PROCESS WATER REUSE FACILITY

ENGINEERING REPORT

Prepared for City of Pasco

April 10, 2023

22-0034

RH2 Engineering, Inc.
300 Simon Street SE, Suite 5
East Wenatchee, WA 98802
509.886.2900 / rh2.com

Valley Science and Engineering
12720 E Nora Avenue, Suite A
Spokane Valley, WA 99216
509.921.0290 / valleyirrigation.com/se

The Probst Group
17035 West Wisconsin Avenue, Suite
120 Brookfield, WI 53005
262.264.5665/ probstgroup.com

Biogas Engineering
2321 E. 28th St, Suite 400
Signal Hill, CA 90755
562.786.5656/ Biogaseng.com

Evoqua Water Technologies
210 Sixth Avenue, Suite 3300 Pittsburgh,
PA 15222
724.772.0044/ Evoqua.com

Advanced Engineering and
Environmental Sciences, LLC
4050 Garden View Drive, Suite 200
Grand Forks, ND 58201
701.746.8087/ ae2s.com

City of Pasco

Process Water Reuse Facility

Engineering Report

April 2023

Chapters 1-3, Sections 5.1-5.4 of Chapter 5, and Chapter 6, excluding Section 6.3, prepared by RH2 Engineering, Inc.
Chapter 4 prepared by Valley Science and Engineering
Section 5.5 of Chapter 5 and Section 6.3.8 of Chapter 6 prepared by The Probst Group
Section 6.3.7.2 of Chapter 6 prepared by BioGas Engineering
Section 6.3 of Chapter 6, excluding Section 6.3.7.2 and 6.3.8, prepared by Evoqua Water Technologies in affiliation with Advanced Engineering and Environmental Sciences, LCC

Prepared for City of Pasco

Note: This Engineering Report was completed under the direct supervision of the following Licensed Professional Engineers registered in the State of Washington.

Sincerely,

RH2 ENGINEERING, INC., VALLEY SCIENCE AND ENGINEERING, THE PROBST GROUP, BIOGAS ENGINEERING, EVOQUA WATER TECHNOLOGIES, AND ADVANCED ENGINEERING AND ENVIRONMENTAL SCIENCES, LLC

DAN J. MAHLUM
STATE OF WASHINGTON
37045
REGISTERED PROFESSIONAL ENGINEER

Exp: 1/30/2025

This stamp and signature applies only to: Chapters 1-3, Sections 5.1-5.4 of Chapter 5, and Chapter 6, excluding Section 6.3, prepared by RH2 Engineering, Inc.
Note: RH2 and Valley worked directly with the City to develop the capacity of the Land Treatment System (LTS) and the overall level of pretreatment required to meet LTS requirements. This included identifying the need for further nitrogen reduction in pretreatment, but does not include alternatives analyses or design criteria for the nitrogen removal system.
Signed: 4/6/2023

CHRISTOPHER LEWIS
STATE OF WASHINGTON
22024239
REGISTERED PROFESSIONAL ENGINEER

Exp: 12/14/2024

This stamp and signature applies only to: Section 5.5 of Chapter 5 and Section 6.3.8 of Chapter 6, prepared by The Probst Group.
Note: The Probst Group and GWT worked directly with the City to review alternatives for nitrogen removal in order to meet the identified LTS capacity for nitrogen, and developed the preliminary engineering including sizing, layout, and design criteria for the nitrogen removal system.
Signed: 4/6/2023

PERRY A. JOHNSON
STATE OF WASHINGTON
38590
REGISTERED PROFESSIONAL ENGINEER

Exp: 10/20/2024

This stamp and signature applies only to: Section 6.3 of Chapter 6, excluding Sections 6.3.7.2 and 6.3.8, prepared by Evoqua Water Technologies in affiliation with Advanced Engineering and Environmental Sciences, LLC.
Signed:04/06/2023.

State of Washington
Hydrogeologist
1660
Licensed Geologist
Exp 12/7/23
Daniel J. Bruner

This stamp and signature applies only to: Chapter 4, prepared by Valley Science and Engineering.

Signed: 4/05/2023.

GREG LANGFORD THURMAN
STATE OF WASHINGTON
32839
REGISTERED PROFESSIONAL ENGINEER

Exp: 07/03/2024

This stamp and signature applies only to: Chapter 4, prepared by Valley Science and Engineering.

Signed: 4/05/2023.

ANDRE GAMANIAN
STATE OF WASHINGTON
21019917
REGISTERED PROFESSIONAL ENGINEER

Exp: 01/18/2024

This stamp and signature applies only to: Section 6.3.7.2 of Chapter 6, prepared by BioGas Engineering.

Signed: 04/05/2023.

City of Pasco

Process Water Reuse Facility Engineering Report

Table of Contents

Tables

Note: Tables 4-A through 4-P are included at the end of this report. All other tables are embedded within the report.

Charts

Note: Charts 4-A through 4-E2 are included at the end of this report. All other charts are embedded within the report.

Figures

Note: Figures are embedded within the report.

Exhibits

Note: Exhibits are included at the end of the report.

Appendices

Note: Appendices are included at the end of the report.

List of Abbreviations

Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
AA	average annual
AD	anaerobic digestion
amsl	above mean sea level
bgs	below ground surface
BDI	Basin Disposal, Inc.
BOD	Biochemical Oxygen Demand
BPA	Bonneville Power Administration
BVF	Bulk Volume Fermenter
CAF	cavitation air flotation
CELS	Columbia East Lift Station
CFR	continuous flow reactors
City	City of Pasco
COD	chemical oxygen demand
COW	Darigold condensate of whey
CRBG	Columbia River Basalt Group
ft^3/day	cubic feet per day
CY	cubic yards
CO_2	carbon dioxide
DAF	dissolved air flotation device
Dam Safety	Ecology's Dam Safety Office
DMRs	discharge monitoring reports
Ecology	Washington State Department of Ecology
ESP	exchangeable sodium percentages
ET	evapotranspiration
FDS	fixed dissolved solids
FTE	full-time employee
FWLS	Foster Wells Lift Station
gpd	gallons per day

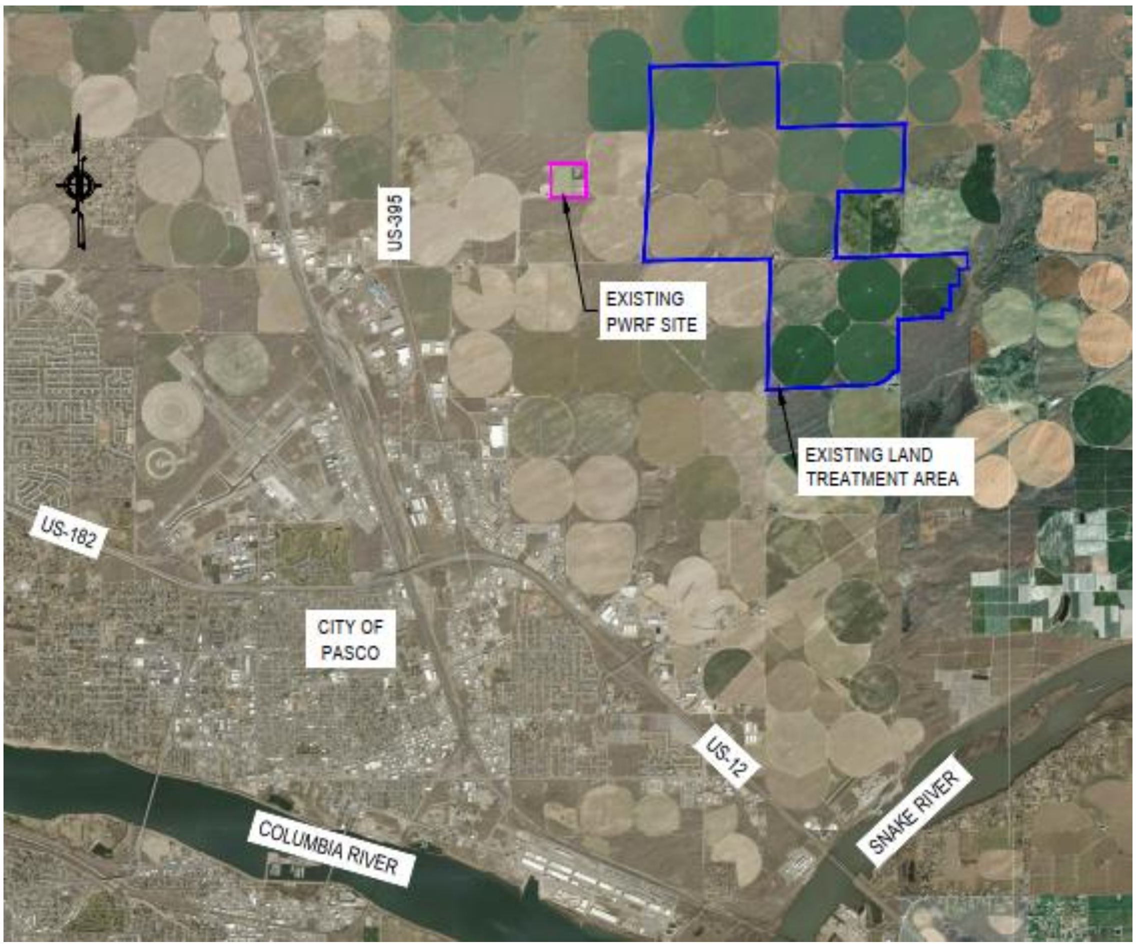
Abbreviation	Definition
gpm	gallons per minute
GWT	Gross-Wen Technology
hp	horsepower
H^2S	hydrogen sulfide
lb/ac/day	pounds per acre per day
IPS	Irrigation Pump Station
LRAD	low-rate anaerobic digesters
LTS	land treatment system
MG	million gallons
MGD	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MM	maximum month
mmhos/cm	millimhos per centimeter
NFPA	National Fire Protection Association
NRCS	National Resources Conservation Service
OM	organic matter
PACE	Pace Engineers, Inc.
Permit	State Waste Discharge Permit Number ST0005369
ppd	pounds per day
PVC	polyvinyl chloride
PWRF	Process Water Reuse Facility
RAB	rotating algal biofilm
RAS	return activated sludge
Reclamation	US Bureau of Reclamation
RNG	renewable natural gas
RWW	Raw Wastewater
sf	square feet
s.u.	standard units
SAR	sodium adsorption ratio
SBR	sequencing batch reactors

Abbreviation	Definition
SCBID	South Columbia Basin Irrigation District
SEPA	State Environmental Policy Act
TDS	total dissolved solids
TN	Nitrogen
TSS	total suspended solids
UASB	Upflow Anaerobic Sludge Blanket
µmhos/cm	micromhos per centimeter
Valley	Valley Science and Engineering
VFD	variable frequency drive
WAC	Washington Administrative Code
WAS	waste activated sludge
Water Quality	Ecology's Water Quality Office
WW	Darigold dairy wastewater
WWTF	wastewater treatment facility

Chapter 1.0 Introduction and Background

The City of Pasco (City) owns and operates a facility for the treatment of industrial wastewater collected from fruit and vegetable processors. The Process Water Reuse Facility (PWRF) consists of a pretreatment and storage facility, as well as a land treatment system (LTS). These areas are located east of US-395 and north of the City limits as shown in **Figure 1-A**.

Figure 1-A – Vicinity Map



In recent years, a study was completed to evaluate future improvements to the PWRF: the 2019 *Process Water Reuse Facility Capital Facilities Plan/Engineering Report* (2019 Facility Plan) from PACE Engineers, Inc., and Jacobs Engineering Group, Inc. The 2019 Facility Plan was approved by the Washington State Department of Ecology (Ecology). However, due to existing processors' requests for flow and load increases, planned addition of new processors, and the City's improved program for collection and analysis of water quality data, flow and load projections have increased recently beyond those previously evaluated in the 2019 Facility Plan. As such, an Engineering Report inclusive of the current projections must be completed to properly plan improvements. This report will meet the requirements of an "Engineering Report" for an industrial wastewater facility in accordance with Washington Administrative Code (WAC) 173-240-130.

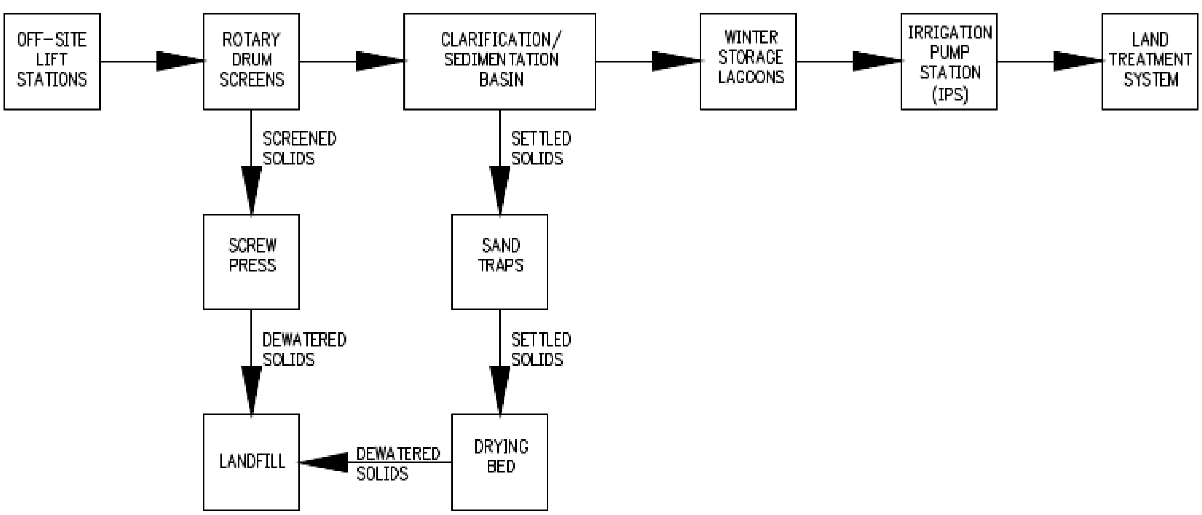
1.1 PWRF Overview

1.1.1 Existing Facility

The PWRF currently provides preliminary and primary treatment of influent process wastewater followed by land treatment via crop irrigation during the growing season. During the non-growing season, the pretreated influent process water is stored in large lined lagoons at the PWRF, referred to as winter storage lagoons. **Figure 1-B** shows a map of the existing site, and **Figure 1-C** shows a process schematic of the existing facility.

Figure 1-B – Existing Site Layout

Figure 1-C – Existing PWRF Process Schematic



1.1.1.1 Conveyance

Processors currently convey their wastewater to the facility via lift stations and force mains. The Foster Wells Lift Station (FWLS) pumps combined flows from Pasco Processing, Baker Produce, Reser's, and Twin City Foods, with temporary service to Freeze Pack. Simplot's process water is conveyed via its own private lift station and force main. A new lift station, the Columbia East Lift Station (CELS) is now operational and will be used to connect Freeze Pack and Grimmway to the PWRF.

Processors' discharges to the collection system are required by permit to meet a pH limit of 5 to 11 standard units (s.u.). Some processors add magnesium hydroxide or sodium hydroxide to meet this requirement.

1.1.1.1.1 Evaluation

The conveyance system provides adequate capacity for processor flows (**Table 1-A**). Simplot may eventually decommission its private lift station and instead connect to the CELS, which will require upgrades to the CELS capacity.

Table 1-A – Existing Lift Station Capacities

Lift Station	Capacity (gpm)
Foster Wells Lift Station (FWLS)	4,300
Columbia East Lift Station (CELS)	2,170
Simplot Lift Station (SLS)	1,200

The pH of process water at the PWRF is low, averaging below 6 s.u. at the influent and below 5 s.u. at the effluent to the irrigation system. The low pH conditions contribute to corrosion of the components at the PWRF and irrigation system and to the generation of odor problems at the PWRF and land treatment sites.

1.1.1.2 Preliminary Treatment

The combined influent process water enters the screenings building, where it passes through two above-grade and enclosed rotary drum screens. These screens provide very fine screenings (0.02 inches) and are intended to substantially reduce particulate Biochemical Oxygen Demand (BOD).

1.1.1.2.1 Evaluation

The two existing screens are needed in operation to pass peak hydraulic flows; therefore, there is no additional screening redundancy during peak conditions. Further, the screens plug frequently. There is insufficient water pressure to clean the screens, and operators expect warm water may be necessary to adequately clean the screens with such a small aperture size.

1.1.1.3 Primary Treatment

The screened influent process water then enters a single rectangular clarification and sedimentation basin intended to remove settleable solids. However, the rectangular clarification and sedimentation basin sludge collection mechanism failed due to the large volume of inert solids (sand and grit) that accumulated in the basin. The City has since added a series of pre-cast concrete tanks (sand traps) to collect inert solids, which is further discussed in **Section 1.1.1.4 – Solids Handling**.

1.1.1.3.1 Evaluation

The lack of a dedicated automatic grit removal system led to the failure of the rectangular sedimentation basin sludge collection mechanism and has prompted the need for the manual removal of settled solids. Although processors provide some level of sand and grit removal, the processor systems still allow a substantial amount of inert solids to be conveyed to the PWRF. A dedicated influent grit removal system is necessary to protect any future downstream treatment systems, and the system should be automated to substantially reduce the City's labor associated with the current process. Removal of inert solids by the industries should continue to be regulated and enforced through the individual processor permits.

1.1.1.4 Solids Handling

Solids screened by the rotary drum screens are removed via an auger and sent to the screw press for dewatering. Dry solids exit the screw press at the discharge and fall into a discharge box. These dewatered, screened solids are hauled offsite for livestock feed during the corn processing season or taken to a landfill during other processing seasons.

Solids settled in the clarification and sedimentation basin are removed via a wasting pump and further settled out in a parallel series of 12 sand traps. Settled sand from the sand traps is removed manually via vactoring and air dried on a paved drying bed prior to landfill disposal.

1.1.1.4.1 Evaluation

The screw press handling the solids removed from the screens is in a temporary configuration and is labor intensive. Solids removal is manual and expensive.

1.1.1.5 Land Treatment System

Process water outfalls to lined storage lagoons after primary treatment. During the irrigation season, an Irrigation Pump Station (IPS), newly constructed after the 2019 Facility Plan, draws from the storage lagoons and discharges to the LTS. The City owns 1,856 acres of agricultural land consisting of 14 center-pivot irrigated fields. Process water from the PWRF is land applied at this site, and supplemental irrigation is provided by separate City-owned irrigation wells located nearby.

Overall, the PWRF and land treatment system have two distinct periods – the non-growing season of December 1st to February 28th, and the growing season from March 1st through November 30th; however, the actual land treatment window is limited by weather. All pretreated process wastewater received from the industries during the non-growing season is stored in on-site lined lagoons until the irrigation season. The new storage described in this report will plan for an extended non-growing season, as discussed in **Chapter 6**.

1.1.1.5.1 Evaluation

Fixed dissolved solids applied to the fields currently exceed performance-based limits prescribed under the State Waste Discharge Permit (SWDP). Fixed dissolved solids are not removed in the PWRF.

Total nitrogen is not reduced before land treatment, which leads to more restrictive cropping choices and may result in exceedances of the agronomic rates for nitrogen application to the land treatment system.

High BOD contributes to odor problems at the land treatment sites. Additionally, operators at the PWRF have noted that fouling of the irrigation nozzles occurs frequently due to starches and organic and inorganic substances within the effluent. The proposed pretreatment system should reduce the BOD, starches, and other substances substantially.

The open storage lagoons can collect tumbleweeds and other debris, causing plugging of the irrigation system. Options should be evaluated to mitigate debris entering the irrigation system.

1.1.1.6 Winter Storage

The site has four lagoons, two of which, the 123 million gallon (MG) and 35 MG lagoons, are used for storage. Water first fills the 123 MG lagoon and then overflows to the 35 MG lagoon. A third 8 MG equalization lagoon can be used to buffer influent flow surges. According to operators, this lagoon is rarely used since its relatively flat, incorrectly sloped bottom makes it difficult to clean. A fourth 5 MG lagoon is used to capture drain water from the screen building and screw press, which is then pumped back to the headworks.

The 123 MG lagoon used to have a capacity of 115 MG, but it was regraded with the construction of the current IPS. The lagoon’s outfall is now at its southwest corner instead of the southeast corner.

1.1.1.6.1 Evaluation

The storage volume is insufficient for newly projected flows.

Odors at the site are significant due to the lack of BOD reduction ahead of the storage lagoons, but odors were significantly reduced by the recent cleaning of stored sediment in the 5 MG pond.

1.1.2 Review Previous Facility Plan Recommendations

The 2019 Facility Plan recommended the following near-term PWRF improvements:

1. Install a third, identical rotary drum screen in the existing headworks building to increase capacity and redundancy.

    Current Evaluation: The third rotary drum screen was intended to provide additional hydraulic capacity for the screening system. However, the increased flow and loading projections prompt renewed analysis of influent screening to support additional pretreatment improvements as discussed in this report.

    The existing very fine screens are intended to provide significant BOD reduction. However, most of the influent BOD is soluble and will not be removed through screening. If BOD reduction is desired, it must be provided through some form of secondary treatment. The type and configuration of a future screening system should be selected to provide sufficient screening and protection of any proposed secondary treatment system.

2. Provide a chemical pH adjustment system for control of pH downstream of the rotary drum screens.

   Current Evaluation: Chemical pH adjustment was intended to reduce odors and corrosion of components at the facility. Chemical pH adjustment needs to be considered relative to the other necessary treatment system improvements. The addition of chemicals should be used in a supporting role to other treatment processes and should be limited due to the operational cost and chemical cost. Chemical additions also increase the fixed dissolved solids (FDS) loading to the land treatment system, which is undesirable.

3. Provide a 90-foot-diameter circular primary clarifier intended to provide solids and grit removal, as well as BOD reduction.

   Current Evaluation: A new clarifier was intended to replace the failed rectangular clarification and sedimentation basin, as well as to replace the temporary sand traps installed as an interim measure for removing inert solids. However, without independent grit removal prior to primary clarification, the main concern would be with mechanism “binding” in dense settled sludge consisting of large quantities of inert solids, similar to the occurrence with the rectangular mechanism.

   Further, since a significant portion of the BOD loading is soluble, fine screens and primary clarification would not be expected to provide sufficient BOD reduction.

4. Provide flow equalization using the existing 35 MG lagoon.

   Current Evaluation: An equalization lagoon is intended to reduce peak flows into the pretreatment system. However, a renewed look at equalization is needed in the context of the currently projected flows and the equalization needs of future treatment processes.

5. Install surface aerators in the 35 MG equalization lagoon for stabilization.

   Current Evaluation: The 2019 Facility Plan proposed to install approximately 1,500 horsepower (hp) of surface aerators in the 35 MG lagoon to create an aerated stabilization basin. The intent was to provide some level of stabilization resulting in BOD reduction and reduced odors. Based on the current BOD loading projections, the total horsepower required to provide sufficient stabilization is much higher than that proposed by the 2019 Facility Plan. It is unlikely that the planned improvements will provide substantial stabilization or reduction in BOD. As discussed in **Chapter 3**, it would be necessary to add nitrogen and phosphorus to the influent wastewater to achieve significant BOD reduction in the aerated stabilization basin. Additionally, some biomass would accumulate within the aerated stabilization basin, requiring periodic sludge removal. The 2019 Facility Plan notes that solids handling pumps would be added for this purpose, but the method for removal, conveyance, dewatering, and off-site disposal is unclear. This would create a new solids handling waste stream for operators to manage.

The 2019 Facility Plan noted that biological treatment would be needed for future flow and loading conditions for BOD reduction. This report will analyze various methods for BOD reduction by the PWRF relative to the current loading projections.

6. Replace the lost 35 MG in storage (from converting the 35 MG storage lagoon to equalization) and provide an additional 86 MG of winter storage.

   Current Evaluation: Current flow projections will require more additional storage than projected in the 2019 Facility Plan and projected storage will be thoroughly analyzed in this report.

The City has not made pretreatment improvements to the PWRF since the 2019 Facility Plan was completed; suggested improvements should be reevaluated based on new flow and loading projections.

1.1.3 Changes Since 2019 Facility Plan

1.1.3.1 Flow and Loading Changes

Since the 2019 Facility Plan, the City has received interest from new and existing industrial users to discharge additional flow and loading to the PWRF. As discussed in **Chapter 3**, the City's recent sampling at processors' facilities as part of its improved program for data collection and analysis also shows higher loading than previously projected. **Exhibit 1-A** shows the PWRF, existing and proposed processors, and available land treatment area.

The 2019 Facility Plan analyzed near-term flow and loading for the following conditions:

- Phase 1 – The existing flow and load (from Pasco Processing, Freeze Pack, Twin City Foods, and Reser's) plus the addition of Simplot (at the original CRF Frozen Foods facility).
- Phase 2 – Phase 1 plus 30-percent growth by Reser's and the addition of Grimmway, which previously pretreated process water and discharged it to the municipal wastewater treatment facility (WWTF).

This report analyzes the following conditions:

- Existing – All Phase 1 processors from the 2019 Facility Plan using 2018 through 2021 data showing higher loading rates than previously predicted.
- Proposed – Increases to existing processors and the addition of Grimmway, a new Reser's facility, Darigold condensate of whey (COW), and Darigold dairy process wastewater (WW).

Table 1-B compares the flow and loading conditions from the 2019 Facility Plan to those measured in 2021. The previous report analyzed the seasonal periods of "summer" and "winter." This report will use the nomenclature of average annual day and maximum month average day, as discussed in more depth in **Chapter 3**.

Table 1-B – Comparison of 2019 Facility Plan Projections to Existing Conditions

	2019 Facility Plan Existing	2019 Facility Plan Phase 2	2021 Existing Data
PWRF Pretreatment Influent Parameter	**Summer Average Day**	**Summer Average Day**	**Maximum Month Average Day**
Hydraulic Loading (MGD)	3.0	5.83	3.86
BOD Loading (ppd)	18,800	43,274	220,000
TN Loading (ppd)	1,900	2,486	6,600

1. *The 2019 Facility Plan did not evaluate monthly maximum flows and loads, but instead separated flows and loads into winter and summer seasons for analysis.*

As shown in the table, 2021 BOD and nitrogen (TN) measurements at the PWRF influent are already above those projected in the 2019 Facility Plan's Phase 2 scenario. As will be evaluated in **Chapter 3**, the planned processor additions will bring PWRF loading even further above the 2019 Facility Plan's projections.

The 2019 Facility Plan pretreatment recommendations were intended to address existing plant deficiencies and support Phase 2 flow and loading but were not intended to support further flow and loading increases. The 2019 Facility Plan stated that biological treatment would be necessary for BOD and nitrogen reduction prior to storage and land treatment at flow and loading beyond Phase 2. As such, the 2019 Facility Plan's recommended improvements are no longer expected to be appropriate or effective.

1.1.3.2 Planned Improvements

Near-term improvements to the PWRF are currently planned in three construction phases.

Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities. City water for both drinking supplies and fire protection will extend from the East Foster Wells Road and Capital Avenue intersection to the IPS, screens building, and office trailer. Power and fiber will be relocated and transitioned from overhead to underground starting at the entrance to the PWRF at E Foster Wells Road to a transformer adjacent to the screens building. Two of the E. Foster Wells force mains will be relocated from the start of the PWRF access road at E Foster Wells Road to the IPS to be better aligned with existing force mains and provide a more uniform utility corridor for future utilities. Construction Phase 1 began in summer 2022. This phase is not further evaluated in this report.

Construction Phases 2 and 3 will construct the improvements identified in **Chapter 6** of this report. Phase 2 will be constructed on the United States Bureau of Reclamation's (Reclamation) 80-acre parcel north of the existing PWRF site. Phase 3 will be constructed on the west 40 acres of the parcel containing the existing PWRF site. Phase 2 provides additional winter storage through proposed lagoons and establishes a construction site for new pretreatment. Phase 3 will construct the new pretreatment improvements. Phases 2 and 3 construction is scheduled to begin in 2023.

Future expansion of the PWRF would occur on Reclamation's 80-acre parcel to the south of the existing PWRF site. The City is in the process of obtaining fee title for this parcel and anticipates transfer of ownership by early 2023. The City could use the south land to construct additional lagoons for winter storage. There currently is no schedule for the future expansion to the south as additional winter storage is not necessary based on currently proposed processor demands. Future expansion to the south is not further evaluated in this report.

1.2 Summary

Improvements to the PWRF will need to address existing facility deficiencies and accommodate newly projected growth. The 2019 Facility Plan pretreatment recommendations are no longer sufficient, so biologic pretreatment will be necessary prior to storage and land treatment. The following chapters will further evaluate improvements to pretreatment, winter storage, and land treatment.

Chapter 2.0 Regulatory and Planning Requirements

2.1 Discharge Permits

2.1.1 PWRF Permit

The PWRF is regulated by State Waste Discharge Permit No. ST0005369 issued by Ecology. The most recent permit was issued in May 2015, expired in June 2019, and is currently being updated. The permit specifies the following influent design criteria for the facility (**Table 2-A**).

Table 2-A – Existing PWRF Influent Permit Limits

Flow Max Month (MGD)	Flow Total Annual (MG)	BOD Max Month (ppd)	Total Nitrogen Total Annual (lbs)
10.6	1,003.4	355,600	866,246

Additionally, the permit regulates the water discharged to the LTS measured at the outfall of the PWRF. Land treatment rates cannot exceed the agronomic demand of the LTS for water and total nitrogen as determined in the annual Farm Operations Report. The treatment season is limited to March 1st through November 31st, and BOD application is limited to 100 pounds per acre per day (lb/ac/day).

Land treatment also must not cause a violation of the groundwater standards (Chapter 173-200 WAC) or the surface water quality standards (Chapter 173-201A WAC). To protect groundwater, the 2015 permit established interim limits for nitrate and FDS (**Table 2-B**). FDS is measured at the PWRF outfall prior to land treatment, and nitrate and pH are measured at groundwater monitoring wells in the land treatment area.

Table 2-B – Existing PWRF Effluent Interim Permit Limits

Effluent Limits		Groundwater Limits	
FDS Max Month (mg/L)	FDS Max Daily (mg/L)	Nitrate (mg/L)	pH (s.u.)
794	957	38.6	6.5-8.5

The permit also requires the PWRF to monitor influent and effluent flow and loading constituents and report results to Ecology in monthly Discharge Monitoring Reports (DMRs). At the influent, the PWRF continuously monitors flow, samples for pH weekly, and takes 24-hour composite samples for total nitrogen and BOD twice per month. At the effluent to land treatment, the PWRF continuously monitors flow, samples for pH weekly, takes 24-hour composite samples for total nitrogen, nitrogen species, BOD, and FDS twice per month, and takes 24-hour composite samples for sodium, calcium, magnesium, sulfate, chloride, alkalinity, and total phosphate twice per year.

2.1.2 Individual Processor Permits

Processors' discharges to the PWRF are regulated by Industrial Waste Discharge Permits issued by the City. Ecology delegated the responsibility to manage processors' permits to the City in 2015, before which Ecology issued the permits. **Table 2-C** shows a summary of current processor permit limits. Existing permits require the processors to continuously monitor flow, sample for pH daily, and take 24-hour composite samples for total nitrogen, BOD, total suspended solids (TSS), and FDS twice per month, and report their results to the City in monthly DMRs. Existing permits do not limit FDS discharges, but the City is expecting to establish FDS limits based on monitoring data and the capacity of the land treatment area as discussed in **Chapter 4**.

Table 2-C – Existing Processor Permit Limits

			Flow			BOD			TN	pH
Processor	Permit No.	Expiration Date	Max Month (MGD)	Total Annual (MG)	Winter Storage (MG)[a]	Max Month (ppd)	Max Day (ppd)	Max Month (mg/L)	Total Annual (lbs)	Min-Max (s.u.)
Current Dischargers to PWRF										
Pasco Processing	IWDP-000601	12/31/2023	2.5	384	80	-	127,000	-	270,000	5.0-11.0
Freeze Pack	IWDP-000700	6/30/2024	0.1	30	-[b]	200	250	-	15,000	5.0-12.0
Twin City Foods	IWDP-000101	9/30/2023	2.4	225	5	140,000	160,000	-	225,000	5.0-12.0
Simplot	IWDP-000201	12/31/2024	1.25	205	25	70,000	80,000	-	150,000	5.0-12.0
Reser's (Existing)	IWDP-000300	6/30/2020	0.3	115	35 [c]	7,200	-	-	72,000	5.0-12.0
TOTAL	**-**	**-**	**6.55**	**959**	**145**	**344,400[d]**	**-**	**-**	**732,000**	**-**
Other Processors										
Grimmway (Pretreated)[e]	IWDP-000501	6/30/2025	-	180	-	-		400	10,800	5.5-9.0

[a] *Existing permits define winter storage as discharges from December 1st to February 29th.*
[b] *Freeze Pack's winter storage allowance is included in Pasco Processing's limit.*
[c] *Reser's current permit does not include a winter storage limit, but the City has separate documentation showing their storage allocation.*
[d] *To estimate the total of maximum month BOD permit limits, 127,000 ppd BOD was used for Pasco Processing since the permit only has a maximum day limit.*
[e] *Grimmway began discharging to the PWRF's storage ponds in July of 2022. Grimmway currently pretreats its wastewater before discharge but is requesting to minimize pretreatment once improved pretreatment is provided at the PWRF. Not shown in the table, Grimmway's current permit also has limits for maximum daily flow (1.2 MGD) and maximum monthly TSS concentration (400 mg/L).*

2.1.2.1 Processor Permit Change Recommendations

New permits should be issued for all processors that will discharge to the PWRF. As seen in **Table 2-C**, not all processors are regulated by consistent criteria. When new permits are issued, it is recommended that all permits have consistent criteria, including maximum month, average annual, and winter storage limits for flow; maximum month limit for BOD; and average annual limit for total nitrogen. Interim limits for FDS concentration should also be added, which will be refined as FDS impact is studied throughout the next permit cycles. The addition of TSS permit limits is not necessary at this time since TSS is not a controlling factor for the design of the proposed treatment described in **Chapter 6**, but processors should still be required to provide grit removal to protect downstream equipment. Sampling frequency for loading should also be increased, likely to two times per week, to provide more representative data. Permit limits should be evaluated based on existing data and processor requests, as discussed in **Chapter 3**, as well as with regard to any future PWRF improvements that may necessitate updating permit conditions.

2.2 Other Permits

The following permits are anticipated for construction of the recommended improvements:

- Ecology Dam Safety Permit
- Ecology Air Quality Permit
- Ecology Water Quality Permit
- Ecology Biosolids Management Permit
- Bonneville Power Administration (BPA) Easement
- State Environmental Policy Act (SEPA) evaluation
- Local Permits:
  - Franklin County Building Permit
  - Franklin County Plumbing Permit
  - Franklin County Mechanical Permit
  - Franklin County Electrical Permit
  - Franklin County Conditional Use Permit
  - Benton Franklin Health District Solid Waste Handling Permit

Chapter 3.0 Evaluation of Processor Flow and Load

3.1 Introduction

The total influent to the PWRF consists of discharges from six industrial processors, including Pasco Processing, Baker Produce, Freeze Pack, Twin City Foods, Simplot, and Reser's. Additionally, Grimmway began discharging to the PWRF in July of 2022. Additional new discharges will include increased discharges from existing users, a new Reser's facility, and a new Darigold facility. **Exhibit 1-A** shows the processors, PWRF, and land treatment area.

No non-contact cooling water will be sent to the PWRF.

3.2 Summary of Existing Processors Discharging to PWRF

3.2.1 Pasco Processing

Pasco Processing is located at 5815 Industrial Way. The facility operates year-round to process assorted fruits and vegetables, including apples, cherries, beets, broccoli, carrots, cauliflower, corn, edamame, onions, parsnips, peas, peppers, potatoes, and squash. The fruits and vegetables processed vary seasonally and based on market demand. Vegetable processing includes cleaning/husking, sorting, cutting, blanching, freezing, and storing. Roasted vegetables and fruits are preprocessed by outside sources before arriving at the facility, where they are roasted, frozen, and stored.

Pasco Processing's pretreatment consists of mud bays, two rotary drum screens, and a dissolved air flotation device (DAF). The rotary drum screens remove solids greater than 0.02-inch diameter. A polymer is injected into the wastewater prior to the DAF, and then dissolved air is injected at the DAF, causing lighter solids to float to the top and heavier solids to sink to the bottom for removal. Magnesium hydroxide is added as needed to meet pH limits. The facility also has an oil/water separator for use in the event of an oil spill. The facility recycles water for washing vegetables using a separate system of settling channels and a rotary drum screen. The facility discharges pretreated wastewater via a gravity line to the FWLS, which then pumps to the PWRF.

Pasco Processing is owned by the Oregon Potato Company, the same parent company that owns Baker Produce and Freeze Pack.

3.2.2 Baker Produce

Baker Produce is located at 1505 E Foster Wells Road. The facility operates seasonally to process potatoes and onions. Potato processing includes washing, sorting, and packaging, and onion processing includes sorting and packaging. The facility recycles its wash water using a treatment system of screening, coagulation and flocculation, and hydrodynamic separators.

Baker Produce currently discharges wastewater to Pasco Processing's pretreatment system. Baker Produce currently does not have its own discharge permit, but the City is working on a new permit for it. For analysis in this chapter, Baker Produce's flow and loading are included in

Pasco Processing's flow and loading projections. When Baker Produce is transferred to its own permit, its flow and loading limits will be reallocated from Pasco Processing's permit limits.

3.2.3 Freeze Pack

Freeze Pack is located at 302 Venture Road. The facility has historically operated year-round to process onions, but in 2021 it only operated in June and July to process blueberries. Onion processing includes washing, cutting, slicing, blanching, and freezing. Blueberry processing includes washing and freezing.

Freeze Pack's pretreatment consist of two cisterns and a rotating drum screen. The facility also has a DAF unit downstream of the screen, but it is currently bypassed and not used for wastewater treatment. Sodium hydroxide can be added before the screen to raise the wastewater pH if needed, but it is not regularly used.

From 2015 until October 2020, Freeze Pack discharged to Simplot's discharge pit, combining its flow with Simplot's to the PWRF; however, this agreement ended, and in 2020 and 2021, Freeze Pack hauled its wastewater by truck to Pasco Processing. Freeze Pack has asked to have capacity built into the PWRF improvements based on its historical onion processing flow and load, but in 2022 it plans to only process blueberries from July through August. For its 2022 operating season, Freeze Pack connected into the new CELS. Now that the CELS is operational, Freeze Pack may process other fruits and vegetables in addition to onions, but this has not been determined. Freeze Pack will have to operate within the permit limits established by this report for any product it processes.

3.2.4 Twin City Foods

Twin City Foods is located at 5405 Industrial Way and primarily processes peas and corn. Corn processing involves steaming, husking, washing, cutting, sizing, blanching, and freezing; pea processing involves cleaning, blanching, freezing, sorting, sizing, and storing. Both processes have a cold storage warehouse. Processing of peas generally runs from early June to late July, and the corn season runs from late July to mid-October. Cob packaging and electronic product inspection runs generally from November through May. Twin City Foods also operates a repack operation year-round.

Twin City Food's pretreatment consist of three double-drum screens, also called dewatering reels, that remove particles larger than 0.02 inches. Liquid magnesium hydroxide is added to the wastewater stream for pH adjustment. Pretreated wastewater is then discharged via a gravity line to the FWLS, which then pumps to the PWRF.

3.2.5 Simplot

Simplot is located at 1825 N Commercial Avenue. The facility has historically processed assorted vegetables, including corn, peas, carrots, onions, and green beans. Processing involves cleaning, husking, cutting, blanching, and quick freezing the vegetables. The facility is planning to process potatoes year-round with other vegetables seasonally.

For pretreatment, wastewater passes through two drum screens followed by a discharge basin. The facility also has a DAF/cavitation air flotation (CAF) system and pH adjustment system, but these are not currently in use. Simplot currently discharges to its own private lift station and force main that pumps wastewater approximately 3.8 miles to the PWRF. The facility may eventually connect into the CELS once the CELS capacity is upgraded; this upgrade would be addressed in a design memorandum as an addendum to this report.

3.2.6 Reser's Existing Facility

Reser's existing facility is located at 5310 Industrial Way. When Reser's new facility (discussed in the following section) began operations, the existing plant was shut down. Since the future of the existing plant is unknown, if it restarts operations with discharge to the PWRF, its allowable flow and loading will be proportioned from the new permit limits established for the new plant.

The existing facility operated 24 hours per day, 5 days a week year-round to produce potato products and side dishes comprised of vegetables and pasta blends. The facility received raw potatoes and then washed, steamed, peeled, cooked, chilled, and packaged them. Some potatoes were further processed into shredded or mashed potatoes. The facility also cooked and packaged vegetables and pasta with seasonings for the side dishes.

The existing facility used a rotary screen for pretreatment. The wastewater regularly met pH limits without adjustment. Wastewater was pumped via a pipeline to the FWLS, which then pumps to the PWRF.

3.3 Summary of Future Processors Discharging to PWRF

3.3.1 Reser's New Facility

Reser's constructed a new facility at 5526 N Capital Avenue, which began operations in late August of 2022. The new facility processes potato products and side dishes year-round, like the existing facility. Reser's plans to gradually increase operations until reaching its typical operations in 2026.

The new facility may use a DAF for pretreatment if needed to meet permit limits. Otherwise, pretreatment is expected to be similar to the existing plant, with screening and pH adjustment as needed. The new facility will discharge to the FWLS for conveyance to the PWRF.

3.3.2 Grimmway

Grimmway is located at 1315 Dietrich Road. The facility processes carrots annually from July through November, with facility cleaning occurring in June and December. From July through November, the facility operates 24 hours per day, 5 to 6 days per week. The facility cuts, peels, chills, and packages the carrots.

Until mid-July of 2022, Grimmway discharged wastewater to the Kahlotus Pump Station, which pumps to the City's municipal WWTF. Starting in mid-July of 2022, Grimmway began discharging to the PWRF via a gravity line to the CELS. To meet permit limits, the facility currently pretreats process water prior to discharge; however, Grimmway is requesting to reduce its own pretreatment once the PWRF's proposed pretreatment improvements are completed. Currently, Grimmway's flows are sent directly to the storage ponds and do not receive pretreatment at the PWRF.

Grimmway's treatment system consists of screens, separators, filters, sediment removal bays, a DAF, and an aerated 3 MG equalization pond. The facility also recycles process water in some processes. Once the PWRF's proposed pretreatment improvements are completed, Grimmway plans to decommission its DAF and equalization pond, but will continue providing its own screening and grit removal.

3.3.3 Darigold

Darigold is proposing a new facility at 8201 N Railroad Avenue that will process dairy to produce protein powder and butter. These processes will produce two separate waste streams: COW water is the water produced when milk is evaporated; and dairy WW is the water produced from other dairy processing. The waste streams will be kept separate because COW water is expected to have minimal suspended solids in comparison to what is currently entering the PWRF system; therefore, it will not require pretreatment before land treatment. Darigold plans to provide screening and pH adjustment as needed to meet permit limits.

The facility is expected to start discharging minor low strength flows to the PWRF in February of 2024 and be fully online in July of 2024. Darigold will provide its own lift station and conveyance to the PWRF, with COW process water conveyed separately from dairy WW process water.

3.4 Historical Flow and Loading

3.4.1 Data Collection

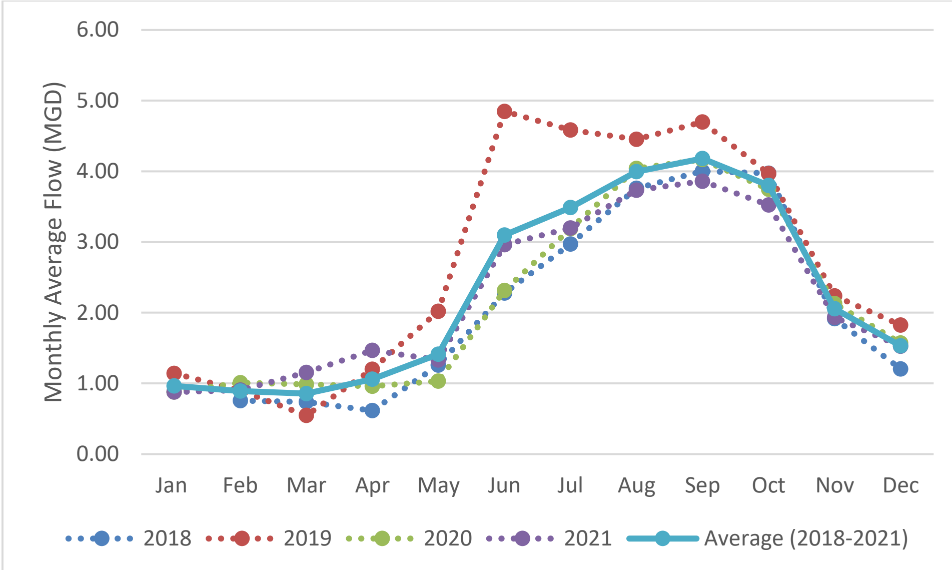
The historical data evaluated in this report includes data from the individual processors' DMRs, the PWRF's DMRs measuring the combined loading, and additional data from recent City sampling. Processors submit DMRs monthly to the City, and the PWRF submits DMRs monthly to Ecology as required by the City's permit. Starting in late July of 2021, the City began sampling at each processor and reporting these sampling results back to the processors to be used for their DMRs. The City's sampling data is considered to be the most reliable data available.

Some issues have been identified with the data provided in the processors' DMRs. First, sampling was relatively infrequent (currently twice per month by permit) and may not have been fully representative of load. As discussed in **Chapter 2**, it is recommended that processors' sampling frequency for loading be increased. Sampling procedures also may need to be improved by the processors. Further, variability was found between various labs used for testing, so now the City sends all samples to the TestAmerica lab for consistency.

3.4.2 Historical Flow

Flow data is available from continuous monitoring at each processor's effluent and the PWRF influent. The historical 2018 through 2021 PWRF influent flow is graphed in **Chart 3-A**.

Chart 3-A – Historical PWRF Monthly Average Influent Flow (2018 to 2021)



Flows have historically peaked in summer or early fall and been lowest throughout the winter. The highest average monthly flow since 2018 was 4.85 million gallons per day (MGD) experienced in June of 2019. For other years, the maximum month flow occurred in September. In most months, 2019 had higher flows than 2018, 2020, and 2021, but there is not a clear trend between years. **Table 3-A** breaks down the monthly flow from each processor.

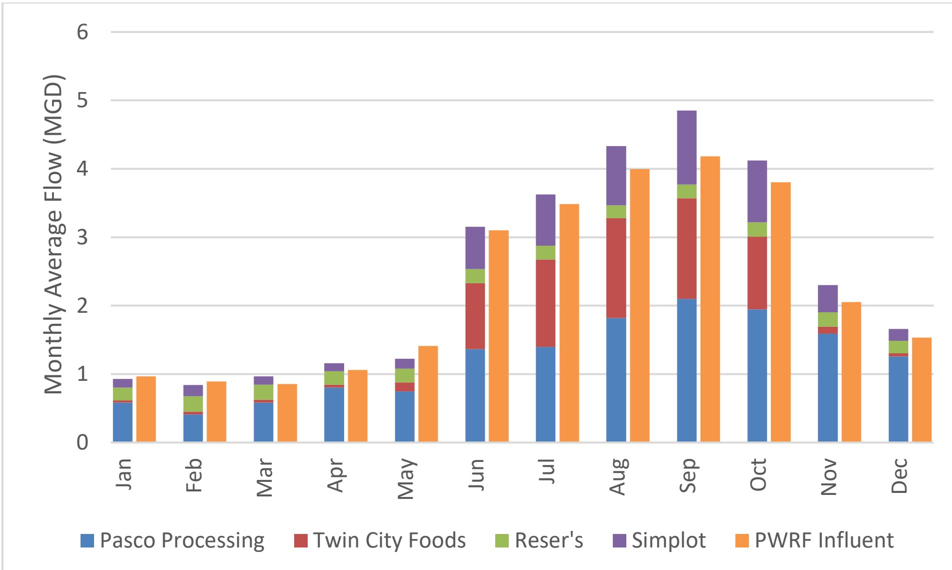
Table 3-A – Historical Average Month Flows (2018 to 2021) (MGD)

Month	Processor DMR Data					PWRF Influent Data
	Pasco Processing[a]	Twin City Foods	Reser's	Simplot[b]	Cumulative	
Jan	0.58	0.04	0.18	0.13	**0.93**	**0.97**
Feb	0.41	0.04	0.22	0.16	**0.84**	**0.89**
Mar	0.58	0.04	0.22	0.12	**0.97**	**0.86**
Apr	0.80	0.05	0.19	0.12	**1.16**	**1.06**
May	0.75	0.13	0.20	0.15	**1.22**	**1.41**
Jun	1.36	0.96	0.20	0.62	**3.15**	**3.10**
Jul	1.40	1.28	0.20	0.75	**3.62**	**3.49**
Aug	1.82	1.46	0.19	0.87	**4.33**	**4.00**
Sep	2.10	1.47	0.20	1.08	**4.85**	**4.18**
Oct	1.94	1.06	0.21	0.90	**4.12**	**3.80**
Nov	1.59	0.10	0.21	0.40	**2.30**	**2.06**
Dec	1.26	0.05	0.18	0.17	**1.66**	**1.53**

[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.
[b]Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.

Pasco Processing is the largest discharger to the PWRF year-round. Twin City Foods is the second largest discharger during summer months but the smallest discharger during winter months. Pasco Processing, Twin City Foods, and Simplot all have seasonal flow patterns that peak in September and remain low throughout the winter. Reser's discharges consistently year-round. **Chart 3-B** compares the sum of the processors' data to the PWRF's influent data.

Chart 3-B – Historical Monthly Average Processor Flow Data vs PWRF Influent Flow Data (2018 to 2021)



Based on **Chart 3-B**, in summer months the PWRF has recorded slightly lower influent flows than the processors report, and in some spring and winter months the PWRF has recorded slightly higher flows than the processors report. This discrepancy is likely due to variation between the PWRF's and processors' flow meters. Processors are required to maintain and calibrate their flow meters.

Table 3-B shows the average annual (AA) and maximum month (MM) flows for 2018 through 2021.

Table 3-B – Historical Average Annual and Maximum Month Flows

Processor	Flow (MGD)							
	2018		2019		2020		2021	
	AA	MM	AA	MM	AA	MM	AA	MM
Pasco Processing[a]	-	-	1.10	1.99	1.21	2.19	1.34	2.11
Twin City Foods	0.56	1.44	0.65	2.10	0.51	1.33	0.52	1.39
Reser's	0.26	0.29	0.24	0.28	0.19	0.22	0.12	0.17
Simplot[b]	0.47	1.29	0.58	1.59	0.44	1.00	0.34	0.76
Total Processor Data	**-**	**-**	**2.56**	**5.96**	**2.34**	**4.73**	**2.32**	**4.42**
PWRF Influent Data	**2.13**	**4.00**	**2.70**	**4.85**	**2.17**	**4.17**	**2.21**	**3.86**

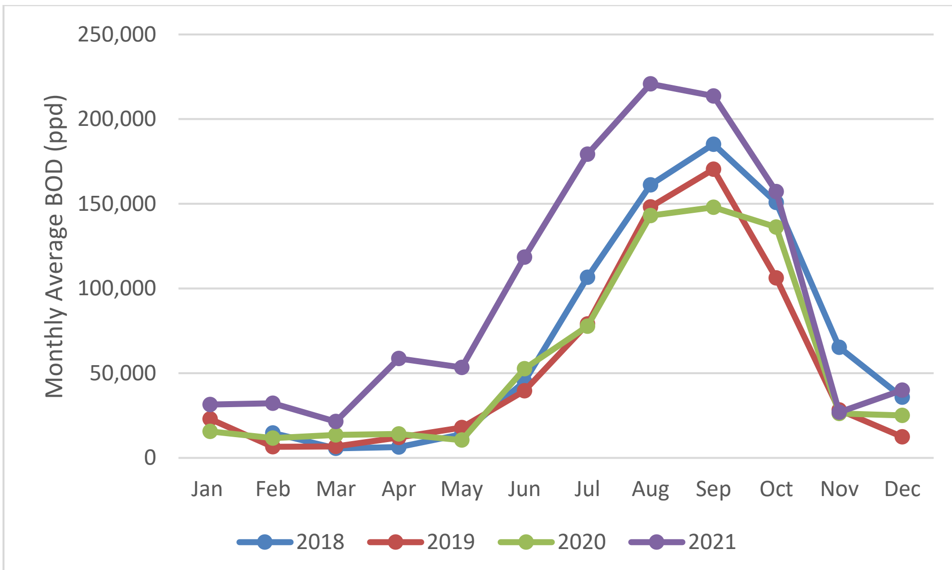
[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.
[b] Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.

Pasco Processing's highest average annual flow of 1.34 MGD occurred in 2021; however, according to plant operators, this was a higher than normal production year since one of the company's other plants was temporarily out of service. The other processors' highest average annual flows occurred in 2019, with 0.65 MGD for Twin City Foods, 0.24 MGD for Reser's, and 0.58 MGD for Simplot. Based on information from the Reser's plant operators, Reser's 2021 flow was lower than normal since the company is preparing to start up a new facility. The sum of the processors' maximum month flows are greater than that measured at the PWRF since not all processors' peak operating months coincide.

3.4.3 Historical BOD Loading

BOD data is available from sampling at each processor's effluent and the PWRF influent. Historical PWRF influent BOD loading is graphed in **Chart 3-C**.

Chart 3-C – Historical PWRF Influent BOD (2018 to 2021)



The BOD loading historically follows the same pattern as the flow, with loads peaking in summer or early fall and low loads throughout the winter. The historical maximum month BOD loading measured at the PWRF influent was approximately 222,000 pounds per day (ppd) in August 2021.

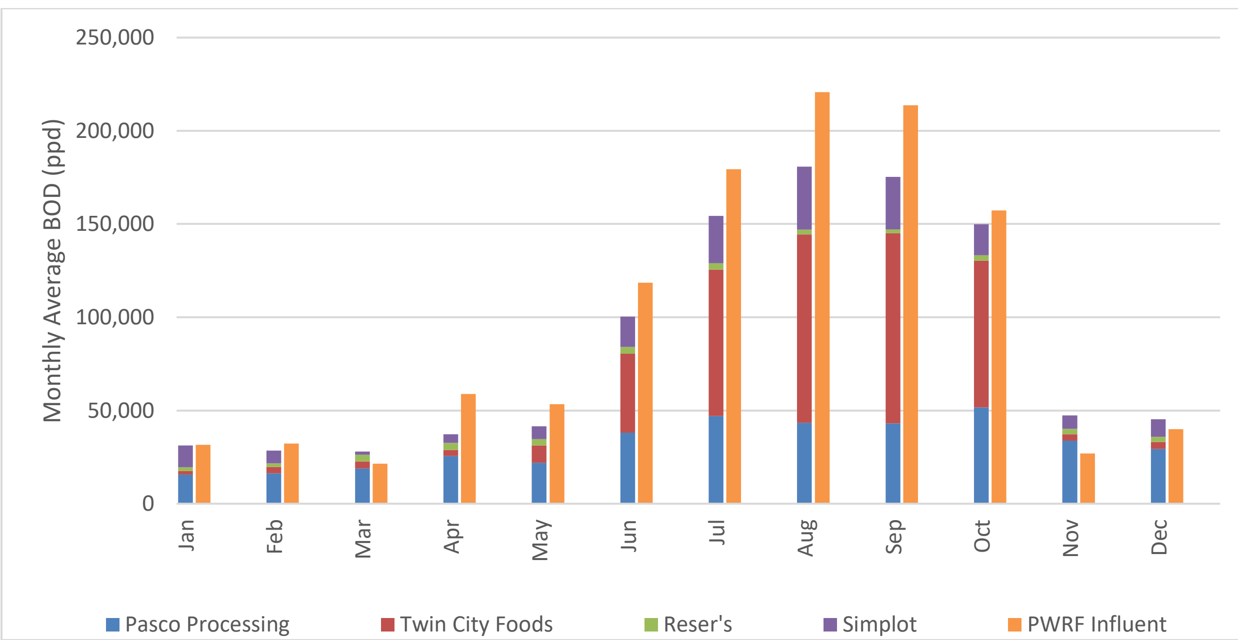
Table 3-C breaks down the BOD loading reported by the processors compared to the cumulative PWRF influent measurement, and **Chart 3-D** shows the monthly distribution in 2021.

Table 3-C – Historical BOD Loading (2018 to 2021)

Processor	BOD Loading (ppd)							
	Data Prior to City Sampling						Data Includes City Sampling	
	2018		2019		2020		2021[c]	
	AA	MM	AA	MM	AA	MM	AA	MM
Pasco Processing [a]	-	-	2,900	8,100	2,200	5,500	25,300	51,800
Twin City Foods	3,000	10,500	2,600	12,100	1,000	3,300	36,900	102,500
Reser's	3,900	6,000	4,200	4,900	3,700	5,200	3,200	7,100
Simplot[b]	1,200	3,200	2,400	9,600	1,100	2,400	10,400	33,600
Total Processor Data	**8,100**	**19,700**	**12,100**	**34,700**	**8,100**	**16,300**	**75,800**	**195,100**
PWRF Influent Data	**71,900**	**185,200**	**54,200**	**170,400**	**56,200**	**148,000**	**80,500**	**221,900**

[a] *Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*
[b]*Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.*
[c]*City sampling began in July of 2021; this table's data for July through December 2021 includes both processor DMRs and City samples.*

Chart 3-D – Historical Monthly Average Processor BOD Data vs PWRF Influent BOD Data (2021)



In **Table 3-C,** prior to 2021, the sum of the processors' BOD loading data is much lower than the BOD loading measured at the PWRF influent. The sampling and laboratory changes in 2021 are believed to have closed this gap significantly. In 2021, there is still a difference in the maximum month of about 25,000 ppd of BOD, but prior to 2021 this difference was greater than 130,000 ppd of BOD. The remaining difference between processor and PWRF measurements may be due to solids breaking down during conveyance from the processors to the PWRF. It also should be noted that processors' operations do not all peak in the same month, so the individual maximum month loadings would be expected to add up to more than the maximum month experienced at the PWRF. For example, the 2021 cumulative monthly processor load in **Chart 3-D** peaks at around 180,000 ppd in August, approximately 15,000 ppd less than the sum of all processors' 2021 maximum months. **Chart 3-D** also shows that in high flow months the PWRF has recorded higher influent BOD loading than the processors report, and in some low flow months the PWRF has recorded slightly lower loading than the processors report. As will be discussed in **Section 3.5 – Projected Flow and Loading**, a correction factor was applied to projected BOD loads for existing processors to account for the increase in loading measurements between the processors' facilities and the PWRF.

Table 3-D calculates the average BOD concentration during each processor's historic maximum month loading.

Table 3-D – Historical Maximum Month BOD Loading (2018 to 2021)

	BOD Load	Corresponding Month Flow [b]	Calculated BOD Concentration [c]		
Processor	ppd	MGD	mg/L	Month	Data Source
Pasco Processing [a]	51,800	2.03	3,100	Oct-21	Processor DMR
Twin City Foods	102,500	1.39	8,900	Sep-21	Processor DMR
Reser's	7,100	0.13	6,700	May-21	Processor DMR
Simplot	33,600	0.76	5,300	Aug-21	City Sampling

[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.

[b] Corresponding Month Flow is the average daily flow over the month when the maximum month BOD loading occurred. This is not necessarily the same as the maximum month flow experienced from 2018 to 2021.

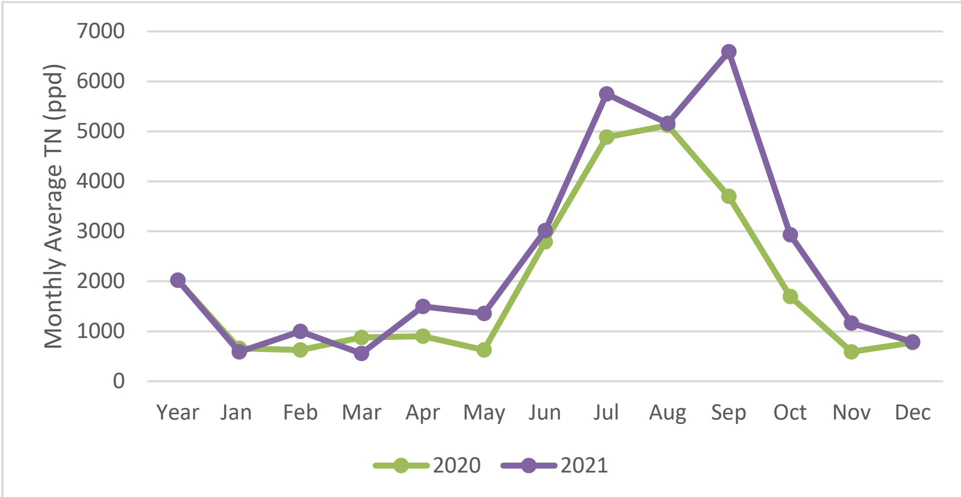
[c] BOD concentration was calculated from BOD load and corresponding month flow and rounded up to the next 100 mg/L.

The calculated historical maximum month BOD concentrations vary by processor, ranging from 3,100 milligrams per liter (mg/L) to 8,900 mg/L, with the lowest concentration for Pasco Processing and the highest concentration for Twin City Foods.

3.4.4 Historical Nitrogen Loading

TN data is available from sampling at each processor's effluent and the PWRF influent. Historical PWRF influent TN loading is graphed in **Chart 3-E**.

Chart 3-E – Historical PWRF Influent TN (2020 to 2021)



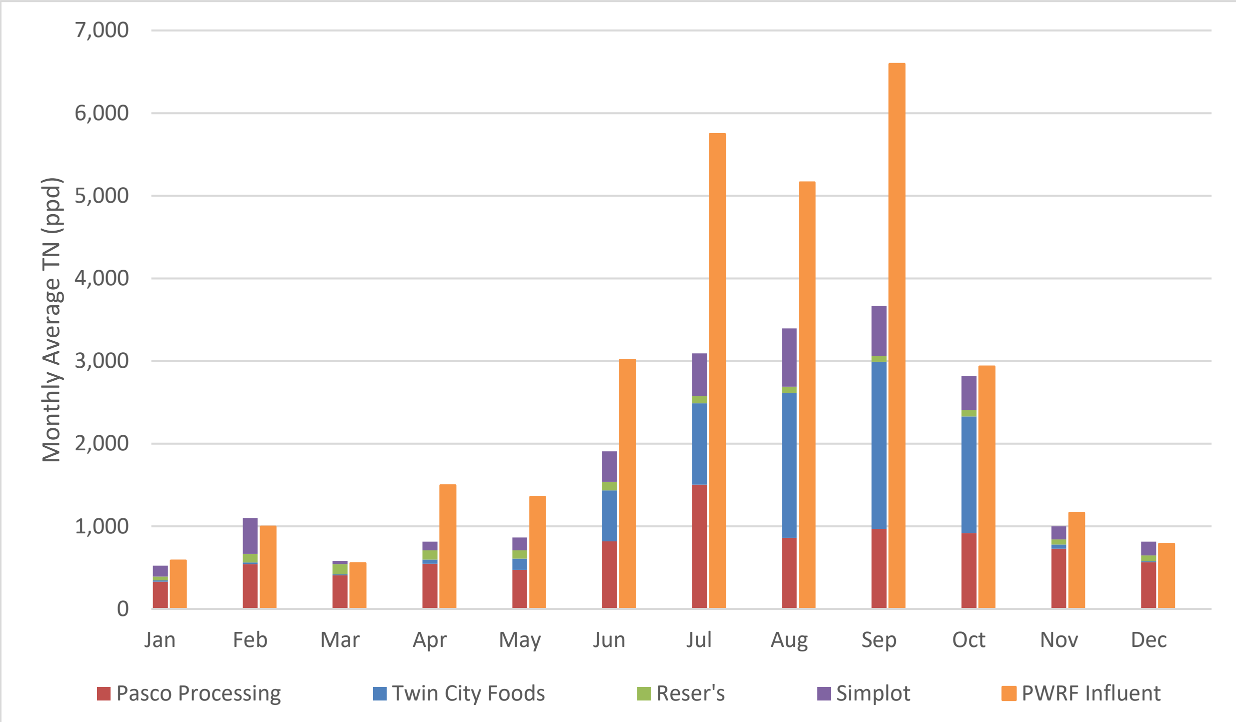
The TN loading historically follows the same pattern as flow and BOD, with loads peaking in summer or early fall and low loads throughout the winter. The historical maximum month TN loading measured at the PWRF influent was approximately 6,600 ppd in September 2021. **Table 3-E** breaks down the TN loading reported by the processors compared to the cumulative PWRF influent measurement, and **Chart 3-F** shows the monthly distribution in 2021.

Table 3-E – Historical TN Loading (2020 to 2021)

Processor	Historical TN Loading (ppd)			
	Data Prior to City Sampling		Data Includes City Sampling	
	2020		2021[c]	
	AA	MM	AA	MM
Pasco Processing [a]	320	610	720	1,500
Twin City Foods	110	280	590	2,020
Reser's	170	300	90	120
Simplot[b]	140	290	320	710
Total Processor Data	**800**	**1,500**	**1,700**	**4,400**
PWRF Influent Data	**1,900**	**5,100**	**2,500**	**6,600**

[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.
[b] Simplot's flow and loading includes 2020 discharges from Freeze Pack.
[c] City sampling began in July of 2021; this table's data for July through December 2021 includes both processor DMRs and City samples.

Chart 3-F – Historical Monthly Average Processor TN Data vs PWRF Influent TN Data (2021)



Like BOD loading, the sum of processors' TN loading data is lower than the loading measured at the PWRF influent, and the largest difference is in peak processing months. As will be discussed in **Section 3.5 – Projected Flow and Loading**, a correction factor was applied to projected TN loads for existing processors to account for the increase between processors' facilities and the PWRF.

Table 3-F calculates the average TN concentration during each processor's historic maximum month loading.

Table 3-F – Historical Maximum Month TN Loading (2020 to 2021)

Processor	TN Load ppd	Corresponding Month Flow [c] MGD	Calculated TN Concentration [d] mg/L	Month	Data Source
Pasco Processing [a]	1,505	1.64	110	Jul-21	City Sampling
Twin City Foods	2,024	1.39	180	Sep-21	City Sampling
Reser's	300	0.22	170	Nov-20	Processor DMR
Simplot[b]	707	0.76	120	Aug-21	City Sampling

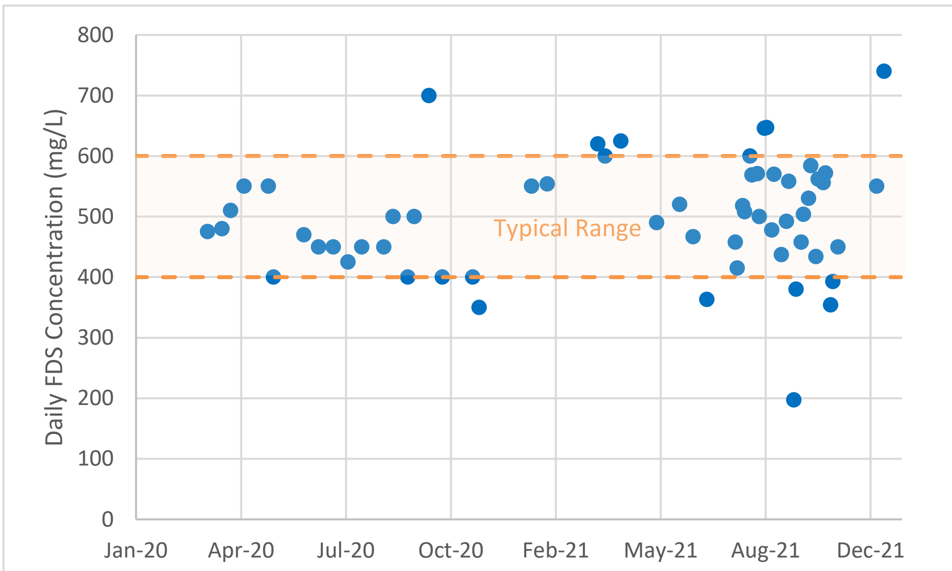
[a] *Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*
[b] *Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.*
[c] *Corresponding Month Flow is the average daily flow over the month when the maximum month TN loading occurred. This is not necessarily the same as the maximum month flow experienced from 2020 to 2021.*
[d] *TN concentration was calculated from TN load and corresponding month flow and rounded up to the next 10 mg/L.*

The historical maximum month TN concentrations vary by processor, ranging from 110 mg/L to 180 mg/L, with the lowest concentration for Pasco Processing and the highest concentration for Twin City Foods.

3.4.5 Historical FDS Loading

Historical FDS data is limited. Data from City sampling is available for all processors from July through December 2021 but was not sampled for earlier DMRs. At the PWRF, FDS is sampled at the effluent prior to land treatment (**Chart 3-G**), which has similar FDS content as the influent since the existing pretreatment has minimal impact on FDS.

Chart 3-G – Historical PWRF Effluent FDS Concentration Single Sample Values (2020 to 2021)



There is not a clear monthly pattern of FDS concentration variation, but the concentration averages around 500 mg/L, and most samples are between 400 and 600 mg/L. **Table 3-G** breaks down the FDS loading by processor.

Table 3-G – Historical FDS Loading (2021)

	Data Includes City Sampling		
	2021[b]		
Processor	Average Concentration	AA Flow	Calculated AA Load
	mg/L	MGD	ppd
Pasco Processing [a]	475	1.34	5,310
Twin City Foods	515	0.52	2,220
Reser's	730	0.12	730
Simplot	525	0.34	1,510
Total Processors	**505**	**2.32**	**9,800**
PWRF Effluent	**515**	**2.21**	**9,500**

[a] *Pasco Processing's flow and loading includes discharges from Freeze Pack and Baker Produce.*

[b] *This table uses City sampling data for July through December 2021.*

Since FDS was only measured at the processors during part of 2021, the average annual FDS loading could not be directly evaluated. Instead, the measured concentrations were averaged to estimate an average annual concentration, and then used to estimate the average annual load. Unlike BOD and TN, the weighted average FDS concentration from each processor is close to that measured at the PWRF, and the difference may be explained by variation in sampling equipment and sampling times.

3.4.6 Summary of Existing Flow and Loading

The existing (2021) flow and loading conditions to the PWRF are summarized in **Table 3-H**.

Table 3-H – Summary of Existing (2021) PWRF Flow and Loading

	Existing (2021)
Flow	
Annual Average Day (MGD)	2.21
Maximum Month Average Day (MGD)	3.86
Total Annual (MG)	807
BOD	
Annual Average Day (ppd)	80,500
Concentration (mg/L)	*4,368*
Maximum Month Average Day (ppd)	221,900
Concentration (mg/L)	*6,859*
TN	
Annual Average Day (ppd)	2,500
Concentration (mg/L)	*136*
Maximum Month Average Day (ppd)	6,600
Concentration (mg/L)	*205*
FDS	
Annual Average Day (ppd)	9,500
Concentration (mg/L)	*515*

3.5 Projected Flow and Loading

3.5.1 Introduction

Flow projections were made based on the processors' requests for growth and compared to the historical flow data. Loading projections were made based on the City's sampling data at existing processors, processors' requests for growth, and sampling data at facilities similar to new processors. To represent typical operating patterns, average monthly distributions were developed for flow, BOD loading, and TN loading. Since historic data showed an increase in BOD and TN loading measured at the PWRF influent compared to that measured at existing processors, an influent correction factor was added to the monthly projections. The peak month shown in the average monthly operating patterns is representative of the maximum month expected at the PWRF, even though processors have requested maximum month permit limits above their average operations.

3.5.2 Projected Flow

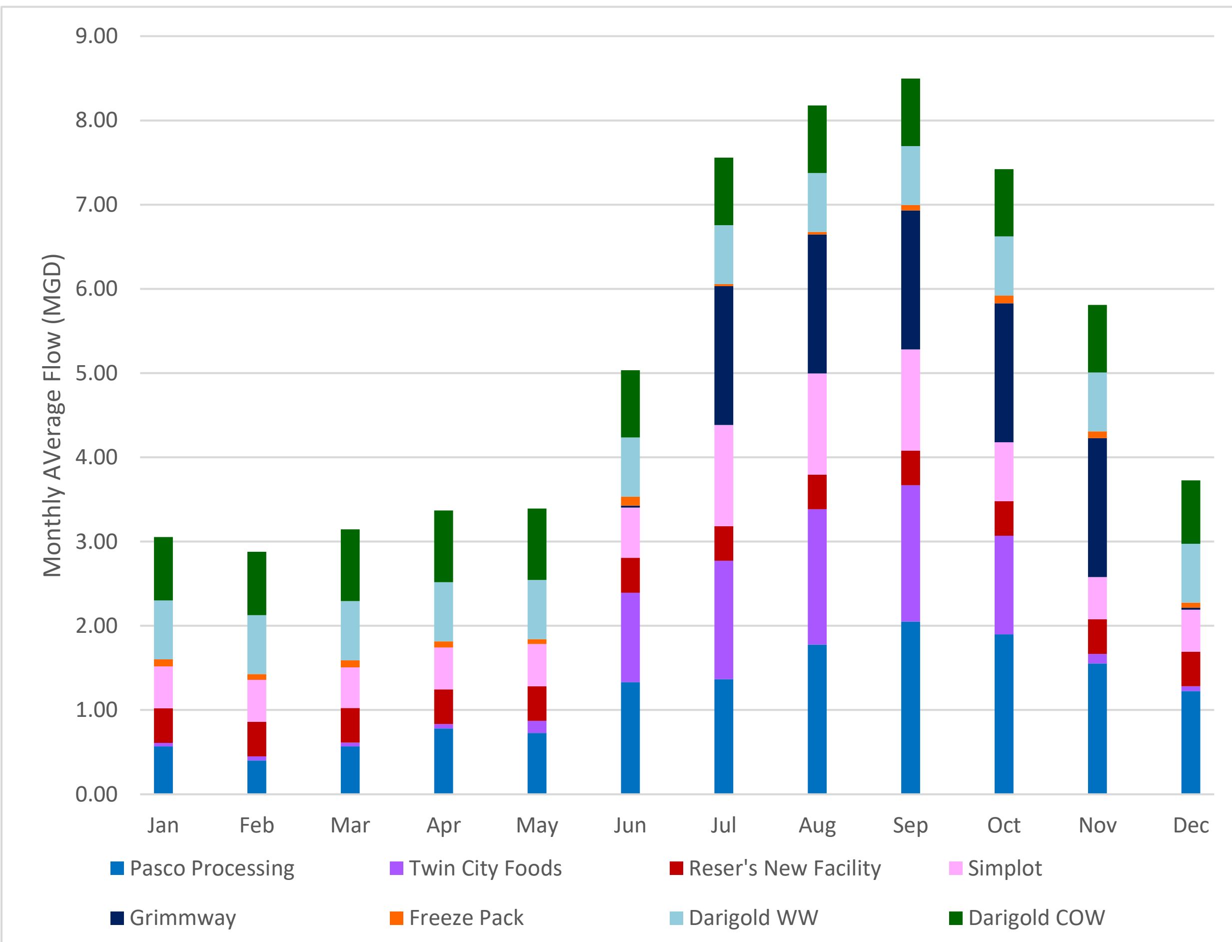
Each processor requested a total annual and maximum month flow limit to be accommodated with the PWRF improvements (**Table 3-I**). Annual flows were distributed by month to represent average operating patterns (**Chart 3-H**). Darigold's COW process water is tabulated separately from other processors' flows since it is low strength and will not require biologic treatment prior to land treatment. No non-contact cooling water will be sent to the PWRF.

Table 3-I – Projected Flow

	Total Annual Flow (MG)	Average Annual Daily Flow (MGD)	Max Month Daily Flow (MGD)[a]
Pasco Processing	435	1.19	2.50
Freeze Pack	25	0.07	0.11
Twin City Foods	225	0.62	1.80
Reser's New Plant	150	0.41	0.41
Simplot	255	0.70	1.25
Grimmway	254	0.70	1.65
Darigold WW	256	0.70	0.84
Total (no COW)	**1,600**	**4.38**	**8.56**
Darigold COW	292	.80	0.95
Total (with COW)	**1,892**	**5.19**	**9.51**

[a] *Conservative maximum month permit limit requested by industry.*

Chart 3-H – Projected Monthly Average Flow Distribution



Pasco Processing requested an increase from its current permit flow limit to increase its processing capacity. For the monthly estimates, this flow was distributed proportionally to the average flow pattern in its 2018 to 2021 DMRs. Pasco Processing's projected flow peaks in September and remains lower throughout the winter.

Freeze Pack requested to have capacity for its historical onion processing, so its allowance and distribution was based on flow from its 2019 DMR, the most recent year of onion processing. Freeze Pack makes up a very small portion of the flow and loading to the PWRF year-round.

Twin City Foods requested no changes, so its current permit flow limit will be planned for. Like Pasco Processing, the monthly estimates were achieved by distributing the annual flow proportionally to the average flow pattern in its 2018 to 2021 DMRs. Twin City Foods' projected flow peaks in August and September, with very low flows over the winter.

Simplot requested an increase from its current permit flow limit, and the processor provided an estimated monthly flow distribution. Simplot's projected flow peaks in July through September and remains lower in winter months. With the new flow distribution, Simplot expects to operate more over the winter than it has historically, so its seasonal variation is reduced.

For its new facility, Reser's requested an increase from its existing facility's current permit limit and expects consistent year-round flows. Reser's existing facility is not planned for separately, but if it restarts operations with discharge to the PWRF, its allowable flow and loading will be proportioned from the new permit limits established for the new plant.

Grimmway plans to follow a specific operating pattern. From January through May, the facility will produce no flows to the PWRF. Then in June, the facility will start-up with minor flows for cleaning. The facility will process produce from July through November with consistent flows, and then in December produce only minor flows for cleaning and winterizing.

Darigold plans to operate its dairy (WW) process consistently year-round with slight seasonal variation in its COW process.

Overall, **Chart 3-H** shows projected flow to the PWRF peaking in September at an average monthly flow of 7.7 MGD (8.5 MGD including Darigold COW), with lower flows throughout the winter. The overall system will be designed for the maximum month flow shown in **Table 3-I**, which is conservatively higher than the peak shown in the monthly average flow distribution.

Chapter 6 evaluates the winter storage needed based on the projected flow distribution.

3.5.3 Projected BOD Loading

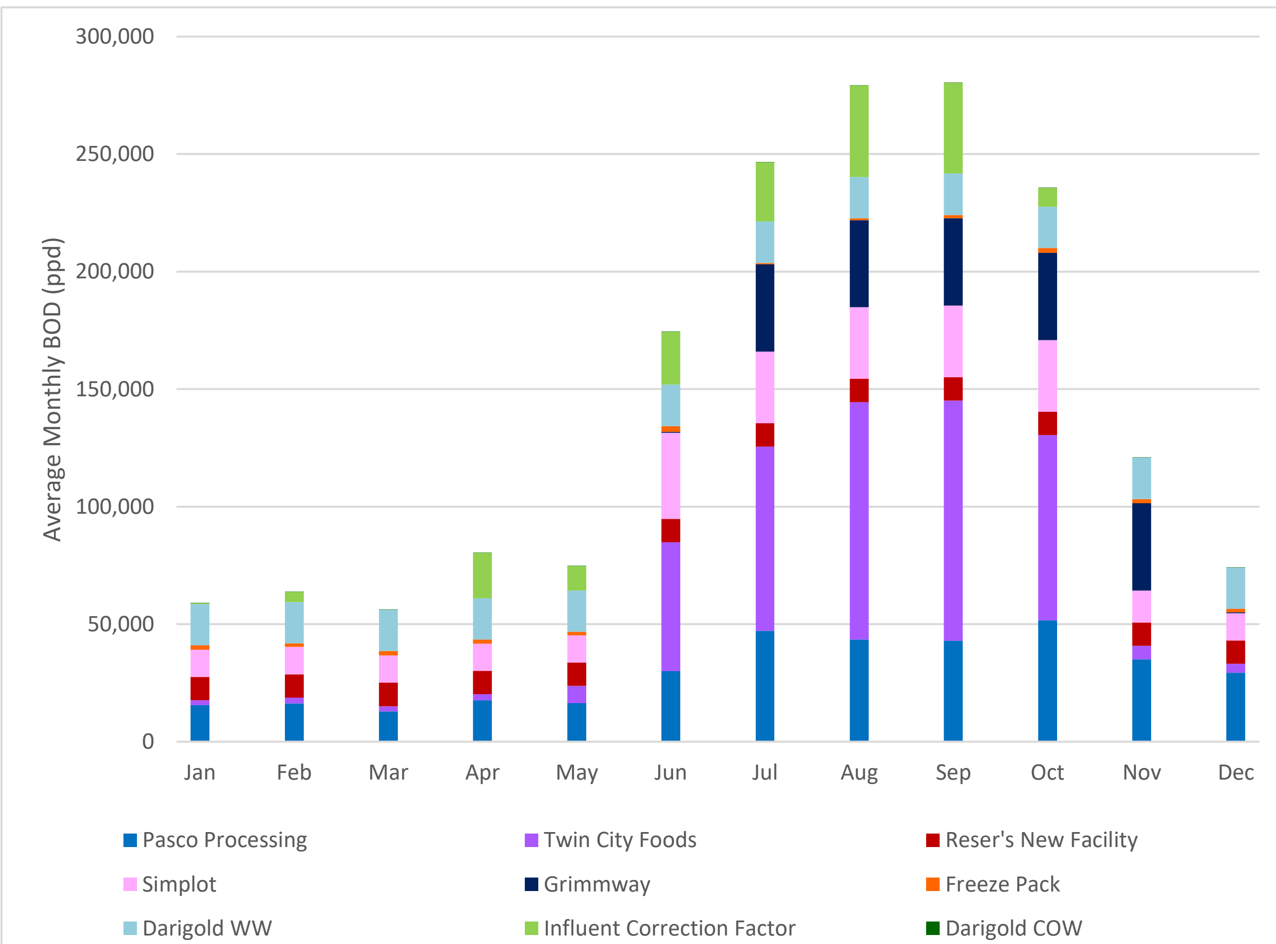
The projected average annual, maximum month, and monthly average BOD loading distributions were estimated for each processor (**Table 3-J** and **Chart 3-I**).

Table 3-J – Projected BOD Loading

Processor	Average Annual Daily Load (ppd)	Max Month Daily Load (ppd)[a]
Pasco Processing	30,000	65,000
Freeze Pack	1,600	2,600
Twin City Foods	37,000	105,000
Reser's New Plant	10,000	10,200
Simplot	20,200	70,000
Grimmway	15,700	37,200
Darigold WW	17,600	24,600
Influent Correction Factor	14,000	39,000
Total (No COW)	**146,000**	**354,000**
Darigold COW	33	40

[a] *Conservative maximum month permit limit requested by industry.*

Chart 3-I – Projected Monthly Average BOD Distribution



Loading projections for existing processors were made based on City-collected data at the existing facilities and processors' requests for growth. Since historical data showed higher BOD loading measured at the PWRF than at the processors, an influent correction factor was added for each month proportional to the difference in historical data. For months where data reported higher loading at the processors than the PWRF, no influent correction factor was added.

At Grimmway, samples of raw process water were collected before the facility's pretreatment system. These measurements were used to estimate the process water quality when the facility stops providing its own pretreatment.

The process water quality of Darigold's two streams was estimated based on sampling data collected at one of Darigold's similar facilities.

Overall, **Chart 3-I** shows projected BOD loading to the PWRF peaking in September at an average monthly load of 280,500 ppd (without Darigold COW), with lower loading throughout the winter. The overall system will be designed for the maximum month load shown in **Table 3-J**, which is conservatively higher than the peak shown in the monthly average load distribution. Twin City Foods is the largest BOD contributor, with most of its loading occurring from June through October. In order, the next highest BOD contributors are Pasco Processing, Simplot, Darigold WW, Reser's, and Grimmway. Darigold COW and Freeze Pack contribute very low BOD compared to the other processors.

From the monthly average loading distribution, the flow-weighted average BOD concentration to the PWRF pretreatment system each month was estimated (**Table 3-K**, excludes Darigold COW). The combined concentration to the PWRF varies each month as the ratio of flow between processors changes.

Table 3-K – Projected Monthly Average PWRF Pretreatment Influent BOD Concentration

Month	Average PWRF Influent Concentration (No COW) (mg/L)
January	3,250
February	3,760
March	3,060
April	3,900
May	3,560
June	4,960
July	4,400
August	4,600
September	4,410
October	4,320
November	2,940
December	3,070
Annual Average (Flow-Weighted)	**3,990**

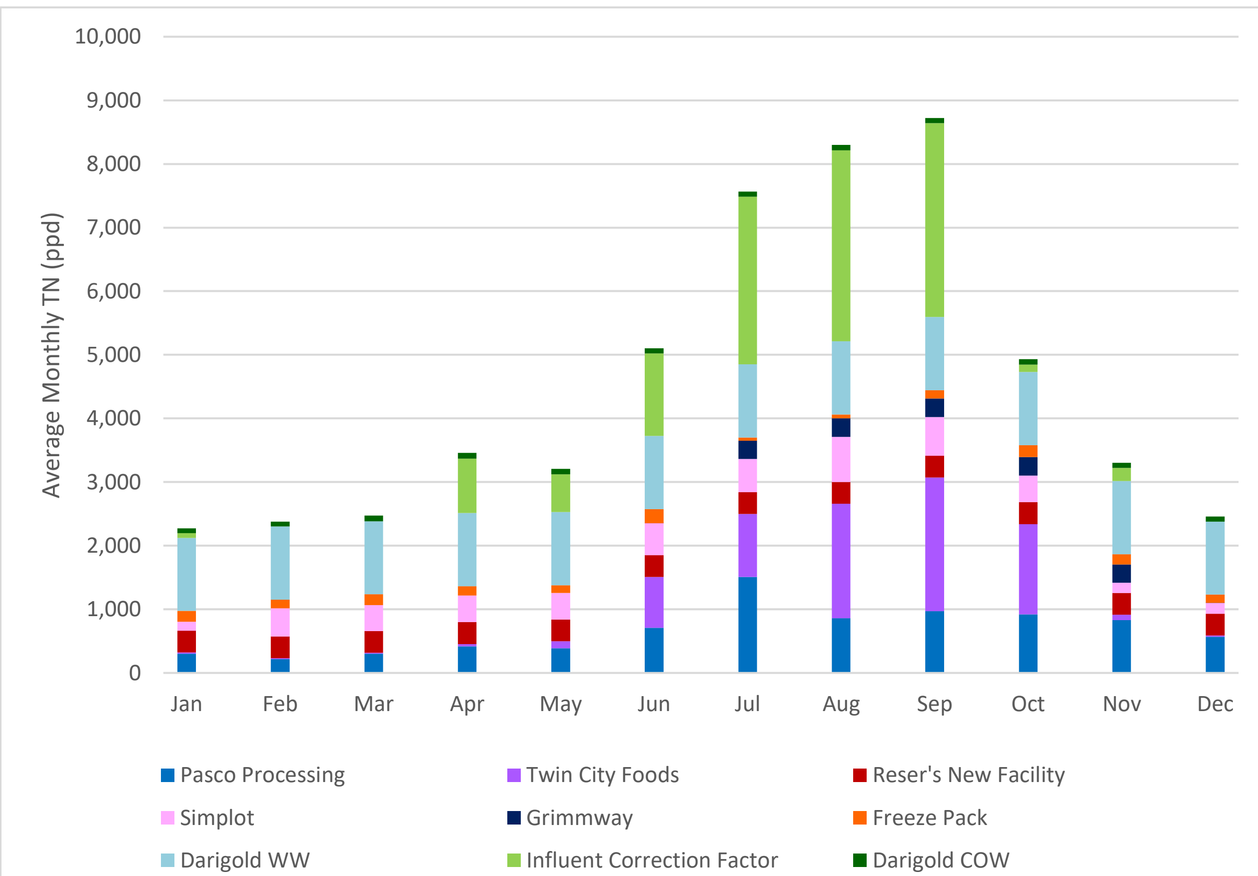
3.5.4 Projected TN Loading

Like BOD, average annual and average monthly TN loading distributions were estimated for each processor (**Table 3-L** and **Chart 3-J**). Projections were based on the same data sources and processor requests described for the BOD projections.

Table 3-L – Projected TN Loading

Processor	Average Annual Daily Load (ppd)
Pasco Processing	670
Freeze Pack	140
Twin City Foods	620
Reser's New Plant	345
Simplot	410
Grimmway	120
Darigold WW	1,150
Influent Correction Factor	990
Total (No COW)	**4,450**
Darigold COW	85

Chart 3-J – Projected Monthly Average TN Distribution



Overall, **Chart 3-J** shows projected TN loading to the PWRF peaking in September at an average monthly load of 8,640 ppd (without Darigold COW), with lower loading throughout the winter. The largest TN contributor is Darigold WW, followed by Pasco Processing, Twin City Foods, and Simplot.

From the average loading distribution, the flow-weighted average TN concentration to the PWRF pretreatment system each month was estimated (**Table 3-M,** excludes Darigold COW). Like BOD, the combined concentration to the PWRF varies each month as the ratio of flow between processors changes.

Table 3-M – Projected Monthly Average PWRF Pretreatment Influent TN Concentration

Month	Average PWRF Influent Concentration (No COW) (mg/L)
January	121
February	136
March	130
April	164
May	149
June	143
July	134
August	136
September	136
October	89
November	79
December	99
Annual Average (Flow-Weighted)	**122**

3.5.5 Projected FDS Loading

To predict FDS loading, an average concentration was determined for each processor, and the average annual load was calculated from the average concentrations and projected flows (**Table 3-N**). Average concentration for existing processors was determined from the City's sampling data at the existing facilities. An average concentration for Darigold's process water streams was estimated from sampling data collected at one of Darigold's similar facilities. Since historical data showed similar FDS measurements at processors compared to the PWRF, an influent correction factor was not added.

Table 3-N – Projected FDS Loading

Processor	Average Concentration (mg/L)	Average Annual Daily Load (ppd)
Pasco Processing	475	4,700
Freeze Pack	850	500
Twin City Foods	515	2,600
Reser's New Plant	730	2,500
Simplot	530	3,100
Grimmway	360	2,100
Darigold WW	1,655	9,700
Average (Flow-Weighted)	**690**	**-**
Total (No COW)	**-**	**25,200**
Darigold COW	105	710
Total (with COW)	**-**	**25,910**

From the average concentrations and flow distribution, the flow-weighted average FDS concentration to the PWRF each month was estimated (**Table 3-O**). The combined FDS concentration to the PWRF varies each month as the ratio of flow between processors changes. The concentration is highest in winter months since more of the flow comes from Darigold WW, which has the highest concentration of FDS.

Table 3-O – Projected Monthly Average PWRF Influent FDS Concentration

Month	Average PWRF Pretreatment Influent Concentration (No COW) (mg/L)	Average Concentration (All Processors) (mg/L)
January	960	740
February	980	740
March	950	710
April	890	690
May	870	680
June	730	630
July	610	550
August	620	570
September	600	550
October	630	570
November	640	570
December	830	680

3.5.6 Projected TSS Loading

Table 3-P summarizes the projected TSS loading. A monthly distribution was not evaluated since TSS is not a controlling factor for treatment. To remove inert solids and protect downstream equipment, individual processors and the PWRF should continue to provide grit removal.

Table 3-P – Projected TSS Loading

Processor	Average Annual Daily Load (ppd)	Max Month Daily Load (ppd)
Pasco Processing	15,910	42,500
Freeze Pack	320	550
Twin City Foods	13,580	50,800
Reser's New Plant	7,310	10,800
Simplot	12,360	20,000
Grimmway	1,690	13,770
Darigold WW	2,330	2,790
Influent Correction Factor	25,000	87,000
Total (No COW)	**82,700**	**228,300**
Darigold COW	170	200

3.5.7 Summary of Projected Flow and Loading

Projected flow and loading to the PWRF is summarized in **Table 3-Q** and in **Appendix 3-A**. The overall system will be designed to receive the average annual and maximum month flow and loading in **Table 3-Q**, and will be evaluated for the monthly average flow and loading distributions in **Appendix 3-A**.

Table 3-Q – Projected PWRF Influent Design Criteria Summary

	Processors, Excluding Darigold COW	Darigold COW
Flow		
Annual Average Day (MGD)	4.38	0.80
Total Annual (MG)	1600	292
Maximum Month Average Day (MGD)[a]	8.56	0.95
BOD		
Annual Average Day (ppd)	146,000	33
Average Concentration (mg/L)	*4,000*	*5*
Maximum Month Average Day (ppd) [a]	354,000	40
TN		
Annual Average Day (ppd)	4,450	85
Average Concentration (mg/L)	*122*	*13*
FDS		
Annual Average Day (ppd)	25,200	710
Calculated Average Concentration (mg/L)	*690*	*105*

[a] Conservative maximum month permit limit requested by industry.

Other loading constituents will be discussed in **Chapter 4** as they relate to land treatment.

As will be discussed in **Chapter 4**, the projected nitrogen loading from raw process water will significantly exceed the capacity of the existing LTS, as well as that provided by the land available for LTS expansion (Beus and Voss properties), so pretreatment is needed.

As will be discussed in **Chapter 5** and **Chapter 6**, the selected method of pretreatment is screening and grit removal for preliminary treatment followed by low rate anaerobic digesters (LRADs) and rotating algal biofilm (RAB) for biologic treatment. The biologic systems are sized to reduce loading to within the LTS capacity. The pretreatment system design combines process streams from different levels of pretreatment: some process water receives preliminary treatment only; some receives preliminary and LRAD treatment; and some receives preliminary, LRAD, and RAB treatment.

Two annual scenarios were developed to model effluent flow and loading sent to either storage lagoons or the LTS each month. The Average Annual Scenario is summarized in **Appendix 3-B,** and the Maximum Month Scenario is summarized in **Appendix 3-C**. The Average Annual Scenario describes the projected monthly average operating patterns for each processor presented in this chapter and is considered the typical operating scenario. The Maximum Month Scenario describes a theoretical scenario where all processors operate at their maximum month permit limits in August and September, and then produce lower flows in other months to stay within their average annual permit limits. The Maximum Month Scenario will be used in **Chapter 4** to evaluate the LTS since it is more conservative for evaluating loading to the fields.

Chapter 4.0 Evaluation of Land Treatment System

4.1 Project Description

4.1.1 Introduction and Purpose

The City of Pasco (City) treats and reuses food process wastewater (process water) from a variety of vegetable processing facilities (Food Processors) by irrigation to agricultural crops in a City-owned land treatment system (Site). The process water is currently applied to a total of 1,856 acres of agricultural land. The Site is operated within the terms of State Waste Discharge Permit Number ST0005369 (Permit), effective July 1, 2015 (Washington Department of Ecology 2015). An additional 514 irrigated acres are proposed for expansion of the land treatment system.

The purpose of this engineering report chapter is to describe, characterize, and clarify the technical and environmental aspects of the proposed expansion. This chapter does not provide final design plans that can be used for construction of improvements, but rather outlines the design parameters to meet the stated objectives. The proposed expansion fields are not yet connected to the land treatment system. This chapter is specifically designed to provide sufficient information to allow the addition of the proposed fields to the Permit for the expressed purpose of using process water irrigation as a water supplement and partial fertilizer nutrient supply.

Except for items addressed in other chapters, this chapter has been prepared to comply with the requirements for an Engineering Report in “Guidelines for Preparation of Engineering Reports for Industrial Wastewater Land Application Systems” (Washington State Department of Ecology, Water Quality Program 1993) and the Washington Administrative Code (WAC) Chapter 173 Section 240 (Submission of Plans and Reports for Construction of Wastewater Facilities, 173 WAC § 240 2000).

4.1.2 Food Processors

Currently, there are 6 Food Processors including Reser’s Fine Foods, Pasco Processing, Twin City Foods, Freeze Pack, Simplot RDO, and Grimmway Enterprises (**Exhibit 4-A**). The City anticipates additional processors in the near future including Darigold, which will contribute both process water and COW water (containing low concentrations of nitrogen and salts) in separate conveyances (**Exhibit 4-B**). The City plans to phase in new Food Processors and provide sufficient, additional process water treatment capacity with additional pretreatment components and the proposed expansion.

4.1.3 Land Treatment Site

The existing Site consists of 14 center-pivot irrigated fields (Circles 1 – 13 and 15) (**Exhibits 4-A** and **4-C**). Crops typically include alfalfa, potato, triticale, and corn. Little Circles 2 and 7 are operated as part of Circles 2 and 7, respectively. Irrigation flow to Little Circles 2 and 7 is possible only as part of the flow to Circles 2 and 7, respectively; flow monitoring to each of these large circles includes the flow to their respective little circle. All aspects of operation and management (e.g., irrigation, tillage, planting, harvesting, etc.) are identical on the respective circles. All reporting related to Circles 2 and 7 includes their respective little circle.

During the irrigation period, March through November, the process water is land applied to the circles for final treatment. The process water is conveyed from the storage ponds into the Irrigation Pump Station (IPS) and pumped to the circles for crop irrigation.

4.1.4 Land Treatment Site Expansion Circles

The City plans to expand the land treatment site by 514 acres (**Exhibit 4-A**). The City will own 408 acres within Circles V16, V17, Little V17 (collectively considered Circle V17), and V18 (**Exhibit 4-C**). Circle B19, comprising of 111 acres, will receive process water and be managed by the City via a long-term lease with the property owner.

4.1.5 Fresh Water

Fresh water is provided from groundwater wells on the Site to help meet the supplemental irrigation needs (crop water requirements) of the crops. Fresh water, with the exception of expansion Circle B19, can be blended with process water at each circle or applied independently depending on the requirements of irrigation operations. Expansion Circles V16, V17, and V18 receive fresh water from the South Columbia Basin Irrigation District (SCBID) via canal. Circles V16, V17, and V18 receive an additional irrigation water contribution from an underdrain network installed under Circles V17 and V18.

4.1.6 Process Water and Cow Water

Process water is conveyed from the Food Processors to the Process Water Reuse Facility (PWRF) via underground pipelines (**Exhibits 4-A** and **4-B**). Process water from Reser's Fine Foods, Twin City Foods, and Pasco Processing flows via gravity to the Foster Wells pump station from which it is then pumped approximately 2.5 miles. Process water from Simplot RDO is pumped approximately 4 miles to the PWRF from the Simplot RDO pump station, while the combined process water from Freeze Pack and Grimmway will be pumped approximately 6 miles from the Columbia East Lift Station. Darigold process water and cow water will be pumped approximately 2 miles via separate conveyances from the Darigold pump station.

4.1.7 Projected Treatment and Storage

The City evaluated the Site capacity (**Section 4.4.3**) compared to the projected untreated process water loads (**Table 3-Q**) and determined pretreatment is required. In summary, the process water will be pretreated for liquid-solid separation via screening, biochemical oxygen demand reduction via low rate anaerobic digesters, and nitrogen reduction via rotating algal biofilm (**Exhibit 4-B**).

The process water and COW water will be stored in separate lined storage ponds during the non-irrigation period (December through February). As discussed in **Chapter 6**, total storage capacity will be 487 MG, of which, approximately 106 MG will be separate and dedicated to the Darigold COW water, which will not receive pretreatment (**Exhibit 4-B**). The example land treatment design flows as described in the following sections of Chapter 4 were the basis for the storage pond design capacities to ensure sizing was sufficient to store the monthly accumulation of process water and COW water prior to land application.

4.1.8 Flow Measurement

Flow meters are used to monitor incoming and outgoing process water flow, process water load by circle, and supplemental fresh water load by circle. Incoming flow is monitored ahead of the pretreatment system, while the outgoing flow is monitored at the irrigation pump station before discharge to the land treatment site (**Exhibit 4-B**). In addition, each circle is equipped with flow meters to independently measure the process water and supplemental fresh water loads to each circle. The circle-specific flows are used to determine circle-specific constituent loads and water balances.

4.1.9 Domestic Wastewater

Domestic wastewater produced at the PWRF is discharged to a septic system and leach field for final treatment and disposal. No domestic sanitary wastewater is discharged to the Site.

4.1.10 Stormwater

Stormwater discharge from the PWRF infiltrates into the surrounding ground surface or is directed into the PWRF treatment system. A Stormwater Pollution Prevention Plan is located on file at the PWRF.

4.2 Site Use and Considerations

The existing Site is located approximately 5 miles north of the City, 1 mile east of U.S. Highway 395, and north of East Foster Wells Road (**Exhibits 4-A** and **B**) and includes:

- Sections 3, 11, and 2 (N ½ and SW ¼), Township 9 North, Range 30 East of the Willamette Meridian
- Section 34 (S ½), Township 10 North, Range 30 East of the Willamette Meridian

All existing acreage is owned and operated by the City.

The expansion Circles V16, V17, and V18 are located adjacent to the north end of the existing Site and expansion Circle B19 is located approximately 1 mile west of the existing Site at the following locations:

- Circles V16, V17, and V18: Section 27 (S ½ of the NE ¼, and SE ¼; Section 34 (NE ¼, and E ½ of the NW ¼) Township 10 North, Range 30 East of the Willamette Meridian
- Circle B19: Section 32 (SE ¼) Township 10 North, Range 30 East of the Willamette Meridian

4.2.1 Historical Land Use, Land Ownership, and Neighboring Land Uses

Land use in the area of the Site ranges from irrigated agriculture to urban development approximately 2 miles away. The area immediately surrounding the Site is agricultural land and farm residences. A confined animal feeding operation is located approximately 0.3 miles from the northwestern corner (Circle 13) of the land treatment fields (**Exhibit 4-C**). The Snake River is approximately 3 miles south and the Columbia River is approximately 5 miles southwest (**Exhibit 4-A**).

4.2.2 Climate

Climate conditions including precipitation and crop evapotranspiration (ET) are important considerations of a land treatment system. Precipitation and ET rates are used in the circle-specific hydraulic budgets.

The climate consists of a relatively cool, moist fall and winter, with a relatively hot, dry spring and summer. The average monthly and annual precipitation for the Site was determined using data from the Washington State University AgWeatherNet CBC Pasco weather station, which is located about 5 miles west of the Site at an elevation of 404 ft amsl (Washington State University n.d.). The elevation of the Site is slightly higher at about 500 ft amsl. The long-term (2001-2021) average precipitation is 5.7 inches. The 10-year return frequency high precipitation (highest precipitation expected every 10 years) is 8.3 inches, which is derived from the second highest precipitation year in the last 20 years of recorded data (**Table 4-A**, **Appendix 4-A1**).

4.2.3 Topography and Surface Hydrology

The Site is located in an area that is nearly level to gently sloping to the east. The elevation of the existing Site is in the range of 450- to 550-ft amsl and generally slopes to the east and southeast. The northern and western parts of the Site drain south and east toward the central and eastern circles. Drainage to the east is blocked by Piekaraski Road, and Circle 1 would drain to the southeast toward Lower Smith Canyon.

4.2.4 Expansion Circles

Circles V16, V17, and V18 range in elevation between 510- to 570-ft amsl. Circle V16 has a maximum slope of approximately 3.8% and an average slope of 1.3% generally to the southeast. Circle V17, including Little Circle V17, and has a maximum slope of approximately 2.2% with an average slope of less than 1.0% generally to the southeast. Circle V18 has a maximum slope of approximately 2.5% with an average slope of less than 1.0% generally to the southeast. Circle B19 ranges in elevation between 525- to 555- ft amsl. Circle B19 has maximum slope of approximately 2.7% with an average slope of less than 1% generally to the north and east.

4.2.5 Soil Characterization

The existing Site and expansion circles are included in the Soil Survey of Franklin County, Washington (U.S. Department of Agriculture - Soil Conservation Service 2006) and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Web Soil Survey (Soil Survey Staff, Natural Resources Conservation Service n.d.). The soils of the existing Site were characterized by direct observation during a field evaluation in November 2017 by a Valley Science and Engineering (Valley) soil scientist. Soils for the “V” circles and “B” circle were investigated by a Valley soil scientist in October 2021 and June 2022, respectively.

The purpose of the soil characterization was to understand the extent of the soils and to quantify their properties, especially those relevant to the capacity of the Site for process water. Field work commenced with reconnaissance across the Site to identify areas with soil that were expected to be the major soil types compared to the soil survey mapping. Soil pits were excavated in locations specifically selected to observe the soil profiles for comparison to the available soil survey information and to collect soil samples. Soil investigations also occurred using auger borings to 60 inches. The physical and chemical properties of the soil samples were determined through laboratory analysis. The field observations and laboratory analysis results generally confirm that the published soil survey information is accurate. Therefore, the soil survey information can be used to determine the extent of the soil types across each circle and calculate their estimated soil water capacity.

The soils predominantly consist of mixed eolian sands, with minor portions of underlying glaciofluvial deposits. Additional soils consisting of sandy alluvium and loess over layered lacustrine deposits make up approximately 10% of the remaining soils. The soil textures across the Site are predominantly loamy fine sand or sandy loam surface soils underlain by fine sand or loamy fine sand. There are 11 soil map units identified across the Site (**Table 4-B, Exhibit 4-D**, and **Appendix 4-B**). The soil units and key characteristics are summarized here.

- **Soil Map Unit 29** – Hezel loamy fine sand, 0- to 15-% slopes (approximately 7.9% of the irrigated area). Hezel soils consist of very deep, somewhat excessively drained, typically consisting of soils with a loamy find sand surface over fine sandy loam subsoil. Hezel soils occur on dissected terraces and terrace escarpments. This soil is limited to the central and eastern portion of V17, eastern portion of V18, central and northeast part of Circle 1, a portion of the north half of Little Circle 2, and is the predominant soil of Circle 12.
- **Soil Map Unit 43** – Kennewick silt loam, 0- to 2-% slopes (approximately 6.3% of the irrigated area). Kennewick soils consist of very deep, well drained, silt loams. Kennewick soils occur on dissected terraces and terrace escarpments of remnant fans. This soil is limited to the eastern portion of V18.
- **Soil Map Unit 89** – Quincy loamy fine sand, 0- to 15-% slopes (approximately 61.1% of the irrigated area). Quincy soils consist of very deep, excessively drained soils formed in sands on dunes and terraces. Quincy soils occur on uplands, fan piedmonts and terraces, some having a ridged, hummocky, or dune micro-relief. This is the predominant soil of Circles 3, 4, 6, 8, 9, 10, 11, 13, 15, V16, V17, V18, and B19. Quincy soils are also located in the southeastern part of Circle 1, northeastern part of Circle 2, portions of Little Circle 2, southern part of Circle 5, western part of Circle 7, northern part of Circle 12.
- **Soil Map Unit 92** – Quincy loamy fine sand, loamy substratum, 0- to 10-% slopes (approximately 7.1% of the irrigated area). Quincy soils are excessively drained and occur on dunes and terraces. This soil consists of approximately 85% Quincy and similar soils with 15% contrasting inclusions of very fine sandy loam in the upper 52 inches and calcareous soils throughout the profile. These soils occur in the southeast half of Little Circle 2, the northwestern part of Circle 6, northeastern part of Circle 7, all of Little Circle 7, western and southeastern parts of Circle 8, northeast part of Circle 13, portions of V16, V17, V18, and the northern part of B19.
- **Soil Map Unit 97** – Quincy-Hezel complex, 0- to 15-% slopes (approximately 9.6% of the irrigated area). This complex consists of approximately 50% Quincy and similar soils, 25% Hezel and similar soils, and 25% contrasting inclusions. The Quincy-Hezel complex is somewhat excessively to excessively drained and occur on convex areas of dunes and terraces (Quincy soils) as well as concave areas of terraces (Hezel soils). The Quincy-Hezel complex occur in the central parts of Circle 11, northern and southern parts of Circle 15, eastern part of Circle 1, western part of Circle 2, northeastern and southern parts of Circle 4, and the majority of Circle 5.

- **Soil Map Unit 126** – Royal loamy fine sand, 0- to 10-% slopes (approximately 0.1% of the irrigated area). This soil consists of approximately 85% Royal and similar soils with 15% contrasting inclusions of Sagehill soils. Royal soils are well drained and occur on terraces. This soil is located in the northeastern part of Circle 11.
- **Soil Map Unit 128** – Royal loamy fine sand, 0- to 2-% slopes (approximately 5.1% of the irrigated area). Royal soils are well drained with a fine sandy loam surface over very fine sandy loam subsoil and occur on terraces. This soil is located in the western part of Circle 6, western and southern parts of Circle 8, northeastern part of Circle 10, is the predominant soil of Circle 7, and a major soil type for B19.
- **Soil Map Unit 129** – Royal loamy fine sand, 2- to 5-% slopes (approximately 0.3% of the irrigated area). Royal soils are well drained with a fine sandy loam surface over very fine sandy loam subsoil and occur on terraces. This soil is located in the southern and eastern portion of V17.
- **Soil Map Unit 144** – Sagemoor very fine sandy loam, 0- to 2-% slopes (approximately 5.1% of the irrigated area). Sagemoor soils are very deep, well-drained soils on gently sloping to steeply dissected terraces. This soil is located in the northwestern part of Circle 1, northeastern part of Circle 3, eastern part of Circle 12, central part of Circle 15, and is the predominate soil in Circle 2.
- **Soil Map Unit 145** – Sagemoor very fine sandy loam, 2- to 5-% slopes (approximately 2.9% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is located in the southern part of Circle 1, northeastern part of Circle 2, northern and eastern parts of Circle 3, south and central part parts of Circle 5, northeastern part of Circle 12, and central part of Circle 15.
- **Soil Map Unit 146** – Sagemoor very fine sandy loam, 5- to 10-% slopes (approximately 0.5% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is limited the southeastern part of Circle 12.

The majority of the Site (68.2%) is mapped in the Web Soil Survey as Quincy Loamy Fine Sand (soil map units 89 and 92, combined). All soils at the Site are deep (> 60 inches), provide adequate drainage, and are suited to a wide variety of commercial crops, if irrigated, including, for example, grass (for seed, pasture, or hay), alfalfa, wheat, potatoes, and corn.

4.2.6 Water Holding Capacity

Soil water holding capacity (field capacity) is the water content of the soil after the drainage of excess water, by gravity, has ceased. In other words, field capacity is the amount of water the soil can hold. Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. At permanent wilting point, remaining water in the soil is held too tightly to be available to most plants.

Table 4-B presents the water holding capacity of a 60-inch deep soil profile for each soil map unit. Field capacity ranges from 6.3 inches (soil map unit 89) to 15.1 inches soil (map units 144,

145, and 146). Available water content ranges from 4.9 inches (soil map units 43 and 89) to 11.5 inches (soil map units 144, 145, and 146). These soil water holding capacity values were used as the basis to compute circle-specific soil water hydraulic budgets. The acreage of each soil type within each circle, as measured using the Web Soil Survey, was used in conjunction with the soil water holding capacity values published in the web soil survey to estimate the average soil profile water capacity characteristics for each circle (**Table 4-C**).

Average field capacity ranges from 6.3- to 12.0-inches (**Table 4-C**). These values were used in the soil water hydraulic budgets to help determine the hydraulic capacity of the Site for precipitation, process water, and supplemental fresh well water irrigation.

4.2.7 Expected Infiltration Rates and Permeability

The soil map units found at the Site are described as being well drained to excessively drained. The saturated hydraulic conductivity of the most limiting soil horizon for each soil map unit (surface) ranges from moderately high to very high (0.2 to 20 inches per hour), Soil Survey (U.S. Department of Agriculture - Soil Conservation Service 2006), and is not a design limiting parameter. The risk of erosion by water is low.

4.2.8 Soil Fertility

Soil fertility is important in maintaining soil and crop growth conditions favorable for land treatment system use and uptake (treatment) of the process water hydraulic and nutrient loadings. The information presented is based on the soil conditions in 2021 and 2022. Soils data from the existing Site is as reported in the 2022 Farm Operations Report (Valley Science and Engineering 2022). Soils data for the “V” and “B” circles was collected by Valley in October 2021 and June 2022, respectively. **Table 4-D** presents the soil analytical results.

The Oregon State University Extension Service has published a Soil Test Interpretation Guide (Horneck, et al. 2011) that provides a consistent reference for evaluating soil test results and guiding general fertility recommendations in Oregon and Washington. This document was used to evaluate the soil test results presented in the following paragraphs.

Soil pH is important to soil nutrient availability and crop growth. Soil pH ranged from 7.4 to 8.1 standard units (s.u.) in the surface one-foot of soil. Soils at the Site have pH values that are in an acceptable range. A pH of 8.5 s.u. or more would be considered strongly alkaline and likely reduce soil nutrient availability and crop growth. Soil pH should continue to be monitored at the Site to identify any significant trends in pH that indicate the need for operations adjustment. The pH observed for all expansion circles are compatible for land treatment needs.

The exchangeable sodium percentages (ESP) ranged from 1.2- to 3.9-%. When ESP values are greater than 15%, water infiltration in the soil is likely to decrease substantially, although this threshold value will vary for different soil types and is dependent on other soil properties such as saturation paste extract electrical conductivity (ECe) and soil texture (clay content). Since these values are below 15% and the soil clay content is low, soil ESP is not a limiting concern for water infiltration and drainage at the Site. The ESP observed for all expansion circles are compatible for land treatment needs.

Soil organic matter (OM) is important in soil chemical reactions and soil-water relations. Maintaining or increasing soil OM is beneficial in sandy soils, such as those found at the Site.

Soil OM in the surface one-foot of soil across the Site ranged from 0.5- to 1.5-% across all existing and expansion circles and averaged 1.2% in the fall of 2021 on the existing circles. The OM levels at the existing Site have remained generally stable in comparison to fall 2011, which ranged from 0.7- to 1.6-% and averaged 1.1% (Cascade Earth Sciences 2012). Soil OM levels are likely to remain relatively stable, being maintained by the inclusion of perennial and annual forage crops (alfalfa and grasses) within the overall crop rotation. OM ranges from 0.5- to 0.9-% on the expansion circles which will likely increase with process water irrigation and inclusion of perennial forage crop rotations such as alfalfa. The OM ranges observed for all expansion circles are compatible for land treatment needs.

Test results indicate that some available soil nitrogen is present for crop growth on all circles. The plant available soil nitrogen (ammonium-nitrogen plus nitrate-nitrogen (NO_3-N)) ranged from 3.1- to 24.9- milligrams per kilogram (mg/kg) in the surface one-foot of soil of all circles. The other primary plant nutrients (phosphorus and potassium) appear to be at levels that do not require addition from commercial fertilizers. Of the secondary nutrients, magnesium, sulfate-sulfur, and calcium concentrations are considered sufficient. These nutrient ranges observed for all expansion circles are compatible for land treatment needs.

Soluble salts (electrical conductivity, EC) in the surface one-foot of soil are within acceptable levels. The EC in the surface one-foot ranged from 0.2- to 1.7- millimhos per centimeter (mmhos/cm) across all fields, with an average of 0.4 millimhos per centimeter (mmhos/cm). The highest soil EC of 1.7 mmhos/cm was located in expansion circle V18, which is not connected to the land treatment system. The soil EC levels are not a limiting factor for process water irrigation at this Site, but should continue to be monitored. The EC ranges observed for all expansion circles are compatible for land treatment needs.

4.2.8.1 Historical Soil Nitrate-Nitrogen and Soluble Salt Concentrations

Field-specific soil NO_3-N and soluble salt (represented by EC) concentrations were compiled using fall soil sample analytical results from years 2001 through 2022 (**Charts 4-A and 4-B**). Soil analytical results are presented for discrete 12-inch intervals from 0 to 60 inches below ground surface.

Fluctuations of soil NO_3-N in the upper soil profile are not unusual in land treatment systems, as reserve nitrogen can be stored for the subsequent cropping season with low risk of groundwater contamination. Soil NO_3-N concentrations in the lower profile, 36-to 48-inches (4th foot) and 48- to 60-inches (5^{th} foot) intervals, are of greater concern from a groundwater protection perspective. Management of lower profile soil NO_3-N through crop utilization and minimization of excessive percolate losses is important as translocation of soil NO_3-N to depths beyond the root zone is possible if the soil water volume exceeds the crop usage and soil water holding capacity. The use of deep rooted perennial crops such as alfalfa, and judicious irrigation management can result in soil NO_3-N utilization at these lower depths if elevated concentrations are present.

The historical soil NO_3-N trend charts (**Charts 4-A**) show the majority of circles having generally low 5^{th} foot soil NO_3-N concentrations below 10 mg/kg, with some periods of elevated concentrations for some circles. No long term soil NO_3-N increasing trends are apparent from the historical soil trend charts. Circle 12 demonstrated an increasing 5th foot soil NO_3-N concentration trend from 2009 to 2012, and had the highest 5th foot soil NO_3-N concentration of all circles at approximately 38 mg/kg in October 2012. Circle 12, with historical 5th foot soil NO_3-N concentrations greater than 10 mg/kg, was unlike the majority of circles.

Soil EC at all depths were within acceptable agronomic levels and were generally stable and low for all circles (**Charts 4-B**). No long term increasing soil EC trend is apparent in the historical trend charts. Circle 12 demonstrated a decreasing trend in soil EC for all depths from 2008 to 2012, and maintained stable levels through 2022.

4.2.9 Conclusions and Recommendations

According to this soil characterization analysis, the soils at the Site are suitable for receiving the process water for land treatment purposes. Irrigation management practices, including soil moisture monitoring and irrigation scheduling, are important considerations for these soils with relatively low water holding capacities across the Site. Irrigation amount (depth of water applied per pass or per set) should be managed to supply enough irrigation to meet the crop water use requirements, avoid runoff, and limit deep percolation to the estimated leaching requirement when needed to maintain soluble salts at acceptable levels in the root zone.

4.3 Geology and Hydrogeology

The land treatment site lies within the Columbia Plateau physiographic province. The Columbia Plateau occupies most of Eastern Washington, Northeastern Oregon, and Western Idaho, occupying approximately 70,000 square miles. The Columbia Plateau is bounded to the west by the Cascade Range, bounded to the east by the Rocky Mountains, bounded to the north by the Okanogan Highlands, and bounded to the south by the Blue Mountains (Lane and Whiteman 1989).

4.3.1 Regional Geology

The Columbia Plateau hosts is an extensive volcanic plateau consisting of Columbia River Basalt Group (CRBG) basalt flows (Alt and Hyndman 1984). The CBRG basalt flows are Miocene in age, emplaced 6 to 17 million years ago. The basalt flows are overlain by sedimentary deposits from ancestral floods that blanketed the region near the end of the most recent ice age (Schuster 2005). Recent deposits of windblown loess mantle the higher slopes and sand dunes occur throughout the region. Alluvium and mass-wasting deposits are present near erosional channels.

The Site lies within the Palouse sub-province, which is east of the Yakima Fold Belt. The Palouse sub-province is characterized by structurally simple basalt flows of the CBRG that dip shallowly to the southwest (Bauer and Hansen 2000). The CBRG basalt flows are more than 15,000 feet (ft) thick and sub-divided into 4 formations, starting from oldest to youngest, the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. (Drost, Whiteman and Gonthier 1990). Sediment deposits of sand, silt, and gravel overlie basaltic bedrock associated with Miocene Age CRBG.

A generalized description of geologic units is described below from youngest to oldest (Reidel, Fecht and Washington State 1994):

- **Dune Sand** (Holocene) – Eolian medium to fine sand and silt; grains composed of quartz, basalt, and or feldspar includes Mazama tephra at numerous places; active and stabilized dunes occur through-out the low terrain, mostly in the northeastern part of the map area; age inferred from geomorphology, ages of parent materials, and presence of Mazama tephra.
- **Outburst-Flood deposits** (Pleistocene) – Consist of outburst flood gravels with beds of fine sediment that have normal polarity.
- **Ringold Formation** (Pliocene to Miocene) – The Ringold Formation consists of the upper and lower unit described below.
    - The upper unit contains continental sand, silt, and clay beds - interbedded fluvial and lacustrine facies, local pebble lenses, and stringers; silt clay units are horizontally laminated and generally lack current-generated sedimentary structures; silt and sand units display horizontal, ripple and cross-bedding; sand chiefly composed of quartz and feldspar, locally micaceous; commonly capped by pedogenic carbonate or silcrete; contains diatomite beds, ash beds, and fossils; white, gray, green, red, and tan. Exposed along the east side of the Columbia River, eastern Rattlesnake Hills, and as isolated outcrops between Richland and Kennewick.
    - The lower unit consists of continental conglomerate - varicolored pebble to cobble conglomerate with sand matrix; clasts well rounded and chiefly composed of quartzite, granite, basalt, metamorphic rocks, and porphyritic volcanics; generally well-sorted, massively bedded; locally imbricated; included lenses of course to medium quartz-feldspathic sand that are cross-bedded or foreset bedded in places; commonly uncemented, but in places moderately to poorly indurated with silica, iron oxide, and calcite. Exposed along the White Bluffs and along the flank basaltic ridge west of Richland.
- **Volcanic Rocks, CRBG** (upper Miocene) – The Ice Harbor Member of the Columbia River Basalt Group consist of flows, vents, northwest-trending feeder dikes, and minor tephra between flows; plagioclase phenocrysts that are commonly more tabular than in other Saddle Mountains Basalt flows; less than 30 meters thick in most places; about 8.5 million years ago, based on potassium-argon age estimates.

4.3.2 Regional Hydrogeology

The geological units described above host groundwater in the regions. The Columbia Plateau aquifer system underlies about 50,600 square miles of the Columbia Plateau of central and Eastern Washington, North-central and Eastern Oregon, and a small part of Northwestern Idaho (Bauer and Hansen 2000).

Two groundwater systems are present in the Columbia Plateau region. A shallow unconfined aquifer is hosted by predominately unconsolidated sedimentary deposits that overlies the CRBG basalts, as well as fractured basalt immediately beneath the sediment. A lower confined aquifer is associated with basalt flows of the CRBG. Due to the mostly impermeable nature of this aquifer, groundwater is recharged through localized cracks and fissures, whereas the majority of the aquifer is confined beneath an aquiclude of unfractured basalt. Permeable glacial outwash deposits overlying the unconfined aquifer accommodate rapid groundwater recharge by significant precipitation events and surface water seepage (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

Groundwater is recharged north of the Site by surface water infiltration in the Smith Canyon area and the Esquatzel Coulee. Groundwater flows to the south/southwest following the natural topography of the region and southwesterly dip of the CRBG lava flows. Groundwater ultimately discharges into the Snake and Columbia Rivers south of the Site (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

Groundwater hydraulic conductivities in the unconfined aquifer range from approximately 100- to 1,000-ft/day, with a representative regional value of 400 ft/day (Bauer and Hansen 2000). The water table elevation decreases from approximately 550- to 350-ft over 18 miles, for a hydraulic gradient of 0.003 ft/ft. The groundwater flow velocity, based on a literature value of 0.25 effective porosity, is calculated to range from 1.2- to 12-ft/day with an approximate velocity of 5 ft/day (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019)

4.3.3 Local Hydrogeology

The following narrative was prepared for the expansion circles based upon previous work at the Site (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

4.3.3.1 Surface Geology

The surface geology for expansion Circles V16, V17, and V18, located immediately adjacent to the north of the existing Site are primarily Holocene age, eolian, sand dune deposits composed of medium to fine sand and silt, with mineralogical compositions of quartz, basalt, and feldspars. Expansion Circle B19 located west of the current land treatment site also includes Pleistocene alluvial outburst flood gravels with fine-grained interbeds (Bauer and Hansen 2000).

4.3.3.2 Well Log Review

Water well reports obtained from Washington State Department of Ecology identified 52 wells within one-mile of the land treatment site drilled between 1963 and 2018 (Appendices C1 and C2, and **Exhibit 4-E**). Of the 52 wells, 12 are irrigation wells; 4 are monitoring wells; 7 are test wells; 19 are domestic wells; 1 production well; 1 abandoned well; and 8 wells that do not have a recorded use. Wells completed in sediment are 94- to 229-ft deep with static water levels of 8- to 186-ft. Wells completed in basalt are 157- to 571-ft deep with static water levels of 36- to 240-ft.

The well logs confirm the presence of the unconfined sediment-hosted aquifer and the lower confined basalt aquifer. Of the 52 well logs reviewed, 36 wells are near the expansion circles (excludes well reports that are abandoned, no record of use, geotechnical, or are testing wells). Of these wells, 16 are completed in basalt and 20 are completed in sediment. However, only 1 of the wells completed in basalt (#44) appears to be constructed in a manner that pumps groundwater exclusively from a confined aquifer deep within the basalt (421 to 571 ft deep). Eight wells likely extract groundwater from the unconfined aquifer and deeper confined basalt aquifers because they are drilled deep into the basalt, but the well casings barely penetrate the top of the basalt. The rest of the wells were completed in the unconfined aquifer.

4.3.3.3 Local Unconfined Aquifer

Since the expansion circles are adjacent to the existing Site and overlie the same regional unconfined aquifer, previous work conducted to characterize the aquifer at the Site is applicable to the aquifer beneath the expansion circles.

Drilling records indicate that the 9 monitoring wells and 12 irrigation wells at the Site were installed in borings through unconsolidated sediment of the vadose zone and unconfined aquifer. Unconfined perched groundwater conditions occur seasonally above a discontinuous semi-impermeable silt/clay layer at MW-1. Monitoring well MW-1 is installed southeast of Circle V16 and northwest of Circle 13 (**Exhibit 4-E**). Boring depths of the irrigation wells range from 114 to 235 ft, where monitoring wells were terminated within approximately 10 ft below the water table. Irrigation wells were drilled further below the water table and often terminated at the base of the sedimentary deposits when basalt was encountered.

Hydrographs for the monitoring wells are provided in **Charts 4-C**. Groundwater monitoring records from the monitoring wells indicate groundwater flows towards the southwest (**Exhibit 4-E**). As stated above, the average water table gradient is 0.003 ft/ft towards the southwest.

Transmissivity values determined from well yield data obtained from driller's logs for the current land treatment site ranged from 50,000- to 500,000- gpd per foot. Using the transmissivity values from these adjacent land treatment areas and the average aquifer thickness of 70 ft, projected calculated hydraulic conductivity estimates for the existing Site range from 700- to 7,000-gpd per square foot (ft^2). This converts to approximately 90- to 900-ft/day, which is comparable to the regional range of 100- to 1,000-ft/day. Monitoring at the existing Site indicates the groundwater gradient and flow direction are fairly consistent.

4.3.3.4 Historical Monitoring Well Quality

Trend charts of historical (2002 through 2022) groundwater quality for NO_3-N and total dissolved solids (TDS) are provided in **Charts 4-D** and **Charts 4-E**, respectively. In general, NO_3-N concentrations remained stable from 2002 until 2015 in all wells with the exception of MW-1. From 2015 through 2022, the majority of wells, with the exception of MW-2 and MW-9, appear to exhibit increases in NO_3-N concentration. Nitrate concentrations in MW-1 increased from approximately 2004 to 2011, decreased from 2011 to 2015 when monitoring was ceased until 2021. Concentrations of TDS exhibited increases from 2002 to 2022. No attempt has been made as part of this report to assess potential causes of these groundwater quality trends with respect to regional or local influences.

4.3.4 Proposed Groundwater Monitoring Network

The monitoring network will be expanded to add 4 groundwater monitoring wells surrounding the expansion circles to be completed in the uppermost portion of the unconfined aquifer.

The proposed well locations are shown on **Exhibit 4-F**. Locations are approximate and may vary laterally by 100 ft, depending on encountered Site conditions (i.e., utilities, surface topography, obstructions, etc.). The hydrogeologic positions and potential well depths are presented in

Appendix 4-D. All monitoring wells will be constructed to allow monitoring of the upper 10- to 15-ft of the uppermost-saturated zone.

4.3.4.1 Monitoring Well Design and Installation Plan

All drilling and well construction will be performed in accordance with WAC 173-160 (Minimum Standards for Construction and Maintenance of Wells, 173 WAC § 160 2008).

A Washington-licensed well driller will drill 6-inch diameter boreholes and construct monitoring wells in the boreholes. The drilling, logging, and construction of the monitoring wells will be conducted under the guidance of a Washington-licensed hydrogeologist (LHG). Based on the construction and monitoring records from the existing wells at the Site, monitoring well completion depths are expected to range from about 60- to 180-ft bgs. All monitoring wells will be constructed to allow monitoring of the upper 10- to 15-ft of the saturated zone.

The well construction specifications will generally conform with the following description, with any minor deviations for comparable materials or methods to be approved by the LHG. Care will be taken to prevent bridging of well materials during well construction. The well casing (blank and screen) will consist of threaded nominal 2-inch diameter Schedule 40 polyvinyl chloride (PVC). The screen will be machine-slotted with 0.010-inch apertures. The filter pack will consist of 20/40 mesh Colorado Silica Sand. The well casing will be centered in the borehole using stainless steel or plastic centralizers. The filter pack will be placed from the bottom of the borehole to approximately 2- to 3-ft above the screen, as the temporary steel casing is slowly removed from the ground. Each well will be sealed using 3/8-inch bentonite chips from the top of the filter pack to approximately 2 ft bgs. Concrete will be poured over the bentonite and into a 3-ft square or round, 4-inch thick pad that slopes away from the well casing. An aboveground monument will be set over the PVC casing and into the base of the concrete pad. The aboveground monument will consist of a steel casing with a locking cap. A PVC slip cap or expandable well cap with a small hole will be installed on the top of the PVC casing. To protect the well from collisions by vehicles and equipment, 3 protective posts will be set in concrete in an array around each well.

All drilling equipment placed in the borehole will be cleaned to remove all visible sediment and/or bentonite before use and again between boreholes. Cleaning may include brushing or high-pressure steam cleaning for stubborn deposits.

4.3.4.2 Well Development

Prior to the installation of water sampling equipment, the well screen intervals will be developed by surging and pumping or bailing to remove fine sediment and reduce turbidity for groundwater sampling. The goal of well development will be to achieve a turbidity of 50 nephelometric turbidity units or less.

Groundwater levels and groundwater quality parameters will be monitored in the field during development with portable meter(s) and recorded on a form or notebook.

Groundwater samples will be collected as each casing volume is purged for field parameter measurements, including turbidity, temperature, pH, and EC. Groundwater levels will be used to assess drawdown and adjust pumping rates to the extent practicable. If the well goes dry during development (at a minimum purging rate of 0.5 gallons per minute (gpm)), the well will be allowed to recharge to within 90% of the static water column and purged once more before development is terminated. If the well does not go dry during development, well development will proceed until field parameter readings have stabilized or at least 60 gallons have been purged (2 hours at a minimum flow rate of 0.5 gpm), whichever occurs first. Water quality stabilization criteria are listed below:

- turbidity < 50 nephelometric turbidity units
- temperature +/- 0.5 °C
- pH +/- 0.2 s.u.
- EC +/- 50 microSiemens per centimeter

4.3.4.3 Wellhead Survey

The wellheads will be surveyed to calculate groundwater elevations and prepare potentiometric groundwater maps. The location, elevation of the land surface, and the elevation of the top of the casing (reference point) of each well will be surveyed. The survey reference point will be a permanent ink mark or notch filed at the top of each PVC well casing on the north side. The location survey will have a horizontal accuracy of ±1.0 ft, the land surface elevation will have a vertical accuracy of ±0.1 ft, and the top of well casing elevation will have a vertical accuracy of ±0.01 ft. A Washington Registered Land Surveyor or Professional Engineer will perform the survey.

4.4 Land Treatment System Management

Irrigation of agricultural land with process water conserves water and plant nutrients. The success of a land treatment system depends on the process water hydraulic and constituent loads, cropping, climate conditions, and management. Cropping, soils, and climate determine the nutrient and hydraulic capacities of the Site. The crop rotation tolerance to salinity influences the leaching requirement.

This section presents:

- process water and cow water design considerations
- crop rotation information
- agronomic constituent and hydraulic capacities
- constituent management
- irrigation management of the Site

4.4.1 Design Considerations

This section discusses the quantity and quality of process water, cow water, and quality of supplemental fresh water. Irrigation of process water, cow water, and/or supplemental fresh water is practiced during March through November, whereas process water and cow water is received year round from Food Processors and must be stored during non-irrigation months. Irrigation is not practiced during December, January, or February. As presented in **Section 3.5.7-**

Summary of Projected Flow and Loading, a Maximum Month Scenario was used to evaluate process water and cow water constituent loads in comparison to the land treatment system capacity. The Maximum Month Scenario is a theoretical scenario where all processors operate at their maximum month permit limit in August and September, and then produce lower flows in other months to stay within their average annual permit limits.

4.4.1.1 Projected Process and Cow Water Quantity

The operational year is ordered from November of the previous year through October of the subsequent year to match the cropping cycles of planting and harvest. The average monthly process water and cow water flow values are important in consideration of the irrigation hydraulic loads for land treatment management projections. The projected monthly process water flow in the Maximum Month Scenario ranges from 56 MG in February to 264 MG in August (**Table 4-E**). The projected monthly cow water flow ranges from 21 MG in February to 26 MG in March through May. The projected annual process water and cow water hydraulic loads are 1,600 MG and 292 MG, respectively.

4.4.1.2 Projected Process Water and Cow Water Quality

The City evaluated the Site capacity (**Section 4.4.3**) compared to the projected untreated process water loads (**Table 3-Q**) and determined pretreatment is required. Monthly pretreated process water and untreated cow water quality is presented in **Appendix 3-C. Table 4-F** presents the projected monthly combined process water and cow water quality for select constituents. The process water and cow water quality presented in **Table 4-F** represents the projected combined quality of existing Food Processors, additions from Grimmway and Darigold, and includes estimates of pretreatment effects from screening, low rate anaerobic digestion with pH adjustment using magnesium hydroxide, and rotating algal biofilm.

4.4.1.3 Sodium Adsorption Ratio

The sodium adsorption ratio (SAR) must be considered for land treatment. Too much sodium in a soil can cause the soil particles to disperse, sealing the surface of the soil, and limiting the ability of water to penetrate into the soil resulting in runoff and poor crop growth. The average process water SAR (computed from the calcium, magnesium, and sodium concentrations) is projected to be 1.8 (**Table 4-F**). If SAR is less than 6, there should be no problem with soil sealing (Canessa and Hermanson 1994). This is especially true of the soils at the Site with very little clay. As such, the SAR of the process water should not limit process water application at the Site.

4.4.1.4 pH

The process water pH must be considered for land treatment. A pH range of 3 to 11 s.u. has been applied successfully to land treatment systems (U.S. Environmental Protection Agency 2006). Irrigated process water quality at the Site has historically averaged at the low end of this range. Process water and cow water pH is projected to be 7.2 s.u. (**Table 4-F**), which is within the acceptable range for land treatment and should not limit process water application at the Site.

4.4.1.5 Supplemental Fresh Water Quality

Supplemental fresh water is provided to help meet the crop water requirements at the Site. It is important to account for the supplemental fresh water quality in land treatment system management. There are several wells (IW-6 through IW-15) that supply supplemental fresh well water to specific existing circles (**Table 4-G**). Historically, more than 1,000 MG (not shown) of supplemental fresh well water has been typically applied to the Site to meet the crop water demand not met by the process water. The City-owned fresh water wells are hydraulically connected in a distribution network with the combined water quality sampled annually. Because of the nature of the fresh water well distribution network, individual fresh water well constituent concentrations are not available. Fresh water quality is summarized below for the fresh water from the wells and the SCBID water, which includes the underdrain water and is therefore not characterized separately.

Supplemental fresh water quality is as follows:

- TDS ranges from 181-(SCBID) to 625-milligrams per liter (mg/L) (IW-5 through IW-15).
- NO_3-N ranges from 0.8- (SCBID) to 32.6-mg/L (V17 and V18 underdrain water). The fresh water well NO_3-N concentrations range from 12.1- (IW-1 through IW-3) to 23.7-mg/L (IW-5 through IW-15).
- EC ranges from 283- (SCBID) to 977-micromhos per centimeter (µmhos/cm) (IW-5 through IW-15).

4.4.1.5.1 Underdrain Water

An underdrain system consisting of a network of buried corrugated plastic drainage pipe is located in expansion Circles V17 and V18. The drain lines vary in buried depth, but are generally deeper than the extent of the soils investigation (60-inches bgs) conducted by Valley.

All buried drain lines gravity flow to a 20-ft deep sump, from which a 20-horsepower pump delivers the drainage water through a return line connected to the SCBID canal water mainline that serves Circles V16, V17, and V18 (**Exhibit 4-C**). When the SCBID water pump station is in operation (servicing SCBID canal water irrigation to Circles V16, V17, and V18), the drainage water is combined with SCBID canal irrigation water and delivered as irrigation water to the circles that are receiving irrigation. When the SCBID pump station that serves the “V” circles is not in operation, but the 20-horsepower pump is running, the drainage water is then discharged to the SCBID canal.

Based on the drain system design, it should not serve as a limitation for land treatment. The underdrain water TDS concentration is lower compared to the existing Site fresh water wells, but is higher in NO_3-N (**Table 4-G**). An inline valve is available for routine sampling of underdrain water quality. A flow meter is installed to track underdrain water flow, and the resulting hydraulic and constituent loads can be attributed to each of the “V” circles based on circle-specific flow meters at each pivot.

The underdrain flow is estimated at 0.3 million gallons per day (based on 200 gpm). This projected daily hydraulic load estimate and associated nitrogen and TDS load has been accounted for on Circles V16, V17, and V18. All projected fresh water loads for the "V" circles beyond what can be supplied by underdrain water is met with SCBID fresh water quality.

4.4.2 Cropping

Crop management plays a critical role in using process water on farmland. Beneficial use of process water nutrients is achieved by harvest and removal of plant material. Higher crop yields increase Site capacity for process water loads. The crops chosen for the Site must grow well in the local area and under the process water and soil conditions at the Site. Perennial crops such as alfalfa have been successfully grown at the Site. Perennial crops consume water and nutrients throughout the extent of the growing season, from early spring to late fall, which coincides with early and late season process water application as needed.

The perennial crops may be maintained in place for several years until productivity begins to decline. They are re-established after rotation to another crop for one or more crop growing seasons. Rotation to another crop before re-establishment is an agronomic best management practice. As a system best management practice, an established crop or cover crop should be maintained on all circles in the fall to take up nutrients and increase ET. Maintaining a crop or cover crop helps to remove nitrogen that may be available in the soil profile ahead of the winter precipitation period. This practice limits the potential for migration of nitrogen beyond the root zone during winter precipitation events. The established crops also provide soil protection against wind and water erosion during winter and early spring.

4.4.2.1 Crop Rotation

Table 4-H presents the circles, acres, and crops grown at the Site during 2018 through 2021 (Cascade Earth Sciences 2019, 2020, Valley Science and Engineering 2021, 2022) as well as the design basis limiting crop rotation used to calculate the Site hydraulic, nitrogen, and BOD capacities. The design basis crop rotation represents the minimum nitrogen capacity of any planned future crop mix with the expansion circles.

The typical rotation has been to maintain alfalfa in a majority of the circles, grow potatoes in 3 circles, and double-crop 3 other circles. Double-cropping examples include triticale followed by corn or one cutting of alfalfa followed by corn. Lower nutrient removal rates may be expected during rotation periods compared to when a perennial crop is fully established and maintained. Keeping a majority of the fields in a perennial crop maintains nitrogen capacity. Established cover crops help maintain hydraulic capacity during late fall and winter months.

For example, in 2018, the potato crop in Circle 5 was harvested in September and the circle was planted to alfalfa, which is shown as potato/alfalfa (**Table 4-H**). The potato crop consumed water and nutrients until September, while the alfalfa did so through the remainder of the season. The alfalfa has since been maintained. In 2020, the alfalfa in Circle 6 was harvested in May and the circle was planted to corn, which is shown as alfalfa/corn. The alfalfa consumed water and nutrients through May, while the corn did so through late September when it was harvested. In this case, the circle remained in corn residue (stalks and leaves) after harvest and was planted to potato the following spring. The corn residues controlled wind erosion, but the nitrogen capacity was limited the following season because a limited amount of process water was applied to potato compared to a perennial forage crop, such as alfalfa.

4.4.2.2 Planting, Cultivation, Harvest, and Crop Nitrogen Capacity

Table 4-I presents example planting and harvest months, crop yields, crop nitrogen removal, and nitrogen capacity by crop type. The expected yields and crop nitrogen capacities are based on historical Site data.

Crops will be planted using accepted agronomic seeding rates and methods, and those circles with established crops (alfalfa, for example) will not require planting until they are rotated, as discussed above. Where two or more crops are listed for one circle, the second crop will be planted following harvest of the first crop and after any necessary cultivation for seedbed preparation.

Alfalfa will be harvested for hay (cut, cured, and baled, or green-chopped for haylage). Any other crops that may be grown at the Site will be harvested according to local and industry standard means. Harvest periods for each circle will be coordinated to improve crop removal management flexibility, but managed to allow process water application at all times in consideration of individual circle harvest schedules. The actual schedule will vary depending on weather and crop growth.

Crop nitrogen capacity shown in **Table 4-I** is historical average crop nitrogen removal increased to account for volatilization and denitrification losses of nitrogen. Process water nitrogen availability has been estimated to be 89% based on recommendations in (Meisinger and Randall 1991) using the average process water nitrogen concentration (**Table 4-F**).

$$\text{Available Process Water Nitrogen} = [((\text{TKN} - \text{ammonia-nitrogen } NH_3\text{-N}) + (NH_3\text{-N} \times 0.80) + (NO_3\text{-N})) \times 0.96] \div (\text{TKN} + NO_3\text{-N}).$$

4.4.2.3 Fertilizer, Herbicide, and Pesticides Application

Commercial fertilizer will be applied, as needed, for the specific circle and crop to maintain healthy, viable land treatment system crops for maximum nutrient uptake under process water treatment conditions. The term viable may be defined as capable of living, developing, or germinating under maximum favorable conditions. Process water nitrogen availability will be considered in any decision to apply fertilizer. Fertilizer application will be according to soil test results, crop tissue test results, and recommended nutrient levels from state and local extension service and consultants. Nitrogen may be applied at recommended starter rates for legume crops (i.e., alfalfa). Once established, nitrogen fertilizer will not be required because legume crops are able to harness their own nitrogen in addition to utilizing the nitrogen supplied by the process water. Nitrogen may also be applied to non-legume crops (e.g., corn) if a deficiency is identified between the recommended amount and the amount that will be applied in the process water.

Pesticides, including herbicides, insecticides, and fungicides, will be used, as necessary, under the advice of a professional crop consultant. Herbicides for weed control are planned for use. Insecticides or fungicides will be used only if needed to treat specific problems. Herbicides are generally applied to alfalfa at the end of February and in mid-March. Actual herbicide use will vary depending on the weed problem, crop, time of year, and product availability from year to year. Aerial application or ground sprayer can apply pesticides with dependence on time, weather, soil wetness, price, suitability, and availability. All pesticides will be used and applied according to product labels.

4.4.3 Design Basis Capacity

The capacity of a land treatment site for nutrient and hydraulic loading is an important consideration for good management and design of a system that is protective of groundwater. Proper design and good management of process water application and nutrients encompasses the requirements of all known, available, and reasonable methods of prevention, control, and treatment (AKART) farming for land treatment.

The term agronomic capacity is defined in the Implementation Guidance for the Ground Water Quality Standards (Washington State Department of Ecology 2005) as the "rate at which a viable crop can be maintained and there is minimal leaching of chemical downwards below the root zone. Crops should be managed for maximum nutrient uptake when used for wastewater treatment." Therefore, agronomic rates can be used in combination with the design basis crop rotation to establish the design basis capacity of the land treatment site for both irrigation and nutrients.

The purpose of this section is to define the nutrient and hydraulic load capacities of the Site and evaluate the nutrient and hydraulic balances. This section also defines the capacities of other important parameters for land treatment design. The design basis for the land treatment capacity defined in this Engineering Report is the most limiting projected crop rotation presented in **Table 4-H**. The design basis crop rotation (**Table 4-H**) is used to determine the minimum nutrient and hydraulic capacities of the Site. The design basis crop rotation has the minimum number of acres that would be in perennial and high yielding crops such as alfalfa and more acres of other crops (i.e., potato), which use the least amount of process water nitrogen. It represents the lower limit of crop nitrogen removal from the Site in future operational years. As the perennial and high yield crop acreage changes, hydraulic and nutrient capacities also change at the Site and may be greater than the limiting rotation in some years.

The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit. The Permit states that the total nitrogen and water applied to the Site must not exceed the crop requirements as determined by the Farm Operations Report. The design basis capacity defined in this Engineering Report should be considered the potential minimum agronomic capacity for the Site.

4.4.3.1 Hydraulic Capacity

The hydraulic capacity of the Site depends on the crop water needs (ET), precipitation, soil water holding capacity, leaching requirements, and nitrogen capacity. Soil hydraulic budgets were developed to determine the hydraulic capacity of the Site using these variables (**Appendix 4-E**).

The capacity for process water, cow water, and fresh water is dependent on the crop nitrogen capacity. The soil hydraulic budgets were constructed as examples using the design basis (limiting) crop rotation (**Table 4-H**) to demonstrate the minimum potential nitrogen capacity rotational year. Total process water, cow water, and freshwater nitrogen loads to each circle cannot exceed the crop nitrogen capacity.

The budgets take into account the normalized 10-year return precipitation and ET (**Table 4-A**) and total water content at field capacity (**Table 4-C**). Bare soil evaporation is calculated using the 10-year return precipitation and average reference evapotranspiration data (Snyder, et al. 2007). Bare soil evapotranspiration is used when AgWeatherNet evapotranspiration is less than fallow evapotranspiration or when crops are not in place such as the post-harvest period of potato or corn crops. They were constructed with the initial soil water content of 85% of field capacity. Budgets were prepared with example process water and supplemental fresh well water irrigation loads that result in estimated percolate loss (leaching fraction) at or less than the salts leaching requirement. The gross irrigation inputs into the soil hydraulic budgets illustrate an example of the potential hydraulic capacity of the Site, and thus, the agronomic capacity of the Site.

A leaching requirement was determined based on respective process water, cow water, and supplemental fresh water EC with the desired equilibrium soil salinity of 2 mmhos/cm. The combined process water and cow water has an average EC of 1,181 µmhos/cm (process water EC at 1,361 µmhos/cm and cow water at 197 µmhos/cm) and the supplemental fresh water has an EC that ranges from 283- to 977-µmhos/cm (**Tables 4-F** and **4-G**, respectively). The calculated leaching requirement for the combined process water and supplemental fresh well water averages 9.7% of the average hydraulic load to the Site (**Table 4-J** and **Appendix 4-E**). Additional cow water and supplemental fresh well water irrigation may be scheduled during the late fall or early spring to achieve a leaching fraction up to to the leaching requirement (**Table 4-J** and **Appendix 4-E**). The actual practice of irrigating extra cow water and supplemental fresh water for leaching will depend on the need to decrease soil salts if indicated by the fall and spring soil test results.

The leaching fractions shown in **Table 4-J** are equal to the leaching requirements for all circles as an example scenario where maximum leaching is required. Leaching is typically preferred in the winter when trying to meet a leaching requirement. Example hydraulic loads have been projected to limit leaching during the growing season, with none scheduled when process water is being applied. The leaching requirement for the Site can often be partially met by natural precipitation during the winter storage period, which corresponds to a low consumptive water use period for the crops.

The sum of the gross process water, cow water, and supplemental fresh water inputs represent the total irrigation capacity of the Site since they were balanced with the precipitation, ET, soil water holding capacity, and leaching fractions. Process water irrigation was not scheduled during the storage season of December, January, and February.

Table 4-J presents a summary of the annual totals from the soil hydraulic budgets for each circle including precipitation, gross irrigation (including process water, cow water, and supplemental fresh water), ET, and leaching. Gross process water irrigation ranges from 8.5- to 38.5-inches, gross cow water irrigation ranges from 0- to 8.9-inches, and gross supplemental fresh water irrigation ranges from 0- to 22.9-inches. No fresh water is projected for Circle B19 as a supplemental fresh water connection is not planned for Circle B19. Cow water irrigation is

not projected for all "V" fields as SCBID water connected to these fields is of a lower nitrogen and salt concentration. The potential ET ranges from 38.4- to 44.4-inches.

In this example, the Site design basis capacity for gross process water irrigation ranges from 47- to 264-MG per month (**Table 4-K**). Cow water and supplemental fresh water loads are used for supplementing the process water to meet crop water requirements as well as providing a source of irrigation water low in nitrogen and salts concentrations for planned leaching. Cow water irrigation loads range from 24 MG in June to 123 MG in March. Supplemental fresh water irrigation loads range from 9 MG in April, September, and October to 251 MG in July. The total irrigation capacity in this example is 2,773 MG per year during the irrigation season (i.e., November, and March through October).

The annual example hydraulic capacities in **Table 4-K** were used with the process water and cow water quality (**Appendix 3-C)** and supplemental fresh water quality (**Table 4-G**) to calculate constituent mass loads from the process water, cow water, and supplemental fresh water irrigation for comparison to the Site capacities discussed in the following section.

4.4.3.2 Nitrogen Capacity

There are two mechanisms of nitrogen treatment in a land treatment system. The first and largest is uptake by the crops growing and removal in the harvested portion of the crop. **Table 4-L** shows the past performance of the crops grown at the Site to remove nitrogen applied in process water, cow water, supplemental fresh water, and commercial fertilizer.

As the crop mix acreage changes, nutrient capacities also change. The projected crop nitrogen removal by the design basis crop rotation (**Table 4-H**) is presented in **Table 4-L** to show the most limiting projected Site nitrogen capacity. Note that the crop nitrogen removal of the design basis crop rotation is significantly larger compared to previous years (2017-2021) due to the inclusion of the expansion circles.

The second nitrogen treatment mechanism in land treatment systems is denitrification and volatilization (i.e., gaseous losses), which must be considered as part of the treatment and removal process for estimating nitrogen capacity. The applied process water nitrogen will be mostly in inorganic forms (nitrate and ammonia) following pretreatment before it is land applied.

Denitrification of the nitrate is typically promoted by the dose and rest cycles of the irrigation systems in conjunction with the labile carbon content represented by the BOD_5 load (U.S. Environmental Protection Agency 2006, Smith, J.H., J.R. Peterson 1982). However, the BOD_5 concentration of the process water will not drive significant amounts of denitrification. In addition, not all of the organic nitrogen is considered available because it will not easily mineralize following irrigation (Overcash and Pal 1979). The slightly to moderately alkaline pH of the soils and broadcast nature of sprinkler irrigation promotes a limited amount of volatilization of NH_3-N. These considerations have been accounted for in the equation below.

Based on the following equation, accounting for gaseous nitrogen losses, the available nitrogen load from process water is conservatively expected to be 89% of the total nitrogen applied (Meisinger and Randall 1991):

Equation:

Available Nitrogen % = [((TKN - NH_3-N) + (NH_3-N × 0.80)
+ (NO_3-N)) × 0.96] ÷ (TKN + NO_3-N) × 100%

Calculation:

Available Nitrogen % = [((32 mg/L - 19 mg/L) + (19 mg/L × 0.80) + (19 mg/L)) × 0.96]
÷ (32 mg/L + 19 mg/L) × 100%
= 89%

Accounting for the 89% nitrogen availability, the Site gross nitrogen capacity is approximately 12% greater than the crop nitrogen removal (same as an 11% loss of gross nitrogen load). Therefore, the Site nitrogen capacity of 1,034,800 lb was calculated by increasing the crop nitrogen removal rate by approximately 12% to account for the gaseous losses expected with process water application (**Table 4-L**).

Example Calculation:

Nitrogen Removal Increase Factor = (1,034,800 pounds [lb] nitrogen capacity - 921,000 lb nitrogen removal) ÷ 921,000 lb nitrogen removal = 12.36% increase from crop nitrogen removal

4.4.3.3 Untreated Process Water Nitrogen Load

The untreated influent nitrogen load to the PWRF is estimated at 1,652,210 lb per year based on the projections presented in **Appendix 3-A**. The untreated nitrogen load will be significantly greater than the site nitrogen capacity of 1,034,800 lb per year. Therefore, nitrogen is a limiting constituent of concern. The City determined that pretreatment of the influent for nitrogen reduction was required to meet the site nitrogen capacity as part of the land treatment system design.

4.4.3.4 Design Basis Nitrogen Load

Table 4-M presents the design basis nitrogen capacity and operational analysis across the Site with an example operational year nitrogen load scenario. The example operational load represents the gross nitrogen loads from process water, cow water, and supplemental fresh water for each circle based on the hydraulic capacity analysis above. The example operational nitrogen loads were calculated from the process water, cow water, and supplemental fresh water nitrogen concentrations (**Tables 4-F** and **4-G**, respectively) and respective irrigation amounts projected in the soil hydraulic budgets. Nitrogen load from the supplemental fresh water will be significant with limited gaseous losses. The available nitrogen load from the supplemental fresh water is conservatively estimated to be 96% of the nitrogen concentration with an assumed gaseous loss of 4% from denitrification.

Table 4-M presents an example process water nitrogen contribution of 774,572 lb, cow water nitrogen contribution of 30,213 lb, and a supplemental fresh water nitrogen contribution of 134,527 lb. The total operational load of 939,312 lb is within the Site nitrogen capacity of 1,034,791 lb. **Table 4-M** also shows that the example operational circle-specific nitrogen loads

(sum of process water, cow water, and supplemental fresh water nitrogen) do not exceed their respective circle-specific nitrogen capacities.

4.4.3.5 Mineral Salts and Salinity Management

The FDS is a measure of the mineral salts present in the irrigation water and used to evaluate the salinity and mass of salts discharged to the Site (**Tables 4-N and 4-O**). The FDS that make up the process water, cow water, and supplemental fresh water salinity include calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate ions. The FDS loads range from 1,396 to 6,325 pounds per acre (lb/ac) from process water, 92 to 212 lb/ac from cow water, and 891 to 3,240 lb/ac from fresh water. Total annual FDS loads range from 4,050 to 7,053 lb/ac. Annual average FDS load rates across the Site are 4,085 lb/ac (process water), 108 lb/ac (cow water), 1,603 lb/ac (fresh water), and 5,796 lb/ac (total load). Projected crop removal of salts ranges from 589 to 1,696 lb/ac and averages 1,469 lb/ac. Crops are projected to remove an average of 26% of the FDS load (not shown). Projected salts balances range from 2,354 to 5,453 lb/ac and averages 4,327 lb/ac. Projected annual FDS mass loads across the Site are 9,680,000 pounds (lb) from process water, 260,000 lb from cow water, and 3,800,000 lb from fresh water. The projected annual salts balance across the Site is 10,260,000 lb after accounting for a crop salts removal of 3,480,000 lb.

The FDS load monitoring and management is important to manage accumulation of salts in the soil profile to prevent reductions in crop yields. The total FDS load from process water, cow water, and supplemental fresh water will determine the leaching requirements for each circle. The Site soil and crop FDS capacity is the calculated leaching requirement for each circle (**Table 4-J**, **Appendix 4-E**). The EC of the water irrigated onto the Site is an indirect measure of the FDS (salinity) of the water. Therefore, irrigation water EC is used for computing the leaching requirement. Annual leaching fractions will not exceed calculated leaching requirements to limit the impact on groundwater quality. Soil salts will be monitored through annual soil sampling to determine effectiveness of scheduled leaching.

4.4.3.6 Leaching Requirement

The leaching requirement is the fraction of the total crop water supply from all sources that should percolate through the soil to control salt build-up in the soil profile. Leaching is required to prevent excessive amounts of salts from accumulating in the root zone. If not leached regularly, salts from both process water and supplemental fresh well water can build up in the soil profile to levels that could inhibit crop production. The salinity in the root zone should be maintained at or below the point of yield decline. A soil ECe of 2 mmhos/cm or less, which is suitable for most irrigated crops, was used to generate the leaching requirements. Given the limited precipitation in the region, it may be necessary to irrigate some cow water and supplemental fresh well water in the late fall or early spring to meet the leaching requirement. At the same time, irrigation should minimize deep percolation losses so that FDS losses from the soil are managed to control impacts to groundwater. The deep percolation rate (leaching fraction) should be equal to or less than the leaching requirement.

The leaching requirement, presented as a percentage of total irrigation, depends on the average electrical conductivity of the total water supply to the crop for the year. A leaching requirement is as follows (Canessa and Hermanson 1994):

$$LR = \frac{ECiw}{((5 \times ECe) - ECiw)}$$

Where:

LR = Fraction of the applied irrigation water that should become deep percolation

ECiw = EC of the irrigation water

ECe = Desired ECe of a soil saturated paste extract

Leaching requirements shall be computed each year in the hydraulic budget calculations in the annual Farm Operations Report based on the actual water quality and hydraulic loads. Soil moisture monitoring technology may be implemented in representative locations at the Site to track real-time (via remote telemetry) soil moisture in the crop root zone. Soil moisture monitoring can guide irrigation rates and timing to meet crop water demands and determine optimal timing and quantity of additional cow water and supplemental fresh water loads to achieve desired leaching rates. In addition, the soil hydraulic budget calculations can also be used each year to compare the leaching requirement to the recorded circle-specific soil moisture levels, recorded percolate losses, and the farm report calculated leaching fraction as a check on agronomic irrigation management.

During the winter when leaching may occur from rainfall, there is low potential for nitrate to be leached if it has been adequately consumed by the crops. Cropping and loading rates can be managed to maintain a healthy crop to consume the available soil NO_3-N and maintain low nitrate concentrations in the soil before the time that winter leaching is more likely to occur.

4.4.3.7 Biochemical Oxygen Demand Capacity

The treatment capacity for BOD_5 depends on soil, temperature, and irrigation practices. The soil needs to allow sufficient oxygen transfer, the temperature affects the rate of microbial digestion of the organic components, and the irrigation practices provide sufficient water to maintain microbial function without extended soil saturation that would prevent sufficient oxygen. The BOD_5 capacity is most influenced by the soil texture and drainage rate because that affects the rate of oxygen diffusion into the soil. Sandier soils, such as those described for the Site, have larger soil pores with better oxygen diffusion potential, and thus, have a higher capacity for BOD_5 treatment than finer textured soils such as silt loams.

Crops also require an oxygenated soil. If the BOD_5 load is too great, the soil will become anaerobic and the crops will suffer stress that reduces performance, nutrient uptake, and yield. **Table 4-O** presents a potential annual BOD_5 load of 4,980,000 lb based on a projected flows and respective BOD_5 concentrations for process water and cow water. Based on 2,370 acres, 275 growing season days during the operational year, and irrigation water loads applied to meet nitrogen capacities, the annual loading rate averages approximately 8 pounds per acre per day (lb/ac/day) BOD_5. This BOD_5 load is below the commonly referenced 45- to 450-lb/ac/day BOD_5 range given for land treatment of wastewater by the Environmental Protection Agency (U.S. Environmental Protection Agency, 2006) and also below the existing permit limit of 100 lb/ac/day. The daily BOD_5 design load by field by month will range up to a maximum of 19 lb/ac/day; well below the 100 lb/ac/day Permit irrigation land application best management practice (**Table 4-P**).

4.4.4 Irrigation System Operation

Proper irrigation system operation is important for optimum process water treatment and agronomic capacity. The irrigation systems are operated to distribute the water across the circles for optimum control on irrigation depth and timing. Standard best management practices include:

- visual observations of circles for runoff or ponding,
- routine soil profile sampling of moisture, salts, and nutrients,
- implementation of real-time soil moisture monitoring in representative locations,
- application rate monitoring, and
- leak and mechanical repair.

4.5 Summary

The soils at the proposed expansion circles are suitable for receiving the pretreated process water and untreated cow water for land treatment purposes. The design crop rotation load scenario across the existing Site and expansion circles indicates that the nitrogen and hydraulic loads are within the agronomic capacity of the proposed Site expansion. The proposed land treatment system expansion will be protective of groundwater if operated within the Site agronomic capacity. The agronomic capacity will vary from year to year depending on the crop mix. The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit. The agronomic capacity of each crop rotation must be sufficient to meet the projected hydraulic and nitrogen loads proposed in the annual Farm Operations Report.

Chapter 5.0 Evaluation of Pretreatment Alternatives

5.1 Introduction

As discussed in **Chapter 1**, the PWRF has historically provided basic pretreatment (screening and grit removal) and relied on the LTS for treatment and beneficial use of the process water. As detailed in **Chapter 4**, the projected loading from raw process water will significantly exceed the capacity of the existing LTS, as well as that provided by the land available for LTS expansion (Beus and Voss properties), so pretreatment is needed.

Significant expansion of the LTS area, in lieu of pretreatment improvements, is not feasible since sufficient additional nearby land area is not available. Land treatment alone would not remedy the odors from the high BOD water from the PWRF either, nor would it alleviate the low pH causing corrosion of the irrigation system components. Any additional LTS area also would require supplemental irrigation water due to the high load to flow ratio of the raw process water.

Further pretreatment of the process water will be necessary to allow the projected process water volume to be discharged to the expanded LTS. Alternatives for pretreatment are reviewed in this chapter.

5.2 Flow and Loading Criteria

Table 5-A provides the recommended basic design criteria for sizing the biological pretreatment systems at the PWRF, as determined from projections in **Chapter 3**.

Table 5-A – Influent Design Criteria for Biological Pretreatment

	Influent Design Criteria[a]
Flow	
Annual Average Day (MGD)	4.38
Total Annual (MG)	1,600
Maximum Month Average Day (MGD)	8.56
BOD	
Maximum Month Average Day (ppd)	300,000[b]
TN	
Annual Average Day (ppd)	4,450

[a] Pretreatment design flow and loading excludes Darigold COW water since COW water will be stored separately from other process water and will not be pretreated.
[b] Refer to the discussion for selection of BOD loading design criteria in subsequent paragraphs.

The design criteria in **Table 5-A** were determined as follows.

Chapter 4 defined nitrogen loading as the limiting factor for the capacity of the LTS, which makes nitrogen reduction the primary goal of biologic pretreatment. Biological pretreatment will be sized to reduce the process water total nitrogen load to within the capacity of the LTS based on the projected nitrogen load in **Chapter 3**.

Flow to the LTS can be managed by providing sufficient winter storage to allow for all water to be disposed of during the growing season, as analyzed in **Chapter 6**. Biological pretreatment primarily will be sized and configured as necessary to maintain nitrogen loading within the capacity of the LTS.

The projected total annual BOD loading would be within the permitted LTS capacity of 100 lb/ac/day. However, nitrogen cannot be reduced without also reducing BOD. Reducing BOD will provide the advantages of mitigating the current aesthetic and operational issues created by the high BOD loading by reducing odors at the site and stabilizing the process water pH. Depending on the biological pretreatment system chosen, the chemical addition necessary for pH adjustment can be significantly reduced compared to other alternatives. From **Table 3-J**, the PWRF may experience maximum month BOD loading up to 354,000 ppd. The biological pretreatment system will be sized to receive a maximum month BOD load of only 300,000 ppd since it is not necessary that all flows receive biological pretreatment as long as nitrogen is sufficiently reduced. For the majority of the year the biological pretreatment system will treat all flows.

FDS can be managed through operation of the LTS as shown in **Chapter 4**. Therefore, FDS reduction via pretreatment is not warranted at this time. This may be revisited in the future if additional processors with additional FDS loading are considered for connection to the PWRF, or if permit requirements change.

5.3 Preliminary Screening of Alternatives

The general categories of treatment options for process wastewater similar to the PWRF influent consist of the following:

- Physical – which includes the physical separation of particulates from the waste stream via equipment such as screening, DAF, clarification, etc.
- Chemical – which can include various techniques such as coagulation-processes, pH adjustment, etc.
- Biological – which generally consists of microbial organisms breaking down organic constituents under aerobic or anaerobic conditions.

Currently, both the individual processors and the PWRF facility provide physical and chemical treatment systems as discussed in **Chapter 1**. These systems do not significantly reduce total nitrogen or BOD, both of which are largely present in soluble form in the influent. As described in **Chapter 4**, a significant reduction in total nitrogen will be necessary through pretreatment for the expanded LTS to provide sufficient capacity for the disposal of the projected process water. Biological treatment via aerobic activated sludge is one proven and common approach for reduction of BOD and total nitrogen in wastewater. Pretreatment alternatives that do not include biological treatment are not considered viable for the projected PWRF loading and LTS configuration and are not analyzed further.

Due to the significant component of soluble BOD in the influent, another common and proven approach to biological treatment includes anaerobic treatment for BOD reduction followed by aerobic treatment for nitrogen reduction. The initial anaerobic treatment significantly reduces BOD with low energy consumption (no aeration) and high solids destruction and produces biogas that provides a renewable energy source. This allows for the sizing of the aerobic treatment system to be substantially reduced.

As described in **Chapter 1**, the 2019 Facility Plan recommended an aerated stabilization basin to support near-term flow and loading, which has now been exceeded. For future flow and loading increases, the 2019 Facility Plan recommended biological pretreatment for TN and BOD reduction in the form of an anaerobic followed by aerobic treatment, similar to that described above. The preferred form of anaerobic treatment identified in the 2019 Facility Plan consisted of Upflow Anaerobic Sludge Blanket (UASB) reactors, a type of high-rate anaerobic system. However, a renewed evaluation of anaerobic treatment options, to be discussed in **Section 5.4.2 – BOD Reduction Alternative 2 – Anaerobic Treatment**, will explain why a low-rate anaerobic treatment would be better for this application.

Based on this initial screening of options, the leading alternatives for biologic pretreatment are analyzed in this chapter. This analysis is conducted in two parts: **Section 5.4 – BOD Reduction Alternative Analysis** evaluates processes for BOD reduction, and **Section 5.5 – Nitrogen Reduction Alternatives Analysis** evaluates processes for nitrogen reduction. The selected BOD and nitrogen reduction alternatives will be paired for the recommended improvements in **Chapter 6**.

5.4 BOD Reduction Alternatives Analyses

Two alternatives for BOD reduction at the PWRF are analyzed in this chapter:

- Alternative 1 – Aerobic activated sludge treatment
- Alternative 2 – Anaerobic treatment

This section evaluates each alternative's use for BOD reduction, but nitrogen reduction also will need to be considered, as evaluated in **Section 5.5 – Nitrogen Reduction Alternatives Analysis**. Alternative 1 also could be operated such that it provides nitrogen reduction, but Alternative 2 would need an additional treatment process(es) for nitrogen reduction. Items that would be identical in cost and configuration to both alternatives, such as preliminary treatment to protect the secondary treatment systems, are not included in this alternatives analysis. Ancillary treatment processes to support these systems are identified with each analysis herein.

5.4.1 BOD Reduction Alternative 1 – Aerobic Activated Sludge Process

5.4.1.1 Overview

An aerobic activated sludge treatment process could be operated to provide BOD reduction or to provide both BOD reduction and nitrogen reduction. In an aerobic activated sludge treatment process, bacteria break down organic matter as they grow biomass. An aeration system of diffusers and blowers supplies oxygen to aerate the biomass, and the required aeration demand is generally dependent on the influent BOD and nitrogen loading. Unaerated zones, or cycles, must be provided to achieve total nitrogen reduction as these provide anoxic conditions in which nitrate (produced from oxidation of ammonia under aerobic conditions) is converted to nitrogen gas and released from the process.

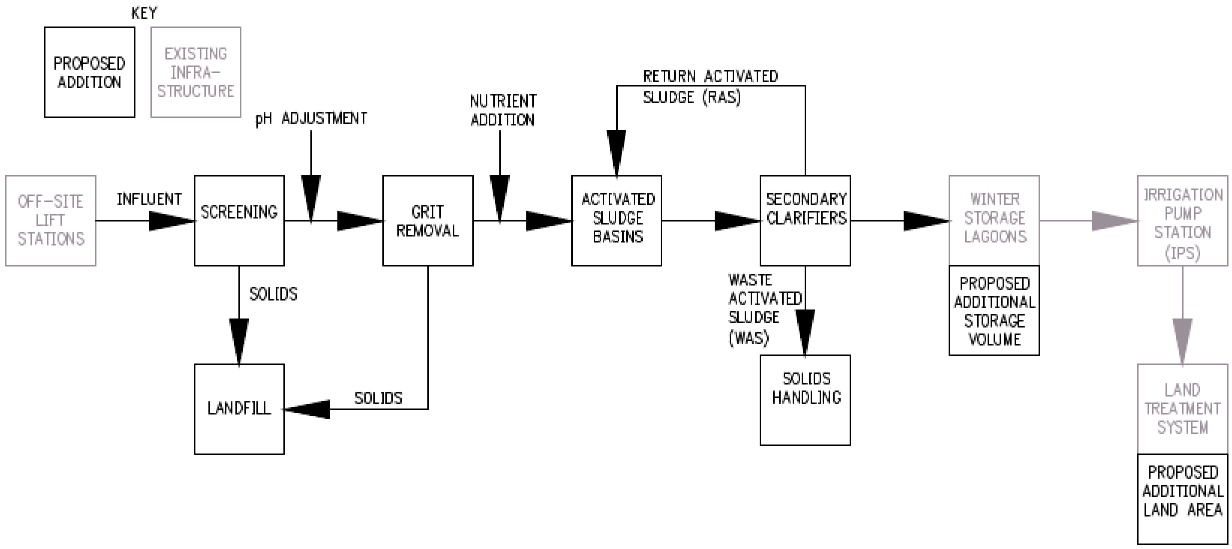
There are various configurations of aerobic activated sludge treatment processes that could be employed at the PWRF. Common configurations include continuous flow reactors (CFR), in which basins are compartmentalized into anoxic or aerobic zones and followed by clarifiers, and sequencing batch reactors (SBR) in which anoxic and aerobic conditions, as well as biomass settling, all occur via cycles within a tank. These processes provide a high level of treatment relative to footprint and could fit within the available space for treatment at the site without impacting the footprint needed for winter storage. Larger low-rate processes, such as aerated lagoons, are not considered due to the necessary footprint for such processes.

An SBR configuration, compared to a CFR, avoids compartmentalized tanks, secondary clarifiers, and associated equipment, and is likely to have a similar, though potentially lower capital cost to a CFR for this facility. For the purposes of comparing Alternative 2 to Alternative 1, an aerobic activated sludge treatment process in a CFR configuration is assumed, as this is likely to provide a slightly more conservative estimate of capital costs for the system.

A CFR configuration is assumed to include two identical basins, each compartmentalized to create anoxic and aerobic zones. Diffused aeration would be provided in the aerobic zones. Mixers are provided for each anoxic zone to homogenize the mixed liquor, a combination of wastewater and biomass. Mixed liquor is internally recycled, with some effluent from the final basin returning to the first basin and the rest continuing to a secondary clarifier where sludge settles to the bottom. Some settled sludge is returned to the activated sludge basins, called return activated sludge (RAS), while the rest is sent to solids handling, called waste activated sludge (WAS).

Figure 5-A provides a diagrammatic overview of the Alternative 1 treatment system.

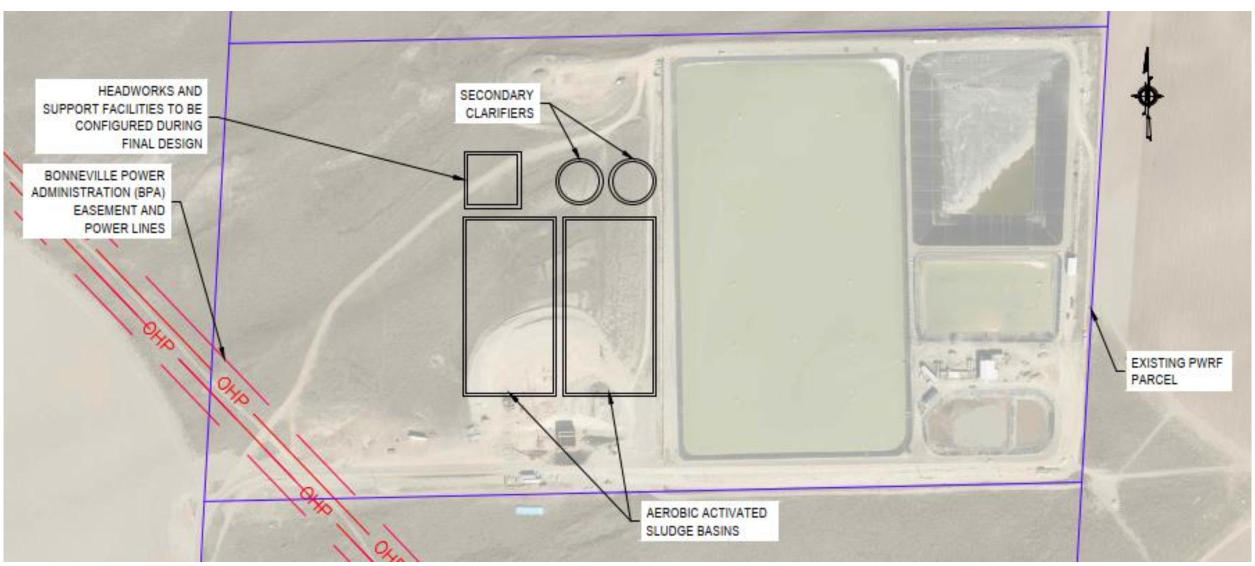
Figure 5-A – BOD Reduction Alternative 1 Process Schematic (CFR Option Shown)



As shown in the figure, the activated sludge process would be preceded by preliminary treatment consisting of screening and grit removal. A solids handling system would be necessary to process the waste sludge from the system.

Figure 5-B provides a preliminary basic layout of the treatment system footprint at the proposed PWRF site.

Figure 5-B – BOD Reduction Alternative 1 Conceptual Site Plan



The major considerations for this system are provided in the following section.

5.4.1.2 Major Considerations

5.4.1.2.1 Secondary Treatment (Basins and Clarifiers)

In this alternative, an aerobic activated sludge system would biologically remove organic matter and suspended solids from the wastewater, and then sludge would settle in secondary clarifiers.

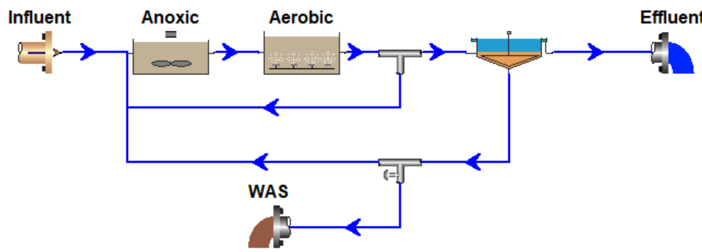
The 2019 Facility Plan recommended primary treatment prior to secondary treatment to reduce BOD. As previously stated, most of the influent BOD is soluble and is unlikely to be removed by conventional primary treatment methods, such as gravity separation. Some manufacturers promote DAF equipment as a form of primary treatment for BOD reduction in industrial wastewater, but this equipment would be expected to reduce the particulate fraction of BOD and not the soluble portion. Some of the existing processors already pretreat with DAF equipment, and the process water discharged from these facilities remains high in soluble BOD. For comparing secondary treatment alternatives, assuming no primary treatment is the most conservative approach and is recommended.

Screened and de-gritted influent would flow by gravity to the aerobic activated sludge system. The basins likely would be earthen impoundments with synthetic liners and concrete floors. Two basins are recommended: both basins would be operated in tandem to treat peak loading, and a single basin could be operated during the winter months. Configuration of the basin walls and berm construction would be analyzed in detail during final design. The basins likely would have an approximate volume of 20 MG each, with a side water depth of approximately 20 feet pending further analysis during final design. To maximize oxygen transfer within the basin volumes proposed, dense grids of fine bubble membrane aeration diffusers would be mounted to the concrete floor of the basins. Each basin would need to be periodically drained to perform maintenance on the diffusers; however, the basins could be sequentially taken offline for maintenance during the low loading season. The aeration system would need to be sized to meet the very large oxygen demands that would result from the high BOD loading. Based on preliminary modeling, the system is expected to require aeration blower capacity in excess of 5,000 hp. Due to this large size, it is expected that these aeration blowers would be housed on exterior concrete pads near the basins.

Two circular secondary clarifiers in concrete tanks, each approximately 120 feet in diameter, would be installed downstream of the activated sludge aeration basins. Full redundancy in the secondary clarifier system is not necessarily required, and as such, each clarifier is assumed to be sized to handle approximately 75 percent of the loading for this analysis. Each clarifier would include a RAS pump station consisting of a wet well with submersible sewage pumps for returning RAS to the influent upstream of the basins.

Figure 5-C shows the basic process configuration used in the BioWin® modeling of this alternative.

Figure 5-C – BOD Reduction Alternative 1 BioWin® Schematic



5.4.1.2.2 Solids Handling System

WAS would be pumped from the bottom of the clarifiers to a solids handling process. The activated sludge system likely will create approximately 0.75 to 1 pound of biomass per pound of influent BOD, resulting in large quantities of solids that must be wasted continually for processing prior to disposal. Based on this ratio, the average annual solids generated are expected to be on the order of 100,000 to 130,000 dry pounds per day. Due to this quantity, on-site stabilization through digestion, air drying, or other processes is likely not practical or economically feasible. Instead, it is likely that the solids will need to be dewatered onsite via permanent dewatering equipment. The most cost-effective disposal method for the dewatered sludge would be land application near the PWRF. However, the solids will not be stabilized through digestion; therefore, they will have a high volatile content. The content will make immediate tilling into fields or other measures necessary to reduce odor and vector attraction. In the winter months, lime addition or other methods for stabilization may need to be considered prior to storage of the dewatered sludge if fields are not accessible for application and tilling.

For the purposes of comparing alternatives, the solids handling system is configured to include sufficient dewatering and conveyance equipment to handle the projected WAS loading, with all sludge disposal occurring offsite via land application.

5.4.1.2.3 pH Adjustment

Magnesium hydroxide would need to be continually added to boost alkalinity prior to the activated sludge process since the low pH of influent process water would adversely affect an aerobic process. This addition would create significant ongoing chemical costs and increase the FDS loading to the land treatment sites. Preliminary calculations estimate that greater that 1,600 gallons per day (gpd) of a 60-percent magnesium hydroxide solution would be needed for Alternative 1, more than 7 times that estimated for Alternative 2.

5.4.1.2.4 Nutrient Addition

Per **Chart 3-I** and **3-J**, the average September (peak month) loading of 254,000 ppd BOD and 8,400 ppd TN equates to a BOD:TN ratio of 100:3.3, whereas the typical ratio for nutrient-limited waters for biological treatment is 100:5 BOD:TN. Based on preliminary BioWin® modeling, it appears likely that an aerobic activated sludge system would require the addition of both nitrogen and phosphorus. Feed systems for nutrients, in addition to the influent pH adjustment, would be provided upstream of the aerobic process. This represents a substantial ongoing chemical cost as described in the sections that follow. The uptake of nitrogen through assimilation into the activated sludge bacteria will remove most of the nitrogen with the influent BOD from the liquid stream. However, most of the influent nitrogen and the added nitrogen will be incorporated into the WAS. If all of the waste solids were to be disposed of by land application on the City-owned sprayfield, the nitrogen loading would be significantly higher than it is currently. Therefore, the waste solids would have to be transported elsewhere.

5.4.1.3 Expected Effluent Quality

Table 5-B provides the expected effluent water quality for the improvements proposed in Alternative 1.

Table 5-B – BOD Reduction Alternative 1 Expected Effluent Water Quality

Parameter		Units
pH	6.0 - 7.5	s.u.
BOD	< 300	mg/L
TSS	< 300	mg/L
TN	< 50	mg/L

5.4.1.4 Design Summary

Table 5-C provides the basic design criteria for the major components of the Alternative 1 pretreatment system.

Table 5-C – BOD Reduction Alternative 1 Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	1/4 in
Screen Quantity	3
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed impeller
Grit Washing System	Cyclone/classifier
pH adjustment	
60% $Mg(OH)_2$ Solution	>1,600 gpd
Solids Handling	
Mechanical Dewatering Equipment	
Solids Generation	100k-130k ppd
Activated Sludge Basins	
Basin Quantity	2
Basin Size	20 MG
Aeration Blowers	>5,000 hp
Clarifiers	
Clarifier Quantity	2
Clarifier Diameter	120 ft

5.4.1.5 Capital Cost Estimate

Table 5-D provides the estimated capital costs for the Alternative 1 pretreatment system. These costs assume that the project is completed as a single, standalone project. This table excludes costs that are identical between the systems. Total costs for the recommended improvements are provided in **Chapter 6**.

Table 5-D – BOD Reduction Alternative 1 Capital Costs

Item	Cost
Secondary Treatment (Activated Sludge)	$62,500,000
Solids Handling System	$25,100,000
PROJECT TOTAL	**$87,600,000**

1. *Costs rounded to nearest $100,000.*
2. *Costs include tax and indirect costs.*
3. *Contingency omitted for alternatives comparison.*

5.4.1.6 Estimated Operating and Maintenance Costs

The improvements for Alternative 1 are estimated to require four full-time operators, which represents approximately a two full-time employee (FTE) increase over the current PWRF staffing. This increase is prompted by the significant sludge dewatering operation required for this alternative. The major electrical loads are primarily associated with the large aeration system. Chemical costs include pH adjustment, influent nitrogen and phosphorus adjustment, and substantial polymer usage by the new system for processing WAS. The aerobic process will generate large quantities of solids, requiring hauling and disposal on a continual basis. Maintenance and equipment replacement costs are calculated as a portion of equipment that will require replacement within 20 to 30 years, including blowers and pumps.

Table 5-E provides the estimated annualized total operating costs for the processes presented in Alternative 1. The costs do not include operating costs for existing processes (i.e. the IPS) that will be maintained in all alternatives.

Table 5-E – BOD Reduction Alternative 1 Annual Costs

Item	Cost
Labor	$400,000
Electrical (Major Loads)	$1,500,000
Chemical	$2,800,000
Sludge Hauling and Disposal	$1,500,000
Equipment Maintenance and Replacement	$900,000
Total Annual	**$7,100,000**

5.4.2 BOD Reduction Alternative 2 – Anaerobic Treatment

5.4.2.1 Overview

This alternative would consist of an anaerobic treatment system to reduce the majority of the influent BOD. Other treatment processes, as evaluated in **Section 5.5 – Nitrogen Reduction Alternatives Analysis**, also would be necessary to provide nitrogen reduction.

In an anaerobic treatment system, bacteria grow in the absence of oxygen and break down organic matter in wastewater. The bacteria remove over 90 percent of the organic matter (BOD) and suspended solids from the wastewater. There are high rate and low rate anaerobic treatment systems. High rate systems, such as a UASB digester, allow for high loading relative to footprint and are applicable for treating high strength wastewater with low suspended solids concentrations. However, the suspended solids in the mixed process water to the PWRF likely would be problematic for a UASB, so a high rate treatment system is not recommended. Low-rate anaerobic digesters (LRAD), often constructed in earthen impoundments, are a common approach to treatment for process water similar to that discharged to the PWRF. An LRAD operates with a long hydraulic retention time, long solids retention time, and low biomass growth rate. This is the recommended approach to anaerobic treatment at the PWRF.

LRADs are typically engineered, turnkey systems for which there are multiple experienced designers, as well as vendors with packaged systems. The configuration of each system varies between designers, but generally includes the fundamental elements discussed in this report. For the purposes of analyzing these systems, Evoqua Water Technologies (Evoqua) was engaged to provide a basic design scope and quotation of an LRAD system, which they refer to under the trade name of Bulk Volume Fermenter (BVF). The BVF reactor was invented by ADI

Systems, which is now a part of Evoqua. A summary of Evoqua's design is provided in **Appendix 5-A**.

Figure 5-D provides a diagrammatic overview of the Alternative 2 treatment system.

Figure 5-D – BOD Reduction Alternative 2 Process Schematic

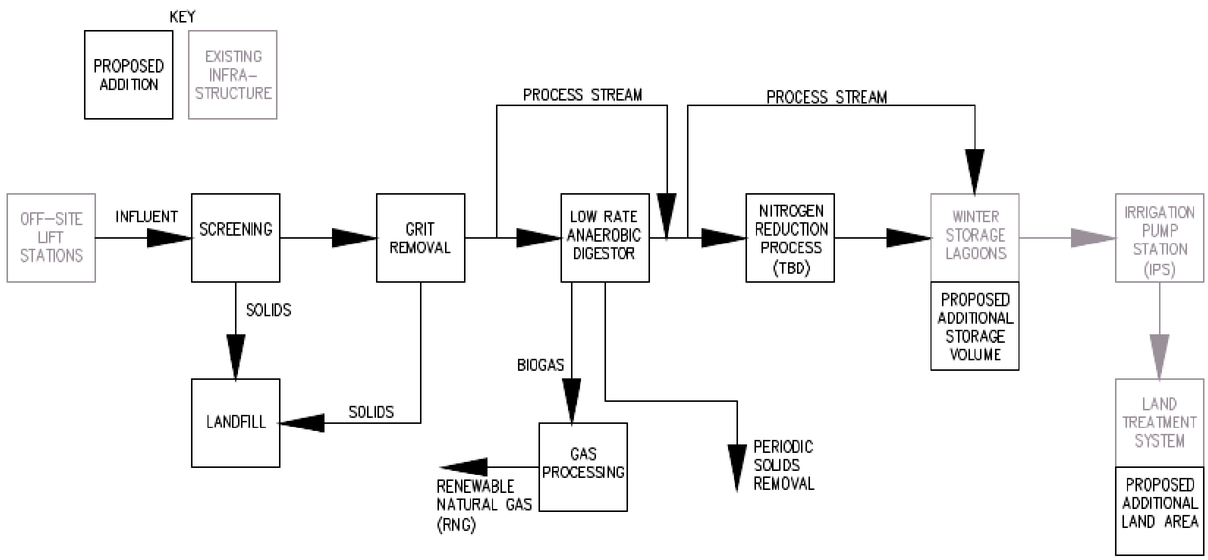
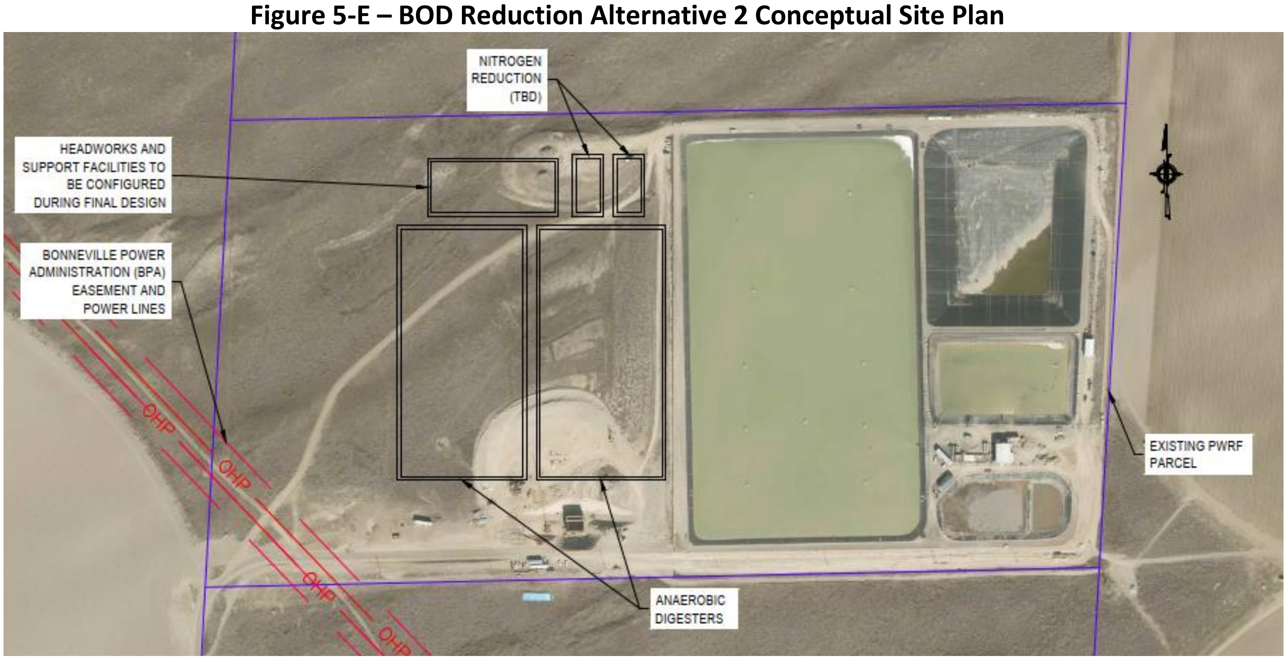


Figure 5-E provides a preliminary basic layout of the treatment system footprint at the proposed PWRF site.

Figure 5-E – BOD Reduction Alternative 2 Conceptual Site Plan



The major considerations for this system are provided in the following section.

5.4.2.2 Major Considerations

5.4.2.2.1 Influent Feed Tank

Evoqua's design includes tankage for influent storage to equalize peak flows to the LRAD system. An above-grade 40,000-gallon influent feed tank is fed by gravity from the headworks and then to a pump station prior to entering secondary treatment. The influent feed tank system also includes an overflow for peak volumes over/above the required treatment volumes. The overflow will route the flow directly to the storage lagoons.

5.4.2.2.2 Secondary Treatment (Anaerobic Treatment for BOD Reduction)

Downstream of the headworks, influent is discharged to LRAD reactors. Sludge from the reactors is recycled to the influent portion of the reactor to facilitate biomass contact and provide mixing in this area. The LRAD reactors are configured in a rectangular design with influent distributed across the short sides. The LRAD system consists of lagoons constructed within earth impoundments with a synthetic liner and upper concrete parapet walls. Based on the loading projected for the PWRF, two identical LRADs of approximately 34.5 MG each would provide sufficient capacity for the maximum month BOD load. Effluent flows by gravity from the opposite end of the LRAD reactor to the influent. Sludge settles within the LRAD and is wasted infrequently, as discussed in **Section 5.4.2.2.3 – Solids Handling**.

5.4.2.2.3 Solids Handling

A major advantage of anaerobic treatment of high strength wastewater is the limited sludge production relative to aerobic treatment as the digester destroys a large fraction of the volatile solids. Sludge generated by the anaerobic treatment of wastewater settles and is stored in the sludge storage zone of the digester, allowing wasting to occur only periodically. Evoqua's design estimates that 8.4 MG of sludge at 4-percent solids content will be wasted from the LRADs at a rate of two times per year.

Burnham SEV Pasco LLC (Burnham) (the contractor discussed in **Section 6.7 – Project Schedule and Delivery Method**) has proposed the following plan for solids removal. Twice per year, sludge will be pumped from the bottom of the digester to one of two rented Andritz DLX centrifuges for dewatering in order to reduce trucking costs. A centrifuge has been selected over belt presses because it requires less polymer and less water wash. The centrifuges will require the use of a polymer. They will dewater the sludge to approximately 18-percent solids. The dewatered sludge will then be sent into the bed of waiting haul-off trailers provided by Basin Disposal, Inc (BDI). Water will be returned to the treatment system. Basin Disposal has provided a trucking estimate and program that is 30-percent less than the initially estimated disposal costs. Approximately half of the cost is the pass through of tariffs from Finley Buttes landfill. Upon initial startup, the sludge will be analyzed to confirm composition and suitability for land application. If the sludge is suitable for land application, BDI will land apply the sludge at suitable third-party farms according to its typical practices and in compliance with all relevant permits and regulations, which will result in reduced disposal costs from elimination of the landfill tariffs.

5.4.2.2.4 Gas Handling

The bacteria in the LRAD produce biogas as a byproduct, which consists primarily of methane, carbon dioxide, ammonia, and hydrogen sulfide. The biogas is captured and collected by a floating geomembrane cover over the basin. The membrane also serves to insulate the basin and help maintain an LRAD operating temperature of approximately 85 degrees Fahrenheit. The biogas is conveyed from the LRAD by blowers. The collected biogas has multiple potential uses:

- Fuel source for firing on-site boilers to heat the LRAD influent;
- Flaring of excess gas; and
- Processing and discharge as a renewable natural gas.

For the purposes of comparing treatment alternatives in this chapter, costs are compared as if excess biogas will be used for LRAD heating and/or flared onsite. However, as will be discussed in **Chapter 6**, a benefit of an LRAD is the potential for processing biogas into renewable natural gas (RNG), which will be implemented at the facility.

The Burnham team has provided the following information on implementing an RNG system.

Producing RNG results in much lower air emissions compared to flaring the biogas, and RNG is a highly valued fuel, so it is more economic to generate and sell RNG than combust the biogas onsite for LRAD heating.

The biogas will be conveyed by blowers to a gas system, which contains two primary sub-systems: a hydrogen sulfide (H_2S) removal system and a carbon dioxide (CO_2)removal system. The H_2S removal system will utilize a regenerative catalyst to remove the H_2S from the biogas, converting the H_2S to elemental sulfur and reusing the catalyst. Approximately 1,500 ppd at 50-percent solids will be produced. The sulfur will be collected in a bin and will be landfilled by BDI.

The CO_2 removal system utilizes membranes to separate the CO_2 from the biogas and will then be emitted to atmosphere. The output of the upgrading system, RNG, then gets compressed and sent to the utility interconnect for injection. The system will have a single location for flaring biogas and off-quality RNG and/or gas volume that exceeds the capacity of the upgrading system or interconnect.

The upgrading system will be a net generator of water, at approximately 725 gpd average. The water will be condensed out of the biogas flow, and it will consist only of water and constituents that were present in the wastewater stream and digester. No new constituents will be introduced other than in trace forms. It is acceptable to the digester design for this stream to be reintroduced to the headworks system, and it will not cause an increase in the volume of any system design criteria, such as BOD, nitrogen, or FDS.

Relevant permits, including air permits, will be obtained for the gas upgrading system.

5.4.2.2.5 LRAD Heating

In order to maintain the desired operating temperature of the LRAD system, supplemental heat is required. Hot water boilers are used to provide hot water to heat exchangers for heating process water. Typically, LRAD contents are looped through heat exchangers continuously for this purpose.

Natural gas is typically used for initial heating and startup of the LRAD system. As previously noted, biogas can be used to fire the boilers once the LRAD system is operable.

5.4.2.2.6 Chemical Addition

Per Evoqua's design, magnesium hydroxide will be added as needed upstream of the LRAD to raise the influent pH. Evoqua estimated that 207 gpd of a 60-percent magnesium hydroxide solution would be needed for pH adjustment. It is expected that the chemical addition can be decreased after startup since the large LRAD volume will act as a buffer for the influent pH. A chemical feed system will be provided as part of the pretreatment improvements.

5.4.2.3 Expected Effluent Quality

Table 5-F provides the expected effluent water quality from Evoqua's design for the improvements proposed in Alternative 2.

Table 5-F – BOD Reduction Alternative 2 Expected Effluent Water Quality

Parameter	LRAD Effluent	Units
pH	6.5 – 7.5	s.u.
BOD	350	mg/L
TSS	460	mg/L
TN	100	mg/L

5.4.2.4 Design Summary

Table 5-G provides the basic design criteria for major components of the Alternative 2 pretreatment system.

Table 5-G – BOD Reduction Alternative 2 Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary drum
Screen Opening	1/4 in
Screen Quantity	2
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed impeller
Grit Washing System	Cyclone/classifier
pH Adjustment	
60% $Mg(OH)_2$ Solution	207 gpd
LRAD	
Basin Quantity	2
Basin Volume (per LRAD)	34.5 MG

5.4.2.5 Capital Cost Estimate

Table 5-H provides the estimated capital costs for the Alternative 2 pretreatment system. These costs assume that the project is completed as a single, standalone project. This table excludes costs that are identical between alternatives. Total costs for the recommended improvements are provided in **Chapter 6**.

Table 5-H – BOD Reduction Alternative 2 Capital Costs

Item	Cost
Secondary Treatment (Anaerobic System)	$50,000,000
Additional Costs	$6,500,000
PROJECT TOTAL	**$56,500,000**

1. *Costs rounded to nearest $100,000.*
2. *Costs include tax and indirect costs.*
3. *Contingency omitted for alternatives comparison.*

5.4.2.6 Estimated Operating and Maintenance Costs

Burnham (the contractor discussed in **Section 6.7 – Project Schedule and Delivery Method**) developed an estimate for the annualized total operating costs for the processes presented in **Section 5.4.2 – BOD Reduction Alternative 2 – Anaerobic Treatment** based on Evoqua's design proposal (**Table 5-I**).

Evoqua estimated that an LRAD coupled with its SBR system for nitrogen reduction would require 3 operators working at 12 hours per day, 7 days per week, as well as 1 FTE for maintenance. The operating costs from Evoqua's estimate were reduced in **Table 5-I** to approximate operating costs for an LRAD without additional processes for nitrogen removal. Labor costs include costs for operations, maintenance, and an asset fee. The annualized solids handling costs will cover the periodic removal of sludge from the LRAD. Consumables costs include chemical addition for pH adjustment, as needed, and minor equipment replacement. Per discussion with Burnham's team, their capital costs estimate (**Table 5-H**) also includes costs for pre-purchase of spare equipment, so costs for equipment replacement typical of this type of estimate are captured between the capital and operating and maintenance costs. Costs assume that biogas can be used to heat the LRADs.

Table 5-I – BOD Reduction Alternative 2 Annual Costs

Item	Cost
Labor	$800,000
Electricity	$250,000
Sludge Hauling and Disposal	$1,100,000
Consumables	$400,000
Total Annual	**$2,550,000**

1. *Estimate developed by Burnham based on Evoqua's design proposal.*

5.5 Nitrogen Reduction Alternatives Analyses

This section was prepared by the Probst Group, using information in **Section 5.4 – BOD Reduction Alternative Analysis** to revise Alternative 2 to include a Revolving Algal Biofilm (RAB) system for nitrogen removal.

5.5.1 Alternative 2A – Aerobic Algae Treatment for Nitrogen Reduction

5.5.1.1 Overview

This alternative would consist of an anaerobic treatment system, which reduces the majority of the influent BOD, followed by an aerobic treatment system to reduce nitrogen. The proposed aerobic treatment system to reduce nitrogen will utilize algae as a more sustainable alternative compared to activated sludge processes. By substantially reducing BOD with the anaerobic system, a much smaller aerobic system is necessary than proposed in Alternative 1.

A summary of Gross-Wen Technology's (GWT) design of the RAB is provided in **Appendix 5-B**.

Figure 5-F provides a diagrammatic overview of the Alternative 2A treatment system.

Figure 5-F – Nitrogen Reduction Alternative 2A Process Schematic

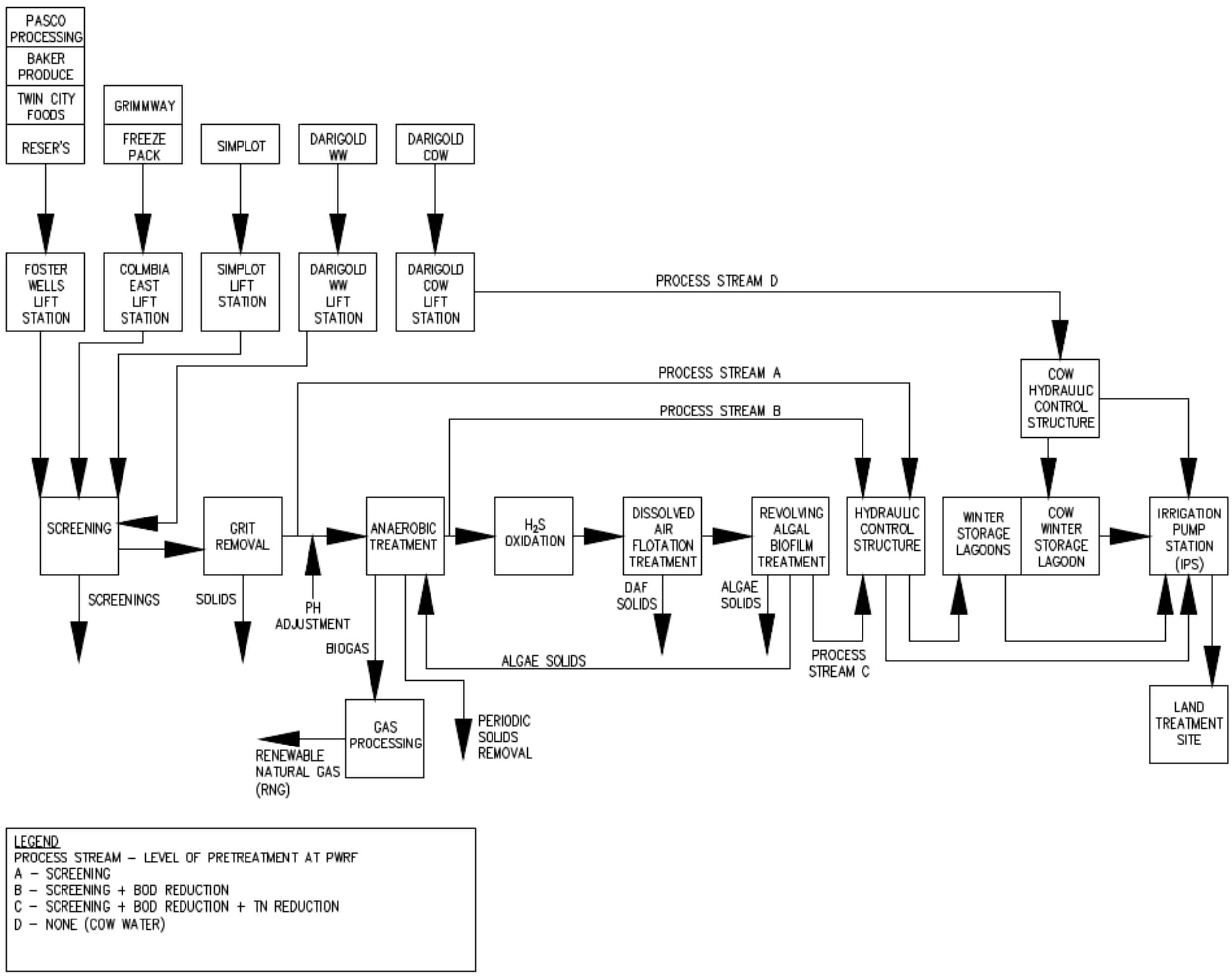
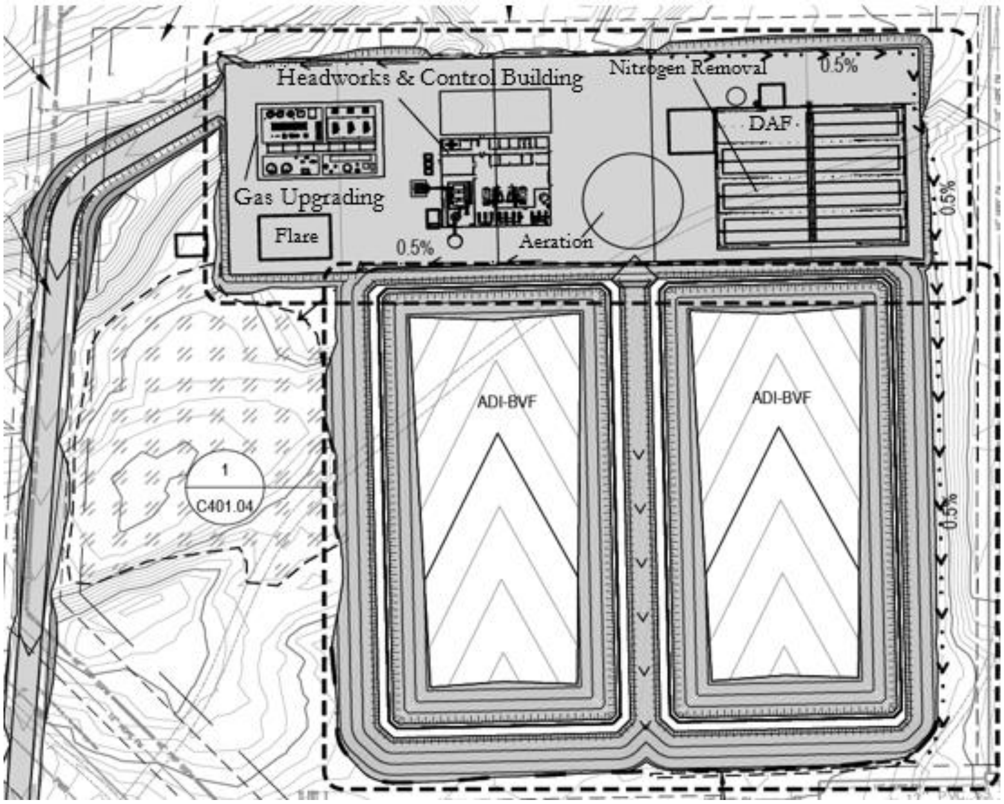


Figure 5-G provides a preliminary basic layout of the treatment system footprint at the proposed PWRF site.

Figure 5-G – Nitrogen Reduction Alternative 2A Site Plan



The major considerations for this system are provided in the following section.

5.5.1.2 Major Considerations

5.5.1.2.1 Influent Feed Tank

The influent feed tank for this alternative would be the same as described for Alternative 2 in **Section 5.4.2.2.1 – Influent Feed Tank**.

5.5.1.2.2 Secondary Treatment (Anaerobic Treatment for BOD Reduction)

Anaerobic Treatment for this alternative would be the same as described for Alternative 2 in **Section 5.4.2.2.2 – Secondary Treatment (Anaerobic Treatment for BOD Reduction)**.

5.5.1.2.3 Aeration before DAF Process

Following the LRADs will be an aeration tank. This tank will be sized to provide at least 4 to 5 hours of retention time and will be aerated with coarse bubble diffusers. This uncovered tank will oxidize any hydrogen sulfide from the water before entering any enclosed environments.

5.5.1.2.4 Solids Removal Following LRAD Prior to RAB Process

Following the LRADs will be a DAF system whose function is to remove any carry-over suspended solids from the LRADs prior to treatment in GWT's RAB. A very small amount of chemical addition at the DAFs is anticipated due to the low inlet TSS concentration. The solids from the DAF will be dewatered by a centrifuge and disposed offsite.

5.5.1.2.5 Secondary Treatment (Aerobic Treatment for Nitrogen Reduction)

Following the LRAD, a portion of wastewater would be sent to an aerobic algae treatment process for nitrogen removal. Only partial treatment would be needed since reducing nitrogen loading below the acceptable rate for land treatment is not beneficial.

In principle, an aerobic treatment system for nitrogen reduction following an anaerobic system will function as discussed in Alternative 1 and could use various configurations, such as CFR or SBR. Alternatively, the secondary aerobic treatment process can be replaced with an algae-based wastewater treatment technology, known as the RAB. As previously noted, the anaerobic system greatly reduces the organic influent load, which allows the aerobic system to be sized significantly smaller. For the purposes of this alternatives analyses, GWT has provided a scope, quotation, and design for an RAB system to follow anaerobic treatment. An RAB system consists of a series of vertically oriented conveyor belts that slowly rotate in a wastewater medium. The system is housed within a commercial greenhouse. In this way, the system provides an optimal environment for algae to grow rapidly. The algae grows on the surface of the rotating belts and is periodically harvested (removing the nutrients) to allow for more algae to grow. The wastewater flow is passed in series from one stage of RAB treatment to the next. Each stage of treatment performs a fraction of the required treatment and the cumulative removal of all stages is designed to meet the mass removal targets of the facility. Similar to LRADs, RABs are typically engineered, turnkey systems and GWT is the only manufacturer with a patented RAB process. Based on the necessary nitrogen reduction at the projected flow and loading, GWT recommends 13 identical RABs constructed in rectangular concrete tanks, each providing approximately 0.040 MG in operating volume. GWT also recommends installing additional infrastructure to allow for easy capacity expansion in the future. In short, GWT will be supplying 13 total RAB modules within 14 total reservoir basins and a properly sized greenhouse.

The effluent from the RAB will combine with other pretreatment process streams at a hydraulic control structure and flow to the storage lagoons or the IPS.

5.5.1.2.6 Solids Handling

Solids handling from the LRADs for this alternative would be the same as described for Alternative 2 in **Section 5.4.2.2.3 – Solids Handling**.

Solids handling from the DAF preconditioning step is discussed in **Section 5.5.1.2.4 – Solids Removal Following LRAD Prior to RAB Process**, and solids handling from the RAB is discussed in **Section 6.3.8.4 – RAB Algae Solids Removal**.

5.5.1.2.7 Gas Handling

Gas Handling from the LRADs for this alternative would be the same as described for Alternative 2 in **Section 5.4.2.2.4 – Gas Handling**.

5.5.1.2.8 LRAD Heating

LRAD heating for this alternative would be the same as described for Alternative 2 in **Section 5.4.2.2.5**.

5.5.1.2.9 Chemical Addition

The pH of RAB influent should be maintained above approximately 6.5 to allow for stable algae growth.

5.5.1.3 Expected Effluent Quality

Table 5-J provides the expected effluent water quality from GWT's design for the improvements proposed in Alternative 2A.

Table 5-J – Nitrogen Reduction Alternative 2A Expected Effluent Water Quality

Parameter	LRAD Effluent	RAB Effluent	Units
pH	6.5 -7.5	7.0- 9.0	s.u.
BOD	350	< 100	mg/L
TSS	460	< 100	mg/L
TN	100	32	mg/L

5.5.1.4 Design Summary

Table 5-K provides the basic design criteria for major components of the Alternative 2A pretreatment system.

Table 5-K – Nitrogen Reduction Alternative 2A Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary drum
Screen Opening	1/4 in
Screen Quantity	2
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed impeller
Grit Washing System	Cyclone/classifier
pH Adjustment	
60% $Mg(OH)_2$ Solution	207 gpd
LRAD	
Basin Quantity	2
Basin Volume (per LRAD)	34.5 MG
RAB	
Basins with RAB	13
Spare Basins	1
Basin Volume (per RAB module)	0.040 MG
Belt Surface Area (per RAB module)	16,150 SF

5.5.1.5 Capital Cost Estimate

Table 5-L provides the estimated capital costs for the Alternative 2A pretreatment system. These costs assume that the project is completed as a single, standalone project. This table excludes costs that are identical between alternatives. Total costs for the recommended improvements are provided in **Chapter 6**.

Table 5-L – Nitrogen Reduction Alternative 2A Capital Costs

Item	Cost
Secondary Treatment (Anaerobic System)	$50,000,000
Secondary Treatment (Aerobic Algae System)	$35,500,000
Additional Costs	$6,500,000
PROJECT TOTAL	**$92,000,000**

1. *Costs rounded to nearest $100,000.*
2. *Costs include tax and indirect costs.*
3. *ContinGency omitted for alternatives comparison.*

5.5.1.6 Estimated Operating and Maintenance Costs

Burnham (LRAD supplier, the contractor discussed in **Section 6.7 – Project Schedule and Delivery Method**) and GWT (RAB supplier) adapted an estimate for the annualized total operating costs for the processes presented in Alternative 2A based on Evoqua's design proposal (**Table 5-M**).

Burnham, using Evoqua's and GWT's proposals as references, bid the operations and maintenance of the facility to qualified firms and have included these in the buildup of labor costs, which in **Table 5-M** includes costs for operations, maintenance, and an asset fee. The annualized solids handling costs will cover the periodic removal of sludge from the LRAD. Consumables costs include chemical addition for pH adjustment, as needed, and minor equipment replacement. Per discussion with Burnham's team, their capital costs estimate (**Table 5-L**) also includes costs for pre-purchase of spare equipment, so costs for equipment replacement typical of this type of estimate are captured between the capital and operating and maintenance costs. Costs assume that biogas can be used to heat the LRADs and do not include costs for the RNG system.

Table 5-M – Nitrogen Reduction Alternative 2A Annual Costs

Item	Cost
Labor	$1,500,000
Electricity	$300,000
Sludge Hauling and Disposal	$1,100,000
Consumables	$500,000
Total Annual	**$3,400,000**

1. *Estimate adapted by Burnham based on Evoqua's and GWT's design proposals.*

5.5.1.7 Comparison of Alternatives and Recommendation

Both systems will be configured in a manner that alleviates the deficiencies of the current PWRF pretreatment system. Further, both secondary treatment alternatives can be configured to provide sufficient capacity for the proposed flow and loading, and both systems will provide sufficient treatment to allow effluent to be discharged within the capacity of the LTS as described in **Chapter 4**. For the purposes of analyzing the two alternatives, the capital costs are assumed to funded over 25 years with an interest rate of 5 percent in order to establish annual debt service costs. The primary difference between the two alternatives is the life-cycle costs. The estimated life-cycle costs for the two alternatives are summarized in **Table 5-N**.

Table 5-N - Comparison of Alternatives 1 and 2 Life-Cycle Costs over 25 years

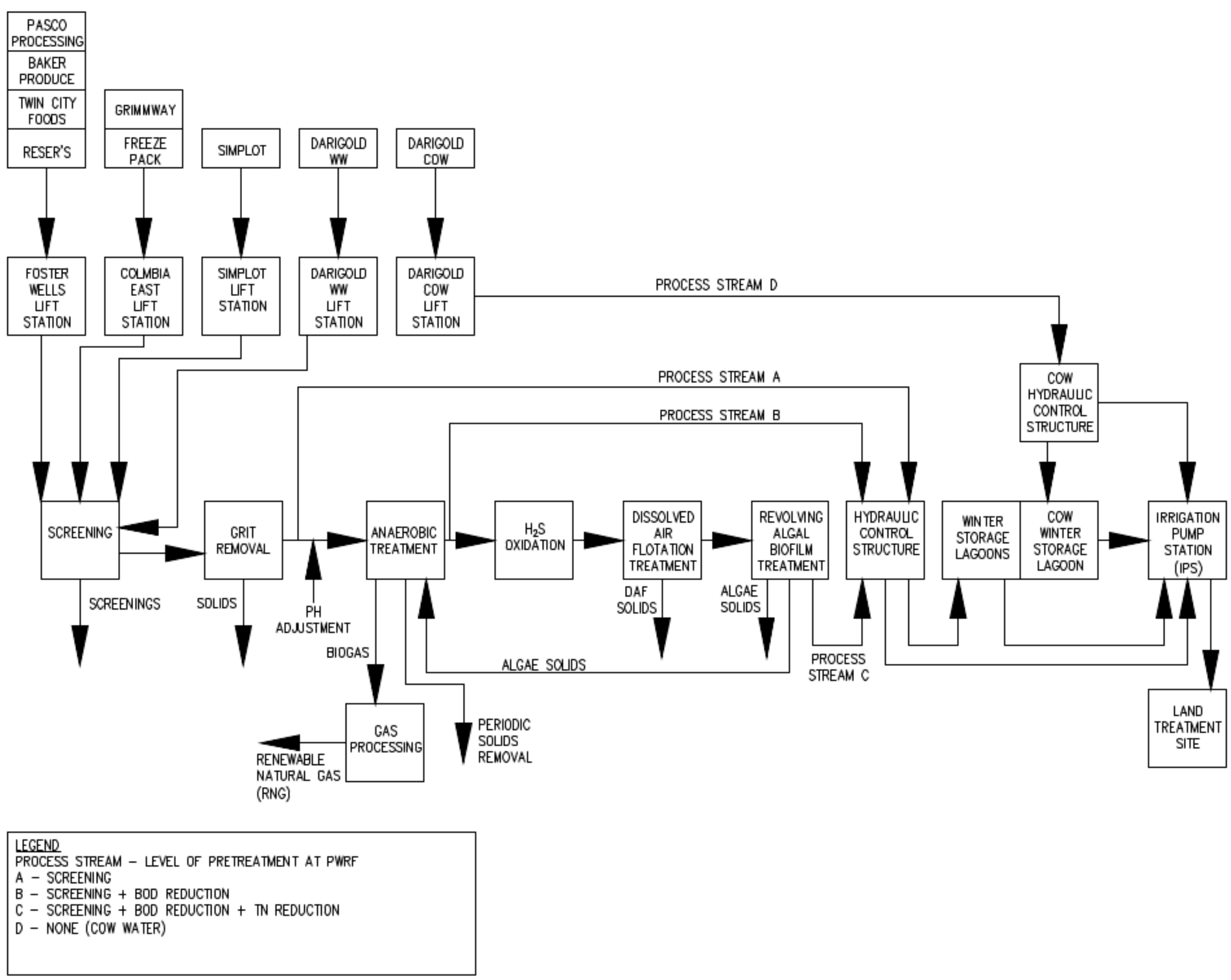
	Alternative 1 (Aerobic Only)	Alternative 2A (Anaerobic + Aerobic Algae (RAB))
Capital Cost		
Secondary Treatment (Activated Sludge)	$62,500,000	-
Solids Handling System	$25,100,000	-
Secondary Treatment (Anaerobic System)	-	$50,000,000
Secondary Treatment (Aerobic System)	-	$35,500,000
Additional Costs	-	$6,500,000
Capital Costs Project Total	**$87,600,000**	**$92,000,000**
Annualized Costs		
Annual Debt Service (5%, 25-yr)	**$6,300,000**	**$6,600,000**
Operations & Maintenance Costs		
Labor	$400,000	$1,500,000
Electricity	$1,500,000	$300,000
Sludge Hauling and Disposal	$1,500,000	$1,000,000
Consumables	$0	$500,000
Chemical	$2,800,000	$0
Equipment Maintenance and Replacement	$900,000	$0
Total Operations & Maintenance Costs	**$7,100,000**	**$3,400,000**
Total Annual Cost Estimate	**$13,400,000**	**$10,000,000**
Percent above lowest option	34%	0%

Alternative 2A, consisting of an LRAD system followed by aerobic algae treatment for nitrogen reduction, is the preferred alternative due to lower life-cycle costs. This alternative has lower operating costs for aeration, chemical addition, and solids handling. Preliminary sizing and additional details for the recommended alternative are discussed in **Chapter 6**.

Chapter 6.0 Implementation of Recommended Improvements

Based on the analyses of the previous chapters, the PWRF will be reconfigured to include biological treatment, including anaerobic followed by aerobic treatment, prior to discharge of effluent to the expanded LTS. Additional winter storage lagoons also will be constructed. This chapter intends to provide a sufficiently detailed description of the proposed improvements such that the design of the system can commence upon approval of this report in accordance with WAC 173-240-130. **Figure 6-A** provides a basic schematic of the proposed system.

Figure 6-A – Proposed Process Schematic



As shown in the figure, the existing and new processors will convey their process water to one of five lift stations. The Darigold COW water stream will go to a hydraulic control structure that will direct flow to either a designated storage lagoon or directly to the IPS. All other process water streams will combine to enter the proposed headworks for screening and grit removal. The screened and de-gritted influent will enter the anaerobic treatment system, which will substantially reduce BOD. The effluent from the anaerobic treatment system, or a portion of it depending on flow and loading, will flow to the aerobic treatment system for nitrogen reduction. The aerobic treatment system will consist of DAF treatment for preconditioning followed by RAB treatment for nitrogen reduction. As labeled, process streams A, B, and C will each receive a different level of pretreatment before combining at a hydraulic control structure. The flows in each process stream will be controlled to meet pretreatment goals. Treated effluent can discharge from the hydraulic control structure to the IPS for distribution to the LTS or to the lagoons for storage. During non-irrigation months, process water will remain in the storage lagoons.

As discussed in **Section 1.1.3.2 – Planned Improvements**, improvements are proposed to be constructed in three distinct phases. Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities and relocates a portion of two of the FWLS force mains. Construction Phase 2 provides additional winter storage through proposed lagoons and begins grading a construction site for pretreatment. Construction Phase 3 will construct the pretreatment improvements. The project delivery method is further discussed in **Section 6.7 – Project Schedule and Delivery Method**.

6.1 Site Layout

The proposed overall site layout is summarized in **Exhibit 6-A**. Storage lagoons will be placed on the 80-acre Reclamation parcel north of the existing PWRF, and pretreatment improvements will be placed on the west 40 acres of the City's parcel with the existing PWRF. The layout of pretreatment improvements in the allocated area is included in **Figure 5-G**.

The overall site layout, which was chosen through an analysis of multiple alternatives, most cost effectively balances the hydraulic profile needs with excavation, grading, and utility extension costs. This layout efficiently provides the necessary footprint for the required pretreatment and storage areas discussed in this chapter.

6.2 Utilities and Other Improvements

6.2.1 Site Access

The only established access to the PWRF site is through a 60-foot access and utility easement on neighboring parcels. There is a 20-foot-wide access road that traverses through the easement. Utilities within the easement include five process water force mains, a proposed water main, and proposed power/fiber conduits. The recorded easement language precludes any additional utilities from being installed. **Figure 6-B** shows the off-site utility routing to the PWRF.

The proposed site layout places the pretreatment site in the west half of the existing City parcel. This would provide easy access for the Phase 3 contractor from the existing access easement, as only a short access road would need to be constructed. This also would limit the amount of access by the Phase 3 contractor through the City and northern Reclamation parcels, allowing the City to secure its site.

Figure 6-B – Off-Site Utility Routing

6.2.2 Process Water Conveyance

Processors are not proposing increases to peak flows, so the existing lift station and force main capacities (FWLS, CELS, and SLS) are sufficient for conveying the proposed flows from Pasco Processing, Baker Produce, Freeze Pack, Twin City Foods, Simplot, Reser's, and Grimmway (**Table 6-A**). Simplot may eventually decommission its private lift station and instead connect into the CELS, which will require upgrades to the CELS capacity at that time; this upgrade is outside the scope of this report and will be addressed with a future design memorandum. Darigold will construct two private lift stations and force mains to separately convey its wastewater and COW water streams to the PWRF. Darigold will be responsible for constructing its lift stations and force mains to the PWRF, and the City will review their system design.

Table 6-A – Lift Station Peak Flow Capacities

Lift Station	Initial Capacity (gpm)	Future Capacity (gpm)	Force Main Diameters
Foster Wells Lift Station (FWLS)	4,300	4,300	(1) 8” (1) 16” (1) 20”
Columbia East Lift Station (CELS)	2,174	4,171	(2) 20”
Simplot Lift Station (SLS)	1,200	Shutdown	(1) 10”
Darigold WW Lift Station	700	700	TBD
Total (No COW)	**8,400**	**9,200**	**-**
Darigold COW Lift Station	700	700	TBD

Table 6-B compares the existing and proposed flows to the FWLS. As shown in the table, the projected maximum month flow to the FWLS is less than that currently permitted. Similarly, the peak flows to the FWLS are not projected to increase; processors have requested increases to their total annual flows but not to their peak flows, so the lift station capacity is still sufficient.

Table 6-B – FWLS Existing and Projected Flows

Dischargers to FWLS	Existing Permitted MM Flow (MGD)	Projected MM Flow (MGD)
Pasco Processing & Baker Produce	2.5	2.5
Twin City Foods	2.4	1.8
Reser’s	0.3	0.41
Total (MGD)	**5.2**	**4.7**
Equivalent Total (gpm)	**3,600**	**3,300**

Table 6-C shows the proposed flows to the CELS; the CELS design occurred prior to this report, and it was designed to accept flows from Grimmway and Freeze Pack. Peak flows for these processors have not increased, so the lift station capacity is still sufficient.

Table 6-C – CELS Projected Flows

Dischargers to CELS	Projected MM Flow (MGD)
Grimmway	1.65
Freeze Pack	0.11
Total (MGD)	**1.8**
Equivalent Total (gpm)	**1,200**

The six force mains from the existing lift stations currently extend to the existing screenings building. As part of Phase 1 construction, two of the FWLS force mains will be relocated from the start of the PWRF access road at E Foster Wells Road to the IPS to be better aligned with existing force mains and provide a more uniform utility corridor for future utilities. All force mains will need to be extended to the proposed headworks building located on the pretreatment site.

6.2.3 On-Site COW Water

Darigold's COW process water is expected to be relatively clean compared to other processors' water streams; therefore, it has flexible uses. The COW process water may be used for direct land treatment, mixed with other treated process water, or used onsite for lagoon washdown. A lift station and force main is proposed for conveying COW process water within the PWRF site to give flexibility for the process water's on-site use.

6.2.4 Natural Gas

Natural gas will need to be supplied to the site for heating the BVF (Evoqua's trade name for its LRAD). It is proposed that a 4-inch natural gas main be extended to the site along the existing 60-foot access and utility easement from E Foster Wells Road; however, the existing easement is explicit in its language regarding the number and type of utilities. Natural gas is not a listed utility. The Phase 3 contractor will bear the responsibility and costs for obtaining a new easement and for extending the natural gas pipeline. Alternatively, if an easement cannot be acquired from E Foster Wells Road, the natural gas main may come from north of the site.

6.2.5 Domestic Water

The City is installing a 20-inch high-density polyethylene (HDPE) water service from the E Foster Wells Road and Capital Avenue intersection to the IPS, screens building, and office trailer as part of the Phase 1 PWRF improvements to provide fire protection and potable water. This service will need to be extended to the pretreatment site to provide fire protection and potable water there as well.

6.2.6 Power and Fiber

The City is extending underground power and fiber infrastructure to existing facilities as part of the PWRF Phase 1 improvements. Franklin Public Utility District will install cables, conductors, and switch gear, and energize the power system as they are the utility purveyor. Power and fiber infrastructure for existing and proposed demands, including pretreatment, will be extended from E Foster Wells Road to the existing screens building as part of the Phase 1 improvements. Power and fiber infrastructure will then need to be extended to the pretreatment site.

6.2.7 Domestic Wastewater

Currently, domestic wastewater produced at the PWRF is discharged to a septic system. No domestic sanitary wastewater is discharged to the PWRF treatment system. A new small septic system to support the proposed pretreatment facilities will be evaluated during final design.

6.2.8 Stormwater

Stormwater discharge from the PWRF currently infiltrates into the surrounding ground surface or is directed into the PWRF treatment system. A Stormwater Pollution Prevention Plan (SWPPP) is located on file at the PWRF. The proposed improvements are intended to retain and infiltrate stormwater onsite. The detailed stormwater improvements design and permitting will be completed during final design. The SWPPP will be updated to address new construction.

6.3 Pretreatment System Improvements

The recommended pretreatment alternative is low rate anaerobic treatment followed by aerobic RAB treatment, as determined by the alternatives analysis in **Chapter 5** and summarized in the following sections.

Evoquas's design for the pretreatment system is included in **Appendix 5-A**. GWT's design for the RABs is included in **Appendix 5-B.**

6.3.1 Flow and Loading Criteria

The pretreatment system design criteria previously established in **Table 5-A** is reproduced in **Table 6-D**. Darigold's COW process water stream is shown separately in the table as it will not be discharged to the pretreatment system.

Table 6-D – Pretreatment System Flow and Loading Criteria

	Process Water to Pretreatment	Darigold COW
Flow		
Annual Average Day (MGD)	4.38	0.80
Total Annual (MG)	1,600	292
Maximum Month Average Day (MGD)	8.56	0.95
Peak Hour (Cumulative Lift Station Capacities) (gpm)	9,200	700
BOD		
Maximum Month Average Day (ppd)	300,000	40
TN		
Annual Average Day (ppd)	4,450	85

Note: Darigold's COW process water stream will not be discharged to the pretreatment system.

6.3.2 Raw Wastewater Pump Station

The proposed design includes a Raw Wastewater (RWW) Pump Station to which all force mains discharge. The RWW is intended to lift the combined influent to a new above-grade headworks facility as discussed in **Section 6.3.3 – Preliminary Treatment**. The pump station is designed with multiple pumps, with 100-percent redundancy in the largest pump. The pumps will operate on variable frequency drives (VFDs) for flow control. The pumps will be installed within a wet well.

6.3.3 Preliminary Treatment – Screening and Grit Removal, Headworks

A secondary treatment system for this application should be preceded by preliminary treatment consisting of screening and grit removal to protect downstream processes. The existing screens have much finer openings at 0.02 inch and are intended to provide BOD reduction as previously discussed. The proposed design includes a new screening system installed in conjunction with an automated grit removal system, both co-located at a new headworks facility. Construction of a new headworks will avoid disturbing the existing preliminary treatment system during construction and will allow the new headworks to be located near the other recommended pretreatment system improvements.

The new design includes two ¼-inch rotary drum screens, which are predominately in place as a protection mechanism for downstream processing. The raw wastewater enters a headbox where the energy is dissipated, and the flow is evenly distributed onto the interior of the rotary screening drums capable of handling a peak flow of 4,600 gallons per minute (gpm) each, for a total of 9,200 gpm. Solid particles are retained on the screen surface while the liquid flows radially out through the screen openings. Screened solids are transported axially, by internal flights, to the open end of the rotary drum screen. The entire screening surface is intermittently washed by a fixed external spray bar. Screened solids will be transferred and collected in a storage dumpster bin for final disposal. Evoqua has successfully used this technology on numerous projects processing similar wastewater, working with similar and in some instances the same processors as in this project. Benefits of this technology as compared to other systems are minimal associated equipment required, and it is proven to be a reliable, low-maintenance solution to an application of this scale. Evoqua's vendor for this unit has a book of experience in the market, responsive customer service, and a widespread network of service and maintenance facilities.

The design also includes a grit removal system which uses a grit vortex hydrodynamic/cyclone separation system to pull small particles out of the flow stream (e.g., Grit King by Hydro International). This system can handle a peak flow of 9,200 gpm. The gravity fed grit vortex system is designed to remove grit, sediment, and sand via a tangentially positioned inlet, causing a rotational flow path around the dip-plate and spiraling down the wall of the chamber to allow solids to settle out by gravitational forces. The grit collects in the grit pot at the base of the unit for efficient dumpster bin collection and disposal. Evoqua specified this equipment primarily due to the small footprint, compared with the traditional vortex system, and the equipment's ability to handle the maximum flow requirements for this project while still having the ability to install the unit inside the operations building. The minimal equipment, including one electric motor and two control valves, associated with the unit and proven reliability reduces the need to store expensive maintenance parts or have issues with unscheduled maintenance. The other options considered were grit chambers and grit basins. These were dismissed to their larger footprint and greater operations and maintenance (O&M) concerns due to having more moving parts.

Solids from screening and the grit removal system will be periodically removed from the facility in dumpsters by the local waste hauler, BDI, as part of the broader waste management services they are providing to the facility. No conditioning will be necessary. As a conservative approach, current plans for the removed screening and grit solids are for them to be sent to the Finley Buttes landfill. Once operational, if materials testing confirms suitability for land application and a willing third party that is not part of the PWRF land treatment system is identified, the solids will be land-applied by BDI in order to reduce costs.

The headworks is sized to accommodate the peak hour flow of 9,200 gpm. The basic design criteria for the preliminary treatment system is provided in **Table 6-E**.

Table 6-E – Preliminary Treatment Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	¼ in
Screen Quantity	2
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed Impeller
Grit Washing System	Cyclone/Classifier

The headworks equipment will be enclosed in a building for weather protection and to confine influent odors.

6.3.4 Influent Feed Tank

An above-grade 40,000-gallon influent feed tank is fed by gravity from the headworks and then to a pump station prior to entering secondary treatment. The influent feed tank system also includes an overflow for peak volumes over/above the required treatment volumes. The overflow will route the flow directly to the storage lagoons.

6.3.5 Influent Pump Station

The design includes an influent pump station to convey process water to secondary treatment. The pump station is designed with 3 pumps with 100-percent redundancy in the largest pump. The pumps will operate on VFDs for flow control. The pumps are end-suction centrifugal and will be housed in the building.

The pump station is configured to allow flow to be diverted and metered between the normal discharge to the anaerobic system, as well as to bypass to the effluent system.

6.3.6 Influent Odor Control

Areas of high odor potential are open-flow areas prior to the BVF’s. These processes have been designed to be located within the headworks building and completely closed off to the other functional areas. Additionally, the screening and grit removal processes are designed to predominately separate inorganic compounds, allowing the organic compounds (odor source) to pass through to the BVFs.

6.3.7 Low Rate Anaerobic Digestion for BOD Reduction

The proposed design includes two 34.5 MG BVFs. The two BVF reactors are self-contained lagoon structures that will not impound surface water runoff or impede the watershed hydraulics. Each BVF is 602 feet long by 301 feet wide (inside dimensions face to face of interior concrete walls). Relative to the existing grade of approximately 545 ft above sea level, the exterior of the BVF will consist of a 17-foot-high earthen berm with a concrete wall extending approximately 4.0 feet above the embankment. Total height of 21 ft from existing grade. The top of the concrete wall will be at elevation 566 ft. On the interior, the concrete wall will extend down 16 feet to the top of the interior earthen berm which will slope down to an elevation of approximately 10 feet below grade. The BVF floors and walls will be covered with an XR5 Geomembrane. Influent is distributed at one end of the BVF, and effluent flow is collected at the opposite end of the digester. All pipes enter the BVF through the parapet wall and sealed liner for mixing, sludge recycle and removal, inflow and outflow. Each BVF Lagoon will have an underdrain system to collect any seepage. The underdrain will flow to a monitored sump that will continuously record the water level within the sump and provide notification to the control room of any increase in flows. A monitoring alarm and notification system will be set up so that operations are timely notified of any issues.

The BVFs were sized to provide 90 percent BOD reduction for the maximum month BOD loading of 300,000 ppd. It is expected that the BVFs can accept BOD loading above this rate for up to one week, but provisions for bypass to the storage lagoons should be provided in case of longer sustained high loading. The BVFs also are expected to minimally reduce TN, which necessitates the downstream aerobic treatment system for the majority of the TN reduction.

The design includes two sets of pumps and conveyance within each BVF. The supernatant recycle system, intended to buffer the effects of loading variation, conveys supernatant from the influent surface of each BVF to the influent sludge bed of each BVF. The supernatant recycle system also includes heat exchangers to be used with boilers to heat the BVFs to their design operating temperature of 85 degrees Fahrenheit. The RANS system, intended to improve biomass-substrate contact, recycles sludge from the floor of the effluent end to the influent of each BVF. The RANS system also can be used to waste sludge from the BVFs as needed.

The BVFs will require Dam Safety permits and Dam Safety's approval of plans. This is currently being coordinated with Dam Safety.

6.3.7.1 BVF Solids Handling

The BVFs will produce sludge that needs to be removed from the system periodically. The equation for the total volume of sludge produced is [Sludge from Bios Yield] + [Undigested Solids].

- The influent criteria for the PWRF has an average chemical oxygen demand (COD) load of 262,000 ppd, average net removal of TSS of 62,000 ppd.
- The influent criteria from the GWT/RAB system is an average 86 ppd, 50-percent destruction in anaerobic digestion (AD).
- The design criteria of the AD process is 90-percent COD removal for a yield 0.04 lbs suspended/lbs COD removed.
- Calculation:
  - [(0.04 lbs/lbs x 262k ppd x 0.90)+(62k x 0.1)] + [0.5 x 86] = 15.6k lbs TSS/day
  - It is assumed that the solids content is 4-percent and thus the total daily solids volume is: [(15.6k lbs TSS/day)/(0.04 x 8.34)] = 46k gpd @ 4-percent solids, OR 16.8 MG/year.

Twice a year, 8.4 MG of sludge is targeted to be removed and dispositioned through a third-party contractor, Basin Disposal. The sludge will be pumped from the bottom of the digester, where it will be at about 4-percent solids, to one of two rented Andritz DLX centrifuges for dewatering to reduce trucking costs. A centrifuge has been selected over belt presses because it requires less polymer and less water wash. The centrifuges will require the use of a polymer and dewater the sludge to approximately 18-percent solids. The dewatered sludge will then be sent into the bed of waiting haul-off trailers provided by BDI. Water will be returned to the treatment system. BDI has provided a trucking estimate and program that is 30-percent less than the initially estimated disposal costs. Approximately half of the cost is the pass through of tariffs from Finley Buttes landfill. Upon initial startup, the sludge will be analyzed to confirm composition and suitability for land application. If the sludge is suitable, BDI will land apply the sludge at suitable third-party farms according to its typical practices, which will result in reduced disposal costs from elimination of the landfill tariffs.

6.3.7.2 Gas Handling and Renewable Natural Gas

A geomembrane covers the BVF basins and retains the biogas produced by the anaerobic process. The biogas will be processed into RNG for resale, as discussed in **Section 6.7 – Project Schedule and Delivery Method**. Per the design, biogas production from the BVF is estimated at an average annual rate of 1,830,000 cubic feet per day (ft^3/day) and a maximum month rate of 4,190,000 ft^3/day. Since biogas production trends with BOD loading, the maximum month biogas production will far exceed the average annual production. It is not expected to be financially advantageous to design the biogas processing for the maximum month production, so biogas in excess of the processing capacity will be flared. When biogas is being processed for resale, external natural gas is expected to be used in the boilers to heat the BVFs to their optimal operating temperature.

The upgrading system contains two primary sub-systems: an H_2S removal system and a CO_2 removal system. The H_2S removal system will utilize a regenerative catalyst to remove the H_2S from the biogas, converting the H_2S to elemental sulfur and reusing the catalyst. The CO_2 removal system utilizes membranes to separate the CO_2 from the biogas and will then be emitted to atmosphere. The output of the upgrading system, RNG, then gets compressed and sent to the utility interconnect for injection. The system will have a single location for flaring biogas and off-quality RNG and/or gas volume that exceeds the capacity of the upgrading system or interconnect.

The system will be a net generator of water, at approximately 725 gpd average. The water will be condensed out of the biogas flow, and it will consist only of water and constituents that were present in the wastewater stream and digester. No new constituents will be introduced other than in trace forms. It is acceptable to the digester design for this stream to be reintroduced to the headworks system, and it will not cause an increase in the volume of any system design criteria, such as BOD, nitrogen, or FDS.

The facility design uses a regenerative catalyst to convert the H_2S in the biogas stream from the anaerobic digesters to elemental sulfur. Approximately 1,500 ppd at 50-percent solids will be produced. The sulfur will be collected in a bin and will be landfilled by BDI.

The facility will obtain all necessary air permits from Ecology in order to operate the gas upgrading system.

6.3.8 Revolving Algal Biofilm Treatment for Nitrogen Reduction

6.3.8.1 Aeration Before DAF Process

Following the BVFs will be an aeration tank. This uncovered tank will be aerated with fine bubble diffusers and will function to oxidize any hydrogen sulfide from the BVF effluent before entering the downstream enclosed environment.

6.3.8.2 Solids Removal Following BVF Prior to RAB Process

Following the aeration tank, the DAF will function to remove any carry-over suspended solids from the BVFs prior to treatment in the RAB system. The DAF is sized to treat the entire RAB system influent. A very small amount of chemical addition at the DAF is anticipated due to the low inlet TSS concentration. The sludge will be dewatered by means of a centrifuge to approximately 20-percent solids approximately 36 cubic yards per day. Removed water will be returned to the aeration tank. The solids will be collected in a bin and will be removed by BDI to be disposed of in a landfill.

6.3.8.3 RAB Nitrogen Reduction

The effluent from the DAF process will flow to the RAB system. GWT's design uses thirteen 0.040 MG RAB basins, each with approximately 16,500 sf of belt surface area and 4 feet of wall height (3 feet of water height) for aerobic algae-based nutrient removal. The system is designed to take the BVF effluent after some preconditioning (accomplished with a DAF system for solids removal). The algae takes all carbon needed from the surrounding atmosphere. The average annual TN concentration is expected to vary by month and reach an annual average below 32 mg/L. Since nitrogen reduction is only needed to stay below the land treatment capacity, flows above 4 MGD will not receive RAB treatment.

Each RAB consists of ten belt units. The belt units rotate slowly in and out of the wastewater media, providing the algae access to nutrients within it. When the belts rotate out of the wastewater, the algae are exposed to light and CO_2, giving the organisms their energy and carbon source. The 13 RABs are staged in series, with flow going directly from one RAB to the next. Each RAB does a fraction of the total mass removal required. Collectively, the required mass removal is accomplished with all systems removing a fraction of the total. Refer to GWT's design proposal for RAB treatment in **Appendix 5-B**.

6.3.8.4 RAB Algae Solids Removal

The algae and biomass that grows on the RAB belts is periodically removed from the system. The typical schedule is to remove the material after 7 days of growth. The material is never removed from the entire system all at once. An automatic harvesting tool is programmed to harvest a set length of belt on a repeating schedule. For example, for a 10-belt module, the belts are harvested on a weekly schedule such that 2 belts are harvested each day, with no belts harvested on 2 days. An estimated 24K gallons per week of solids will be generated; calculations and further details are outlined in **Appendix 5-B**.

A 5,000 gallon 'day tank' is required to store the material before it is conditioned and dewatered in the dewatering box. For redundancy, two 5,000-gallon storage tanks are to be used. To concentrate the material from 3-percent solids to a minimum of 15-percent solids, GWT will use containerized dewatering boxes to remove the free water that is captured during the harvest of the belts. Some polymer is added to the harvested material to speed up the dewatering process and ensure that all material is captured in the dewatering box.

The proposed facility will accommodate two 30 cubic yards (CY) roll-off dewatering boxes. Each box has approximately 5,000 gallons of working volume for dewatered biomass. Since the material will be concentrated from 3-percent to 15-percent solids, each 30 CY box can process approximately 25,000 gallons of harvested material. The estimated production of harvested material is approximately 25,000 gallons per week. Each box will be removed by GWT once per week so that the algae can be processed offsite.

Ten percent of the dewatered algal solids will be re-introduced to the digester to support gas production, with the sizing of the RAB system designed to support this reintroduction. The remaining 90-percent will be disposed of by GWT either as fertilizer or be landfilled. The reject water that is removed from the algae sludge is largely ‘free water’ that is not encapsulated in the algae cells. This water has similar water quality to the water that the algae grew in (i.e. the water that is being treated). The water that is drained from the box will be returned to the aeration tank (prior to the DAF process) for treatment. Several floor drains should be used to collect and return the reject water.

The algae is expected to be marketed by GWT as a product to be used as a fertilizer. This expectation is derived from material testing of algae produced by the RAB system in other projects. These laboratory analyses conclude that the algae meets U.S. Environmental Protection Agency 503 Classification Standards and thus is suitable for use as fertilizer. If the material in this project is outside of necessary specifications, GWT is contractually obligated to dispose of the algae at its cost, with the expectation being that it would be landfilled.

6.3.9 Chemical Addition

The facility design does not include process use of hazardous chemicals. It will include substances, such as oil and grease, used in the services of the equipment within the facility (compressors, bearings, etc.). Secondary containment requirements will be met where required by respective governing bodies/policies, and generally for all bulk storage of non-hazardous chemicals.

Magnesium hydroxide will be added as needed upstream of the BVF to raise the influent pH. Evoqua estimated that 207 gpd of a 60-percent magnesium hydroxide solution would be needed for pH adjustment. It is expected that the chemical addition can be decreased after startup since the large BVF volume will act as a buffer for the influent pH. The pH of RAB influent should be maintained above approximately 6.5 s.u. to allow for stable algae growth. Magnesium hydroxide addition was predicted for each month based on the average annual flow distribution (**Table 6-F)**, and the FDS impact was included in evaluation of the LTS in **Chapter 4**.

Table 6-F – Average Monthly Magnesium Hydroxide Addition

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pretreatment Influent Flow (MGD)	2.3	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.7	6.62	5.01	2.98
$Mg(OH)_2$ (gpd)	109	101	108	119	120	200	319	349	364	313	237	141

A chemical feed system will be provided as part of the pretreatment improvements. A 15,000-gallon tank and dual metering pumps are included in the system design.

All planned chemicals are described in **Table 6-G**.

Table 6-G – Pretreatment Chemical Usage

Location	Chemical	Purpose	Volume	Hazardous?	FDS Impact
BVF	Magnesium Hydroxide	pH control	207 gpd	No	Yes
DAF	Aluminum Chlorhydrate	Coagulant	1,000 gpd	No	No
DAF	Polytech PT-11128BD (Cationic Emulsion Polymer)	Polymer	50 gpd	No	No
RAB Dewatering	Polytech PT-11128BD (Cationic Emulsion Polymer)	Dewatering	0.5 gpd	No	No
Headworks	N/A	N/A	N/A	No	No
Gas Upgrading	Sulfcat Catalyst	H_2S Removal	30 gpd	No	No

6.3.10 Other Considerations

6.3.10.1 Effluent Screening

Operators at the PWRF have noted that fouling of the irrigation nozzles occurs frequently. The new BVF system will substantially reduce the starches and other substances that may cause fouling in the existing system. However, the open storage lagoons can collect tumbleweeds and other debris. The City is currently evaluating options to mitigate debris entering the irrigation system, including fencing around the storage lagoons and/or coarse screening of the effluent.

6.3.10.2 Sampling

Flow-proportionate composite sampling will be required for the raw influent, the hydraulic control structure where all flows from pretreatment combine, and the IPS effluent to the LTS for permit reporting. Other intermediate sampling locations for process control sampling may require additional samplers and will be considered during final design.

6.3.10.3 Fire Protection Requirements

The Construction Phase 1 improvements will provide a sufficiently sized domestic water pipe to the proposed pretreatment site for fire flow. During final design, additional fire protection measures shall be evaluated in accordance with the appropriate National Fire Protection Association (NFPA) codes and standards, especially for wastewater process areas and gas handling areas.

6.3.10.4 Electrical Classification

The National Electrical Code and NFPA must be thoroughly reviewed during the final design to determine the electrical system requirements for each area of the pretreatment process. The extents and requirements for classified spaces, such as those where the hazard of flammable gas ignition is present, must be identified and the electrical system appropriately designed for these applications. In addition to providing suitable climate and odor control, building ventilation must be designed to meet NFPA requirements if air exchanges are used to reduce electrical classification.

6.3.10.5 Building Construction and Materials Selection

The final design will review the occupancy and classification of the buildings proposed for the site and will determine the appropriate materials of construction for each building to meet the intended use, classification, and fire protection requirements. The Washington State Energy Code will be reviewed to determine the specific construction requirements for each structure.

6.3.10.6 Back-Up Power

The proposed facility design includes an emergency/back-up natural gas generator. This system will be engaged by means of an automatic transfer switch to automatically back up the critical facility loads in the event of an outage of the primary service.

6.3.10.7 Management, Administration, and Maintenance

Burnham will build, own, and operate the Phase 3 treatment facility. Burnham will have on-site management and administration and will outsource the primary operations and maintenance to Aquatech, a qualified, global, and industry-recognized operations and maintenance provider.

The existing PWRF pretreatment facilities will be abandoned after the construction of the new pretreatment improvements. As such, the proposed improvements will require consideration of restrooms, offices, kitchen, breakroom, storage areas, maintenance shop or garage, and other items to be determined and configured in the final design. A small on-site laboratory is recommended for performing process control testing and potentially may be expanded to complete all permit testing if desired by the City. Proper separation of the administration and maintenance areas from process areas is critical to a suitable work environment for the operators and should be thoroughly reviewed during final design.

6.3.10.8 Site Security

Currently, the PWRF site is unsecured. The new treatment facility and gas processing equipment will include perimeter fencing and access gates.

6.3.10.9 Odor Control

A facility-wide odor control plan will be developed and implemented as part of the facility permit.

6.3.11 Summary of Design Criteria for Recommended Pretreatment Improvements

The pretreatment flow and loading design criteria from **Table 6-D** is reproduced in **Table 6-H**, and a summary of the pretreatment design criteria is provided in **Table 6-I**.

Table 6-H – Pretreatment System Flow and Loading Criteria

	Process Water to Pretreatment
Flow	
Annual Average Day (MGD)	4.38
Total Annual (MG)	1,600
Maximum Month Average Day (MGD)	8.56
Peak Hour (Cumulative Lift Station Capacities) (gpm)	9,200
BOD	
Maximum Month Average Day (ppd)	300,000
TN	
Annual Average Day (ppd)	4,450

Table 6-I – Pretreatment Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	¼ in
Screen Quantity	2
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed Impeller
Grit Washing System	Cyclone/Classifier
pH Adjustment	
60% $Mg(OH)_2$ Solution	207 gpd
BVF	
Basin Quantity	2
Basin Volume (per BVF)	34.5 MG
RAB	
Basins with RAB	13
Spare Basins	1
Basin Volume (per RAB module)	0.040 MG
Basin Surface Area (per RAB module)	16,150 sf

6.4 Storage System Improvements

6.4.1 Storage Projections

Process water produced outside of the irrigation season is stored in storage lagoons until the spring. By permit, land treatment is not allowed from December 1st through February 28th; however, the land treatment window is further limited by weather and crop demand, so storage should be planned for parts of November and March as well. Irrigation has been scheduled based on individual field soil water holding capacities and the design limiting crop rotation. As discussed in **Section 4.4.3.1 – Hydraulic Capacity**, the land treatment system irrigation will occur only during appropriate climatic conditions and within the agronomic capacity and growing conditions of the field-specific crop rotation.

Projected winter storage needs can be estimated from the average monthly flow distribution to the PWRF established in **Section 3.5.2 – Projected Flow** and the irrigation demand to the fields. Winter storage calculations are included in **Appendix 6-A**. As an initial estimate, RH2 Engineering, Inc., calculated the storage volume needed for each processor using a storage season of November 15th through March 15th (**Table 6-J**). This estimate assumes all process water produced outside of the storage season can be promptly applied to the fields, and all process water produced within the storage season must be stored through March 15th.

A more detailed analysis of the storage requirement was completed by comparing the average monthly flow distribution to the PWRF with the monthly flow to the fields. In **Chapter 4**, Valley evaluated the controlling scenario for loading to the fields, based on the theoretical Maximum Month Scenario summarized in **Appendix 3-C** and **Section 3.5. – Summary of Projected Flow and Loading**. The theoretical Maximum Month Scenario was controlling for loading to the fields, but the controlling scenario for winter storage is the Average Annual Scenario in **Appendix 3-B**, in which each processor produces the full contracted winter flows. Valley also projected flows to fields for the Average Annual Scenario, included in the **Appendix 6-A** calculations. The Average Annual Scenario yielded a storage requirement of 97 MG for the COW lagoon and 351 MG for the other lagoons (**Table 6-J**). Adding 8-percent contingency, the minimum recommended storage is approximately 106 MG for the COW lagoon and 381 MG for other lagoons. The existing PWRF site already provides 158 MG of winter storage (from the 123 and 35 MG storage lagoons), so at least 106 MG of COW winter storage and 223 MG of other process water winter storage must be added.

Table 6-J – Projected Winter Storage

	Nov. 15 - Mar. 15 Winter Storage Estimate (MG)
Pasco Processing	99
Twin City Foods	7
Reser's	50
Simplot	60
Grimmway	25
Freeze Pack	9
Darigold WW	85
Total (no COW)	**323**
Darigold COW	93
Total (with COW)	**416**

	LTS Design Basis Winter Storage Estimate (MG)
COW Lagoons	**97**
Other Lagoons	**351**

Note: March 1^{st}-15^{th} and November 15^{th}-30^{th} storage are estimated as half of each monthly flow volume

6.4.2 Storage Lagoons

The proposed winter storage lagoons will be constructed on the Reclamation parcel north of the existing PWRF as shown in **Exhibit 6-A**. The site layout in **Exhibit 6-A** proposes approximately 329 MG of new storage divided between 3 new lagoons, including a designated approximately 106 MG lagoon for Darigold's COW process water stream. The proposed storage volume meets the required storage determined in **Section 6.4.1 – Storage Projections**. The incremental cost to add additional storage beyond the required volume is very low compared to the cost of separately constructing that storage capacity in the future, so storage should be constructed to utilize the full parcel.

A Dam Safety Report along with 90% plans and specifications for Phase 2 storage improvements have been submitted to Ecology's Dam Safety Office (Dam Safety) for review. The Dam Safety report includes structural design of the lagoons, seepage analysis, multiple breach analysis, drawdown analysis, and hazard classification. Plans and specifications will be submitted to Ecology's Water Quality Office (Water Quality) following Dam Safety's review.

Embankments will be constructed with 3H:1V side slopes. Lagoons will have 4.0' of freeboard at maximum storage. The total embankment height will typically be under 15 feet, with toe drains being added for portions over 15 feet, keeping the lagoons in a low dam classification with Dam Safety. Crest width will be approximately 30 feet between proposed lagoons. The crest between the existing ponds and the proposed ponds will be approximately 60 feet wide. Gravel access roads will be constructed along the top of all embankments. A 14-foot-wide access road will be constructed around the toe of the outer embankments to aid in inspection and maintenance. Overflow weirs will be installed between the storage lagoons, with a final emergency overflow weir and spillway provided from the east proposed storage lagoon.

The proposed lagoons will be single-lined with a 40-mil reinforced polyethylene (RPE) liner. The 40-mil RPE liner is laminated with a woven, interior HDPE scrim and an exterior LDPE coating that has been treated for UV resistance. The RPE liner provides superior puncture and tear resistance compared to 60 mil high density polyethylene (HDPE) liners and is installed in larger panels, reducing the number of seams. A double layer of RPE will be installed along access roads and outfalls to prevent punctures and wearing of the liner. The liner will have venting at the top to allow trapped air and gasses to escape. Ballast bags will be constructed with sandbags and a piece of RPE liner welded over the top of the bags. Ballast bags will be spaced approximately every 50 feet along the lagoon embankments to secure the liner during windstorm events. Seams between liner paneling will be air tested for leakage. Preliminary liner specification are included in **Appendix 6-B**; final liner specifications will be provided when Phase 2 plans and specifications are submitted to Water Quality.

Groundwater quality monitoring wells will be installed to measure upgradient and downgradient groundwater quality. Based on previous geological investigations, groundwater is expected approximately 80 feet below the site. Groundwater monitoring well design will be submitted to Ecology as a separate phase of construction that will coincide with the timing of the Phase 2 construction.

Exhibit 6-A also includes proposed settlement monuments to detect embankment settlement and seepage monitoring wells to detect leakage in the immediate vicinity of the lagoons, as required by Dam Safety.

Additionally, the existing 5 MG lagoon will be decommissioned once all proposed PWRF improvements are operational. The lagoon will be filled in and all pipes routed to it will be capped.

6.5 Land Treatment System Improvements

The proposed LTS improvements are evaluated and described in **Chapter 4**. Approximately 514 acres of land treatment area will be added from the Beus Farms (Circle B19 in **Exhibit 4-F**) and Voss Farms land (Circles V6, V17, and V18 in **Exhibit 4-F**), making the total land treatment area 2,370 acres. Groundwater monitoring wells will be installed adjacent to the new fields (**Exhibit 4-F**).

Design of the irrigation system will be completed separately from this report, and a design memorandum will be issued as an addendum before the irrigation system is constructed.

Conveyance will be installed from the existing IPS to the proposed land treatment areas. PACE Engineers, Inc., (PACE) completed a separate study, the 2022 *Process Water Reuse Facility Land Treatment Evaluation* (2022 LTE), which evaluated the improvements needed to incorporate the proposed Voss Farms land, including the proposed conveyance.

The existing IPS was constructed to replace the previous IPS following recommendations from the 2019 Facility Plan. It conveys process water to the LTS via a 24-inch-diameter irrigation force main. PACE's 2022 LTE recommended that the existing 24-inch-diameter force main be dedicated to convey process water to the Voss Farm circles and 2 existing north circles, and a new parallel 30-inch-diameter force main be installed to convey to the rest of the existing LTS circles.

The proposed conveyance to the Beus Farms land will tee off the existing 24-inch-diameter IPS discharge at the southeast corner of the existing PWRF parcel, run north to the north boundary of the Reclamation parcel, and then turn west to the Beus property and route to its center irrigation pivot. This routing may change with final design. Based on preliminary sizing calculations, a 12-inch-diameter HDPE pipe would be sufficient for this force main.

The Voss Farm circles are already equipped with pivots for irrigation. The Beus Farm circle will need to be equipped with an irrigation pivot and prepared for planting crops. The respective landowners will be responsible for improvements within their irrigation circles.

6.6 Compliance Points

Ecology will designate compliance points, enforcement limits, and monitoring requirements in the updated PWRF permit. The compliance point for evaluating the overall pretreatment system performance will be at the hydraulic control structure where flows from all levels of pretreatment combine. It is anticipated that the pretreatment compliance point will have AA and MM limits for total nitrogen loading, since pretreatment targets TN reduction. Since pretreatment does not target FDS, the FDS compliance point will be at the IPS where COW water is combined with other process streams before being sent to the fields. The LTS will be evaluated on an annual basis in the annual farms report for other constituents. BOD is anticipated to be well below the current permit limit of 100 lb/ac/day and will be reported annually in the farms report. The load to each field will be measured by the concentration at the IPS and the corresponding flow to each field.

Per discussions during preparation of this report, Ecology anticipates establishing TDS instead of FDS limits in the future. However, additional data collection and study is needed to determine that limit and any improvements necessary to comply. It is anticipated that Ecology will allow the next two permit cycles for TDS data to be collected, impacts studied, and an amendment written to this Engineering Report to propose any improvements for TDS reduction, if needed.

6.7 Project Schedule and Delivery Method

Near-term improvements to the PWRF are currently planned in three construction phases:

- Construction Phase 1 – Off-site Utilities – Began Summer 2022
- Construction Phase 2 – Winter Storage Expansion – Begin Winter 2023
- Construction Phase 3 – Pretreatment System – Begin Winter 2023

Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities and relocates a portion of two of the E Foster Wells Road force mains. Construction Phase 2 then constructs the proposed storage lagoons, begins site grading, and extends utilities constructed in Phase 1 to the proposed pretreatment site. In conjunction with Phase 2 construction, Darigold's WW and COW lift stations and force mains will be constructed, which will be Darigold's responsibility up to connection into the pretreatment facility. Construction Phases 1 and 2 will be implemented with a traditional design-bid-build project delivery method.

Construction Phase 3 will construct the pretreatment improvements on the designated area of the PWRF site. The existing pretreatment system will stay operational throughout construction of Phase 3 improvements; therefore, bypass of the existing system will not be necessary. The City is pursing completing Construction Phase 3 through a design-build-own-operate project delivery method. This method was selected due to a third-party's interest in the financial opportunity of reselling processed biogas from the BVF as RNG. Through a public bid process, the City selected Burnham for the design, construction, operation, maintenance, and financing of the proposed pretreatment system, including the gas processing facility. Burnham will select subcontractors to design and construct the pretreatment improvements through a design-build contract. It is anticipated that GWT will be part of Burnham's scope of work in providing the pretreatment system.

Burnham will build, own, and operate the Phase 3 treatment facility. Burnham will have on-site management and administration and will outsource the primary operations and maintenance to Aquatech, a qualified, global, and industry-recognized operations and maintenance provider. Burnham will own the pretreatment improvements and lease the land from the City. The City will own and operate the conveyance lift stations, force mains, storage lagoons, and influent pump station.

The LTS improvements, including installing conveyance from the PWRF to the LTS and equipping the LTS for irrigation, will be complete in conjunction with Phase 3 improvements, separate from Burnham's contract.

Table 6-K shows the schedule for improvements. All improvements are planned to be completed by winter of 2024.

Table 6-K – Project Schedule

Year	2021				2022												2023												2024									
Month	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Phase 1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																		
Planning & Permitting	■	■	■	■	■	■	■	■	■																													
Design & Bidding	■	■	■	■	■	■	■	■	■	■																												
Construction												■	■	■	■	■	■	■	■	■																		
Phase 2					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Planning & Permitting					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																		
Design & Bidding											■	■	■	■	■	■	■	■	■	■	■	■	■															
Construction																							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Phase 3					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Planning & Permitting					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																
Design Build					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

1. *LTS improvements will occur with the same overall schedule as the Phase 3 improvements under a separate contract.*

6.8 Estimated Capital Costs

The capital costs are summarized in the following Engineer's Opinion of Probable Construction Costs (OPCC) for Phase 1 (**Table 6-L**), Phase 2 (**Table 6-M**), Phase 3 (**Table 6-N**), and the LTS improvements (**Table 6-O**). The costs are planning-level estimates and have not yet been developed in detail.

Table 6-L – Phase 1 OPCC

Item Description	Total Amount
Preparation	$719,000
Water	$1,151,000
Sewer	$678,000
Electrical	$664,000
Surfacing/Paving	$1,132,000
Grading	$93,000
Erosion Control and Planting	$39,000
Traffic	$47,000
Other Items	$146,000
Subtotal	**$4,669,000**
Sales Tax - 8.1%	$374,000
Net Total, Including Sales Tax	**$5,043,000**

1. *Costs rounded to nearest $1,000 .*

Table 6-M – Phase 2 OPCC

Item Description	Total Amount
Preparation	$882,000
COW Water Lift Station and Force Main	$915,000
Potable Water	$73,000
Process Water	$2,529,000
Electrical	$26,000
Darigold Utilities	$612,000
Surfacing/Paving	$588,000
Grading	$14,583,000
Erosion Control and Planting	$79,000
Other Items	$832,000
Subtotal	**$21,117,000**
Contingency - 35%	$7,391,000
Sales Tax - 8.1%	$2,452,000
Net Total, Including Sales Tax	**$30,960,000**

1. *The “Darigold Utilities” item includes cost to construct lift stations and conveyance from Darigold’s facility up to connection into the PWRF, which will be Darigold’s responsibility.*
2. *Costs rounded to nearest $1,000.*

Table 6-N – Phase 3 OPCC

Item Description	Total Amount
Preliminary Treatment	$12,500,000
BVFs for BOD Reduction	$50,000,000
RABs for Nitrogen Removal	$35,500,000
Additional Costs	$6,500,000
Total	**$104,500,000**

1. *Costs rounded to nearest $100,000.*
2. *Costs includes tax and indirect costs.*
3. *Estimate for BVFs, RABs, and Additional Costs provided by Burnham based on Evoqua's design and GWT's design.*
4. *Estimate does not include cost for RNG processing facility.*

Table 6-O – Land Treatment System Improvements OPCC

Item Description	Total Amount
Voss Farms and Existing LTS Conveyance	$3,401,000
Beus Farms Conveyance	$900,000
Subtotal	**$4,301,000**
Contingency - 40%	$1,720,000
Sales Tax - 8.1%	$490,000
Net Total, Including Sales Tax	**$6,511,000**

1. *The "Voss Farms and Exiting LTS Conveyance" item is the rough order of magnitude cost estimates from PACE's 2022 LTE.*
2. *Costs rounded to neared $1,000.*

The total estimated capital cost of the proposed improvements is $147 million.

6.9 Estimated Operating and Maintenance Costs

Burnham (the Phase 3 contractor discussed in **Section 6.7 – Project Schedule and Delivery Method**) developed an estimate for the annualized total operating costs for the proposed pretreatment improvements based on Evoqua's design proposal (**Table 6-P**).This estimate does not include costs for RNG processing.

Per Evoqua's and GWT's proposal, the improvements are estimated to require two operators working 12 hours per day, 7 days per week, as well as 1 FTE for maintenance. Labor costs include costs for operations, maintenance, and an asset fee. The annualized solids handling costs will cover the periodic removal of sludge from the BVF. Consumables costs include chemical addition for pH adjustment, as needed, and minor equipment replacement. Per discussion with Burnham's team, their capital costs estimate (**Table 6-N**) also includes costs for pre-purchase of spare equipment, so costs for equipment replacement typical of this type of estimate are captured between the capital and operating and maintenance costs. Costs assume that biogas can be used to heat the BVFs.

Table 6-P – Annual Operating and Maintenance Costs

Item	Cost
Labor	$1,500,000
Electricity	$300,000
Sludge Hauling and Disposal	$1,100,000
Consumables	$500,000
Total Annual	**$3,400,000**

1. *Estimate developed by Burnham.*
2. *Estimate does not include costs for RNG processing facility.*

6.10 Future Expansion

Per Burnham, the design life of the pretreatment system is considered to be at least 25 years, and costs expected to occur before this time are included in the capital or operating and maintenance costs.

The processors have committed to the projections outlined in this report through 2030. If processors request to increase production after 2030, an amendment to this report would be issued to outline the improvements needed prior to those increases.

The proposed site design leaves several options for expansion, if warranted in the future. A BVF expansion of approximately 20-percent could be incorporated with the proposed design by adding an additional, smaller BVF between the access road and the BVF. Additionally, a spare empty basin will be built with Phase 3 that could host an additional RAB in the future. The south half of parcel no. 113090058, south of the existing PWRF, also could be configured for additional winter storage or pretreatment. Additionally, in the future, more land could be added to the LTS.

6.11 SEPA Compliance Statement

The SEPA Checklist has been completed and currently is under review by the City Planning Department.

No other state or local water quality monitoring plans will limit the project.

References

Alt, David D, and Donald W Hyndman. 1984. *Roadside geology of Washington.* Missoula, MT: Mountain Press Publishing.

Bauer, H. H., and Jr, A. J. Hansen. 2000. *Hydrology of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho.* Tacoma, WA: U.S. Department of the Interior, U.S. Geological Survey, Information Services. (Water-Resources Investigations Report No. 96-4106).

Canessa, Peter, and Ronald E. Hermanson. 1994. *Irrigation management practices to protect ground water and surface water quality state of Washington.* WA: Washington State University Cooperative Extension and U.S. Department of Agriculture. (EM4885).

Cascade Earth Sciences. 2012. *2012 Farm operations report - City of Pasco, Washington.* Spokane, WA: Author. 2011230039.

—. 2013. *2013 Farm operations report - City of Pasco, Washington.* Spokane, WA: Author. 2011230039.

—. 2018. *2018 Farm operations report - City of Pasco - Pasco, Washington.* Spokane Valley: Author. 2018230006.

—. 2019. *2019 Farm operations report - City of Pasco, Washington.* Spokane Valley, WA: Author. 2013230046.

—. 2020. *2020 Farm operations report - City of Pasco - Pasco, Washington.* Spokane Valley, WA: Author. 2015230005.

CH2M Hill Engineers, Inc. 2018. *Hydrogeologic assessment report - City of Pasco process wastewater reuse facility.* Bellevue, WA: PACE Engineers, Inc.

Drost, B W, K J Whiteman, and J B Gonthier. 1990. *Geologic framework of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho.* Portland, OR: Department of the Interior, U.S. Geologic Survey. (Water-Resources Investigations Report No. 87-4238).

2019. "Engineering Report, 173 WAC § 240.130."

Horneck, D. A., D. M. Sullivan, J. S. Owen, and J. M. Hart. 2011. *Soil test interpretation guide.* Oregon State University Extension Service. (EC 1478).

Lane, R C, and K J Whiteman. 1989. *Ground-water levels spring 1985 and ground-water level changes spring 1983 to spring 1985, in three basalt units underlying the Columbia Plateau, Washington and Oregon.* Department of the Interior, United States Geological Survey. (Water-Resources Investigation Report No. 88-4018).

Meisinger, J J, and G W Randall. 1991. "Estimating nitrogen budgets for soil-crop systems." Chap. 5 in *Managing nitrogen for groundwater quality and farm profitability*, by Soil Society of America, edited by R F Follett, D R Keeney and R M Cruse, 85-124. Madison, WI: Soil Society of America Inc.

2008. "Minimum Standards for Construction and Maintenance of Wells, 173 WAC § 160."

Overcash, Michael R, and Dhiraj Pal. 1979. *Design of land treatment systems for industrial wastes - theory and practice.* Ann Arbor, MI: Ann Arbor Science Publishers Inc.

PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group. 2019. *Process water reuse facility - capital facilities plan engineering report - City of Pasco, Washington.* Pasco, WA: Author.

Reidel, S. P., K. R. Fecht, and Washington State. 1994. *Geologic map of the Richland 1:100,000 quadrangle, Washington.* Olympia, WA: Washington Division of Geology and Earth Resources.

Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. and Papenlick. 2009. "Estimating generalized soil-water characteristics from texture." *Soil Science Society of America Journal* (Soil Science Society of America) 50 (6.02.74): 1031-1036. http://hydrolab.arsusda.gov/soilwater/Index.htm.

Schuster, J Eric. 2005. *Geologic map of Washington State.* Olympia: Washington State Department of Natural Resources, Washington Division of Geology and Earth Resources. (Geologic Map GM-53).

Smith, J.H., J.R. Peterson. 1982. "Recycling of nitrogen through land application of agricultural food processing, and municipal wastes." In *Nitrogen in Agricultural Soils. Vol. 22*, by Frank J. Stevenson (ed), 791-831. Madison: American Society of Agonomy, Inc. Crop Science Society of America, Inc.

Snyder, R L, M Orang, S Matyac, and S Eching. 2007. Crop coefficients. Davis, CA: University of California. http://biomet.ucdavis.edu/Evapotranspiration/CropCoef/Kc.pdf.

Soil Survey Staff, Natural Resources Conservation Service. n.d. *Web soil survey - Franklin County, Washington.* U.S. Department of Agriculture. Accessed October 2018. https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

2000. "Submission of Plans and Reports for Construction of Wastewater Facilities, 173 WAC § 240."

U.S. Department of Agriculture - Soil Conservation Service. 2006. *Soil survey of Franklin County, Washington.* WA: Author.

U.S. Environmental Protection Agency. 2006. *Process design manual for land treatment of municipal wastewater effluents.* Cincinnati, OH: Author. (EPA/625/R-06/016).

U.S. Salinity Laboratory Staff. 1954. *Diagnosis and improvement of saline and alkali soils.* Washington D.C.: U.S. Department of Agriculture. (Agriculture Handbood No. 60).

Valley Science and Engineering. 2022. *2022 Farm operations report - City of Pasco - Pasco, Washington.* Spokane Valley, WA: Author. 2016230028.

—. 2021. *2021 Farm operations report - City of Pasco - Pasco, Washington.* Spokane Valley, WA: Author. 2016230001.

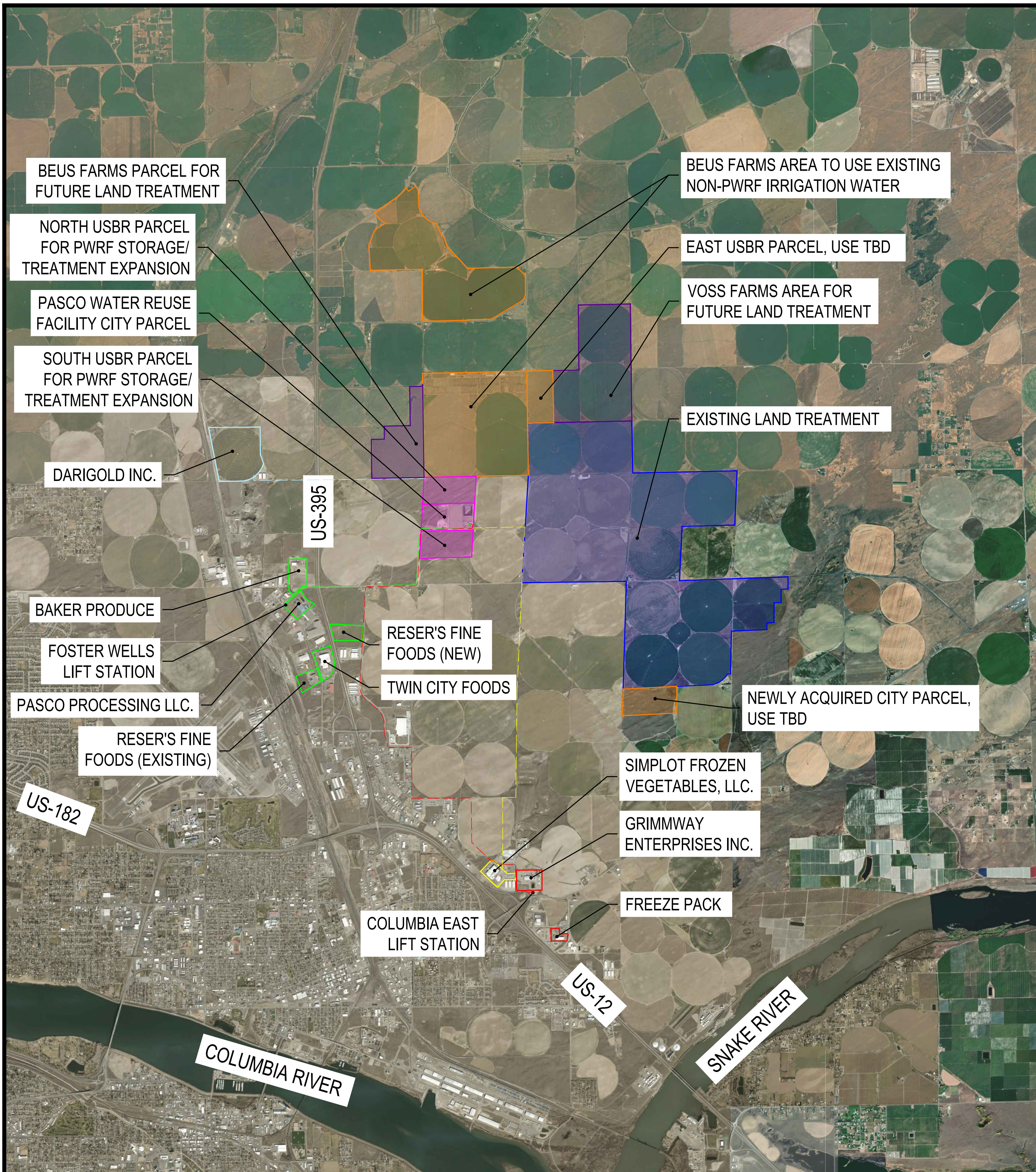
Washington Department of Ecology. 2015. "State waste discharge permit number ST0005369." Spokane, WA: Author.

Washington State Department of Ecology. 2005. *Implementation guidance for the ground water quality standards.* Olympia, WA: Author. (Publication No. 96-02).

Washington State Department of Ecology, Water Quality Program. 1993. *Guidelines for preparation of engineering reports for industrial wastewater land application systems.* Olympia, WA: Department of Ecology Publications Distribution Center. (Publication No. 93-36).

Washington State University. n.d. *Period of climate data - Pasco, Washington.* Vers. [Data file]. Accessed January 25, 2021. http://weather.wsu.edu.

Exhibits



LEGEND

- EXISTING LAND TREATMENT
- PROPOSED LAND TREATMENT
- PWRF PROPERTY
- OTHER PROPERTY (LABELED)
- COLUMBIA EAST LIFT STATION (CELS) CONVEYANCE (APPROX. 6 MI)
- FOSTER WELLS LIFT STATION (FWLS) CONVEYANCE (APPROX 2.5 MI)
- DARIGOLD CONVEYANCE (APPROX. 2 MI)
- SIMPLOT CONVEYANCE (APPROX. 4 MI)
- PROCESSOR DISCHARGING TO CELS
- PROCESSOR DISCHARGING TO FWLS
- DARIGOLD
- SIMPLOT

NOTES

LIFT STATION PEAK FLOW CAPACITIES
CELS = 2,174 GPM CURRENT; 4,171 GPM FUTURE
FWLS = 4,300 GPM
DARIGOLD WASTEWATER = 700 GPM
DARIGOLD COW = 700 GPM
SIMPLOT LIFT STATION = 1,200 GPM CURRENT; FUTURE SHUTDOWN

EXHIBIT 1-A OVERVIEW

PASCO PROCESS WATER REUSE FACILITY

SCALE: 1"=5000'
0" 1/2" 1"
DRAWING IS FULL SCALE WHEN BAR MEASURES 1"

PLOT DATE: 7/13/2022
FILE PATH: \\corp.rh2.com\dfs\projects\Data\PSC\22-0034\CAD\pwrf-e-overview.dwg

Exhibit 4-A. Area Map

0 4500'
1" = 4500'
(SCALE AND LOCATIONS ARE APPROXIMATE)

N

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 3/24/2023	
DWG NO: 2022230003 EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

C:\Users\dr702784\OneDrive – Valmont Industries\Desktop\Working Drafting DJR\2022230003 RH2 EngRpt\DWG\2022230003 Exhibits.dwg December 30, 2022 NG711452

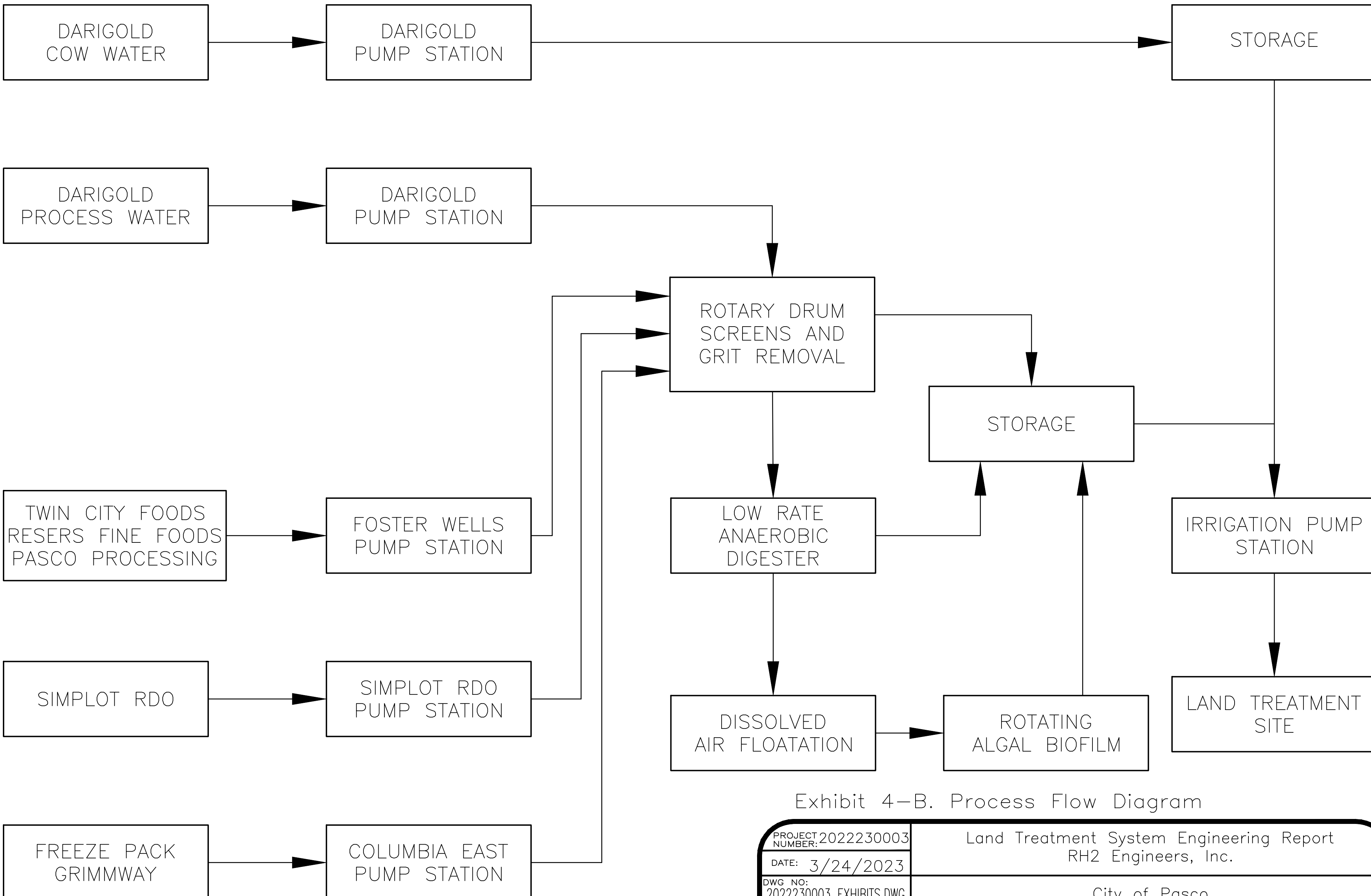


Exhibit 4–B. Process Flow Diagram

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 3/24/2023	
DWG NO: 2022230003 EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG / PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING

C:\Users\dr702784\OneDrive – Valmont Industries\Desktop\Working Drafting DJR\2022230003 RH2 EngRpt\DWG\2022230003 Exhibits.dwg December 30, 2022 NG711452

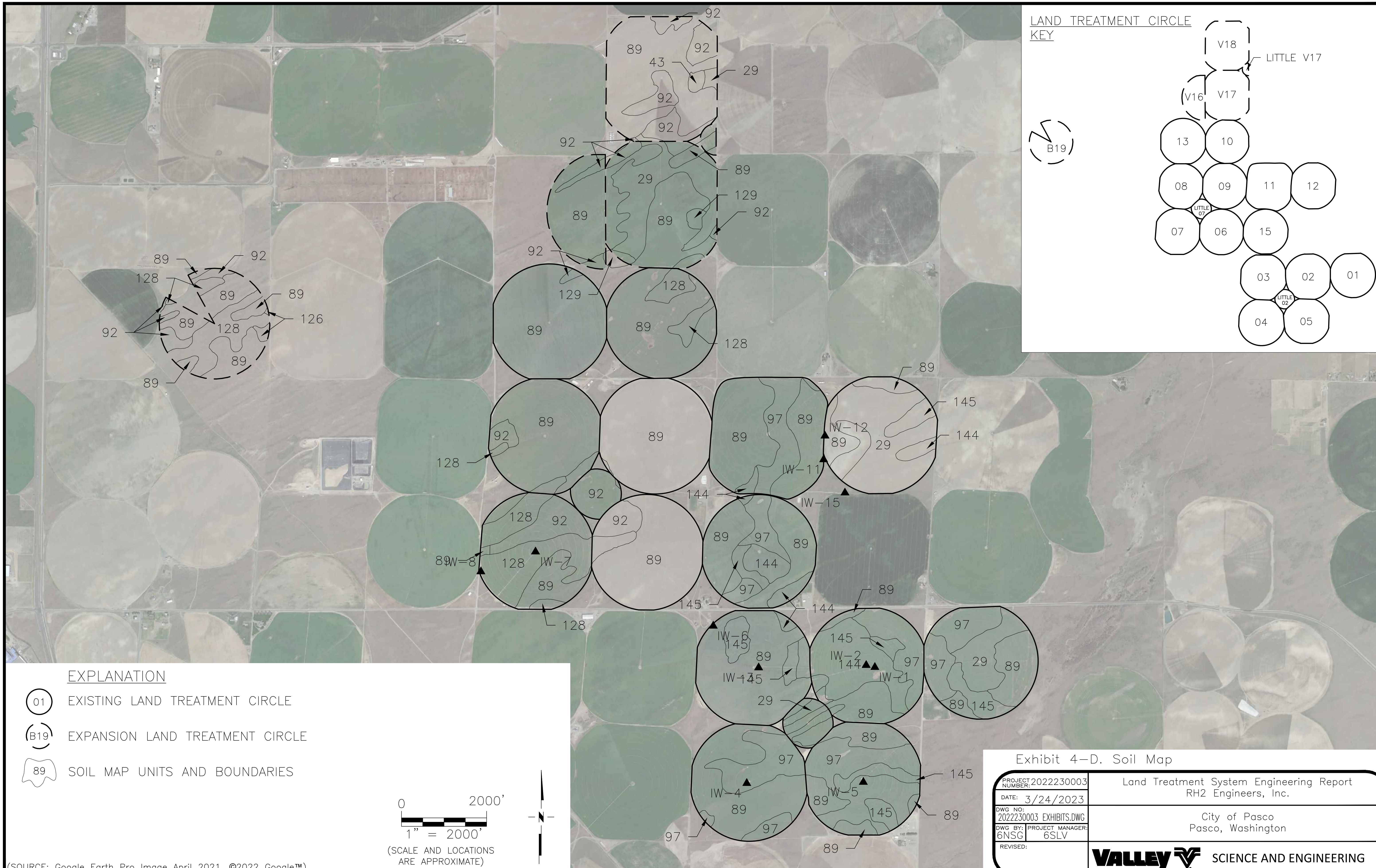
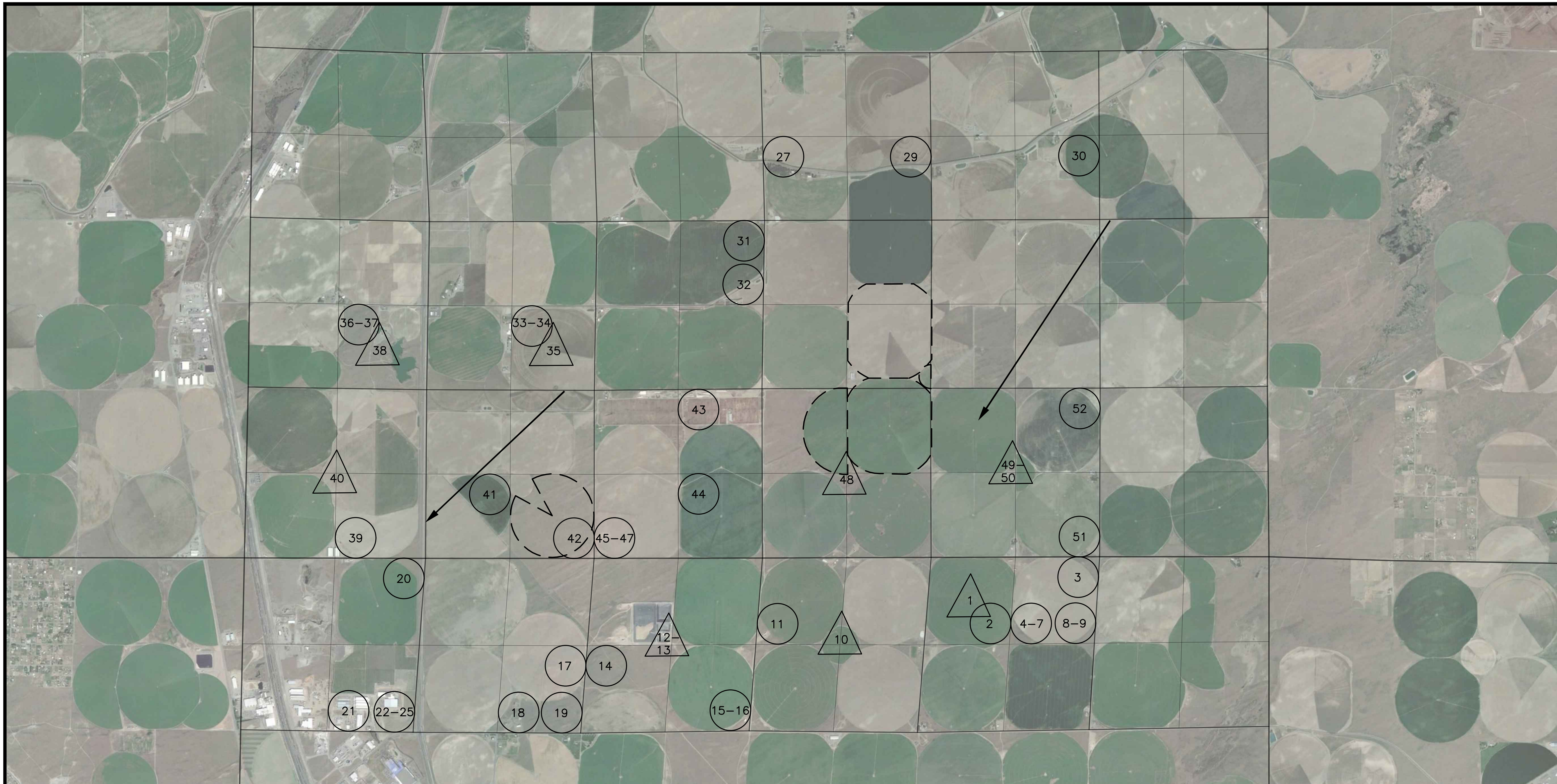


Exhibit 4-D. Soil Map

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 3/24/2023	
DWG NO: 2022230003 EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG / PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING

C:\Users\dr702784\OneDrive – Valmont Industries\Desktop\Working Drafting DJR\2022230003 RH2 EngRpt\DWG\2022230003 Exhibits.dwg December 30, 2022 NG711452



EXPLANATION

WELL LOCATION IDENTIFICATION QUARTER OF SECTION OR NOT RECORDED

WELL LOCATION IDENTIFICATION QUARTER QUARTER OF SECTION

EXPANSION LAND TREATMENT CIRCLE

ESTIMATED DIRECTION OF GROUNDWATER FLOW

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

SECTION KEY:

T10N R30E

19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36
06	05	04	03	02	01

T09N R30E

0 3000'

1" = 3000'

(SCALE AND LOCATIONS ARE APPROXIMATE)

N

Exhibit 4–E. Wells Within 1–Mile of the Expansion Sites

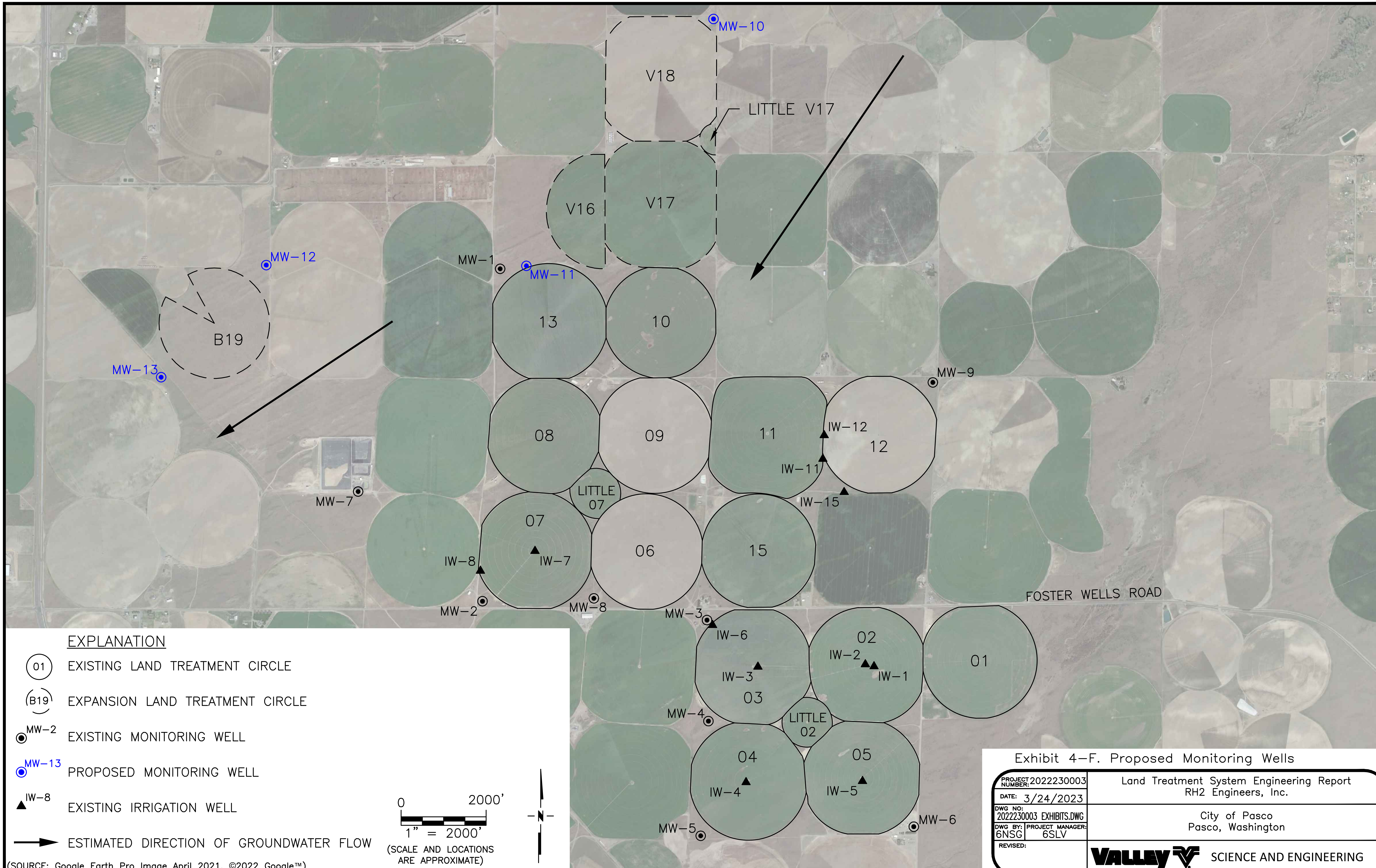
PROJECT NUMBER: 2022230003
DATE: 3/24/2023
DWG NO: 2022230003 EXHIBITS.DWG
DWG BY: 6NSG PROJECT MANAGER: 6SLV
REVISED:

Land Treatment System Engineering Report
RH2 Engineers, Inc.

City of Pasco
Pasco, Washington

VALLEY SCIENCE AND ENGINEERING

C:\Users\dr702784\OneDrive – Valmont Industries\Desktop\Working Drafting DJR\2022230003 RH2 EngRpt\DWG\2022230003 Exhibits.dwg December 30, 2022 NG711452



C:\Users\dr702784\OneDrive – Valmont Industries\Desktop\Working Drafting DJR\2022230003 RH2 EngRpt\DWG\2022230003 Exhibits.dwg December 30, 2022 NG711452

OVERALL SITE PLAN

1" = 150'

LAGOON STORAGE

Lagoon	Winter Storage (MG)
PROPOSED 106 MG LAGOON	106
PROPOSED 103 MG LAGOON	103
PROPOSED 120 MG LAGOON	120
Total	**329**

EARTHWORK

Proposed Earthwork Quantities	Cut (cu. Yd)	Fill (cu. Yd)	Net (cu. Yd)
Total	1,430,200	170,000	1,260,200 CUT

Exhibit 6-A

CONCEPTUAL SITE LAYOUT

PROCESS WATER REUSE FACILITY

Pasco

SCALE: NTS

Tables

Table 4-A. Climate Summary

Month	Precipitation [1]		Potential Crops and Evapotranspiration [2]							
	Average	Normalized 10-Year Return	Alfalfa	Potato / Alfalfa	Alfalfa / Corn	Timothy / Corn	Corn	Potato	Triticale / Corn	Bare Soil [3]
	inches									
Nov	0.6	0.8	1.0	0.8	1.0	1.0	0.8	0.8	1.0	0.8
Dec	1.0	1.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Jan	0.8	1.2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Feb	0.5	0.7	1.2	0.8	1.2	1.1	0.8	0.8	1.1	0.8
Mar	0.5	0.7	2.7	1.3	2.7	2.6	1.3	1.3	2.6	1.3
Apr	0.4	0.6	4.3	1.4	4.3	4.1	1.0	1.4	4.1	1.6
May	0.5	0.8	5.9	4.5	5.9	5.6	3.8	4.5	5.6	1.9
Jun	0.5	0.7	7.1	9.0	5.6	5.5	8.4	9.0	5.5	2.0
Jul	0.1	0.2	8.1	10.3	8.1	8.1	10.8	10.3	8.1	2.1
Aug	0.2	0.2	6.6	4.9	7.7	7.7	7.7	4.9	7.7	1.9
Sep	0.3	0.4	4.0	2.0	0.8	0.8	0.8	1.6	0.8	1.6
Oct	0.5	0.7	2.2	2.2	0.8	0.8	0.8	1.2	0.8	1.2
Total	**5.7**	**8.3**	**44.4**	**38.7**	**39.4**	**38.4**	**37.6**	**37.2**	**38.4**	**16.5**

NOTES:
All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Average precipitation is based on actual monthly precipitation from 2001 through 2021. The normalized 10-year return is the 2nd highest total annual precipitation out of 20 years (8.3 inches from 2015-2016) normalized in relation to the long-term average for each month for design purposes.

2 Evapotranspiration is based on averages of actual monthly data from 2001-2021 for crops typically grown at the land treatment site.

3 Bare soil evaporation is calculated using the 10-year return precipitation and average reference evapotraspiration data (Snyder, Orang, Matyac, & Eching, 2007). Bare soil evapotranspiration is used when AgWeatherNet evapotranspiration is less than fallow evapotranspiration or when crops are not in place.

Table 4-B. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
					inches	g/cc	in/hr	in/in	Thickness				%
									inches				
29	Hezel loamy fine sand, 0 to 15% slopes	Hezel	7.9%	loamy fine sand	0-7	1.25-1.45	1.3	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	1.3	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	1.3	0.13-0.21	33	5.61	1.46	7.07	0.0-0.5
								Total	**60**	**9.01**	**2.24**	**11.25**	
43	Kennewick silt loam, 0 to 2% slopes	Kennewick	0.2%	silt loam	0-8	1.15-1.35	9.2	0.19-0.21	8	1.60	0.45	2.05	0.5-1.0
				silt loam	8-60	1.30-1.50	2.8	0.18-0.20	52	9.88	3.64	13.52	0.0-0.5
								Total	**60**	**11.48**	**4.08**	**15.56**	
89	Quincy loamy fine sand, 0 to 15% slopes	Quincy	61.1%	loamy fine sand	0-4	1.50-1.65	13.0	0.09-0.11	4	0.40	0.09	0.49	0.5-1.0
				loamy fine sand, fine sand	4-60	1.50-1.65	13.0	0.05-0.11	56	4.48	1.35	5.83	0.0-0.5
								Total	**60**	**4.88**	**1.44**	**6.32**	
92	Quincy loamy fine sand, loamy substratum, 0 to 10% slopes	Quincy	7.1%	loamy fine sand	0-3	1.25-1.45	13.0	0.08-0.11	3	0.29	0.10	0.39	1.0-2.0
				loamy fine sand	3-52	1.30-1.50	13.0	0.08-0.11	49	4.66	1.18	5.83	0.0-0.5
				silt loam, very fine sandy loam, fine sandy loam	52-60	1.50-1.70	1.3	0.16-0.18	8	1.36	0.41	1.77	0.0-0.5
								Total	**60**	**6.30**	**1.69**	**7.99**	
97	Quincy-Hezel complex, 0 to 15% slopes	Quincy	9.6%	loamy fine sand	0-7	1.50-1.65	13.0	0.09-0.11	7	0.70	0.16	0.86	0.5-1.0
				loamy fine sand, fine sand	7-18	1.50-1.65	13.0	0.05-0.11	11	0.88	0.26	1.14	0.0-0.5
		Hezel		loamy fine sand	0-7	1.25-1.45	13.0	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	13.0	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	0.4	0.13-0.21	33	5.61	1.69	7.30	0.0-0.5
Quincy (7-18 inches) + Hezel (18-60 inches)								**Total**	**60**	**8.72**	**2.46**	**11.18**	
Hezel								**Total**	**60**	**9.01**	**2.89**	**13.48**	
126	Royal loamy fine sand, 0 to 10% slopes	Royal	0.1%	loamy fine sand	0-6	1.35-1.45	13.0	0.09-0.11	6	0.60	0.21	0.81	0.5-1.0
				fine sandy loam, very fine sandy loam	6-19	1.30-1.50	4.0	0.13-0.17	13	1.95	0.66	2.61	0.0-0.5
				stratified fine sand to very fine sandy loam	19-60	1.40-1.60	4.0	0.10-0.14	41	4.92	1.36	6.28	0.0-0.5
								Total	**60**	**7.47**	**2.24**	**9.71**	

Table 4-B. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
					inches	g/cc	in/hr	in/in	Thickness				%
									inches				
128	Royal fine sandy loam, 0 to 2% slopes	Royal	5.1%	fine sandy loam	0-5	1.30-1.40	4.0	0.13-0.15	5	0.70	0.27	0.97	0.5-1.0
				fine sandy loam, very fine sandy loam	5-15	1.30-1.50	4.0	0.13-0.17	10	1.50	0.51	2.01	0.0-0.5
				stratified fine sand to very fine sandy loam	15-60	1.40-1.60	4.0	0.10-0.14	45	5.40	2.30	7.70	0.0-0.5
								Total	**60**	**7.60**	**3.08**	**10.68**	
129	Royal fine sandy loam, 2 to 5% slopes	Royal	0.3%	fine sandy loam	0-5	1.30-1.40	28.2	0.13-0.15	5	0.70	0.35	1.05	0.5-1.0
				fine sandy loam	5-15	1.30-1.50	28.2	0.13-0.17	10	1.50	0.51	2.01	0.0-0.5
				fine sand, very fine sandy loam	15-60	1.40-1.60	28.2	0.10-0.14	45	5.40	1.50	6.90	0.0-0.5
								Total	**60**	**7.60**	**2.35**	**9.95**	
144	Sagemoor very fine sandy loam, 0 to 2% slopes	Sagemoor	5.1%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
145	Sagemoor very fine sandy loam, 2 to 5% slopes	Sagemoor	2.9%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
146	Sagemoor very fine sandy loam, 5 to 10% slopes	Sagemoor	0.5%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	

NOTES:
Summary of Natural Resource Conservation Service Web Soil Survey of area of interest (Soil Survey Staff, Natural Resources Conservation Service, n.d.).
Abbreviations: g/cc = grams per cubic centimeter, in/hr = inches per hour, in/in = inches per inch, Perm = permeability.
1 The permeability range values are from the Web Soil Survey for Franklin County. Permeability is the same as saturated hydraulic conductivity (Ksat), which is substantially lower than infiltration.
2 Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. The average available soil water holding capacity (inches) was calculated using the average of the range of the in/in values multiplied by the thickness of the horizon.
3 Estimated using estimates of sand, silt, organic matter, and gravel content to match the average soil available water holding capacity for each horizon using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).
4 Field capacity is the water content of the soil after the drainage of excess water by gravity has ceased.

Table 4-C. Circle-Specific Soil Water Capacity

Soil Map Unit [1]		29	43	89	92	97	126	128	129	144	145	146	Average Field Capacity [7]	Average Available Capacity [7]
Depth	inches	60	60	60	60	60	60	60	60	60	60	60		
Field Capacity [2]		11.2	6.3	6.3	8.0	13.5	9.7	10.7	10.0	15.1	15.1	15.1		
Available Capacity [3]		9.0	4.9	4.9	6.3	9.0	7.5	7.6	7.6	11.5	11.5	11.5		
Wilting Point [4]		2.2	1.4	1.4	1.7	2.9	2.2	3.1	2.4	3.6	3.6	3.6		
Circle [5]	acres	Percentage [6]											inches	
1	122	25.4	--	27.6	--	16.0	--	--	--	19.5	11.5	--	11.4	8.6
2	152	4.4	--	28.7	--	24.2	--	--	--	39.5	3.2	--	12.0	8.9
3	128	--	--	81.3	--	--	--	--	--	5.7	13.0	--	8.0	6.1
4	128	--	--	65.5	--	34.5	--	--	--	--	--	--	8.8	6.3
5	128	--	--	30.9	--	55.2	--	--	--	--	13.9	--	11.5	8.1
6	128	--	--	81.1	12.5	--	--	6.4	--	--	--	--	6.8	5.2
7	152	--	--	28.5	42.0	--	--	29.5	--	--	--	--	8.3	6.3
8	128	--	--	85.3	10.3	--	--	4.4	--	--	--	--	6.7	5.1
9	128	--	--	99.8	0.2	--	--	--	--	--	--	--	6.3	4.9
10	128	--	--	83.3	--	--	--	16.7	--	--	--	--	7.0	5.3
11	150	--	--	75.0	--	22.1	0.7	--	--	2.2	--	--	8.1	6.0
12	128	61.5	--	16.4	--	--	--	--	--	4.5	7.5	10.1	11.3	8.9
13	128	--	--	98.5	1.5	--	--	--	--	--	--	--	6.3	4.9
15	128	--	--	59.3	--	19.0	--	--	--	16.3	5.4	--	9.6	7.1
V16	70	--	--	89.2	10.4	--	--	--	0.4	--	--	--	6.5	5.0
V17	169	38.6	--	49.7	6.4	--	--	1.8	3.4	--	--	--	8.5	6.7
V18	164	2.7	2.3	68.5	26.5	--	--	--	--	--	--	--	6.9	5.4
B19	111	--	--	52.8	10.8	--	2.1	34.4	--	--	--	--	8.1	6.0

NOTES:

Summary of information from the Natural Resource Conservation Service Web Soil Survey of area of interest (Soil Survey Staff, Natural Resources Conservation Service, n.d.).

Abbreviation: -- = soil map unit not found.

1 The soil map unit is used to represent the soil unit on the soil survey map.

2 Field capacity is the maximum amount of water the soil can hold against gravitational forces.

3 Available water is the amount of water available to the crop. It is the difference between field capacity and the water content at wilting point.

4 Wilting point is the water content remaining in the soil that is too difficult for the crop to uptake.

5 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle V17 plus Little Circle V17.

6 The percentage of each soil unit by circle is based on the Web Soil Survey mapping.

7 Averages are weighted by soil-type (soil map unit) percentages. Average field capacity = the sum of products of circle-specific field capacity and soil map unit percentages, divided by the sum of the soil map unit percentages (100). Average available capacity is calculated in the same way as field capacity, except using available capacity instead of field capacity.

Table 4-D. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
1	1	3.1	9.3	1.2	770	13.3	7.5	911	0.39	0.36	8.5	2.4	404	16	7.7
	2	2.2	8.3	0.4	307	5.3	1.1	699	0.22	0.25	9.4	3.0	234	10	7.9
	3	1.7	9.4	0.5	368	6.7	1.6	698	0.27	0.31	14.5	3.1	163	17	8.2
	4	1.9	10.6	0.3	285	1.5	1.0	395	0.18	0.39	15.4	3.4	100	8	8.4
	5	2.5	11.2	0.3	235	3.0	1.0	694	0.19	0.48	14.4	3.7	157	7	8.5
2	1	2.2	12.3	1.3	1,021	11.2	4.6	915	0.40	0.31	9.2	3.4	470	16	7.5
	2	2.3	12.7	0.6	539	5.0	1.1	761	0.29	0.43	15.2	4.1	194	13	8.1
	3	2.4	15.4	0.5	525	5.9	2.4	753	0.29	0.56	16.8	5.6	229	14	8.2
	4	2.3	15.5	0.4	378	3.4	1.1	736	0.29	0.55	17.6	5.8	241	14	8.5
	5	2.8	17.5	0.4	340	7.7	1.0	706	0.39	0.73	18.1	6.7	283	26	8.5
3	1	2.4	10.9	1.1	1,188	3.3	13.7	1,115	0.22	0.29	7.6	3.3	425	5	7.7
	2	2.8	12.5	0.4	560	1.2	1.4	900	0.26	0.52	14.3	3.9	200	24	8.3
	3	2.3	12.4	0.3	471	1.3	2.1	887	0.31	0.42	14.8	3.9	145	28	8.2
	4	2.2	12.5	0.2	381	4.4	1.6	843	0.24	0.43	14.4	4.3	143	16	8.3
	5	2.3	11.7	0.2	364	6.5	1.5	888	0.25	0.41	12.7	4.2	190	13	8.2
4	1	2.4	8.5	1.0	1,047	4.7	11.6	1,113	0.21	0.20	4.7	2.3	377	4	7.4
	2	3.0	6.5	0.3	363	1.0	1.0	864	0.15	0.27	6.7	2.4	255	5	8.0
	3	2.2	7.2	0.3	379	1.8	1.7	851	0.18	0.28	10.1	2.6	222	7	8.0
	4	2.3	7.0	0.2	338	4.1	1.0	825	0.19	0.30	10.6	2.3	169	8	8.0
	5	1.8	7.8	0.2	320	7.1	1.1	783	0.25	0.28	12.8	2.1	176	12	8.2
5	1	2.0	9.5	1.2	1,158	7.5	15.0	1,150	0.28	0.23	8.0	2.3	458	5	7.7
	2	2.8	7.8	0.3	386	2.7	1.1	860	0.23	0.35	9.9	2.5	175	11	8.2
	3	2.6	7.1	0.3	380	2.5	1.5	866	0.26	0.28	7.8	2.2	154	13	8.1
	4	2.9	7.1	0.2	360	3.6	1.0	875	0.24	0.28	7.8	1.9	135	10	8.1
	5	2.6	10.4	0.2	348	6.3	1.0	852	0.28	0.37	11.3	2.7	148	12	8.2
6	1	3.2	9.9	1.3	1,168	8.8	9.7	1,175	0.39	0.34	6.4	2.7	542	12	7.5
	2	2.0	11.6	0.4	567	19.5	1.3	1,021	0.50	0.33	12.6	4.2	384	30	7.8
	3	1.8	11.5	0.3	515	10.9	2.1	1,033	0.32	0.35	14.9	3.4	198	14	8.0
	4	2.2	10.6	0.2	425	16.8	1.2	1,048	0.34	0.39	13.6	3.4	130	11	8.2
	5	2.4	10.8	0.1	296	4.2	1.2	1,118	0.20	0.35	11.2	3.0	150	4	8.3
7	1	2.1	11.4	1.5	1207	4.4	17.3	1,240	0.25	0.27	8.4	3.1	376	5	7.6
	2	2.5	10.5	0.5	497	2.7	1.5	1,055	0.25	0.43	14.8	3.7	205	15	8.2
	3	3.3	10.2	0.4	455	8.8	1.8	948	0.40	0.58	15.1	3.8	128	25	8.2
	4	2.4	10.9	0.3	422	3.7	2.1	926	0.39	0.51	16.2	3.7	103	25	8.2
	5	2.1	11.3	0.3	366	2.9	1.3	931	0.28	0.42	16.3	3.2	134	17	8.2

Table 4-D. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
8	1	2.0	9.8	1.3	1,117	5.0	8.2	1,142	0.22	0.22	6.8	2.7	378	6	7.5
	2	2.1	9.6	0.5	547	2.5	1.1	976	0.28	0.31	12.1	3.7	237	10	7.8
	3	1.7	10.7	0.5	553	4.7	1.7	958	0.26	0.34	17.8	3.4	163	10	8.1
	4	1.8	10.3	0.3	402	4.0	1.0	996	0.21	0.32	16.2	3.2	117	8	8.2
	5	1.2	11.9	0.3	361	3.4	1.0	930	0.19	0.29	19.3	3.4	148	8	8.3
9	1	2.5	11.1	1.2	1,044	7.8	8.0	1,207	0.38	0.31	9.1	2.9	403	14	7.6
	2	2.5	10.8	0.3	378	30.3	1.4	995	0.52	0.42	13.4	3.5	261	15	7.8
	3	2.1	11.2	0.3	375	12.8	2.3	905	0.35	0.35	12.9	3.8	204	13	8.0
	4	2.1	11.1	0.2	237	12.7	1.2	990	0.29	0.37	14.1	3.2	119	8	8.1
	5	2.3	11.3	0.2	239	16.3	1.1	1,033	0.29	0.39	13.2	3.3	127	7	8.3
10	1	1.7	11.7	1.3	1133	7.5	7.9	1,260	0.27	0.23	10.9	2.9	437	6	7.5
	2	1.4	11.3	0.5	527	1.8	1.0	1,087	0.21	0.29	16.7	3.7	245	11	8.0
	3	1.7	11.5	0.4	572	9.1	2.9	1,107	0.36	0.39	19.2	4.0	161	20	8.1
	4	1.9	11.2	0.3	434	8.9	1.0	1,124	0.27	0.38	16.9	3.5	118	11	8.3
	5	1.6	11.8	0.4	451	2.9	1.2	1,178	0.20	0.31	14.6	4.3	193	9	8.3
11	1	3.2	9.7	1.2	1,074	5.0	9.5	1,152	0.24	0.31	5.6	3.0	301	6	7.5
	2	3.9	9.3	0.4	466	3.6	1.0	1,091	0.24	0.36	5.6	3.2	126	7	7.9
	3	2.4	9.9	0.4	514	3.4	1.7	1,175	0.22	0.34	10.7	2.9	130	6	8.0
	4	1.6	10.7	0.4	434	4.4	1.5	1,199	0.24	0.33	16.9	3.1	112	14	8.2
	5	1.5	10.6	0.2	385	4.5	1.3	1,174	0.27	0.30	16.4	3.1	124	13	8.2
12	1	3.0	10.0	1.1	874	5.7	4.9	1,075	0.28	0.31	6.6	3.0	275	12	7.6
	2	2.1	11.6	0.4	406	20.6	1.5	897	0.51	0.36	14.1	4.1	163	34	7.8
	3	2.3	14.5	0.4	382	20.1	3.1	852	0.44	0.51	16.9	5.7	125	24	8.1
	4	2.3	16.5	0.3	248	13.8	1.4	782	0.34	0.61	19.8	6.1	119	16	8.3
	5	3.0	19.4	0.2	217	11.1	1.1	851	0.40	0.85	19.5	7.5	229	20	8.4
13	1	2.2	9.2	1.1	1,068	1.6	13.6	1,047	0.21	0.19	5.4	2.5	253	4	7.5
	2	3.2	8.4	0.3	363	1.0	1.1	861	0.17	0.30	7.1	2.8	187	3	8.0
	3	2.2	10.3	0.3	461	1.1	3.6	917	0.21	0.35	12.8	3.2	128	7	8.1
	4	1.5	11.8	0.2	277	2.7	1.0	969	0.22	0.29	15.5	3.3	96	13	8.3
	5	1.7	11.6	0.2	230	6.9	1.2	894	0.30	0.31	14.6	2.9	119	17	8.3
15	1	3.2	9.6	1.1	941	2.4	12.4	1,078	0.25	0.30	5.6	2.6	345	4	7.5
	2	2.9	8.3	0.3	271	1.3	1.2	935	0.22	0.33	9.6	2.7	195	12	8.0
	3	2.2	9.0	0.4	317	2.3	2.5	972	0.28	0.31	12.4	2.7	132	20	8.0
	4	1.6	8.6	0.2	177	3.8	1.2	949	0.25	0.28	13.9	2.6	89	12	8.2
	5	1.9	9.9	0.2	195	12.1	1.2	923	0.27	0.34	13.7	2.9	118	13	8.2

Table 4-D. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
V16	1	2.1	9.1	0.6	--	1.9	1.2	15	0.26	0.19	5.7	2.5	72	6	7.6
	2	--	--	--	--	1.5	0.5	--	0.26	--	--	--	--	--	--
	3	--	--	--	--	1.9	0.0	--	0.22	--	--	--	--	--	--
	4	--	--	--	--	1.9	0.3	--	0.31	--	--	--	--	--	--
	5	--	--	--	--	1.9	0.2	--	0.21	--	--	--	--	--	--
V17	1	2.6	7.8	0.8	--	1.8	2.4	27	0.28	0.20	4.7	2.0	87	6	7.6
	2	--	--	--	--	1.6	1.5	--	0.30	--	--	--	--	--	--
	3	--	--	--	--	5.0	1.0	--	0.56	--	--	--	--	--	--
	4	--	--	--	--	7.3	1.0	--	0.59	--	--	--	--	--	--
	5	--	--	--	--	4.5	0.6	--	0.78	--	--	--	--	--	--
V18	1	2.3	9.4	0.9	--	23.1	1.8	33	1.71	0.22	8.5	2.3	168	14	8.1
	2	--	--	--	--	3.6	0.7	--	0.35	--	--	--	--	--	--
	3	--	--	--	--	4.7	0.7	--	0.26	--	--	--	--	--	--
	4	--	--	--	--	4.9	0.7	--	0.06	--	--	--	--	--	--
	5	--	--	--	--	4.2	0.7	--	0.72	--	--	--	--	--	--
B19	1	1.2	7.5	0.5	--	2.1	1.8	9	0.36	0.09	7.3	1.4	302	2	7.8
	2	--	--	--	--	1.1	1.7	--	0.27	--	--	--	--	--	--
	3	--	--	--	--	1.4	1.6	--	0.27	--	--	--	--	--	--
	4	--	--	--	--	1.5	1.4	--	0.39	--	--	--	--	--	--
	5	--	--	--	--	1.8	1.3	--	0.64	--	--	--	--	--	--

NOTES:
Soil samples were collected from Circles 1-12 November 18, 2021; Circles V16, V17, and V18 October 19, 2021; and Circle B19 June 9, 2022.
Abbreviations: Ca = calcium, CEC = cation exchange capacity, EC = electrical conductivity, ESP = exchangeable sodium percentage, ft bgs = feet below ground surface, K = potassium, meq/100g = milliequivalents per 100 grams of soil, Mg = magnesium, mg/kg = milligrams per kilogram, mmhos/cm = millimhos per centimeter, Na = sodium, NH_4-N = ammonia-nitrogen, NO_3-N = nitrate-nitrogen, OM = organic matter, P = phosphorus, s.u. = standard units, SO_4-S = sulfate-sulfur, TKN = total Kjeldahl nitrogen.
1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

Table 4-E. Projected Process Water and Cow Water Flow

Month [1]	Process Water	Cow Water	Total
	million gallons		
November	120	24	144
December	62	23	85
January	62	23	85
February	56	21	77
March	62	26	88
April	60	26	86
May	78	26	104
June	127	24	151
July	228	25	252
August	264	25	288
September	255	24	279
October	228	25	252
Total	**1,600**	**292**	**1,892**

NOTES:

Projected process and cow water flow represents estimates of incoming flow to the City of Pasco Process Water Reuse Facility based on theoretical scenario where all processors operate at their respective maximum month permit limits.

1 The operational year runs from November through October, which corresponds with the approximate beginning of the reduced crop growing period through the completion of crop harvest.

Table 4-F. Projected Combined Process and Cow Water Quality (Maximum Month Load Scenario)

Month	Flow	pH	EC [1]	Total N	TKN	NO_3 + NO_2-N	NH_3-N	BOD_5	FDS	Na [2]	Ca [2]	Mg [2]	SO_4 [2]	Cl [2]	Total P [2]	SAR
	million gallons	s.u.	µmhos/cm	milligrams per liter												
Nov	144	7.2	1,091	15	9	5	5	100	582	54	35	24	71	45	68	1.7
Dec	85	7.2	1,246	14	9	5	5	100	664	62	39	28	81	51	78	1.9
Jan	85	7.2	1,409	19	12	7	7	100	752	70	45	31	92	58	88	2.0
Feb	77	7.2	1,433	22	14	8	8	100	764	72	45	32	94	59	90	2.0
Mar	88	7.2	1,354	21	13	8	8	100	722	68	43	30	88	56	85	1.9
Apr	86	7.2	1,279	30	19	11	11	100	682	64	40	29	84	52	80	1.9
May	104	7.2	1,312	30	19	11	11	100	699	66	42	29	86	54	82	1.9
Jun	151	7.2	1,229	45	28	17	17	121	655	61	39	27	80	50	77	1.8
July	252	7.2	1,097	73	45	27	27	268	585	55	35	24	72	45	69	1.7
Aug	288	7.2	1,123	82	51	31	30	788	599	56	36	25	73	46	70	1.8
Sep	279	7.2	1,091	82	51	31	30	788	582	55	35	24	71	45	68	1.7
Oct	252	7.2	1,130	43	27	16	16	268	602	56	36	25	74	46	71	1.8
Combined Average [3]		7.2	1,181	51.0	32	19	19	353	630	59	37	26	77	48	74	1.8
Process Water Average [3]		7.2	1,361	58	36	23	22	372	726	68	43	30	89	56	85	1.8
Cow Water Average [3]		7.2	197	12	12	0.5	1	5	105	10	6	4	13	8	12	1.8

NOTES:

This table presents the projected combined process water and cow water quality to the City of Pasco Process Water Reuse Facility (PWRF) storage lagoons. Data for nitrogen, pH, FDS, and BOD_5 are estimates based on based a theoretical scenario where all processors operate at their respective maximum month permit limits. Nitrogen, pH, FDS, and BOD_5 quality include estimated pretreatment effects from screening, low rate anaerobic digester, and revolving algae biofilm for process water.

Abbreviations: BOD_5 = five-day biochemical oxygen demand, Ca = calcium, Cl = chloride, EC = electrical conductivity, FDS = fixed dissolved solids, Mg = magnesium, Na = sodium, NH_3-N = ammonia-nitrogen, NO_3 + NO_2-N = nitrate + nitrite-nitrogen, P = phosphorus, s.u. = standard units, SAR = sodium adsorption ratio, SO_4 = sulfate, TKN = total Kjeldahl nitrogen, total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen), µmhos/cm = micromhos per centimeter.

1 EC is estimated as follows: EC = FDS × 1.20 ÷ 0.64 assuming FDS is 80% of total dissolved solids and the standard relationship of EC = total dissolved solids ÷ 0.64 (U.S. Salinity Laboratory Staff, 1954).

2 Data for Na, Ca, Mg, SO_4, Cl, and total P are based on the proportional relationship to FDS using process water analytical data reported in the 2022 Farm Operations Report (Valley Science and Engineering, 2022).

3 Averages are flow weighted by month.

Table 4-G. Irrigation Fresh Water Quality

Water Source	Circle [1]	TDS [2]	NO_3-N	EC [3]
		mg/L		µmhos/cm
IW-1	1-3	466	12.1	728
IW-2	1-3	466	12.1	728
IW-3	1-3	466	12.1	728
IW-4	4	535	13.0	836
IW-5	5, 6-15	625	23.7	977
IW-6-9	6-15	625	23.7	977
IW-7	6-15	625	23.7	977
IW-8-10	6-15	625	23.7	977
IW-11-13	6-15	625	23.7	977
IW-12	6-15	625	23.7	977
IW-15	6-15	625	23.7	977
V17, V18 Underdrain	V16-V18	426	32.6	666
SCBID	V16-V18	181	0.8	283

NOTES:

Supplemental irrigation water (fresh water) was sampled by City of Pasco in August 2021 from the individual City of Pasco wells (labeled "IW"). Underdrain water from Circles V18 and V19 was sampled by City of Pasco in December 2021. SCBID water was sampled by SCBID during 7 events between April and October 2021, and values shown are averages.

Abbreviations: EC = electrical conductivity, IW = irrigation well, mg/L = milligrams per liter, NO_3-N = nitrate-nitrogen, SCBID = South Columbia Basin Irrigation District, TDS = total dissolved solids, µmhos/cm = micromhos per centimeter.

1 Circles served from corresponding fresh water sources. Flow from IW-6 through IW-15 is commingled and quality is not tracked separately.

2 The SCBID TDS concentration is estimated using the relationship of TDS = EC × 0.64 (U.S. Salinity Laboratory Staff, 1954).

3 Electrical conductivity calculated for City of Pasco wells and the V18, V19 underdrain using the relationship of EC = TDS ÷ 0.64 (U.S. Salinity Laboratory Staff, 1954).

Table 4-H. Crop Rotations

Circle [1]	Acres	2018	2019	2020	2021	Design Basis Crop Rotation [2]
1	122	Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Alfalfa
2	152	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa
3	128	Alfalfa	Alfalfa	Potato / Sudangrass	Triticale / Alfalfa	Alfalfa / Corn
4	128	Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa
5	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa
6	128	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa
7	152	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa
8	128	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn
9	128	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa
10	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa
11	150	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa	Triticale / Corn
12	128	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa	Alfalfa / Corn
13	128	Alfalfa	Alfalfa	Potato / Sudangrass	Triticale / Alfalfa	Alfalfa
15	128	Alfalfa	Alfalfa / Corn	Potato / Corn	Triticale / Alfalfa	Alfalfa
V16	70	--	--	--	--	Alfalfa
V17	169	--	--	--	--	Triticale / Corn
V18	164	--	--	--	--	Alfalfa / Corn
B19	111	--	--	--	--	Alfalfa
Total	**2,370**					

Summary by Crop (acres)	2018	2019	2020	2021	Design Basis Crop Rotation
Alfalfa	1,168	1,170	1,216	966	1,199
Alfalfa / Corn	152	128	256	122	548
Triticale / Corn	0	0	0	0	319
Potato / Alfalfa	408	558	0	384	304
Other	128	0	384	384	0

NOTES:

Cropping information obtained from the Annual Farm Operations Reports (Cascade Earth Sciences, 2019, 2020; Valley Science and Engineering, 2021, 2022). Where two crops are listed together, the first crop is grown and harvested followed by planting and harvest of the second crop, except for the crop after potatoes, which is planted but not harvested until the following growing season.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle 17.

2 Design basis crop rotation is the most limiting projected crop mixture used to calculate the limiting design basis capacity for the land treatment site.

Table 4-I. Crop Planting, Harvest, and Nitrogen Management

Crop	Planting Month	Number of Harvest(s) - Harvest Month(s)	Expected Yield	Crop Salts [1]	Crop Nitrogen	
				Removal [2]		Capacity [3]
			tons/ac/yr	pounds per acre per year		
Alfalfa	September to Early October	3 to 4 harvests - May, June / July, July / August, September	7.7	1,600	484	540
Alfalfa / Corn	Established / May	May / October	13.8	1,537	337	380
Corn	March or April	October	8.6	830	216	240
Potato	April	September	29.5	589	228	260
Triticale / Silage Corn	September / May	May / October	22.6	1,696	271	300

NOTES:

Planting and harvest months, expected yield, and crop nitrogen are based on City of Pasco records.

Abbreviations: mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen, tons/ac/yr = tons per acre per year.

1 Crop removal of salts calculated from ash content and harvested dry matter.

2 Removal values represent the average removal rate expected based on historical land treatment site crop removal records.

3 Nitrogen capacity is the crop nitrogen need increased to account for net available process water nitrogen after volatilization and denitrification losses.
Nitrogen need = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((32 mg/L - 19 mg/L) + (19 mg/L × 0.80) + (19 mg/L)) × 0.96] ÷ (32 mg/L + 19 mg/L)

Table 4-J. Summary of Circle-Specific Monthly Soil Hydraulic Budgets - Annual Totals

Circle [1]	Acres	Crop [2]	Gross Precip [3]	Gross Irrigation [4] Process	Cow	Fresh	Total	Net Irrigation [5]	Evapotranspiration [6] Potential	Estimated	Leaching LF [7]	LR [8]
			inches				MG	inches			%	
1	122	Alfalfa	8.3	34.4	5.5	8.5	160	46.4	44.4	38.9	10.6	10.6
2	152	Potato / Alfalfa	8.3	13.9	6.2	16.0	149	35.8	38.7	33.2	7.7	7.7
3	128	Alfalfa / Corn	8.3	21.7	4.7	18.6	156	42.7	39.4	36.7	9.0	9.0
4	128	Alfalfa	8.3	32.8	5.5	9.4	166	45.6	44.4	38.6	10.6	10.6
5	128	Alfalfa	8.3	34.6	5.5	8.8	170	46.9	44.4	39.1	11.0	11.0
6	128	Alfalfa	8.3	31.4	5.5	11.2	167	45.8	44.4	38.8	10.8	10.8
7	152	Potato / Alfalfa	8.3	8.5	3.9	22.9	146	35.0	38.7	32.0	8.7	8.7
8	128	Alfalfa / Corn	8.3	17.0	6.4	15.0	133	37.9	39.4	32.7	9.1	9.1
9	128	Alfalfa	8.3	31.0	5.5	11.5	167	45.6	44.4	38.9	10.7	10.7
10	128	Alfalfa	8.3	31.5	5.5	10.1	164	45.0	44.4	38.1	10.8	10.8
11	150	Triticale / Corn	8.3	13.0	4.1	20.9	155	37.3	38.4	33.4	9.2	9.2
12	128	Alfalfa / Corn	8.3	18.0	4.5	16.5	136	38.5	39.4	34.9	9.6	9.6
13	128	Alfalfa	8.3	31.2	5.5	10.2	163	44.7	44.4	38.1	10.7	10.7
15	128	Alfalfa	8.3	33.5	5.5	7.8	163	45.1	44.4	37.9	10.9	10.9
V16	70	Alfalfa	8.3	29.8	0.0	17.0	89	44.5	44.4	38.3	9.5	9.5
V17	169	Triticale / Corn	8.3	17.4	0.0	18.7	166	36.2	38.4	33.4	7.7	7.7
V18	164	Alfalfa / Corn	8.3	23.8	0.0	16.9	181	39.9	39.4	34.7	8.8	8.8
B19	111	Alfalfa	8.3	38.5	8.9	0.0	143	45.5	44.4	38.9	10.8	10.8
Average			**8.3**	**24.9**	**4.5**	**13.7**	**156**	**41.7**	**41.7**	**36.2**	**9.7**	**9.7**
Total (MG) [9]			**531**	**1,600**	**292**	**881**	**2,773**	**2,685**	**2,683**	**2,331**		

NOTES:

Abbreviations: LF = leaching fraction, LR = leaching requirement, MG = million gallons, Precip = precipitation.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle V17.

2 Design basis crop rotation.

3 Gross precipitation is based on monthly precipitation from the years with sufficient data from 2001-2021 from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.) and represents a 10-year return. The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-2016) were normalized in relation to the long-term average for each month to create the 10-year return precipitation data for design purposes.

4 Gross irrigation = inches of process and fresh water delivered at the irrigation system discharge point (i.e., sprinkler heads). No connection to fresh irrigation water is planned for Circle B19, so no fresh water irrigation is projected for Circle B19 in this scenario.

5 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is based on average of available data from 1995-2016 for crops that are grown at the land treatment site from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.). Estimated evapotranspiration calculated from potential evapotranspiration and soil moisture content.

7 Leaching fraction = percent of gross input estimated to percolate beyond the root zone (total percolate loss ÷ [precipitation + gross irrigation]).

8 Leaching requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

9 Total MG = acres × 27,154 gallons per acre-inch ÷ 1,000,000.

Table 4-K. Design Basis Hydraulic Capacity

Month	Process Water	Cow Water	Fresh Water	Total
	million gallons			
Nov	47	69	75	190
Dec	0	0	0	0
Jan	0	0	0	0
Feb	0	0	0	0
Mar	47	123	144	314
Apr	252	0	9	260
May	230	25	16	271
Jun	127	24	213	363
Jul	228	51	251	530
Aug	264	0	156	420
Sep	250	0	9	259
Oct	157	0	9	166
Total	**1,600**	**292**	**881**	**2,773**

NOTES:
Million gallons calculated from irrigation of process water, cow water, and fresh water scheduled to all fields within the monthly soil hydraulic budgets based on the design basis crop rotation. Hydraulic capacity was developed considering crop irrigation and nitrogen requirements.

Table 4-L. Crop Nitrogen Removal and Capacity

Year	2017	2018	2019	2020	2021	Design Basis Crop Rotation [1]
	pounds per year					
Crop Nitrogen Removal [2]						
Crop Removal	541,952	658,880	759,104	796,224	647,744	921,000
Site Gross Nitrogen Capacity [3]						
Gross Capacity						1,034,800

NOTES:

Abbreviations: lb/ac = pounds per acre, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

1 Design basis crop rotation is the most limiting projected crop mixture resulting in the limiting design basis capacity for the land treatment site. Values rounded to the nearest hundred.

2 Crop nitrogen removal calculated from historical crop yield and crop tissue nitrogen concentration data from the City of Pasco records.

3 Site gross nitrogen capacity is crop nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses. Site gross nitrogen capacity = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((30 mg/L - 16 mg/L) + (16 mg/L × 0.80) + (12 mg/L)) × 0.96] ÷ (30 mg/L + 12 mg/L)

Table 4-M. Design Basis Nitrogen Capacity and Operational Analysis

Circle [1]	Process Water	Cow Water	Fresh Water [2]	Total Load [3]	Capacity [4]
	pounds nitrogen				
1	55,157	1,892	2,718	59,767	66,380
2	27,753	2,641	6,413	36,807	38,992
3	36,465	1,685	6,261	44,411	48,431
4	55,178	1,985	3,409	60,572	69,645
5	58,206	1,985	5,784	65,976	69,645
6	52,823	1,985	7,404	62,212	69,645
7	16,981	1,660	17,977	36,618	38,992
8	28,599	2,314	9,896	40,810	48,431
9	52,150	1,985	7,602	61,737	69,645
10	52,991	1,985	6,677	61,653	69,645
11	25,629	1,722	16,153	43,503	45,651
12	30,285	1,631	10,908	42,824	48,431
13	52,487	1,985	6,743	61,214	69,645
15	56,356	1,985	5,156	63,497	69,645
V16	27,397	0	3,579	30,976	38,087
V17	38,648	0	9,503	48,151	51,434
V18	51,300	0	8,343	59,643	62,053
B19	56,167	2,775	0	58,941	60,395
Total	**774,572**	**30,213**	**134,527**	**939,312**	**1,034,791**

NOTES:

Pounds of nitrogen calculated from the inches of process water, cow water, and fresh water scheduled to each field within monthly soil hydraulic budgets based on the projected nitrogen concentrations of each respective irrigation source.

Abbreviations: mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle V17.

2 Fresh water nitrogen load accounts for assumed gaseous losses of 4% due to denitrification. No connection to fresh irrigation water is planned for Circle B19, so fresh water irrigation is not projected for Circle B19.

3 Example total operational load is less than capacity due to crop-dependent agronomic irrigation management considerations such as crop dry-down and harvest periods. Example total operational load includes the use of cow water and fresh water for planned leaching events.

4 Capacity is the field by field design basis crop rotation nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses. Nitrogen capacity = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((31 mg/L - 19 mg/L) + (19 mg/L × 0.80) + (19 mg/L)) × 0.96] ÷ (31 mg/L + 19 mg/L)

Table 4-N. Design Basis Salts Loads and Removals

Circle[1]	Process Water	Cow Water	Fresh Water	Total Load	Crop Removal[1]	Salts Balance[2]
	pounds per acre fixed dissolved solids					
1	5,651	131	891	6,674	1,600	5,074
2	2,282	147	1,688	4,117	589	3,528
3	3,561	111	1,957	5,629	1,537	4,093
4	5,388	131	1,139	6,658	1,600	5,058
5	5,684	131	1,238	7,053	1,600	5,453
6	5,158	131	1,585	6,874	1,600	5,274
7	1,396	92	3,240	4,729	589	4,140
8	2,793	153	2,118	5,064	1,537	3,527
9	5,092	131	1,627	6,851	1,600	5,251
10	5,175	131	1,429	6,735	1,600	5,135
11	2,136	97	2,950	5,183	1,696	3,487
12	2,957	108	2,335	5,400	1,537	3,863
13	5,125	131	1,443	6,700	1,600	5,100
15	5,503	131	1,104	6,738	1,600	5,138
V16	4,892	0	1,084	5,976	1,600	4,376
V17	2,858	0	1,192	4,050	1,696	2,354
V18	3,910	0	1,078	4,988	1,537	3,451
B19	6,325	212	0	6,536	1,600	4,936
Average	**4,085**	**108**	**1,603**	**5,796**	**1,469**	**4,327**
pounds fixed dissolved solids						
Total	**9,680,000**	**260,000**	**3,800,000**	**13,740,000**	**3,480,000**	**10,260,000**

NOTES:
Totals are rounded to the nearest 10,000 pounds.
Pounds fixed dissolved solids calculated from the inches of process water, cow water, and fresh water scheduled to each field within monthly soil hydraulic budgets based on the projected fixed dissolved solids concentration of each respective irrigation source.
1 Crop removal values are using the design basis crop rotation and average salts removal rates expected based on historical land treatment site crop salts removal records.
2 Salts balance calculated as the total salts load minus crop salts removal.

Table 4-O. Design Basis Annual Mass Loads

Source	Flow	Total N	BOD_5	FDS
	million gallons	pounds		
Process Water [1]	1,600	774,572	4,970,000	9,680,000
Cow Water [2]	292	30,213	10,000	260,000
Fresh Water [3]	881	134,527	--	3,800,000
Total	2,773	939,312	4,980,000	13,740,000

NOTES:

BOD_5 and FDS rounded to the nearest 10,000 pounds.

Abbreviations: -- = not calculated, BOD_5 = five-day biochemical oxygen demand, FDS = fixed dissolved solids, mg/L = milligrams per liter, SCBID = South Columbia Basin Irrigation District, TDS = total dissolved solids, TKN = total Kjeldahl nitrogen, Total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen).

1 Process water mass loads calculated using maximum-month scenario flow weighted process water constitutent concentrations for total N (58 mg/L), BOD_5 (372 mg/L), FDS (726 mg/L), and flow scheduled to each field within the monthly soil hydraulic budgets.

2 Cow water mass loads calculated using flow weighted cow water constitutent concentrations for total N (12 mg/L), BOD_5 (5 mg/L), FDS (105 mg/L), and flow scheduled to each field within the monthly soil hydraulic budgets.

3 Fresh water mass loads calculated using the 2021 constitutent concentrations of total N and TDS from the City of Pasco fresh water wells, SCBID irrigation water, and V-circles underdrain system with flows scheduled to each field within the monthly soil hydraulic budgets. BOD_5 data not available.

Table 4-P. Design Five-Day Biochemical Oxygen Demand Daily Loads

Circle [1]	Month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	pounds BOD_5 per acre per day											
1	5	0	0	0	0	12	9	7	14	17	17	12
2	0	0	0	0	0	5	9	1	5	2	9	7
3	0	0	0	0	5	11	11	9	8	3	5	7
4	4	0	0	0	0	12	9	7	14	17	17	9
5	5	0	0	0	0	12	9	7	14	17	17	13
6	3	0	0	0	0	12	9	7	14	17	17	7
7	0	0	0	0	0	3	5	0	0	0	7	8
8	0	0	0	0	5	11	11	3	3	3	4	7
9	3	0	0	0	0	12	9	7	14	17	17	5
10	3	0	0	0	0	12	9	7	14	17	17	7
11	0	0	0	0	7	12	5	3	0	0	5	3
12	0	0	0	0	5	12	11	3	6	3	5	4
13	3	0	0	0	0	12	9	7	14	17	17	5
15	5	0	0	0	0	12	9	7	14	17	17	10
V16	3	0	0	0	0	12	9	7	14	17	16	2
V17	0	0	0	0	5	8	14	0	4	14	0	3
V18	0	0	0	0	5	11	15	5	11	11	5	1
B19	4	0	0	0	0	12	14	19	16	19	8	12

NOTES

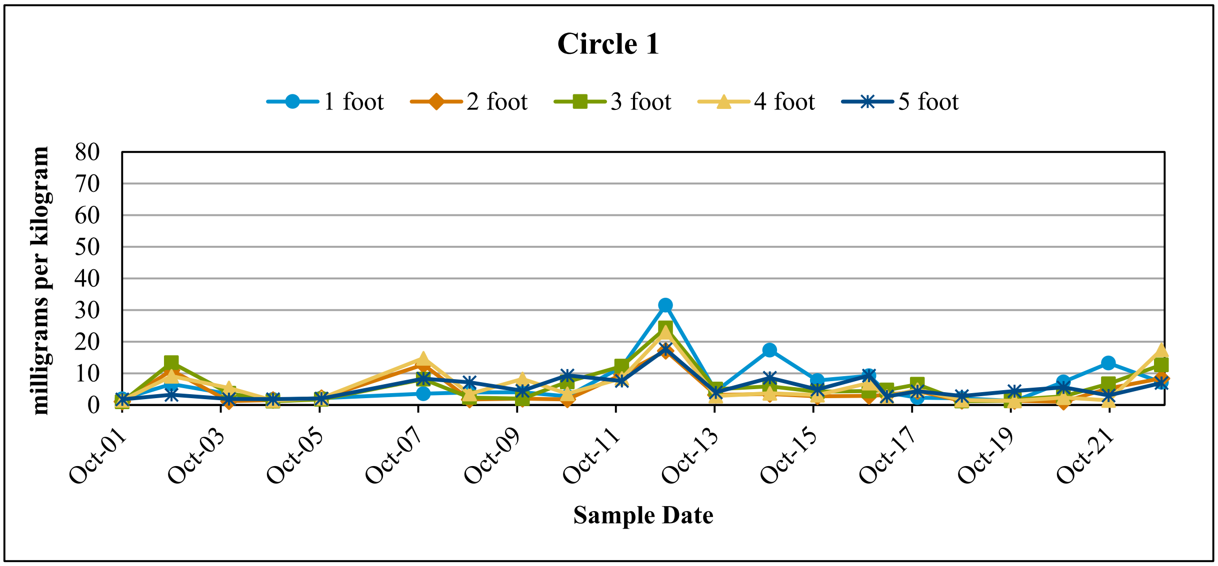
Projected BOD_5 loads based on monthly process water and cow water design flow and an estimated BOD_5 concentrations of 372 and 5 mg/L, respectively. Calculation as follows: million gallons × 8.34 million pounds per million gallons × BOD_5 concentration in mg/L ÷ acres ÷ days per month.

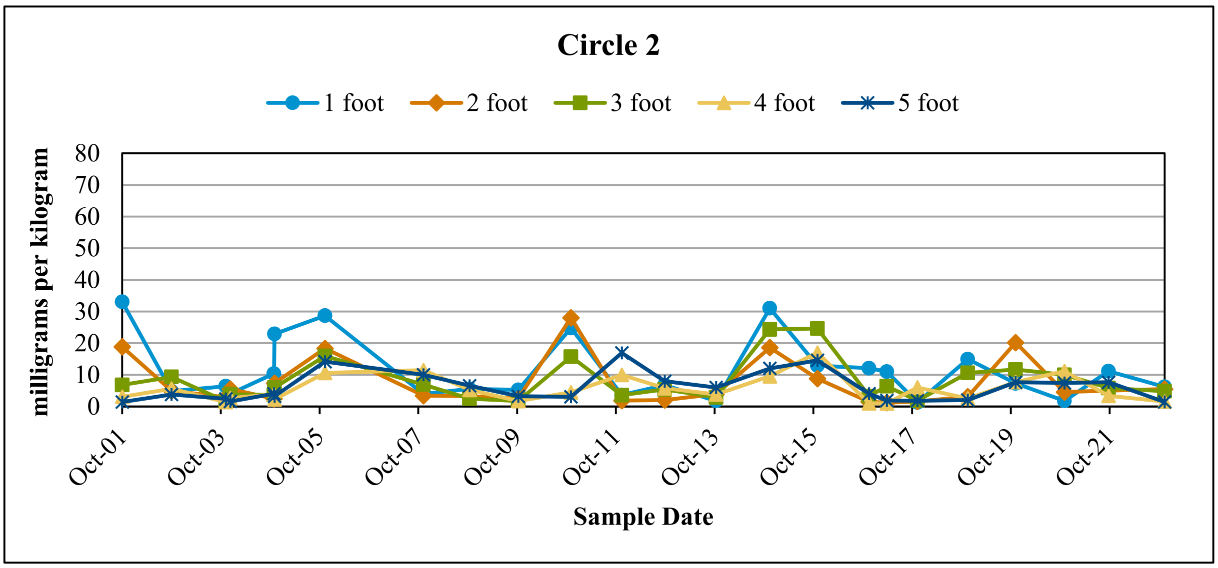
Abbeviations: BOD_5 = five-day biochemical oxygen demand, mg/L - milligrams per liter.

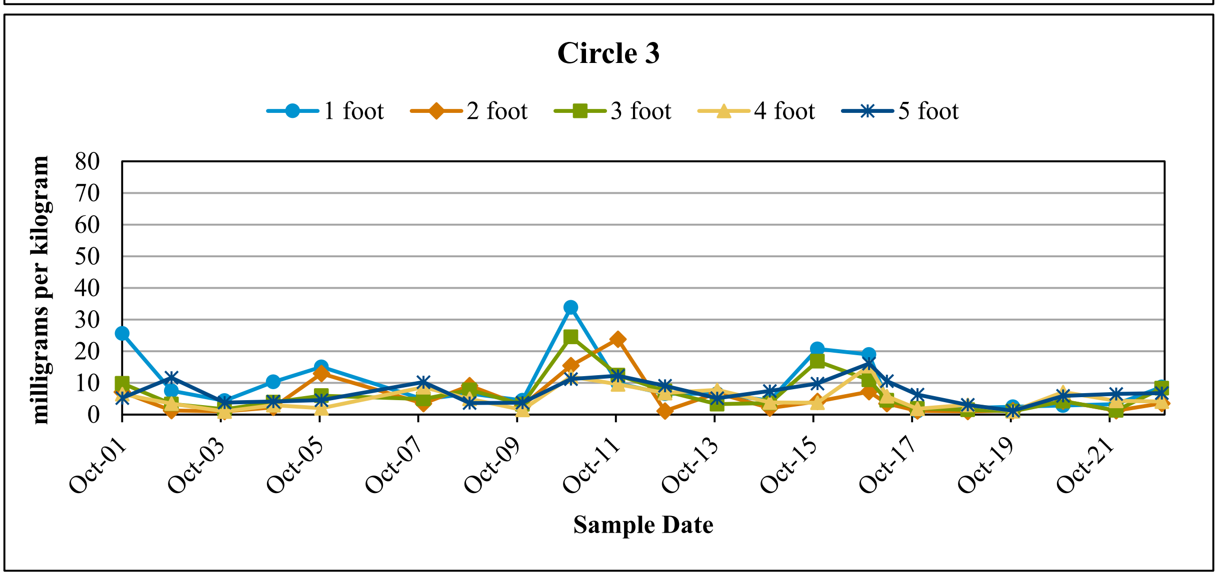
1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle V17 plus Little Circle V17.

Charts

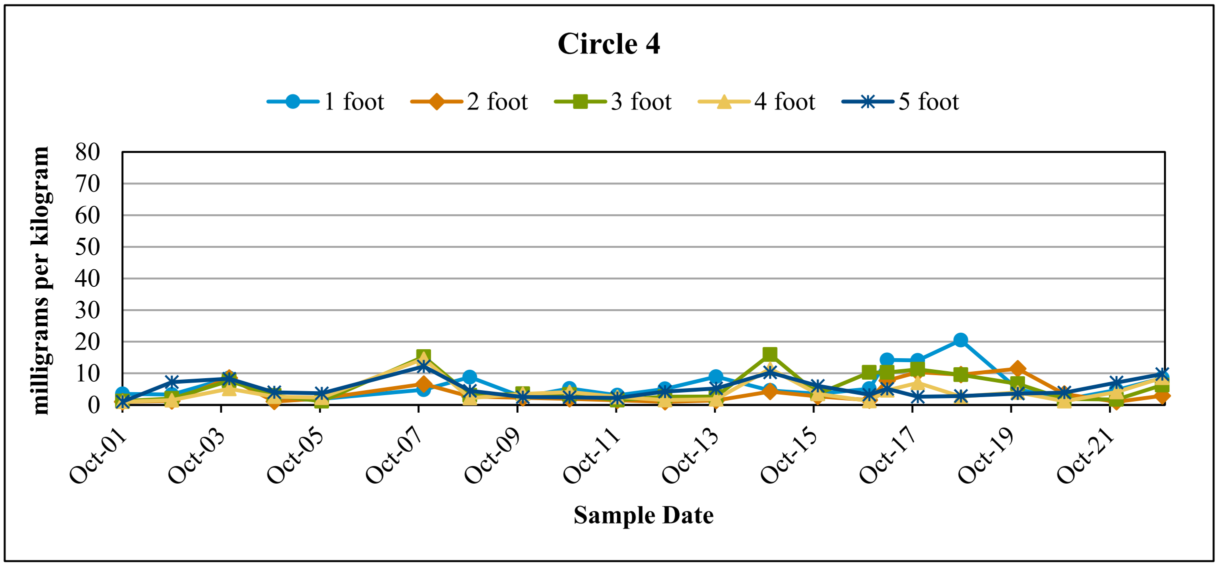
Charts 4-A. Historical Soil Nitrogen Concentrations

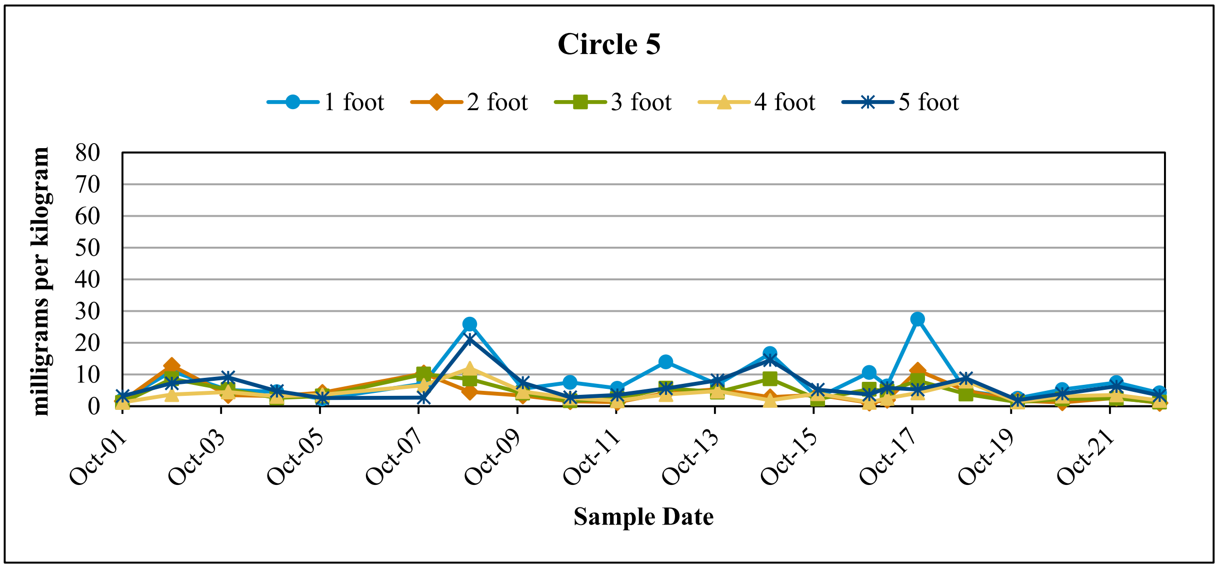


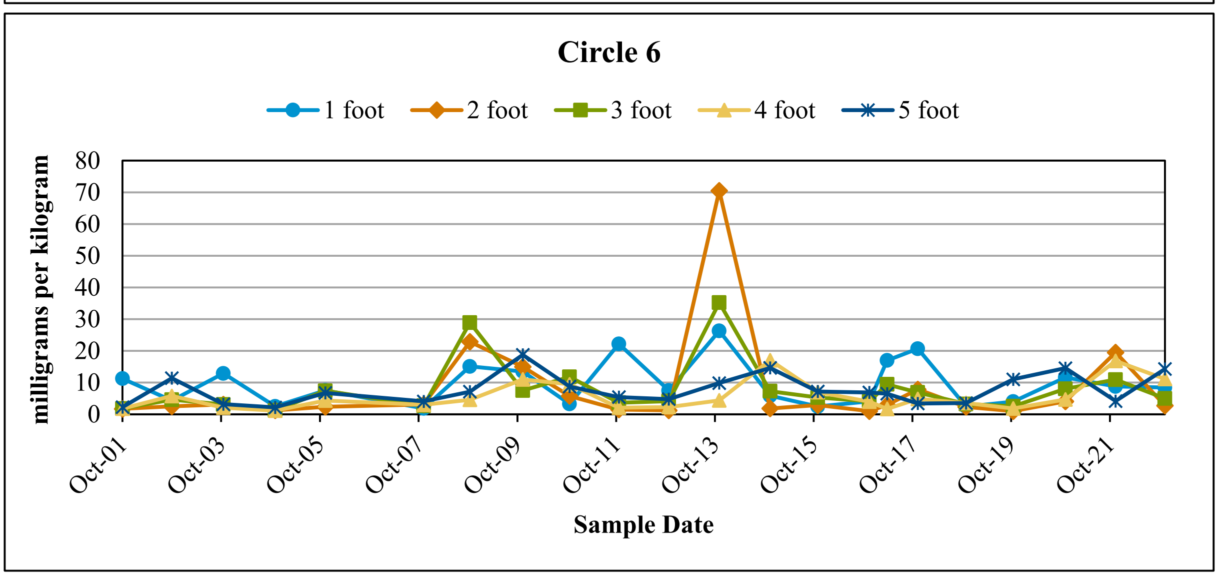




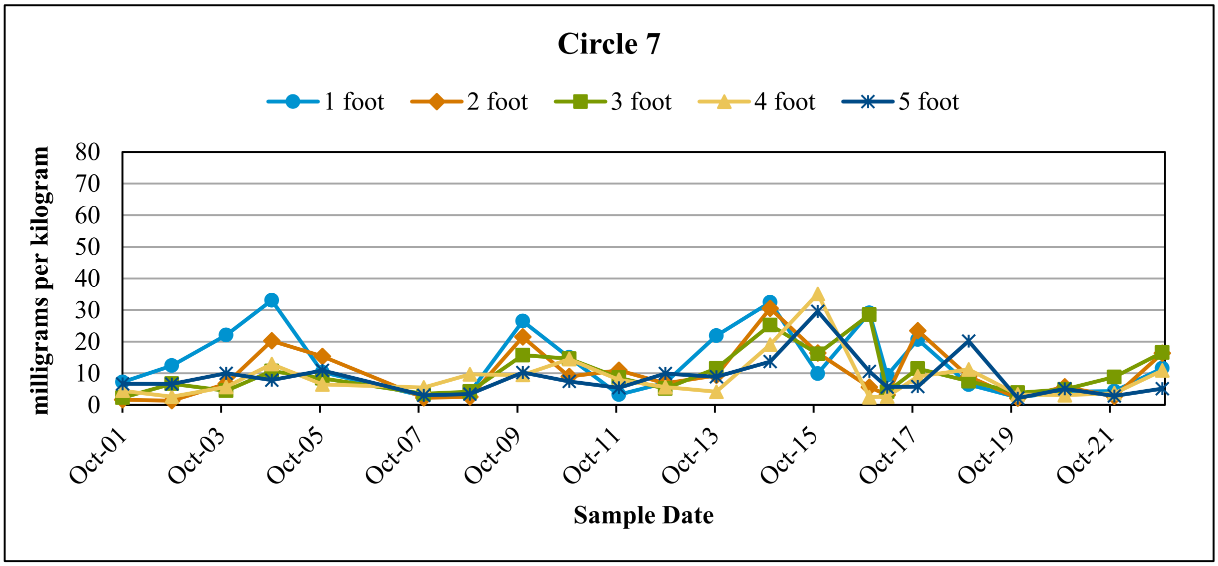
Charts 4-A. Historical Soil Nitrogen Concentrations

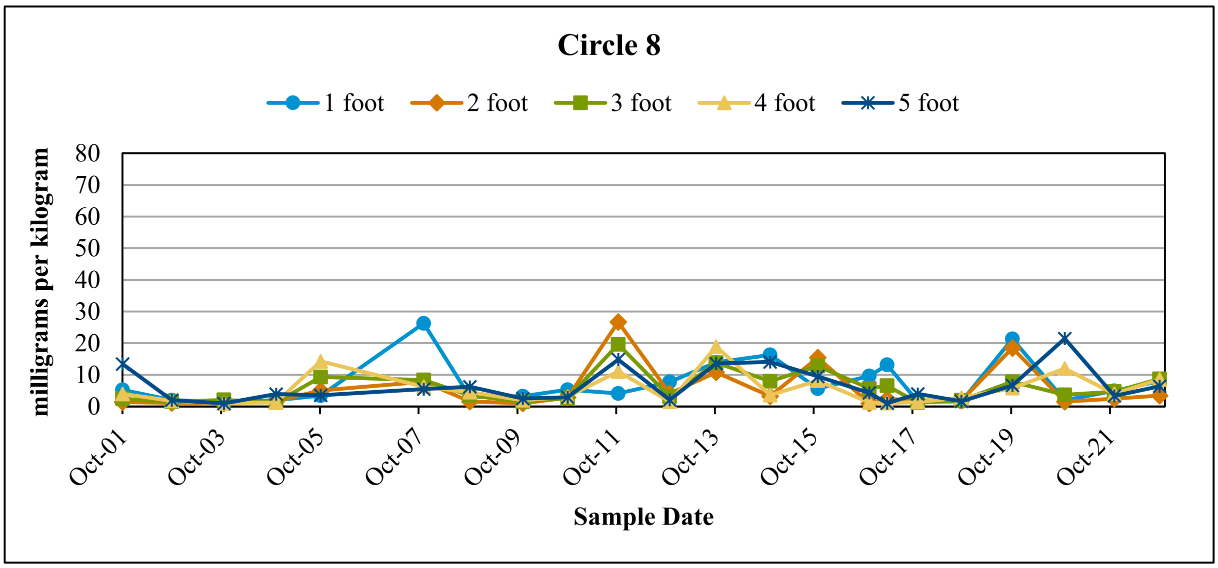


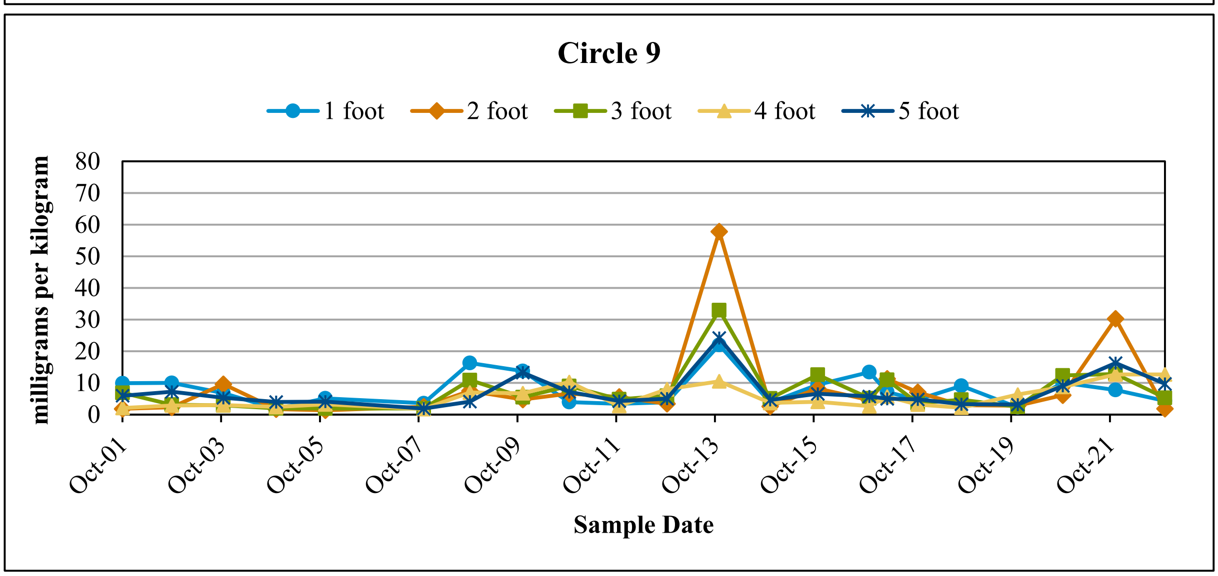




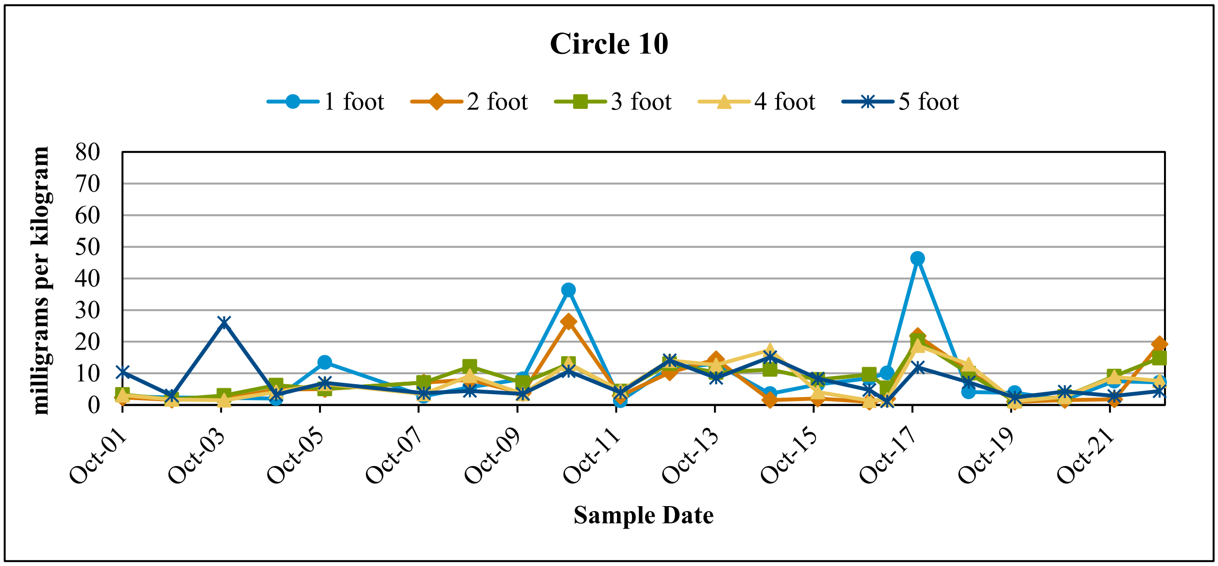
Charts 4-A. Historical Soil Nitrogen Concentrations

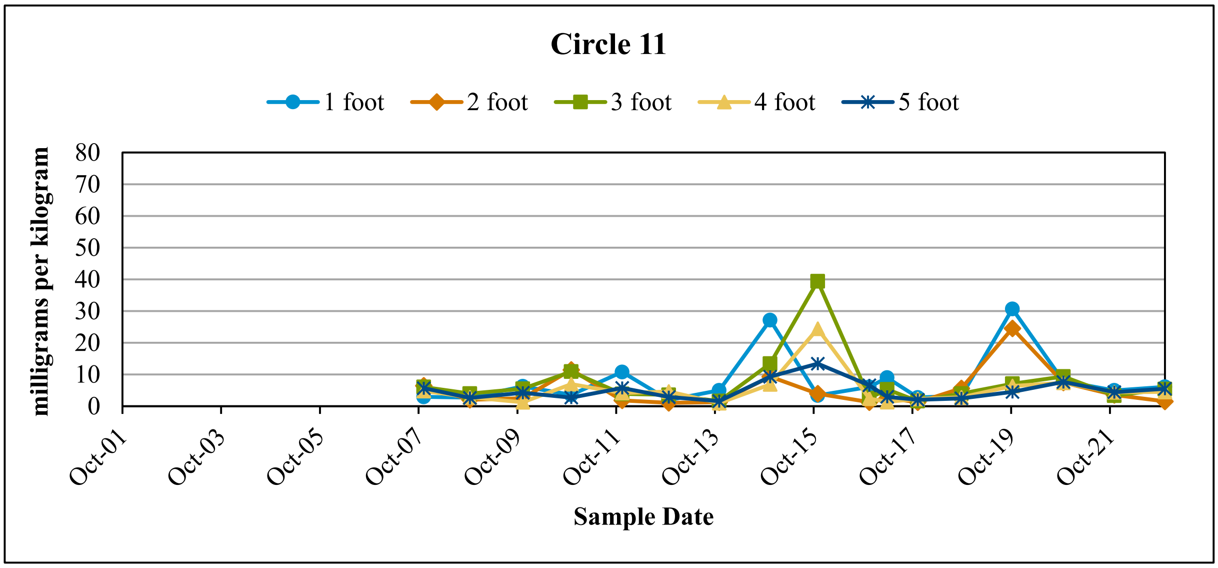


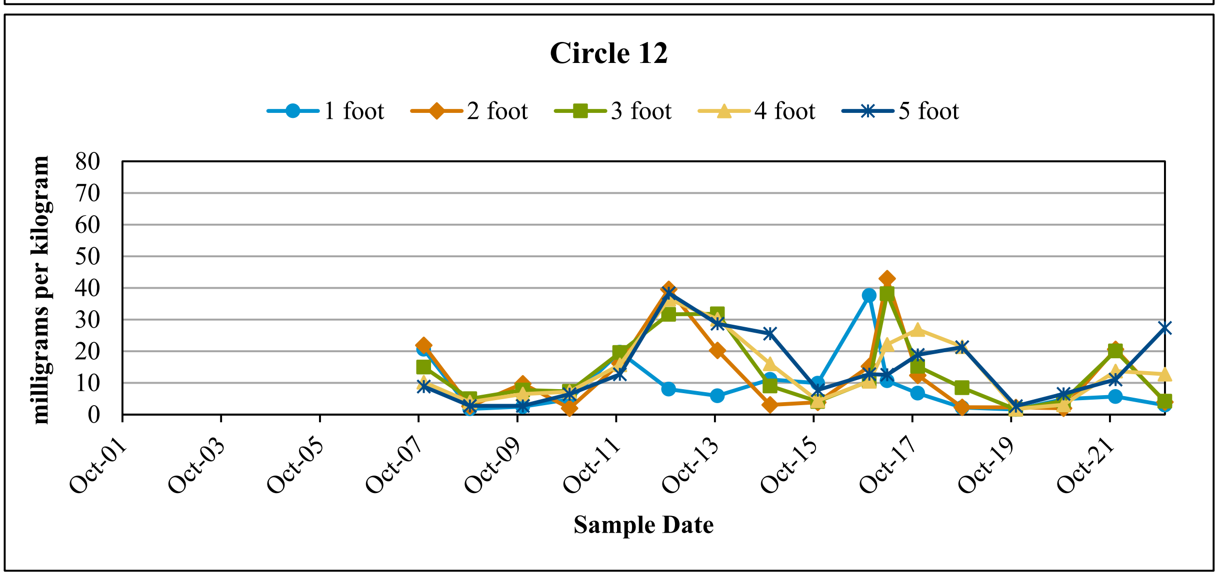




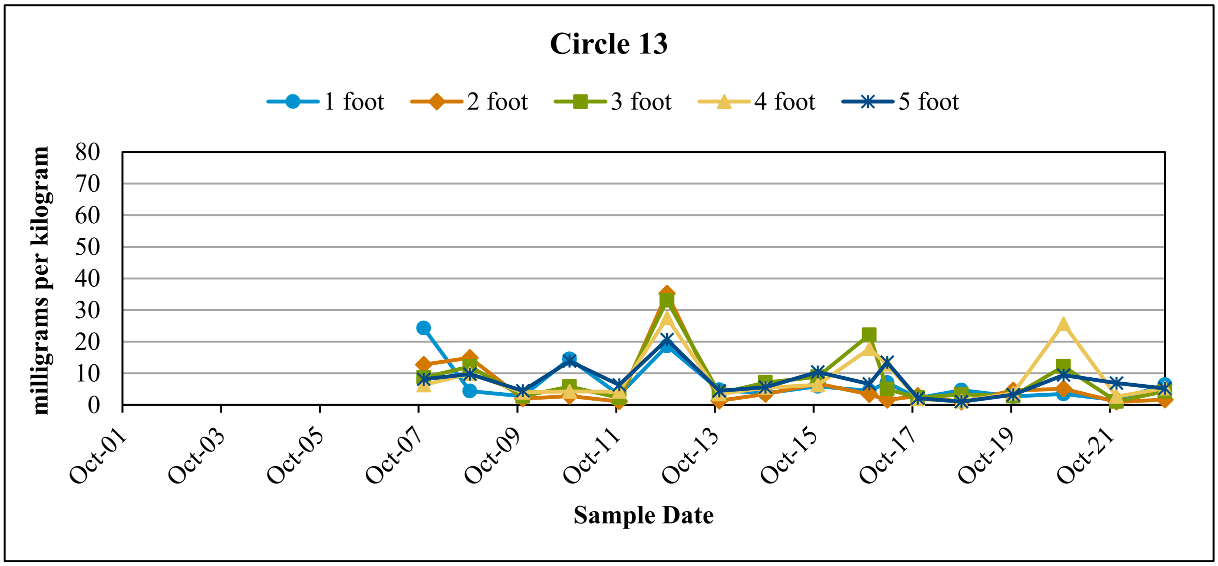
Charts 4-A. Historical Soil Nitrogen Concentrations

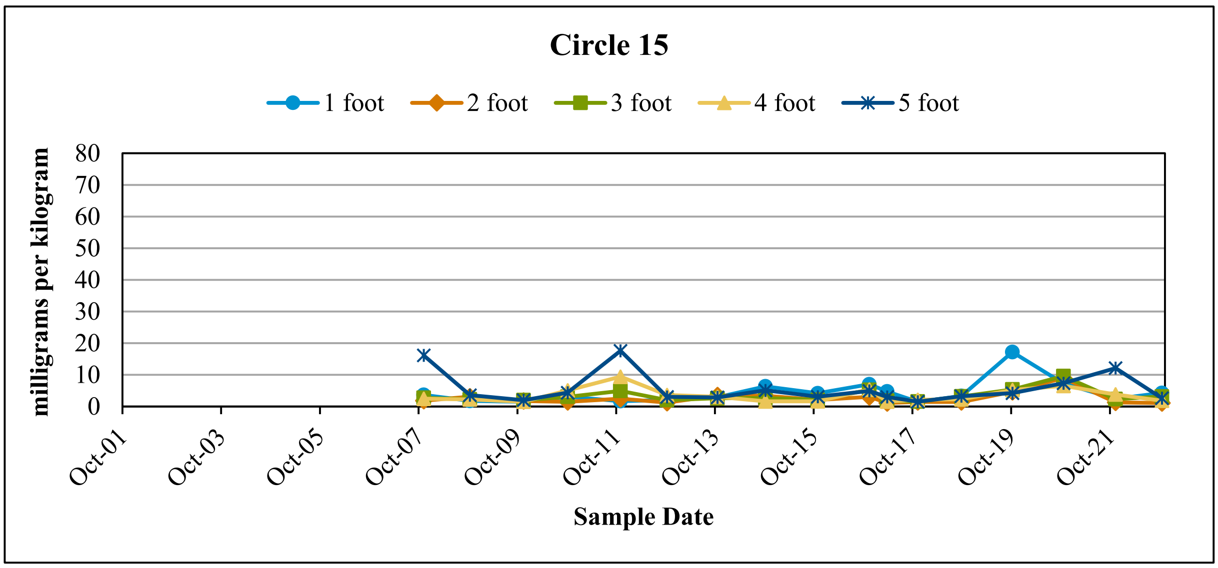




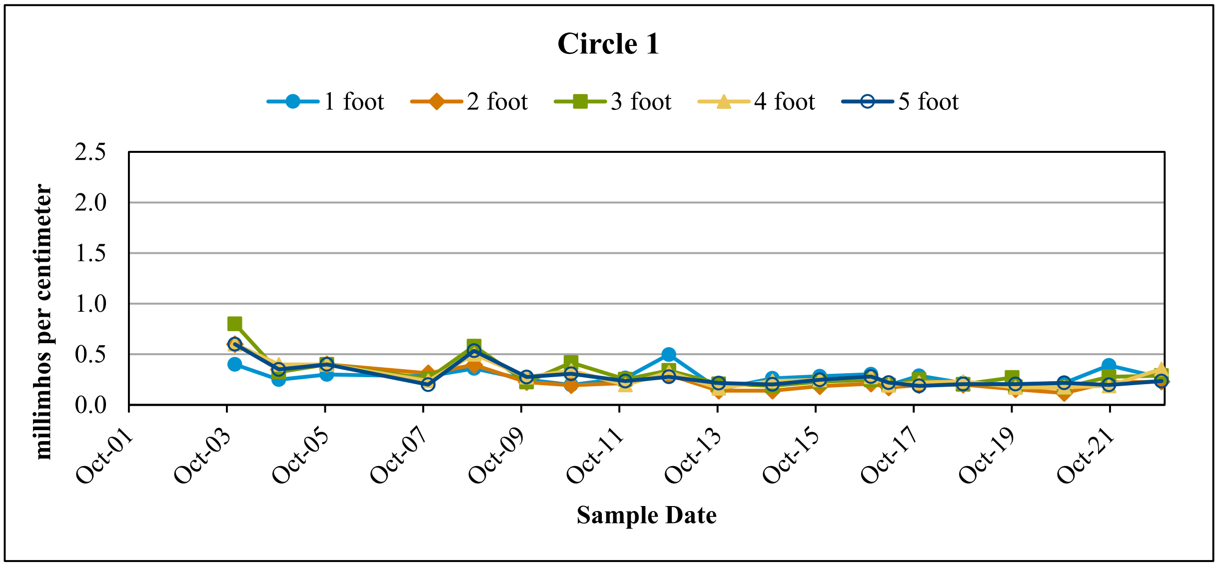


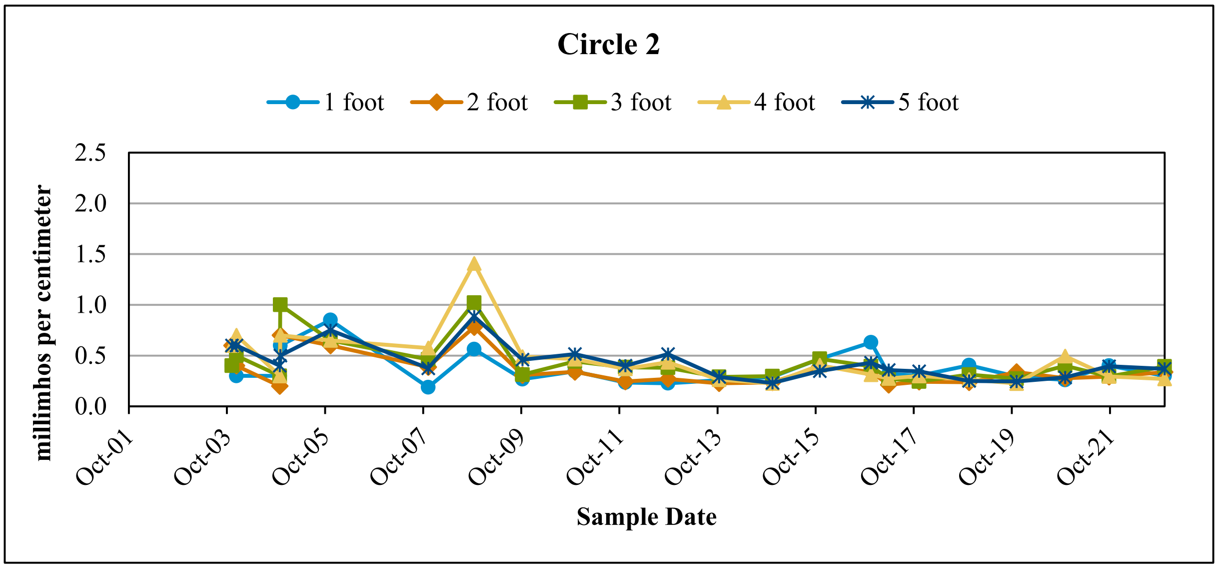
Charts 4-A. Historical Soil Nitrogen Concentrations

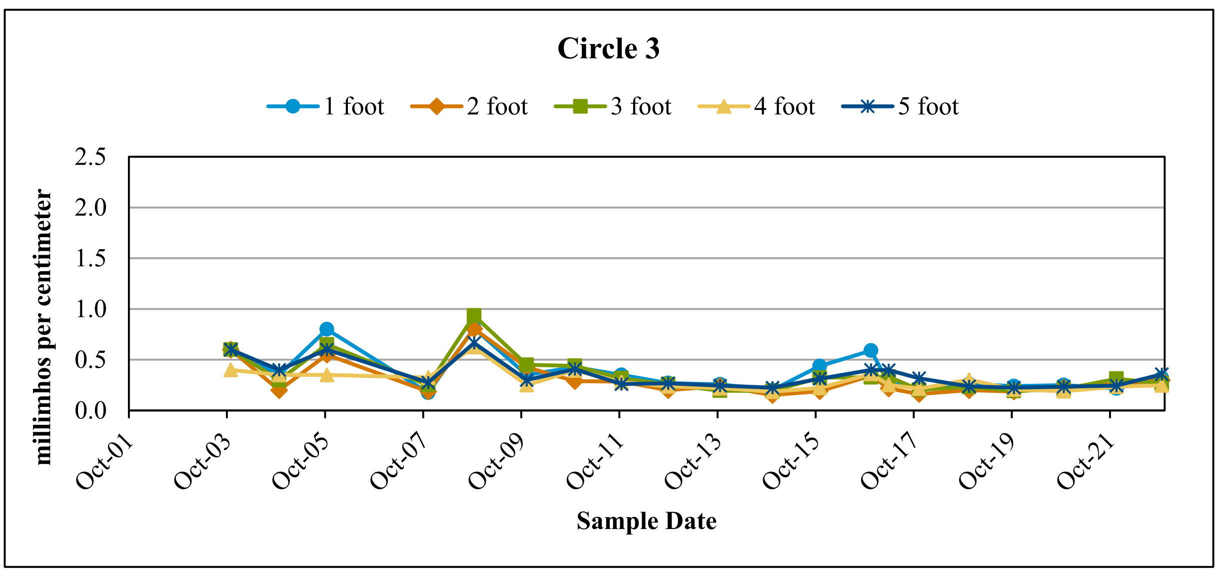




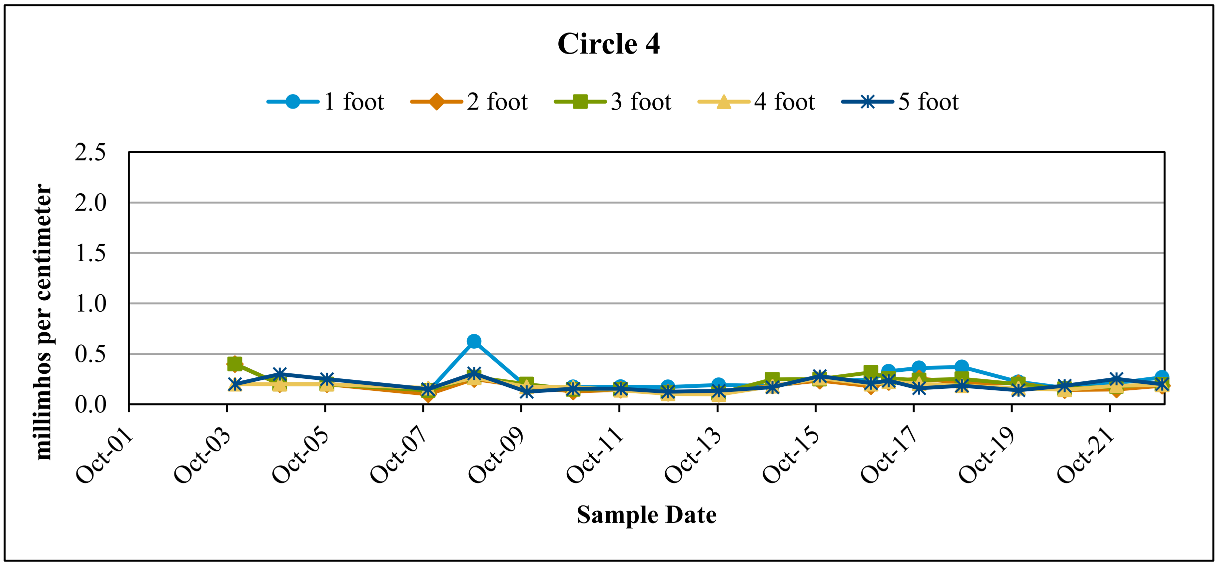
Charts 4-B. Historical Soil Electrical Conductivity

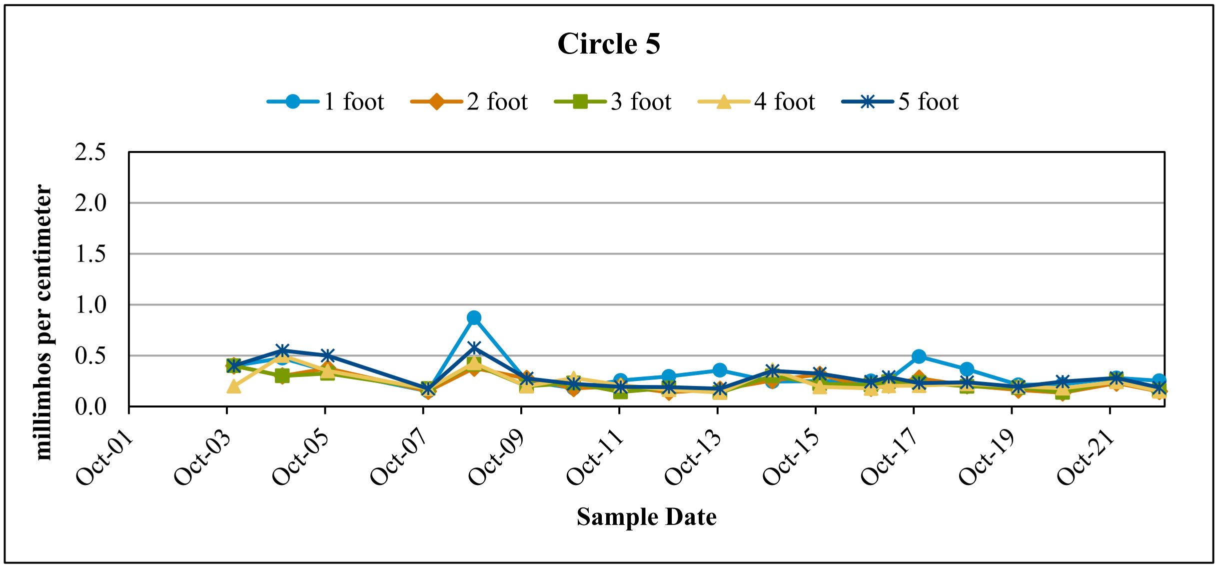


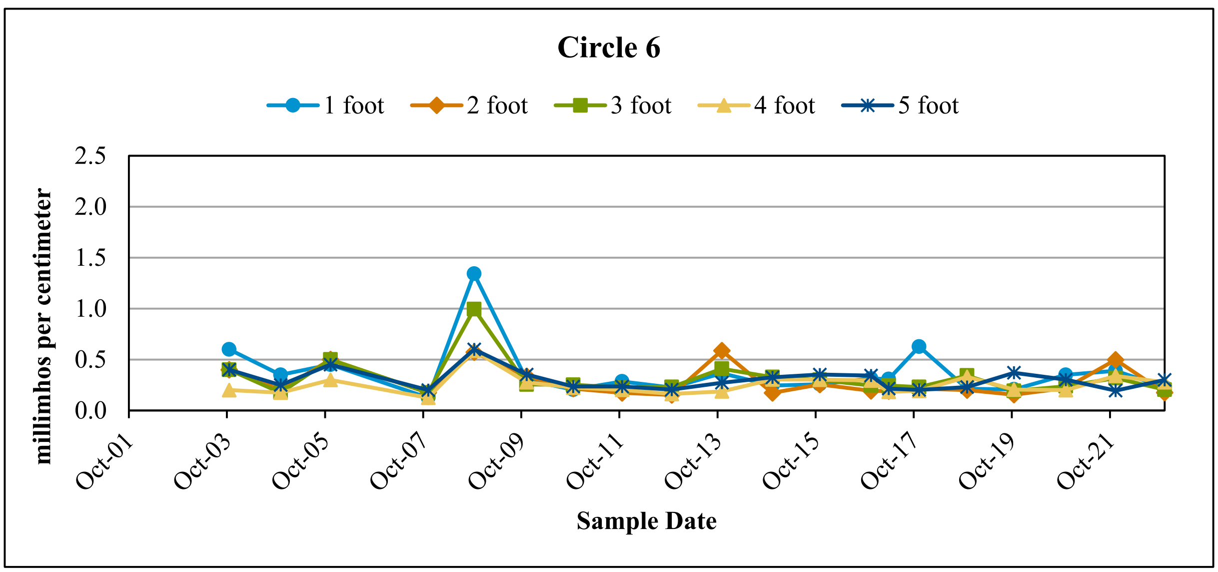




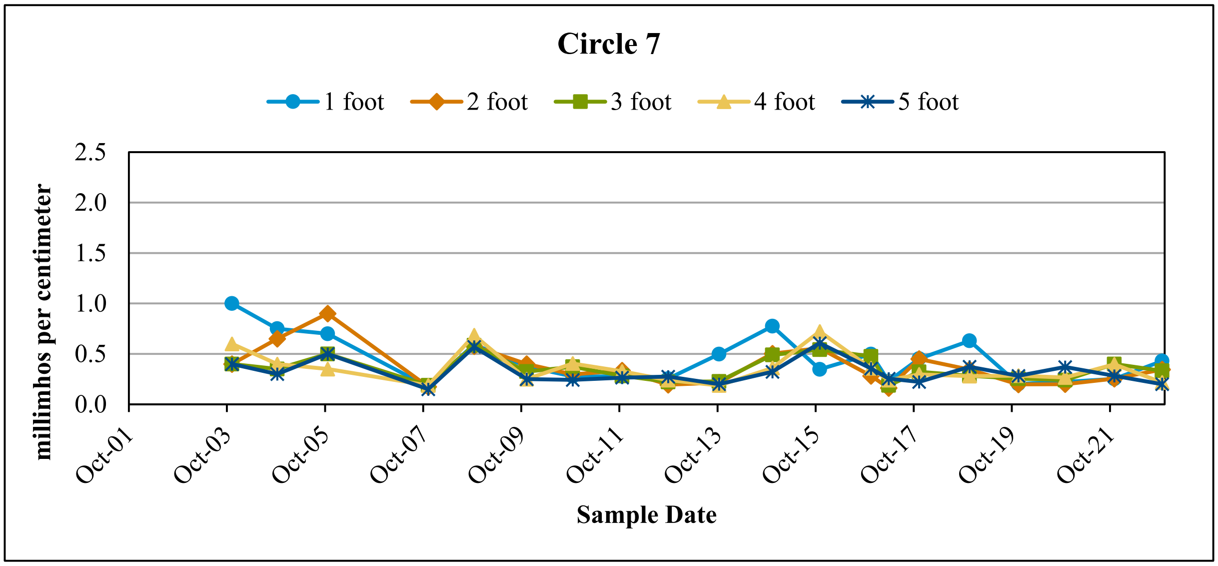
Charts 4-B. Historical Soil Electrical Conductivity

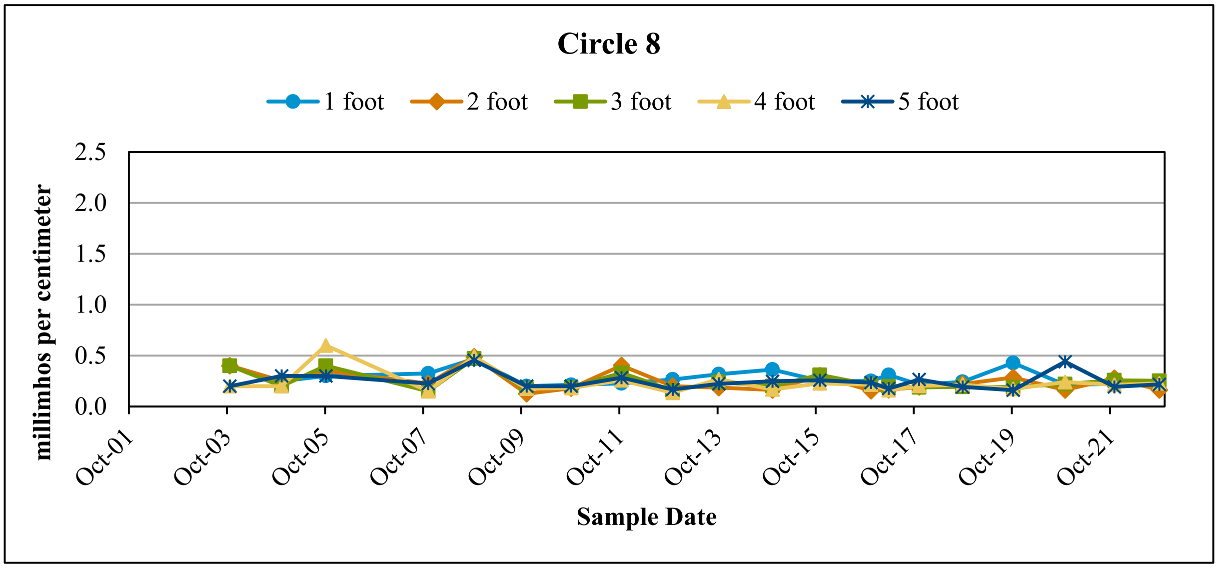


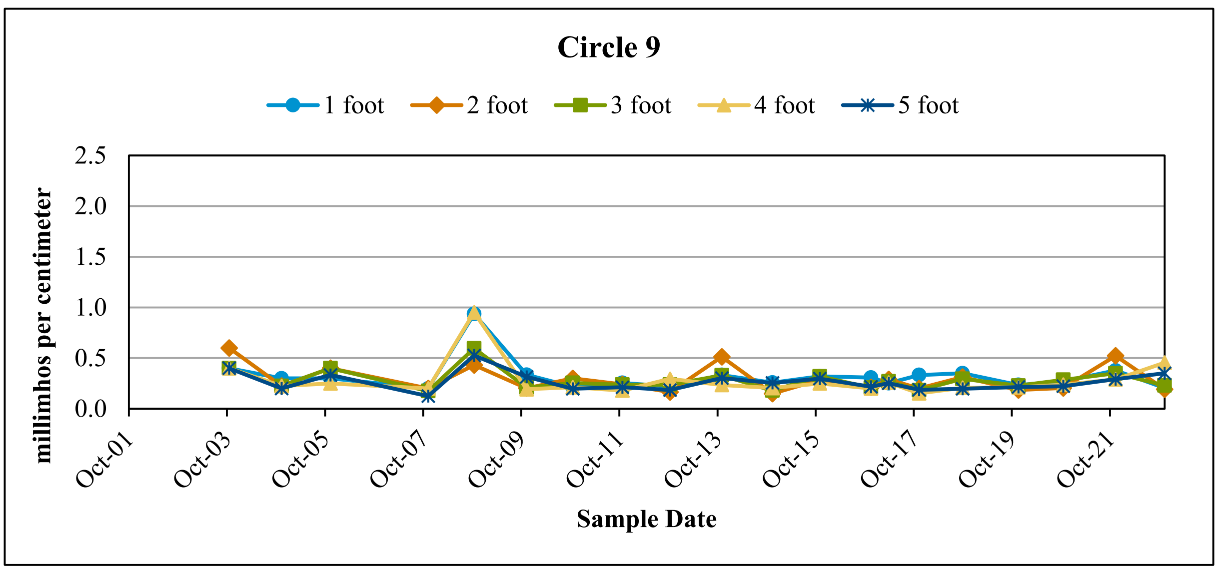




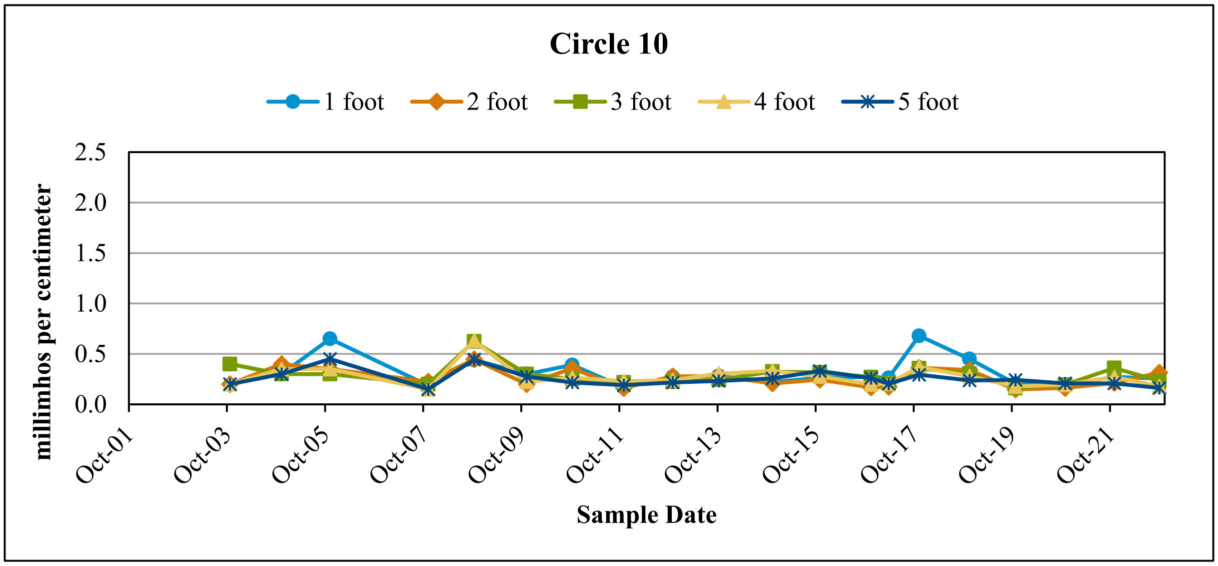
Charts 4-B. Historical Soil Electrical Conductivity

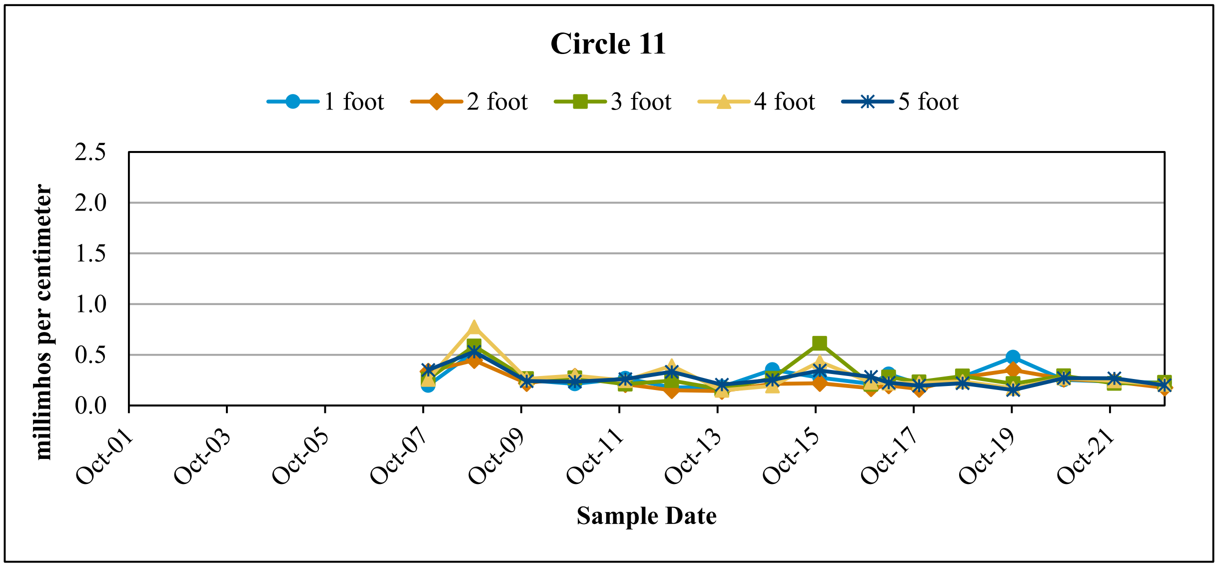


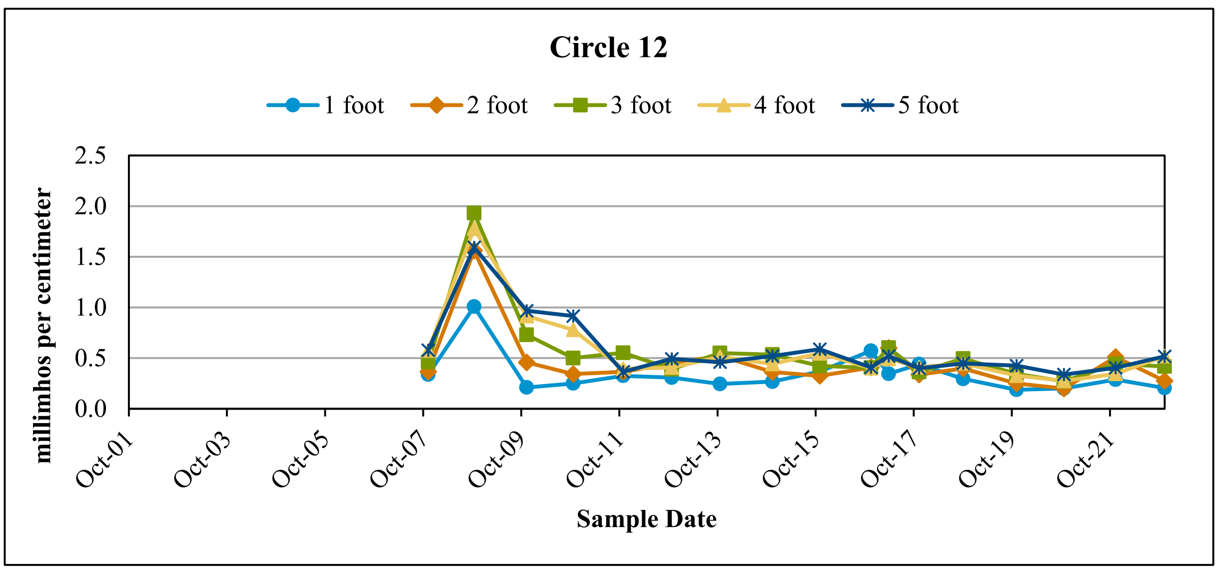




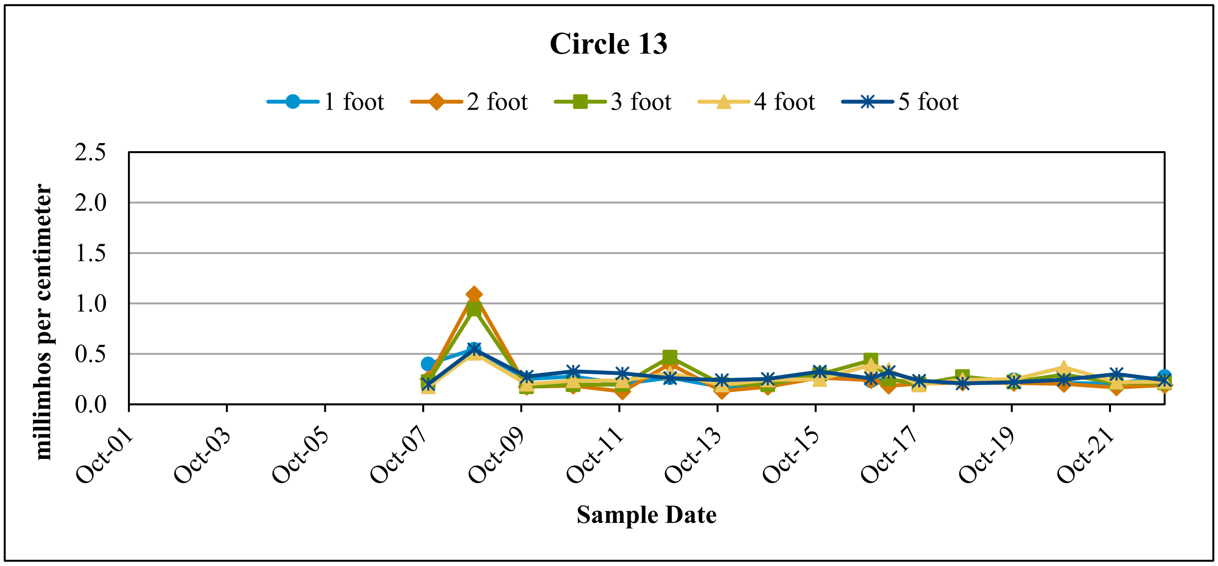
Charts 4-B. Historical Soil Electrical Conductivity

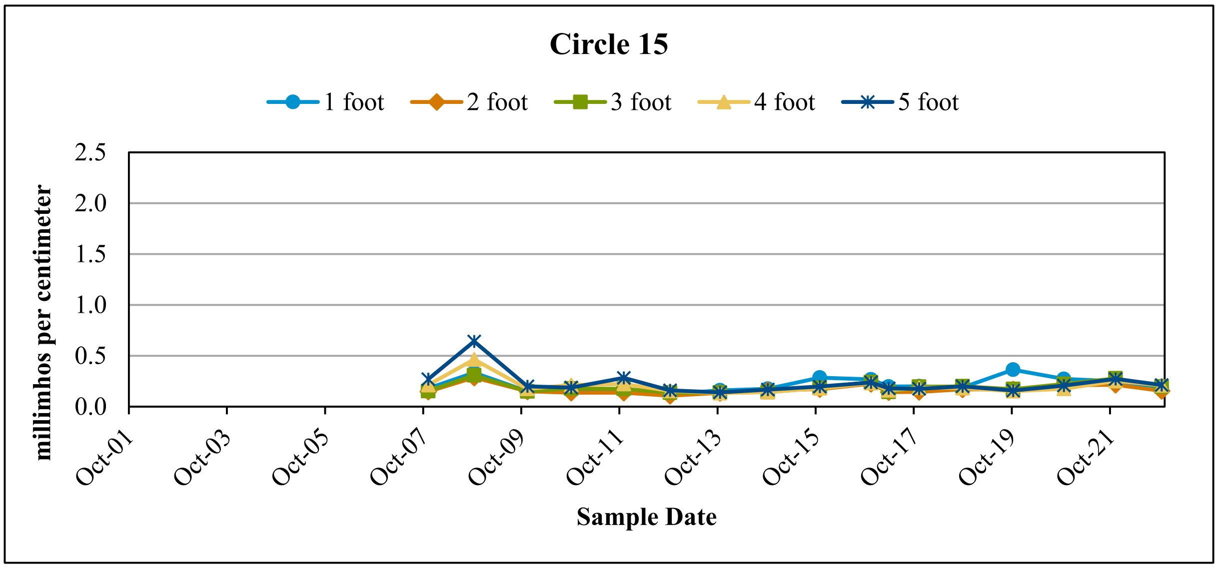




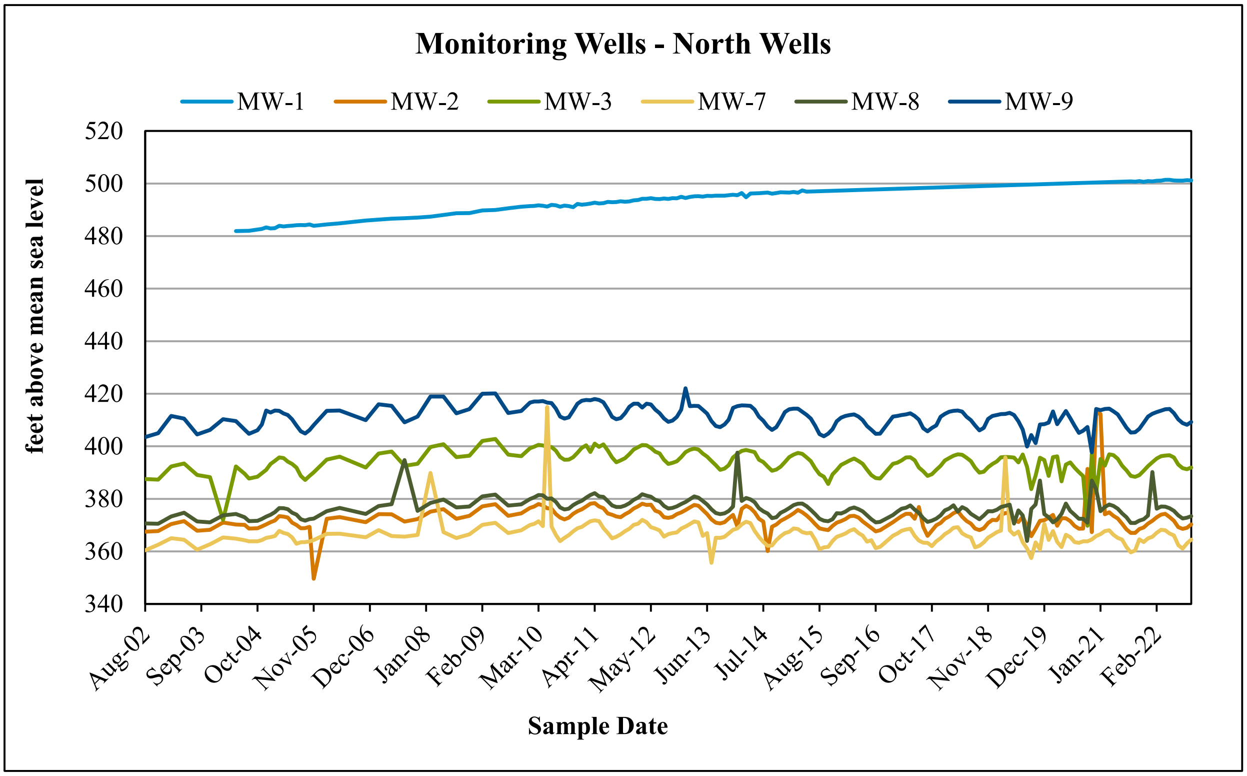


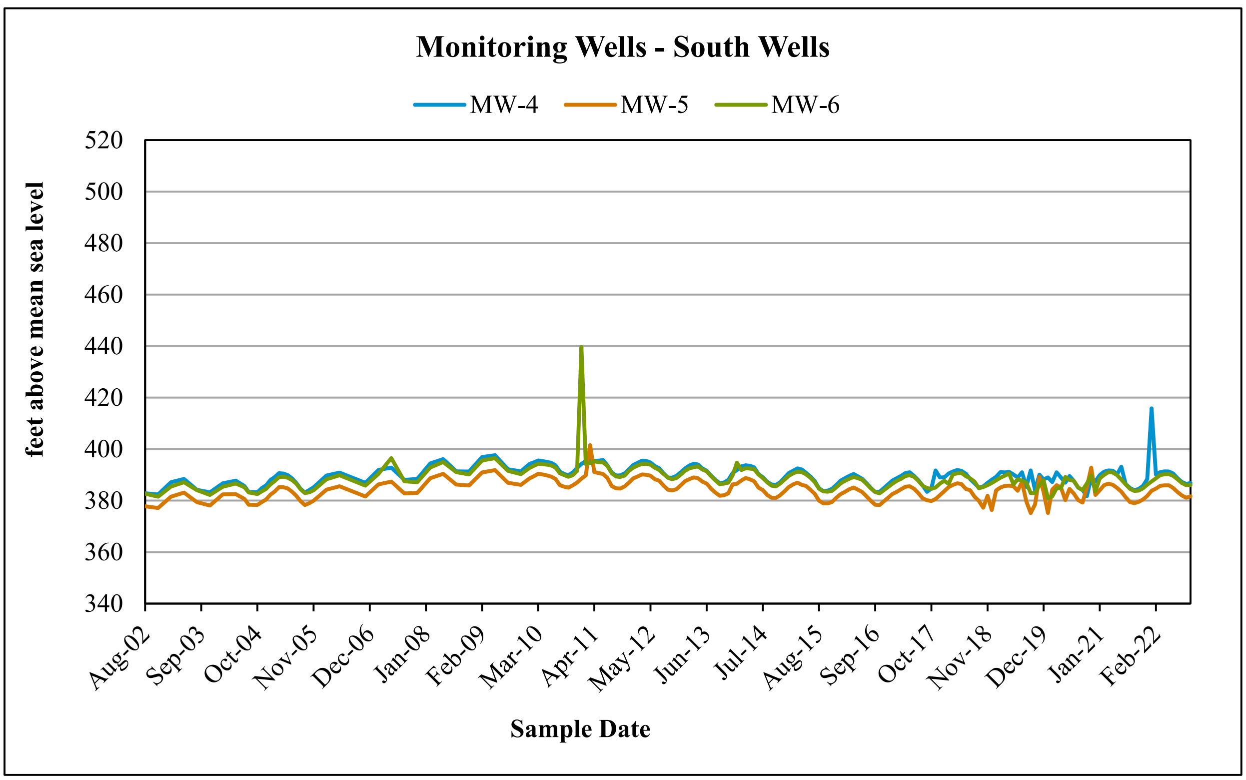
Charts 4-B. Historical Soil Electrical Conductivity



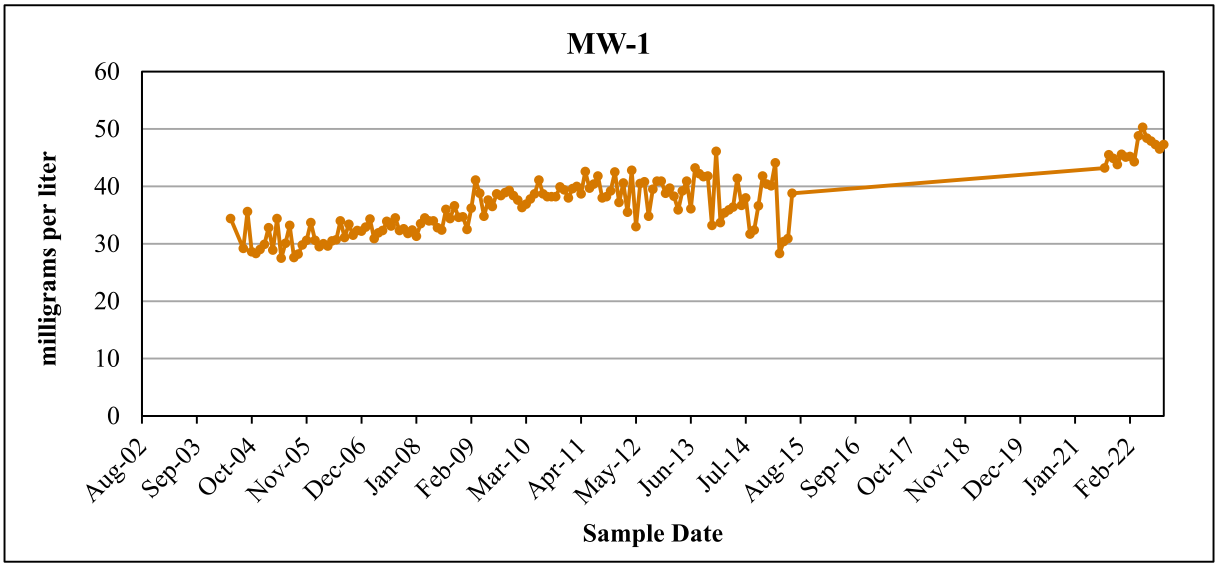


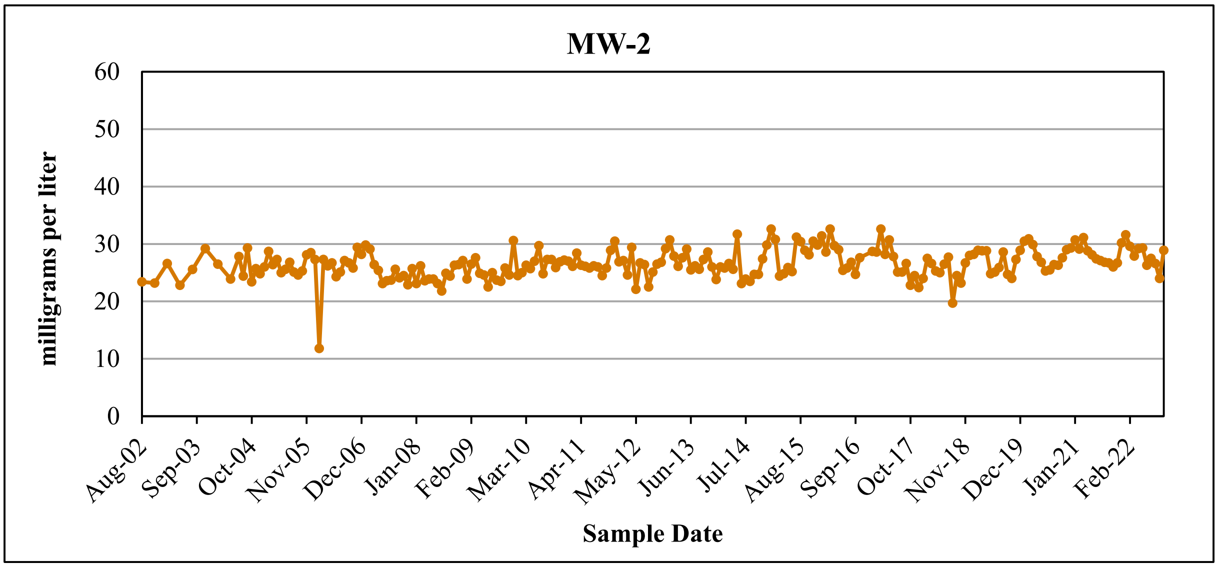
Charts 4-C. Historical Monitoring Well Groundwater Elevations

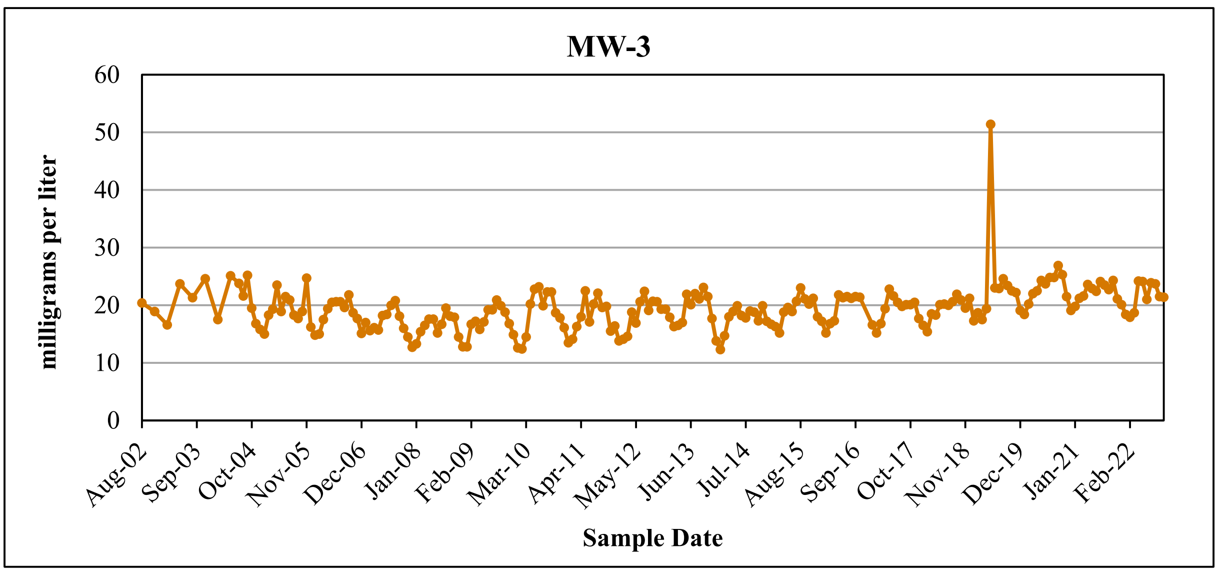




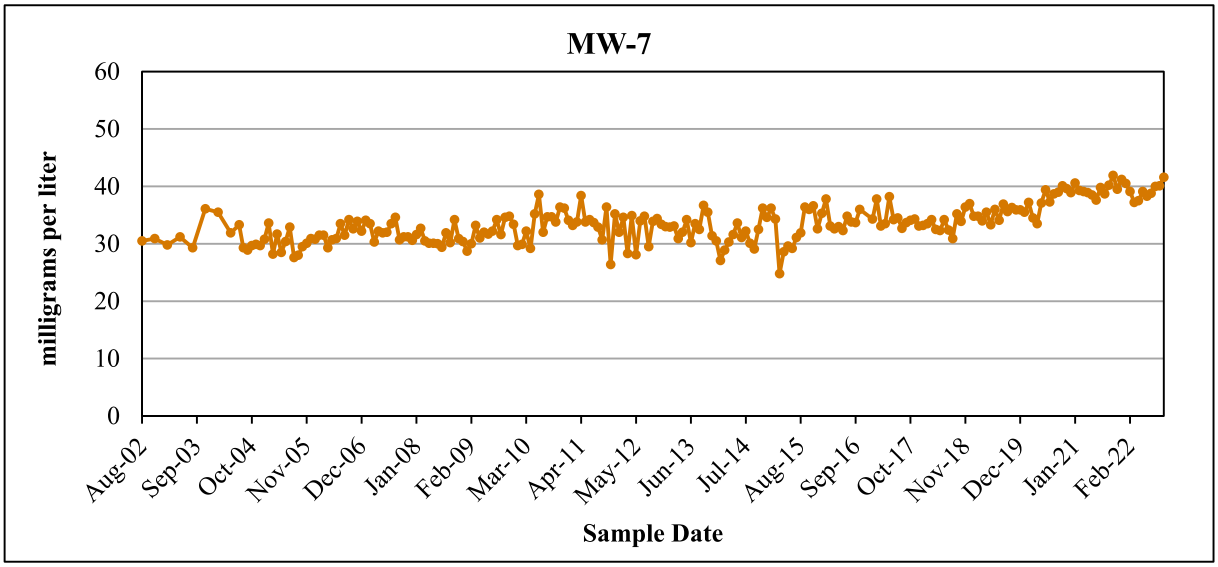
Charts 4-D1. Historical Monitoring Well Nitrate-Nitrogen Concentrations - North Wells

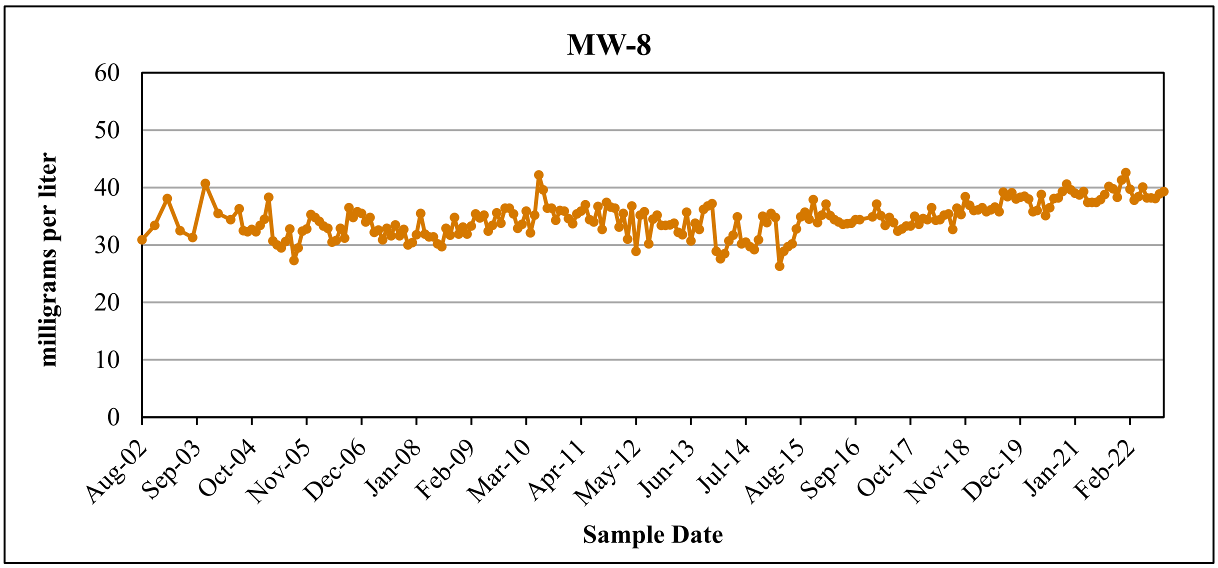


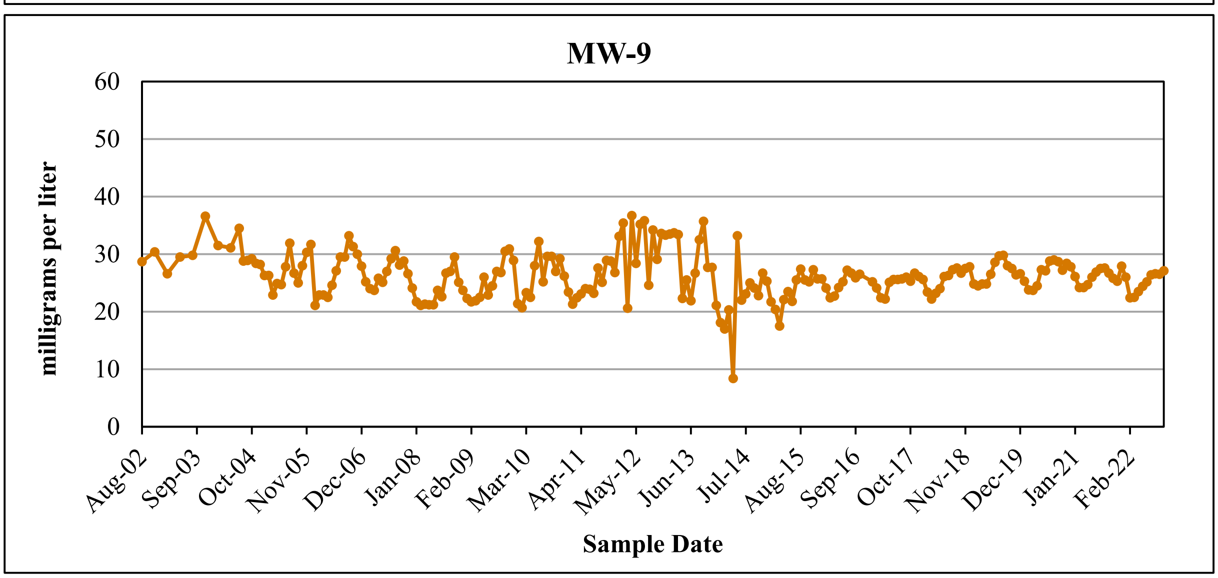




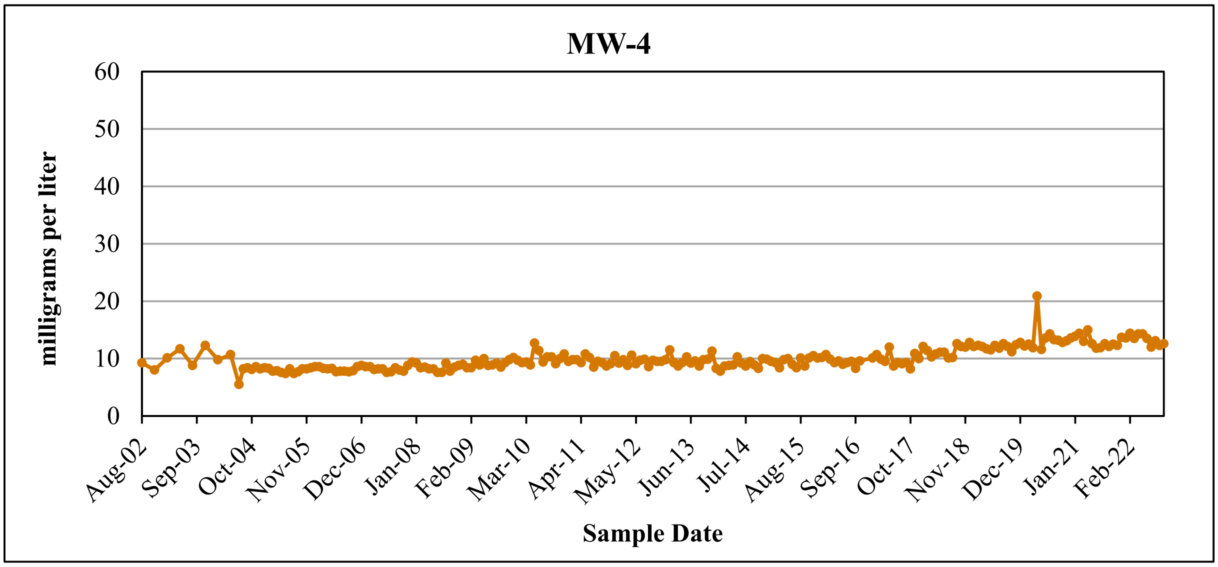
Charts 4-D1. Historical Monitoring Well Nitrate-Nitrogen Concentrations - North Wells

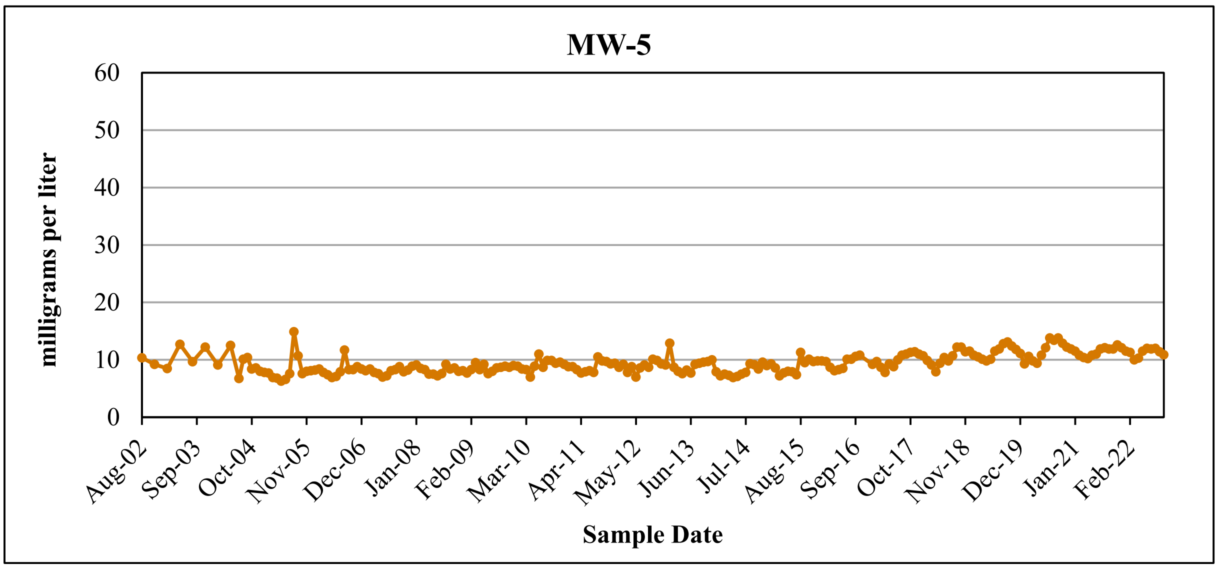


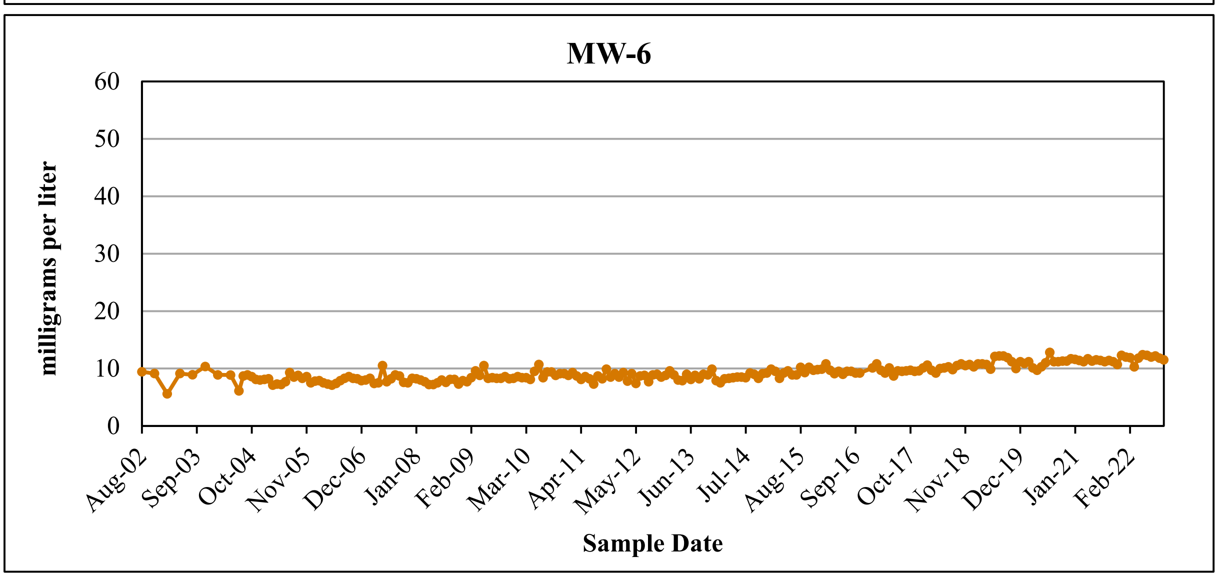




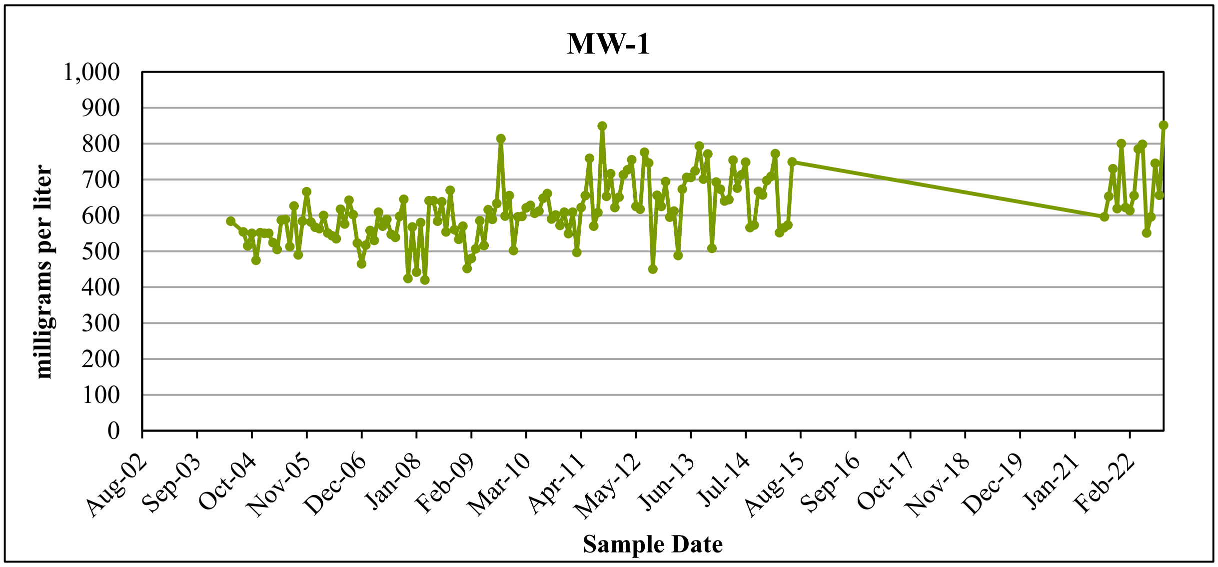
Charts 4-D2. Historical Monitoring Well Nitrate-Nitrogen Concentrations - South Wells

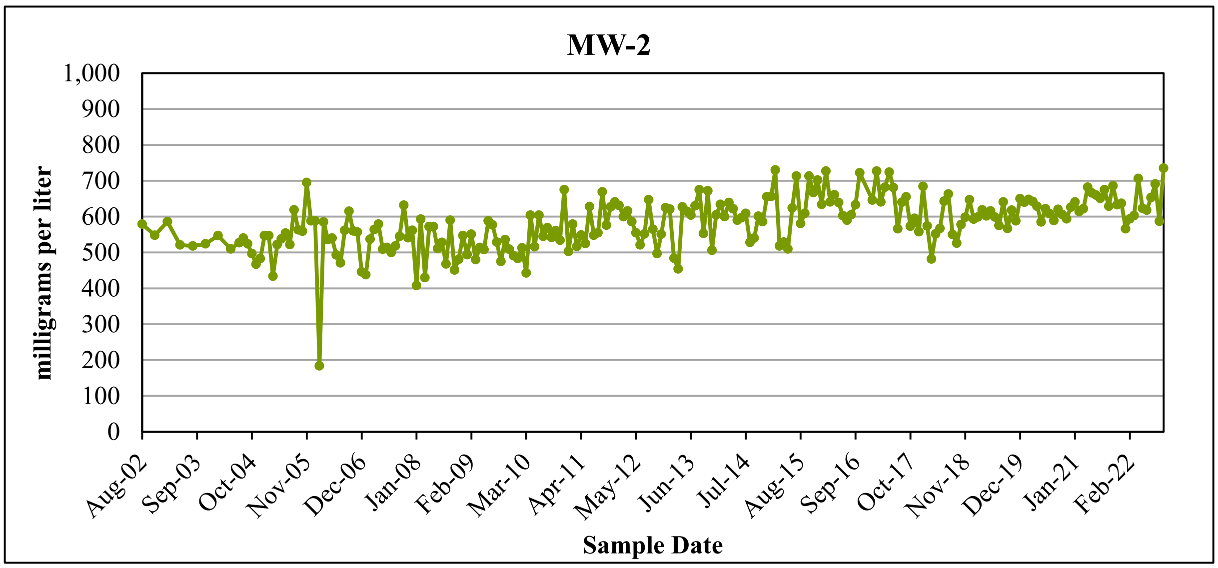


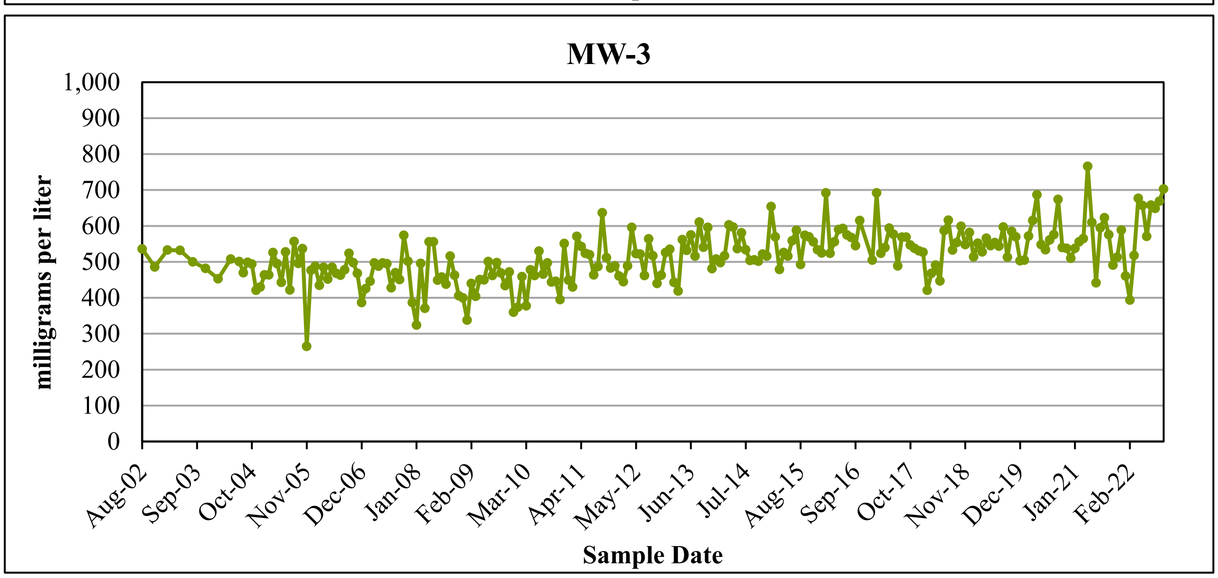




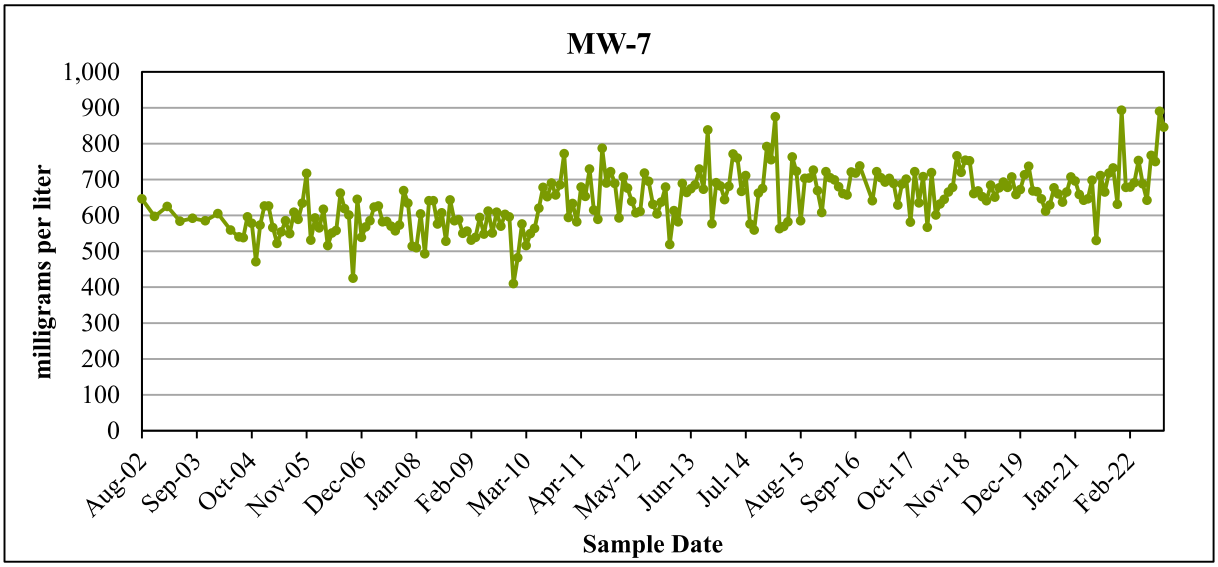
Charts 4-E1. Historical Monitoring Well Total Dissolved Solids Concentrations - North Wells

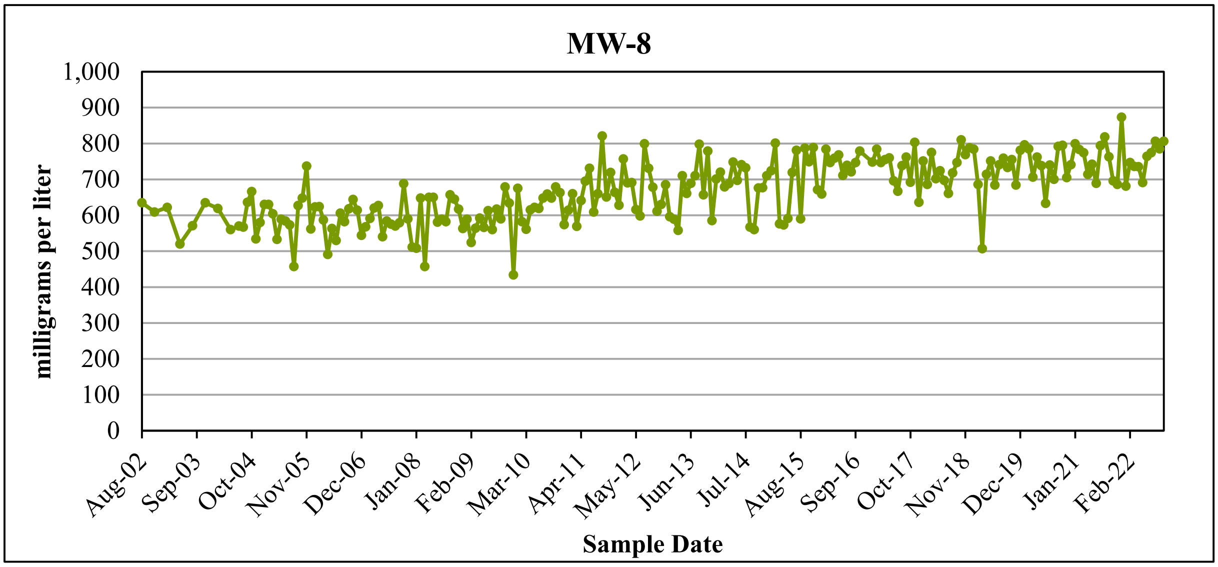


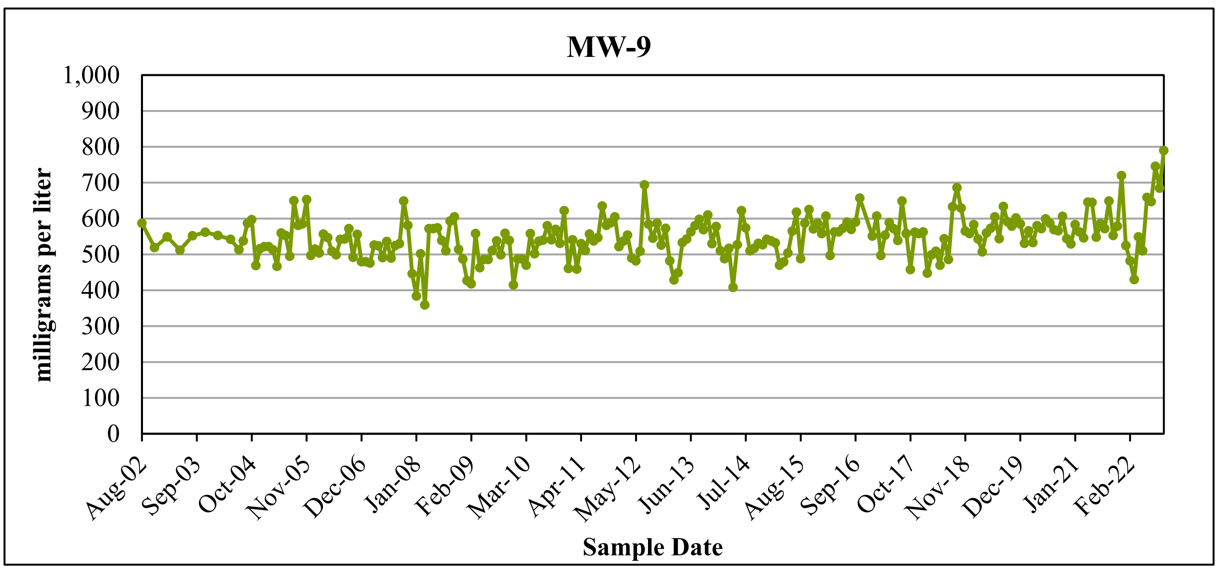




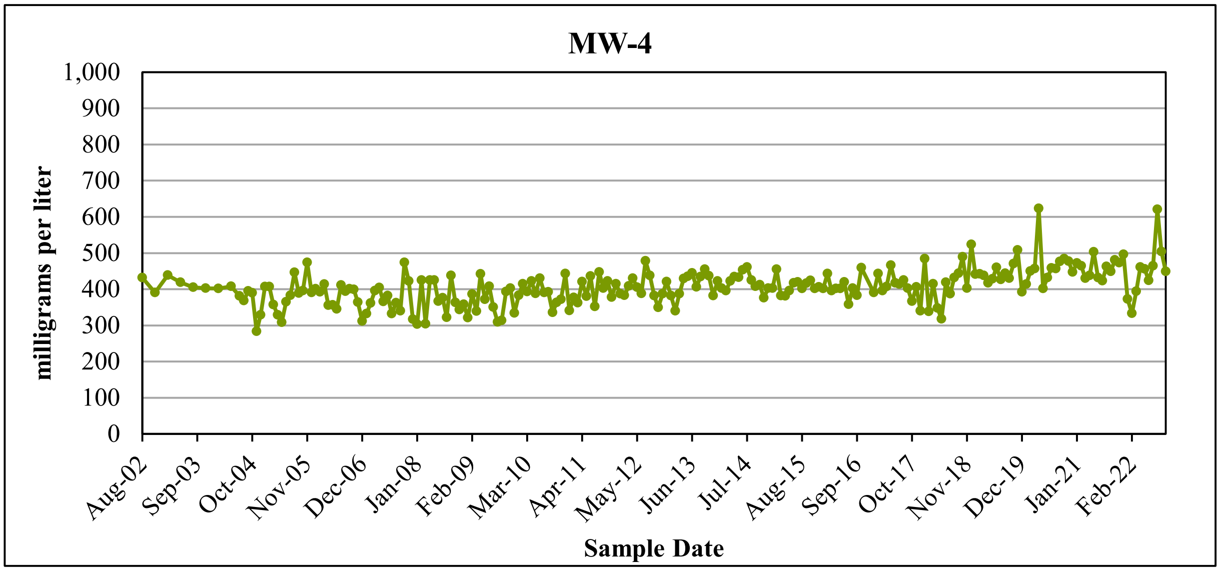
Charts 4-E1. Historical Monitoring Well Total Dissolved Solids Concentrations - North Wells

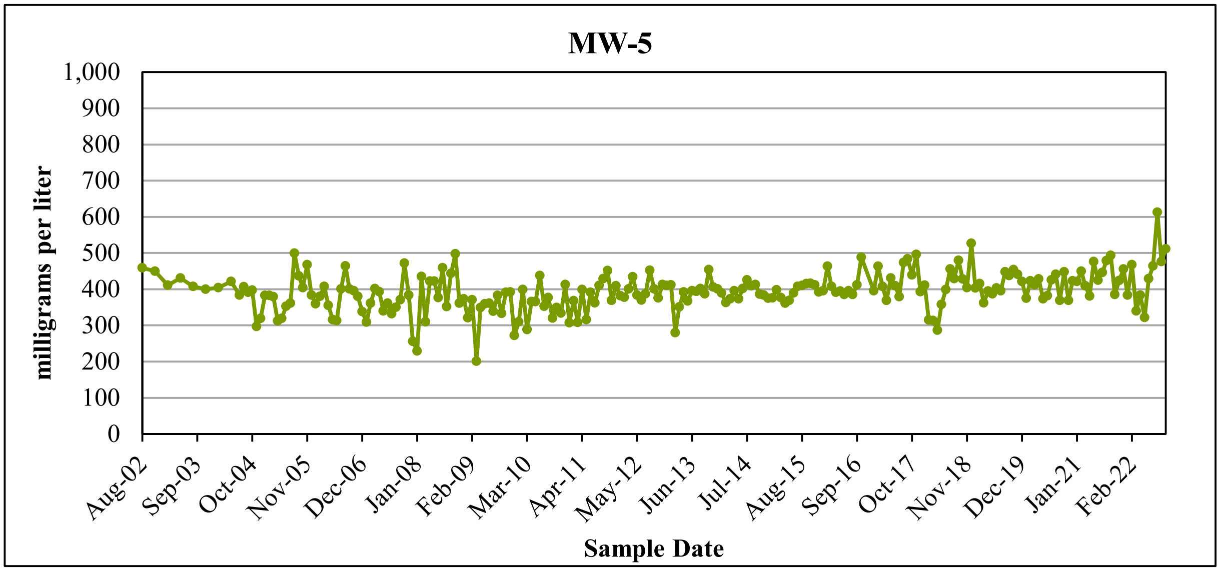


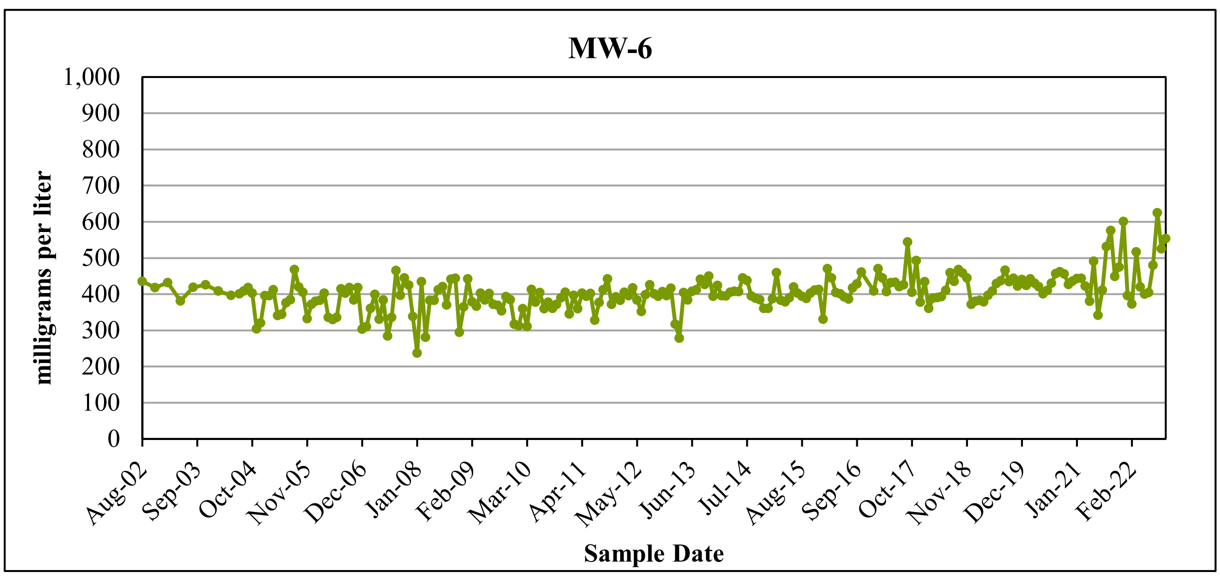




Charts 4-E2. Historical Monitoring Well Total Dissolved Solids Concentrations - South Wells







Appendices

Appendix 3-A

Summary of PWRF Influent Projections

Appendix 3-A Summary of PWRF Influent Projections

City of Pasco
PWRF Influent Average Monthly Hydraulic Loading
12/1/2022

PWRF Influent Total Expected Average Daily Flow by Month (MGD)										
Month	Influent to Pretreatment								Darigold COW	Total (with COW)
	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (no COW)		
January	0.57	0.04	0.41	0.50	0.00	0.08	0.70	**2.30**	0.75	**3.05**
February	0.40	0.05	0.41	0.50	0.00	0.07	0.70	**2.13**	0.75	**2.88**
March	0.57	0.04	0.41	0.48	0.00	0.08	0.70	**2.29**	0.85	**3.14**
April	0.78	0.05	0.41	0.50	0.00	0.07	0.70	**2.52**	0.85	**3.37**
May	0.73	0.14	0.41	0.50	0.00	0.06	0.70	**2.54**	0.85	**3.39**
June	1.33	1.06	0.41	0.60	0.02	0.11	0.70	**4.23**	0.80	**5.03**
July	1.37	1.41	0.41	1.20	1.65	0.02	0.70	**6.76**	0.80	**7.56**
August	1.78	1.61	0.41	1.20	1.65	0.03	0.70	**7.38**	0.80	**8.18**
September	2.05	1.62	0.41	1.20	1.65	0.06	0.70	**7.70**	0.80	**8.50**
October	1.90	1.17	0.41	0.70	1.65	0.09	0.70	**6.62**	0.80	**7.42**
November	1.55	0.11	0.41	0.50	1.65	0.08	0.70	**5.01**	0.80	**5.81**
December	1.23	0.05	0.41	0.50	0.02	0.06	0.70	**2.98**	0.75	**3.73**

PWRF Influent Total Expected Flow by Month (MG)										
Month	Influent to Pretreatment								Darigold COW	Total (with COW)
	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (no COW)		
January	17.62	1.24	12.74	15.50	0.00	2.55	21.74	**71.39**	23.25	**94.64**
February	11.24	1.33	11.51	14.00	0.00	1.85	19.64	**59.57**	21.00	**80.57**
March	17.67	1.36	12.74	15.00	0.00	2.58	21.74	**71.09**	26.35	**97.44**
April	23.48	1.50	12.33	15.00	0.00	2.20	21.04	**75.54**	25.50	**101.04**
May	22.62	4.40	12.74	15.50	0.00	1.86	21.74	**78.86**	26.35	**105.21**
June	39.99	31.84	12.33	18.00	0.60	3.23	21.04	**127.03**	24.00	**151.03**
July	42.34	43.59	12.74	37.20	51.15	0.72	21.74	**209.49**	24.80	**234.29**
August	55.04	49.85	12.74	37.20	51.15	0.95	21.74	**228.66**	24.80	**253.46**
September	61.48	48.59	12.33	36.00	49.50	1.92	21.04	**230.87**	24.00	**254.87**
October	58.87	36.25	12.74	21.70	51.15	2.84	21.74	**205.29**	24.80	**230.09**
November	46.62	3.37	12.33	15.00	49.50	2.38	21.04	**150.23**	24.00	**174.23**
December	38.04	1.68	12.74	15.50	0.62	1.92	21.74	**92.24**	23.25	**115.49**
TOTAL	**435**	**225**	**150**	**256**	**254**	**25**	**256**	**1600**	**292**	**1892**

City of Pasco
PWRF Influent Average Monthly BOD Loading, All Processors Including Darigold COW
12/13/2022

PWRF Influent Total Expected Average Daily BOD by Month (ppd)											
	Influent to Pretreatment										
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Influent Correction Factor	Total (No COW)	Average Flow-Weighted Concentration (mg/L) (No COW)	Darigold COW
January	15,600	2,000	9,940	11,600	0	1,888	17,600	318	59,000	3,250	31
February	16,300	2,462	9,940	11,600	0	1,515	17,600	4,328	63,800	3,760	31
March	12,834	2,266	9,940	11,600	0	1,912	17,600	0	56,200	3,060	35
April	17,624	2,583	9,940	11,600	0	1,678	17,600	19,277	80,400	3,900	35
May	16,430	7,343	9,940	11,600	0	1,375	17,600	10,434	74,800	3,560	35
June	30,014	54,888	9,940	36,520	450	2,471	17,600	22,475	174,400	4,960	33
July	47,100	78,500	9,940	30,470	37,150	536	17,600	25,281	246,600	4,400	33
August	43,500	100,900	9,940	30,470	37,150	699	17,600	38,871	279,200	4,600	33
September	43,000	102,100	9,940	30,470	37,150	1,469	17,600	38,683	280,500	4,410	33
October	51,700	78,700	9,940	30,470	37,150	2,098	17,600	7,991	235,700	4,320	33
November	34,992	5,802	9,940	13,556	37,150	1,818	17,600	0	120,900	2,940	33
December	29,300	3,800	9,940	11,600	450	1,422	17,600	0	74,200	3,070	31

PWRF Influent Total Expected BOD by Month (lbs)										
	Influent to Pretreatment									
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Influent Correction Factor	Total (No COW)	Darigold COW
January	483,600	62,000	308,154	359,600	0	58,536	545,600	9,860	1,828,000	970
February	456,400	68,945	278,332	324,800	0	42,427	492,800	121,180	1,785,000	876
March	397,868	70,233	308,154	359,600	0	59,258	545,600	0	1,741,000	1,099
April	528,714	77,490	298,213	348,000	0	50,353	528,000	578,299	2,410,000	1,063
May	509,318	227,619	308,154	359,600	0	42,637	545,600	323,445	2,317,000	1,099
June	900,418	1,646,641	298,213	1,095,600	13,500	74,131	528,000	674,262	5,231,000	1,001
July	1,460,100	2,433,500	308,154	944,570	1,151,650	16,621	545,600	783,713	7,644,000	1,034
August	1,348,500	3,127,900	308,154	944,570	1,151,650	21,680	545,600	1,205,013	8,654,000	1,034
September	1,290,000	3,063,000	298,213	914,100	1,114,500	44,059	528,000	1,160,495	8,413,000	1,001
October	1,602,700	2,439,700	308,154	944,570	1,151,650	65,040	545,600	247,726	7,306,000	1,034
November	1,049,760	174,058	298,213	406,680	1,114,500	54,549	528,000	0	3,626,000	1,001
December	908,300	117,800	308,154	359,600	13,950	44,082	545,600	0	2,298,000	970
TOTAL	**10,935,678**	**13,508,886**	**3,628,263**	**7,361,290**	**5,711,400**	**573,375**	**6,424,000**	**5,103,994**	**53,247,000**	**12,181**

City of Pasco
PWRF Influent Average Monthly Nitrogen Loading, All Processors Including Darigold COW
12/1/2022

PWRF Influent Total Expected Average Daily TN by Month (ppd)											
Month	Influent to Pretreatment										Darigold COW
	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Influent Correction Factor	Total (No COW)	Average Flow-Weighted Concentration (mg/L) (No COW)	
January	303	19	343	140	0	168	1,151	74	2,200	121	78
February	214	19	343	440	0	135	1,151	0	2,310	136	78
March	304	14	343	404	0	170	1,151	0	2,390	130	88
April	418	37	343	417	0	150	1,151	855	3,380	164	88
May	389	107	343	417	0	123	1,151	593	3,130	149	88
June	711	797	343	500	4	220	1,151	1,296	5,030	143	83
July	1,510	990	343	520	289	48	1,151	2,635	7,490	134	83
August	860	1,800	343	710	289	62	1,151	3,000	8,220	136	83
September	970	2,100	343	610	289	131	1,151	3,046	8,640	136	83
October	920	1,420	343	420	289	187	1,151	119	4,850	89	83
November	829	84	343	160	289	162	1,151	203	3,230	79	83
December	570	17	343	170	4	127	1,151	0	2,390	99	78

PWRF Influent Total Expected TN by Month (lbs)										
Month	Influent to Pretreatment									Darigold COW
	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Influent Correction Factor	Total (No COW)	
January	9,402	589	10,626	4,340	0	5,215	35,671	2,281	69,000	2,404
February	6,000	532	9,598	12,320	0	3,780	32,219	0	65,000	2,172
March	9,431	434	10,626	12,510	0	5,279	35,671	0	74,000	2,725
April	12,532	1,125	10,283	12,510	0	4,486	34,521	25,647	102,000	2,637
May	12,073	3,304	10,626	12,927	0	3,799	35,671	18,387	97,000	2,725
June	21,343	23,903	10,283	15,012	105	6,604	34,521	38,877	151,000	2,482
July	46,810	30,690	10,626	16,120	8,958	1,481	35,671	81,671	233,000	2,565
August	26,660	55,800	10,626	22,010	8,958	1,931	35,671	93,000	255,000	2,565
September	29,100	63,000	10,283	18,300	8,669	3,925	34,521	91,381	260,000	2,482
October	28,520	44,020	10,626	13,020	8,958	5,794	35,671	3,701	151,000	2,565
November	24,883	2,527	10,283	4,800	8,669	4,860	34,521	6,099	97,000	2,482
December	17,670	527	10,626	5,270	109	3,927	35,671	0	74,000	2,404
TOTAL	**244,425**	**226,450**	**125,113**	**149,139**	**44,428**	**51,083**	**420,000**	**361,045**	**1,622,000**	**30,208**

City of Pasco
PWRF Influent Average Monthly FDS Loading
12/1/2022

PWRF Influent Total Expected Average Daily FDS by Month (ppd)											
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (No COW)	Average Flow-Weighted Concentration (no COW) (mg/L)	Darigold COW	Total (with COW)
January	2,251	79	2,502	2,210	0	584	9,681	17,400	960	657	18,000
February	1,590	87	2,502	2,210	0	468	9,681	16,600	980	657	17,200
March	2,258	74	2,502	2,139	0	591	9,681	17,300	950	744	18,000
April	3,100	100	2,502	2,210	0	519	9,681	18,200	890	744	18,900
May	2,890	403	2,502	2,210	0	425	9,681	18,200	870	744	18,900
June	5,280	4,559	2,502	2,652	60	764	9,681	25,500	730	701	26,200
July	5,411	5,700	2,502	5,304	4,954	166	9,681	33,800	610	701	34,500
August	7,033	7,640	2,502	5,304	4,954	216	9,681	37,400	620	701	38,100
September	8,119	6,790	2,502	5,304	4,954	454	9,681	37,900	600	701	38,600
October	7,523	5,510	2,502	3,094	4,954	648	9,681	34,000	630	701	34,700
November	6,156	318	2,502	2,210	4,954	562	9,681	26,400	640	701	27,100
December	4,861	82	2,502	2,210	60	440	9,681	19,900	830	657	20,500

PWRF Influent Total Expected FDS by Month (lbs)										
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (no COW)	Darigold COW	Total (with COW)
January	69,782	2,449	77,570	68,513	0	18,093	300,105	536,600	20,360	557,000
February	44,532	2,436	70,063	61,883	0	13,114	271,062	463,100	18,390	482,000
March	69,995	2,294	77,570	66,303	0	18,316	300,105	534,600	23,075	558,000
April	93,015	3,000	75,068	66,303	0	15,564	290,424	543,400	22,330	566,000
May	89,602	12,482	77,570	68,513	0	13,179	300,105	561,500	23,075	585,000
June	158,407	136,777	75,068	79,564	1,801	22,913	290,424	765,000	21,017	787,000
July	167,737	176,700	77,570	164,431	153,573	5,137	300,105	1,045,300	21,717	1,068,000
August	218,024	236,840	77,570	164,431	153,573	6,701	300,105	1,157,300	21,717	1,180,000
September	243,567	203,700	75,068	159,127	148,619	13,618	290,424	1,134,200	21,017	1,156,000
October	233,224	170,810	77,570	95,918	153,573	20,103	300,105	1,051,400	21,717	1,074,000
November	184,680	9,545	75,068	66,303	148,619	16,861	290,424	791,500	21,017	813,000
December	150,687	2,542	77,570	68,513	1,861	13,625	300,105	615,000	20,360	636,000
TOTAL	**1,723,253**	**959,575**	**913,321**	**1,129,803**	**761,619**	**177,225**	**3,533,491**	**9,199,000**	**255,792**	**9,455,000**

City of Pasco
Projected PWRF Pretreatment System Influent Criteria
12/13/2022

Processor	Wastewater Flow			BOD				Total Nitrogen		TSS				FDS		Processor Notes
	Total Annual Flow (MG)	Average Annual Daily Flow (MGD)	Max Month Average Day Flow (MGD)	Average Concentration (mg/L)	Average Annual Daily Load (ppd)	Max Month Concentration (mg/L)	Max Month Daily Load (ppd)	Average Concentration (mg/L)	Average Annual Daily Load (ppd)	Average Concentration (mg/L)	Average Annual Daily Load (ppd)	Max Month Concentration (mg/L)	Max Month Daily Load (ppd)	Average Concentration (mg/L)	Average Daily Load (ppd)	
Pasco Processing	435	1.19	2.50	3,018	30,000	3,118	65,000	67	670	1,600	15,910	2,038	42,500	475	4,700	Assorted Fruits/Vegetables
Freeze Pack	25	0.07	0.11	2,801	1,600	2,834	2,600	245	140	550	320	600	550	850	500	Blueberries for now, Onions/other in future
Twin City Foods	225	0.62	1.80	7,197	37,000	6,994	105,000	121	620	2,640	13,580	3,384	50,800	515	2,600	Corn & Peas Processing
Reser's New Plant	150	0.41	0.41	2,918	10,000	2,983	10,200	101	345	2,130	7,310	3,158	10,800	730	2,500	Potatoes/Pasta cooked products
Simplot	255	0.70	1.25	3,467	20,200	6,715	70,000	70	410	2,120	12,360	1,918	20,000	530	3,100	Assorted Fruits/Vegetables
Grimmway	254	0.70	1.65	2,705	15,700	1,000	37,200	21	120	1,000	5,810	1,000	13,770	360	2,100	Carrots
Darigold WW	256	0.70	0.84	3,009	17,600	3,511	24,600	197	1,150	397	2,330	397	2,790	1,655	9,700	Dairy (Butter) Wastewater
Influent Correction Factor	0	0	0	-	14,000	-	39,000	-	990	-	25,000	-	87,000	-	0	Based on processor vs PWRF data
Average (flow weighted)	-	-	-	3,996	-	4,953	-	122	-	2,260	-	3,197	-	689	-	-
Total	1,600	4.38	8.56	-	146,100	-	353,600	-	4,445	-	82,620	-	228,210	-	25,200	-

Notes
Processor data is based on data provided by processors to the City on or before May 18th, 2022. Grimmway projections updated with City data collected up to September 2022.
Influent correction factor is based on City-collected data at PWRF influent from July 2021 through March 2022.

Appendix 3-B

PWRF Average Annual Scenario Monthly Effluent Projection Tables

Appendix 3-B PWRF Average Annual Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Average Monthly Effluent Projections													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total MG**
Average Monthly Flow (MGD) (no COW)	2.30	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.70	6.62	5.01	2.98	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.23	2.76	3.38	3.70	2.62	1.01	0	
C - Screen+LRAD+RAB	2.30	2.13	2.29	2.52	2.54	4.00	4.00	4.00	4.00	4.00	4.00	2.98	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**3.05**	**2.88**	**3.14**	**3.37**	**3.39**	**5.03**	**7.56**	**8.18**	**8.50**	**7.42**	**5.81**	**3.73**	**1,892**
Flow (Total MG)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	7	85	105	111	81	30	0	
C - Screen+LRAD+RAB	71	60	71	76	79	120	124	124	120	124	120	92	
D - COW Water (untreated)	23	21	26	26	26	24	25	25	24	25	24	23	
Total	**95**	**81**	**97**	**101**	**105**	**151**	**234**	**253**	**255**	**230**	**174**	**116**	

Appendix 3-B PWRF Average Annual Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Average Monthly Effluent Projections													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual Total MG**
Average Monthly Flow (MGD) (no COW)	2.30	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.70	6.62	5.01	2.98	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.23	2.76	3.38	3.70	2.62	1.01	0	
C - Screen+LRAD+RAB	2.30	2.13	2.29	2.52	2.54	4.00	4.00	4.00	4.00	4.00	4.00	2.98	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**3.05**	**2.88**	**3.14**	**3.37**	**3.39**	**5.03**	**7.56**	**8.18**	**8.50**	**7.42**	**5.81**	**3.73**	**1,892**
BOD													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
BOD (mg/L)													
A - Screening Only	3,250	3,760	3,060	3,900	3,560	4,960	4,400	4,600	4,410	4,320	2,940	3,070	
B - Screening + LRAD	360	380	360	390	360	500	440	460	450	440	360	360	
C - Screen+LRAD+RAB	100	100	100	100	100	100	100	100	100	100	100	100	
D - COW Water (untreated)	5	5	5	5	5	5	5	5	5	5	5	5	
BOD (ppd)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	976	10,121	12,952	13,871	9,622	3,026	0	
C - Screen+LRAD+RAB	1,921	1,775	1,912	2,100	2,122	3,336	3,336	3,336	3,336	3,336	3,336	2,482	
D - COW Water (untreated)	31	31	35	35	35	33	33	33	33	33	33	31	Avg conc. (mg/L)
Total	**1,952**	**1,806**	**1,948**	**2,135**	**2,157**	**4,345**	**13,490**	**16,321**	**17,240**	**12,991**	**6,396**	**2,513**	**161**
BOD (Total lbs)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	29,273	313,743	401,502	416,133	298,272	90,793	0	
C - Screen+LRAD+RAB	59,542	49,693	59,283	63,000	65,773	100,080	103,416	103,416	100,080	103,416	100,080	76,942	
D - COW Water (untreated)	970	876	1,099	1,063	1,099	1,001	1,034	1,034	1,001	1,034	1,001	970	**Annual Total lbs**
Total	**60,511**	**50,569**	**60,382**	**64,064**	**66,871**	**130,354**	**418,194**	**505,952**	**517,213**	**402,723**	**191,873**	**77,911**	**2,546,618**

Appendix 3-B PWRF Average Annual Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Average Monthly Effluent Projections														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total MG**	
Average Monthly Flow (MGD) (no COW)	2.30	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.70	6.62	5.01	2.98	1600	
	Effluent													
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31		
Flow														
Flow (MGD)														
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	0.23	2.76	3.38	3.70	2.62	1.01	0		
C - Screen+LRAD+RAB	2.30	2.13	2.29	2.52	2.54	4.00	4.00	4.00	4.00	4.00	4.00	2.98		
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**	
Total	**3.05**	**2.88**	**3.14**	**3.37**	**3.39**	**5.03**	**7.56**	**8.18**	**8.50**	**7.42**	**5.81**	**3.73**	**1,892**	
TN														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
TN (mg/L)														
A - Screening Only	121	136	130	164	149	143	134	136	136	89	79	99		
B - Screening + LRAD	111	126	120	154	139	133	124	126	126	79	69	89	Avg	Max Month
C - Screen+LRAD+RAB	23	28	27	43	37	47	42	43	43	19	15	19	33	47
D - COW Water (untreated)	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4		
Total Flow-weighted (no COW)	**23**	**28**	**27**	**43**	**37**	**52**	**75**	**81**	**83**	**43**	**26**	**19**	54	83
Total Flow-weighted (w/COW)	**20**	**24**	**23**	**35**	**31**	**45**	**69**	**74**	**76**	**39**	**24**	**18**	47	76
TN (ppd)														
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	260	2,852	3,548	3,884	1,728	580	0		
C - Screen+LRAD+RAB	442	497	516	903	785	1,568	1,401	1,434	1,434	634	500	472		
D - COW Water (untreated)	78	78	88	88	88	83	83	83	83	83	83	78		
Total	**519**	**574**	**604**	**991**	**873**	**1,910**	**4,336**	**5,065**	**5,401**	**2,444**	**1,163**	**549**		
TN (Total lbs)														
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	7,787	88,419	109,977	116,517	53,553	17,402	0		
C - Screen+LRAD+RAB	13,695	13,914	16,006	27,090	24,336	47,038	43,435	44,469	43,034	19,649	15,012	14,619		
D - COW Water (untreated)	2,404	2,172	2,725	2,637	2,725	2,482	2,565	2,565	2,482	2,565	2,482	2,404	**Annual Total lbs**	
Total	**16,099**	**16,086**	**18,731**	**29,727**	**27,061**	**57,306**	**134,418**	**157,010**	**162,034**	**75,767**	**34,896**	**17,023**	**746,159**	

Appendix 3-B PWRF Average Annual Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Average Monthly Effluent Projections														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total MG**	
Average Monthly Flow (MGD) (no COW)	2.30	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.70	6.62	5.01	2.98	1600	
	Effluent													
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31		
Flow														
Flow (MGD)														
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	0.23	2.76	3.38	3.70	2.62	1.01	0		
C - Screen+LRAD+RAB	2.30	2.13	2.29	2.52	2.54	4.00	4.00	4.00	4.00	4.00	4.00	2.98		
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**	
Total	**3.05**	**2.88**	**3.14**	**3.37**	**3.39**	**5.03**	**7.56**	**8.18**	**8.50**	**7.42**	**5.81**	**3.73**	**1,892**	
FDS														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
Chemical Adjustment (gpd)														
60% Mg(OH)2	109	101	109	120	121	200	320	349	364	313	237	141		
FDS (mg/L)														
60% Mg(OH)2	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214		
Processors w/o COW	960	980	950	890	870	730	610	620	600	630	640	830		
COW Water (untreated)	105	105	105	105	105	105	105	105	105	105	105	105	Avg	Max Month
Total Flow-weighted (no COW)	**990**	**1,010**	**980**	**920**	**900**	**759**	**640**	**650**	**630**	**660**	**670**	**860**	**738**	**1,010**
Total Flow-weighted (w/COW)	**772**	**774**	**743**	**714**	**701**	**655**	**583**	**596**	**580**	**600**	**592**	**708**	**640**	**774**
FDS (ppd)														
60% Mg(OH)2	568	527	568	626	631	1,043	1,669	1,820	1,898	1,632	1,236	735		
Processors w/o COW	18,439	17,393	18,167	18,690	18,459	25,777	34,381	38,140	38,511	34,793	26,731	20,600		
COW Water (untreated)	657	657	744	744	744	701	701	701	701	701	701	657		
Total (no COW)	**19,007**	**17,919**	**18,736**	**19,316**	**19,090**	**26,820**	**36,049**	**39,960**	**40,409**	**36,425**	**27,966**	**21,336**		
Total (w/ COW)	**19,664**	**18,576**	**19,480**	**20,060**	**19,834**	**27,521**	**36,750**	**40,660**	**41,109**	**37,126**	**28,667**	**21,992**		
FDS (Total lbs)														
60% Mg(OH)2	17,619	14,746	17,619	18,771	19,559	31,286	51,726	56,413	56,940	50,594	37,074	22,792		
Processors w/o COW	571,601	486,992	563,191	560,703	572,221	773,323	1,065,800	1,182,334	1,155,324	1,078,593	801,921	638,614		
COW Water (untreated)	20,360	18,390	23,075	22,330	23,075	21,017	21,717	21,717	21,017	21,717	21,017	20,360	**Annual Total lbs**	
Total	**609,580**	**520,128**	**603,884**	**601,805**	**614,855**	**825,626**	**1,139,243**	**1,260,465**	**1,233,280**	**1,150,904**	**860,011**	**681,766**	**10,101,548**	

Appendix 3-B PWRF Average Annual Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Average Monthly Effluent Projections													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total MG
Average Monthly Flow (MGD) (no COW)	2.30	2.13	2.29	2.52	2.54	4.23	6.76	7.38	7.70	6.62	5.01	2.98	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.23	2.76	3.38	3.70	2.62	1.01	0	
C - Screen+LRAD+RAB	2.30	2.13	2.29	2.52	2.54	4.00	4.00	4.00	4.00	4.00	4.00	2.98	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**3.05**	**2.88**	**3.14**	**3.37**	**3.39**	**5.03**	**7.56**	**8.18**	**8.50**	**7.42**	**5.81**	**3.73**	**1,892**
TSS													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
TSS (mg/L)													
A - Screening Only													
B - Screening + LRAD	440	440	440	440	440	440	440	440	440	440	440	440	
C - Screen+LRAD+RAB	100	100	100	100	100	100	100	100	100	100	100	100	
D - COW Water (untreated)	397	397	397	397	397	397	397	397	397	397	397	397	
TSS (ppd)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	859	10,121	12,389	13,563	9,622	3,699	0	
C - Screen+LRAD+RAB	1,921	1,775	1,912	2,100	2,122	3,336	3,336	3,336	3,336	3,336	3,336	2,482	
D - COW Water (untreated)	2,483	2,483	2,814	2,814	2,814	2,649	2,649	2,649	2,649	2,649	2,649	2,483	
Total	**4,404**	**4,258**	**4,727**	**4,914**	**4,936**	**6,843**	**16,106**	**18,373**	**19,548**	**15,606**	**9,684**	**4,965**	
TSS (Total lbs)													
A - Screening Only	0	0	0	0	0	0	0	0	0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	25,761	313,743	384,046	406,885	298,272	110,969	0	
C - Screen+LRAD+RAB	59,542	49,693	59,283	63,000	65,773	100,080	103,416	103,416	100,080	103,416	100,080	76,942	
D - COW Water (untreated)	76,980	69,531	87,244	84,430	87,244	79,464	82,112	82,112	79,464	82,112	79,464	76,980	**Annual Total lbs**
Total	**136,522**	**119,224**	**146,528**	**147,430**	**153,017**	**205,304**	**499,272**	**569,574**	**586,429**	**483,801**	**290,512**	**153,922**	**3,491,534**

Appendix 3-C

PWRF Max Month Scenario Monthly Effluent Projection Tables

Appendix 3-C PWRF Max Month Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Max Month Scenario Effluent Projections													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total MG**
Average Monthly Flow (MGD) (no COW)	2.00	2.00	2.00	2.00	2.52	4.22	7.34	8.50	8.50	7.34	4.00	2.00	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	1.0	1.0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.22	3.34	3.50	3.50	3.34	0.00	0	
C - Screen+LRAD+RAB	2.00	2.00	2.00	2.00	2.52	4.00	4.00	4.00	4.00	4.00	4.00	2.00	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**2.75**	**2.75**	**2.85**	**2.85**	**3.37**	**5.02**	**8.14**	**9.30**	**9.30**	**8.14**	**4.80**	**2.75**	**1,892**
Flow (Total MG)													
A - Screening Only	0	0	0	0	0	0	0	31	30	0	0	0	
B - Screening + LRAD	0	0	0	0	0	7	104	109	105	104	0	0	
C - Screen+LRAD+RAB	62	56	62	60	78	120	124	124	120	124	120	62	
D - COW Water (untreated)	23	21	26	26	26	24	25	25	24	25	24	23	
Total	**85**	**77**	**88**	**86**	**104**	**151**	**252**	**288**	**279**	**252**	**144**	**85**	

Appendix 3-C PWRF Max Month Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Max Month Scenario Effluent Projections													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total MG
Average Monthly Flow (MGD) (no COW)	2.00	2.00	2.00	2.00	2.52	4.22	7.34	8.50	8.50	7.34	4.00	2.00	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	1.0	1.0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.22	3.34	3.50	3.50	3.34	0.00	0	
C - Screen+LRAD+RAB	2.00	2.00	2.00	2.00	2.52	4.00	4.00	4.00	4.00	4.00	4.00	2.00	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**2.75**	**2.75**	**2.85**	**2.85**	**3.37**	**5.02**	**8.14**	**9.30**	**9.30**	**8.14**	**4.80**	**2.75**	**1,892**
BOD													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
BOD (mg/L)													
A - Screening Only	3,250	3,760	3,060	3,900	3,560	4,960	4,650	4,650	4,650	4,650	2,940	3,070	
B - Screening + LRAD	360	380	360	390	360	500	470	470	470	470	360	360	
C - Screen+LRAD+RAB	100	100	100	100	100	100	100	100	100	100	100	100	
D - COW Water (untreated)	5	5	5	5	5	5	5	5	5	5	5	5	
BOD (ppd)													
A - Screening Only	0	0	0	0	0	0	0	38,781	38,781	0	0	0	
B - Screening + LRAD	0	0	0	0	0	917	13,092	13,719	13,719	13,092	0	0	
C - Screen+LRAD+RAB	1,668	1,668	1,668	1,668	2,102	3,336	3,336	3,336	3,336	3,336	3,336	1,668	
D - COW Water (untreated)	31	31	35	35	35	33	33	33	33	33	33	31	Avg. conc (mg/L)
Total	**1,699**	**1,699**	**1,703**	**1,703**	**2,137**	**4,287**	**16,461**	**55,870**	**55,870**	**16,461**	**3,369**	**1,699**	316
BOD (Total lbs)													
A - Screening Only	0	0	0	0	0	0	0	1,202,211	1,163,430	0	0	0	
B - Screening + LRAD	0	0	0	0	0	27,522	405,856	425,298	411,579	405,856	0	0	
C - Screen+LRAD+RAB	51,708	46,704	51,708	50,040	65,152	100,080	103,416	103,416	100,080	103,416	100,080	51,708	
D - COW Water (untreated)	970	876	1,099	1,063	1,099	1,001	1,034	1,034	1,001	1,034	1,001	970	**Annual Total lbs**
Total	**52,678**	**47,580**	**52,807**	**51,103**	**66,251**	**128,603**	**510,306**	**1,731,959**	**1,676,090**	**510,306**	**101,081**	**52,678**	**4,981,441**

Appendix 3-C PWRF Max Month Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Max Month Scenario Effluent Projections														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total MG	
Average Monthly Flow (MGD) (no COW)	2.00	2.00	2.00	2.00	2.52	4.22	7.34	8.50	8.50	7.34	4.00	2.00	1600	
							Effluent							
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31		
Flow														
Flow (MGD)														
A - Screening Only	0	0	0	0	0	0	0	1.0	1.0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	0.22	3.34	3.50	3.50	3.34	0.00	0		
C - Screen+LRAD+RAB	2.00	2.00	2.00	2.00	2.52	4.00	4.00	4.00	4.00	4.00	4.00	2.00		
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**	
Total	**2.75**	**2.75**	**2.85**	**2.85**	**3.37**	**5.02**	**8.14**	**9.30**	**9.30**	**8.14**	**4.80**	**2.75**	**1,892**	
TN														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
TN (mg/L)														
A - Screening Only	121	136	130	164	149	143	134	136	136	89	79	99		
B - Screening + LRAD	111	126	120	154	139	133	124	126	126	79	69	89	Avg	Max Month
C - Screen+LRAD+RAB	22	26	24	37	36	47	42	43	43	19	15	15	32	47
D - COW Water (untreated)	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4		
Total Flow-weighted (no COW)	**22**	**26**	**24**	**37**	**36**	**51**	**79**	**88**	**88**	**46**	**15**	**15**	58	88
Total Flow-weighted (w/COW)	**19**	**22**	**21**	**30**	**30**	**45**	**73**	**82**	**82**	**43**	**15**	**14**	51	82
TN (ppd)														
A - Screening Only	0	0	0	0	0	0	0	1,134	1,134	0	0	0		
B - Screening + LRAD	0	0	0	0	0	244	3,454	3,678	3,678	2,201	0	0		
C - Screen+LRAD+RAB	367	434	400	617	757	1,568	1,401	1,434	1,434	634	500	250		
D - COW Water (untreated)	78	78	88	88	88	83	83	83	83	83	83	78		
Total	**445**	**511**	**488**	**705**	**845**	**1,895**	**4,938**	**6,329**	**6,329**	**2,917**	**583**	**328**		
TN (Total lbs)														
A - Screening Only	0	0	0	0	0	0	0	35,161	34,027	0	0	0		
B - Screening + LRAD	0	0	0	0	0	7,321	107,077	114,016	110,338	68,218	0	0		
C - Screen+LRAD+RAB	11,376	12,143	12,410	18,515	23,455	47,038	43,435	44,469	43,034	19,649	15,012	7,756		
D - COW Water (untreated)	2,404	2,172	2,725	2,637	2,725	2,482	2,565	2,565	2,482	2,565	2,482	2,404	**Annual Total lbs**	
Total	**13,780**	**14,315**	**15,135**	**21,152**	**26,180**	**56,840**	**153,076**	**196,211**	**189,882**	**90,432**	**17,494**	**10,161**	**804,658**	

Appendix 3-C PWRF Max Month Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Max Month Scenario Effluent Projections														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total MG	
Average Monthly Flow (MGD) (no COW)	2.00	2.00	2.00	2.00	2.52	4.22	7.34	8.50	8.50	7.34	4.00	2.00	1600	
	Effluent													
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31		
Flow														
Flow (MGD)														
A - Screening Only	0	0	0	0	0	0	0	1.0	1.0	0	0	0		
B - Screening + LRAD	0	0	0	0	0	0.22	3.34	3.50	3.50	3.34	0.00	0		
C - Screen+LRAD+RAB	2.00	2.00	2.00	2.00	2.52	4.00	4.00	4.00	4.00	4.00	4.00	2.00		
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**	
Total	**2.75**	**2.75**	**2.85**	**2.85**	**3.37**	**5.02**	**8.14**	**9.30**	**9.30**	**8.14**	**4.80**	**2.75**	**1,892**	
FDS														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Chemical Adjustment (gpd)														
60% Mg(OH)2	109	101	109	120	121	200	320	349	364	313	237	141		
FDS (mg/L)														
60% Mg(OH)2	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214	625,214		
Processors w/o COW	960	980	950	890	870	730	610	620	600	630	640	830		
COW Water (untreated)	105	105	105	105	105	105	105	105	105	105	105	105	Avg	Max Month
Total Flow-weighted (no COW)	**994**	**1,012**	**984**	**927**	**900**	**760**	**637**	**646**	**627**	**657**	**677**	**874**	**726**	**1,012**
Total Flow-weighted (w/COW)	**752**	**764**	**722**	**682**	**699**	**655**	**585**	**599**	**582**	**602**	**582**	**664**	**630**	**764**
FDS (ppd)														
60% Mg(OH)2	568	527	568	626	631	1,043	1,669	1,820	1,898	1,632	1,236	735		
Processors w/o COW	16,013	16,346	15,846	14,845	18,285	25,692	37,342	43,952	42,534	38,566	21,350	13,844		
COW Water (untreated)	657	657	744	744	744	701	701	701	701	701	701	657		
Total (no COW)	**16,581**	**16,873**	**16,414**	**15,471**	**18,916**	**26,735**	**39,010**	**45,772**	**44,432**	**40,198**	**22,586**	**14,580**		
Total (w/ COW)	**17,238**	**17,530**	**17,159**	**16,215**	**19,660**	**27,436**	**39,711**	**46,472**	**45,133**	**40,898**	**23,287**	**15,236**		
FDS (Total lbs)														
60% Mg(OH)2	17,619	14,746	17,619	18,771	19,559	31,286	51,726	56,413	56,940	50,594	37,074	22,792		
Processors w/o COW	496,397	457,699	491,226	445,356	566,823	770,766	1,157,587	1,362,506	1,276,020	1,195,541	640,512	429,176		
COW Water (untreated)	20,360	18,390	23,075	22,330	23,075	21,017	21,717	21,717	21,017	21,717	21,017	20,360	**Annual Total lbs**	
Total PW	**534,376**	**490,835**	**531,920**	**486,458**	**609,457**	**823,069**	**1,231,030**	**1,440,637**	**1,353,977**	**1,267,852**	**698,602**	**472,328**	**9,940,540**	

Appendix 3-C PWRF Max Month Scenario Monthly Effluent Projection Tables

City of Pasco
PWRF Land Treatment System Loading from PWRF Effluent
3/23/2023

PWRF Max Month Scenario Effluent Projections													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total MG**
Average Monthly Flow (MGD) (no COW)	2.00	2.00	2.00	2.00	2.52	4.22	7.34	8.50	8.50	7.34	4.00	2.00	1600
	Effluent												
Days/Month	31	28	31	30	31	30	31	31	30	31	30	31	
Flow													
Flow (MGD)													
A - Screening Only	0	0	0	0	0	0	0	1.0	1.0	0	0	0	
B - Screening + LRAD	0	0	0	0	0	0.22	3.34	3.50	3.50	3.34	0.00	0	
C - Screen+LRAD+RAB	2.00	2.00	2.00	2.00	2.52	4.00	4.00	4.00	4.00	4.00	4.00	2.00	
D - COW Water (untreated)	0.75	0.75	0.85	0.85	0.85	0.80	0.80	0.80	0.80	0.80	0.80	0.75	**Annual Total MG**
Total	**2.75**	**2.75**	**2.85**	**2.85**	**3.37**	**5.02**	**8.14**	**9.30**	**9.30**	**8.14**	**4.80**	**2.75**	**1,892**
TSS													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
TSS (mg/L)													
A - Screening Only	2300	2300	2300	2300	2300	3200	3200	3200	3200	3200	2300	2300	
B - Screening + LRAD	440	440	440	440	440	440	440	440	440	440	440	440	
C - Screen+LRAD+RAB	100	100	100	100	100	100	100	100	100	100	100	100	
D - COW Water (untreated)	397	397	397	397	397	397	397	397	397	397	397	397	
TSS (ppd)													
A - Screening Only	0	0	0	0	0	0	0	26,688	26,688	0	0	0	
B - Screening + LRAD	0	0	0	0	0	807	12,256	12,844	12,844	12,256	0	0	
C - Screen+LRAD+RAB	1,668	1,668	1,668	1,668	2,102	3,336	3,336	3,336	3,336	3,336	3,336	1,668	
D - COW Water (untreated)	2,483	2,483	2,814	2,814	2,814	2,649	2,649	2,649	2,649	2,649	2,649	2,483	
Total	**4,151**	**4,151**	**4,482**	**4,482**	**4,916**	**6,792**	**18,241**	**45,516**	**45,516**	**18,241**	**5,985**	**4,151**	
TSS (Total lbs)													
A - Screening Only	0	0	0	0	0	0	0	827,328	800,640	0	0	0	
B - Screening + LRAD	0	0	0	0	0	24,219	379,950	398,152	385,308	379,950	0	0	
C - Screen+LRAD+RAB	51,708	46,704	51,708	50,040	65,152	100,080	103,416	103,416	100,080	103,416	100,080	51,708	
D - COW Water (untreated)	76,980	69,531	87,244	84,430	87,244	79,464	82,112	82,112	79,464	82,112	79,464	76,980	**Annual Total lbs**
Total	**128,688**	**116,235**	**138,952**	**134,470**	**152,396**	**203,763**	**565,479**	**1,411,008**	**1,365,492**	**565,479**	**179,544**	**128,688**	**5,090,193**

Appendix 4-A1

Historical and Design Precipitation – 2001 through 2021

Appendix 4-A1. Historical and Design Precipitation – 2001 through 2021

Month	Average [1]	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	Normalized [2] Factor	Normalized [2] Return Precipitation (Design)
	inches																						inches
Nov	0.57	1.08	0.29	0.14	0.54	0.91	1.00	1.13	0.76	0.36	0.54	0.14	0.71	0.30	0.37	0.46	0.37	0.76	0.52	0.12	0.94	10%	0.8
Dec	0.96	0.59	2.16	1.34	0.71	1.77	1.51	0.69	0.64	0.74	2.21	0.07	0.80	0.28	1.18	1.66	0.40	0.78	0.66	0.33	0.63	17%	1.4
Jan	0.84	0.26	1.85	1.36	0.63	1.38	0.29	0.99	1.08	1.47	0.64	0.47	0.24	0.47	0.94	1.36	0.42	0.76	1.16	0.65	0.41	15%	1.2
Feb	0.47	0.74	0.84	0.64	0.05	0.24	0.35	0.41	0.68	0.41	0.35	0.32	0.03	0.48	0.55	0.27	1.20	0.22	0.90	0.16	0.54	8%	0.7
Mar	0.46	0.31	0.21	0.15	0.11	0.30	0.70	0.42	1.27	0.30	1.11	0.68	0.12	0.42	0.30	0.79	0.98	0.31	0.35	0.33	0.06	8%	0.7
Apr	0.38	0.23	0.77	0.16	0.18	0.86	0.24	0.12	0.27	0.63	0.41	0.77	0.33	0.21	0.14	0.21	0.60	0.83	0.49	0.11	0.04	7%	0.6
May	0.53	0.18	0.52	0.80	0.00	0.62	0.60	0.31	0.06	1.19	1.32	0.16	0.36	0.19	1.35	1.18	0.16	0.52	0.33	0.67	0.12	9%	0.8
Jun	0.45	0.91	0.00	1.15	0.00	1.25	0.60	0.48	0.05	1.14	0.17	1.12	0.78	0.12	0.00	0.31	0.36	0.06	0.12	0.31	0.16	8%	0.7
Jul	0.12	0.29	0.00	0.00	0.25	0.00	0.60	0.00	0.01	0.28	0.00	0.55	0.00	0.00	0.00	0.22	0.00	0.00	0.03	0.06	0.01	2%	0.2
Aug	0.17	0.20	0.00	0.47	0.05	0.00	0.48	0.80	0.04	0.25	0.01	0.15	0.19	0.46	0.00	0.02	0.03	0.00	0.12	0.11	0.00	3%	0.2
Sep	0.25	0.00	0.23	0.13	0.56	0.24	0.79	0.02	0.11	1.17	0.00	0.00	0.50	0.04	0.02	0.17	0.11	0.00	0.56	0.01	0.38	4%	0.4
Oct	0.45	0.14	0.07	0.00	0.45	0.39	0.30	0.03	1.01	1.28	0.47	0.75	0.01	0.63	0.02	1.60	0.42	0.30	0.24	0.20	0.78	8%	0.7
Winter [3]	2.27	1.59	4.85	3.34	1.39	3.39	2.15	2.09	2.40	2.62	3.20	0.86	1.07	1.23	2.67	3.29	2.02	1.76	2.72	1.14	1.58		3.3
Annual [4]	**5.65**	**4.93**	**6.94**	**6.34**	**3.53**	**7.96**	**7.46**	**5.40**	**5.98**	**9.22**	**7.23**	**5.18**	**4.07**	**3.60**	**4.87**	**8.25**	**5.05**	**4.54**	**5.48**	**3.06**	**4.07**	100%	8.3
Statistics [5]																							
Rank (m)		13	6	7	19	3	4	10	8	1	5	11	16	18	14	2	12	15	9	20	17		
Exceedance Probability		62%	29%	33%	90%	14%	19%	48%	38%	5%	24%	52%	76%	86%	67%	10%	57%	71%	43%	95%	81%		
Recurrance Interval (T)		1.6	3.5	3.0	1.1	7.0	5.3	2.1	2.6	21.0	4.2	1.9	1.3	1.2	1.5	10.5	1.8	1.4	2.3	1.1	1.2		

NOTES:

All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 The average precipitation is based on actual monthly precipitation from 2001 through 2021.

2 The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-16 [shaded]) were normalized in relation to the long term average for each month to create the 10-year return precipitation data for design purposes.

3 Winter period is December through February.

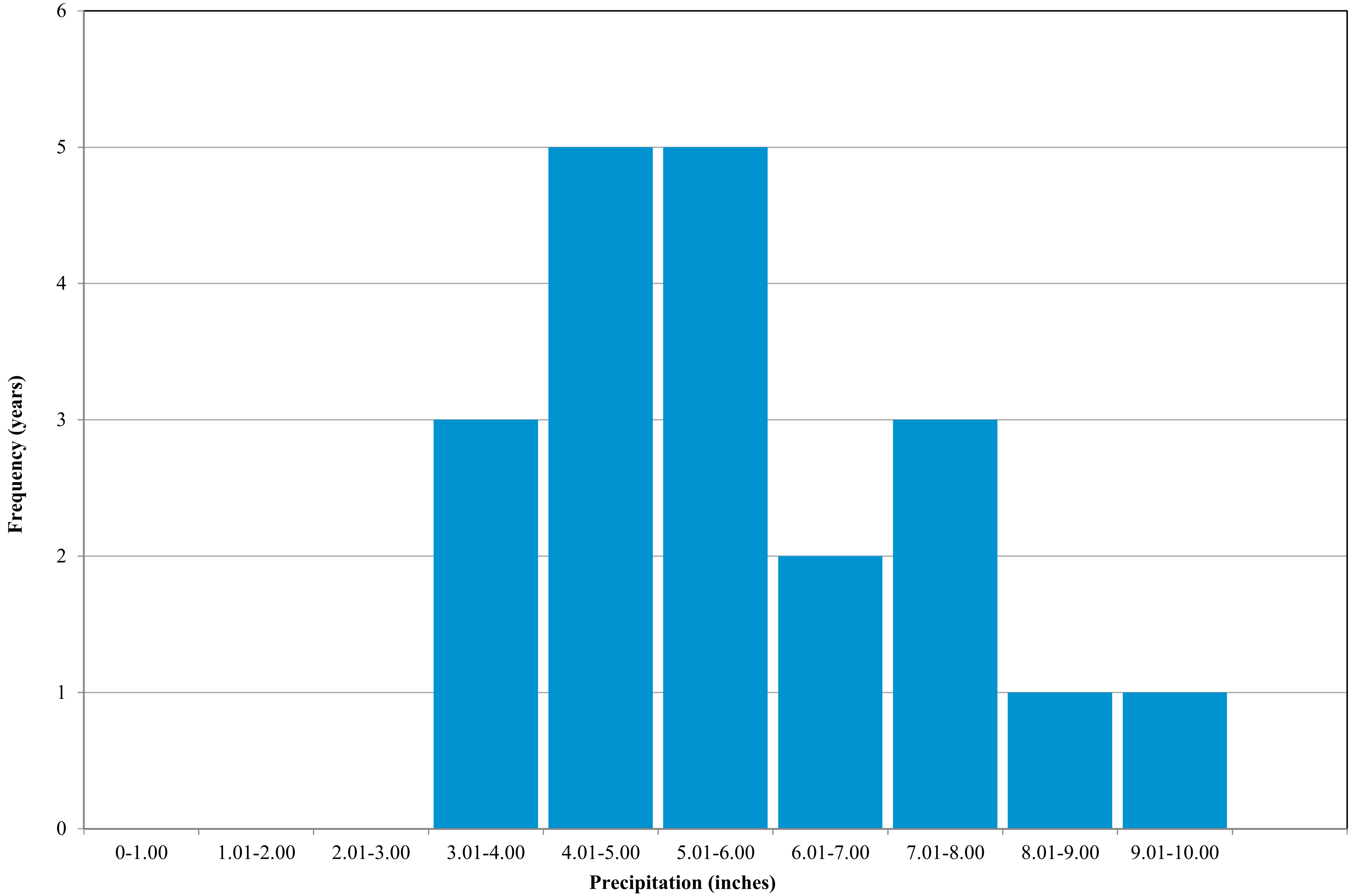
4 Annual precipitation is based on the land treatment system operating year November through October.

5 Rank (m) = rank of annual precipitation, where 1 is given to the highest precipitation and 20 is given to the lowest precipitation.
Exceedance Probability (p) = probability of precipitation equal to or higher in any given year. Calculated as p = m ÷ (n + 1), where n = number of years in data set.
Recurrance Interval (T) = average number of years between precipitation events equal to or higher than any given year. Calculated as T = 1 ÷ p = (n + 1) ÷ m, where n = number of years in data set.

Appendix 4-A2

20-Year Precipitation Histogram

Appendix 4-A2. 20-Year Precipitation Histogram



Appendix 4-B

Web Soil Survey Results

Appendix 4-B. Web Soil Survey Results

United States Department of Agriculture

NRCS

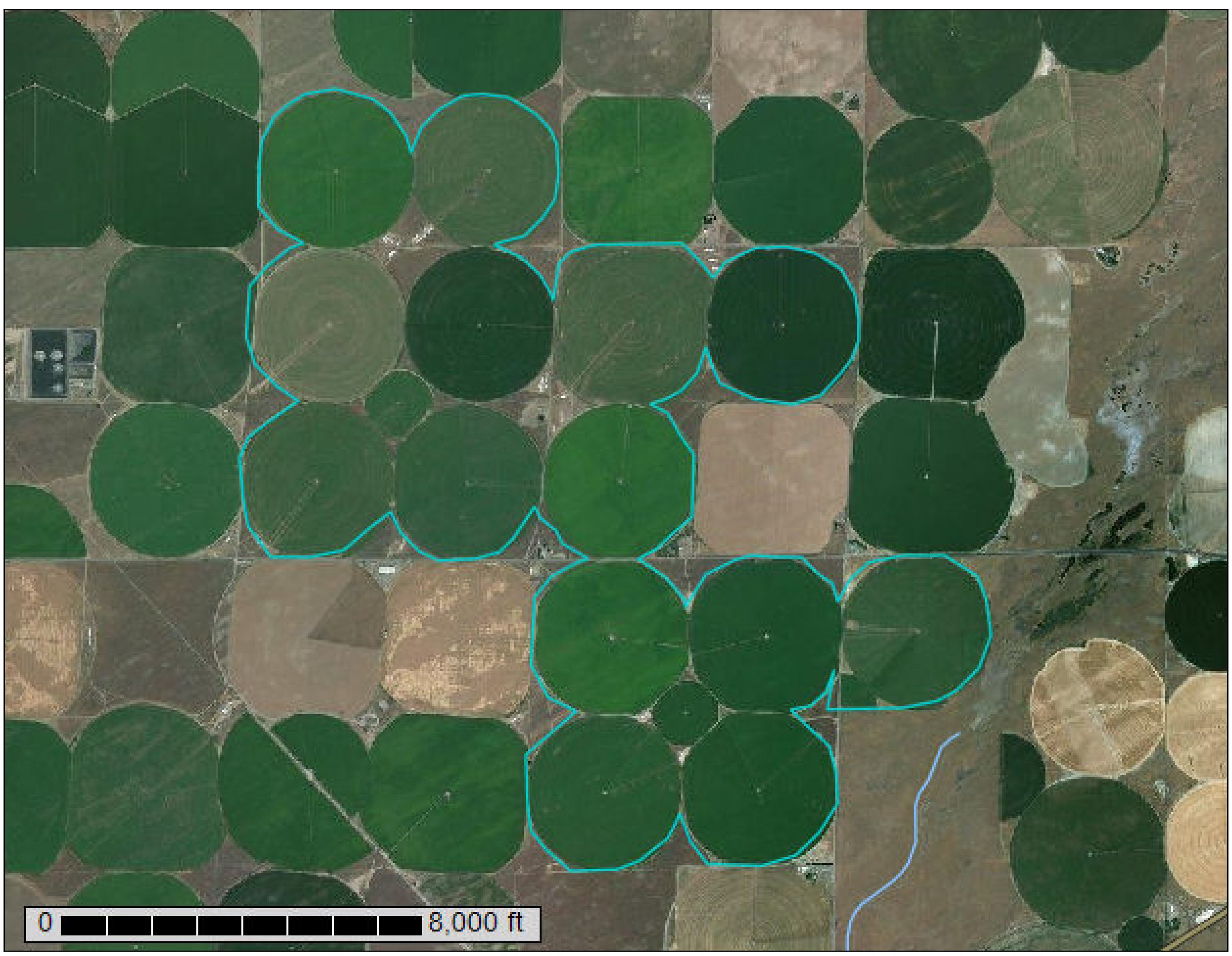
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Franklin County, Washington

City of Pasco Land Application Site



October 16, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Appendix 4-B. Web Soil Survey Results

Soil Map

Map Scale: 1:31,000 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 450, 900, 1800, 2700

Feet: 0, 1500, 3000, 6000, 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

Appendix B. Web Soil Survey Results

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 14, Sep 8, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 28, 2014—Sep 11, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Hezel loamy fine sand, 0 to 15 percent slopes	125.2	6.1%
89	Quincy loamy fine sand, 0 to 15 percent slopes	1,255.1	60.7%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	92.7	4.5%
97	Quincy-Hezel complex, 0 to 15 percent slopes	255.4	12.4%
126	Royal loamy fine sand, 0 to 10 percent slopes	1.0	0.0%
128	Royal fine sandy loam, 0 to 2 percent slopes	111.8	5.4%
144	Sagemoor very fine sandy loam, 0 to 2 percent slopes	135.9	6.6%
145	Sagemoor very fine sandy loam, 2 to 5 percent slopes	74.3	3.6%
146	Sagemoor very fine sandy loam, 5 to 10 percent slopes	14.7	0.7%
Totals for Area of Interest		**2,066.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

29—Hezel loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dm1
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hezel and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting

Landform: Terraces
Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Quincy

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

Sagehill

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e

Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

97—Quincy-Hezel complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dvt
Elevation: 350 to 2,500 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 50 percent
Hezel and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Description of Hezel

Setting

Landform: Terraces

Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 5 percent
Landform: Dunes, terraces
Hydric soil rating: No

Kennewick

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

Warden

Percent of map unit: 5 percent
Landform: Terraces, dunes
Hydric soil rating: No

126—Royal loamy fine sand, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2df7
Elevation: 400 to 1,400 feet

Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 19 inches: fine sandy loam
H3 - 19 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: SANDY 6-10 PZ (R007XY501WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

144—Sagemoor very fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dgj
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 1

Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

145—Sagemoor very fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dgl
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

146—Sagemoor very fine sandy loam, 5 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dgn
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Franklin County, Washington

June 2, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

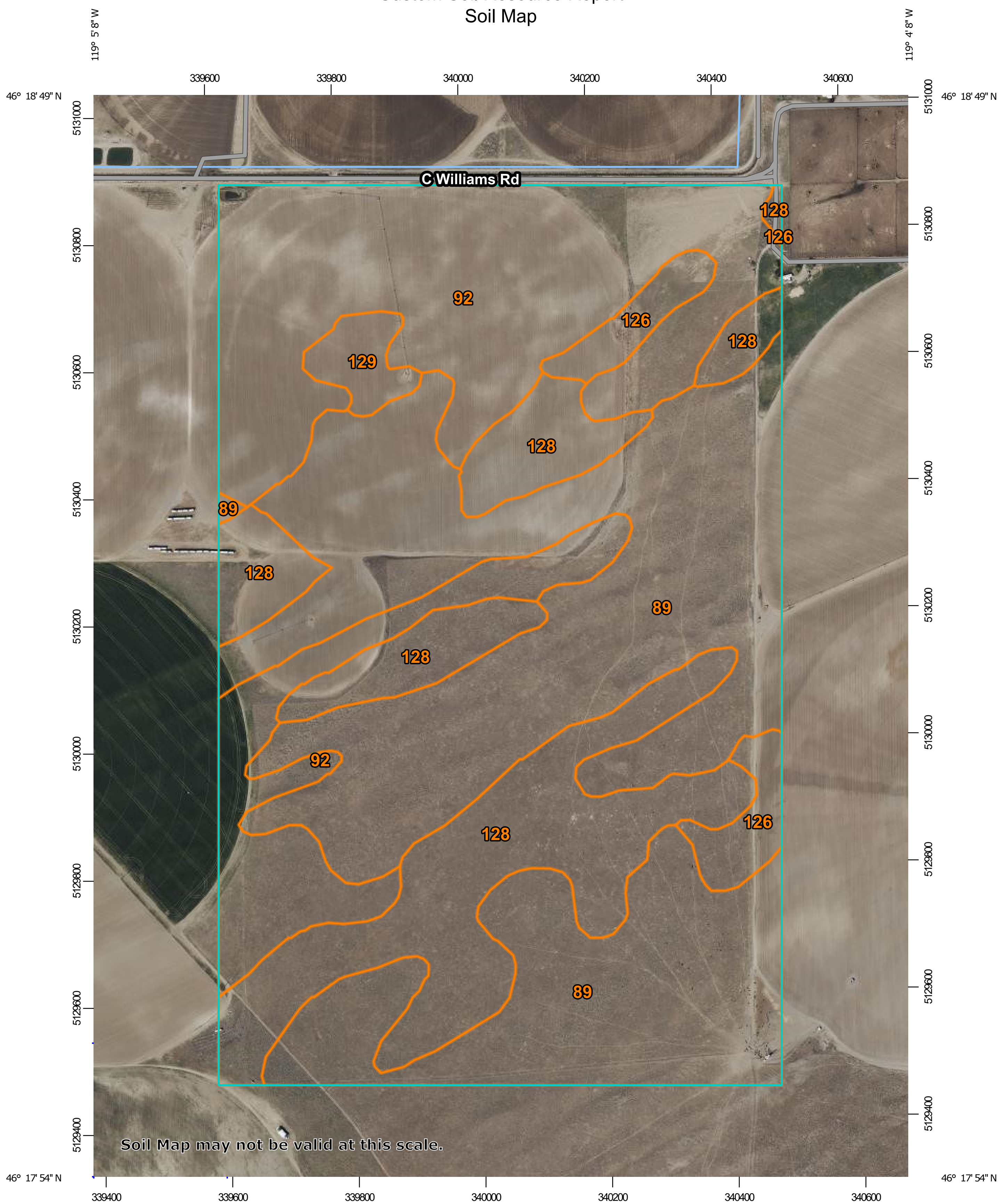
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:8,290 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 100, 200, 400, 600

Feet: 0, 400, 800, 1600, 2400

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 19, Aug 23, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 16, 2021—Apr 17, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
89	Quincy loamy fine sand, 0 to 15 percent slopes	141.7	45.3%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	90.6	29.0%
126	Royal loamy fine sand, 0 to 10 percent slopes	9.7	3.1%
128	Royal fine sandy loam, 0 to 2 percent slopes	65.9	21.1%
129	Royal fine sandy loam, 2 to 5 percent slopes	4.5	1.4%
Totals for Area of Interest		**312.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

126—Royal loamy fine sand, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2df7
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 19 inches: fine sandy loam
H3 - 19 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent

Landform: Terraces
Hydric soil rating: No

129—Royal fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dff
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
89—Quincy loamy fine sand, 0 to 15 percent slopes														
Quincy	0-4	-80-	-17-	1- 4- 6	1.50-1.58-1.65	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8-1.0	.24	.24	5	2	134
	4-60	-79-	-17-	1- 4- 7	1.50-1.58-1.65	42.34-92.00-141.14	0.05-0.08-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.20	.20			
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes														
Quincy	0-3	-80-	-17-	0- 4- 7	1.25-1.35-1.45	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	1.0- 1.5-2.0	.24	.24	5	2	134
	3-52	-79-	-17-	1- 4- 7	1.30-1.40-1.50	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	52-60	-34-	-59-	5- 8- 10	1.50-1.60-1.70	4.23-9.00-14.11	0.16-0.17-0.18	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
126—Royal loamy fine sand, 0 to 10 percent slopes														
Royal	0-6	-79-	-16-	2- 5- 8	1.35-1.40-1.45	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	2	134
	6-19	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	19-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.15	.15			
128—Royal fine sandy loam, 0 to 2 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-66-	-27-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.55	.55			
129—Royal fine sandy loam, 2 to 5 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.15	.15			

Particle Size and Coarse Fragments

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
89—Quincy loamy fine sand, 0 to 15 percent slopes										
Quincy	H1	0-4	-80-	-17-	1- 4- 6	—	—	—	—	—
	H2	4-60	-79-	-17-	1- 4- 7	—	—	—	—	—
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes										
Quincy	H1	0-3	-80-	-17-	0- 4- 7	4	4	—	—	—
	H2	3-52	-79-	-17-	1- 4- 7	4	4	—	—	—
	H3	52-60	-34-	-59-	5- 8- 10	4	4	—	—	—
126—Royal loamy fine sand, 0 to 10 percent slopes										
Royal	H1	0-6	-79-	-16-	2- 5- 8	6	4	2	—	—
	H2	6-19	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	19-60	-92-	- 1-	3- 7- 10	6	4	2	—	—
128—Royal fine sandy loam, 0 to 2 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-66-	-27-	3- 7- 10	6	4	2	—	—

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
129—Royal fine sandy loam, 2 to 5 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-92-	- 1-	3- 7- 10	6	4	2	—	—

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Franklin County, Washington

September 8, 2021

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

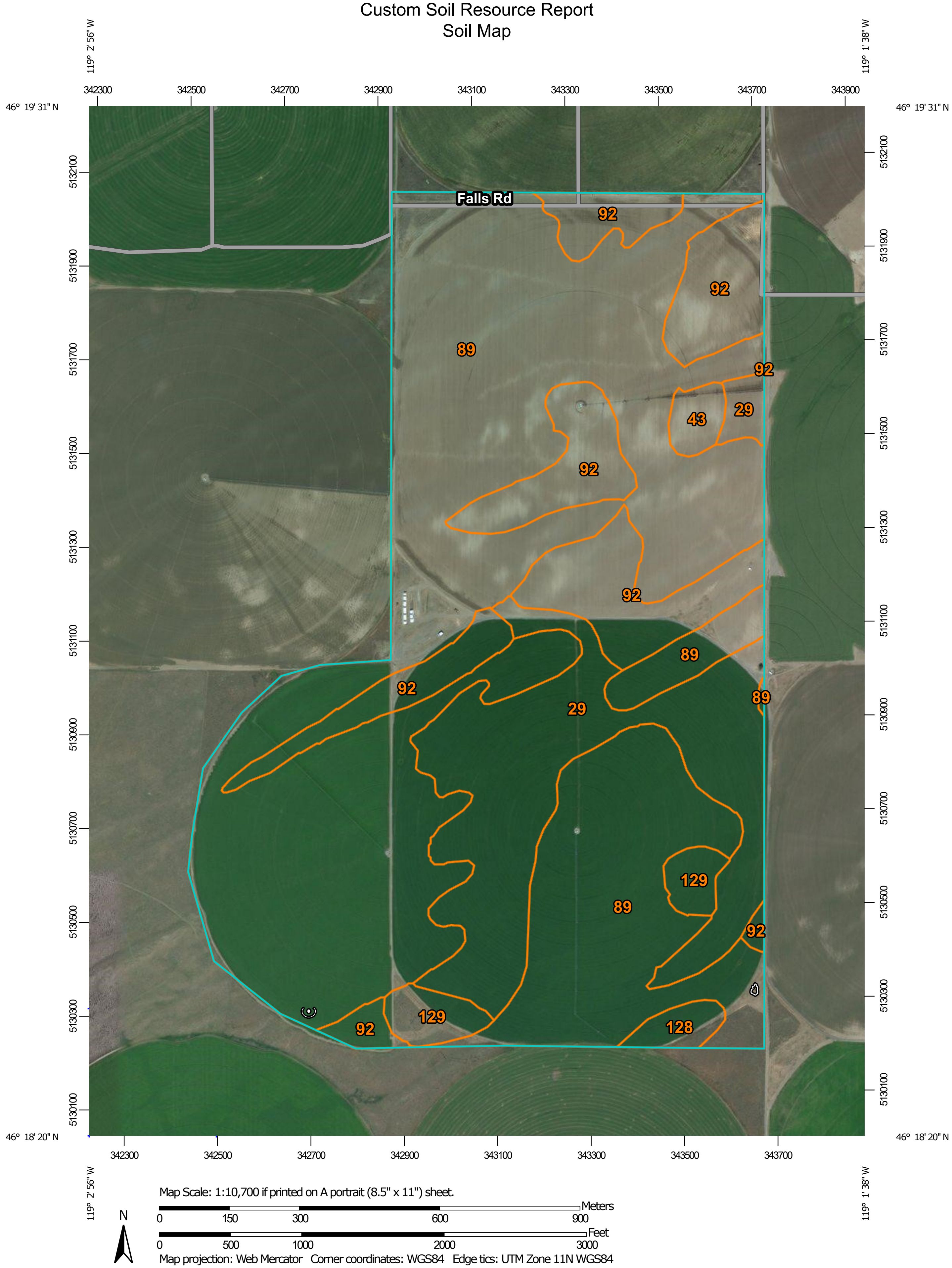
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


119° 2' 56" W
119° 1' 38" W
46° 19' 31" N
46° 18' 20" N
342300
342500
342700
342900
343100
343300
343500
343700
343900
5132100
5131900
5131700
5131500
5131300
5131100
5130900
5130700
5130500
5130300
5130100
Falls Rd
92
89
29
43
129
128
Map Scale: 1:10,700 if printed on A portrait (8.5" x 11") sheet.
Meters
0 150 300 600 900
Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 18, Jun 4, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 28, 2014—Jul 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Hezel loamy fine sand, 0 to 15 percent slopes	70.3	16.3%
43	Kennewick silt loam, 0 to 2 percent slopes	3.8	0.9%
89	Quincy loamy fine sand, 0 to 15 percent slopes	279.3	64.6%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	65.9	15.3%
128	Royal fine sandy loam, 0 to 2 percent slopes	3.7	0.9%
129	Royal fine sandy loam, 2 to 5 percent slopes	9.0	2.1%
Totals for Area of Interest		**432.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

29—Hezel loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dm1
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hezel and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting

Landform: Terraces
Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Quincy

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

Sagehill

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

43—Kennewick silt loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dnf
Elevation: 300 to 1,500 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 130 to 210 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Kennewick and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kennewick

Setting

Landform: Terraces
Parent material: Lacustrine deposits

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R007XY701WA - CALCAREOUS LOAM 6-10 PZ
Hydric soil rating: No

Minor Components

Warden

Percent of map unit: 3 percent
Landform: Terraces
Hydric soil rating: No

Royal

Percent of map unit: 2 percent
Landform: Terraces
Hydric soil rating: No

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e

Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

129—Royal fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dff
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A

Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

AOI Inventory

This folder contains a collection of tabular reports that present a variety of soil information. Included are various map unit description reports, special soil interpretation reports, and data summary reports.

Component Text Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the selected area. The component descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the associated soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas (components) for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

The "Map Unit Component Nontechnical Descriptions" report gives a brief, general description of the soil components that occur in a map unit. Descriptions of nonsoil (miscellaneous areas) and minor map unit components may or may not be included. This description is written by the local soil scientists responsible for the respective soil survey area data. A more detailed description can be generated by the "Map Unit Description" report.

Additional information about the map units described in this report is available in other Soil Data Mart reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the Soil Data Mart reports define some of the properties included in the map unit descriptions.

Report—Component Text Descriptions

Franklin County, Washington

Map Unit: 29—Hezel loamy fine sand, 0 to 15 percent slopes

Description Category: GENSOIL

Hezel: 85 percent

The Hezel component makes up 85 percent of the map unit. Slopes are 0 to 15 percent. This component is on dissected terraces. The parent material consists of glaciofluvial deposits with a mantle of eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat excessively drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 0 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 6e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Quincy: 10 percent

Generated brief soil descriptions are created for major soil components. The Quincy soil is a minor component.

Description Category: GENSOIL

Sagehill: 5 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 43—Kennewick silt loam, 0 to 2 percent slopes

Description Category: GENSOIL

Kennewick: 95 percent

The Kennewick component makes up 95 percent of the map unit. Slopes are 0 to 2 percent. This component is on terraces. The parent material consists of lacustrine deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY701WA Calcareous Loam 6-10 Pz ecological site. Nonirrigated land capability classification is 6c. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Warden: 3 percent

Generated brief soil descriptions are created for major soil components. The Warden soil is a minor component.

Description Category: GENSOIL

Royal: 2 percent

Generated brief soil descriptions are created for major soil components. The Royal soil is a minor component.

Map Unit: 89—Quincy loamy fine sand, 0 to 15 percent slopes

Description Category: GENSOIL

Quincy: 85 percent

The Quincy component makes up 85 percent of the map unit. Slopes are 0 to 15 percent. This component is on terraces. The parent material consists of mixed eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is excessively drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 7e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 2 percent.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Description Category: GENSOIL

Quincy: 85 percent

The Quincy component makes up 85 percent of the map unit. Slopes are 0 to 10 percent. This component is on terraces. The parent material consists of mixed eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is excessively drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 7e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Map Unit: 128—Royal fine sandy loam, 0 to 2 percent slopes

Description Category: GENSOIL

Royal: 85 percent

The Royal component makes up 85 percent of the map unit. Slopes are 0 to 2 percent. This component is on terraces. The parent material consists of sandy alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY501WA Sandy 6-10 Pz ecological site. Nonirrigated land capability classification is 6c. Irrigated land capability classification is 1 This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 129—Royal fine sandy loam, 2 to 5 percent slopes

Description Category: GENSOIL

Royal: 85 percent

The Royal component makes up 85 percent of the map unit. Slopes are 2 to 5 percent. This component is on terraces. The parent material consists of sandy alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY501WA Sandy 6-10 Pz ecological site. Nonirrigated land capability classification is 6e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Selected Soil Interpretations

This report allows the customer to produce a report showing the results of the soil interpretation(s) of his or her choice. It is useful when a standard report that displays the results of the selected interpretation(s) is not available.

When customers select this report, they are presented with a list of interpretations with results for the selected map units. The customer may select up to three interpretations to be presented in table format.

For a description of the particular interpretations and their criteria, use the "Selected Survey Area Interpretation Descriptions" report.

Report—Selected Soil Interpretations

Selected Soil Interpretations–Franklin County, Washington			
Map symbol and soil name	Pct. of map unit	AWM - Irrigation Disposal of Wastewater	
		Rating class and limiting features	Value
29—Hezel loamy fine sand, 0 to 15 percent slopes			
Hezel	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	1.00
		Slow water movement	0.22
		Too steep for sprinkler application	0.10
43—Kennewick silt loam, 0 to 2 percent slopes			
Kennewick	95	Somewhat limited	
		Slow water movement	0.22

Selected Soil Interpretations–Franklin County, Washington			
Map symbol and soil name	Pct. of map unit	AWM - Irrigation Disposal of Wastewater	
		Rating class and limiting features	Value
89—Quincy loamy fine sand, 0 to 15 percent slopes			
Quincy	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	1.00
		Droughty	0.25
		Too steep for sprinkler application	0.10
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes			
Quincy	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	0.32
128—Royal fine sandy loam, 0 to 2 percent slopes			
Royal	85	Not limited	
129—Royal fine sandy loam, 2 to 5 percent slopes			
Royal	85	Somewhat limited	
		Too steep for surface application	0.08

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Hydric Soil List - All Components

This table lists the map unit components and their hydric status in the survey area. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; Hurt and others, 2002).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2). Definitions for the codes are as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
    A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
    B. Show evidence that the soil meets the definition of a hydric soil;
3. Soils that are frequently ponded for long or very long duration during the growing season.
    A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or

B. Show evidence that the soil meets the definition of a hydric soil;

4. Map unit components that are frequently flooded for long duration or very long duration during the growing season that:
   A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
   B. Show evidence that the soil meets the definition of a hydric soil;

Hydric Condition: Food Security Act information regarding the ability to grow a commodity crop without removing woody vegetation or manipulating hydrology.

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. Doc. 2012-4733 Filed 2-28-12. February, 28, 2012. Hydric soils of the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Vasilas, L.M., G.W. Hurt, and C.V. Noble, editors. Version 7.0, 2010. Field indicators of hydric soils in the United States.

Report—Hydric Soil List - All Components

Hydric Soil List - All Components–WA021-Franklin County, Washington					
Map symbol and map unit name	**Component/Local Phase**	**Comp. pct.**	**Landform**	**Hydric status**	**Hydric criteria met (code)**
29: Hezel loamy fine sand, 0 to 15 percent slopes	Hezel	85	Terraces	No	—
	Quincy	10	Terraces	No	—
	Sagehill	5	Terraces	No	—
43: Kennewick silt loam, 0 to 2 percent slopes	Kennewick	95	Terraces	No	—
	Warden	3	Terraces	No	—
	Royal	2	Terraces	No	—
89: Quincy loamy fine sand, 0 to 15 percent slopes	Quincy	85	Terraces	No	—
	Sagehill	15	Dunes,terraces	No	—
92: Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	Quincy	85	Terraces	No	—
128: Royal fine sandy loam, 0 to 2 percent slopes	Royal	85	Terraces	No	—
	Sagehill	15	Terraces	No	—
129: Royal fine sandy loam, 2 to 5 percent slopes	Royal	85	Terraces	No	—
	Sagehill	15	Terraces	No	—

Taxonomic Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2003). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. This table shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Alfisols.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udalfs (*Ud*, meaning humid, plus *alfs*, from Alfisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludalfs (*Hapl*, meaning minimal horizonation, plus *udalfs*, the suborder of the Alfisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Hapludalfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, active, mesic Typic Hapludalfs.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

References:

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. (The soils in a given survey area may have been classified according to earlier editions of this publication.)

Report—Taxonomic Classification of the Soils

[An asterisk by the soil name indicates a taxadjunct to the series]

Taxonomic Classification of the Soils–Franklin County, Washington	
Soil name	**Family or higher taxonomic classification**
Hezel	Sandy over loamy, mixed, superactive, nonacid, mesic Xeric Torriorthents
Kennewick	Coarse-silty, mixed, superactive, calcareous, mesic Xeric Torriorthents
Quincy	Mixed, mesic Xeric Torripsamments
Royal	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids

Soil Erosion

This folder contains a collection of tabular reports that present soil erosion factors and groupings. The reports (tables) include all selected map units and components for each map unit. Soil erosion factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

Conservation Planning

This report provides those soil attributes for the conservation plan for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. It provides the soil description along with the slope, runoff, T Factor, WEI, WEG, Erosion class, Drainage class, Land Capability Classification, and the engineering Hydrologic Group and the erosion factors Kf, the representative percentage of fragments, sand, silt, and clay in the mineral surface horizon. Missing surface data may indicate the presence of an organic surface layer. Further information on these factors can be found in the National Soil Survey Handbook section 618 found at the url http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054223#00 .

Soil properties and interpretations for conservation planning. The surface mineral horizon properties are displayed. Organic surface horizons are not displayed.

Conservation Planning–Franklin County, Washington																		
Map symbol and soil name	Pct. of map unit	Slope RV	USLE Slope Length ft.	Runoff	T Fact or	WEI	WEG	Erosion	Drainage	NIRR LCC	Hydro logic Group	Surface						
												Depths in.	Kf Fact or	Frag- ments RV	Sand RV	Silt RV	Clay RV
29—Hezel loamy fine sand, 0 to 15 percent slopes																	
Hezel	85	8.0	—	—	5	134	2	—	Somewhat excessively drained	6e	C	0 - 7	.28	—	79	16	3
43—Kennewick silt loam, 0 to 2 percent slopes																	
Kennewick	95	1.0	—	—	5	56	5	—	Well drained	6c	C	0 - 7	.64	—	21	70	7
89—Quincy loamy fine sand, 0 to 15 percent slopes																	
Quincy	85	8.0	—	—	5	134	2	—	Excessively drained	7e	A	0 - 3	.24	—	79	16	3
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes																	
Quincy	85	5.0	—	—	5	134	2	—	Excessively drained	7e	A	0 - 3	.24	4	79	16	3
128—Royal fine sandy loam, 0 to 2 percent slopes																	
Royal	85	1.0	—	—	5	86	3	—	Well drained	6c	A	0 - 5	.28	6	65	27	7
129—Royal fine sandy loam, 2 to 5 percent slopes																	
Royal	85	4.0	—	—	5	86	3	—	Well drained	6e	A	0 - 5	.28	6	65	27	7

RUSLE2 Related Attributes

This report summarizes those soil attributes used by the Revised Universal Soil Loss Equation Version 2 (RUSLE2) for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. Soil property data for each map unit component include the hydrologic soil group, erosion factor Kf for the surface horizon, erosion factor T, and the representative percentage of sand, silt, and clay in the mineral surface horizon. Missing surface data may indicate the presence of an organic layer.

Report—RUSLE2 Related Attributes

Soil properties and interpretations for erosion runoff calculations. The surface mineral horizon properties are displayed or the first mineral horizon below an organic surface horizon. Organic horizons are not displayed.

RUSLE2 Related Attributes–Franklin County, Washington								
Map symbol and soil name	Pct. of map unit	Slope length (ft)	Hydrologic group	Kf	T factor	Representative value		
						% Sand	% Silt	% Clay
29—Hezel loamy fine sand, 0 to 15 percent slopes								
Hezel	85	—	C	.28	5	79.9	16.6	3.5
43—Kennewick silt loam, 0 to 2 percent slopes								
Kennewick	95	—	C	.64	5	21.7	70.8	7.5
89—Quincy loamy fine sand, 0 to 15 percent slopes								
Quincy	85	—	A	.24	5	79.9	16.6	3.5
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes								
Quincy	85	—	A	.24	5	79.9	16.6	3.5
128—Royal fine sandy loam, 0 to 2 percent slopes								
Royal	85	—	A	.28	5	65.2	27.3	7.5
129—Royal fine sandy loam, 2 to 5 percent slopes								
Royal	85	—	A	.28	5	65.2	27.3	7.5

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Particle Size and Coarse Fragments

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
29—Hezel loamy fine sand, 0 to 15 percent slopes										
Hezel	H1	0-7	-80-	-17-	2- 4- 5	—	—	—	—	—
	H2	7-18	-81-	-17-	0- 3- 5	—	—	—	—	—
	H3	18-27	-66-	-28-	5- 7- 8	—	—	—	—	—
	H4	27-60	-71-	-22-	5- 7- 8	—	—	—	—	—
43—Kennewick silt loam, 0 to 2 percent slopes										
Kennewick	H1	0-8	-22-	-71-	3- 8- 12	—	—	—	—	—
	H2	8-60	-21-	-69-	3-11- 18	—	—	—	—	—
89—Quincy loamy fine sand, 0 to 15 percent slopes										
Quincy	H1	0-4	-80-	-17-	1- 4- 6	—	—	—	—	—
	H2	4-60	-79-	-17-	1- 4- 7	—	—	—	—	—
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes										
Quincy	H1	0-3	-80-	-17-	0- 4- 7	4	4	—	—	—
	H2	3-52	-79-	-17-	1- 4- 7	4	4	—	—	—
	H3	52-60	-34-	-59-	5- 8- 10	4	4	—	—	—

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
128—Royal fine sandy loam, 0 to 2 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-66-	-27-	3- 7- 10	6	4	2	—	—
129—Royal fine sandy loam, 2 to 5 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-92-	- 1-	3- 7- 10	6	4	2	—	—

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
29—Hezel loamy fine sand, 0 to 15 percent slopes														
Hezel	0-7	-80-	-17-	2- 4- 5	1.25-1.35-1.45	42.34-92.00-141.14	0.09-0.11-0.13	0.0- 1.5- 2.9	0.0- 0.3-0.5	.28	.28	5	2	134
	7-18	-81-	-17-	0- 3- 5	1.40-1.50-1.60	42.34-92.00-141.14	0.08-0.10-0.12	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	18-27	-66-	-28-	5- 7- 8	1.30-1.40-1.50	4.23-9.00-14.11	0.13-0.17-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.43	.43			
	27-60	-71-	-22-	5- 7- 8	1.30-1.40-1.50	1.40-3.00-4.23	0.13-0.17-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
43—Kennewick silt loam, 0 to 2 percent slopes														
Kennewick	0-8	-22-	-71-	3- 8- 12	1.15-1.25-1.35	4.23-9.00-14.11	0.19-0.20-0.21	0.0- 1.5- 2.9	0.5- 0.8-1.0	.64	.64	5	5	56
	8-60	-21-	-69-	3-11- 18	1.30-1.40-1.50	1.40-3.00-4.23	0.18-0.20-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			
89—Quincy loamy fine sand, 0 to 15 percent slopes														
Quincy	0-4	-80-	-17-	1- 4- 6	1.50-1.58-1.65	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8-1.0	.24	.24	5	2	134
	4-60	-79-	-17-	1- 4- 7	1.50-1.58-1.65	42.34-92.00-141.14	0.05-0.08-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.20	.20			

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes														
Quincy	0-3	-80-	-17-	0- 4- 7	1.25-1.35-1.45	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	1.0- 1.5-2.0	.24	.24	5	2	134
	3-52	-79-	-17-	1- 4- 7	1.30-1.40-1.50	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	52-60	-34-	-59-	5- 8- 10	1.50-1.60-1.70	4.23-9.00-14.11	0.16-0.17-0.18	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			
128—Royal fine sandy loam, 0 to 2 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-66-	-27-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.55	.55			
129—Royal fine sandy loam, 2 to 5 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.15	.15			

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Appendix 4-C1

Well Inventory Summary

Appendix 4-C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 9N, Range 30E, Section 2											
1	#3	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	10/10/1974	NW	I, T	NR	159.0	0 to 158.6 (16)	None	UA	95
2	4	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	6/2/1975	SE of NW	T	Not Tested	140.0	0 to 140 (6)	None	UA	68
3	MW-9 AFF 590	City of Pasco Pasco, WA	4/18/2001	NE of NE	NR	NR	125.0	3 to 95 (4)	95 to 125	UA	104
4	4A	Tippet Land and Morgage Franklin County	12/30/1988	SW of NE	I	NR	139.5	+6 to 120.5 (16)	120.5 to 138.5	UA	89
5	4	Tippet Land and Morgage Franklin County	12/9/1988	SW of NE	I, A	NR	NR	NR to 88 (16)	NR	NR	NR
6	5	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	3/19/1975	SW of NE	I, T	NR	165.0	0 to 165 (16)	None	UA	98
7	#1 APJ 201	Carson Ay LLC 28 Pasco Kahlotus Rd Pasco, WA 99301	4/9/2008	SW of NE	MW	Not Tested	96.0	+2 to 96 (2)	76 to 96	UA	81.5
8	#3 APJ 203	Carson Ay LLC 28 Pasco Kahlotus Rd Pasco, WA 99301	5/9/2008	SE of NE	MW	Not Tested	94.0	1.5 to 94 (2)	74 to 94	UA	80
9	#1	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	7/3/1974	SE of NE	I, T	2,451 4 hours 8-foot drawdown pump	127.0	0 to 127 (16)	None	UA	80
Township 9N, Range 30E, Section 3											
10	MW-03	City of Pasco Wastewater Treatment Facility Franklin County	1/26/1995	NR	NR	NR	139.0	+3.3 to 106.7 106.7 to 136.7 136.7 to 139.15 139.15 to 139.43	NR	UA	NR
11	NR	City of Pasco Pasco, WA	3/17/1995	SW of NW	MW	NR	NR	NR	NR	NR	NR
Township 9N, Range 30E, Section 4											
12	PW-1	City of Pasco Wastewater Treatment Facility	1/17/1975	NR	P	40-50	253.4	Not legible	Not legible	UA	175

Appendix 4-C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
13	MW-02a	City of Pasco Wastewater Treatment Facility Franklin County	2/20/1975	NR	MW	NR	178.0	+3.5 to 145.27 145.27 to 175.29 175.29 to 177.68 177.68 to 178.0	Not legible	UA	NR
14	NR	Earl Blasdel 2001 E Foster Wells Rd Pasco, WA 99301	11/2/1993	NW of SW	I	1,860 12 hours 20-foot drawdown	220.0	+1 to 197	197 to 217	UA	175
15	NR	JE Lentz Franklin County	1/1/1978	SE of SE	I	NR	242.0	+1 to 216 (16)	216 to 237	UA	165
16	NR	Jim Minnehan Highway E 410 Pasco, WA 99301	7/31/1974	SE of SE	I	1,212 4 hours 16-foot drawdown	186.0	0 to 184 (12)	None	UA	146
Township 9N, Range 30E, Section 5											
17	29	NR	3/20/1973	NE of SE	I	NR	230.0	0 to 230 (16)	None	UA	166
18	AHK 268	Earl Blasdel E Foster Wells Rd and Commercial Rd Pasco, WA 99301	10/29/2002	SW of SE	D	50 Air 4 hours	203.5	+1.5 to 194 (8)	194 to 149	UA	162
19	NR	Herb Rode Collins	10/3/1992	SE of SE	D	NR	240.0	+1 to 217 (6)	None	BA	164
Township 9N, Range 30E, Section 6											
20	ACE 623	David Vooge 1532 North 14th Ave Pasco, WA 99301	8/20/1996	NE of NE	D	35 Air	124.0	+1 to 124 (6)	None	UA	87
21	NR	Robert Tippett 3400 W Clearwater Kennewick, WA 99336	3/4/1977 6/16/1977	SW of SE	D	15 estimated	101.0 154.0	0 to 154 (6)	40 slot	UA	78
22	NR	Gordon Bradshaw Franklin County	6/28/1993	SE of SE	D	35 Air 3 hours	245.0	+1 to 215 (6)	None	BA	155
23	BCF 552	Rogers Potato Railroad Ave Pasco, WA 99301	4/24/2012	SE of SE	D	50 Air 2 hours	144.0	+2 to 144 (8)	None	UA	87.5
24	ACX 249	Robertt Micheal McKee Benton	7/2/1998	SE of SE	D	50 Air 2 hours	225.0	+1 to 205 (6)	None	BA	161.0
25	NR	Robert Tippett 3400 W Clearwater Kennewick, WA 99336	9/5/1973	SE of SE	I	1,000 5 hours 25-foot drawdown	132.0	0 to 127 (16) 127 to 132 (12)	None	UA	97

Appendix 4-C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 10N, Range 30E, Section 21											
26	NR	USBR	4/16/1966	SE of SE	NR	NR	51.0	NR	NR	NR	NR
Township 10N, Range 30E, Section 22											
27	NR	Gary Pfisher Falls Rd Pasco, WA 99301	1/26/1977	NW of SW	D	NR	410.0	0 to 203 (6)	None	BA	218
28	AKW 941	Jerry Osswan 40 Falls Rd Pasco, WA 99301	8/31/2004	SW of SW	D	40 Air 1 hour	410.0	+1 to 192.5 (6) 192.5 to 410 (4.5)	None	BA	174
29	AKO 582	Mike McBee 33826 2181 PR SE Kennewick, WA 99336	9/29/2004	NE of SE	D	30 Air NR	157.0	+1 to 24 (6) -7 to 157 (4)	None	UA	36
Township 10N, Range 30E, Section 23											
30	BHW 074	Kerry Calaway 2160 Falls Rd Pasco, WA 99301	6/27/2014	NE of SE	D	30 Air 1 hour	200.0	+2 to 116 (6)	None	BA	78
Township 10N, Range 30E, Section 28											
31	BJA 054	Dennis Bens NKA E Vineyard Dr Pasco, WA 99301	12/9/2016	NE of NE	D	50+ Air 1 hour	400.0	+1.5 to 176 (6) -140 to 400 (4.5)	None	BA	176
32	NR	Tom Crigler Franklin County	5/28/1986	SE of NE	D	NR	140.6	+1 to 112.5 (6) 107 to 140.6 (4.5)	None	UA	41
Township 10N, Range 30E, Section 29											
33	BHT 030	Brent Preston 52 E Vineyard Pasco, WA 99301	11/1/2013	NW of SE	D	100 Air 2 hours	237.0	+1.5 to 177 (8) -7 to 237 (6)	None	BA	132
34	NR	Mike Franklin Franklin County	7/20/1994	NE of SE	D	15 Air 2 hours	160.0	+1 to 120 (6)	None	UA	8
35	ALC 743	Brent Preston 502 E Vineyard Pasco, WA 99301	5/5/2006	SW	D	75 Air 3 hours	363.0	+1 to 170.5 (8) 163 to 363 (6)	None	BA	151
Township 10N, Range 30E, Section 30											
36	ABX 793	Balcom + Moe Inc PO Box 968 Pasco, WA 99301	3/19/1996	NW of SE	D	None	120.0	0 to 199 (6)	None	UA	8.0

Appendix 4-C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
37	ABX 801	Maury Balcom PO Box 968 Pasco, WA 99301	4/5/1996	NW of SE	D	NR	118.0	0 to 118 (6)	None	UA	80
38	NR	El Paso Natural Gas Company PO Box 1526 Salt Lake City, UT	11/14/1966	SE	NR	NR	285.0	0 to 163 (10)	NR	BA	NR
Township 10N, Range 30E, Section 31											
39	NR	Burlington Northern	1/4/1982	SW of SE¼	I	NR	170.0	+1 to 140 (16)	140 to 165	UA	109
40	NR	Duane Guenther 1524 W Howard Pasco, WA 99301	1/20/1965	NR	NR	20 1 hour 30-foot drawdown	218.0	0 to 158 (6)	NR	UA	NR
Township 10N, Range 30E, Section 32											
41	NR	Lentz Farms 1304 W Yakima St Pasco, WA 99301	3/11/1975	NW of SW	T	20 2 hours 2-foot drawdown	222.0	0 to 222 (6)	205 to 220 210 to 222	UA	167
42	NR	Lentz Franklin County	10/10/1975	SE of SW	I	1,557 4 hours 11-foot drawdown	192.0	+1 to 153 (16)	154 to 184	UA	138
Township 10N, Range 30E, Section 33											
43	NR	Northern Pacific Railway Company Seattle, Washington	7/13/1966	NW of NE	NR	NR	487.0	0 to 155 (6)	NR	BA	240
44	NR	Northern Pacific Railway Company Seattle, Washington	10/20/1966	SW of NE	NR	150 4 hours 188-foot drawdown	571.0	0 to 154 (10) 2 to 421 (8)	NR	BA	213
45	NR	Don Beus Franklin County	3/11/1978	SW of SW	I	NR	221.6	+1 to 197 (16)	197 to 218	UA	180
46	NR	Don Beus Franklin County	7/13/1977	SW of SW	I	NR	223.0	+1 to 197 (16)	197 to 223	UA	186
47	NR	Don Beus Franklin County	6/22/1977	SW of SW	T	NR	229.0	+1 to 218 (8)	219 to 224 223 to 228	UA	180
Township 10N, Range 30E, Section 34											
48	MW-04	City of Pasco Wastewater Treatment	2/6/1995	NR	NR	NR	145.0	+3 to 110.57 110.57 to 140.60 140.60 to 142.95 142.95 to 143.29	NR	UA	NR

Appendix 4-C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 10N, Range 30E, Section 35											
49	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	3/3/1975	SW	I	NR	122.5	0 to 105.5 (16)	104.5 to 117 117 to 122.5	UA	94
50	NR	Ray Voss State Route 1 Pasco, WA 99301	2/11/1975	SW	T	NR	152.5	Pulled	None	UA	NR
51	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	2/3/1975	SE of SE	I	NR	130.0	0 to 113 (16)	111 to NR NR to 130	UA	94
52	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	2/3/1975	NE of NE	D	18 1.5 hours 8-inch drawdown	147.0	0 to 122 (6)	126.6 to 122	UA	93

NOTES:

All information based on original Washington State Department of Ecology well log data (Washington State Department of Ecology, n.d.).

Abbreviations: E = east, gpm = gallons per minute, ID = identification, N = north, NE = northeast, NR = not reported, NW = northwest, SE = southeast, SW = southwest, USBR = United States Bureau of Reclamation, W = west.

1 A = abandoned, D = domestic, I = irrigation, MW = monitoring well, NR = not recorded, P = production well, T = test well.

2 Yield information is presented in sequence as follows: gallons per minute, test duration, drawdown, and test method (e.g., "Air").

3 Casing reported in feet below ground surface and diameter reported in inches.

4 Where no screen or perforations was reported, open borehole well construction was assumed.

5 BA = lower basalt bedrock aquifer, UA = uppermost unconfined sedimentary aquifer.

6 Static water level based on original well log data.

Appendix 4-C2

Well Logs Within 1-Mile of Expansion Sites

The Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

1

WATER WELL REPORT
STATE OF WASHINGTON

Application No. TEST WEL
G3 22491
Permit No. XXXXXXXXXXX

(1) OWNER: Name ROBERT TIPPETT Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN 1300ft.N. & 1300ft.W.from center 2 Sec 2 T 9 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XX Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)........ # 3
New well XX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 159 ft. Depth of completed well 159 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 158.6 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes XX No ☐
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from 145 ft. to 157 ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No XX
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No XX Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes XX No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name did not enstall
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level 502 ft.
Static level 95 ft. below top of well Date 9-11-74
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No ☐ If yes, by whom? Green Valley
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" did do not give us a report " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

[redacted] Date of test .....
[redacted]ler test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	20
Fine sand	20	30
Fine sand	30	50
Course sand	50	62
Small course gravel	62	75
Course sand and gravel	75	85
Course sand	85	95
Course gravel and sand	95	105
Course gravel and sand	105	118
Silt and sand	118	130
Silt and sand	130	145
Course gravel and sand	145	157
Water came in	145	
Basalt	157	
16 inch Lakewood Drive shoe		

2160 gpm 1/2 sec ft
1700 ac
1200

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 8-8, 19 74 Completed 10-10, 19 74

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] Ed Goetz
(Well Driller)

License No. 0158 Date 10-10, 19 74

12/08/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

2

Application No. 25061
Permit No. TEST WELL

(1) OWNER: Name ROBERT TIPPET Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN — SE ¼ NW ¼ Sec. 2 T. 9N N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well XXXX Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4
New well XXX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XXX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 ft. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 140 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded XXX " Diam. from ft. to ft.

Perforations: Yes XXX No ☐
Type of perforator used MILLS
SIZE of perforations ¼ in. by 1 in.
perforations from 102 ft. to 108 ft.
x perforations from x ft. to x ft.
x perforations from x ft. to x ft.

Screens: Yes ☐ No XXXX
Manufacturer's Name
Type XXXXXXXXXXXXXXXXXXXXXXXXXX Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No XXX Size of gravel:
Gravel placed from XXXXXXXXXXXXXXXXXXXXXXX ft. to ft.

Surface seal: Yes XX No ☐ To what depth? 18 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No XX
Type of water? XX Depth of strata XXXX
Method of sealing strata off XXXX

(7) PUMP: Manufacturer's Name XXX
Type: XXXX H.P. XXX

(8) WATER LEVELS: Land-surface elevation above mean sea level.... XX 520 ft.
Static level XXX 68 ft. below top of well Date 6/21/75
Artesian pressure XXX lbs. per square inch Date XXX
Artesian water is controlled by XXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No XX If yes, by whom? XXX
Yield: gal./min. with ft. drawdown after hrs.
" " " "
XXXXXXXXXXXXXXXXXXXXXXXXXX
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	XXXXXXXXXXXXXXX				

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water XXXXXXXXXXXXXXXXXXXXXXXXXXXX Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
~~Top Soil~~ Surface Seal	0	18
Top soil	0	42
Black gravel and course dand	42	105
Black gravel and course sand	105	140
6 inch drive shoe (Blue Crown)		
Perforated by Mills perforator from 102 ft. to 108 ft.		

Copied

Work started Jan. 24, 1975 Completed ~~May XX~~ JUNE 2, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. (Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] David L. Whitehead (Well Driller)

License No. 0554 Date July 7, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

11/20/75

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

3

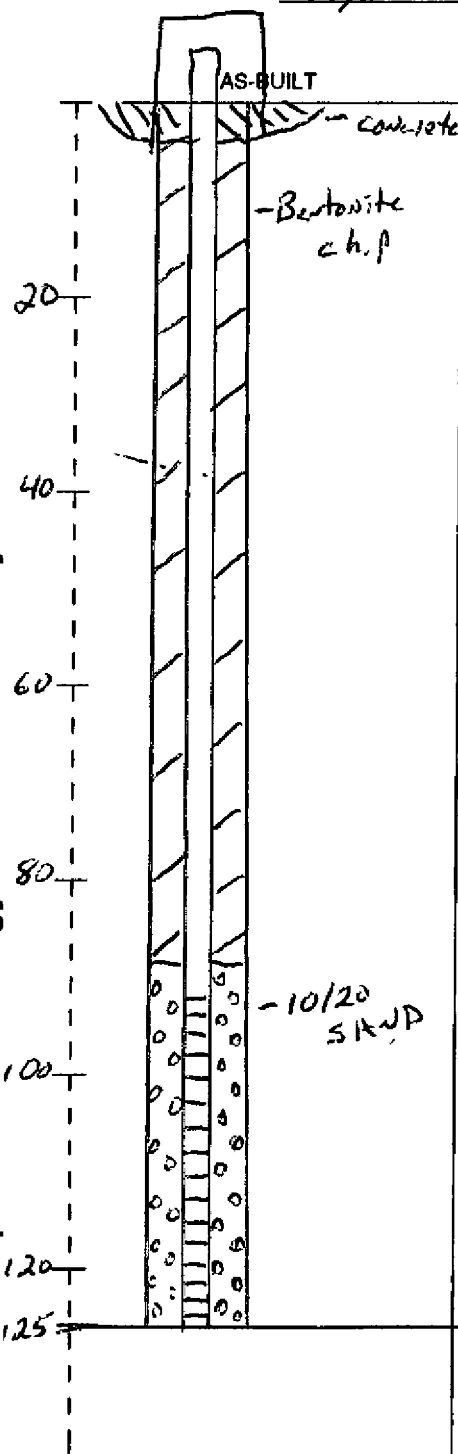
93237

RESOURCE PROTECTION WELL REPORT

START CARD NO R43241

PROJECT NAME City of Pasco Process water reuse facility	COUNTY Franklin
WELL IDENTIFICATION NO MW-9 AFF590	LOCATION NE¼ NE¼ Sec 2 Twn 9N R 30E
DRILLING METHOD Air Rotary	STREET ADDRESS OF WELL
DRILLER Ronald Sink	
FIRM Environmental West Exp	WATER LEVEL ELEVATION 104
SIGNATURE [signature]	GROUND SURFACE ELEVATION
CONSULTING FIRM Landau	INSTALLED 4/16 - 4/18/01
REPRESENTATIVE Ryan Reich	DEVELOPED 4/18/01

AS-BUILT



WELL DATA

Use of Well: Monitor

Bore hole: 9"

Screen: .010 95' to 125' 4" PVC

Casing: +3' to 95' 4" PVC

Sand: 10/20 92' to 125'

Bentonite chips 2' to 92'

FORMATION DESCRIPTION

Depth	Description
0–30	Fine Sand
30–55	Med. to Coarse Sand
55–63	Sandy gravels
63–67	Silty Sand
67–90	Gravels w/some sand
90–125	Gravely sand

APR 2001
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

SCALE 1" = 20' PAGE 1 OF 1

ECY 050-12 (Rev 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

4

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3 22499

(1) OWNER: Name Tippel Land and Morgage Address

(2) LOCATION OF WELL: County Franklin SW ¼ NE ¼ Sec 2 T. 9 N., R. 30 E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) New well 12 feet East of old well

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4 A
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 139'6" inches.
Drilled 16" feet. Depth of completed well 139'6" ft.

(6) CONSTRUCTION DETAILS: 375 Wall
Casing installed: 16 " Diam. from +6 ft. to 120'6" ft.
Welded ☒ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐
Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 16T Slot size 150 from 120'6" ft. to 138'6" ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ____ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 89 ft. below top of well Date 12-30-88
Artesian pressure ____ lbs. per square inch Date
Artesian water is controlled by ____ (Cap, valve, etc.))

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	12
Silt Tan Sandy	12	20
Sand Blk Sandy silt	20	22
Silt Tan Sandy	22	43
Gravel 6" minus sand Black water @ 89'	43	100
Sand Black, gravel very silty	100	105
Gravel 6" minus sand Blk	105	114
Gravel, cobbles, boulders sand Blk	114	138'6"
Basalt Black	138'6	139'6

RECEIVED
JAN - 9 1989
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started ____, 19__. Completed 12-30, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Argent Pasco
(Signed) James Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD148CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

5

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3-22499

(1) OWNER: Name Tippel Land + Morgage Address

(2) LOCATION OF WELL: County Franklin SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4

Abandoned ☒ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled ____ feet. Depth of completed well ____ ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ____" Diam. from ____ ft. to ____ ft.
Welded ☐ ____" Diam. from ____ ft. to ____ ft.
Liner installed ☐
Threaded ☐ ____" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 6 in.
8 around perforations from 86 ft. to 10 ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☐ No ☐ To what depth? ____ ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ____ Depth of strata ____
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level ____ ft. below top of well Date ____
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.))

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Screen Broke while pulling		
from well - Closed To 88		
feet with 16" casing		
Perforated Casing pumped		
Bentonite 88 Feet To 3 feet		
Cement - 3 Feet To 0 feet		

RECEIVED
JAN - 9 1989
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 12-5, 19 . Completed 12-9, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling, Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 10036 W Arvent Pasco

(Signed) James Nelson (WELL DRILLER) License No. 361

Contractor's Registration No. NELSOWD198CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

6

Application No. G3-22491
Permit No. Test Well

(1) OWNER: Name Robert Tippitt Address 3400 W. Clearwater, Kenmewick, wn. 99301

(2) LOCATION OF WELL: County Franklin — SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30E W.M.

[redacted]ng and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 165 ft. Depth of completed well 165 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 165 ft.
Threaded ☐ X " Diam. from X ft. to X ft.
Welded ☒ X " Diam. from X ft. to XX ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 2 in.
432 perforations from 98 ft. to 134 ft.
228 perforations from 144 ft. to 163 ft.
X perforations from X ft. to X ft.

Screens: Yes ☐ No ☒
Manufacturer's Name XXX
Type XXXX Model No.
Diam. XXX Slot size X from X ft. to XX ft.
Diam. X Slot size X from X ft. to XX ft.

[redacted]**Gravel packed:** Yes ☐ No ☒ Size of gravel: XXXX
Gravel placed from XXX ft. to XXX ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? XXX Depth of strata XXXXX
Method of sealing strata off XXXXX

(7) PUMP: Manufacturer's Name XX
Type: XX H.P. X

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ~~500~~ 510 ft.
Static level 98 ft. below top of well Date 3/19/75
Artesian pressure X lbs. per square inch Date X
Artesian water is controlled by XXXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

[redacted]te of test
[redacted]er test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	0	18
Sandy loam	0	45
Sandy loam, sand	45	55
Course black gravel, 1½ minus	55	98
Course sand & gravel, all colors ½ minus	98	110
Hit water		98
Pea gravel, black, white, brown	110	120
Course black sand and gravel	120	123
Course black & white gravel, peasize	123	132
Course gravel, sand all colors	132	135
Fine brown sand	135	140
Gravel, black, pea size	140	141
Sand and gravel	141	143
Mix sand and gravel	143	151
1½ minus rock and sand	151	163
Black basalt	163	165
16 inch Lakewood Drive shoe		

@ 2160 gpm
1116 sq. ft.
240 acres
OK

Work started 2/20, 1975. Completed 3/19, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Golden Autumn Const. Co., Inc. (Person, firm, or corporation) (Type or print)

Address P.O. Box 811, PASCO, WN. 99301

[Signed] Guy Kelly (Well Driller)

License No. 0606 Date 3/25/75, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

307574

7

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission (*"x" in circle*)
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* #1

CURRENT
Notice of Intent No. R035442
Unique Ecology Well ID Tag No. APJ 201
Water Right Permit No.
Property Owner Name Carson Ag LLC
Well Street Address 28 Pasco Kahlotus Rd
City Pasco County Franklin
Location SW 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 EWM or WWM circle one
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. 113 710 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned ☐ Deepened
Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6x2 inches, drilled 96 ft.
Depth of completed well 96 ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded ____" Diam. from ____ ft. to ____ ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☒ Threaded 2" Diam. from +2 ft. to 96 ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 76' to 96'
Manufacturer's Name ____
Type ____ Model No. ____
Diam. 2" Slot size ____ from 76' ft. to 96 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ____
Materials placed from 73 ft. to 96 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 73 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 81½ ft. below top of well Date 4/9/08
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
FINE TAN SAND	0	28
FINE BLACK SAND	28	35
COARSE BLACK SAND	35	42
FINE BLACK SAND	42	67
ABOVE WITH TRACE OF BROWN SILT	67	73
COARSE BLACK SAND	73	94
COARSE BLACK SAND & GRAVEL	94	96
TAN SAND & GRAVEL	96	

RECEIVED MAR 09 2009 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED MAY 14 2008 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 4/8/08 Completed Date 4/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson
Driller/Engineer/Trainee Signature Jim Nelson
Driller or trainee License No. 361

If TRAINEE,
Driller's Licensed No. ____
Driller's Signature ____

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST.
City, State, Zip PASCO WA 99301
Contractor's Registration No. NELSOWD 198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

307573

8

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* #3

CURRENT Notice of Intent No. R035441
Unique Ecology Well ID Tag No. APJ 203
Water Right Permit No.
Property Owner Name Carson Oe LK
Well Street Address 28 Pasco Kahlotus #10
City Pasco County Franklin
Location SE 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 EWM or WWM circle one
Lat/Long (s, t, r Still REQUIRED) Lat Deg ___ Lat Min/Sec ___ Long Deg ___ Long Min/Sec ___
Tax Parcel No. 113 710 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring

TYPE OF WORK: Owner's number of well (if more than one) ___
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 x 2 inches, drilled 98 ft.
Depth of completed well 94 ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded ___" Diam. from ___ ft. to ___ ft.
☐ Liner installed ___" Diam. from ___ ft. to ___ ft.
☒ Threaded 2" Diam. from 1½ ft. to 94 ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ___
SIZE of perfs ___ in. by ___ in. and no. of perfs ___ from ___ ft. to ___ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 74' TO 94'
Manufacturer's Name ___
Type PVC Model No. ___
Diam. 2" Slot size ___ from 74 ft. to 94 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ___
Materials placed from 70 ft. to 94 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 70 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

PUMP: Manufacturer's Name ___
Type: ___ H.P. ___

WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 80 ft. below top of well Date 5/9/08
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ___
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ___
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TAN SAND FINE	0	63
BLACK SAND FINE	63	84
BLACK SAND & GRAVEL	84	94
TAN SAND & GRAVEL FINE	94	98

RECEIVED MAR 09 2009 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED MAY 14 2008 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 5/8/08 Completed Date 5/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 361

If TRAINEE, Driller's Licensed No. ___
Driller's Signature ___

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST. ~~PASCO~~
City, State, Zip PASCO WA. 99301
Contractor's Registration No. NELSOWD198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

9

Application No. G3-22491
Permit No. G3-22491 P

(1) OWNER: Name Robert Tippett #1 Address 3400 W. Clearwater Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin NW 1/4 of SE 1/4 NE 1/4 Sec 2 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one).... #1
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 127 ft. Depth of completed well 127 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 1½ in.
616 perforations from 97 ft. to 125 ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 510 ft.
Static level 80 ft. below top of well Date
Artesian pressure ..... lbs. per square inch Date
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley
Yield: 2451 gal./min. with 8 ft. drawdown after 4 hrs.
" " " "
" did not "send us a report" "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	38
Small gravel and sand	38	53
Course sand and gravel	53	68
Course sand and gravel	68	87
Water	90	
Course sand and gravel	87	90
Small gravel and black sand	90	110
Small gravel and black sand	110	125
16 inch Gopher Drive shoe		

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

2160 gpm
1160 ac. ft.
240 ac.

Work started 6-3, 1974 Completed 7-3, 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Ed [signature] (Well Driller)

License No. 0158 Date 7-3-74, 19

12/07/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71). 3

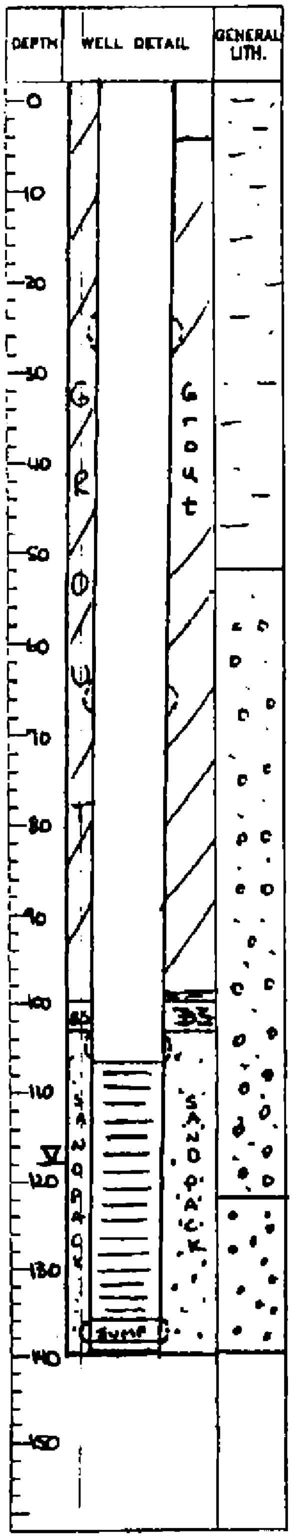
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco / Wastewater Treatment
Project No.: 89534

Well No.: MW-03
Boring No.: MW-03
Start Card No.: R-02816

Horizontal Coords: [1] ______ Ground Surface Elevation: ______
[2] ______ Top of PVC Well Casing: ______

Section 3 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY	
Total Borehole Depth:	139.6 ft bgs
Borehole Diameter:	8.5 - inches
Drilling Contractor:	Ponderosa Drilling - Spokane, WA
Driller(s):	Roger Kelly
Rig(s):	Reichdrill T625 Rotary/Circulation Medium: Air
Bit(s):	Tricone Roller

TIME LOG	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	1/20/95	1418	1/24/95	0930
Geophys. Logging	N/A			
Casing	1/26/95	0917	1/26/95	1109
Sand Pack	1/26	1130	1/26	1535
Grout	1/27	0824	1/27	1743
Bentonite Seal	1/26	1548	1/26	1610
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Schedule 80, 4-inch PVC, flush-threaded
Casing(s): B=blank; S=screen; EC=end cap

Depth (ft)	Casing	Elevation [1] (ft)
+3.3 - 106.7	B	
106.7 - 136.7	S	
136.7 - 139.15	B	
139.15 - 139.43	EC	

Screen Type/Size: Factory slot / 0.030
Surface Seal (ft):
Mfr/Mtrl/Qty: 0
Grout Seal (ft): 98.95 - 3 bgs
60 bags 22.4 ft³ Mfr/Mtrl/Qty: Cement - high early 95% Baroid Aquagel 4%
1 1/2 inch - 98.95 bgs
Bentonite Seal (ft): 103.5 ft to 100.0 ft
1.5 buckets Mfr/Mtrl/Qty: Enviroplug tablets 3/8-inch (8) buckets
Sand Pack (ft): 139.6 ft to 103.5 ft bgs
25 bags Mfr/Mtrl/Qty: Colorado Silica Sand #8-12 / 50# bags
Bottom Seal (ft:) N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED
DEPARTMENT OF ECOLOGY

Comments: ~~[1] Tennessee Coordinate System~~. [2] ~~Oregon State Coordinate System~~
Stainless steel centralizers @ 24 ft, 64 ft, 104 ft, and 137 ft bgs.

See Wellhead Detail for surface construction information.

Generated by: Terry McPhetridge Date: 1/26/95 Checked by: ______ Date: ______

RUST ENVIRONMENT & INFRASTRUCTURE

11

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

4782

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. A0 33458
UNIQUE WELL I.D. # None
Water Right Permit No.

(1) OWNER: Name City of Pasco Address Pasco, WA

(2) LOCATION OF WELL: County Franklin - SW 1/4 NW 1/4 Sec 3 T. 9 N., R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) E. Foster Wells Road

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☒

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☒ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ______ inches.
Drilled ______ feet. Depth of completed well ______ ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: ______" Diam. from ______ ft. to ______ ft.
Welded ☐ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______" Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☐
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☐ No ☐ To what depth? ______ ft.
Material used in seal ______
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level ______ ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Monitor well decommission:		
1. Pulled 4" PVC casing		
2. Tremmie grouted well with neat cement		
3. Pulled 10" steel conductor casing		
4. Poured concrete cap over well head		

Work Started 17 Mar, 1995 Completed 17 Mar, 1995

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME PONDEROSA DRILLING & DEVELOPMENT INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 6010 E. Broadway, Spokane, WA 99212

(Signed) [signature] (WELL DRILLER) License No. 0996

Contractor's Registration No. PONDEI*248JE Date 26 Mar, 1995

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

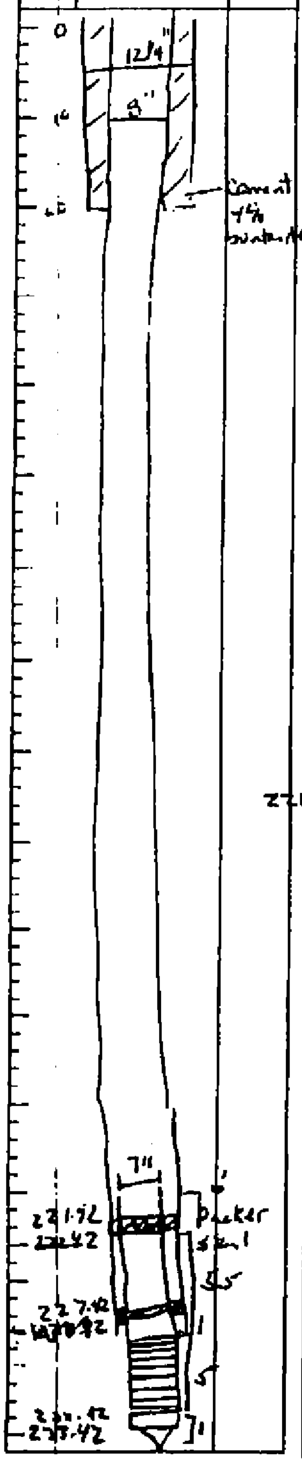
~~MONITORING WELL~~ CONSTRUCTION SUMMARY
Production Well

Project Name: Waste water Treatment - City of Pasco
Project No.:

Well No.: PW-1
Boring No.: —
Start Card No.: W-044461

Horizontal Coords:[1] T 9N, R30E, Sect 4
Ground Surface Elevation:
Top of PVC Well Casing:

DEPTH	WELL DETAIL	GENERAL LITH.



DRILLING SUMMARY

Total Borehole Depth:	233.42'
Borehole Diameter:	
Drilling Contractor:	Ponderosa
Driller(s):	Roger Kelly
Rig(s):	Bush T625
	Rotary/Circulating Med = Air
Bit(s):	12 1/2" Tricone
	7 7/8" Tricone Roller

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:	1-12-95	0807	1-13-95	1420
Air Rotary - Casing Drive				
12" Surface Casing	1-12-95	0847	1-12-95	0915
Geophys. Logging	—	—	—	—
Casing 8" steel	1-12-95	0847	1-13-95	1420
Casing				
Sand Pack None	—	—	—	—
Grout Surface Seal	1-17-95	1355	1-17-95	
Bentonite Seal				
Rubber				
Development (Start)	1-16-95	1543	1-16-95	1709
~~Development (Finish)~~				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: __

Casing Material: 8" steel
Casing welded every 20'
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation[1] (ft)
~~0-221.92~~ 0-222.42	B	-
221.92-222.42	Rub Seal	-
222.42-227.42	SB	-
227.42-232.42	S	-
233.42-232.42	EC	-

Screen Type/Size: 4" - 5' long Stainless Steel Johnson 8" 20 slot
Surface Seal (ft): 0-20 Cement 4% bentonite
Mfr/Mtrl/Qty: Cement, bentonite
Grout Seal (ft): None See above
Mfr/Mtrl/Qty:
Bentonite Seal (ft): 220.92-222.92 Rubber
Mfr/Mtrl/Qty: Rubber, Packer Seal 8"
Sand Pack (ft): None
Mfr/Mtrl/Qty:
Bottom Seal (ft): None
Mfr/Mtrl/Qty:

WELL DEVELOPMENT

Method: Air Lift Pneumatic Drop - Surge
Total Volume Purged: 3480 gal
Starting Level: 174.5 bgs
Finishing Level: 175.78 bgs

Stabilization Test Data

Date	Time	Volume	pH	Cond Spec	Temp (°C)	
1-16-95	1543	5	7.39	2.46 ms	17.1	V: 6.0 Sediment
	1551	60	8.16	2.653	15.5	MT
	1555	180	8.07	2.83 ms	15.4	ST
	1600	225	8.33	2.73 ms	16.4	ST
	1607	315	8.18	2.75	16.4	MT
	1618	495	8.11	2.60	15.8	clear some
	1624	270	8.44	2.70	16.5	"
	1634	450	8.28	2.70	16.4	"
	1645	495	8.21	2.69	16.5	"
	1701	720	8.23	2.70	16.5	"

Comments: [1]Tennison Coordinate System. [2]Oregon State Coordinate System
measured flow through pipe to 5 g bucket 10 sec + 9 sec = 30 g/min
loosing 10-20 other plugs 40-50 gpm

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

cad/forms/wellsum2.for

Generated by: Checked by: Date: 1/12 - 1/17

13

MONITORING WELL CONSTRUCTION SUMMARY

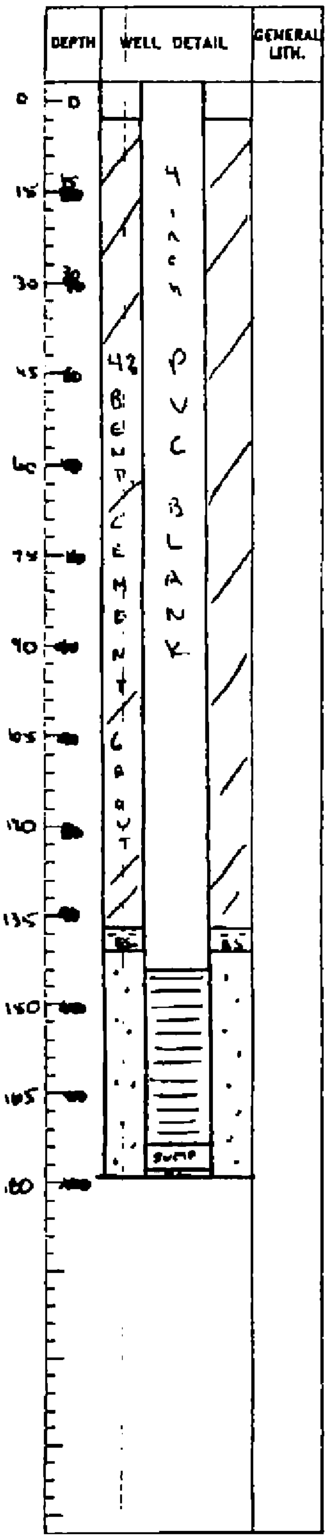
Project Name: City of Pasco - WWTP
Project No.: 89534

Well No.: MW-02a
Boring No.: MW-02a
Start Card No.: R-17349

Horizontal Coords: ¹ ____________ Ground Surface Elevation: ____________

² ____________ Top of PVC Well Casing: ____________

Section 4 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY	
Total Borehole Depth:	178 ft bgs
Borehole Diameter:	8.6-inches
Drilling Contractor:	Ponderosa Drilling - Spokane, WA
Driller(s):	Roger Kelly
Rig(s):	Rockwell T625 Air Rotary / Casing Drive
Bit(s):	7 7/8-inch Tricone Roller Bit

TIME LOG	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	2-20	1220	2-21	1352
Geophys. Logging	NA			
Casing	2-22	0610	2-22	0848
Sand Pack	2-22	0857	2-22	1238
Grout	2-23	0919	2-23	1348
Bentonite Seal	2-22	1243	2-22	1313
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:

Geologic Log: ✓ Geophysical Log: ___

Casing Material: Sched. 80, 4-inch Flush-threaded, PVC

Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation ¹ (ft)
+3.5 - 145.27	B	-
145.27 - 175.27	S	-
175.28 - 177.68	B	-
177.68 - 178.0	EC	-
-		-

Screen Type/Size: Wall Well Prepack Factory 30 slot

Surface Seal (ft):

Mfr/Mtrl/Qty:

Grout Seal (ft): 137.2 to 3.0 ft

Mfr/Mtrl/Qty: Ash Grove PC (94#) 37 bags w/ 6% Halliburton (100#) 2 bags

Bentonite Seal (ft): 141.2 to 137.2 ft

Mfr/Mtrl/Qty: Enviroplug/3/8 inch pellets/2 (50#) buckets

Sand Pack (ft): 178.0 to 141.2 ft

Mfr/Mtrl/Qty: CSSI/#8-12/12 bags (100#)

Bottom Seal (ft:) N/A

Mfr/Mtrl/Qty: ————

WELL DEVELOPMENT

Method:

Total Volume Purged:

Starting Level:

Finishing Level:

Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

Comments: ¹~~Yenison Coordinate System~~ ²Oregon State Coordinate System
STAINLESS STEEL CENTRALIZERS PLACED @ 177 ft, 144 ft, 104 ft, 64 ft, & 24 ft bgs.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

c:\forms\wellsum2.for

Date: ____
Checked by: ____
Date: ____
Generated by: ____

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

195739

WATER WELL REPORT

STATE OF WASHINGTON

14

Start Card No. W 22903
UNIQUE WELL I.D. #
Water Right Permit No. G3 28775P

(1) **OWNER:** Name Earl Blasdel Address 2001 East Foster Wells Rd Pasco

(2) **LOCATION OF WELL:** County Franklin NW 1/4 SW 1/4 Sec 4 T. 9 N., R 30 W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address)

(3) **PROPOSED USE:** ☐ Domestic ☒ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) **TYPE OF WORK:** Owner's number of well (If more than one)
☐ Abandoned ☒ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☒ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 220 6" feet. Depth of completed well 220 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from +1 ft. to 197 ft.
☒ Welded " Diam. from ft. to ft.
☐ Liner installed
☐ Threaded " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Huston
Type Stainless Steel Model No.
Diam. 16 Slot size 250 from 197 ft. to 217 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 175 ft. below top of well Date 11-2-93
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne Bowler
Yield: 1860 gal./min. with 20 ft. drawdown after 72 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	8	9
Sand Tan Silty	9	104
Sand Tan	104	135
Sand Tan Silty	135	162
Sand Black Silty	162	173
Sand Black water at 175'	170	180
Gravel Fine Sand Tan	180	181
Gravel 6" minus sand Tan	181	217
Gravel 6" minus sand Tan silty water shut off	217	220 6"

RECEIVED
NOV 24 1993
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 10-11, 19. Completed 11-2, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 W Argent Pasco
(Signed) Jim Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD181Q Date 11-2, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

15

Application No. G325178
Permit No. G3 25178P

(1) OWNER: Name J E Lentz Address

(2) LOCATION OF WELL: County FRANKlin NW4 SE ¼ SE ¼ Sec 4 T 9 N., R 30E W.M.

Bearing and distance from section or subdivision corner 1200' N - 1200' W of SE Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 242 ft. Depth of completed well 242 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16 " Diam. from +1 ft. to 216 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Low Carbon Shupd Model No. wellline
Diam. 16" Telescope Slot size 250 from 216 ft. to 237 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite + Sand
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 530 ft.
Static level 165 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Silt TAN Sandy	0	27
SAND Brown Fine Silty	27	145
SAND Black Fine Silty	145	147
SAND Black 4" Minus Gravel Silty	147	149
SAND Tan 1" minus gravel Silty	149	152
Silt TAN	152	164
SAND Black 2" minus gravel Silt Balls	164	168
SAND - Gravel 3" minus Brown Tan + Gray Water Bearing	168	196
Gravel + Sand Ringold Slow Water	196	212
Gravel 6" Minus Sand TAN ~~Water Bearing~~ Ringold	212	237
Gravel Sand Cemented	237	242
Basalt	242	
1600 gpm 333.3 AF/yr 160 Ac		
Eltopia 15'		

Work started 11-18, 1977 Completed 1-10, 1978

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc (Person, firm, or corporation) (Type or print)

Address 10036 W Argent

[Signed] Dave Wellins (Well Driller)

License No. 0659 Date 3-13, 1978

4/15/78

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

16

Application No. G3 23408
Permit No. TEST WELL

(1) OWNER: Name Jim Minnehan Address Highway East 410 Pasco, Wn. 99301

(2) LOCATION OF WELL: County Franklin SE ¼ SE ¼ Sec. 4 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 186 ft. Depth of completed well 186 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 12 " Diam. from 0 ft. to 184 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 3 in.
182 perforations from 171 ft. to 184 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Soft Depth of strata 40
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: did not install H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level. 540 520 ft.
Static level 146 ft. below top of well Date 7/31/74
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley
Yield: 1212 gal./min. with 16 ft. drawdown after 4 hrs.
" " " "
" did not give us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

[redacted] of test 7/30/74
B[redacted]st gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Top soil, sandy and brown	0	16
Silt, light gray	16	26
Silt , light gray	26	93
Sand fine silty, brown	93	104
Silt, brown, sandy	104	160
Sand, fine, white (water bearing)	160	164
Gravel, course, sand	164	186

12 inch Gopher Drive shoe

gpm ft.
400 ac.
1 acres
2140

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started JUNE 5 , 1974 Completed July 31 , 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Frank A. Crowe
(Well Driller)

License No. 0090 Date JULY 31, 1974 19

12/08/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

0129

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

17

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No ....

(1) OWNER: Name ________ Address ________

(2) LOCATION OF WELL: County ________ NE ¼ SE ¼ Sec 5 T 1 N., R 30

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 29
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16" inches.
Drilled 230 ft. Depth of completed well 230 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from 0 ft. to 230 ft.
Threaded ☐ ____" Diam. from ____ ft. to ____ ft.
Welded ☐ ____" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations 3/8 in. by 3 in.
____ perforations from ____ ft. to ____ ft.
900 perforations from 195 ft. to 230 ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ________
Type ________ Model No. ________
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ________
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? ____ ft.
Material used in seal Puddled Clay/Bent.
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ________ Depth of strata ________
Method of sealing strata off ________

(7) PUMP: Manufacturer's Name ________
Type: ________ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 166 ft. below top of well Date ____
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ________ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ________
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ________
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand	0	190
Water at 155		
Sand Gravel Cobble	190	230
Bed Rock	230	—

Work started Dec 20, 1923. Completed Mar 20, 1924

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME St George Drilling Co. (Person, firm, or corporation) (Type or print)
Address 701 So. 45th Ave
[Signed] Peter L. St George (Well Driller)
License No. 0482 Date 3-29-, 1974

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

18

WATER WELL REPORT

ECOLOGY Original & 1st copy Ecology 2nd copy owner 3rd copy driller

Construction/Decommission (x in circle) 125085

☒ Construction

○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ____

CURRENT Notice of Intent No W 160 6184

Unique Ecology Well ID Tag No AHK 278

Water Right Permit No ____

Property Owner Name Earl Bluschel

Well Street Address E Foster Wells Rd + Commercial DR

City Pasco County Franklin

Location SW 1/4 1/4 SE 1/4 Sec 5 Twn 9N R 30 EWM (circle one) or WWM

Lat/Long (s t r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No ____

PROPOSED USE ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK Owner s number of well (if more than one) ____
☒ New Well ☐ Reconditioned *Method* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS Diameter of well 8 inches, drilled 2036 ft
Depth of completed well 2036 ft

CONSTRUCTION DETAILS

Casing Installed ☒ Welded 8 Diam from +1 1/2 ft to 194 ft
☐ Liner installed ____ Diam from ____ ft to ____ ft
☐ Threaded ____ Diam from ____ ft to ____ ft

Perforations ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in by ____ in and no of perfs ____ from ____ ft to ____ ft

Screens ☒ Yes ☐ No ☐ K Pac Location 193
Manufacturer s Name Cook
Type Stainless Model No ____
Diam 6T Slot Size 40 from 194 ft to 199 ft
Diam ____ Slot Size ____ from ____ ft to ____ ft

Gravel/Filter packed ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ____ ft to ____ ft

Surface Seal ☒ Yes ☐ No To what depth? 20 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP Manufacturer s Name ____
Type ____ H P ____

WATER LEVELS Land surface elevation above mean sea level ____ ft
Static level 162 ft below top of well Date 10-29-02
Artesian pressure ____ lbs per square inch Date ____
Artesian water is controlled by ____ (cap valve etc)

WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes by whom? ____
Yield ____ gal /min with ____ ft drawdown after ____ hrs
Yield ____ gal /min with ____ ft drawdown after ____ hrs
Yield ____ gal /min with ____ ft drawdown after ____ hrs
Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal /min with ____ ft drawdown after ____ hrs
Airtest 50 gal /min with stem set at 190 ft for 4 hrs
Artesian flow ____ g p m Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered
(USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Sand Tan	0	8
Sand Tan silty	8	37
Sand Tan	37	153
Sand Black gravel	153	163
Gravel, Sand Tan Water Bearing	163	200
Sand Tan Gravel silty	200	2034 1/2

RECEIVED DEC 23 2002

Start Date 10-18-02 Completed Date 10-29-02

WELL CONSTRUCTION CERTIFICATION I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson

Driller/Engineer/Trainee Signature Jim Nelson

Driller or Trainee License No 361

If trainee, licensed driller s Signature and License no ____

Drilling Company Nelson Well Drilling INC

Address 2505 W Court

City State Zip Pasco WA 99301

Contractor s Registration No NELSOWD 198C8 Date 11-7-02

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

7916

19

Start Card No. [redacted]

STATE OF WASHINGTON

Water Right Permit No. R

(1) OWNER: Name Herb Rode Address Collins.

(2) LOCATION OF WELL: County ~~Benton~~ Franklin SE ¼ SE ¼ Sec 5 T. 9 N., R 30 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 240 feet. Depth of completed well 240 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 217 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ]
Threaded [ ] " Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 46 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 164 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 60 gal./min. with stem set at 220 ft. for 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Cement Gravel 2Kt 7/8	0	47
Brown clay	47	163
Ash	163	174
Brown + Gray clay	174	217
Brocken Redsh Brown Basalt	217	221
Brocken Black Basalt Bearing water	221	240

RECEIVED
JAN 18 1995
DEPARTMENT OF ECOLOGY
CENTRAL REGIONAL OFFICE

RECEIVED
DEC 2 1992
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work started 10/31/92, 19. Completed , 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 201 So 45 AVE W. Richland
(Signed) Pete E St George License No. 0483 (WELL DRILLER)
Contractor's Registration No. 601-048-715 Date 11-4-92, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 18

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

31791

20

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W-28406
UNIQUE WELL I.D. # ACE-623
Water Right Permit No.

(1) OWNER: Name David Vooge. Address 1532 North 14th Ave, Pasco, WA 99301

(2) LOCATION OF WELL: County Franklin. NE 1/4 NE 1/4 Sec 6 T. 9 N., R. 30 E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 124 feet. Depth of completed well 124 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6" Diam. from +1 ft. to 124 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 87 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 35 gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand	0	16
Brown Sand Gravel	16	26
Brown Sand	26	68
Brown Sand Gravel	68	87
Brown Sand Gravel/Moist	87	105
Brown Sand Gravel/Bearing Water	105	124

RECEIVED MAR 17 1997 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED JAN 22 1997 DEPARTMENT OF ECOLOGY CENTRAL REGIONAL OFFICE

Work Started 8/20/96, 19. Completed 8/20/96, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 201 S 45 E AVE W. Richland
(Signed) [signature] (WELL DRILLER) License No. 0483

Contractor's Registration No. 061 C48-715 Date 8/20/96, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No.
Permit No. DOMESTIC

(1) OWNER: Name ROBERT TIPPETT Address 3400 W. Clearwater, Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin SW ¼ SE ¼ Sec 6 T 9 N., R 30 E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic XX Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well XX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 101 ft. Depth of completed well 101 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 101 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded XX " Diam. from ft. to ft.

Perforations: Yes ☐ No XX
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No XX
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No XX Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes XX No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ XX No ☐ XX
Type of water XXX Depth of strata
Method of sealing strata off XXX

(7) PUMP: Manufacturer's Name XXXXXXXXXXXX
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 78 ft. below top of well Date 3/3/77
Artesian pressure XXX lbs. per square inch Date XX
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No XXXXXXXXXXXX
Yield: gal./min. with ft. drawdown after hrs.

ESTIMATED 15 GAL/ MIN. BY DRILLER

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
XXXXXXXXXXXXXXXXXXXXXXXXXXXX					

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Surface seal	0	20
Top Soil	0	2
Sand and Gravel	2	16
CEmented gravel	16	38
Fine heaving sand, some water	38	42
Sand, cemented	42	58
Sand and gravel	58	82
Sand, gravel and water	82	101

6 INCH BLUE CROWN DRIVE SHOE

RECEIVED
MAR 8 1977
DEPT. OF ECOLOGY
CENTRAL REGIONAL OFFICE

RECEIVED
APR - 6 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 3/1, 19 77 Completed 3/4, 19 77

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONSTRUCTION CO., INC. (Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] (Well Driller)

License No. 0564 Date 3/6, 19 77

4/8/77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. .... Domestic

(1) OWNER: Name Robert Tippett Address 3400 W. Clearwater, Kennewick, Wa. 99336

(2) LOCATION OF WELL: County Franklin — SW ¼ SE ¼ Sec 6 T. 9 N., R30E W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic xx Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened xx Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 53 ft. Depth of completed well 154 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 154 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded xx " Diam. from ft. to ft.

Perforations: Yes ☐ No xx
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes xx No ☐
Manufacturer's Name Johnson
Type 40 slot Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No xx Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes xx No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No xx
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name xxxxx
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 445 ft.
Static level 78 ft. below top of well Date 6/17/77
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
XXXXXXXXXXXXXXXXX

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
		XXXXXXXXXXXXXX			

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
CEMENTED SAND AND GRAVEL	101	114
Cemented Sand and Gravel with Clay	114	118
Cemented sand & gravel	118	140
Sand, small gravel	140	152
White clay and sand	152	154
5 foot Johnson 40 slot screen		

Work started 6/6 19 77 Completed 6/16 19 77

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC.
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 611, PASCO, WASH. 99301

[Signed] HD Brown
(Well Driller)

License No. 0569 Date June 17 19 77

1/24/77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

22

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

9421
Start Card No. [redacted]

Water Right Permit No. ______

(1) OWNER: Name Gordon Bradshaw Address ______

(2) LOCATION OF WELL: County ~~Benton~~ Franklin SE ¼ SE ¼ Sec 6 T 9 N., R 30 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 245 feet. Depth of completed well 245 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 215 ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______ " Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 60 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 155 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.))

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 35 gal./min. with stem set at 200 ft. for 3 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand Gravel	0	41
Brown clay	41	161
Brown Sand Gravel	161	174
Blue Gray clay	174	215
Brocken Redsh Brocken Basalt Bearing water	215	245

RECEIVED
JAN 18 1995

Work started 6-28-93, 19. Completed ______, 19 ______

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St. George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 206 S 45 AVE. W. Richland
(Signed) Pete E. St. George (WELL DRILLER) License No. 0483
Contractor's Registration No. 601-048-715 Date 6-28-93, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

454131

23

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

ECOLOGY

Construction/Decommission *("x" in circle)*

(X) Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

CURRENT Notice of Intent No. WE14443

Unique Ecology Well ID Tag No. BCF 552

Water Right Permit No. ______

Property Owner Name Rogers Potato

Well Street Address Railroad Ave

City Pasco County 11-Franklin

Location SE 1/4-1/4 SE 1/4 Sec 6 Twn 9N R 30 EWM or WWM (circle one)

Lat/Long (s, t, r Still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. 113110357

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned ☐ Deepened *Method:* ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 148 ft.

Depth of completed well 144 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +2 ft. to 144 ft.

☐ Liner installed ______" Diam. from ______ ft. to ______ ft.

☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______

Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite chips

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 87.5 ft. below top of well Date 4/24/12

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.

Airtest 50 gal./min. with stem set at 140 ft. for 2 hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water 65 Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Sand	0	24
Black Course Sand, Gravel	24	55
Gravel, Sand	55	146
Tan clay	146	148

RECEIVED
MAY 22 2012
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 4/20/12 Completed Date 4/24/12

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Forest Hoopes

Driller/Engineer/Trainee Signature Forest Hoopes

Driller or trainee License No. 2910

If TRAINEE, Driller's Licensed No. ______

Driller's Signature ______

Drilling Company Blue Star Enterprises

Address 2018 Butler Loop

City, State, Zip Richland WA. 99354

Contractor's Registration No. Bluesen 942RM Date 4-26-12

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

24

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

57787

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W-087946
UNIQUE WELL I.D. # ACX-249
Water Right Permit No. ______

(1) OWNER: Name Robert Michael McKee Address ______

(2) LOCATION OF WELL: County Benton SE 1/4 SE 1/4 Sec 8 T. 9 N., R 30 W.M. R

(2a) STREET ADDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 225 feet. Depth of completed well 225 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 205 ft.
Welded ☒ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______" Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 161 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 50 gal./min. with stem set at 220 ft. for 2 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand Gravel	0	2
cemented Gravel	2	37
Brown clay	37	160
Ash with Gravel	160	175
Brown & Gray clay	175	205
Redish Brown Brocken Porse Basalt Bearing water Apx 50 Gpm	205	225

RECEIVED
AUG - 7 1998
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work Started 7/2/98, 19. Completed 7/2/98, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 701 S 45 AVE W Richland

(Signed) [signature] License No. 0483
(WELL DRILLER)

Contractor's Registration No. 601048-715 Date 7/8/98, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

25

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 12306
Permit No. G3-00932

(1) OWNER: Name Robert G. Tippett Address 3411 Clearwater Kennewick

(2) LOCATION OF WELL: County Franklin SE ¼ SE ¼ Sec. 6 T. 9 N., R. 30 W.M.

Bearing and distance from section or subdivision corner 1240' West 1240' N of SE Corner Section

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 145 ft. Depth of completed well 132 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ 12" Diam. from 127 ft. to 132 ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations 3/8 in. by 3 in.
600 perforations from 105 ft. to 132 ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Puddle Clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level 459 ft.
Static level 97 ft. below top of well Date .....
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Fosseen

Yield: gal./min.	with ft. drawdown	after hrs.
1000	24	5
"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
30 sec	recovery				

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water 57 Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand	0	50
Sand with ~~Sand~~ Small Gravel	50	97
Gravel with Sand	97	110
Heavy Gravel	110	132
Water 105		
Clay	132	145

900 gpm
1200 gpm AF
675 A
135

Work started 8-13, 19 73 Completed 9-5, 19 73

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME St George Drilling Co. (Person, firm, or corporation) (Type or print)

Address 701 S045 W Richland Wash

[Signed] [signature] (Well Driller)

License No. 223-02-6920 Date 9-12, 1973

OK
TMO
10-4-73

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

26

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name USBR, Drainage Observation Well

(2) LOCATION OF WELL: County .... SE ¼ SE ¼ Sec 21 T 10 N., R 30 W.M.

Bearing and distance from section or subdivision corner 29' W. - 200' N. of SE Cor.

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well .... inches.
Drilled .... ft. Depth of completed well .... ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ...." Diam. from .... ft. to .... ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☐ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☐
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☐ No ☐ To what depth? .... ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level ... 604.9 ft.
Static level .... ft. below top of well Date ....
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand, fine	0	20
Sand w/clay	20	51

Work started ...., 19 .... Completed 4/14, 1966

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Henry Bach (Person, firm, or corporation) (Type or print)

Address Yakima

[Signed] .... (Well Driller)

License No. .... Date ...., 19 ....

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

27

STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name GARY [redacted] Pfister Address Falls Rd. Pasco, Wn.

(2) LOCATION OF WELL: County Franklin — NW ¼ SW ¼ Sec 22 T 10 N., R 30 E W.M.
Bearing and distance from section or subdivision corner Eltopia

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 410 ft. Depth of completed well 410 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 203 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level 700 ft.
Static level 218 ft. below top of well Date 1/26/77
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand& Clay	0	185
fractured basalt	185	203
black basalt 9	203	350
black porous basalt&clay seams water bearing 1-2 gpm	350	363
black basalt	363	375
decomposed basalt& sandstone waterbearing 18 to 20 gpm.	375	410

RECEIVED
FEB 11 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Copy

Eltopia

Work started ......, 19...... Completed ......, 19......

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H&H DRILLING INC.
(Person, firm, or corporation) (Type or print)

Address Rt. 2 Box 13H Richland Wa.

[Signed] James E. Hoag
(Well Driller)

License No. 196 Date 1/26, 1977

2/11/77

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY 070-28

28

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

154583

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ______

CURRENT Notice of Intent No. W 179665
Unique Ecology Well ID Tag No. AKW 941
Water Right Permit No. ______
Property Owner Name Jerry Ossman
Well Street Address 40 Falls Rd
City Pasco County: Franklin
Location SE 1/4-1/4 SE 1/4 Sec 22 Twn 10N R 30 (EWM) *circle one* or WWM
Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______
Tax Parcel No. ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 410 ft.
Depth of completed well 410 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from +1 ft. to 192¼ ft.
☒ Liner installed 4½" Diam. from 172 ft. to 410 ft.
☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used SAW
SIZE of perfs 1/8 in. by 6 in. and no. of perfs 80 from 370 ft. to 410 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 19 ft
Materials used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 174 ft. below top of well Date 8/31/04
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 40 gal./min. with stem set at 380 ft. for 1 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
SILT & BROWN SAND	0	6
BROWN SAND	6	51
SILTY TAN CLAY	51	76
FINE BROWN SAND	76	88
TAN CLAY	88	99
BROWN SAND	99	108
STICKY TAN CLAY	108	134
RED SILTSTONE	134	152
TAN CLAY	152	153
RED SILTSTONE	153	191
BLACK BASALT MED	191	234
PORUS BLACK BASALT	234	268
PORUS RED & BLACK BASALT	268	276
BLACK BASALT HARD	276	341
PORUS RED & BLACK	341	348
" BLACK BASALT	348	370
" BLACK BASALT &	370	
BLUE SILTSTONE W/H2O	3	404
HARD BLACK BASALT	404	410

RECEIVED SEP 15 2004 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 8/26/04 Completed Date 8/31/04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jeremy Rude
Driller/Engineer/Trainee Signature [signature]
Driller or Trainee License No. 2651

If trainee, licensed driller's Signature and License no. ______

Drilling Company Nelson Well Drilling
Address 2505 W Court
City, State, Zip Pasco WA 99301
Contractor's Registration No. NELSOCO 0 198CQ Date 9-4-04

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 4/01)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

29

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

CURRENT Notice of Intent No. W179802

Unique Ecology Well ID Tag No. AKO-582

Water Right Permit No. ______

Construction/Decommission *("x" in circle)*

☒ Construction

○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ______

156086

Property Owner Name MIKE MCBEE J

Well Street Address 33826 2181 PR SE

City KENNEWICK County: BENTON

Location NE 1/4- 1/4 SE 1/4 Sec 22 Twn 10N R 30 EWM *circle one* or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 157 ft.

Depth of completed well 157 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from +1 ft. to 24 ft.

☐ Liner installed 4" Diam. from -7 ft. to 157 ft.

☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No

Type of perforator used SAW

SIZE of perfs 1/8 in. by 12 in. and no. of perfs 33 from 137 ft. to 157 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______

Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft

Materials used in seal BENTONITE

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 36 ft. below top of well Date 9-29-04

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap,valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.

Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.

Airtest 30 gal./min. with stem set at ______ ft. for ______ hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water 62° Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
SAND + COBBLES	0	19
BLACK SAND	19	24
GRAY BASALT	24	106
BLACK BASALT SOFT	106	118
GRAY CLAYSTONE	118	129
BLACK BASALT SOFT	129	141
BROWN BASALT	141	145
GRAY BASALT	145	160

DEPT. OF ECOLOGY Received OCT 1 2004 CENTRAL REGION OFFICE

Start Date 9-28-04 Completed Date 9-29-04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☒ Trainee Name (Print) BILL MCHAFFIE JR.

Driller/Engineer/Trainee Signature [signature]

Driller or Trainee License No. 2724T

If trainee, licensed driller's Signature and License no. [signature] 2094

Drilling Company FIVE STAR DRILLING

Address 36301 HWY 12

City, State, Zip DAYTON, WA 99328

Contractor's Registration No. FIVESDX077MB Date 9-30-04

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 4/01)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

DEPARTMENT OF ECOLOGY State of Washington

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

CURRENT

Notice of Intent No. W355490

Unique Ecology Well ID Tag No. BHW 074

Water Right Permit No. NO

Property Owner Name Kerry Calaway

Well Street Address 2160 Falls Rd.

City Pasco County Franklin

Location NE 1/4-1/4 SE 1/4 Sec 23 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____

Long Deg ____ Long Min/Sec ____

Tax Parcel No. (Required) 124610096

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ____

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 200 ft.

Depth of completed well 200 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from +2 ft. to 116 ft.

☐ Liner installed ____" Diam. from ____ ft. to ____ ft.

☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ______

Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite Dry

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.

Static level 78 ft. below top of well Date 10/27/14

Artesian pressure ____ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest 30 gal./min. with stem set at 198 ft. for 1 hrs.

Artesian flow ____ g.p.m. Date 10/27/14

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown Sand	0	38'
Brown Sticky Sand & Clay	38'	55'
Black Sand & Gravel	55'	67'
Brown Clay Soft	67	111'
Brown Clay & Sandstone Tough	111'	109'
Brown Clay & Broken		
Brown Basalt Soft	109'	113'
Brown Broken Basalt	113'	170'
Little H2O 1-2GPM		
Hard Gray Basalt	170'	173'
Black Soft Basalt	173'	179'
Broken Brown Basalt		
Little water 5-6GPM	179'	192'
Broken Brown & Red		
Basalt Good water 25GPM	192'	198'
Broken Brown & Red Clay	198'	200'

NOV [illegible] 2014

Start Date 10/27/14 Completed Date 10/27/14

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☒ Trainee Name (Print) Cole

Driller/Engineer/Trainee Signature D. Cole

Driller or trainee License No. 3165T

IF TRAINEE: Driller's License No: 1267

Driller's Signature: Mitch Markess

Drilling Company D C Drilling Inc

Address PO Box 1269

City, State, Zip Royal City WA 99357

Contractor's Registration No. DCDRICD875OF Date 10/27/14

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ____

CURRENT

Notice of Intent No. WE-26153

Unique Ecology Well ID Tag No. BJA-054

Water Right Permit No. –

Property Owner Name Dennis Beus

Well Street Address NKA E. Vineyard Dr.

City Pasco County Franklin

Location NE1/4-1/4 NE1/4 Sec 28 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long
Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____

Tax parcel No. (Required) 124650013

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 400 ft.
Depth of completed well 400 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from +1½ ft. to 176 ft.
☒ Liner installed 4½" Diam. from -140 ft. to 400 ft.
☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used SAW
SIZE of perfs 1/8 in. by 6 in. and no. of perfs 180 from 360 ft. to 400 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ____
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 50 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 176 ft. below top of well Date 12-9-16
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 50+ gal./min. with stem set at 380 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

RECEIVED
JAN 12 2017
Department of Ecology
Eastern Washington Office

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown Sand + Silt	0	50
Brown + Tan Clay	50	73
Brown Silt	73	90
Tan Clay	90	115
Brown Silty Clay	115	172
Black Basalt Soft	172	212
Black Basalt Med	212	230
Black Porus + Green Clay	230	236
Black Basalt Hard	236	322
Red Basalt	322	328
Black Basalt Med	328	372
Red Porus Basalt	372	381
Black Porus Basalt w/ Blue Scoria	381	390
Black Basalt Soft w/ fractures	390	400

RECEIVED

Start Date 12-6-16 Completed Date 12-9-16

Department of Ecology
Eastern Washington Office

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name Josh Burns
Driller/Engineer/Trainee Signature JB
Driller or trainee License No. 2866
IF TRAINEE: Driller's License No: ____
Driller's Signature: ____

Drilling Company Nelson Drilling LLC
Address 600 W. Vineyard Dr.
City, State, Zip Pasco Wa. 99301
Contractor's Registration No. NELSODL895WM Date 12-9-16

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

32

WATER WELL REPORT
STATE OF WASHINGTON

Application No.
Permit No.

(1) OWNER: Name Tom Crylez Address

(2) LOCATION OF WELL: County Franklin SE ¼ NE ¼ Sec 28 T 10 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 8" ft. Depth of completed well 140 8" ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from +1 ft. to 126 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ 4½ " Diam. from 102 ft. to 140 8 ft.

Perforations: Yes ☒ No ☐
Type of perforator used Saw
SIZE of perforations 1/8 in. by 6 in.
60 perforations from 118 ft. to 140 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 25 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 41 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 25 gal./min. with 75 ft. drawdown after 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand Tan silty	0	14
Sand Black	14	17
Sand Tan silty wet	17	42
Sand Tan silty	42	66
Sand Brown	66	71
Clay Tan	71	115
Claystone Brown water Bearing	115	140

RECEIVED
JUN 23 1986
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 5-21, 1986. Completed 5-28, 1986

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc (Person, firm, or corporation) (Type or print)

Address 10036 Wargut Pasco

[Signed] James Nelson (Well Driller)

License No. 361 Date 5-29, 1986

6/24/86

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

33

WATER WELL REPORT 506696

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

DEPARTMENT OF ECOLOGY State of Washington

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

CURRENT

Notice of Intent No. WE-17320

Unique Ecology Well ID Tag No. BHT-030

Water Right Permit No. ______

Property Owner Name Brent Preston

Well Street Address 52 E. Vineyard Dr.

City Pasco County Franklin

Location NW1/4-1/4 SE1/4 Sec 29 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____

Long Deg ____ Long Min/Sec ____

Tax Parcel No. (Required) 124660040

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 240 ft.

Depth of completed well 237 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +1.5 ft. to 177 ft.

☒ Liner installed 6" Diam. from -7 ft. to 237 ft.

☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☒ Yes ☐ No

Type of perforator used SAW

SIZE of perfs 1/8 in. by 8 in. and no. of perfs 90 from 210 ft. to 234 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____

Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 20 ft.

Material used in seal Bentonite

Did any strata contain unusable water? ☒ Yes ☐ No

Type of water? High Nitrate Depth of strata 120-160

Method of sealing strata off Drive Shoe + Casing

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.

Static level 132 ft. below top of well Date 11-1-13

Artesian pressure ____ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest 100 gal./min. with stem set at 230 ft. for 2 hrs.

Artesian flow ____ g.p.m. Date ______

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Tan Silt + Clay	0	28
3/8" Gravel + Black Sand	28	63
3/8" Gravel + Tan Sand	63	78
Brown Sandstone 'Hard'	78	92
Tan Siltstone	92	115
Gravel + Tan Sand	115	140
1" Gravel + Sand	140	160
Cemented Sand + Gravel	160	175
Black Basalt	175	220
Porous Bslt + Green Clay	220	236
Airtest		
100gpm @ 230		
50gpm @ 200		

RECEIVED MAR 14 2014 Department of Ecology Eastern Regional Office

Start Date 10-29-13 Completed Date 11-1-13

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jeff Burns

Driller/Engineer/Trainee Signature [signature]

Driller or trainee License No. 2866

IF TRAINEE: Driller's License No:

Driller's Signature:

Drilling Company Nelson Drilling, LLC

Address 600 W. Vineyard Dr.

City, State, Zip Pasco, WA. 99301

Contractor's Registration No. NELSODL895WA Date ______

 If you need this document in an alternate format, please call the Water Resources Program at 360-407-6872. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

34

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

186997

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 045196
UNIQUE WELL I.D. # ____
Water Right Permit No. ____

(1) **OWNER:** Name Mike Franklin Address ____

(2) **LOCATION OF WELL:** County [illegible] Franklin — Ne 1/4 Se 1/4 Sec 29 T. 10 N., R 30 W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) ____

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) **TYPE OF WORK:** Owner's number of well (If more than one) ____
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 160 feet. Depth of completed well 160 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from +1 ft. to 120 ft.
Welded ☒ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐ ____ " Diam. from ____ ft. to ____ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 75 ft.
Material used in seal Bentonite cement
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ____ ft.
Static level 8 ft. below top of well Date ____
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 15 gal./min. with stem set at 160 ft. for 2 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Ash	0	20
Brown Sand Gravel / Bearing water	20	65
Gray clay	65	120
Brocken Black Basalt Bearing water	120	160

RECEIVED
SEP 12 1994
DEPARTMENT OF ECOLOGY
REGION OFFICE

RECEIVED
MAY 15 2000
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 7/20/94, 19. Completed ____, 19 ____

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 701 South 45 AVE W. Richland
(Signed) [signature] (WELL DRILLER) License No. 0483
Contractor's Registration No. 601-048-714 Date 8-30-94, 19 ____

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

Please print, sign and return to the Department of Ecology

35

Water Well Report

Original – Ecology, 1st copy – owner, 2nd copy – driller

Construction/Decommission 200073

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

Current Notice of Intent No. W 224175

Unique Ecology Well ID Tag No. ALC 743

Water Right Permit No. ______

Property Owner Name Brent Preston

Well Street Address 502 E Vineyard

City Pasco County Franklin

Location ___1/4-1/4 SW 1/4 Sec 29 Twn 10 R 30 EWM ☒ or WWM ☐ circle one

Lat/Long (s, t, r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 363 ft.
Depth of completed well 363 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +1 ft. to 170± ft.
☒ Liner installed 6 PVC Diam. from 163 ft. to 363 ft.
☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used SAW
SIZE of perfs 1/8 in. by 6 in. and no. of perfs 45 from 351 ft. to 363 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 170± ft.
Material used in seal BENTONITE & CASING
Did any strata contain unusable water? ☒ Yes ☐ No
Type of water? HIGH NITRATES Depth of strata 127 - 168
Method of sealing strata off CASING & BENTONITE

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 151 ft. below top of well Date 5/5/06
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 75 gal./min. with stem set at 275 ft. for 3 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TAN SAND & SILT	0	34
TAN CLAY	34	46
WHITE CLAY	46	49
WHITE CLAY & GRAVEL	49	57
TAN CLAY & GRAVEL	57	68
TAN SILT	68	73
TAN CLAY	73	96
CEMENTED BROWN SAND	96	106
BROWN SILTSTONE	106	109
BROWN SILTSTONE & ROCKS	107	127
GRAVEL TAN SAND	127	168
PORICE BLK BASALT	168	169
BLACK BASALT	169	187
PORICE BLACK BASALT	187	198
BLACK BASALT HARD	198	231
PORICE BLACK BASALT	231	–
W/ BLUE SILTSTONE & CLAY	–	242
PORICE RED & BLACK BASALT	242	246
PORICE BLACK H_2O 136PM	246	249
BLACK BASALT HARD	249	335
BLUE CLAY	335	351
GREENISH GREY SAND H_2O	351	356
BLACK BASALT HARD	356	363

RECEIVED
JUL 19 2006
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 5/1/06 Completed Date 5/5/06

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Driller/Engineer/Trainee Name (Print) JEREMY L RUSS
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2691

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST
City, State, Zip PASCO WA. 99301
Contractor's Registration No. NELSOWD 198 CA Date 5/5/06

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 2/03)

36

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

37745

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 050068
UNIQUE WELL I.D. # ABX 793
Water Right Permit No.

(1) OWNER: Name BALCOM+MOE INC Address PO BOX 968 PASCO, WA. 99301

(2) LOCATION OF WELL: County FRANKLIN - NW 1/4 SE 1/4 Sec 30 T. 10 N., R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 120 feet. Depth of completed well 120 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 199 ft.
Welded ☑ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☑ No ☐
Type of perforator used
SIZE of perforations 1/4 in. by 1/2 in.
150 perforations from 105 ft. to 115 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☑
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 75 ft. below top of well Date 3-18-96
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 40 gal./min. with stem set at 100 ft. for 6 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand - Brown	0	8'
Gravel & Sand	8'	13'
Sand	13'	32'
Sand & Gravel	32'	50'
Sand	50'	54'
Sand & Gravel Trace of Water	54'	93'
Clay, Brown	93'	96'
Sand & Gravel water Bearing 40 GPM	96'	120'

RECEIVED
APR - 3 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 3-15-96, 19. Completed 3-19-96, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Statewide Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2839 W Kenn #330 Kenn WA 99336
(Signed) [signature] (WELL DRILLER) License No. 2343

Contractor's Registration No. STATEWD 077 DQ Date 4-96, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

37

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

37751

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W050074
UNIQUE WELL I.D. # ABY-801
Water Right Permit No.

(1) OWNER: Name Maury Balcom Address PO Box 968 Pasco WA 99301

(2) LOCATION OF WELL: County Franklin NW 1/4 SE 1/4 Sec 30 T 10 N R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (if more than one) 2
☐ Abandoned ☑ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☐ Cable ☑ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 118 feet. Depth of completed well 118 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 118 ft.
☑ Welded
☐ Liner installed
☐ Threaded
Diam. from ft. to ft.
Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☑
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 20'+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 50' ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time Water Level Time Water Level Time Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 40 gal./min. with stem set at 100 ft. for 3 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand - Brown	0'	43'
Silt, Clay & Sand	43'	72'
Sand, Some Gravel - (Trace of water)	72'	97'
Sand & Gravel (Water Sand)	97'	103'
Course Gravel (40 GPM)	103'	118'

Work Started 4-3-96 Completed 4-5-96

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Stallcup Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2337 W 15th Ave Kenn WA 99336
(Signed) [signature] License No. 2343
Contractor's Registration No. STALLWD017DG Date 4-96 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

38

UNRECORDED

WATER WELL REPORT
STATE OF WASHINGTON

File Original and First Copy with the Division of Water Resources
Second Copy — Owner's Copy
Third Copy — Driller's Copy

Application No. ....
Permit No. ....

(1) OWNER:
Name El Paso Natural Gas Company
Address P.O. Box 1526
Salt Lake City 10, Utah

(2) LOCATION OF WELL:
County Franklin Owner's number, if any—
¼ SE ¼ Section 30 T. 10 R. 30 E W.M.
Bearing and distance from section or subdivision corner

Elev 508

Eltopia

(3) TYPE OF WORK (check):
New Well ☐ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED: Threaded ☐ Welded ☒
10 " Diam. from 0 ft. to 163 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(7) PERFORATIONS: Perforated? ☐ Yes ☐ No
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(8) SCREENS: Well screen installed ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:
Was well gravel packed? ☐ Yes ☐ No Size of gravel:
Gravel placed from ft. to ft.
Was a surface seal provided? ☐ Yes ☐ No To what depth? ft.
Material used in seal—
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? Depth of strata
Method of sealing strata off

(10) WATER LEVELS:
Static level ft. below land surface Date
Artesian pressure lbs. per square inch Date
Water is controlled by
(Cap, valve, etc.)

(11) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No

(12) WELL LOG: Diameter of well inches.
Depth drilled ft. Depth of completed well ft.

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sandy soil	2	2
Sand & gravel	37	39
Sandy gray clay w/gravel	12	51
Light brown clay	7	58
Hard sandy clay	10	68
Light brown clay	15	83
Gravel w/some sand	8	91
Cement gravel	10	101
Washed gravel & sand	15	116
Gravel & sand	12	128
sand w/little gravel	36	164
Broken rock	3	167
Black broken basalt	42	209
Black basalt & blue clay	15	224
Dark gray rock (hard)	46	270
Light " " "	15	285

Work started 10-3 1966. Completed 11-14 1966

(13) PUMP:
Manufacturer's Name
Type: H.P.

Well Driller's Statement:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Moore & Anderson
(Person, firm, or corporation) (Type or print)
Address P.O. Box 1228, Walla Walla, Wash.
[Signed] [signature]
(Well Driller)
License No. Date 12-12, 1966

(USE ADDITIONAL SHEETS IF NECESSARY)

F. No. 7356--(Rev. 9-62)—8-62—5M. 75168.

39

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

(4) – 13

WATER WELL REPORT
STATE OF WASHINGTON

Application No

Permit No 63270-30P

(1) OWNER Name Burlington Northern Address

(2) LOCATION OF WELL County — SW ¼ ~~SW~~ SE¼ ¼ Sec 31 T 10 N R 30 W M

Bearing and distance from section or subdivision corner

(3) PROPOSED USE Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK Owner's number of well (if more than one)
New well ☒ Method Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS Diameter of well 16 inches
Drilled 170 ft Depth of completed well 170 ft

(6) CONSTRUCTION DETAILS
Casing installed 16 Diam from +1 ft to 140 ft
Threaded ☐ Diam from ft to ft
Welded ☐ Diam from ft to ft

Perforations Yes ☐ No ☐
Type of perforator used
SIZE of perforations in by in
perforations from ft to ft
perforations from ft to ft
perforations from ft to ft

Screens Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No —
Diam 12" PS Slot size 60 from 140 ft to 165 ft
Diam Slot size from ft to ft

Gravel packed Yes ☒ No ☐ Size of gravel F-5
Gravel placed from 109 ft to 167 ft

Surface seal Yes ☐ No ☐ To what depth? ft
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP Manufacturer's Name
Type H.P

(8) WATER LEVELS Land surface elevation above mean sea level 470 ft
Static level 109 ft below top of well Date
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap valve etc)

(9) WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes by whom?
Yield gal /min with ft drawdown after hrs

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal /min with ft drawdown after hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG

Formation Describe by color character, size of material and structure and show thickness of aquifers and the kind and nature of the material in each stratum penetrated with at least one entry for each change of formation

MATERIAL	FROM	TO
Sand Tan Silty	0	7
Sand Blk 3" minus gravel	7	32
Boulders	32	34
Gravel 3" minus Sand Blk	34	52
Boulders	52	54
Sand Tan	54	83
Silt Tan Sandy	83	85
Sand Tan	85	87
Silt Tan Sandy	87	118
Sand Tan Silty	118	120
Gravel 6" minus Sand Med Water	120	131
Sand Tan Fine Gravel 6" minus Water	131	165
Basalt Blk	165	170
31 Feet 12" STD Well Pipe		
26 Feet 12" 60 Slot SS Screen		
5 Feet 12" STD Well Pipe		

RECEIVED
MAR 19 1982
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 12-17 19 81 Completed 1-4 19 82

WELL DRILLER'S STATEMENT

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief

NAME Nelson Well Driller Inc (Person firm or corporation) (Type or print)

Address 10036 W. Clergent Road

[Signed] James Nelson (Well Driller)

License No 361 Date 1-6 19 82

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

ECY 050-1 20 3

Reg. # 3953

WELL LOG

OWNER:
NAME Duane Guenther
ADDRESS 1524 W. Howard Pasco
DATE DRILLED: Jan. 4-20 1965

LOCATION OF WELL: Elev 480 (E1 top
COUNTY Franklin BLOCK 17 UNIT 46
____ ¼ ____ ¼ SECTION 31 T. 10N R. 30E W.M.
TYPE OF WORK: New USE: Dom. & L.S

CASING: DIAMETER: 6 inch WEIGHT: 18.97/FT. DRIVE SHOE B-C
TOTAL CASING: 160'-6" CASED BELOW SURFACE 158'-6"
TOTAL WELL DEPTH: 218 OPEN END: 59'-6" SIZE: 5-15/16"
ALL CASING JOINTS DOUBLE TAPERED AND TRIPLE WELDED.

SCREEN: SURFACE SEAL: 2 Sacks Bentonite

TEST: STATIC WATER LEVEL: 135 FT. Top Casing BAILER TEST ✓ PUMP TEST
YIELD: 20 GAL./MIN. WITH 30 FT. DRAWDOWN AFTER 1 HRS.
YIELD: GAL./MIN. WITH FT. DRAWDOWN AFTER HRS.
TEMPERATURE: 63 Degrees WELL CHLORINATED: Yes

PUMP SETTING: For a yield of 15-20 GPM we suggest setting pump intake @ 180 FT. This well may yield 30-35 GPM. with pump intake set @ 210 to 212 FT. [redacted]

MATERIAL	S. W. L.	THICKNESS	DEPTH	CASING
Sandy Soil		9	9	
Fine Gr. & S.		12	21	
Cemented Gr.		15	36	
Clay & Some Fine Gr. & S.		13	49	
Silty Sand		17	66	
Sandy Clay		6	72	
Sand, Some Fine Gr. & Cl.		8	80	
Fine Gravel & Sand		4	84	
Fine Gravel, S. & Cl.		3	87	
Clay-Occassional Layer F.Gr. & S.		49	136	
Cemented Gr.		9	145	
Sandy Clay		8	153	
Dec. Bas.		2	155	
Partially Dec. Bas.		3	158	
Med. Hard Bas. - Cl. Sediment		20	178	(Trace H_2O-17
Med. Hard Bas.		4	182	
Very Hard Bas.		20	202	
Frac. Med Hard Bas		4	206	(Trace H_2O-2
Porous Bas (Water)		11	217	
Med. Hard Bas		1	218	

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

X

WATER WELL REPORT
STATE OF WASHINGTON

41

Application No. ....
Permit No. 63-24193

(1) **OWNER:** Name Lentz Farms Address 1304 W. Yakima St - Pasco, Wash 99301

(2) **LOCATION OF WELL:** County Franklin NE ¼ SW ¼ Sec. 32 T. 10 N., R. 30 W.M.
Bearing and distance from section or subdivision corner South Central Part

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 222 ft. Depth of completed well 222 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 222 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used..........
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. ......
Diam. 6 Slot size 20 from 205 ft. to 220 ft.
Diam. 6 Slot size 40 from 210 ft. to 222 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?...... Depth of strata......
Method of sealing strata off......

(7) **PUMP:** Manufacturer's Name......
Type: ...... H.P. ......

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... 520 ft.
Static level 167 ft. below top of well Date 3/2/75
Artesian pressure ...... lbs. per square inch Date......
Artesian water is controlled by...... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test 20 gal./min. with 2 ft. drawdown after 2 hrs.
Artesian flow...... g.p.m. Date......
Temperature of water...... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand & Clay with Silt	0	162
1/16" Sand some 1/4" gravel - Water	162	168
Water	168	169
Coarse Sand 1/8" - Heaves in Casing More Water	169	180
Fine sand - some gravel - Still Heaves	180	190
Cemented Gravel - No Water	190	200
Fine Sand - some gravel 1/4"	200	205
Heaving Fine Sand - Traces of Gravel	205	212
Loose Gravel 1/4" to 2" - Some Sand	212	221
Bedrock	221	222

90" Sprk
1500
744
160 Acres
Eltopia

Work started 2/24, 19 75. Completed 3/11, 19 75

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & H Drilling (Person, firm, or corporation) (Type or print)
Address Rt. 3 Box 3365A - Kennewick, Wash 99336
[Signed] Leonard Bultena (Well Driller)
License No. 0066 Date 3/11, 19 75

(USE ADDITIONAL SHEETS IF NECESSARY)

Second Copy — Owner's Copy
Third Copy — Driller's Copy

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

STATE OF WASHINGTON 42 Permit No. G3 24193 P

(1) OWNER: Name Lentz Address

(2) LOCATION OF WELL: County Franklin — SE ¼ SW ¼ Sec 32 T. 10 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 197 ft. Depth of completed well 192 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from +1 ft. to 153 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐ 16" TO 12" Slip Packer
Manufacturer's Name Johnson
Type Low Carbon Model No.
Diam. 12" Slot size .060 from 154 ft. to 184 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☑ No ☐ Size of gravel F-5 Filter
Gravel placed from 150 ft. to 186 ft.

Surface seal: Yes ☒ No ☐ To what depth? 33 ft.
Material used in seal Cement - Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 540 ft.
Static level 138 ft. below top of well Date 10-9
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: 1557 gal./min. with 11 ft. drawdown after 4 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Soil - Sandy - TAN	0	4
Sand - Silty - TAN	4	84
Sand - Med - Gray	84	101
Silt - Sandy - TAN	101	145
Sand - Med - Gray	145	163
Sand - Gravel - Ringold Formation - Loose	163	184
Sand - Gravel - Ringold Formation Silty Tight	184	192
Basalt Broken - Black	192	197

N 1550
1744
1600 A
Co

Screen - Total Lenght 42-6"
192-184 - 12" Casing - 184 - 154
30 FT 12" pipe size .060 Low
Carbon Johnson Screen - 154
150 - 4 FT 12" casing - Lead 16"
To 12" Slip Packer on Top

Work started 19 Completed 10-10 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling (Person, firm, or corporation) (Type or print)

Address P.O. Box 2814 Pasco

[Signed] James Nelson (Well Driller)

License No. 0361 Date 10-14 1975

12/14/76

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

#1

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES A-8250
P-7664

WELL LOG

Record by: Driller

Source: Driller's Record

Location: State of WASHINGTON

County: Franklin

Area:

Map:

NW ¼ NE ¼ sec 33 T 10 N., R 30 E

Diagram of Section: 33

Drilling Co. Charles Jungmann Drilling Company

Address: 115 Rees Ave. Walla Walla, Washington

Method of Drilling: Cable Date: , 19

Owner: Northern Pacific Railway Company

Address: Seattle, Washington

Land surface, datum: ft. above / below

SWL: 240' Date: July 13, 19 66 Dims. 8" x 487'

CORRELATION	MATERIAL	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Stock use		
	Sand	0	155
	Basalt	155	487
	Casing: 8" from 0 to 155'		
	Has permanent pump capacity of well 90 gpm with 200' drawdown.		
	This well was previously drilled with no records available. Formations and casing are assumptions, after drilling well nearby.		

Turn up Sheet ....of.... sheets

#2

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES A-8250
P-7664

WELL LOG

Record by: Driller
Source: Driller's Record

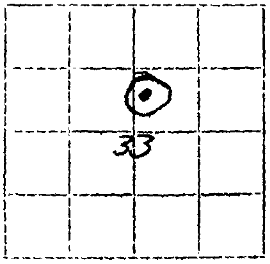


Diagram of Section

Location: State of WASHINGTON
County: Franklin
Area:
Map:
SW ¼ NE ¼ sec. 33 T. 10 N., R. 30 E.

Drilling Co. Charles Jungmann Drilling Company
Address: 115 Rees Avenue, Walla Walla, Wash.
Method of Drilling: Cable Date: Oct. 24, 1966
Owner: Northern Pacific Railway Company
Address: Seattle, Washington
Land surface, datum .... ft. above/below
SWL: 213' Date: Oct. 20, 1966 Dims: 10" and 8" x 471'

CORRELATION	MATERIAL	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Stock use		
	Sand	0	154
	Basalt, black	154	172
	Basalt, gray, very hard	172	245
	Basalt, broken, black, & clay	245	276
	Basalt, very hard, gray	276	367
	Basalt, soft, black	367	386
	Basalt, gray	386	394
	Conglomerate (rock, clay)	394	423
	Basalt, gray	423	432
	Basalt, black, soft	432	450
	Basalt, hard, black	450	571
	Casing: 10" from 0 to 154'		
	8" from 2 to 421'		
	Perforated from 390 to 400'		
	(over)		

Turn up Sheet ..... of ..... sheets

WELL LOG—Continued No. 10/30-33R

CORRELATION	MATERIAL	From (feet)	To (feet)
	Depth forward	→	
	Yield: 150 gpm with 188' dd after 4 hrs.		
	Complete recovery in 30 min.		
	Date: 10/20/66		

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

45

Application No. #3
Permit No. G3-25678

(1) OWNER: Name Dan Beus Address G3-25166

(2) LOCATION OF WELL: County Franklin SW SW SW ¼ Sec. 33 T. 10 N., R. 30 W.M.

Bearing and distance from section or subdivision corner 35'N - 60'E. of SW Corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 221-6 ft. Depth of completed well 221-6 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from +1 ft. to 197 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson Stainless
Type...... Model No......
Diam. 16 Slot size .250 from 197 ft. to 218 ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 80 ft.
Material used in seal Bentonite & Sand
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?...... Depth of strata......
Method of sealing strata off......

(7) PUMP: Manufacturer's Name......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 550 ft.
Static level 180 - ft. below top of well Date 3-11-78
Artesian pressure ...... lbs. per square inch Date......
Artesian water is controlled by...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test......
Bailer test...... gal./min. with...... ft. drawdown after...... hrs.
Artesian flow...... g.p.m. Date......
Temperature of water...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand - Tan Silty	0	14
Silt	14	20
Sand - Tan - Silty	20	184
Sand - Grey & Black 2-3" gravel No	184	189
Sand - Fine Tan & Black Coarse 2-4" Ringold gravel	189	218
Sand - Fine Tan - 2-3" gravel Ringold	218	221-6
Basalt Brown Firm	221-6	222

Pump test per hr Capacity
300 gpm
1500
3000

RECEIVED
[date illegible] 1980
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Screen measurements
1'4" Packer & Blank
20'5 Screen
3-6 Blank

Work started 2-6 1978. Completed 3-11 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc. (Person, firm, or corporation) (Type or print)

Address 10036 W. Argent Pasco WA

[Signed] Bruce Williams (Well Driller)

License No. 0659 Date 3-17, 1978

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

#3

S. F. No. 7356—OS—(Rev 4-71)
ECY-070-28

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

46

Application No. #2
Permit No. G3-25678

(1) OWNER: Name Don Bues Address G3-25166

(2) LOCATION OF WELL: County Franklin SW SW, SW ¼ Sec 33 T. 10 N., R. 30 W.M.

Bearing and distance from section or subdivision corner 180'N + 360'E of SW Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled - 223 ft. Depth of completed well 223 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from +1 ft. to 197 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used .....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name JOHNSON
Type STAINLESS Model No. .....
Diam. 14" Slot size .250 from 197 ft. to 223 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 27 ft.
Material used in seal BenTonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level. 550 ft.
Static level 186 ft. below top of well Date 7-13-77
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SAND-TAN, Brown-SILTY	0	182
SAND-Grey + BLACK, 2-4" gravel H2O	182	216
SAND-Fine TAN, 2-6" gravel Ringold —	216	223

Permitted 300 g/m
~~1400~~ 1500 300 A/F

RECEIVED
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 6-22, 1977 Completed 7-13, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling (Person, firm, or corporation) (Type or print)

Address 10036 W. ARGENT PASCO, WN

[Signed] Bruce Williams (Well Driller)

License No. 0659 Date 7-15, 1977

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev 4-71)
ECY-070-28

#2

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

47

STATE OF WASHINGTON

Application No. G3 25673 #1
Permit No. G3-25166

(1) OWNER: Name Don Bues Address

(2) LOCATION OF WELL: County Franklin SW ¼ SW ¼ Sec 33 T 10 N., R 30 W.M.

Bearing and distance from section or subdivision corner 350' N - 550' E of SW Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 229 ft. Depth of completed well 229 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8 " Diam. from +1 ft. to 218 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 8 Slot size 035 from 218 ft. to 223 ft.
Diam. 8 Slot size 050 from 223 ft. to 228 ft.

Gravel packed: Yes ☐ No ☐ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level... 550 ft.
Static level 180 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand Silty Tan	0	92
Sand Blk Fine silty	92	93
Sand Silty Tan	93	121
Sand Tan Silty & Caliche	121	121.5
Sand Tan Silty	121.5	145
Sand Blk Gray silty	145	160
Silt Tan	160	161
Sand Blk & Grey Fine Silty	161	178
Gravel Black Sand 4" minus	178	181
Gravel - Sand Tan Ringold Formation	181	229
Basalt Blk	229	
Screen		
Packer		
1 Ft Blank		
5 Ft 035 Slot		
5 Ft 050 Slot		
1 Ft Blank		
Bail Bottom		

RECEIVED
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 5-7, 1977. Completed 6-22, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc
(Person, firm, or corporation) (Type or print)

Address 10036 West Clearwater

[Signed] Bruce Nelson
(Well Driller)

License No. 654 Date 6-22, 1977

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

#1

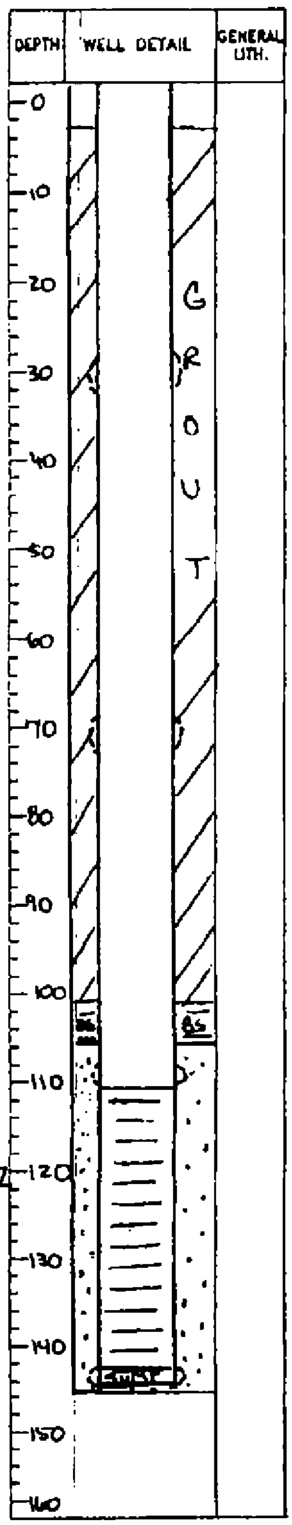
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco/Wastewater Treatment
Project No.: 8958 4

Well No.: MW-04
Boring No.: MW-04
Start Card No.: R-02815

Horizontal Coords: [1] ______ Ground Surface Elevation: ______
[2] ______ Top of PVC Well Casing: ______

Section 34 T. 10N R. 30 EWM Franklin Co



DRILLING SUMMARY
Total Borehole Depth: 145 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa
Drilling - Spokane, WA
Driller(s): Roger Kalk
Rig(s): Reichdrill T625
Rotary/Circulating Medium = Air
Bit(s): 7 7/8-inch Tri-cone
Roller Bit.

TIME LOG	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	2/2/95	1332	2/3/95	1436
Geophys. Logging	N/A	—	—	—
Casing	2/6	0950	2/6	1115
Sand Pack	2/6	1128	2/6	1616
Grout	2/7	0735	2/7	1256
Bentonite Seal	2/6	1624	2/6	1648
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Sched. 80, 4-inch Flush-Threaded PVC.
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation [1] (ft)
+3.0 - 110.51	B	-
110.51 - 140.60	S	-
140.60 - 142.95	B	-
142.95 - 143.29	EC	-
-		-

Screen Type/Size: Louvered Fac. Slot/30 mesh
Surface Seal (ft):
Mfr/Mtrl/Qty: ~~[illegible]~~
Grout Seal (ft): 100.0 ft to 3.0 ft bgs
Mfr/Mtrl/Qty: Ash Grove TC 44 @ 47 bgs [illegible]
Bentonite Seal (ft): 106.5 ft to 100.0 ft bgs
Mfr/Mtrl/Qty: Enviroplug/3/8-inch/2 [illegible]
Sand Pack (ft): 145.0 ft to 106.5 ft bgs
Mfr/Mtrl/Qty: CSSI/#8-12/25 bags
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: ———

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

Comments: ~~[1] Tennison Coordinate System~~ ~~[2] Oregon State Coordinate System~~ 8L STBT

Stainless steel centralizers @ 30 ft, 70 ft, 110 ft, and 141 ft bgs.

See Wellhead Detail for surface construction information.

Generated by: Terry McP[illegible] Date: 2-6-95
Checked by: ______ Date: ______

RUST ENVIRONMENT & INFRASTRUCTURE

cldformstwellsum2.for

Third Copy — Driller's Copy

49

STATE OF WASHINGTON

Permit No G3-23386

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, BOX 205, MESA, WN.

(2) LOCATION OF WELL: County FRANKLIN — ¼ SW ¼ Sec 35 T 10 N., R 30 E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 136 ft. Depth of completed well 122-6 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 105-6 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☑ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type 304 STAINLESS Model No. TELES
TELESCOPE Diam. 16 Slot size 070 from 104½ ft. to 117 ft.
Diam. Slot size 100 from 117 ft. to 122½ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 94 ft. below top of well Date 3/3/75
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
GRAYISH SOIL	0	34
SILTY BLACK S.	10	46
GRAYISH SOIL	10	56
SILTY S.	2	58
GRAYISH SOIL	10	68
F.GR. + S	9	77
F.S.	3	80
F.GR., C.S.	17	97
F.GR. S.	2	99
S. SOME F.GR.	3	102
C.S. + F.GR.	8	110
" " SOME F.GR.	4	114
" " TRACE " "	4	118
" " SOME " "	3	121
F.GR., C.S.	2	123
YELLOW CLAY	13	136

9PM
SAPHY
ACRES
230
1617
1623

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/14, 1975. Completed 3/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENNEWICK

[Signed] (Well Driller)

License No. 0166 Date 3/4, 1975

4/25/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

50

Ap[redacted]on No. ....
Permit No. ....

(1) OWNER: Name RAY VOSS Address RT. 1 PASCO, WASH.

(2) LOCATION OF WELL: County FRANKLIN — ¼ SW ¼ Sec 35 T. 10 N., R. 30 W.M.
Bearing and distance from section or subdivision corner Eltopia

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test ~~Well~~ HOLE ☑ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 152 1/2 ft. Depth of completed well 0 ft.

(6) CONSTRUCTION DETAILS: PULLED
Casing installed: ......" Diam. from ...... ft. to ...... ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☐ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☐
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☐ No ☐ To what depth? ...... ft.
Material used in seal ......
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level 520 ft.
Static level ...... ft. below top of well Date ......
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

ate of test ......
ler test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SANDY SOIL	0	29
COMPACT GR	3	32
CLAYISH SOIL	19	51
BLK. S. & SED	7	58
CLAYISH SANDY SOIL	4	62
COMPACT F.S TR. F.GR	10	72
" SAND F.GR & SED.	3	75
LOOSE C. BLK S.	6	81
SANDY CLAY	13	94
C. BLK. S.	2	96
CLAY	5	101
SANDY CLAY	14	115
BLK S & SED.	2	117
SILTY SAND	2	119
C. S & F.GR.	3	122
" " " " TIGHT	2	124
" " " "	1	125
CLAY	12	137
CLAYISH SILTY S.	8	145
SILTY S. TR. F.GR.	1	146
F.GR. & S	3 1/2	149 1/2
GREY F.GR. & S	1 1/2	151
" GREEN COMPACT GR - S	1/2	151 1/2
BASALT	1	152 1/2

Eltopia

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/5, 1975. Completed 2/11, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] [signature] (Well Driller)

License No. 0406 Date 2/10, 1975

4/25/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

3374 3860 3861 51 Application No.
Permit No. 63-23386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, MESA, WASH

(2) LOCATION OF WELL: County FRANKLIN SE ¼ SE ¼ SE ¼ Sec 35 T 10 N., R 30 W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 131 ft. Depth of completed well 130 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16 " Diam. from 0 ft. to 113.2 ft.
Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.
Welded ☑ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Johnson
Type TELES Model No. 304
Diam. 16 Slot size 025 from 111 ft. to ____ ft.
Diam. ____ Slot size 075 from ____ ft. to 130 ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ____ Depth of strata ____
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ____ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 518 ft.
Static level 23.6 ft. below top of well Date
Artesian pressure ____ lbs. per square inch Date
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Artesian flow ____ g.p.m. Date
Temperature of water 43 Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	2	2
Clayish Soil	35	37
Comp Blks S & Sed	6	43
Bld S & Cl	5	48
Clayish Soil	12	60
Sandy Silty Tr F.Gr	5	65
Compact Rocks & S	3	68
" Gr & S	10	78
S, 3in minus Gr	10	88
Compact F.Gr & S	4	92
C.S & F.Gr	2	94
F.Gr.	4	98
Silty S & Sed	2	100
Sand & Gr	21	121
C.Gr.	5	126
Comp Gr.	2	128
Coarse "	3	131
Clay		

0 230 1 14 14

Work started 1/21 1975 Completed 2/3 1975

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING Co. (Person, firm, or corporation) (Type or print)
Address P.O. Drawer E, Kenn
[Signed] [signature] (Well Driller)
License No. 0446 Date 2/3 1975

2/5/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

52

Application No. ______
Permit No. G3-2386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, BOX 205, MESA

(2) LOCATION OF WELL: County FRANKLIN SE ¼ SE ¼ SE ¼ Sec 35 T. 10 N., R. 30 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☑ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 147 ft. Depth of completed well 128 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 122 ft.
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.
Welded ☑ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type TELESCOPE Model No. 304
Diam. 5 Slot size .040 from 126.8 ft. to 122 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 40 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ______ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 518 ft.
Static level 93'-4 ft. below top of well Date 2/3/75
Artesian pressure ______ lbs. per square inch Date
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? CDCo
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" 18 " 8 INCHES " 1½ "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 2/3/75
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Soil	1½	1½
Grayish Soil	35½	37
Compact Blk S. & Sed	6	43
Brownish S & Cl	5	48
Grayish Soil	12	60
Sandy & Silty Tr. F. Gr.	5	65
Compact Gr & S	12	77
F Gr & S	10	87
Compact F Gr & S	8	95
Silty S & Sed	2	97
" " Tr. F Gr & Sed	4	101
Blk S & F Gr	7	108
F Gr & S	5	113
Sand	3	116
C S & F Gr Much Sed	3	119
" " " "	2	121
" " " "	4	125
F Gr	4	129
Yellow Clay (Cased)	3	132
" "	5	138
Silty S	4	142
Cem. Gr & S	4	146
Bas. (??)	1	147

RECEIVED
FEB 05 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

230
167
320

Work started Jan 9, 1975. Completed 2/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO.
(Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] ______
(Well Driller)

License No. 0466 Date 2/3, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

2/5/75 KG

S. F. No. 7356—OS—(Rev. 4-71).

Appendix 4-D

Proposed Groundwater Monitoring Wells

Appendix 4-D. Proposed Groundwater Monitoring Wells

Well	Hydrogeologic Position [1]	Surface Elevation [2]	Target Aquifer [3]	Potential Well Depth	Potential Well Bottom Elevation [4]
		ft amsl		feet	ft amsl
MW-10	Upgradient of Circles V16, V17, and V18	561	unconfined aquifer	141	420
MW-11	Downgradient of Circles V16, V17, and V18	541	unconfined aquifer	151	390
MW-12	Upgradient of Circles B16	540	unconfined aquifer	170	370
MW-13	Downgradient of Circle B16	544	unconfined aquifer	179	365

NOTES:

Abbreviation: ft amsl = feet above mean sea level.

1 Hydrogeologic position is professional judgement based upon review of well logs, published research and previous work at adjacent Site.

2 Surface elevations obtained from Google Earth.

3 Target aquifers and potenital well depths identified from existing water well logs.

4 Potential well bottom elevations were calculated by subtracting potential well depths from surface elevations.

Appendix 4-E

Circle-Specific Monthly Soil Hydraulic Budgets

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **1** | **Acres:** 122 | **Soil Water Content at Field Capacity [7]:** 11.4

Crop: Alfalfa | **Rooting Depth [3] (approximate):** 60 | **Initial Soil Water Content [8]:** 9.7

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	2.0	0.0	0.0	1.8	0.0	0.0	2.6	1.0	1.0	11.4	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	11.4	0.7
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.4	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	10.9	0.0
Mar	0.7	0.0	3.6	4.5	0.0	3.2	4.0	7.9	2.7	2.6	11.4	4.7
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	11.3	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	9.2	0.0
Jun	0.7	2.4	0.5	3.0	1.7	0.3	2.1	4.8	7.1	6.4	7.6	0.0
Jul	0.2	5.3	1.0	1.0	3.7	0.7	0.7	5.3	8.1	6.6	6.3	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.9	6.1	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	3.0	8.5	0.0
Oct	0.7	4.4	0.0	0.0	4.0	0.0	0.0	4.6	2.2	1.9	11.2	0.0
Total	8.3	34.4	5.5	8.5	26.7	4.6	6.8	46.4	44.4	38.9		6.0

Leaching Fraction [11]	10.6%
Leaching Requirement [12]	10.6%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 2 **Acres:** 152 **Soil Water Content at Field Capacity [7]:** 12.0

Crop: Potato / Alfalfa **Rooting Depth [3] (approximate):** 48 **Initial Soil Water Content [8]:** 10.2

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	0.0	4.3	0.0	0.0	3.8	0.0	4.7	0.8	0.7	12.0	2.1
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	12.0	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	12.0	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	0.8	11.9	0.0
Mar	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.3	1.3	11.2	0.0
Apr	0.6	2.0	0.0	0.0	1.6	0.0	0.0	2.2	1.4	1.3	12.0	0.0
May	0.8	3.4	0.5	0.0	2.7	0.4	0.0	3.9	4.5	4.5	11.4	0.0
Jun	0.7	0.5	0.5	3.0	0.4	0.3	2.1	3.4	9.0	8.8	6.1	0.0
Jul	0.2	1.7	1.0	8.0	1.2	0.7	5.6	7.6	10.3	7.3	6.4	0.0
Aug	0.2	0.6	0.0	5.0	0.4	0.0	3.5	4.2	4.9	3.6	7.0	0.0
Sep	0.4	3.2	0.0	0.0	2.5	0.0	0.0	2.9	2.0	1.5	8.4	0.0
Oct	0.7	2.5	0.0	0.0	2.3	0.0	0.0	2.9	2.2	1.8	9.4	0.0
Total	8.3	13.9	6.2	16.0	11.1	5.2	11.2	35.8	38.7	33.2		3.4

Leaching Fraction [11]	7.7%
Leaching Requirement [12]	7.7%

NOTES:

Circle 2 includes circle 2 plus little circle 2.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **3** | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 8.0

Crop: Alfalfa / Corn | **Rooting Depth [3] (approximate):** 60 | **Initial Soil Water Content [8]:** 6.8

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	0.0	2.8	2.6	0.0	2.5	2.3	5.6	1.0	1.0	8.0	3.4
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.0	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.0	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	7.4	0.0
Mar	0.7	2.0	0.0	0.0	1.8	0.0	0.0	2.5	2.7	2.6	7.3	0.0
Apr	0.6	4.0	0.0	0.0	3.2	0.0	0.0	3.8	4.3	4.1	6.9	0.0
May	0.8	4.0	0.5	0.0	3.2	0.4	0.0	4.4	5.9	5.5	5.8	0.0
Jun	0.7	3.3	0.5	4.0	2.3	0.3	2.8	6.1	5.6	4.8	7.1	0.0
Jul	0.2	2.8	1.0	7.0	2.0	0.7	4.9	7.7	8.1	7.7	7.2	0.0
Aug	0.2	1.0	0.0	5.0	0.7	0.0	3.5	4.4	7.7	7.3	4.4	0.0
Sep	0.4	2.0	0.0	0.0	1.6	0.0	0.0	2.0	0.8	0.6	5.7	0.0
Oct	0.7	2.5	0.0	0.0	2.3	0.0	0.0	2.9	0.8	0.7	8.0	0.0
Total	8.3	21.7	4.7	18.6	17.1	3.9	13.5	42.7	39.4	36.7		4.8

Leaching Fraction [11]	9.0%
Leaching Requirement [12]	9.0%

NOTES:
Abbreviation: Precip = precipitation.
All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).
1 Precipitation is the normalized 10-year return values.
2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.
3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.
4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.
7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).
8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.
9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.
10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.
11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).
12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 4 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 8.8

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 7.5

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	1.5	0.0	0.0	1.4	0.0	0.0	2.2	1.0	1.0	8.7	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.8	0.7
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.8	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	8.2	0.0
Mar	0.7	0.0	3.6	4.4	0.0	3.2	4.0	7.9	2.7	2.6	8.8	4.7
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	8.6	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	6.6	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	6.1	5.9	0.0
Jul	0.2	5.3	1.0	1.0	3.7	0.7	0.7	5.3	8.1	6.6	4.5	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.7	4.5	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	7.0	0.0
Oct	0.7	3.3	0.0	0.0	3.0	0.0	0.0	3.6	2.2	2.0	8.6	0.0
Total	8.3	32.8	5.5	9.4	25.3	4.6	7.5	45.6	44.4	38.6		5.9

Leaching Fraction [11]	10.6%
Leaching Requirement [12]	10.6%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 5 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 11.5

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 9.8

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	2.0	0.0	0.0	1.8	0.0	0.0	2.6	1.0	1.0	11.4	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	11.5	0.7
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.5	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	10.9	0.0
Mar	0.7	0.0	3.6	4.8	0.0	3.2	4.3	8.2	2.7	2.6	11.5	5.0
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	11.4	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	9.3	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	6.4	8.4	0.0
Jul	0.2	5.3	1.0	0.0	3.7	0.7	0.0	4.6	8.1	6.9	6.0	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.8	6.0	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	8.4	0.0
Oct	0.7	4.6	0.0	0.0	4.1	0.0	0.0	4.8	2.2	1.9	11.3	0.0
Total	8.3	34.6	5.5	8.8	26.9	4.6	7.1	46.9	44.4	39.1		6.3

Leaching Fraction [11]	11.0%
Leaching Requirement [12]	11.0%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 6 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.8

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 5.8

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	1.0	0.0	0.0	0.9	0.0	0.0	1.7	1.0	1.0	6.6	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.8	0.6
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.8	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	6.3	0.0
Mar	0.7	0.0	3.6	4.7	0.0	3.2	4.2	8.1	2.7	2.6	6.8	5.0
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	6.7	0.0
May	0.8	3.2	0.5	1.0	2.6	0.4	0.8	4.5	5.9	5.8	5.4	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	6.3	4.6	0.0
Jul	0.2	5.3	1.0	1.5	3.7	0.7	1.1	5.6	8.1	6.6	3.6	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.7	3.5	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	5.9	0.0
Oct	0.7	2.4	0.0	0.0	2.2	0.0	0.0	2.8	2.2	2.1	6.7	0.0
Total	8.3	31.4	5.5	11.2	24.0	4.6	8.9	45.8	44.4	38.8		6.1

Leaching Fraction [11]	10.8%
Leaching Requirement [12]	10.8%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 7 **Acres:** 152 **Soil Water Content at Field Capacity [7]:** 8.3

Crop: Potato / Alfalfa **Rooting Depth [3] (approximate):** 48 **Initial Soil Water Content [8]:** 7.1

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	0.0	2.0	2.1	0.0	1.8	1.9	4.5	0.8	0.7	8.3	2.5
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.3	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	0.8	8.2	0.0
Mar	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.3	1.3	7.5	0.0
Apr	0.6	1.0	0.0	0.0	0.8	0.0	0.0	1.4	1.4	1.3	7.5	0.0
May	0.8	2.0	0.5	0.0	1.6	0.4	0.0	2.8	4.5	4.3	6.0	0.0
Jun	0.7	0.0	0.5	8.5	0.0	0.3	6.0	6.9	9.0	7.7	5.3	0.0
Jul	0.2	0.0	1.0	8.5	0.0	0.7	6.0	6.8	10.3	8.2	3.9	0.0
Aug	0.2	0.0	0.0	3.8	0.0	0.0	2.7	2.9	4.9	3.4	3.4	0.0
Sep	0.4	2.5	0.0	0.0	2.0	0.0	0.0	2.4	2.0	1.3	4.5	0.0
Oct	0.7	3.0	0.0	0.0	2.7	0.0	0.0	3.4	2.2	1.6	6.2	0.0
Total	8.3	8.5	3.9	22.9	7.1	3.2	16.5	35.0	38.7	32.0		3.8

Leaching Fraction [11]	8.7%
Leaching Requirement [12]	8.7%

NOTES:

Circle 7 is circle 7 plus little circle 7.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **8** **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.7

Crop: Alfalfa / Corn **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 5.7

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	0.0	4.5	0.0	0.0	4.1	0.0	4.9	1.0	1.0	6.7	2.9
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.7	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.7	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	6.1	0.0
Mar	0.7	2.0	0.0	0.0	1.8	0.0	0.0	2.5	2.7	2.6	6.0	0.0
Apr	0.6	4.0	0.0	0.0	3.2	0.0	0.0	3.8	4.3	4.1	5.7	0.0
May	0.8	4.0	0.5	0.0	3.2	0.4	0.0	4.4	5.9	5.4	4.7	0.0
Jun	0.7	1.0	0.5	2.5	0.7	0.3	1.8	3.4	5.6	4.7	3.4	0.0
Jul	0.2	1.0	1.0	6.0	0.7	0.7	4.2	5.7	8.1	5.8	3.4	0.0
Aug	0.2	1.0	0.0	6.5	0.7	0.0	4.5	5.5	7.7	5.5	3.4	0.0
Sep	0.4	1.5	0.0	0.0	1.2	0.0	0.0	1.6	0.8	0.6	4.4	0.0
Oct	0.7	2.5	0.0	0.0	2.3	0.0	0.0	2.9	0.8	0.6	6.7	0.0
Total	8.3	17.0	6.4	15.0	13.8	5.5	10.5	37.9	39.4	32.7		4.2

Leaching Fraction [11]	9.1%
Leaching Requirement [12]	9.1%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 9 | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 6.3

Crop: Alfalfa | **Rooting Depth [3] (approximate):** 60 | **Initial Soil Water Content [8]:** 5.4

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	1.0	0.0	0.0	0.9	0.0	0.0	1.7	1.0	1.0	6.1	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	5.8	0.0
Mar	0.7	0.0	3.6	4.5	0.0	3.2	4.1	7.9	2.7	2.5	6.3	4.8
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	6.2	0.0
May	0.8	3.2	0.5	1.0	2.6	0.4	0.8	4.5	5.9	5.8	4.9	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	6.3	4.2	0.0
Jul	0.2	5.3	1.0	2.0	3.7	0.7	1.4	6.0	8.1	6.6	3.6	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.9	3.4	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	5.7	0.0
Oct	0.7	2.0	0.0	0.0	1.8	0.0	0.0	2.5	2.2	2.1	6.1	0.0
Total	8.3	31.0	5.5	11.5	23.7	4.6	9.1	45.6	44.4	38.9		6.0

Leaching Fraction [11]	10.7%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 10 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 7.0

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 6.0

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	1.0	0.0	0.0	0.9	0.0	0.0	1.7	1.0	1.0	6.8	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	7.0	0.5
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	7.0	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	6.5	0.0
Mar	0.7	0.0	3.6	4.6	0.0	3.2	4.1	8.0	2.7	2.6	7.0	4.9
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	6.9	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	4.8	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	5.9	4.5	0.0
Jul	0.2	5.3	1.0	1.5	3.7	0.7	1.1	5.6	8.1	6.4	3.6	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.7	3.6	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	6.0	0.0
Oct	0.7	2.5	0.0	0.0	2.3	0.0	0.0	2.9	2.2	2.0	6.9	0.0
Total	8.3	31.5	5.5	10.1	24.1	4.6	8.0	45.0	44.4	38.1		6.0

Leaching Fraction [11]	10.8%
Leaching Requirement [12]	10.8%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **11** | **Acres:** 150 | **Soil Water Content at Field Capacity [7]:** 8.1

Crop: Triticale / Corn | **Rooting Depth [3] (approximate):** 60 | **Initial Soil Water Content [8]:** 6.9

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	0.0	2.2	2.4	0.0	1.9	2.1	4.9	1.0	0.9	8.1	2.8
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.1	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.1	0.6
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	1.1	7.7	0.0
Mar	0.7	2.5	0.0	0.0	2.3	0.0	0.0	2.9	2.6	2.5	8.1	0.0
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.1	4.1	8.1	0.0
May	0.8	2.0	0.5	0.0	1.6	0.4	0.0	2.8	5.6	5.6	5.3	0.0
Jun	0.7	1.0	0.5	4.0	0.7	0.3	2.8	4.5	5.5	4.4	5.4	0.0
Jul	0.2	0.0	1.0	7.0	0.0	0.7	4.9	5.7	8.1	6.6	4.5	0.0
Aug	0.2	0.0	0.0	7.5	0.0	0.0	5.3	5.5	7.7	5.7	4.3	0.0
Sep	0.4	2.0	0.0	0.0	1.6	0.0	0.0	2.0	0.8	0.6	5.7	0.0
Oct	0.7	1.0	0.0	0.0	0.9	0.0	0.0	1.6	0.8	0.7	6.6	0.0
Total	8.3	13.0	4.1	20.9	10.7	3.3	15.1	37.3	38.4	33.4		4.2

Leaching Fraction [11]	9.2%
Leaching Requirement [12]	9.2%

NOTES:
Abbreviation: Precip = precipitation.
All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).
1 Precipitation is the normalized 10-year return values.
2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.
3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.
4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.
7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).
8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.
9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.
10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.
11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).
12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **12** **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 11.3

Crop: Alfalfa / Corn **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 9.6

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	0.0	2.6	3.0	0.0	2.3	2.7	5.9	1.0	1.0	11.3	3.2
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	11.3	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	10.7	0.0
Mar	0.7	2.0	0.0	0.0	1.8	0.0	0.0	2.5	2.7	2.6	10.6	0.0
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.2	10.6	0.0
May	0.8	4.0	0.5	0.0	3.2	0.4	0.0	4.4	5.9	5.7	9.3	0.0
Jun	0.7	1.0	0.5	2.5	0.7	0.3	1.8	3.4	5.6	5.1	7.6	0.0
Jul	0.2	2.2	1.0	5.0	1.5	0.7	3.5	5.9	8.1	6.6	6.8	0.0
Aug	0.2	1.0	0.0	6.0	0.7	0.0	4.2	5.1	7.7	6.0	6.0	0.0
Sep	0.4	2.0	0.0	0.0	1.6	0.0	0.0	2.0	0.8	0.6	7.4	0.0
Oct	0.7	1.3	0.0	0.0	1.2	0.0	0.0	1.9	0.8	0.6	8.6	0.0
Total	8.3	18.0	4.5	16.5	14.3	3.7	12.2	38.5	39.4	34.9		4.5

Leaching Fraction [11]	9.6%
Leaching Requirement [12]	9.6%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **13** | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 6.3

Crop: Alfalfa | **Rooting Depth [3] (approximate):** 60 | **Initial Soil Water Content [8]:** 5.4

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	1.2	0.0	0.0	1.1	0.0	0.0	1.9	1.0	1.0	6.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.3	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	5.8	0.0
Mar	0.7	0.0	3.6	4.2	0.0	3.2	3.8	7.7	2.7	2.5	6.3	4.6
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	6.2	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	4.1	0.0
Jun	0.7	2.4	0.5	4.0	1.7	0.3	2.8	5.5	7.1	5.7	3.9	0.0
Jul	0.2	5.3	1.0	2.0	3.7	0.7	1.4	6.0	8.1	6.3	3.5	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.9	3.4	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	5.7	0.0
Oct	0.7	2.0	0.0	0.0	1.8	0.0	0.0	2.5	2.2	2.1	6.1	0.0
Total	8.3	31.2	5.5	10.2	23.9	4.6	8.0	44.7	44.4	38.1		5.9

Leaching Fraction [11]	10.7%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 15 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 9.6

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 8.1

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	1.8	0.0	0.0	1.6	0.0	0.0	2.5	1.0	1.0	9.6	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	9.6	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	9.6	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	9.0	0.0
Mar	0.7	0.0	3.6	4.3	0.0	3.2	3.9	7.8	2.7	2.6	9.6	4.6
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	9.4	0.0
May	0.8	3.2	0.5	0.0	2.6	0.4	0.0	3.7	5.9	5.8	7.4	0.0
Jun	0.7	2.4	0.5	2.0	1.7	0.3	1.4	4.1	7.1	6.2	5.2	0.0
Jul	0.2	5.3	1.0	1.5	3.7	0.7	1.1	5.6	8.1	6.0	4.9	0.0
Aug	0.2	6.4	0.0	0.0	4.5	0.0	0.0	4.7	6.6	4.7	4.9	0.0
Sep	0.4	6.2	0.0	0.0	4.9	0.0	0.0	5.3	4.0	2.9	7.3	0.0
Oct	0.7	3.7	0.0	0.0	3.3	0.0	0.0	4.0	2.2	1.9	9.4	0.0
Total	8.3	33.5	5.5	7.8	25.9	4.6	6.3	45.1	44.4	37.9		6.0

Leaching Fraction [11]	10.9%
Leaching Requirement [12]	10.9%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **V16** **Acres:** 70 **Soil Water Content at Field Capacity [7]:** 6.5

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 5.5

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	1.3	0.0	0.0	1.1	0.0	0.0	2.0	1.0	1.0	6.5	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.5	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.5	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	6.0	0.0
Mar	0.7	0.0	0.0	6.5	0.0	0.0	5.9	6.5	2.7	2.6	6.5	3.4
Apr	0.6	4.5	0.0	0.8	3.6	0.0	0.6	4.8	4.3	4.3	6.5	0.5
May	0.8	3.2	0.0	0.8	2.6	0.0	0.7	4.0	5.9	5.9	4.6	0.0
Jun	0.7	2.4	0.0	3.5	1.7	0.0	2.5	4.8	7.1	6.0	3.5	0.0
Jul	0.2	5.3	0.0	3.0	3.7	0.0	2.1	6.0	8.1	5.9	3.6	0.0
Aug	0.2	6.4	0.0	0.8	4.5	0.0	0.6	5.3	6.6	4.8	4.0	0.0
Sep	0.4	5.8	0.0	0.8	4.6	0.0	0.6	5.6	4.0	3.2	6.5	0.0
Oct	0.7	0.9	0.0	0.8	0.8	0.0	0.7	2.2	2.2	2.2	6.5	0.0
Total	8.3	29.8	0.0	17.0	22.6	0.0	13.6	44.5	44.4	38.3		5.2

Leaching Fraction [11]	9.5%
Leaching Requirement [12]	9.5%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: V17 **Acres:** 169 **Soil Water Content at Field Capacity [7]:** 8.5

Crop: Triticale / Corn **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 7.3

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	0.0	0.0	3.7	0.0	0.0	3.3	4.2	1.0	0.9	8.5	2.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.5	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.5	0.6
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	1.1	8.1	0.0
Mar	0.7	1.7	0.0	0.8	1.5	0.0	0.7	2.9	2.6	2.5	8.5	0.0
Apr	0.6	3.0	0.0	0.8	2.4	0.0	0.6	3.6	4.1	4.1	8.0	0.0
May	0.8	5.2	0.0	0.8	4.2	0.0	0.7	5.6	5.6	5.4	8.2	0.0
Jun	0.7	0.0	0.0	1.5	0.0	0.0	1.1	1.7	5.5	5.3	4.5	0.0
Jul	0.2	1.5	0.0	7.0	1.1	0.0	4.9	6.1	8.1	5.9	4.8	0.0
Aug	0.2	5.0	0.0	2.5	3.5	0.0	1.8	5.5	7.7	5.7	4.5	0.0
Sep	0.4	0.0	0.0	0.8	0.0	0.0	0.6	1.0	0.8	0.6	5.0	0.0
Oct	0.7	1.0	0.0	0.8	0.9	0.0	0.7	2.3	0.8	0.6	6.6	0.0
Total	8.3	17.4	0.0	18.7	13.5	0.0	14.4	36.2	38.4	33.4		3.4

Leaching Fraction [11]	7.7%
Leaching Requirement [12]	7.7%

NOTES:

Circle V17 includes circle 17 plus little circle 17.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **V18** **Acres:** 164 **Soil Water Content at Field Capacity [7]:** 6.9

Crop: Alfalfa / Corn **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 5.9

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
		inches										
Nov	0.8	0.0	0.0	4.6	0.0	0.0	4.1	5.0	1.0	1.0	6.9	3.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	6.9	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.9	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	6.3	0.0
Mar	0.7	1.9	0.0	0.8	1.7	0.0	0.7	3.1	2.7	2.6	6.9	0.0
Apr	0.6	3.9	0.0	0.8	3.1	0.0	0.6	4.3	4.3	4.3	6.9	0.0
May	0.8	5.5	0.0	0.8	4.4	0.0	0.7	5.8	5.9	5.9	6.9	0.0
Jun	0.7	2.0	0.0	0.8	1.4	0.0	0.6	2.6	5.6	5.6	3.9	0.0
Jul	0.2	4.0	0.0	4.0	2.8	0.0	2.8	5.8	8.1	6.1	3.6	0.0
Aug	0.2	4.0	0.0	3.5	2.8	0.0	2.5	5.5	7.7	5.5	3.6	0.0
Sep	0.4	2.0	0.0	0.8	1.6	0.0	0.6	2.6	0.8	0.6	5.6	0.0
Oct	0.7	0.5	0.0	0.8	0.5	0.0	0.7	1.8	0.8	0.7	6.7	0.0
Total	8.3	23.8	0.0	16.9	18.3	0.0	13.3	39.9	39.4	34.7		4.3

Leaching Fraction [11]	8.8%
Leaching Requirement [12]	8.8%

NOTES:
Abbreviation: Precip = precipitation.
All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).
1 Precipitation is the normalized 10-year return values.
2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.
3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.
4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).
6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.
7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).
8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.
9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.
10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.
11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).
12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 4-E. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **B19** **Acres:** 111 **Soil Water Content at Field Capacity [7]:** 8.1

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 6.9

Month	Precip [1]	Gross Irrigation [2]			Net Irrigation [4]			Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Cow	Fresh	Process	Cow	Fresh		Potential	Estimate		
	inches											
Nov	0.8	1.5	0.0	0.0	1.4	0.0	0.0	2.2	1.0	1.0	8.1	0.0
Dec	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.1	0.8
Jan	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.1	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.2	7.5	0.0
Mar	0.7	0.0	7.9	0.0	0.0	7.1	0.0	7.8	2.7	2.6	8.1	4.7
Apr	0.6	4.5	0.0	0.0	3.6	0.0	0.0	4.2	4.3	4.3	7.9	0.0
May	0.8	5.0	0.0	0.0	4.0	0.0	0.0	4.8	5.9	5.8	6.9	0.0
Jun	0.7	7.0	0.0	0.0	4.9	0.0	0.0	5.6	7.1	6.6	5.9	0.0
Jul	0.2	6.0	1.0	0.0	4.2	0.7	0.0	5.1	8.1	6.9	4.1	0.0
Aug	0.2	7.0	0.0	0.0	4.9	0.0	0.0	5.1	6.6	4.6	4.6	0.0
Sep	0.4	3.0	0.0	0.0	2.4	0.0	0.0	2.8	4.0	3.0	4.3	0.0
Oct	0.7	4.5	0.0	0.0	4.1	0.0	0.0	4.7	2.2	1.6	7.4	0.0
Total	8.3	38.5	8.9	0.0	29.4	7.8	0.0	45.5	44.4	38.9		6.0

Leaching Fraction [11]	10.8%
Leaching Requirement [12]	10.8%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix 5-A

Evoqua Pretreatment Design Documentation

WASTEWATER TREATMENT SYSTEM PROCESS DESIGN MANUAL

TO: SWINERTON ENERGY

FOR: PASCO RESOURCE RECOVERY CENTER (PRRC), PASCO, WA

Project: 6069000103

Revision: 03

Date: March 16, 2023

This design manual was prepared by Evoqua Water Technologies Canada Ltd. For Swinerton Energy/Pasco Resource Recovery Center

The material in it reflects Evoqua's best judgment in light of the information available to it at the time of presentation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Evoqua accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

ADI Systems
EVOQUA

ABBREVIATIONS

‘	Feet	Min	Minute
“	Inches	MLSS	Mixed Liquor Suspended Solids
Ø	Diameter	MLVSS	Mixed Liquor Volatile Suspended Solids
Amp	Amperage	MMBtu	Million British Thermal Units
AOR	Actual Oxygen Requirement	OLR	Organic Loading Rate
AT	Aeration Tank	PFD	Process Flow Diagram
BOD	Biochemical Oxygen Demand	P&ID	Process and Instrumentation Diagram
Cfm	Cubic Feet per Minute	PC	Process Control
COD	Chemical Oxygen Demand	PDM	Process Design Manual
DC	Direct Current	PLC	Programmable Logic Controller
DO	Dissolved Oxygen	PVC	Polyvinyl Chloride
EMT	Electrical Metallic Tubing	RANS	Return Anaerobic Sludge
EOF	Emergency overflow	SMT	Sediment/Moisture Trap
EQ	Equalization	SREC	Supernatant Recycle
°F	Degrees Fahrenheit	SRT	Solids Retention Time
FIT	Flow Indicating Transmitter	SS	Stainless Steel
F:M	Food to Microorganism Ratio	STP	Standard Temperature and Pressure
FOG	Fat, Oil, and Grease	STSTR	Soft Starter
FVNR	Full Voltage - Non Reversing	TEFC	Totally Enclosed Fan Cooled
Gal	Gallons	TKN	Total Kjeldahl Nitrogen
Gpd	Gallons per day	TN	Total Nitrogen
Gpm	Gallons per minute	TOW	Top of Wall
H	Hour	TP	Total Phosphorus
HDPE	High Density Polyethylene	TS	Total Solids
HGL	Hydraulic Grade Lines	TSS	Total Suspended Solids
HMI	Human Machine Interface	V	Volts
HRT	Hydraulic Retention Time	VAC	Voltage Alternating Current
LIT	Level Indicating Transmitter	VFD	Variable frequency drive
LWL	Low Water Level	VSS	Volatile Suspended Solids
MCC	Motor Control Center	WANS	Waste Anaerobic Sludge
mg/l	Milligrams per Liter	WC	Water Column
MG	Million Gallons	WWTP	Wastewater Treatment Plant
MGD	Million Gallons per Day		

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Evoqua Quality System Checks			
Project No.:	6069000103	Date:	March 16 2023
Issue Status:	DRAFT	Revision No.:	03
Prepared By:	Scarlett Zelaya		
Reviewed By:	Daniel Bertoldo Shannon Grant Troy Dorcas Andrew Shaw		

1 INTRODUCTION

This process design manual (PDM) has been prepared for the PRRC (Pasco Resource Recovery Center) in Pasco, WA.

The wastewater treatment system designed to treat the combined industrial wastewater consists of an influent pump station, two rotary drum screens, a vortex grit system, a 40,000 gal feed tank, two 34.5 MG low-rate, anaerobic, Type L ADI-BVF® reactors, a 2.3 MG aeration tank, a dissolved air flotation (DAF) system, and a sludge dewatering system.

1.1 Objectives of the Process Design Manual

The primary objective of the process design manual is to allow the process designers to communicate the following information to the detailed design team, customer, and governing authorities:

- Overall process description/review and battery limits
- Detailed unit-by-unit review of the treatment process (i.e., design criteria, how each unit is to be operated, interrelationship between units)
- Wastewater/sludge/effluent quantities (minimum, average and peak) and characteristics
- Projected biogas generation rate and biogas system components
- Instrumentation required (flow meters, level transmitters, pressure transmitters, etc.)
- Process controls
- Details on equipment.
- Unique features of the system

1.2 Using the Process Design Manual

The PDM represents the process engineer's concept of how the treatment plant (and its individual components) operates. The information presented in the PDM is not "irrevocable" and is subject to review during the detailed design phase.

2 PLANT HYDRAULICS AND PIPING

2.1 Hydraulic

The hydraulic grade lines (HGLs) for all gravity flows and pumped waste streams within the treatment plant, including any bypass system, should be prepared to ensure that adequate provision has been made for all flow situations and head losses, etc. A drawing showing the HGL at maximum flow is recommended. In calculating the HGLs, changes in head caused by all factors should be considered, including the following:

1) Head losses due to channel and pipe wall friction with allowance for sludge friction factors where necessary
2) Head losses due to sudden enlargement or sudden contraction in flow cross-section.
3) Head losses due to sudden changes in direction such as at bends, elbows, Y-branches, and tees
4) Head losses due to sudden changes in slopes, or drops
5) Head losses due to obstruction in conduit
6) Head required to allow flow over weirs, orifices and other measuring, controlling, or flow division devices
7) Head losses caused by flow through screens, tankage, filters, and other treatment units when applicable
8) Head losses caused by gas entrainment or gas binding (take care to prevent/overcome gas locks in lines carrying anaerobic fluid)
9) Head losses incurred due to flow splitting along the side of a channel or conduit.
10) Head increases caused by pumping
11) Head allowances for expansion requirements and/or process changes
12) Head allowances due to maximum water levels in tanks/sumps/etc.

Designers are cautioned to consider the consequences of excessive or inadequate allowances for head losses through wastewater treatment works. If pumping is required, excessive head loss allowances result in energy wastage. If inadequate head loss allowances are made, operation will be difficult.

2.2 Piping

All piping used in this treatment plant should be manufactured in accordance with applicable standards. In the general piping arrangement, sufficient space should be provided for piping to be removed, and the pipe design should provide for the proper isolation of pipe sections through valves to enable them to be repaired or replaced.

The designer should allow for the possibility that piping could be installed when temperature conditions are different from the design conditions, and substantial differences in pipe lengths could occur. Where pipe is cast-in-place, due allowance should be made for differential expansion between the pipe material and structures. The piping designer must check with the geotechnical engineer for final settlement estimates.

Piping should be arranged so that all valves and other items which may require regular inspection or maintenance are conveniently accessible. All liquid piping should be provided with drains at low points and air release valves at all high points.

The design of the piping should allow for proper restraint under all anticipated conditions, particularly where surges may occur and high transient pressure could result, or where different temperatures occur seasonally.

Where piping connections are made between adjacent structures, at least one flexible coupling should be provided if there is any possibility that differential settlement may occur. Particular attention should be given to pipe bedding in areas adjacent to structures to avoid settlement damage.

In sizing and selecting the material and pressure requirements of piping for use here, the following factors must be considered:

- Likelihood of blockage and size of line required
- Line size required to produce scouring velocities (3 ft/s and higher) and thus minimize solids deposition
- Nature and temperature of material to be conveyed and suitable piping materials for the application
- Flow characteristics of material to be conveyed and head requirements of pumps, or differential head required for gravity flow
- Possible settlement and need for support
- Need for future repair
- Need for future removal of pipe sections

2.3 Emergency Overflows

The EOF is to protect the basin contents from spilling over the top of the tank wall and potentially damaging the cover of the tank.

Emergency overflows (EOF) are required:

- EOF for the covered feed tank

3 DESIGN WASTEWATER CHARACTERISTICS AND EFFLUENT OBJECTIVES

The design raw wastewater, ADI-BVF® effluent, and aerobic effluent characteristics provided to Evoqua are listed in Table 3.1.

Table 3.1 - Design Raw Wastewater, ADI-BVF® Effluent, and DAF Effluent Characteristics

Parameter	Raw Wastewater	ADI-BVF® Reactor Effluent	DAF Effluent
Avg. Annual Day Design Flow (mgd)	4.38	4.38	---
Max. Month Day Flow (mgd)	8.56	8.56	4**
Peak Day Flow (mgd)	12.5	12.5	4**
BOD, AVG (mg/l)	3,590	350	300
BOD, Daily AVG. Load (lb/d)	131,035	12,800	---
BOD, Max. Month Load (lb/d)	300,000	30,000	---
COD, AVG (mg/l)*	7,180	720	720
COD, Daily AVG. Load (lb/d)*	262,070	26,200	---
COD, Daily Month Load (lb/d)*	600,000	60,000	---
TSS, AVG (mg/l)	2,140	460	100
TSS, AVG. Load (lb/d)	78,170	16,070	---
TSS, Max Month Load (lb/d)	227,885	41,680	---
TN, AVG (mg/l)	114	100	100
TN, Daily AVG. Load (lb/d)	4,170	3,650	---
TN, Max. Month Load (lb/d)	8,140	7,140	---
pH (s.u.)	---	6.5-7.5	6.5-8
Temperature (°F)	74*	85-98	---

*Assumed

**BVF reactor effluent flows >4 MGD to bypass aerobic system to storage lagoons

3.1 System Components

The design of the anaerobic and aerobic wastewater treatment system for the Pasco Resource Recovery Center shall consist of the following major components:

1. Raw wastewater station complete with:
   - Three raw wastewater pumps (3 @ 4,600 gpm) with VFDs
   - Instrumentation

2. Two rotary drums screen (perforation of 1/4”, two duty, one for future)

3. One vortex grit system

4. One 40,000 gal covered bolted steel feed tank complete with:
   - Fixed cover
   - Three feed pumps (3 @ 4,600 gpm) with VFDs

5. Two 34.5 MG in-ground Type ‘L’ ADI-BVF reactors, each complete with:
   - Floating, flexible, insulated geomembrane cover system
   - Two mixers (2 @ 6 hp)
   - Two recycle pumps (2 @ 1,900 gpm) with VFDs
   - Three BVF reactor effluent pumps (3 @ 4,340 gpm) with VFDs
   - Sludge loadout connection
   - Heat exchanger and heat loop pump
   - One 800 hp boiler for heat addition on the recycle line

6. One 15,000 gal $Mg(OH)_2$ tank complete with:
   - Two metering pumps
   - One mixer
   - Instrumentation and controls

7. Biogas collection, transmission, and flare system complete with:
   - Emergency vents
   - Five biogas blowers (5 @ 1,070 scfm, four duty, one standby) with VFDs
   - Two enclosed flares with dedicated control panels
   - Instrumentation and controls
   - Bulk H_2S reduction system (by others)
   - Biogas upgrading system to RNG pipeline quality (by others)
   - Condensate sump with condensate pump

8. Aerobic system complete with:
    - One 2.3 MG aeration tank
        - Fine bubble diffused aeration system complete with aeration manifold piping, air diffusers, and three aeration blowers (150 hp per blower)
        - Instrumentation, including level and DO/temperature transmitters
        - Automatic effluent flow control valve
        - Effluent flow meter
        - Effluent discharge piping
    - DAF system complete with:
        - DAF tank (304L SS tank and 304 SS frame) with maintenance/operating platform and access stairs (galvanized steel)
        - Flash/floc tank (304 SS tank) with mixers
        - Air dissolving pipe (ADP) with automatic gas release valve, drain, pressure relief valve, whitewater injection ports, air rotameter with needle valve, and pressure gauges
        - Two Hellbender recirculation pumps
        - Float skimmer and hopper
        - Bottom auger system
        - 8,500 gal coagulant tank with metering pump
        - Polymer metering pump
        - Two float pumps
        - Dedicated control panel

9. Algae system (by others)

10. Dewatering system complete with:
    - One 80,000 gal sludge tank
    - Two sludge pumps (2 @ 120 gpm)
    - One centrifuge with dedicated panel
    - Polymer metering pump
    - Sludge cake auger

4 PHYSICAL ASPECTS AND CONTROL OF THE WASTEWATER TREATMENT SYSTEM

4.1 Raw Wastewater Lift Station

The raw wastewater will be collected and pumped (by others) to the raw wastewater (RWW) lift station. The preliminary dimensions of the raw wastewater station are 16’ L x 10’ W x 18' TH (12.5’ LD). The pump station will be an in-ground concrete wet well.

A level transmitter will continuously monitor the liquid level in the RWW pump station. The level transmitter will be used to control the operation of the RWW pumps and will be trended on the HMI. Alarms will be implemented for high-high, high, and low-low conditions.

4.1.1 Raw Wastewater (RWW) Pumps

Three RWW submersible pumps, each with a capacity of 4,600 gpm will be used to pump the raw wastewater to the rotary screens for solids removal. The pumps will be configured in a two duty/one standby arrangement; designations will alternate after a fixed time period. Each RWW pump will be equipped with a VFD. The VFDs are required for these pumps such that they stay on their pump curve through the expected operating level changes (indicated by the raw wastewater level transmitter) in the RWW station.

At the HMI, the operator will enter the following setpoints:

- RWW lift station low level
- RWW lift station high level
- RWW lift station max level

4.2 Raw Wastewater Rotary Drum Screens

The raw wastewater will be pumped to the rotary screens before delivery to the grit vortex system. The raw wastewater enters a headbox where the energy is dissipated, and the flow is evenly distributed onto the interior of the rotary screening drum (two duty for current conditions, one for future conditions) capable of handling a peak flow of 4,600 gpm. Solids particles (> ¼") are retained on the screen surface while the liquid flows radially out through the screen openings. Screened solids are transported axially, by internal flights, to the open end of the rotary drum screen. The entire screening surface is intermittently washed by a fixed external spray bar. The rotary drum screens use clean water for screen washing via a solenoid valve. Screened solids will be transferred and collected in a storage bin for final disposal.

4.3 Grit Vortex System

The screened raw wastewater will be delivered to a grit vortex system for grit removal capable of handling a peak flow of 9,200 gpm. The raw wastewater is introduced into the grit system via a tangentially positioned inlet, causing a rotational flow path around the dip plate. The flow spirals down the wall of the chamber as solids settle out by gravitational forces and forces created by the rotating flow. The grit collects in the grit pot as the center cone directs flow away from the base, up and around the center shaft into the inside of the dip plate. The upward flow rotates at a slower velocity than the outer downward flow. The resulting "shear" zone scrubs out the finer particles. The concentrated grit underflow is discharged to a grit bin for disposal (by others). A vortex system bypass line will be used when the vortex system is off the line, and the screened wastewater will be delivered to the feed tank.

4.4 Feed Tank

The wastewater will flow by gravity to the Feed tank. The Feed tank has dimensions of 17.83'Ø x 25.52' TOW, 23' maximum liquid depth (40,000 liquid volume) and has a steel cone roof. The contents of the influent Feed tank will be pumped to either the anaerobic ADI-BVF® reactors (via the reactor feed pumps), or the effluent structure (via the bypass line).

The Feed tank is designed to operate approximately 2' from the top of the wall. An emergency overflow level is set 1' below the top of the wall. The emergency overflow discharges to the effluent structure.

4.4.1 Feed Tank Level

A pressure-transducer type level transmitter will be used to continuously measure the liquid level in the Feed tank. Feed Tank level will be trended at the HMI. Level alarm setpoints will be entered for high-high, high, low, and low-low levels.

4.4.2 Influent Pumps

The three influent pumps, each with a capacity of 4,600 gpm, convey screened wastewater from the Feed tank to either the anaerobic ADI-BVF® reactors or the effluent structure.

The flow meter signals are used to control the speeds of the variable-speed influent pumps in order to maintain the BVF reactor and RWW bypass flow rate setpoints (operator-adjustable). The influent pumps operate in a lead/lag configuration; lead and lag designations alternate with each pumping cycle. The operation of the EQ pumps will be interlocked with the influent level transmitter reading; the influent pumps will not be permitted to operate if the low-low level alarm is active for the feed tank.

At the HMI, the operator will enter the following setpoints:

- Feed tank target level
- Feed tank high level
- Feed tank max level
- Normal flow rate
- Max flow rate

When the Feed tank level reaches the high level, the lead influent pumps will be called to operate. The pump VFD will modulate the pump speed in order to maintain the normal flow rate, as measured by the flow meter. When the Feed tank level reaches the target level, the lead influent pumps will stop. In the event that Feed tank level reaches the max level, the lead influent pumps VFD will modulate the pumps speed in order to maintain the max flow rate, as measured by the flow meters. The max flow rate will be targeted by the lead influent pump until the target Feed tank level has been reached, at which point the influent pumps will stop.

4.4.3 Raw Wastewater (RWW) Bypass Line to Effluent Structure

A raw wastewater bypass line to the effluent structure is provided to allow flow of wastewater to go direct to the effluent structure, if and when necessary. This would only be used on very high peak day flow conditions when an operator deems it necessary (i.e., when flow is in excess of 12.5 mgd).

A RWW bypass flow meter and modulating control valve is located on the influent pumps' forcemain directing wastewater to the effluent structure. The instantaneous flow meter reading should be trended at the HMI. Totalized daily flows for the current day and previous 7 days will be displayed at the HMI.

The signal from the bypass flow meter is used to control the automatic, modulating bypass control valve in order to maintain the raw bypass flow rate setpoint (operator-adjustable).

4.4.4 Influent Sampler

An automatic influent sampling system is to be located on the common forcemain from the influent pumps. The flow-paced composite sampler is installed to collect flow-proportioned composite raw wastewater samples. The automatic sampler is to be controlled by a signal from the PLC based on measured flow (automatic sampler works in conjunction with the influent flow meters).

The PLC will signal an air actuated solenoid valve, connected to the pressurized influent forcemain, to collect flow-paced samples of raw wastewater. A sample line will flow to a container for sample collection located inside a small refrigerated unit. The sample line from the forcemain to the container should be as short as possible, and flow downward to the container.

The operator should be able to adjust how frequently an automatic sample is taken by adjusting the volumetric flow interval on the HMI.

4.5 Magnesium Hydroxide Metering System

The magnesium hydroxide (MagOx) dosing station serves to supply MagOx (i.e., supplemental alkalinity) to the BVF reactors. The MagOx dosing station consists of injection quills to the influent piping for each BVF reactor, a chemical storage tank (15,000 gal), two dosing pumps, pump flow and back-pressure calibration equipment, and water backflush ports.

The operator may set the dosing pump in Program mode, where the pump operates on an operator-adjustable cycle timer at an operator-adjustable pump speed. Alternatively, the operator may operate the chemical dosing pump in Operator mode at an operator-adjustable pump speed.

At design conditions, 207 gpd of 60% MagOx is required to satisfy the supplemental alkalinity requirements for the biomass in the BVF reactors. The alkalinity dosing pumps should be sized for 3,000 gpd (to account for peak day flows and safety factor).

The 15,000 gal, FRP, well-mixed MagOx storage tank consists of a truck loadout connection, a top-mounted mixer (7.5 hp with VFD), and a top-down LIT:

- The truck loadout connection may be used to pump a truckload of MagOx into the tank, as necessary.
- The level transmitter will monitor the MagOx tank Low-Low, Low, High, and High-High alarms and level setpoints. The level transmitter readings are displayed and trended at the HMI, and alarms will register at the HMI.
- The mixer is used to continuously mix the contents of the MagOx tank (to prevent settling and hardening of the MagOx). The operator may operator it on an operator-adjustable cycle timer.

Note: On a regular basis, operators should use the water backflush ports to keep the MagOx dosing system piping clean.

4.6 The ADI-BVF® Reactors

The ADI-BVF® anaerobic reactors are designed to biologically digest the organic load in the wastewater in the absence of oxygen. A long solids retention time (SRT) allows a large mass of slow-growing anaerobic microorganisms to be held in the reactor. Effective contact between the bios and the organic matter in the wastewater is achieved with the design of the influent distribution system and recycle flows.

Two 34.5 MG type 'L' ADI-BVF® reactors (with interior dimensions of' 602' x 301' x 32' TOW, 30' LD) will anaerobically digest solids and organic matter in the wastewater and convert the organics to biogas. The design criteria for the BVF reactors are presented in Table 4.1. Influent flows and concentrations in Table 4.1 are from PRCC design basis tables. Both reactors shall have the same design and be able to handle the design conditions herein. Further BVF reactor process design and sizing calculations are provided in Section 7.

Table 4.1 - Design Criteria for ADI-BVF® Reactors

Parameter	Design Conditions
Number of BVF Reactors	2
Total reactive volume per reactor (MG)	34.5
Avg. Annual Day Design Flow (mgd)	4.38
Max. Month Day Flow (mgd)	8.56
Peak Day Flow (mgd)	12.5
BOD, AVG (mg/l)	3,590
BOD, Daily Avg. Load (lb/d)	131,035
BOD, Load Max. Month (lb/d)	300,000
COD, Avg. (mg/l)*	7,180
COD, Daily Avg. Load (lb/d)*	262,070
COD, Load Max. Month (lb/d)*	600,000
TSS, AVG (mg/l)	2,140
TSS, Avg. Load (lb/d)	78,170
TSS Max Month Load (lb/d)	227,885
TN, Avg. (mg/l)	114

Parameter	Design Conditions
TN, Daily Avg. Load (lb/d)	4,170
TN, Load Max. Month (lb/d)	8,140
Operating pH (s.u.)	6.5-7.5
Temperature (ºF)	85-98
Avg. HRT (days)	15.8
Max. Month HRT(days)	8.1
AVG. Organic Loading Rate (kg/COD/m^3·d)	0.5
Max Month Organic Loading Rate (kg/COD/m^3·d)	1.04
WANS (lb/d)**	15,645
WANS (MG/y)***	16.4
Biogas Flow, Annual Avg. (ft^3/d)	1,830,000
Biogas Flow, Month Peak (ft^3/d)	4,190,000

*Assumed
**Dry weight basis, consisting of anaerobic biosolids and undigested raw wastewater TSS and WAS
*** Assumed wasted at 4 percent solids concentration

4.6.1 BVF Reactor Recycle Pumps

4.6.1.1 Supernatant Recycle Pump (SREC)

A supernatant recycle (SREC) system, with one SREC pump (1,900 gpm) and the SREC piping, serves to recycle digester supernatant from near the top of the reactor (through a single draw-off point) back into the influent line and into the sludge bed. Recycle provides attenuation of any shock loadings, pH and temperature swings and provides better bios/substrate contact. The supernatant collection point will be approximately 3' below the normal operating level (NOL), located close to the influent end and within the influent lateral zone.

An inline flow meter will be installed on the discharge of the SREC pump to monitor the SREC flow rate. Instantaneous and totalized daily flow rates will be displayed and trended at the HMI.

4.6.1.2 Return Anaerobic Sludge (RANS) Pump

A return anaerobic sludge (RANS) system with one RANS pump (1,900 gpm) and RANS piping, consisting of laterals on the bottom of the reactor at the effluent end, is used to recycle settled anaerobic sludge from the back half of the reactor into the influent distribution system. The RANS system serves to improve biomass-substrate contact and ensure that a sludge bed is maintained over the influent distribution system. RANS lines can also be used to waste excess reactor sludge (WANS) via sludge loadout connection for off-site disposal.

RANS laterals in the effluent end of the reactor are to be installed on the reactor floor, each complete with vented (under cover) cleanouts on both ends. Outside the reactor, each RANS lateral will have a plug valve to isolate and alternate the RANS lateral(s) in service. The plug valves should be easily accessible using a valve operator. The RANS lines will converge downstream of the manual valves.

A gas elimination chamber (GEC) will be installed on the common RANS line on the suction side of the RANS pump. The GEC is a fiberglass (or stainless steel) vessel used for removal of entrained biogas in the RANS to minimize the chance of pump cavitation. The GEC should be located as close as possible to the RANS pump inlet to minimize the amount of entrained gas entering the pump. Removed gas will be vented back to the BVF reactor.

The recycle pump control system should allow for the following:

- Operator to select the mode of operation (SREC or RANS) for each pump
- Pump selected in SREC mode to operate in one of the following methods:
    - Continuous operation when BVF reactor heating is required (this is the normal mode of SREC pump operation)
    - Operate using a repeating cycle timer
    - Operation interlocked with the reactor feed pumps (SREC pump activates when the duty reactor feed pump(s) is called to operate)

- Interlocks to prevent the simultaneous operation of the SREC and RANS pumps. Priority is assigned to the following (in order of highest priority):
    1. RANS
    2. SREC

The control system should allow for easy operator control of the recycle pumps through the HMI.

Manual sample taps are to be provided on the discharge side of the SREC and RANS pumps. Gas venting at all high points on the recycle lines should also be provided using a sewage air release valve.

The characteristics of the SREC and RANS/WANS for the BVF reactors are summarized in Table 4.2.

Table 4.2 - BVF Reactor SREC and RANS/WANS Characteristics

Parameter	SREC	RANS/WANS
Flow (gpm)	1,900	1,900
pH	6.5 -7.5	6.5 – 7.5
Solids (mg/l)	0 – 3,000	0.5 - 8%*
Temperature (°F)	85 – 98	85 - 98
Gas**	May contain significant quantities	Will contain significant quantities
*Up to 8% at commencing of pumping before falling to 1 to 4%. Use 3% for continuous flow design. **Special care is required in the design of the recycle system, and it is essential to prevent gas locks and associated pumping problems.		

4.6.2 Waste Anaerobic Sludge Removal

Waste anaerobic sludge (WANS) is removed via the RANS system (laterals and pump). It requires the operator to manually set valves to direct the flow through the loadout connection to a truck. The loadout should be located in a location with truck access. Refer to Table 4.1 for calculations of expected WANS quantities.

4.6.3 BVF Reactor Heating

At average design conditions, 746 MMBtu/d of heat will need to be supplied to the BVF reactors (373 MMBtu/d per reactor) to maintain the reactors at 85 ºF. Accounting for energy losses, up to 878 MMBtu/d of natural gas will need to be supplied to the heating system at average conditions (439 MMBtu/d per reactor).

At peak design conditions, 1216 MMBtu/d of heat will need to be supplied to the BVF reactors (608 MMBtu/d per reactor) to maintain the reactors at 85 °F. Accounting for energy losses, up to 1430 MMBtu/d of natural gas will need to be supplied to the heating system at peak design conditions (715 MMBtu/d per reactor).

A heat exchanger will be installed on each BVF reactor supernatant recycle (SREC) line. The heat exchanger will be used to add supplemental heat to the BVF reactor during normal operation (if/when required) and during start-up conditions or extended plant shutdowns during which no wastewater is delivered to the BVF reactors.

During normal operation, each heat exchanger will transfer up to 26.8 million Btu/hr of thermal energy to the BVF recycle (SREC). A bypass line around the heat exchanger will be installed and will be used during RANS recycle, boiler or heat exchanger maintenance.

Temperature transmitters are to be installed on the BVF reactor SREC line (upstream and downstream of the heat exchanger) which will continually monitor the recycle temperature as a means of indicating reactor operating temperature and heating performance. E. low, low, high, and E. high temperature alarms should be signaled at the HMI.

Two 800 hp boilers (one dedicated to each BVF reactor) will be installed to provide supplemental heat to the anaerobic reactor. Hot water from the boiler will be circulated through the heat exchanger to transfer heat to the BVF reactor SREC, which will maintain the BVF reactor within a temperature range of 85 to 98°F.

The SREC pump will be called to run continuously by the main WWTP PLC when BVF reactor heating is required.

A three-way control valve on the boiler recirculation loop will modulate to maintain the boiler return water temperature, as measured by the boiler return water temperature transmitter, at a setpoint. The purpose of this control loop is to control the heat load on the boiler and heat exchanger to a value within acceptable design limits for the boiler and heat exchanger as the BVF reactor temperature changes.

The duty hot water recirculation pump will be started whenever the boiler is required to run and stopped after the boiler has been stopped and not called to run for a period of time. While the pump is operating, its speed will be modulated via a VFD to maintain the water recirculation loop flow rate (as measured by the associated flow transmitter) at a fixed setpoint.

The boiler will be started when the BVF reactor temperature, as measured by the SREC temperature transmitter on the inlet side of the heat exchanger, falls to a “Boiler Start Setpoint”, and stopped when the BVF reactor temperature rises to a “Boiler Stop Setpoint”.

Each boiler is controlled using a dedicated control panel, and includes a local HMI that provides access to boiler configuration and control functions and displays boiler parameters, fault annunciation, and alarm history. The control system provides firing rate control to maintain the hot water supply temperature at a setpoint. The basic principles of boiler operation are as follows:

- Prior to operation, the boiler goes through a pre-purge cycle, where the air blower motor is started and the air damper opens to its fully-opened position. Opening the damper allows a flow of purging air through the boiler prior to the ignition cycle.
- Following the air purge, the damper returns to its low fire position and the ignition cycle begins. The ignition transformer and gas pilot valve are energized, and once a pilot flame is established, the main fuel valves are energized. Once the main flame is established, the ignition transformer and gas pilot valve are deenergized.
- When the main flame is established, the control system allows for operation above the low-fire range. In automatic control, the firing rate will be controlled by the air damper and fuel valves.
- The burner will fire until water temperature in excess of demand is generated. In this scenario, the air damper will return to the low fire position, the fuel valves are deenergized and the main flame is extinguished. The air blower continues to run to force air through the boiler during a post-purge period.

4.6.4 BVF Reactor Level

A pressure-transducer type level transmitter is used to continuously measure the liquid level in the BVF reactor. Reactor level is to be trended at the HMI. E. low, low, high, and E. high reactor level alarms should be signaled at the HMI. Interlocks to be provided in the control logic to prevent recycle pump operation when either the low or E. low level alarm condition is active.

Table 4.3 – BVF Reactor Effluent Characteristics

Parameter	BVF Reactor Effluent
Flow, minimum (gpm)	0
Flow, avg (gpm)	1,520 per reactor
Flow, peak (gpm)	4,340 per reactor
pH	6.5 – 7.5
TSS (mg/l)	460
Temperature (°F)	85-98
Dissolved gases (CH_4, CO_2, H_2S)	effervescent, odorous, corrosive, toxic, and flammable

4.6.5 BVF Reactor Effluent Pumps

The three inline BVF reactor effluent pumps (3 @ 4,340 gpm, two duty, one standby) with VFDs will deliver flow to the aeration tank, as well as send anaerobic effluent to the effluent structure based on automatic control valves, flow meters, and corresponding operator-adjustable setpoints. The aeration tank can only accept 4 MGD, and all excess flow is directed to the effluent structure.

4.7 Aeration Tank (AT)

The aeration tank will be 130.72’ Ø x 26.49’ (3’ of freeboard), resulting in a reactive volume of 2.3 MG, bolted epoxy-coated carbon steel tank. During normal operation, up to 4 MGD of BVF reactor effluent will be pumped to the aeration tank, and any additional BVF reactor effluent will bypass directly to the final effluent structure. The tank will be aerated to oxidize dissolved sulfides in the anaerobic effluent. Aeration tank effluent will discharge to the DAF system.

The design criteria and projected performance for the aerobic system are listed in Table 4.4.

Table 4.4 – Aerobic System Design Summary

Parameter	Design Conditions
Peak Daily Flow (mgd)	4
Influent BOD, Avg. (mg/l)(1)	350
Influent BOD, Daily Avg. Load (lb/d)	12,000
Influent TSS, Avg. (mg/l)	460
Assumed Influent Sulfide Concentration (mg/l)	20
Avg. HRT (hr)	13.8

Mixing and aeration for the aeration are provided by the fine-bubble diffused aeration system which supply sufficient agitation and oxygen transfer to meet the respiration requirements for the biological process.

The aeration system will consist of 22 headers to distribute air throughout the base of the aeration tank. The aeration system is sized to handle the design air demand requirements (see Section 7.4 for AOR calculations).

Three aeration blowers will be used to supply air to the aeration tank. Each aeration blower will have a 150 hp motor and VFD for blower speed control. Each aeration blower will be equipped with a temperature switch that prevents the blower from running if a high temperature is measured. If a high temperature is measured by the switch, the associated blower will shut down, and an alarm will register at the HMI.

Each aeration blower enclosure is equipped with a cooling fan operated by FVNR starter. The cooling fans are interlocked with the operation of the aeration blowers such that the cooling fans will run continuously when the associated aeration blower is running and stop when the associated aeration blower is stopped.

A DO/temperature probe and transmitter will be used to continuously monitor the DO concentration and temperature of the aeration tank contents. The DO and temperature will be trended and displayed at the control system HMI. The DO probe should be installed sufficiently deep in the aeration tank (approximately 6’ below TOW) to ensure the probe is submerged in liquid at all times in order to protect the probe.

A control loop will be used to modulate the speed of the duty aeration blowers in order to maintain a target DO concentration range in the aeration tank.

The DO transmitter sends a 4-20 mA signal to the PLC, which periodically changes the target duty aeration blower's speed depending on whether the aeration tank DO concentration is rising or falling. If the VFD for the duty aeration blowers ramps the blowers down to their minimum operating speed and the DO concentration is within or above the target range, the duty aeration blowers will continue to operate at the minimum operating speed. The normal DO target range will be 1-2 mg/l.

At the HMI, the operator will enter values for the following setpoints:

- Maximum DO (mg/l)
- High DO (mg/l)
- Low DO (mg/l)
- Minimum DO (mg/l)
- Maximum aeration (%)
- Minimum aeration (%)
- Update interval (seconds)
- Large negative adjustment (%)
- Small negative adjustment (%)
- Small positive adjustment (%)
- Large positive adjustment (%)

4.7.1 Aeration Tank Level

A differential pressure level transmitter will be installed in aeration tank. The transmitter is used to continuously measure the liquid level in the tank. The tank level is to be trended at the HMI. E. low, low, high, and E. high tank level alarms should be signaled at the HMI.

4.7.2 Aeration Tank Effluent

The maximum operating level in the aeration tank is approximately 23.46 ft.

Aeration tank effluent will flow by gravity, at a controlled flow rate, to the DAF system. A flow meter and automatic, modulating flow control valve will be installed on the aeration tank effluent line. The instantaneous flow meter readings will be displayed and trended at the HMI. Totalized daily flows for the current day and previous 7 days will be displayed at the HMI.

4.8 Dissolved Air Flotation (DAF) System

The DAF system is an efficient, safe flotation technology which will separate low-density solids from the liquid stream. The DAF uses air, which is injected into the DAF recycle stream to form a dissolved gas-in-water solution. This recycle stream is mixed with incoming wastewater in an internal contact chamber where the dissolved gas comes out of solution in the form of micron-sized bubbles that attach to the solids. The bubbles and solids rise to the surface and form a floating bed of material that is removed by a surface skimmer into an internal hopper for further handling. Clarified DAF effluent will be discharged by gravity to the algae system.

4.8.1 Flash/Floc Tank

Aeration tank effluent will discharge, at a controlled flow rate, to the flash/floc tank. The flash mix and flocculation tank (21’-9” L x 10’-7” W x 9’-11” H), is a 316 SS tank divided into two cells with an underflow baffle separating the cells, with a total active volume of 11,220 gal (5,610 gal per cell). Each cell contains a mixer for mixing the cell contents.

The coagulant tank will be 10’ Ø x 16 TH (1.5’ of freeboard), resulting in a reactive volume of 8,500 gal. A level transmitter is used to continuously measure the liquid level in the alum storage tank.

Coagulant for flotation and removal of suspended solids is added to the DAF flash mix cell using a coagulant metering pump to promote the chemical coagulation for flotation and removal of suspended solids. The coagulant metering pump is operated by a local pump controller with remote/run stop, remote speed setpoint, and running status signals to/from the DAF control panel.

Polymer is added to the floc cell using a polymer metering pump to promote aggregation of floc particles for removal in the downstream DAF tank. The polymer metering pump is operated by a local pump controller with remote/run stop, remote speed setpoint, and running status signals to/from the DAF control panel.

4.8.2 DAF Tank

The DAF tank (57'-6" x 13' x 10 H, 598 ft^2 active surface area) consists of a rectangular flotation tank constructed of 304 SS plate reinforced with 304 SS tubular vertical wall structural supports. The tank is supported on a stainless steel base consisting of horizontal beams across the width of the tank and a continuous beam structure down both sides of the length of the tank. The base is constructed to allow for easy cleaning around and under the tank. The tank is designed for above-ground positioning on a suitable concrete pad or steel frame and is constructed for indoor or outdoor conditions.

4.8.3 Contact Chamber

Effluent from the flash/floc tank enters the DAF tank through a flanged influent header into the contact chamber. The recycle (whitewater) stream is mixed with the influent through a series of injection ports in the contact chamber and the influent header. The contact chamber serves as an internal weir which provides even distribution and mixing of the process flow across the width of the tank. The contact chamber has two cutouts in the bottom to allow settled solids to drain to the bottom of the DAF.

4.8.4 Recirculation (Whitewater) System

The recirculation system is designed to saturate, under pressure, a clarified effluent stream with air to create a dissolved air solution or whitewater. When the whitewater stream is introduced into the contact chamber of the DAF tank, fine, micro-bubbles are released to make contact with flocculated contaminants which rise to the surface within the flotation tank for removal.

Clarified wastewater from the effluent discharge is recycled through the tank by two Hellbender™ DAF recycle pumps (each at 400 gpm, one duty, and one standby) designed to operate at pressures above 90 psi. Air is supplied into the recycle stream under pressure from the recycle pump. Air flow into the pump is regulated by an air control panel and solenoid valve.

The recycle stream is routed through an Air Dissolving Pipe (ADP) that provides additional hydraulic retention time under pressure and allows the separation and removal of large, undissolved air bubbles. The ADP is a vertical section of stainless steel pipe in the recycle piping system that is equipped with a bottom valve for draining and servicing. Liquid level in the ADP is automatically maintained by an air release valve with an inline equalizer.

Discharge pressure from the recycle pump and the ADP is controlled by a series of whitewater injection points into the contact chamber and influent header through stainless steel ball valves. A mid-tank injection system provides the option of adding whitewater into the flotation cell just downstream of the contact chamber. A liquid filled pressure gauge is provided for monitoring recycle pressurization performance.

The recirculation pump, ADP, and all recirculation piping are mounted to the flotation tank.

4.8.5 Float Removal System

The tank is equipped with a chain and flight top float (skimming) removal system driven by a low speed, gear reducer with motor assembly. The float material is removed in a concurrent direction. This design involves moving the float bed on the surface down the length of the tank in the direction of flow and allows for longer float residence time prior to removal, resulting in drier float material.

- The top skimmer system consists of double strands of 304 SS double pitch roller chain, supported by UHMW shoes on stainless steel guide angles. The chain supports adjustable skimmer blades retained on 304 SS angle plates with stainless steel fasteners. The skimmer blades are spaced approximately every 3-5 ft along the chain length. The chain system operates on single duty, stainless steel sprockets mounted on stainless steel shafts turning in adjustable bearing supports. The correct chain tension is indicated by a chain tensioning indication system that shows when the chain tension requires adjustment. The system is driven by a gear drive with TEFC motor through a chain and sprocket system. Adjustable timer controls provide for intermittent skimmer operation which allows for flexibility in the removal of float material from the tank.

- On the effluent end, the skimmer pulls the collected surface material (float) up a curved beach and into an internal float hopper. The beach is curved to allow for efficient removal of float material by the skimmer wiper. The internal float hopper is sized to allow intermediate storage of the material prior to discharge through a flanged nozzle for pumping to the sludge storage tank. Level in the float hopper is monitored by a level transmitter, and the duty float pump operates to control the level in the float hopper within the high and low level setpoints.

At average design conditions, 36,000 gpd of DAF float at 4% solids will be generated from the DAF system.

4.8.6 Sludge Removal System

Full-length sloped side walls channel settleable sludge to a trough in the bottom of the tank for removal by an auger system pulling the material towards the influent end of the tank (counter-current). The counter-current design removes settled material quickly from the tank at the opposite end from the treated water discharge. The material is discharged through a flanged nozzle located in the influent end of the tank base. The auger system consists of a 6" diameter, 6" pitch 304 SS auger in the trough located in the V-shaped bottom of the tank. The auger extends the full length of the DAF. Adjustable timer controls provide for intermittent auger operation, which allows for flexibility in the removal of bottom material from the tank.

An actuated valve on the suction side of the DAF float pumps will periodically open to allow the DAF float pumps (each @ 200 gpm, one duty, one standby) to transfer floating solids to the to the sludge tank or aeration tank.

4.8.7 DAF Effluent

At the effluent end, a vertical baffle directs the clarified DAF effluent up into a header box and through an adjustable weir system. The weir is adjustable to determine the optimum liquid level in the tank and is designed to provide minimum fluctuation of the tank liquid level with the variation of influent flow. Clarified effluent overflowing the weir collects in an internal trough and will be discharged by gravity to the algae system.

4.9 Sludge Storage Tank

One sludge storage tank (24.62’ Ø x 25.52’ TOW, 23.52’ LD, 80,000 gal maximum liquid volume) will be used to store waste sludge from the DAF.

4.9.1 Sludge Tank Level

A differential pressure level transmitter will be installed in sludge tank. The transmitter is used to continuously measure the liquid level in the tank. The tank level is to be trended at the HMI. E. low, low, high, and E. high tank level alarms should be signaled at the HMI.

4.9.2 Sludge Tank Mixing

The sludge tank mixing is accomplished with one side-entry mechanical mixer operated by the soft starter. The mixer will be equipped with a 2.5 hp motor. The mixer will operate using an operator-adjustable repeating cycle timer. The operation of the mixer will be interlocked with the sludge tank level transmitter reading; the mixer will not be permitted to operate if the low-low sludge tank level alarm is active.

4.10 Dewatering System

The dewatering system will thicken the sludge from the sludge tank and generate a sludge cake for off-site disposal (by others). Sludge from the sludge tank will be pumped to a centrifuge using speed-controlled sludge pumps (each at 120 gpm max capacity, one duty, one standby). Each sludge pump will be controlled using the dedicated centrifuge system control panel. Based on the estimated 36,000 gpd of 4% DAF float sludge generated at design conditions, the sludge pumps are sized to operate 5 hours per day on average, but long time periods when necessary for peak conditions.

The dewatering system will consist of sludge feed pumps, a centrifuge, polymer mixing/injection system, sludge cake conveyor, and dedicated control panel. Polymer and coagulant will be mixed with the incoming sludge to further flocculate the solids. The centrifuge will form a thickened sludge cake which will be conveyed to a hopper using a screw conveyor. At average design conditions, the centrifuge will generate 36 yd^3/d of sludge cake at 20% solids concentration.

The centrifuge will have a dedicated control panel which will connect to the main WWTP control system via Ethernet, allowing operators to view the centrifuge status at the WWTP HMI.

The centrifuge will be started when a process start button is pressed (at either the local centrifuge control panel or the main plant HMI) and stopped when a process stop button is pressed (at either the local centrifuge control panel or the main plant HMI). The sludge feed pumps and centrifuge will not be permitted to operate if the level in the low-low level alarm condition is active for the sludge storage tank.

Centrate generated from sludge dewatering will be discharged to the headhouse building sump. A level transmitter will be used to continuously measure the liquid level in the sump. Sump level will be trended at the HMI. Level alarm setpoints will be entered for high-high, high, low, and low-low levels. Sump pumps (one duty, one standby) will pump liquid from the headhouse building sump to the aeration tank to maintain the sump level at the level setpoint.

Sludge cake generated from the centrifuge will discharge into the conveyor system. Sludge cake will be discharged into a sludge cake hopper, which will need to be periodically emptied.

5 BIOGAS COLLECTION, TRANSMISSION, UTILIZATION, AND FLARING SYSTEM

5.1 Components of the Biogas System

1. Collection: The biogas generated in the BVF reactor will be collected and transported through the main gas pipeline to the blower system. A biogas vent line must be provided for emergency use.

2. Transmission: Five positive displacement blowers (four duty/one standby) will be used to pressurize and transmit the biogas to either the enclosed waste gas flare system or to a utilization system. Each biogas blower is sized for a flow of 1,070 scfm (discharge pressure to be verified during detailed design). The blower speed will be controlled by a variable frequency drive (VFD), via a signal from the PLC, based on the readings of the BVF cover pressure transmitter.

3. Venting: A vent stack will be used for release of the biogas from beneath the BVF cover when the blowers are not available. Position switches on the vent and transmission valves will prevent the blowers from running when the vent is open.

4. Flaring: Biogas that is not utilized will be combusted in two enclosed flares complete with flame trap assembly and natural gas pilot.

5.2 Quantities and Characteristics of Biogas

The projected quantity and quality of biogas generated in the BVF reactor are shown in Table 5.1.

Table 5.1 - Projected Quantity/Quality of Biogas

Parameter	Value
Annual Average Biogas Flow (ft^3/d)	1,830,000
Max. Month Biogas Flow (ft^3/d)	4,190,000
Annual Average Biogas Energy (MMBtu/d)	1,190
Max. Month Biogas Energy (MMBtu/d)	2,720
Methane, CH_4 (%)	60 - 70 typical 50 - 80 extreme range
Carbon Dioxide, CO_2 (%)	30 - 40 typical 20 - 50 extreme range
Hydrogen Sulfide, H_2S (ppm)	4280*
Temperature (°F)	85-98
Water Vapor	saturated

Parameter	Value
Oxygen, O_2 (%)	normally < 0.5

*Assumed value as no wastewater sulfur concentration was provided

5.3 Biogas Pipelines and Valves

All biogas piping is to be SS 316L. All biogas isolation valves are to be rubber-lined (Buna-N), cast iron-bodied, wafer butterfly type valve with all 316 SS trim.

All pipes and valves for the biogas system should be selected/sized considering:

- Estimated biogas flows
- Wet and corrosive nature of biogas
- Temperature and pressure of blower discharge
- Suction piping to include sediment moisture trap

5.4 Floating Geomembrane Covers

Each BVF reactor will be covered with an insulated floating geomembrane cover. The cover system is designed to insulate the reactor, collect biogas, and prevent odors. Since the cover is flexible and floating, it allows for some variation in operating level. The reactor cover is constructed using geomembrane material and includes insulation, sampling ports, a rainwater collection and pumps, access hatches, cleanouts and perimeter attachment system. ½" of closed cell insulation on the cover system allows for sufficient buoyancy to permit personnel with appropriate safety equipment to safely walk on the cover system for maintenance and sampling.

To allow for automatic disposal of rainwater into the reactor, the membrane cover is arranged with a series of bay floats and weight pipes that force the rainwater to sumps that get pumped into the reactor.

The capped sampling ports allow access to reactor contents for temperature profiles, sludge height measurements, and collection of supernatant and sludge samples. A minimum of 16 ports is suggested.

5.5 Description of Biogas Components

5.5.1 Cover Pressure Transmitter and Manometer

A differential pressure instrument continuously compares the pressure under the cover to atmospheric pressure. It sends a 4-20 mA signal to the PLC which changes the biogas withdrawal rate (i.e., the biogas blower speed) in order to control system pressure within a target range. In addition, high and low pressure setpoints will register alarms through the PLC.

Selection of the pressure transmitter should consider:

- Wet, corrosive nature of biogas.
- Measurement range (-1.5” to +1” WC).
- Transmitter will be located in an enclosure that provides weatherproof protection. In order for the system to work properly, the transmitter should be as close as possible to the reactor, and the designer must verify that the biogas pipeline headlosses from the BVF reactor to the control transmitter location on the suction side are insignificant compared to the normal operating range (i.e., +0.05’’ to +0.15’’ WC); otherwise, the control transmitter should be as close as possible to the reactor.
- "Atmosphere" line on differential pressure cell must be protected from wind; use ½” diameter.
- Field calibration of instrument.
- Line from transmitter to the biogas pipeline must slope down to the pipeline and be free-draining to eliminate condensate accumulation or any restrictions that would give false readings.

A manometer will be installed in the heated fiberglass enclosure to verify the cover pressure transmitter reading.

5.5.2 Biogas Vent (manually operated)

The purpose of the vent is to permit venting of biogas directly to atmosphere without damage to the BVF reactor cover in the event that the biogas transmission system is disabled (e.g., extended power outages or blower failure), or during the start-up period. The vent should also be used to vent biogas if the gas oxygen content is greater than 5%.

Design considerations for the vent include:

- Sized to prevent the cover from inflating under peak gas flow conditions

- Vent and biogas transmission isolation valves are to be controlled manually, have easily accessible manual handwheel operators, include suitable heat tracing to prevent freezing and limit switches to verify open/closed positions and alarm at the HMI
- Metering of biogas through vent is not required
- Opening of the vent valve (after closing the biogas transmission isolation valve) will be initiated by the operator after a high-pressure alarm is sounded
- If the blowers are off because of mechanical or electrical failure, then a high-pressure alarm must sound when the cover just begins to rise off the liquid surface. This will alert the operator of the need to open the vent. The vent must remain open until the blowers are back in service.
- The limit switches on the biogas vent and transmission valves must be interlocked with the operation of the biogas blowers. If the vent valve is not in the fully closed position and the biogas transmission valve is not in the fully opened position, the PLC shall prevent operation of the blowers until the valve positions are positioned correctly.
- Before the vent is opened, the operator must be able to positively verify that the blowers are off

5.5.3 Pressure Gauges

The designer should include pressure gauges for monitoring of the biogas transmission system.

5.5.4 Purge Points

These permit purging of the biogas handling system (or specific sections of the system) into or out of service with an approved inert gas (e.g., carbon dioxide, nitrogen, argon) for the purpose of preventing the occurrence of explosive methane-oxygen mixtures. Purge points can also be used as extraction ports to obtain biogas samples. Purge points are to be properly sealed and accompanied by a ball valve and threaded plug to prevent gas leakage. They are to be located at various key points along the biogas transmission system.

5.5.5 Gas Liquid Sediment Trap and Drip Traps

The purpose of the gas liquid sediment trap (GLST) is to remove particulate matter and condensation from the biogas stream immediately prior to the blower system. The GLST should be piped to a suitable drain. In addition, drip traps will be located at all low spots in the gas piping system. Each drip trap should be piped to a suitable drain.

5.5.6 Biogas Condensate Sump

Biogas condensate from gas liquid sediment trap (GLST) and drip traps will be discharged to a condensate sump along with condensate from the biogas upgrading system. The condensate pump will pump condensate into the RWW station.

5.5.7 Biogas Blowers

Five positive-displacement blowers (1,070 scfm) with gastight mechanical seals will be installed to handle the peak biogas flow generated from the BVF reactors. Each blower shall be driven by a high-efficiency motor. Motor type should be suitable for operation in a Class 1, Div. 2 environment and particular attention to power requirements throughout its operating range is required. The motor must also be suitable for operation with a VFD.

Blower operating temperature must also be acceptable, especially at low flow conditions, such that high temperatures do not cause problems with other components of the biogas delivery system. Another important point to consider is blower turndown; the blower should be capable of running for extended periods at low flow conditions, i.e., when biogas flow is low. In the event of very low biogas production, the duty blower will run at its minimum operating speed to minimize motor stops/starts. Blower lobes shall be teflon coated with extra tolerances between the lobes.

5.5.8 Variable-Frequency Drives

The variable-frequency drive (VFD) units drive the motors which power the biogas blowers. They are a part of the biogas control loop which includes the cover pressure transmitter, the PLC, and the blowers.

The purpose of the VFD units is to match blower capacity with biogas production, with the intention of maintaining the reactor cover pressure within a setpoint range. The PLC processes the signal from the cover pressure transmitter and, in turn, relays a control signal to the VFD units to establish the proper blower operating speed.

5.5.9 Blower Discharge Temperature Transmitters

Temperature transmitters are provided at the discharge piping of each blower. If the blower discharge temperature exceeds the preset limit (indicating a possible blockage in downstream the biogas piping), the blower will be shut down (by the PLC) and an alarm will be sounded. When alarmed, the PLC should switch duty to the other blower, provided that it is available to operate and no alarm conditions exist for that blower.

5.5.10 Biogas Upgrading System

The biogas blowers will transmit raw biogas from the BVF reactors to the bulk H_2S reduction system, which is designed to reduce H_2S content from 4,280 ppm to 100 ppm. Scrubbed biogas flows up to 2,500 cfm will be further upgraded to generate RNG. Scrubbed biogas flow in excess of 2,500 cfm will be sent to the enclosed biogas flares for combustion.

5.5.11 Flow Control Valves

Two flow control valves will be used to discharge scrubbed biogas to the enclosed biogas flares. The valve positions will modulate to maintain an even split of biogas to the flares, as measured by the flow meters.

5.5.12 Biogas Flow Meters

Biogas flow meters will be installed on the scrubbed biogas line and the enclosed flare line. The instantaneous flow meter readings will be displayed and trended at the HMI. Totalized daily flow for the current day and previous 7 days will be displayed at the HMI.

5.5.13 Enclosed Biogas Flares

The enclosed biogas flares will be burn either the raw biogas, scrubbed biogas, or off-spec gas from upgrading system. Each biogas flare will have a dedicated control panel. The biogas flares will be sized to handle the peak biogas flow. Natural gas is provided as pilot fuel to light each flare before sending any biogas to the flares. A flame trap assembly with flame arrestor, thermal shutoff valve, and drip trap will be located upstream of each flare. The purpose of the flame trap assembly is to prevent flares flash backs through the biogas piping system. The flares must be located a minimum of 50 ft from the digester.

5.5.14 Biogas Analysers

A Dräger kit and portable O_2 analyzer will be provided to manually analyze the biogas for CO_2, H_2S, and O_2 content; this testing is necessary to determine the integrity of the cover system (increasing O_2 might mean leaks in the cover) and biogas composition (sudden changes in composition might indicate reactor upset).

5.6 Biogas System Control/Operation

The duty blowers draw the biogas from beneath the cover(s) and deliver it to the upgrading system or the biogas flares. The rate of biogas production within the reactors is not constant and varies according to changes in flow, wastewater characteristics, system temperature, and other operating parameters.

The biogas collection and transmission components are controlled in the following manner. The speed of the duty biogas blowers is controlled using a PID loop in order to maintain the setpoint cover pressure. Each BVF reactor is equipped with a pressure transmitter located as close to the reactor as possible. The transmitter measures the biogas pressure under the cover and transmits a 4-20 mA signal to the PLC. The PLC compares that pressure to the desired pre-set range (which may be reset). The PLC then sends a 4-20 mA signal to the blower VFD to adjust blowers speed so that the pressure will increase, decrease, or remain the same, as required. For example, if the setpoint range is +0.05” to +0.15” WC and the average cover pressure measured over the time interval inputted in the control logic is +0.20” WC, the blower VFD will increase the speed of the duty biogas blowers in order to maintain the target cover pressure. The biogas controls will be tuned such that any imposed changes in blower speed should be adequate to handle changes in gas production rates without allowing the cover to inflate.

The system described in the previous paragraph accomplishes two things: it matches the rate of biogas transmission with biogas production, and it maintains a slight positive pressure underneath the BVF reactor to prevent air infiltration.

The blowers will automatically shut down in an alarm situation and produce an alarm at the computer screen. The duty blower will automatically try to restart after a set time delay, and setpoint conditions for automatic shutdown no longer exist.

Should the supply of biogas start falling for any reason, the blower output will be automatically reduced (in proportion to the decrease in flow) to the minimum output or speed setting. If gas production continues to fall, the blower will shut down and restart automatically once cover pressure has returned to the setpoint range.

5.6.1 Biogas Alarm System

There are a number of possible scenarios which initiate an alarm condition and/or automatic blower shutdown. If the biogas blower discharge temperature increases to a high setpoint (temperature TBD), or the suction pressure (as measured at the reactor) decreases below the low-pressure alarm condition for longer than a few seconds (or the blower speed falls below a pre-set minimum), the blowers will automatically shut down. The blowers will automatically restart when the cover pressure reaches the desired set range.

Table 5.2 summarizes the conditions that result in a biogas alarm and blower shutdown. In addition to these, the operator shall use the biogas oxygen analyser daily to test the biogas for the presence of oxygen. If O_2 concentration reaches 1 percent, the biogas system, including the cover, should be carefully checked for leaks. If O_2 concentration reaches 2 percent, the blower should be shutdown until leaks are repaired.

Table 5.2 – Biogas Alarm Conditions

Alarm Condition	Setpoint	Possible Cause	Result
High blower(s) discharge temperature	TBD	Blockage in blower(s) discharge piping	Blower(s) shut down; automatic restart after alarm reset.
Low blower speed	TBD	Insufficient gas production at BVF reactor	Blower(s) shut down; automatic restart after fixed time delay and cover pressure returning to setpoint
High cover pressure alarm	TBD	Blower down due to mechanical/ electrical failure, excess biogas production	Investigate and monitor prior to blower shut down.
E. high cover pressure alarm	TBD	Blower down due to mechanical/ electrical failure, blockage in suction line	Manually open valve leading to vent. Close valve leading to blower.
Low cover pressure alarm	TBD	Malfunction of blower speed control	Investigate and monitor prior to blower shut down.
E. low cover pressure alarm	TBD	Malfunction of blower speed control	Blower shut down, computer alarm.
First (low) O_2 (based on manual measurements)	1% O_2 in biogas	Leak in reactor cover or blower suction piping	Operator to shut down biogas blower and vent to atmosphere and find leaks.
Second (high) O_2 (based on manual measurements)	2% O_2 in biogas	Leak in reactor cover or blower suction piping	Operator to shut down biogas blower, vent to atmosphere, close valve leading to blower, and find leaks.

Alarm Condition	Setpoint	Possible Cause	Result
Biogas or vent valve position	Open/close positions of valves improper	One or more valves are improperly positioned	Blower will not operate, alarm reset after valves are properly positioned

6 CONTROL BUILDING AND UTILITY REQUIREMENTS

6.1 Control Building

The control building will be a pre-engineered metal building. The building has dimensions of 140' x 120'

The control building will house the following:

- Rotary drum screens (2 rotary screens)
- Debris collection bins
- Grit vortex system
- Concentrator system
- SREC pumps
- RANS pumps
- Chemical storage area for $Mg(OH)_2$ tank and metering system
- Boilers and heat exchanger area
- Electrical room housing MCC, control system, VFD's, transformer and other panels.
- Utility /service room
- Washrooms
- Offices
- Meeting room
- HVAC systems as required
- Laboratory
- Maintenance shop area

6.2 Utility Requirements

The utility requirements for the building and WWTP system are listed below

- Phone line & internet – access to phone and internet are required for communication and data transfer to Evoqua.
- Natural gas – Natural gas will be supplied to the boiler to provide heat to the heat exchanger. Natural gas will be used as pilot gas for the enclosed biogas flares

7 PROCESS DESIGN CALCULATIONS

The wastewater characteristics upon which the design calculations are based are listed in Table 3.1.

7.1 BVF Reactor Sizing

7.1.1 BVF Reactor Volume

BVF reactor sizing is based on a volumetric organic loading rate of 1.045 kg COD/m^3 d for the Max Month Daily loading conditions, which is 600,000 lb COD /d

$$\textbf{Volume} = \frac{600{,}000\ \text{lb/d}/2.2\ \text{lb/kg}}{(1.045\ \text{kg COD}/m^3\text{d})\ \text{x}\ (0.003758\ \ \text{m}^3/\text{gal})} = \textbf{69 MG}$$

Using 2 reactors, each reactor volume = 69 MG/2 = **34.5 MG**

7.1.2 BVF Reactor Hydraulic Retention Time (HRT)

Basis:

- BVF Volume: 34.5MG per reactor
- Avg. Flow: 4.38 MGD (2.19 MGD per reactor)
- Max. Month Day Flow: 8.56 MGD (4.28 MGD per reactor)

$$\textbf{Average HRT per reactor} = \frac{34.5\ \text{MG}}{2.19\ \text{MGD}} = \textbf{15.8 d}$$

$$\textbf{Max. Month HRT per reactor} = \frac{34.5\ \text{MG}}{4.28\ \text{MGD}} = \textbf{8.1 d}$$

7.2 BVF Reactor Biogas Production

Basis:

- Average COD load: 262,070 lb/d
- Month COD load: 600,000 lb/d
- Theoretical methane produced per lb COD removed: 5.6 ft3/lb COD removed
- Biogas methane concentration: 65 percent
- COD removal: 90 percent
- Fraction of the removed COD converted to methane: 90%

Methane calculation (average conditions):

$$CH_4 = 262{,}070\ \frac{lb}{d}\ \times\ 0.90 \times 5.6 \frac{ft^3}{lb} \times 0.90 = 1{,}189{,}000\ \frac{ft^3}{d}$$

Biogas calculation (average conditions):

$$\textbf{Biogas} = 1{,}189{,}000\ \frac{ft^3}{d} \div 0.65 = \mathbf{1{,}830{,}000\ \frac{ft^3}{d}}$$

Methane calculation (max. month conditions):

$$CH_4 = 600{,}000\ \frac{lb}{d}\ \times\ 0.90 \times 5.6 \frac{ft^3}{lb} \times 0.90 = 2{,}721{,}600 \frac{ft^3}{d}$$

Biogas calculation (max. month conditions):

$$\textbf{Biogas} = 2{,}721{,}600\ \frac{ft^3}{d} \div 0.65 = \mathbf{4{,}190{,}000\ \frac{ft^3}{d}}$$

7.3 Sludge Production

7.3.1 BVF Reactors WANS

Design basis for sludge estimate:

- Average BVF influent COD load = 262,070 lb/d
- COD removal efficiency = 90% COD removal
- Assumed yield = 0.04 lb SS/lb COD removed
- Average BVF influent TSS load =78,170 lb/d
- Average BVF efluent TSS load = 16,070 lb/d
- Net undigested influent solids = 10%

Sludge from bios yield = 0.04 lb/lb x 262,070 lb/d x 0.90 = 9,435 lb SS/d

Undigested solids = (78,170 – 16,070) x 0.1] = 6,210 lb SS/d

Sludge from bios yield + undigested solids = 9,435 + 6,210 = **15,645 lb SS/d**

Assuming the WANS is wasted from the BVF reactor at 4% solids concentration, the liquid volume of WANS generated per year is estimated as:

$$\textbf{WANS} = \frac{15{,}645 \text{ lb SS/d}}{0.04 \times 8.34} = \textbf{46,900 gpd @ 4\% solids}$$

WANS = 16.4 MG/yr @ 4 % solids

7.3.2 Aeration Tank Hydraulic Retention Time (HRT)

Basis:

- Aeration tank volume: 2.3 MG
- Design Flow: 4 MGD

$$\textbf{Average HRT} = \frac{2.3 \text{ MG}}{4 \text{ MGD}} \text{x}24 = \textbf{13.8 h}$$

7.3.3 Aerobic Sludge Production

Design basis for sludge estimate:

- Average influent flow: 4 MGD
- TSS aeration tank influent: 460 mg/l
- TSS DAF effluent: 100 mg/l

Sludge production (dwb) = (460 mg/l - 100 mg/l) x 4 MGD x 8.34 = 12,000 lb/d

Assuming the sludge is wasted from the DAF at 4% solids concentration, the liquid volume of sludge generated at design conditions is estimated as:

$$\textbf{Float Sludge} = \frac{12{,}000 \text{ lb/d}}{0.04 \times 8.34} = \textbf{36,000 gpd}$$

Assuming the sludge is dewatered to 20% solids concentration, the volume of sludge cake generated at design conditions is estimated as:

$$\textbf{Sludge Cake} = \frac{12{,}000 \text{ lb/d}}{0.2 \times 8.34 \times 202 \text{ gal}/yd^3} = \boldsymbol{36 yd^3/d}$$

7.4 Actual Oxygen Required (AOR) for the Aeration Tank

The AOR for the system at peak day design conditions is calculated based on the following assumptions:

- 1.3 lb O_2/lb BOD removed (BOD oxidation)
- Influent BOD: 350 mg/l
- 2 lb O_2/lb sulfide oxidized
- Assumed 20 mg/l sulfide in aeration tank influent
- Peak Flow: 4 MGD
- Peak aeration factor: 33%
- Assume 35% BOD removal

AOR required at average day design conditions:

AOR, AVG = [(1.3 x 350 mg/l x 0.35) + (2.0 x 20 mg/l)] x 4 MGD x 8.34

AOR, Avg = 6,650 lb O_2/d

AOR, Avg = 6,650 lb O_2/d/ 24 hr = 277 lb O_2/h

AOR required at peak day design conditions:

AOR, Peak = 277 lb O_2/h x 1.33

AOR, Peak = 370 lb O_2/h

APPENDIX A: LABORATORY TESTING AND MONITORING SCHEDULE

The following laboratory analyses will be routinely conducted by the operators (additional testing may be required, depending on local regulations):

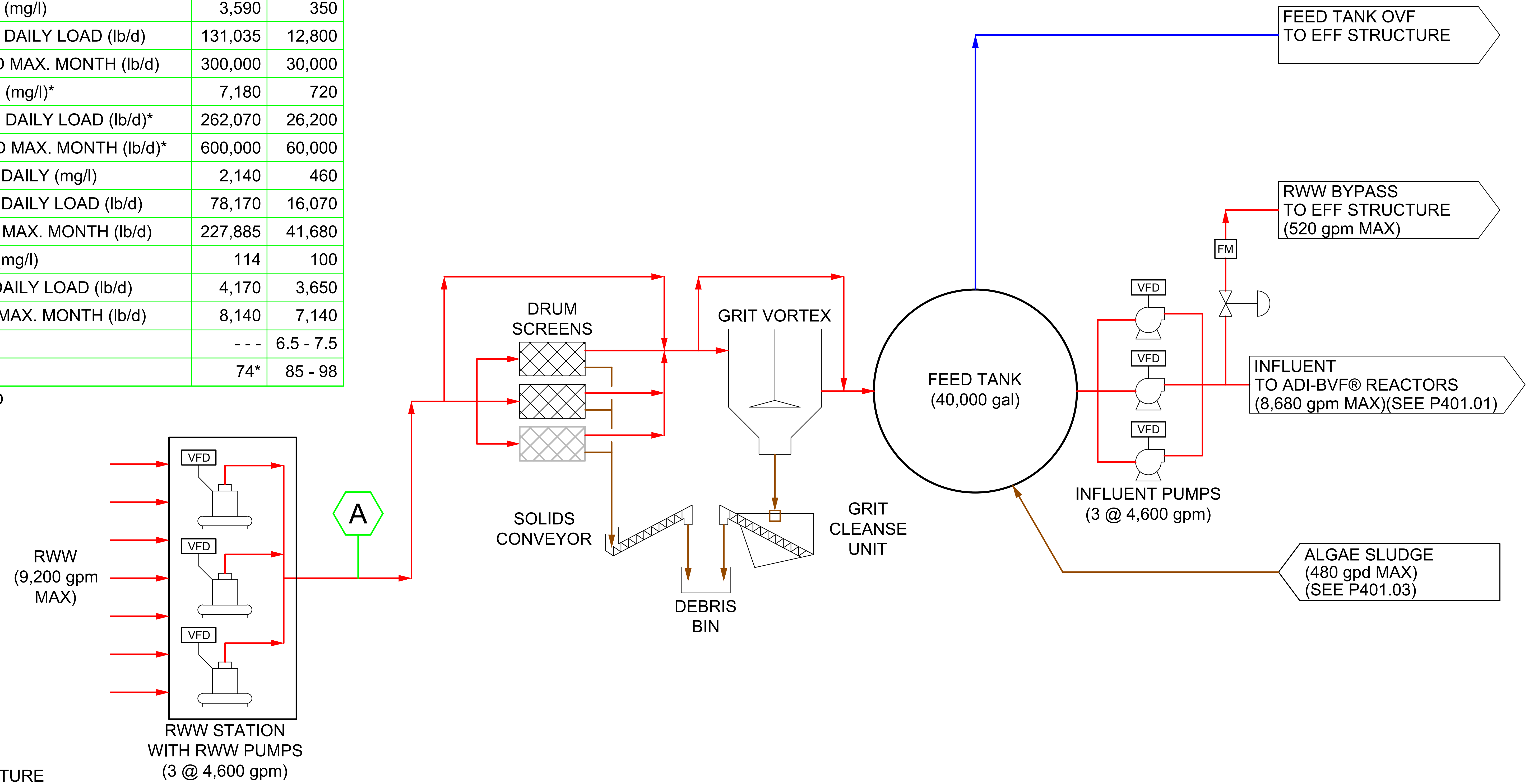
Laboratory Testing and Monitoring Schedule

Parameter	RWW (24 hr Composite)	BVF Reactor Effluent	SREC	BVF Sludge Profile	Biogas	Aeration Tank Contents	DAF Effluent
Flow (gpd)	On-line	-	-	-	-	On-line	-
COD_T (mg/l)	D	D	-	-	-	-	D
COD_F (mg/l)	D	D	-	-	-	-	-
BOD_5 (mg/l)	3	3	-	-	-	-	3
TSS (mg/l)	D	D	-	3M	-	3	D
VSS (mg/l)	W	W	-	3M	-	-	W
TS (mg/l)	-	-	-	3M	-	-	-
TVS (mg/l)	-	-	-	3M	-	-	-
Alkalinity (mg/l)	-	-	D	-	-	-	-
VA (mg/l)	-	-	D	-	-	-	-
VA/PA	-	-	D	-	-	-	-
pH	D	D	D	-	-	-	D
Temp (ºF)	D	D	D	-	-	-	D
DO (mg/l)	-	-	-	-	-	On-line	-
Settleability (ml/l)	-	-	-	-	-	-	-
TN (mg/l)	AR	AR	-	-	-	-	3
TKN (mg/l)	AR	AR	-	-	-	-	AR
NH_3-N (mg/l)	3	3	-	-	-	-	3
PO_4-P (mg/l)	AR	AR	-	-	-	-	3
CO_2 (%)	-	-	-	-	2	-	-
CH_4 (%)	-	-	-	-	2	-	-
H_2S (%)	-	-	-	-	2	-	-
O_2 (%)	-	-	-	-	2	-	-
D = DAILY; 3M = EVERY 3 MONTHS; 2 = TWO TIMES PER WEEK, W = WEEKLY; AR = AS REQUIRED; 3 = THREE TIMES PER WEEK							

APPENDIX B: PROCESS FLOW DIAGRAMS

PARAMETER	A	B
AVG. ANNUAL DAILY FLOW (MGD)	4.38	4.38
MAX. MONTH DAY FLOW (MGD)	8.56	8.56
PEAK DAY FLOW (MGD)	12.5	12.5
BOD, AVG. (mg/l)	3,590	350
BOD, AVG. DAILY LOAD (lb/d)	131,035	12,800
BOD, LOAD MAX. MONTH (lb/d)	300,000	30,000
COD, AVG. (mg/l)*	7,180	720
COD, AVG. DAILY LOAD (lb/d)*	262,070	26,200
COD, LOAD MAX. MONTH (lb/d)*	600,000	60,000
TSS, AVG. DAILY (mg/l)	2,140	460
TSS, AVG. DAILY LOAD (lb/d)	78,170	16,070
TSS LOAD MAX. MONTH (lb/d)	227,885	41,680
TN, AVG. (mg/l)	114	100
TN, AVG. DAILY LOAD (lb/d)	4,170	3,650
TN LOAD, MAX. MONTH (lb/d)	8,140	7,140
pH	- - -	6.5 - 7.5
TEMP. (°F)	74*	85 - 98

*ASSUMED



C:\Vault_Pro_Workspace\CAD_Content\Plant_3D\Projects\FY2022\00566\Orthos\DWGs\P&IDs\PFDs\V112051379-01.dwg 3/9/2023 tyler.hogan

REV	DATE	DESCRIPTION	DRN BY	CHK BY	APRV BY
1	2/2/2023	60% PFD	J.BREWER	J.SNOWDO	J.SNOWDO
2	3/6/2023	PRRC PROGRESS SET FOR ECOLOGY REVIEW	T.HOGAN	J.SNOWDO	J.SNOWDO

GENERAL CONTRACTOR:

TECHNOLOGY SUPPLIER: EVOQUA WATER TECHNOLOGIES

GENERAL CONTRACTOR: SWINERTON

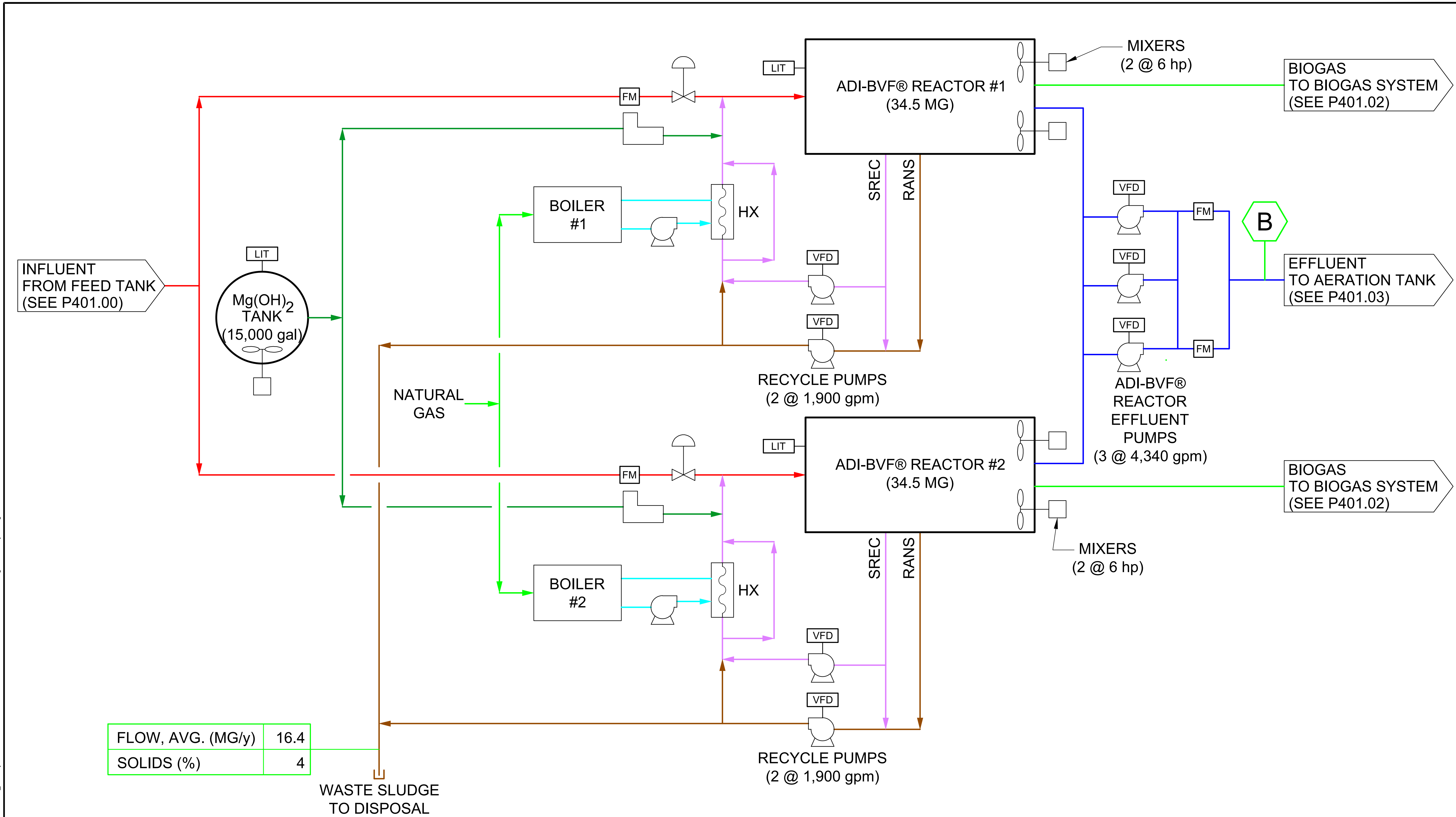
ENGINEER-OF-RECORD

BIOGAS ENGINEERING
2321 E. 28TH STREET,
SUITE 400
SIGNAL HILL,
CA 90755,
Ph: (562) 726-3565
EMAIL:
INFO@BIOGASENG.COM

PROCESS FLOW DIAGRAM(S)
WASTEWATER TREATMENT SYSTEM
RAW WASTEWATER TO ADI-BVF® REACTOR 1 & 2

BURNHAM SEV PASCO, LLC
PASCO RESOURCE RECOVERY
CENTER (PRRC)
981 E. FOSTER WELLS ROAD,
PASCO, WA 99301

DRAWING NO.
P401.00



REV	DATE	DESCRIPTION	DRN BY	CHK BY	APRV BY
1	2/2/2023	60% PFD	J.BREWER	J.SNOWDO	J.SNOWDO
2	3/6/2023	PRRC PROGRESS SET FOR ECOLOGY REVIEW	T.HOGAN	J.SNOWDO	J.SNOWDO

GENERAL CONTRACTOR:

TECHNOLOGY SUPPLIER:
evoqua WATER TECHNOLOGIES

GENERAL CONTRACTOR:
SWINERTON

ENGINEER-OF-RECORD
2321 E. 28TH STREET, SUITE 400
SIGNAL HILL, CA 90755,
Ph: (562) 726-3565
EMAIL: INFO@BIOGASENG.COM

PROCESS FLOW DIAGRAM(S)
WASTEWATER TREATMENT SYSTEM
ADI-BVF® REACTOR 1 & 2

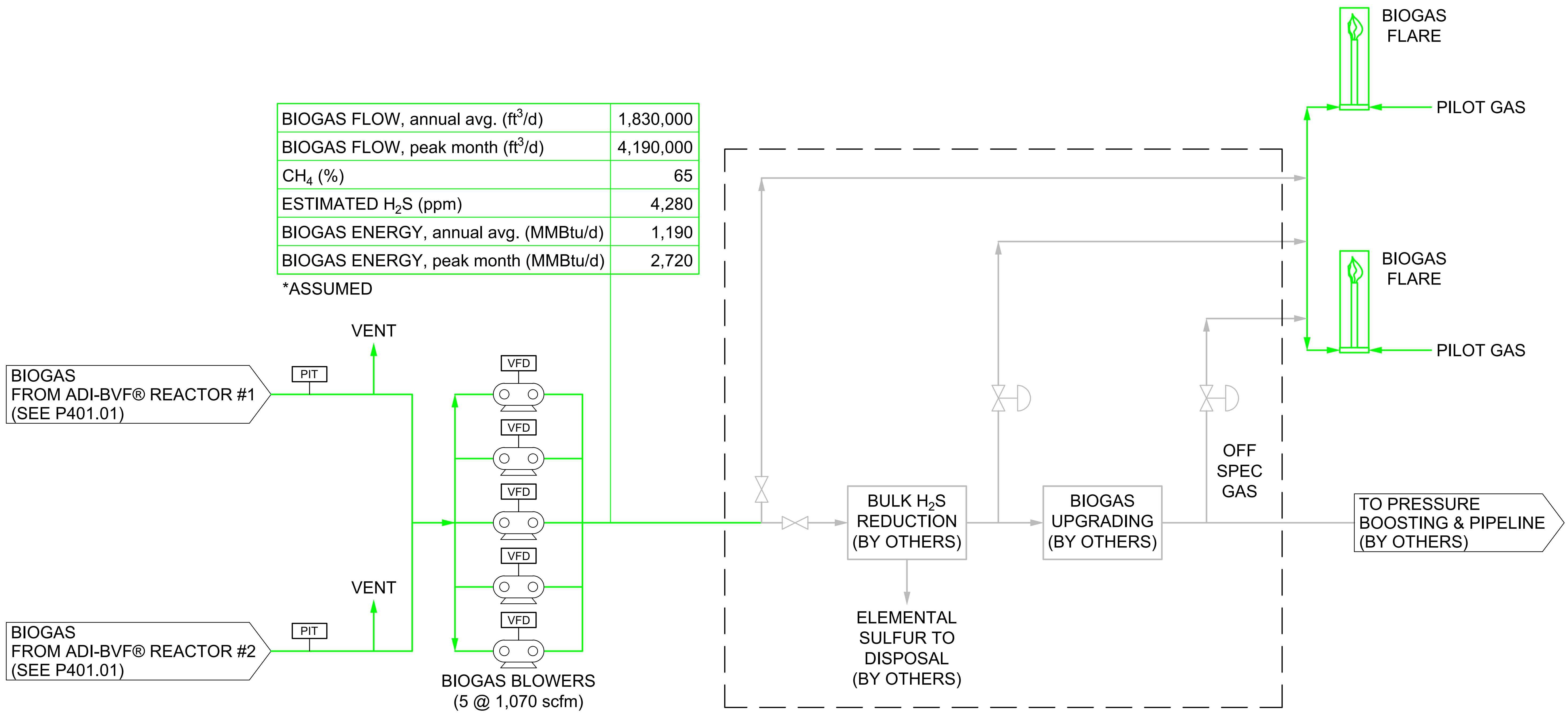
BURNHAM SEV PASCO, LLC
PASCO RESOURCE RECOVERY CENTER (PRRC)
981 E. FOSTER WELLS ROAD, PASCO, WA 99301

DRAWING NO.
P401.01

C:\Vault_Pro_Workspace\CAD_Content\Plant_3D\Projects\FY2022\00566\Orthos\DWGs\P&IDs\PFDs\V112051379-02.dwg 3/9/2023 tyler.hogan

BIOGAS FLOW, annual avg. (ft^3/d)	1,830,000
BIOGAS FLOW, peak month (ft^3/d)	4,190,000
CH_4 (%)	65
ESTIMATED H_2S (ppm)	4,280
BIOGAS ENERGY, annual avg. (MMBtu/d)	1,190
BIOGAS ENERGY, peak month (MMBtu/d)	2,720

*ASSUMED



— — BY OTHERS

REV	DATE	DESCRIPTION	DRN BY	CHK BY	APRV BY
1	2/2/2023	60% PFD	J.BREWER	J.SNOWDO	J.SNOWDO
2	3/6/2023	PRRC PROGRESS SET FOR ECOLOGY REVIEW	T.HOGAN	J.SNOWDO	J.SNOWDO

GENERAL CONTRACTOR:

TECHNOLOGY SUPPLIER: EVOQUA WATER TECHNOLOGIES

GENERAL CONTRACTOR: SWINERTON

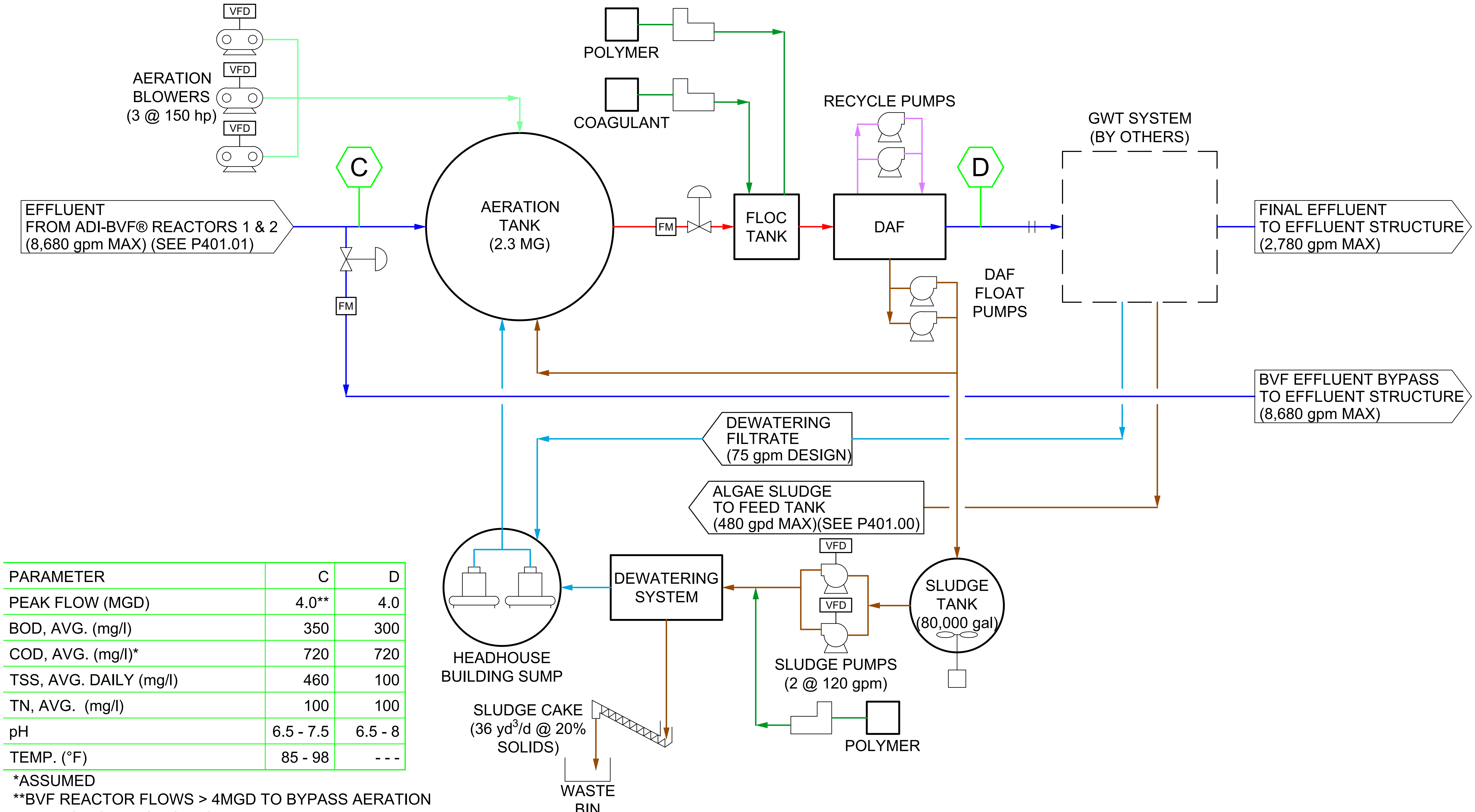
ENGINEER-OF-RECORD
BIOGAS ENGINEERING
2321 E. 28TH STREET, SUITE 400 SIGNAL HILL, CA 90755, Ph: (562) 726-3565 EMAIL: INFO@BIOGASENG.COM

PROCESS FLOW DIAGRAM(S)
WASTEWATER TREATMENT SYSTEM
BIOGAS SYSTEM

BURNHAM SEV PASCO, LLC
PASCO RESOURCE RECOVERY CENTER (PRRC)
981 E. FOSTER WELLS ROAD, PASCO, WA 99301

DRAWING NO. P401.02

C:\Vault_Pro_Workspace\CAD_Content\Plant_3D\Projects\FY2022\00566\Orthos\DWGs\P&IDs\PFDs\V112051379-03.dwg 3/9/2023 tyler.hogan



PARAMETER	C	D
PEAK FLOW (MGD)	4.0**	4.0
BOD, AVG. (mg/l)	350	300
COD, AVG. (mg/l)*	720	720
TSS, AVG. DAILY (mg/l)	460	100
TN, AVG. (mg/l)	100	100
pH	6.5 - 7.5	6.5 - 8
TEMP. (°F)	85 - 98	- - -

*ASSUMED

**BVF REACTOR FLOWS > 4MGD TO BYPASS AERATION TANK TO HOLDING PONDS

REV	DATE	DESCRIPTION	DRN BY	CHK BY	APRV BY
1	2/2/2023	60% PFD	J.BREWER	J.SNOWDO	J.SNOWDO
2	3/6/2023	PRRC PROGRESS SET FOR ECOLOGY REVIEW	T.HOGAN	J.SNOWDO	J.SNOWDO

GENERAL CONTRACTOR:

TECHNOLOGY SUPPLIER: EVOQUA WATER TECHNOLOGIES

GENERAL CONTRACTOR: SWINERTON

ENGINEER-OF-RECORD
BIOGAS ENGINEERING
2321 E. 28TH STREET, SUITE 400
SIGNAL HILL, CA 90755,
Ph: (562) 726-3565
EMAIL: INFO@BIOGASENG.COM

PROCESS FLOW DIAGRAM(S)
WASTEWATER TREATMENT SYSTEM
AERATION TANK

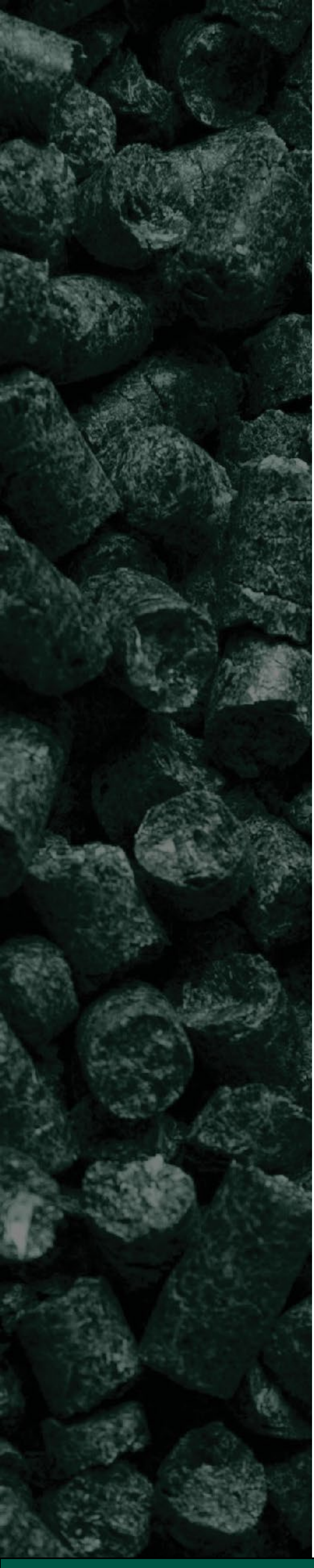
BURNHAM SEV PASCO, LLC
PASCO RESOURCE RECOVERY CENTER (PRRC)
981 E. FOSTER WELLS ROAD,
PASCO, WA 99301

DRAWING NO. P401.03

C:\Vault_Pro_Workspace\CAD_Content\Plant_3D\Projects\FY2022\00566\Orthos\DWGs\P&IDs\PFDs\V112051379-04.dwg 3/9/2023 tyler.hogan

Appendix 5-B

Gross-Wen Technology Rotating Algal Biofilm Pretreatment Design Documentation



TREATMENT PROCESS CALCULATIONS

REVOLVING ALGAL BIOFILM (RAB™)

PASCO PROCESS WATER RECOVERY FACILITY (PWRF)

DATE PREPARED: March 15, 2023

VERSION: 2.0

We Don't Just Think Green, We Grow It!

1. Executive Summary

The City of Pasco is in the process of upgrading the Pasco Process Water Reuse Facility (PWRF). This facility must be upgraded to accommodate new industrial growth in the community. As required by the facility, nitrogen must be removed before the wastewater can be land applied to the land treatment system (LTS). One of the proposed methods to remove this nitrogen is with the Revolving Algal Biofilm (RAB) system.

This document provides supplementary information and treatment calculations about this technology at the PWRF.

Key Terms/ Definitions:

- SALR = Surface Area based Loading Rate (g/m^2/day)
- SARR = Surface Area based Removal Rate (g/m^2/day)
- TN = Total Nitrogen
- MGD = Million Gallons per Day
- 1 gallon of water = 8.34 lbs
- ppm = parts per million
- SA = surface area
- 1 lb = 453.6 g
- ppd = lbs per day

Treatment Calculations Preface

The monthly flows and concentrations used in the sample calculations were provided to GWT from RH2 Engineering. The process calculations presented In this document represent the most up to date information available at the time. If future changes to the flows and loads are made, GWT will update this document to reflect the updated information.

Table of Contents

2. GWT Background

Gross-Wen Technologies' (GWT) Revolving Algal Biofilm (RAB™) treatment system has historically been used to treat municipal and industrial wastewaters for nutrient removal and industrial pretreatment applications.

The RAB treatment system is a unique approach to wastewater treatment. The RAB has been shown to be an effective technology to help many communities and industries cost-effectively and sustainably meet their wastewater treatment needs. The RAB technology is a unique method to remove and recover nutrients from wastewater. The energy requirements for the system are significantly less than conventional treatment technologies. See the treatment process diagram in Figure 1.

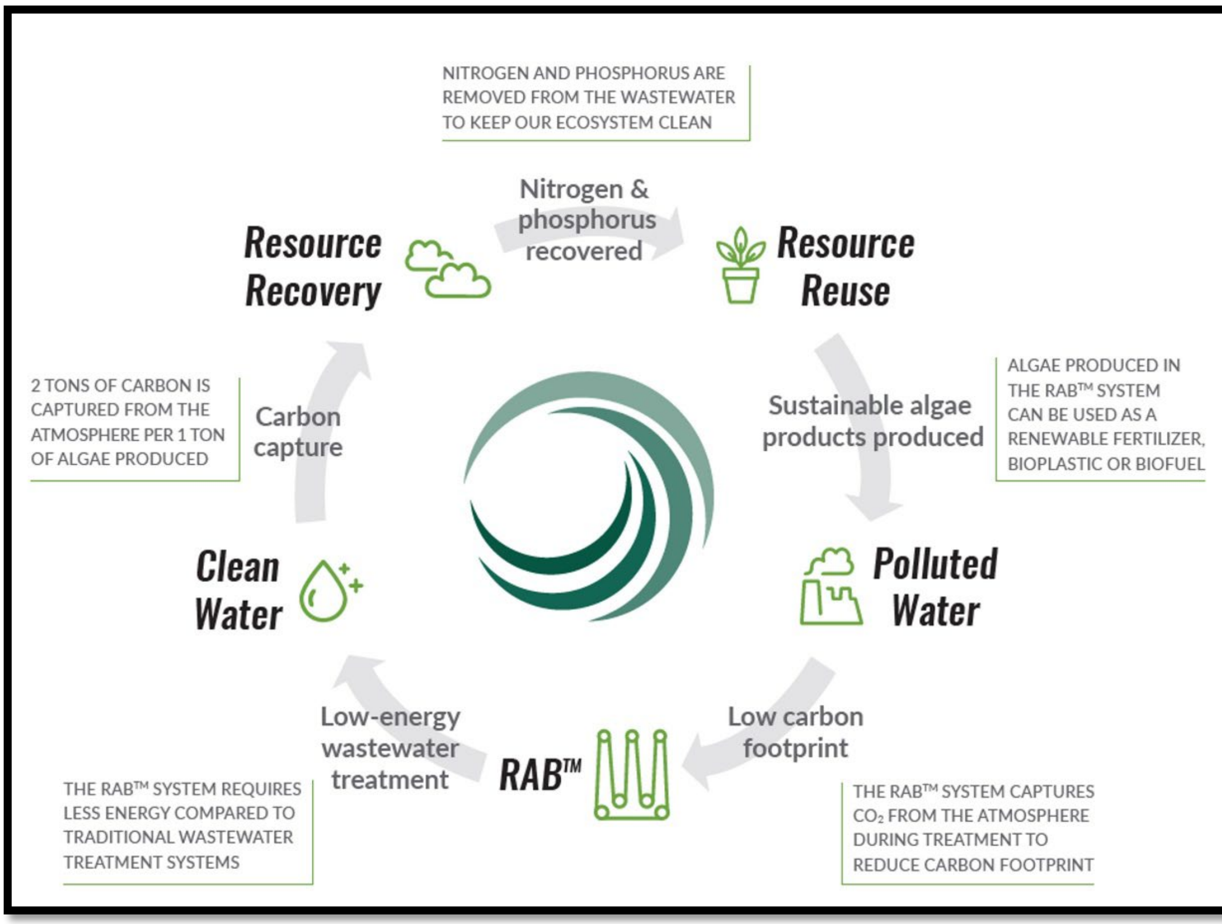


Figure 1 - GWT Sustainability Impact

3. Model Background

GWT uses an empirical model based on years of operating data from numerous treatment plants. The model is built on a relationship between surface area loading rate (SALR, $g/m^2/day$) and surface area removal rate (SARR, $g/m^2/day$). This relationship predicts the removal rate of nutrients by the algae biomass based on their availability in the wastewater. The general equation is listed below in Equation 1, where SARR is the predicted result based on the historic SARR max and the empirically derived Ks factor.

$$SARR_{Predicted} = (SARR_{Max} * \frac{SALR_{Design}}{K_s + SALR_{Design}})$$

Equation 1 - Prediction Model General Equation

The general relationship of this model is presented in Figure 2. The curve shown is not specific to any particular project or parameter.

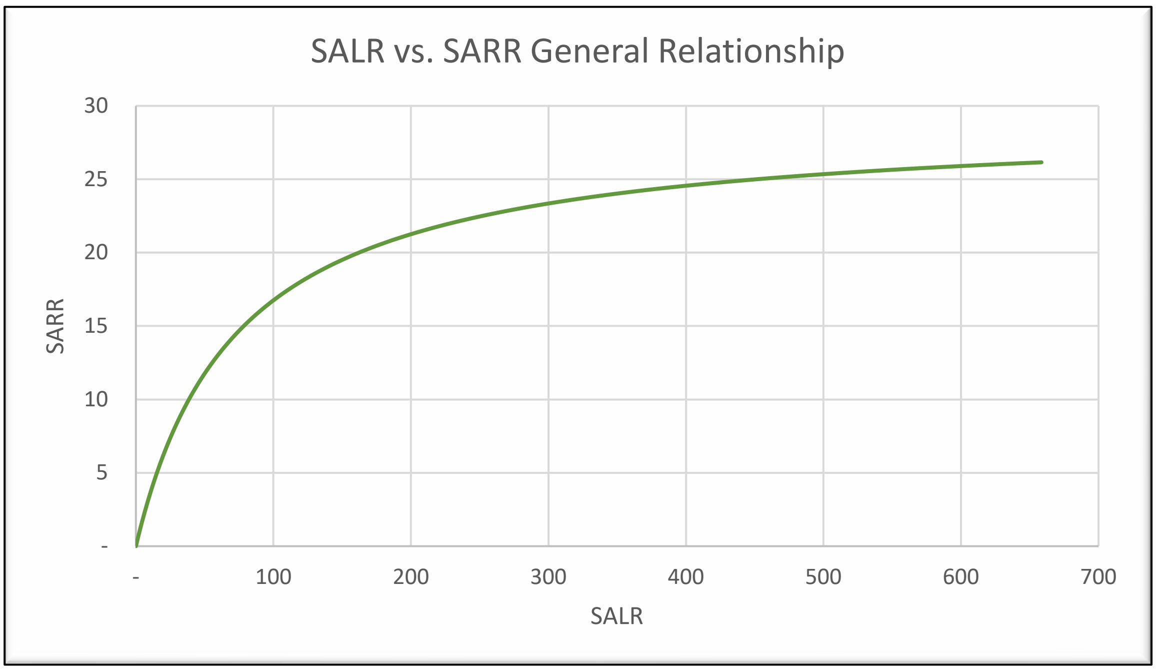


Figure 2 - SALR vs. SARR General Relationship

This treatment curve is applied in each stage of the treatment process. This makes the RAB model an iterative process where each stage of the treatment process does a fraction of required treatment, with no single stage able to perform all treatment by itself.

4. Treatment Model and Sizing

The steps below outline the process that was taken to derive the models used for sizing the PWRF RAB system.

4.1. Identify Relevant Data

GWT has performed pilot and demonstration scale testing on the RAB system since 2016. In the process the RAB system has been deployed and tested at more than 20 sites, gathering a wealth of treatment data. The data gathered at these sites is used to build the treatment models that predict the full-scale system design.

The RAB system is a versatile technology that has been utilized for nutrient removal in both municipal and industrial settings. Specifically, GWT has deployed the RAB system in several applications including.

- Treatment of industrial and municipal Anaerobic Digester effluent
- Treatment of industrial and municipal Primary effluent
- Treatment of industrial and municipal Tertiary Effluent
- Treatment of industrial food and beverage effluent before discharge to POTW.

GWT recognizes that these applications vary widely in both water composition and RAB performance. For this reason, the only data brought into the model was comparable data to the proposed PWRF. Specifically, data when the RAB system was treating anaerobic digestate and had a high nitrogen loading was used to build the treatment model. The raw datasets can be provided by request.

4.2. Derive Treatment Curve

Once the raw dataset has been selected, it can be used to fit a treatment curve to model the system. To do this, the excel data solver tool is used to minimize the difference between the predicted and observed SARR value for any observed SALR value. The result is the best fit line that is used to model future systems.

This exercise was done for the Pasco PWRF and the treatment curves used to model the system were derived.

4.3. Total Nitrogen Treatment Curve

The treatment curve for total nitrogen used in the modeling the Pasco PWRF is presented in Figure 3.

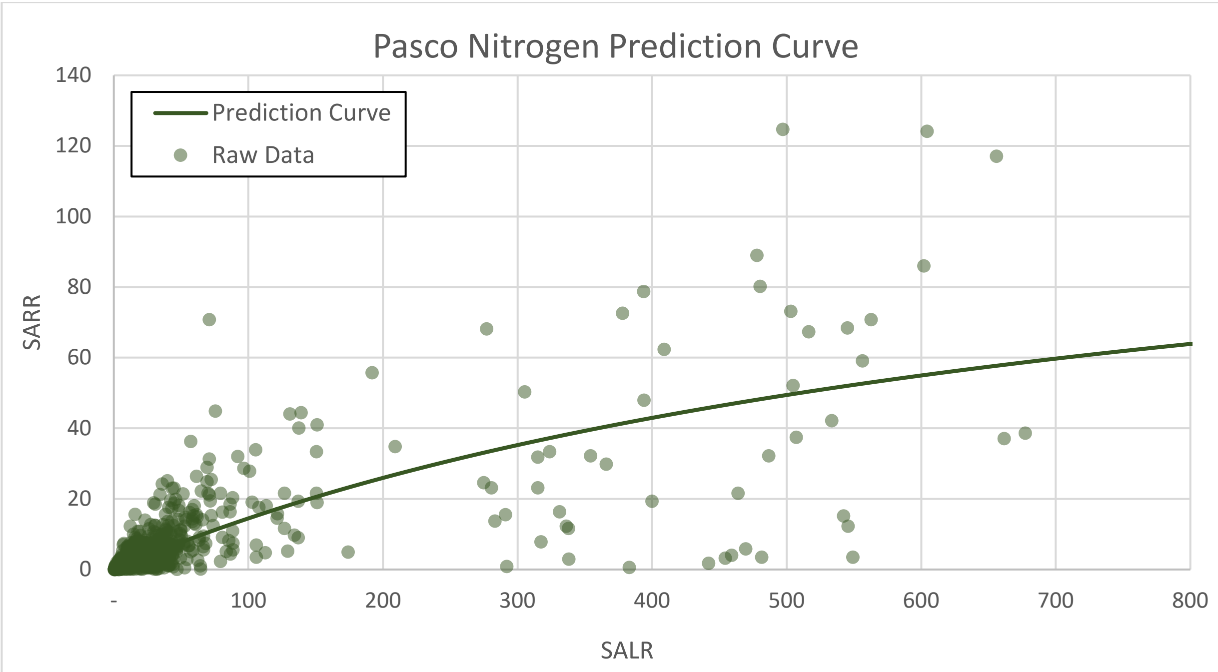


Figure 3 - Total Nitrogen Prediction Curve

The derived coefficients are a SARRmax of 124.73 and a Ks factor of 761.44, yielding the following equation:

$$TN\ SARR = 124.73(\frac{TN\ SALR}{761.44 + TN\ SALR})$$

4.4. COD Treatment Curve

The treatment curve for COD used in the modeling the Pasco PWRF is presented in Figure 4.

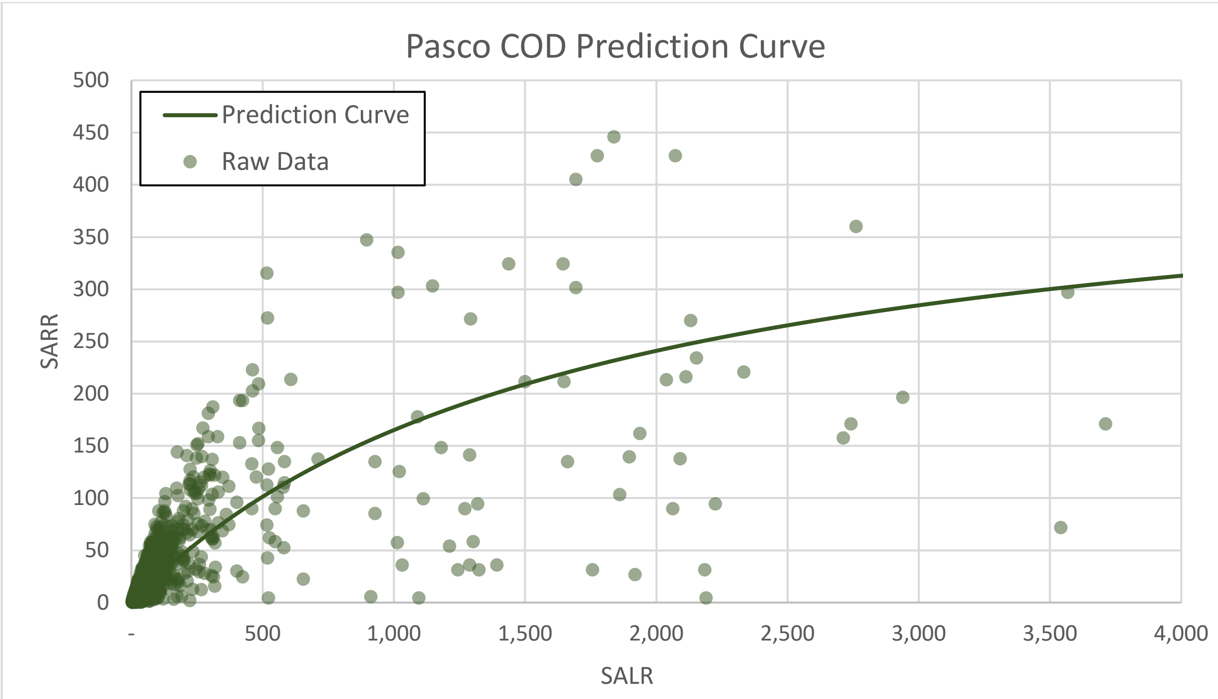


Figure 4 - COD Prediction Curve

The derived coefficients are a SARRmax of 445.95 and a Ks factor of 1700.18, yielding the following equation:

$$COD\ SARR = 445.95\ \left(\frac{COD\ SALR}{1{,}700.18 + COD\ SALR}\right)$$

4.5. Model Limitations and Constraints

The derived models have limitations and can only be applied when to systems that fall within the model bounds.

a) The project site must have a similar climate to where the modeling data was gathered.
   - Pasco, WA is similar in climate to Des Moines, IA in both seasonal temperatures and hours of sunlight.
     - GWT has collected data at multiple sites in central Iowa and surrounding states, Des Moines is used as a central reference point to all projects used to develop the treatment curves in Pasco.
   - These are the two most critical factors that impact the treatment rates.
   - There was no adjustment needed to use the data gathered from past projects to use the prediction model for Pasco.

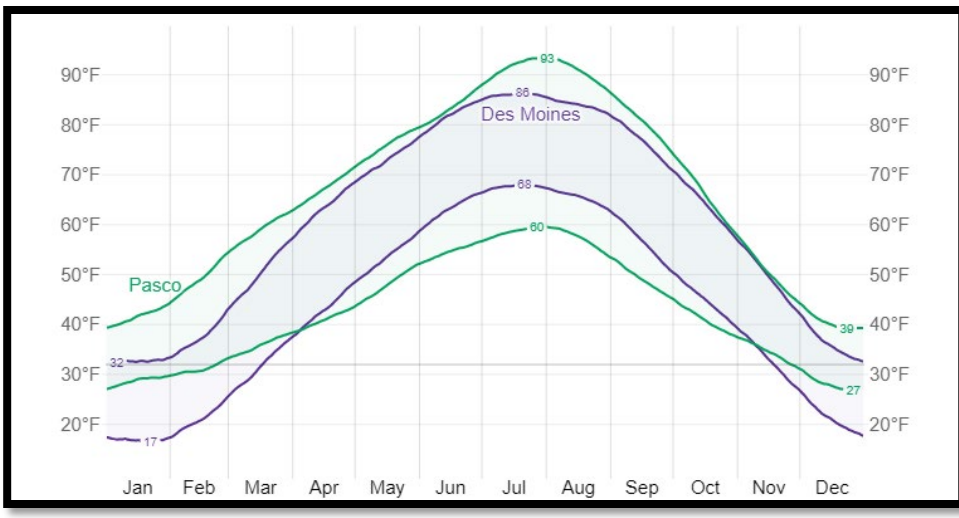


Figure 5 - Seasonal Temperature Des Moines vs. Pasco

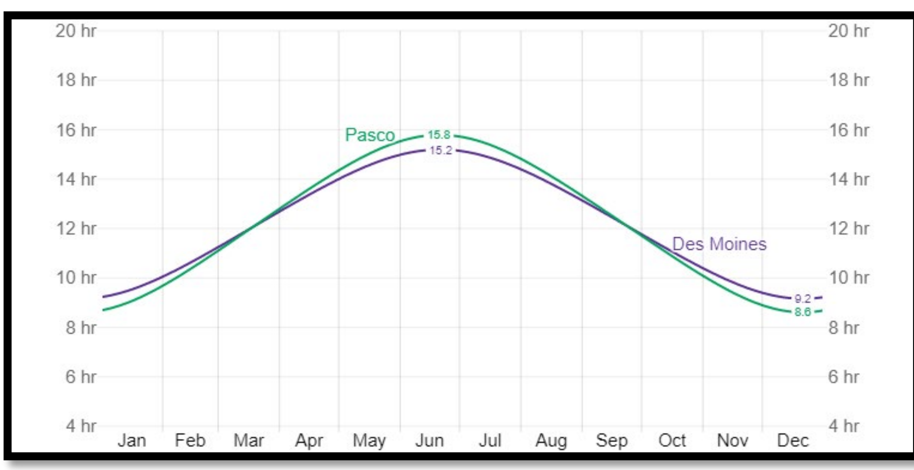


Figure 6 – Hours of Sunlight Des Moines vs. Pasco

b) The system must be placed in a commercial greenhouse that is designed to maintain an operating temperature between 50-120°F and provide sufficient ventilation.
   - The greenhouse should be ventilated in the summer months, to keep the air temperature <120°F. This is to maintain a safe work environment for the operators and prevent electrical components from overheating.
   - The greenhouse should be heated in the winter to maintain an air temperature >50°F. This is to prevent any freezing from occurring within the greenhouse and prevent substantial temperature losses from the influent water.
   - Due to the seasonal temperatures in Pasco the greenhouse system was designed to have ventilation during the summer months and heating during the winter months to maintain an operating temperature between 50-120°F.
   - The greenhouse system heating and ventilation systems are designed to comply with greenhouse design standards:
     - Ventilation Guide
     - Heating Guide

c) Based on the historic treatment data the minimum retention in each stage of treatment should be 0.24 hours. The maximum retention time in the entire system (all stages combined) should be at most 48 hours based on historic data.
   - The basin dimensions for each stage of treatment in Pasco are 110' x 15' x 3.25' deep, yielding 5,363 ft^3 of volume or ~40,000 gallons per stage of working volume.
   - At peak flow through the RAB facility (4.0 MGD) the retention time is as follows:
     - 4,000,000gpd / 40,000 gallons = 100 cycles per day
     - 24 hours/day / 100 cycles = 0.24 hours.
     - At the maximum anticipated flow rate, the retention time is sufficient to for the model to accurately predict the treatment.
   - There is no design minimum flow rate through the system, but it can be assumed that the flow will always be greater than 1.0 MGD. If 1.0 MGD is used as the minimum flow rate the retention time in the entire system is as follows:
     - 1,000,000gpd / 40,000 gallons = 25 cycles per day
     - 24 hours/day / 25 cycles = 0.96 hours per stage.
     - There are 13 stages with RAB systems for treatment, however there are 14 basins constructed to allow room for future growth.
     - 14 basins * 0.96 hours/basin = 13.44 hours maximum retention time.
     - At the minimum anticipated flow rate, the retention time is sufficient to for the model to accurately predict the treatment.

d) The ambient air must have sufficient carbon dioxide for the algae to grow.
   - All data used to create the treatment models was gathered from RAB systems housed in well ventilated greenhouses. It is assumed that the CO_2 concentration in the greenhouse is equal to the CO_2 concentration in the surrounding environment.
   - Globally, CO_2 concentration do not vary greatly by location. Generally, the atmospheric CO_2 concentration can vary between 390-410 ppm of CO_2.

- In Pasco, an atmospheric CO_2 concentration of 400 ppm as assumed. This is similar to the atmospheric CO_2 concentration of the locations where data was gathered to build the treatment model.
- Due to fossil fuel consumption the atmospheric CO_2 concentration is anticipated to rise throughout the lifetime of the project. This will not negatively impact the RAB system.
- Following the ventilation guide from the greenhouse manufacturer (https://ngma.com/wp-content/uploads/2018/05/VentandCool2010.pdf) the greenhouse will have airflow of 1 1/2 to 2 CFM per square foot (SF) of floor space.
    - The proposed greenhouse SF = 192' * 228 = 43,776 SF * 1.5 CFM = 65,664 CFM
    - 65,664 CFM * 1440 min/day = 94.5 million cubic feet per day recycle
    - Assume CO2 concentration is 400 ppm (0.04 %)
    - Assume density of air is 0.0797 lbs/ CF
    - 94.5 Million CF * 0.0797 lbs = 7.533 million lbs of air
    - 7.533 million lbs * 0.04 % CO2 = ~300,000 lbs of CO2 available per day
- Algae requires 1.83 lbs CO2 per lbs of algae grown.
    - 300,000 lbs / 1.83 = 163,700 lbs/day of algae can be grown with the CO2 available in the air.
    - This equates to ~30,000 US tons of algae per year, this is more than 100x the predicted algae production for the Pasco PRRF.
- Conclusion: There is ample CO2 available in the atmosphere to grow algae effectively in a greenhouse environment.

e) The influent TSS should be below 1,000 ppm.
- GWT keeps the reservoirs well mixed with a small paddlewheel mixer. This keeps each stage of treatment homogenous and ensures the entire stage receives treatment.
- If significant solids loading enters the RAB system, the mixing will be inadequate and there is a greater chance for solids to settle in the basin.
- In Pasco, the anticipated TSS leaving the LRAD system is 460 mg/L average daily concentration (per Evoqua).
- A DAF system is placed upstream of the RAB to prevent any slug loads of solids from entering the RAB system.

f) The system should have sufficient macro and micronutrient for biological growth.
- The anticipated influent N concentration varies monthly from approximately 60-140 ppm TN.
- It was assumed that the RAB system will see an annual average nitrogen concentration of 100 ppm.
- Design criteria for phosphorous was not provided to GWT to design a system for phosphorous removal. However, the existing facility has an influent phosphorus concentration that is typically between 15-25 ppm TP.
- It was assumed that the RAB system will see an annual average phosphorous concentration of 20 ppm.
- This yields an N:P ratio of 5:1.

- Typically, N:P ratio is close to 12:1 for the RAB system to removal all available N and P simultaneously. This means that at the Pasco PWRF, nitrogen is the limiting macro nutrient. I.e., all nitrogen will be removed before all phosphorous can be removed.
- The influent carbon (BOD) from the LRAD is anticipated to be 350 ppm of BOD on an annual average.
- This yields a C:N:P ratio of 18:5:1. This is lower than conventional activated sludge processes would use. The RAB system is not an activated sludge system and the carbon required for the algae to grow comes from the atmosphere not the water.

4.6. Apply the Model

The City of Pasco and RH2 Engineering provided flows and loads for the anticipated influent to the RAB system. In working with Evoqua to estimate the treatment performance of the LRAD system the predicted influent to the RAB system determined. There are seasonal fluctuations in the anticipated influent to the RAB system.

Table 1 - Monthly Flow and Concentration to RAB

Month	**Ave Flow Rate, MGD**	**Influent to RAB, mg/L TN**	**Loading to RAB, ppd TN**	**Notes**
January	2.30	111	2,129	
February	2.13	126	2,238	
March	2.29	120	2,292	
April	2.52	154	3,237	
May	2.54	139	2,945	
June	4.00	133	4,437	Max Month
July	4.00	124	4,137	
August	4.00	126	4,203	
September	4.00	126	4,203	
October	4.00	79	2,635	
November	4.00	69	2,302	
December	2.98	111	2,212	
Annual Average	3.23	114	3,083	Average

The anticipated RAB effluent was predicted for each month, to determine that the total mass sent to the LTS meets the limits for the facility. GWT can provide detailed treatment process calculations for each month if desired. However, for this exercise, GWT has provided sample calculations for the average and maximum months that the RAB will see from the digester effluent in Table 2.

Table 2 – RAB Design Annual Average Influent

Annual Average Design Influent to RAB System	**Design Ave Influent**	**Design Max Influent**	**Units**
Flow to RAB Annual Ave (Calculated)	3.23	4.0	MGD
Total Nitrogen to RAB Annual Ave (Calculated)	114	133	mg/L
COD to RAB Annual Ave (per Evoqua)*	600	600	mg/L

**Assume DAF process removes COD in solids removal prior to RAB process.*

4.6.1. Annual Average Total Nitrogen Treatment Calculations

The treatment process calculations for total nitrogen removal on an annual average basis have provided below.

Stage 1

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 3.23 MGD
    c. Concentration = 114 mg/L TN
    d. Loading Rate = 3.23 * 114 * 8.34 = 3,083 ppd
    e. SALR = (3,083 ppd * 453.6 g /lb) / 1,500 m^2 = **932.2 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{932.2}{761.44+932.2})$ = **68.7 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 68.7 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **227 ppd**
    b. Remaining mass = 3,083 ppd – 227 ppd = **2,856 ppd remaining**
    c. Concentration going to next stage = 2,856 ppd / (3.23 * 8.34) = **105.9 mg/L**

Stage 2

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 3.23 MGD
    c. Concentration = 105.9 mg/L TN
    d. Loading Rate = 3.23* 105.9 * 8.34 = 2,856 ppd
    e. SALR = 2,856 ppd * 453.6 g /lb) / 1,500 m^2 = **863.5 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{863.5}{761.44+863.5})$ = **66.3 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 66.3 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **219 ppd**
    b. Remaining mass = 2,856 ppd – 219 ppd = **2,636 ppd remaining**
    c. Concentration going to next stage = 2,636 ppd / (3.23 * 8.34) = **97.7 mg/L**

Stage 3

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 3.23 MGD
    c. Concentration = 97.7 mg/L TN
    d. Loading Rate = 3.23* 97.7 * 8.34 = 2,636 ppd
    e. SALR = 2,636 ppd * 453.6 g /lb) / 1,500 m^2 = **797.2 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{797.2}{761.44+797.2})$ = **63.8 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 63.8 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **211 ppd**
b. Remaining mass = 2,636 ppd – 211 ppd = **2,425 ppd remaining**
c. Concentration going to next stage = 2,425 ppd / (3.23 * 8.34) = **89.9 mg/L**

Stage 4

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 89.9 mg/L TN
   d. Loading Rate = 3.23* 89.9 * 8.34 = 2,425 ppd
   e. SALR = (2,425 ppd * 453.6 g /lb) / 1,500 m^2 = **733.4 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{733.4}{761.44+733.4})$ = **61.2 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 61.2 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **202 ppd**
   b. Remaining mass = 2,425 ppd – 202 ppd = **2,223 ppd remaining**
   c. Concentration going to next stage = 2,223 ppd / (3.23 * 8.34) = **82.4 mg/L**

Stage 5

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 82.4 mg/L TN
   d. Loading Rate = 3.23* 82.4 * 8.34 = 2,223 ppd
   e. SALR = (2,223 ppd * 453.6 g /lb) / 1,500 m^2 = **672.3 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{672.3}{761.44+672.3})$ = **58.5 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 58.5 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **193 ppd**
   b. Remaining mass = 2,223 ppd – 193 ppd = **2,030 ppd remaining**
   c. Concentration going to next stage = 2,030 ppd / (3.23 * 8.34) = **75.2 mg/L**

Stage 6

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 75.2 mg/L TN
   d. Loading Rate = 3.23* 75.2 * 8.34 = 2,030 ppd
   e. SALR = (2,030 ppd * 453.6 g /lb) / 1,500 m^2 = **613.8 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{613.8}{761.44+613.8})$ = **55.7 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 55.7 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **184 ppd**
b. Remaining mass = 2,030 ppd – 184 ppd = **1,846 ppd remaining**
c. Concentration going to next stage = 1,846 ppd / (3.23 * 8.34) = **68.4 mg/L**

Stage 7

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 68.4 mg/L TN
   d. Loading Rate = 3.23* 68.4 * 8.34 = 1,846 ppd
   e. SALR = 1,846 ppd * 453.6 g /lb) / 1,500 m^2 = **558.1 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{558.1}{761.44+558.1})$ = **52.8 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 52.8 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **174 ppd**
   b. Remaining mass = 1,846 ppd – 174 ppd = **1,671 ppd remaining**
   c. Concentration going to next stage = 1,671 ppd / (3.23 * 8.34) = **61.9 mg/L**

Stage 8

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 61.9 mg/L TN
   d. Loading Rate = 3.23* 61.9 * 8.34 = 1,671 ppd
   e. SALR = (1,671 ppd * 453.6 g /lb) / 1,500 m^2 = **505.3 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{505.3}{761.44+505.3})$ = **49.8 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 49.8 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **165 ppd**
   b. Remaining mass = 1,671 ppd – 165 ppd = **1,507 ppd remaining**
   c. Concentration going to next stage = 1,507 ppd / (3.23 * 8.34) = **55.8 mg/L**

Stage 9

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 55.8 mg/L TN
   d. Loading Rate = 3.23* 55.8 * 8.34 = 1,507 ppd
   e. SALR = (1,507 ppd * 453.6 g /lb) / 1,500 m^2 = **455.6 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{455.6}{761.44+455.6})$ = **46.7 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 46.7 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **154 ppd**
b. Remaining mass = 1,507 ppd – 154 ppd = **1,352 ppd remaining**
c. Concentration going to next stage = 1,352 ppd / (3.23 * 8.34) = **50.1 mg/L**

Stage 10

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 50.1 mg/L TN
   d. Loading Rate = 3.23* 50.1 * 8.34 = 1,352 ppd
   e. SALR = (1,352 ppd * 453.6 g /lb) / 1,500 m^2 = **408.9 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{408.9}{761.44+408.9})$ = **43.6 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 43.6 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **144 ppd**
   b. Remaining mass = 1,352 ppd – 144 ppd = **1,208 ppd remaining**
   c. Concentration going to next stage = 1,208 ppd / (3.23 * 8.34) = **44.8 mg/L**

Stage 11

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 44.8 mg/L TN
   d. Loading Rate = 3.23* 44.8 * 8.34 = 1,208 ppd
   e. SALR = (1,208 ppd * 453.6 g /lb) / 1,500 m^2 = **365.3 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{365.3}{761.44+365.3})$ = **40.4 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 40.4 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **134 ppd**
   b. Remaining mass = 1,208 ppd – 134 ppd = **1,074 ppd remaining**
   c. Concentration going to next stage = 1,074 ppd / (3.23 * 8.34) = **39.8 mg/L**

Stage 12

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 39.8 mg/L TN
   d. Loading Rate = 3.23* 39.8 * 8.34 = 1,074 ppd
   e. SALR = (1,074 ppd * 453.6 g /lb) / 1,500 m^2 = **324.9 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{324.9}{761.44+324.9})$ = **37.3 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 37.3 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **123 ppd**
b. Remaining mass = 1,074 ppd – 123 ppd = **951 ppd remaining**
c. Concentration going to next stage = 951 ppd / (3.23 * 8.34) = **35.3 mg/L**

<u>Stage 13</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 3.23 MGD
   c. Concentration = 35.3 mg/L TN
   d. Loading Rate = 3.23* 35.3 * 8.34 = 951 ppd
   e. SALR = (951 ppd * 453.6 g /lb) / 1,500 m^2 = **287.6 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{287.3}{761.44+287.6})$ = **34.2 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 34.2 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **113 ppd**
   b. Remaining mass = 951 ppd – 113 ppd = **838 ppd remaining**
   c. Concentration going to next stage = 837 ppd / (3.23 * 8.34) = **31.1 mg/L**

The **annual average effluent** is **31.1 mg/L**.

There are no more stages required after stage 13 because **sufficient loading has been removed to meet the land treatment system loading requirements.**

4.6.2. Max Month Total Nitrogen Treatment Calculations

The treatment process calculations for total nitrogen removal during the max month (June) anticipated at the plant.

Stage 1

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 133 mg/L TN
    d. Loading Rate = 4.0 * 133 * 8.34 = 4,444 ppd
    e. SALR = (4,444 ppd * 453.6 g /lb) / 1,500 m^2 = **1,343.8 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{1{,}343.8}{761.44+1{,}343.8})$ = **79.6 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 79.6 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **263 ppd**
    b. Remaining mass = 4,444 ppd – 263 ppd = **4,180 ppd remaining**
    c. Concentration going to next stage = 4,180 ppd / (4.0 * 8.34) = **125.3 mg/L**

Stage 2

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 125.3 mg/L TN
    d. Loading Rate = 4.0 * 115.3 * 8.34 = 4,180 ppd
    e. SALR = 4,180 ppd * 453.6 g /lb) / 1,500 m^2 = **1,264.2 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{1{,}264.2}{761.44+1{,}264.2})$ = **77.8 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 77.8 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **257 ppd**
    b. Remaining mass = 4,180 ppd – 257 ppd = **3,923 ppd remaining**
    c. Concentration going to next stage = 3,923 ppd / (4.0 * 8.34) = **117.6 mg/L**

Stage 3

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 117.6 mg/L TN
    d. Loading Rate = 4.0 * 117.6 * 8.34 = 3,923 ppd
    e. SALR = 3,923 ppd * 453.6 g /lb) / 1,500 m^2 = **1,186.3 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{1{,}186.3}{761.44+1{,}186.3})$ = **76.0 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 76.0 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **251 ppd**
b. Remaining mass = 3,923 ppd – 251 ppd = **3,672 ppd remaining**
c. Concentration going to next stage = 3,672 ppd / (4.0 * 8.34) = **110.1 mg/L**

<u>Stage 4</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 110.1 mg/L TN
   d. Loading Rate = 4.0 * 110.1 * 8.34 = 3,672 ppd
   e. SALR = 3,672 ppd * 453.6 g /lb) / 1,500 m^2 = **1,110.3 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{1{,}110.3}{761.44+1{,}110.3})$ = **74.0 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 74.0 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **245 ppd**
   b. Remaining mass = 3,672 ppd – 245 ppd = **3,427 ppd remaining**
   c. Concentration going to next stage = 3,427 ppd / (4.0 * 8.34) = **102.7 mg/L**

<u>Stage 5</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 102.7 mg/L TN
   d. Loading Rate = 4.0 * 102.7 * 8.34 = 3,427 ppd
   e. SALR = 3,427 ppd * 453.6 g /lb) / 1,500 m^2 = **1,036.4 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{1{,}036.4}{761.44+1{,}036.4})$ = **71.9 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 71.9 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **238 ppd**
   b. Remaining mass = 3,427 ppd – 238 ppd = **3,189 ppd remaining**
   c. Concentration going to next stage = 3,189 ppd / (4.0 * 8.34) = **95.6 mg/L**

<u>Stage 6</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 95.6 mg/L TN
   d. Loading Rate = 4.0 * 95.6 * 8.34 = 3,189 ppd
   e. SALR = 3,189 ppd * 453.6 g /lb) / 1,500 m^2 = **964.5 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{964.5}{761.44+964.5})$ = **69.7 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 69.7 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **230 ppd**
b. Remaining mass = 3,189 ppd – 230 ppd = **2,959 ppd remaining**
c. Concentration going to next stage = 2,959 ppd / (4.0 * 8.34) = **88.7 mg/L**

Stage 7

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 88.7 mg/L TN
    d. Loading Rate = 4.0 * 88.7 * 8.34 = 2,959 ppd
    e. SALR = 2,959 ppd * 453.6 g /lb) / 1,500 m^2 = **894.8 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{894.8}{761.44+894.8})$ = **67.4 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 67.4 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **223 ppd**
    b. Remaining mass = 2,959 ppd – 223 ppd = **2,736 ppd remaining**
    c. Concentration going to next stage = 2,736 ppd / (4.0 * 8.34) = **82.0 mg/L**

Stage 8

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 82.0 mg/L TN
    d. Loading Rate = 4.0 * 82.0 * 8.34 = 2,736 ppd
    e. SALR = 2,736 ppd * 453.6 g /lb) / 1,500 m^2 = **827.4 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{827.4}{761.44+827.4})$ = **65.0 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
    a. Mass removed = 65.0 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **215 ppd**
    b. Remaining mass = 2,736 ppd – 215 ppd = **2,521 ppd remaining**
    c. Concentration going to next stage = 2,521 ppd / (4.0 * 8.34) = **75.6 mg/L**

Stage 9

1. Determine the SALR in the stage.
    a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
    b. Flow = 4.0 MGD
    c. Concentration = 75.6 mg/L TN
    d. Loading Rate = 4.0 * 75.6 * 8.34 = 2,521 ppd
    e. SALR = 2,521 ppd * 453.6 g /lb) / 1,500 m^2 = **762.4 g/m²/day**
2. Determine the SARR in the stage.
    a. Apply SARR prediction curve for TN removal derived from empirical data.
    b. $TN\ SARR = 124.73(\frac{762.4}{761.44+762.4})$ = **62.4 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.

a. Mass removed = 62.4 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **206 ppd**
b. Remaining mass = 2,521 ppd – 206 ppd = **2,315 ppd remaining**
c. Concentration going to next stage = 2,315 ppd / (4.0 * 8.34) = **69.4 mg/L**

<u>Stage 10</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 69.4 mg/L TN
   d. Loading Rate = 4.0 * 69.4 * 8.34 = 2,315 ppd
   e. SALR = 2,315 ppd * 453.6 g /lb) / 1,500 m^2 = **700.0 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{700.0}{761.44+700.0})$ = **59.7 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 59.7 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **198 ppd**
   b. Remaining mass = 2,315 ppd – 198 ppd = **2,117 ppd remaining**
   c. Concentration going to next stage = 2,117 ppd / (4.0 * 8.34) = **63.5 mg/L**

<u>Stage 11</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 63.5 mg/L TN
   d. Loading Rate = 4.0 * 63.5 * 8.34 = 2,117 ppd
   e. SALR = 2,117 ppd * 453.6 g /lb) / 1,500 m^2 = **640.3 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{640.3}{761.44+640.3})$ = **57.0 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 57.0 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **188 ppd**
   b. Remaining mass = 2,117 ppd – 188 ppd = **1,929 ppd remaining**
   c. Concentration going to next stage = 1,929 ppd / (4.0 * 8.34) = **57.8 mg/L**

<u>Stage 12</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 57.8 mg/L TN
   d. Loading Rate = 4.0 * 57.8 * 8.34 = 1,929 ppd
   e. SALR = 1,929 ppd * 453.6 g /lb) / 1,500 m^2 = **583.3 g/m^2/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{583.3}{761.44+583.3})$ = **54.1 g/m^2/day**
3. Determine the mass removed and resulting concentration from stage.

  a. Mass removed = 54.1 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **179 ppd**
  b. Remaining mass = 1,929 ppd – 179 ppd = **1,750 ppd remaining**
  c. Concentration going to next stage = 1,750 ppd / (4.0 * 8.34) = **52.5 mg/L**

<u>Stage 13</u>

1. Determine the SALR in the stage.
   a. 1 Module with 10 Belts = 10 * 150 m^2/belt = 1,500 m^2 of belt SA
   b. Flow = 4.0 MGD
   c. Concentration = 52.5 mg/L TN
   d. Loading Rate = 4.0 * 52.5 * 8.34 = 1.750 ppd
   e. SALR = 1,750 ppd * 453.6 g /lb) / 1,500 m^2 = **529.2 g/m²/day**
2. Determine the SARR in the stage.
   a. Apply SARR prediction curve for TN removal derived from empirical data.
   b. $TN\ SARR = 124.73(\frac{529.2}{761.44+529.2})$ = **51.1 g/m²/day**
3. Determine the mass removed and resulting concentration from stage.
   a. Mass removed = 51.1 g/m^2/day * 1,500 m^2 * 1lb / 453.6 g = **169 ppd**
   b. Remaining mass = 1,750 ppd – 169 ppd = **1,581 ppd remaining**
   c. Concentration going to next stage = 1,581 ppd / (4.0 * 8.34) = **47.4 mg/L**

During peak month flow, the effluent of **the anticipated effluent is 47.4 mg/L**.

4.6.3. COD Treatment Calculations

The same method as described for nitrogen removal is applied to BOD & COD treatment, using the curve specifically derived to predict COD treatment. Using this method, the anticipated effluent gets below the target of 200 mg/L in the 11^{th} stage of treatment. However, because total nitrogen requires 13 stages to meet the target there are several redundant stages for to meet the COD treatment target.

4.7. Summary of Treatment – TN

Annual Average

The anticipated effluent quality in each stage of treatment for Total Nitrogen during the annual average flow and concentration is provided in Table 3.

Table 3 – Annual Average Total Nitrogen Staged Treatment

Stage	**Number of Belts**	**Hydraulic Retention Time**	**SALR**	**SARR**	**Mass Removed**	**Mass Remaining**	**Effluent Concentration**
No.	No.	Hours	$g/m^2/day$	$g/m^2/day$	ppd	ppd	mg/L
0	0	N/A				3,083	114.3
1	10	0.30	932.2	68.7	227.0	2855.6	105.9
2	10	0.30	863.5	66.3	219.2	2636.4	97.7
3	10	0.30	797.2	63.8	211.0	2425.5	89.9
4	10	0.30	733.4	61.2	202.4	2223.1	82.4
5	10	0.30	672.3	58.5	193.4	2029.7	75.2
6	10	0.30	613.8	55.7	184.1	1845.6	68.4
7	10	0.30	558.1	52.8	174.5	1671.1	61.9
8	10	0.30	505.3	49.8	164.5	1506.6	55.8
9	10	0.30	455.6	46.7	154.4	1352.2	50.1
10	10	0.30	408.9	43.6	144.1	1208.1	44.8
11	10	0.30	365.3	40.4	133.7	1074.3	39.8
12	10	0.30	324.9	37.3	123.4	951.0	35.3
13	10	0.30	287.6	34.2	113.1	837.9	31.1

Max Month

The anticipated effluent quality in each stage of treatment for Total Nitrogen during the max month flow and concentration is provided in Table 3.

Table 4 – Max Month Total Nitrogen Staged Treatment

Stage	Number of Belts	Hydraulic Retention Time	SALR	SARR	Mass Removed	Mass Remaining	Effluent Concentration
No.	No.	Hours	g/m^2/day	g/m^2/day	ppd	ppd	mg/L
0	0	N/A				4,444	133.2
1	10	0.24	1,343.8	79.6	263.3	4,180	125.3
2	10	0.24	1,264.2	77.8	257.4	3,923	117.6
3	10	0.24	1,186.3	76.0	251.2	3,672	110.1
4	10	0.24	1,110.3	74.0	244.7	3,427	102.7
5	10	0.24	1,036.4	71.9	237.8	3,189	95.6
6	10	0.24	964.5	69.7	230.5	2,959	88.7
7	10	0.24	894.8	67.4	222.8	2,736	82.0
8	10	0.24	827.4	65.0	214.8	2,521	75.6
9	10	0.24	762.4	62.4	206.4	2,315	69.4
10	10	0.24	700.0	59.7	197.6	2,117	63.5
11	10	0.24	640.3	57.0	188.4	1,929	57.8
12	10	0.24	583.3	54.1	178.9	1,750	52.5
13	10	0.24	529.2	51.1	169.1	1,581	47.4

4.8. Summary of Treatment - COD

Annual Average

The anticipated effluent quality in each stage of treatment for COD during the annual average flow and concentration is provide in Table 5.

Table 5 – Annual Average COD Staged Treatment

Stage	**Number of Belts**	**Hydraulic Retention Time**	**SALR**	**SARR**	**Mass Removed**	**Mass Remaining**	**Effluent Concentration**
No.	No.	Hours	g/m2/day	g/m2/day	ppd	ppd	mg/L
0	0	N/A				16,186	600.0
1	10	0.30	4,894.6	331.0	1,094.5	15,092	559.4
2	10	0.30	4,563.7	324.9	1,074.4	14,017	519.6
3	10	0.30	4,238.7	318.3	1,052.5	12,965	480.6
4	10	0.30	3,920.5	311.1	1,028.6	11,936	442.5
5	10	0.30	3,609.4	303.2	1,002.5	10,934	405.3
6	10	0.30	3,306.3	294.5	973.9	9,960	369.2
7	10	0.30	3,011.7	285.0	942.6	9,017	334.2
8	10	0.30	2,726.7	274.7	908.3	8,109	300.6
9	10	0.30	2,452.0	263.3	870.9	7,238	268.3
10	10	0.30	2,188.7	251.0	830.0	6,408	237.5
11	10	0.30	1,937.7	237.5	785.5	5,622	208.4
12	10	0.30	1,700.2	223.0	737.4	4,885	181.1
13	10	0.30	1,477.2	207.3	685.6	4,199	155.7

<u>Max Month</u>

The anticipated effluent quality in each stage of treatment for COD during the max month flow and concentration is provide in Table 6.

Table 6 – Max Month COD Staged Treatment

Stage	**Number of Belts**	**Hydraulic Retention Time**	**SALR**	**SARR**	**Mass Removed**	**Mass Remaining**	**Effluent Concentration**
No.	No.	Hours	$g/m^2/day$	$g/m^2/day$	ppd	ppd	mg/L
0	0	N/A				20,016	600.0
1	10	0.24	6,052.7	348.2	1,151.3	18,865	565.5
2	10	0.24	5,704.6	343.6	1,136.1	17,729	531.4
3	10	0.24	5,361.0	338.6	1,119.6	16,609	497.9
4	10	0.24	5,022.4	333.2	1,101.8	15,507	464.8
5	10	0.24	4,689.3	327.3	1,082.3	14,425	432.4
6	10	0.24	4,362.0	320.9	1,061.1	13,364	400.6
7	10	0.24	4,041.1	313.9	1,038.0	12,326	369.5
8	10	0.24	3,727.2	306.3	1,012.8	11,313	339.1
9	10	0.24	3,421.0	297.9	985.1	10,328	309.6
10	10	0.24	3,123.1	288.8	954.9	9,373	281.0
11	10	0.24	2,834.3	278.7	921.8	8,451	253.3
12	10	0.24	2,555.6	267.8	885.6	7,566	226.8
13	10	0.24	2,287.8	255.8	846.0	6,720	201.4

5. Algae Product, Storage and Processing Requirements

The algae and biomass that grows on the belts is periodically removed from the system. The typical schedule is to remove the material after 7 days of growth. The material is never removed from the entire system all at once. The harvesting tool is programmed to harvest a set length of belt on a repeating schedule. For example, for each 10-belt module the belts will be harvested on weekly schedule such as the one below.

- Mondays: Harvest belts 1 & 2
- Tuesdays: Harvest belts 3 & 4
- Wednesdays: Harvest belts 5 & 6
- Thursdays: Harvest belts 7 & 8
- Fridays: Harvest belts 9 & 10
- Saturdays: No harvest.
- Sundays: No harvest.

The assumptions made to estimate the quantity of algae produced is as follows:

- 13 RAB Modules
- 130 RAB Belts
- Harvest cycle is 7 days
- Harvest is Monday-Friday, 2 belts per day per module.
- Anticipated growth rate is 20 g/m^2/day.
    - Measured by the belt surface area.
    - Dry weight
- The material is removed at 3% solids.
    - Density is equal to water when it is harvested.
- 260 days per year where facility is staffed, and harvest is performed.
    - The harvest is automatic, but it is advised that staff are present to ensure the dewatering is performed.

The estimated annual volume is:

130 belts *150 m2/belt * 20 g/m2/day * 365 days/yr * 1kg / 1000g = 142,350 kg = **142 metric tons dry algae solids per year**

142,350 kg = 313,828 lbs dry algae solids. / 0.03 % by mass = 10,460,933 lbs wet material harvested from the belts / 8.34 = 1,254,300 gallons of material harvested from the belts annually.

1,254,300 gallons/yr / 260 harvest days = 4,824 gallons of material every harvest day

4,824 gallons per day * 5 days per week harvest = 24,121 gallons per week.

At minimum a 5,000 gallon 'day tank' is required to store the material before it is conditioned and dewatered in the dewatering box. For redundancy two 5,000 gallon storage tanks are recommended.

To concentrate the material from 3% solids to a minimum of 15% solids, GWT has used containerized dewatering boxes to remove the free water that is captured during the harvest of the belts. Some polymer is added to the harvested material to speed up the dewatering process and ensure that all material is captured in the dewatering box. The runoff from the box should be returned to the process water stream to be treated.

Figure 7 - Example Dewatering Box

In Pasco the proposed facility will accommodate two (2) 30 CY roll-off dewatering boxes. Each box has approximately 5,000 gallons of working volume for dewatered biomass. Since the material will be concentrated from 3% to 15% solids, each 30 CY box can process ~25,000 gallons of harvested material. The estimated production of harvested material is ~25,000 gallons per week. Each box will be removed once per week so that the algae can be processed offsite.

In practice this means that one box will be filled throughout the week and remove at the end of the week. The other box will then begin to be filled the following week while the first box is returned from the processing facility. This cycle will be repeated every week, ensuring that at least one box is available for material to be dewatered at any time.

The algae that is placed in the box will be dewatered. The reject water that is removed from the algae sludge is largely 'free water' that is not encapsulated in the algae cells. This water has similar water quality to the water that the algae grew in (i.e., the water that is being treated). The water that is drained from the box will need to be returned to the influent of the RAB system (i.e., post DAF process) for treatment. Several floor drains should be used to collect and return the reject water.

The algae is expected to be marketed as a product to be used as a fertilizer. This expectation is derived from material testing of algae produced by the RAB system in other projects. These laboratory analyses conclude that the algae meets EPA 503 Classification Standards and thus is suitable for use as fertilizer. If the material in this project is outside of necessary specifications, GWT is contractually obligated to dispose of the algae at their cost, with the expectation being that it would be landfilled.

Appendix 6-A

Winter Storage Calculations

City of Pasco
PWRF Storage Calculations by Processor, Average Annual Scenario
3/31/2023

PWRF Average Daily Flow by Month (MGD)										
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (no COW)	Darigold COW	Total (with COW)
January	0.57	0.04	0.41	0.50	0.00	0.08	0.70	**2.30**	0.75	**3.05**
February	0.40	0.05	0.41	0.50	0.00	0.07	0.70	**2.13**	0.75	**2.88**
March	0.57	0.04	0.41	0.48	0.00	0.08	0.70	**2.29**	0.85	**3.14**
April	0.78	0.05	0.41	0.50	0.00	0.07	0.70	**2.52**	0.85	**3.37**
May	0.73	0.14	0.41	0.50	0.00	0.06	0.70	**2.54**	0.85	**3.39**
June	1.33	1.06	0.41	0.60	0.02	0.11	0.70	**4.23**	0.80	**5.03**
July	1.37	1.41	0.41	1.20	1.65	0.02	0.70	**6.76**	0.80	**7.56**
August	1.78	1.61	0.41	1.20	1.65	0.03	0.70	**7.38**	0.80	**8.18**
September	2.05	1.62	0.41	1.20	1.65	0.06	0.70	**7.70**	0.80	**8.50**
October	1.90	1.17	0.41	0.70	1.65	0.09	0.70	**6.62**	0.80	**7.42**
November	1.55	0.11	0.41	0.50	1.65	0.08	0.70	**5.01**	0.80	**5.81**
December	1.23	0.05	0.41	0.50	0.02	0.06	0.70	**2.98**	0.75	**3.73**

PWRF Average Flow by Month (MG)										
Month	Pasco Processing	Twin City Foods	Reser's	Simplot	Grimmway	Freeze Pack	Darigold WW	Total (no COW)	Darigold COW	Total (with COW)
January	17.62	1.24	12.74	15.50	0.00	2.55	21.74	**71.39**	23.25	**94.64**
February	11.24	1.33	11.51	14.00	0.00	1.85	19.64	**59.57**	21.00	**80.57**
March	17.67	1.36	12.74	15.00	0.00	2.58	21.74	**71.09**	26.35	**97.44**
April	23.48	1.50	12.33	15.00	0.00	2.20	21.04	**75.54**	25.50	**101.04**
May	22.62	4.40	12.74	15.50	0.00	1.86	21.74	**78.86**	26.35	**105.21**
June	39.99	31.84	12.33	18.00	0.60	3.23	21.04	**127.03**	24.00	**151.03**
July	42.34	43.59	12.74	37.20	51.15	0.72	21.74	**209.49**	24.80	**234.29**
August	55.04	49.85	12.74	37.20	51.15	0.95	21.74	**228.66**	24.80	**253.46**
September	61.48	48.59	12.33	36.00	49.50	1.92	21.04	**230.87**	24.00	**254.87**
October	58.87	36.25	12.74	21.70	51.15	2.84	21.74	**205.29**	24.80	**230.09**
November	46.62	3.37	12.33	15.00	49.50	2.38	21.04	**150.23**	24.00	**174.23**
December	38.04	1.68	12.74	15.50	0.62	1.92	21.74	**92.24**	23.25	**115.49**
TOTAL	**435**	**225**	**150**	**256**	**254**	**25**	**256**	**1600**	**292**	**1892**
Nov 15-Mar 15 Storage	99	7	50	60	25	9	85	334	93	427

Note: See Storage Calculations by Flow to Fields for additional calculations.

City of Pasco
PWRF Storage Calculations by Flow to Fields, Average Annual Scenario
3/31/2023

Storage in COW Water Lagoon					
Month	COW Influent to PWRF	COW to Fields	Delta Storage	Storage in Use	
Jan	23.25	0	23	76	
Feb	21	0	21	97	Peak Storage
Mar	26.35	123	-97	0	
Apr	25.5	0	26	26	
May	26.35	25	1	27	
Jun	24	24	0	27	
Jul	24.8	51	-27	0	
Aug	24.8	0	25	25	
Sep	24	0	24	49	
Oct	24.8	0	25	74	
Nov	24	69	-45	29	
Dec	23.25	0	23	52	
TOTAL	**292**	**292**	**0**		

Storage in Non-COW Lagoon					
Month	Influent to PWRF	To Fields	Delta Storage	Storage in Use	
Jan	71	0	71	267	
Feb	60	0	60	327	
Mar	71	47	24	351	Peak Storage
Apr	76	252	-176	174	
May	79	253	-174	0	
Jun	127	127	0	0	
Jul	209	209	0	0	
Aug	229	229	0	0	
Sep	231	231	0	0	
Oct	205	205	0	0	
Nov	150	47	104	104	
Dec	92	0	92	196	
TOTAL	**1600**	**1600**	**0**		

Storage in All Lagoons					
Month	Influent to PWRF	To Fields	Delta Storage	Storage in Use	
Jan	95	0	95	343	
Feb	81	0	81	423	Peak Storage
Mar	97	170	-73	351	
Apr	101	252	-151	200	
May	105	278	-173	27	
Jun	151	151	0	27	
Jul	234	261	-27	0	
Aug	253	229	25	25	
Sep	255	231	24	49	
Oct	230	205	25	74	
Nov	174	115	59	133	
Dec	115	0	115	248	
TOTAL	**1892**	**1892**	**0**		

City of Pasco
PWRF Storage Calculations by Flow to Fields, Max Month Scenario
3/31/2023

Storage in COW Lagoon					
Month	COW Influent to PWRF	COW to Fields	Delta Storage	Storage in Use	
Jan	23.25	0	23	76	
Feb	21	0	21	97	Peak Storage
Mar	26.35	123	-97	0	
Apr	25.5	0	26	26	
May	26.35	25	1	27	
Jun	24	24	0	27	
Jul	24.8	51	-27	0	
Aug	24.8	0	25	25	
Sep	24	0	24	49	
Oct	24.8	0	25	74	
Nov	24	69	-45	29	
Dec	23.25	0	23	52	
TOTAL	**292**	**292**	**0**		

Storage in Non-COW Lagoon					
Month	Influent to PWRF	To Fields	Delta Storage	Storage in Use	
Jan	62	0	62	273	
Feb	56	0	56	329	
Mar	62	47	15	344	Peak Storage
Apr	60	252	-192	152	
May	78	230	-152	0	
Jun	127	127	0	0	
Jul	228	228	0	0	
Aug	264	264	0	0	
Sep	255	250	5	5	
Oct	228	157	71	76	
Nov	120	47	73	149	
Dec	62	0	62	211	
TOTAL	**1600**	**1600**	**0**		

Storage in All Lagoons					
Month	Influent to PWRF	To Fields	Delta Storage	Storage in Use	
Jan	85	0	85	349	
Feb	77	0	77	426	Peak Storage
Mar	88	170	-82	344	
Apr	86	252	-166	177	
May	104	255	-151	27	
Jun	151	151	0	27	
Jul	252	279	-27	0	
Aug	288	264	25	25	
Sep	279	250	29	54	
Oct	252	157	96	149	
Nov	144	115	29	178	
Dec	85	0	85	263	
TOTAL	**1892**	**1892**	**0**		

Incremental Stage Storage Analysis

Table 1
Stage Storage Analysis by Lagoon

103 MG Lagoon			106 MG Lagoon			120 MG Lagoon		
Contour Elevation (ft)	Contour Area (acres)	Volume (acre-ft)	Contour Elevation (ft)	Contour Area (acres)	Volume (acre-ft)	Contour Elevation (ft)	Contour Area (acres)	Volume (acre-ft)
523	0.01	0.00	-	-	-	-	-	-
524	0.19	0.08	524	0.01	0.00	-	-	-
525	0.62	0.47	525	0.20	0.08	-	-	-
526	1.29	1.40	526	0.63	0.47	-	-	-
527	2.20	3.13	527	1.30	1.42	-	-	-
528	3.33	5.89	528	2.22	3.16	528	0.01	0.00
529	4.34	9.73	529	3.38	5.93	529	0.22	0.09
530	5.31	14.55	530	4.67	9.97	530	0.68	0.52
531	6.28	20.35	531	5.83	15.23	531	1.39	1.53
532	7.25	27.11	532	6.95	21.61	532	2.36	3.38
533	8.24	34.85	533	8.06	29.12	533	3.57	6.32
534	9.24	43.59	534	9.18	37.73	534	5.05	10.61
535	10.24	53.32	535	10.30	47.47	535	6.77	16.50
536	11.25	64.06	536	11.42	58.33	536	8.75	24.24
537	12.28	75.83	537	12.55	70.31	537	10.98	34.08
538	13.34	88.63	538	13.71	83.44	538	13.44	46.27
539	14.41	102.51	539	14.88	97.74	539	15.98	61.01
540	15.07	117.32	540	15.97	113.20	540	18.08	78.06
541	15.32	132.52	541	16.39	129.43	541	20.10	97.16
542	15.58	147.97	542	16.65	145.95	542	21.99	118.23
543	15.84	163.68	543	16.91	162.73	543	23.22	140.89
544	16.09	179.65	544	17.16	179.76	544	24.03	164.54
545	16.35	195.87	545	17.42	197.06	545	24.48	188.83
546	16.61	212.35	546	17.69	214.61	546	24.77	213.46
547	16.87	229.09	547	17.95	232.43	547	25.05	238.37
548	17.14	246.10	548	18.21	250.51	548	25.34	263.56
549	17.40	263.37	549	18.48	268.86	549	25.63	289.05
550	17.67	280.90	550	18.74	286.37	550	25.92	314.83
551	17.93	298.71	551	19.01	305.25	551	26.22	340.90
552	18.20	316.77	552	19.28	324.40	552	26.51	367.26
553	18.47	335.11	553	19.55	343.81	553	26.81	393.92
554	18.74	353.72	554	19.82	363.50	554	27.10	420.87
555	19.01	372.60	555	20.09	383.46	555	27.40	448.13
556	19.35	391.69	556	20.64	403.64	556	27.76	475.62

Notes:
1.) The normal pool elevation is 552 feet and the crest elevation is 556 feet.
2.) 1 million gallons = 3.07 acre-feet

Appendix 6-B

Preliminary Lagoon Liner Specifications

2.11.21 Reinforced Polyethylene Membrane

Part 1 – General

A reinforced polyethylene (RPE) membrane shall be used as a lagoon liner for the proposed 103mg, 106mg, and 120mg lagoons.

Part 2 – Product

Product

The material supplied under these specifications shall be first quality goods specifically formulated and tested for the containment of the material(s) as set forth in the accompanying specifications.

The material used for the lining shall be a high-density polyolefin reinforced low density polyethylene coated membrane and shall have been satisfactorily demonstrated by prior use and testing to be suitable, appropriate, and durable for the purpose of this work.

The membrane shall be manufactured by the application of low-density coating over high density scrim(s) and shall be uniform in color, thickness, size and surface texture. The finished lining shall be a sunlight (UV), weather resistant (Cold temperature), plant and fish safe membrane that is a flexible, durable, liquid tight product free from pinholes, blisters, contaminates or other off specification defects.

The membrane shall be manufactured from a composition of high-quality ingredients, specifically compounded for use in hydraulic structures. Only high-quality resins and additives shall be used. Reprocessed materials will not be acceptable other than clean rework materials of the same virgin ingredients generated from the manufacturer's own production. Nominal finished thickness shall be plus or minus 10% of manufacturer's specification.

The membrane shall have a textured surface that is to be placed face-up to provide a non-slip walking surface. The nominal thickness of the membrane shall be 40 mil not including the textured surface. Grab tensile strength shall be 740 lb in the machine direction and 655 lb in the transverse direction per ASTM D7004. Puncture resistance shall be 370 lb. per ASTM D4833. Nominal weight shall be 23.5 oz/cy^2.

The membrane shall retain greater than 90% strength after 2,000 hrs. of accelerated weathering at 0.77 E/m^2/nm per ASTM G151.

RPE membranes shall be equal to Intertape Polymer Group ArmorGrip 40.

Manufacturer Roll Sampling

Each roll upon delivery from the manufacturer to the fabricator shall be visually inspected. Each roll shall be wrapped individually, and each roll shall be clearly labeled with a roll number and lot number.

Prior to placing the roll into production, the roll number and lot number will be recorded on the shop drawing and production order. A 6" wide sample taken from the entire width of the roll will be removed and cut into 2 pieces 6"x 6' long and welded together for sampling and material integrity testing. Peel testing of the sample shall be done to insure weldability and careful inspection at weld separation shall be checked for delamination. If delamination failure is present, retest as described above, after removing 15 feet from the roll. If failure is still apparent the roll shall be labeled as rejected and removed from the production area. These procedures apply to all new rolls and roll splice joints. All roll tests are to be recorded in the test log.

Factory Fabrication

The individual widths of the RPE fabric shall be assembled into large sheets custom-designed for the specific project to minimize field seaming. All factory seams shall provide a bond between the sheet goods sufficiently strong to meet the test requirements of these specifications.

All machines used in the seaming process shall be tested daily, prior to any fabrication, by welding a 6' long test sample of the material and manually peel testing along the entire length. Each test must show film tear bonding along the length of the seam to be considered a "pass". All results shall be recorded in the test report log and must include Date, time, machine #, operator, temp and speed as well as pass\fail indication. If the sample fails the testing, make appropriate corrections to the equipment and retest as stated above.

Machines will be further requalified after the following: change of material, unexpected power loss, change of operator, or shutdowns of 45 minutes or longer.

The factory seaming shall be performed on thermal welding equipment with pressure wheels and shall consist of seams of 2" minimum width in the case of wedge welding, 1.5" width in the case of hot air welding, which will provide a film-tearing bond of 80% of the fabric tensile strength. All seams shall be visually inspected along their entire length, and destructive tested at an interval not to exceed 500 lineal feet of factory seam per machine.

Panel Packaging and Handling

Factory fabricated panels shall be accordion folded during production to width of approximately 6' wide. Upon completion each bundle shall be folded or rolled by hand or machine based on the total square footage of the panel. Finished panels weighing 1300 lbs. (600 kg) or more are rolled by machine and include a core and continuous unroll strap. When appropriate to shipping method, each roll shall be secured to a pallet or export container designed to be moved by a forklift or similar piece of equipment. Each factory-fabricated panel shall be prominently marked with the panel size and unrolling directions. When appropriate each panel will then be wrapped with its own protective wrap and marked again as to size and installation direction. Packaged factory liner sections, which are delivered to a project site, shall be stored in their original shipping wrappers and stored in a dry area and protected from harsh weather elements when at all possible. When palletized, liner panels shall not be stacked to avoid damage.

Part 3 – Installation

The installer of the lining fabric shall be experienced in the installation of flexible membrane linings and shall be approved by the supplier of the material.

Lining Base Structure Preparation

A base shall be prepared on the bottom, slopes and sidewalls of any area to be lined. This base shall be free of all sharp objects, roots, grass and vegetation. Unsuitable material found during the pre-installation inspection by the installer shall be removed and/or appropriately covered with adequate protective materials prior to the installation of the liner.

Any structure or containment area built from man-made materials (metal, concrete, etc.) shall not allow protrusions, pinch points or movement of the supporting structure which might damage the liner material and adversely affect the ability of the membrane to perform its waterproofing function.

The base (subgrade) material shall be native materials or materials obtained from a borrow source compacted in accordance with the Technical Specifications or an approved construction fabric of at least 100 mils thickness, weighing a minimum of 8 ozs. per square yard with a grab tensile strength of at least 275 lbs. per square inch and a Mullen burst strength of at least 450 pounds per square inch, which will provide a finished subgrade suitable for the flexible membrane lining.

Foreign materials, vegetation, protrusions, voids, cracks and other penetrating or raised sources shall be removed from the base, slopes and sidewalls of the containment area or structure. Loose rocks, rubble and other foreign matter shall be collected and deposited in an appropriate site out of the area to be lined. The excavated and filled areas shall be trimmed to elevations and contours shown on the drawings and shall be smooth, uniform and free of all foreign matter, vegetation and sudden changes in grade.

A pre-installation inspection shall be called for and ALL interested parties, including the Contractor, Department of Ecology's Dam Safety Office, the Engineer, and the City shall be present for this inspection. Any parties not participating in this inspection shall be construed as accepting the site preparation and will acknowledge this defacto acceptance in writing at the appropriate time.

Final Subgrade Preparation

The subgrade shall be prepared or be confirmed ready immediately prior to the placing of the liner. The surface on which the liner is to be placed is to be firm, clean, dry and smooth. Anchor trench excavation and any structure sealing or preparation should be completed before the lining installation begins.

Lining Installation

A continuous sheet of liner shall be installed throughout the installation site as according to the drawings.

The lining shall be placed over the prepared surfaces to be lined in such a manner as to assure a minimum of handling. The sheets shall be of prescribed lengths and widths and shall be placed in such a manner as to minimize field seams. Only those pieces of fabric that can be installed and anchored in place during the workday shall be unpacked and placed in position.

Sandbags and/or other suitable ballast may be used as required to hold the lining in position during the installation. The weights shall not have any sharp edges, which may snag or otherwise penetrate the liner fabric. Care should be taken to keep the seam areas as clean as possible. It may be necessary to wipe down the edges prior to heat-sealing the panels together.

No materials or equipment shall be dragged across the face of the liner nor shall the workmen while installing the liner subject the liner to abuse. All installation party members shall wear soft-soled shoes or boots while working on the surface of the liner.

Lining sheets shall be closely fitted around all penetrations through the liner. Lining to concrete seals shall be accomplished with mechanical anchors and stainless steel batten strips as shown on drawings. All piping, structures and irregular projections shall be sealed and flashed with prefabricated pipe boots or other approved sealing methods.

A meeting of all interested parties shall proscribe the method of backfilling of the site with the appropriate materials. The lining installation manager prior to commencement of the backfilling program shall approve all actions undertaken to place the top cover material.

Field Seams

All seaming shall be done with thermal heat-sealing equipment. Automatic wedge welding shall be the method of field seaming whenever possible.

Wedge welders for field seams shall be qualified prior to beginning field seaming. A 6' section of material, at current ambient temperature, shall be welded and manually torn apart to insure proper welding adhesion.

Lap joints require a minimum of 2.5" overlap of the factory fabricated panels. The contact surfaces of the panels must be cleaned and all moisture and other foreign material must be removed prior to heat sealing.

If the sub-surface area is not capable of 92% compaction it may require the placement of a back board or rub sheet under the liner to give a firm, dry and clean welding surface.

Extreme caution should be taken throughout the installation to avoid wrinkling the edge of the liner. These "fish mouths" must be slit back sufficiently to remove them and the liner sealed to assure total integrity.

Any portion of the liner damaged or hurt for any reason shall be repaired or replaced by the installation crew before it departs. Normally the ends of the panels can be used for a patching source.

Patching

Any repairs resulting from damage during installation shall be repaired with like fabric and heat sealing to ensure a secure lining. It is recommended that at least 2"-4" of overlap be used on any penetrations. It is suggested that any major scuffing be replaced with undamaged liner.

Inspection

A thorough inspection of the completed liner installation shall be undertaken by a representative of the installer and a representative of the owner or the engineer in charge of the project. All government agencies involved in the project should also have an inspector or designated representative on site during the installation and after completion of same so as to register any complaints at that time. Any and all discrepancies to the permit process or license shall be attended to at this time.

Field Testing

All field seams shall require nondestructive testing using the Air Lance method (ASTM D4437) as outlined:

- Installer will supply a compressor and air wand with a fixed nozzle tip with an opening approx. 3/16".
- Compressor shall be equipped with an output gauge and the ability to continuously supply 50 psi of air pressure.
- The non-destructive test involves running the nozzle of air 2" away from the outside edge of the field seam for its entire length. If air penetrates the seam area the audible noise or visual puffing of the seam indicates an area of concern and should be marked and repaired accordingly.

2.11.22 High Density Polyethylene Geomembrane

Part 1 – General

This specification includes furnishing and installing a 60-mil textured (high density polyethylene) HDPE geomembranes with a formulated sheet density of 0.940 g/cc or greater equal to Layfield. A HDPE membrane shall be used as a lagoon liner for repair and replacement of liner on the existing 123 MG and 35 MG lagoons.

References

A. American Society for Testing and Materials (ASTM):

1. D 638, Standard Test Method for Tensile Properties of Plastics.
2. D 4439 Terminology for Geosynthetics.
3. D 751, Standard Test Methods for Coated Fabrics.
4. D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. D 1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
6. D 1204, Standard Test Method for Linear Dimensional Changes of Non-Rigid Thermoplastic Sheeting or Film at Elevated Temperature.
7. D 1238, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

8. D 1505, Standard Test Method for Density of Plastics by Density Gradient Technique.

9. D 1603, Standard Test Method for Carbon Black in Olefin Plastics.

10. D 3895, Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.

11. D 4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

12. D4437 – 08, Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

13. D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

14. D 5199, Standard Test Method for Measuring Nominal Thickness of Smooth Geomembranes.

15. D 5397, Standard Test Method for Evaluation of Stress Crack. Resistance of Polyolefins using Notched Constant Tensile Load Test.

16. D 5596, Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.

17. D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.

18. D 5721, Practice for Air-Oven Aging of Polyolefin Geomembranes.

19. D 5820, Test Method for Air Testing.

20. D 5885, Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.

21. D 5994, Standard Test Method for Measuring Nominal Thickness of Textured Geomembranes.

22. D 6365, Standard Practice for the Nondestructive Testing of Geomembrane Seams using The Spark Test.

23. D5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes.

24. D 6392-08, Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

25. D7002, Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method.

26. D7007-15, Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials.

27. ASTM D7466, Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

B. Geosynthetic Research Institute (GRI)

1. GRI GM 9, Cold Weather Seaming of Geomembranes

2. GRI GM 10, The Stress Crack Resistance of HDPE Geomembrane Sheet

3. GRI GM 13, Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

4. GRI GM 14, Test Frequencies for Destructive Seam Testing Selecting, variable intervals for taking geomembrane destructive samples using the method of attributes.

6. GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

7. GRI GM 20, Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts.

Submittals

Submit the following to the Engineer or Owner, for review and approval, within a reasonable time so as to expedite shipment or installation of the Geomembrane:

1. Documentation of manufacturer's qualifications as specified in subsection 1.04A of this Section.

2. Manufacturer's Quality Control program manual or descriptive documentation. Guidelines for Installation of:

3. A material properties sheet, including at a minimum all properties specified in GRI GM 13 or GRI GM 17, including test methods used.

4. Sample of the material.

5. Documentation of Installer's qualifications, as specified below and in subsection 1.04B of this Section.

a. Submit a list of at least ten completed facilities. For each installation, provide: name and type of facility; its location; the date of installation; name and telephone number of contact at the facility; type and thickness of geomembrane and; surface area of the installed geomembrane.

b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and IAGI Certified Welding Technicians (CWTs) to be assigned to this project.

c. Quality Control Program.

6. Example Material Warranty and Liner Installation Warranty.

Shop Drawings

1. Submit copies of shop drawings for engineer's approval within a Submit copies of shop drawings for engineer's approval within a reasonable time so as not to delay the start of geomembrane installation. Shop drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow the direction of the slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Owner's Representative. Butt seams on a slope, if allowed, should be staggered.

2. Placement of geomembrane should not be allowed to proceed until Owner's Representative has received and approved the shop drawings.

Additional Submittals (In-Progress and at Completion)

1. Manufacturer's warranty

2. Geomembrane installation warranty

Daily written acceptance of subgrade surface

4. Low-temperature seaming procedures if applicable

5. Prequalification test seam samples

6. Field seam non-destructive test results

7. Field seam destructive test results

8. Daily field installation reports

9. Installation record drawing

Quality Control

The manufacturer of geomembrane of the type specified or similar product shall have at least five years' experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have manufactured at least 1,000,000 M2 (10,000,000 FT^2) of the specified type of geomembrane or similar product during the last five years.

Installer's Qualifications

The Geomembrane Installer shall be the Manufacturer, approved Manufacturer's Installer or a contractor approved by the Owner's Representative to install the geomembrane.

The Geomembrane Installer shall have at least three years' experience in the installation of the specified geomembrane or similar. The Geomembrane Installer shall have installed at least 10 projects involving a total of 500,000 M2 (5,000,000 FT2) of the specified type of geomembrane or similar during the last three years.

Installation shall be performed under the direction of a field Installation Supervisor who shall be responsible throughout the geomembrane installation, for geomembrane panel layout, seaming, patching, testing, repairs, and all other activities of the Geomembrane Installer. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects involving a total of 500,000 M2 (5,000,000 FT2) of geomembrane of the type specified or similar product.

Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) who has seamed a minimum of (3,000,000 FT^2) of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.

All seaming, patching, other welding operations, and testing shall be performed by qualified technicians employed by the Geomembrane Installer.

Delivery, Storage and Handling

Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll dimensions and roll weight.

Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

Rolls shall be stored away from high traffic areas. Continuously and uniformly support rolls on a smooth, level prepared surface.

Project Conditions

Geomembrane should not be installed in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Section 3.03.

Material Warranty

The manufacturer of the geo-membrane shall offer a 10 year warranty on standard HDPE materials and 20 years for high UV HDPE. (Pro-Rated Material Weathering Warranty)

Geomembrane Installation Warranty

A geomembrane pre-construction meeting shall be held at the site prior to installation of the geomembrane. At a minimum, the meeting shall be attended by the Geomembrane Installer, Owner, Owner's representative (Engineer and/or CQA Firm), and the Earthwork Contractor.

Geomembrane Pre-Construction Meeting

A geomembrane pre-construction meeting shall be held at the site prior to installation of the geomembrane. At a minimum, the meeting shall be attended by the Geomembrane Installer, Owner, Owner's representative (Engineer and/or CQA Firm), and the Earthwork Contractor.

Topics for this meeting shall include:

1. Health and Safety

2. Lines of authority and communication. Resolution of any project document ambiguity.

3. Methods for documenting, reporting and distributing documents and reports.

4. Procedures for packaging and storing archive samples.

5. Review of time schedule for all installation and testing.

6. Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane.

7. Procedures and responsibilities for preparation and submission of as built panel and seam drawings.

8. Temperature and weather limitations. Installation procedures for adverse weather conditions. Defining acceptable subgrade, geomembrane, or ambient moisture and temperature conditions for working during liner installation.

9. Subgrade conditions, dewatering responsibilities, and subgrade maintenance plan.

10. Deployment techniques including allowable subgrade for the geomembrane.
11. Plan for controlling expansion/contraction and wrinkling of the geomembrane.
12. Covering of the geomembrane and cover soil placement.
13. Measurement and payment schedules.
14. Responsibilities of each party.

The meeting shall be documented by a person designated at the beginning of the meeting and minutes shall be transmitted to all parties.

Part 2 – Products

Source Quality Control

Manufacturing Quality Control

The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geomembrane prior to delivery, shall be in accordance with GRI GM 13 for HDPE geomembrane or modified as required for project specific conditions.

2. The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, as specified in subsection 2.01.A.3 of this Section, must be supplied to the Owner's Representative to verify that the materials supplied for the project are in compliance with all product and or project specifications in this Section. The certification shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

3. The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project are made from the same material type and are compatible.

Geomembrane

The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane rolls shall be seamless, high density polyethylene (HDPE - Formulated Sheet Density ≥ 0.940g/cc) containing no plasticizers, fillers or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in line spark or equivalent testing. The geomembrane shall be supplied as a continuous sheet with no factory seams in rolls. The geomembrane will meet the property requirements as shown in Table 1a or 2a (GRI GM 13) or Table 1a or 2a (GRI GM 17).

Material conformance testing by the Owner's Representative, if required, will be conducted using in-plant sampling or as specified for the project.

The geomembrane seams shall meet the property requirements as shown in Table 2, (Attachment B) or as required by project specifications.

Part 3 – Execution

Subgrade Preparation

The subgrade shall be prepared in accordance with the project specifications. The geomembrane subgrade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.

The Geomembrane Installer and Owner's Representative shall inspect the surface to be covered with the geomembrane on each day's operations prior to placement of geomembrane to verify suitability.

The Geomembrane Installer and Owner's Representative shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner, during geomembrane installation, to ensure subgrade suitability.

All subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired prior to placement of the geomembrane. All repairs shall be approved by the Owner's Representative and the Geomembrane Installer. This damage, repair, and the responsibilities of the contractor and Geomembrane Installer shall be defined in the preconstruction meeting.

Geomembrane Placement

No geomembrane shall be deployed until the applicable certifications and quality control certificates listed in subsection 1.03 of this Section are submitted to and approved by the Owner's Representative within the timeframe specified in the contract documents. If the material does not meet project specifications it shall be removed from the work area.

The geomembrane shall be installed to the limits shown on the project drawings and essentially as shown on approved panel layout drawings.

No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 0 degrees C (32 degrees F) unless otherwise approved by the Owner's Representative. The specified minimum temperature for material deployment may be adjusted by the Owner's Representative. Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be anchored and seamed together in one day should be deployed.

No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure vehicle or equivalent.

Sandbags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geomembrane.

Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.

Damaged panels or portions of the damaged panels which have been rejected shall be marked and their removal from the work area recorded.

The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. The geomembrane shall rest in intimate contact with the subgrade.

Wrinkles caused by panel placement or thermal expansion should be minimized in accordance with section 1.09 B11.

Considerations on site geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Owner's Representative.

Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 75 mm (3 in.).

Seaming Procedures

Cold weather installations should follow guidelines as outlined in GRI GM9.

No geomembrane material shall be seamed when liner temperatures are less than 0 degrees C (32 degrees F) unless the following conditions are complied with:

- Seaming of the geomembrane at material temperatures below 0 degrees C (32 degrees F) is allowed if the Geomembrane Installer can demonstrate to the Owner's Representative, using pre-qualification test seams, that field seams comply with the project specifications, the safety of the crew is ensured, and geomembrane material can be fabricated (i.e. pipe boots, penetrations, repairs. etc.) at subfreezing temperatures.
- The Geomembrane Installer shall submit to the Owner's Representative for approval, detailed procedures for seaming at low temperatures, possibly including the following:
  - Preheating of the geomembrane.
  - The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.
  - Number of test welds to determine appropriate seaming parameters.
- No geomembrane material shall be seamed when the sheet temperature is above 75 degrees C (170 degrees F) as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Owner's Representative. This approval will be based on recommendations by the manufacturer and on a field demonstration by the Geomembrane Installer using prequalification test seams to demonstrate that seams comply with the specification.
- Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.

- Fishmouths or excessive wrinkles at the seam overlaps shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to effect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm (1/2 in) diameter hole) so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

Pipe and Structure Penetration Sealing System

Provide penetration sealing system as shown in the Project Drawings.

Penetrations shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Project Drawings. The prefabricated or field fabricated assembly shall be field welded to the geomembrane as shown on the Project Drawings so as to prevent leakage. This assembly shall be tested as outlined in section 3.05.B. Alternatively, where field non-destructive testing cannot be performed, attachments will be field spark tested by standard holiday leak detectors in accordance with ASTM 6365.

Spark testing should be done in areas where both air pressure testing, and vacuum testing are not possible.

- Equipment for spark testing shall be comprised of but not limited to a handheld holiday spark tester and conductive wand that generates a high voltage.
- The testing activities shall be performed by the Geomembrane Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non-welded segment shall be subject to a calibration test to ensure that such a defect (nonwelded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester.and hold approximately 25mm (1 in) above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If there is no spark the weld is leak free.
- A spark indicates a hole in the seam. The faulty area shall be located, repaired, and retested by the Geomembrane Installer.
- Care should be taken if flammable gases are present in the area to be tested.

Field Quality Control

The Owner's Representative shall be notified prior to all pre-qualification and production welding and testing, or as agreed upon in the pre-construction meeting.

Prequalification Test Seams

Test seams shall prepare and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.

Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 meters (10 feet) long for fusion welding and

1 meter (3 feet) long for extrusion welding with the seam centered lengthwise. At a minimum, tests seams should be made by each technician 1 time every 4–6 hours; additional tests may be required with changes in environmental conditions.

Two 25 mm (1 in) wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen should fail in the parent material and not in the weld, "Film Tear Bond"(F.T.B. failure). Seam separation equal to or greater than 25% of the track width shall be considered a failing test.

The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Subsection 3.05.C.4 of this Section. Four specimens shall pass and the fifth specimen must meet or exceed 80% of the required seam strength for the test seam to be a passing seam.

If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.

A sample from each test seam shall be labeled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

Field Seam Non-destructive Testing

All field seams shall be non-destructively tested by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all non-destructive testing shall be recorded and submitted to the Owner's Representative.

Testing should be done as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found during testing shall be numbered and marked immediately after detection. All defects found should be repaired, retested and remarked to indicate acceptable completion of the repair.

Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.

Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify the test procedures are valid.

Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 and ASTM D 5641 with the following equipment and procedures:

- Equipment for testing extrusion seams shall be comprised of but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, port hole or valve assembly and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connections; a plastic bucket; wide paint brush or mop; and a soapy solution.

- The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa (5 psig).
- The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3m (12 in) by 1.2m (48 in) (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa (5 psig) for approximately five (5) seconds. The geomembrane should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five (5) seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.
- All areas where soap bubbles appear shall be marked, repaired and then retested.
- At locations where seams cannot be nondestructively tested, such as pipe penetrations, alternate nondestructive spark testing (as outlined in section 3.04.B) or equivalent should be substituted.
- All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment and procedures:

- Equipment for testing double fusion seams shall be comprised of but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa (30 psig), mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.
- The testing activities shall be performed by the Geomembrane Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa (30 psig), and the valve closed. Allow two (2) minutes for the injected air to come to equilibrium in the channel, and sustain pressure for five (5) minutes. If pressure loss does not exceed 28 kPa (4 psig) after this five minute period the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.

If loss of pressure exceeds 28 kPa (4 psig) during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested by the Geomembrane Installer.

Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

Destructive Field Seam Testing

One destructive test sample per 150 linear m (500 linear ft) seam length or another predetermined length in accordance with GRI GM14 or GRI GM20 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses.

All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.

The destructive sample size shall be 300 mm (12 in) wide by 1 m (36 in) long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in paragraph 4 below.

For field testing, the Geomembrane Installer shall cut 10 identical 25 mm (1 in) wide replicate specimens from the sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, 4 of 5 test specimens must pass the stated criteria in section 2.02 with less than 25% separation. The fifth specimen must meet or exceed 80% of the required seam strength.

If independent seam testing is required by the specifications, it shall be conducted in accordance with ASTM 5820 or ASTM D4437.

Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.

For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Engineer; typically 3 m (10 ft.) on either side of the failed sample and laboratory seam tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 M in length (150 FT) shall be destructively tested.

Identification of Defects

Panels and seams shall be inspected by the Installer and Owner's Representative during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials and signs of contamination by foreign matter.

Evaluation of Defects: Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described in Section 3.05.B. Each location which fails nondestructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

1. If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.
2. Defective seams, tears or holes shall be repaired by re-seaming or applying an extrusion welded cap strip.
3. Reseaming may consist of either:
   a. Removing the defective weld area and rewelding the parent material using the original welding equipment; or
   b. Reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.
4. Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm (6 in) beyond all edges of the defects.
5. All repairs shall be measured, located and recorded.

Verification of Repairs on Seams

Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be reseamed and retested until a passing test results. The number, date, location, technician and test outcome of each patch shall be recorded.

Daily Field Installation Reports

At the beginning of each day's work, the Installer shall provide the Engineer with daily reports for all work accomplished on the previous work day. Reports shall include the following:

1. Total amount and location of geomembrane placed;
2. Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;
3. Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing;
4. Results of pre-qualification test seams;
5. Results of non-destructive testing; and
6. Results of vacuum testing of repairs.

Destructive test results shall be reported prior to covering of liner or within 48 hours.

Liner Acceptance

Geomembrane liner will be accepted by the Owner's Representative when:

1. The entire installation is finished or an agreed upon subsection of the installation is finished;
2. All Installer's QC documentation is completed and submitted to the owner;
3. Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

Anchor Trench

Construct as specified on the project drawings.

Disposal of Scrap Materials

On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner. No scrap material shall be allowed to remain on the geomembrane surface.

GSI GM13 SPECIFICATION

This section shall include the current GSI GM13 manufacturer's specification or a revision of GSI GM13 specific to the unique project requirements and/or standards, as determined by the owner or owners' agent.

Geomembrane Nominal Thickness	**60 Mils**
Hot Wedge Seams	
Shear Strength, lb/in.	120
Shear Elongation at break, %	50
Peel Strength, lb/in.	91
Peel Separation, %	25
Extrusion Fillet Seams	
Shear Strength, lb/in.	120
Shear Elongation at break, %	50
Peel Strength, lb/in.	78
Peel Separation, %	25