Technical Support Document

Powder River Basin Bacteria TMDL

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State of Oregon
DEQ Department of Environmental Quality

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1. Introduction

1.1 Document purpose and organization

This draft document provides comprehensive supporting information on technical analyses completed for the Total Maximum Daily Load and Water Quality Management Plan for addressing bacteria impairments in the waters of the Powder River Basin. This document provides explanation of TMDL concepts and analysis and support for conclusions and requirements included in the Powder River Basin TMDL and WQMP, which will be proposed for adoption by Oregon's Environmental Quality Commission, by reference, into rule [OAR 340-042-0090(2) (a) and (b)].

This document is organized into sections with titles reflective of the TMDL elements required by OAR 340-042-0040(4) in the Powder River Basin TMDL for bacteria. This organization is intended to assist readers to readily access the information relied on for TMDL element-specific determinations.

1.2 Overview of TMDL elements

According to OAR 340-042-0030 Definitions (15): Total Maximum Daily Load means a written quantitative plan and analysis for attaining and maintaining water quality standards and includes the elements described in OAR 340-042-0040. Determinations on each element are presented in the Powder River Basin TMDL for Bacteria. Technical and policy information supporting those determinations are presented in this report at the section headings that correspond to the TMDL elements for which complex analysis was undertaken.

In plain language, a TMDL is a water quality budget plan to ensure that the receiving water body can attain water quality standards that protect beneficial uses of the water. This budget calculates and assigns pollutant loads for discharges of point (end of pipe) and non-point (landscape) sources, in consideration of natural background levels, along with determination of a margin of safety and reserve capacity.

A margin of safety takes into account the uncertainty in predicting how well pollutant reductions will result in meeting water quality standards and can be expressed either explicitly, as a portion of the allocations, or implicitly, by incorporating conservative assumptions in the analyses. Reserve capacity sets aside some portion of the loading capacity for use for pollutant discharges that may result from future growth and new or expanded sources.

A key element of analysis is the amount of pollutant that a waterbody can receive and still meet the applicable water quality standard is referred to as the "loading capacity" of a waterbody. Because the loading capacity must not be exceeded by pollutant loads from all existing sources plus the margin of safety and reserve capacity, it can be considered the maximum load. Hence, the loading capacity is often referred to as the TMDL.

Another key element of analysis is allocating portions of the loading capacity or TMDL to known sources. Allocations are quantified measures that assure water quality standards will be met and may distribute the pollutant loads between nonpoint and point sources. "Load allocations" are portions of the loading capacity that are attributed to: 1) non-point sources such as urban, agriculture, rural residential or forestry activities; and 2) natural background sources such as soils or wildlife. “Wasteload allocations” are portions of the total load that are allotted to point sources of pollution, such as permitted discharges from sewage treatment plants, industrial wastewater or stormwater. As noted above, allocations can also be reserved for future uses, termed “reserve capacity.”

This general TMDL concept is represented by the following equation:

$$TMDL = \sum \text{Wasteload Allocations} + \sum \text{Load Allocations} + \text{Reserve Capacity} + \text{Margin of Safety}$$

Together, these elements establish the pollutant loads necessary to meet the applicable water quality standards for impaired pollutants and protect beneficial uses.

2. Location

Per Oregon Administrative Rule 340-042-0040(a), this element describes the geographic area for which the TMDL is developed. This Powder River Basin TMDL covers all freshwater perennial and intermittent streams in the Powder River Basin (HUC6 170502).

The Powder River Basin is one of 20 designated drainage basins in Oregon, with basin-specific water quality standards described in OAR 340-041-0260. The basin forms a portion of the border of Oregon with Idaho and lies mostly within Baker County, with small portions in Union, Wallowa and Malheur Counties, as well as Idaho. The portion of the basin in Oregon drains 3,444 square miles (8,925 km^2). Elevation ranges from 1,640 feet (500 m) above sea level at the junction with the Snake River to 9,563 feet (2,914 m) above sea level in the Wallowa and Elkhorn Mountain ranges in the northeastern portion of the watershed. The average elevation is 4,237 feet (1,291 m) above sea level. As shown in Figure 2.0, the Powder River Basin is comprised of three smaller subbasins that drain to Brownlee Reservoir, which sits on the Oregon-Idaho border and is an impoundment of the Snake River. The entire Powder River Basin falls within the Blue Mountains Level III Ecoregion (Omernik, 1987). A summary of basin characteristics relevant for water quality assessment is compiled in DEQ’s November 2013 Powder Basin Status Report and Action Plan (DEQ 2013), available on DEQ’s website.

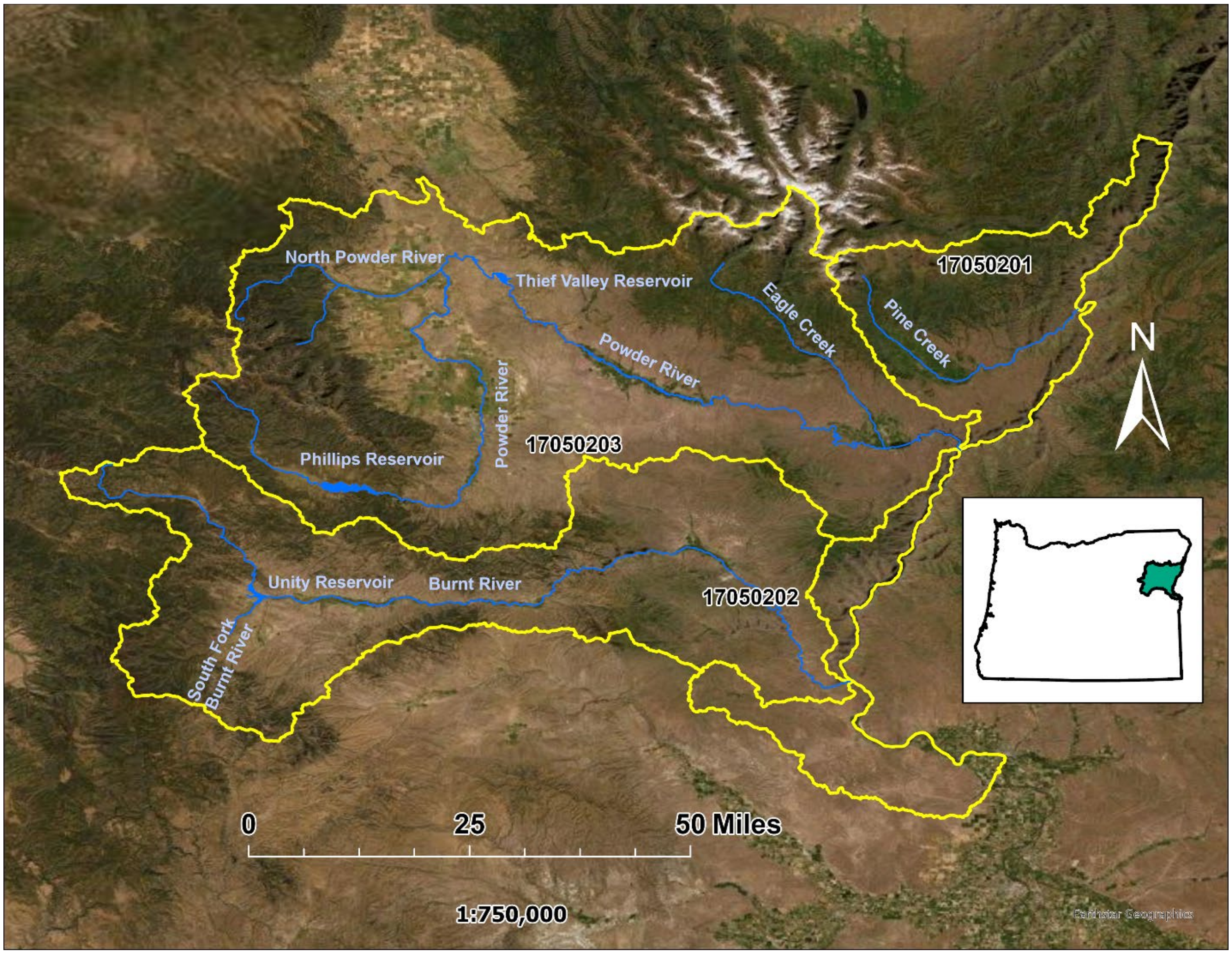

Figure 2.0: The Powder River Basin (HUC 170502), Oregon.

Within the United States Geologic Survey's Hydrologic Unit Code classification system, the Powder River Subbasin is a 6-digit HUC code (170502) comprised of three smaller 8-digit HUC code subbasins as listed in Table 2.0.

Table 2.0: Powder River Subbasins

HUC8 Code	Subbasin Name
17050201	Brownlee Subbasin
17050202	Burnt River Subbasin
17050203	Powder River Subbasin

2.1 Climate

The climate of the Powder Basin is influenced by the Cascade Mountains located approximately 200 miles to the west. This mountain range forms a barrier against the modifying effects of warm, moist fronts from the Pacific Ocean. As a result, the overall climate is classified as Temperate Continental-cool summer phase. Light precipitation, low relative humidity, rapid evaporation, abundant sunshine and wide temperature and precipitation fluctuations are characteristics of this climate. Over the past 30 years (1991 – 2020), the mean annual temperature for the Powder Basin was 45.3°F (7.4°C), with a mean annual minimum temperature of 33.3°F (0.8°C) and a mean annual maximum temperature of 64.9°F (18.3°C).

The majority of annual precipitation falls as snow during winter. Over the past 30 years (1991 – 2020), annual precipitation has averaged 22.0 inches (56.0 cm) across the Powder Basin, with an average of 10.2 inches (25.9 cm) in the valleys and foothills an average of 78.2 inches (198.6 cm) at the highest elevations of the Elkhorn, Wallowa, and Blue Mountains (Daly, et al., 2008). Portions of the basin commonly experience rain-on snow events, which reduce the snow pack and may cause brief localized flooding.

2.2 Hydrology

The major rivers/streams in the Powder River Basin include the Powder River, North Powder River, Burnt River and Pine Creek, as shown in Figure 2. The Burnt River headwaters are located in the southern Blue Mountains near the town of Unity, from there it flows approximately 100 miles east to the Snake River near the town of Huntington. The Powder River has headwater areas in the Elkhorn Mountains west of Baker City near the town of Sumpter, where Cracker Creek and McCully Fork join to form the Powder River. It flows north through the Baker Valley, and then southeast through the Keating Valley and reaches Brownlee Reservoir on the Snake River near the town of Richland. The total length of the Powder River is approximately 144 miles. Major tributaries include the North Powder River and Eagle Creek. The Brownlee Subbasin includes all the streams that drain directly to the Snake River from an area just north of Ontario to the Hells Canyon area just north of the Wallowa County/Baker County line. The largest stream in the Brownlee Subbasin is Pine Creek, which is located in the northern portion of the subbasin near the town of Halfway.

Flow duration intervals based on available flow data for the largest rivers/streams draining each watershed within the Powder River Basin are shown in Figures 2.2a, 2.2b, and 2.2c. DEQ's categories names for flow intervals are explained in Section 4.4. Flow duration intervals in all three watersheds show flows typical of a snowmelt driven hydrologic regime with peak flows in the spring and low flows typically in late summer and fall. However, the highest flows during the periods of record reflect rain on snow events occurring during winter months.

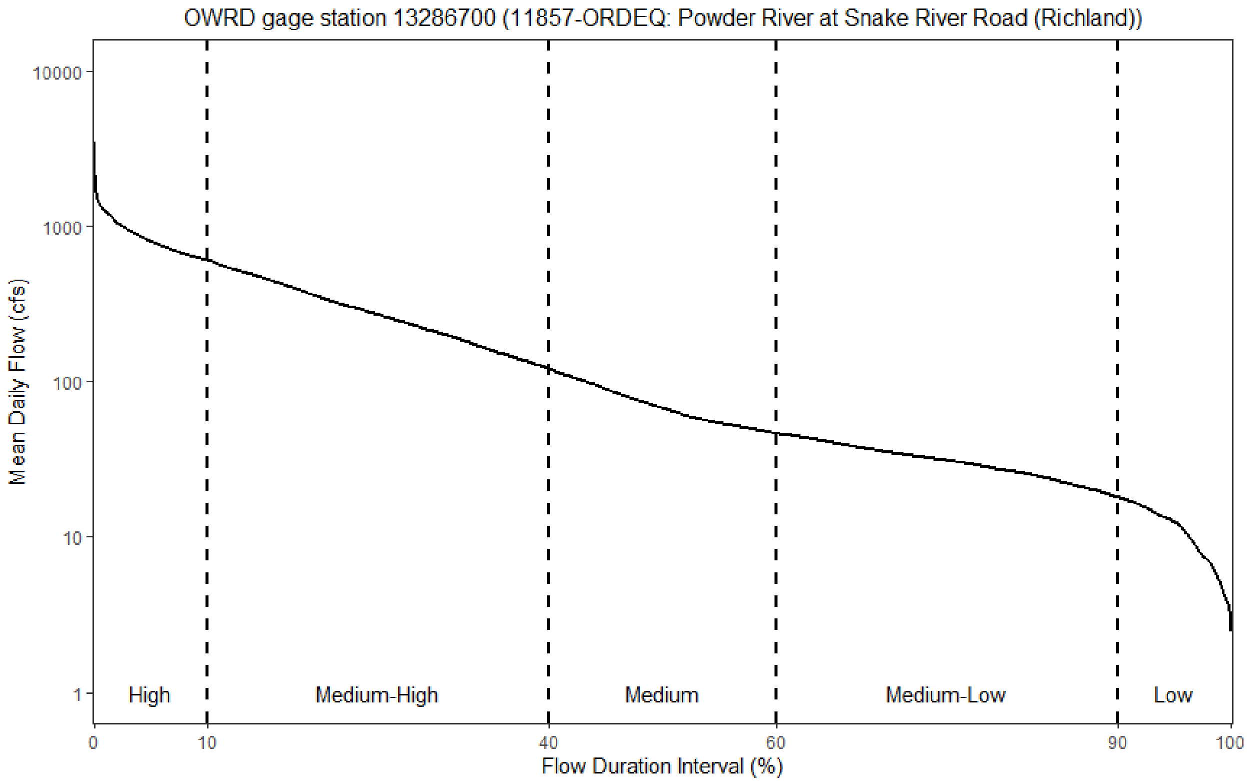

Figure 2.2a: Flow duration intervals for the Powder River

Figure 2.2a represents flows in the Powder Watershed just upstream from the confluence with Brownlee Reservoir based on data from 10/1/1994 to 9/30/2017. Based on DEQ flow categories, low flows in the Powder River just before entering Brownlee Reservoir on the Snake River ranged from 2.5 to 17.8 cfs, medium-low flows ranged from 17.9 to 46.1 cfs, medium flows ranged from 46.2 to 120.0 cfs, medium-high flow ranged from 121.0 to 563.0 cfs, and high flows ranged from 564.0 to 9255.0 cfs from 1994-2017.

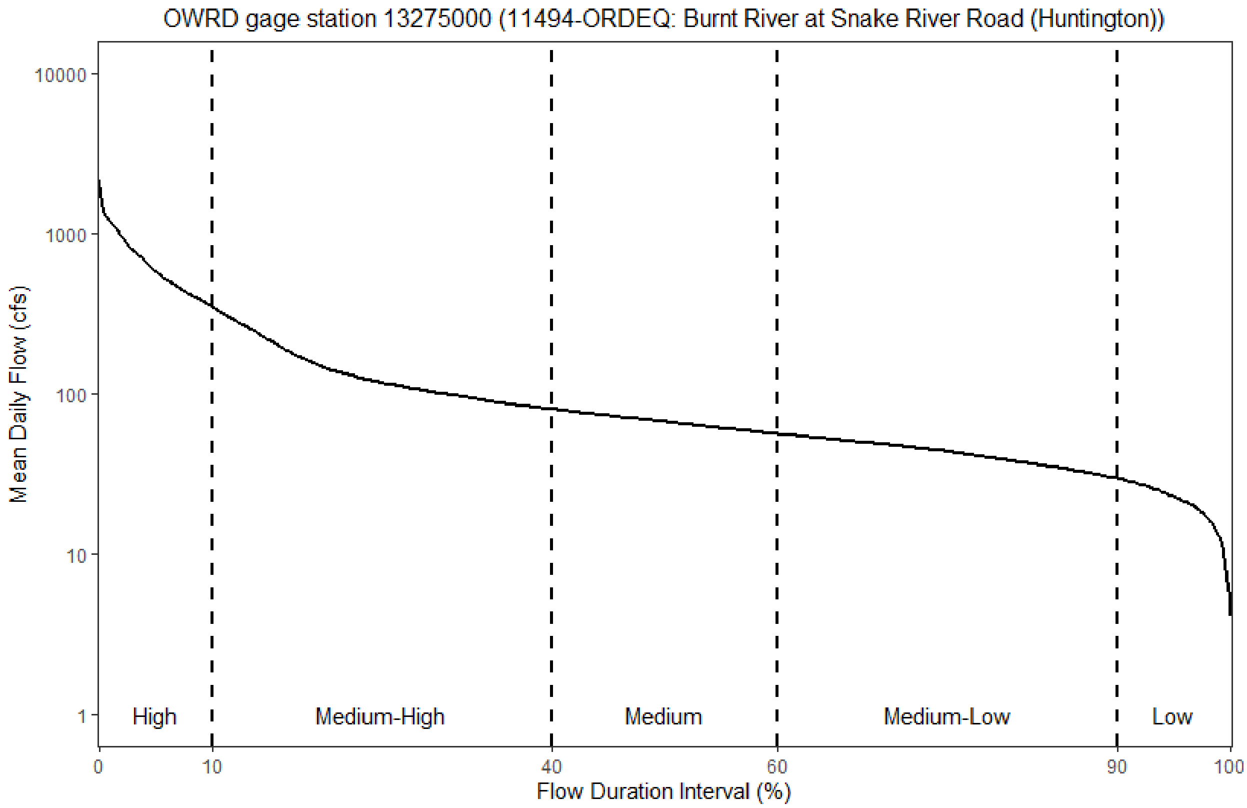

Figure 2.2b: Flow duration intervals for the Burnt River

Figure 2.2b represents flows in the Burnt Watershed just upstream from the confluence with Brownlee Reservoir based on data from 1/1/1990 to 9/30/202017. Low flows in the Burnt River just before entering Brownlee Reservoir on the Snake River ranged from 4.0 to 31.0 cfs, medium-low flows ranged from 31.1 to 58.0 cfs, medium flows ranged from 58.1 to 82.0 cfs, medium-high flow ranged from 82.1 to 304.0 cfs, and high flows ranged from 305.0 to 2180.0 cfs from 1990-2017. Low flows and medium-low flows in the Burnt River are modulated below the City of Huntington by effluent released by the wastewater treatment plant. Upstream of Huntington reflects a similar hydrologic regime to that of the Powder River and Pine Creek.

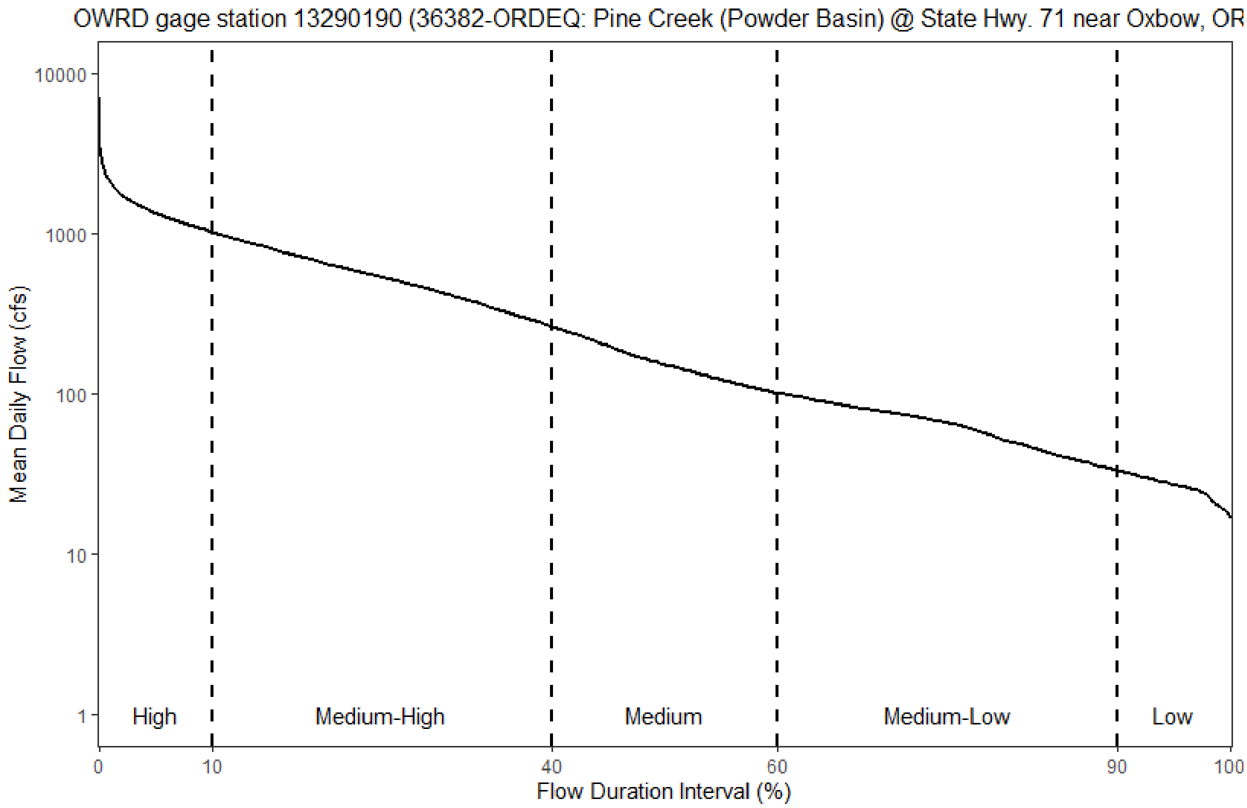

Figure 2.2c: Flow duration intervals for Pine Creek

Figure 2.2c represents flows in the Brownlee Watershed just upstream from the confluence with Brownlee Reservoir based on data from 1/1/1990 to 9/30/2017. Low flows in Pine Creek just before entering Brownlee Reservoir on the Snake River ranged from 10.0 to 34.6 cfs, medium-low flows ranged from 34.7 to 100.0 cfs, medium flows ranged from 101.0 to 250.0 cfs, medium-high flow ranged from 251.0 to 977.0 cfs, and high flows ranged from 978.0 to 7000.0 cfs from 1990-2017.

According to Oregon Water Resources Department records, there are 69 dams with a height over 10 feet in the Powder Basin and most of the water impounded by these reservoirs is used for irrigation. There are three irrigation or water control districts in the Powder Subbasin: Baker Valley Irrigation District, Lower Powder Irrigation District, and Powder Valley Water Control District (divided into the Wolf Creek and Pilcher Creek sub-districts). Irrigation in the Burnt River Subbasin is managed by the Burnt River Irrigation District. There are no formal irrigation or water control districts in the Brownlee Reservoir Subbasin, irrigation is managed by individuals or informal user groups. Available water in the Powder Basin is fully appropriated. In low water years, reservoirs are often drawn down to minimum levels and there is not enough water to supply all users.

There are five reservoirs in the Powder Basin with a storage capacity greater than 5,000 acre-feet. Unity Dam on the Burnt River, and Thief Valley Dam and Mason Dam on the Powder River, were constructed by the U.S. Bureau of Reclamation and are operated by local irrigation districts. Pilcher Creek Dam and Wolf Creek Dam are owned and operated by the Powder Valley Water Control District. These projects are discussed in more detail in following subsections.

2.2.1 Burnt River Irrigation Project

As shown on Figure 2.0, Unity Dam and Reservoir are located on the upper Burnt River about 40 miles southwest of Baker City. Lands served by the irrigation project are scattered along the Burnt River downstream from Unity Reservoir near the towns of Hereford, Bridgeport, Durkee, Weatherby, Dixie, Lime, and Huntington. In addition, some lands upstream from the reservoir are included in the project. Based on 1992 data, 15,070 acres received project water for growing forage crops (approximately 13,670 acres) and cereal crops such as corn and barley.

The Bureau of Reclamation reports that Unity Dam is a zoned earthfill dam 82 feet high and 694 feet long and the maximum reservoir capacity is 25,800 acre-feet with a surface area of 926 acres. Unity Dam was completed in 1937 to take advantage of the existing distribution system and the dam and reservoir have since been operated and maintained by the Burnt River Irrigation District and offer no flood control benefits.

Along with irrigation, Unity Reservoir provides area residents with recreation benefits such as camping, fishing and boating administered by the Oregon State Parks Department.

2.2.2 Baker Irrigation Project

The Upper Division of the Baker Project provides irrigation water from Phillips Reservoir to 18,500 acres of land along both sides of the Powder River just north of Baker City. The Lower Division provides a supplemental water supply from Thief Valley Reservoir to about 7,300 acres of land along the Powder River in the Keating Valley about 10 miles northeast of Baker City. The Bureau of Reclamation reports that Thief Valley Dam is a concrete slab and buttress dam 390 feet long and 73 feet high with a maximum reservoir capacity of 17,600 acre-feet and a surface area of 740 acres. Water stored in Thief Valley Reservoir is released for diversion downstream into existing distribution canals and laterals. The operation of Thief Valley Dam and facilities of the Lower Division were taken over by the Lower Powder River Irrigation District on June 1, 1932.

Mason Dam is a zone earth and rockfill embankment dam, 173 feet high and 895 feet long and impounds the Powder River near Sumpter, OR. Phillips Reservoir has a maximum capacity of 95,500 af and a surface area of 2,235 acres and stored water is released into the Powder River for diversion downstream into existing distribution canals and laterals. Operation and maintenance of Upper Division facilities was transferred to the Baker Valley Irrigation District on August 23, 1968.

2.2.3 Powder Valley Water Control District

The Powder Valley Water Control District owns and operates Wolf Creek and Pilcher Creek Reservoirs, which provide irrigation water to land located in the North Powder and northern Baker valleys in the vicinity of the City of North Powder. Completed in 1974, the reservoir behind Wolf Creek dam is approximately 220 acres in surface area and stores approximately 12,000 acre-feet. Pilcher Creek Reservoir was completed in 1984 and is approximately 222 acres in surface area and stores approximately 5,900 acre-feet. Operated as one pool, Wolf Creek Reservoir usually draws down quicker than Pilcher Creek Reservoir, so to balance out the system, water is transferred via a canal between the Wolf Creek and Pilcher Creek reservoirs. Additional water from Pilcher Creek Reservoir is also put instream via the North Powder River for irrigation both to the north and south of the river. Due to the connectivity of the system, the project is often referred to as the Wolf Creek Reservoir Complex.

2.3 Land Use

As shown in Figure 2.3a and summarized in Table 2.3, the largest percentage of land use/land cover in the basin as of 2019 (Dewitz & USGS, 2021) is scrub-shrub, followed by forest and grasslands; developed urban areas are minimal, with the largest being Baker City (population approximately 9,700), located near the center of the basin; and private and federal ownership are about equal and dominant. Areas of irrigated agriculture are found in the along the Burnt River, the Baker Valley north of Baker City, the Keating Valley, near Richland and in the Pine Valley near Halfway. Grassland/shrub areas are located in the plains and foothill areas, and forested areas are concentrated in the mountains.

Table 2.3: National Land Cover Database classes and percentages in the Powder River Basin in 2019

NLCD Land Cover Class	Acres	Percent of the basin
Shrub/Scrub	1016650	46.1
Evergreen Forest	593939	26.9
Herbaceous	366166	16.6
Hay/Pasture	78513	3.6
Cultivated Crops	65532	3.0
Developed, Open Space	24548	1.1
Emergent Herbaceous Wetlands	20737	0.9
Open Water	13869	0.6
Barren Land	7770	0.4
Developed, Low Intensity	6675	0.3
Woody Wetlands	5871	0.3
Developed, Medium Intensity	3527	0.2
Developed, High Intensity	215	<0.1
Deciduous Forest	103	<0.1
Mixed Forest	45	<0.1
Total:	**2204160**	**100.0**

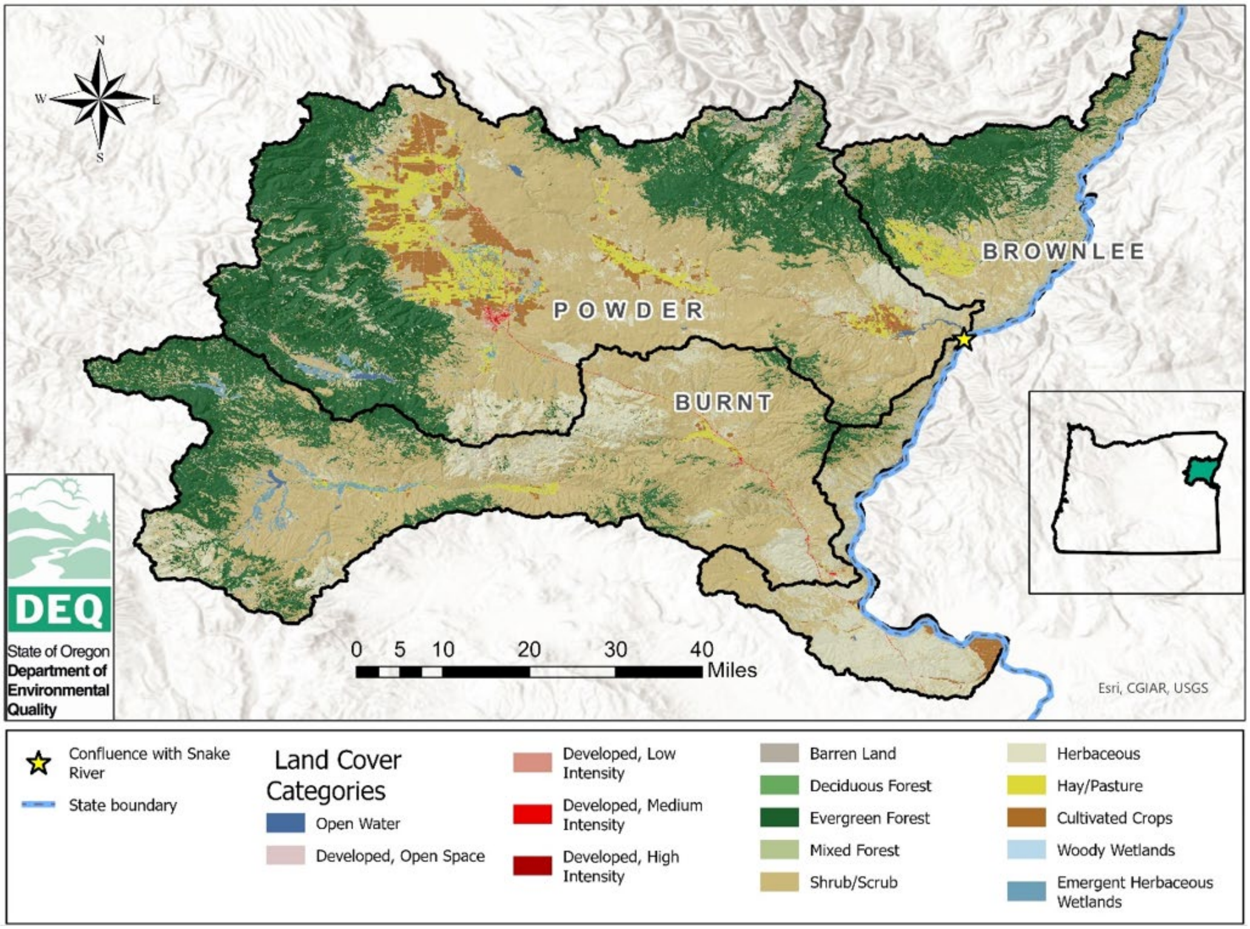

Figure 2.3a: 2019 National Land Cover Database Land Cover Classes in the Powder River Basin.

2.4 Geology and Soils

The soils and geology of the Powder River Basin represent a complex history of basalt flows, uplift of continental material, sedimentary formations, glaciation and deposition of alluvium (Walker & MacLeod, 1991). As shown in Figure 2.4a, mountain ranges and upland areas consist of various igneous and metamorphic formations and lowland valleys largely consist of sedimentary and unconsolidated rocks. Agriculture, urban and rural residential development largely occurs in the low-relief areas underlain by sedimentary and unconsolidated formations (Figures 2.3a and 2.4a).

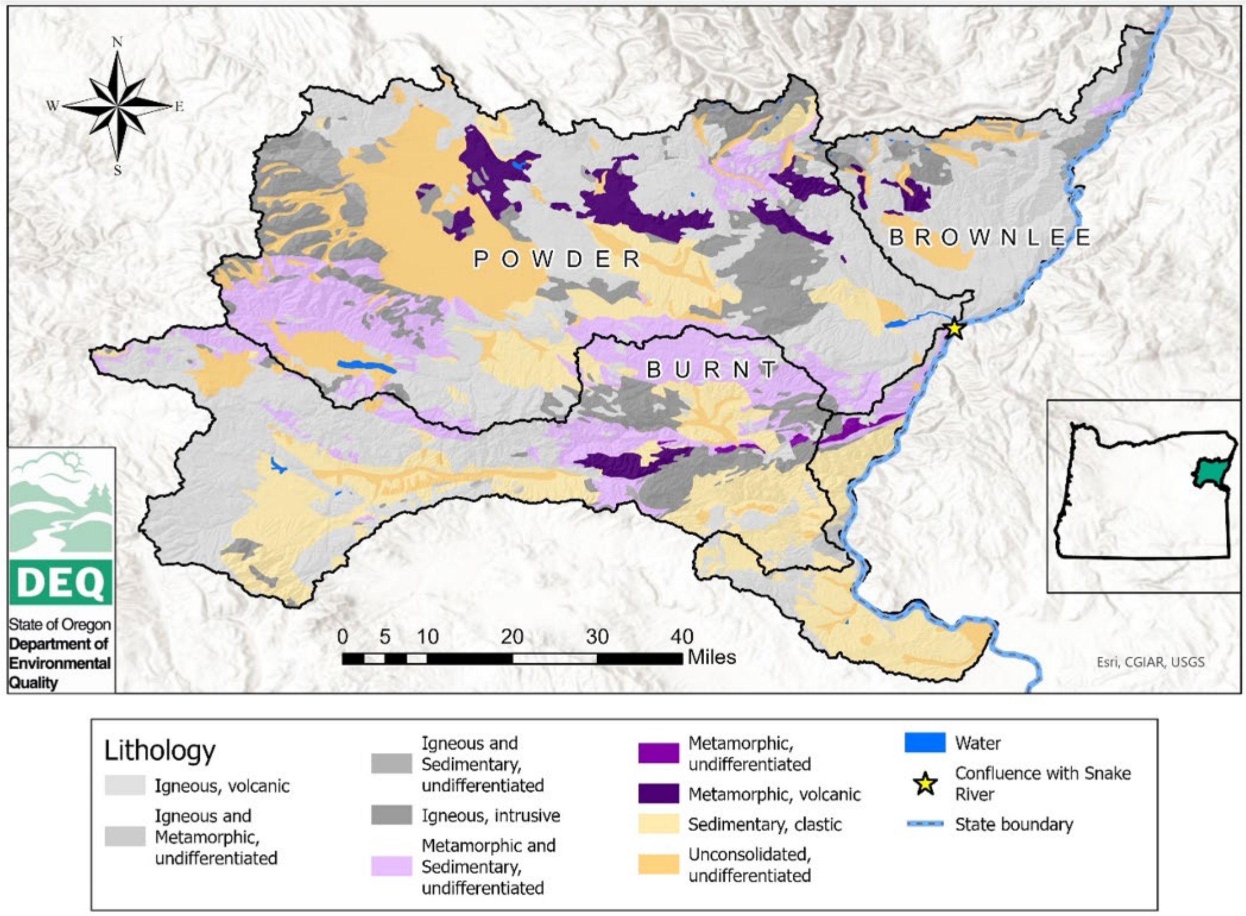

Figure 2.4a: Lithology of the Powder River Basin

Surface and shallow subsurface runoff transport fecal bacteria into surface waters in these subbasins. Flow over the soil surface occurs when the precipitation rate is higher than the infiltration rate of the underlying soil; subsurface flow occurs when the reverse occurs. Moisture, temperature and organic matter content all can influence bacterial transport in overland and subsurface flow.

The Powder River Basin contains 767 soil series, according to the 2017 SSURGO/STATSGO2 database from the USDA NRCS (NRCS, 2022). Translating these soils into USDA NRCS Hydrologic Groups shows the portions of the basin susceptible to overland runoff versus portions where water infiltration dominates (Figure 2.4b). Much of the basin is characterized by soils with moderately high to high runoff potential. Soils with the highest runoff potentials tend to be found in the lower portions of the Powder watershed and the divide between the Powder and Burnt watersheds (Figure 2.4b). Soils with the lowest runoff potentials (and hence highest infiltration rates) tend to be found north of Baker City in the Baker Valley (Figure 2.4b).

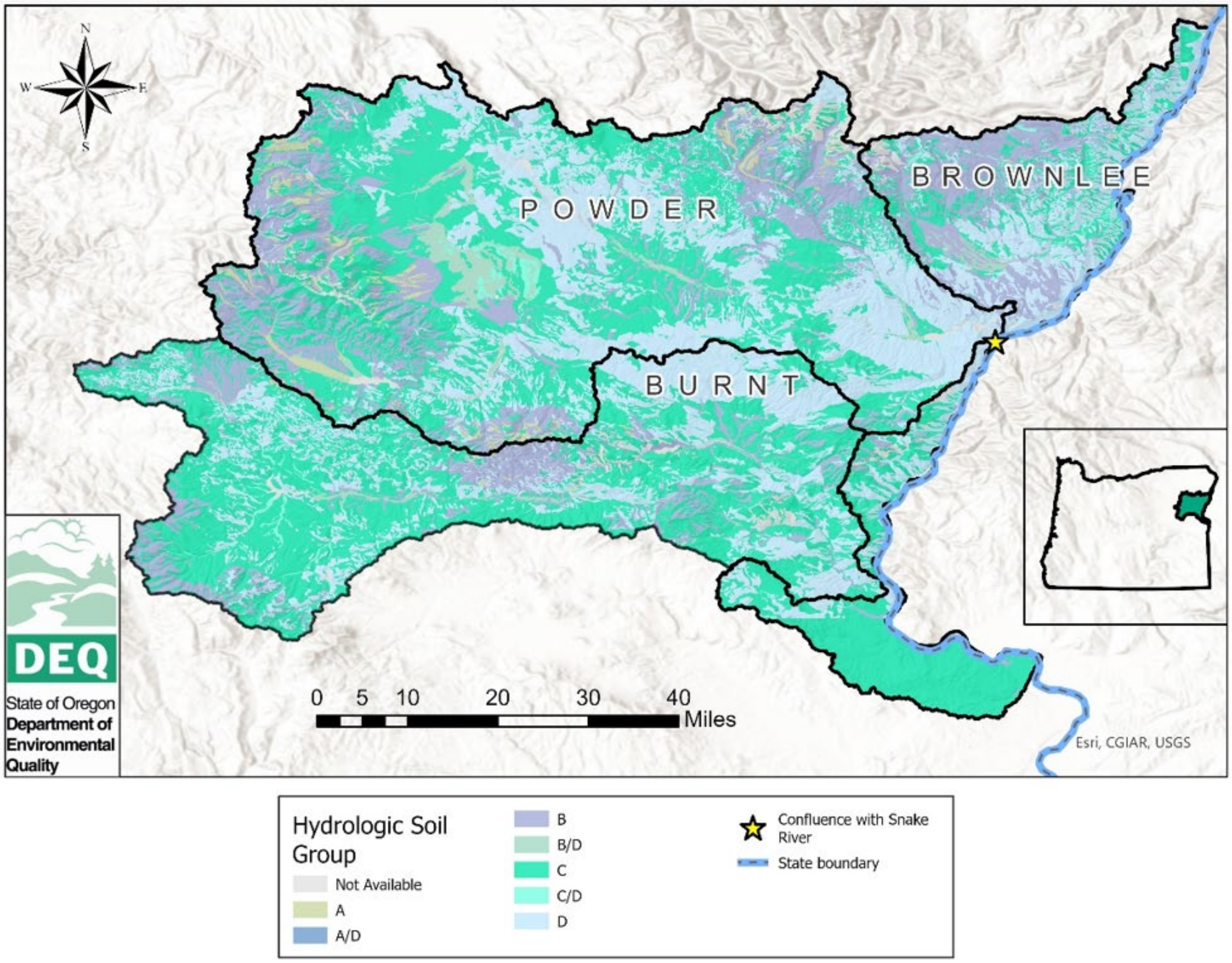

Figure 2.4b: Hydrologic Soils Groups in the Powder River Basin

3. Bacteria water quality standards and beneficial uses

Fecal indicator bacteria are used as a surrogate for potential fecal pathogen contamination in waterbodies. In Oregon freshwaters, the primary fecal indicator bacteria is *Escherichia coli* (abbreviated as *E. coli*). Fecal contamination of waterbodies originates from both point and nonpoint sources containing feces from humans, domestic animals and wildlife. Examples of point sources include: wastewater treatment plants, stormwater conveyance systems, and combined sewer overflows. Nonpoint sources of fecal contamination include: direct deposition of livestock or wildlife fecal matter into streams or reservoirs; and surface runoff that contacts pastures used by livestock and/or wildlife or failing on-site septic systems.

Recreational use of fecal contaminated waters could lead to mild to severe illnesses in humans. Recreational use includes swimming, but also any activity that could result in ingestion of water, such as fishing through contact of hands with water, any water sports or children playing along the banks or shores. Water with high levels of fecal bacteria can also pose a disease risk to livestock and wildlife, such as Johne's disease (caused by the ingestion of *Mycobacterium avium spp.*). Fecal contamination of irrigation water can also raise the risk of *Listeria monocytogenese* in fresh produce crops (Weller, Wiedmann, & Strawn, 2015).

Irrigation and livestock watering sources are designated beneficial uses, but are not the main ones addressed in this TMDL. The most sensitive beneficial use addressed directly in this TMDL is water contact recreation with respect to potential pathogenic exposure from fecal material.

Table 3.0 presents stream and watershed assessment units within the Powder River Basin that were listed as impaired for bacteria on DEQ's 2022 Clean Water Act Section 303(d) List (as part of DEQ's Integrated Report), which was approved by EPA on September 1, 2022. Status category designations are prescribed by Sections 305(b) and 303(d) of the Clean Water Act and are summarized as follows: Category 5 – available data indicate that at least one designated use is not being supported or is threatened and a TMDL is needed; Category 4 – available data indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed (4a – a TMDL is in place, 4b – other required control measures are expected to result in attainment, 4c – non-attainment is not caused by a pollutant); Category 3 – there is insufficient data to make a designated use support determination; Category 2 – available data indicate that some, but not all designated uses are supported; Category 1 – all designated uses are support, no use is threatened (USEPA, 2023). DEQ does not use Category 1 designations.

For the freshwater AU identified as impaired for fecal coliform (OR_SR_1705020302_05_102815) in Table 3.1, DEQ reviewed the applicability of the Section 303d status for fecal coliform. Based on the 2018/2020 Integrated Report methodology and the 2016 revisions to Oregon's Bacteria Standards – OAR 340-041-0009, DEQ concluded that identifying this AU as impaired for fecal coliform is a legacy of the prior bacteria standard combined with EPA's additions to Oregon's Section 303d list in 2010. DEQ's Standards and Assessment Program confirmed that (a) fecal coliform is not the applicable criterion for the designated freshwater beneficial use (A. Borok, personal communication) and (b) since sufficient *E. coli* data is available for assessment in these freshwater AUs, that information supersedes the legacy fecal coliform Section 303d listings for fecal coliform and these will be removed in the 2024 Integrated Report cycle (L. Merrick, personal communication). Since *E. coli* data was used in the 2018-2020 and 2022 assessments and Integrated Reports to determine water quality status for bacteria this AU, the Section 303d listings for fecal coliform (Table 3.1) is not addressed in the Powder River Basin bacteria TMDL.

For the watershed unit OR_WS_170502010101_05_103097, identified as Category 4A for *E. coli* in Table 3.1, DEQ determined that this Moores Hollow AU was improperly associated with the Malheur Basin bacteria TMDL for the 2022 Integrated Report listing. Because this unit was not addressed by the Malheur TMDL, it should have been listed as Categorgy 5. As such, DEQ included this unit in the Powder River Basin bacteria TMDL. Although data limitations prevented development of flow duration curves for this unit, it is reasonable to apply the results of nearby analyses, such that the allocations will also apply to the Moores Hollow unit. Thus, DEQ will correct the TMDL associated with this unit in the 2024 Integrated Report, and it will remain as Category 4A.

Table 3.0: Powder River Basin bacteria assessment units and status on 2022 Integrated Report

Waterbody	Assessment Unit	AU Description	Pollutant	Listing Category
Powder River	OR_SR_1705020302_05_102815	Phillips Res. To Sutton Cr.	Fecal Coliform	5
North Powder River	OR_SR_1705020305_05_102817	Anthony Cr. to Powder R.	*E. coli*	5
Powder River	OR_SR_1705020309_05_102829	Goose Cr. to Eagle Cr.	*E. coli*	5
Eagle Creek	OR_SR_1705020310_05_102830	Two Color Cr. to Powder R.	*E. coli*	5
South Fork Burnt River	OR_SR_1705020202_05_103265	Whited Res. To Unity Res.	*E. coli*	5
Burnt River	OR_SR_1705020205_05_102805	Indian Cr. to Marble Cr.	*E. coli*	5
HUC 12: Middle Fork Burnt River	OR_WS_170502020107_05_103118	1st through 4th order streams	*E. coli*	5
HUC 12: Moores Hollow	OR_WS_170502010101_05_103097	1st through 4th order streams	*E. coli*	4A
Powder River	OR_SR_1705020306_05_102821	Thief Valley Reservoir to Big Creek	*E. coli*	3
Unity Reservoir	OR_LK_1705020201_05_100584	Lake/Reservoir Unit	*E. coli*	2
Phillips Lake	OR_LK_1705020301_05_100588	Lake/Reservoir Unit	*E. coli*	2
Thief Valley Reservoir	OR_LK_1705020306_05_100597	Lake/Reservoir Unit	*E. coli*	2
Brownlee Reservoir	OR_LK_1705020311_05_100605	Lake/Reservoir Unit	*E. coli*	2
Pine Creek	OR_SR_1705020106_05_102790	West Fork Pine Creek to Dry Creek	*E. coli*	2
Pine Creek	OR_SR_1705020106_05_102793	North Pine Creek to confluence with Snake River	*E. coli*	2
Burnt River	OR_SR_1705020204_05_102803	Unity Reservoir to Indian Creek	*E. coli*	2
Burnt River	OR_SR_1705020208_05_102810	Durkee Creek to confluence with Snake River	*E. coli*	2
Dixie Creek	OR_SR_1705020208_05_102811	Thornton Gulch to confluence with Burnt River	*E. coli*	2
Powder River	OR_SR_1705020301_05_102814	McCully Fork to Phillips Lake	*E. coli*	2
Powder River	OR_SR_1705020302_05_102815	Phillips Lake to Sutton Creek	*E. coli*	2
Powder River	OR_SR_1705020303_05_102816	Sutton Cr. to Old Settlers Slough	*E. coli*	2
Powder River	OR_SR_1705020304_05_102818	Old Settlers Slough to North Powder River	*E. coli*	2
Powder River	OR_SR_1705020308_05_102826	Big Creek to Goose Creek	*E. coli*	2
HUC12 Name: West Fork Burnt River	OR_WS_170502020106_05_103117	Watershed Unit (1st through 4th order streams)	*E. coli*	2

4. Water Quality Data Evaluation and Analyses

4.1 Analysis Overview

An overview of the analyses undertaken is presented in Figure 4.1 and detailed information is presented in sections that follow in the order of flow noted in the schematic.

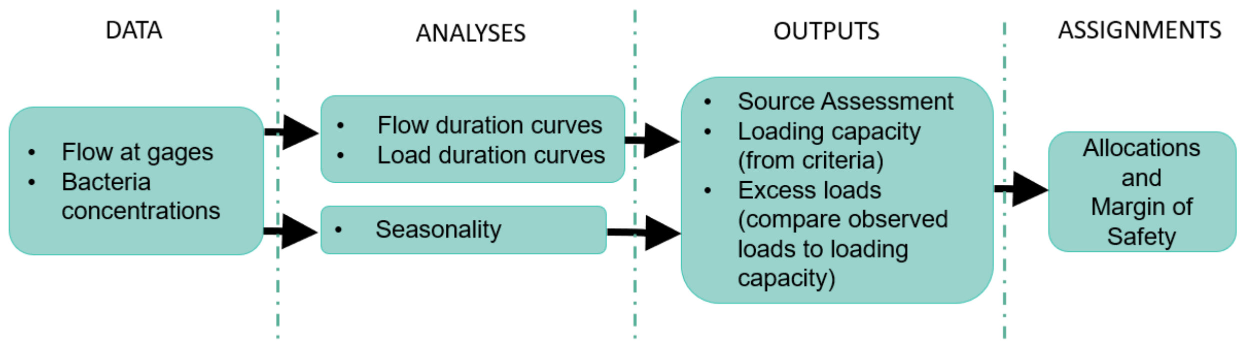

Figure 4.1: Powder River Basin bacteria analysis overview

EPA used the data from sources described below to develop load duration curves to provide information on current bacteria loads and loading capacities within the basin, for DEQ to develop the TMDL, assign allocations and determine the needed management approaches (EPA 2019).

4.2 Description of waterway reaches evaluated

DEQ directly excerpted EPA's description of reaches for load duration curve analysis from EPA's technical memorandum (EPA 2019).

As shown in Figure 4.2, the Burnt River is a tributary to Snake River. It is fed by Middle Fork Burnt River and South Fork Burnt River just upstream of Unity Lake. Three load duration curves have been developed for points along Burnt River, which is listed as impaired from RM 0 to 45.1. Segments of Middle Fork Burnt River (RM 0 to 11) and South Fork Burnt River (RM 0 to 11.5) are also listed as impaired. There are ODEQ monitoring stations for both of those segments, but no flow data.

- Burnt River (RM 0) – confluence with the Snake River; Huntington, OR
- Burnt River (RM 45) – intersection with Clark Creek Rd.; near Bridgeport, OR
- Burnt River (RM 77) – Unity Dam
- Middle Fork and South Fork Burnt River (*Load duration curves were not developed for these, as there was not enough flow data.)

The Powder River is also a tributary to Snake River (Figure 3.2). It joins Snake River north of Burnt River. Three load duration curves have been developed for points along Powder River, which is listed as impaired from RM 0 to 130. The tributaries to Powder River for this project are

Eagle Creek and North Powder River. Eagle Creek is listed as impaired from RM 0 to 21.1 and one load duration curve has been developed for it. Two load duration curves have been developed for North Powder River, which is listed as impaired from RM 1 to 24.3.

- Powder River (RM 130) – above Phillips Reservoir
- Powder River – at Baker City, OR
- Powder River (RM 22) – near Richland, OR
- Eagle Creek – near confluence with the Powder River; near Richland, OR
- North Powder River – intersection with Miller Road
- North Powder River – intersection with Hwy 30

Pine Creek is a tributary to Snake River north of Powder River's confluence with Snake River. A load duration curve was developed for this water to demonstrate what the measurements look like for a non-impaired waterbody. It is a good example of an area with significant cattle use that has low levels of bacteria.

- Pine Creek – intersection with Hwy 71

As noted in Section 3.1, the Catergoy 4A listing shown on Figure 4.2 for the Moores Hollow watershed assessment should be Category 5 and is being addressed by this TMDL.

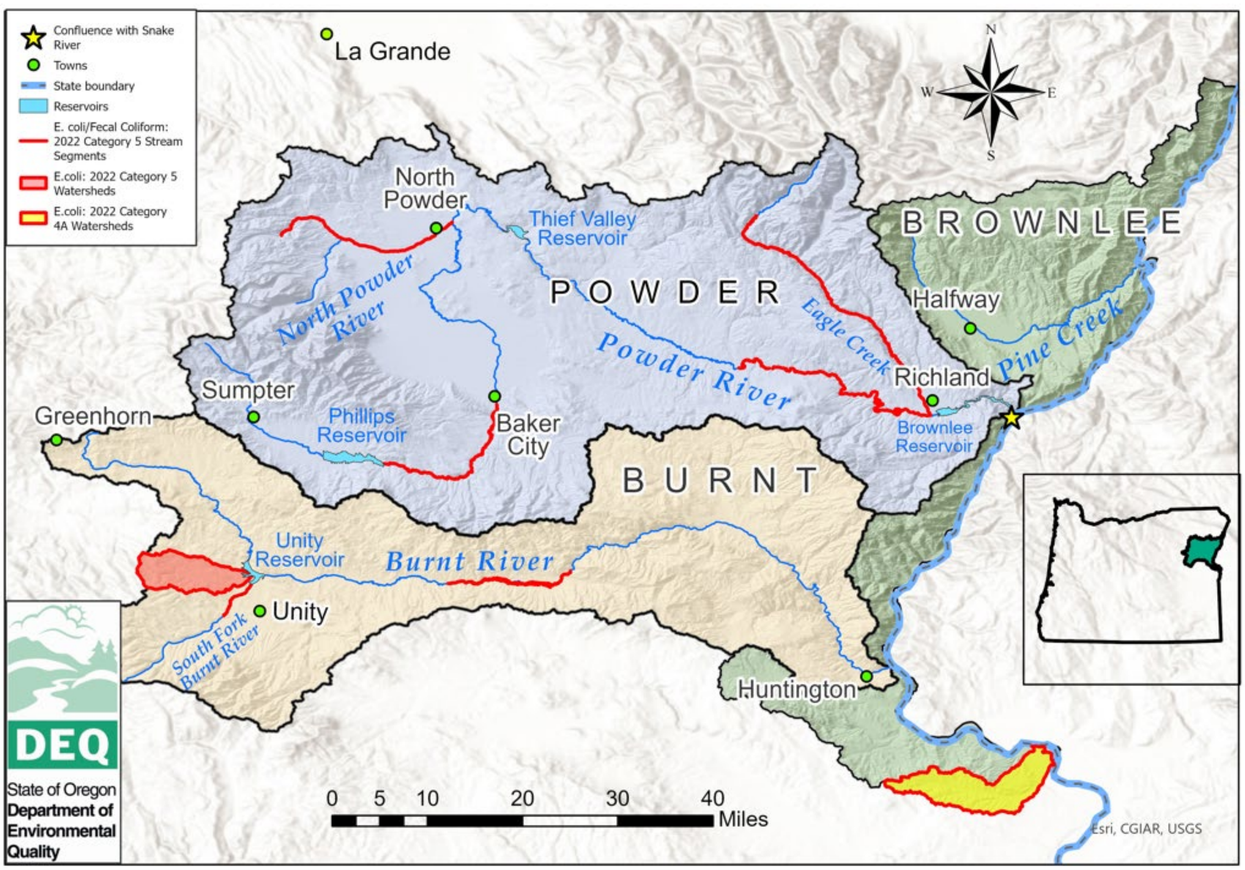

Figure 4.2: Bacteria (*E. coli*/fecal coliform) impairments in the Powder River Basin.

4.3 Data

The water quality monitoring stations where bacteria data were collected and the associated flow monitoring stations are presented in Tables 4.3a, 4.3b and 4.3c. DEQ data collection followed the protocols documented in the Sampling and Analysis Plan governing Oregon's Ambient Monitoring program (DEQ 2016) and the Powder/Burnt Quality Assurance Project Plan and amendments (DEQ 2007-2013) that were filed with and approved by DEQ's Laboroatory and are available on DEQ's website. Details below about the bacteria and flow data are excerpted directly from EPA's technical memorandum (EPA 2019).

Bacteria:
The source of *E. coli* data came entering from DEQ Water Quality Monitoring Stations and consisted of:

- Data collected 2007 (start of TMDL monitoring) and later
- Data collected in MPN (most probable number) per 100 mL. Oregon's Water Quality Standards (WQS) define the bacteria criteria in terms of organisms per 100 mL. It is appropriate to use data collected in terms of MPN in comparison to these criteria because MPN is a probabilistic estimate of the number of organisms.

Flow:
Sources of flow monitoring data in the Powder River Basin include:

  - Idaho Power (2023)
  - Oregon Water Resources Department (2023)
  - U.S. Bureau of Reclamation (2023)
- All available data from January 1, 1990 thru Sept 30, 2017 was used.
  - *Note*: An exception to this was for the flow gage for Burnt River at Huntington (13275000). The record from 1990 to 2000 had several long periods of zero flow, and it was difficult to discern if this was meant to be marked as 'no measurement' or if it truly was zero for those periods. Thus, only data from the year 2000 and onward was used for the load duration curve developed using data from this gage.
  - The period of record for each gage consisted of at least 10 years of data; thus, the flow data used to develop the load duration curves should capture the variability present for each location.
- Flow units are the stream daily average discharge in cfs.
- Period of record for each gage:
  - Burnt River below Unity Dam (UNY) - 1/1/1990 – 9/30/2017
  - Burnt River above Clarks Creek (13274020) - 3/14/2007 – 9/30/2017
  - Burnt River at Huntington (13275000) - 10/2/2000 – 9/30/2017
  - Eagle Creek near Richland (13288300) - 4/16/1999 – 9/30/2017
  - North Powder River at Miller Road (13282550) - 5/22/1999 – 9/30/2017
  - Powder River above Phillips Reservoir (PRHO) - 1/1/1990 – 9/30/2017
  - Mason Dam and Phillips Lake near Sumpter (PHL) - 1/1/1990-9/30-2017
  - Powder River at Baker City (PWDO) - 1/1/1990 – 9/30/2017
  - Powder River near Richland (PRRO) - 1/1/1990 – 8/29/2017
  - Pine Creek near Oxbow (13290190) - 1/1/1990 – 9/30/2017

Assumptions

- Irrigation diversions were not factored into calculations.

- Where present, estimated values were used for bacteria data (Burnt R. @ Huntington (11494) & Powder R. @ Baker (11490)).
- Where present, approximate values were used for bacteria data. For “<1,” “1” was used in calculations. For “>#,” the number value was used in calculations.
- Duplicate samples were collected for some of the bacteria data. To eliminate samples taken on the same date, one value was randomly selected to be eliminated. In some cases, this random selection may have eliminated exceedances of the water quality criteria.
- Some days did not have any flow reported, so those flow data were removed from calculations, under the assumption that flow was not collected on those days.
- The North Powder River at Hwy 30 monitoring station is approximately 6 miles downstream of the North Powder River at Miller Road flow gage, which was used for that load duration curve.
- One flow gage (13282550, N. Powder River @ Miller Rd.) presented a sharp drop off nearing zero flow between the 99-100th percentile. The point isn’t captured on the load duration chart because it is way below the next lowest point. Because of this, the 100th percentile was excluded from the calculation of the TMDL loading capacity for the low flow interval on the load duration curve. When the 100th percentile was included in the calculations, the resulting log mean was skewed disproportionally lower. Load reductions would have been required, even though the monitored values never exceeded the loading capacity on the particular day they were collected. With the 100th percentile included, the loading capacity (as a log mean of the flow interval) would be 2.79 billion organisms per day, requiring a 64% reduction. With the 100th percentile excluded, the loading capacity would be 12.54 billion organisms per day, requiring zero reduction from existing conditions. For this flow gage, the 90-99th percentile is much more representative of loading capacity of the low flow interval most of the time.

Table 4.3a: Burnt River water quality monitoring stations and associated flow data

Waterbody Information		**Water Quality Monitoring Station**	**Flow Gage**
Water Body	**Burnt River**	**36195**	**UNY** (USBR)
Basin Name	Middle Snake-Powder	Burnt @ Unity Dam	Burnt R. below Unity Dam; RM 77
Subbasin	Burnt		
4th Field HUC	17050202	**34256**	**13274020** (IPC)
Record ID	24356 & 13675	Burnt River @ Clark Cr. Road	Burnt River above Clarks Cr. Near Bridgeport, OR; RM 45
LLID	1172299443641		
River Miles	0 to 45.1	**11494**	**13275000** (IPC)
Segment Miles	45.1	Burnt River @ Huntington	Burnt River @ Huntington (mouth); RM 0
Water Body	**Middle Fork Burnt River**		
Basin Name	Middle Snake-Powder		
Subbasin	Burnt		
4th Field HUC	17050202	**36197**	*no flow gage*
Record ID	24377 & 24378	Middle Fork Burnt	
LLID	1181965445059		
River Miles	0 to 11		
Segment Miles	11		

Waterbody Information		Water Quality Monitoring Station	Flow Gage
Water Body	**South Fork Burnt River**		
Basin Name	Middle Snake-Powder		
Subbasin	Burnt		
4th Field HUC	17050202	**36196**	*no flow gage*
Record ID	24374 & 24375	South Fork Burnt	
LLID	1181903445029		
River Miles	0 to 11.5		
Segment Miles	11.5		
Notes: USBR = US Bureau of Reclamation, IPC = Idaho Power Company			

Table 4.3b: Eagle Creek and Powder River water quality monitoring stations and associated flow data

Waterbody Information		Water Quality Monitoring Station	Flow Gage
Water Body	**Eagle Creek**		
Basin Name	Middle Snake-Powder		
Subbasin	Powder		
4th Field HUC	17050203	**36193**	**13288300** (IPC)
Record ID	24355	Eagle Creek near Richland	Eagle Cr. near Richland (mouth)
LLID	1171699447463		
River Miles	0 to 21.1		
Segment Miles	21.1		
Water Body	**North Powder River**		
Basin Name	Middle Snake-Powder	**36192**	**13282550** (OWRD)
Subbasin	Powder	North Powder @ Miller Rd.	North Powder R. @ Miller Rd.
4th Field HUC	17050203		
Record ID	24365 & 24366	**36191**	**13282550** (OWRD)
LLID	1178956450385	North Powder @ Hwy 30	North Powder R. @ Miller Rd.
River Miles	0 to 24.3		
Segment Miles	24.3		
		34250	**PRHO** (USBR)
Water Body	**Powder River**	Powder River above Phillips Reservoir	Powder River above Phillips Reservoir
Basin Name	Middle Snake-Powder		
Subbasin	Powder	**26601**	**PHL** (USBR)
4th Field HUC	17050203	Powder River at Mason Dam	Mason Dam and Phillips Lake near Sumpter, OR
Record ID	24346 & 24347		
LLID	1170508447455	**11490**	**PWDO** (USBR)
River Miles	0 to 130	Powder River @ Baker City	Powder River @ Baker City
Segment Miles	130		
		11857	**PRRO** (USBR)

Waterbody Information		Water Quality Monitoring Station	Flow Gage
		Powder River at Snake River Rd (Richland)	Powder River at Snake River Rd (Richland)
Notes: USBR = US Bureau of Reclamation, OWRD = OR Water Resources Department			

Table 4.3b: Pine Creek water quality monitoring stations and associated flow data

Waterbody Information		Water Quality Monitoring Station	Flow Gage
Water Body	**Pine Creek**	**36382**	**13290190** (IPC)
		Pine Creek @ Hwy 71	Pine Cr. near Oxbow (mouth); RM 0
Notes: IPC = Idaho Power Company			

4.4 Flow Categories

DEQ uses the flow category names represented in Table 4.4 to be consistent in all TMDLs beginning in 2022 and for clarity in communicating with the TMDL implementers and the public. The exceedance probability ranges describe flow duration intervals and are consistent with groupings in EPA's Load Duration Curve Guidance referred to respectively as: Low Flows; Dry Conditions; Mid-Range Flows; Moist Conditions; and High Flows (EPA 2007). DEQ's flow categories were also informed by flow regimes described in the US Geological Survey report on a regression-based method for predicting flow-duration curves, and roughly coincide with USGS' nonexceedance probability ranges: Low Flow (0.02%-10%); Medium Flow (20%-90%); and High Flow (95%-99.98%) (Russell et al. 2018). Table 4.4 includes a column of flow categories EPA used in the Powder River Basin analyses and the DEQ flow categories they correspond to. DEQ converted all flow duration curves evaluated in the DEQ categories.

Table 4.4: Flow Categories

DEQ Flow Category	EPA Flow Category	Exceedance Probability	Hydrologic Description
Low	Low	90%-100%	Watershed soils dry, may be drought conditions, storage empty, channel levels near or below lowest (7Q10) flow, long dry and warm periods between weather events, entirely groundwater return flow as source to stream flow
Medium-Low	Dry	60%-90%	Watershed soils much below saturated, storage empty, channels much less than bank-full, extended dry periods between weather events, some shallow subsurface, but mainly groundwater return flow as source to stream flow
Medium	Typical	40%-60%	watershed soils partially saturated, storage almost empty, channels less than bank-full, typical size storms or snow melt events, surface, shallow subsurface and groundwater return flow as source to stream flow
Medium-High	Transitional	10%-40%	watershed soils partially saturated, storage partially full, channels near bank-full, moderate size storms or snow melt events, mainly surface or shallow subsurface flow as source to stream flow
High	High	0%-10%	watershed soils completely saturated, storage near capacity, channels at or near flood stages, large storms or snow melt events, mainly surface or shallow subsurface flow as source to stream flow

4.5 Bacteria load duration curves

4.5.1 Calculation of load duration curves

DEQ excerpted EPA's explanation of how load duration curves were calculated directly from EPA's technical memorandum (EPA 2019). Load duration curves for the Powder River Basin are presented below as Figures 4.5.1a through 4.5.1j.

All load duration curves were calculated using Microsoft Excel. The steps to do so are listed below.

1. Calculate the flow at each flow percentile. This was done by using the PERCENTILE function in Excel for the entire flow period of record to calculate the flow at each percentile interval. The intervals are 0, 1, 5, 10 … [continue every 5] … 95, 99, 100.

2. Calculate the acceptable load for each flow percentile interval. This becomes the load duration curve. The equation for calculating the load is:

   LOAD = (86,400*28,316.85*FLOW [cfs] * CRITERION [org/100 mL])/100

   Two water quality criteria, from Oregon's Administrative Rule 340-041-0009, are used to develop two curves:
   a. Single sample criterion of 406 organisms/100 mL
   b. 90-day log mean criterion of 126 organisms/100 mL

3. The load duration curve is divided into five flow regimes:

a. High flows (0^{th} – 9^{th} percentile)
b. Transitional flows (10^{th} – 39^{th} percentile)
c. Typical flows (40^{th} – 59^{th} percentile)
d. Dry flows (60^{th} – 89^{th} percentile)
e. Low flows (90^{th} – 100^{th} percentile)

4. For each measured data point, calculate the observed load. This is done by using the measured flow for the day the bacteria sample was collected. The equation for calculating the load is:

   LOAD = (86,400*28,316.85*FLOW [cfs] * BACTERIA CONC. [org/100 mL])/100

5. Measured bacteria loads are shown in two ways:
   a. By season:
      i. Spring (Mar – May)
      ii. Summer (Jun – Aug)
      iii. Fall (Sep – Nov)
      iv. Winter (Dec – Feb)
   b. By irrigation season:
      i. Irrigation (May – Oct)
      ii. Non-irrigation (Nov – Apr)

6. Calculate TMDL components:
   a. TMDL loading capacity (to meet the 126 org/100 mL log mean criterion) = log mean of each flow group
   b. Margin of Safety (MOS) = 10% of the loading capacity
   c. The Wasteload Allocation (WLA) is equal to zero.
   d. Load Allocation (LA) = TMDL – MOS – WLA

7. Calculate the percent reductions:
   a. For the log mean criterion, 126 org./100 mL:
      Calculate the log mean of the measured load of each flow group (‘Log Mean of Observed Data’). Then, subtract the 10% MOS from the TMDL loading capacity. Since the WLA is zero, it is equal to the Load Allocation in this case. The percent reduction is calculated as the reduction needed from the Log Mean of Observed Data to meet the Load Allocation.

   b. For the single sample criterion, 406 org./100 mL:
      Calculate the acceptable load for the day with the highest measured value in each flow group, by using the flow measured on that day. The percent reduction is calculated as the reduction needed from the highest measured value to meet the acceptable load for that day.

   c. In addition to the overall percent reductions, the reductions for irrigation versus non-irrigation season to meet the log mean criterion were calculated. Within each flow group, the same method was applied to obtain the required percent reduction, except instead of calculating the log mean of all observed data within a flow group, the log mean of observed data for only the irrigation months was taken for one set of percent reduction calculations, and the log mean of observed data for only the non-irrigation months was taken for the other set of percent reduction calculations.

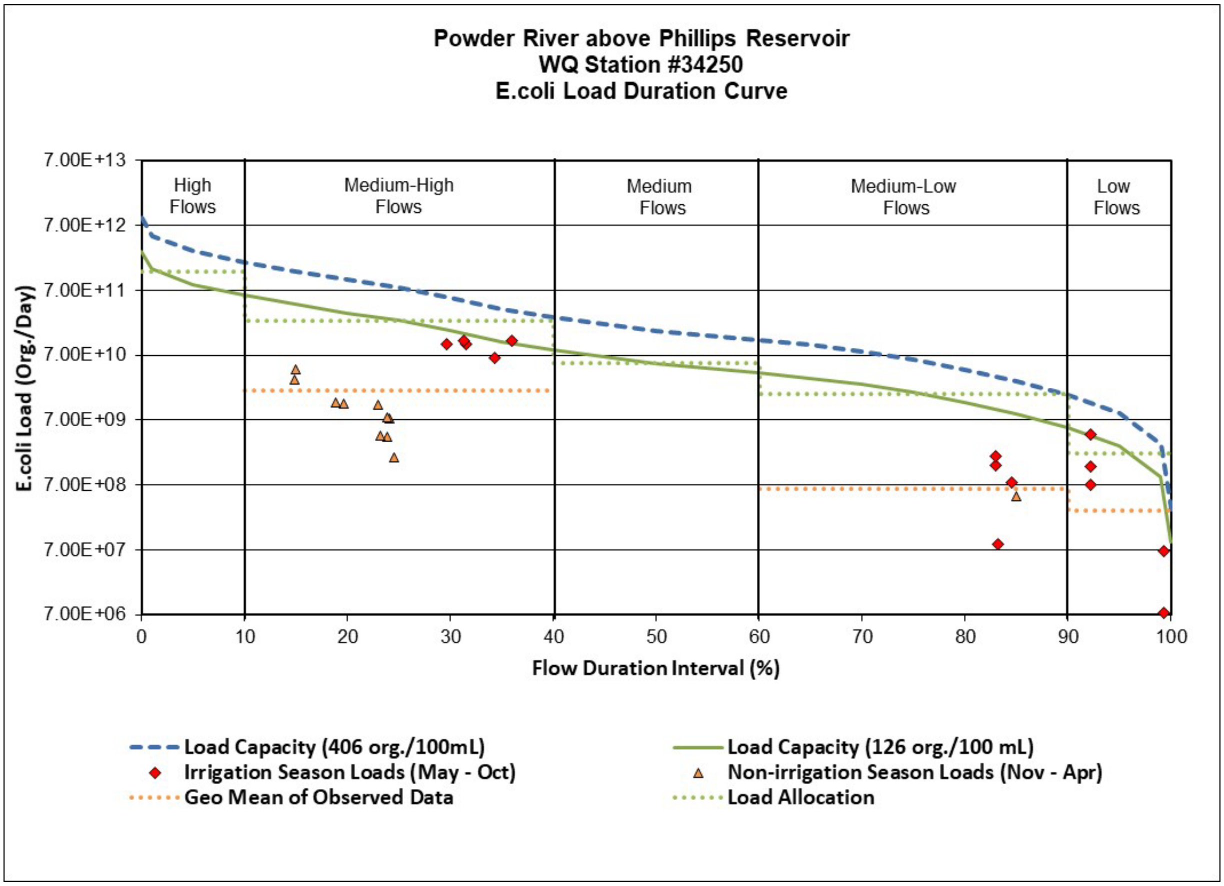

Figure 4.5.1a: ***E. coli*** **load duration curve Powder River above Phillips Reservoir**

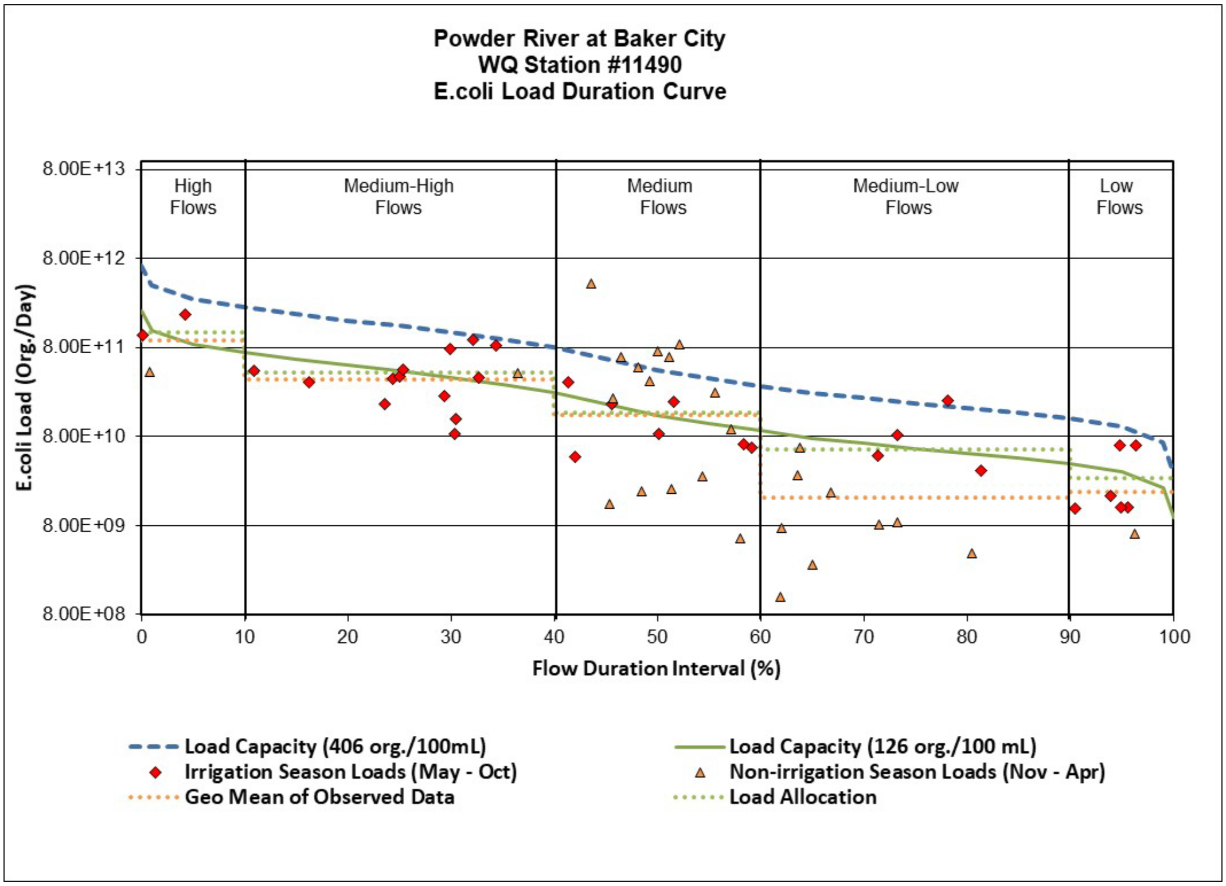

Figure 4.5.1b: ***E. coli*** **load duration curve Powder River at Baker City**

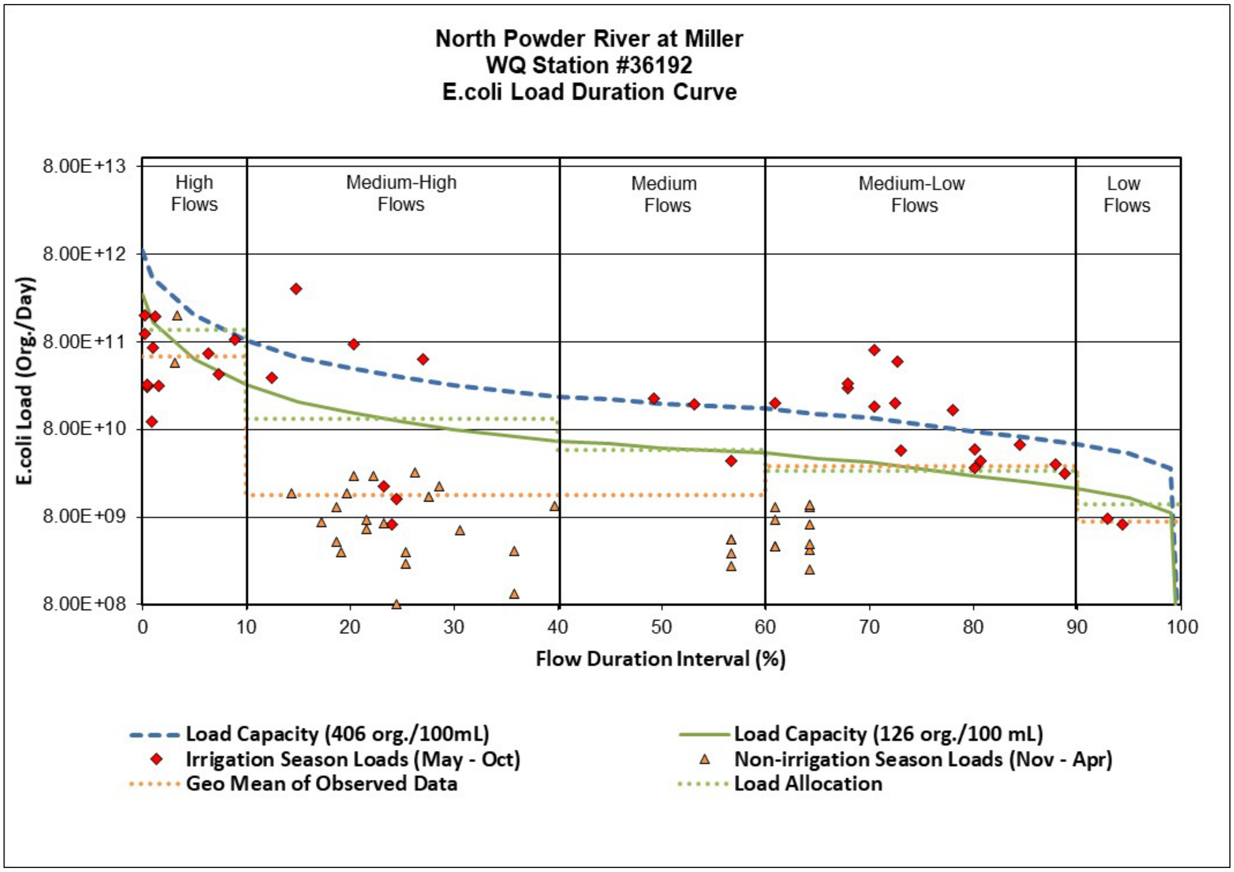

Figure 4.5.1c: *E. coli* load duration curve North Powder River at Miller Road

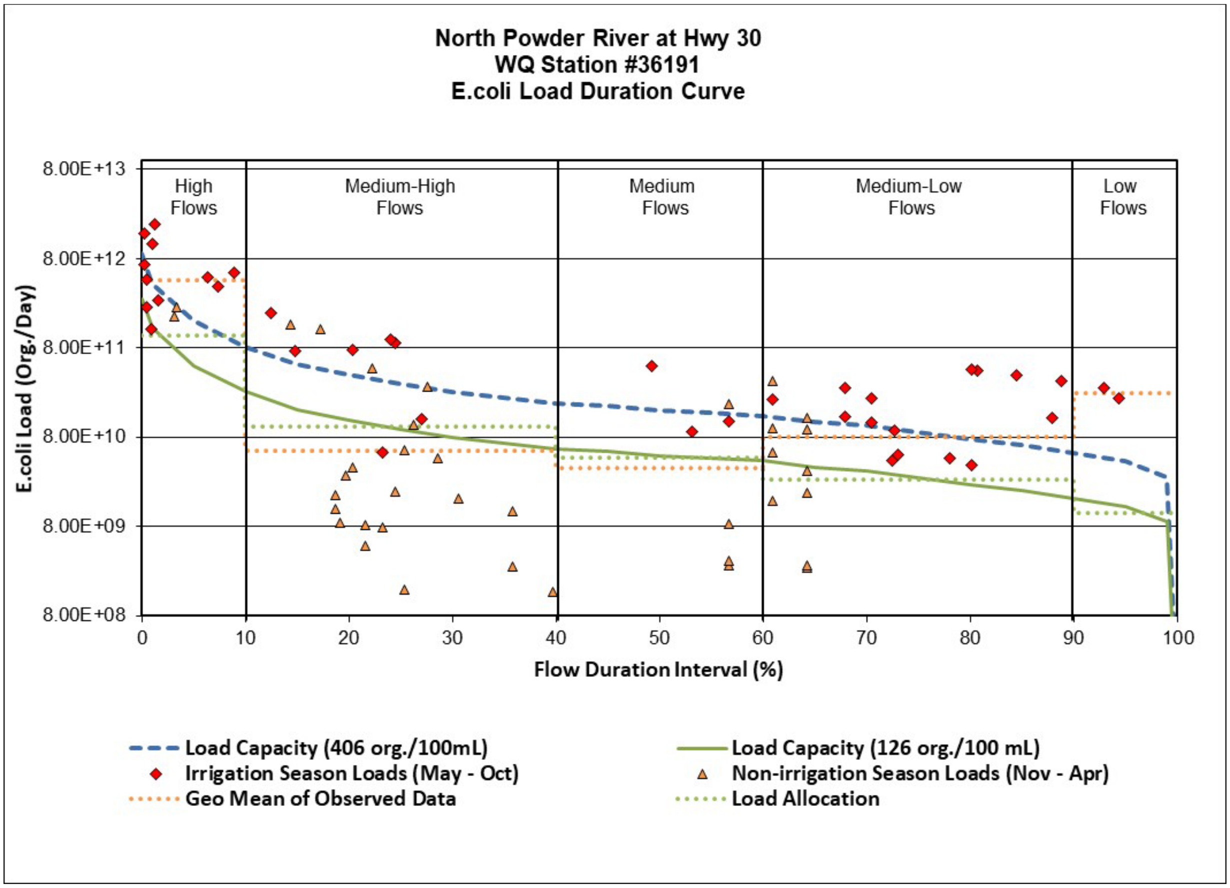

Figure 4.5.1d: ***E. coli*** **load duration curve North Powder River at Highway 30**

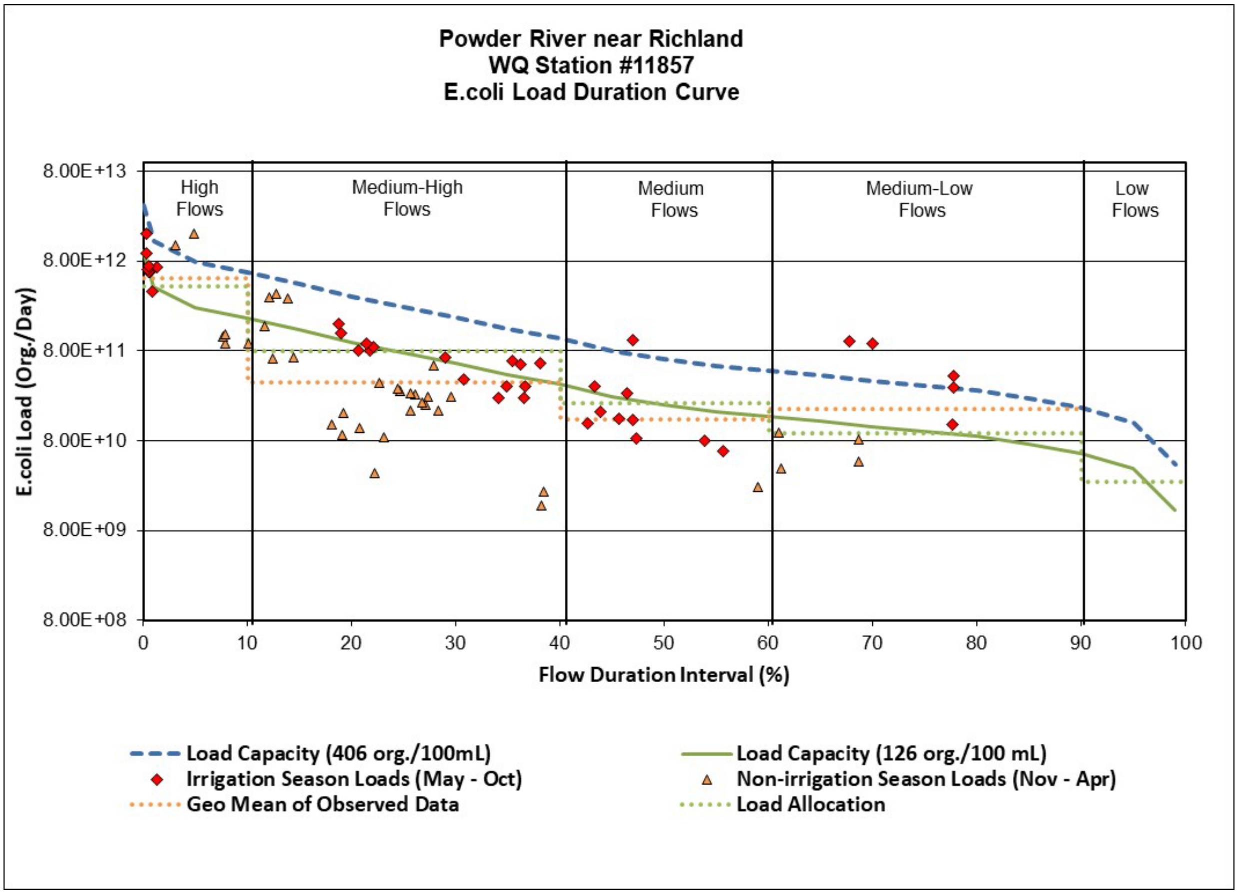

Figure 4.5.1e: ***E. coli*** **load duration curve Powder River near Richland**

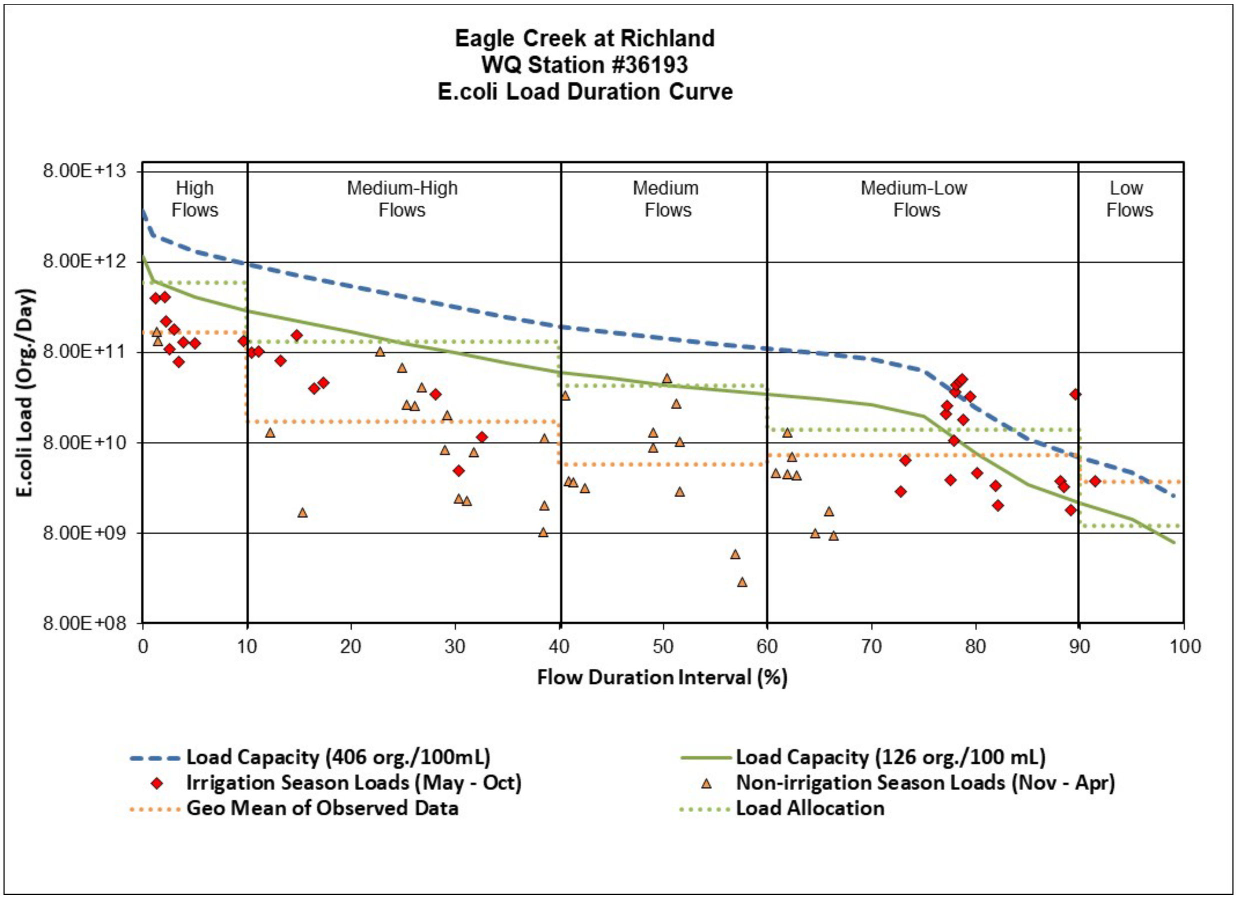

Figure 4.5.1f: ***E. coli*** **load duration curve Eagle Creek near Richland**

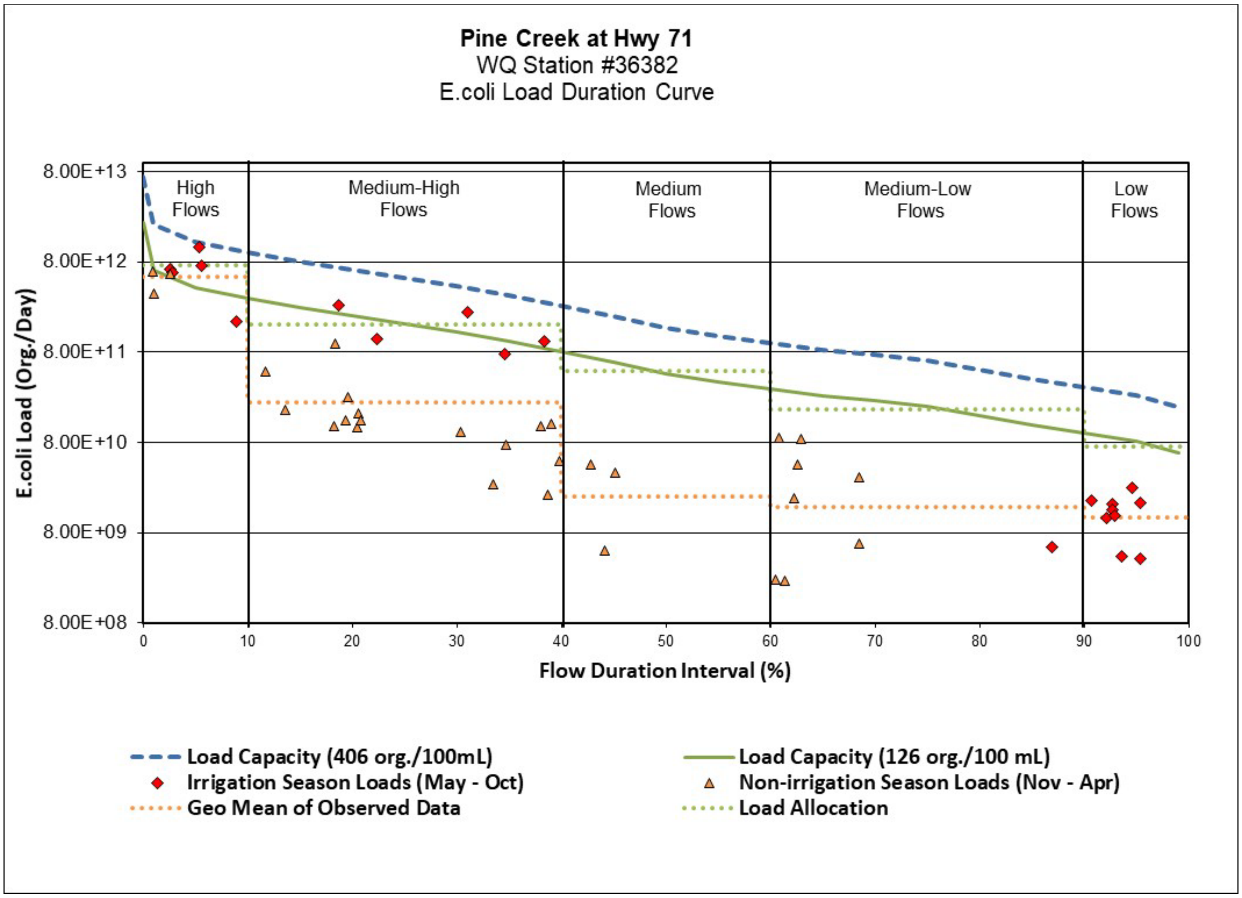

Figure 4.5.1g: ***E. coli*** **load duration curve Pine Creek at Highway 71**

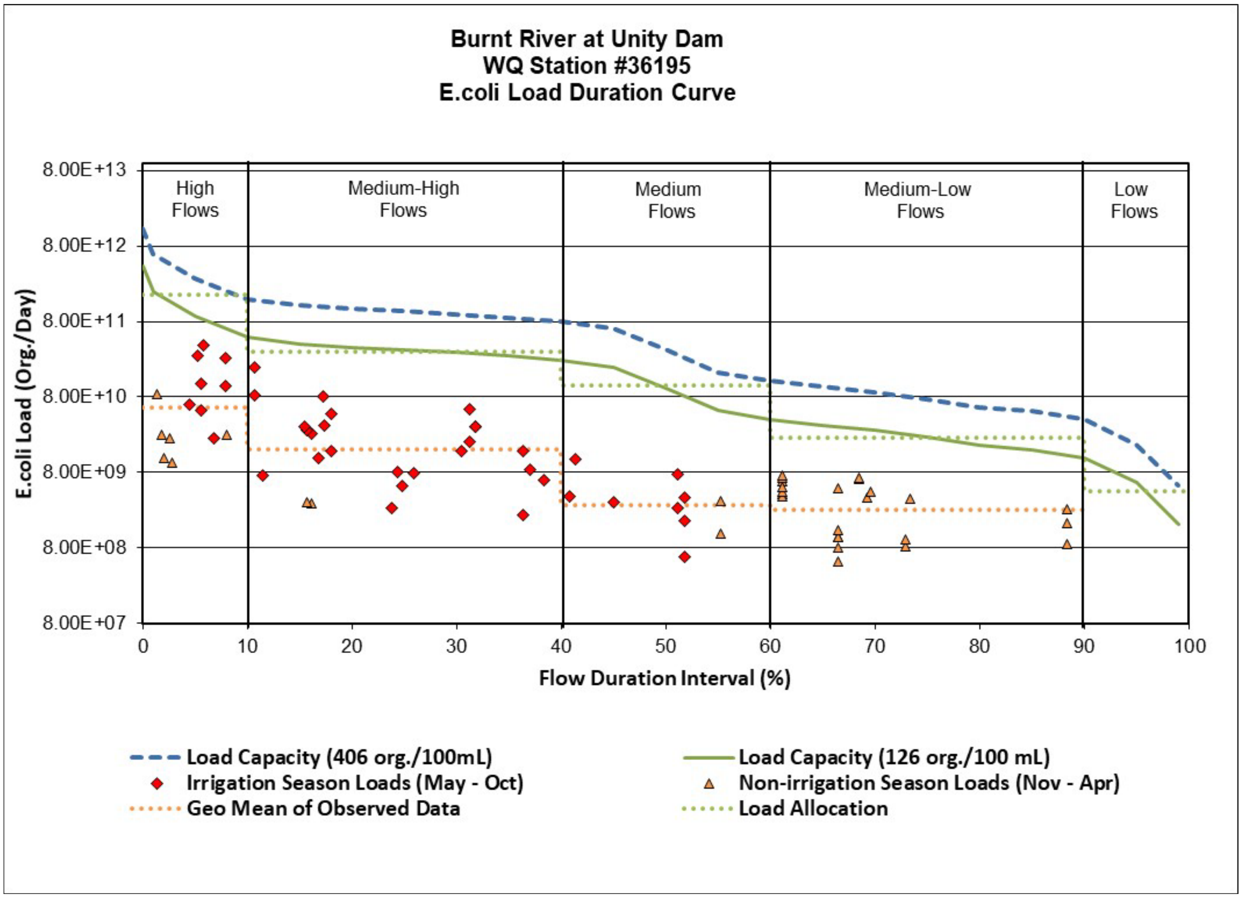

Figure 4.5.1h: ***E. coli*** **load duration curve Burnt River at Unity Reservoir**

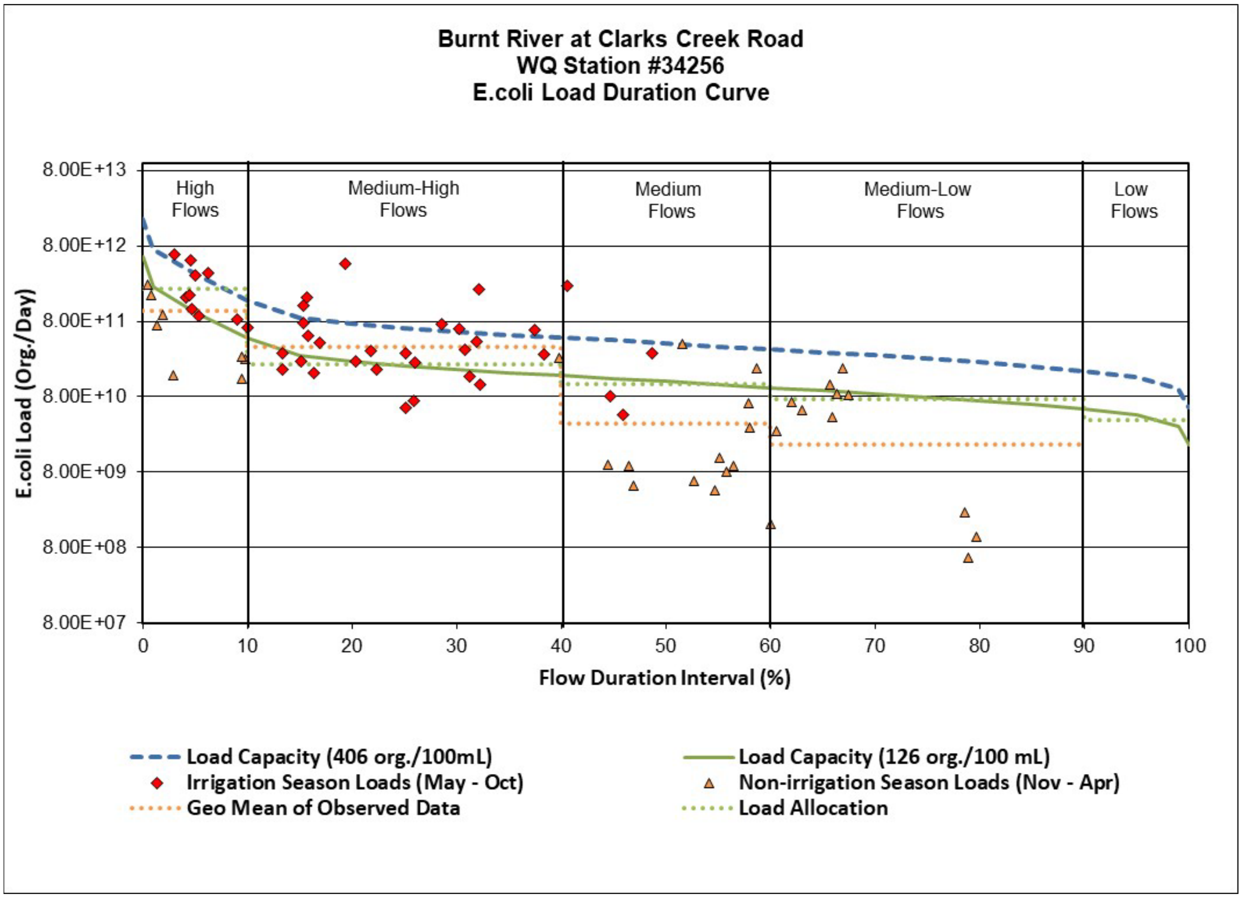

Figure 4.5.1i: ***E. coli*** **load duration curve Burnt River at Clarks Creek Road**

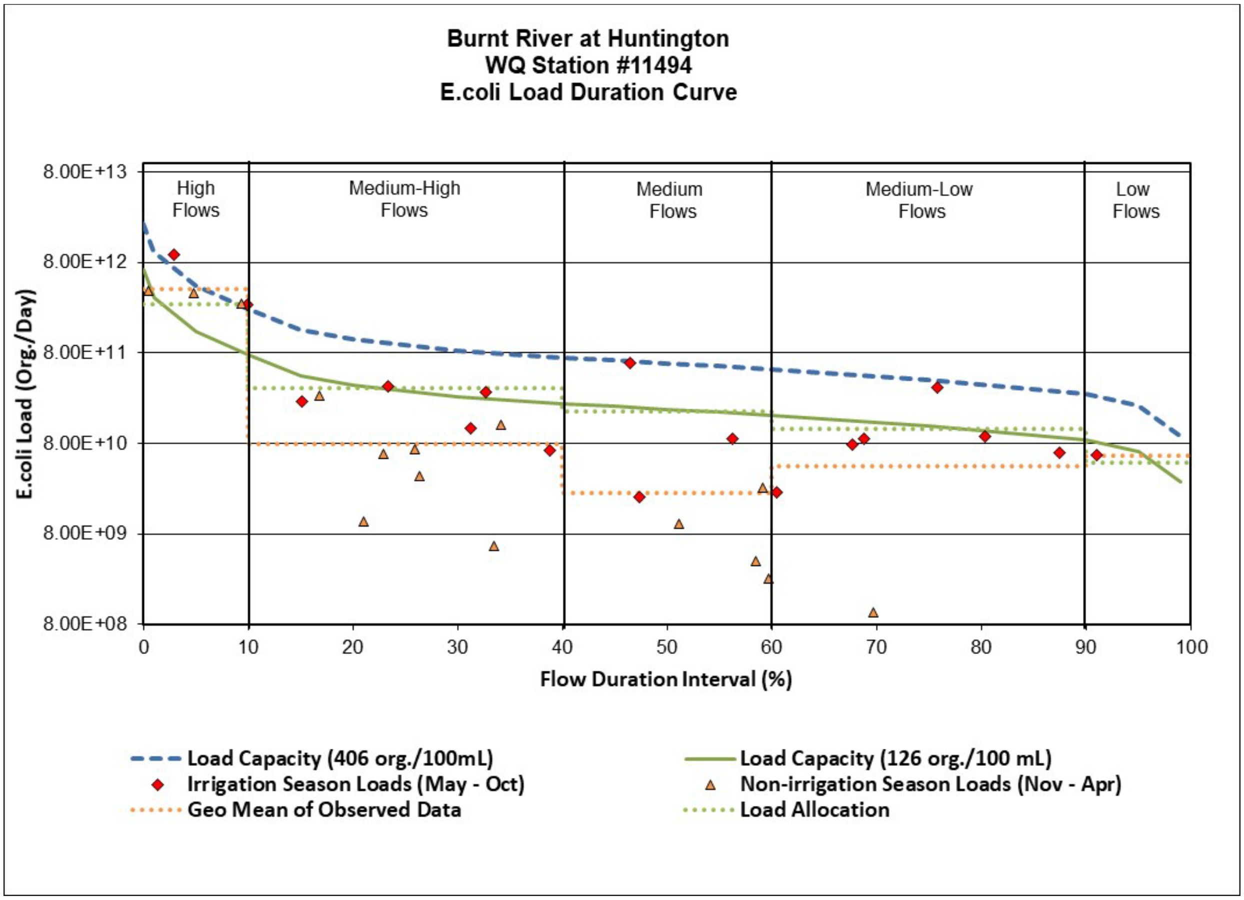

Figure 4.5.1j: ***E. coli*** **load duration curve Burnt River at Huntington**

4.5.2 Load duration curve calculated outputs

DEQ evaluated the outputs and curves calculated by EPA and selected paired sets of calculations for the geometric mean and single sample maximum criteria from 10 locations representing the range of flows during irrigation season and non-irrigation season (Section 4.5.1). Dividing the analysis between these two water management-based periods provides insight onto the sources and transport mechanisms for *E. coli* to receiving waters. For example, if the highest percent reductions need to occur during the irrigation season in areas where livestock only have access during the non-irrigation period, then reducing livestock access or removing manure deposits before irrigation season and/or changes to irrigation practices may be needed to achieve reductions year-round.

DEQ used the approach to apply the maximum percent reduction needed to meet either geometric mean or single sample criteria within individual flow categories and seasons to all criteria, flow categories, and seasons for each of the 10 reaches. Using this approach ensures that both criteria will be met during all flow conditions and across seasons. This approach is appropriate because of the potential for disconnect between when and where fecal bacteria are deposited on the landscape in manure and the flow mechanisms responsible for delivering fecal bacteria to surface waters (runoff and irrigation practices).

Load duration curves were calculated for reaches in which enough data were collected to allow for calculations of percent reductions for both geometric mean criteria and single sample criteria for at least three of the five flow categories for non-irrigation and irrigation seasons. For the flow category/season combinations in which data were not available to calculate percent reductions for both geometric mean and single sample criteria, the maximum percent reduction identified for the reach applied.

Except for converting to DEQ's flow categories and simplifying titles, Tables 4.5.2a through 4.5.2nn are excerpted directly from EPA's technical memorandum (EPA 2019). In each of these tables, potential allocations are highlighted with orange shading. The potential load allocations presented are the determined loading capacity needed to meet that applicable bacteria criterion minus explicit calculations of margin of safety (explicitly calculated as 10% of the loading capacity, See Section 6.4) and reserve capacity (calculated as 0% of the load capacity see Section 6.3). When adequate data were available, percent reductions are were calculated as: Percent Reduction = (Measured Load - Load Capacity) / (Measured Load) * 100; and are highlighted in yellow.

The percent reduction represents the amount of the current load that needs to be reduced for the applicable water quality standard for *E. coli* to be met. Tables 4.5.2oo and 4.5.2pp summarize measured loads, load capacities, and, where applicable, percent reductions needed to meet load capacities for all flow categories and irrigation/non-irrigation seasons. Table 4.5.2qq summarizes the maximum percent reductions across all flow categories and seasons. These maximum percent reductions apply across all flow categories and seasons as a layer of insurance that water quality standards are met.

DEQ presents final allocations in Tables 9.1b-f in the TMDL document. For allocations by stream reach and flow category (inclusive of both non-irrigation and irrigation season), DEQ calculated loading capacities using the geometric mean criterion for *E. coli* (126 organisms/100 mL). Using this allocation approach ensures that both single sample and geometric mean criteria for *E. coli* will be met. Maximum percent reductions needed based on geometric mean or single sample criteria across flow categories and seasons provide an additional margin of safety to ensure that *E. coli* criteria are met with pollution reduction activities.

Table 4.5.2a: Load duration calculations Powder River above Phillips Reservoir (34250-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.53E+12	2.64E+11	5.86E+10	1.98E+10	2.38E+09
Margin of Safety (10% of LC)				
1.53E+11	2.64E+10	5.86E+09	1.98E+09	2.38E+08
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.53E+10	2.64E+09	5.86E+08	1.98E+08	2.38E+07
Load Allocation				
1.36E+12	2.35E+11	5.22E+10	1.76E+10	2.12E+09
Measured Load (geo mean of observed values in each flow group)				
N/A	9.86E+10	N/A	6.44E+08	2.86E+08
Percent Reduction				
N/A	0	N/A	0	0

Table 4.5.2b: Load duration calculations Powder River above Phillips Reservoir (34250-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.53E+12	2.64E+11	5.86E+10	1.98E+10	2.38E+09
Margin of Safety (10% of LC)				
1.53E+11	2.64E+10	5.86E+09	1.98E+09	2.38E+08
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.53E+10	2.64E+09	5.86E+08	1.98E+08	2.38E+07
Load Allocation				
1.36E+12	2.35E+11	5.22E+10	1.76E+10	2.12E+09
Measured Load (geo mean of observed values in each flow group)				
N/A	9.05E+09	N/A	4.76E+08	N/A
Percent Reduction				
N/A	0	N/A	0	0

Table 4.5.2c: Load duration calculations Powder River above Phillips Reservoir (34250-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
N/A	1.18E+11	N/A	1.97E+09	4.15E+09
Flow (cfs on day with highest measured value)				
N/A	46	N/A	4	1
Load Capacity (on day with highest measured value)				
N/A	4.58E+11	N/A	3.48E+10	1.31E+10
Margin of Safety (10% of LC)				
N/A	4.58E+10	N/A	3.48E+09	1.31E+09
Reserve Capacity (0% of LC)				
N/A	0	N/A	0	0
Wasteload Allocation				
N/A	4.58E+09	N/A	3.48E+08	1.31E+08
Load Allocation				
N/A	4.07E+11	N/A	3.09E+10	1.17E+10
Percent Reduction				
N/A	0	N/A	0	0

Table 4.5.2d: Load duration calculations Powder River above Phillips Reservoir (34250-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
N/A	4.14E+10	N/A	4.76E+08	N/A
Flow (cfs on day with highest measured value)				
N/A	130	N/A	3	N/A
Load Capacity (on day with highest measured value)				
N/A	1.29E+12	N/A	3.07E+10	N/A
Margin of Safety (10% of LC)				
N/A	1.29E+11	N/A	3.07E+09	N/A
Reserve Capacity (0% of LC)				
N/A	0	N/A	0	N/A
Wasteload Allocation				
N/A	1.29E+10	N/A	3.07E+08	N/A
Load Allocation				
N/A	1.15E+12	N/A	2.73E+10	N/A
Percent Reduction				
N/A	0	N/A	0	N/A

Table 4.5.2e: Load duration calculations Powder River at Baker City (11490-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.31E+12	4.66E+11	1.64E+11	6.37E+10	3.02E+10
Margin of Safety (10% of LC)				
1.31E+11	4.66E+10	1.64E+10	6.37E+09	3.02E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.31E+10	4.66E+09	1.64E+09	6.37E+08	3.02E+08
Load Allocation				
1.17E+12	4.15E+11	1.46E+11	5.67E+10	2.68E+10
Measured Load (geo mean of observed values in each flow group)				
1.44E+12	3.43E+11	1.10E+11	7.22E+10	2.30E+10
Percent Reduction				
9%	0%	0%	12%	0%

Table 4.5.2f: Load duration calculations Powder River at Baker City (11490-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.31E+12	4.66E+11	1.64E+11	6.37E+10	3.02E+10
Margin of Safety (10% of LC)				
1.31E+11	4.66E+10	1.64E+10	6.37E+09	3.02E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.31E+10	4.66E+09	1.64E+09	6.37E+08	3.02E+08
Load Allocation				
1.17E+12	4.15E+11	1.46E+11	5.67E+10	2.68E+10
Measured Load (geo mean of observed values in each flow group)				
4.25E+11	4.12E+11	1.56E+11	8.65E+09	6.44E+09
Percent Reduction				
0%	0%	0%	0%	0%

Table 4.5.2g: Load duration calculations Powder River at Baker City (11490-ORDEQ) – single sample criteria –irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.88E+12	9.76E+11	3.25E+11	2.03E+11	6.40E+10
Flow (on day with highest measured value)				
295	116	80	17	9
Load Capacity (on day with highest measured value)				
2.93E+12	1.15E+12	7.91E+11	1.69E+11	9.12E+10
Margin of Safety (10% of LC)				
2.93E+11	1.15E+11	7.91E+10	1.69E+10	9.12E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
2.93E+10	1.15E+10	7.05E+09	1.69E+09	9.12E+08
Load Allocation (LC-RC)				
2.60E+12	1.02E+12	6.28E+11	1.50E+11	8.12E+10
Percent Reduction				
0	0	0	17%	0

Table 4.5.2h: Load duration calculations Powder River at Baker City (11490-ORDEQ) – single sample criteria –non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
4.25E+11	4.12E+11	4.20E+12	6.05E+10	6.44E+09
Flow (on day with highest measured value)				
370	97	71	24	9
Load Capacity (on day with highest measured value)				
3.68E+12	9.66E+11	7.05E+11	2.42E+11	9.17E+10
Margin of Safety (10% of LC)				
3.68E+11	9.66E+10	7.05E+10	2.42E+10	9.17E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
3.68E+10	9.66E+09	7.05E+09	2.42E+09	9.17E+08
Load Allocation (LC-RC)				
3.27E+12	8.60E+11	6.28E+11	2.16E+11	8.16E+10
Percent Reduction				
0	0	83%	0	0

Table 4.5.2i: Load duration calculations North Powder River at Highway 30 (36191-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
Margin of Safety (10% of LC)				
1.23E+11	1.19E+10	5.22E+09	3.00E+09	1.25E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.23E+10	1.19E+09	5.22E+08	3.00E+08	1.25E+08
Load Allocation				
1.10E+12	1.06E+11	4.64E+10	2.67E+10	1.12E+10
Measured Load (geo mean of observed values in each flow group)				
5.34E+12	4.90E+11	1.78E+11	1.46E+11	2.48E+11
Percent Reduction During Irrigation Season				
77%	76%	71%	79%	95%

Table 4.5.2j: Load duration calculations North Powder River at Highway 30 (36191-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
Margin of Safety (10% of LC)				
1.23E+11	1.19E+10	5.22E+09	3.00E+09	1.25E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.23E+10	1.19E+09	5.22E+08	3.00E+08	1.25E+08
Load Allocation: TMDL LC- MOS-RC				
1.10E+12	1.06E+11	4.64E+10	2.67E+10	1.12E+10
Measured Load (geo mean of observed values in each flow group)				
2.01E+12	2.72E+10	1.12E+10	3.34E+10	N/A
Percent Reduction During Non-Irrigation Season				
39%	0%	0%	10%	N/A

Table 4.5.2k: Load duration calculations North Powder River at Highway 30 (36191-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.96E+13	1.97E+12	5.00E+11	4.56E+11	2.84E+11
Flow (on day with highest measured value)				
403	67	17	8	5
Load Capacity (on day with highest measured value)				
4.00E+12	6.66E+11	1.69E+11	7.65E+10	4.77E+10
Margin of Safety (10% of LC)				
4.00E+11	6.66E+10	1.69E+10	7.65E+09	4.77E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
4.00E+10	6.66E+09	1.69E+09	7.65E+08	4.77E+08
Load Allocation				
3.56E+12	5.92E+11	1.50E+11	6.81E+10	4.24E+10
Percent Reduction				
80%	66%	66%	83%	83%

Table 4.5.2l: Load duration calculations North Powder River at Highway 30 (36191-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
2.26E+12	1.46E+12	1.90E+11	3.36E+11	N/A
Flow (on day with highest measured value)				
238	57	15	14	N/A
Load Capacity (on day with highest measured value)				
2.36E+12	5.66E+11	1.49E+11	1.39E+11	N/A
Margin of Safety (10% of LC)				
2.36E+11	5.66E+10	1.49E+10	1.39E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
2.36E+10	5.66E+09	1.49E+09	1.39E+09	N/A
Load Allocation				
2.10E+12	5.04E+11	1.33E+11	1.24E+11	N/A
Percent Reduction				
0%	61%	22%	59%	N/A

Table 4.5.2m: Load duration calculations North Powder River at Miller Road (36192-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
Margin of Safety (10% of LC)				
1.23E+11	1.19E+10	5.22E+09	3.00E+09	1.25E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.23E+10	1.19E+09	5.22E+08	3.00E+08	1.25E+08
Load Allocation				
1.10E+12	1.06E+11	4.64E+10	2.67E+10	1.12E+10
Measured Load (geo mean of observed values in each flow group)				
4.97E+11	1.29E+11	9.96E+10	9.91E+10	7.05E+09
Percent Reduction				
0	8%	48%	70%	0

Table 4.5.2n: Load duration calculations North Powder River at Miller Road (36192-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
Margin of Safety (10%)				
1.23E+11	1.19E+10	5.22E+09	3.00E+09	1.25E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.23E+10	1.19E+09	5.22E+08	3.00E+08	1.25E+08
Load Allocation				
1.10E+12	1.06E+11	4.64E+10	2.67E+10	1.12E+10
Measured Load (log mean of observed values in each flow group)				
8.64E+11	6.78E+09	3.40E+09	5.38E+09	N/A
Percent Reduction				
0	0	0	0	N /A

Table 4.5.2o: Load duration calculations North Powder River at Miller Road (36192-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.60E+12	3.26E+12	1.81E+11	6.50E+11	7.63E+09
Flow (on day with highest measured value)				
645	55	17	11	5
Load Capacity (on day with highest measured value)				
6.41E+12	5.46E+11	1.69E+11	1.09E+11	4.77E+10
Margin of Safety (10%)				
6.41E+11	5.46E+10	1.69E+10	1.09E+10	4.77E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
6.41E+10	5.46E+09	1.69E+09	1.09E+09	4.77E+08
Load Allocation				
5.70E+12	4.86E+11	1.50E+11	9.72E+10	4.24E+10
Percent Reduction				
0	83%	7%	83%	0

Table 4.5.2p: Load duration calculations North Powder River at Miller Road (36192-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.60E+12	2.59E+10	4.40E+09	1.10E+10	N/A
Flow (on day with highest measured value)				
238	31	15	13	N/A
Load Capacity (on day with highest measured value)				
2.36E+12	3.08E+11	1.49E+11	1.29E+11	N/A
Margin of Safety (10%)				
2.36E+11	3.08E+10	1.49E+10	1.29E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
2.36E+10	3.08E+09	1.49E+09	1.29E+09	N/A
Load Allocation				
2.10E+12	2.74E+11	1.33E+11	1.15E+11	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2q: Load duration calculations Powder River at Snake River Rd (Richland) (11857-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
4.65E+12	8.83E+11	2.31E+11	1.07E+11	3.11E+10
Margin of Safety (10% of LC)				
4.65E+11	8.83E+10	2.31E+10	1.07E+10	3.11E+09
Reserve Capacity (5% of LC)				
0	0	0	0	0
Wasteload Allocation				
5.12E+10	1.36E+10	7.08E+09	5.84E+09	5.08E+09
Load Allocation				
4.13E+12	7.81E+11	2.01E+11	9.02E+10	2.29E+10
Measured Load (geo mean of observed values in each flow group)				
7.10E+12	5.87E+11	1.65E+11	4.34E+11	N/A
Percent Reduction				
35%	0	0	75%	N/A

Table 4.5.2r: Load duration calculations Powder River at Snake River Rd (Richland) (11857-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
4.65E+12	8.83E+11	2.31E+11	1.07E+11	3.11E+10
Margin of Safety (10% of LC)				
4.65E+11	8.83E+10	2.31E+10	1.07E+10	3.11E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
5.12E+10	1.36E+10	7.08E+09	5.84E+09	5.08E+09
Load Allocation				
4.13E+12	7.81E+11	2.01E+11	9.02E+10	2.29E+10
Measured Load (geo mean of observed values in each flow group)				
3.05E+12	2.68E+11	2.44E+10	6.21E+10	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2s: Load duration calculations Powder River at Snake River Rd (Richland) (11857-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.59E+13	1.58E+12	1.04E+12	1.02E+12	N/A
Flow (on day with highest measured value)				
2110	348	74	40	N/A
Load Capacity (on day with highest measured value)				
2.10E+13	3.46E+12	7.32E+11	3.96E+11	N/A
Margin of Safety (10% of LC)				
2.10E+12	3.46E+11	7.32E+10	3.96E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
2.14E+11	3.93E+10	1.21E+10	8.73E+09	N/A
Load Allocation				
1.86E+13	3.07E+12	6.47E+11	3.48E+11	N/A
Percent Reduction				
0	0	30%	61%	N/A

Table 4.5.2t: Load duration calculations Powder River at Snake River Rd (Richland) (11857-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.59E+13	3.41E+12	2.44E+10	9.78E+10	N/A
Flow (on day with highest measured value)				
795	502	50	47	N/A
Load Capacity (on day with highest measured value)				
7.89E+12	4.98E+12	4.92E+11	4.65E+11	N/A
Margin of Safety (10% of LC)				
7.89E+11	4.98E+11	4.92E+10	4.65E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
8.37E+10	5.46E+10	9.69E+09	9.42E+09	N/A
Load Allocation				
7.02E+12	4.43E+12	4.33E+11	4.09E+11	N/A
Percent Reduction				
50%	0	0	0	N/A

Table 4.5.2u: Load duration calculations Eagle Creek near Richland (36193-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (log mean of loading capacity in each flow group)				
5.32E+12	1.18E+12	3.84E+11	1.24E+11	1.08E+10
Margin of Safety (10% of LC)				
5.32E+11	1.18E+11	3.84E+10	1.24E+10	1.08E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
5.32E+10	1.18E+10	3.84E+09	1.24E+09	1.08E+08
Load Allocation: TMDL LC – MOS-RC				
4.73E+12	1.05E+12	3.42E+11	1.10E+11	9.62E+09
Measured Load (geo mean of observed values in each flow group)				
1.35E+12	3.38E+11	N/A	8.30E+10	2.97E+10
Percent Reduction				
0	0	N/A	0	64%

Table 4.5.2v: Load duration calculations Eagle Creek near Richland (36193-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
5.32E+12	1.18E+12	3.84E+11	1.24E+11	1.08E+10
Margin of Safety (10% of LC)				
5.32E+11	1.18E+11	3.84E+10	1.24E+10	1.08E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
5.32E+10	1.18E+10	3.84E+09	1.24E+09	1.08E+08
Load Allocation: TMDL LC- MOS-RC				
4.73E+12	1.05E+12	3.42E+11	1.10E+11	9.62E+09
Measured Load (geo mean of observed values in each flow group)				
1.20E+12	7.82E+10	4.55E+10	2.62E+10	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2w: Load duration calculations Eagle Creek near Richland (36193-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
3.22E+12	1.24E+12	N/A	4.08E+11	2.97E+10
Flow (on day with highest measured value)				
1410	575	N/A	24	5
Load Capacity (on day with highest measured value)				
1.40E+13	5.71E+12	N/A	2.41E+11	5.02E+10
Margin of Safety (10% of LC)				
1.40E+12	5.71E+11	N/A	2.41E+10	5.02E+09
Reserve Capacity (0% of LC)				
0	0	N/A	0	0
Wasteload Allocation				
1.40E+11	5.71E+10	N/A	2.41E+09	5.02E+08
Load Allocation (LC-RC)				
1.25E+13	5.08E+12	N/A	2.15E+11	4.46E+10
Percent Reduction				
0	0	N/A	41%	0

Table 4.5.2x: Load duration calculations Eagle Creek near Richland (36193-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.35E+12	8.13E+11	4.13E+11	1.03E+11	N/A
Flow (on day with highest measured value)				
1550	367	114	85	N/A
Load Capacity (on day with highest measured value)				
1.54E+13	3.65E+12	1.13E+12	8.47E+11	N/A
Margin of Safety (10% of LC)				
1.54E+12	3.65E+11	1.13E+11	8.47E+10	N/A
Reserve Capacity (5% of LC)				
7.70E+11	1.82E+11	5.65E+10	4.24E+10	N/A
Wasteload Allocation				
1.54E+11	3.65E+10	1.13E+10	8.47E+09	N/A
Load Allocation (LC-RC)				
1.37E+13	3.24E+12	1.01E+12	7.54E+11	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2y: Load duration calculations Pine Creek at Highway 71 near mouth (to Snake River) (36382-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
8.26E+12	1.81E+12	5.41E+11	2.06E+11	8.02E+10
Margin of Safety (10% of LC)				
8.26E+11	1.81E+11	5.41E+10	2.06E+10	8.02E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
8.26E+10	1.81E+10	5.41E+09	2.06E+09	8.02E+08
Load Allocation				
7.36E+12	1.61E+12	4.82E+11	1.83E+11	7.13E+10
Measured Load (geo mean of observed values in each flow group)				
5.65E+12	1.40E+12	N/A	5.53E+09	1.20E+10
Percent Reduction (all seasons)				
0	0	N/A	0	0

Table 4.5.2z: Load duration calculations Pine Creek at Highway 71 near mouth (to Snake River) (36382-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
8.26E+12	1.81E+12	5.41E+11	2.06E+11	8.02E+10
Margin of Safety (10% of LC)				
8.26E+11	1.81E+11	5.41E+10	2.06E+10	8.02E+09
Reserve Capacity (5% of LC)				
4.13E+11	9.05E+10	2.70E+10	1.03E+10	4.01E+09
Wasteload Allocation				
8.26E+10	1.81E+10	5.41E+09	2.06E+09	8.02E+08
Load Allocation: TMDL LC - MOS				
7.36E+12	1.61E+12	4.82E+11	1.83E+11	7.13E+10
Measured Load (geo mean of observed values in each flow group)				
5.07E+12	1.25E+11	2.04E+10	1.73E+10	N/A
Percent Reduction (all seasons)				
0	0	0	0	N/A

Table 4.5.2aa: Load duration calculations Pine Creek at Highway 71 near mouth (to Snake River) (36382-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
1.17E+13	2.65E+12	N/A	5.53E+09	2.53E+10
Flow (on day with highest measured value)				
1310	692	N/A	38	27
Load Capacity (on day with highest measured value)				
1.30E+13	6.87E+12	N/A	3.74E+11	2.71E+11
Margin of Safety (10% of LC)				
1.30E+12	6.87E+11	N/A	3.74E+10	2.71E+10
Reserve Capacity (0% of LC)				
0	0	N/A	0	0
Wasteload Allocation				
1.30E+11	6.87E+10	N/A	3.74E+09	2.71E+09
Load Allocation				
1.16E+13	6.12E+12	N/A	3.33E+11	2.41E+11
Percent Reduction				
0	0	N/A	0	0

Table 4.5.2bb: Load duration calculations Pine Creek at Highway 71 near mouth (to Snake River) (36382-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
6.18E+12	9.79E+11	4.52E+10	8.95E+10	N/A
Flow (on day with highest measured value)				
2190	702	228	98	N/A
Load Capacity (on day with highest measured value)				
2.18E+13	6.97E+12	2.26E+12	9.74E+11	N/A
Margin of Safety (10% of LC)				
2.18E+12	6.97E+11	2.26E+11	9.74E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
2.18E+11	6.97E+10	2.26E+10	9.74E+09	N/A
Load Allocation				
1.94E+13	6.21E+12	2.02E+12	8.67E+11	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2cc: Load duration calculations Burnt River at Unity Reservoir discharge (36195-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of load capacity in each flow group)				
1.99E+12	3.59E+11	1.28E+11	2.54E+10	4.98E+09
Margin of Safety (10% of LC)				
1.99E+11	3.59E+10	1.28E+10	2.54E+09	4.98E+08
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.99E+10	3.59E+09	1.28E+09	2.54E+08	4.98E+07
Load Allocation: TMDL LC – MOS-RC				
1.77E+12	3.20E+11	1.14E+11	2.26E+10	4.43E+09
Measured Load (geo mean of observed values in each flow group)				
1.15E+11	1.84E+10	3.25E+09	N/A	N/A
Percent Reduction				
0	0	0	N/A	N/A

Table 4.5.2dd: Load duration calculations Burnt River at Unity Reservoir discharge (36195-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of load capacity in each flow group)				
1.99E+12	3.59E+11	1.28E+11	2.54E+10	4.98E+09
Margin of Safety (10% of LC)				
1.99E+11	3.59E+10	1.28E+10	2.54E+09	4.98E+08
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
1.99E+10	3.59E+09	1.28E+09	2.54E+08	4.98E+07
Load Allocation				
1.77E+12	3.20E+11	1.14E+11	2.26E+10	4.43E+09
Measured Load (log mean of observed values in each flow group)				
2.35E+10	3.17E+09	2.04E+09	2.61E+09	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2ee: Load duration calculations Burnt River at Unity Reservoir discharge (36195-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
3.83E+11	1.97E+11	1.20E+10	0.00E+00	N/A
Flow (on day with highest measured value)				
265	155	78	N/A	N/A
Load Capacity (on day with highest measured value)				
2.63E+12	1.54E+12	7.75E+11	N/A	N/A
Margin of Safety (10% of LC)				
2.63E+11	1.54E+11	7.75E+10	N/A	N/A
Reserve Capacity (0% of LC)				
0	0	0	N/A	N/A
Wasteload Allocation				
2.63E+10	1.54E+10	7.75E+09	N/A	N/A
Load Allocation				
2.34E+12	1.37E+12	6.90E+11	N/A	N/A
Percent Reduction				
0	0	0	N/A	N/A

Table 4.5.2ff: Load duration calculations Burnt River at Unity Reservoir discharge (36195-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
8.75E+10	3.18E+09	3.33E+09	7.25E+09	N/A
Flow (on day with highest measured value)				
596	65	17	13	N/A
Load Capacity (on day with highest measured value)				
5.92E+12	6.46E+11	1.69E+11	1.29E+11	N/A
Margin of Safety (10% of LC)				
5.92E+11	6.46E+10	1.69E+10	1.29E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
5.92E+10	6.46E+09	1.69E+09	1.29E+09	N/A
Load Allocation				
5.27E+12	5.75E+11	1.50E+11	1.15E+11	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2gg: Load duration calculations Burnt River at Clarks Creek Road (34256-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
2.39E+12	2.40E+11	1.33E+11	8.25E+10	4.30E+10
Margin of Safety (10% of LC)				
2.39E+11	2.40E+10	1.33E+10	8.25E+09	4.30E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
2.39E+10	2.40E+09	1.33E+09	8.25E+08	4.30E+08
Load Allocation				
2.12E+12	2.13E+11	1.19E+11	7.34E+10	3.83E+10
Measured Load (geo mean of observed values in each flow group)				
2.15E+12	3.77E+11	2.27E+11	N/A	N/A
Percent Reduction				
N/A	36%	41%	N/A	N/A

Table 4.5.2hh: Load duration calculations Burnt River at Clarks Creek Road (34256-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of loading capacity in each flow group)				
2.39E+12	2.40E+11	1.33E+11	8.25E+10	4.30E+10
Margin of Safety (10% of LC)				
2.39E+11	2.40E+10	1.33E+10	8.25E+09	4.30E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
2.39E+10	2.40E+09	1.33E+09	8.25E+08	4.30E+08
Load Allocation: TMDL LC- MOS-RC				
2.12E+12	2.13E+11	1.19E+11	7.34E+10	3.83E+10
Measured Load (geo mean of observed values in each flow group)				
5.03E+11	2.62E+11	1.90E+10	1.88E+10	N/A
Percent Reduction				
0	8%	0	0	N/A

Table 4.5.2ii: Load duration calculations Burnt River at Clarks Creek Road (34256-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
6.11E+12	4.61E+12	2.38E+12	N/A	N/A
Flow (on day with highest measured value)				
483	78	49	N/A	N/A
Load Capacity (on day with highest measured value)				
4.80E+12	7.74E+11	4.91E+11	N/A	N/A
Margin of Safety (10% of LC)				
4.80E+11	7.74E+10	4.91E+10	N/A	N/A
Reserve Capacity (0% of LC)				
0	0	0	N/A	N/A
Wasteload Allocation				
4.80E+10	7.74E+09	4.91E+09	N/A	N/A
Load Allocation				
4.27E+12	6.89E+11	4.37E+11	N/A	N/A
Percent Reduction				
21%	83%	79%	N/A	N/A

Table 4.5.2jj: Load duration calculations Burnt River at Clarks Creek Road (34256-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
2.41E+12	2.62E+11	4.02E+11	1.93E+11	N/A
Flow (on day with highest measured value)				
857	50	40	30	N/A
Load Capacity (on day with highest measured value)				
8.51E+12	4.97E+11	3.97E+11	3.00E+11	N/A
Margin of Safety (10% of LC)				
8.51E+11	4.97E+10	3.97E+10	3.00E+10	N/A
Reserve Capacity (5% of LC)				
4.26E+11	2.48E+10	1.98E+10	1.50E+10	N/A
Wasteload Allocation				
8.51E+10	4.97E+09	3.97E+09	3.00E+09	N/A
Load Allocation (LC-RC)				
7.58E+12	4.42E+11	3.54E+11	2.67E+11	N/A
Percent Reduction				
0	0	1%	0	N/A

Table 4.5.2kk: Load duration calculations for Burnt River at Huntington (11494-ORDEQ) – geometric mean criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of load capacity in each flow group)				
3.10E+12	3.63E+11	1.98E+11	1.29E+11	5.51E+10
Margin of Safety (10% of LC)				
3.10E+11	3.63E+10	1.98E+10	1.29E+10	5.51E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
3.57E+10	8.40E+09	6.75E+09	6.06E+09	5.32E+09
Load Allocation: LC -RC				
2.75E+12	3.19E+11	1.71E+11	1.10E+11	4.43E+10
Measured Load (geo mean of observed values in each flow group)				
5.12E+12	1.78E+11	1.04E+11	8.31E+10	5.88E+10
Percent Reduction				
40%	0	0	0	6%

Table 4.5.2ll: Load duration calculations for Burnt River at Huntington (11494-ORDEQ) – geometric mean criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Load Capacity (geo mean of load capacity in each flow group)				
3.10E+12	3.63E+11	1.98E+11	1.29E+11	5.51E+10
Margin of Safety (10% of LC)				
3.10E+11	3.63E+10	1.98E+10	1.29E+10	5.51E+09
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
3.57E+10	8.40E+09	6.75E+09	6.06E+09	5.32E+09
Load Allocation: LC -RC				
2.75E+12	3.19E+11	1.71E+11	1.10E+11	4.43E+10
Measured Load (geo mean of observed values in each flow group)				
3.41E+12	4.42E+10	7.24E+09	1.10E+09	N/A
Percent Reduction				
9%	0	0	0	N/A

Table 4.5.2mm: Load duration calculations for Burnt River at Huntington (11494-ORDEQ) – single sample criteria – irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
9.79E+12	3.45E+11	6.16E+11	3.35E+11	5.88E+10
Flow (on day with highest measured value)				
691	103	65	40	27
Load Capacity (on day with highest measured value)				
6.86E+12	1.02E+12	6.47E+11	3.94E+11	2.68E+11
Margin of Safety (10% of LC)				
6.86E+11	1.02E+11	6.47E+10	3.94E+10	2.68E+10
Reserve Capacity (0% of LC)				
0	0	0	0	0
Wasteload Allocation				
7.34E+10	1.50E+10	1.12E+10	8.71E+09	7.45E+09
Load Allocation: LC-RC				
6.10E+12	9.06E+11	5.71E+11	3.46E+11	2.34E+11
Percent Reduction				
30%	0	0	0	0

Table 4.5.2nn: Load duration calculations for Burnt River at Huntington (11494-ORDEQ) – single sample criteria – non-irrigation season

High	Medium-High	Medium	Medium-Low	Low
Measured Load (highest value)				
3.90E+12	2.70E+11	2.59E+10	1.10E+09	N/A
Flow (on day with highest measured value)				
1340	133	53	45	N/A
Load Capacity (on day with highest measured value)				
1.33E+13	1.32E+12	5.26E+11	4.47E+11	N/A
Margin of Safety (10% of LC)				
1.33E+12	1.32E+11	5.26E+10	4.47E+10	N/A
Reserve Capacity (0% of LC)				
0	0	0	0	N/A
Wasteload Allocation				
1.38E+11	1.80E+10	1.00E+10	9.24E+09	N/A
Load Allocation: LC-RC				
1.18E+13	1.17E+12	4.64E+11	3.93E+11	N/A
Percent Reduction				
0	0	0	0	N/A

Table 4.5.2oo: Compiled loading capacity and excess load by station - geometric mean criterion

Station		Geometric Mean Criterion									
		Irrigation Season					Non-irrigation season				
	Flow Category	High	Medium-High	Medium	Medium-Low	Low	High	Medium-High	Medium	Medium-Low	Low
36382-ORDEQ: Pine Creek at Hwy 71	Measured Load (organisms/day)	5.65E+12	1.40E+12	N/A	5.53E+09	1.20E+10	5.07E+12	1.25E+11	2.04E+10	1.73E+10	N/A
	Load Capacity (organsims/day)	8.26E+12	1.81E+12	5.41E+11	2.06E+11	8.02E+10	8.26E+12	1.81E+12	5.41E+11	2.06E+11	8.02E+10
	Excess Load (% reduction)	0%	0%	N/A	0%	0%	0%	0%	0%	0%	N/A
34250-ORDEQ: Powder River above Phillips	Measured Load (organisms/day)	N/A	9.86E+10	N/A	6.44E+08	2.86E+08	N/A	9.05E+09	N/A	4.76E+08	N/A
	Load Capacity (organsims/day)	1.53E+12	2.64E+11	5.86E+10	1.98E+10	2.38E+09	1.53E+12	2.64E+11	5.86E+10	1.98E+10	2.38E+09
	Excess Load (% reduction)	N/A	0%	N/A	0%	0%	N/A	0%	N/A	0%	N/A
11490-ORDEQ: Powder River at Baker City	Measured Load (organisms/day)	1.44E+12	3.43E+11	1.10E+11	7.22E+10	2.30E+10	4.25E+11	4.12E+11	1.56E+11	8.65E+09	6.44E+09
	Load Capacity (organsims/day)	1.31E+12	4.66E+11	1.64E+11	6.37E+10	3.02E+10	1.31E+12	4.66E+11	1.64E+11	6.37E+10	3.02E+10
	Excess Load (% reduction)	9%	0%	0%	12%	0%	0%	0%	0%	0%	0%
36192-ORDEQ: North Powder River at Miller Rd	Measured Load (organisms/day)	4.97E+11	1.29E+11	9.96E+10	9.91E+10	7.05E+09	8.64E+11	6.78E+09	3.40E+09	5.38E+09	N/A
	Load Capacity (organsims/day)	1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10	1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
	Excess Load (% reduction)	0%	8%	48%	70%	0%	0%	0%	0%	0%	N/A
36191-ORDEQ: North Powder River at Hwy 30	Measured Load (organisms/day)	5.34E+12	4.90E+11	1.78E+11	1.46E+11	2.48E+11	2.01E+12	2.72E+10	1.12E+10	3.34E+10	N/A
	Load Capacity (organsims/day)	1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10	1.23E+12	1.19E+11	5.22E+10	3.00E+10	1.25E+10
	Excess Load (% reduction)	77%	76%	71%	79%	95%	39%	0%	0%	10%	N/A
36193-ORDEQ: Eagle Creek near Richland	Measured Load (organisms/day)	1.35E+12	3.38E+11	N/A	8.30E+10	2.97E+10	1.20E+12	7.82E+10	4.55E+10	2.62E+10	N/A
	Load Capacity (organsims/day)	5.32E+12	1.18E+12	3.84E+11	1.24E+11	1.08E+10	5.32E+12	1.18E+12	3.84E+11	1.24E+11	1.08E+10
	Excess Load (% reduction)	0%	0%	N/A	0%	64%	0%	0%	0%	0%	N/A
11857-ORDEQ: Powder River near Richland	Measured Load (organisms/day)	7.10E+12	5.87E+11	1.65E+11	4.34E+11	N/A	3.05E+12	2.68E+11	2.44E+10	6.21E+10	N/A
	Load Capacity (organsims/day)	4.65E+12	8.83E+11	2.31E+11	1.07E+11	3.11E+10	4.65E+12	8.83E+11	2.31E+11	1.07E+11	3.11E+10
	Excess Load (% reduction)	35%	0%	0%	75%	N/A	0%	0%	0%	0%	N/A
36195-ORDEQ: Burnt River at Unity Reservoir	Measured Load (organisms/day)	1.15E+11	1.84E+10	3.25E+09	N/A	N/A	2.35E+10	3.17E+09	2.04E+09	2.61E+09	N/A
	Load Capacity (organsims/day)	1.99E+12	3.59E+11	1.28E+11	2.54E+10	4.98E+09	1.99E+12	3.59E+11	1.28E+11	2.54E+10	4.98E+09
	Excess Load (% reduction)	0%	0%	0%	N/A	N/A	0%	0%	0%	0%	N/A
34256-ORDEQ: Burnt River at Clarks Creek Rd	Measured Load (organisms/day)	2.15E+12	3.77E+11	2.27E+11	N/A	N/A	5.03E+11	2.62E+11	1.90E+10	1.88E+10	N/A
	Load Capacity (organsims/day)	2.39E+12	2.40E+11	1.33E+11	8.25E+10	4.30E+10	2.39E+12	2.40E+11	1.33E+11	8.25E+10	4.30E+10
	Excess Load (% reduction)	0%	36%	41%	N/A	N/A	0%	8%	0%	0%	N/A
11494-ORDEQ: Burnt River at Huntington	Measured Load (organisms/day)	5.12E+12	1.78E+11	1.04E+11	8.31E+10	5.88E+10	3.41E+12	4.42E+10	7.24E+09	1.10E+09	N/A
	Load Capacity (organsims/day)	3.10E+12	3.63E+11	1.98E+11	1.29E+11	5.51E+10	3.10E+12	3.63E+11	1.98E+11	1.29E+11	5.51E+10
	Excess Load (% reduction)	40%	0%	0%	0%	6%	9%	0%	0%	0%	N/A

Notes: N/A indicates no data. Highest reductions needed are highlighted in pale orange. Year-round implementation of highest reduction indicated at any flow is protective of all flows and both criteria.

Table 4.5.2pp: Compiled loading capacity and excess load by station – single sample criterion

Station		Single Sample Maximum Criterion									
		Irrigation Season					Non-irrigation season				
	Flow Category	High	Medium-High	Medium	Medium-Low	Low	High	Medium-High	Medium	Medium-Low	Low
36382-ORDEQ: Pine Creek at Hwy 71	Measured Load (organisms/day)	1.17E+13	2.65E+12	N/A	5.53E+09	2.53E+10	6.18E+12	9.79E+11	4.52E+10	8.95E+10	N/A
	Load Capacity (organsims/day)	1.30E+13	6.87E+12	N/A	3.74E+11	2.71E+11	2.18E+13	6.97E+12	2.26E+12	9.74E+11	N/A
	Excess Load (% reduction)	0%	0%	N/A	0%	0%	0%	0%	0%	0%	N/A
34250-ORDEQ: Powder River above Phillips	Measured Load (organisms/day)	N/A	1.18E+11	N/A	1.97E+09	4.15E+09	N/A	4.14E+10	N/A	4.76E+08	N/A
	Load Capacity (organsims/day)	N/A	4.58E+11	N/A	3.48E+10	1.31E+10	N/A	1.29E+12	N/A	3.07E+10	N/A
	Excess Load (% reduction)	N/A	0%	N/A	0%	0%	N/A	0%	N/A	0%	N/A
11490-ORDEQ: Powder River at Baker City	Measured Load (organisms/day)	1.88E+12	9.76E+11	3.25E+11	2.03E+11	6.40E+10	4.25E+11	4.12E+11	4.20E+12	6.05E+10	6.44E+09
	Load Capacity (organsims/day)	2.93E+12	1.15E+12	7.91E+11	1.69E+11	9.12E+10	3.68E+12	9.66E+11	7.05E+11	2.42E+11	9.17E+10
	Excess Load (% reduction)	0%	0%	0%	17%	0%	0%	0%	83%	0%	0%
36192-ORDEQ: North Powder River at Miller Rd	Measured Load (organisms/day)	1.60E+12	3.26E+12	1.81E+11	6.50E+11	7.63E+09	1.60E+12	2.59E+10	4.40E+09	1.10E+10	N/A
	Load Capacity (organsims/day)	6.41E+12	5.46E+11	1.69E+11	1.09E+11	4.77E+10	2.36E+12	3.08E+11	1.49E+11	1.29E+11	N/A
	Excess Load (% reduction)	0%	83%	7%	83%	0%	0%	0%	0%	0%	N/A
36191-ORDEQ: North Powder River at Hwy 30	Measured Load (organisms/day)	1.96E+13	1.97E+12	5.00E+11	4.56E+11	2.84E+11	2.26E+12	1.46E+12	1.90E+11	3.36E+11	N/A
	Load Capacity (organsims/day)	4.00E+12	6.66E+11	1.69E+11	7.65E+10	4.77E+10	2.36E+12	5.66E+11	1.49E+11	1.39E+11	N/A
	Excess Load (% reduction)	80%	66%	66%	83%	83%	0%	61%	22%	59%	N/A
36193-ORDEQ: Eagle Creek near Richland	Measured Load (organisms/day)	3.22E+12	1.24E+12	N/A	4.08E+11	2.97E+10	1.35E+12	8.13E+11	4.13E+11	1.03E+11	N/A
	Load Capacity (organsims/day)	1.40E+13	5.71E+12	N/A	2.41E+11	5.02E+10	1.54E+13	3.65E+12	1.13E+12	8.47E+11	N/A
	Excess Load (% reduction)	0%	0%	N/A	41%	0%	0%	0%	0%	0%	N/A
11857-ORDEQ: Powder River near Richland	Measured Load (organisms/day)	1.59E+13	1.58E+12	1.04E+12	1.02E+12	N/A	1.59E+13	3.41E+12	2.44E+10	9.78E+10	N/A
	Load Capacity (organsims/day)	2.10E+13	3.46E+12	7.32E+11	3.96E+11	N/A	7.89E+12	4.98E+12	4.92E+11	4.65E+11	N/A
	Excess Load (% reduction)	0%	0%	30%	61%	N/A	50%	0%	0%	0%	N/A
36195-ORDEQ: Burnt River at Unity Reservoir	Measured Load (organisms/day)	3.83E+11	1.97E+11	1.20E+10	0.00E+00	N/A	8.75E+10	3.18E+09	3.33E+09	7.25E+09	N/A
	Load Capacity (organsims/day)	2.63E+12	1.54E+12	7.75E+11	N/A	N/A	5.92E+12	6.46E+11	1.69E+11	1.29E+11	N/A
	Excess Load (% reduction)	0%	0%	0%	N/A	N/A	0%	0%	0%	0%	N/A
34256-ORDEQ: Burnt River at Clarks Creek Rd	Measured Load (organisms/day)	6.11E+12	4.61E+12	2.38E+12	N/A	N/A	2.41E+12	2.62E+11	4.02E+11	1.93E+11	N/A
	Load Capacity (organsims/day)	4.80E+12	7.74E+11	4.91E+11	N/A	N/A	8.51E+12	4.97E+11	3.97E+11	3.00E+11	N/A
	Excess Load (% reduction)	21%	83%	79%	N/A	N/A	0%	0%	1%	0%	N/A
11494-ORDEQ: Burnt River at Huntington	Measured Load (organisms/day)	9.79E+12	3.45E+11	6.16E+11	3.35E+11	5.88E+10	3.90E+12	2.70E+11	2.59E+10	1.10E+09	N/A
	Load Capacity (organsims/day)	6.86E+12	1.02E+12	6.47E+11	3.94E+11	2.68E+11	1.33E+13	1.32E+12	5.26E+11	4.47E+11	N/A
	Excess Load (% reduction)	30%	0%	0%	0%	0%	0%	0%	0%	0%	N/A

Notes: N/A indicates no data. Highest reductions needed are highlighted in pale orange. Year-round implementation of highest reduction indicated at any flow is protective of all flows and both criteria.

Table 4.5.2qq: Compiled percent reductions needed for reaches in the Powder Basin

Station and stream reach	Percent reduction	Criterion based upon	Season based upon	Flow category based upon
11490-ORDEQ: Powder River at Baker City	83%	Single Sample	Non-Irrigation	Medium
11857-ORDEQ: Powder River at Snake River Rd (Richland)	75%	Geometric Mean	Irrigation	Medium-Low
36193-ORDEQ: Eagle Creek near Richland	64%	Geometric Mean	Irrigation	Low
36191-ORDEQ: North Powder River at Hwy 30	95%	Geometric Mean	Irrigation	Low
36192-ORDEQ: North Powder River at Miller Rd	83%	Single Sample	Irrigation	Medium-High & Medium-Low
34256-ORDEQ: Burnt River at Clarks Creek Rd	83%	Single Sample	Irrigation	Medium High
11494-ORDEQ: Burnt River at Huntington	40%	Geometric Mean	Irrigation	High
34250-ORDEQ: Powder River above Phillips Reservoir	0%	Geometric Mean & Single Sample	Irrigation & Non-Irrigation	All
36382-ORDEQ: Pine Creek at Hwy 71	0%	Geometric Mean & Single Sample	Irrigation & Non-Irrigation	All
36195-ORDEQ: Burnt River at Unity Reservoir Discharge	0%	Geometric Mean & Single Sample	Irrigation & Non-Irrigation	All

5. Source Assessment and Load Contributions

Fecal indicator bacteria, such as *E. coli*, and associated pathogens originate from human, livestock and wildlife waste. The pathways by which *E. coli* and associated pathogens enter waterbodies depends on the specific sources, locations of origin, transport mechanisms and landscape management practices.

5.1 Summary of source assessment bacteria data

Water in the Powder River Basin is highly managed for irrigation. Thus, water storage and release affect *E. coli* concentrations in surface waters at different times of the year. Low flows typically occur in the winter months and high flows occur during spring and summer as snowmelt and water stored in reservoirs is released for irrigation. A large proportion of the basin experiences flood irrigation with significant irrigation return flows to streams. Irrigation induced erosion is generally highest in spring and early summer. This erosion can carry sediment, nutrients and *E. coli* to local waterbodies.

The sections that follow present tabulated *E. coli* data, collected on a quarterly basis by DEQ in the Powder River, Brownlee Reservoir and Burnt River Subbasins between 2007-2013, along with discussion of evaluation of the data. The data are grouped as irrigation season (May through October) and non-irrigation season (November through April).

Bacteria data for the Powder and Brownlee subbasins are summarized in Tables 5.1a and sample locations are shown on Figures 5.1.1a, 5.1.2 and 5.1.3a. Bacteria data for the Burnt subbasin is summarized in Table 5.1b and sample locations are shown in Figure 5.1.4a.

Table 5.1a: Powder River and Brownlee Reservoir Subbasins bacteria data 2007-2013

Station Number and Name	Sample dates	River Mile	Irrigation Season 5/1-10/31				Non-irrigation Season 11/1-4/30			
			Number of Samples	Log Mean	Max.	%> 406	Number of Samples	Log Mean	Max.	%> 406
34249 -Cracker Cr. above Wind Cr. confluence	07	4	19	4	40	0	5	1	2	0
34250 -Powder R.above Phillips Reservoir Dam	07-08	138.5	25	14	272	0	8	6	23	0
26601 -Powder R. at RM 131.1, d/s Of Mason Dam	07-08	131	28	1	4	0	22	1	3	0
10725 -Powder R. 3 miles south of Baker	07-08	117	22	138	1414	14	5	135	727	20
11490 -Powder R. at Hwy 7 (in Baker City)*	07-13	113	38	72	2420	10	21	51	687	10
34252 - Powder R. upstream of N. Powder confluence	07-08	88	21	224	1986	38	24	54	1290	8
12624 - Powder R. at Deane Bidwell Rd.	11-12	84	1	N/A	140	0	10	39	147	0
36191 - N. Powder R. at Hwy. 30 bridge	10-13	2	45	372	2420	47	30	61	980	27
36192 - N. Powder R. at Miller Rd. bridge	10-13	10	45	84	2419	16	32	20	2419	12
10724 -Powder R. at Hwy 86 (east of Baker City)*	07-13	37	18	107	2420	11	13	61	488	8
11857 -Powder R. at Snake R. Rd.(Richland)	10-13	10	45	148	1046	18	30	36	191	0
36193 -Eagle Cr. at Snake R. Rd. near Richland	10-13	0.5	45	34	1966	11	30	17	236	0
36194 -Powder R. Arm of Brownlee Res.	10	7.5	25	19	517	4	8	110	248	0
36382 - Pine Cr. at Hwy 71	11-13	0.1	30	33	365	0	21	9	146	0

Notes: * DEQ ambient water quality site
Blue shaded results exceed WQ Criteria (log mean 126 org/100ml, single sample maximum of 406 org/100ml)
NA = not enough data to calculate a geomean

Table 5.1b: Burnt River Subbasin bacteria data 2010-2013

Station Number and name	Sample Dates	River Mile	Irrigation Season 5/1-10/31				Non-irrigation Season 11/1-4/30			
			Number of Samples	Log Mean	Max.	%> 406	Number of Samples	Log Mean	Max.	%>406
36198 - WF Burnt R. at Rice Rd.	10-13	2.5	43	24	1733	2	19	33	101	0
36197 - MF Burnt R. at Rice Rd.	10-13	1.5	43	97	1533	14	32	17	148	0
36196 - SF Burnt R. at Rouse Ln.	10-13	1	43	410	2420	56	31	40	1553	16
36195 - Burnt R. at Unity Res. Dam	10-13	77	43	6	59	0	35	9	28	0
34256 - Burnt R. at Clarks Cr.	10-13	46	43	193	2420	26	32	29	411	3
36384 -Dixie Cr. near mouth at Hwy 30	11-12	0.25	3	150	866	33	4	14	33	0
36385 - Burnt R. at Hwy 30 upstream of Huntington	11-12	3.5	4	63	118	0	4	22	108	0
11494 - Burnt R. at Snake R. Rd. Huntington*	11-12	1	18	85	579	17	15	20	137	0

Notes: * DEQ ambient water quality site
Blue shaded results exceed WQ Criteria (log mean 126 org/100ml, single sample maximum of 406 org/100ml)

5.1.1 Upper Powder River to Baker City

Bacteria monitoring locations in the Powder River and tributaries from the headwaters to Baker City are shown in Figure 5.1.1a. Land uses in this reach consist of forest interspersed with pastures used for livestock grazing. Based on monitoring data, bacteria loading above Phillips Reservoir (Cracker Creek and Powder River sample locations) appears to be minimal, with no exceedances of criteria. Irrigated pastures and hay fields that are often seasonally grazed by livestock become more frequent and extensive downstream of Phillips Reservoir. The Powder River South of Baker City (10725-ORDEQ), located approximately 14 miles downstream of Phillips Reservoir, had exceedances of both geometric mean and single sample criteria year round (Table 5.1a). Based on monitoring data, exceedances of criteria become less frequent at the monitoring station in Baker City (Table 5.1a). Bacteria concentrations declined at 11490-

ORDEQ between 2000 and 2019, with only one exceedance of the single sample criteria between 2015 and 2019 (Figure 5.1.1b). According to the loading capacity and excess load calculated for station 11490, this is the only location with a greater percent reduction required during the non-irrigation season rather than the irrigation season (Table 4.5.2qq). Station 11490 is located within Baker City at highway 7 and just downstream of several public parks. Unlike other monitoring locations, water quality at this site includes influence from urban activities such as roadway runoff and potential contamination from wildlife and pet waste. These additional influences are not limited to the irrigation season and may be greater when runoff is naturally higher. Based on monitoring data and information on land use/land cover, the area concern for bacteria loading in this reach, due to livestock and irrigation practices, occurs immediately upstream of Baker City and downstream of Phillips Reservoir.

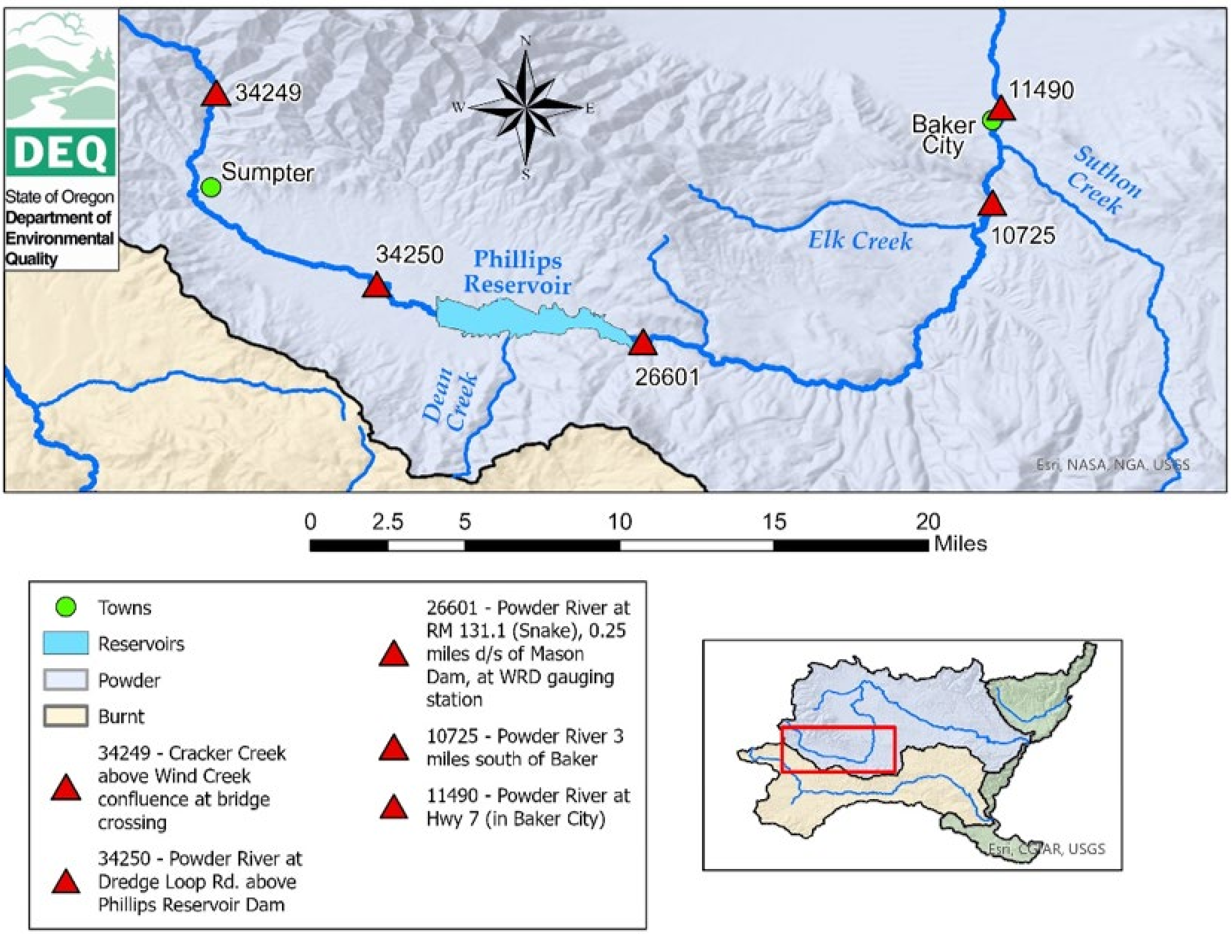

Figure 5.1.1a: Bacteria sampling locations and DEQ station numbers in the Powder River and tributaries from headwaters to Baker City

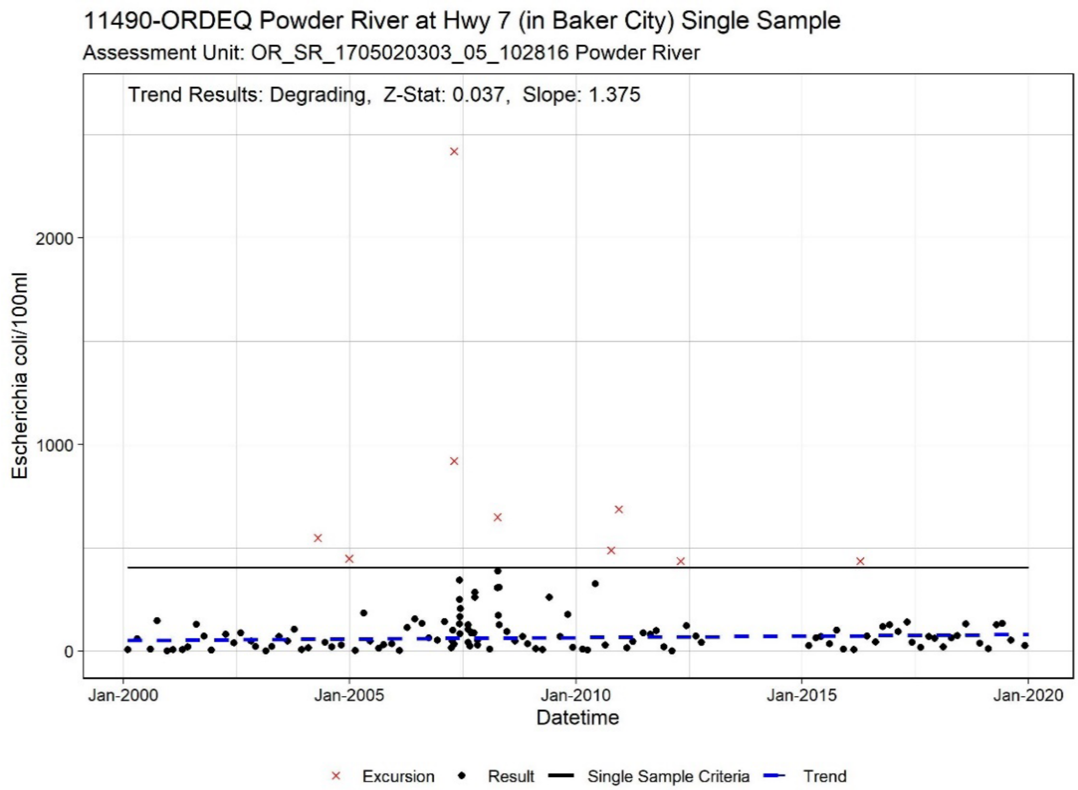

Figure 5.1.1b: Bacteria data from Powder River at Highway 7 in Baker City (11490), 2000-2019. DEQ 2020 Water Quality Status and Trends Report

5.1.2 Powder River from Baker City to Thief Valley Reservoir, including lower North Powder River

Downstream of Baker City, bacteria concentrations generally increase in the Powder River as it flows through a lowland valley area dominated by irrigated pastures and livestock (Table 5.1a and Figure 5.1.2). Bacteria concentrations at the Powder River at I-84 (34252-ORDEQ) and the North Powder River at the Hwy 30 (36191-ORDEQ) exceeded both the log mean and single sample criteria during the irrigation season and the single sample criteria in the non-irrigation season based on monitoring data from 2007-2013. Due to the high populations of livestock and predominance of flood irrigation practices, bacteria load reductions to this reach of the Powder and lower North Powder River should be a high priority.

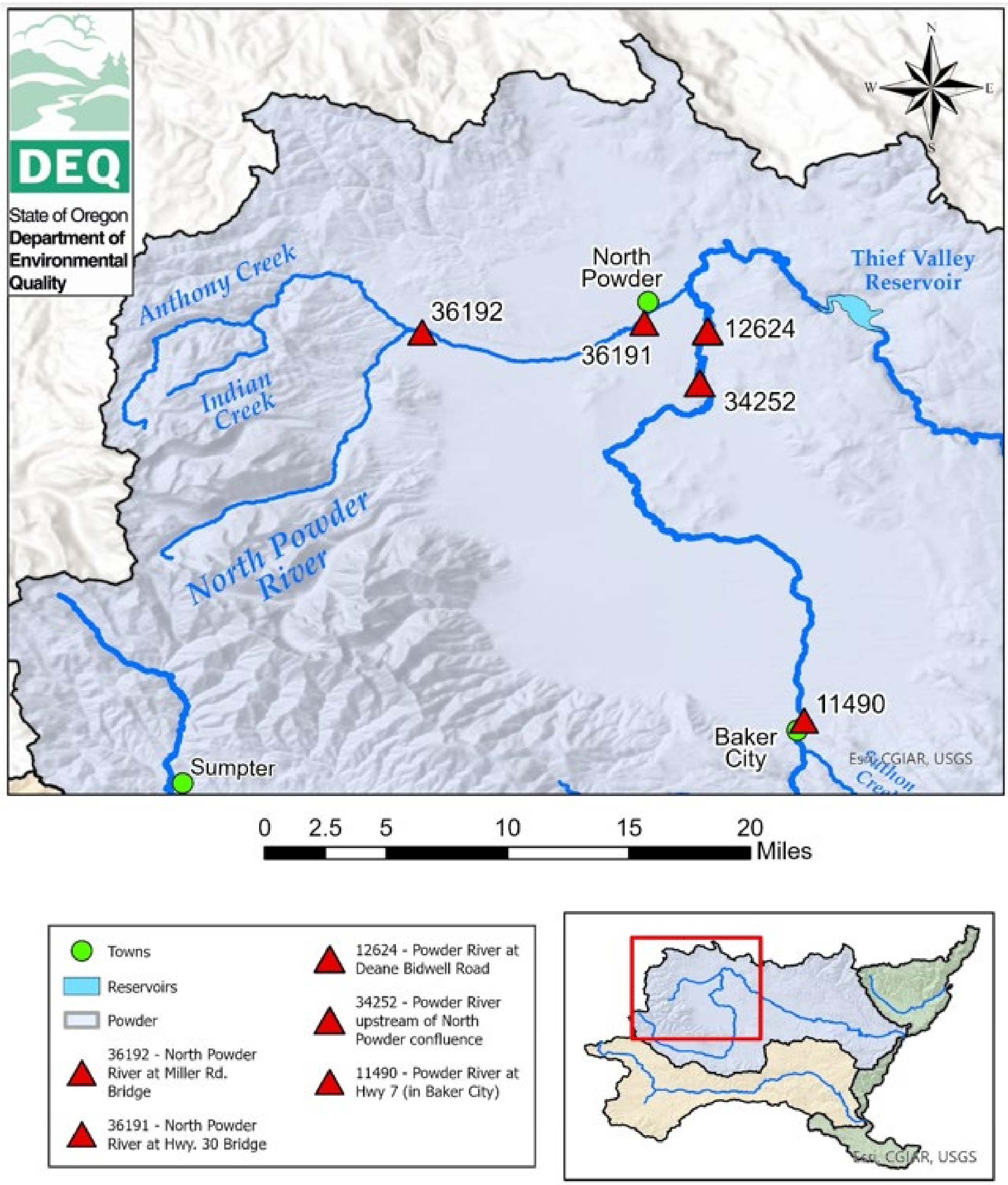

Figure 5.1.2: Bacteria sampling locations in the Powder River and tributaries from Baker City to Thief Valley Reservoir

5.1.3 Lower Powder River from Thief Valley Reservoir to Brownlee Reservoir and Pine Creek

DEQ has observed cattle within the footprint of the dewatered portions of Thief Valley Reservoir during the last decade. During discussions with DEQ, US Bureau of Reclamation staff have stated that there are no grazing allotments within the reservoir lands. However, cattle deposit observable amounts of manure in the reservoir footprint during the summer months.

The Powder River below Thief Valley Reservoir transitions into an area with high topographic relief interspersed with agricultural areas in valley bottoms (Figure 5.1.3a). The most prominent of these is the Keating Valley midway between Thief Valley Reservoir and near Richland, which contains irrigated hay fields and seasonal livestock usage along the river (Figure 5.1.3b). Bacteria monitoring data from 2000-2019 at the Powder River near Keating (10724-ORDEQ) indicates consistient bacteria loading from agricultural (livestock) sources in this area during irrigation and non-irrigation seasons (Table 5.1a).

Near Richland and the confluence with Eagle Creek, the river enters a broad valley with extensive irrigated pastures and hay fields before joining the Snake River in Brownlee Reservoir (Figure 5.1.3a). Exceedances of both the log mean and single sample criteria occured during the irrigation season in Powder River at Snake River Rd (Richland) (11857-ORDEQ) from 2000-2019 (Table 5.1a). However, there were no exceedances of criteria in the non-irrigation season during this period. Bacteria concentrations at the monitoring station for Eagle Creek near Richland (36193-ORDEQ) for 2007-2013 indicate bacteria loading contributes to periodic single sample criteria exceedances during irrigation season (Table 5.1a).

Pine Creek drains a portion of the Brownlee watershed that enters directly into the Snake River below Oxbow Dam (Figure 5.1.3a). The upper portion of the watershed near Halfway contains extensive irrigated pastures and hay fields. The lower portion flows through an area of high topographic relief with minimal development. Monitoring data for Pine Creek at Hwy 71 (36382-ORDEQ) from 2007-2013 do not indicate exceedances of bacteria criteria during irrigation or non-irrigation seasons (Table 5.1a).

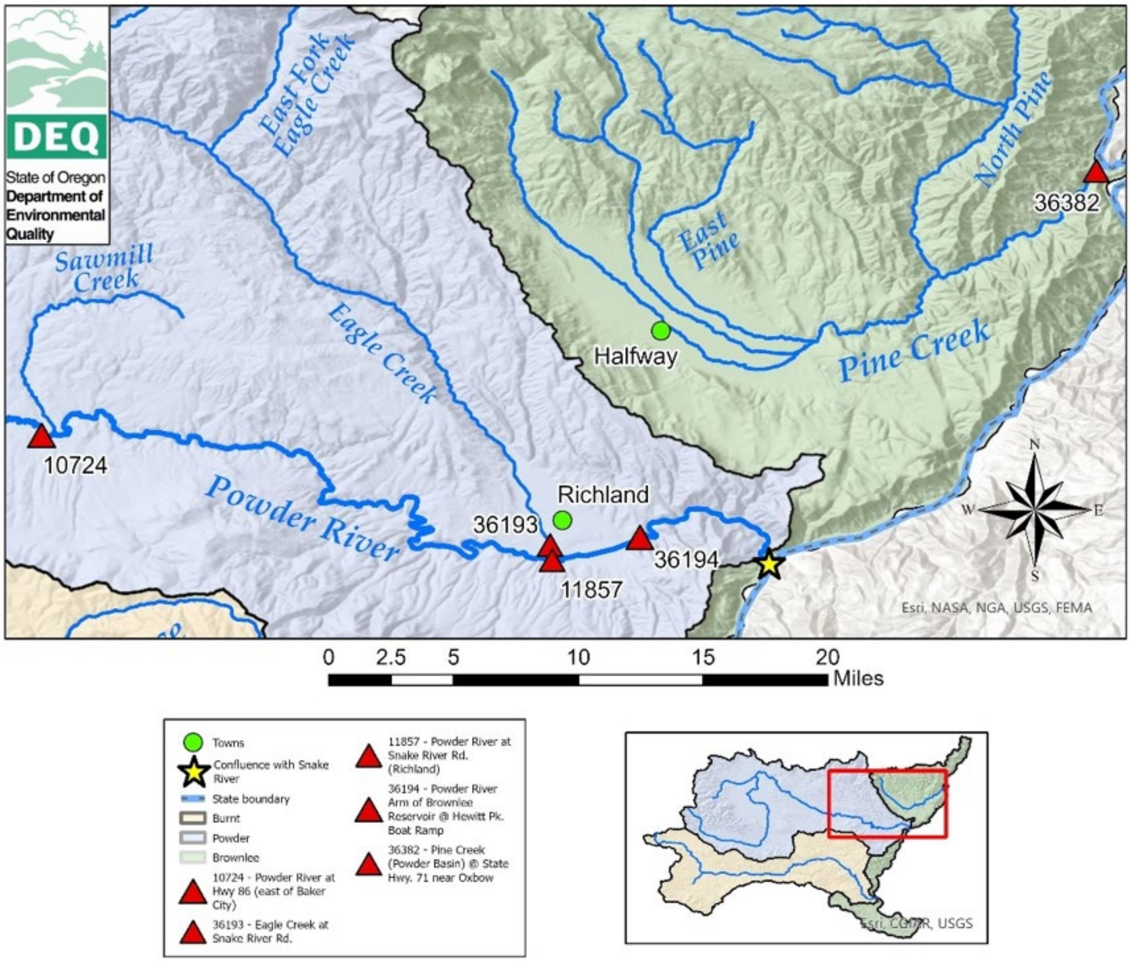

Figure 5.1.3a: Bacteria sampling locations in the Powder River and tributaries from Thief Valley Reservoir to Brownlee Reservoir and Pine Creek

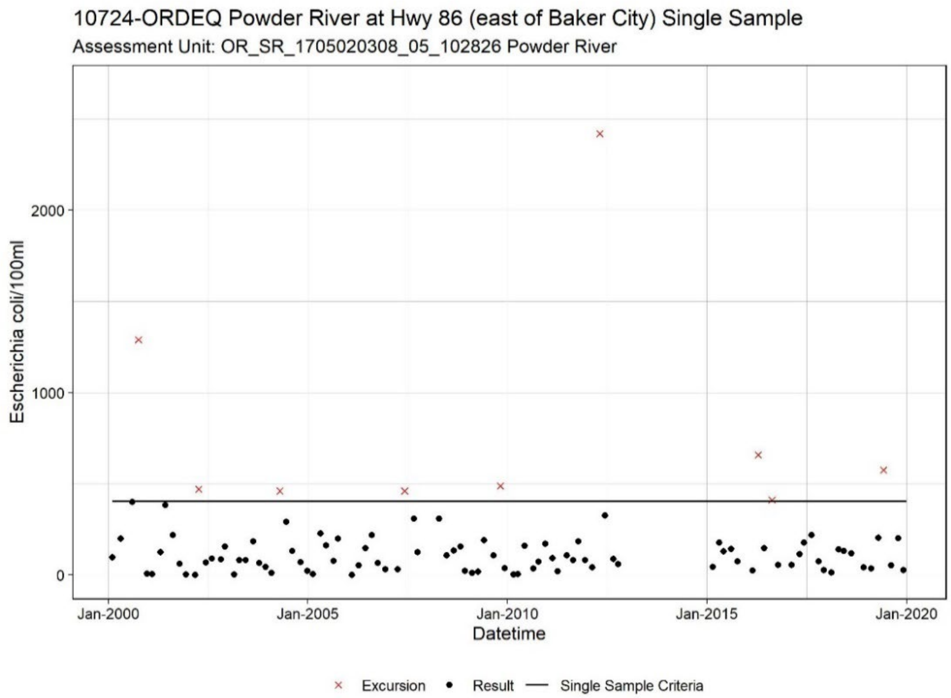

Figure 5.1.3b: Bacteria data from Powder River at Highway 86 east of Baker City/ near Keating (10724), 2000-2019. DEQ 2020 Water Quality Status and Trends Report

5.1.4 Upper Burnt River above Unity Reservoir

The upper Burnt River Watershed above Unity Reservoir contains a mixture of managed and unmanaged land uses/land covers. The upper portions of the forks are mostly forested. The North and West Forks of Burnt River contains limited pasturelands along a portion of the channel just upstream of the Reservoir. The Middle and South Forks contain more pastures areas near the reservoir, with the South Fork having the largest areas of irrigated pastures and hayfields.

Bacteria data have been collected from the West, Middle, and South Forks of the Burnt River. The North Fork has not been sampled due to lack of access to the river in the vicinity of the reservoir (Figure 5.1.4a). Of the monitoring data available for the forks, the South Fork had frequent exceedances of both the log mean and single sample criteria in the irrigation season and several single sample criterion exceedances in the non-irrigation season from 2007-2013 (Table 5.1b). The Middle and West Forks had several exceedances of the single sample criterion during the irrigation season only during 2007-2013 (Table 5.1b). Because there was no measured flow data available for the North, Middle, West and South Forks of the Burnt River, it was not possible to calculate percent load reductions needed in these reaches. The nearest reach with load duration curve was calculated using flow data measured below Unity Dam, where the downstream reservoir dynamics influence biological processes and bacteria levels. As noted above and based on observed criteria exceedances, the South Fork Burnt River should be the highest priority for bacteria reductions in the tributaries upstream of the Burnt River.

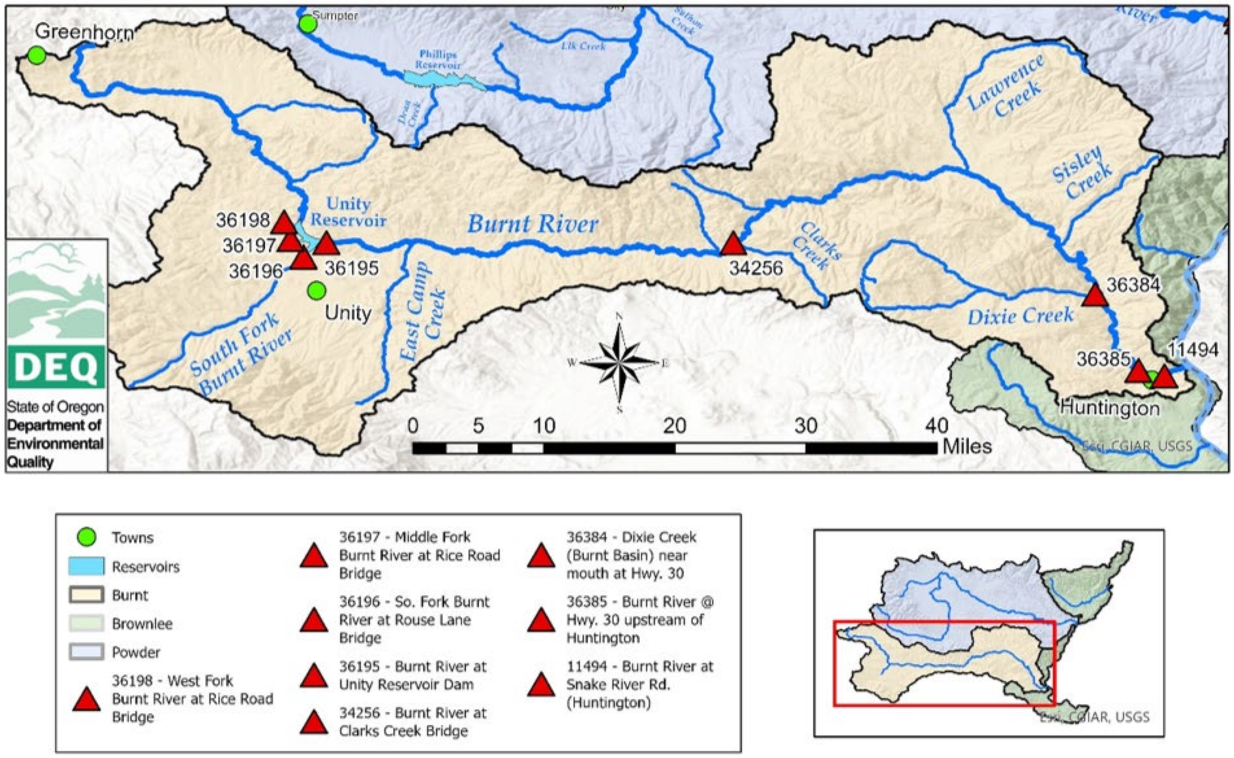

Figure 5.1.4a: Bacteria sampling locations and DEQ station numbers in the Burnt River and tributaries

5.1.5 Burnt River from Unity Reservoir to Huntington

The Burnt River below Unity Reservoir flows through a 30-mile long valley with irrigated pastures and cultivated hay, along with the communities of Hereford and Bridgeport. Below Bridgeport (34256-ORDEQ; Burnt River at Clark Creek), the Burnt River enters a steep canyon for 15 miles. Most of the land is managed by the Bureau of Land Management with minimal agriculture and grazing. Below the canyon, the Burnt River flows through the fields and scattered cottonwood gallery forests in the Durkee Valley followed by another canyon reach before flowing into the Snake River (Brownlee Reservoir) below the community of Huntington (Figure 5.1.4a). Dixie Creek enters the Burnt River upstream of Huntington. The Huntington WWTP (DEQ# 40981, EPA# OR0020052) discharges into the Burnt River below Huntington and is reflected in samples collected at 11494-ORDEQ.

Quarterly monitoring for the Burnt River at Unity (36195-ORDEQ) from 2010-2013 suggest extremely low bacteria levels (no criteria exceedances) entering the river from the outlet of the dam (Table 5.1b). Bacteria entering from sources upstream likely die off in the reservoir.

Bacteria monitoring for the Burnt River at Clark Creek Road (34256-ORDEQ) from 2010-2013 indicate exceedances of geometric mean and single sample criteria during the irrigation season and single sample criterion during the non-irrigation season. This sampling location reflects the influence of agricultural activities downstream of Unity Reservoir.

Monitoring data from Dixie Creek at Hwy 30 (36384-ORDEQ) indicate exceedances of geometric mean and single sample criteria during irrigation season of 2011-12. However, there were no exceedances of criteria during non-irrigation season. On the Burnt River upstream of Huntington (36385-ORDEQ), no exceedances of bacteria were observed during all seasons from 2010-2013. However, exceedances of the single sample criterion were observed during irrigation season downstream of Huntington (11494-ORDEQ) over the same time period (Table 5.1b). Single sample exceedances were also observed at this site from 2000-2019 (Figure 5.1.4b). Although this site is located downstream of the WWTP outfall, calculations based on permitted limits suggest that nonpoint sources still compose most bacteria present in water samples (Table 4.5.2kk-nn).

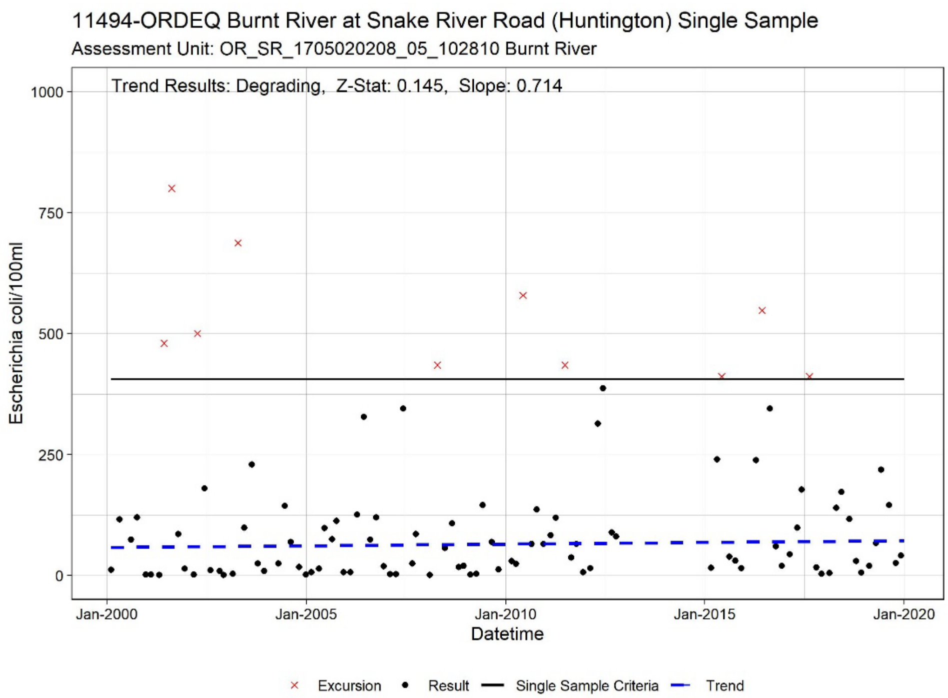

Figure 5.1.4.b: Bacteria data from Burnt River at Huntington (11494), 2000-2019. DEQ 2020 Water Quality Status and Trends Report.

5.2 Bacteria sources

Based on the analysis of monitoring data presented in Section 5.1, DEQ identified waterbodies downstream of irrigated pastures, hay fields and livestock grazing as prone to exceedances of criteria for fecal bacteria. Only two locations may be influenced by discharges from WWTPs. However, based on permit effluent limits for these facilities, the potential contributions to riverine loads are minimal (Section 4.5.2). Thus, DEQ contends that nonpoint source input of bacteria is the largest source of fecal contamination to surface waters in the Powder Basin. In this section, DEQ considers various potential sources of bacteria and discusses different agricultural and water management practices that may facilitate the delivery of bacteria to surface waters.

5.2.1 Livestock grazing and pasture irrigation

The locations of bacteria criteria exceedances and upstream land use/land cover suggests that livestock, specifically cattle with access to irrigated farmland, pastures and surface water, as the primary source of *E. coli* contamination in river reaches that exceeded loading capacity in the Powder River Basin. Data from Baker County (which occupies most of the Powder Basin and generally reflects conditions in adjacent counties) shows that cattle/calves make up the vast majority of livestock compared to hogs, sheep, horses and chickens. Based on the USDA Census of Agriculture, 71,187 and 75,187 cattle/calf animal units were recorded in Baker County during 2012 and 2017, respectively (USDA-NASS 2019). During the same time periods, combined hogs, sheep, horses and chickens never exceeded 8,343 animal units. As a comparison, different types and age classes of cattle produce on average 26-136 pounds manure per day versus <1-8 pounds per day for other livestock types listed above (Statistics Canada 2006). According to the USDA Agricultural Census data (USDA-NASS 2019), most of the cattle had access to pasture or rangeland at some point during the year, allowing waste and fecal pathogens to be deposited to the landscape. DEQ thus concludes that reductions of *E. coli* from lands occupied seasonally or annually by cattle will be needed to achieve recreational-based water quality criteria for fecal indicator bacteria.

5.2.2 Residential septic systems

The population of Baker County, which represents most of the population within the Powder Basin, as of 2020 was 16,668 (US Census Bureau 2021). Approximately 68% of the county's population lived within areas serviced by centralized sewage systems (US Census Bureau 2021) with permits to limit bacteria discharge to surface waters. The remaining population likely uses some form of onsite septic treatment system. These systems are designed to minimize the leaching of fecal wastes to adjacent waterways. Over time, these systems may become compromised and fail to provide removal functions. However, given the low population on septic systems, the dispersed nature of this population, and the likelihood that only a small percentage of systems are failing at any given time, DEQ concludes, therefore, that leaching of *E. coli* from failing septic systems constitutes a possible but likely insignificant source to listed waters in the Powder River Basin.

5.2.3 Permitted wastewater and stormwater discharges

Table 5.2.3 lists all National Pollutant Discharge Elimination System permits for discharge of wastewater and stormwater within the Powder River Basin.

Table 5.2.3: Powder River Basin wasterwater and stormwater discharge permits

Discharge type	DEQ file number	EPA number	Permittee	Facility type	NPDES Permit type	Receiving water	River Mile
Municipal wastewater	5324	OR0020699	City of Baker City*	sewage treatment	DOM-C1b	Powder River	116.3
	36156	OR0023329	City of Halfway**	sewage treatment	DOM-Db	Pine Creek	19.5
	40981	OR0020052	City of Huntington	sewage treatment	DOM-Db	Burnt River	2
	61600	OR0022403	City of North Powder	sewage treatment	DOM-Db	Powder River	82.4
Industrial wastewater	2142	OR0002526	Amalgamated Sugar Co, Inc	food preparation	IW-B04	Snake River	252
	41297	OR0027278	Idaho Power Co - Hells Canyon Plant	electric power	IW-O	Snake River	247
	41299	OR0027286	Idaho Power Co - Oxbow Plant	electric power	IW-O	Snake River	273
Stormwater	125054	ORR303528	Rare Earth Resources, LLC - Bonnanza Mine	gold ore	GEN12Z	Pine Creek	26.43
	126933	ORR303529	Bayhorse Silver (USA) Inc.	silver ore	GEN12Z	Snake River	317
	102507	ORR211070	Ash Grove Cement Co	limestone	GEN12Z	Burnt River	27
	108030	ORR211613	Ash Grove Cement Co - Lime Plant	concrete products	GEN12Z	Burnt River	8.5
	101822	ORS110870	Oregon Department of Transportation	highway	MS4 - Phase I	various	NA

Notes:
* Baker City ceased discharge to the Powder River in summer 2022. Water Pollution Control Facility (no discharge) permit application in process. However, discharge resumed in summer of 2023 under the NPDES permit.
**Halfway ceased discharge to Pine Creek in 2018. NPDES permit terminated and WPCF permit issued in 2019.
NA = Not applicable because outfalls are located along the road system throughout the basin

5.2.3.1 Wastewater discharges

As shown in Table 5.2.3, there are three active industrial wastewater discharge permits within the Powder River Basin. DEQ determined that the processes involved in these sugar and power facilities do not have a reasonable potential for bacteria in discharges.

Table 5.2.3 also lists four permitted municipal wastewater facilities that regulated bacteria discharges. As detailed in the table and its notes, the active sewage treatment plants discharging in the Powder River Basin are at Baker City (≤2 MGD to the Powder River), North Powder (≤1 MGD to the North Powder River) and Huntington (≤1 MGD to the Burnt River). *E. coli* concentrations in effluents from these facilities are not permitted to be above the recreation-based criteria according to OAR 340-041-0009. Based on available data on wastewater treatment infrastructure, DEQ concluded that point source discharge of treated sewage wastewater does not contribute a significant amount of *E. coli* to most of the listed waterbodies in the Powder River Basin with the possible exception of the Burnt River downstream of

Huntington and the Powder River downstream of Baker City and below the confluence with the North Powder River.

5.2.3.2 Stormwater discharges

Stormwater running off from lands following exposure to manure from livestock, wildlife, pets or poorly functioning septic systems is a potentially significant nonpoint source of bacteria to waterways in the basin. This source originates from a variety of land uses within the basin and may be conveyed to waters as overland flows, along roadways or other conveyances and can be addressed using nonpoint source management strategies.

DEQ determined that the handful of ore operations in the basin registered under the NPDES 1200Z Industrial Stormwater general permit do not have reasonable potential to contribute bacteria in discharges and cumulative flow volumes would be miniscule. The only permitted point source of bacteria in stormwater discharge in the basin is through the Oregon Department of Transportation management of stormwater from highways statewide under a Phase I Municipal Separate Storm Sewer System (or MS4) permit. Although ODOT's MS4 permit does not specify an effluent limit for fecal indicator bacteria and highway stormwater runoff is not anticipated to be a significant source of bacteria, manure and background sources of bacteria are likely to be present at times in highway stormwater conveyances within the Powder River Basin. Therefore, DEQ opted to assign a wasteload allocation of at least 1% of the loading capacity for ODOT's MS4 permit. EPA's draft TMDLs to Stormwater Permits Handbook (USEPA, 2016) offers several methods for calculating wasteload allocations for NPDES stormwater permits, including MS4 permits. DEQ chose the ratio of jurisdictional boundary method, which calculates the ratio of ODOT jurisdictional area to the total watershed area to determine a percentage of the bacteria loading capacity to be given as the wasteload allocation for ODOT's MS4 permit discharges within the watershed.

Because a readily available source of the extents of the ODOT jurisdictional boundary within the watershed does not exist, DEQ estimated right-of-way area using road centerlines from 2019 Oregon Transportation Network spatial data (Oregon Explorer 2022). Roads designated as owned by ODOT were clipped to the HUC6 boundary of the Powder Basin. A 30-ft planar buffer around the ODOT roads was used to calculate the area of the right-of-way using the Buffer tool in ArcGIS Pro 3.0. This resulted in a MS4 jurisdictional area of 3,350 acres assigned to ODOT. Based on the Powder Basin area (2,630,554 acres), the proportion of the basin that fell within the jurisdictional boundary of the ODOT MS4 was 0.1%.

There is uncertainty in the estimation of jurisdictional area and resultant potential bacteria loads due to the following factors:

- Roads tend to be near the valley bottoms and adjacent to streams;
- The episodic nature of pollutant loads from roads makes it difficult to capture only using jurisdictional boundary area to watershed area ratio and;
- The mixture of impervious and pervious contributing areas results in variations in loads from different locations within the estimated jurisdictional boundaries, even for the same events.

5.2.4 Wildlife

Wildlife were considered to be a potential source of bacteria pollution to surface waters in the Powder Basin, particularly in areas where they congregate at artificial feeding areas. In 2019 and 2020, the Powder Basin Watershed Council conducted a bacteria and total phosphorus water quality study at two elk feeding areas managed by the Oregon Department of Fish and

Wildlife. The feeding sites are located on the east side of the Elkhorn Mountains along Anthony Creek and the North Powder River.

Both elk feeding sites have irrigated livestock pastures with fenced riparian areas and water gaps. Riparian condition is considered to be good and cattle graze the pastures in rotations between May 1 and October 1 each year. Elk are generally present during the winter months when deep snow drives them out of the mountains and into the Baker Valley. Water quality samples were collected upstream and downstream of each feeding area during January (elk feeding), April-May (runoff), and August (base flows during livestock grazing period). An additional site was located on the North Powder River approximately 2 miles downstream of the North Powder Feeding area near North Powder Pond 1.

All bacteria water sample results from the feeding sites had less than 10% of the single sample criteria for *E. coli* (406 organisms/100 ml) except for the downstream samples during the baseflow period in August. Maximum *E. coli* concentrations during the baseflow period ranged from 348 MPN per 100 mL at Anthony Creek to 1600 MPN per 100 mLat the North Powder site. The baseflow results from the monitoring site near North Powder Pond 1 site were also above 300 MPN per 100 mL.

The results of this study suggest that the elk feeding areas are not a significant source of bacteria contamination to nearby waterbodies during the elk feeding season, but may be a source of bacteria during the livestock grazing period. Additional studies may be necessary to assess wildlife bacteria contributions in other areas of the basin.

In regions other than the Powder River Basin, resident and migratory waterfowl in high densities haved been demonstrated to contribute to elevated *E. coli* in waterbodies (Meerburg et al. 2011). However, the transitory nature of waterfowl and lower overall densities compared to livestock indicates that waterfowl as an *E. coli* source is minor in the Powder River Basin. Based on a report produced by the Idaho Power Company (Holthuijzen 2003), the density of wintering waterfowl in the Powder River arm of Brownlee Reservoir was 120.3±68.5 birds per river mile (mean±standard deviation). DEQ used the Idaho Power study to do a rough, conservative calculation of bird density in Powder River Basin areas originally listed as impaired for *E. coli* in the 2010 DEQ Integrated Report, which encompasses a larger area than the current listings. Applying the approximate upper 95% confidence interval boundary density of 258 birds per river mile (mean + two standard deviations) to the 221.8 river miles of the Powder River, North Powder River, Burnt River, South Fork Burnt River amounts to 57,225 overwintering waterfowl in areas with past or current *E. coli* impairments. The amount of manure produced by waterfowl varies widely according to species. Farmed ducks are reported to produce 0.33 pounds/day (Woynarovich 1979) and Canadian geese produce 1.75 pounds per day (Weyant 2021). The report from Holthuijzen (2003) suggested that only 6.1% of the surveyed populations were Canadian geese, with mallard ducks, goldeneye, and common merganser making up the majority. DEQ conservatively assumed that the 57,225 overwintering waterfowl were all Canadian geese and that populations have remained similar since the original survey period (which is supported by recent ODFW hunting forecasts for the area (ODFW 2018)). This suggests an upper amount of 100,143 pounds of manure potentially produced per day (258 birds/mile x 221.8 miles x 1.75 pounds per day) in the area during the overwintering season. In comparison, based on the recent agricultural census (USDA-NASS 2019), using the low end of potential manure produced by cattle animal units (26 pounds per day; Statistics Canada 2006), a lower end amount of 1,850,862 pounds of manure per day could potentially be produced just in Baker County. This conservatively suggests that the upper potential amount of waterfowl produced manure across the Powder Basin is 5% of the lower potential amount of manure produced by cattle in Baker County. The comparable amount of waterfowl versus cattle manure is probably much lower due to the species composition of waterfowl, the migratory nature of waterfowl, and the potential for larger amounts of manure to be produced daily by cattle. Nonetheless, waterfowl produced manure in the basin is small compared to livestock produced manure in the basin.

In summary, wildlife sources, although ubiquitous throughout the area, are likely not a major source of *E. coli* to listed waterbodies in the Powder River Basin. A study examining elk in the North Powder Subbasin did not suggest that this common wildlife species in the basin was a significant sources of *E. coli* contamination in adjacent waterbodies (Powder Basin Watershed Council 2021). By extension, DEQ concludes that mule deer, bighorn sheep and mountain goats also do not contribute substantive *E. coli* contamination to the basin's listed waterbodies.

6. Allocation Approach

As indicated by the data analysis to identify and assess bacteria sources, point source contributions are extremely limited and nonpoint sources are the main drivers of bacteria loads in rivers and streams of the Powder Basin. In line with these proportional contributions, point source waste load allocations make up the smallest fraction of the allocation distribution, followed by the margin of safety and substantial load allocations for nonpoint sources, inclusive of background sources. The allocation distribution among sources reflects proportional contributions, as well as allowing for uncertainty and any subsequent change to permitted discharges. Proportionality and conservative margin of safety support reasonable assurance of implementation.

6.1 Impacts from WLAs

As noted in Table 5.2.3, four facilities within the basin are permitted to discharge industrial stormwater and three facilities are permitted to discharge industrial wastewater. DEQ determined that stormwater exposed to the activities at these ore and concrete processing facilities and wastewater associated with sugar and power operations do not have reasonable potential to increase bacteria in streams. This is because bacteria is unlikely to be associated with these activities, is not monitored under the permits and cumulative discharge flows are anticipated to be minor. Therefore, no bacteria reductions are needed and the wasteload allocations for the NPDES 1200Z Industrial Stormwater general permit and the three industrial wastewater permits are set at current, unquantified loads, with the narrative requirement of implementing the permits.

DEQ developed wasteload allocations for the wastewater treatment plants serving the cities of Baker City, North Powder and Huntington. Based on the permit limits for these facilities, DEQ used a maximum discharge of 2 MDG at Baker City and 1 MGD at North Powder and Huntington with the maximum *E. coli* concentration allowed by the geometric mean criterion, 126 organisms/100 mL, to ensure the recreation-based criteria were attained. For the Huntington facility, the calculated wasteload allocation is 4.77E+09 organisms/day. This amounts to 0.2 to 8.7% of the loading capacity for 11494-ORDEQ: Burnt River at Huntington based on the geometric mean criterion across the gradient of high to low flow categories. For the Baker City and North Powder facilities' combined 3 MGD, the calculated wasteload allocation is 1.43E+10 organisms/day. This amounts to 0.3 to 46.1% of the loading capacity for 11857-ORDEQ: Powder River near Richland based on the geometric mean criterion across the gradient of high to low flow categories. Discharges typically operate well within their permit limits and discharge smaller loads than those presented above, especially in consideration of chlorination treatment. When operating properly, they will not cause or contribute to water quality violations. Because the facilities have existing permits, no additional reductions are required.

Although the calculated ratio of jurisdiction area assigned to ODOT to the area of the Powder Basin was 0.1%, DEQ assigned 1% of the loading capacity as the ODOT MS4 (Phase I permit) wasteload allocation following recommendations by the EPA's draft TMDLs to Stormwater Permits Handbook (EPA 2008). Implementation of the ODOT MS4 permit conditions and control measures is anticipated to keep bacteria loads in highway stormwater discharges within the watershed below the wasteload allocation of 1% of the loading capacity. These conditions and measures include:

- Public education and outreach – including information specifically on bacteria
- Public involvement and participation – including facilitation of a public website with bacteria information and illicit discharge reporting
- Illicit discharge detection and elimination – including procedures for addressing potential illicit dumping of wastes
- Construction site runoff control – requiring use and maintenance of controls for erosion, sediment and waste materials management at all ground disturbing projects, from initial clearing through final stabilization, to reduce all potential pollutants in stormwater
- Post-construction site runoff control – including inventorying and maintaining all water quality facilities, which reduce loads of bacteria and other pollutants
- Pollution prevention and good housekeeping – including inspection and cleanout of catch basins and litter control, both of which contribute to reducing loads of bacteria and other pollutants.

6.2 Nonpoint Source and Background Load Allocation Methodology

DEQ used a two step process for determining load allocations for each reach and identifying reaches where reductions in fecal indicator bacteria loading were needed. First, DEQ calculated the loading capacity, margin of safety, wasteload allocation, and load allocation for each flow category based on the 90-day geometric mean criterion of 126 organisms/100 mL to ensure that both geometric mean and single sample criteria are met in both irrigation and non-irrigation seasons. Second, for each flow category and season, DEQ compared observed data based on season (irrigation vs. non-irrigation) against both geometric mean and single sample criteria to identify the maximum potential percent reduction in loads to meet the applicable criteria. Percent reductions were calculated according to methods described in Section 4.5.1. As an additional layer for margin of safety, DEQ applied the maximum percent reduction identified for an individual criterion-flow category-season combination to all criteria, flow categories, and seasons to ensure that both gemeometric mean and single sample criteria will be met annually under all flow scenarios.

Based on the source assessment presented in Section 5.2, nonpoint sources constitute the dominant source of fecal indicator bacteria (*E. coli*) to the Powder Basin. DEQ assigned nonpoint source load allocations to all areas of the basin on an annual basis. Thus, load allocations calculated from the percent reduction and margin of safety calculations for each reach apply to contributing land areas with agricultural land uses (including areas occupied by livestock or influenced by livestock waste) and nonagricultural areas occupied by wildlife and rural residences (Tables 4.5.2a – 4.5.2qq). The reductions apply to nonpoint sources only in the contributing land area and irrigation return water within the reach. If another designated reach for reductions occurs upstream, only the loads from the contributing area downstream of the upstream station apply. Load allocations apply year-round, including both irrigation and non-irrigation seasons.

As described in section 5.2.2, failing septic systems constitute a possible but probably insignificant *E. coli* source to listed waters in the Powder River Basin. Based on the information presented in section 5.2.4, wildlife sources were considered as a background source of bacteria (OAR 340-042-0030(1)).

6.3 Reserve Capacity

As indicated in OAR 340-042-0040(k), reserve capacity is an element of the TMDL which is an allocation for increases in specific pollutant loads from future growth and new or expanded sources. Alternatively, a TMDL may allocate no reserve capacity. For this TMDL, DEQ assumed minimal growth and development in the Powder Basin and explicitly reserved zero percent of the load capacity. New sources or increased discharges from existing sources will be allowed however they will be required to meet bacteria standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Allocation of any available capacity may be considered on a case-by-case basis by DEQ for NPDES permitted point sources, should the need arise in the future.

6.4 Margin of Safety

As indicated in OAR 340-042-0040(4)(i), margin of safety can be calculated either explicitly or implicitly. Implicit margins of safety incorporate conservative assumptions in water quality targets, sources or restoration effectiveness and uncertainty ranges (Minnesota Pollution Control Agency 2017). In comparison, explicit margins of safety set conservative water quality targets, add a specific safety factor to pollutant load estimates or reserve a portion of the load capacity. For this TMDL, DEQ adopted an explicit margin of safety that specifically reserves a 10 percent portion of the loading capacity.

An explicit 10 percent margin of safety was used in the calculation of percent reductions needed to meet load allocations based on the log-mean E.coli criterion of 126 organisms/100 mL and the single sample maximum criterion of 406 organisms/100 mL.

In addition, the following conservative analytical assumptions were included to incorporate an additional, implicit margin of safety. DEQ used reasonable maximum scenarios for each part of the analysis to ensure that estimated loads would be the highest actual loads that may be encountered. For instance, death and decay of *E. coli* is likely during the time spent on land runoff and stream/river transport, given the long distances to downstream monitoring sites and the presence of reservoirs in some reaches. However, DEQ assumed that all source bacteria reach the streams, rather than accounting for die-off of bacteria. In calculating wasteload allocations for wastewater treatment facilities, DEQ used permitted discharge limits for *E. coli* without considering the bacteria reduction from chlorination applied to remove all pathogens from effluent prior to discharge. DEQ also chose to apply reductions needed as the maximum from among those calculated based on geometric mean or single sample criteria across all flow categories and both seasons.This approach ensures additional reductions are applied to sources contributing during flows other than those associated with the maximum observed concentration.

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