CLACKAMAS

WATER ENVIRONMENT SERVICES

Biosolids Management Plan

September 2022

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List of Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ADWF	average dry weather flow
BMP	Best Management Practice
BSMP	Biosolids Management Plan
CAS	Conventional Activated Sludge
CFR	Code of Federal Regulations
CFU	Colony Forming Units
DAFT	Diffused Air Flotation Thickener
DEQ	Oregon Department of Environmental Quality
EPA	United States Environmental Protection Agency
ft	feet
GIS	Geographic Information System
gpm	gallons per minute
GPS	Global Positioning System
IMD	Internal Management Directive
kW	kilowatts
MBR	membrane bioreactor
MGD	million gallons per day
mm	millimeter
MPN	Most Probable Number
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
OERS	Oregon Emergency Response System
OSU	Oregon State University
PAN	Plant available nitrogen
Plants	WES wastewater treatment Plants
RAS	return activated sludge
RBC	rotating biological contactor
RM	river mile
RST	Rotating Screen Thickener
scfm	standard cubic feet per minute
STP	Sewage Treatment Plant
TS	total solids
UV	ultraviolet
WAS	waste activated sludge
WES	Water Environment Services
Plant	Water Pollution Control Plant
WRRF	Water Resource Recovery Facility

Section 1: Introduction

Biosolids Management Plans are required by the Plants National Pollutant Discharge Elimination System (NPDES) permit. This Plan addresses the requirements set forth in Oregon's OAR Chapter 340 Division 50 and EPA's Title 40 CFR Part 503 and includes the following: Liquids, solids and septage processes at each Plant; how biosolids are produced to meet federal and state requirements; how biosolids are managed at the facility and after they leave the facility.

Clackamas County Water Environment Services (WES) owns and operates four municipal wastewater treatment Plants (Table 1.1). A summary of select biosolids related capabilities of each Plant are presented in Table 1.2. While the Boring STP is not capable of producing biosolids, it is included in this plan as required by DEQ. Biosolids management is addressed in this Biosolids Management Plan (Plan) for all four Plants.

Table 1.1: Wastewater treatment plants operated by WES and covered in this Plan

Tri-City Water Pollution Control Plant NPDES[1] Permit Number: 101168 File Number: 89700 Contact Title: Wastewater Operations Supervisor Contact Phone: (503) 557-2804 Plant Telephone Number: (503) 557-2801	***Kellogg Creek Water Resource Recovery Facility*** NPDES[1] Permit Number: 100983 File Number: 16590 Contact Title: Wastewater Operations Supervisor Contact Phone: (503) 794-8046 Plant Telephone Number: (503) 794-8050
Hoodland Sewage Treatment Plant NPDES[1] Permit Number: 100962 File Number: 39750 Contact Title: Wastewater Operations Supervisor Contact Phone: (503) 794-8046 Plant Telephone Number: (503) 742-4547	***Boring Sewage Treatment Plant*** NPDES[1] Permit Number: 100968 File Number: 16592 Contact Title: Wastewater Operations Supervisor Contact Phone: (503) 794-8046 Plant Telephone Number: (503) 742-4547

[1]National Pollutant Discharge Elimination System

Table 1.2: Summary of select biosolids production capabilities for WES Plants

	Wastewater Treatment Plant			
Select Biosolids- related Capabilities	**Tri-City**	**Kellogg Creek**	**Hoodland**	**Boring**
Can produce Class B biosolids	YES	YES	YES	NO
Land applies biosolids	YES	YES	NO	NO
Industrial pretreatment program required	YES	YES	NO	NO
Accepts septage	YES	NO	NO	NO

Note: Wastewater received by all Plants is primarily of domestic origin.

This Biosolids Management Plan (Plan) was last approved on May 26, 2016 and is being updated to address changes to Plant operations and the land application program. The contents of this plan closely follow all requirements for biosolids management planning listed in OAR 340-050-0031.

Section 2: Wastewater Treatment Facilities

The following subsections describe the standard operating processes at the four WES operated wastewater treatment Plants (Plants).

2.1 Tri-City Plant

2.1.1 Liquids Processing

WES operates an activated sludge and Membrane Bioreactor (MBR) facility at the Tri-City Plant located at 15941 S. Agnes Avenue, Oregon City, OR 97045 in Clackamas County. The Tri-City Plant became operational in 1983. The MBR portion of the Plant became operational in 2011. Treated effluent is discharged year round to the Willamette River at river mile (RM) 25.5. The designed average dry weather flow (ADWF) for the Plant is 11.9 million gallons per day (MGD). Actual flows during the 2021 dry season averaged 7.01 MGD and during the wet season averaged 14.41 MGD. The peak design flow capacity is 68.6 MGD, although at that flow, approximately 35.2 MGD would receive secondary treatment and the remainder would receive primary treatment and disinfection. The ADWF for the MBR is 4.0 MGD with a peak hour of 10.0 MGD. The origin of the wastewater processed is 96.1 percent domestic and commercial sources, and 3.9 percent industrial sources.

The unit processes of the Plant consist of an influent pump station, course screening, aerated grit removal, primary treatment, conventional activated sludge treatment (aeration, secondary clarification, and chemical disinfection), membrane bioreactor treatment (intermediate pumping, fine screening, hollow fiber membrane trains, ultraviolet (UV) disinfection). An overview of the treatment process is illustrated in Figure 1.

2.1.1.1 Influent Pump Station

The wastewater enters the Tri-City Plant through the influent pump station, where two 5,000 gallon per minute (gpm) (7.2 MGD) variable speed pumps and three 12,500 gpm (18 MGD) variable speed pumps are operated.

2.1.1.2 Pretreatment and Primary Treatment

Pretreatment is accomplished by the headworks and primary clarifiers. The headworks provide screening and grit removal. The influent is screened with four bar screens to remove materials such as rags, plastic and large debris:

- one 4 feet wide (10.4 MGD) mechanically cleaned bar screen with 5/8 inch spacing
- one 7 feet wide (25 MGD) mechanically cleaned bar screens with 3/8 inch spacing
- one 7 feet wide (25 MGD) mechanically cleaned bar screen with 3/8 inch spacing
- one 7 feet wide (25 MGD) manually cleaned bar screen with 5/8 inch spacing

The screened material is conveyed to a hopper, where the material is transferred to trucks and transported to a solid waste landfill approved to receive this material.

Parshall flumes measure the volume of influent flow that passes from the screens to the aerated grit basins. Two 55,023 gallon aerated grit basins operate with three minute detention times up to 50 MGD.

Settled grit is pumped as slurry to hydrocyclone classifiers for dewatering. The grit is washed in grit washers and removed for disposal to an approved solid waste landfill.

After grit removal, the influent flows to six 125 feet by 20 feet primary clarifiers with average side water depth of 11 feet. Flow to the clarifiers is controlled by sluice gates. Primary solids are pumped to anaerobic digesters and scum is skimmed from the clarifier surface, dewatered then pumped to the anaerobic digesters.

2.1.1.3 Conventional Activated Sludge Secondary Treatment

The conventional activated sludge (CAS) secondary treatment system consists of four aeration basins and two secondary clarifiers. The four aeration basins are 639,000 gallons each and the two secondary clarifiers are 1,938,000 gallons per unit. Air is supplied to the basins through both coarse bubblers and fine diffusers. In addition to plug flow, the basins may be operated in step feed mode.

Flows then proceed to two 120-foot diameter secondary clarifiers with side water depths of 18 feet. Secondary solids are thickened by gravity belt thickeners and sent to anaerobic digestion. Secondary scum is pumped to the headworks, just before the bar screens.

The secondary effluent is disinfected using sodium hypochlorite prior to discharge. Contact time is provided by two 274,500 gallon contact basins. Sodium bisulfite is used for dechlorination.

2.1.1.4 MBR Secondary Treatment

Primary effluent is pumped from the primary effluent channel to the MBR fine screens for additional pretreatment. Three pumps are available for operation. One pump is 3500 gpm (5.0 MGD) and two are 6950 gpm (9.9 MGD).

Two fine screens have 2 millimeter (mm) perforated screen panels which can process up to 15 MGD each. The fine screens are a self-contained screening system which effectively captures and transports undesirable materials to a sluice conveyor for compaction and disposal. The screened primary effluent flows by gravity to the MBR aeration basin.

The MBR secondary treatment system consists of one aeration basin and four membrane trains. The aeration basin has one anaerobic zone, three anoxic zones and four aerobic zones. The aerobic zones are equipped with dome diffusers. Mixed liquor flows by gravity to the MBR trains. Each MBR train has nine cassettes with space for one more cassette. The cassettes are submerged in the mixed liquor. Pumps create a slight vacuum on the hollow fibers of each cassette which allows clean water to pass through, but not particulate material including bacteria. The hollow fibers are kept clean by air scouring and periodic chemical cleans. The filtrate is then pumped through UV disinfection channels and combines with CAS effluent before being discharged to the Willamette River.

2.1.2 Solids Stabilization Process

Anaerobic digesters receive and digest the waste solids generated at the Tri-City Plant primary and secondary solids and primary scum are pumped directly to the digesters for stabilization. A more detailed description of the biosolids production process is described below.

Primary solids are pumped from the sludge hoppers at the primary clarifiers to the anaerobic digesters through a common sludge line by air-operated diaphragm pumps. This maximizes the primary sludge solids concentration to between three and five percent total solids. Waste activated sludge (WAS) is pumped from the secondary clarifier or MBR process to the gravity belt thickeners (GBTs). The GBTs thicken the WAS to between five and six percent total solids. The thickened primary and WAS are then pumped to one of three anaerobic digesters. The primary sludge and thickened waste activated sludge (TWAS) are automatically split by valves that alternate the sludge feed between the digesters on a predetermined time interval.

The two heated 65-foot diameter anaerobic digesters, digesters #1 and #2, each have a volume of about 1,017,000 gallons (136,000 cubic feet). Digester #3 has a 70-foot diameter and an active volume of approximately 1,300,000 gallons (173,800 cubic feet). The hydraulic detention time for each digester operating in parallel exceeds the regulatory guideline of 15 days. The solids loading on the parallel process will be less than 0.10 lbs. volatile solids per cubic foot (VS/ft^3). The digesters are completely mixed by a pump mix system and are maintained at a temperature of 98°F. The system is operated with a time and temperature that exceeds the minimum criteria to produce a Class B biosolids.

Following digestion the biosolids are dewatered in one of two centrifuges to 20-23 percent solids content. The biosolids are then loaded into haul trucks with approximately 32 wet ton capacity. Truck loading is accomplished via a load out bin that will hold approximately one day of production. The loaded trucks transport biosolids to DEQ authorized land application sites for beneficial use or are placed in temporary storage at the Tri-City Plant.

2.1.3 Septage Processing

A septage receiving station is located in the headworks screening building. Septage haulers discharge septage (from septic tanks and chemical toilets) into a receiving vault equipped with a bar rack. Septage is contained in a storage tank with a 10,000 gallon capacity. The septage storage tank is located by the screenings building complex. Septage enters the treatment stream after the influent pump station and prior to screening. In 2021, approximately 1,260,000 gallons were received with an average daily receiving volume of approximately 3400 gallons per operating day. All septage received has pH readings taken and must be between 6 and 9 standard units.

2.1.4 Pretreatment Program

The Tri-City Plant receives 3.9 percent of its flow from industrial dischargers. Tri-City has an industrial pretreatment program in place to address these flows. Federal and State industrial pretreatment requirements (e.g. industrial user permitting and pollutant monitoring) help to ensure the quality of biosolids that are land applied meet federal and state biosolids regulations.

2.1.5 Back-up Biosolids Dewatering and Biosolids Storage Building

In 2011, a 6,000-square feet covered biosolids storage facility was completed. A skid-mounted centrifuge dewatering system adjacent to the storage facility was completed in February 2012. This building provides contained storage and dewatering in the event of equipment breakdowns, operational constraints, treatment process upsets, or inclement weather conditions that arise at the facility or the authorized land application sites. The WES operated Kellogg Creek Water Resource Recovery Facility also utilizes this centrifuge and storage facility.

2.1.5.1 Biosolids Storage Building

Construction of the biosolids storage building was completed in 2011. The building is designed for storage of dewatered biosolids, as needed, to optimize biosolids management and ensure that Land Application Authorization requirements for land application are maintained.

The biosolids storage building is a fabricated metal building approximately 100 feet by 60 feet by 17 feet with a concrete floor, a roof, access doors for truck loading and floor drains that direct runoff and wash water back into the Plant. A front-end loader is used for moving biosolids within the building, moving separation barriers and loading trucks destined for land application sites. The building is not equipped with a mechanical odor control system but does have freezer slats installed on the west door to help mitigate odors.

Tri-City dewatered biosolids that are not transported directly to DEQ authorized land application sites can be placed in the storage building. Kellogg Creek biosolids are also stored in the facility as needed. Moveable barriers and signage are used as needed to ensure separation of Kellogg Creek and Tri-City biosolids kept in storage. The storage building design is intended to provide at least one week of storage capacity for Tri-City dewatered biosolids. When empty, the building is cleaned as needed to ensure good housekeeping.

2.1.5.2 Back-up Centrifuge and Day Tanks

The skid-mounted centrifuge system is designed to provide Tri-City with redundancy for their existing centrifuge dewatering facility. It also dewaters all biosolids produced at the Kellogg Creek Plant.

Two 35,000 gallon day tanks support the skid-mounted centrifuge system. Liquid biosolids are placed into these tanks and gradually fed into the skid-mounted centrifuge. Each day tank can receive biosolids from either the Tri-City Plant or the Kellogg Creek WRRF. Contents are identified by signage and other operational controls. Sources are processed and stored separately.

Figure 1: Tri-City Plant Solids Flow

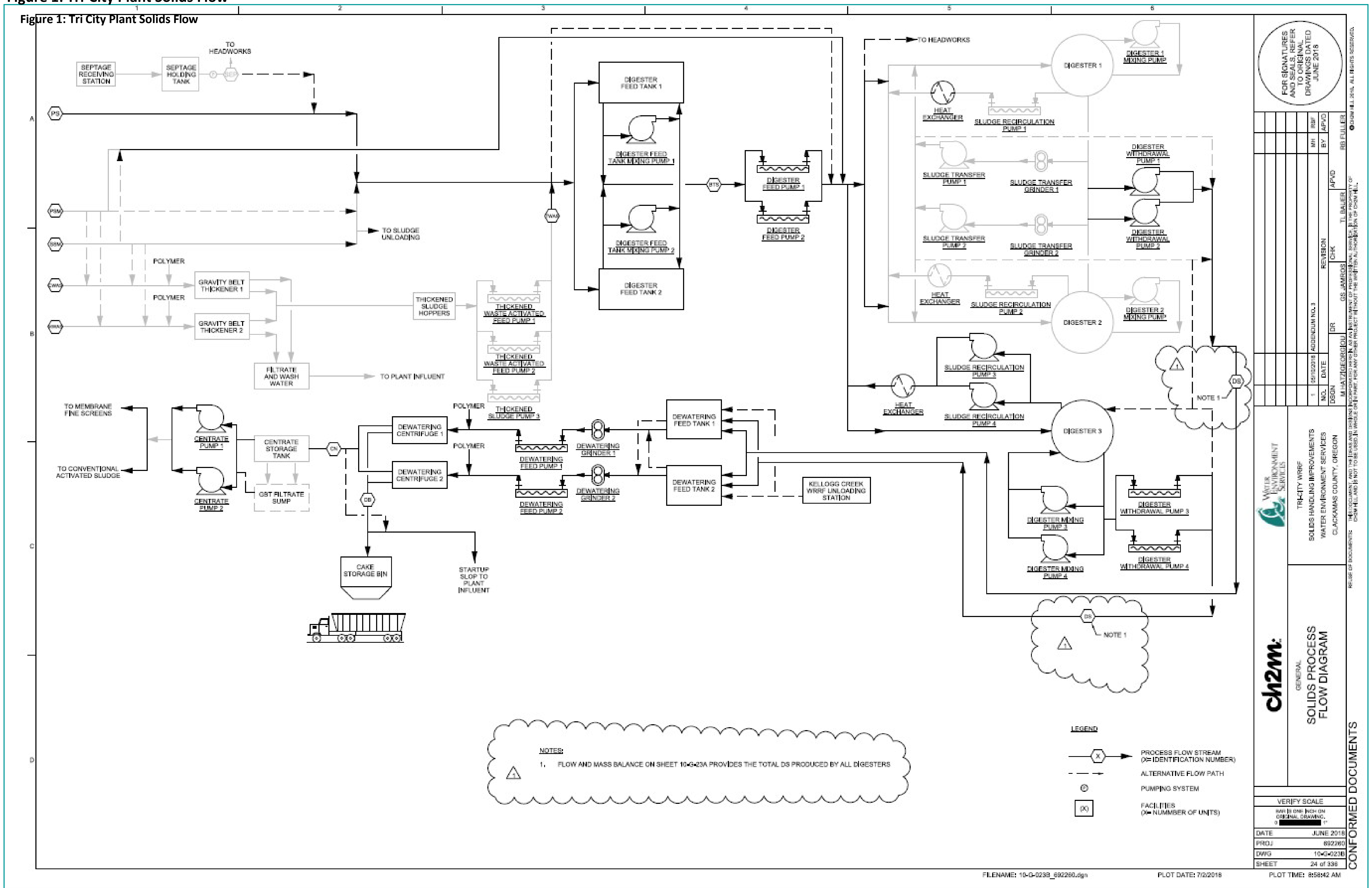
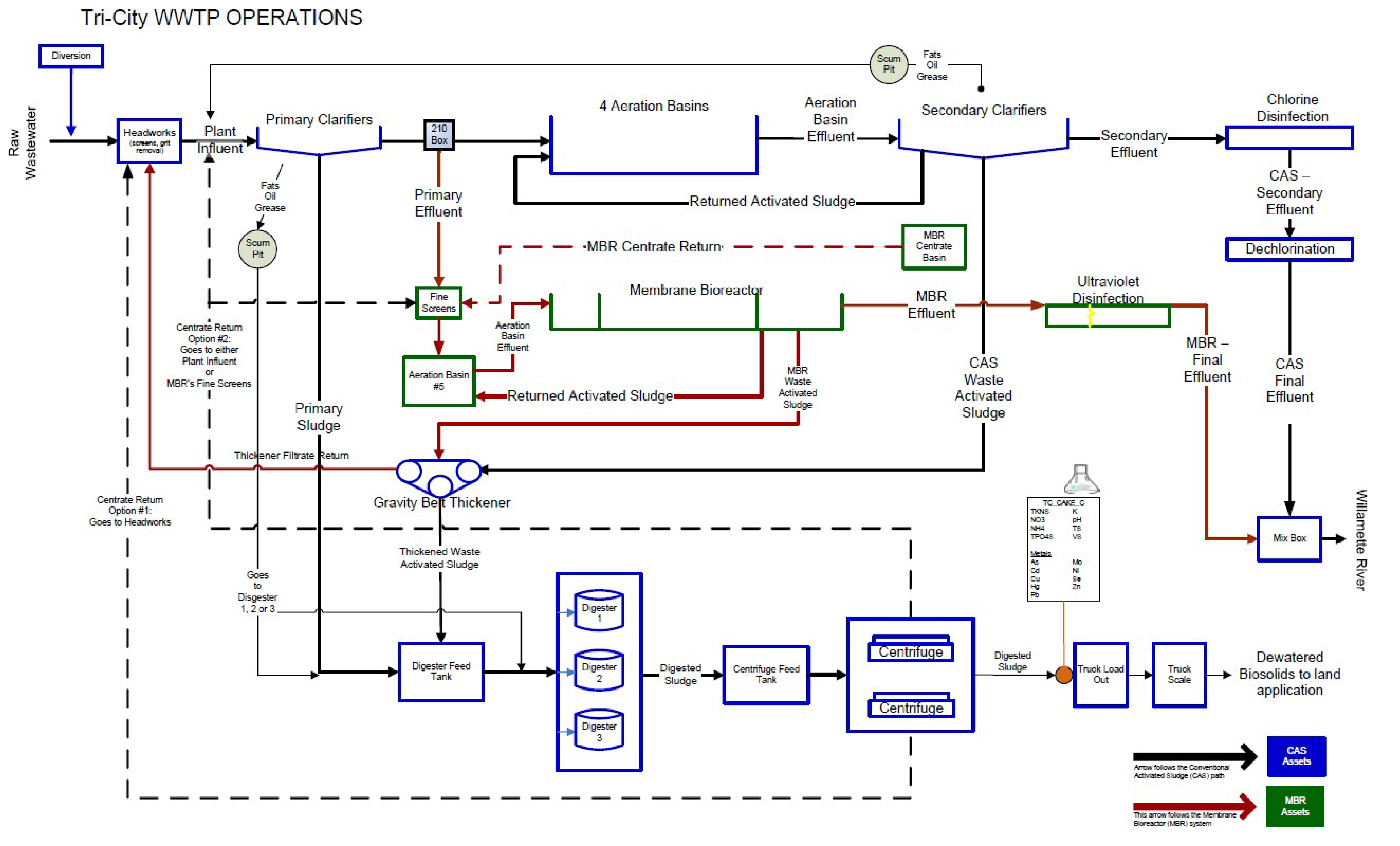


Figure 1A: Tri-City plant solids flow schematic



2.2 Kellogg Creek WRRF

2.2.1 Liquids Processing

The Kellogg Creek WRRF is a conventional activated sludge treatment facility located at 1152 SE McLoughlin Blvd. Milwaukie, OR 97222 in Clackamas County. Treated effluent is discharged year-round to the Willamette River at RM 18.5. The designed ADWF is 10.0 MGD. Actual flows during the year 2021 dry season averaged 5.25 MGD and the average wet season averaged 7.54 MGD. The origin of the wastewater processed is 95 percent domestic and commercial sources, and 5 percent industrial sources.

The Plant was constructed in 1973-1974 and became operational in August 1974. The Kellogg Creek WRRF site plan is shown in Figure 2. Incoming raw sewage is lifted 40 feet from the main interceptor in the influent pump station consisting of four pumps (two at 200 horsepower and two at 60 horsepower) to the headworks. From the headworks, the sewage flows through two 3/8 inch bar screens and a non-aerated grit chamber. The flow splits between two primary clarifiers and continues to four aeration basins. From there, the flow travels to two secondary clarifiers. Waste activated sludge is pumped from the secondary clarifiers to the Diffused Aeration Flotation Thickener (DAFT) in the solids building to thicken and remove the solids. The liquid from there is returned to the headworks. Return activated sludge (RAS) is also pumped (approximately 30 percent of flow) from the two secondary clarifiers back to the beginning of the aeration basins. The weir overflow from the secondary clarifiers then travels to the chlorine contact chamber and out through two UV disinfection channels. From there, it enters an outfall pipe that discharges to the Willamette River. The outfall near river mile 18.5 in the Willamette River extends 134 feet from the river bank reaching a depth of approximately 65 feet via a 108 foot long, multiport diffuser that consists of seven ports.

2.2.2 Solids Processing

The conventional anaerobic digestion facilities at the Kellogg Creek WRRF were constructed in 1986-1987 and became operational in March 1987.

Primary solids are pumped from the bottom of each primary clarifier to the anaerobic digesters. WAS is pumped from the secondary clarifier to the dissolved air flotation thickener (DAFT). This unit concentrates solids in the sludge and recycles the supernatant back to the Plant wastewater influent. The thickened WAS is pumped to the anaerobic digesters. Scum, from the primary clarifiers and secondary clarifiers, is pumped directly to the DAFT.

Two heated anaerobic digesters, each having an inside diameter of 65 feet and a maximum side water depth of 41 feet, are provided for digestion and storage. The volume of each digester is about 1,017,000 gallons. The active digestion volume is about 1,418,200 gallons with the other volume dedicated to liquid storage, grit and scum accumulation and gas storage. Hydraulic detention time exceeds the regulatory guideline of 15 days. Solids storage detention time at design conditions ranges from 5 -20 days depending on the extent that recuperative thickening is performed. Digestion occurs in series, with the majority of the digestion occurring in the primary digester. The secondary digester is typically used for storage. The primary digester is completely mixed by a pump mix system. Each digester is equipped with a sludge grinder which shreds material in re-circulated sludge. Primary clarifier sludge is ground before it enters the primary digester. Anaerobic digestion is done in the mesophilic treatment range, of approximately 96-101°F.

Anaerobically digested biosolids can be recuperatively thickened by the use of a Rotary Drum Thickener (RDT). The use of this thickening is dependent upon digester levels, solids concentration and ammonia concentration for the recycle stream. Biosolids are only thickened within the secondary digester. The RDT is located within the thickener building. The average feed rate is 30 gpm. The solids pumped to the RDT have an average concentration of approximately two percent solids dry weight. The thickened solids are approximately five to six percent dry weight. The filtrate solids have a concentration of approximately 0.05 percent and are returned to the DAFT.

The biosolids loading facility uses a counter balanced swing arm for top loading of the sludge tanks. The two sludge loading pumps each have a capacity of 600 gpm. Liquid Biosolids are hauled to the Tri-City Plant for dewatering using the back-up centrifuge. Dewatered solids are then hauled to Sherman County for application on agricultural fields. In the future a dewatering facility or other secondary processing of liquid biosolids may be considered. Once an option is selected, changes will be reflected in a revised BSMP that will be submitted to DEQ for approval and public comment before operations commence.

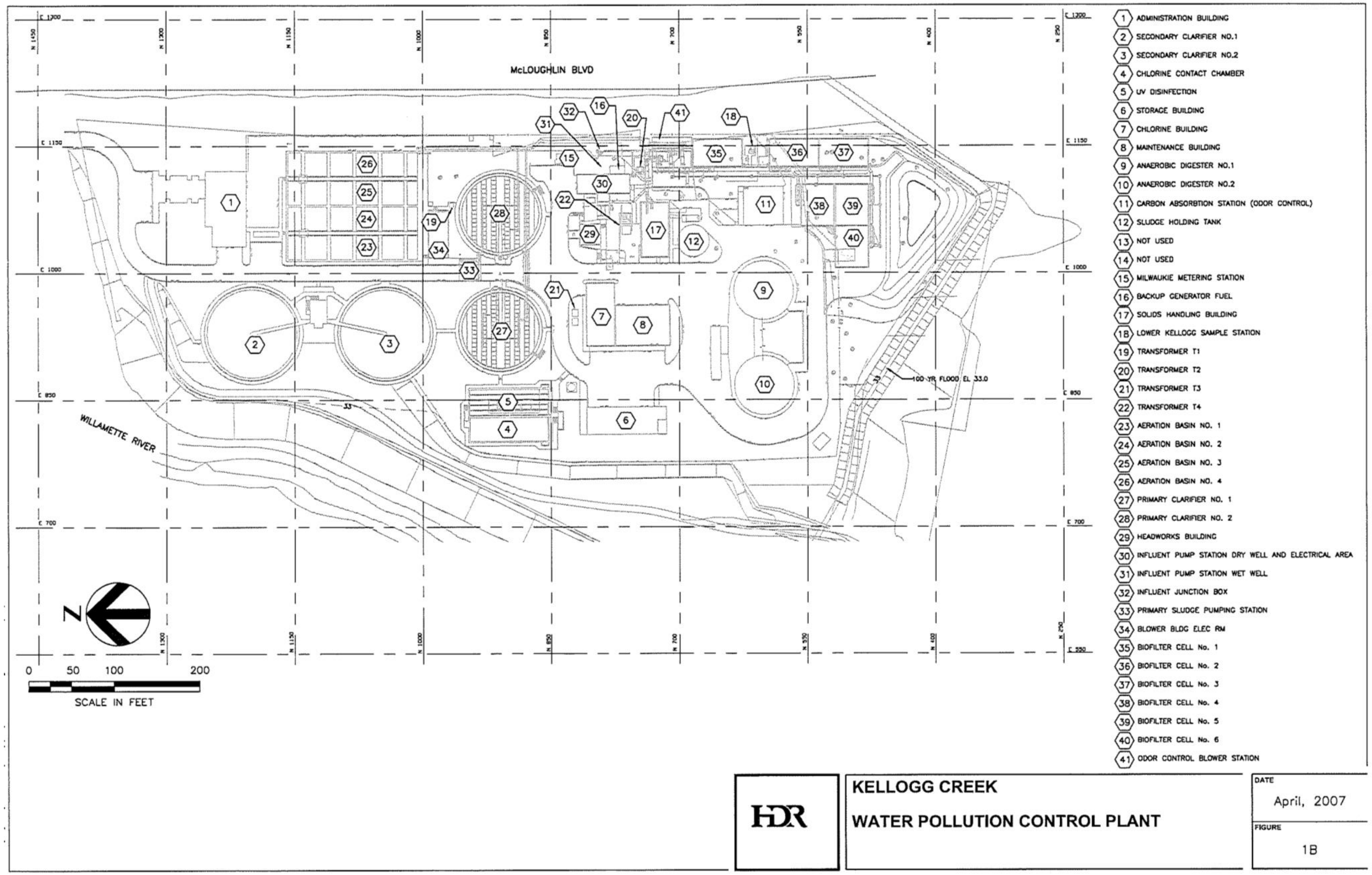
2.2.3 Septage Processing

The Kellogg Creek WRRF does not accept septage.

2.2.4 Pretreatment Program

In 2021, the Kellogg Creek Plant received 5.0 percent of its flow from industrial dischargers. WES has an industrial pretreatment program to address these flows. Federal and state industrial pretreatment requirements (e.g. industrial user permitting and pollutant monitoring) help to ensure that the quality of biosolids that are land applied meet federal and state biosolids regulations.

Figure 2: Kellogg Creek Plant Site Plan



2.3 Hoodland STP

2.3.1 Liquid Processing

The Hoodland STP is a rotating biological contactor (RBC) process treatment Plant located at 24596 E. Bright Avenue, Welches, OR in Clackamas County. Treated effluent is discharged year round to the Sandy River at RM 41. The designed peak flow capacity is 0.9 MGD. Actual flows during the 2021 dry season averaged 0.315 MGD and during the wet season averaged 0.588 MGD. The Plant only treats domestic wastewater with no industrial or septage added. The Plant was constructed in 1981-1982 and became fully operational in June 1982. A process flow diagram of the Hoodland STP is provided in Figure 3.

As flow enters the Plant, it is processed by a step screen system to remove rags and other debris. The grit settles out as the flow passes through the aerated grit chamber. It then leaves the headworks building and goes directly to the primary clarifiers where settleable solids and scum are removed. The primary effluent then typically flows by gravity into one of two RBC trains consisting of three rotating biological contactors apiece. The flow leaves the RBCs and enters the secondary clarifiers where solids settle out.

The secondary effluent is disinfected with a 12.5% sodium hypochlorite solution right before it travels through a Parshall flume and enters the chlorine contact chamber. From there, the effluent is de-chlorinated and flows by gravity to the outfall diffuser system embedded in the Sandy River.

2.3.2 Solids Processing

The method of sludge treatment utilized at the Hoodland STP is aerobic digestion. Settled solids from the secondary clarifiers are returned by the secondary sludge pumps to the primary inlet channel, from which they flow to the primary clarifiers with the incoming Plant flow. Secondary and primary solids are settled together in the primary clarifiers and then pumped to the aerobic digesters. Aerobic digestion is comprised of two stages and capable of either parallel or series operation. Total digester volume is about 130,000 gallons (17,343 cubic feet), with two adjoining rectangular concrete basins, each 17.6 feet wide by 43.5 feet long by 13 feet deep. Digester Number 1 has a volume of 68,816 gallons (9,200 cubic feet). Digester Number 2 has a smaller volume of 60,910 gallons (8,143 cubic feet), since a decant basin is built into the south end of the tank. Hydraulic detention time is 24 days at 0.90 MGD, which provides a solids loading rate of 0.07 pounds volatile solids per cubic foot of digester per day. Air is provided both for mixing at the maximum rate of 44 standard cubic feet per minute (scfm) per 1,000 cubic feet and to satisfy volatile solids demand (1 pound oxygen transferred per pound of volatile solids added). Digester supernatant is collected by floating draw off devices in each basin and returned to the headworks aerated grit chamber through a separate digester transfer pump. Digested biosolids are pumped to load tanker trucks and hauled to the Kellogg Creek WRRF and/or the Tri-City Plant for further processing. Typically 18,000 gallons are hauled from Hoodland weekly.

In the future, alternatives to the current solids processing may be considered to increase the efficiency of the program. Any changes made will be reflected in a revised BSMP.

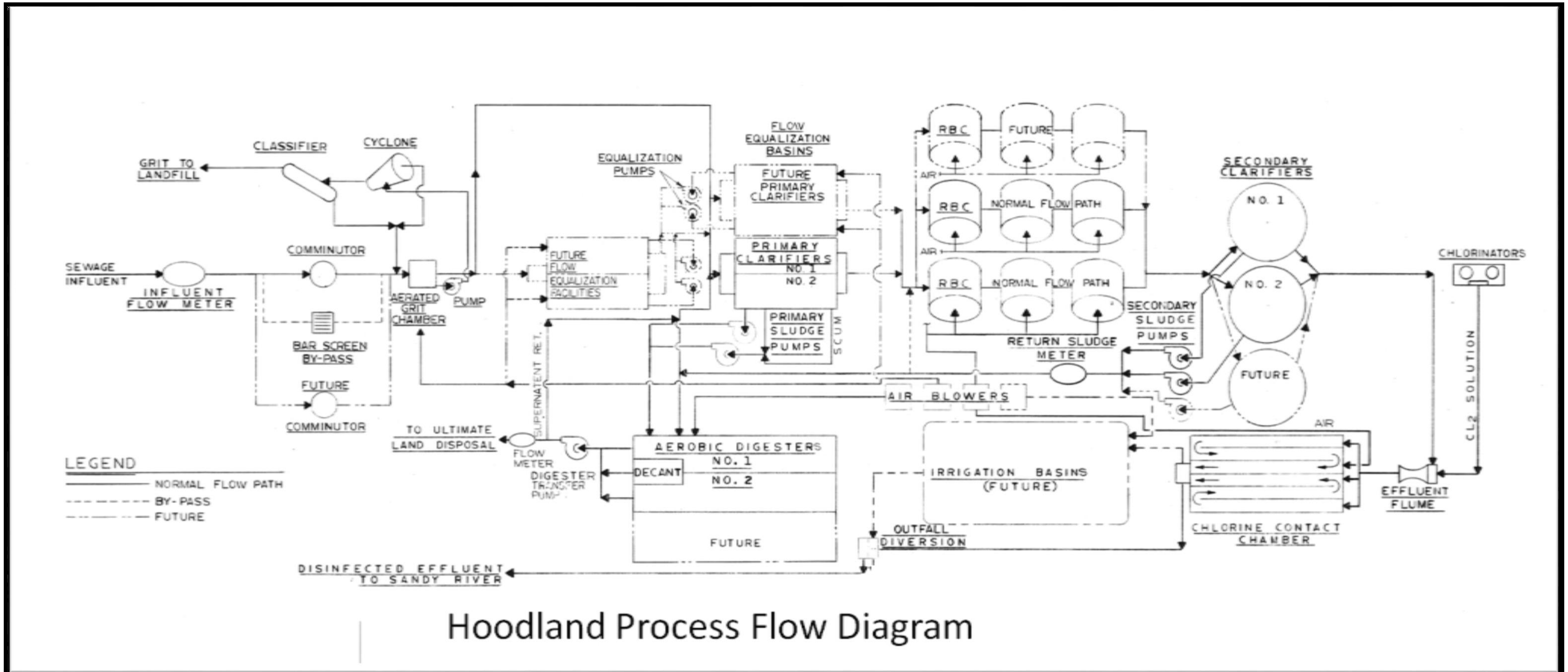
2.3.3 Septage Processing

The Hoodland STP is not equipped to handle septage.

2.3.4 Pretreatment Program

The Hoodland STP is not required to implement an industrial pretreatment program.

Figure 3: Hoodland STP Process Flow Diagram



2.4 Boring STP

2.4.1 Liquid Processing

WES operates the Boring STP, located at 13305 SE Richey Road, Boring, OR in Clackamas County, which consists of two aerated lagoons in series with approximately 160,800 gallons of capacity each, two slow-rate, 1,600 square-foot sand filters, a Trojan Ultra Violet disinfection system is used with retention of the previous chlorine disinfection system with a detention time of approximately 60 minutes, and a de-chlorination system, being retained as a backup to UV. A collection system of approximately 4,800 feet gravity feeds into the Plant. The Boring STP was built in the spring and summer months of 1984 to serve the local business and residents of small lots in the central Boring area. Treated effluent is discharged year round as needed (not continuously) into the North Fork Deep Creek at river mile 3.0. Under normal operations, discharge occurs between 3- 5 of 7 days. The design flow is 0.02 MGD (at the time of design, drawings did not make a distinction between dry weather and wet weather flows). The origin of wastewater processed is entirely domestic, and no septage or significant industrial flow is handled at the Boring Plant.

Flows during the year 2021 dry season averaged 0.009 MGD and the wet season averaged 0.012 MGD.

2.4.2 Solids Handling

Waste sludge has been pumped from the lagoons five times since the Plant first opened. Approximately 72,000 gallons of “settled” sludge, averaging one percent total solids is removed once every 5-6 years. This sludge is hauled to another facility for further processing. The sand from the sand filter is removed once every 4-5 years. It is analyzed and used as clean fill when analysis supports that use otherwise it is landfilled.

2.4.3 Septage Processing

The Boring STP is not equipped to handle septage.

2.4.4 Pretreatment Program

The Boring STP is not required to implement an industrial pretreatment program.

Section 3: Biosolids Treatment Processes to Achieve Class B

3.1 Pathogen Reduction and Vector Attraction Reduction

In accordance with 40 CFR Part 503 and OAR 340-050, pathogen reduction and vector attraction reduction for biosolids must be met prior to land application. Vector attraction reduction requirements can also be met at the time of land application if biosolids are injected below the surface of the land or incorporated into the soil within six hours after application to the land. Pathogen reduction must be met before or at the same time that vector attraction reduction is achieved.

WES uses the reduction strategies outlined in Table 3.1. Reference Appendices A and B for supporting data.

Table 3.1: Pathogen reduction and vector attraction reduction strategies

Plant	Treatment Method	Pathogen Reduction	Vector Attraction Reduction
		Alternative:	Alternative:
Tri-City	Anaerobic digestion	40 CFR §503.32(b)(3)[a]	40 CFR §503.33(b)(1)[c]
Kellogg Creek	Anaerobic digestion	40 CFR §503.32(b)(2)[b]	40 CFR §503.33(b)(1)[c]
Hoodland	Aerobic digestion	NA - No biosolids land applied	NA - No biosolids land applied
Boring	Lagoon	NA – No biosolids produced	NA – No biosolids produced

[a] Anaerobic Digestion. Class B Alternative 2, Appendix B to Part 503, Processes to Significantly Reduce Pathogens. During digestion, the biosolids will be treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for mean cell residence time and temperature will be between 15 days at 35 to 55 degrees Celsius (95 to 131 degrees Fahrenheit) and 60 days at 20 degrees Celsius (60 degrees Fahrenheit).

[b] Fecal Coliform Limit. Class B Alternative 1. The geometric mean of the density of fecal coliform of seven representative samples will be less than either 2 million Most Probable Number (MPN) or 2 million Colony Forming Units (CFU) per gram of total solids (dry weight basis) at the time of land application.

[c] Vector Attraction Reduction Option 1. The mass of volatile solids during sewage sludge treatment will be reduced by a minimum of 38 percent. WES uses the Van Kleeck method to calculate the percent reduction in volatile solids as outlined in EPA's Manual "Control of Pathogens and Vector Attraction in Sewage Sludge," 2003 (EPA-625/R-92/013), Appendix C, Pages 120-126.

At the Kellogg Creek Plant, sampling for fecal coliform occurs as the dewatered biosolids fall off the conveyer belt. All samples are stored and transported in a cooler with ice packs to maintain temperature and are delivered to the lab within six hours of sample collection to commence volatile solids and total solids testing.

In the future, WES intends to meet pathogen reduction requirements at the Kellogg Creek Plant for Class B biosolids using anaerobic digestion conditions of 35°C (95°F) with a 15-day residence-time.

Section 4: Biosolids Monitoring and Characteristics

4.0 Biosolids Monitoring and Characteristics

Biosolids produced at the Tri-City and Kellogg Plants have historically met the following requirements for classification as Class B biosolids for land application (Appendix A and B). All monitoring and reporting will be conducted in accordance with plant NPDES permits.

Samples collected and analyzed will be representative of the biosolids to be land applied. Sampling and monitoring will include the following major elements: Pollutant levels, pathogen reduction and vector attraction reduction.

4.1 Pollutant Levels

Biosolids produced at the Tri-City and Kellogg Creek Plants will be sampled a minimum of once per 60 days and analyzed for the characteristics shown in Table 1 of 40 CFR §503.13 and OAR 340-050-0035(2)(a). Biosolids from both facilities have historically met the ceiling concentrations in Table 1 of 40 CFR §503.13 and the pollutant concentrations shown in Table 3 of 40 CFR §503.13 (Appendix A and B). The monitoring parameters, sampling frequency and sample type for routine biosolids pollutant monitoring are shown in Table 4.1 below.

Table 4.1: Monitoring for Pollutants, Nutrients and Physical Properties

Parameter	Reporting Units	Sampling Frequency	Sample Type[1,2]
Total Kjeldahl Nitrogen (TKN), Nitrate-Nitrogen (NO_3-N), Ammonium-Nitrogen (NH_4-N), Total Phosphorus (Total-P), Potassium (K), pH, Total Solids (TS), and Volatile Solids (VS)	Report pH in Standard Units and all other parameters %, dry weight	Once per 60 days	Composite
Arsenic (As), Cadmium (Cd), Copper (Cu), Mercury (Hg), Lead (Pb), Molybdenum (Mo), Nickel (Ni), Selenium (Se), and Zinc (Zn)	All in mg/kg, dry weight	Once per 60 days	Composite

% = percent, dry weight

mg/kg = parts per million (ppm), dry weight

1%, dry weight equals 10,000 mg/kg, dry weight

[1] Samples must be representative of the anaerobically digested dewatered biosolids being hauled from the treatment plants for land application.

[2] Collect at least seven individual grab samples of equal volume spread over a typical biosolids production day, mix well, and composite for testing by qualified laboratory.

4.2 Pathogen Reduction

Biosolids at the Tri-City and Kellogg Creek Plants will be processed to comply with 40 CFR §503.32 (Appendix A and B). At the Tri-City Plant, Class B pathogen reduction requirements for land application will be met by anaerobic digestion. At the Kellogg Creek Plant, anaerobic digesters will be operated to lower fecal coliform pathogen indicators in the solids to the extent they meet Class B levels required for land application.

Table 4.2: Monitoring for Pathogen Reduction

Plant	Parameter	Reporting Unit	Sampling Location	Type of Samples
Tri-City	Operating Temperatures	Degree Fahrenheit (°F)	Anaerobic Digester(s)	Daily, Record
	Solids Residence Times	Mean Detention Time, Days		Calculate, Record[1]
Kellogg Creek	Fecal Coliform	Dry Weight, MPN/gram, or CFU/gram	Digested Dewatered Biosolids	Collect at least 7 individual grab samples for pathogen and total solids testing.[2,3]

MPN/gram = Most Probable Number per gram of total solids (dry weight)

CFU/gram = Colony Forming Units (CFU) per gram of total solids (dry weight)

[1] Solids residence times to be factored as outlined in EPA's Manual "Control of Pathogens and Vector Attraction in Sewage Sludge," 2003 (EPA-625/R-92/013), Appendix E, Pages 133-136.

[2] 40 CFR §503.32(b)2(ii) requires that for Class B biosolids at least seven grab samples must be individually analyzed for pathogens, and these results must be averaged using geometric mean to determine pathogen concentrations.

[3] The geometric mean of the density of fecal coliform of seven representative samples must be less than either 2 million MPN or 2 million CFU/gram of total solids (dry weight) at the time of land application.

4.3 Vector Attraction Reduction

The purpose of vector attraction reduction is to reduce biosolids odors and attractiveness of the biosolids to rodents, flies, mosquitos, or other organisms capable of transporting infectious agents.

At the Tri-City and Kellogg Creek Plants, the plants will meet vector attraction reduction requirements of 40 CFR §503.33 through Option 1: 40 CFR §503.33(b)(1): The mass of volatile solids during sewage sludge treatment will be reduced by a minimum of 38 percent (%). To verify volatile solids reduction, the plants will, at a minimum, monitor for the following at its anaerobic digesters at least once per 60 days:

1. Volatile solids concentrations of raw and final sludge streams (VS_{in}, VS_{out}).
2. Calculations showing 38% reduction in volatile solids.

The plants will use the Van Kleeck Method to calculate the percent reduction in volatile solids in biosolids as outlined in EPA's Manual "Control of Pathogens and Vector Attraction in Sewage Sludge," July 2003 (EPA-625/R-92/013), Appendix C, Pages 120-126.

4.4 Sampling Techniques and Equipment

WES biosolids will be routinely sampled at the Tri-City and Kellogg Creek Plants in accordance with the following good sampling techniques to ensure that representative biosolids samples are collected as required by plant NPDES permits.

1. All sampling equipment will be properly cleaned and decontaminated prior to use as summarized in Table 4.3.
2. No galvanized or zinc coated sampling equipment will be used in sampling. This includes any buckets, hand shovels, scoops, etc., used to mix the samples.
3. All sampling equipment used for fecal coliform sampling will be sterilized prior to use.
4. The samples will only be placed in polyethylene, polypropylene, or glass sample containers, preferably laboratory cleaned and supplied.
5. The sample containers used for fecal coliform testing will be lab sterilized prior to sampling/use.
6. All samples will be immediately preserved before testing by refrigeration or placement on ice (cool promptly to 4 degrees Celsius).
7. All samples collected at the site will be labeled with date, time, location, and sampler's initials and shipped to a qualified laboratory for testing on the day of sample collection if possible.

Table 4.3. Standard Sampling Equipment Preparation and Decontamination

1. Use stiff brush to remove all visible particles. 2. Rinse with tap water. 3. Wash with good quality laboratory detergent (phosphate free detergent), scrub equipment to remove all visible residues. 4. After scrubbing, triple rinse the equipment with tap water. 5. For the final rinse, rinse at least three times with deionized/distilled water. 6. Air dry. 7. When sampling for fecal coliform, sterilize sampling equipment by steam cleaning, autoclave, or sterilizing solution (10% bleach solution) prior to use.

SPECIAL NOTE: The fecal coliform samples must be delivered to the testing laboratory shortly after collection because sample incubation at the laboratory must be started no later than 8 hours from the time of collection for the data results to be valid by Standard Methods 9221 C E and 9222 D. For aerobically or anaerobically digested biosolids, the holding time may be extended to 24 hours by using either EPA Method 1680 (LTB-EC) or 1681 (A-1) or by keeping the biosolids samples cool at 4°C prior to testing.

4.5 Sample Analysis and Data Reduction

WES biosolids samples will be routinely analyzed by WES's NELAP accredited laboratory or other qualified laboratories using methods listed in 40 CFR §503.8(b), OAR 340-050-0035(2)(b) and 40 CFR §136.3. Published methods for completing proper analyses may be found in the following documents:

- Environmental Regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge (Including Domestic Septage Septage Under 40 CFR Part 503), July 2003. EPA/625/R-92/013. https://www.epa.gov/biosolids/control-pathogens-and-vector-attraction-sewage-sludge

- Guidelines Establishing Test Procedures for the Analysis of Pollutants. 40 CFR, Part 136. https://www.epa.gov/cwa-methods.
- Standard Methods for the Examination of Water and Wastewater (Standard Methods), American Public Health Association, 1015 15th Street, NW., Washington, DC 20005

  https:/www.standardmethods.org/
- Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (EPA Publication SW-846). EPA Publication SW-846 (https://www.epa.gov/hw-sw846).

WES's biosolids sampling data will be compared to the biosolids quality standards listed in OAR 340-050-0026. For land application or reuse, the biosolids will at a minimum need to be treated to reduce pathogens and vector attraction per 40 CFR §503.32 and §503.33 and the quality must meet pollutant concentration limits per 40 CFR §503.13. All biosolids quality data collected under this plan will be used to define the nature of the biosolids for reuse/recycling on land.

Section 5: Biosolids Storage

Biosolids storage is necessary to accommodate fluctuations in biosolids production rates, equipment maintenance, agricultural cropping changes and adverse weather conditions which can prevent immediate biosolids application.

5.1 Biosolids Storage Building

The biosolids storage building at the TC Plant is designed for storage of dewatered biosolids, as needed, to optimize biosolids management and ensure that Land Application Authorization requirements for land application are maintained. Details of the building are provided in section 2.1.5.

5.2 Treatment Facility

With the use of existing digester capacity, the Kellogg Creek Plant and the Tri-City Plant have the potential to store sludge during periods of wet weather in their digesters. The biosolids storage volume at TC is three to four days. KC has 10 days of storage capacity if the level is kept under 30 feet.

5.3 Field Staging

The unloading and placement of dewatered biosolids in designated areas at DEQ authorized land application sites may occur on a limited time basis, typically 14 to 21 days. When field staging of biosolids occurs, the requirements outlined in the DEQ Land Application Authorization letters for each site are followed. If staged biosolids can't be land applied within the time period designated in the Land Application Authorization, WES requests an extension from DEQ. Piles are managed to ensure that biosolids are contained well within the designated storage areas. Typically unloaded biosolids do not exceed four feet in height.

Biosolids are loaded from the piles into a manure spreader using a front-end loader. The loader is also used to manage the site and maintain tidy storage areas.

5.4 Short-Term Field Storage

The short-term storage of dewatered biosolids may occur in designated staging areas at certain DEQ-approved land application sites for up to six months when weather conditions do not allow biosolids to be properly spread due to wet or frozen soil conditions. Areas selected for the short-term field storage of biosolids will meet the selection criteria provided in Table 5.1 below.

Table 5.1: Criteria for Selecting Short-Term Storage Sites

Criteria	Details
Climate	Areas with low rainfall potential will be selected for short-term field storage of biosolids.
Topography	Field stockpiles will not be in areas that are regularly inundated, in drainage ways or in wetlands. The stockpiles will be placed on nearly level ground. Stockpiles will be situated near the top of slopes to minimize exposure to up-slope runoff.
Soils and Geology	Field stockpiles will not be situated on excessively moist or wetland soils where very low infiltration rates regularly lead to standing water or excessive runoff after storm events. Stockpiles will also not be located on soils with extremely high conductivities (such as gravels) that have excessive infiltration rates.
Buffer Zones	Field stockpiles will not be located within 50-feet of any ditch, channel, pond, or waterway or within 200-feet of a domestic water source well.
Odor Minimization and Aesthetic	Field stockpiles will not be located adjacent to residential areas and the visibility of the storage site will be reduced when possible. Stockpiles will be in areas that limit the tracking of mud/biosolids onto roadways.

Field-stored biosolids will be spread or removed from the fields as soon as field conditions become favorable.

Field-stored biosolids will be regularly inspected (e.g., every two weeks) until all the material is land applied. The inspections will ensure that the stored biosolids are not running off the site and that there is no excessive odor at the site. Problems identified will be corrected as soon as practical, typically within 24-hours of discovery. All inspections will be documented and logged on the Biosolids Stockpile Inspection Form provided in Appendix D.

Field storage areas will be restored shortly after all the stored biosolids have been spread by:

1. Removing and spreading the residual biosolids in the storage areas by using a bucket loader and/or other methods to closely skim or scape biosolids from the ground.

2. Tilling, plowing, chain-dragging or other methods to address area soil compaction.
3. Seeding or cropping the area to take up any residual nutrients.

Section 6: Transportation

WES contracts with haulers to transport Class B biosolids to authorized land application sites. WES will maintain one truck for emergency backup hauling should the primary hauler be unable to meet hauling needs or schedules. WES requires each hauler to have a written Spill Response Plan describing haul routes, safety and spill response that becomes part of the contract between WES and the hauler.

Hauling equipment consists of dump trucks and dump pup trailers with a combined payload of approximately 30 wet tons per load. All dump boxes in the trucks are required to be watertight and covered with a tarp when hauling biosolids.

Kellogg liquid biosolids are transported daily to Tri-City for dewatering; Hoodland solids are transported about every two weeks to Kellogg or Tri -City for further treatment by incorporation into the KC or TC process. WES owned and operated liquid tankers and pups are used to transport liquid biosolids between facilities. This combination can haul about 5,600 gallons per load. In the future, WES may install dewatering technology at the Kellogg Creek Plant to eliminate the need for daily hauling from KC to TC.

Section 7: Remedial Procedures

7.1 Spill Reporting

WES and its haulers will immediately report all spills into waters of the state or spills on the ground that are likely to enter waters of the state to Oregon Emergency Response System (OERS) at 1-800-452-0311 and the Department of Environmental Quality's (DEQ) regional biosolids specialist at 503-229-5292.

WES and its contractors will report all spills of 50 gallons (¼ cubic yard) or more on the ground to the DEQ's regional biosolids specialist within 24 hours of becoming aware of the spill incident. If WES and/or its haulers have to report a spill to the OERS, WES and/or its haulers will provide the following information to DEQ/OERS:

1. Contact names and phone numbers
2. Estimate of the amount of biosolids spilled
3. Address or nearest cross street or highway exit
4. Highway mile post
5. GPS coordinates or landmark
6. Measures being taken to clean up the spill
7. Description of any resources damage (e.g. dead fish, vegetation)

More on DEQ spill reporting and mitigation can be found at the DEQ spill website https://www.oregon.gov/deq/Hazards-and-Cleanup/er/Pages/How-To-Report-A-Spill.aspx

SPECIAL NOTE: WES employees and haulers are aware that any amount of oil or hazardous materials spilled to any waters of the state and oil spills on land in excess of 42 gallons must be immediately reported to DEQ.

7.2 Spill during transportation of biosolids

The Spill Response Plan required of each contract hauler requires that the hauler notify WES, DEQ and the Oregon State Police in the event of a spill. Each plan also requires the hauler to be equipped to clean any spill and to train employees on all aspects of the plan. If a spill occurs during the transport of biosolids between the sewage treatment plant and a land application site, the contract hauler will at a minimum:

1. Contain the spill with containment booms and/or other equipment as appropriate.
2. Protect any nearby storm drains from being impacted by the spill if possible. This is particularly important if the spill takes place when it is raining or rainfall is anticipated.
3. Post the area and set up temporary fencing if there is a potential for public exposure.
4. Remove spilled biosolids with a front-end loader, shovels, heavy-duty shop brooms and/or a vacuum truck as appropriate.
5. Cover the area with hydrated dry lime if needed.
6. Apply absorbent (e.g., sand or clean-fill) if needed.
7. Transport spilled materials to a DEQ-authorized biosolids land application or disposal site.
8. File a written release form or report to the DEQ within five days following the release or spill.

7.3 Solids Treatment Process Failure or Modification

If a mechanical problem occurs with digesters or other biosolids treatment components and replacement parts are not in stock at the treatment facility, an emergency parts order is placed. During this period, treatment, storage, handling and transportation activities are modified to ensure that pathogen reduction, vector attraction reduction, and pollutant concentration limits do not result in non-compliance with the requirements of 40 CFR Part 503 and OAR 340-050. If solids were not to meet pathogen and vector attraction reduction criteria, several options exist for management:

- Dewater and take to landfill
- Transport to another wastewater treatment plant for additional treatment
- Transport to business that offers dewatering and landfill services

The Tri-City Plant has a building onsite for three to five days of cake storage. This storage is also used for KC cake storage. A back-up centrifuge with two storage tanks is available to process liquid biosolids from the Tri-City Plant if necessary. If the biological mass was killed, the Plants would need to be re- seeded with healthy biological organisms from a sister Plant or another wastewater Plant.

Procedures for properly maintaining, operating and addressing repairs of WES' treatment processes are outlined in operation and maintenance manuals located at the individual wastewater Plants.

7.4 Odor Response

All complaints related to land application activities, to include odors, receive an immediate response. WES staff speaks with the complainant by phone or in person. Information is gathered from the complainant such as their name and address; date, time and location of the odor event; and any other pertinent site information such as other ongoing farm operations at the time of the alleged odor incident.

Problems identified will be corrected as soon as practical, typically within 24 hours of discovery. WES will consider the prevalent wind direction for each time of year when it selects storage areas to minimize the potential for nuance odors. When possible, storage locations are selected that are not visible from a public roadway.

Section 8: Biosolids Utilization and Land Application Site Management Practices

In calendar year 2021 WES beneficially reused approximately 85% of the biosolids generated at the TC plant and approximately 79% of biosolids generated at the KC Plant. All together WES land applies about 2,288 dry tons of dewatered biosolids to farmland from year to year. This biosolids land application plan outlines agronomic application rate and site crops, where biosolids are applied, site selection criteria for a new site and site and crop management practices.

8.1 Biosolids Land Application Plan

The beneficial use practices are governed under this DEQ approved Biosolids Management Plan and DEQ approved Land Application Authorizations. WES' biosolids land application program consists of several key elements, including:

- Producing biosolids that meet pathogen reduction, vector attraction reduction, and pollutant concentrations in accordance with 40 CFR Part 503 and OAR 340-050 (these elements are explained in detail in Sections 3 and 4 of this plan)
- Obtaining biosolids Land Application Authorizations from DEQ. This includes selecting sites using, at a minimum, criteria specified in OAR 340-050-0070.
- Determining appropriate agronomic rate calculations based on crop nitrogen requirements as required by OAR 340-050-0025 and OAR 340-050-0080.
- Soil sampling in accordance with this plan and OAR 340-050-0080(4) and OAR-050-0080(5).
- Implementing site management practices as required in the DEQ Land Application Authorization

8.1.1 Site Inventory of Existing and Potential Land Application Sites

WES is authorized to apply Class B biosolids on approximately 8,558 acres of farmland in Sherman County.

WES may elect to seek additional DEQ Land Application Authorizations for Class B biosolids land application anywhere in Oregon, but at present is considering pursuing additional land application sites in the following Counties: Yamhill, Clackamas, Marion, Wasco, Sherman, Gilliam, Morrow, Washington, Polk, and Linn. WES intends to immediately pursue Land Application Authorizations in Marion and Linn counties for dry weather application.

Appendix C contains the current list of active DEQ authorized biosolids land application sites. Specific site information such as authorized acreage, nitrogen loading limits, and time of year authorized for land application is contained within each DEQ Land Application Authorization letter and on file at WES.

8.1.2 Land Application Authorizations

A land application authorization letter issued by DEQ outlines site management conditions that are based on the characteristics of the biosolids being land applied and the specific location where land application occurs. The provisions stated in the letter are permit requirements and are enforceable conditions under each Plant's NPDES permit.

When WES wants to land apply Class B biosolids to a new site, WES provides DEQ with the information specified in DEQ's *Biosolids Land Application Site Authorization Request: Documentation Checklist* to the appropriate DEQ Regional Biosolids Specialist. For easy reference, Appendix E of this plan includes the information that must be submitted to DEQ to obtain a new Land Application Authorization. The DEQ form in Appendix E can also be viewed at https://www.oregon.gov/deq/wq/programs/Pages/Biosolids-Assistance.aspx.

8.1.3 Site Selection Criteria for New Land Application Sites

At a minimum and in accordance with OAR 340-050, the following site selection criteria are used by WES when selecting new biosolids land application sites:

a) Sites are on a stable geologic formation not subject to flooding or excessive runoff from adjacent land. If periodic flooding cannot be avoided, the period of application is restricted and soil incorporation may be implemented.
b) If liquid biosolids are applied, the minimum depth to permanent groundwater is 4 feet and the minimum depth to temporary groundwater is 1 foot at the time when application occurs.
c) Topography of the site is suitable to allow normal agricultural operations. Where needed, runoff and erosion control measures are constructed. Well vegetated sites with slopes up to 30 percent may be used for dewatered biosolids.
d) Soil has a minimum rooting depth of 24 inches.

When selecting application sites, WES uses soil survey maps and information provided by Natural Resources Conservation Service to determine suitability of soil type, soil depth and depth to groundwater. WES uses topographic maps to determine site suitability with respect to slope and proximity to waters of the state of Oregon. Consideration is given to wells on or near the site, the extent of buffer zones that may limit the site's use, crop selection and farming practices of the site owner/controller, the ability to restrict public access to the site and accessibility of the site to deliver and apply biosolids.

8.1.4 Public Notification

WES is required to notify the public (immediate neighbors only) of any proposed new land application sites. WES mails a letter to residents 30 days prior to submitting the site authorization request to DEQ. Any verbal or written questions or comments obtained from residents are addressed by WES. WES may also contact DEQ's Regional Biosolids Coordinator to discuss issues. Written comments or questions are maintained by WES.

WES also notifies neighbors of routine, planned land application activities.

8.1.5 Site Management Practices

Site access restrictions and setbacks are followed as outlined in DEQ Land Application Authorization letters. WES ensures that access is restricted as required by the Land Application Authorization letter by appropriate means as necessary, such as fencing or posting of signs at the land application sites. Biosolids land application does not occur in those areas designated as buffer strips and the application areas are identified through accurate measurement of required buffers prior to commencing land application. In addition, WES will meet, at a minimum, the management practices listed in 40 CFR §503.14 and OAR 340-050-0065.

8.1.6 Agronomic Application Rates and Site Crops

8.1.6.1 Introduction

Class B biosolids are required to be land applied to a site at a rate that is equal to or less than the agronomic rate for the site. An agronomic rate is the whole biosolids application rate (dry weight basis) designed to provide the annual total amount of nitrogen needed by a crop and to minimize the amount of nitrogen passing below the root zone of the crop or vegetation to groundwater.

8.1.6.2 Agronomic Application Rates

Biosolids application rates for WES sites are developed based on the Pacific Northwest Extension's *Worksheet for Calculating Biosolids Application Rates in Agriculture (PNW 511).* For ease of reference, a copy of this worksheet may be found in Appendix F of this plan and the on-line version of worksheet may be found at the OSU website https://catalog.extension.oregonstate.edu/pnw511. An Excel version of the worksheet may also be downloaded at https://puyallup.wsu.edu/soils/biosolids.

Biosolids agronomic application rates for WES sites are developed following OSU Extension Service Fertilizer Guides for the specific crops receiving biosolids. These crops may include soft white winter wheat, hard red wheat, grass hay, pasture, grass seed, forest and nursery stock. Other crops may be added to the program in the future. Specific site agronomic loading limits and authorized months of application are specified in the DEQ issued Land Application Authorization letters.

Nitrogen requirements for specific crops vary from field to field and year to year depending on soil fertility, crop productivity, cropping methods and history, fertilizer applications, weather and crop management. The plant available nitrogen (PAN) needed from biosolids to produce the desired yield of a crop is determined by using OSU fertilizer guides as well as specific information pertaining to elements such as yield, biosolids quality, and nitrogen cycling dynamics. PAN needed from biosolids varies based on this specific information and thus alters the actual agronomic rate for a given land application site.

WES uses the following regional university and federal and state agency references to assist with agronomic application rate calculations.

- Lutcher, L.K, Horneck, D.A., Wysocki, D.J., Hart, J.M., Petrie, S., and Christensen, N.W. Reprinted April 2007. *Winter Wheat in Summer Fallow Systems (Low Precipitation Zone) Fertilizer Guide FG80.* Oregon State University, Corvallis, OR. Link to on-line version: http://catalog.extension.oregonstate.edu/fg80
- *Biosolids Management Guidelines for Washington State.* Link to on-line version: https://fortress.wa.gov/ecy/publications/documents/9380.pdf
- Sullivan, D.M.; Tomasek, A.; Griffin-LaHue, D.; Verhoeven, B.; Moore, A.D.; Brewer, L.J.; Bary, A.I.; Cogger, C.G.; Biswanath, D. April 2022. *Fertilizing with Biosolids*. *PNW 508*. Pacific Northwest Extension Publishing. https://catalog.extension.oregonstate.edu/pnw508

8.1.6.3 Soil Sampling

Prior to the initiation of biosolids application to a new site, representative soil samples are collected across the entire site and analyzed by an independent commercial laboratory that routinely performs soil analyses on agricultural soils. This is done to assess pre-planting soil nutrient levels and to establish background metals levels prior to initial application. The soil samples collected for nitrate analyses will be tested according to protocols published by the American Society of Agronomy and Oregon State University [OAR 340-050-0080(5)(b)].

Available nitrogen concentrations in soil for a given season are affected by other sources of nitrogen; soil pH; rainfall; and carry-over from previous year’s applications or crop residuals. Existing nitrogen levels in the soil profile are subtracted from the OSU Fertilizer Guide application rates for the crop and the biosolids application rate is adjusted.

WES generally samples fields in August and September after harvest. WES may elect to meet only minimum requirements in the future which states that in the event of annual biosolids application to the same field for three consecutive years, soils are sampled from the field and tested for nitrate and ammonia nitrogen prior to the third year’s biosolids application in accordance with OAR 340-050- 0080(5)(a).

WES consults the following regional university and federal and state agency references to assist with soil sampling procedures:

- *Post-harvest Soil Nitrate Testing for Manured Cropping Systems West of the Cascades - second section on detailed suggestions for soil sampling and planning*, May 2003, OSU Extension Service publication EM 8832-E. Link to on-line version: http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20221/em8832-e.pdf
- *Soil Sampling*, August 1997 (reprint), University of Idaho Cooperative Extension System Bulletin 704 (revised). Link to on-line version: http://www.cals.uidaho.edu/edcomm/pdf/EXT/EXT0704.pdf
- *Soil Test Interpretation Guide*, Revised July 2011; Reviewed July 2019, OSU Extension Service publication EC 1478. Link to on-line version: https://catalog.extension.oregonstate.edu/ec1478

Section 9: Recordkeeping and Reporting Procedures

9.1 Recordkeeping

WES, as the preparer and land applier of biosolids, is required to maintain records to demonstrate that federal and state biosolids requirements are met. Records are kept on file by WES and are available to DEQ and the community upon request. Monitoring and sampling records are retained for a period no less than five years, unless otherwise required by the NPDES permit or a DEQ Land Application Authorization letter. The minimum required records include the following information:

- Pollutant concentrations of each parameter stated in the Plant's NPDES permit.
- Pathogen requirements as stated in the Plant's permit for Class B.
- Description of how one of the vector attraction reduction requirements in 40 CFR Part 503.33(b)(1) through (8) is met.
- Description of how the management practices in 40 CFR §503.14 and site restrictions in 40 CFR Part 503.32(b)(5) are met for each biosolids land application site.
- Certification that the information submitted is accurate to determine compliance with pathogen and vector attraction reduction requirements, and site restriction/management requirements.

Each of these components is found in the Biosolids Annual Report.

9.2 Annual Reporting

The DEQ and USEPA Annual Biosolids Reports are due February 19 of each year for the previous year's Class B biosolids management. The reports are submitted to the DEQ and EPA Region 10, respectively. The annual report includes the quality and quantity of biosolids produced and land applied and sites that received biosolids. DEQ and USEPA provide templates for report submission. DEQ's Wastewater Solids and Biosolids Annual Report

Form and its instructions may be found at the DEQ Water Quality Programs website https://www.oregon.gov/deq/wq/programs/Pages/Biosolids-Assistance.aspx.

For WES Plants that land apply biosolids, the Annual Biosolids Reports have a signature line to certify pathogen reduction and vector attraction reduction. The person signing the statements is the operator of record at the wastewater treatment Plant. Methods for achieving vector attraction reduction are identified (e.g., time and temperature) for biosolids generated at the Tri-City and Kellogg Plants.

Certification of pathogen reduction is required and is satisfied by submittal of test results in the DEQ Annual Biosolids Report. All the previous year's biosolids sampling and analysis that is required by the permit is included in each year's annual report. Those portions of the annual reports are included as Appendices A and B.

The dates, volumes, and locations of Class B biosolids land applications are recorded. Land application records are kept for at least five years.

9.3 Certification Statements

The Tri-City and Kellogg Plants are capable of meeting alternatives for achieving biosolids pathogen and vector attraction reduction criteria. Signed Class B biosolids and vector attraction certification statements are maintained at Clackamas County WES and are available upon request. As required in accordance with 40 CFR §503.17, WES retains a certification statement indicating whether compliance with pathogen reduction, vector attraction reduction, and certain site restrictions have been met. The certification statement is retained for a period of at least five years, and submitted with the annual report that is due February 19 or as required by the permit. WES retains the certification statement and it is signed by the Operations Supervisor for each Plant.

The following certification statements are applicable to WES' biosolids management program:

Class B Biosolids Pathogen and Vector Attraction Reduction Requirements

"I certify, under penalty of law, that the information that will be used to determine compliance with the Class B pathogen requirements in 40 CFR §503.32(b), the vector attraction reduction requirement in 40 CFR §503.33(b)(1), and the site restrictions in 40 CFR §503.32(b)(5) for each site on which Class B sewage sludge was applied, was prepared under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate this information. I am aware that there are significant penalties for false certification, including the possibility of fine and imprisonment."

Signature____**Date**______________________

WES is also required as the land applier to certify that the management practices in 40 CFR Part 503.14 are being met. This certification includes that biosolids are being land applied at approved agronomic loading rates as specified in DEQ issued Land Application Authorization letters.

All the above required certification statements are embedded in the formatted annual report, and are signed by the Plant Operations Supervisor.

In addition, WES contractor is required to sign the following statement:

"I certify, under penalty of law that the management practices in 40 CFR §503.14 have been met for each site on which bulk biosolids were land applied during the year. This determination has been made under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices have been met. I am aware that there are significant penalties for false certification, including the possibility of fine and imprisonment."

This statement will be included as an attachment to the Biosolids Annual Report.

Section 10: Modification of Plan

This plan may be subject to change, or modification should state regulations change and/or site conditions significantly change.

Appendix A: Tri-City Biosolids Data – Pollutants, Nutrients, Pathogen Reduction and VSR

BIOSOLIDS POLLUTANT MONITORING, TC 2021									
	Biosolids Type: Class A ☐ Class B ☒								
	Pollutant Concentrations								
Sample frequency	**As (mg/kg)**	**Cd (mg/kg)**	**Cu (mg/kg)**	**Pb (mg/kg)**	**Hg (mg/kg)**	**Mo (mg/kg)**	**Ni (mg/kg)**	**Se (mg/kg)**	**Zn (mg/kg)**
60 days	3.0	1.19	186	16.3	0.479	6.36	19.5	<5.1	688
60 days	2.4	1.10	178	13.0	0.383	7.14	15.6	4.8	670
60 days	2.5	1.02	181	10.5	0.424	7.30	16.2	5.1	680
60 days	3.5	0.988	191	10.5	0.114	6.82	17.6	4.6	823
60 days	4.0	1.30	227	12.8	0.443	8.63	18.1	6.2	1010
60 days	3.2	0.961	173	12.8	0.256	6.89	18.7	4.1	648
Annual Mean	3.1	1.09	189	12.7	0.350	7.19	17.6	4.56	753
Table 1[1] Ceiling Limit	75	85	4300	840	57	75	420	100	7500
Table 3[2] Pollutant Limit	41	39	1500	300	17	N/A	420	100	2800

[1] 40 CFR § 503.13 Table 1 – Ceiling concentrations. Samples with pollutant concentrations that exceed the Table 1 limits are not eligible for land application and must be disposed by other means.

[2] 40 CFR § 503.13 Table 3 – Pollutant Concentrations. Samples with pollutant concentrations that exceed the Table 3 limits are subject to cumulative pollutant loading rates in 40 CFR § 503.13 Table 2. Annual and cumulative pollutant additions to land application sites must be submitted with the annual report.

BIOSOLIDS NUTRIENT MONITORING, TC 2021

Report nutrient monitoring data from collected samples. Express results in mg/kg (ppm) based on dry weight, except where otherwise noted. *Please attach laboratory reports for results only. No lab QA/QC.*.

Biosolids Type: Class A ☐ Class B ☒

	Nutrient Concentrations							
Sample Frequency	**TKN (mg/kg)**	**NO_3-N (mg/kg)**	**NH_4-N (mg/kg)**	**P (mg/kg)**	**K (mg/kg)**	**pH (S.U.)**	**Total solids (%)**	**F. coli MPN CFU**
60 days	118000	19.7	9900	14800	2140	8.6	19.8	See Time and Temperature Attachment
60 days	79900	28.0	8100	11700	1900	8.6	21.4	See Time and Temperature Attachment
60 days	94000	11.7	7880	14400	2090	8.7	19.7	See Time and Temperature Attachment
60 days	40100	<52.9	7460	14400	1890	8.3	19.8	See Time and Temperature Attachment
60 days	73500	1030	6080	16700	1870	8.4	20.7	See Time and Temperature Attachment
60 days	72000	43.7	6920	12300	1900	8.2	22.7	See Time and Temperature Attachment
Annual Mean	79583	193.3	6541	14050	1965	8.0	20.7	See Time and Temperature Attachment

Volatile Solids Reduction (VSR), TC 2021	
Biosolids Type: Class A ☐ Class B ☒	
Month	**Monthly average**
January	47%
February	55%
March	54%
April	49%
May	46%
June	53%
July	60%
August	49%
September	56%
October	49%
November	59%
December	49%
Annual Mean	52%

Pathogen Reduction, Time and Temperature, TC 2021						
Biosolids Type: Class A ☐ Class B ☒						
Month	Digester #1		Digester #2		Digester #3	
	Temp, ºF	Solids Retention Time 15-day Rolling Average (days)	Temp, ºF	Solids Retention Time 15-day Rolling Average (days)	Temp, ºF	Solids Retention Time 15-day Rolling Average (days)
January	offline	offline	offline	offline	97.3	23.0
February	offline	offline	offline	offline	97.4	30.1
March	offline	offline	offline	offline	97.5	23.4
April	offline	offline	offline	offline	97.4	21.6
May	offline	offline	offline	offline	97.7	19.9
June	offline	offline	offline	offline	97.7	20.1
July	offline	offline	offline	offline	97.7	23.7
August	offline	offline	offline	offline	97.7	23.0
September	offline	offline	97.6	30.6	97.7	23.5
October	offline	offline	97.6	75.4	97.7	30.2
November	offline	offline	97.5	70.1	97.7	28.3
December	offline	offline	97.6	35.5	97.7	36.7
Annual Mean	offline	offline	97.6	52.9	97.6	25.3

Appendix B: Kellogg Creek Biosolids data - Pollutants, Nutrients, Pathogen Reduction and VSR

BIOSOLIDS POLLUTANT MONITORING, KC 2021												
Biosolids Type: Class A ☐ Class B ☒												
	Pollutant Concentrations, KC 2021 mg/kg											
Sampling frequency	**As**	**Cd**	**Cu**	**Pb**	**Hg**	**Mo**	**Ni**	**Se**	**Zn**	**Cr**	**Ag**	**Volatile Solids (%)**
Quarterly	3.1	1.56	209	12.0	0.442	15.0	47.0	5.2	806	54.6	15.4	15.9
Quarterly	2.7	1.29	229	11.9	0.487	13.8	48.4	5.6	848	46.6	33.4	6.3
Quarterly	3.1	1.26	227	11	0.474	10.7	58.8	5.2	1040	47.4	22.1	15.4
Quarterly	3.5	1.31	225	11.2	0.428	12.3	48.4	6.0	932	55.9	8.14	15.5
Annual Mean	3.1	1.36	223	11.5	0.458	13.0	50.7	5.5	907	51.1	19.8	15.8
Table 1[1] Ceiling Limit	75	85	4300	840	57	75	420	100	7500	n/a	n/a	n/a
Table 3[2] Pollutant Limit (avg.)	41	39	1500	300	17	n/a	420	100	2800	n/a	n/a	n/a

[1] 40 CFR § 503.13 Table 1 – Ceiling concentrations. Samples with pollutant concentrations that exceed the Table 1 limits are not eligible for land application and must be disposed by other means.

[2] 40 CFR § 503.13 Table 3 – Pollutant Concentrations. Samples with pollutant concentrations that exceed the Table 3 limits are subject to cumulative pollutant loading rates in 40 CFR § 503.13 Table 2. Annual and cumulative pollutant additions to land application sites must be submitted with the annual report.

BIOSOLIDS NUTRIENT MONITORING, KC 2021								
Biosolids Type: Class A ☐ Class B ☒								
	Nutrient Concentrations							
Sample frequency	**TKN (mg/kg)**	**NO3-N (mg/kg) (nitrate nitrite**	**NH4-N (mg/kg) (ammonia nitrogen)**	**P (mg/kg)**	**K (mg/kg)**	**pH (S.U.)**	**Total solids (%)**	**F. coli MPN CFU**
Quarterly	78300	38.9	16000	23200	2020	8.6	21.3	45520
Quarterly	91000	13.1	13700	25100	1970	8.7	21.4	103023
Quarterly	87100	<52.4	12700	26600	1780	8.6	20.0	63637
Quarterly	65500	64	18000	25300	1700	8.8	20.3	48191
Annual Mean	80488	35.6	15100	25050	1868	8.7	20.8	65093

BIOSOLIDS PATHOGEN REDUCTION MONITORING, KC 2021						
Biosolids Type: Class A ☐ Class B ☒						
Parameter	Allowable Level in Sludge	Pathogen		Frequency of Analysis	Sample Type	Analytical Technique
		Geometric Mean	Units			
Fecal Coliform	$2x10^6$ MPN per gram of total solids or $2x10^6$ CFU per gram of total solids	See table below	MPN/gram TS	Quarterly	Grab	SM9221E

Date Sampled	Result	Date Sampled	Result	Date Sampled	Result	Date Sampled	Result
03/08/21	89300	06/14/21	38900	09/20/21	21000	12/13/2021	80700
03/08/21	60900	06/15/21	24500	09/21/21	415000	12/13/2021	11100
03/09/21	23400	06/15/21	24500	09/21/21	37200	12/16/2021	79200
03/09/21	37300	06/17/21	260000	09/23/21	31700	12/16/2021	58800
03/19/21	21700	06/17/21	167000	09/23/21	22500	12/17/2021	24200
03/22/21	62900	06/21/21	750000	09/24/21	816000	12/29/2021	101000
03/22/21	62500	06/23/21	162000	09/24/21	22400	12/29/2021	59200
geo mean	45520	geo mean	103023	geo mean	63637	geo mean	48191

BIOSOLIDS VOLATILE SOLIDS REDUCTION MONITORING, KC 2021	
Biosolids Type: Class A	Class B ☒
January	51%
February	60%
March	62%
April	65%
May	57%
June	58%
July	58%
August	62%
September	58%
October	59%
November	60%
December	58%
Annual Mean	59%

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Field number	Owner Name	Location	Crop type	Spreadable acres	Ag rate Lb. N/ac	Site Capacity lbs. N/yr.	Time of year applied	Harvest cycle
P01701	Pat Powell	T1N R17E S13 TL 3900	Winter wheat	151.7	132	20,024	Year round	Annual
P01702	Pat Powell	T1N R17E S13 TL 3900 & 4100	Winter wheat	113.4	132	14,972	Year round	Annual
P01703	Pat Powell	T1N R17E S23 & S24 TL 4100	Winter wheat	185	132	24,420	Year round	Annual
P01704	Pat Powell	T1N R16E S10 TL 1200	Winter wheat	306.4	132	40,443	Year round	Annual
P01705	Pat Powell	T1S R16E S35 TL 6200; T2S R16E S2 TL 300; T2S R16E S3 TL 400	Winter wheat	709.1	132	93,602	Year round	Annual
P01710	Pat Powell	T1N R17E S23 & 14 TL 4100	Winter wheat	151.8	132	20,033	Year round	Annual
P01711	Pat Powell	T1N R17E S23 & 14 TL 4100	Winter wheat	71.6	132	9,448	Year round	Annual
P01712	Pat Powell	T1N R17E S13 TL 3900	Winter wheat	149.8	132	19,776	Year round	Annual
P01716	Pat Powell	T2S R16E S2 & 11 TL 200	Winter wheat	515.9	132	68,099	Year round	Annual
P01717	Pat Powell	T1S R16E S33 TL 5600	Winter wheat	413	132	54,516	Year round	Annual
P01718	Pat Powell	T1S R16E S15 TL 2100	Winter wheat	253.6	132	33,475	Year round	Annual
P01719	Pat Powell	T2S R17E S3, 9 & 10 TL 700 & 1700	Winter wheat	695.2	132	91,766	Year round	Annual

Field number	Owner Name	Location	Crop type	Spreadable acres	Ag rate Lb. N/ac	Site Capacity lbs. N/yr.	Time of year applied	Harvest cycle
P01720	Pat Powell	T2S R17E S9 TL 1600	Winter wheat	78.7	132	10,384	Year round	Annual
P01721	Pat Powell	T2S R17E S4 & S5 TL 1000	Winter wheat	342.3	132	45,188	Year round	Annual

Field number	Owner Name	Location	Crop type	Spreadable acres	Ag rate Lb. N/ac	Site Capacity lbs. N/yr.	Time of year applied	Harvest cycle
T01202	Bill Trimble	T1N R18E S36-NW1/4 TL 6700	Winter wheat	150.9	132	19,923	Year round	Annual
T01203A	Bill Trimble	T1N R18E S23 & S26 TL 4000	Winter wheat	88	132	11,614	Year round	Annual
T01204	Bill Trimble	T1N, R18E, S36-NE1/4, TL 6700	Winter wheat	76.2	132	10,054	Year round	Annual
T01206	Bill Trimble	T1N R18E S26 TL4000	Winter wheat	130	132	17,160	Year round	Annual
T01207	Bill Trimble	Part of SE1/4 of S24 and NE 1/4 S25, T01N, R18E; and Part of SW 1/4 S19 and NW 1/4 S30, T01N, R19E, TL 3100 & 4000	Winter wheat	129.9	132	17,148	Year round	Annual
T01208	Bill Trimble	Part of NE1/4, S25, T01N, R18E and W 1/2, S30, T01N, R19E	Winter wheat	128	132	16,901	Year round	Annual

Field number	Owner Name	Location	Crop type	Spreadable acres	Ag rate Lb. N/ac	Site Capacity lbs. N/yr.	Time of year applied	Harvest cycle
W01901	Weedman Farms	T1N R18E S7 TL102	Winter wheat	152.5	132	20,129	Year round	Annual
W01902	Weedman Farms	T1N R18E S21 TL3800	Winter wheat	136.5	132	18,019	Year round	Annual
W01903A	Weedman Farms	Part of NE1/4, S21, T01N, R18E, TL3103	Winter wheat	162.5	132	21,448	Year round	Annual
W01903B	Weedman Farms	Part of W1/2, S22, T01N, R18E, TL3103	Winter wheat	209.8	132	27,699	Year round	Annual
W01904	Weedman Farms	T1N R18E S15 TL2900	Winter wheat	152.5	132	20,124	Year round	Annual
W01905	Weedman Farms	T1N R18E S22, 26 & 27 TL 3103 & 4500	Winter wheat	127.8	132	16,871	Year round	Annual
W01907	Weedman Farms	T1N R17E S12 & 13 TL3700	Winter wheat	171.1	132	22,585	Year round	Annual
W01908	Weedman Farms	TLs800&3200;07&18 T1N R18E WM	Winter wheat	283.9	132	37,470	Year round	Annual
W01910	Dutton Ranch Trust	T1N R18E S08, 09 & 17 TL1900	Winter wheat	234.2	132	30,913	Year round	Annual
W01911	Dutton Ranch Trust	T1N R18E S08, 09 &17 TL1900	Winter wheat	61.4	132	8,108	Year round	Annual
W01920	Weedman Farms	Part of W1/2, S22, T01N, R18E, TL3103	Winter wheat	167.6	132	22,127	Year round	Annual
W01921	Weedman Farms	T1N R18E S8&S17 TL1900	Winter wheat	119.1	132	15,715	Year round	Annual

Field number	Owner Name	Location	Crop type	Spreadable acres	Ag rate Lb. N/ac	Site Capacity lbs. N/yr.	Time of year applied	Harvest cycle
W01923	Weedman Farms	T1N R18E S11 TL 2300	Winter wheat	74.8	132	9,877	Year round	Annual
W01925	Weedman Farms	T1N R18E S35 & S36 TL 6600	Winter wheat	214.2	132	28,275	Year round	Annual
W01926	Weedman Farms	T1N R18E S35 & S36 TL6600	Winter wheat	100.2	132	13,230	Year round	Annual
W01927	Weedman Farms	T1N R18E S36 TL6600	Winter wheat	104.5	132	13,794	Year round	Annual
W01928	Weedman Farms	T1N, R18E, S6, TL1100	Winter wheat	140.9	132	18,594	Year round	Annual
W01930	Weedman Farms	1N, R18E, S25, TL4300	Winter wheat	160.4	132	21,174	Year round	Annual

Appendix D – Biosolids Stockpile Inspection Form

Inspector's Name: ______________________________ **Inspection Date:** ____________________

Location of Stockpile (Township, Range, Quarter Section, Section, and County)

Township: __________ **Range:** __________ **Quarter Section:** __________ **Section:** __________ **County:** __________

Stockpile Start Date: ____________________ **Approximate Size of Stockpile:** ____________________

Weather: ____________________ **General Wind Speed and Direction:** ____________________

Stockpile Inspection Items

(Circle Yes or No below and please provide an explanation in the comments or observations section of this form on what actions were taken to correct any problems observed at the stockpile site. Keep in mind that any observed problems must be corrected within 24-hours of discovery)

Are there strong odors at the stockpile or downwind of the stockpile?	Yes	No
Have you logged or received any odor complaints in regard to the stockpile?	Yes	No
Is the stockpile site properly posted to discourage public access?	Yes	No
Are cattle and other farm animals being kept away from the stockpile?	Yes	No
Any biosolids runoff to water bodies or other drainages?	Yes	No
Any evidence of erosion or movement of stockpile biosolids?	Yes	No
Are stockpile access roads free of spilled or drag-out biosolids?	Yes	No
Are all required daily biosolids site activities being logged and maintained?	Yes	No

Comments or Observations

____

____

____

____

Anticipated Date of Removal of Stockpile: ______________________________

____

Inspector Signature

BIOSOLIDS STOCKPILE INSPECTION FORM

INSPECTIONS REQUIRED EVERY TWO WEEKS UNTIL ALL BIOSOLIDS ARE SPREAD

The purpose of this inspection form is to ensure that biosolids staged or stockpiled for land application at an authorized land application site are being properly managed to control public access, grazing animals, wind drift, run-on, run-off, erosion, odors, and movement of biosolids from the site.

Appendix E: Biosolids Land Application Site Authorization Request: Documentation Checklist

Biosolids Land Application Site Authorization Request Documentation Checklist

State of Oregon
DEQ Department of Environmental Quality

DEQ requests the following information be submitted with the biosolids land application site authorization request.

SITE INFORMATION

- ☐ Vicinity map (e.g., USGS, tax lot, county assessor) indicating location of proposed land application site and acreage, including gross and net (any area or buffer areas not available for biosolids application) acreage
- ☐ Site location including street address (if not available, then state directions to site), tax reference number, section, township, range, and county
- ☐ Site owner name, address, and phone number. Site renter name, if applicable
- ☐ Detailed map showing property boundaries, and setbacks from roadways, occupied buildings, other manmade features, surface waters, and domestic water source or wells. (Recommended: plot on aerial photograph.) Distance (in feet) from biosolids land application site boundary to nearest residence(s), other publicly occupied building(s) (e.g., retail store, school, apartment building), and public use areas such as parks or hiking trails.
- ☐ Site management agreement between the biosolids generating source and the site owner(s) of record and/or authorized representative operator
- ☐ Site Zoning
- ☐ Description of adjacent land uses

SOIL INFORMATION

- ☐ USDA Natural Resources Conservation Service (NRCS) soil survey map
- ☐ Copy of the soil survey map description for each soil series indicated on a NRCS map at the proposed land application site
- ☐ Not required for all sites but if available, the most recent soil analysis (of organic matter, NO3-N, total N, Bray or Olsen P, pH, buffer pH, trace metals from biosolids list)

AGRICULTURAL AND CROP MANAGEMENT INFORMATION

- ☐ Crop to be grown at the site and intended market (e.g., barley for seed, feed, brewing, food, or commodity sale). Crop assimilative capacity (nitrogen)
- ☐ Crop sequences and the time(s) of year biosolids will be land applied to the crop site. Crop harvest method (e.g., silage vs. pasture) and tilling practices
- ☐ Irrigation practices and fertilizer use
- ☐ Not required but if available, typical harvest information (e.g., quantity, protein content) from site

BIOSOLIDS AND LAND APPLICATION INFORMATION

- ☐ Biosolids characteristics from the most recent biosolids analyses, including data on:
  - Total kjeldahl nitrogen, nitrate nitrogen, ammonium nitrogen, total phosphorus, potassium, total solids, volatile solids (expressed as percent dry weight), pH; and
  - Arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, and if required, silver and chromium (expressed as mg/kg dry weight)
- ☐ Forecast of first year biosolids application rate (gallons or dry tons/acre/year).
- ☐ Nutrient and metal loadings based on biosolids analyses and total acreage land applied for the year
- ☐ Calculations used for forecasting annual biosolids application rate
- ☐ Site life calculations (if applicable)
- ☐ Field staging and/or storage practices (if applicable)

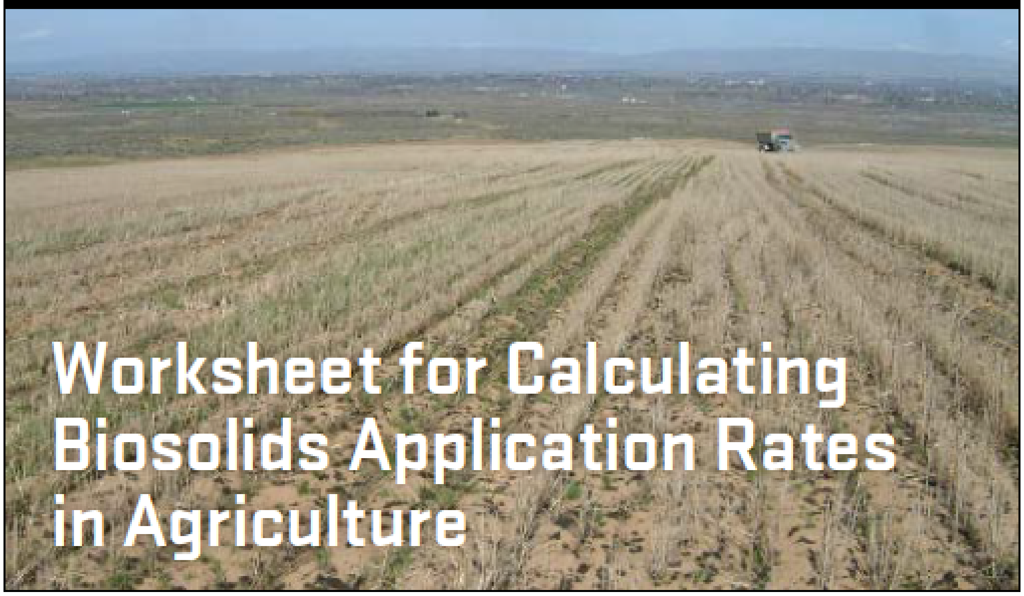
PUBLIC PARTICIPATION INFORMATION

- ☐ Documentation on Public Notification, including:
  - Copy of any written notification materials
  - Who received notification (including name, address, and telephone number, if known)
  - How notification was made (e.g., information flyer left at the door, mail, conversation with occupant, etc.)
  - Date and, for direct contacts, time of notification
  - Summary of any responses to notification and how they were addressed

Revision 1.1, Feb. 7, 2022
R. Doughten

Appendix F: Worksheet for Calculating Biosolids Application Rates in Agriculture (PNW 511).

A PACIFIC NORTHWEST EXTENSION PUBLICATION



Worksheet for Calculating Biosolids Application Rates in Agriculture

Photo: Brian Campbell, Natural Selection Farms

Dan M. Sullivan, Deirdre Griffin LaHue, Biswanath Dari, Andy I. Bary and Craig G. Cogger

Biosolids are a product of municipal wastewater treatment. Raw sewage solids must be processed to meet U.S. Environmental Protection Agency standards before they can be called biosolids. Biosolids contain organic matter and nutrients that are beneficial for soil and crop productivity.

This publication focuses on matching the nitrogen (N) supplied by biosolids to the nitrogen needs of the crop. Regulatory agencies require agronomic rate calculations for most biosolids applications to cropland.

Overview: agronomic rate calculation

There are six steps to calculate the agronomic rate of a biosolids application:

1. Collect information on the site and crop, including crop N requirement.
2. Estimate the plant-available N needed from the biosolids application.
3. Collect biosolids N data.
4. Estimate plant-available N per dry ton of biosolids.
5. Calculate the agronomic biosolids application rate on a dry ton basis.
6. Convert the application rate to an "as is" basis.

In determining biosolids application rates, it's important to evaluate trace element concentrations in biosolids and the regulatory limits for trace element application (see Appendix A). However, in almost all cases, nitrogen controls the biosolids application rate.

A companion publication, *Fertilizing with Biosolids* (PNW 508), provides additional information about the value of biosolids as a fertilizer. The "For more information" section of this publication gives a summary of Pacific Northwest research and Extension publications on land application of municipal biosolids.

Dan M. Sullivan, Extension soil scientist and professor of nutrient management, and Biswanath Dari, agronomist and assistant professor, both of the Department of Crop and Soil Science, Oregon State University; Deirdre Griffin LaHue, sustainable soil management specialist and assistant professor, Andy I. Bary, senior scientific assistant, and Craig C. Cogger, Extension soil scientist (emeritus), all of the Department of Crop and Soil Sciences, Washington State University

Oregon State University • University of Idaho • Washington State University
PNW 511 • February 2021

WORKSHEET

For guidance on completing this worksheet, see "How to Use the Worksheet," starting on page 5.

Step 1. Collect site information

Soil and crop information:

Line number		Your information	Example
1.1	Soil series and texture (NRCS soil survey)		Puyallup sandy loam
1.2	Yield goal (units/acre/year*) estimated from grower records or by agronomist**		5 tons/acre
1.3	Crop rotation (grower; e.g., wheat, fallow, wheat)		perennial grass
1.4	Plant-available N needed to produce yield goal (university fertilizer/nutrient management guide; agronomist) (lb N/acre/year)		200 lb N/acre

Plant-available N provided by other sources:

Line number		Your calculation	Example	Unit
Pre-application testing				
1.5	Nitrate-N applied in irrigation water		10	lb N/acre
1.6	Preplant nitrate-N in root zone (east of Cascades)***		—	lb N/acre
Adjustments to typical soil N mineralization				
1.7	Plowdown of cover or green manure crop***		—	lb N/acre
1.8	Previous biosolids applications (see Table 1, page 7)		30	lb N/acre
1.9	Previous manure applications		—	lb N/acre
Grower information				
1.10	N applied at seeding (starter fertilizer)		—	lb N/acre
Total				
1.11	Total plant-available N from other sources = sum of lines 1.5 through 1.10		40	lb N/acre

* Yield goals may be expressed in weight (tons, pounds, etc.) or in volume (bushels).

** The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See https://www.certifiedcropadviser.org for more information.

*** Do not list here if these N sources were accounted for in the nitrogen fertilizer recommendation from a university fertilizer/nutrient management guide.

Step 2. Estimate the amount of plant-available N needed from biosolids

Line number		Your calculation	Example	Unit
2.1	Plant-available N needed to produce yield goal (from line 1.4)		200	lb N/acre
2.2	Plant-available N from other sources (from line 1.11)		40	lb N/acre
2.3	Amount of plant-available N needed from biosolids = line 2.1 – line 2.2		160	lb N/acre

Step 3. Collect biosolids data

Application information:

Line number		Your information	Example
3.1	Moisture content of biosolids		liquid
3.2	Biosolids processing method (see Table 3, page 10)		anaerobic
3.3	Method of application (surface or injected)		surface
3.4	Number of days to incorporation of biosolids		no incorporation
3.5	Expected application season		March to September

Laboratory biosolids analysis (dry weight basis):

If your biosolids analysis is on an "as is" or wet weight basis, you will need to divide your analysis by the percent total solids (line 3.10) and multiply the result by 100 to convert to a dry weight basis.

Line number		Your calculation	Example	Unit
3.6	Total Kjeldahl N (TKN)*		50,000	mg/kg
3.7	Ammonium N*		10,000	mg/kg
3.8	Nitrate N *,**		not analyzed	mg/kg
3.9	Organic N*,*** = line 3.6 – line 3.7		40,000	mg/kg
3.10	Total solids		2.5	percent

* If your analysis is in percent, multiply by 10,000 to convert to mg/kg.
** Nitrate-N analysis required for composted or aerobically digested biosolids, but not for anaerobically digested biosolids.
*** Organic N = total Kjeldahl N – ammonium N.

Step 4. Estimate plant-available N per dry ton of biosolids

Convert biosolids N analysis to lb per dry ton:

Line number		Your calculation	Example	Unit
4.1	Total Kjeldahl N (TKN)*		100	lb N/dry ton
4.2	Ammonium N*		20	lb N/dry ton
4.3	Nitrate N*		not analyzed	lb N/dry ton
4.4	Organic N = line 4.1 – line 4.2		80	lb N/dry ton

*Multiply mg/kg (from lines 3.6 through 3.9) × 0.002. If your analyses are expressed in percent, multiply by 20 instead of 0.002.

Estimate inorganic N retained:

Line number		Your calculation	Example	Unit
4.5	Percent of ammonium-N retained after application (see Table 2, page 9)		55	percent
4.6	Ammonium-N retained after application = line 4.2 × (line 4.5 ÷ 100)		11	lb N/dry ton
4.7	Biosolids inorganic N retained = line 4.3 + line 4.6		11	lb N/dry ton

Estimate organic N mineralized:

Line number		Your calculation	Example	Unit
4.8	Percent of organic N that is plant-available in Year 1 (see Table 3, page 10)		35	percent
4.9	First year plant-available organic N = line 4.4 × (line 4.8 ÷ 100)		28	lb N/dry ton

Plant-available N:

Line number		Your calculation	Example	Unit
4.10	Estimated plant-available N = available inorganic N (line 4.7) + available organic N (line 4.9)		39	lb N/dry ton

Step 5. Calculate the agronomic biosolids application rate

Line number		Your calculation	Example	Unit
5.1	Amount of plant-available N needed from biosolids (from line 2.3)		160	lb N/acre
5.2	Estimated plant-available N in biosolids (from line 4.10)		39	lb N/dry ton
5.3	Agronomic biosolids application rate = line 5.1 ÷ line 5.2		4.1	dry ton/acre

Step 6. Convert to "as is" biosolids basis

Desired units		Your calculation	Example
Gallons per acre =	(line 5.3 ÷ line 3.10) × 24,000		39,400
Inches per acre =	(line 5.3 ÷ line 3.10) × 0.88		1.44
Wet tons per acre =	(line 5.3 ÷ line 3.10) × 100		164

HOW TO USE THE WORKSHEET

Step 1. Collect site information

Soil series and surface soil texture (line 1.1)

Find the location on the Natural Resources Conservation Service (NRCS) soil survey. Record the series name and surface texture of the predominant soil. NRCS soil survey data is available online at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

Crop yield goal (line 1.2)

Field records are the best source for crop yield estimates. You can find proven yields for most grain farms from the local Farm Service Agency office. For most other cropping systems, grower records are the only source available. Be sure to note whether the yield records are on an "as is" or dry matter basis.

A site used repeatedly for biosolids application should have yield data collected each year. Use this accumulated data for determining crop nitrogen requirement.

Yield data is typically not available for grazed pastures because grazing animals consume the crop in the field. In these cases, omit the yield goal and go directly to line 1.4. Estimate plant nitrogen needs from the appropriate university fertilizer/nutrient management guide, based on the level of pasture management.

Crop rotation (line 1.3)

Consult with the grower and discuss possible crop rotations. Rotations that include root crops or other crops with long post-application waiting periods are not suitable for Class B biosolids application. A companion publication (*Fertilizing with Biosolids*, PNW 508) provides more information about USEPA standards for Class A and Class B biosolids.

Plant-available N needed to produce yield goal (line 1.4)

You can estimate plant-available N needs by referring to university fertilizer/nutrient management guides.

University fertilizer and nutrient management guides

Land grant universities (for example, Washington State University, Oregon State University, and the University of Idaho) publish fertilizer and nutrient management guides that estimate plant-available N needs. Use the guide most appropriate for the site and crop. For major crops, guides may cover irrigated or rainfed (dryland) cropping and different geographic areas. Don't use guides produced for irrigated sites when evaluating dryland sites. When appropriate guides do not exist, consult university Extension agronomists/

soil scientists or professional agronomists (Certified Crop Advisors) who have expertise working within the cropping system.

Nitrogen fertilizer application rates listed in the fertilizer/nutrient management guides are based on field trials conducted under the specified climate and cultural conditions. Growth trial results are averaged over a variety of soil types and years. Note that guide recommendations are not the same as crop uptake. This is because the guides account for N available from mineralization of soil organic matter and the efficiency of N removal by the crop.

The N rate recommended in fertilizer/nutrient management guides assumes average yields, good management practices, and removal of N from the field through crop harvest or grazing. In terms of satisfying crop N needs, plant-available N from biosolids application is considered equal to fertilizer N.

Agronomist calculations

Because of the general nature of university fertilizer and nutrient management guides, it may be worthwhile to have a professional agronomist calculate how much plant-available N is needed for a specific field. The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See https://www.certifiedcropadviser.org for more information.

Always use the same method to calculate the N requirements. You will need to document your reasons for using agronomist calculations instead of the university guide.

Photo: Andy Bary, ©Washington State University

Dewatered biosolids stockpile at field application site

Plant-available N provided by other sources (lines 1.5 to 1.11)

To make sure there isn't too much nitrogen applied to a crop, you must determine how much nitrogen comes from sources other than biosolids and soil organic matter. These sources of N are grouped into three categories in the worksheet:

- Plant-available N estimated by pre-application testing
- Adjustments to typical soil organic N mineralization (usually obtained from an agronomist)
- Information supplied by the grower

N estimated by pre-application testing (lines 1.5 to 1.6)

Irrigation water

Since the amount of nitrate-N in irrigation water varies, it should be determined by water testing. Irrigation water containing 5 mg nitrate-N per liter will contribute 1.1 pounds of nitrogen per acre-inch applied; irrigation water containing 10 mg nitrate-N per liter will contribute 2.3 pounds of N per acre-inch.

Preplant nitrate-N in the root zone (east of Cascades)

You can estimate the preplant nitrate-N in the root zone by testing the soil in early spring. Sample in 1-foot increments to a depth of at least 2 feet.

Some university fertilizer/nutrient management guides use preplant soil nitrate-N when calculating N fertilizer application rates. If you use these guides, don't count soil test nitrate-N in our worksheet—it has already been accounted for in the recommended fertilizer N rate prescribed in the university fertilizer/nutrient management guide.

In dryland cropping systems, soil testing below 3 feet is used to assess long-term N management. Accumulation of nitrate below 3 feet indicates that past N applications were not efficiently utilized by the crop. However, soil nitrate-N below 3 feet is typically not included as a credit when making a N fertilizer recommendation.

Adjustments to typical soil N mineralization (lines 1.7 to 1.9)

Nitrogen mineralization is the release of nitrogen from organic forms to plant-available inorganic forms (ammonium and nitrate). Soil organic matter supplies plant-available N through mineralization, but this is accounted for in the university fertilizer/nutrient management guides. Sites with a history of cover crops, biosolids applications, or manure applications supply more plant-available N than do sites without a history of these inputs, and biosolids recommendations must be adjusted based on this additional supply of N.

Plowdown of cover crops

Cover crops are not removed from the field, but are recycled back into the soil. You can get an estimate of the total N contributed by estimating the biomass dry matter (lb per acre) and the nitrogen concentration (percent total) in the cover crop. Plant-available N provided by a cover crop typically ranges from 10 to 40 percent of the total N contained in aboveground cover crop biomass. Consult *Estimating Plant-Available Nitrogen Release from Cover Crops* (PNW 636) for more information.

Previous biosolids applications

Previous biosolids applications contribute to plant-available nitrogen in the years after the initial application. In the worksheet, they are considered as "N from other sources." We estimate that 8, 3, 1, and 1 percent of the organic N *originally applied* mineralizes in Years 2, 3, 4, and 5, respectively, after application (Table 1). After Year 5, biosolids N is considered part of "stable" soil organic matter and is not included in calculations.

In using Table 1, consider the following example. Suppose:

- You applied biosolids with an average organic N content of 30,000 mg/kg
- Applications were made the previous 2 years
- The application rate was 4 dry tons per acre

Table 1 gives estimates of nitrogen credits *in terms of the organic N originally applied*. Look up 30,000 mg/kg under Year 2 and Year 3 columns in the table. The table estimates 4.8 lb plant-available N per dry ton for year 2, and 1.8 lb plant-available N for year 3 (two-year credit of 6.6 lb N per dry ton). To calculate the N credit in units of lb per acre, multiply your application rate (4 dry ton per acre) by the N credit per ton (6.6 lb N per dry ton). The N credit is 26.4 lb plant-available N per acre.

Previous manure applications

Previous manure applications contribute to plant-available nitrogen in a similar manner to previous biosolids applications. To estimate this contribution, consider field history (manure type, application rate, and date of application). The Extension publication *Fertilizing with Manure and Other Organic Amendments* (PNW 533) provides plant-available N estimates.

Information supplied by the grower (line 1.10)

N applied at seeding

Some crops need a starter fertilizer (N applied at seeding) for best growth. These fertilizers usually supply N, P, and S. Examples are 16-20-0, 10-34-0. Starters are usually applied at rates that supply 10 to 30 lb N per acre. Enter all N supplied by starter fertilizer on line 1.10 in the worksheet.

Table 1. Estimated nitrogen credits for previous biosolids applications at a site

	Years after biosolids application			
	Year 2	Year 3	Year 4 and 5	Cumulative (Years 2, 3, 4, and 5)
	Percent of organic N applied first year			
	8	3	1	13
Biosolids organic N as applied (mg/kg dry weight basis)	**Plant-available N released (lb N per dry ton)**			
10,000	1.6	0.6	0.2	2.6
20,000	3.2	1.2	0.4	5.2
30,000	4.8	1.8	0.6	7.8
40,000	6.4	2.4	0.8	10.4
50,000	8.0	3.0	1.0	13.0
60,000	9.6	3.6	1.2	15.6

Photo: Brian Campbell, Natural Selection Farms

Dewatered biosolids application to dryland wheat during fallow

Step 2. Estimate plant-available N needed from biosolids

Next you will estimate the amount of plant-available N the biosolids must provide. This is the difference between the total plant-available N needed to produce the yield goal and the plant-available N from other sources.

Step. 3. Collect biosolids data

To make the calculation, managers will need the following analyses:

- Total Kjeldahl N (TKN)
- Ammonium-N (NH_4-N)
- Nitrate-N (NO_3-N; composted or aerobically digested biosolids only)
- Percent total solids

If your laboratory results are on an "as is" or wet weight basis, you must convert them to a dry weight basis. To convert from an "as is" to a dry weight basis, divide your analysis by the percent solids in the biosolids and multiply the result by 100. Total Kjeldahl N includes over 95 percent of the total N in biosolids. In using the worksheet, we will assume that total Kjeldahl N equals total N.

Ammonium-N usually makes up most of the inorganic N present in biosolids. Depending on your laboratory, results for ammonium-N may be expressed as either ammonia-N (NH_3-N) or ammonium-N (NH_4-N). Make sure that the laboratory determines ammonium-N on a fresh (not dried) biosolids sample. The ammonium-N present in fresh biosolids is lost as gaseous ammonia when biosolids are dried.

There may be significant amounts of nitrate in aerobically digested biosolids or in composts. There is little nitrate in anaerobically digested biosolids; therefore, nitrate analysis is not needed for these materials.

Determine biosolids organic N by subtracting ammonium-N from total Kjeldahl N (line 3.6 minus line 3.7). Percent total solids analyses are used to calculate application rates. Biosolids applications are calculated as the dry weight of solids applied per acre (e.g., dry tons per acre).

Step 4. Estimate plant-available N per dry ton of biosolids

The estimate of plant-available N per dry ton of biosolids includes:

- Some of the ammonium-N
- All of the nitrate-N
- Some of the organic N

Inorganic N retained (lines 4.5 to 4.7)

Ammonium-N (lines 4.5 to 4.6)

Under some conditions, ammonium is readily transformed to ammonia and lost as a gas. This gaseous ammonia loss reduces the amount of plant-available N supplied by biosolids. The following section explains the factors used to estimate ammonia-N retained in plant-available form after application.

Biosolids processing

The following types of biosolids processing cause most of the ammonia-N to be lost as ammonia gas or converted to organic forms before application:

- Drying beds
- Alkaline stabilization at pH 12
- Composting

Application method

Ammonia loss occurs only with surface application. Injecting liquid biosolids eliminates most ammonia loss, since the injected liquid is not exposed to the air. Surface applications of liquid biosolids lose less ammonia than do dewatered biosolids. For liquid biosolids, the ammonia is less concentrated and is held as NH_4^+ on negatively-charged soil surfaces after the liquid contacts the soil.

Ammonia loss is fastest just after application to the field. As ammonia is lost, the remaining biosolids are acidified—that is, each molecule of NH_3 lost generates H^+ (acidity). Acidification gradually slows ammonia loss.

Biosolids that remain on the soil surface will eventually reach a pH near 7, and further ammonia losses will be small. Ammonia loss takes place very rapidly after application, with most of the loss occurring during the first two days after application.

Time to soil incorporation

Tillage to cover biosolids can reduce ammonia loss by adsorption of ammonium-N onto soil particles.

Table 2 estimates the amount of ammonium-N retained after field application. To use this table, you will need information on biosolids stabilization processes, method of application (surface or injected), and the number of days to soil incorporation.

Nitrate-N (line 4.3)

We assume 100 percent availability of biosolids nitrate-N.

Photo: City of Portland, Bureau of Environmental Services

Spring grass growth on dryland pasture following dewatered biosolids application (top) vs. no biosolids (bottom)

Organic N mineralized (lines 4.8 to 4.9)

Biosolids organic N, which includes proteins, amino acids, and other organic N compounds, is not available to plants at the time of application. Plant-available N is released from organic N through microbial activity in soil. This process is called mineralization. It is more rapid in soils that are warm and moist, and is slower in soils that are cold or dry. Biosolids organic N mineralization rates in soil also depend on the treatment plant processes that produced the biosolids.

Use Table 3 (page 10) to estimate biosolids mineralization rates based on processing. Use the middle of the range presented, unless you have information specific to the site or biosolids that justify using higher or lower values within the range.

Step 5. Calculate the agronomic biosolids application rate

Perform this calculation using the results of the previous sections, as shown in lines 5.1 through 5.3.

Step 6. Convert agronomic biosolids application rate to “as is” basis

Use the appropriate conversion factors (given in Table 4, page 10) to convert to gallons, acre-inches, or wet tons per acre.

Table 2. Estimates of ammonium-N retained after biosolids application

	Surface-applied			Injected
	Liquid biosolids	Dewatered biosolids	Composted, air-dried, or heat-dried biosolids	All biosolids
Time to incorporation by tillage	Ammonium-N retained (percent of applied)			
Incorporated immediately	95	95	100	100
After 1 day	70	50	100	100
After 2 days	60	30	100	100
No incorporation	55	20	100	100

Table 3. First year mineralization estimates for organic N in biosolids

Processing	First-year organic N mineralization rate (percent of organic N)
Fresh*	
Anaerobic digestion, liquid or dewatered	30–40
Aerobic digestion, liquid or dewatered	30–40
Drying bed	30–40
Heat-dried	30–40
Lagoon	
Less than 6 months	30–40
6 months to 2 years	20–25
2 to 10 years	10–20
More than 10 years	5–10
Composting	0–10
Blends and soil products	†

*"Fresh" includes all biosolids that have not been stabilized by long-term storage in lagoons or composting.

†Because blends (with woody materials) and soil products that contain biosolids vary widely in composition and age depending on intended use, available N may vary widely among products. For blends, available N can be estimated through laboratory incubation studies.

Table 4. Conversion factors

1%	=	10,000 mg/kg or ppm 20 lb/ton
1 mg/kg	=	1 ppm 0.0001 % 0.002 lb/ton
1 wet ton	=	1 dry ton ÷ (percent solids × 0.01)
1 dry ton	=	1 wet ton × (percent solids × 0.01)
1 acre-inch	=	27,000 gallons

Other considerations for calculations

Small acreage sites without a reliable yield history

Some communities apply biosolids to small acreages managed by part-time farmers. In many of these cases, there is no reliable yield history for the site, and the goal of management is not to make the highest economic returns. You can be sure of maintaining agronomic use of biosolids nitrogen on these sites by applying at a rate substantially below that estimated for maximum yield.

Equipment limitations at low application rates

At some low-rainfall dryland cropping locations east of the Cascades, the agronomic rate calculated with the worksheet will be lower than can be spread with manure spreaders (usually 2 to 3 dry tons per acre). At these locations, you may be able to apply the dewatered biosolids at the equipment limit, but check with your permitting agency for local requirements.

Appendix A: Cumulative loading of trace elements

Under EPA regulations (40 CFR Part 503.13), managers must maintain records on cumulative loading of trace elements only when bulk biosolids do not meet EPA Exceptional Quality Standards for trace elements (Table 5). Contact your regulatory agency for details on record keeping if your biosolids do not meet the standards in Table 5.

Table 5. Trace elements concentration limits for land application

		Concentration limit	
Element	Symbol	Exceptional quality standard (EPA Table 3)* (mg/kg)	Ceiling limit (EPA Table 1)* (mg/kg)
Arsenic	As	41	75
Cadmium	Cd	39	85
Copper	Cu	1,500	4,300
Lead	Pb	300	840
Mercury	Hg	17	57
Molybdenum	Mo	**	75
Nickel	Ni	420	420
Selenium	Se	100	100
Zinc	Zn	2,800	7,500

Source: EPA 40 CFR Part 503

*EPA Table 3 and Table 1 refer to tables in EPA biosolids rule (40 CFR Part 503).

**Molybdenum concentration standard level is under review by the EPA.

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