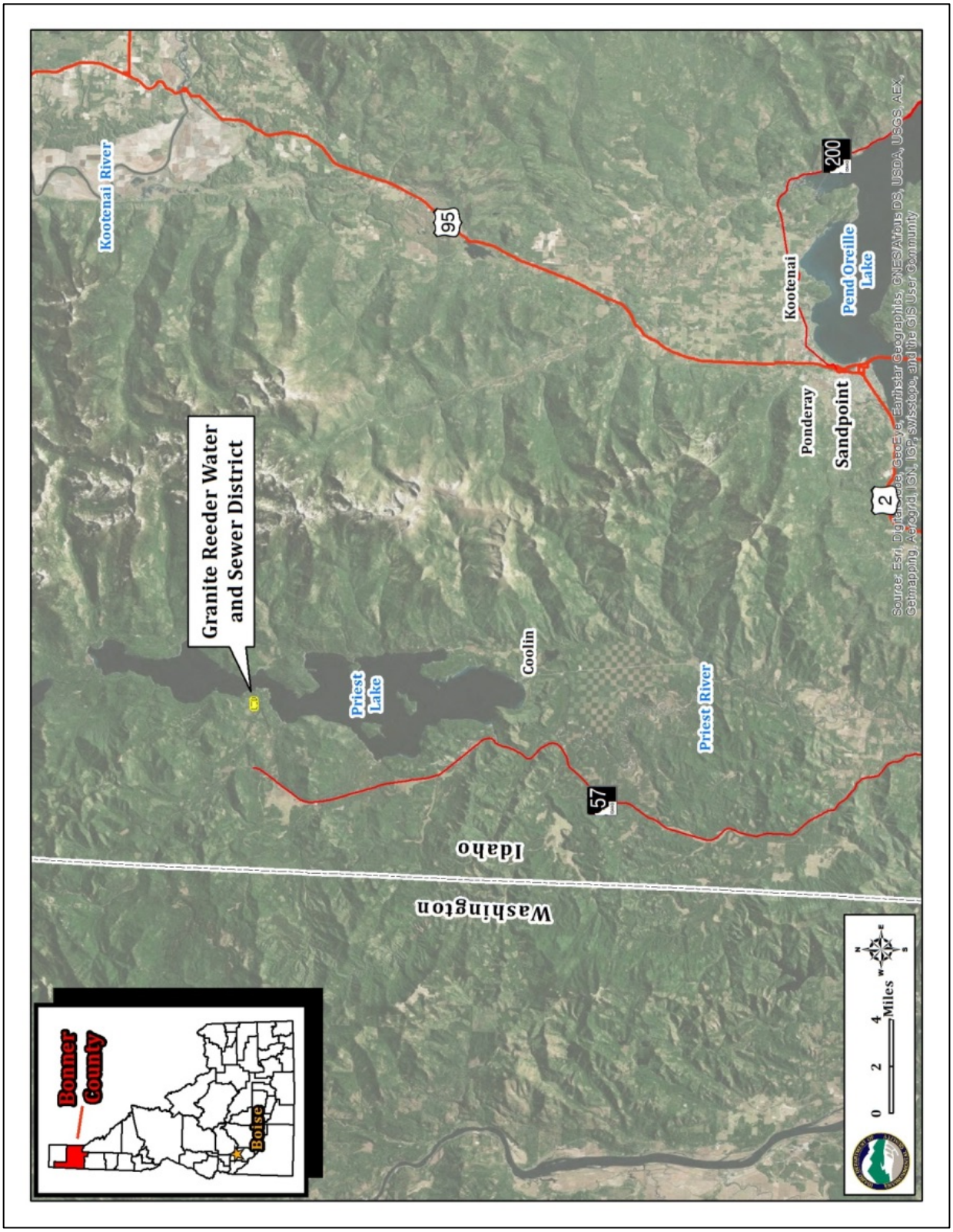


Figure 1. Granite Reeder Vicinity Map

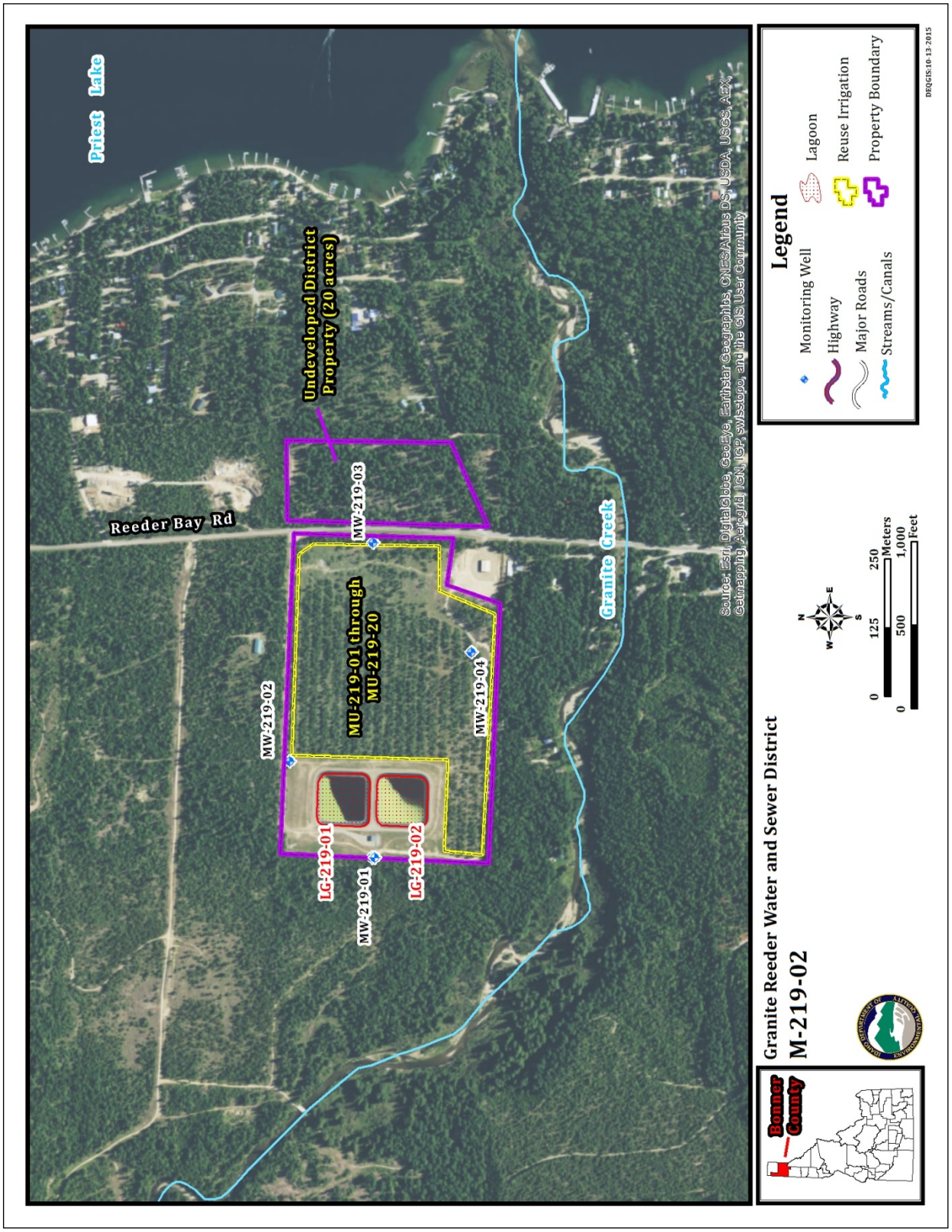


Figure 2. Granite Reeder Facility Map

3 Process Description

Prior to the construction of the current wastewater facilities, wastewater throughout the Granite Reeder service area was disposed of through individual or community subsurface systems that were considered to be substandard by the Panhandle Health District (PHD). As a result, the District proposed a reuse project to address wastewater treatment and disposal within the service area.

Sewer Collection System

The sewer collection system consists of grinder pumps installed at each building and raw wastewater is pumped through 2-inch and 8-inch diameter high density polyethylene (HDPE) pipe up to the lagoons. There are a few residences served by an 8-inch 3034 PVC gravity collection main with a common lift station. Initial design flows for the collection system were estimated to be about 75 gpd/ERU with a 30% factor of safety based on the information provided by similar systems in the area (Comer 2014). The current reuse permit (LA-000219-01) requires that the District monitor the daily wastewater inflow to the lagoons.

Wastewater Treatment Lagoons

Wastewater treatment is achieved by two (2) aerated, lined lagoons designed for a build-out population of 800 ERUs and a capacity of 16 MG designed for the non-growing season storage (October 1st through April 30th – 242 days). The lagoons have a combined surface area of 2.3 acres at full capacity excluding freeboard. Surface aerators add oxygen to the lagoons to help with treatment and mitigate potential odors. According to the lagoon water balance included with the technical report, there is adequate storage capacity at the design build-out at this time (Comer 2014). Treated effluent is disinfected with 12.5% liquid sodium hypochlorite solution in a contact pipe providing a contact time between 20 minutes and 120 minutes depending on the number of pumps running.

Reuse Site

After biological treatment, wastewater effluent is pumped from two (2) 30 horsepower irrigation pumps located in the control building and where the 12.5% solution of sodium hypochlorite is injected for disinfection. These pumps are also capable of pumping wastewater between the lagoons and at the design flowrate throughout the lagoons' operating range. A single pump is designed to irrigate a single zone and both pumps running were designed to irrigate two zones; however, the facility is limited to operating a single zone at a time due to the required contact time needed to ensure that the disinfection goals are met. There is a single flow meter located in the control building on the outlet of a common pipeline that both pumps share. This means that the current pipe configuration of the facility would not be capable of accurately metering the irrigation flows in the event that two different zones were irrigated at once. The District may want to consider an additional flow meter located between the two (2) existing pumps for future modifications to the control building. This would allow the District to determine the flow rates from each individual pump if two separate zones are irrigated simultaneously.

Disinfected wastewater then flows through four (4) separate 24-inch PVC contact pipe that can be controlled by the operator to provide a variable contact time depending on the need. After disinfection contact time, the recycled water is pumped to the reuse site manifold which is operated manually by valves to direct the flow to a single lateral for each management unit and through the sprinkler head risers. The irrigation pumps are designed to provide 10-12 gallons per minute (gpm) to each sprinkler head and should be operated for a single management unit at one time (Cordes 2011).

Currently, the District is permitted to irrigate about 25 inches of recycled water (about 28 million gallons annually over 41.2 acres). There are twenty (20) hydraulic management units (MU) planned with nineteen (19) currently developed.

4 Site Characteristics

4.1 Site Management History

Construction of the wastewater facilities and the reuse site was completed in 2010 and recycled water was first irrigated during the 2012 growing season. Recycled water is permitted to be irrigated during the growing season. Both lagoons are lowered annually at the end of the growing season to provide adequate storage capacity to account for winter storage of the wastewater influent and any precipitation into the lagoons.

There are currently twenty (20) hydraulic management units ranging from one and one-half (1.5) to two and one-half (2.5) acres in the current permit; however only nineteen (19) management units have been developed. The District has not proposed any additional management units or modifications at this time (see Table 1). DEQ staff will propose minor modifications to the serial numbering convention for each management unit in order to be more consistent with the new naming convention within the region and state.

Table 1. Hydraulic management unit description and serial identification

Proposed Serial Number	Description	Acres	Proposed Number	Description	Acres
MU-219-01	Zone #1	2.5	MU-219-11	Zone #11	2.0
MU-219-02	Zone #2	2.0	MU-219-12	Zone #12	2.0
MU-219-03	Zone #3	2.0	MU-219-13	Zone #13	2.0
MU-219-04	Zone #4	2.5	MU-219-14	Zone #14	2.0
MU-219-05	Zone #5	1.5	MU-219-15	Zone #15	2.0
MU-219-06	Zone #6	2.0	MU-219-16	Zone #16	2.0
MU-219-07	Zone #7	2.0	MU-219-17	Zone #17	2.0
MU-219-08	Zone #8	2.0	MU-219-18	Zone #18	2.0
MU-219-09	Zone #9	2.0	MU-219-19	Zone #19	2.5
MU-219-10	Zone #10	2.0	MU-219-20[1]	Zone #20	2.5

1. MU-219-20 has not been developed for reuse irrigation at this time. Plans and specifications to develop this management unit for reuse purposed must be submitted to DEQ for review and approval prior to construction commencing.

Management of the forested site will be based on the recommendations of the approved Silvicultural Plan prepared by Hansen Timber Management for the reuse site on April 2, 2007.

4.2 Climatic Characteristics

Climate characteristic data was taken from the Bonner's Ferry Station (101079) off the ET-Idaho website (*http://data.kimberly.uidaho.edu/ETIdaho/stninfo.py?station=101079*) located east of the irrigation site is summarized below (see Table 2).

Table 2. Climatic data from the Bonner's Ferry (101079)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Precipitation [inches]	2.61	1.71	1.46	1.55	1.68	1.69	0.89	0.90	1.19	1.75	2.83	3.17
Avg. Max Temp [°F]	32.4	33.4	39.1	46.6	54.8	60.6	66.0	67.9	64.3	54.7	43.8	35.0
Avg. Min Temp [°F]	23.7	26.2	32.1	39.8	47.2	55.3	60.5	64.0	55.6	45.0	34.8	27.0

Based on the Bonner's Ferry station data, the average annual precipitation total is 21.43-inches of which 6.35-inches occurs during the growing season. The highest monthly average maximum temperature is 67.9°F and occurs in August. The lowest monthly average minimum temperature is 23.7°F and occurs in January.

4.3 Soils

Strata Geotechnical Engineering (STRATA) prepared a geotechnical report titled *Geotechnical Engineering Evaluation Proposed Priest Lake Sewer Project, January 12, 2007* that characterized the subsurface and surface soil conditions at the reuse site. Soil conditions in this area were evaluated based on the information reviewed from the National Research Conservation (NRCS) Soil Survey, five (5) test pits excavated up to 16 feet, and twenty-two (22) exploratory borings about 6 feet below the ground surface (bgs). Soils were classified based on ASTM and USDA standard methods. The site is located within Kaniksu National Forest and has not been mapped by the NRCS.

According to the geotechnical evaluation, the site generally consists of a top soil, an upper alluvium layer, and a lower alluvium layer. Slopes vary gradually toward the southwest portion of the site with a total elevation change of 20 feet. Portions of the property owned by the District have excessive slopes; however there are no plans to irrigate in these areas. Top soil characteristics were identified as reddish-brown silty sand with a high organic content ranging from 6 to 18 inches from the ground surface. The upper alluvium layer was described as reddish-brown silty sand with a variable gravel content ranging from 18 to 24 inches bgs. The lower alluvium layer consists of brown/gray sand with variable silt, cobble, and boulders (Warrick & Gado 2007). Soil permeability through the soil varies from about 1.6 inches per hour (in/hr) to 5.0 in/hr (Tindall, 2009).

4.4 Surface Water

There are two (2) surface waters within one half mile of the reuse site (see Figure 2). The nearest surface water is Granite Creek located about 346 feet south of the reuse site at the closest

point (396 feet with the additional 50 foot buffer around the reuse site). Priest Lake is located about 1,994 feet east of the reuse site at the closest point (Tindall, 2009).

Idaho Water Quality Standards designate Priest Lake with the following uses listed below (IDAPA 58.01.02.110.06 [6]). Additional details regarding these designated uses can be reviewed in the listed subsections of the Water Quality Standards.

- Cold water communities aquatic life (COLD; 100.01.a)
- Salmonid spawning (SS; 100.01.b)
- Primary contact recreation (PCR; 100.02.a)
- Domestic water supply (DWS; 100.03.a)

Idaho Water Quality Standards show that Granite Creek is undesignated (IDAPA 58.01.02.110.06 [22]). Surface water Staff with the Coeur d'Alene regional office has assessed Granite Creek in accordance with the "Idaho Water Body Assessment Guidance" policy identified in IDAPA 58.01.02.054 and has at this time established the following existing uses:

- Cold water communities aquatic life (COLD; 100.01.a)
- Salmonid spawning (SS; 100.01.b)
- Primary contact recreation (PCR; 100.02.a)

4.5 Ground Water & Hydrogeology

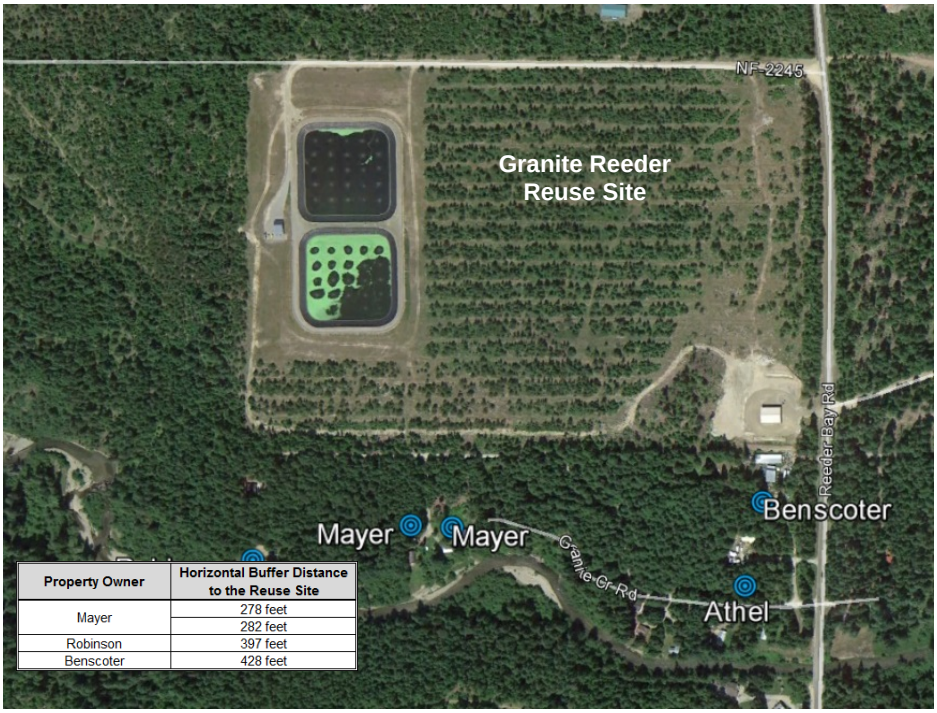
A hydrogeological evaluation of the reuse site was prepared by STRATA on May 17, 2007 to evaluate the hydraulic conductivity, the hydraulic gradient, and background nitrate concentrations within the aquifer. Four (4) groundwater monitoring wells were constructed and ranged from 40 and 65 feet below ground surface at each property boundary of the reuse site (see Figure 2). In addition, STRATA completed three (3) exploratory borings to characterize soil and subsurface conditions. The conclusion from the hydrogeological evaluation characterized the groundwater at the site as an unconfined aquifer with a high hydraulic conductivity; a hydraulic gradient of about 0.011 ft/ft flowing east. Water quality sample results indicated that the background nitrate levels ranged from 0.1 to 0.5 mg/L and would be considered negligible (Comstock 2007). The depth to ground water ranges from 15 to 30 feet below ground surface.

Ground water monitoring in the current permit (LA-000219-01) was required in May (prior to irrigation) and within the first two weeks of irrigation or the first two weeks of October (which ever was sooner). The monitoring field parameters include pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), static water levels, nitrate+nitrite as N, and chlorides.

The District collected ground water monitoring data from the existing ground water monitoring wells. Overall, a comparison of the monitoring data from the West Well (upgradient) and the East Well (down gradient) appear to suggest that there are no adverse impacts from the monitored constituents to the ground water as a result of the irrigation activities. There were a total of sixteen (16) ground water samples taken and analyzed for nitrate/nitrite. The resulting monitoring results for these nitrogen constituents were all non-detect. DEQ does not anticipate that irrigation of the recycled water at the reuse site will adversely impact the nearby shallow groundwater wells. Ground water monitoring results are summarized in Appendix D.

Private Source Wells

Ground water is used by the residents in the area as domestic well supplies. The nearest domestic, private ground water source well is located about 276 feet south of the southern reuse site boundary (see Figure 3). DEQ has considered a minimum buffer distance of 500 feet between a reuse site and domestic wells necessary for public health protection in the absence of detailed hydrogeological data on a proposed site. A geotechnical/hydrogeological evaluation titled *Geotechnical Engineering Evaluation, January 12, 2007* prepared by Strata suggests that ground water flow generally flows from the west to the east and the private wells shown in Figure 3 would not be impacted from the wastewater treatment or reuse site operations.



Property Owner	Horizontal Buffer Distance to the Reuse Site
Mayer	278 feet
	282 feet
Robinson	397 feet
Benscoter	428 feet

Figure 3. Private well locations within 500 feet of the Granite Reeder reuse site

Public Source Wells

There are no public source wells within one quarter mile (0.25) of the reuse site at the closest point. The closest public wells are the Grandview Resort (ID 1090044) and the Murray Acres Association (ID 1090087) located about one-half (0.5) mile south of the reuse site.

4.6 Recycled Water Characterization and Loading Rates

Flow monitoring of the wastewater influent into the lagoons was required to be completed five days per week in the current permit. Future modifications are planned for the facility and reuse site based on community growth (Cordes 2007). As such, DEQ staff will recommend continued influent flow monitoring.

4.6.1 Recycled Water Characterization

The mean recycled water constituent concentrations monitored for each year are shown below (see Table 3).

Table 3. Mean recycled water constituent concentrations and the total hydraulic loading rate (HLR) from 2012 to 2014

	NO_2+NO_3 [mg/L]	TKN [mg/L]	Total P [mg/L]	HLR [MG]
2012	2.62	7.14	2.06	4.18
2013	2.42	4.62	2.58	8.72
2014	1.86	3.49	2.73	7.03
Mean	2.27	4.78	2.51	6.64
Std. Dev.	1.11	2.16	0.38	1.87

Disinfection of the recycled water is achieved by injecting a solution of sodium hypochlorite into the treated effluent and meeting the required contact time within the pipeline prior to irrigation. The current permit (LA-000219-01) requires weekly total coliform monitoring during periods of use. Class C disinfection requirements include total coliform limits of 23 organisms per 100mL, as determined from the bacteriological results of the last five (5) days for which analyses have been completed, and a single-sample maximum of 230 organisms per 100mL. Between July 2012 and September 2013 there were four (4) instances where the total coliform results exceeded the permitted limits (see Table 4) All other laboratory sample results completed indicate that the facility achieved the disinfection requirements for both the single sample and five day median. There were no median results for the facility for the first five (sampling) events since the facility began operation in July 2012.

Table 4. Total coliform exceedances; single sample and five day median

Date	TC reported value	Five day median value
07/19/12	>1,600	None
07/28/12	1,600	None
08/16/12	1	70
09/19/13	920	1

4.6.2 Hydraulic Loading Rates

<u>Historical Hydraulic Loading</u>

Annual recycled water volumes irrigated to the site have varied each year from 4.2 MG to 8.7 MG based on the data provided from the annual report submittals (Table 3). The mean hydraulic loading rates for all nineteen (19) active management units are shown in Figure 4.

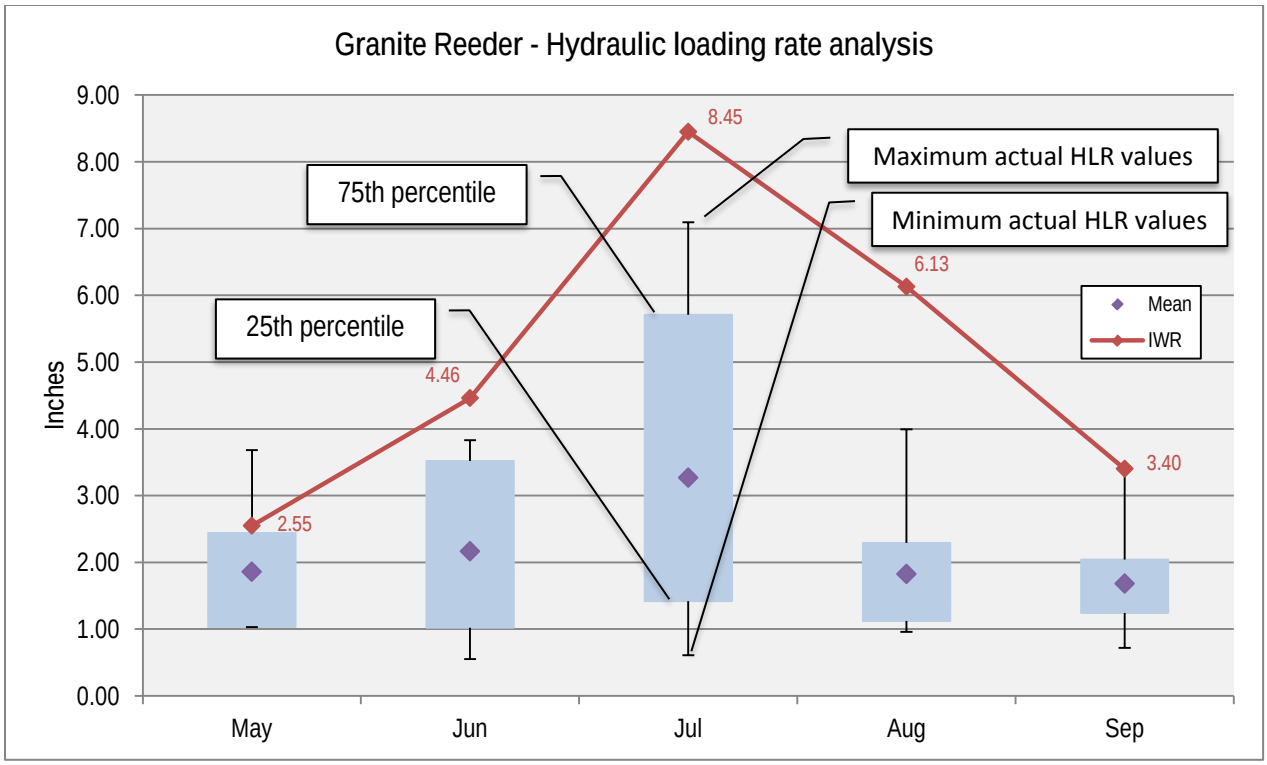


Figure 4. Hydraulic loading rates for each MU (2013-2014) compared to the irrigation water requirement

Overall, the facility is irrigating substantially below the irrigation water requirement estimated for a natural forested site; however, there were a few instances where the site appears to have been hydraulically overloaded in May (individual hydraulic loading rates for each management unit are shown in Appendix C). The current permit requires that irrigation cannot exceed the irrigation water requirement.

Proposed Hydraulic Loading

Growing season hydraulic loading rates should be substantially equal to or less than the irrigation water requirement (IWR) for a natural forested site based on the precipitation deficit values determined by the University of Idaho Research and Extension Center at Kimberly, Idaho (*http://data.kimberly.uidaho.edu/ETIdaho/stninfo.py?station=101079*) for the Bonner's Ferry station (101079). The Bonner's Ferry weather station is flagged as an "irrigated" site which means that the crops are not water stressed and more evapotranspiration can occur. This effectively increases the crop's water demand and IWR; however, native tree species are adapted for the areas' arid climate during the growing season and do not necessarily require additional irrigation water. To minimize hydraulic overloading, DEQ considers the 80% exceedance (the Pdef that has an 80% chance of being exceeded in a given month) to be an acceptable, conservative target for native species' IWR (Cook 2012). The 80% exceedance is the value for a parameter that has an 80% chance of being exceeded that month during any particular year. Conversely, there is a 20% chance that the parameter values will be less than the value shown.

Since native trees are not considered a commercial crop there is no precipitation deficit data for native forest trees on the ET-Idaho website. As a surrogate means of determining an appropriate

IWR, areas with significant native forests (consisting of a tree canopy and understory vegetation) are approximated using a composition approach with *Orchards – Apples and Cherries no ground cover* to represent the tree canopy and *Grass Pasture, high management* used to represent the understory (see Table 5).

Table 5. Precipitation deficit data – 80% Exceedance values for Orchards - Apples and Cherries no ground cover (canopy) and Grass Pasture, high management (understory)

	Orchards - Apples and Cherries no ground cover		*Grass Pasture - high management*	
	Pdef (mm/day)	Pdef[1] (inches)	Pdef (mm/day)	Pdef[1] (inches)
Jan	-0.36	0	0	0
Feb	0.06	0.07	0.03	0.03
Mar	0.28	0.34	0.08	0.10
Apr	0.57	0.67	0.91	1.07
May	1.49	1.82	1.49	1.82
Jun	3.61	4.26	0.86	1.02
Jul	4.95	6.04	0.46	0.56
Aug	3.94	4.81	-0.21	0
Sep	2.17	2.56	-0.13	0
Oct	-0.07	0	-1.19	0
Nov	-2.23	0	-2.03	0
Dec	-1.49	0	-0.28	0

1. Negative Pdef values are assumed to be zero when convert to inches

DEQ staff estimate the tree canopy to cover roughly 80% of the total reuse site acreage and the understory to cover the remaining 20% of the reuse site. A more detailed analysis on the reuse site forested composition or the actual canopy coverage should be determined in an updated silvicultural plan prepared by a professional silviculturalist.

The irrigation system efficiency for solid set irrigation laterals ranges from 60% to 85% (DEQ 2007). DEQ staff will recommend an irrigation efficiency of 80% based on the recommendations from the technical report prepared by the permittee's engineers (Cordes 2014). Using this efficiency value, the mean monthly and 80% exceedance values for the irrigation water requirement were estimated for the reuse site during the growing season (May to October – 184 days). Additional details on the calculation method used to determine the irrigation water requirement values are based on the *Draft 2012 Forest Guidance, 2012* (see Appendix B).

Table 6. Proposed Irrigation Water Requirement (IWR)

	Orchards - Apples and Cherries no ground cover (inches)	*Grass Pasture - high management* (inches)	Composite IWR (inches)
May	2.25	0.87	3.12
Jun	4.64	1.08	5.73
Jul	6.37	1.51	7.88
Aug	5.39	1.42	6.82
Sep	2.17	0.51	2.69
Total	21.43	5.63	27.05

A comparison between the irrigation water requirement from the existing permit and the proposed irrigation water requirement for the new permit are shown below (see Figure **5**). Overall, the IWR increased slightly from the previous permitted limits and is attributed to the lower irrigation efficiency.

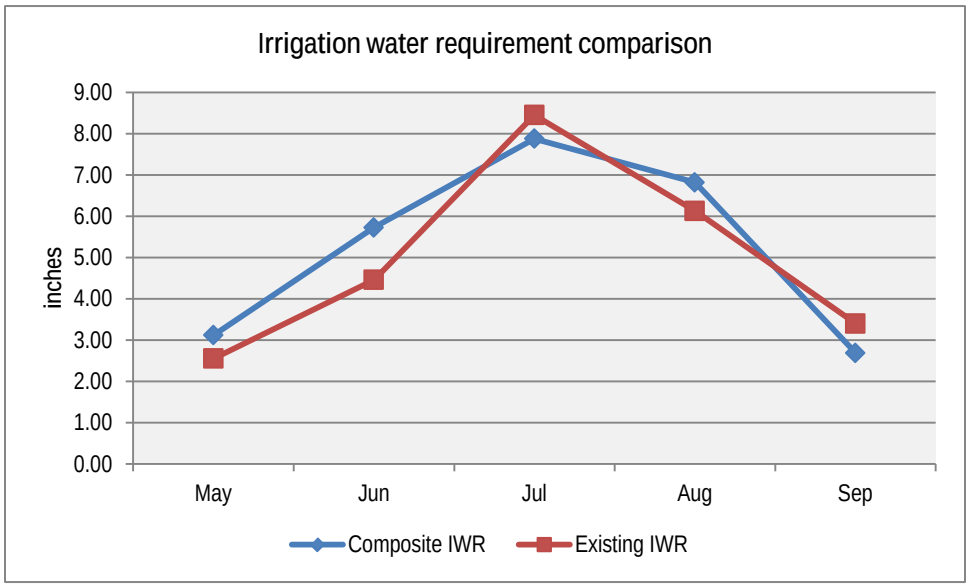


Figure 5. Existing IWR compared to the proposed, composite IWR

The current permit included a daily maximum hydraulic loading rate that limited the volume of recycled water irrigated to the site to 9,975 gpd per acre (based on 23 days of irrigation over the total acreage). At the time, DEQ was concerned about the potential for the recycled water to pond over the ground surface. An unintended consequence of this limitation required the reuse site operator to rotate each management unit every hour to ensure that the daily maximum rates were not exceeded. The District has requested that this permit requirement be modified so that

there is no standing water at the reuse site after each irrigation period and that the irrigation rate not exceeds the monthly irrigation water requirement (Cordes 2014). This approach seems reasonable to DEQ staff and it will be recommended that the draft permit not require a daily maximum hydraulic loading rate limit. The draft permit will require that the reuse site is operated in accordance with there is no standing reuse water on the ground surface after irrigation activities.

4.6.3 Constituent Loading Rates

Total Nitrogen

The current permit requires monthly grab samples for total nitrogen (i.e. Total Kjeldahl Nitrogen, plus nitrate+nitrite as elemental nitrogen) when irrigating recycled water and limits the total nitrogen loading to 225 lb. N/ac annually based on 150% of the typical crop uptake (Tindall 2009). During this permit cycle, there was no exceedance of the allowable total nitrogen loading; the maximum loading observed was about 19.36 lbs. N/ac and the average annual loading was 12.6 lbs. N/ac. The average annual total nitrogen loading in pounds from 2013-2014 is shown in the figure below (see Figure 6).

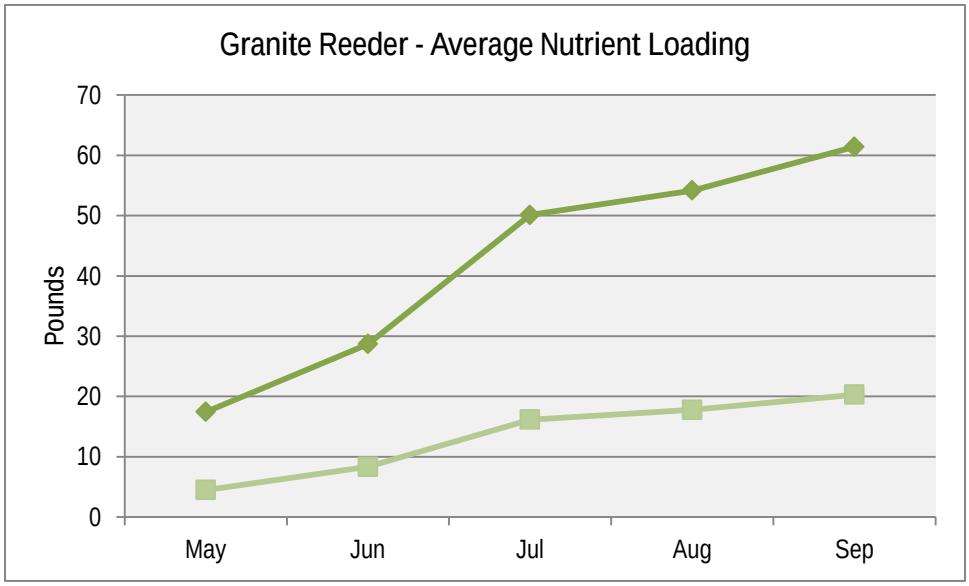


Figure 6. Average total nitrogen and phosphorus loading (2013 and 2014).

Soil monitoring for nitrogen constituents was required in the permit to be completed and the data indicates that the nitrogen within the soil profile is low.

Reuse permits typically include nitrogen loading rate limit of 150% of typical crop uptake; however, the facility proposes to irrigate native forest for which typical uptake values have not yet been established. Staff intends for this permit to be consistent with other permits for forested sites in the area by developing numerical constituent loading rates that are representative of the vegetation on the site and proximity to protected surface water.

A silvicultural plan was prepared for the District in April 2007 and indicates that the irrigation site primarily consists of mature stands (Hansen 2007). It was indicated in the Silvicultural plan that there is a dramatic decline in nutrient uptake for mature stands (Hansen 2007). As a means

of determining an appropriate nitrogen uptake, DEQ staff utilize the NRCS nutrient uptake from the *Draft Guidance for Forested/Poplar Sites, 2012* (see Appendix B).

The updated, draft forested site guidance estimates the net nitrogen uptake ($N_{net\ uptake}$) to be about 88 lbs. N/ac-year for juvenile stands of Douglas fir, between 3-25 years and assuming that only 80% canopy cover (see Table 13 in Draft Forest Guidance) with a partial herbaceous vegetative understory covering roughly 50% of the site (Cook 2012). Nitrogen loss (N_{loss}) due to volatilization or denitrification is assumed to be approximately 25% based on typical values for forests with slightly acidic soils. Nitrogen loading is estimated based on the calculation demonstrated in Equation 1 and indicates that the total nitrogen loading under the conditions described above should be 117 lbs. N/ac annually.

Equation 1. Nitrogen uptake determination for a typical northern Idaho forested site

$$N_{loading\ rate} = \frac{N_{net\ uptake} - N_{credit}}{1 - N_{loss}}$$

- N-uptake for Douglas fir, juvenile stand age 3-25 years = 88 lbs./acre
- N-uptake of herbaceous, thin understory (≈ 50%) = 35 lbs./acre
- Nitrogen credit = 0 lbs./acre; assume no appreciable change in soil storage.
- Nitrogen loss = 25%

$$N_{loading\ rate} = \frac{88\ lbs\ per\ acre - 0\ lbs\ per\ acre}{1-0.25} = \frac{88\ lbs\ per\ acre}{0.75} = 117 \text{ lbs. N per acre annually}$$

The maximum total nitrogen loading from 2014 was 19.36 lbs. N/ac which only accounts for about 18% of the proposed nitrogen limit. Assuming conservative design conditions (i.e. the maximum total nitrogen concentration of 13.74 mg/L occurring in the design year), the nitrogen loading from the recycled water would be 117 lbs N/ac (75% of the proposed nitrogen demand). DEQ does not anticipate the loading rates to increase substantially over the proposed permit cycle.

<u>Phosphorus</u>

The expired permit required that phosphorus concentrations were monitored in the recycled water irrigated to the reuse site in order to estimate the phosphorus loading which is limited to 20 lbs. P/ac annually. Based on the constituent sample data, phosphorus loading has averaged about 1.31 lbs. P/ac (6.6% of permitted limit) with a maximum loading rate value of 2.26 lbs. P/ac or 11.3% of permitted limit (see Figure 6). Staff recommends that phosphorus monitoring and loading limits be removed from the draft reuse permit based on the lower actual loading rates.

Chemical Oxygen Demand

The chemical oxygen demand (COD) is estimated to be about 50 mg/L. The average COD loading rate assuming the mean monthly HLR and the proposed IWR would range from 0.80 lbs COD/ac-day and 1.97 lbs COD/ac-day during the growing season. The guideline annual COD loading rate is 50 lbs/ac-day (DEQ 2007). The constituent loading/concentrations are not expected to change during the next permitting cycle; however, the District has not been required in the past to monitor the COD constituent limits in the recycled water.

Total Dissolved Solids

Total dissolved solids are a measure of the volatile dissolved solids (VDS) plus the nonvolatile dissolved solids (NVDS). High levels of NVDS or salts may reduce soil permeability and reduce the ability for the crop to uptake nutrients. In northern Idaho, salts are typically flushed through the soils from the high precipitation in the area.

DEQ may require a permittee to monitor for TDS or the electrical conductivity (EC; an indirect measure of the TDS) in the recycled water to determine the salt loading at the irrigation site; in the soil profile to determine if there is any significant accumulation of salts; and/or as part of groundwater monitoring to determine if there are any potential impacts to groundwater as a result of excess leaching.

The current permit only requires EC monitoring in the top 36 inches of the soil profile to determine if salts are accumulating or if the concentrations may impact groundwater. Overall, there is no significant trend from the monitoring data that would indicate the TDS is accumulating within the soil profile. TDS concentrations can be estimated as 0.64*EC; the estimated values of TDS at the site range from 8 ppm to 25 ppm which indicate low saline soil conditions. These values are significantly less than the groundwater standard which is 500 ppm TDS.

Table 7. Soil data - Total dissolved solids monitoring data

Constituent	Units	PQL	2012			2014		
			12 inches	24 inches	36 inches	12 inches	24 inches	36 inches
	uS/cm	0.01	34.3	29	15.4	27.6	38.9	13.1
EC	dS/m	Calc.	0.03	0.03	0.02	0.03	0.04	0.01
Estimated TDS	ppm	Calc.	22.0	18.6	9.9	17.7	24.9	8.4

5 Site Management

5.1 Buffer Zones

The District proposes to continue disinfecting the recycled water to meet the Class C disinfection requirements as follows:

- The median number of total coliform organisms does not exceed 23 total coliform organisms/100 mL, as determined from the bacteriological results of the last 5 days for which analyses have been completed. No sample shall exceed 230 total coliform organisms/100 mL in any confirmed sample.

The buffer zones included in the current permit are shown in Table 8 and are substantially consistent with current rule requirements and guidance. An exception to this is the buffer distance between the reuse site and the areas accessible to the Public. The District's property and reuse site is bordered on each side by a 50 foot forested buffer that will not be irrigated with recycled water. DEQ will typically require 3-wire fencing around the perimeter of the reuse site; however, the USFS has requested that no fencing be installed around the perimeter of the reuse site to allow local wildlife to pass through. As a substitute for fencing, warning signs will be posted every 100 feet along the north and west property lines; every 50 feet on the south and east property lines; and at each corner of the property.

The nearest private well is located about 278 feet to the east and according to the ground water evaluation, is not located down gradient from the reuse site. Based on the ground water flow direction, reuse activities are not expected to impact this ground water well.

All other features of concern, including nearby surface waters, appear to meet the minimum horizontal buffer distances described in Table 8 below.

Table 8. Horizontal buffer distances to features of concern

	Public Water Supplies	Private Water Supplies	Inhabited Dwellings	Permanent and Intermittent Surface Water	Irrigation Ditches and Canals	Areas Accessible to the Public
DEQ Rules/Guidance for Class C Rural Area	1,000	500	300	100	50	50
Existing	1,000	278	300	100	50	0
Proposed	1,000	278	300	100	50	0

5.2 Runoff

A runoff management plan has not been developed for the reuse site. The reuse site's soil characteristics and slopes do not indicate a high risk of runoff from the site. General best management practices (BMPs) should be implemented by the facility operator and include the following considerations:

- Maintain the vegetative barrier and horizontal separation between the reuse site and Granite Creek;
- Do not irrigate the reuse site during or immediately following precipitation events;
- There should be no standing water an hour after irrigation

At this time, the District will not need to prepare a Runoff Management Plan.

5.3 Seepage Rate Testing

Per Subsection 493.02 of the Wastewater Rules (IDAPA 58.01.16), all existing lagoons must be seepage tested by a licensed professional engineer or licensed professional geologist by April 15, 2012 and every ten years thereafter. While operation of the lagoon may not have indicated a

problem in the past, the requirement ensures that all wastewater lagoons are maintained and tested to ensure protection of groundwater.

Seepage testing of the existing lagoons was completed in May 2010. The facility's consulting engineer concluded in the *Granite Reeder Water & Sewer District, Lagoon Seepage Testing Results, July 27, 2010* that actual seepage rates from each lagoon was less than the maximum allowable seepage rate of 0.125 inches per day in accordance with the Wastewater Rules (IDAPA 58.01.16.493.03). DEQ approved the test results for both lagoons in a letter dated July 28, 2010. The next seepage test will need to be completed by May 2020.

Staff recommends that the draft permit include a compliance activity requiring that both lagoons are seepage tested prior to May 1, 2020 in accordance to the current Wastewater Rule requirements. Test procedures for completing the seepage testing should be submitted at least 42 days prior to the due date.

Information on seepage testing procedures are located at: *http://www.deq.idaho.gov/water-quality/wastewater/lagoon-seepage-testing.aspx*

5.4 Waste Solids, Biosolids, Sludge, and Solid Waste

A solids management plan has not been prepared or included as part of the existing O&M Manual for the system. The lagoons are relatively new and significant solids accumulation is not expected to occur during this permit cycle. Staff recommends that the draft permit not require preparation of a waste solids management plan at this time.

A waste solids management plan is required to be prepared and approved by DEQ prior to any sludge removal or as part of any necessary repairs to the lagoon liners (IDAPA 58.01.16.650).

5.5 Nuisance Odors

Staff recommends that the draft permit not require preparation of an odor management plan at this time. The District is encouraged to operate the site to minimize potential odors generated from the lagoons and irrigation site.

Should odors become a persistent issue for the facility DEQ may require the District to submit an odor management plan addressing specific design considerations, maintenance procedures, management procedures, and other best management practices to respond to odor issues and complaints.

During the last permit term, there was one (1) odor complaint received District and reported to DEQ. The operator was able to satisfactorily resolve this issue with the concerned party and there have been no additional odor complaints received since.

5.6 Cropping Plan

The irrigation site is a natural forested area. For information regarding necessary cropping, refer to the Silvicultural Plan prepared on April 2, 2007.

5.7 Grazing

The District does not intend to graze animals at the reuse site at this time. A DEQ-approved grazing management plan is required prior to any grazing activities on a permitted reuse site.

5.8 Salts

Supplemental water is not utilized or available at the reuse site. Typically, the addition of supplement source water would help to flush total dissolved solids (salts) through the soil profile. Impacts as a result of salt accumulation in the soil profile may potentially limit soil permeability and reduce the water and nutrient uptake. Electrical conductivity of a water extraction of soil can be used as an indirect measure of the salt content in the soil.

5.9 Silvicultural Plan

A Silvicultural Plan was prepared for the reuse site on April 2, 2007 by the Hansen Timber Management Inc. and prescribes the management practices to ensure the health of the forest's ecosystem. The recommendations in this plan should be implemented and any work completed in accordance with the plan should be reported to DEQ with each annual report submittal. According to the DEQ Reuse Guidance, this plan should also be updated every five (5) years by a qualified silviculturalist.

Staff recommends that the draft permit require the submittal of an updated Silvicultural plan to DEQ to be completed by a qualified silviculturalist within five (5) years of permit issuance. Also, the draft permit will include a requirement to implement the current recommendations of the silvicultural plan and that the operator provides a discussion of work completed in accordance with those recommendations in each annual report submitted to DEQ. This section will also describe future work anticipated to be completed in the upcoming year.

6 Monitoring

The proposed monitoring requirements for the draft permit are described in detail in the following subsections. All monitoring will be conducted in accordance with the facility's Quality Assurance Project Plan (QAPP). See Section 7 for requirements regarding the QAPP.

6.1 Wastewater/Recycled Water Monitoring

<u>Wastewater Monitoring</u>

Flow monitoring of the wastewater influent into the lagoons was required to be completed five days per week in the current permit. Future modifications are planned for the facility and reuse site based on community growth (Cordes 2007). Staff recommends that the District continue the five day wastewater influent monitoring into the lagoons and to compile the data on a monthly and annual basis (million gallons)

<u>Recycled Water Monitoring</u>

Staff recommends the District monitors the following recycled water parameters and constituent concentrations:

- Daily monitoring of recycled water flow rates to each management unit;
- Nitrate and Nitrite-N (monthly during periods of use);
- Total Kjeldahl Nitrogen (TKN) (monthly during periods of use);
- Total coliforms (monthly during periods of use); and
- Chlorine residual (daily during periods of use)

The permittee has requested that DEQ allow for E.coli monitoring instead of total coliform as the disinfection indicator organism. Changing the indicator organism to E.coli presents several benefits to the permittee. The testing equipment needed to run E.coli, the IDEXX Colilert unit, can be purchased and used by the facility operator. Currently, the operator drives weekly coliform samples into Coeur d'Alene, which can take an entire work day due to the distance. The other advantage to the IDEXX unit is that the sample results are ready in 24 hours. Total coliform samples analyzed using the fermentation technique (Standard Method 9221B) by the labs can take as long as 72 hours before results are confirmed. This results in a longer time that systems may be out of compliance with disinfection requirements before being aware of the problem.

DEQ is reviewing alternative approaches for indicator organisms and test methods such as IDEXX Colilert. However, no changes have been approved for implementation at this time. Therefore, as an alternative solution, DEQ would consider reducing the total coliform monitoring to monthly rather than weekly. This is allowable per Section 601.03.a.ii. Monthly monitoring would reduce the number of trips needed to deliver samples to the lab, and allow the operator more time to operate the system. Justification for this reduction in monitoring is demonstrated by the permittee's coliform monitoring history discussed in Section 4.6.1. Additionally, to further ensure adequate disinfection in the absence of more frequent sampling, the draft permit will include a minimum total chlorine residual of 1.0 mg/L.

As discussed in section 4.6.3, actual phosphorus loading is significantly less than the permitted limits. It is recommended that phosphorus be removed from the draft permit as a monitoring constituent (see discussion in Section 4.6.3).

6.2 Soil Monitoring

Staff recommends that the permittee complete representative soil monitoring for the reuse site to be completed in year five (5) and year nine (9) of the permit. The permittee will be required to conduct soil monitoring prior to irrigation activities in those years to determine if soil quality and nutrient management will need to be addressed in the future. The following constituent concentrations will need to be monitored:

- Ammonium-N;
- Nitrate-N;
- Electrical conductivity (EC); and
- pH

6.3 Ground Water Monitoring

Staff recommends that ground water quality samples are taken for the following constituents in year five (5) and nine (9) of the permit prior to irrigation to determine if nutrient management or ground water quality issues will need to be addressed in the future. The following constituent concentrations will need to be monitored:

- Water table elevation (feet)
- Nitrate-nitrogen, as N
- Chlorides
- pH (Standard Units)
- Electrical conductivity (µmhos/cm)
- Temperature (ºC)

6.4 Supplemental Irrigation Water Monitoring

Supplemental irrigation water is not available for the irrigation site. Monitoring requirements for supplemental irrigation will not be required in the draft permit.

6.5 Crop Yield and Tissue Monitoring

Staff does not recommend crop yield and/or crop tissue monitoring because it is difficult to analyze the nutrient contents in the wood and needles of conifer trees. When trees are harvested, the annual report should include the amount of trees and board-feet removed.

6.6 Meteorological Monitoring

The proposed hydraulic loading rates outlined in the draft permit will allow the facility the flexibility to irrigate based on the actual meteorological conditions in a given year. The District will be responsible for demonstrating to DEQ in future annual report submittals that the hydraulic loading rates at the reuse site are substantially equal to or less than an established irrigation water requirement.

Staff recommends that the District use the local weather station data to determine if the reuse water applied to the site meets the substantial irrigation water requirement in a given year. At a minimum, an on-site rain gauge may be sufficient in demonstrating compliance. Each annual report submitted to DEQ should include a discussion of the meteorological data and demonstrate how this data was used to develop a reasonable irrigation water requirement for the irrigation growing season. This calculation methodology must also be incorporated into the irrigation management plan required by Compliance Activity CA-219-01.

6.7 Calculation Methodologies

Calculation methodologies for determining permit compliance with the hydraulic loading rates must be approved by DEQ in the updated PO and supplemental planning documents per CA-

219-01 in the draft permit. It is recommended that when questions arise over calculations methodology, that the facility refer to the Wastewater Land Application Operators Study and Reference Manual located at *http://www.deq.idaho.gov/laws,-rules,-etc/deq-guidance.aspx* which gives a review of calculations methodology including example problems.

7 Quality Assurance Project Plan

The Quality Assurance Project Plan (QAPP) is a written document outlining the procedures used by the permitee to ensure the data collected and analyzed meets the requirements of the permit.

In support of the agency mission, DEQ is dedicated to using and providing objective, correct, reliable, and understandable information. Decisions made by DEQ are subject to public review and may at times, be subject to rigorous scrutiny. Therefore, DEQ's goal is to ensure that all decisions are based on data of known and acceptable quality.

The QAPP is a permit requirement and must be submitted to DEQ as a stand-alone document for review and acceptance. The QAPP is used to assist the permittee in planning for the collection, analysis, and reporting of all monitoring data in support of the reuse permit and explaining data anomalies when they occur.

DEQ does not approve QAPPs, but reviews them to determine if the minimum EPA guideline requirements are met and that the reuse permit requirements are satisfied. The reason DEQ does not approve QAPPs is that the responsibility for validation of the facility sampling data lies with the permittee's quality assurance officer and not with DEQ.

The format of the QAPP should adhere to the recommendations and references in 1) the Assurance and Data Processing sections of the DEQ Guidance and 2) EPA QAPP guidance documents. EPA QAPP guidance documents are available at the following website: *http://www.epa.gov/quality/qapps.html*

8 Site Operation and Maintenance

IDAPA 58.01.16, "Wastewater Rules" specify that all owners of a public wastewater system must place the direct supervision of their facility under the responsible charge of an operator who holds a valid license equal to or greater than the classification of the wastewater facility. The following information pertains to the classification of the facility and its operators:

Collection System Classification: Class I

Treatment System Classification: Class I and Land Application

Travis Clemenson, Responsible Charge Operator (RCO):

- WW Collection, Class II (WWC2-18132)
- WW Treatment, Class II (WWT2-18131)
- WW Treatment – Land Application (WWTLA-19213)

Tom Holman, Backup Operator:

- WW Collection, Class II (WWC2-13663)
- WW Treatment, Class II (WWT2-13664)
- WW Treatment – Land Application (WWTLA-18026)

9 Compliance Activities

9.1 Status of Compliance Activities in Current Permit

1. **CA-0219-01. Operation and Maintenance (O&M) Manual** – *An Operation and Maintenance (O&M) manual for the wastewater land application facilities, incorporating the requirements of this permit, shall be submitted to DEQ for review and approval. The O&M manual shall be designed for use as an operator guide for actual day-to-day operations that includes the wastewater collection system, treatment plant, disinfection system, storage lagoons and reuse irrigation system. Specifically include all permit requirements and daily sampling/monitoring requirements to insure proper operation of the wastewater treatment facilities. The O&M Manual shall contain at a minimum all of the information required by the latest revision of the Plan of Operation Checklist in the WLAP Program Guidance and :*

    a. *An approved Silviculture plan for the site;*
    b. *The record drawings for the reuse site, disinfection system, treatment/storage lagoons and collection system;*
    c. *Details on the operation of the temperature and precipitation measuring devices;*
    d. *Written procedures for the soil and effluent testing; and*
    e. *Procedures to minimize the migration of nuisance odors from the site.*

    Upon approval, the manual shall be incorporated by reference into this permit and shall be enforceable as a part of this permit.

    The Operations and Maintenance Manual was submitted to DEQ on August 5, 2013.

2. **CA-0219-02. Seepage Rate Testing** - *Perform a leakage test on the storage lagoon in accordance with the current DEQ procedures (IDAPA 58.01.16.493). The current allowable seepage rate is 0.125 inches per day (1/8 inches per day). Submit the results to DEQ for review.*

    Seepage testing of the existing lagoons was completed in May 2010. The facility's consulting engineer concluded in the Granite Reeder Water & Sewer District, Lagoon Seepage Testing Results, July 27, 2010 that actual seepage rates from each lagoon was less than the maximum allowable seepage rate of 0.125 inches per day in accordance with the Wastewater Rules (IDAPA 58.01.16.493.03). DEQ approved the test results for both lagoons in a letter dated July 28, 2010.

3. **CA-0219-03. Submit Reuse Renewal Permit Application** – *Submit an application for renewal of the wastewater land application permit.*

   A reuse renewal permit application was submitted to DEQ on September 16, 2014.

9.2 Compliance Activities Required in New Permit

The following Compliance Activities are specified in the draft permit (examples include):

1. **CA-219-01. Updated Plan of Operations -** The permittee shall submit for review and approval a Plan of Operation that reflects current operations and incorporates the requirements of this permit. The PO shall comply with the applicable requirements stated in IDAPA 58.01.17.300.05 and shall address applicable items in the Plan of Operation Checklist in the DEQ Guidance.

   The PO shall include the following site management plans or the permittee may submit the site management plans individually:

   - Buffer zone plan;
   - Emergency operating plan;
   - Irrigation management and scheduling plan;

   The PO shall be updated as needed to reflect current operations. The permittee shall notify DEQ of material changes to the PO and copies shall be kept on site and made available to DEQ upon request.

2. **CA-219-02. Quality Assurance Project Plan (QAPP) -** The permittee shall prepare and implement a QAPP that incorporates all monitoring and reporting required by this permit. A copy of the QAPP along with written notice that the permittee has implemented the QAPP shall be provided to DEQ.

   The QAPP shall be designed to assist in planning for the collection, analysis, and reporting of all monitoring in support of this permit and in explaining data anomalies when they occur. At a minimum, the QAPP must include the following:

   - Details on the number of measurements, number of samples, type of sample containers, preservation of samples, holding times, analytical methods, analytical detection, and quantitation limits for each target compound, type and number of quality assurance field samples, precision and accuracy requirements, sample preparation requirements, sample shipping methods, and laboratory data delivery requirements.
   - Maps indicating the location of each monitoring, and sampling point.
   - Qualification and training of personnel.
   - Names, addresses, and telephone numbers of the laboratories used by or proposed to be used by the permittee.

- Example formats and tables that will be used by the permittee to summarize and present all data in the annual report.

The format and content of the QAPP should adhere to the recommendations and references in the Quality Assurance and Data Processing sections of the DEQ Guidance.

The permittee shall amend the QAPP whenever there is a modification in sample collection, sample analysis, or other procedure addressed by the QAPP. The permittee shall notify DEQ of material changes to the QAPP and copies shall be kept on site and made available to DEQ upon request.

3. **CA-219-03. Seepage Testing** - The following table shows the date by which the permittee shall complete seepage testing on the specified lagoons:

Lagoon:	Seepage Test Due Date:
LG-219-01 (North lagoon)	May 1, 2020
LG-219-02 (South lagoon)	May 1, 2020

Submit to DEQ for review and approval a proposed schedule and procedure for performing the required seepage tests at least 42 days prior to the planned seepage test. Guidance for developing seepage test procedures are available at: http://www.deq.idaho.gov/water-quality/wastewater/lagoon-seepage-testing.aspx The seepage test procedures shall be sealed by the Idaho licensed professional engineer or professional geologist in responsible charge for the test.

Seepage tests shall be completed in accordance with the procedures approved by DEQ. The seepage test report shall be sealed by the person in responsible charge and submitted within 90 days after completion of the seepage test.

For municipal lagoons, the leakage rate for lagoons constructed after April 15, 2007 shall be no more than zero point one hundred twenty-five (0.125) inches (1/8 inch) per day. The leakage rate for existing lagoons constructed prior to April 15, 2007 shall be no more than zero point twenty-five (0.25) inches (1/4 inch) per day. See IDAPA 58.01.16.493.03. Requirements for lagoons leaking above the allowable amount are outlined in IDAPA 58.01.16.493.04.

4. **CA-219-04. Pre-Application Workshop:** If the permittee intends to continue operating the reuse facility beyond the expiration date of this permit, the permittee shall contact DEQ and schedule a pre-application workshop to discuss the compliance status of the facility and the content required for the reuse permit application package.

5. **CA-219-05. Renewal Permit Application:** The permittee shall submit to DEQ a complete permit renewal application package, which fulfills the requirements specified at the pre-application workshop identified in CA-219-04.

10 Recommendations

Staff recommends the draft reuse permit be issued for a duration of ten (10) years. The permit specifies hydraulic and constituent loading limits and establishes monitoring and reporting requirements to evaluate system performance, environmental impacts, and permit compliance.

11 References

Comer, L. 2014. *Reuse Permit Application Technical Report for Wastewater Treatment Facility Submitted to the Granite Reeder Water and Sewer District.* Permit M-219-02

Comer, L. 2014. *Reuse Permit Application Technical Report for Wastewater Treatment Facility Submitted to the Granite Reeder Water and Sewer District.* Supplemental. Permit M-219-02

Comstock, C. 2007. *Hydrogeological Evaluation Proposed Granite Reeder WLAP*.

Cook, M. 2012. *Draft 2012 Forest Guidance*.

Cordes, S. 2008. Plans and specifications for the project titled, *Granite Reeder Wastewater Treatment Facility*. P&S #10583.

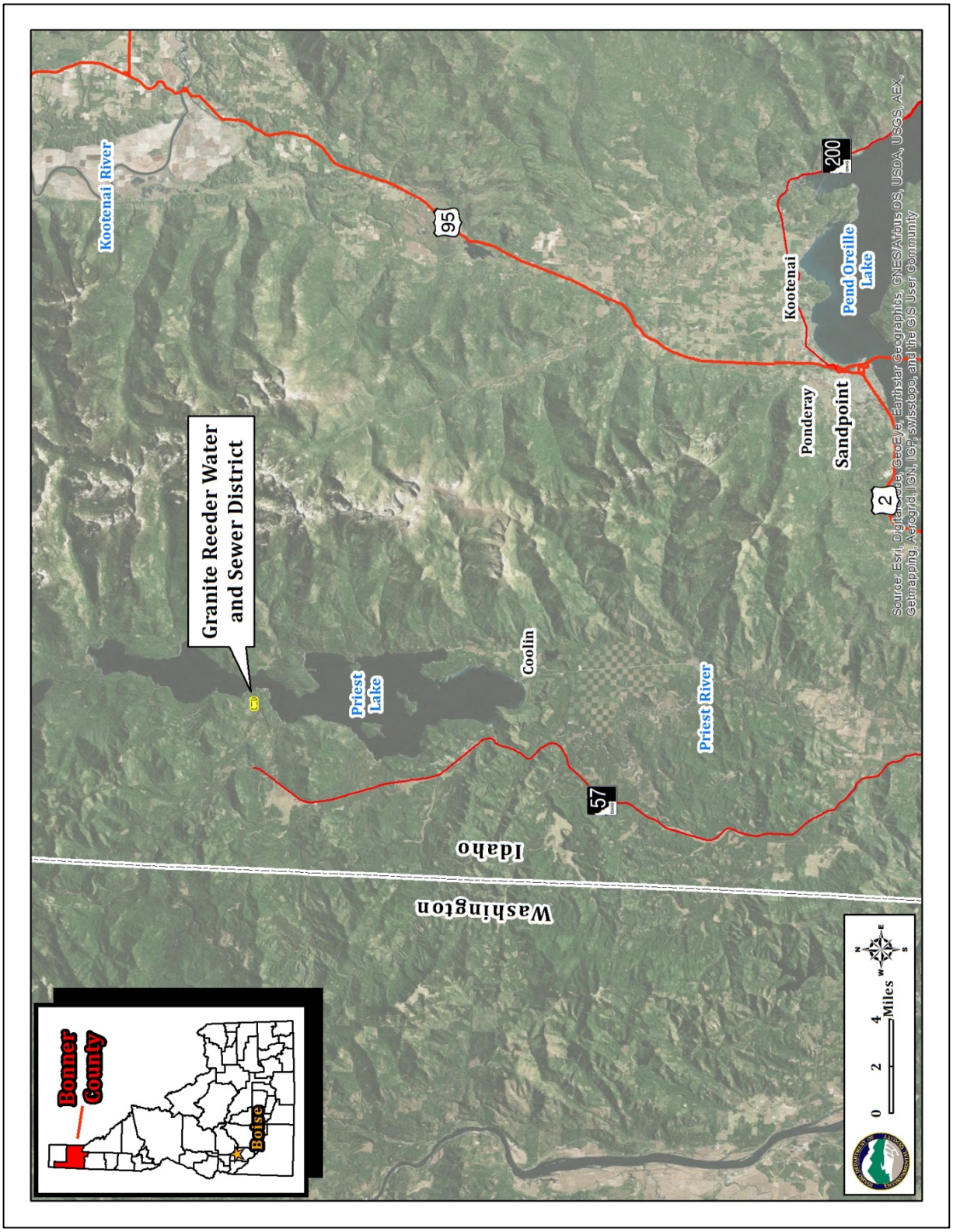
Metcalf 2003. Wastewater Engineering Treatment and Reuse, 4th Edition

Warrick, C. & Gado, D. 2007. *Geotechnical Engineering Evaluation Proposed Priest Lake Sewer Project.*

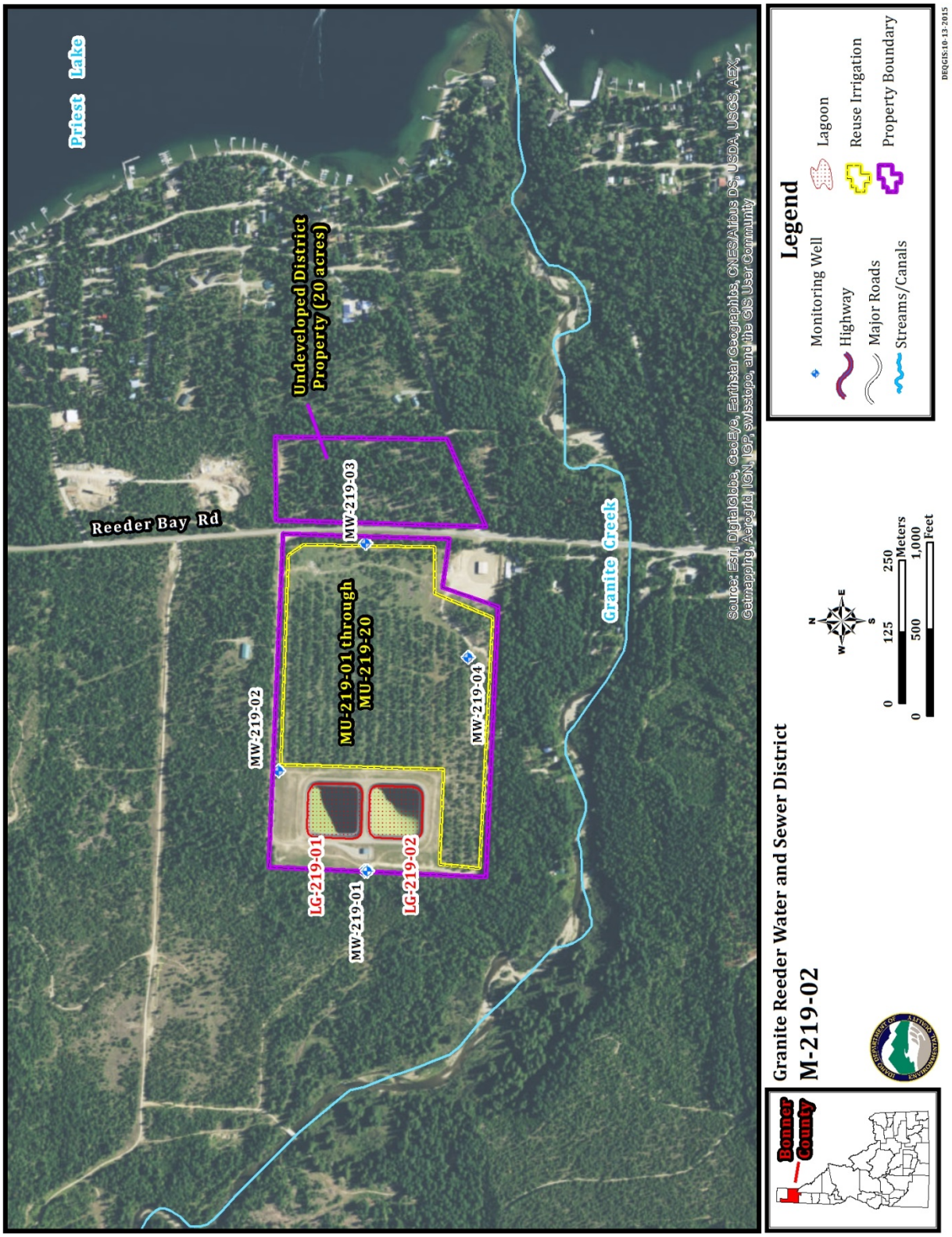
Tindall, J. 2009. *Staff Analysis, Granite Reeder Water and Sewer District*. Permit LA-000219-01

Appendix A. Site Maps

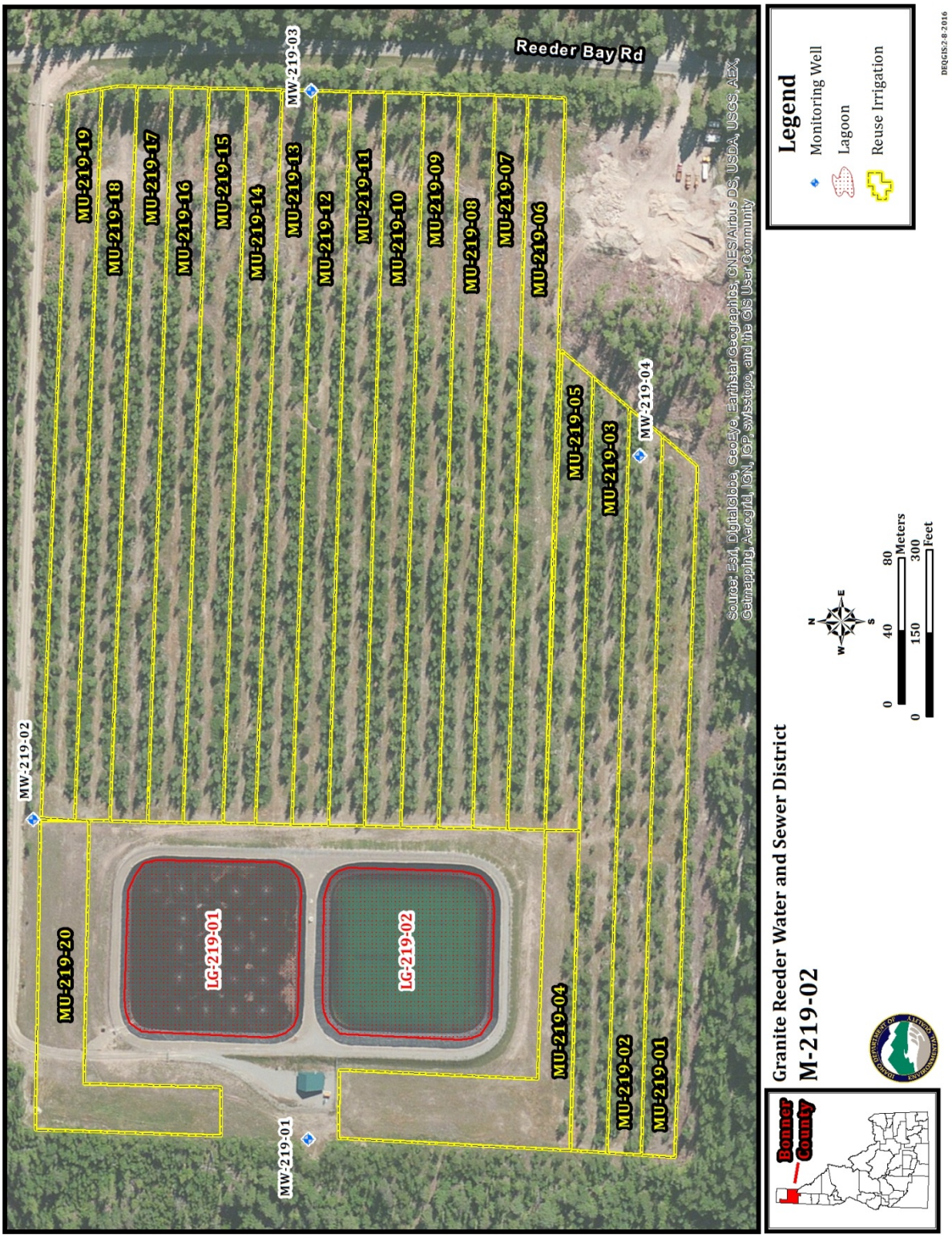
Regional Map



Facility Map



Hydraulic Management Units



Appendix B. Draft 2012 Forest Guidance

4.1 Hydraulic Loading

4.1.3 Forest and Poplar Site Hydraulic Loading

This section provides information on determining appropriate hydraulic loading rates for both forested and poplar plantation reuse sites. Hydraulic loading largely depends on the rates of precipitation and evapotranspiration (ET).

- Where ET is referred to without qualifiers, it refers to the generalized concept.
- Where ET is qualified, such as actual ET (ET_{act}) or potential ET (ET_{pot}), specific definitions are associated with these terms that are important in the section discussion.

Idaho-specific consumptive irrigation requirements and terminology definitions are comprehensively discussed in Allen and Robison (2007). Idaho-specific ET data and other parameters related to consumptive irrigation requirements are found in the ETIdaho website:

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

The following topics are discussed:

- In Section 4.1.3.1, a methodology is provided for calculating an estimate of the hydraulic loading capacity during the nongrowing season for forested and poplar sites.
- Sections 4.1.3.2 and 4.1.3.3 discuss methodologies for estimating ET-related parameters used in determining irrigation requirements in growing and nongrowing seasons for forest and poplar sites, respectively.

Both of these sections include example calculations.

4.1.3.1 Nongrowing Season Hydraulic Loading for Forest and Poplar

There may be instances where nongrowing season recycled water loading is allowed on forest and poplar reuse sites. Equation **1** is used to calculate a guideline hydraulic loading rate. This rate is equal to the available water-holding capacity (AWC) of the soil plus the ET_{act} values for the nongrowing season, less the nongrowing season gross precipitation (PPT_{ngs}). The calculated estimate of the nongrowing season recycled water application capacity of the system is referred to as the nongrowing season hydraulic loading rate (HLR_{ngs}).

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

Equation 1. Nongrowing season hydraulic loading rate

where:

HLR_{ngs} = nongrowing season hydraulic loading rate

AWC = available water holding capacity

ET_{act} = actual ET

PPT_{ngs} = gross precipitation in the nongrowing season

The term ET_{act} is defined in Allen and Robison (2007, 43). Values for ET_{act} and PPT_{ngs} can be obtained on the ETIdaho website. To obtain estimated ET_{act} values, follow the directions provided in section 4.1.3.2.1. Actual ET (ET_{act}) values during the nongrowing season predominantly represent evaporation from soil following precipitation rather than any ET from dormant vegetation. In the case of nongrowing season land application, where the soil is wetted more frequently, the ET may be greater than ET_{act} and be nearer to the potential ET (ET_{pot}) rates provided in ETIdaho. However, nongrowing season recycled water application, if allowed, is generally practiced sparingly on forested or poplar municipal land application sites, so ET_{act} should be used.

This methodology makes no adjustment to ET for tree canopy density although such adjustment is made for the growing season (see section 4.1.3.2.2).

Further discussion of nongrowing season hydraulic loading rates is provided in section 4.4.9. DEQ (2009, 7–10) provides related discussion of growing and nongrowing season hydraulic balances.

4.1.3.2 Forest Evapotranspiration and Irrigation Water Requirement Determinations

To determine recycled water 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. 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 2.

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

Equation 2. Irrigation water requirement .

The relationship of P_{def} to ET is shown in Equation 3:

$$P_{def} = ET - PPT_e$$

Equation 3. Precipitation deficit.

where:

PPT_e = effective precipitation (see section 4.1.1.2.2)

Irrigation-related terms and calculations are discussed in section 4.1.1.2.2. Note that native species (such as forests) are adapted to natural precipitation and do not need irrigation. Terminology related to irrigated agriculture (IR_{net} or P_{def}, IWR, E_i) is used for expedience but has limited applicability for native species living in native conditions.

The next three sections provide instructions on how to determine ET_{act}, P_{def}, and IWR for scenarios that are commonly encountered in recycled water application on forested sites. First, weather station and crop selection are discussed, then canopy density corrections, and, last, an example scenario is provided.

4.1.3.2.1 Weather Station and Crop Selection

Both a weather station and a *crop* must be selected to obtain P_{def} and ET_{act} values from ETIdaho. The weather station and crop selected in ETIdaho determine whether the P_{def} and ET_{act} values obtained are for an irrigated scenario or a nonirrigated scenario, as follows:

- A weather station may be designated (flagged) as irrigated, indicating that managed agricultural crops are typically irrigated. A weather station may not have a flag, indicating that managed agricultural crops are typically not irrigated. See Allen and Robison (2007), Appendix 5, Table 5.2. See the web site:

http://data.kimberly.uidaho.edu/ETIdaho/ETIdaho_Report_April_2007_with_supplement.pdf

- Similarly, a particular crop may be designated as always nonirrigated, always irrigated, or irrigated/nonirrigated depending on the weather station irrigation flag.
- For reuse purposes, values for P_{def} and ET_{act} for an irrigated scenario must be chosen, and care must be exercised to ensure that values for a nonirrigated scenario are not inadvertently selected.

The instructions for the data selection process are provided here.

To obtain P_{def} and ET_{act} data from ETIdaho for forests irrigated with recycled water, do the following:

1. Select the weather station nearest to the site. For example, the Sandpoint KSPT station is selected.
2. Consider the weather station irrigation flags in Allen and Robison (2007), Appendix 5, Table 5.2. Determine whether the particular station that was initially selected has an irrigation flag of 1 or 0 (or no flag).
   - If the weather station irrigation flag = 1, *managed agricultural crops are typically irrigated* (see Allen and Robison [2007], Appendix 5, Table 5.2 footnote), the P_{def} and ET_{act} values obtained for that station would be higher than for a water-limiting nonirrigated scenario because more water would be available to evapotranspire in a water-sufficient scenario.
   - If the station irrigation flag = 0 (or no value), the station has a rainfed (nonirrigated) scenario, and P_{def} and ET_{act} values will not reflect stress imposed by insufficient rainfall.

     For the Sandpoint KSPT station initially chosen for this example, the irrigation flag = 0.
3. After determining the weather station irrigation flag, look up the crop number in Allen and Robison (2007), Table 6 (pages 22-23). For forest sites, use *Orchards—no cover,* crop no. 20 (Allen 2008).
4. Consult Allen and Robison (2007), Table 7 (pages 24-29) to determine the irrigation flag for the particular crop. To determine whether the crop irrigation flag reflects irrigated or nonirrigated conditions, consider the following:

- If the crop irrigation flag = 0 (Allen and Robison 2007, 23), values will always be for nonirrigated conditions, regardless of the weather station flag, so the associated P_{def} and ET_{act} values reflect nonirrigated conditions.
- If the crop irrigation flag = 3, values are always for irrigated conditions, regardless of the weather station irrigation flag, so the associated P_{def} and ET_{act} values reflect irrigated conditions.
- If the crop irrigation flag = 1 or 2, values are for irrigated conditions if the weather station irrigation flag = 1 and for nonirrigated conditions if the weather station flag = 0.

  In this example scenario, crop no. 20 carries a crop flag = 1 (Allen and Robison 2007, Table 7), so determining whether values are for irrigated or nonirrigated conditions depends on the weather station irrigation flag.

5. This combination of flags (flag = 0 for the Sandpoint KSPT weather station and flag = 1 for crop no. 20, *Orchards—no cover*) indicates that the P_{def} and ET_{act} values obtained from ETIdaho—for this station and crop combination—would be for nonirrigated conditions, which probably do not appropriately reflect reuse purposes. However, the following should also be considered:

   - If the effluent loadings are relatively small in relation to precipitation inputs, nonirrigated values would be appropriate (nonirrigated values are not available for all locations but generally are available for locations in northern Idaho.).
   - If effluent loadings are substantial, and somewhat follow potential ET (ET_{pot} is defined in Allen and Robison 2007, 43), then nonirrigated P_{def} and ET_{act} values would not reflect a crop being irrigated. A crop yielding irrigated values should be selected instead (Allen 2008).

     In this example (for a forested site), we are limited to using crop no. 20 and must go on to step 6).

6. As stated above, in this forested site example, only crop 20 can be used. Instead of selecting a different crop, select a different but nearby weather station, one that does not have a station flag = 0, to obtain P_{def} and ET_{act} values that reflect an irrigated scenario.

   In Allen and Robison (2007), Appendix 5, Table 5.2, the Coeur d'Alene 1E station has an irrigation flag = 1, so P_{def} and ET_{act} values from this station for crop no. 20, *Orchards—no cover* would reflect irrigated conditions appropriate for this example.

The type of P_{def} and ET_{act} values obtained from ETIdaho (i.e., whether for irrigated or nonirrigated conditions) for each combination of weather station irrigation flag and crop irrigation flag is shown in Table 1.

Table 1. Type of P_{def} and ET_{act} values obtained for combinations of weather station and crop irrigation flags.

Weather Station Irrigation Flag	Crop Irrigation Flag	Type of P_{def} and ET_{act} Values
Flag = 0 (rainfed or nonirrigated conditions)	Flag = 0 (always nonirrigated)	Nonirrigated
	Flag = 1 or 2 (depends on weather station flag)	Nonirrigated
	Flag = 3 (always irrigated)	Irrigated
Flag = 1 (managed agricultural crops typically irrigated)	Flag = 0 (always nonirrigated)	Nonirrigated
	Flag = 1 or 2 (depends on weather station flag)	Irrigated
	Flag = 3 (always irrigated)	Irrigated

Application to Christmas Tree Farms

For a cropped forested site, such as a Christmas tree farm managed as a commercial farm, reuse permits will likely require irrigation at rates that are substantially according to IWR. This requirement 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.

Application to Minimally Managed Native Forested Sites

Considering the special case of native forested sites, which are not managed as commercial crops, reuse permits will likely not require the manager to account for precipitation events and other meteorological conditions. Such sites would likely be required to apply recycled water at predetermined monthly irrigation volumes not to exceed a certain fixed limit expressed as an IWR.

To minimize hydraulic overloading, the IWR in the case of the native forest would likely be based on the more conservative (i.e., lower) estimate of P_{def} that is 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, which has only a 50% chance of being exceeded in a given month because the value is higher and therefore less likely to be exceeded.

4.1.3.2.2 Canopy Density Correction

The ET of forests during the growing season will vary substantially depending on the density of the trees. A dense forest would be somewhat similar to an orchard (Allen 2008). ET values used in this guidance for forested sites assume a full tree canopy. However, for tree canopies that are not dense enough to fully cover the ground, the understory vegetation will influence the ET rate.

In the case of the forested site where there is no understory at all, ET (and thus P_{def}) will be reduced as canopy cover is reduced. The relationship between P_{def} and canopy cover is shown in Equation 4.

$$P_{def}\ (adj) = d_f * P_{def} = \sqrt{C_f} * P_{def}$$

Equation 4. P_{def} adjustment for canopy cover.

where:

P_{def} (adj) = P_{def} adjusted for canopy cover

C_f = canopy cover fraction

d_f = canopy density factor: $\sqrt{C_f}$

P_{def} is proportionate to approximately the square root of the fraction of forest ground covered by the canopy (i.e., the canopy cover fraction [Allen 2008]). For example, if the canopy cover fraction (C_f) is 0.8 (80%), then the canopy density factor (d_f) would be 0.9, and the P_{def} would be adjusted as follows:

$$P_{def}\ (adj) = \sqrt{0.8} * P_{def} = 0.89 * P_{def}$$

For convenience, Table 2 provides precalculated canopy density factors for common canopy cover fractions.

Table 2. Canopy density correction factors to modify orchard—no cover (no understory) in estimating forest P_{def}.

Fraction of Forest Canopy Covering the Ground (C_f)	Factor to Modify P_{def} for Orchard—No Cover (d_f)
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

There may be significant changes in forest composition and canopy cover through time on sites used for recycled water land application. These changes may result in a need to reassess canopy and understory cover at the end of a permit cycle and recalculate 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}), but the ET rate will be weighted based upon the percent canopy cover and percent understory cover (see section 4.1.3.2.4).

The ET rate for conditions in which there is no understory, but the soil is nearly continuously wet due to frequent effluent land application, would also be similar to that for full canopy cover. However, continuously wet conditions from recycled water land application are seldom encountered in forested sites. In cases of full canopy cover or continuously wet conditions, ET will approach a maximum rate governed by energy available for evaporation (Allen 2008).

4.1.3.2.3 Example Calculation—Forest with no Appreciable Understory

This section provides an example calculation showing how to determine P_{def} and ET_{act} for the forest scenario described in Table 3.

Table 3. Forest P_{def}, IWR, and ET_{act} determination 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	–Recycled water irrigations approach ET_{act} values during the growing season, albeit soils are not continually wet. –The growing season defined by the reuse permit is May–September. –Recycled water irrigations in the nongrowing 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 nongrowing season, the HLR_{ngs} equation (Equation **1**) is used. ET_{act} values from ETIdaho for the Coeur d'Alene 1E weather station and crop no. 20, *Orchards—no cover*, which were identified earlier as the appropriate selections for this example, are reproduced in Table 4.

PPT_{ngs} values from ETIdaho for the Sandpoint KSPT station (not the Coeur d'Alene station) are also reproduced in Table 4. Values from the Sandpoint station are used because it is the nearest weather station and would likely have better estimates of PPT than Coeur d'Alene.

In ETIdaho, values are expressed in millimeters per day (mm/day) and are then typically converted to inches per month as shown. This conversion is done on all succeeding calculation examples in this section, with all values expressed in inches per month. To emphasize the fact that ET_{act} values have application for the nongrowing season, the growing season months have been shaded out.

Table 4. 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)
January	0.28	0.34	3.35	4.09
February	0.76	0.84	2.80	3.09
March	1.27	1.55	2.25	2.75
April	1.83	2.16	1.9	2.24
May				
June				
July				
August				
September				
October	2.22	2.71	2.04	2.49
November	0.75	0.89	4.11	4.85
December	0.22	0.27	3.86	4.71
Nongrowing season totals	—	8.76	—	24.22

The HLR_{ngs} in this example is negative and would therefore be considered zero, as shown in the following calculation:

$$HLR_{ngs} = AWC + ET_{act} - PPT_{ngs} = 4.3 + 8.76 - 24.22 = -11.16\ inches$$

For the growing season, P_{def} (80% exceedance) values obtained from ETIdaho for the Coeur d'Alene 1E station for crop no. 20, *Orchards—no cover* are reproduced in Table 5. A canopy cover density correction factor of 0.71 was used to adjust P_{def} for 50% canopy cover (Table 2). To emphasize that P_{def} values have application during the growing season, the nongrowing season months in Table 5 have been shaded out. Shading conventions in Table 4 and Table 5 are followed throughout the rest of this section.

Table 5. Example P_{def} and IWR calculations for a forested site.

Month	P_{def} (mm/day)	P_{def} (in/month)	Canopy Density Factor (d_f) (from Table 2) (unitless)	Adjusted P_{def} (in/month)	Irrigation Water Requirement (in/month)
January					
February					
March					
April					
May	1.26	1.54	0.71	1.09	1.46
June	3.23	3.81	0.71	2.71	3.61
July	5.03	6.14	0.71	4.36	5.81
August	3.67	4.48	0.71	3.18	4.24
September	2.13	2.52	0.71	1.79	2.38
October					
November					
December					

4.1.3.2.4 Example Calculation—Forest with Appreciable Understory

This section provides an example calculation showing how to determine P_{def} and ET_{act} for the forest scenario with appreciable understory described in Table 6:

Table 6. Forest P_{def}, IWR, and ET_{act} determination example conditions.

	Example Conditions
Vegetation	–Douglas-fir juvenile plantation, 8 years old –Forest canopy covers 50% of the site –Appreciable herbaceous understory; 50%
Location	Sandpoint, ID
Operations	–Recycled water irrigations approach ET_{act} values during the growing season, albeit soils are not continually wet. –The growing season defined by the reuse permit is May–September. –Recycled water irrigations in the nongrowing 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

Both forest ET_{act} values and PPT_{ngs} values are used from the previous example for nongrowing season hydraulic loading limit calculations. Since this example has appreciable understory, the P_{def} and ET_{act} for a crop that represents the understory should be used. The P_{def} and ET_{act} can be estimated by selecting *Grass Pasture—high management* from the Coeur d'Alene 1E station for reasons described in section 4.1.3.3.4. Compute, for both P_{def} and ET_{act}, acreage-weighted values, based on the percent of the site with tree canopy cover and the percent of the site with understory, as shown in Table 7.

Table 7. Example ET_{act} and PPT calculations for a forested site with appreciable understory.

Month	Forest (50%) ET_{act} (in/month)	Pasture, High Management (50%) ET_{act} (mm/d)	Pasture, High Management (50%) ET_{act} (in/month)	Weighted ET_{act} (in/month)	Precipitation PPT (in/month)
January	0.34	0.14	0.17	0.26	4.09
February	0.84	0.41	0.45	0.65	3.09
March	1.55	0.85	1.04	1.29	2.75
April	2.16	2.45	2.89	2.53	2.24
May					
June					
July					
August					
September					
October	2.71	1.97	2.40	2.55	2.49
November	0.89	0.54	0.64	0.76	4.85
December	0.27	0.12	0.15	0.21	4.71
Nongrowing season totals	8.76	—	7.74	8.25	24.22

The HLR_{ngs} in this example is negative and would therefore be considered zero, as shown in the following calculation:

$$HLR_{ngs} = AWC + ET_{act} - PPT_{ngs} = 4.3 + 8.25 - 24.22 = -11.67\ inches$$

For the growing season, P_{def} (80% exceedance) values obtained from ETIdaho for the Coeur d'Alene 1E station for crop no. 20, *Orchards—no cover* are reproduced in Table 8. No canopy cover density correction factor is used to adjust P_{def}; rather, the value will be weighted by 50%. To emphasize that P_{def} values have application during the growing season, the nongrowing season months in Table 8 have been shaded out.

Table 8. Example P_{def} and IWR calculations for a forested site with appreciable understory.

Month	Forest (50%) P_{def} (in/month)	Pasture, High Management (50%) P_{def} (mm/d)	Pasture, High Management (50%) P_{def} (in/month)	Weighted P_{def} (in/month)	Irrigation Water Requirement (in/month)
January					
February					
March					
April					
May	1.54	4.84	5.91	3.73	4.97
June	3.81	5.62	6.64	5.23	6.97
July	6.14	6.36	7.76	6.95	9.27
August	4.48	5.82	7.10	5.79	7.72
September	2.52	3.81	4.50	3.51	4.68
October					
November					
December					

4.1.3.3 Poplar Evapotranspiration and Irrigation Water Requirement Determinations

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

4.1.3.3.1 Maturing and Mature Poplar Stands

ETIdaho has a selection for *Poplar Trees–third year and older*. This selection is described as 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 season, determining poplar P_{def} on recycled water land application sites should be done as follows.

- For poplar plantations that are 3 years and older, use the P_{def} provided in ETIdaho for corresponding conditions. Use these values only after consulting Tables 6 and 7 and Allen and Robison (2007), Appendix 5, Table 5.2, as described in section 4.1.3.2.1 (steps 2, 3, and 4) to see whether values obtained are for irrigated conditions.
- Note 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. For a rainfed crop, the estimated ET rate 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 IWR. If the plantation is rainfed only, ET_{act} will generally be less than ET_{pot}, and ET_{act} values will be similar to precipitation. If P_{def} values obtained are for rainfed (i.e., nonirrigated) conditions, do as described in section 4.1.3.3.3 (steps 5

and 6) to obtain more appropriate irrigated condition P_{def} values for a different but nearby weather station.

For the nongrowing season, determine poplar ET_{act} on recycled water land application sites as follows:

- For poplar plantations that are 3 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 Allen and Robison (2007), Appendix 5, Table 5.2, as described in section 4.1.3.2.1 (steps 2, 3, and 4), to see whether values obtained are for irrigated conditions.
- If ET_{act} values are for a rainfed (i.e., nonirrigated) scenario, do as described in section 4.1.3.2.1 steps 5 and 6 to obtain more appropriate irrigated scenario ET_{act} values for a different but nearby weather station.

4.1.3.3.2 Juvenile Poplar Stands

For recently planted poplar plantations (less than 3 years) with ground cover, the P_{def} and ET_{act} for a crop that represents 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 3 years old but are sparse and not dominant, compute, for both P_{def} and ET_{act}, acreage-weighted average values based on the percent of the site having trees and the percent of the site having ground cover. Use values from ETIdaho for the *Poplar Trees—third year and older* category and the ground-cover type (e.g., *Grass Pasture—high management*).

4.1.3.3.3 Using the Agrimet Website to Determine Hydraulic Loading Rates

An alternative means to find appropriate hydraulic loading rates is to obtain crop coefficients in the Agrimet website and use these to modify reference ET (ET_r) values as described in the "All About Crop Coefficients" text file on the Agrimet website. There are crop coefficient values for first-, second-, third-year poplar growth stages. Values for ET_r can be found on both Agrimet and ETIdaho websites. P_{def} values can then be calculated as described in section 4.1.1.2.2. For the crop coefficients see this website:

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

4.1.3.3.4 Example Calculation—Poplar

In the following example, poplar P_{def} and ET_{act} are calculated, for the scenario provided in Table 9.

Table 9. Poplar P_{def}, IWR, and ET_{act} determination example conditions.

	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	–Recycled water irrigations approach ET_{act} values during the growing season, albeit soils are not continually wet. –The growing season defined by the reuse permit is May–September. –Recycled water irrigations in the nongrowing 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 nongrowing season, ET_{act} values were obtained for this poplar-understory scenario by selecting *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 *Poplar—third year and older* and *Grass pasture—high management* from ETIdaho are reproduced in Table 10.

Table 10. Example poplar ET_{act} calculation.

Month	Poplar 3 Years and Older (40%)		Pasture = High Management (60%)		Weighted
	ET_{act}	ET_{act}	ET_{act}	ET_{act}	Average ET_{act}
	(mm/day)	(in/month)	(mm/day)	(in/month)	(in/month)
January	0.19	0.23	0.14	0.17	0.20
February	0.52	0.57	0.41	0.45	0.50
March	0.91	1.11	0.85	1.04	1.07
April	1.18	1.39	2.45	2.89	2.29
May					
June					
July					
August					
September					
October	2.54	3.10	1.97	2.40	2.68
November	0.66	0.78	0.54	0.64	0.69
December	0.16	0.20	0.12	0.15	0.17
Nongrowing season totals	—	7.38	—	7.74	7.60

The HLR_{ngs} in this case is negative, and, therefore, would be considered zero, as shown in the following calculation:

$$HLR_{ngs} = AWC + ET_{act} - PPT_{ngs} = 4.3 + 7.60 - 24.22 = -12.32\ inches$$

For the growing season, P_{def} values for this poplar-understory scenario were determined by initially selecting values for *Poplar Trees—third year and older* P_{def} and *Grass Pasture—high management* P_{def} from ETIdaho for the Sandpoint KSPT weather station. However, according to Allen and Robison (2007), Appendix 5, Table 5.2, this particular station has an irrigation flag = 0 (blank). This indicates a rainfed (nonirrigated) scenario at this weather station, with ET reduced to reflect stress imposed by insufficient rainfall, so 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 24-29), the crop irrigation flags are 1 and 2, respectively, indicating that values are for nonirrigated conditions at the Sandpoint station, which has a flag = 0. As discussed above for forests (*Orchards—no cover*), Allen and Robison 2007, Appendix 5, Table 5.2 shows that the Coeur d'Alene 1E station has an irrigation flag = 1, so values for both of these crops from this weather station should reflect irrigated conditions. This weather station should be used for this example scenario (see Table 1 for a summary of the type of P_{def} and ET_{act} values obtained [i.e.,

irrigated or nonirrigated] for various combinations between weather station irrigation flag and crop irrigation flag).

Values of P_{def} and ET_{act} obtained from ETIdaho are reproduced in Table 11. 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 E_i to calculate the IWR. This example is for a commercially managed plantation so monthly P_{def} rather than P_{def} (80% exceedance) should be used, and permit requirements should reflect a hydraulic loading limit that is substantially equal to the IWR.

Table 11. Example poplar P_{def} and IWR calculations.

Month	Poplar 3 Years and Older (40%)		Pasture—High Management (60%)		Weighted Average P_{def} (in/month)	Irrigation Water Requirement (in/month)
	P_{def} (mm/day)	P_{def} (in/month)	P_{def} (mm/day)	P_{def} (in/month)		
January						
February						
March						
April						
May	2.08	2.54	4.84	5.91	4.56	6.08
June	4.87	5.75	5.62	6.64	6.28	8.37
July	6.99	8.53	6.36	7.76	8.07	10.76
August	6.06	7.40	5.82	7.10	7.22	9.63
September	3.73	4.41	3.81	4.50	4.46	5.95
October						
November						
December						

References

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4.2 Wastewater Constituent Loading

4.2.2.4.3 Forest and Poplar Plantation Nutrient Loading

Information presented in this section regarding the nitrogen (N) uptake of forested sites in the Pacific Northwest has largely been taken from *Managing Nitrogen from Biosolids* (Henry et al. 1999) and specifically from Tables 6.1, 6.5, and 6.6. This source is an important reference in that the authors have distilled a vast and varied body of research into 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 available for plant uptake over a period that spans several years. A simplifying assumption made for this guidance is that nitrogen in municipal recycled water 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 recycled water (Smith and Hayden 1984).

Another simplifying and conservative assumption that *could* be made for regulatory expedience would be to disregard soil immobilization of nitrogen during first-time application. As shown in Henry et al. (1999) Table 6.2, first-year nitrogen immobilization values can be significant (175 pounds of nitrogen per acre [lb N/ac]). It may not be so important to consider first-year nitrogen immobilization if long-term nitrogen loadings are set at recommended annual uptake rates (Table 12, Table 13, and Table 14).

This is typical permitting practice. Recycled water land application 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 reuse permitting and re-permitting, design loading rates are determined for at least the life of the permit, generally 5 years.

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 reuse site with nitrogen in recycled water applied at a rate of 3,600 pounds of nitrogen over the entire site per year (lb N/site-yr), 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 from 375 to approximately 90 lb N/ac-yr over the entire for 40 acres, which could be used from the fifth year on. Alternatively, the initial design operations could be based on the fifth and following year operations and apply approximately 90 lb N/ac over the entire 40 acres from the start of the permit operation. Lower nitrogen loadings would not induce rapid decomposition of the duff layer as higher nitrogen loadings would.

Documented decreases in forest productivity and increases in tree mortality have been observed in certain studies because of long-term nitrogen additions to forests (Aber and Magill 2004).

Given the potential for significant changes in forest health over time, there may be a need to reassess the site at the end of a permit cycle and revise nutrient loading rates if necessary.

Nutrient Uptake Values and Calculations

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

The net N requirement should then be adjusted for denitrification and volatilization losses of applied recycled water. For recycled water applications, these losses are mainly from denitrification and typically range from 15% to 25% (EPA 1981, 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 nitrogen uptake efficiency factors (e_f) of 0.85 and 0.75, respectively. The e_f values of 0.85 and 0.75 amount to allowable nitrogen loading rates of 117% and 133% of the net N requirement, respectively. These calculations are summarized in Equation 5.

Equation 5. Calculation of the net N requirement.

$$N_{rate} = \frac{(N_{uptake} - N_{cr})}{(1 - N_{loss})} = \frac{N_{req}}{(e_f)}$$

where:

N_{rate} = N loading rate

N_{loss} = N losses from denitrification and volatilization

e_f = uptake efficiency factor (1 - N_{loss})

N_{uptake} = N net uptake

N_{cr} = N credits

N_{req} = N_{uptake} - N_{cr} = N net requirement

Table 12, Table 13, and Table 14 show net nitrogen uptake values for hybrid cottonwood, Douglas fir and white pine, and forest understory, respectively.

Table 12. Hybrid Cottonwood net N uptake rates.

Year of Growth	Tree N Uptake (lb/ac-yr)[a]	Understory N Uptake (lb/ac-yr)	Total N Uptake (lb/ac-yr)
1	50	100	150
2	120	50	170
3	200	0	200
4	220	0	220
5–10	240	0	240

Source: Henry et al. 1999, Tables 6.1 and 6.6
a. Pounds per acre year

Table 13. Douglas fir and pine net N uptake rates.

Condition	Douglas Fir N Uptake (lb/ac-yr)[a]	Pine (Semiarid 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

Source: Henry et al. 1999, Tables 6.1 and 6.6
a. Pounds per acre year

Table 14. Forest understory net N uptake rates.

Condition	Understory N Uptake; lb/ac-yr[a]
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 10% of site)	75[b]
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)	

Source: Henry et al. 1999, Tables 6.1 and 6.6
a. Pounds per acre year
b. Brown (2008).

In particular, the National Resource Conservation Service (NRCS) guidance "Nutrient Uptake and Removal–Nutrients Available from Livestock Manure Relative to Crop Growth Requirements" (Appendix I, Part C) (NRCS 1998) provides general recommendations for both nitrogen and phosphorus (P) application rates for nongrazed privately owned woodlands as follows: 100 lb N/ac and 20 lb P/ac, respectively. NRCS (1998) also recommends applying a 70% *nitrogen recovery factor* (i.e., e_f , the uptake efficiency factor) to the recommended values. An e_f of 0.7 amounts to an allowable nitrogen loading of 143% of the net N requirement, calculated as follows: the reciprocal of e_f (0.7) is 1.43, or as expressed as a percent, 143%. Multiply this value by the net N requirement to calculate the nitrogen loading rate, as shown in Equation 5. See the following NRCS website for more information:

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

A commercial poplar plantation may require specific nitrogen application rates for profitable production. If the allowable volume of land-applied recycled water does not supply the minimum nitrogen amount, supplemental fertilization may be necessary. On the other hand, forested sites used for land application in many cases would otherwise have no additional recycled water 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 15 shows the values used to calculate the nitrogen loading rate.

Table 15. 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 13)
Partial herbaceous understory	35 lb/ac N uptake (Table 14)
Denitrification/volatilization rate	20%
Assume no appreciable change in soil storage from initial time of recycled water application to the end of permit cycle.	0 lb N/ac credit

The values are then substituted in Equation 1 to calculate the example nitrogen loading rate:

$$N_{rate} = \frac{\left(N_{uptake} - N_{cr}\right)}{(1 - N_{loss})} = \frac{[(55 + 35) - 0]}{(1 - 0.20)} = \frac{90}{0.80} = 112.5\ lb\ \ N/ac - yr$$

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* 196. 1–5.

Brown, S. 2008. Seattle, WA: University of Washington. Personal communication to Michael Cook. August 29.

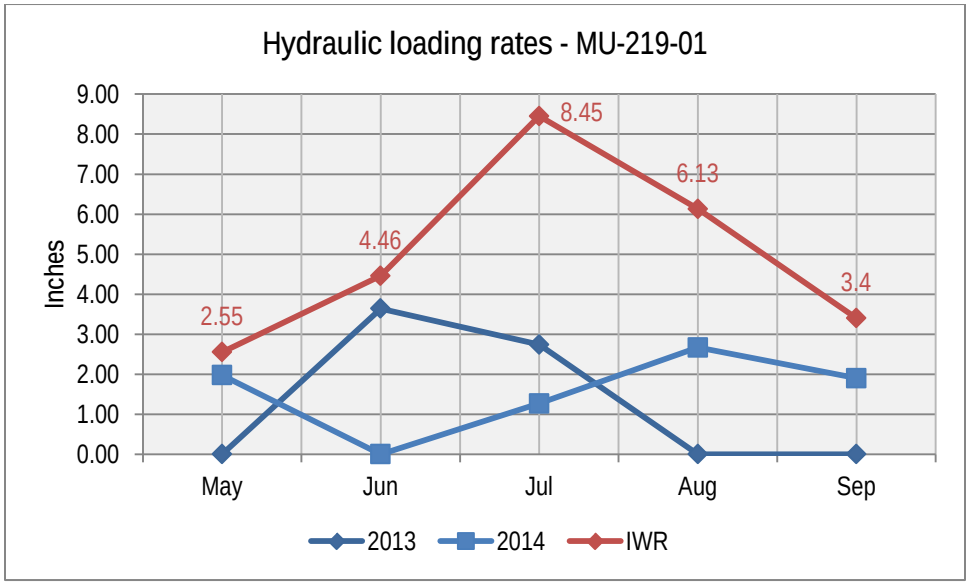
EPA (Environmental Protection Agency). 1981. *Process Design Manual–Land Treatment of Municipal Wastewater*. Cincinnati, OH: Center for Environmental Research Information. EPA 625/1-81-013.

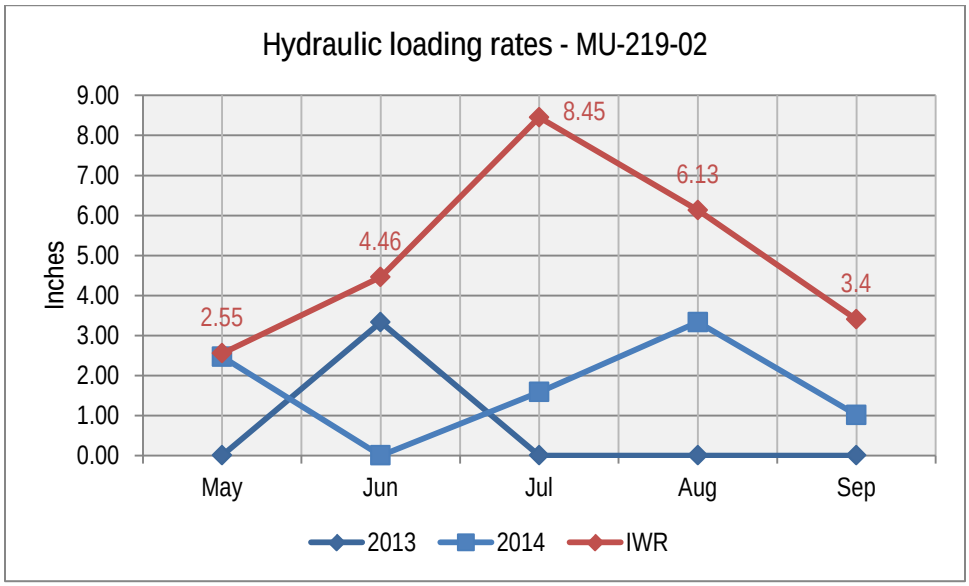
Henry, C., D. Sullivan, R. Rynk, K. Dorsey, and C. Cogger. 1999. *Managing Nitrogen from Biosolids*. Olympia, WA: Washington State Department of Ecology and Northwest Biosolids Management Association.

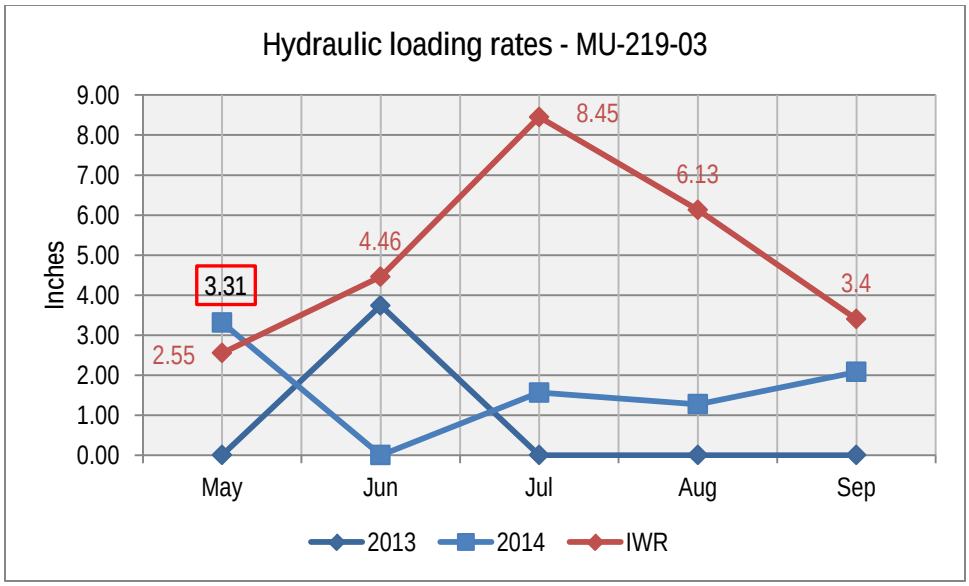
Smith, J.H., and C.W. Hayden. 1984. “Nitrogen Availability from Potato-Processing Wastewater for Growing Corn. *Journal of Environmental Quality* 13(1) January–March.

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

Appendix C. Supplemental Data – Hydraulic Loading Rates



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Inches
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7.00
6.00
5.00
4.00
3.00
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1.00
0.00
May
Jun
Jul
Aug
Sep
3.31
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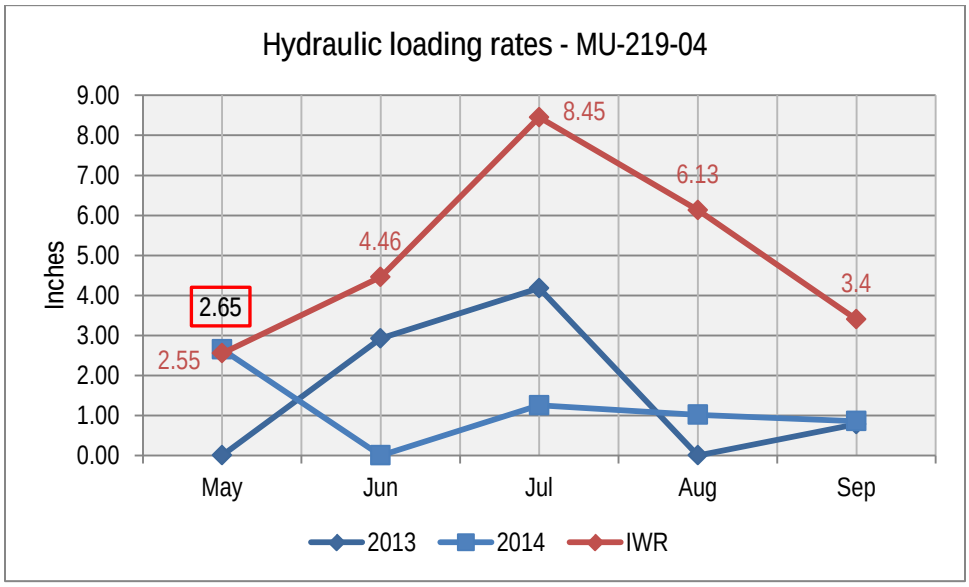
4.46
8.45
6.13
3.4
2013
2014
IWR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May
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Jul
Aug
Sep
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2013
2014
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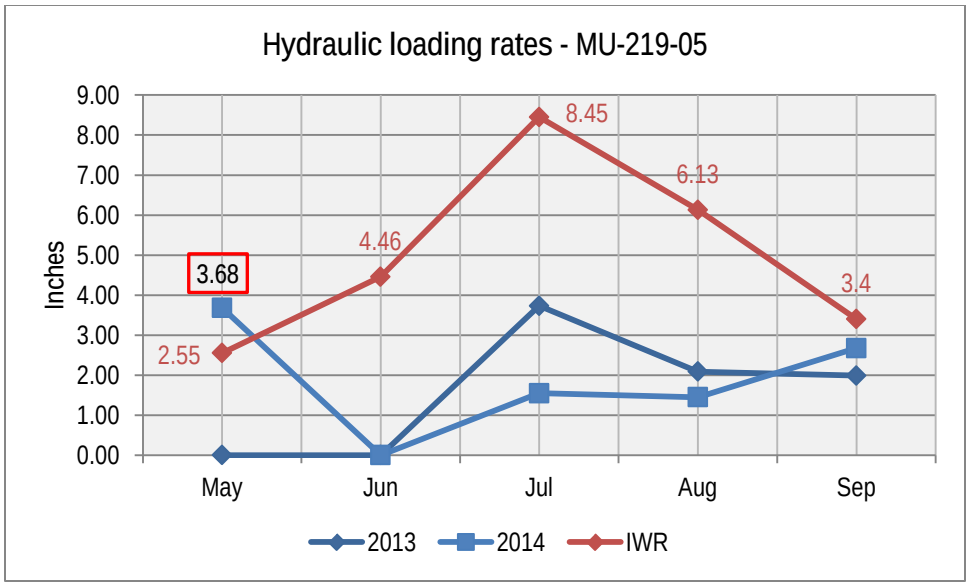
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Jul
Aug
Sep
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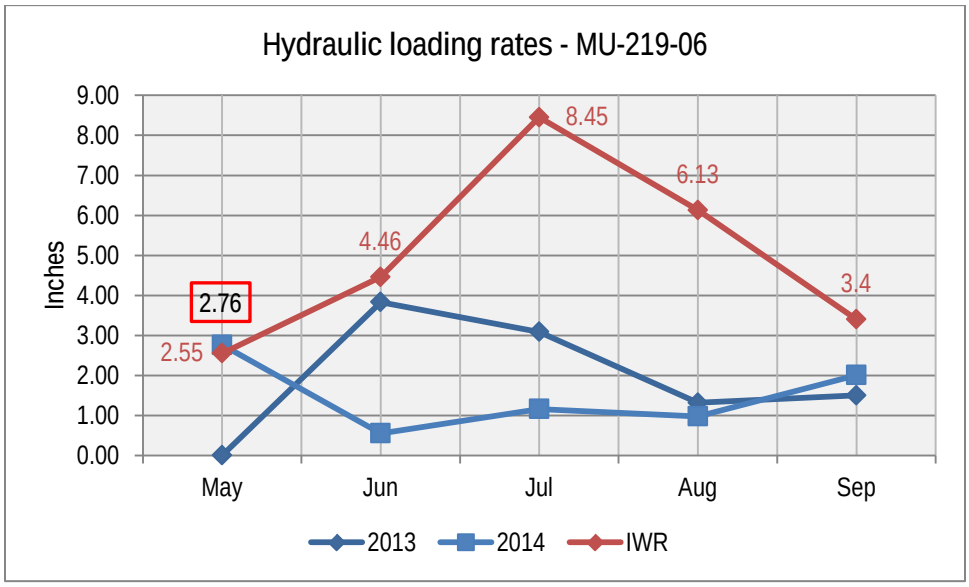
3.4
2013
2014
IWR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Inches
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May
Jun
Jul
Aug
Sep
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4.46
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2013
2014
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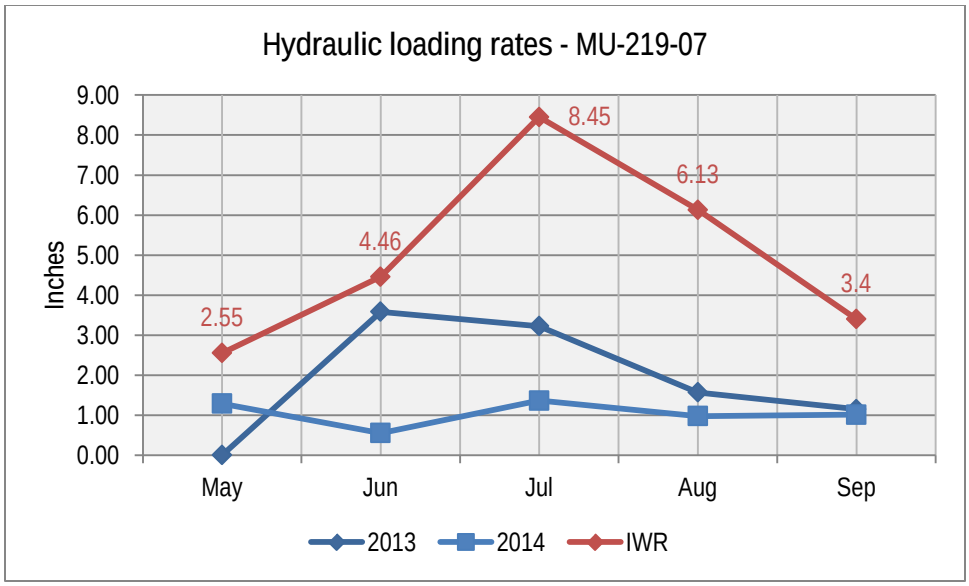
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May
Jun
Jul
Aug
Sep
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2014
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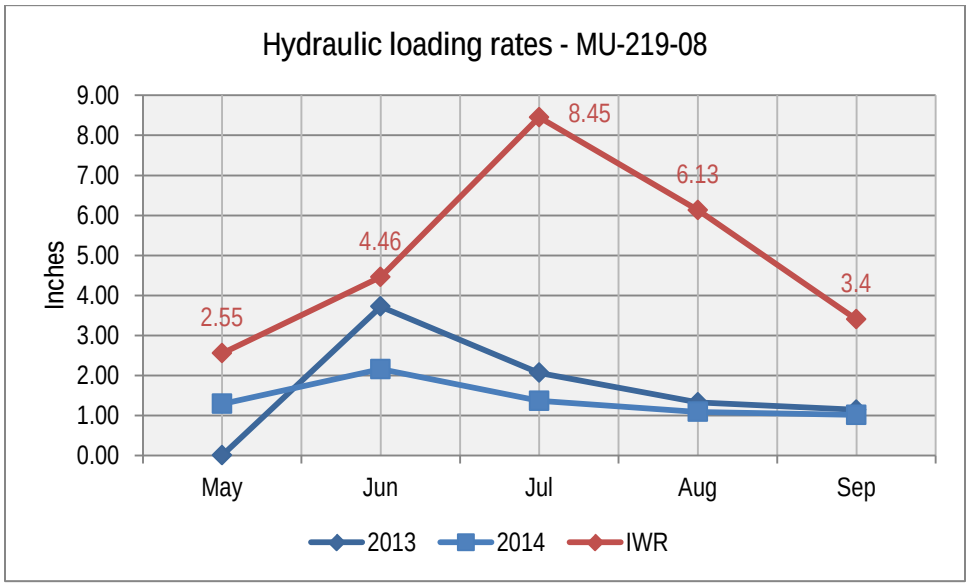
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May
Jun
Jul
Aug
Sep
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2013
2014
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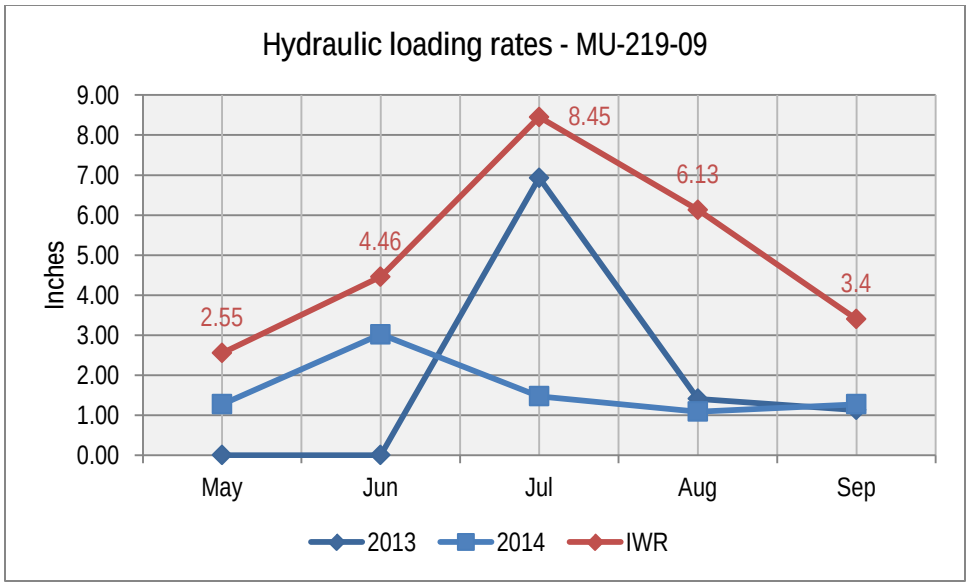
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May
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Jul
Aug
Sep
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3.4
2013
2014
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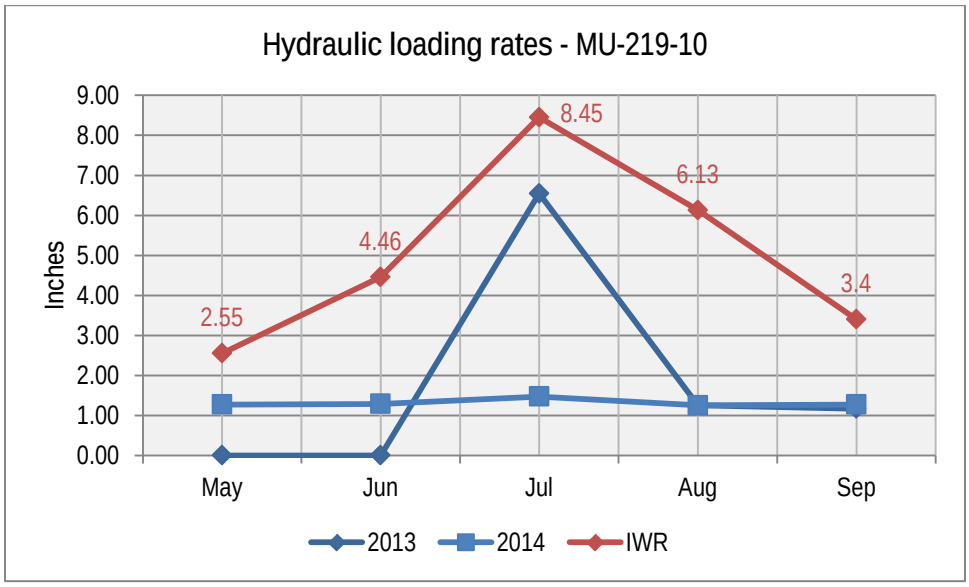
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2.00
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May
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Jul
Aug
Sep
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8.45
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3.4
2013
2014
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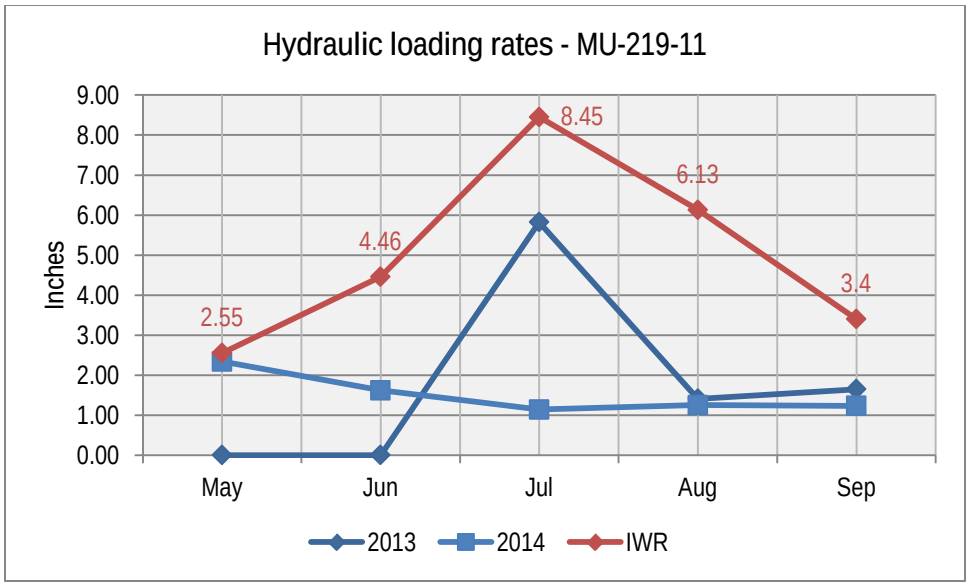
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May
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Jul
Aug
Sep
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8.45
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3.4
2013
2014
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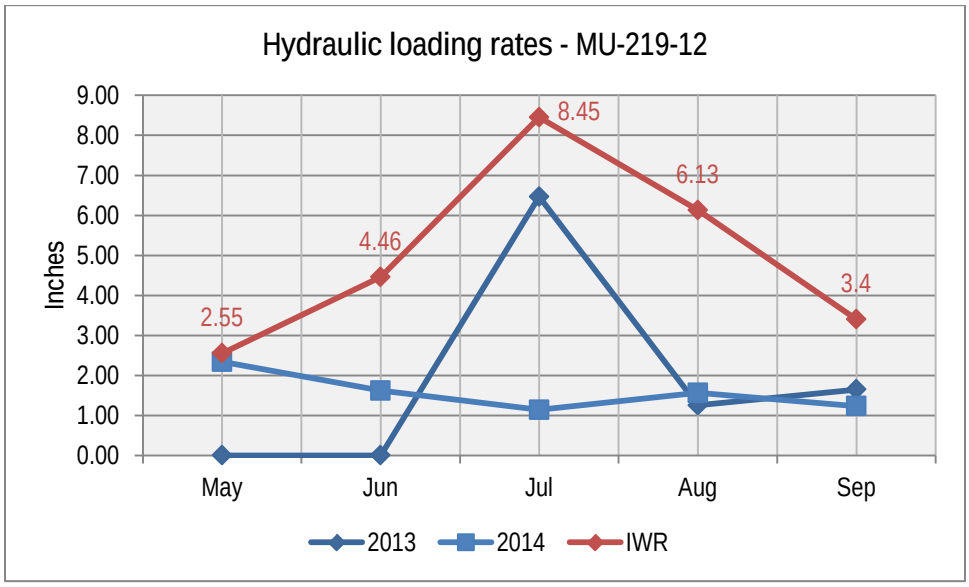
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May
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2013
2014
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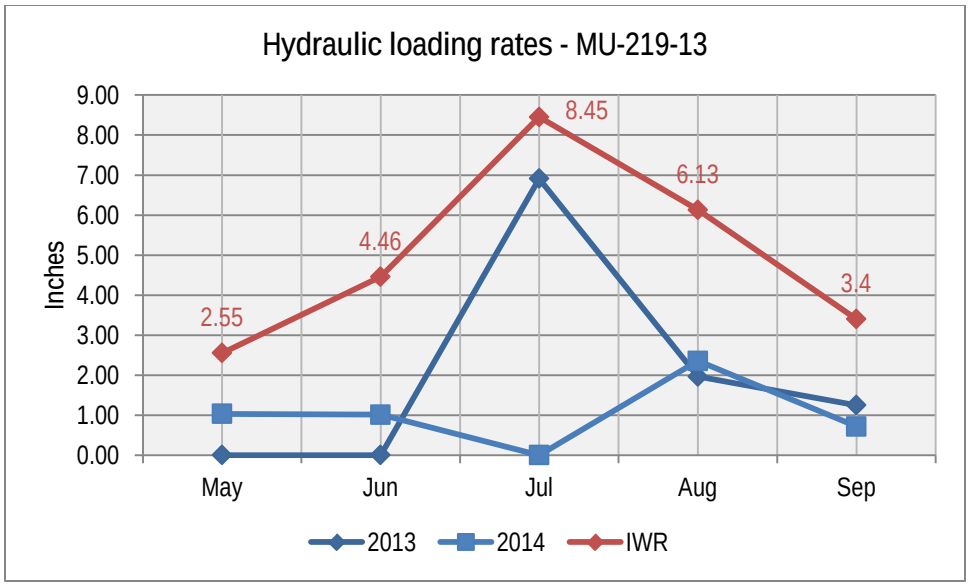
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Jul
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2013
2014
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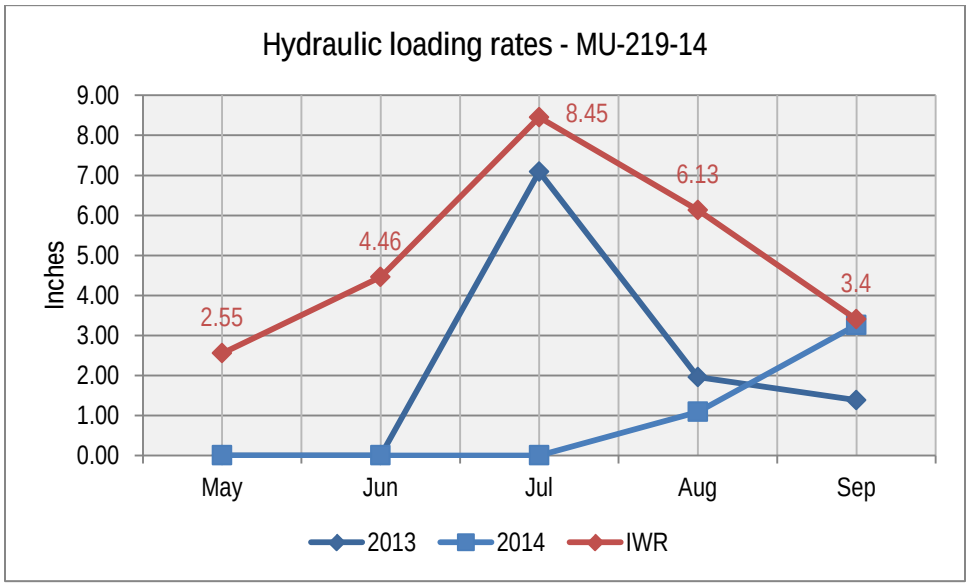
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Jul
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Sep
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2013
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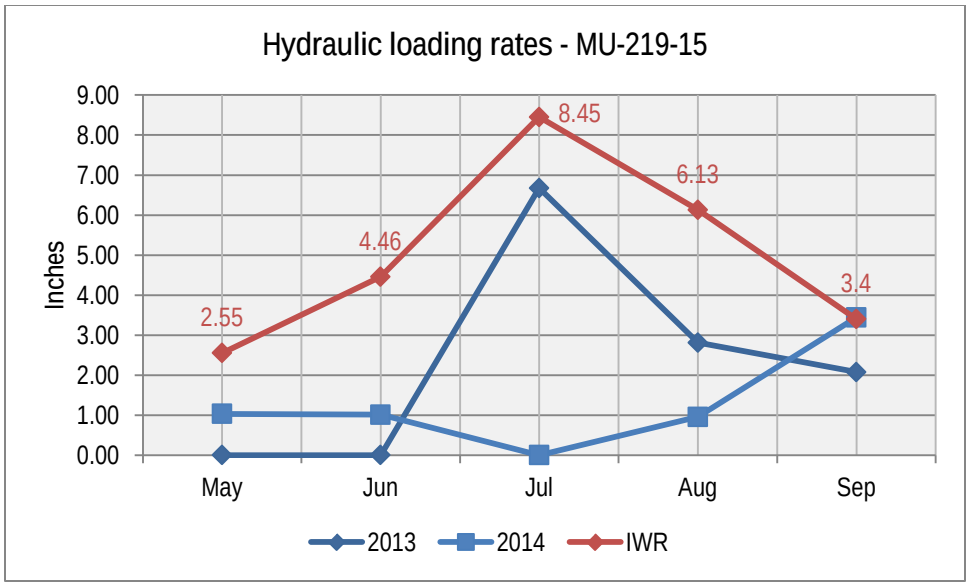
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Inches
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Sep
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2013
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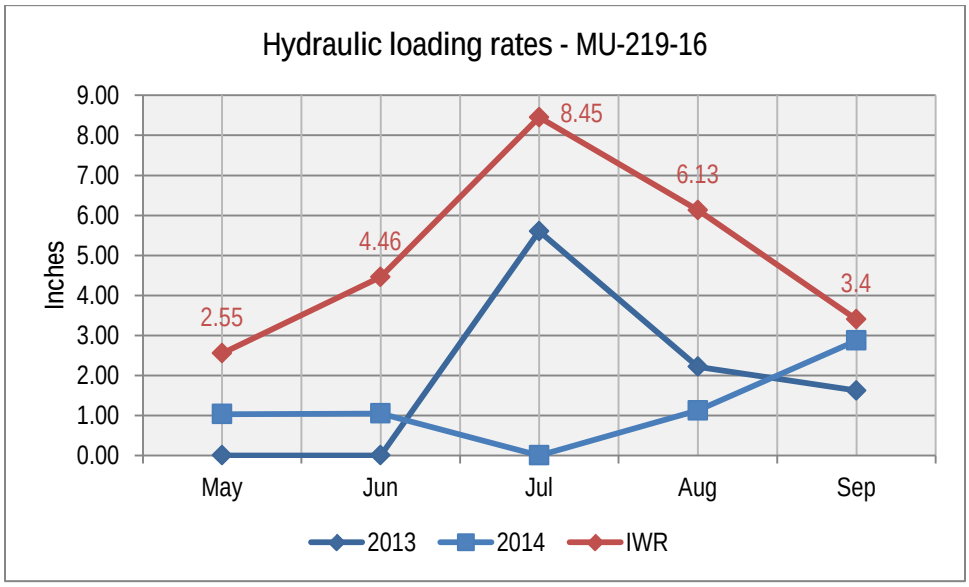
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Sep
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3.4
2013
2014
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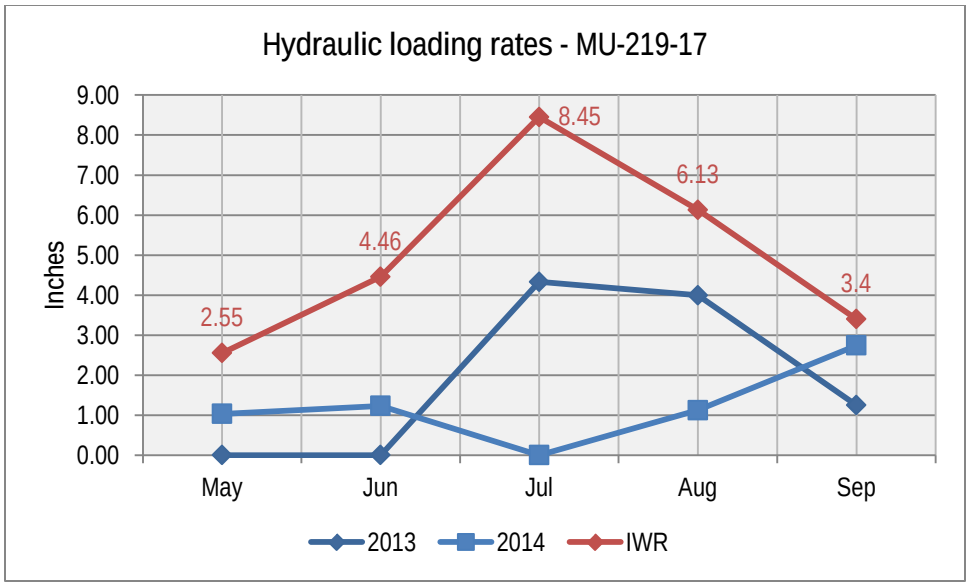
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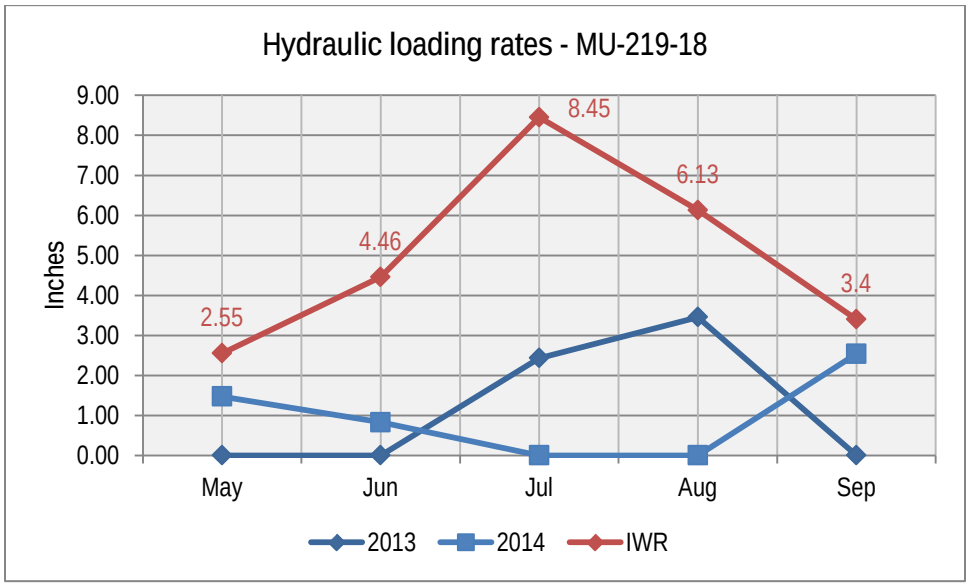
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Inches
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May
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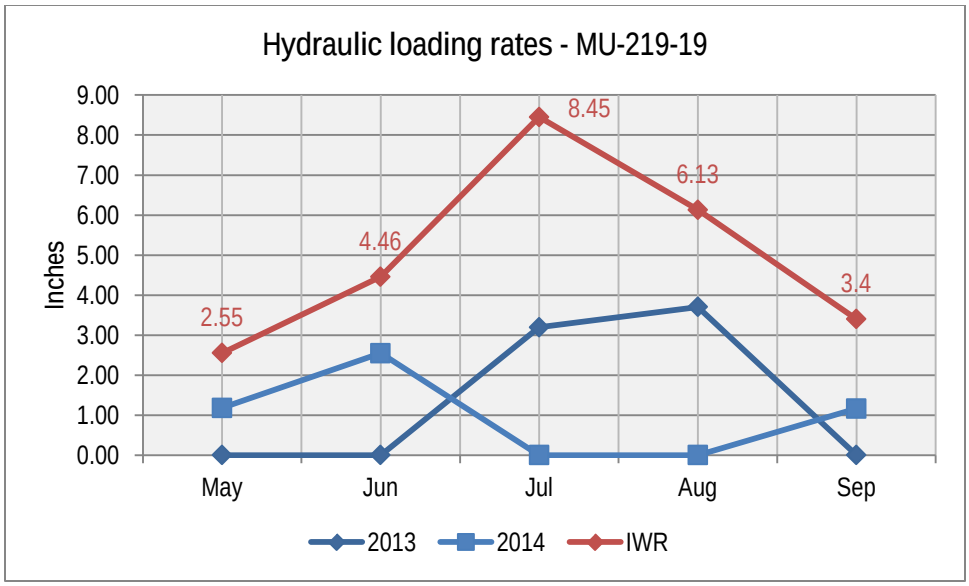
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Inches
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1.00
0.00
2.55
4.46
8.45
6.13
3.4
May
Jun
Jul
Aug
Sep
2013
2014
IWR

Appendix D. Supplemental Data – Ground Water Monitoring

Table 9 - Ground water monitoring for chlorides, nitrate as N, and nitrite as N.

	Chlorides (mg/L)	NO_3-N(mg/L)	NO_2-N (mg/L)
2013			
Jun			
Downgradient	0.25	0.25	0.05
Up gradient	0.25	0.25	0.05
Oct			
Downgradient	0.25	0.25	0.05
Up gradient	0.25	0.25	0.05
2014			
May			
Downgradient	0.25	0.25	0.05
Up gradient	0.25	0.25	0.05
Oct			
Downgradient	0.25	0.25	0.05
Up gradient	0.25	0.25	0.05

Note: All ground water monitoring results for those constituents listed above were reported to DEQ as non-detect (ND). As a conservative means of interpreting this data, DEQ assumes one-half of the practical quantitative limits (PQL).

Table 10 - True gradient, ground water monitoring results for electrical conductivity (EC).

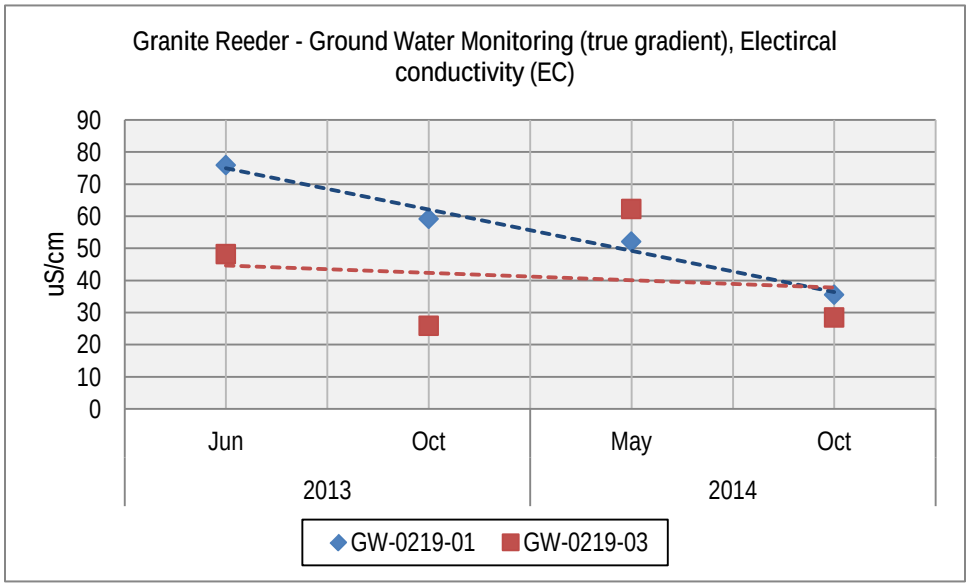

Table 11 - Cross gradient, ground water monitoring results for electrical conductivity (EC).

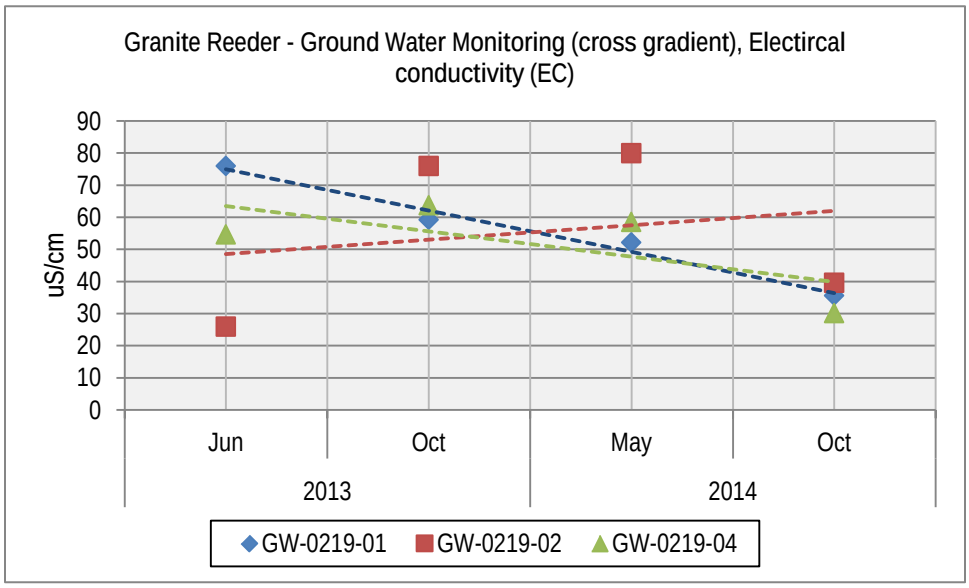

Table 12 - True gradient, ground water monitoring results for dissolved oxygen (DO)

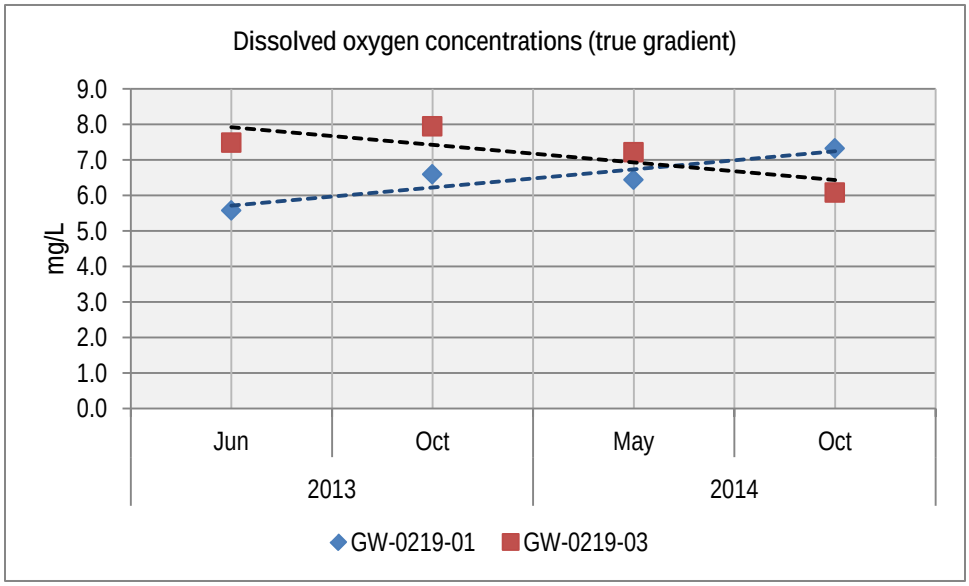

Table 13 - Cross gradient, ground water monitoring results for dissolved oxygen (DO)

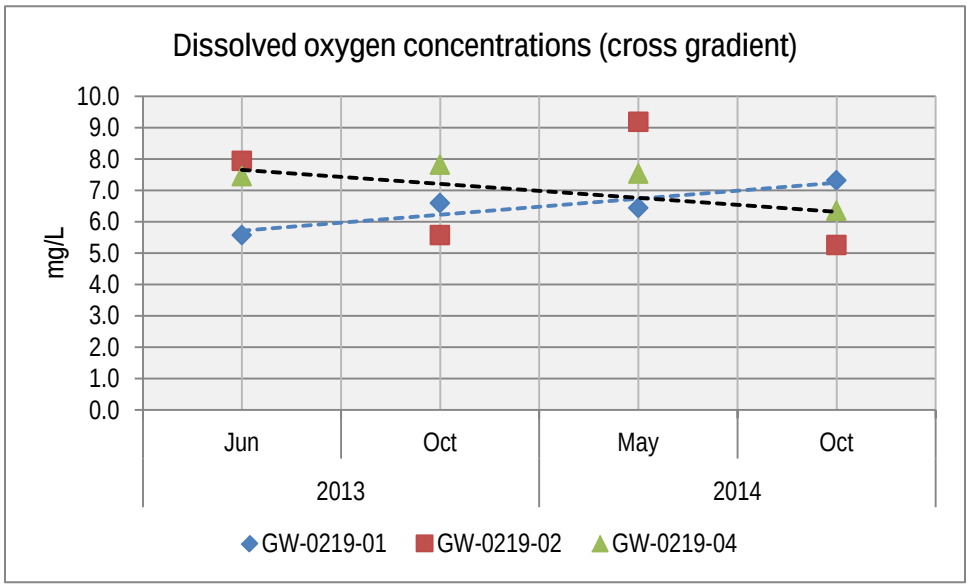
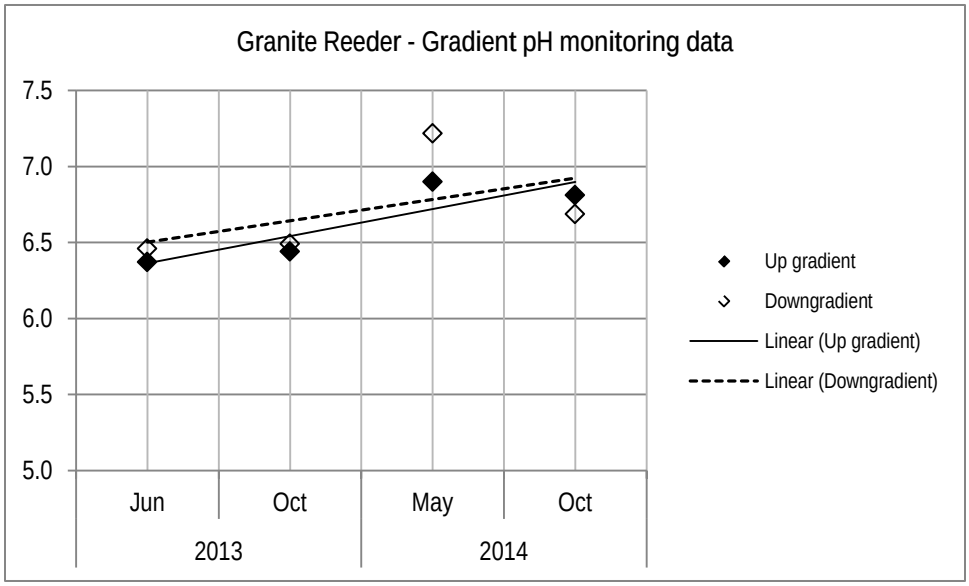
Table 14 - Ground water monitoring results for pH.