Final Report for

OWEB Grant #216-5043

Monitoring the Malheur

May 31, 2019

Malheur Watershed Council

2925 SW6th Ave, Ontario, OR 97914

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Chapter 1 Introduction

On April 26, 2016, the Malheur Watershed Council was awarded a grant (# 216-5043-12452) from the Oregon Watershed Enhancement Board (OWEB) to conduct water quality monitoring in the Malheur River Basin and the Owyhee River Basin of Eastern Oregon for 2016 through 2018. The grant was applied for jointly by the Malheur Watershed Council and the Malheur Soil and Water Conservation District (SWCD).

Water quality data were collected with the goal of understanding whether or not water quality in the Malheur Basin meets state standards and how discharges within the basin contribute to water quality in the Malheur River and the Snake River. It was the intent of this project that the findings from the water quality monitoring would be used to better inform local landowners, operators and producers, and the Malheur Watershed Council and Malheur Soil and Water Conservation District staff where agricultural practices are improving water quality and where there may be areas that would benefit from technical assistance in adjusting agricultural management practices.

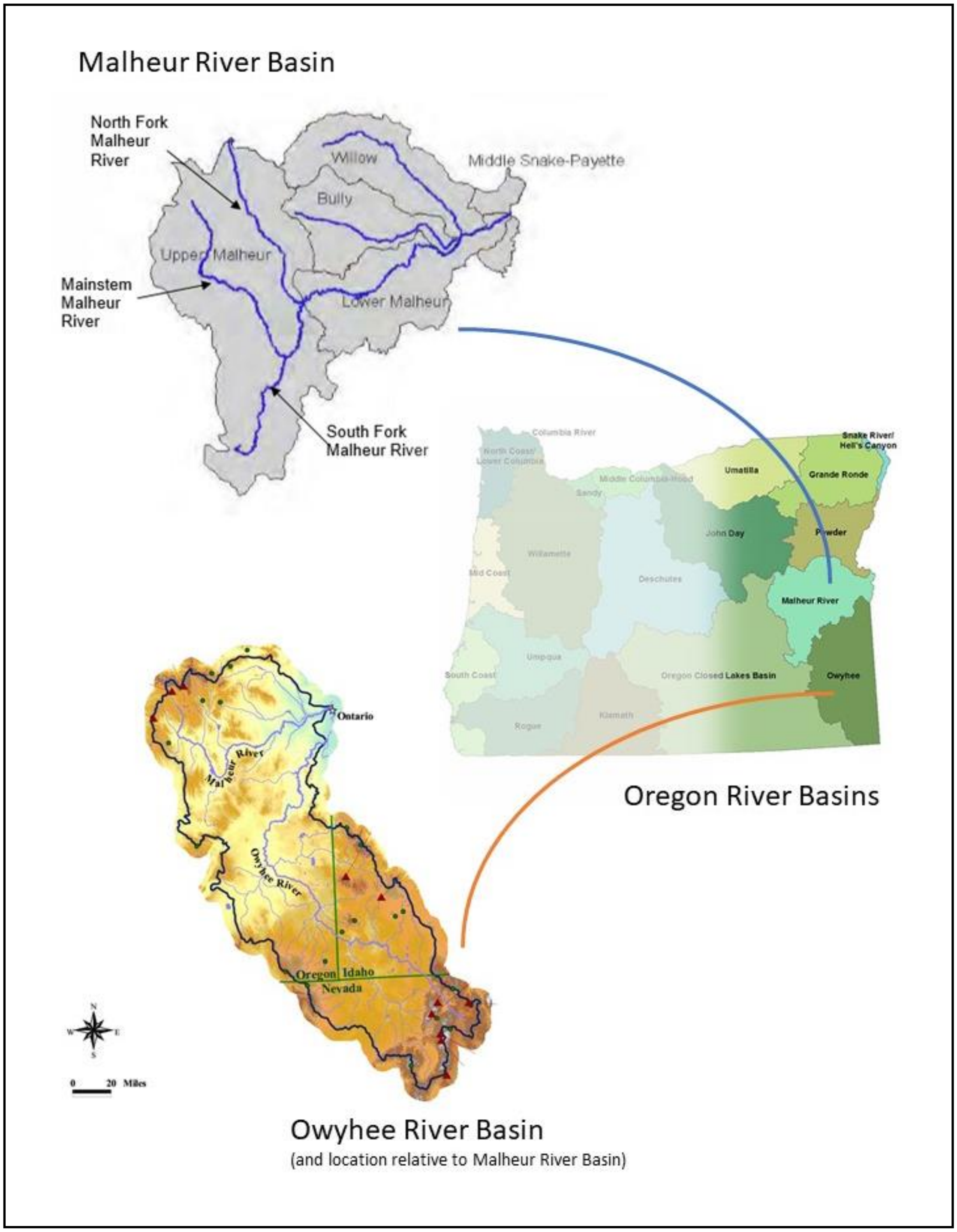
This report contains an assessment of the data collected from 2016 through 2018 under Grant #216-5043, and (where possible) previously collected data to provide a larger and more comprehensive data set. This report includes 3 years of data collected in the Upper Malheur River, up to 14 years of data (collected at river sites) and up to 10 years of data (collected at drain sites) on the lower Malheur River, up to 7 years of data collected on Bully Creek, up to 16 years of data collected on Willow Creek, up to 11 years of data collected on the Owyhee River, and up to 11 years of data collected on selected Snake River Agricultural Drains. All sites in all locations did not have the same density of data or period of record. All data reported here were not collected under the grant for which this report is being written (#216-5043). Some data were collected under other funding sources. All water quality data displayed in this report were collected by the Malheur Watershed Council, the Malheur SWCD or Oregon Department of Environmental Quality (DEQ).

Description of the Malheur River Basin

The Malheur River is a tributary of the Snake River located in southeast Oregon. It is 190 miles long and consists of approximately 5,000 square miles in southeastern Oregon drained by the Malheur River (please see map on following page). Most of the basin is in Malheur and Harney counties and the northern areas are in Grant and Baker counties. Approximately 70% of the Malheur Basin is under federal ownership, managed primarily by Bureau of Land Management (BLM). Topography consists of rolling hills with flat, alluvial valleys along major tributaries in the Vale-Nyssa-Ontario area. The hills are generally covered by sagebrush-grass communities and have multiple uses. The alluvial valleys are used primarily for irrigated crop and pasture land.[1]

The Owyhee River is a tributary of the Snake River located in northern Nevada, southwestern Idaho and southeastern Oregon. It is 346 miles long. The river's drainage basin is 11,049 square miles in area, one of the largest subbasins of the Columbia Basin. The Owyhee River drains a remote area of the arid plateau region on the north edge of the Great Basin, beginning in northeastern Nevada and flowing generally northward near the Oregon-Idaho border to the Snake River (see map on following page).

[1] Wikipedia



Map images from Oregon DEQ and NRCS

Its watershed is very sparsely populated. The Owyhee River enters extreme southeast Oregon in southern Malheur County, flowing generally north in a zigzag course west of the Idaho border. It enters the Snake River from the west on the Oregon–Idaho border approximately 5 miles south of Nyssa, Oregon, and 2 miles south of the mouth of the Boise River.[2] DEQ has placed most of the Malheur and

[2] Wikipedia

Owyhee Rivers and their tributaries on the 303 (d) list due to violations of state water quality standards. A majority of the supporting data for this listing were collected in 1980. The most common problem is temperature, followed by greater than allowable levels of bacteria, nutrients, Chlorophyll a, and toxins.

The majority of human caused water quality problems in the basins seem to result from the cumulative effects of non-point source pollution caused by landscape-wide activities. Irrigated agriculture dominates the bottomlands in the lower reaches of the Malheur and Owyhee Rivers, while livestock grazing occurs on most of the upper drainage areas.

TOTAL MAXIMUM DAILY LOADS (TMDLS)

There are two Total Maximum Daily Loads (TMDLs) that are relevant to this report: the Malheur River Basin TMDL (2010) and the Snake River-Hells Canyon TMDL (2004). TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet water quality standards.

The Snake River-Hells Canyon TMDL established water quality targets for nutrients (total phosphorus), chlorophyll a, pesticides (DDT, DDE, DDE, Dieldrin), sediment (total suspended solids), temperature and total dissolved gas. Only the targets for, but only total phosphorus and total suspended sediments will be discussed in this report. These targets apply to the waters of the Snake River and to the Malheur and Owyhee Rivers at the mouth (where these rivers enter the Snake River). The Malheur River Basin TMDL established water quality targets for nutrients (total phosphorus), bacteria and temperature. The Malheur River Basin TMDL target for total phosphorus will be discussed in this report and applies to all perennial and intermittent streams within the Malheur Basin.

Parameter	**Selected Target**	**Where Applied**
Malheur River Basin TMDL		
Nutrients	Less than or equal to 0.07 mg/L total phosphorus	May through September All perennial and intermittent streams within the Malheur Basin
Snake River-Hells Canyon TMDL		
Nutrients	Less than or equal to 0.07 mg/L total phosphorus	May through September Waters of the Snake River between river mile (RM) 409 (near Adrian, OR) to RM 188 (Salmon River inflow) and inflowing tributaries at the mouth
Sediment	Less than or equal to 80 mg TSS/L for acute events lasting no more than 14 days, and less than or equal to 50 mg TSS/L monthly average	Year-round Waters of the Snake River between river mile (RM) 409 (near Adrian, OR) to RM 188 (Salmon River inflow) and inflowing tributaries at the mouth

The target concentration for phosphorus was set to limit the growth of algae which can cause wide daily variations in dissolved oxygen and pH that, in turn, adversely affect aquatic life. The total suspended sediment target was set to control sediment that also adversely affects aquatic organisms and the aesthetics of the streams.

This report analyses waters in the Malheur and Owyhee Basins that drain to the Snake River, and, therefore, have the potential to affect water quality locally, in their separate drainage basins, and in the Snake River. The Malheur River Basin TMDL and the Snake River-Hells Canyon TMDL established the same TMDL target for total phosphorus (≤ 0.07 mg/L). Only the Snake River-Hells Canyon TMDL established a target for total suspended solids (sediment). The Malheur River Basin TMDL does not identify a target for sediment because it determined that sediment would not adversely affect beneficial uses when the total phosphorus target was achieved. The water quality standard for E. coli identified in this report is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use and is not TMDL-specific.

In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as “Snake River TMDL targets” on all graphs of water quality data presented in this report. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the SR-HC TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur and Owyhee Rivers, where they flow into the Snake.

The TMDL targets have been included on the graphs in this report to provide information on how the water quality measured at a specific monitoring site is contributing to meeting water quality targets within the basin (for those sites located in the Malheur Basin) or in the Snake River (for all sites monitored under this project work).

Monitoring Objectives

Monitoring objectives defined for work funded under OWEB Grant #216-5043 specifically include:

- Continue basin-wide monitoring to determine if any changes in water quality have occurred during the past 7 years of extensive restoration activities and compare findings to the monitoring done in the 1980’s and older using ODA’s database.
- Supplement Malheur River TMDL (2010) information on total phosphorus levels in specific areas mostly in the upper ends of the watershed prior to extensive irrigation activities.
- Continue “Focus Area” monitoring for the Willow Creek area to help prioritize restoration efforts, document and track the progress of local efforts to improve water quality, and account for the effects of recent dry weather.
- Continue Snake River Ag Drain monitoring to prioritize restoration efforts, document and track the progress of local efforts to improve water quality, inform TMDL processes (Snake, Malheur and Owyhee - complement existing data, establish accurate baselines, measure the effectiveness of BMPs (Best Management Practices) already installed, help determine future TMDL for the Owyhee River), and account for the effects of recent dry weather.

Additional objectives of this monitoring grant were to collect water quality data under a DEQ-approved Sample and Analysis Plan (SAP) (plan approved August 2014), collect high (A or B) quality data on nutrients, sediment, bacteria, turbidity, and conductivity to support TMDLs and restoration work in the basin and to submit to the DEQ database (submitted and approved by DEQ April 23, 2019). (A copy of both the approved SAP and data submittal and approval email are included in the digital appendix to this report.)

Layout of this Report Relative to Grant Objectives

This report contains this introduction and six (6) additional chapters, each of which address monitoring that was conducted in six different, distinct areas: Upper Malheur River (including headwaters sites), Malheur River (lower Malheur River sites and agricultural drains), Bully Creek, Willow Creek, Owyhee River and Snake River Agricultural Drains (selected agricultural drains that discharge into the Snake River). The report also contains a final section summarizing overall conclusions and findings.

Each chapter contains a discussion of the area, an explanation of the monitoring conducted in that area, and a discussion of findings. Tables of all monitoring sites (including lat/long information and specific parameters analyzed) are included in the text of each chapter. Also included in the chapter text are maps showing the location of all monitoring sites. Data graphs follow each chapter text.

Because one objective of the monitoring was to collect and interpret data specific to the results of agricultural implementation in the Malheur Basin, the data (where possible) have been divided to show the irrigation season separately from the non-irrigation season. In this way, direct improvement in water quality over the irrigation season, or need for additional improvement in water quality over the irrigation season will not be masked by non-agriculturally-induced phenomenon like spring runoff and winter stormwater flows. It will allow a more direct interpretation of the water quality conditions during the time period when agricultural activities have the greatest influence on water quality.

In many cases, the patterns described by the data collected at one or two sites (within each sampling area) are generally similar to the patterns described by the data collected from all sites. In these cases, to reduce report length and complexity, data from one or two selected sites is discussed in detail in the report chapters. A full set of all data, and all data plots that were not directly included in the report chapters (as a word file), can be found in the "digital" appendix submitted with this report.

The "digital" appendix is formatted to be distributed as a digital (computer) file only, not as a hardcopy and will be submitted only as a digital (computer) file. The appendix includes a complete set of all data collected under this grant as provided to the preparers (as an Excel file).

In addition to the components listed above, the digital appendix also contains the monitoring protocols used to collect the reported data, referenced as *Sample and Analysis Plan,* Malheur Watershed Council 2014-2016 Water Quality Monitoring. This Sample and Analysis Plan (SAP) was approved by Oregon DEQ on August 11, 2014. Laboratory analysis for the monitoring reported here was done by the US Bureau of Reclamation Water Quality Laboratory (Boise, Idaho). A copy of the Bureau of Reclamation Quality Assurance Guidelines for Environmental Measurements is included in the digital appendix. Analytical protocols for the laboratory analyses can be found at
https://www.usbr.gov/tsc/techreferences/mands/mands-pdfs/QualityAssuranceGuidelines_2003.pdf

This report is formatted to function as an outreach tool for both the Malheur Watershed Council and the Malheur SWCD. Each chapter of the report is formatted to be used separately. With long reports, it can be tedious for members of the agricultural community to find the results and data specific to their location or practices in the report document. The format of this report is intended to address this concern. As Watershed Council and SWCD staff meet with local producers and landowners, they can provide local landowners and producers with a copy of the individual chapter of the report that deals with their specific area or location, rather than paging through the full report document. This will put site-specific information and results directly in the hands of those interested in the findings. The full report document can be made available on request. Please keep in mind that in order to make the chapters function as stand-alone documents, some duplication of general information is required.

The report chapters are as follows:

Chapter 1 – Upper Malheur River – Including sites on the Little Malheur, North Fork Malheur, Wolf Creek, Calamity Creek and Beaverdam Creek

Chapter 2 – Malheur River – Including eight (8) sites on the lower Malheur River, one site on the North Fork Malheur River, one site at the Upper Diversion Canal and five (5) sites on agricultural drains (Mallet, Hope, Blanton, Luther and Shoestring)

Chapter 3 – Bully Creek – Including five (5) sites on Bully Creek and one site on the Big Dip Drain

Chapter 4 – Willow Creek – Including three (3) sites on Willow Creek

Chapter 5 – Owyhee River – Including two (2) sites on the Owyhee River and one site on the Old Owyhee Ditch

Chapter 6 – Snake River Agricultural Drains – Including nine (9) agricultural drain sites (Alkali, Kingman, Lockett, Nyssa-Arcadia, L1 Line, Dork, Jacobson Gulch, Sheperd Gulch and New Coyote) and two (2) irrigation water source sites (Dead Ox Pump Station, North Canal)

In each of the following chapters, maps and tables will be embedded in the chapter text, graphs of water quality data for monitored sites will follow at the end of each chapter.

The data analysis in this report does not include a rigorous statistical analysis of water quality trends. Rather, it relies on a visual interpretation of the changes in concentration over time. It is believed that these interpretations can help to inform local producers and stakeholders on the efficacy of the many improvements in agricultural and irrigation practice and management that have been implemented in the area, and encourage the implementation of more such practices.

Statistical trend analysis was not undertaken because, for the vast majority of monitoring sites, water quality data were not available at sufficient density to provide a solid statistical basis to identify trends. While several of the sites monitored under OWEB Grant #216-5043 (Monitoring the Malheur) have eight years of collected water quality data, the number of years of monitoring or a total number of data points should not be the sole metric used to determine whether or not statistical trend analysis is appropriate. As stated in Hirsch et al. 1982[3], water quality trend analysis can be complicated by many factors such as non-normal distributions, seasonality, flow relatedness, missing values, values below the limit of detection, and serial correlation. Hirsch et al. ran simulations at five, ten and twenty years to test the "power" of different statistical trend analysis methodologies, and provided an example where eight years of measured total phosphorus concentration data collected in the Klamath River near Klamath, California, has no trend but statistical analysis shows that there is one.

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[3] Hirsch RM, Slack JR, and Smith RA; Techniques of Trend Analysis for Monthly Water Quality Data; Water Resources Research, Vol. 18, No. 1, pages 107-121, February 1982.

Additionally, there is the added risk that the identification of a trend infers causality. As stated by Hipel and McLeod (1994), "no causality can be inferred from a trend alone. The trend must be explained by other data in conjunction with the trend data." [4] While some data on specific agricultural practices that may result in changes in water quality are collected by Oregon Department of Agriculture (ODA) or Natural Resources Conservation Service (NRCS), these data are incomplete and are not available to this report due to privacy concerns and the fact that the data were not collected in a format where the information could be effectively grouped at a watershed or subbasin level.

The enormous variability in crop rotations, precipitation, air temperature, irrigation deliveries and changes in management practices over time in the Malheur and Owyhee Basins combined with the lack of agricultural implementation data, and the lack of long-term data collection at most sites make the statistical characterization of water quality trends inadvisable at this time.

Every effort was made to standardize the way that data were displayed in order to allow a valid interpretation of relative changes in concentration both within a data set and from one data set to another. Where measured concentrations appeared to decrease or increase, these changes are identified in the report discussion and can help to identify benefits from existing implementation practices and to inform prioritization of future monitoring and implementation.

Water quality data were collected under the methods and protocols outlined and approved in the SAP (please see copy attached in the digital appendix). Summary details are provided in the tables below and on the following page. Laboratory analysis for the data collected under this grant was conducted by the US Bureau of Reclamation Water Quality Laboratory (Boise, Idaho) as outlined previously. Analytical precision and accuracy requirements follow OWEB's Water Quality Monitoring Guidebook Protocols.

Please note: Some of the data from the Bureau of Reclamation Laboratory analyses were reported as a "less than" value (<), indicating that the measured concentration was below the detection limit. Because the computer software being used to graph the water quality data cannot accommodate less than (<) values, in cases where the analytical concentration value in the original data set was listed as a "less than" value (<), a value of one half (1/2) of the detection limit was used in graphing the data and calculating relevant statistics. For example, a data value of <0.3 mg/L would be graphed as 0.15 mg/L.

Parameter	Method Reference	Method Detection Level	Hold Time	Container	Sample Preservation
Nitrate + Nitrite	EPA 353.2	0.05 mg/l as N	28 days	500 ml poly	2 ml H_2SO_4, 4°C
Total Nitrogen (TKN)	EPA 351.2	0.05 mg/l as N	28 days	250 ml Bost. rnd	2 ml H_2SO_4, 4°C
Total Phosphorus	4500-PF	0.01 mg/l as P	28 days	500 ml poly	1 ml HCl, 4°C
Orthophosphate	4500-PF	0.003 mg/l as P	48 hours	250 ml poly	Field filter, 4°C
E. coli	Colilert-24	1 MPN/100ml	24 hours	120 ml carbonate	HO_3S_2, 4°C
Total Suspended Solids	SM method – 2540 D	1 mg/l	7 days	500 ml poly	Store at 4°C

[4] Hipel and McLeod (1994) present methods for testing causality between two time series." NRCS Water Quality Stats Guide 2003.

Parameter	Precision	Accuracy	Measurement Range
E. coli	0.6 log	NA	0 to >2419 colonies
Nitrate + Nitrite	>20 LOQ 10% or less, >5 LOQ <20 LOQ 20% or less, <5 LOQ + 1 LOQ	15%	0.05-10.0 mg/l (range may be extended with sample dilution)
Total Nitrogen	>20 LOQ 10% or less, >5 LOQ <20 LOQ 20% or less, <5 LOQ +/- 1 LOQ	15%	0.1-20.0 mg/l (range may be extended with sample dilution)
Orthophosphate	>20 LOQ 10% or less, >5 LOQ <20 LOQ 20% or less, <5 LOQ +/- 1 LOQ	15%	0.001-10.0 mg/l (range may be extended with sample dilution)
Total Phosphorus	>20 LOQ 10% or less, >5 LOQ <20 LOQ 20% or less, <5 LOQ +/- 1 LOQ	10%	0.001-10.0 mg/l (range may be extended with sample dilution)
Total Suspended Solids	+/- 1 mg/l	+/- 1 mg/l	1-1000 mg/l (range may be extended with sample dilution)
LOQ = Limit of quantitation (determined annually by the lab)			

Chapter 2 – Upper Malheur River

The Malheur River begins in the southern Blue Mountains of southern Grant County, south of Strawberry Mountain in the Strawberry Mountain Wilderness. It flows south through the Malheur National Forest, then southeast past Drewsey and through Warm Springs Reservoir. The South Fork Malheur River joins the mainstem at Riverside, in western Malheur County. The river then makes a sharp turn back northward to Juntura, where the North Fork Malheur River comes in from the north to join the mainstem. From Juntura the river flows generally east past Harper and Vale, flowing into the Snake from the west approximately two miles north of Ontario, Oregon. The inflow of the Malheur River is approximately at Snake River mile (RM) 370. [5]

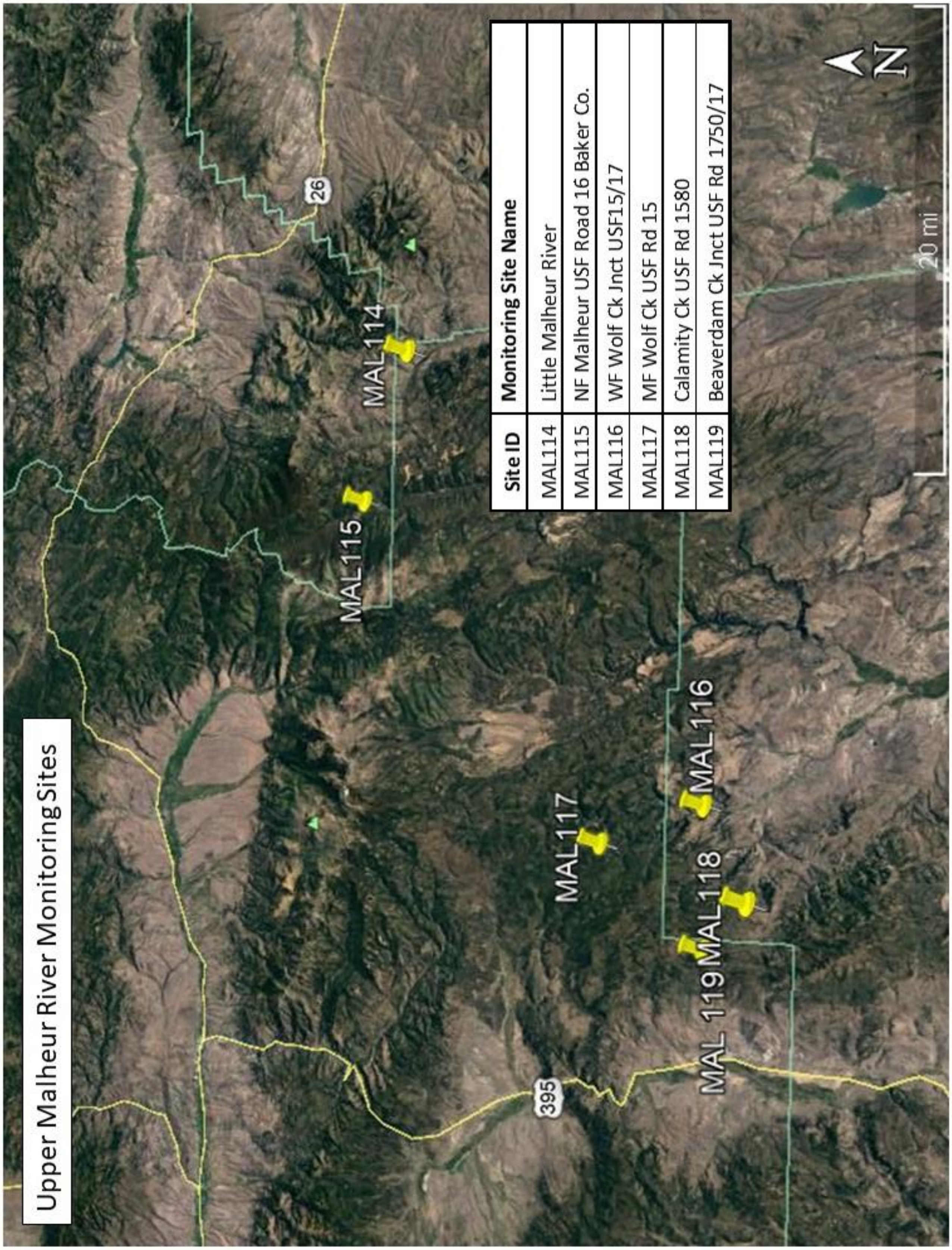
There are two Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin: the Malheur River TMDL and the Snake River-Hells Canyon TMDL. TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet state water quality standards.

In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as “Snake River TMDL targets” on all graphs of water quality data presented in this chapter. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the Snake River-Hells Canyon TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur River, where it flows into the Snake. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use. For additional information on the TMDLs, please see the text in the ‘Introduction’ section of this report.

The Little Malheur River, North Fork Malheur River, Wolf Creek, Calamity Creek and Beaverdam Creek all flow into the Malheur River which, in turn, flows into the Snake River. The quality of water in these tributaries contribute to the quality of water in the Malheur River which, in turn, contributes to water quality in the Snake River. Because of the interconnected nature of these systems, reductions in pollution loading are necessary in these tributaries and in the Malheur River in order to meet water quality standards in the Snake River.

This chapter summarizes data collected by the Malheur Watershed Council and Malheur SWCD at six (6) sites in the upper tributaries of the Malheur River. Agricultural activities that do occur in the upper basin are primarily limited to livestock grazing on forested lands and some managed pasture lands. More intensive agriculture occurs in the downstream areas of the basin. The purpose of this component of the monitoring was to better identify up-gradient or baseline total phosphorus concentrations in the headwaters of the Malheur River, and to provide a comparison to water quality measured lower in the Malheur River Basin (discussed in Chapter 3). All six of these monitoring sites are located within the Malheur National Forest. A map of monitoring sites is included on the following page. These sites are

[5] Wikipedia


Upper Malheur River Monitoring Sites
Site ID | Monitoring Site Name
MAL114 | Little Malheur River
MAL115 | NF Malheur USF Road 16 Baker Co.
MAL116 | WF Wolf Ck Jnct USF15/17
MAL117 | MF Wolf Ck USF Rd 15
MAL118 | Calamity Ck USF Rd 1580
MAL119 | Beaverdam Ck Jnct USF Rd 1750/17
MAL114
MAL115
MAL116
MAL117
MAL118
MAL 119
26
395
N
20 mi

Site ID #	Site Location	Latitude	Longitude	Monitoring Period	Parameters Analyzed
MAL114	Little Malheur River	44.23211	118.39455	May- October, 2016 -2018	Total Phosphorus: 2016-2018. Ortho Phosphorus, NH3-N, NO2+NO3-N, and Kjedahl-N: 2016 only
MAL115	NF Malheur USFS Road 16 Baker Co.	44.26555	118.39455		
MAL116	WF Wolf Ck Jnct USFS15/17	44.00901	118.69868		
MAL117	MF Wolf Ck USFS Rd 15	44.07945	118.73518		
MAL118	Calamity Ck USFS Rd 1580	43.97705	118.78738		
MAL119	Beaverdam Ck Jnct USFS Rd 1705/17	44.00720	118.83040		

listed in the table above along with their respective latitudes and longitudes, periods of monitoring, and water quality parameters analyzed. The following table shows the average, median, 90th percentile, maximum and minimum values for total phosphorus (as P) data collected at these six sites. The information presented shows that all total phosphorus concentrations measured at the two Wolf Creek sites and the North Fork Malheur River site are below the Snake River TMDL target of 0.07 mg/l. Data collected at the Little Malheur River monitoring site show that some measured concentrations were below the Snake River TMDL target and some were above. The average concentration from all total phosphorus data collected at this site was very close to the TMDL target. All of the data collected at both the Calamity Creek and Beaverdam Creek sites show total phosphorus concentrations above the TMDL target.

Total Phosphorus as P, mg/l, 2016-2018					
Site	Average	Median	90th Percentile	Maximum	Minimum
Little Malheur River	0.074	0.059	0.127	0.189	0.037
NF Malheur USF Road 18 Baker Co.	0.042	0.042	0.050	0.053	0.031
WF Wolf Ck Jnct USF15/17	0.035	0.033	0.050	0.056	0.019
MF Wolf Ck USF Rd 15	0.036	0.034	0.048	0.052	0.029
Calamity Ck USF Rd 1580	0.148	0.122	0.209	0.415	0.087
Beaverdam Ck Jnct USF Rd 1705/17	0.151	0.133	0.216	0.263	0.108

The graph on page 15 shows the individual total phosphorus concentrations measured at all six sites over the 2016-2018 period. The Snake River TMDL target for total phosphorus (0.07 mg/l) is also shown. Total phosphorus concentrations at the two Wolf Creek sites, the North Fork Malheur River site and the Beaverdam Creek site are relatively consistent over the three-year monitoring period. The Little Malheur River site shows no concentrations exceeding the Snake River TMDL target in 2016, but measured concentrations increase to exceed the target in both 2017 and 2018. Total phosphorus data from Calamity Creek shows that all measured concentrations were above the Snake River TMDL target. Some concentrations observed in 2018 were much higher than those observed in 2016 and 2017.

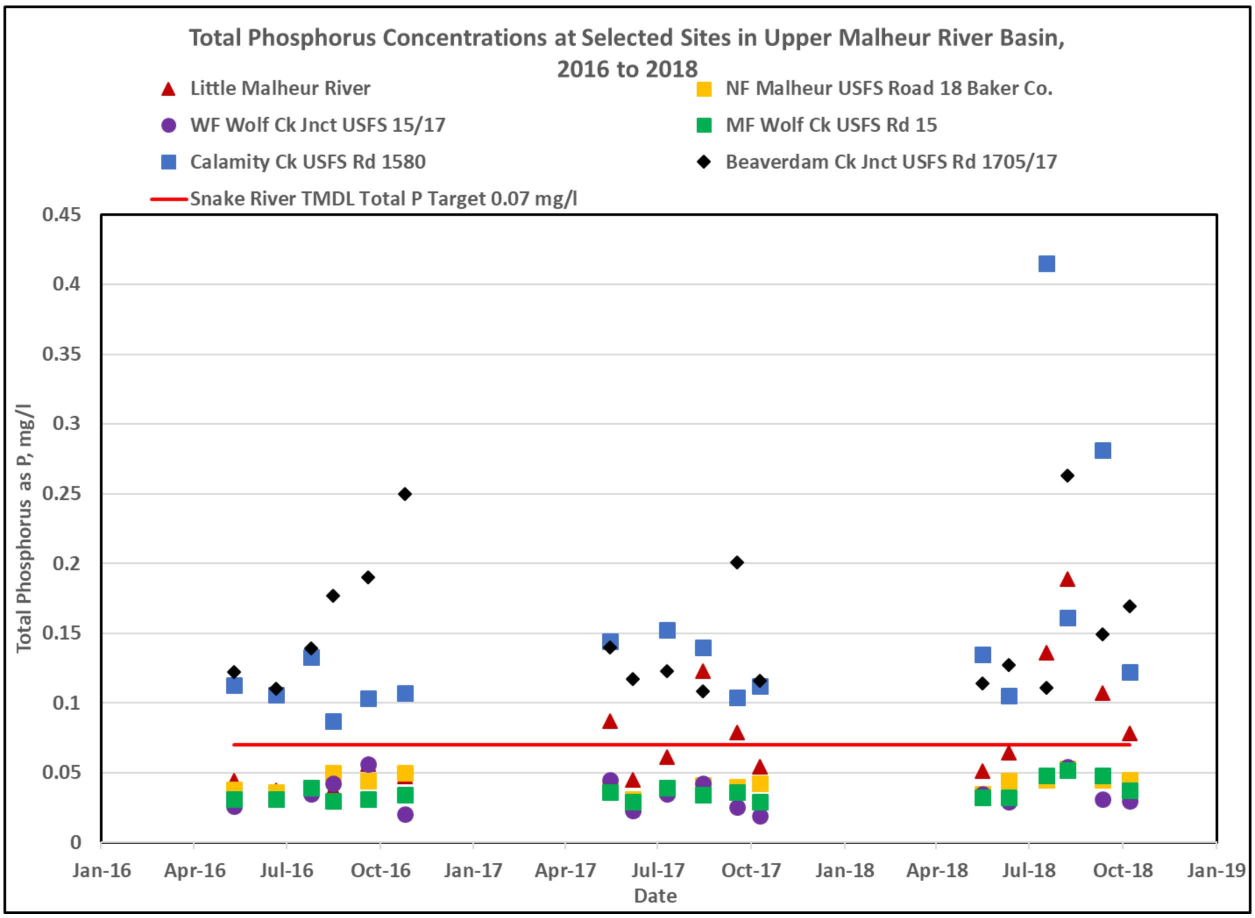
The table on page 15 shows the median and maximum ortho phosphorus and Kjedahl nitrogen concentrations for the year 2016 at all six sites. Ortho phosphorus is one component of total phosphorus in the water column and represents that fraction of the total phosphorus that is most readily available to plant and algal growth. Excessive algal growth in drain and river water leads to reduced dissolved oxygen and changes in pH that can be detrimental to fish and other aquatic life and present maintenance delivery difficulties for water conveyance systems.

Nitrogen is an important nutrient source for plants. If present in excess, it can contribute to algal blooms. Total Kjeldahl Nitrogen (TKN) analysis measures the total concentration of organic nitrogen and

Site	Median Ortho Phosphorus as P, mg/l	Maximum Ortho Phosphorus as P, mg/l	Median Kjedahl-Nitrogen as N, mg/l	Maximum Kjedahl Nitrogen as N, mg/l
Little Malheur River	0.033	0.048	0.06	0.19
NF Malheur USF Road 18 Baker Co.	0.037	0.039	0.06	0.1
WF Wolf Ck Jnct USF15/17	0.032	0.036	0.13	0.19
MF Wolf Ck USF Rd 15	0.022	0.037	0.12	0.26
Calamity Ck USF Rd 1580	0.081	0.114	0.31	1.07
Beaverdam Ck Jnct USF Rd 1705/17	0.103	0.105	0.33	0.38

ammonia, both of which can have an influence of water quality and viable aquatic habitat. TKN was only sampled and analyzed in 2016. Nitrogen monitoring was discontinued after 2016 because of a reduction in available grant funding. As with the total phosphorus statistics, Calamity Creek and Beaverdam Creek both show significantly higher concentrations of ortho phosphorus and TKN than the other four sites.

Both the graph and the total phosphorus and TKN tables suggest that there may be anthropogenic activities above the sampling locations for Calamity and Beaverdam Creeks that are affecting the water quality in these creeks. In the monitoring notes for the 2016 and 2017 monitoring sheets, cattle were observed in both Calamity and Beaverdam Creeks. These activities may be contributing to the measured phosphorus and nitrogen enrichment at these two sites. Further investigation of livestock and other anthropogenic activities in these watersheds is recommended to better characterize sources of enrichment.



Chapter 3 – Malheur River

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There are two Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin: the Malheur River TMDL and the Snake River-Hells Canyon TMDL. TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet state water quality standards.

In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as "Snake River TMDL targets" on all graphs of water quality data presented in this chapter. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the Snake River-Hells Canyon TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur River, where it flows into the Snake. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use. For additional information on the TMDLs, please see the text in the 'Introduction' section of this report.

The North Fork Malheur River and the drains monitored as part of this project all flow into the Malheur River which, in turn, flows into the Snake River. The quality of water in these tributaries and drains contribute to the quality of water in the Malheur River which, in turn, contributes to water quality in the Snake River. Because of the interconnected nature of these systems, reductions in pollution loading are necessary in these tributaries and drains and in the Malheur River in order to meet water quality standards in the Malheur River and in the Snake River.

Malheur River Monitoring

The Malheur Watershed Council and Malheur SWCD have collected water quality samples at eight (8) locations on the Malheur River, one location on the North Fork Malheur River, one location at the Upper Diversion (where irrigation water is diverted from the Malheur River), and five (5) agricultural drains located in the Malheur River drainage. The Malheur Watershed Council has also collected water quality samples from a site on the North Fork Malheur River at Juntura. The table on the following page lists the river monitoring site locations along with their respective latitude, longitude, river mile, monitoring periods and the water quality parameters that were monitored. A map of river monitoring sites is

[6] Wikipedia

included on the following page. A discussion of the drain sites (including a table of sites and a map of sampling locations) is included later in this chapter.

The water quality data collected at each site are discussed in the following paragraphs. For each site, the data have been divided into separate graphs showing the irrigation season (April 15 – October 15) and the non-irrigation season (October 16-April 14) for the Malheur Basin. For comparison purposes, the vertical axes on each of the graphs are the same for both the irrigation and non-irrigation seasons for each parameter.

Sample ID	Latitude	Longitude	River Mile	Monitoring Period	Parameters Monitored
Malheur River at Highway 20 Bridge	43.78565	-118.32998	140.56	September, 2014 to October, 2018	NO2+NO3, NH3 (diss), TKN, Conductivity, Turbidity, Total Suspended Solids, E. coli for 2014-2016 for all sites. Ortho and Total Phosphorus for 2014-2018 for all sites.
Malheur River at Juntura Airport Road	43.73790	-118.07602	96.13	September, 2014 to October, 2018	
Malheur River 1 Mile Below Namorf	43.77690	-117.74040	66.41	September, 2014 to October, 2018	
Malhuer River at Upper Harper Br	43.81638	-117.65888	59.86	September, 2014 to October, 2018	
Malheur River at Little Valley	43.89781	-117.50727	46.92	September, 2014 to October, 2018	
Malheur R 1.1mi US of Bully Crk	43.94236	-117.26470	24.28	September, 2014 to October, 2018	
Malheur R at Butte Drive Bridge	44.00633	-117.08496	10.19	September, 2014 to September, 2016	
Malheur R W of Ontario @ 36th Br	44.04026	-117.02038	3.92	April, 2014 to October, 2018	
North Fork Malheur River at Juntura	43.75523	-118.08279	1.36*	September, 2014 to October, 2018	
Upper Diversion	43.82480	-117.64230	58.81**	August, 2013 to October, 2018	

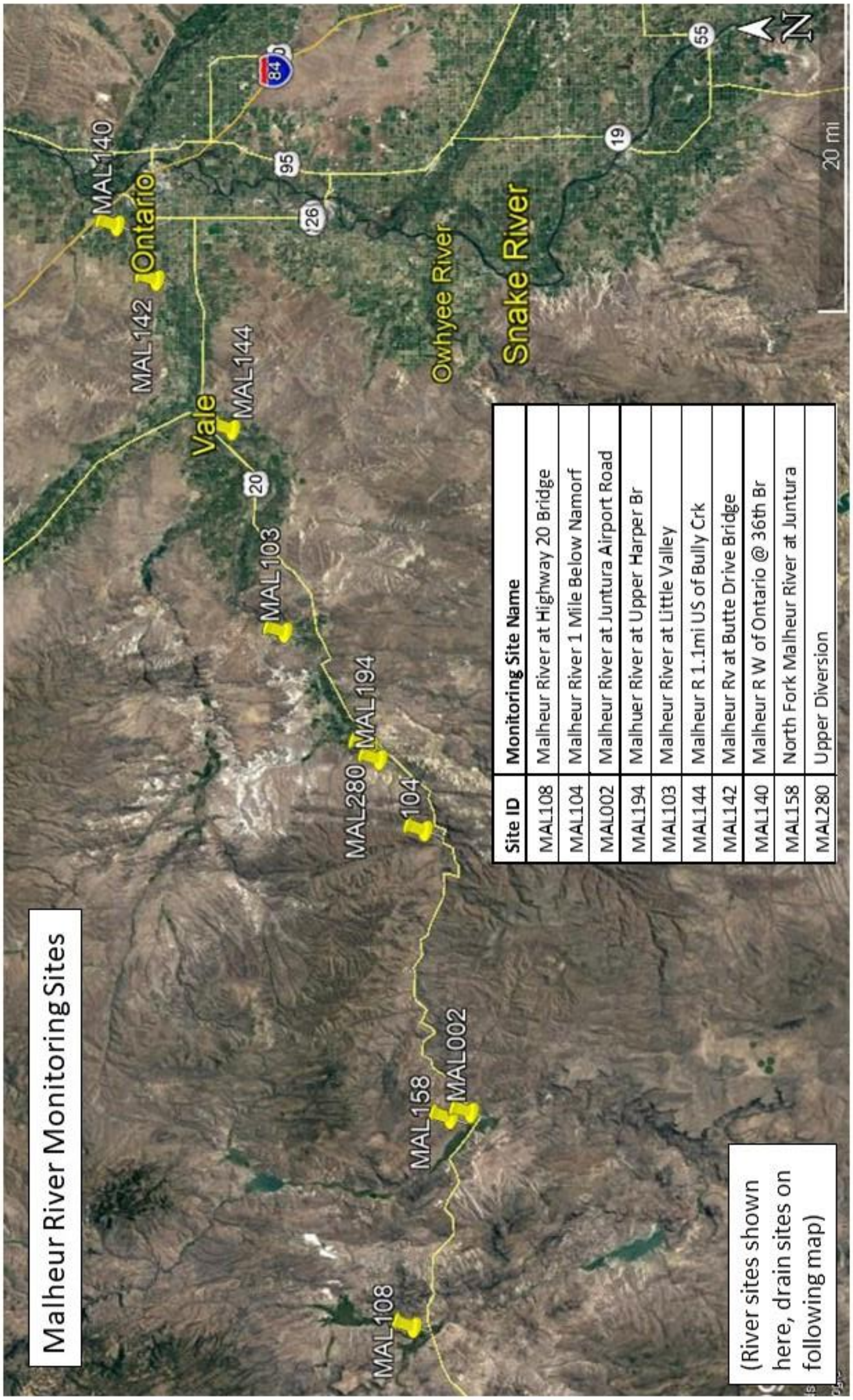
* River Mile on the North Fork. The NF enters the Malheur River at Malheur River Mile 94.3

** River Mile where water is diverted from the Malheur River.

<u>CONCENTRATION BY RIVER MILE</u>

Page 27 shows graphs of ortho phosphorus (as P) by Malheur River mile for the sites on the Malheur River listed in the table above (other monitoring sites will be discussed later in the chapter). Ortho phosphorus is one component of total phosphorus in the water column and represents that fraction of the total phosphorus that is most readily available to plant and algal growth. Excessive algal growth in drain and river water leads to reduced dissolved oxygen and changes in pH that can be detrimental to fish and other aquatic life and present maintenance delivery difficulties for water conveyance systems. The individual monitoring sites are shown from left to right on each graph, starting with the most upstream site and going down river. The top graph on page 27 is for the irrigation season (April 15 to October 15); the bottom graph is for the non-irrigation season (October 16 to April 14). In general, in the Malheur River Basin, the irrigation season runs from April 15 to October 15. Depending on the river and irrigation storage conditions, however, the start and end of water delivery during the irrigation season may be adjusted as needed to accommodate wetter spring weather or drought conditions.

As shown in the graphs on page 27, the ortho phosphorus concentrations appear to be slightly higher during the irrigation season than in the non-irrigation season. Ortho phosphorus concentrations appear



Site ID	Monitoring Site Name
MAL108	Malheur River at Highway 20 Bridge
MAL104	Malheur River 1 Mile Below Namorf
MAL002	Malheur River at Juntura Airport Road
MAL194	Malhuer River at Upper Harper Br
MAL103	Malheur River at Little Valley
MAL144	Malheur R 1.1mi US of Bully Crk
MAL142	Malheur Rv at Butte Drive Bridge
MAL140	Malheur R W of Ontario @ 36th Br
MAL158	North Fork Malheur River at Juntura
MAL280	Upper Diversion

to increase slightly from upstream to downstream during the non-irrigation season. Water quality data collected for these sites on the Malheur River show that concentrations of ortho phosphorus measured in the river water are very often higher than the Snake River TMDL target of 0.07 mg/l for total phosphorus during both the irrigation and non-irrigation seasons.

Page 28 shows graphs of total phosphorus (as P) by river mile for sites on the Malheur River for the irrigation season and the non-irrigation season. Water quality data collected for these sites show that concentrations of total phosphorus measured in the river water are nearly always higher than the Snake River TMDL target of 0.07 mg/l during both the irrigation and non-irrigation seasons. The total phosphorus concentrations appear to increase with distance downstream. Concentrations at the lower river sites are generally higher than those observed at the upper river sites. The total phosphorus concentrations observed at the Highway 20 bridge site (at river mile 140) should be investigated further to help characterize potential sources of phosphorus that may be occurring higher in the basin.

Graphs for TSS for both the irrigation and non-irrigation seasons for sites on the Malheur River are displayed on page 29. During the irrigation season, most of the TSS concentrations measured at sites upstream of Butte Drive Bridge are below the Snake River TMDL target of 50 mg/l. Many of the TSS concentrations measured at the Butte Drive Bridge and the 36th Street Bridge sites exceed the target. During the non-irrigation season, virtually all measured concentrations at all sites are below the target.

Page 30 shows the graphs of E. coli by river mile for sites on the Malheur River for both the irrigation and non-irrigation season. While exceedances are observed throughout the year, there are more observed exceedances of the Oregon E. coli standard (406 CFU/100mls) during the irrigation season than during the non-irrigation season.

Graphs of measured conductivity for sites on the Malheur River are displayed on page 31. Conductivity measures the water's ability to carry an electric current, and is related to the total dissolved salts or ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Conductivity increases as the amount of these dissolved salts and inorganic materials increases. Conductivity levels are mainly influenced by the geology and size of the waterway, the amount of discharged wastewater and/or agricultural runoff, and bacterial metabolism. As a general rule, river conductivity ranges from 50-1500 us/cm. Conductivity data can provide information about how a stream functions and what water sources contribute to the flow in a stream.

During the irrigation season, the measured conductivity increases as the river travels through the more intensively farmed areas, indicating cumulative enrichment from multiple sources is occurring. The conductivity data collected during the irrigation season at the 36th Street Bridge site are distinctly different from the conductivity data collected at all other sites. This may indicate a problem with the data or an unusual condition at the collection site. As only very few samples were collected at this site, no conclusions can be drawn effectively from the existing data and this site should be investigated further. Conductivity appears to be relatively stable during the non-irrigation season.

Concentration over time

The preceding sections present data collected at each site relative to its location on the Malheur River; a display of data vs distance or concentration relative to location on the landscape. While there are a few

exceptions, overall, measured concentrations generally increase with distance downstream, indicating the cumulative effects from combined drain and other runoff-related discharges to the river.
The collected water quality data were also evaluated relative to time to better characterize temporal patterns or relationships within the data set. As the patterns described by the data (when plotted over time) were generally similar at all sites, only data from the Malheur River at the 36th Street Bridge site are displayed (page 32-33) for purposes of discussion. Graphs of the collected data (plotted as concentration over time) for all monitoring sites, including the Upper Diversion site, are available in the digital appendix to this report.

Page 32 shows graphs of concentration vs time for ortho and total phosphorus for the Malheur River at the 36th Street Bridge in Ontario, Oregon. Data are displayed for both the irrigation and non-irrigation seasons. There are more data available for the irrigation season (2004-2005, 2011, 2013-2018) than the non-irrigation season (2004-2005, 2011, 2013-2016), but, for every sample, total phosphorus concentrations exceed the Snake River TMDL target of 0.07 mg/l. Ortho phosphorus concentrations are also generally greater than 0.07 mg/l for both seasons. Neither total nor ortho phosphorus concentrations exhibit a discernible change in concentration over time. The period of data collection, however, is not continuous, which makes it difficult to draw conclusions.

TSS and E. coli data for both the irrigation and non-irrigation seasons are displayed on page 33 for the Malheur River at the 36th Street Bridge site. During the irrigation season, almost all of the measured TSS concentrations exceeded the Snake River TMDL target for TSS of 50 mg/l. During the non-irrigation season, there are more measured concentrations below the TSS target than above.

Most of the E. coli concentrations measured at this site were below the Oregon Standard of 406 count/100mls during both the irrigation and the non-irrigation seasons. (Please see the digital appendix for this report for the graphs of ortho and total phosphorus, TSS, and E. coli concentrations over time for both the irrigation and non-irrigation season for all of the other monitoring sites on the Malheur River.)

Malheur Drain Monitoring

There are many agricultural drains that flow into the Malheur River between Vale and Ontario. During the irrigation season, irrigation water is delivered to fields in the Malheur Basin via flood, furrow and sprinkler irrigation practices. Agricultural drains in the area collect the runoff from these irrigated fields. In some cases, drain water is reused for irrigation of additional fields so water may be applied to the land surface multiple times before it is finally discharged to the river. The specific drains discussed in this section collect irrigation water runoff from fields in the Malheur Basin and eventually discharge that water to the Malheur River. Some drains in the area discharge to larger drains, to the Malheur River and to the Owyhee River. The irrigated land serviced by the drains monitored in this project are located in some of the most intensively farmed areas of the Treasure Valley. While there is some stormwater runoff that is conveyed by these drains, the majority of the water is from runoff of agricultural irrigation. The irrigation season for this area is generally April 15 to October 15. The non-irrigation season is October 16 to April 14. This chapter also includes an irrigation water source site (Upper Diversion) where water quality data were collected. The data from this irrigation water source can be used to provide information on phosphorus, sediment and E. coli concentrations in the irrigation source water (before it is applied to the fields).

The Malheur SWCD has monitored five (5) drains through OWEB grant funding and other funding sources. Water quality data from the drains were collected with the goal of understanding whether or not drain water contributes to water quality exceedances in the Malheur Basin and in better characterizing the drainsheds (all irrigated land where runoff water flows into a specific agricultural drain) where agricultural practices are improving water quality and those that would benefit from technical assistance in adjusting agricultural management practices. A list of the drains monitored is provided in the following table. A map of drain monitoring sites is included on the following page.

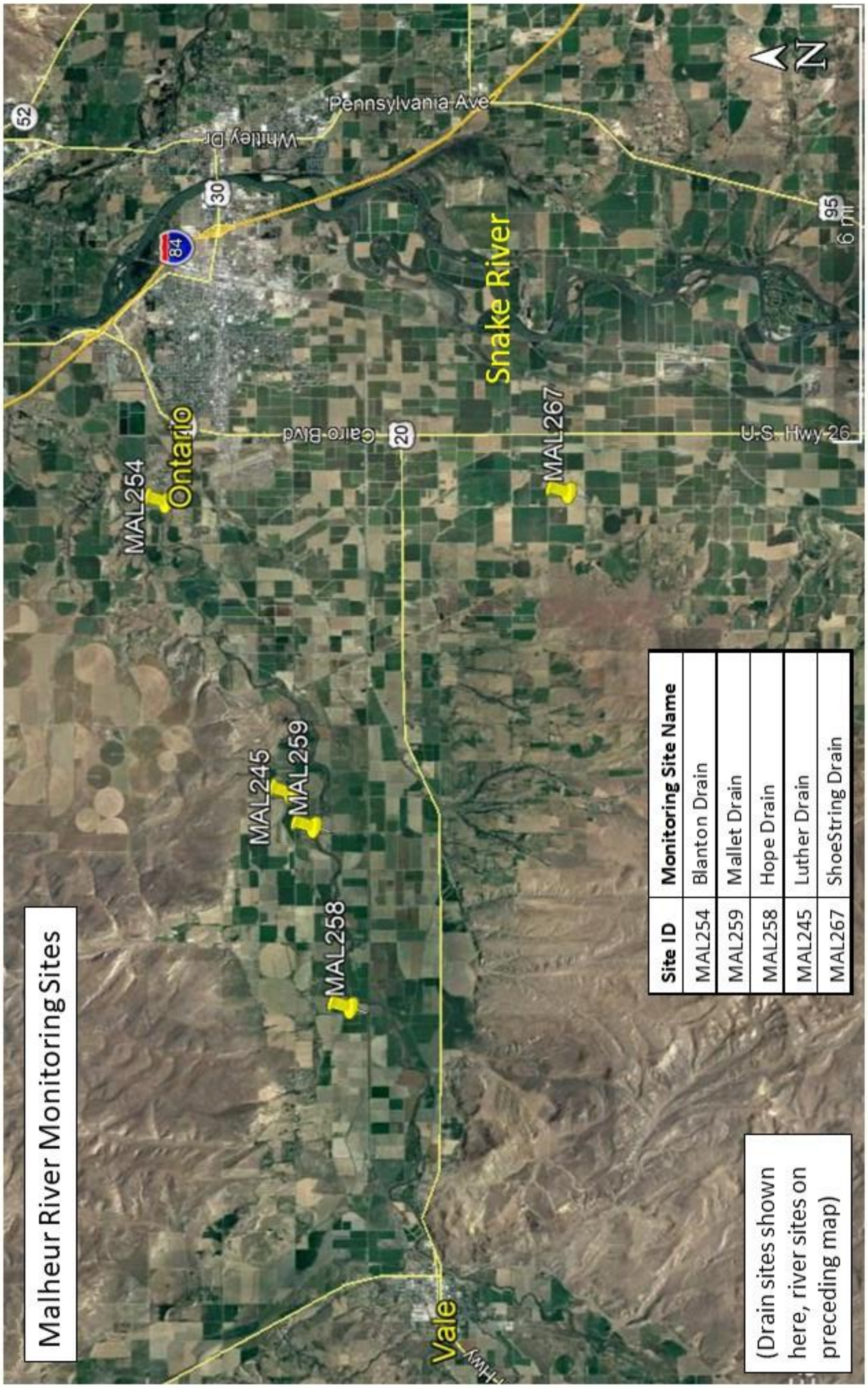
Sample ID	Latitude	Longitude	Enters @River Mile	Monitoring Period	Parameters Monitored
Blanton Drain	44.032082	-117.025435	4.6	2008 to 2018	NO2+NO3, NH3 (diss), TKN, Conductivity, Turbidity, Total Suspended Solids, E. coli for 2014-2016 for all sites. Ortho and Total Phosphorus for 2014-2018 for all sites.
Mallet Drain	44.003183	-117.115467	11	2008 to 2018	
Hope Drain	44.003183	-117.115467	15.1	2008 to 2018	
Luther Drain	44.007567	-117.114400	11.45	2008 to 2018	
ShoeString Drain	43.952167	-117.023667	*	2013 to 2018	
* Discharges to Nevada Ditch					

Site ID	Name	Drained Acres	Discharges to	at GPS W	at GPS N
MAL 254	Blanton	117,215	Malheur River	117 01 31.51	44 02 04.04
MAL 258	Hope	1584	Malheur River	117 09 45.51	43 59 46.02
MAL 245	Luther	884	Malheur River	117 06 50.69	44 00 21.86
MAL 259	Mallett	1638	Malheur River	117 06 46.18	44 00 20.12
MAL 267	Shoestring	12,973	Shoestring Canal	117 01 24.83	43 57 07.72

The Blanton Drain is one of the larger agricultural drains in the Malheur Basin. The data collected from this drain are generally representative of the patterns observed in the data collected from all of the drains discussed in this chapter. Detailed data plots and a discussion of the findings for water quality in the Blanton Drain are included here. Please see the digital appendix of this report for graphs of ortho and total phosphorus, TSS, and E. coli concentrations for both the irrigation and non-irrigation season for the Mallet, Hope, Blanton, Luther and Shoestring Drains, all of which eventually discharge to the Malheur River.

The Blanton Drain captures the runoff from irrigated fields in the area of Ontario, Oregon and discharges that water to the Malheur River at approximately river mile 4.6. The graphs shown on page 34 display the ortho and total phosphorus concentrations measured over time at the mouth of the Blanton Drain during the irrigation and non-irrigation seasons. All of the total phosphorus concentrations measured in the drain exceed the Snake River TMDL target of 0.07 mg/l for both seasons. During the irrigation season, measured total phosphorus concentrations are generally higher than during the non-irrigation season. Concentrations for the irrigation season range from about 0.2 mg/l to 1.5 mg/l. Concentrations for the non-irrigation season range from about 0.3 to 0.6 mg/l. The measured ortho phosphorus concentrations for both seasons are consistently between 0.07 and 0.4 mg/l. The collected phosphorus data do not appear to display any discernable pattern over time.

For the TSS concentration data shown in the graphs on page 35, all but two of the samples taken at the Blanton Drain site during the irrigation season show concentrations that exceeded the Snake River TMDL target of 50 mg/l, but the measured TSS concentrations appear to be declining over the monitoring


Malheur River Monitoring Sites
Site ID | Monitoring Site Name
MAL254 | Blanton Drain
MAL259 | Mallet Drain
MAL258 | Hope Drain
MAL245 | Luther Drain
MAL267 | ShoeString Drain
(Drain sites shown here, river sites on preceding map)
MAL254
Ontario
MAL245
MAL259
MAL258
MAL267
Snake River
Vale
Pennsylvania Ave
Whitley Dr
Cairo Blvd
U.S. Hwy 26
N
6 mi

period. During the non-irrigation season, most of the measured TSS concentrations are below the target.

Water quality data collected for these drains show that concentrations of ortho and total phosphorus measured in the drain water are almost always higher than the Snake River TMDL target for total phosphorus and often higher than the TMDL target for TSS during both the irrigation and non-irrigation seasons. While the TMDL targets do not apply directly to these drains, when the water quality in the drain exceeds TMDL targets, the drain water is contributing to water quality exceedances in the river. When the water quality in the drain is below TMDL targets, the drain water is not contributing to water quality exceedances in the river.

For E. coli in the Blanton Drain (also displayed on page 35), during the irrigation season, many of the measured concentrations are less than the Oregon standard of 406 count/100mls; a little less than half of the measured concentrations exceed the standard. There is no obvious change in concentration observed over time. During the non-irrigation season, all measured E. coli concentrations are below the Oregon standard.

For comparison purposes, water quality data from the Upper Diversion (where irrigation water is diverted from the Malheur River) are displayed on page 36. This site was used to represent the water quality of irrigation water before it has been applied to the field. It is recognized that the water diverted at this location is not diverted for use on all land that drains into the Mallet, Hope, Blanton, Luther and Shoestring Drains. It is also recognized that it represents the quality of water that has been diverted directly from the river and is not necessarily representative of the water that some producers receive which has been used for irrigation (perhaps multiple times) and is therefore enriched before it is applied to their fields. In this section, the water quality measured at the Upper Diversion is used as a “baseline” to measure the change in water quality from the river diversion (where irrigation water is diverted from the river for use) to the drain discharge (where water from irrigation runoff is discharged back into the river).

The graphs shown on page 36 display the ortho and total phosphorus concentrations measured over time at the Upper Diversion during the irrigation season. Only very little data were collected at the Upper Diversion site during the non-irrigation season. The non-irrigation data set was not robust enough to allow interpretation so they are not included as graphs here. All of the total phosphorus concentrations measured at the diversion exceed the Snake River TMDL target of 0.07 mg/l for both seasons. Concentrations at this site range from about 0.1 mg/l to 0.4 mg/l for the irrigation season. The maximum concentration measured in the diverted water is about one quarter of the maximum concentration measured at the mouth of the Blanton Drain. Total phosphorus concentrations measured at the Upper Diversion during the irrigation season are less than the total phosphorus concentrations measured in the Blanton Drain during the non-irrigation season. The ortho phosphorus concentrations measured at the Upper Diversion site range from 0.07 and about 0.2 mg/l. The maximum ortho phosphorus concentrations measured in the diverted water are approximately half of the maximum concentrations measured at the mouth of the Blanton Drain. The collected phosphorus data from the Upper Diversion site do not appear to display any discernable pattern over time.

TSS concentration data collected at the Upper Diversion site are shown in the graphs on page 36. Most of the measured TSS concentrations are well below the Snake River TMDL target of 50 mg/l. The maximum TSS concentrations measured in the diverted water are approximately one tenth of the maximum concentrations measured at the mouth of the Blanton Drain, and are very similar to the TSS concentrations measured at the mouth of the Blanton Drain during the non-irrigation season.

For E. coli (also on page 36), during the irrigation season, none of the measured concentrations are greater than the Oregon standard of 406 count/100mls. The maximum E. coli concentrations measured in the diverted water are approximately one tenth of the maximum concentrations measured at the mouth of the Blanton Drain, and are similar to the E. coli concentrations measured at the mouth of the Blanton Drain during the non-irrigation season.

When the water quality data collected at the Upper Diversion site are compared to the data collected at the mouth of the Blanton Drain, the consistently higher concentrations of phosphorus, TSS and E. coli measured at the mouth of the drain are strongly indicative of substantial enrichment and higher pollutant loading in the drain water.

Comparison of Historic and Current Data

Historic water quality data (1980-1989) are available for two of the monitoring sites detailed in this chapter (Malheur River at Little Valley and Malheur River One Mile below Namorf). Both historic (1980-1989) and current (2016-2018) data are also available for a monitoring site on the Malheur River at the Highway 201 Bridge (very near the inflow to the Snake). This site is located downstream of the Malheur River at the 36th Street Bridge site. The historic data for all three sites and the current data for the Highway 201 Bridge site were collected by Oregon DEQ as part of their ambient monitoring program.

There are some limitations to the data available. For some sites, only a few (< 10) data points were available for the current time period (2016-2018). For the Highway 201 site, this site is very close to the mouth of the Malheur River where it flows into the Snake River. When the Snake River is experiencing high flows, the water at the mouth of the Malheur can back up due to back pressure from the water in the Snake. This may cause changes in water quality in the samples taken at the Highway 201 Bridge site on the Malheur. Additionally, analytical methods have evolved from those used during the 1980s and may not be directly comparable with the analytical methods used today. Please keep these limitations in mind while reviewing the comparison of historic to current water quality presented here.

Data presented in the tables on page 26 shows the percent reduction in concentration from 1980-1989 to 2016-2018 for each site for both the irrigation season and the non-irrigation season.

Even with the limitations of the available data, it is clear that progress is being made over time in the Malheur River Basin and water quality is improving. With only one exception (median total phosphorus concentrations), concentrations of total phosphorus and total suspended solids have decreased in both the irrigation and non-irrigation season at all three sites. Substantial reductions in total phosphorus and suspended solids have occurred in both the irrigation season and the non-irrigation season. In some cases (90th percentile and maximum total phosphorus concentrations at Highway 201 Bridge; 90th percentile and maximum TSS concentrations at Highway 201 Bridge and Little Valley, non-irrigation season) concentrations have realized a reduction of more than 70%.

Additional information is provided in the more detailed tables of this historic to current data comparison in the final section of this report (please see pages 109-110.)

Calculated Removal Efficiency of Wetlands and Sediment Pond

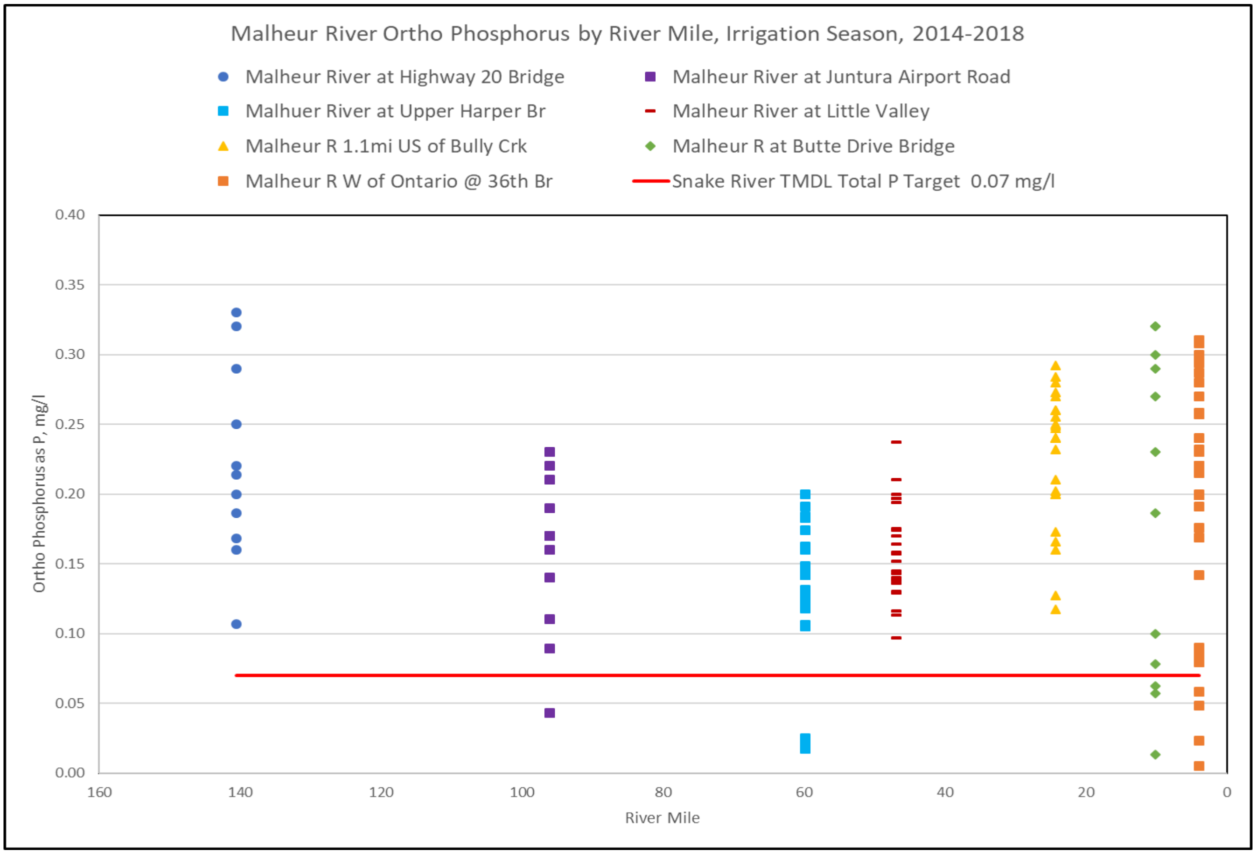
Water quality data were also collected at both the Luther Wetland and the Shoestring Sediment Pond in order to calculate the removal efficiencies for both of these systems. Graphs of the removal efficiencies for total phosphorus and TSS for the Luther wetland are included on page 37. Please see the digital appendix of this report for graphs of the total phosphorus and TSS removal efficiencies for the Shoestring Sediment Pond.

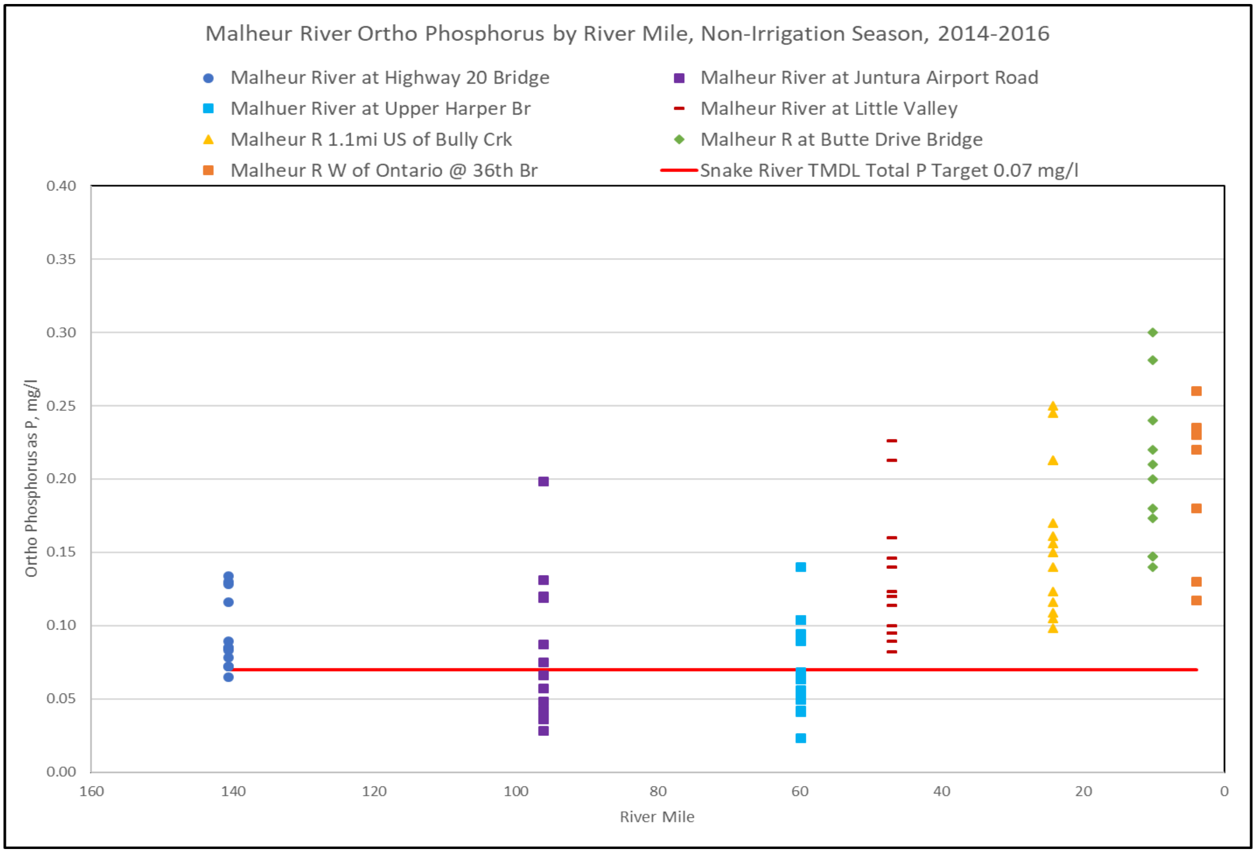
The Luther Wetland was constructed in 2001-2002 and is operating on the Luther Drain for the purpose of capturing sediment and reducing phosphorus and other pollutants. Samples were only collected during the irrigation season. On both graphs, the removal efficiencies are greater than zero most of the time; in fact, many times they are better than 50%, indicating that the wetland is still functioning effectively to reduce pollutant loading.

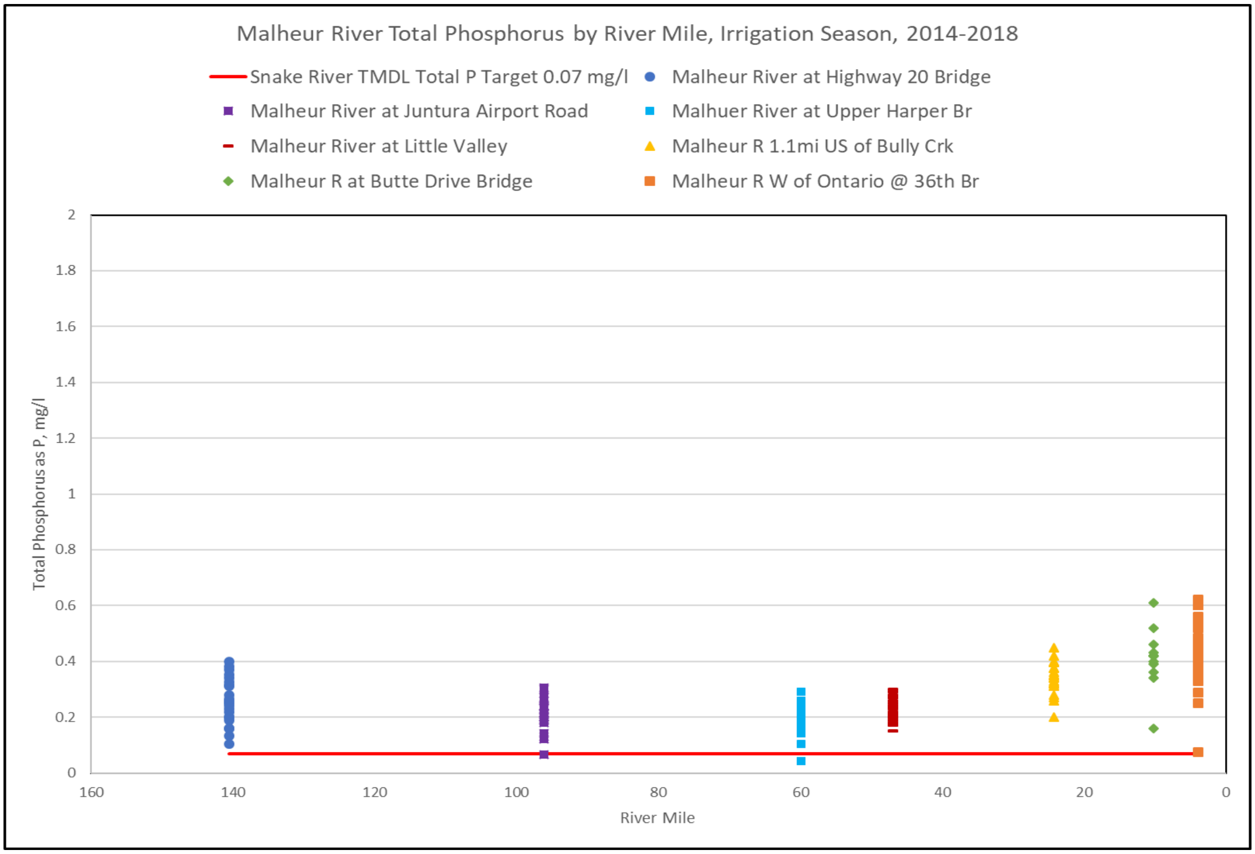
In some instances, however, there is a negative removal efficiency, meaning that the concentration measured in the water leaving the wetland is greater than the concentration measured in the water coming into the wetland. For TSS, most of these instances occurred during August or September and could be the result of increased algal growth. It is unclear what would be causing the total phosphorus efficiencies to be negative unless the wetland vegetation is dying, degrading and releasing phosphorus back into the water column.

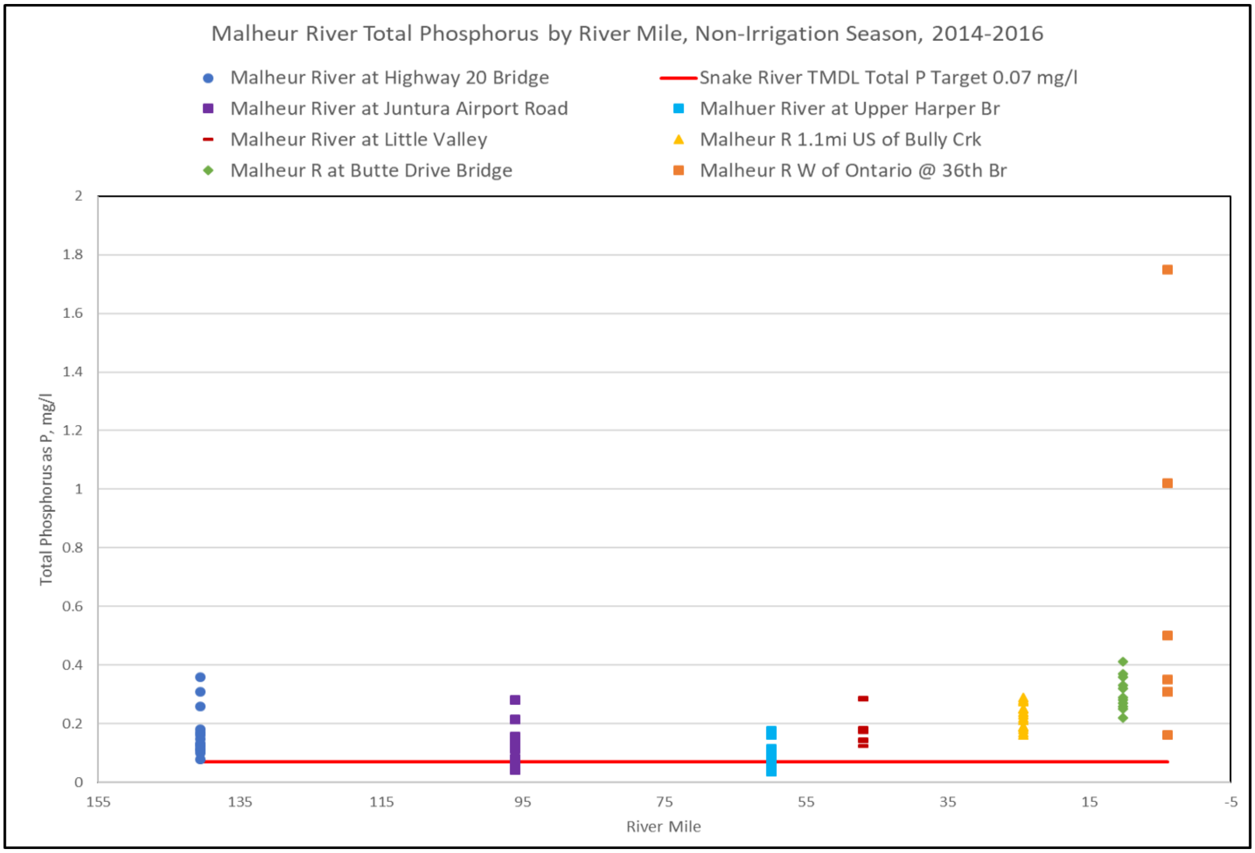
Total Phosphorus Concentration (mg/l), Malheur River Sites									
		Irrigation Season				Non-Irrigation Season			
Site	Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	1980-1989	41	0.374	0.610	0.660	25.000	0.374	1.365	3.010
	2016-2018	9	0.380	0.494	0.510	9.000	0.310	0.360	0.400
Malheur River at Little Valley	1980-1989	20	0.250	0.280	0.320	14.000	0.215	0.280	0.660
	2016-2018	19	0.219	0.254	0.280	9.000	0.170	0.202	0.290
Malheur River One Mile below Namorf	1980-1989	9	0.220	0.242	0.250	N/A	N/A	N/A	N/A
	2016-2018	16	0.198	0.241	0.250	N/A	N/A	N/A	N/A

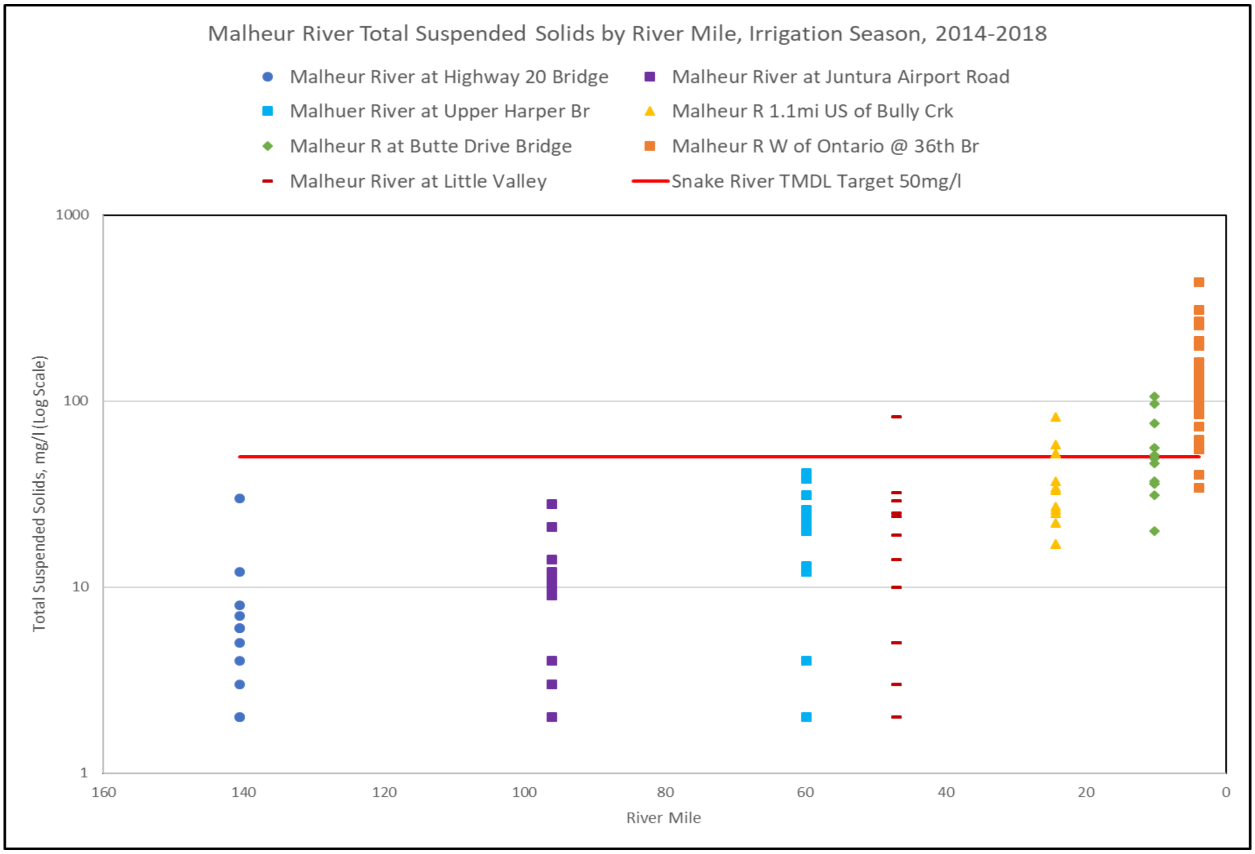
Total Suspended Solids Concentration (mg/l), Malheur River Sites									
		Irrigation Season				Non-Irrigation Season			
Site	Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	1980-1989	37	89	166	244	42	56	655	2579
	2016-2018	9	61	118	133	9	50	117	123
Malheur River at Little Valley	1980-1989	20	29	77	82	22	18	208	734
	2016-2018	8	17	26	29	7	13	26	34
Malheur River One Mile below Namorf	1980-1989	9	17	26	42	N/A	N/A	N/A	N/A
	2016-2018	16	13	21	24	N/A	N/A	N/A	N/A

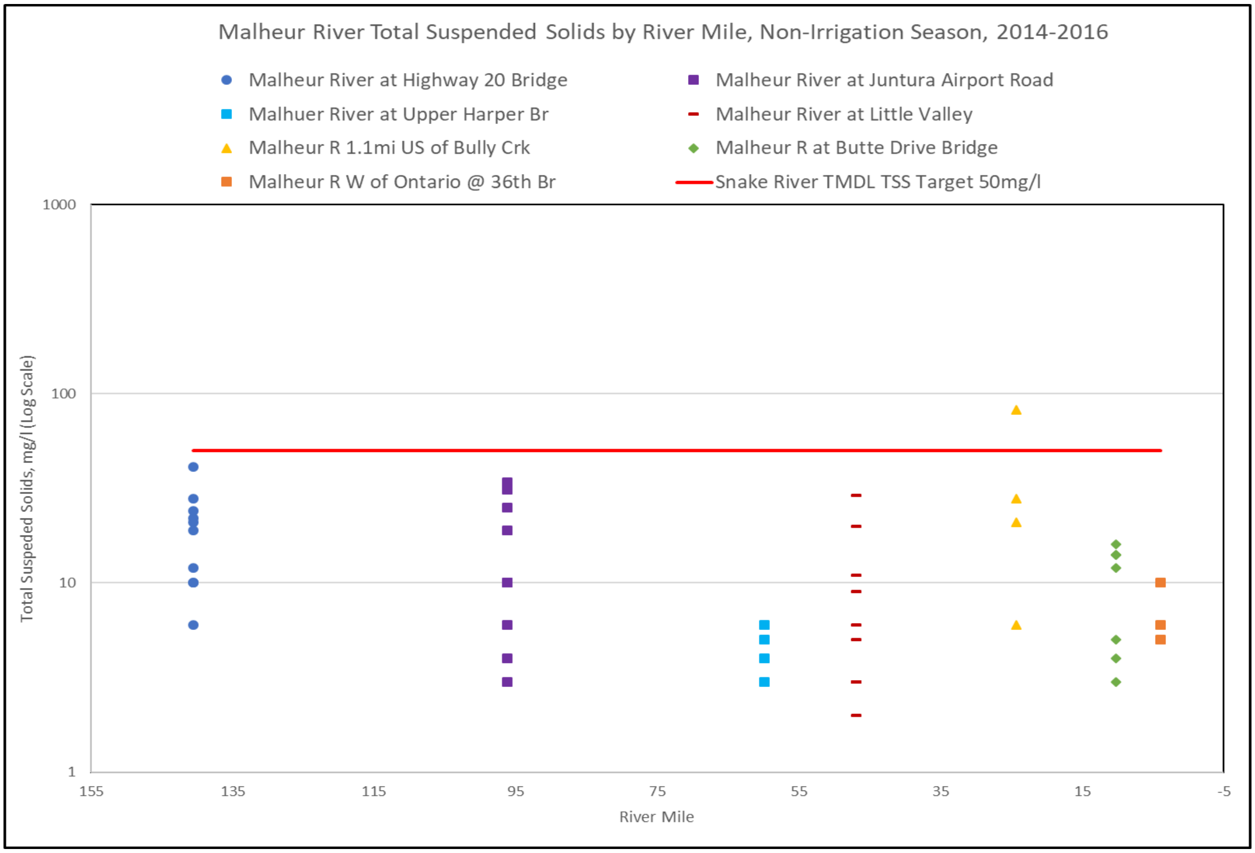

Malheur River Ortho Phosphorus by River Mile, Irrigation Season, 2014-2018
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Snake River TMDL Total P Target 0.07 mg/l
Ortho Phosphorus as P, mg/l
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
160
140
120
100
80
60
40
20
0
River Mile

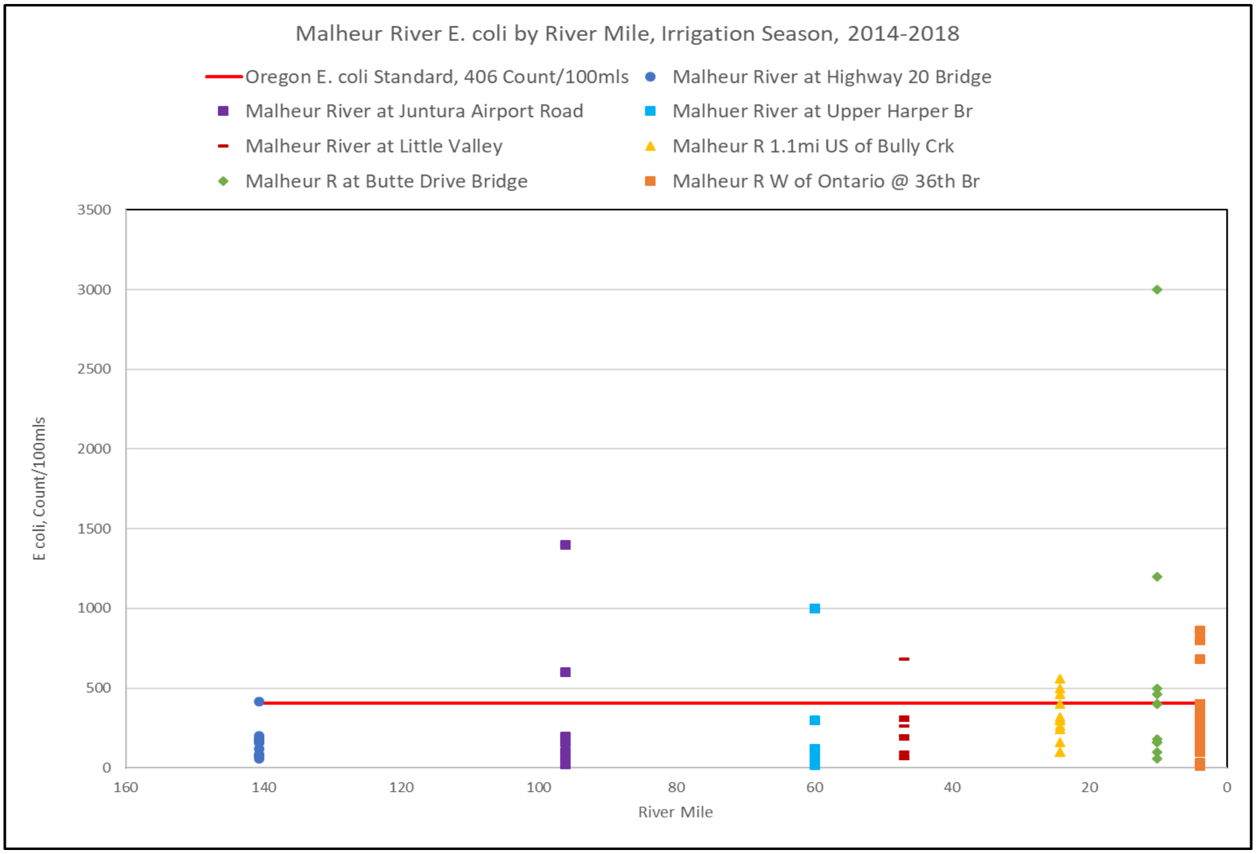

Malheur River Ortho Phosphorus by River Mile, Non-Irrigation Season, 2014-2016
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Snake River TMDL Total P Target 0.07 mg/l
Ortho Phosphorus as P, mg/l
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
160
140
120
100
80
60
40
20
0
River Mile

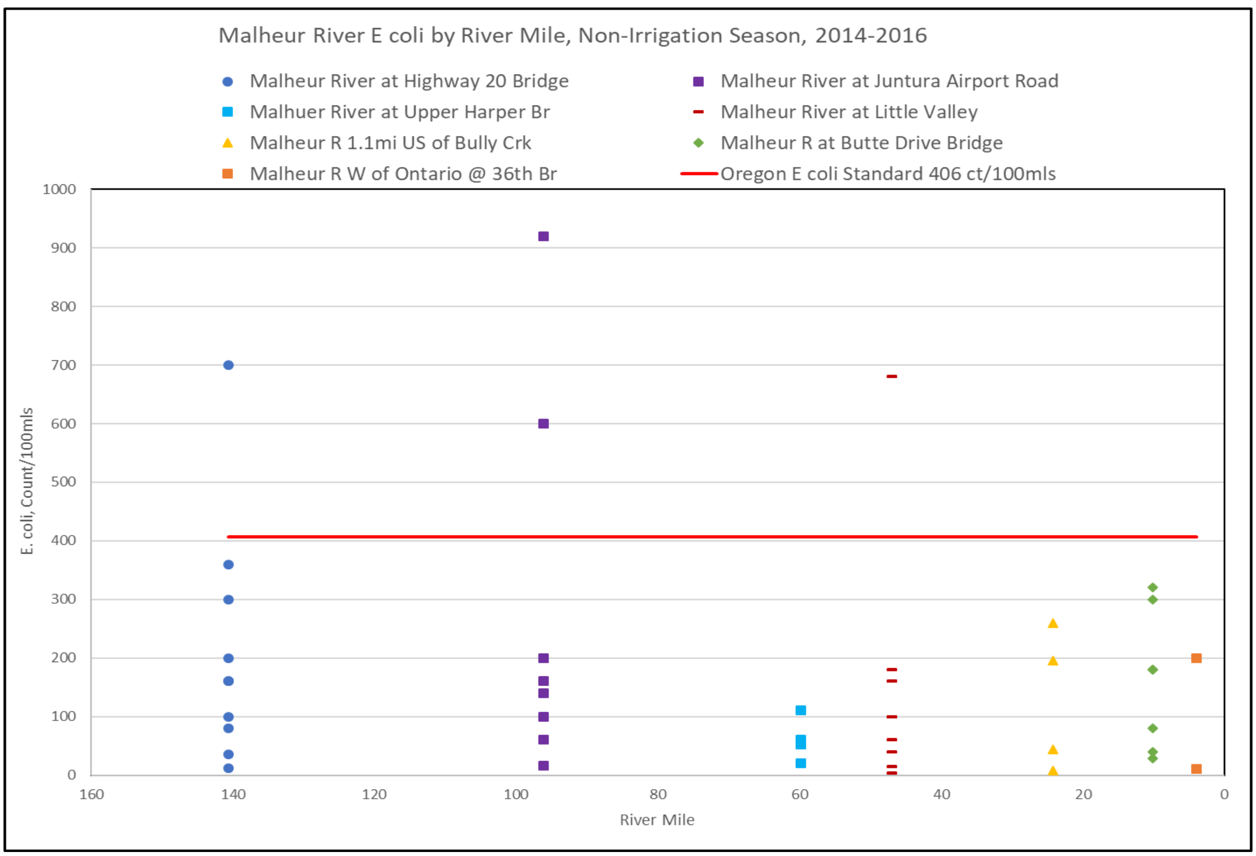

Malheur River Total Phosphorus by River Mile, Irrigation Season, 2014-2018
Snake River TMDL Total P Target 0.07 mg/l
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Total Phosphorus as P, mg/l
River Mile
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
160
140
120
100
80
60
40
20
0

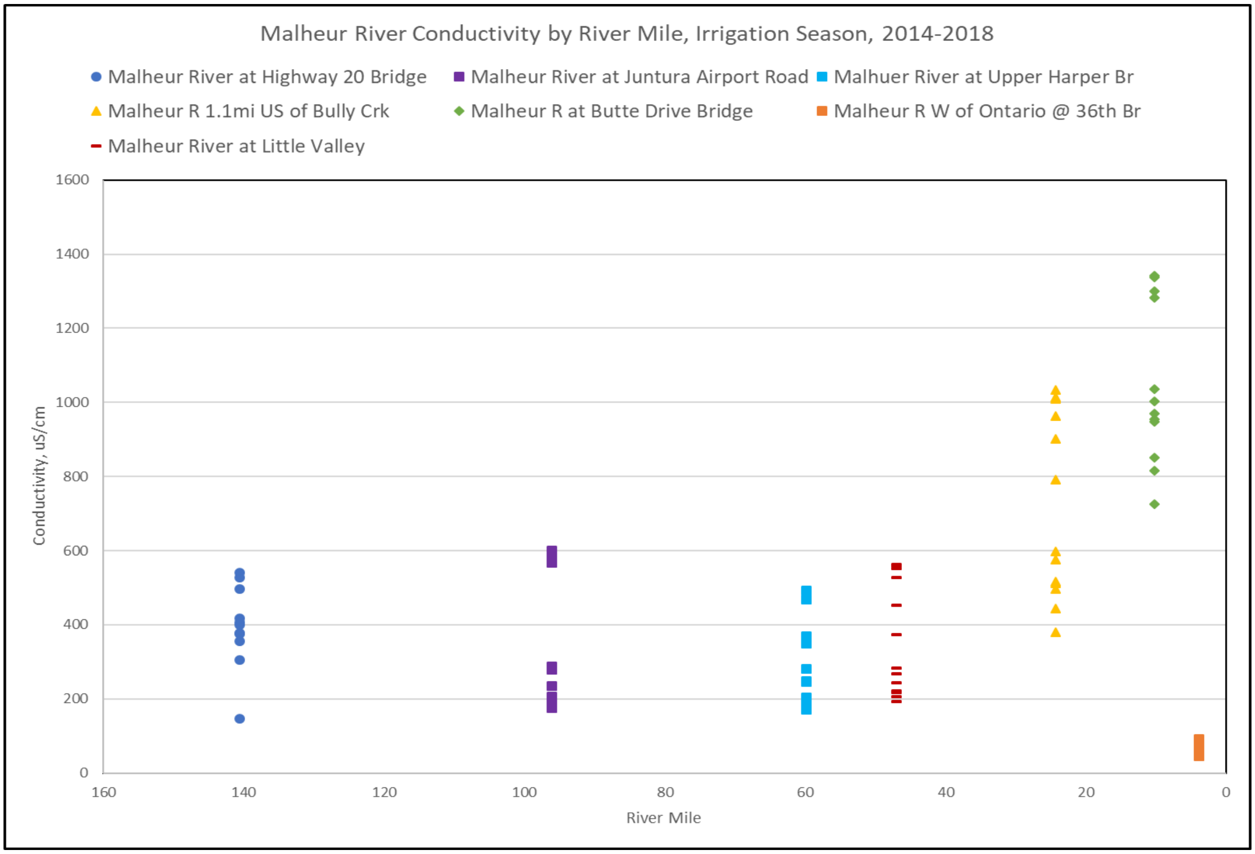

Malheur River Total Phosphorus by River Mile, Non-Irrigation Season, 2014-2016
Malheur River at Highway 20 Bridge
Snake River TMDL Total P Target 0.07 mg/l
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Total Phosphorus as P, mg/l
River Mile
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
155
135
115
95
75
55
35
15
-5

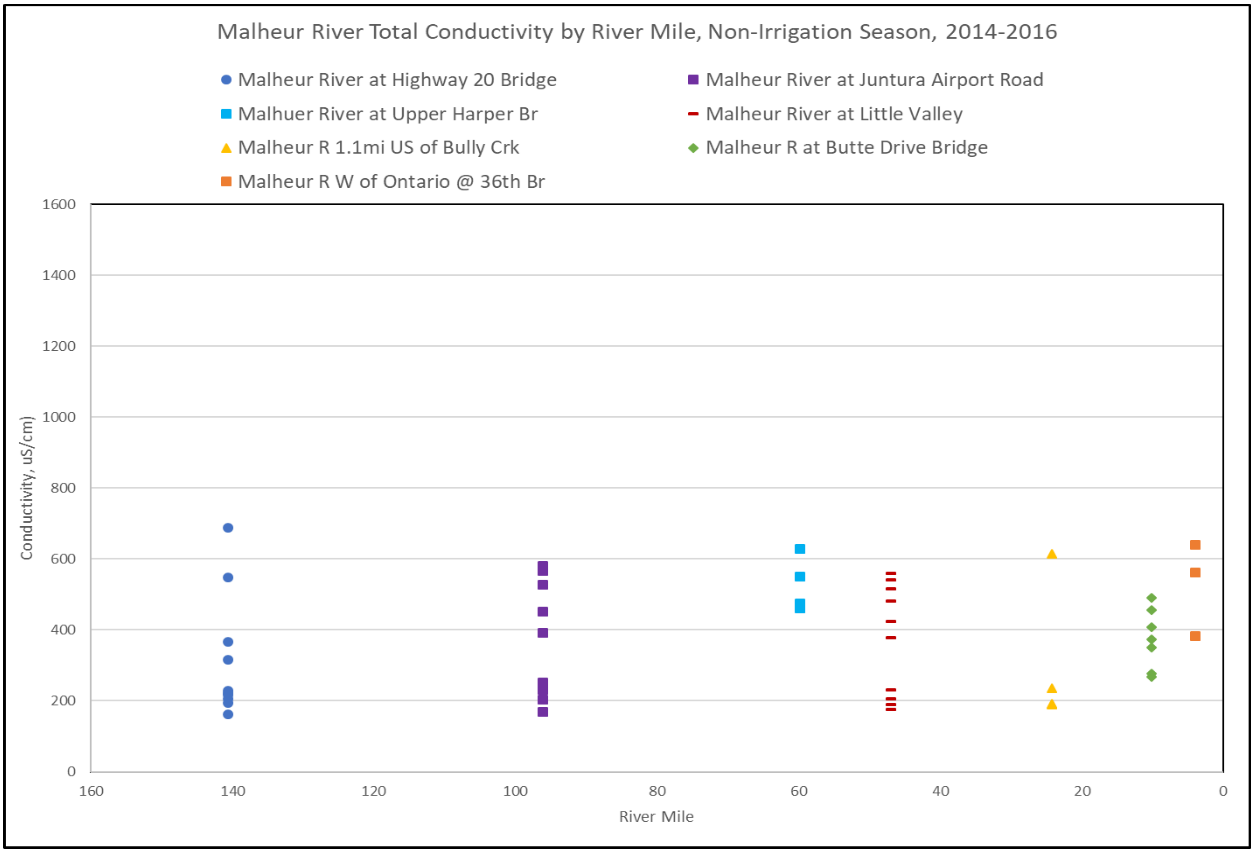

Malheur River Total Suspended Solids by River Mile, Irrigation Season, 2014-2018
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Malheur River at Little Valley
Snake River TMDL Target 50mg/l
Total Suspended Solids, mg/l (Log Scale)
1000
100
10
1
160
140
120
100
80
60
40
20
0
River Mile

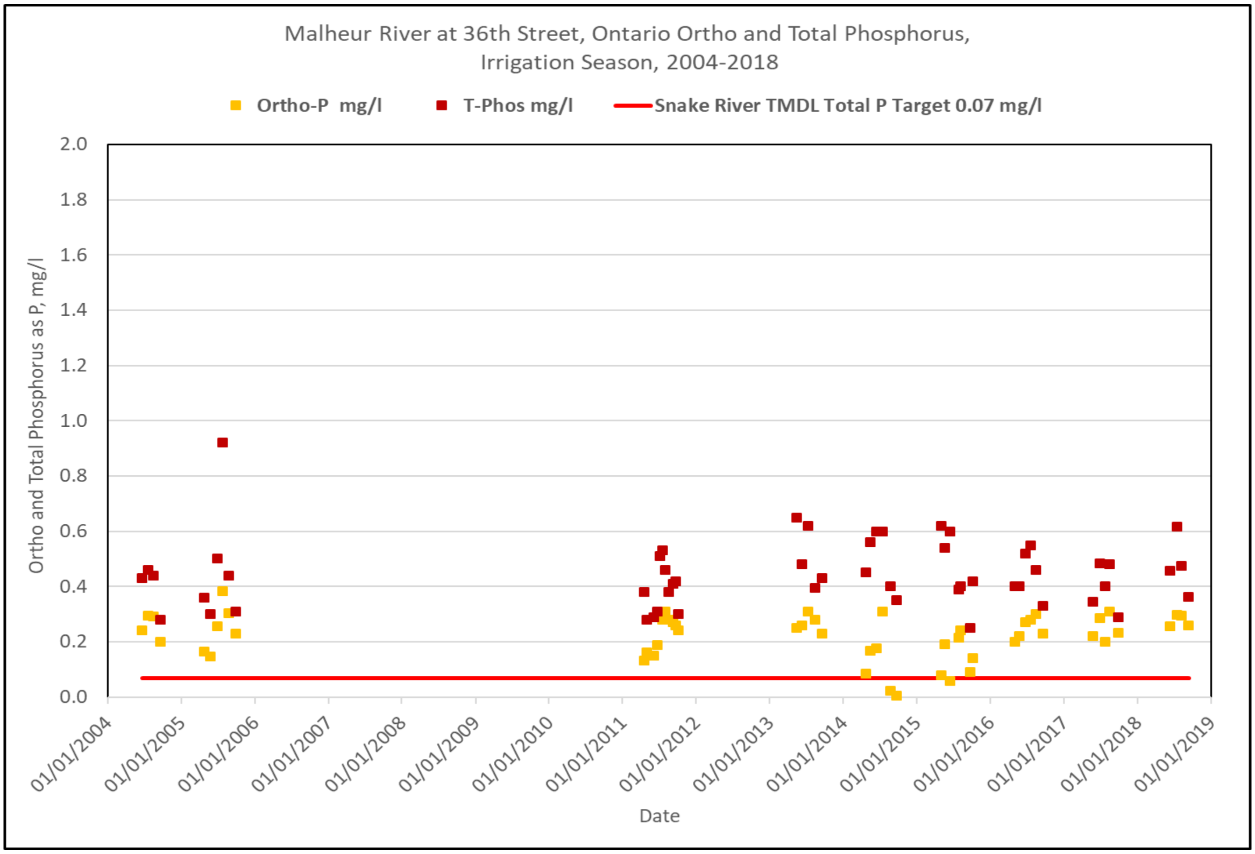

Malheur River Total Suspended Solids by River Mile, Non-Irrigation Season, 2014-2016
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Snake River TMDL TSS Target 50mg/l
Total Suspeded Solids, mg/l (Log Scale)
1000
100
10
1
155
135
115
95
75
55
35
15
-5
River Mile

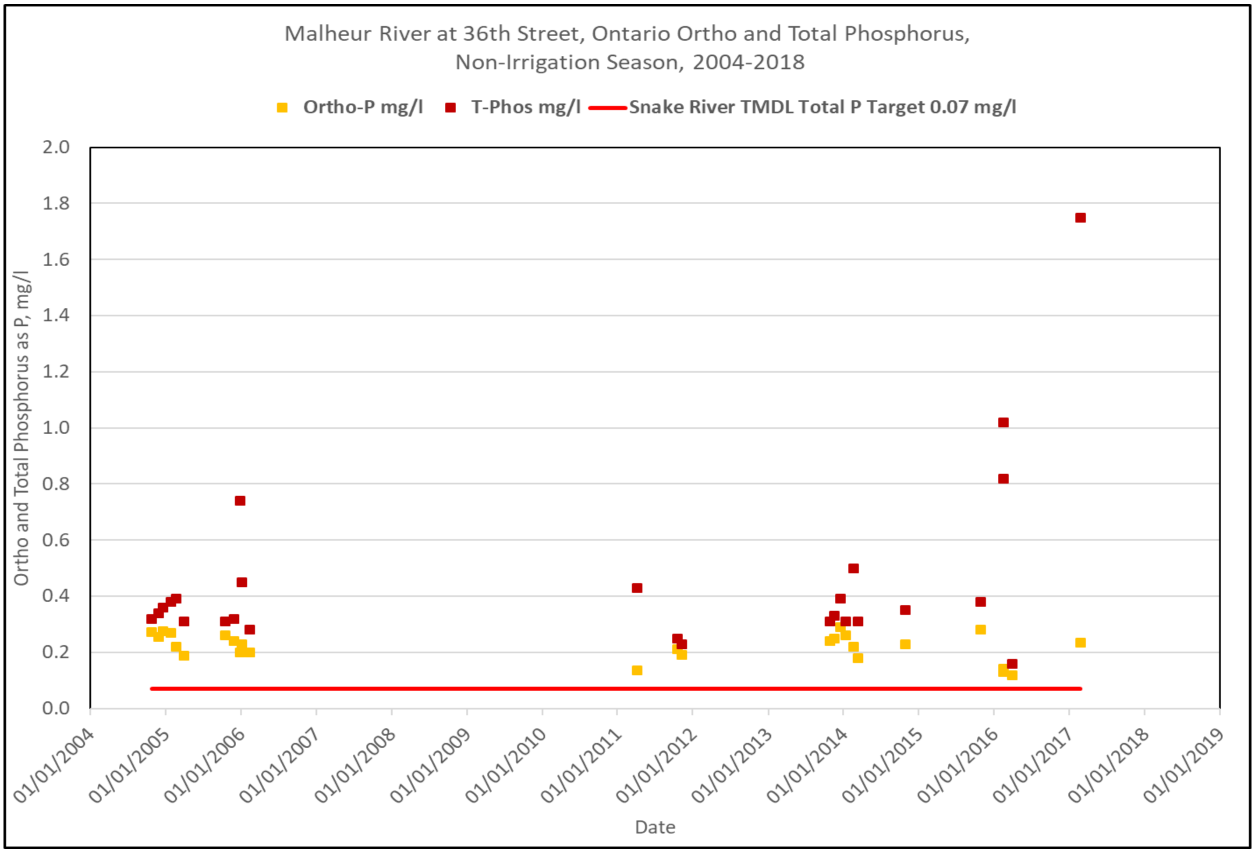

Malheur River E. coli by River Mile, Irrigation Season, 2014-2018
Oregon E. coli Standard, 406 Count/100mls
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
E coli, Count/100mls
3500
3000
2500
2000
1500
1000
500
0
160
140
120
100
80
60
40
20
0
River Mile

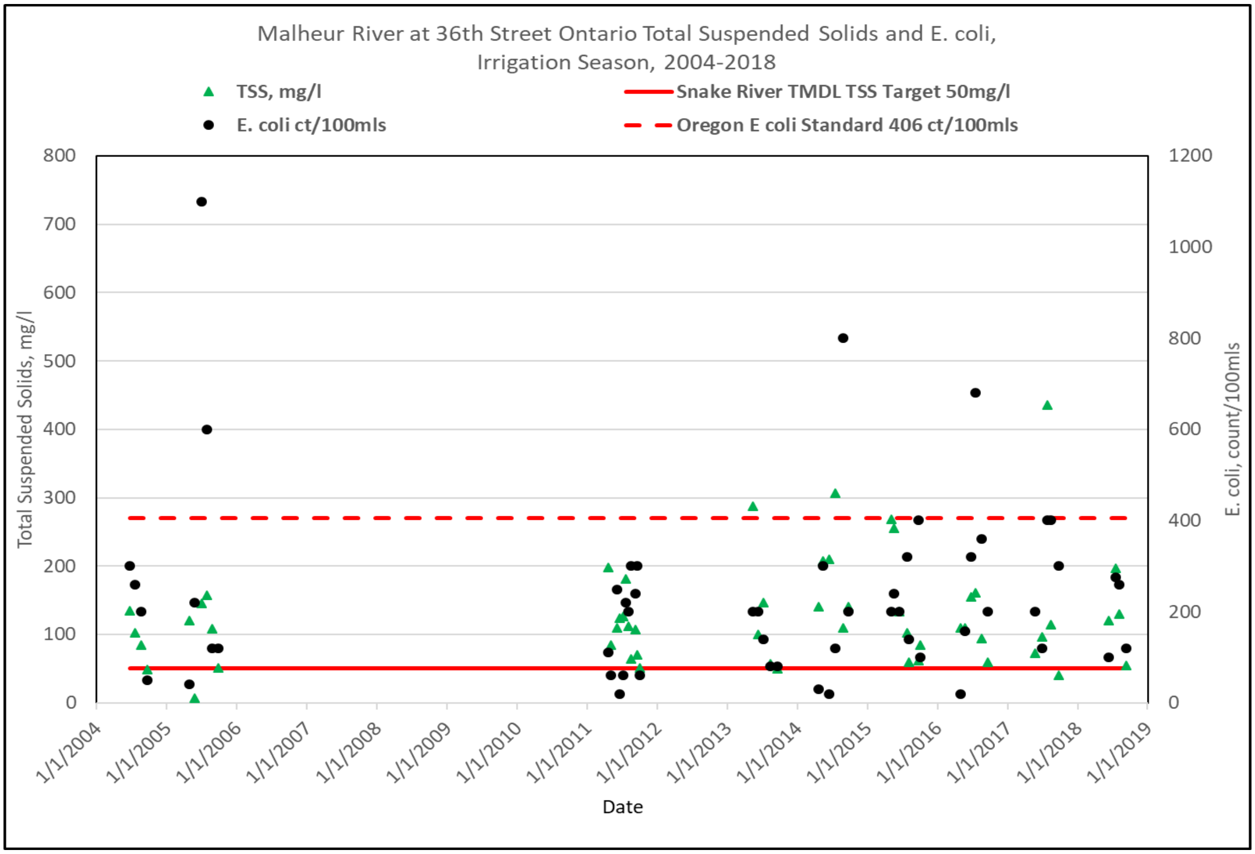

Malheur River E coli by River Mile, Non-Irrigation Season, 2014-2016
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Oregon E coli Standard 406 ct/100mls
E. coli, Count/100mls
1000
900
800
700
600
500
400
300
200
100
0
160
140
120
100
80
60
40
20
0
River Mile

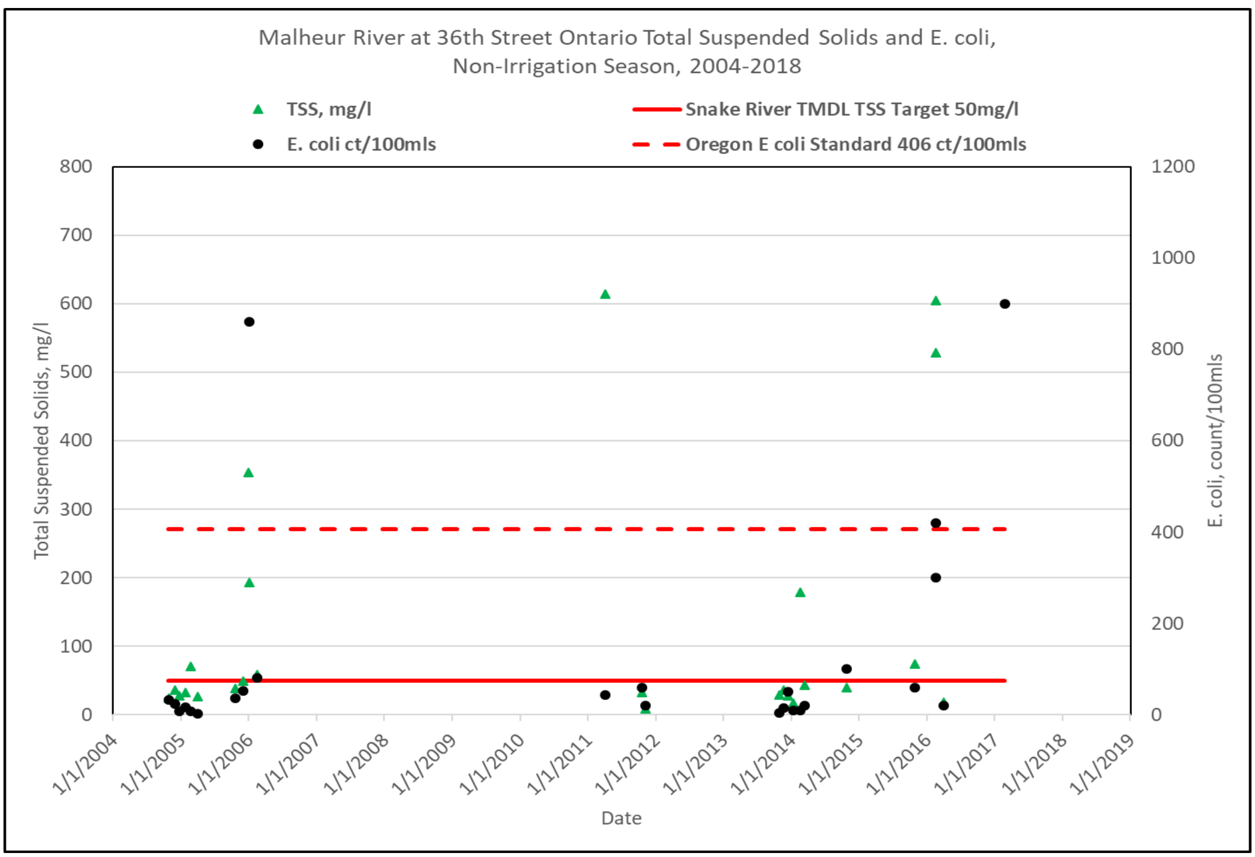

Malheur River Conductivity by River Mile, Irrigation Season, 2014-2018
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Malheur River at Little Valley
Conductivity, uS/cm
River Mile
1600
1400
1200
1000
800
600
400
200
0
160
140
120
100
80
60
40
20
0

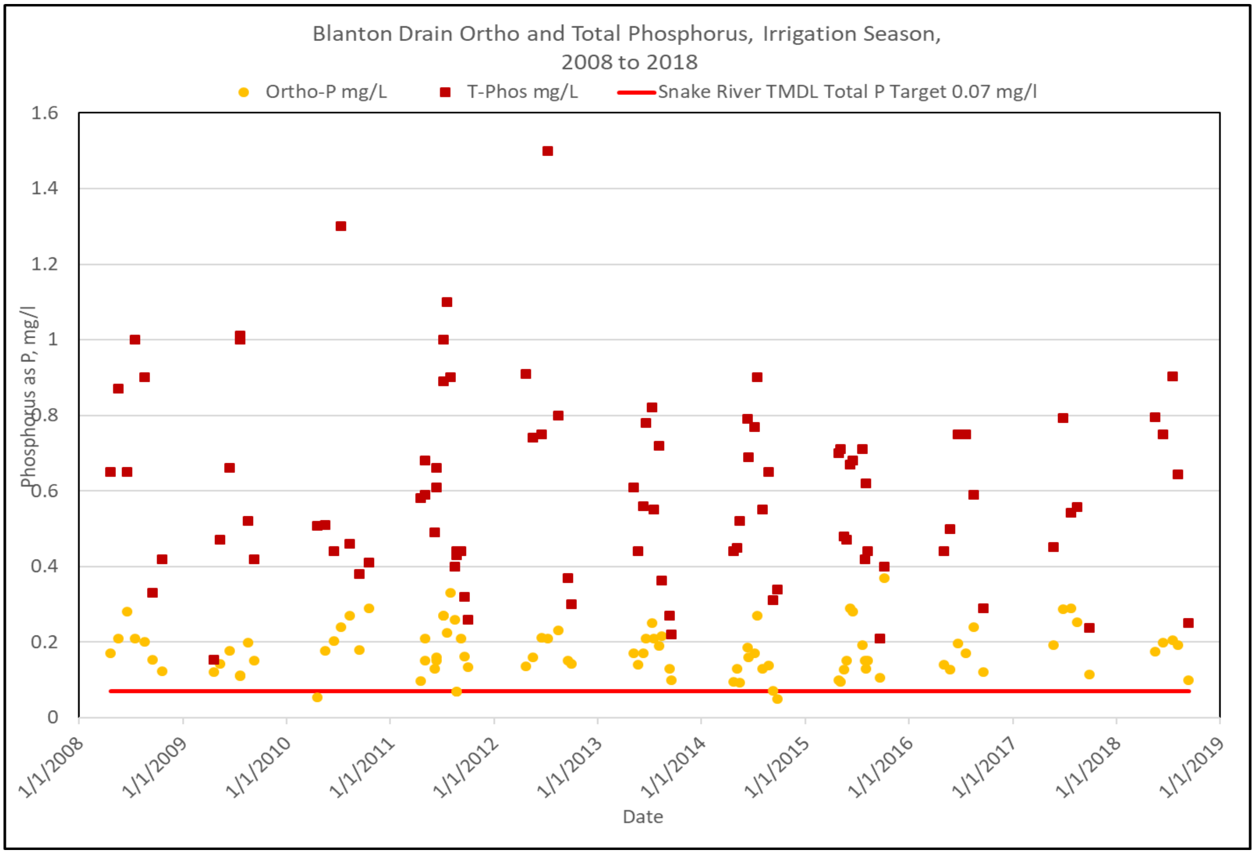

Malheur River Total Conductivity by River Mile, Non-Irrigation Season, 2014-2016
Malheur River at Highway 20 Bridge
Malheur River at Juntura Airport Road
Malhuer River at Upper Harper Br
Malheur River at Little Valley
Malheur R 1.1mi US of Bully Crk
Malheur R at Butte Drive Bridge
Malheur R W of Ontario @ 36th Br
Conductivity, uS/cm)
River Mile
1600
1400
1200
1000
800
600
400
200
0
160
140
120
100
80
60
40
20
0

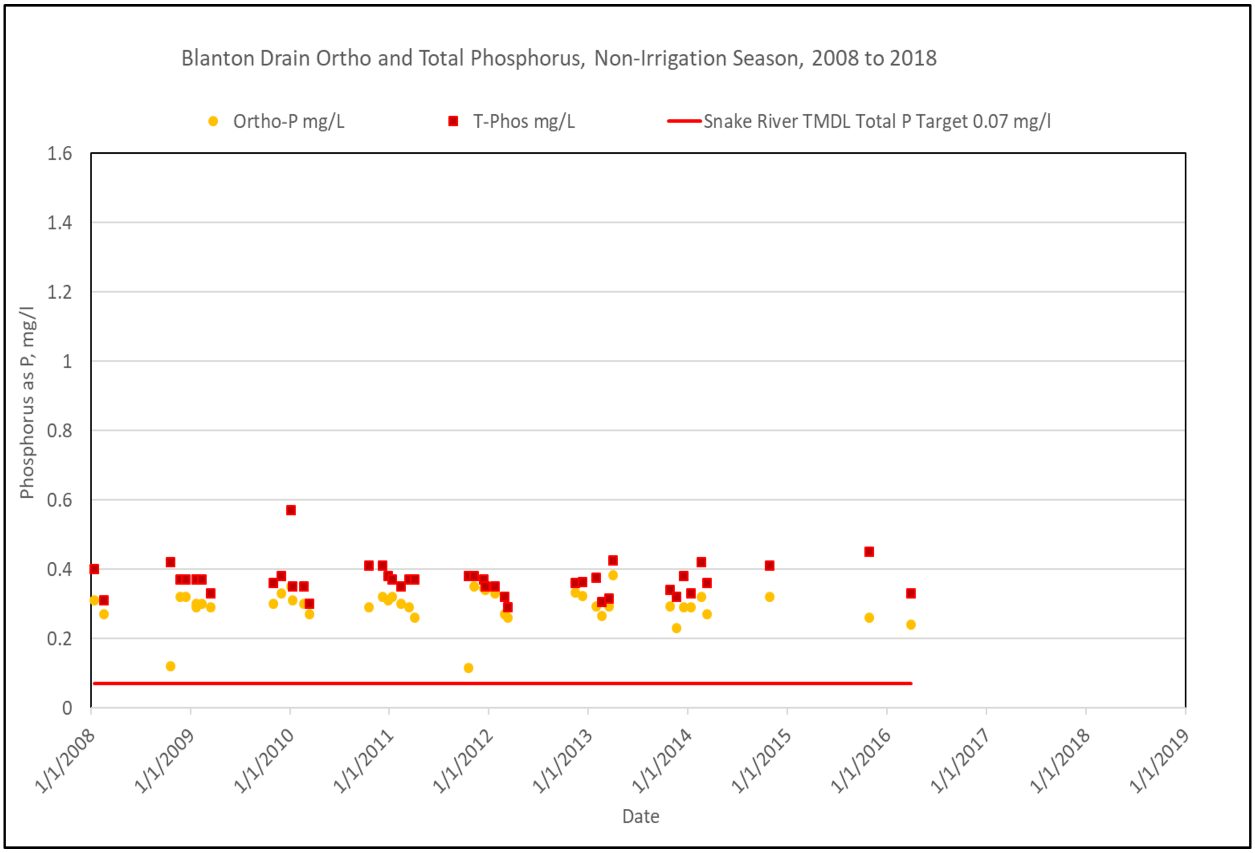

Malheur River at 36th Street, Ontario Ortho and Total Phosphorus,
Irrigation Season, 2004-2018
Ortho-P mg/l
T-Phos mg/l
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
01/01/2004
01/01/2005
01/01/2006
01/01/2007
01/01/2008
01/01/2009
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Date

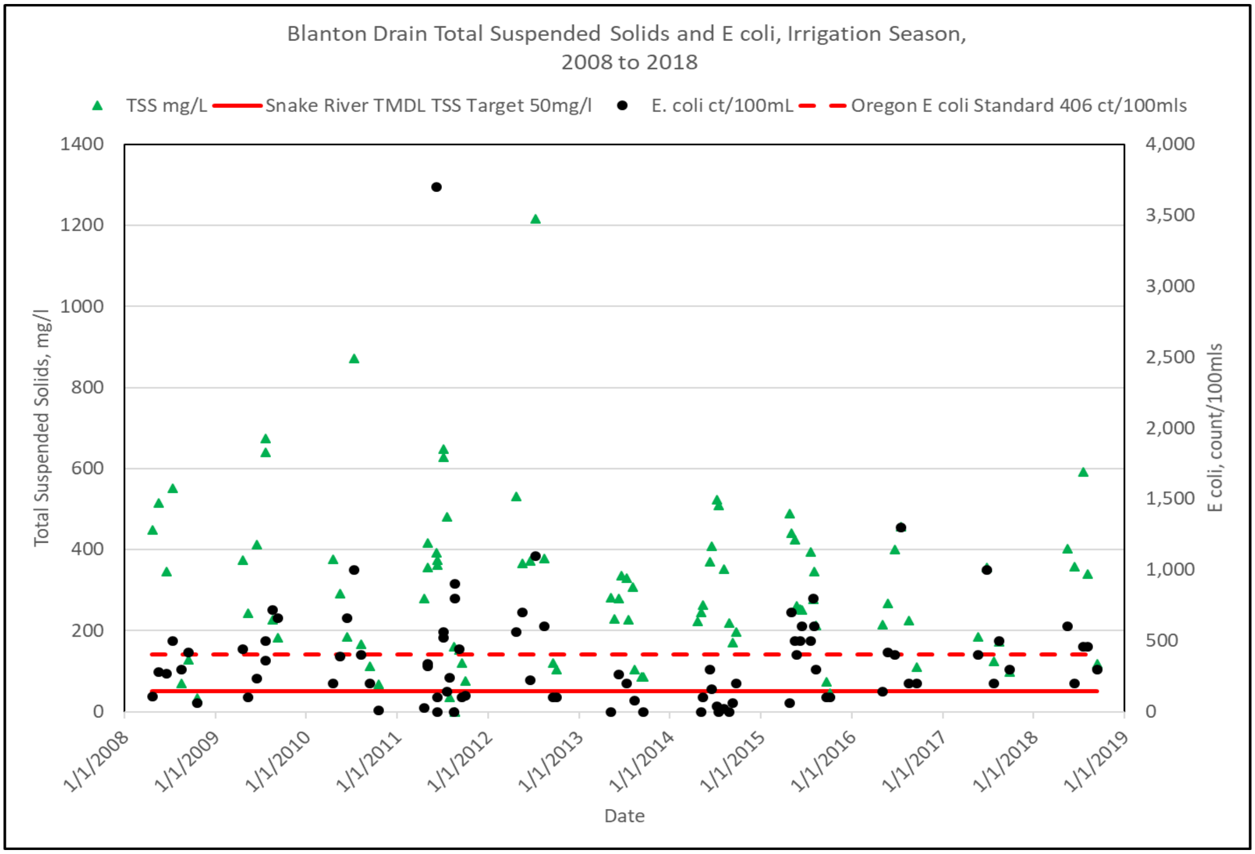

Malheur River at 36th Street, Ontario Ortho and Total Phosphorus,
Non-Irrigation Season, 2004-2018
Ortho-P mg/l
T-Phos mg/l
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
01/01/2004
01/01/2005
01/01/2006
01/01/2007
01/01/2008
01/01/2009
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Date

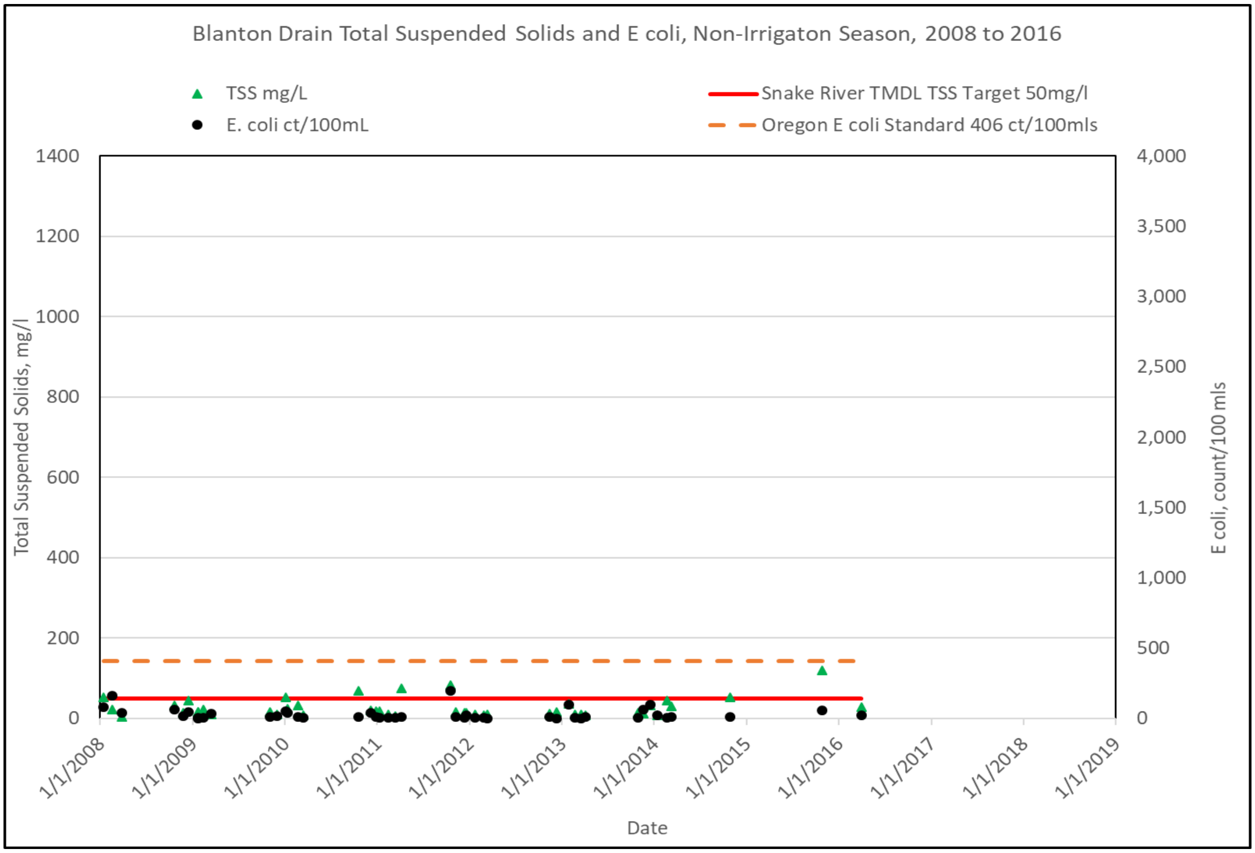

Malheur River at 36th Street Ontario Total Suspended Solids and E. coli, Irrigation Season, 2004-2018
TSS, mg/l
E. coli ct/100mls
Snake River TMDL TSS Target 50mg/l
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E. coli, count/100mls
Date
0
100
200
300
400
500
600
700
800
1000
1200
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

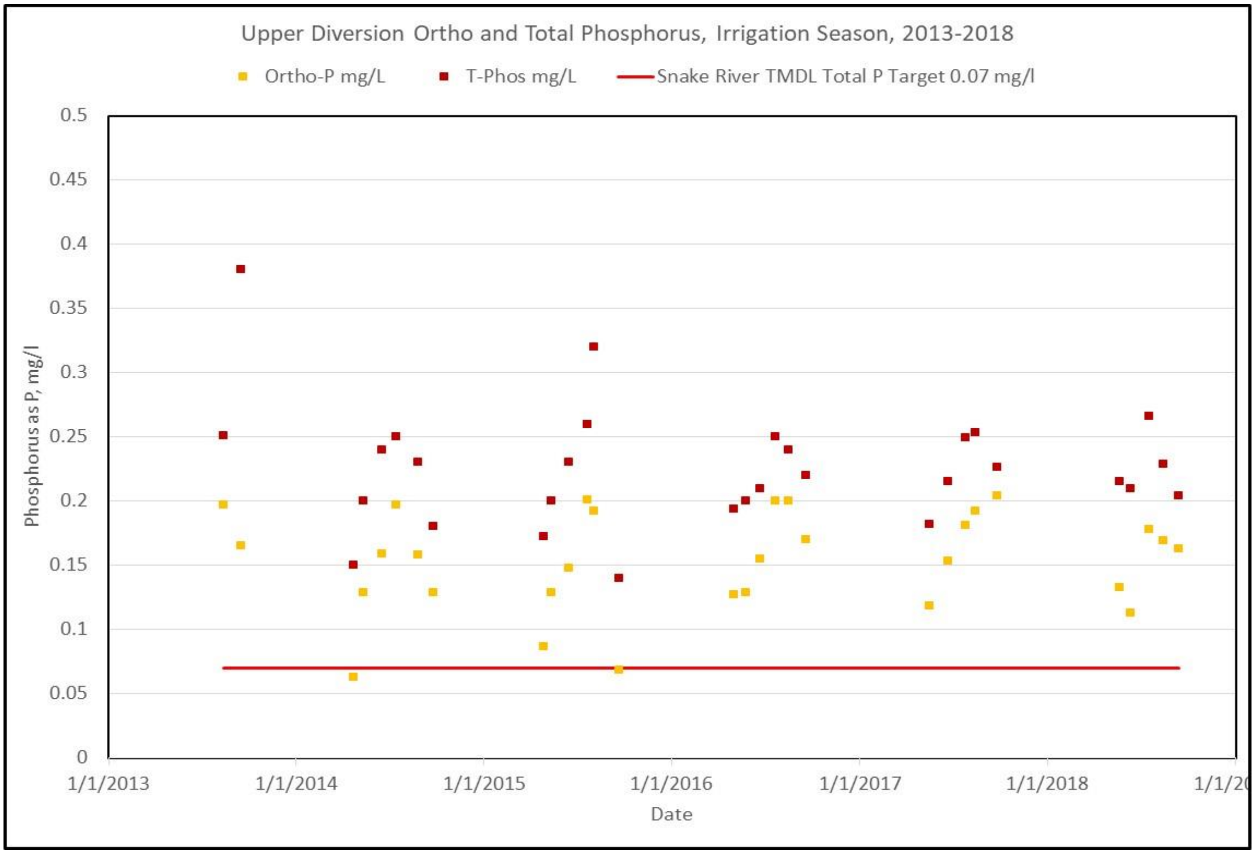

Malheur River at 36th Street Ontario Total Suspended Solids and E. coli, Non-Irrigation Season, 2004-2018
TSS, mg/l
E. coli ct/100mls
Snake River TMDL TSS Target 50mg/l
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E. coli, count/100mls
Date
0
100
200
300
400
500
600
700
800
1000
1200
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

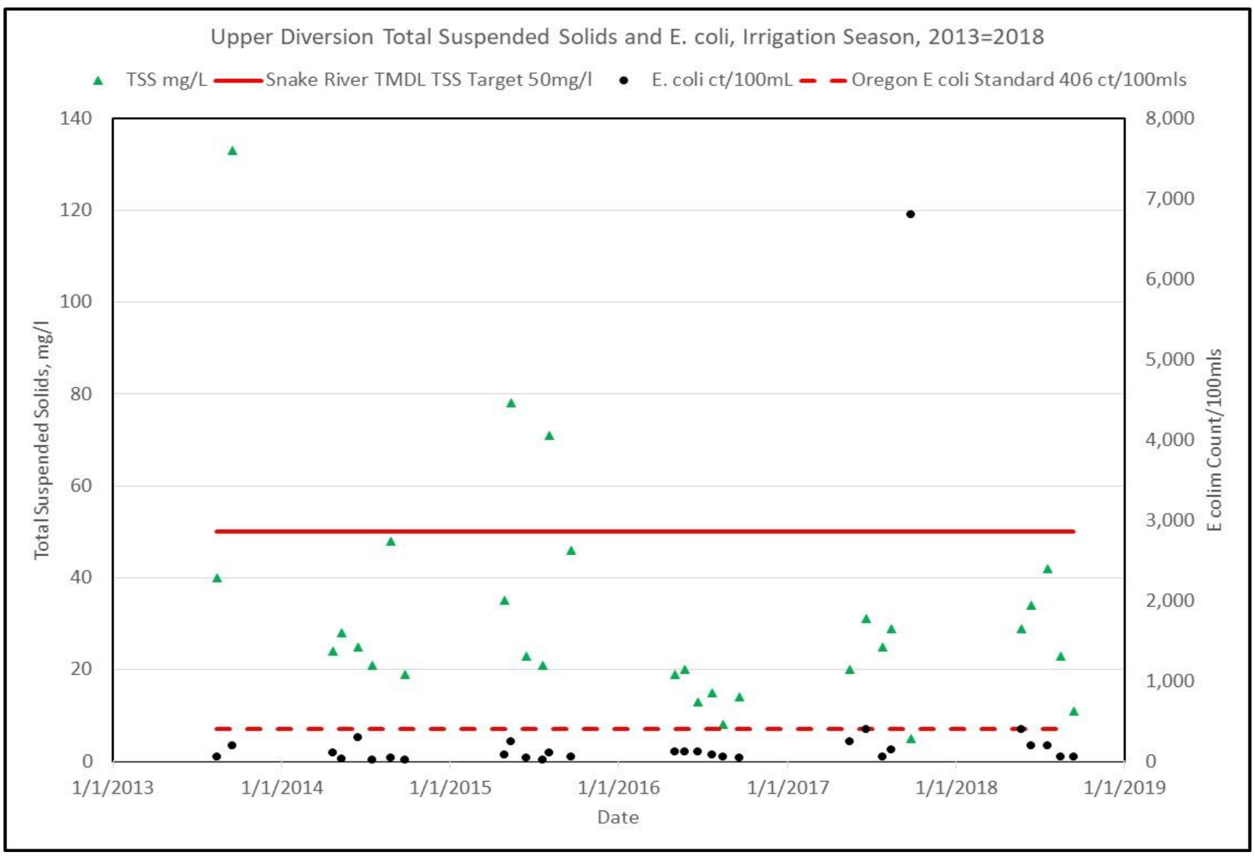

Blanton Drain Ortho and Total Phosphorus, Irrigation Season, 2008 to 2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

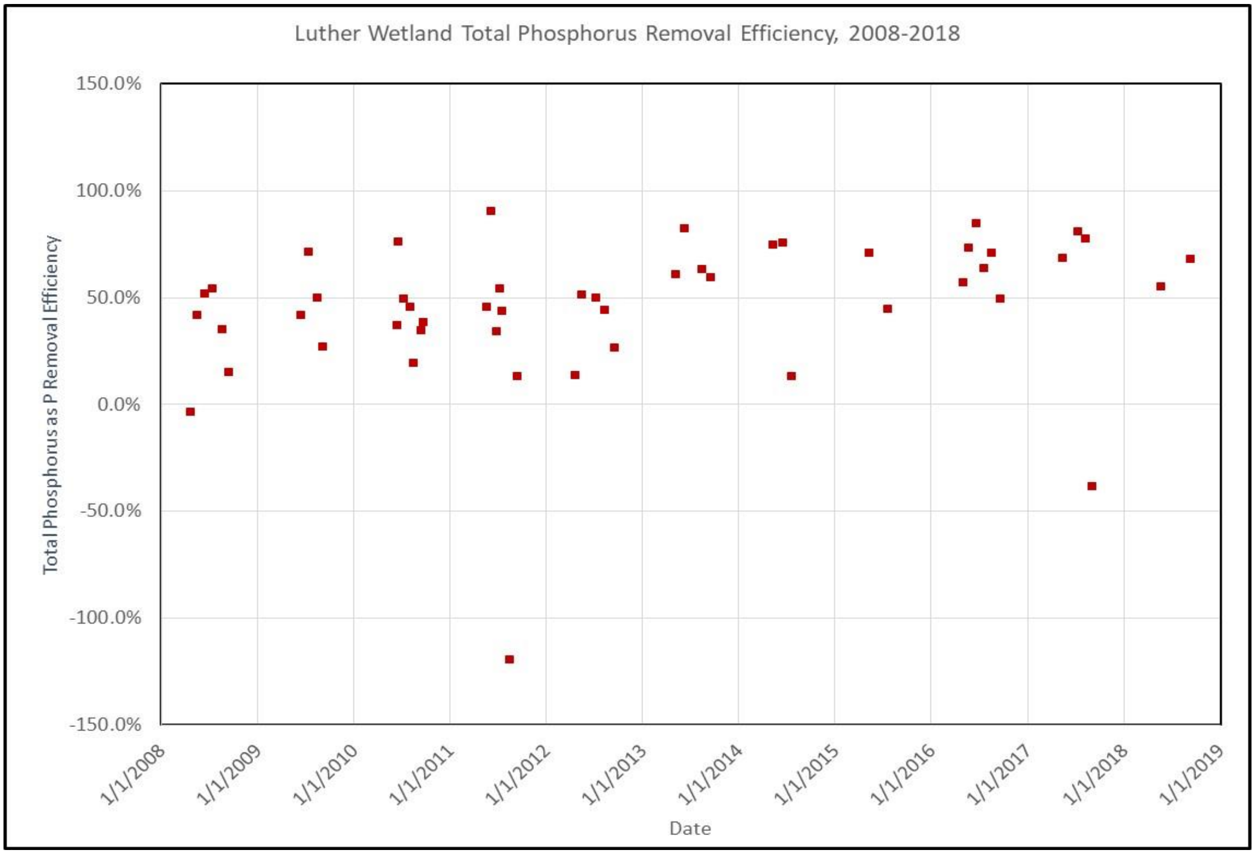

Blanton Drain Ortho and Total Phosphorus, Non-Irrigation Season, 2008 to 2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

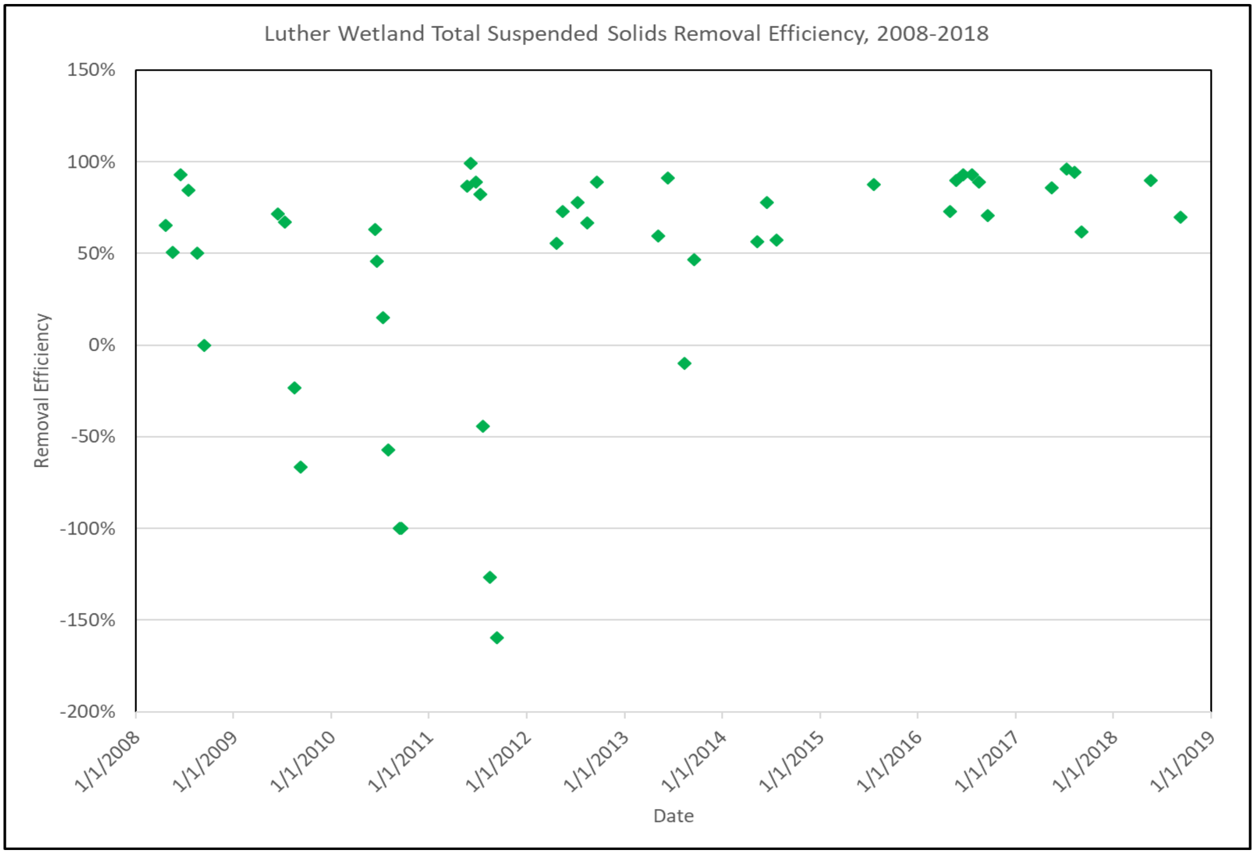

Blanton Drain Total Suspended Solids and E coli, Irrigation Season, 2008 to 2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, count/100mls
Date
0
200
400
600
800
1000
1200
1400
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019


Blanton Drain Total Suspended Solids and E coli, Non-Irrigaton Season, 2008 to 2016
TSS mg/L
E. coli ct/100mL
Snake River TMDL TSS Target 50mg/l
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, count/100 mls
Date
0
200
400
600
800
1000
1200
1400
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019


Upper Diversion Ortho and Total Phosphorus, Irrigation Season, 2013-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
Date


Upper Diversion Total Suspended Solids and E. coli, Irrigation Season, 2013=2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
140
120
100
80
60
40
20
0
E colim Count/100mls
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Luther Wetland Total Phosphorus Removal Efficiency, 2008-2018
Total Phosphorus as P Removal Efficiency
150.0%
100.0%
50.0%
0.0%
-50.0%
-100.0%
-150.0%
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Luther Wetland Total Suspended Solids Removal Efficiency, 2008-2018
Removal Efficiency
150%
100%
50%
0%
-50%
-100%
-150%
-200%
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

Chapter 4 – Bully Creek

Bully Creek is a 62-mile long tributary of the Malheur River, that flows through a portion of Vale, Oregon. Arising in the Blue Mountains, Bully Creek flows generally southeast to its confluence with the Malheur River near Vale. The area of the Bully Creek watershed is 601 square miles.

Bully Creek Reservoir is located about 9 miles west of Vale. Constructed by the Bureau of Reclamation in 1963, the reservoir has a total capacity of 31,650 acre feet.[7] The reservoir is used primarily for irrigation storage, although it supports some recreation and fishing.

Bully Creek is part of the Malheur Basin. Bully Creek flows into the Malheur River which, in turn, flows into the Snake River. The quality of water in Bully Creek contributes to the quality of water in the Malheur River which, in turn, contributes to water quality in the Snake River. Because of the interconnected nature of these systems, reductions in pollution loading are necessary in Bully Creek and in the Malheur River in order to meet water quality standards in the Snake River.

There are two Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin (and therefore apply to the Bully Creek watershed): the Malheur River TMDL and the Snake River-Hells Canyon TMDL. TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet state water quality standards.

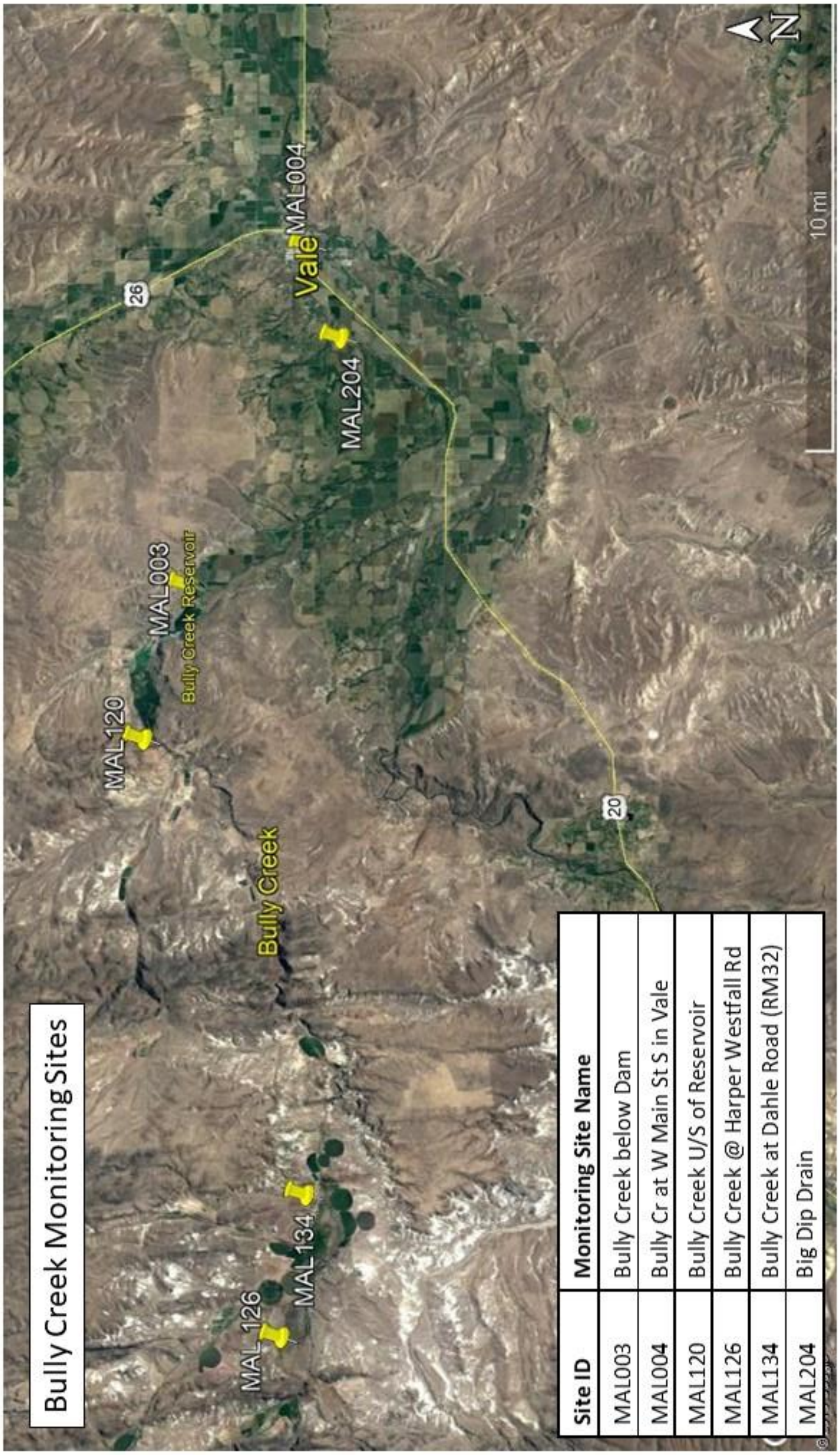
In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as "Snake River TMDL targets" on all graphs of water quality data presented in this chapter. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the Snake River-Hells Canyon TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur River, where it flows into the Snake. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use. For additional information on the TMDLs, please see the text in the 'Introduction' section of this report.

The Malheur Watershed Council has collected water quality samples at five (5) locations on Bully Creek and one location on the Big Dip Drain that flows into Bully Creek at River Mile 3.63. A map of monitoring sites is included on the following page. A table which lists the site locations along with their respective latitude, longitude, and river mile follows the map page. No flow measurements were collected as part of the Bully Creek monitoring project.

Bully Creek Monitoring

The water quality data collected at each site are discussed in the following paragraphs. For each site, the data have been divided into separate graphs showing the irrigation season (April 15 – October 15) and the non-irrigation season (October 16-April 14) for the Malheur Basin. For comparison purposes,

[7] Wikipedia



Site ID	Monitoring Site Name
MAL003	Bully Creek below Dam
MAL004	Bully Cr at W Main St S in Vale
MAL120	Bully Creek U/S of Reservoir
MAL126	Bully Creek @ Harper Westfall Rd
MAL134	Bully Creek at Dahle Road (RM32)
MAL204	Big Dip Drain

Site Location	Latitude	Longitude	River Mile	Monitoring Period	Parameters Monitored
Bully Creek @ Harper Westfall Rd	43.98423	117.70666	33.6	2014-2016	Ortho and Total Phosphorus, Total Suspended Solids, E. coli, conductivity, and turbidity. *
Bully Creek at Dahle Road (RM32)	43.97664	117.64675	29.81	2014-2018	
Bully Creek U/S of Reservoir	44.02585	117.45486	16.72	2014-2016	
Bully Creek below Dam	44.01421	117.39462	12.66	2012, 2014-2018	
Bully Cr at W Main St S in Vale	43.97490	117.24680	0.17	2011, 2014-2018	
Big Dip Drain	43.97142	117.2937	3.63	2014-2018 (summer only)	
*In 2014, samples were also collected and analyzed for several nitrogen species. This monitoring was discontinued after 2014 because of a lack of funding and because nitrogen was not a limiting nutrient in algal formation.					

the vertical axes of the following graphs are the same for both the irrigation and non-irrigation seasons for each parameter.

<u>*Concentration by river mile*</u>

Page 44 shows graphs of ortho phosphorus (as P) by river mile for the sites on Bully Creek listed in the previous table (the Big Dip Drain site will be discussed later in this chapter). Ortho phosphorus is one component of total phosphorus in the water column and represents that fraction of the total phosphorus that is most readily available to plant and algal growth. Excessive algal growth in drain and river water leads to reduced dissolved oxygen and changes in pH that can be detrimental to fish and other aquatic life and present maintenance delivery difficulties for water conveyance systems.
In each graph, the individual monitoring sites are shown from left to right, starting with the most upstream site and going down river. The top graph on page 44 is for the irrigation season (April 15 to October 15); the bottom graph is for the non-irrigation season (October 16 to April 14). In general, in the Malheur River Basin, the irrigation season runs from April 15 to October 15. Depending on the river and irrigation storage conditions, however, the start and end of water delivery during the irrigation season may be adjusted as needed to accommodate wetter spring weather or drought conditions.

For the irrigation season (April 16- October 15) collected data show lower concentrations of ortho-phosphorus above the reservoir (Bully Creek Dam is located at about river mile 13). Downstream of the reservoir, ortho phosphorus concentrations increase dramatically and remain elevated at the Main Street site in Vale. Median ortho phosphorus concentrations are very similar at the Main Street site and the site below the reservoir. The ortho-phosphorus graphs for the non-irrigation season (October 16-April 14) show pattern similar to that observed for the irrigation season.

Both the irrigation and non-irrigation season graphs for total phosphorus (page 45) show patterns that are similar to those for ortho-phosphorus (lower concentrations upstream of the dam, higher concentrations downstream of the dam). Almost all of the total phosphorus concentrations measured in both the irrigation and non-irrigation seasons exceed the Snake River TMDL target concentration of 0.07 mg/l.

The increase in both ortho and total phosphorus between the site above the reservoir and below the dam is likely caused by the reservoir water being anoxic (devoid of oxygen). In such conditions, attached or adsorbed phosphorus can be released from sediments and decomposing algae into the water.

Page 46 shows the TSS graphs. Both the graphs for the irrigation season and the non-irrigation season show that most of the measured TSS concentrations are below the Snake River TMDL TSS target of 50 mg/l. TSS concentrations are consistently lower at the site below the dam than those measured at the site upstream of the reservoir, indicating that the reservoir is likely capturing a portion of the incoming sediment load. This may be due to deposition occurring in the relatively slack waters of the reservoir. Measured irrigation season TSS concentrations are generally lower and less variable than those measured during the non-irrigation season which may be the result of winter and spring precipitation and runoff events.

On page 47 are the graphs for E. coli. Both the irrigation and non-irrigation seasons show that E. coli concentrations are very similar at the Harper-Westfall Road site and the Main Street site in Vale. The site at Dahle Road shows higher concentrations than all other sites for both seasons, and the sites upstream and downstream of the reservoir show consistently lower concentrations for both seasons. Measured data collected during the irrigation season show more samples above the Oregon E. coli standard of 406 counts/100mls than data collected during the non-irrigation season. Only a very few exceedances of the E. coli standard were measured during the non-irrigation season.

Conductivity data are displayed on page 48. Conductivity measures the water's ability to carry an electric current, and is related to the total dissolved salts or ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Conductivity increases as the amount of these dissolved salts and inorganic materials increases. Conductivity levels are mainly influenced by the geology and size of the waterway, the amount of entering wastewater and/or agricultural runoff, and bacterial metabolism. Conductivity data can provide information about how a stream functions and what water sources contribute to the flow in a stream.

Conductivities measured in Bully Creek increase consistently from the Harper-Westfall Road site to the site below the dam, and then decrease slightly at the Main Street site in Vale. The measured conductivity at all sites for both seasons is within the expected range of river conductivity.

As a general rule, river conductivity ranges from 50-1500 us/cm. There are no regulatory water quality standards or guidance values for conductivity for the Malheur River Basin. Oregon DEQ does have a guidance concentration for total dissolved solids (TDS) of 750 mg/l, but it only applies to the Snake River, not to the Malheur River or Bully Creek (Oregon Administrative Rule (OAR)340-41-0207(2)). The guidance value is set to be protective of agricultural irrigation. According to the website *Sciencing* (https://sciencing.com/convert-parts-per-million-conductivity-5903002.html), one can multiply the conductivity by 0.64 to get an approximate idea of the corresponding total dissolved solids (TDS). According to this website, 0.64 is a general average value. "In practice, different ions have different conductivity. Therefore, to be absolutely accurate, it would necessary to know the concentration of every ion present. This is difficult under most circumstances, so we use an accepted average value instead," according to the website referenced above. The highest conductivity reading for the Bully Creek data was at the site below the dam during the non-irrigation season. This reading was 1008 uS/cm. Applying the 0.64 factor to the measured conductivity, the resulting TDS estimate would be 645 mg/l which is well below the 750 mg/l guidance value for the Snake River. Therefore, the conductivity readings for the other sites would also be well below the Snake River TDS guidance.

Finally, page 49 shows the turbidity graphs for both the irrigation and non-irrigation season. There are no state or federal numeric criteria for turbidity that applies to these monitoring sites. Turbidity in water is a measurement of how cloudy or murky the water is. Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. High turbidity can be caused by sediment especially clay and silt, fine organic and inorganic matter, soluble organic compounds, algae, and other microscopic organisms. In many Oregon rivers and streams sediment and algae (especially in shallow systems) are the primary contributors to turbidity. High turbidity can significantly reduce the water quality of lakes and streams, having a harmful impact on recreation and tourism. It can increase the cost of water treatment for drinking and food processing. It can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function.

During the irrigation season, the measured turbidity in Bully Creek increased slightly from the Harper-Westfall Road site to the Main Street site in Vale, but the measured values are relatively low, less than 12 NTU. The non-irrigation season shows higher values for all sites with a few values above the dam over 60 NTU which may be the result of sediment entrained during winter and spring runoff events.

CONCENTRATION OVER TIME

The preceding sections present data collected at each site relative to its location on Bully Creek; concentration vs distance. The water quality data collected on Bully Creek were also evaluated relative to time to better characterize temporal patterns or relationships within the data set. As the patterns described by the data (when plotted over time) were generally similar at all sites, data from only two sites (Bully Creek below the dam and the Main Street site in Vale) are displayed here for discussion purposes. (Please see the digital appendix for this report for the graphs of all the Bully Creek sites not presented here plotted as concentration over time for both the irrigation and non-irrigation season.)

In this section, the graphs of ortho and total phosphorus concentration for the irrigation and non-irrigation seasons are displayed on one page and the graphs of TSS and E. coli are displayed on the following page for each of the two sites. (Note that the vertical axes on all of the following sets of graphs are the same for both the irrigation and non-irrigation seasons for each parameter.)

Page 50 displays the graphs of ortho and total phosphorus concentration for the irrigation and non-irrigation seasons for Bully Creek below the dam. Total phosphorus data are generally available for 2015 through 2018. Ortho-phosphorus data are only available for 2015 and 2016. All of the measured phosphorus concentrations exceeded the Snake River TMDL total phosphorus target of 0.07 mg/l during both the irrigation and non-irrigation seasons. Measured total phosphorus concentrations appear to be decreasing over time. There are too few data to determine whether ortho phosphorus concentrations are decreasing or increasing over time.

Page 51 contains the graphs for TSS and E. coli for Bully Creek below the dam. All of the measured TSS concentrations from both the irrigation and non-irrigation season are below the Snake River TMDL TSS target of 50 mg/l. During the irrigation season, only two measured E. coli concentrations exceeded the Oregon standard of 406 counts/mls. Only one exceedance of the E. coli standard was measured during the non-irrigation season. There are too few data to determine whether TSS and/or E. coli concentrations are decreasing or increasing over time.

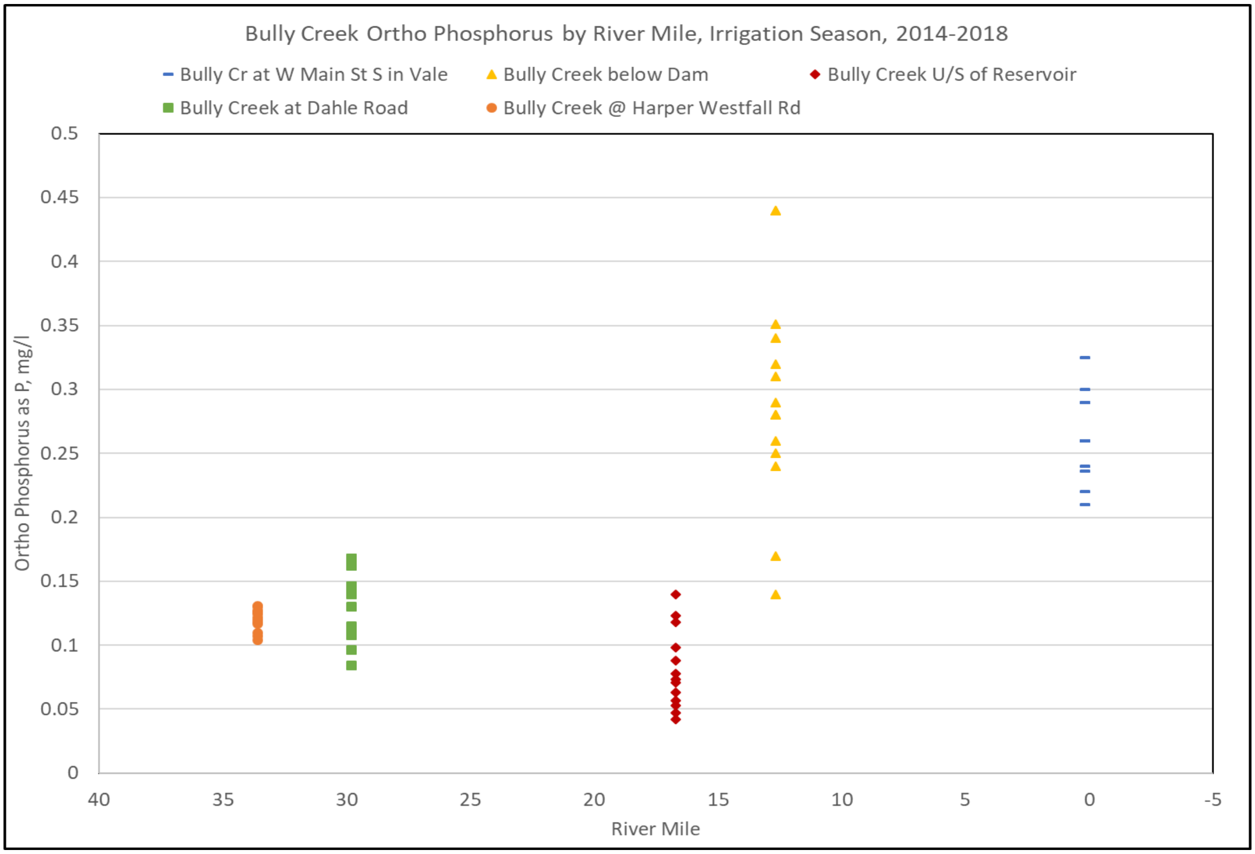
Page 52 displays the graphs of ortho and total phosphorus concentration for the irrigation and non-irrigation seasons for Bully Creek at Main Street in Vale. Total phosphorus data are generally available for 2011, and 2015 through 2018. Ortho-phosphorus data are only available for 2011, and 2015 through 2016. All but one of the measured phosphorus concentrations exceeded the Snake River TMDL total phosphorus target of 0.07 mg/l during both the irrigation and non-irrigation seasons. There does not appear to be a discernable pattern of increasing or decreasing phosphorus concentrations over time in either the irrigation or non-irrigation seasons.

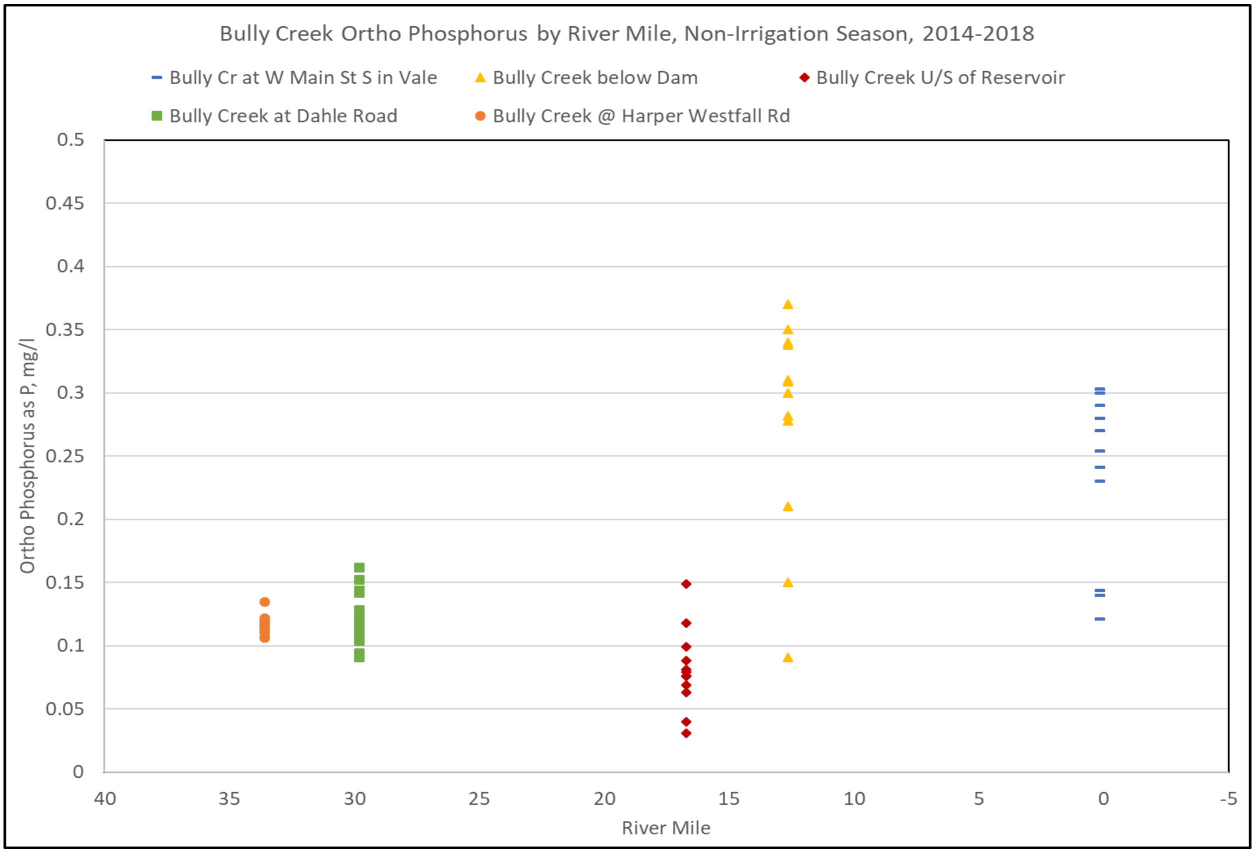
The measured TSS concentrations for both the irrigation and non-irrigation season are displayed on page 53 for Bully Creek at Main Street in Vale. Most of the measured TSS concentrations from both the irrigation and non-irrigation season are below the Snake River TMDL TSS target of 50 mg/l. During the irrigation season, many measured E. coli concentrations exceeded the Oregon standard of 406 counts/mls. E. coli concentrations measured during the irrigation season in 2015, 2016, 2017 and 2018 appear to be generally higher than they were in 2011. No exceedances of the E. coli standard were measured during the non-irrigation season. There does not appear to be a discernable pattern of increasing or decreasing phosphorus concentrations over time in either the irrigation or non-irrigation seasons.

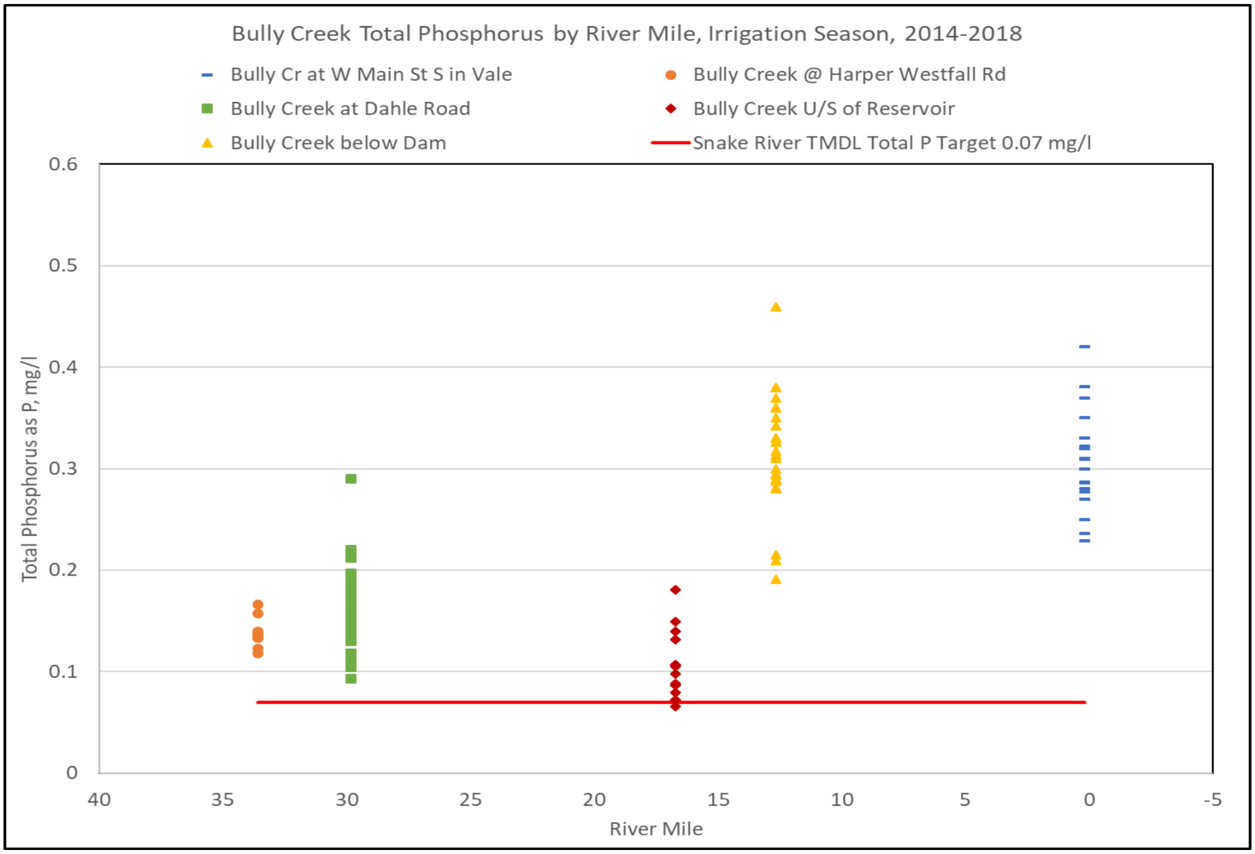
Bully Creek Drain Monitoring

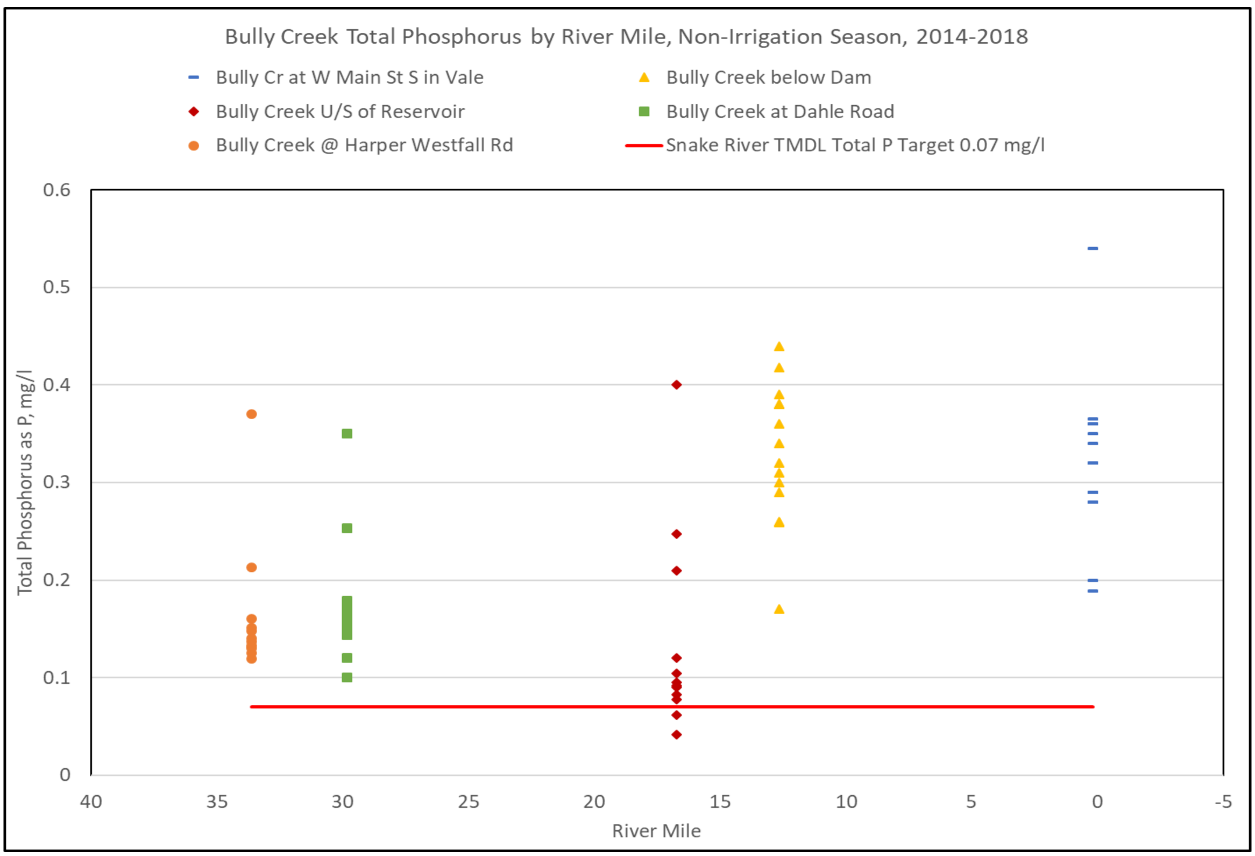
The Big Dip agricultural drain enters Bully Creek at river mile 3.63. Samples collected at the drain inflow were only collected during the irrigation season. Big Dip Drain graphs, including one for irrigation flow, are shown on pages 54 and 55. The measured ortho and total phosphorus concentrations all exceed the Snake River TMDL total phosphorus target concentration of 0.07 mg/l and are similar in concentration to those measured in Bully Creek at the Main Street in Vale site. TSS concentrations measured in the Big Dip Drain are all less than the Snake River TMDL TSS target of 50 mg/l and are slightly less than those measured in Bully Creek at the Main Street in Vale site. About a third of the measured E. coli concentrations exceeded the Oregon standard of 406 counts/100mls and are generally somewhat higher than those measured in Bully Creek at the Main Street in Vale site. There is not a discernable pattern over time in the water quality data collected in the Big Dip Drain.

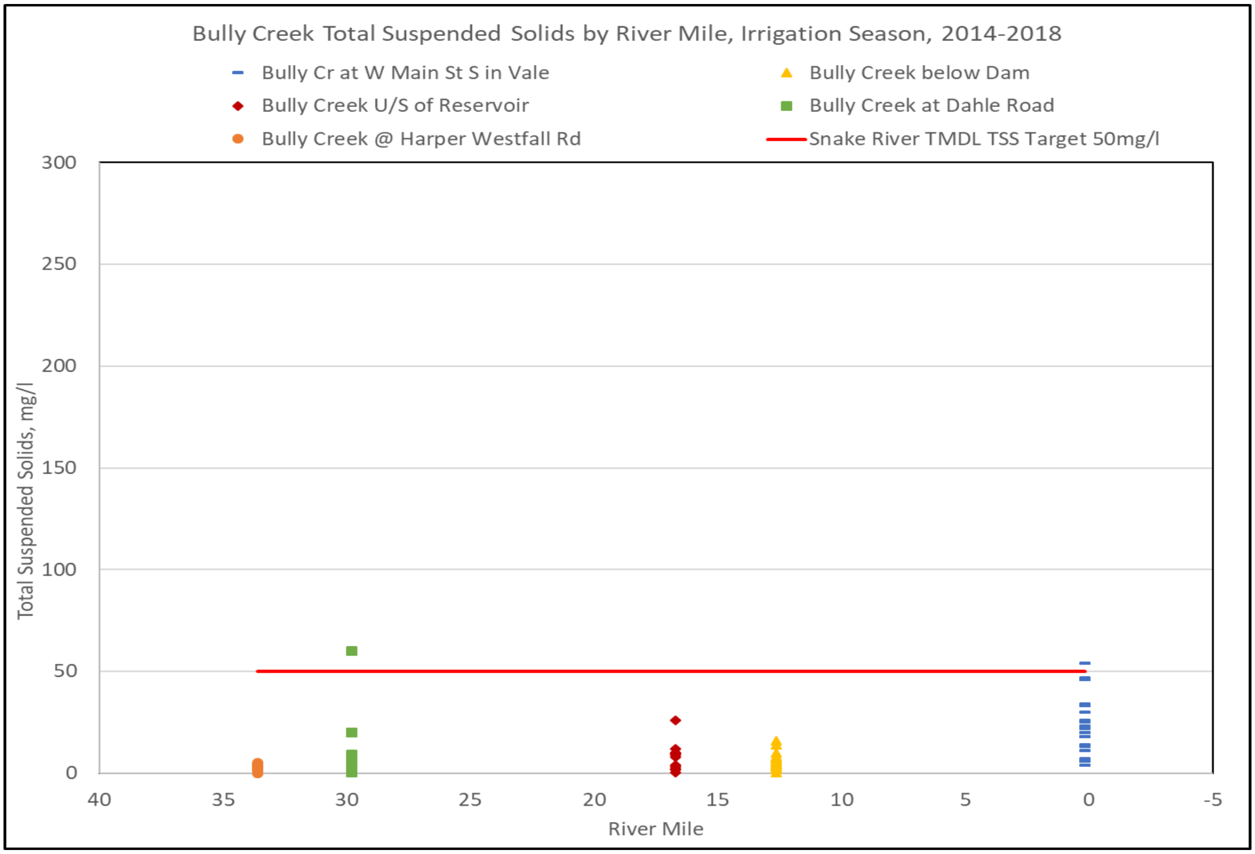
Because the Bully Creek monitoring covered only a few years, it is difficult to determine if water quality is changing unless the changes were very pronounced. A few more years of more robust data would help to characterize patterns or trends in water quality in this area.

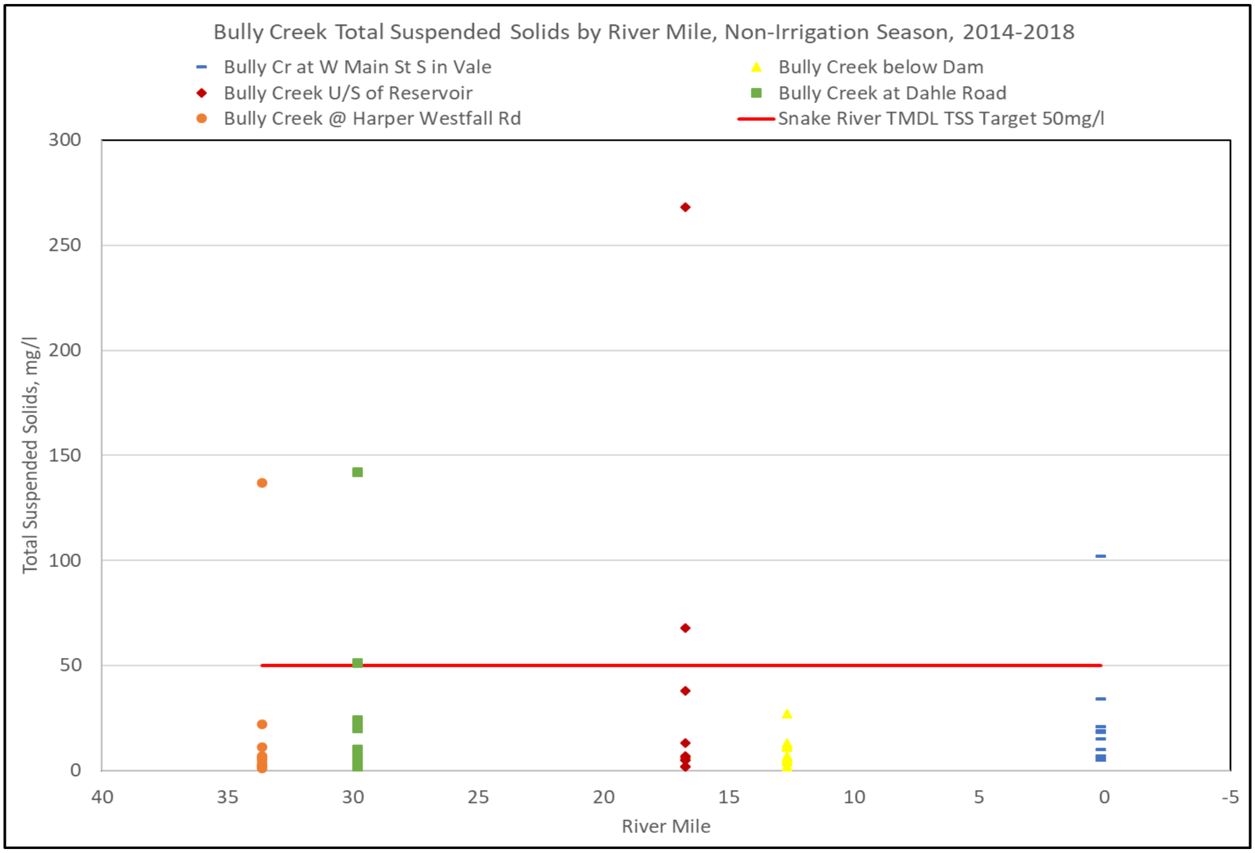

Bully Creek Ortho Phosphorus by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Ortho Phosphorus as P, mg/l
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
40
35
30
25
20
15
10
5
0
-5
River Mile

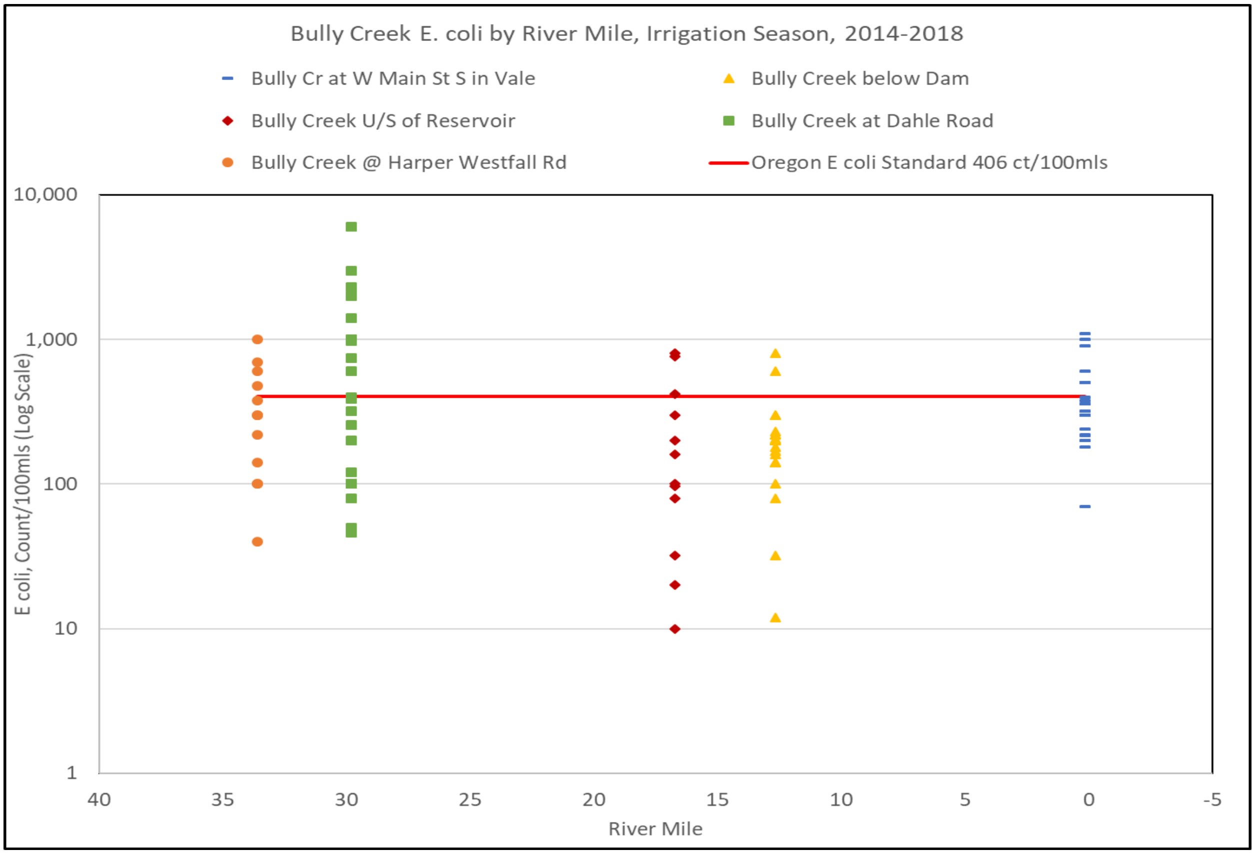

Bully Creek Ortho Phosphorus by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Ortho Phosphorus as P, mg/l
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
40
35
30
25
20
15
10
5
0
-5
River Mile

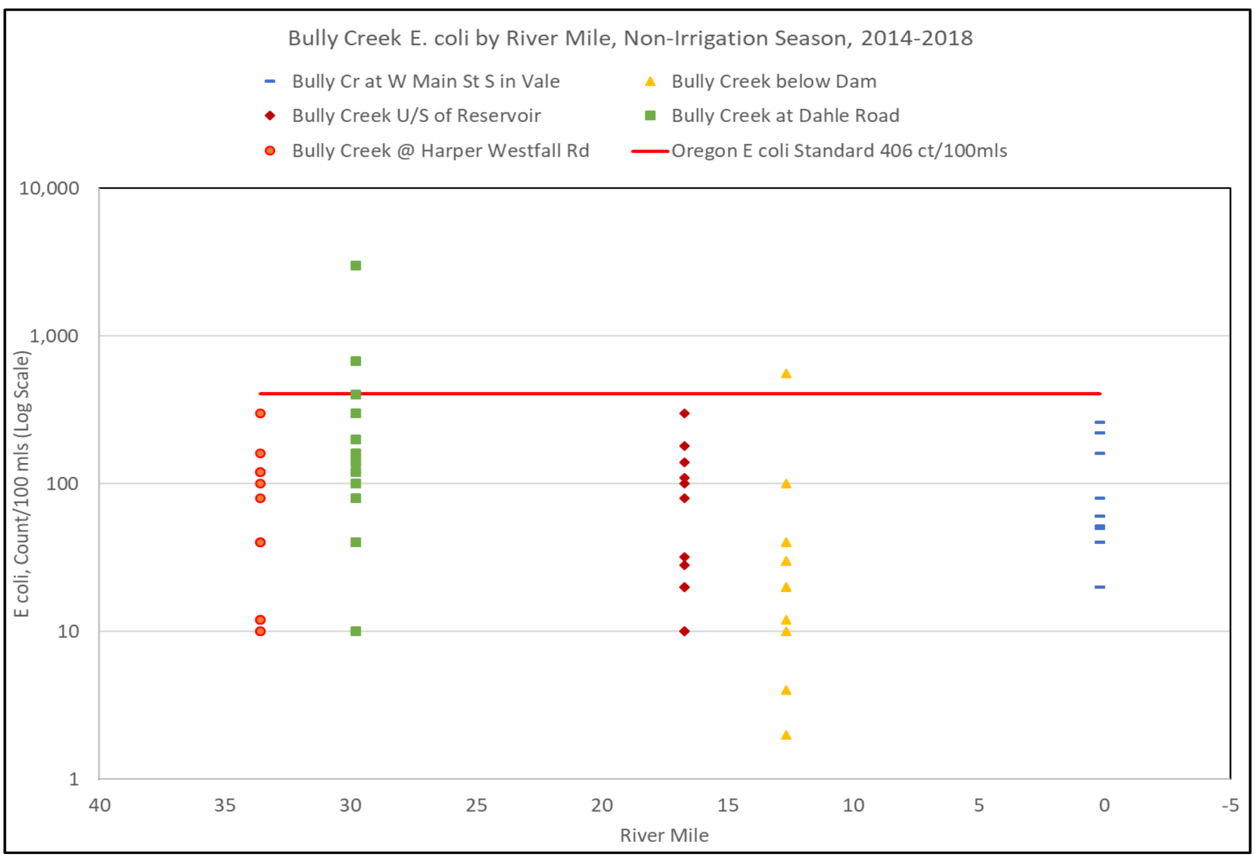

Bully Creek Total Phosphorus by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek @ Harper Westfall Rd
Bully Creek at Dahle Road
Bully Creek U/S of Reservoir
Bully Creek below Dam
Snake River TMDL Total P Target 0.07 mg/l
Total Phosphorus as P, mg/l
0.6
0.5
0.4
0.3
0.2
0.1
0
40
35
30
25
20
15
10
5
0
-5
River Mile

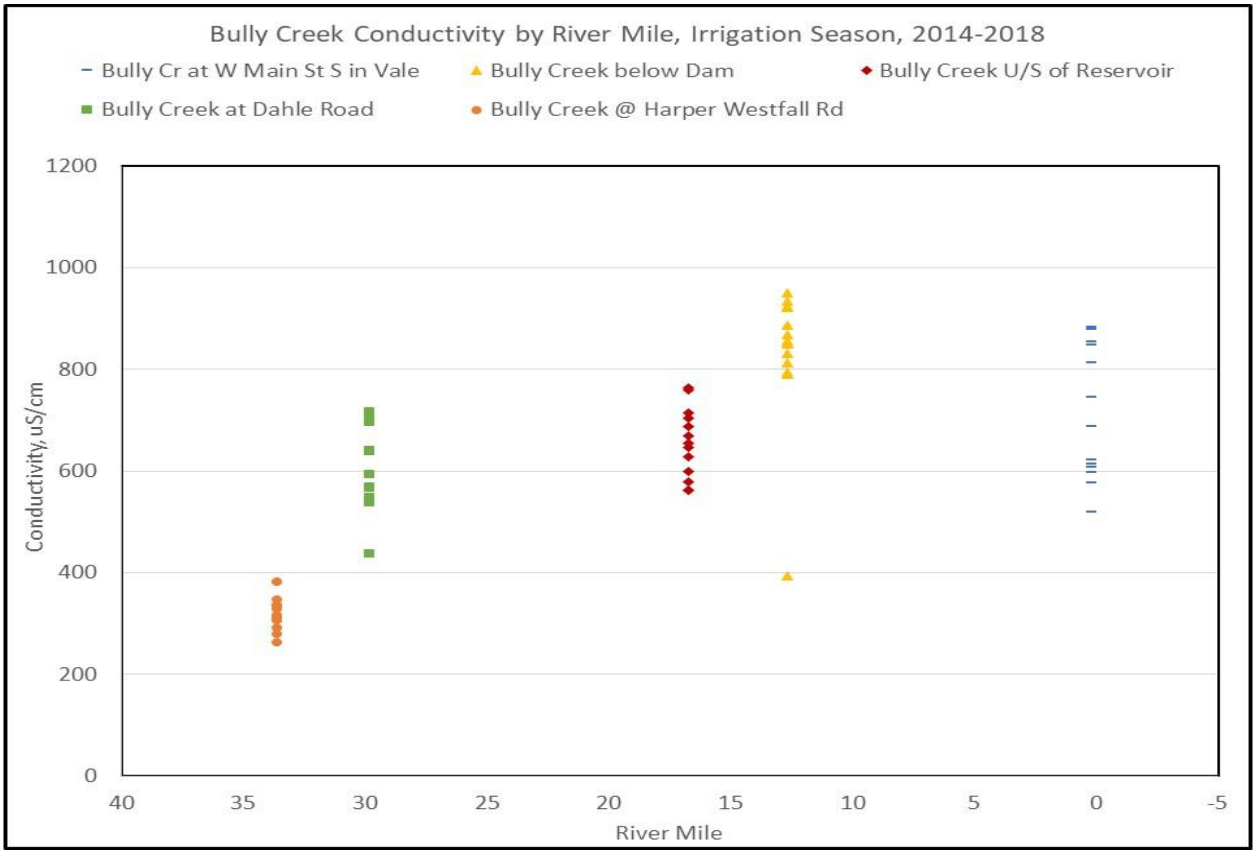

Bully Creek Total Phosphorus by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Snake River TMDL Total P Target 0.07 mg/l
Total Phosphorus as P, mg/l
0.6
0.5
0.4
0.3
0.2
0.1
0
40
35
30
25
20
15
10
5
0
-5
River Mile

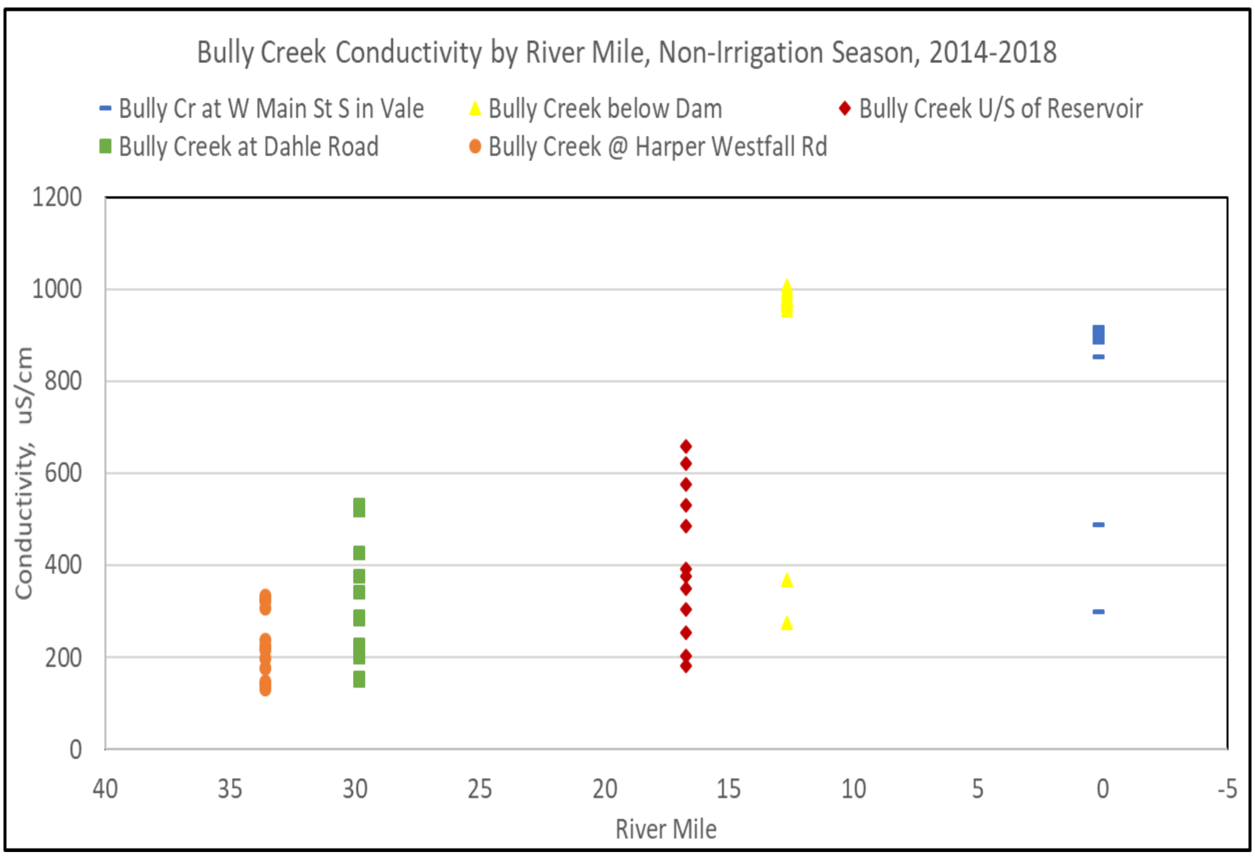

Bully Creek Total Suspended Solids by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Snake River TMDL TSS Target 50mg/l
Total Suspended Solids, mg/l
River Mile
300
250
200
150
100
50
0
40
35
30
25
20
15
10
5
0
-5

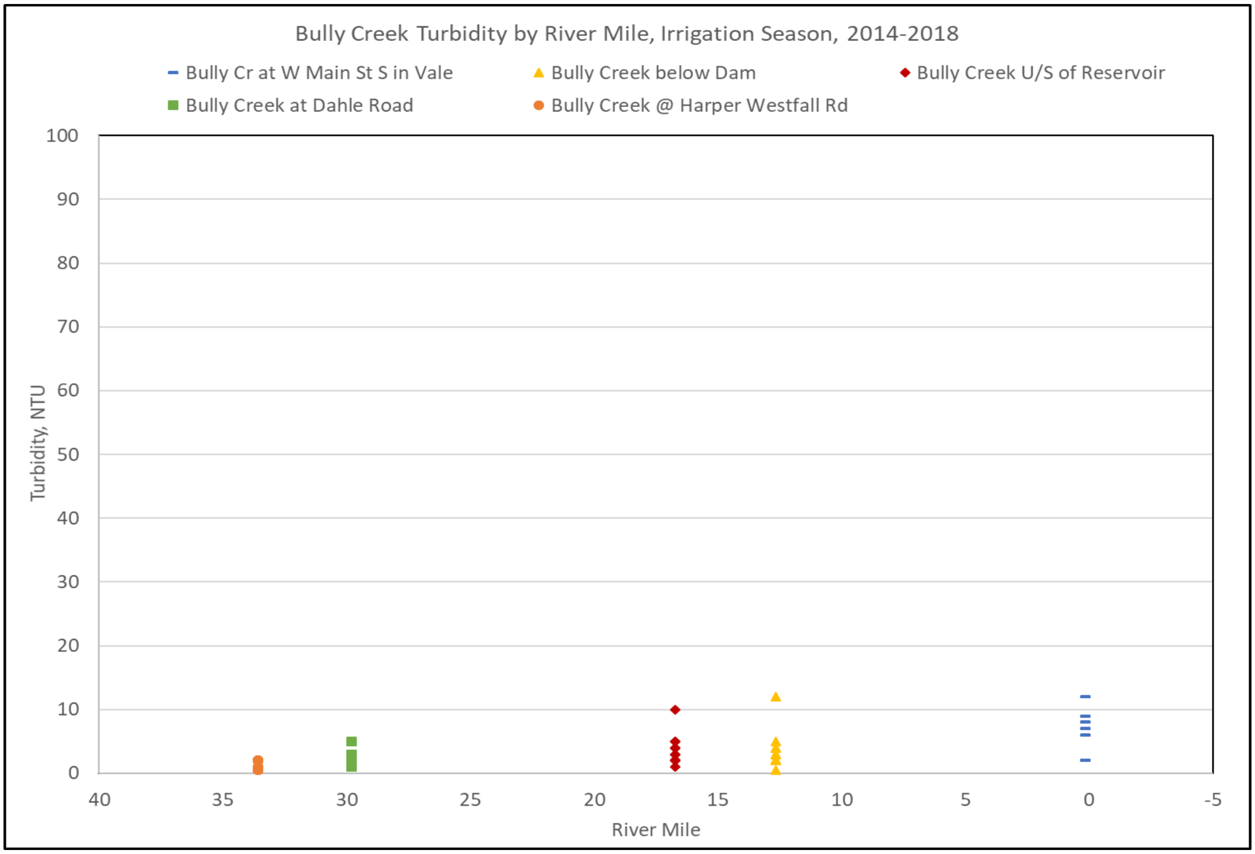

Bully Creek Total Suspended Solids by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Snake River TMDL TSS Target 50mg/l
Total Suspended Solids, mg/l
River Mile
300
250
200
150
100
50
0
40
35
30
25
20
15
10
5
0
-5

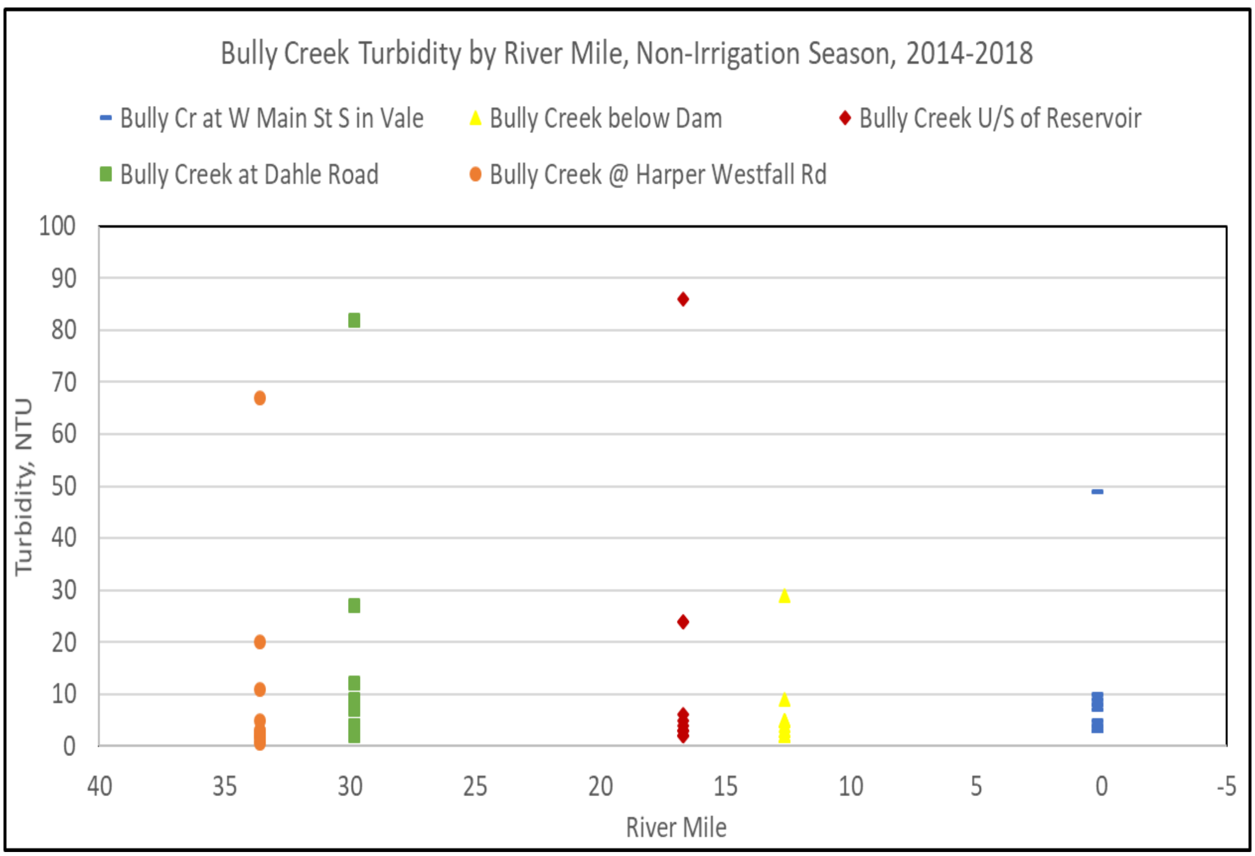

Bully Creek E. coli by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Oregon E coli Standard 406 ct/100mls
E coli, Count/100mls (Log Scale)
10,000
1,000
100
10
1
40
35
30
25
20
15
10
5
0
-5
River Mile

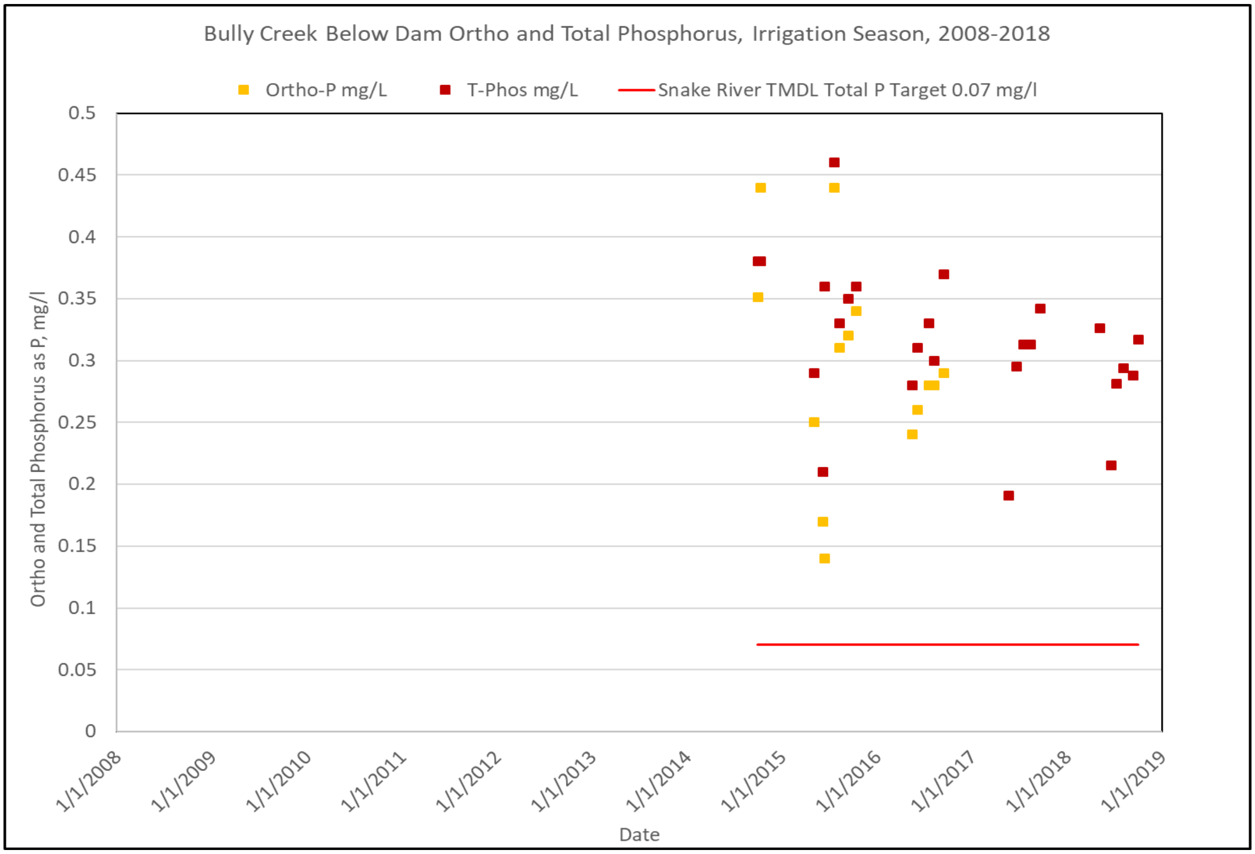

Bully Creek E. coli by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Oregon E coli Standard 406 ct/100mls
E coli, Count/100 mls (Log Scale)
10,000
1,000
100
10
1
40
35
30
25
20
15
10
5
0
-5
River Mile


Bully Creek Conductivity by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Conductivity, uS/cm
River Mile
1200
1000
800
600
400
200
0
40
35
30
25
20
15
10
5
0
-5

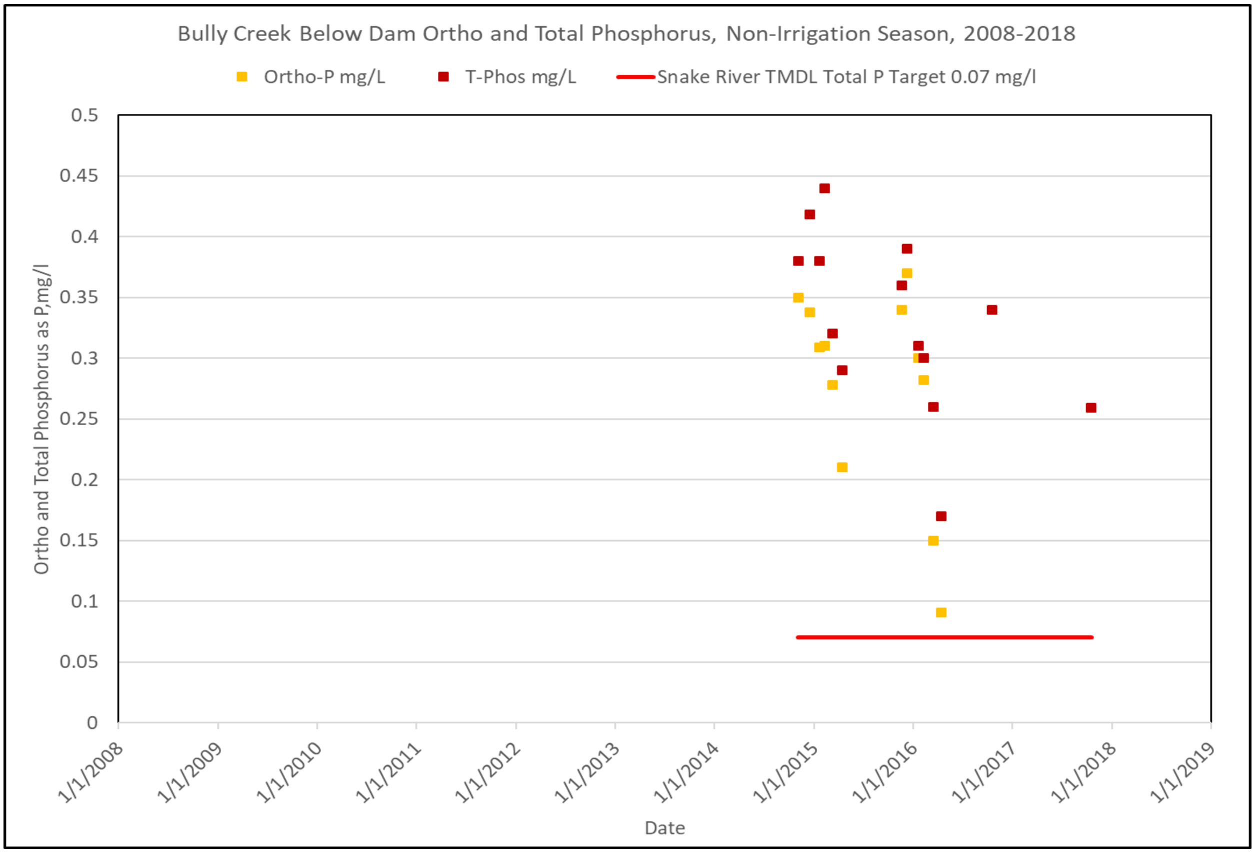

Bully Creek Conductivity by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Conductivity, uS/cm
River Mile
1200
1000
800
600
400
200
0
40
35
30
25
20
15
10
5
0
-5


Bully Creek Turbidity by River Mile, Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Turbidity, NTU
River Mile
100
90
80
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
0
-5

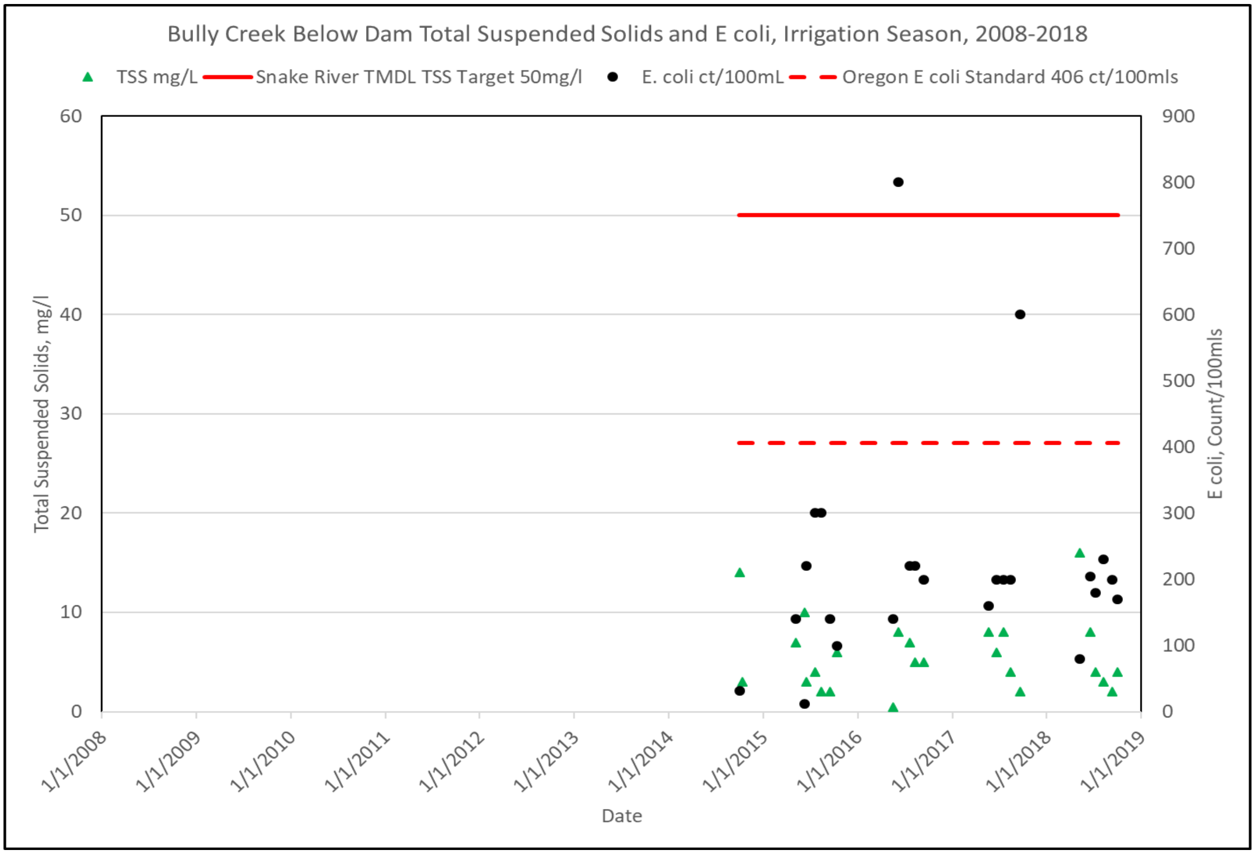

Bully Creek Turbidity by River Mile, Non-Irrigation Season, 2014-2018
Bully Cr at W Main St S in Vale
Bully Creek below Dam
Bully Creek U/S of Reservoir
Bully Creek at Dahle Road
Bully Creek @ Harper Westfall Rd
Turbidity, NTU
River Mile
100
90
80
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
0
-5

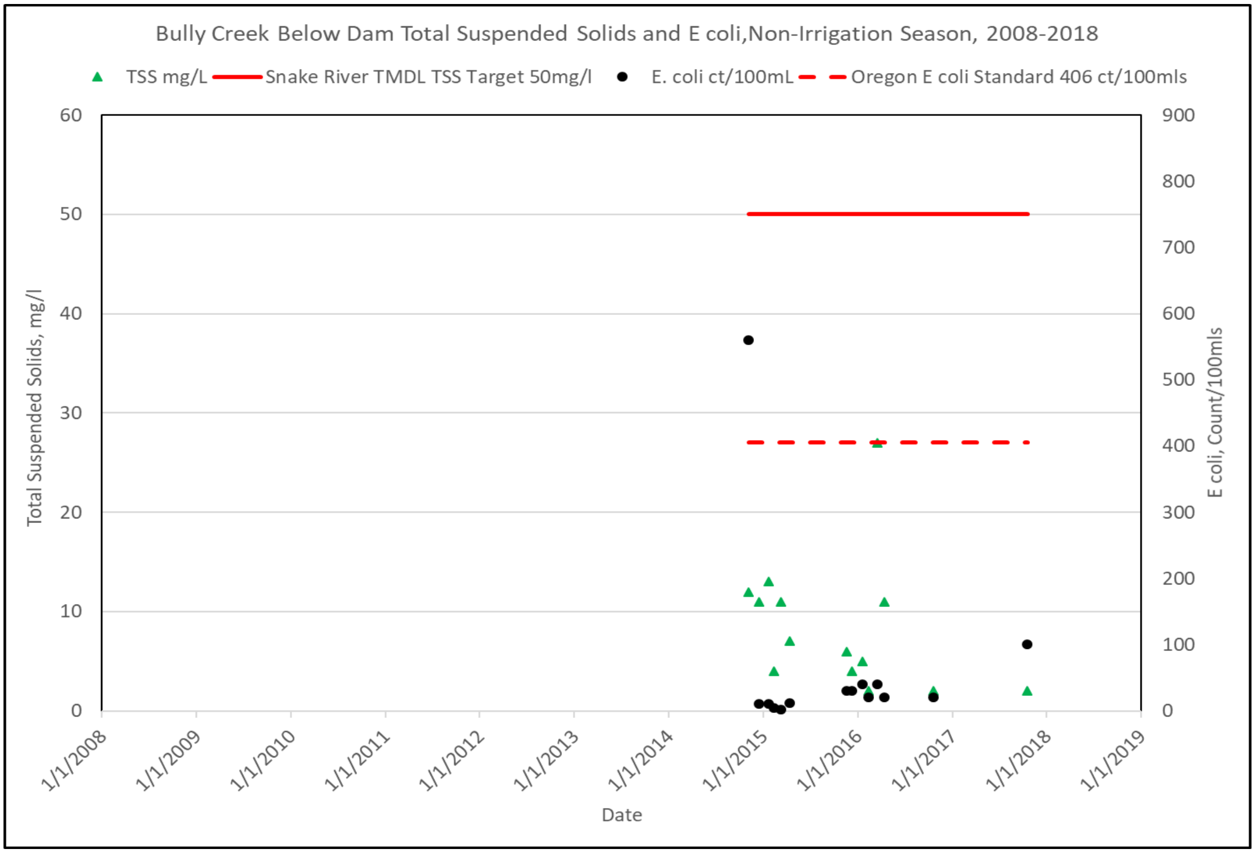


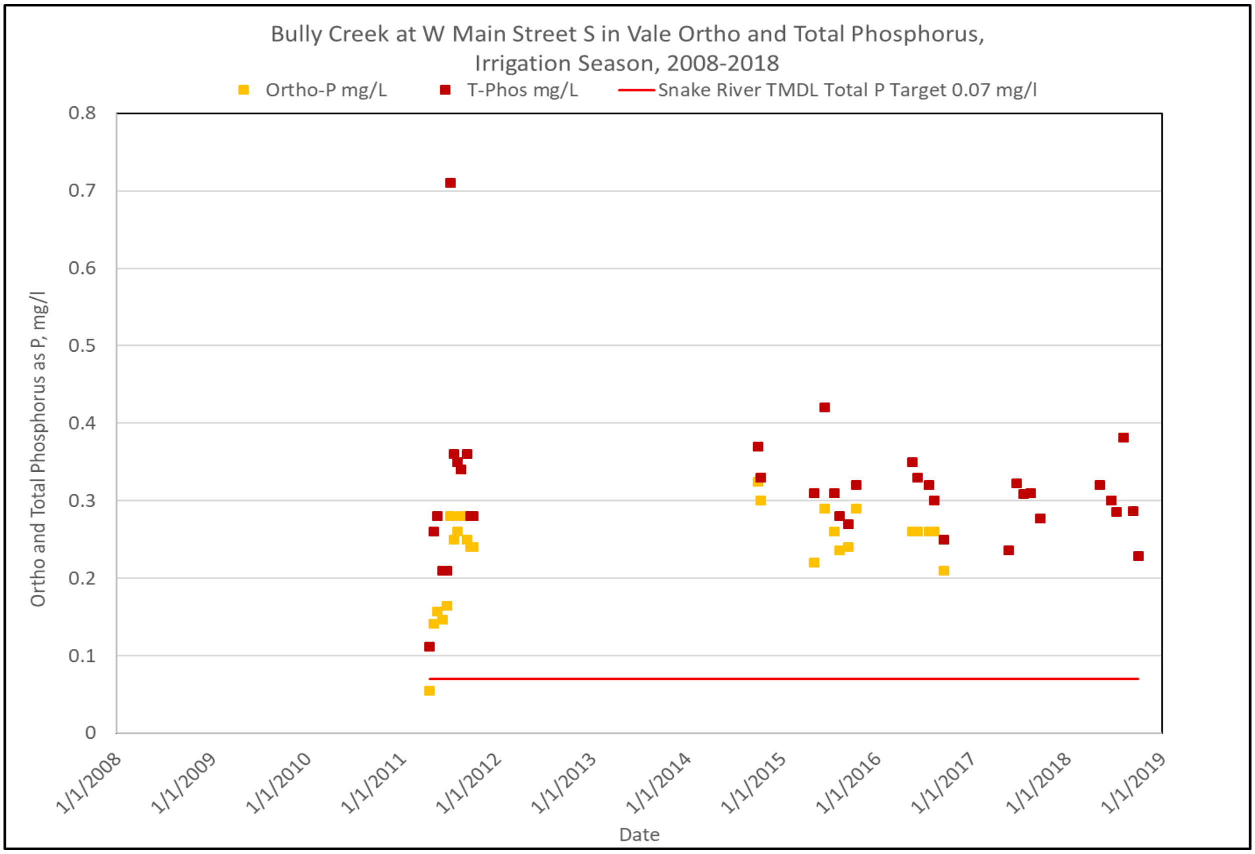
Bully Creek Below Dam Ortho and Total Phosphorus, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

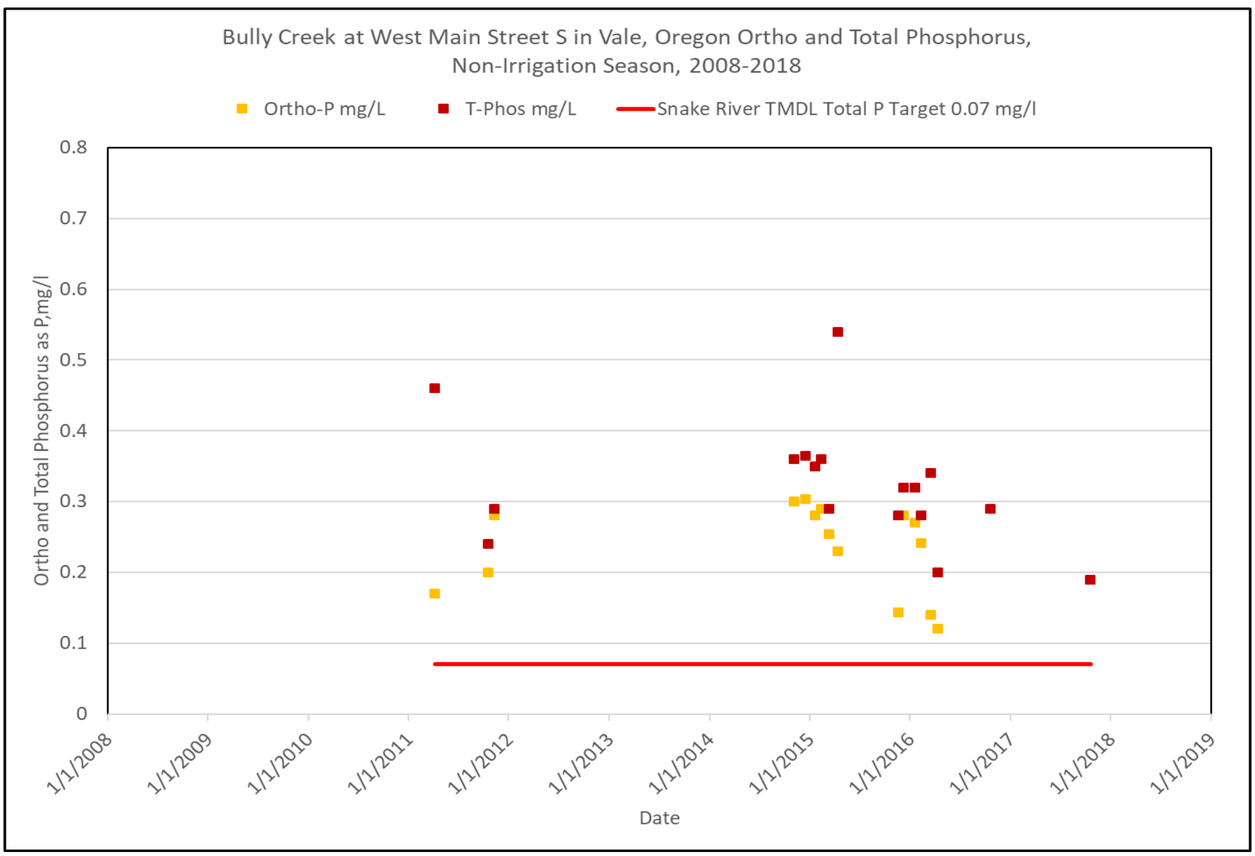


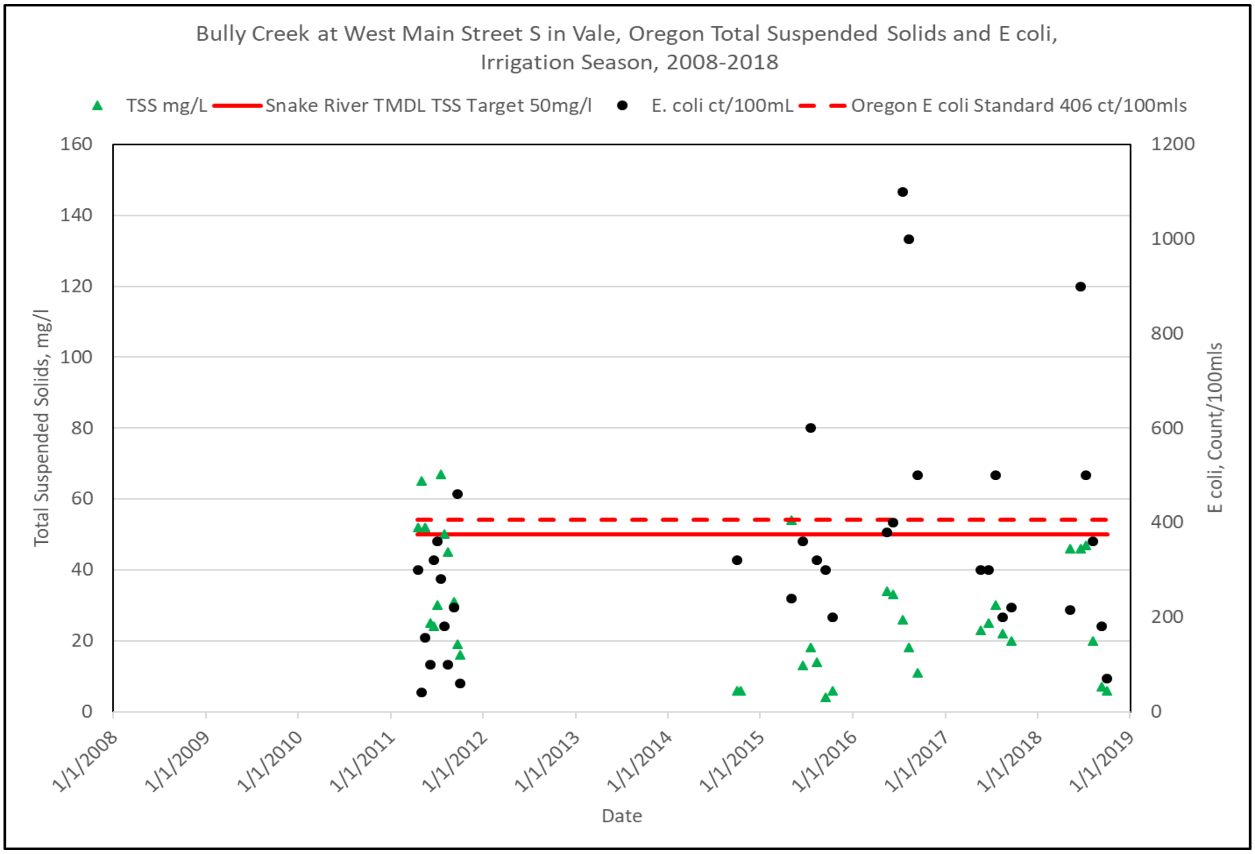
Bully Creek Below Dam Ortho and Total Phosphorus, Non-Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P,mg/l
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

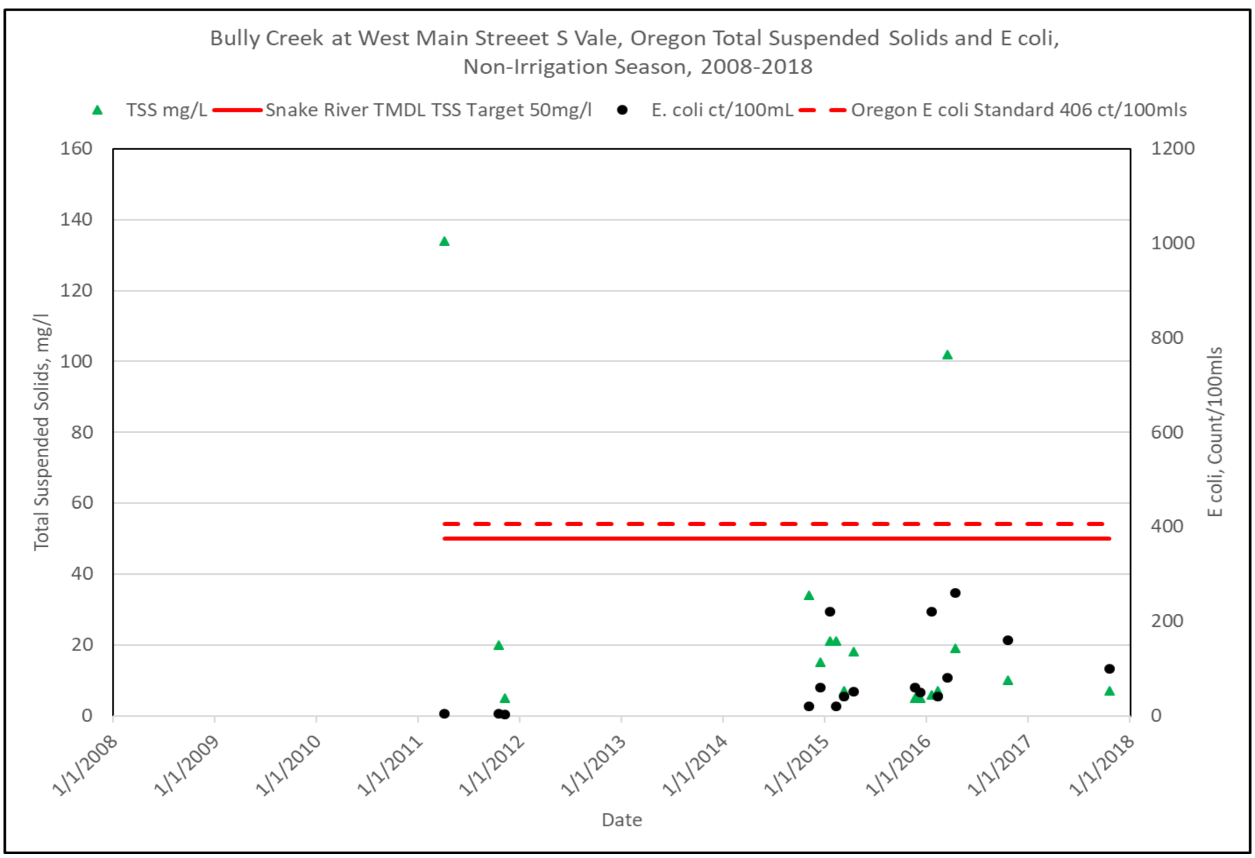

Bully Creek Below Dam Total Suspended Solids and E coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
0
10
20
30
40
50
60
0
100
200
300
400
500
600
700
800
900
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

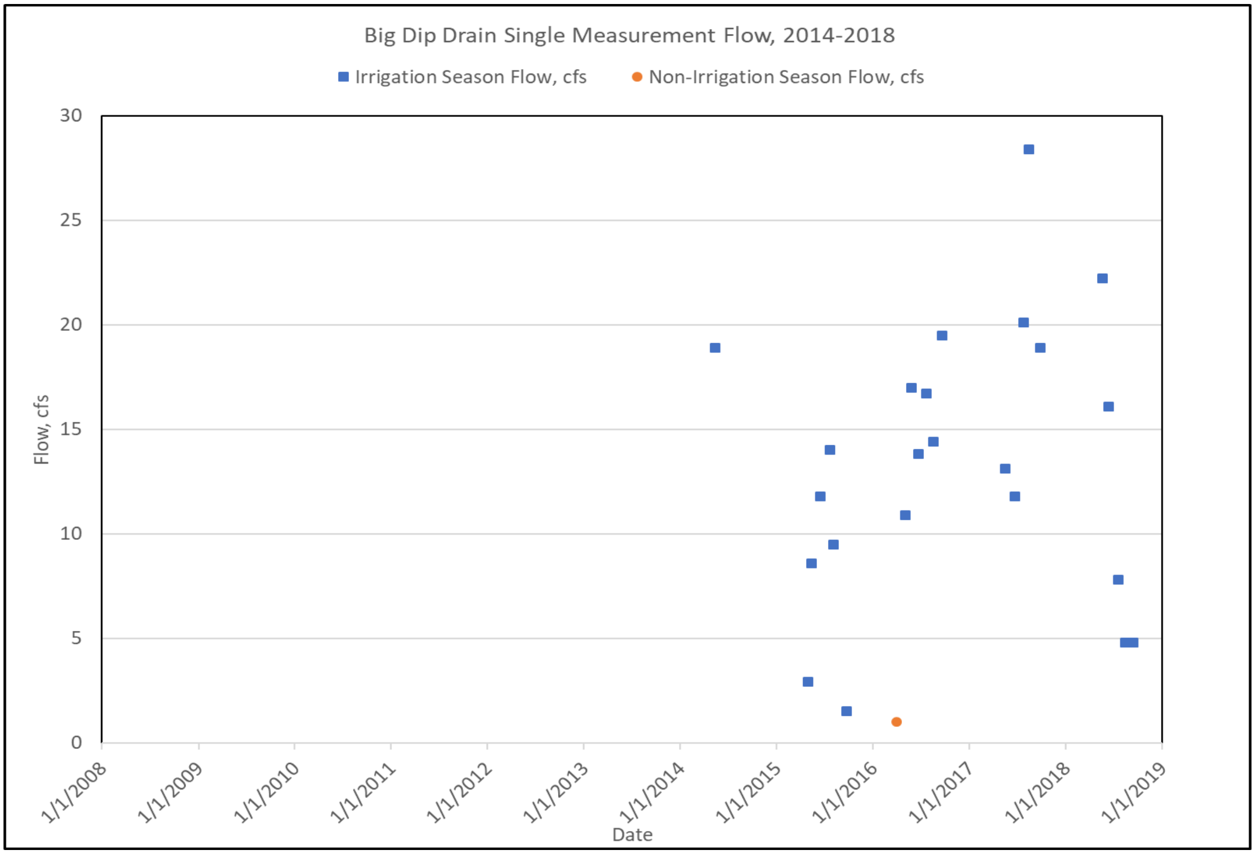

Bully Creek Below Dam Total Suspended Solids and E coli,Non-Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
0
10
20
30
40
50
60
0
100
200
300
400
500
600
700
800
900
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

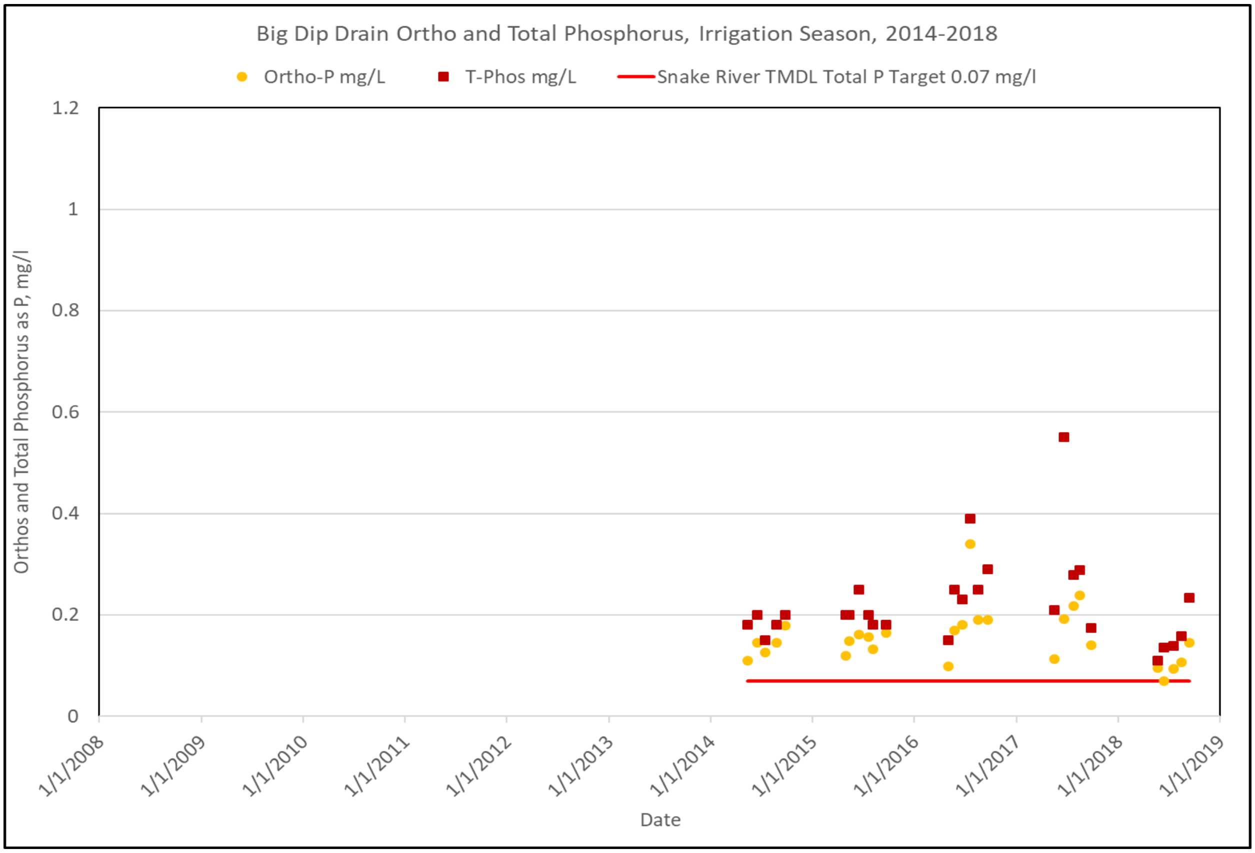

Bully Creek at W Main Street S in Vale Ortho and Total Phosphorus, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

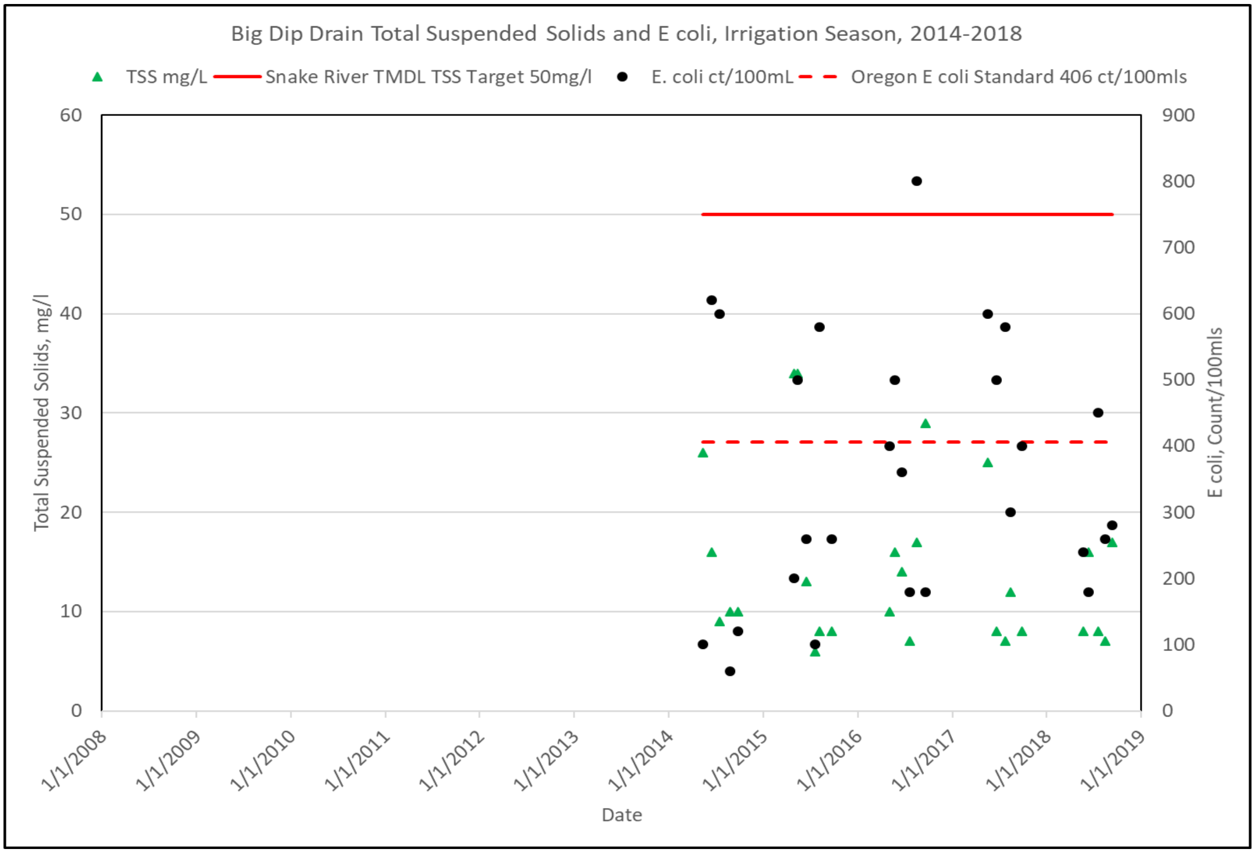

Bully Creek at West Main Street S in Vale, Oregon Ortho and Total Phosphorus, Non-Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P,mg/l
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Bully Creek at West Main Street S in Vale, Oregon Total Suspended Solids and E coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date


Bully Creek at West Main Streeet S Vale, Oregon Total Suspended Solids and E coli, Non-Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date


Big Dip Drain Single Measurement Flow, 2014-2018
Irrigation Season Flow, cfs
Non-Irrigation Season Flow, cfs
Flow, cfs
30
25
20
15
10
5
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Big Dip Drain Ortho and Total Phosphorus, Irrigation Season, 2014-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Orthos and Total Phosphorus as P, mg/l
1.2
1
0.8
0.6
0.4
0.2
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Big Dip Drain Total Suspended Solids and E coli, Irrigation Season, 2014-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date
0
10
20
30
40
50
60
100
200
300
400
500
600
700
800
900
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

Chapter 5 – Willow Creek

Willow Creek is a 57-mile tributary of the Malheur River. The creek, which begins at 3,724 feet above sea level and ends at 2,234 feet, flows generally southeast between Ironside and Vale. Willow Creek's watershed covers 787 square miles of relatively arid land. Willow Creek begins at the confluence of its Middle and South forks, slightly north of Ironside and U.S. Route 26. It flows northeast away from Route 26 through Malheur Reservoir, then turns southeast by Huntington Junction before reaching Route 26 again at Brogan. The creek continues southeast, roughly parallel to the highway, through the communities of Jamieson and Willowcreek before reaching Vale. It enters the Malheur River about 19 miles upstream of where the Malheur enters the Snake River.

Irrigated farming in the basin produces sugar beets, onions, potatoes, corn, mint, grain, alfalfa seed, vegetable seed, and hay. Between Brogan and Vale, the creek has been turned into a drainage and irrigation canal. Above Brogan, as far as the Malheur Reservoir, the historic stream was dredged and placer-mined for gold and silver. For much of the creek, water flow is controlled by releases from the Malheur Reservoir. The upper creek is also used for irrigation.[8]

Willow Creek is part of the Malheur Basin. As Willow Creek flows into the Malheur River which, in turn, flows into the Snake River, the quality of water in Willow Creek contributes to the quality of water in the Malheur River and to water quality in the Snake River. Because of the interconnected nature of these systems, reductions in pollution loading are necessary in Willow Creek and in the Malheur River in order to meet water quality standards in the Snake River.

There are two Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin (and therefore apply to the Willow Creek watershed): the Malheur River TMDL and the Snake River-Hells Canyon TMDL. TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet state water quality standards.

In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as “Snake River TMDL targets” on all graphs of water quality data presented in this chapter. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the Snake River-Hells Canyon TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur River, where it flows into the Snake. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use. For additional information on the TMDLs, please see the text in the ‘Introduction’ section of this report.

This chapter summarizes water quality data collected by the Malheur Watershed Council at three (3) sites along Willow Creek. Water quality data were collected with the goal of understanding whether or not water quality in Willow Creek meets state standards and how it contributes to water quality in the

[8] Wikipedia

Malheur River. It was the intent of this project that the findings from the water quality monitoring would be used to better inform local landowners, operators and producers, and the Malheur SWCD and Malheur Watershed Council staff where agricultural practices are improving water quality and where there may be areas that would benefit from technical assistance in adjusting agricultural management practices. The following table provides information on the locations of the three (3) Willow Creek monitoring sites and the water quality data collected. A map of monitoring sites is included on the following page.

Site Name	Latitude	Longitude	River Mile	Monitoring Period	Parameters Monitored
Willow Creek at Brogan Canyon	44.293433	117.551275	30.35	October 2003 to October 2018	Total Phosphorus, E. coli, and Total Suspended Solids
Willow Creek at 6th Avenue	44.069569	117.281042	6.97		
Willow Cr at RR Xing E Of Vale	43.988416	117.230887	0.20		

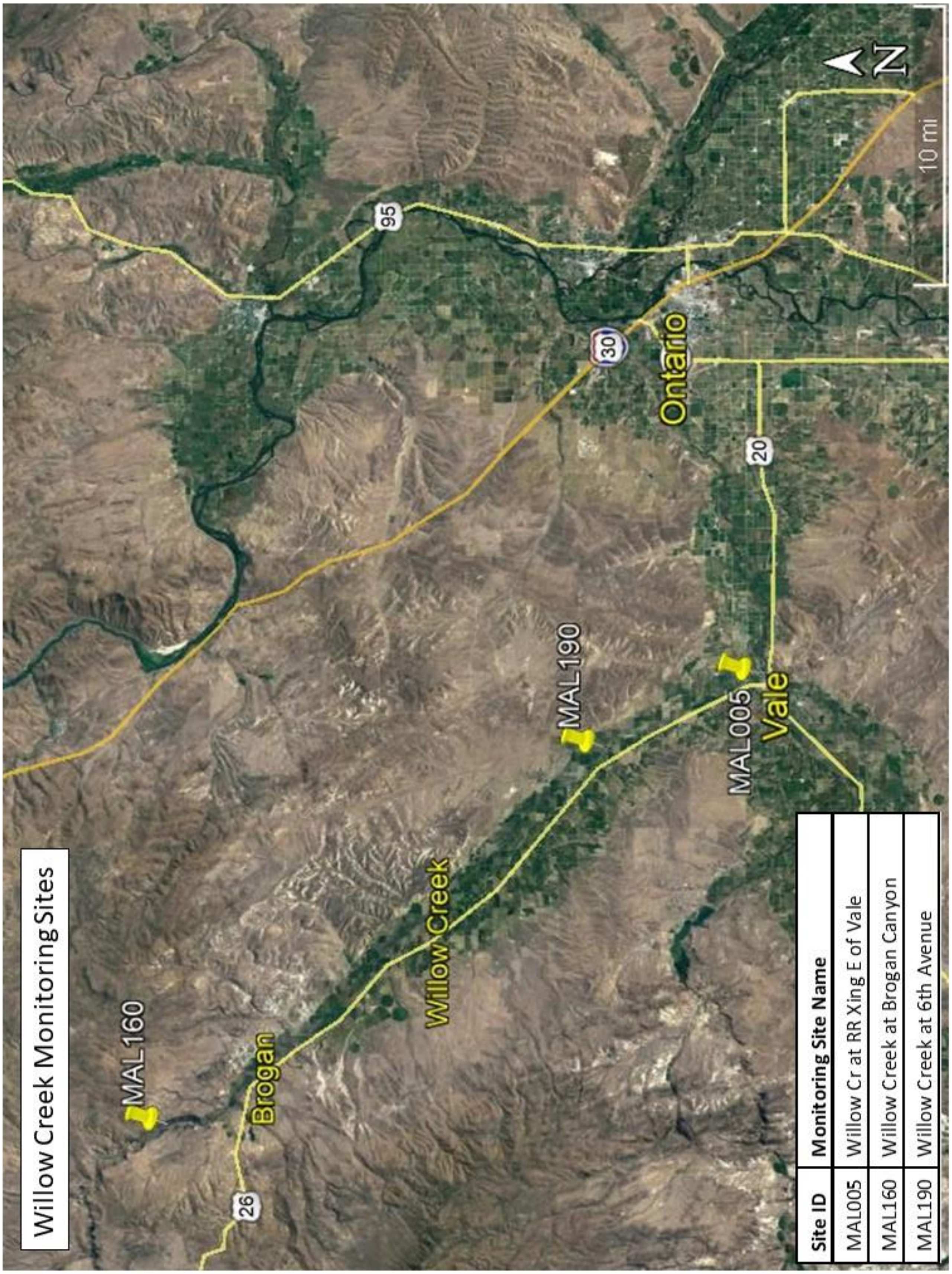
CONCENTRATION BY RIVER MILE

The graphs on the following pages show the measured total phosphorus (as P), E. coli and TSS concentrations by river mile for the irrigation season April 15 to October 15, for the 2016-2018 monitoring period. There were virtually no data collected during the non-irrigation season during this time period except during 2016. Because of this, no graphs are included for the non-irrigation season. In general, in the Malheur River Basin, the irrigation season runs from April 15 to October 15. Depending on the river and irrigation storage conditions, however, the start and end of water delivery during the irrigation season may be adjusted as needed to accommodate wetter spring weather or drought conditions.

The total phosphorus concentrations measured during the irrigation season in Willow Creek are displayed by river mile in the upper graph on page 61. All of the measured concentrations exceed the Snake River TMDL Target of 0.07 mg/l. Total phosphorus concentrations measured at the 6th Avenue site are the highest, followed by the site the railroad crossing near Vale. The lowest concentrations were those measured at Brogan Canyon. This site is located farther upstream on Willow Creek but should not be considered representative of "natural background" conditions as agricultural practices upstream of this site include farming/cropping influences as well as livestock influences.

The second (lower) graph on page 61 shows the measured TSS concentrations by river mile for the three monitoring sites on Willow Creek. The collected TSS data show a pattern of increases downstream similar to that seen for total phosphorus data. The graph shows the measured TSS concentrations are below the Snake River TMDL target of 50 mg/l at Brogan Canyon. At 6th Avenue, about half of the measured concentrations are above the target and at the railroad crossing near Vale a little more than half are above the target.

The graph on page 62 shows the E. coli concentrations measured at the same three sites. The collected E. coli data show a similar pattern of increases downstream as observed in the total phosphorus and TSS data. Virtually all of the E. coli concentrations measured at Brogan Canyon are below the Oregon E. coli standard of 406 count/100mls; while most of the E. coli concentrations measured at both 6th Avenue and at the railroad crossing near Vale are above the standard.


Willow Creek Monitoring Sites
N
10 mi
95
30
Ontario
20
MAL190
MAL005
Vale
Willow Creek
MAL160
Brogan
26
Site ID | Monitoring Site Name
MAL005 | Willow Cr at RR Xing E of Vale
MAL160 | Willow Creek at Brogan Canyon
MAL190 | Willow Creek at 6th Avenue

CONCENTRATION OVER TIME

The preceding sections present data collected at each monitoring site on Willow Creek, relative to the river mile or distance downstream, providing a display of data vs distance (concentration relative to location on the landscape). All of the collected data show an increase in concentration from the most upstream site to the downstream sites. The concentrations observed at the Brogan site are generally lower than those observed at the 6th Avenue site or the site located at the railroad crossing near Vale.

The water quality data collected on Willow Creek were also evaluated relative to time to better characterize temporal patterns or relationships within the data set. As the patterns described by the data (when plotted over time) were generally similar from site to site, only data from the monitoring site at the railroad crossing near Vale (the most downstream site, representing cumulative effects) are displayed in the following sections for discussion purposes. Graphs of the collected data for 2008-2018 (plotted as concentration over time) for the Willow Creek monitoring site near Brogan and the 6th Avenue site are available in the digital appendix to this report. Please see the digital appendix of this report for data and graphs associated with the other Willow Creek sites.

Please note: The data displayed in the following graphs for the Willow Creek site at the railroad crossing near Vale includes both data collected by the Malheur Watershed Council through OWEB grant funding and data collected by Oregon DEQ as part of their ambient monitoring program.

The graphs on page 63 show the measured total phosphorus concentrations from the site at the railroad crossing near Vale for the irrigation season (April 15 to October 15) and the non-irrigation season (October 16 to April 14) for the years 2003 to 2018. All of the measured total phosphorus concentrations at this site, exceed the Snake River TMDL target of 0.07 mg/l year-round. There does not appear to be any discernable change in total phosphorus concentrations over the time period for either the irrigation season or the non-irrigation season. The maximum total phosphorus concentrations measured during the non-irrigation season are greater than those measured during the irrigation season. These non-irrigation season increases may be due to the presence of one or more year-round sources of enrichment. These sources may result in higher concentrations instream due to the lower flows occurring in the non-irrigation season (less water instream means less opportunity for dilution). The source of these maximum concentrations should be evaluated further.

The graphs on page 64 show the measured TSS concentrations for the irrigation and non-irrigation seasons (2003-2018). For both the irrigation season and the non-irrigation season, the measured TSS concentrations show an overall decrease over time. For both seasons, exceedances of the standard still occur, but it appears to be happening with less regularity and, especially in the non-irrigation season, the magnitude of the exceedances appears to be declining.

The graphs on page 65 show the measured E. coli concentrations for both the irrigation and non-irrigation seasons, respectively, for the monitoring period 2003-2018. For both the irrigation season and the non-irrigation season, the measured E. coli concentrations show a slight decrease over time with fewer really high concentrations observed in the later years of the monitoring period and more samples with concentrations less than the state standard of 406 count/100mls. For both seasons, exceedances of the standard still occur, but it appears to be happening with less regularity and, especially in the non-irrigation season, the magnitude of the exceedances appears to be declining, similar to the pattern observed for TSS at this site. Measured concentrations of E. coli are lower in the non-irrigation season than those observed during the irrigation season.

COMPARISON OF HISTORIC AND CURRENT DATA

Historic water quality data (1980-1989) are available for one of the monitoring sites detailed in this chapter (Willow Creek at RR Bridge near Vale). The historic data for the Willow Creek at RR Bridge near Vale site were collected by Oregon DEQ as part of their ambient monitoring program.

There are some limitations to the data available. This site is very close to the mouth Willow Creek where it flows into the Malheur River. When the Malheur River is experiencing high flows, the water at the mouth of Willow Creek can back up due to back pressure from the water in the Malheur. This may cause changes in water quality in the samples taken at the RR Bridge site on Willow Creek. Additionally, analytical methods have evolved from those used during the 1980s and may not be directly comparable with the analytical methods used today. Please keep these limitations in mind while reviewing the comparison of historic to current water quality presented here.

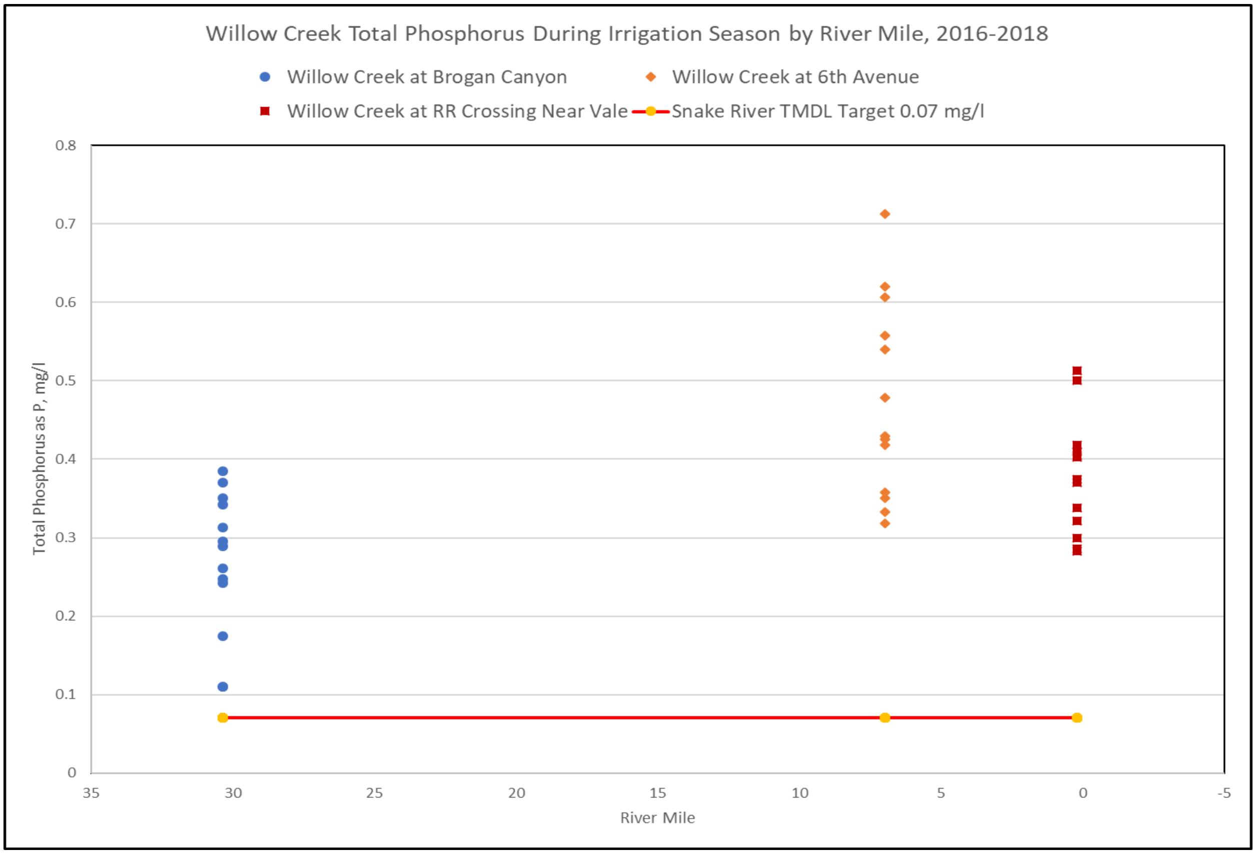
Data presented in the following tables shows the percent reduction in concentration from 1980-1989 to 2016-2018 for each site for both the irrigation season and the non-irrigation season.

Total Phosphorus Concentration (mg/l), Willow Creek at Railroad Bridge near Vale, Oregon								
	Irrigation Season				**Non-Irrigation Season**			
Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
1980-1989	27	0.420	0.520	0.756	19	0.420	0.852	4.490
2016-2018	19	0.370	0.503	0.560	10	0.410	0.511	0.520

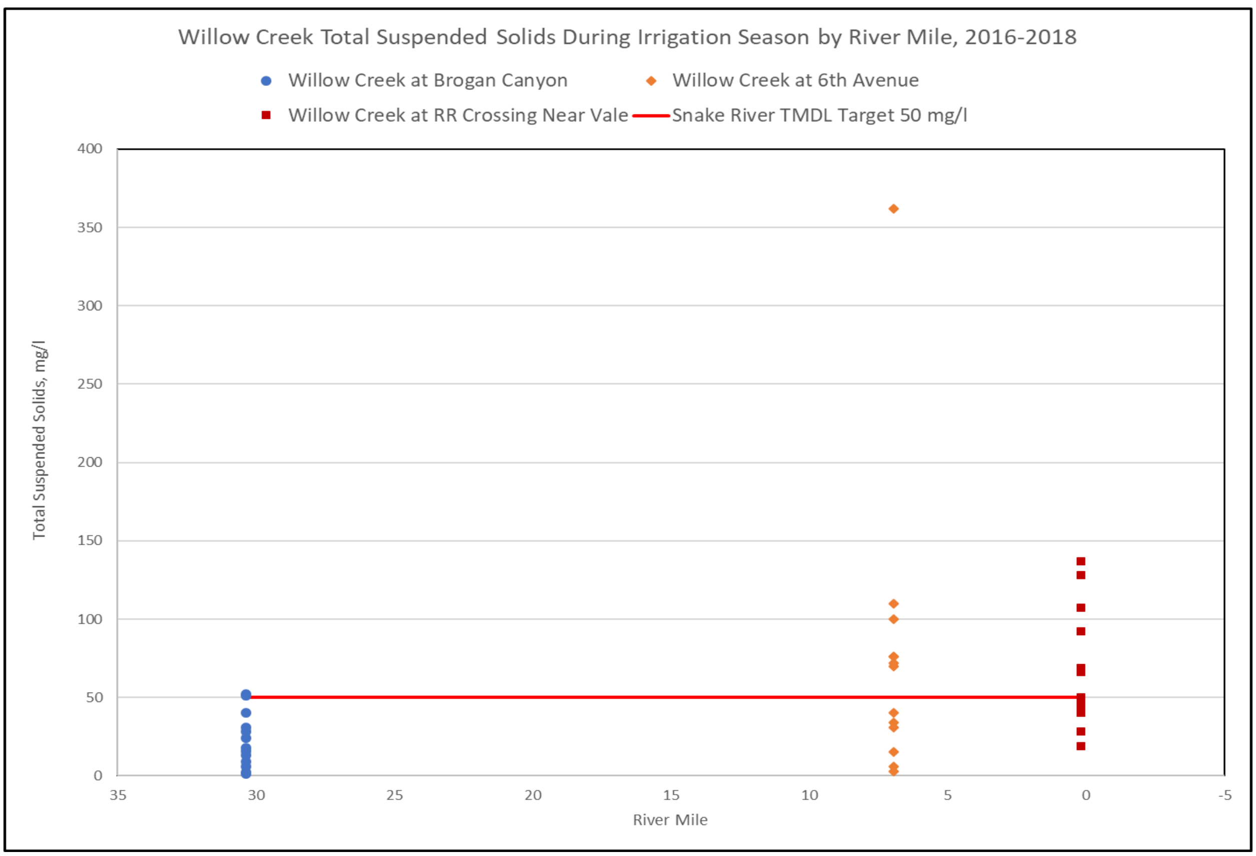
Total Suspended Solids Concentration (mg/l), Willow Creek at Railroad Bridge near Vale, Oregon								
	Irrigation Season				**Non-Irrigation Season**			
Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
1980-1989	29	78	196	457	19	125	504	3980
2016-2018	19	66	131	164	10	95	199	289

Even with the limitations of the available data, it is clear that progress is being made over time in the Willow Creek Subbasin and water quality is improving. Concentrations of total phosphorus and total suspended solids have decreased in both the irrigation and non-irrigation seasons. Substantial reductions in total phosphorus and suspended solids have occurred in both the irrigation season and the non-irrigation season. In some cases (maximum total phosphorus concentrations and maximum TSS concentrations, non-irrigation season) concentrations have realized a reduction of more than 80%.

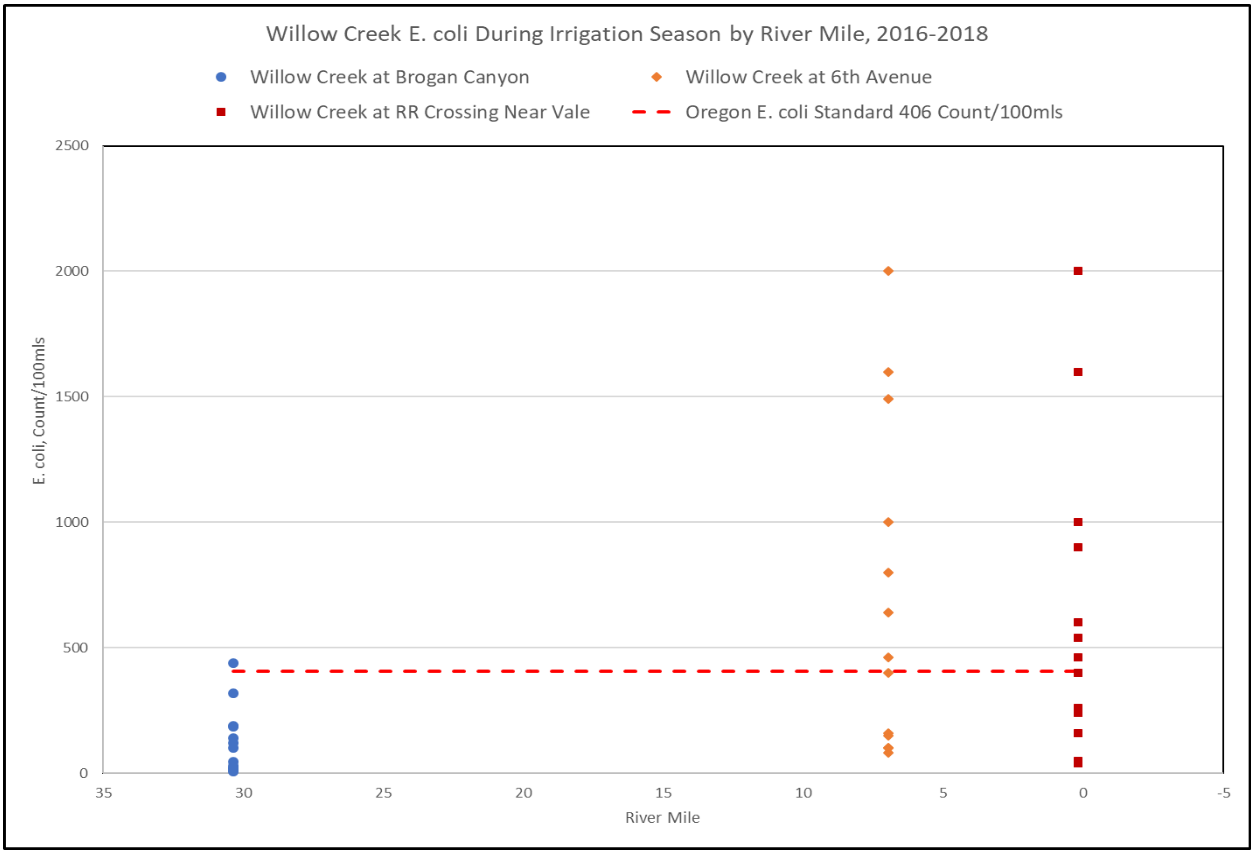
Additional information is provided in the more detailed tables of this historic to current data comparison in the final section of this report (please see page 109-110.)

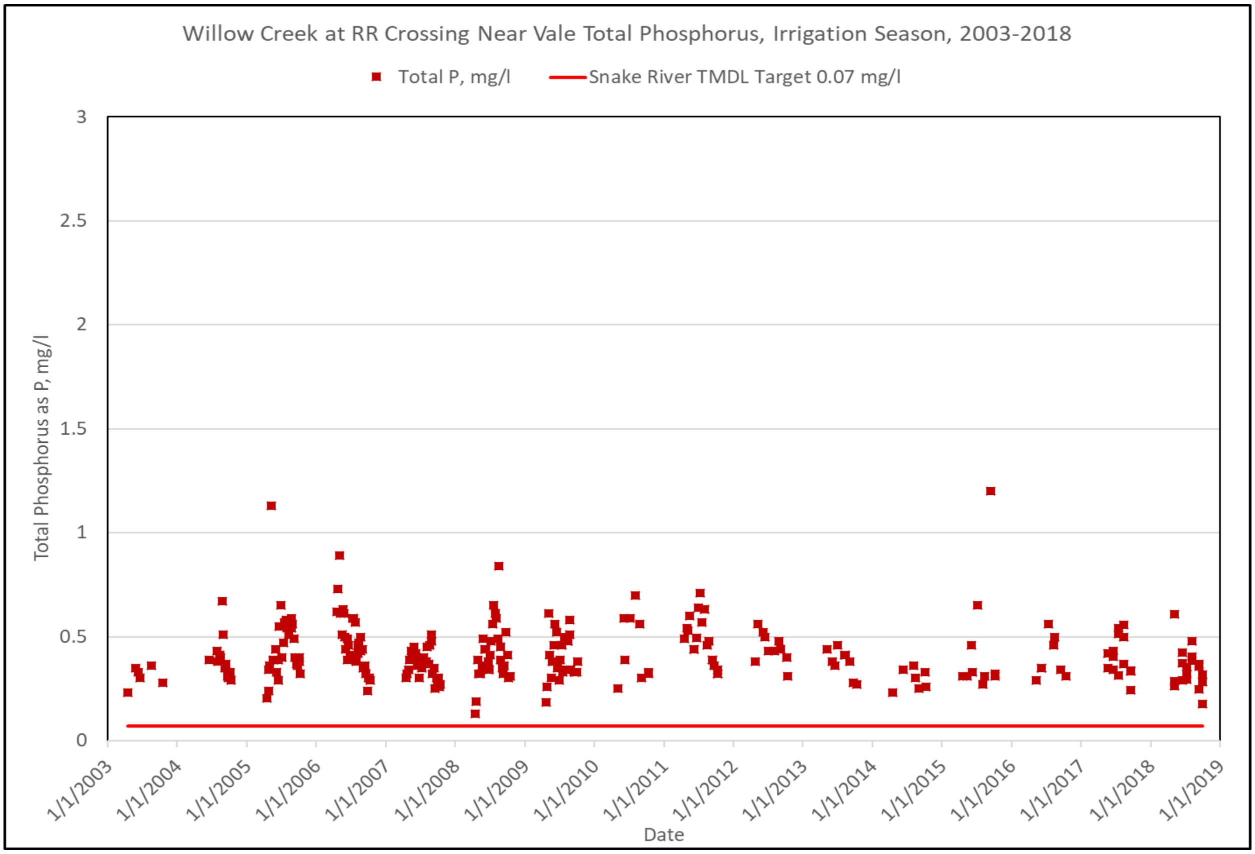


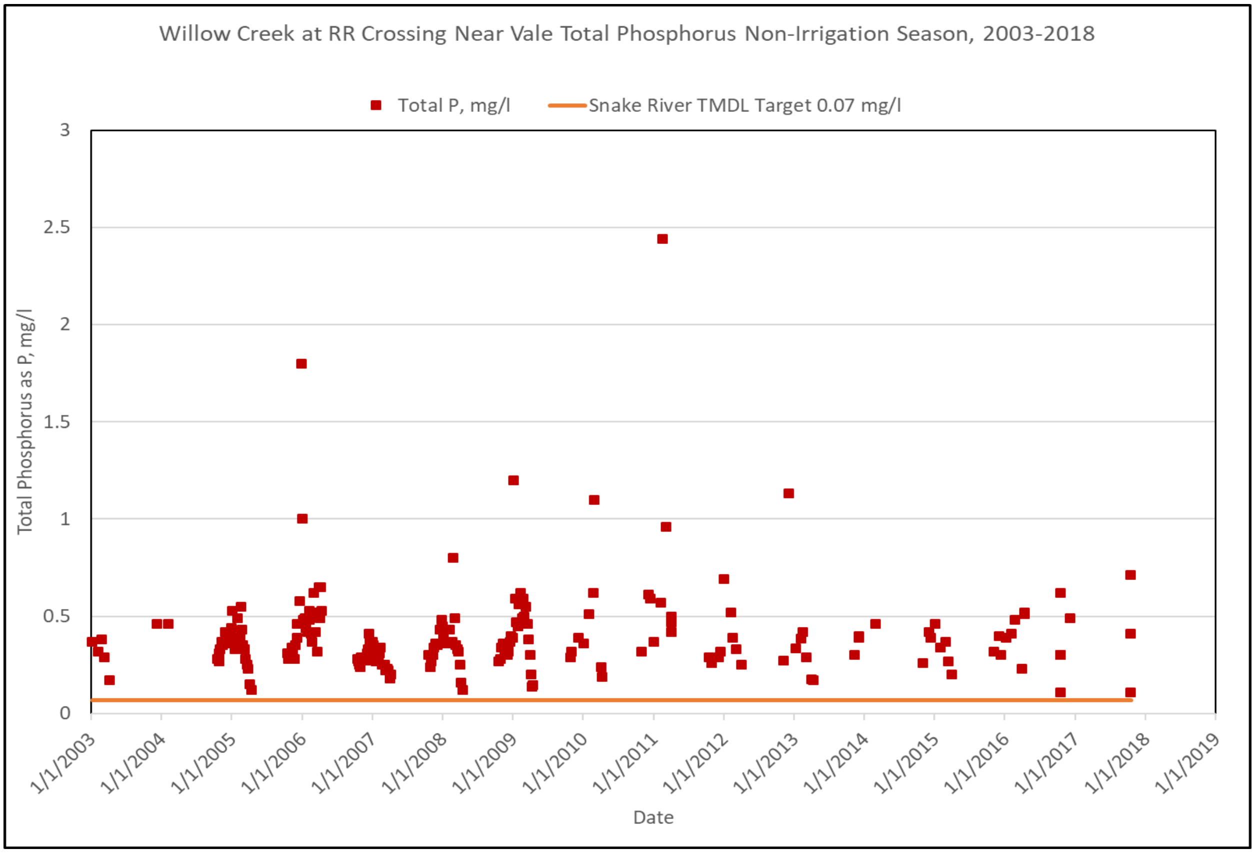
Willow Creek Total Phosphorus During Irrigation Season by River Mile, 2016-2018
Willow Creek at Brogan Canyon
Willow Creek at 6th Avenue
Willow Creek at RR Crossing Near Vale
Snake River TMDL Target 0.07 mg/l
Total Phosphorus as P, mg/l
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
35
30
25
20
15
10
5
0
-5
River Mile

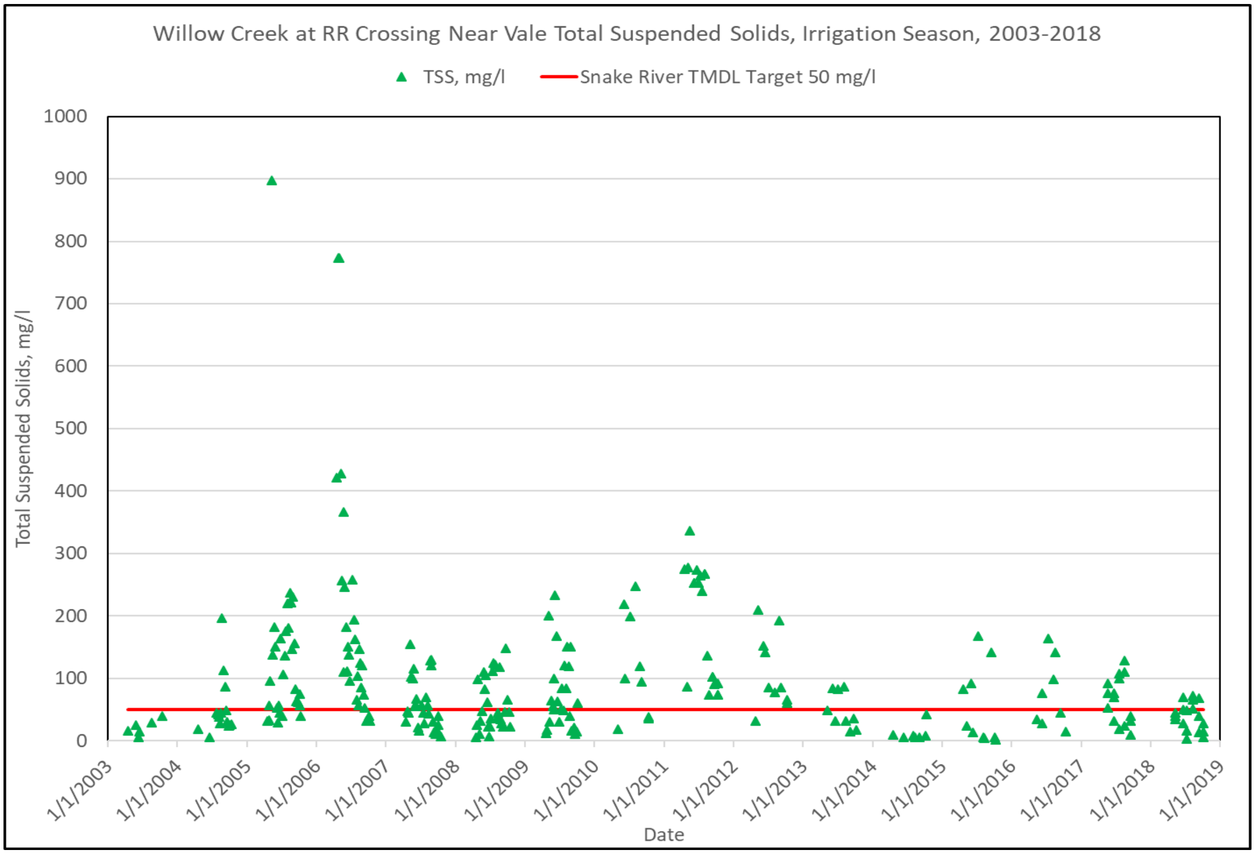


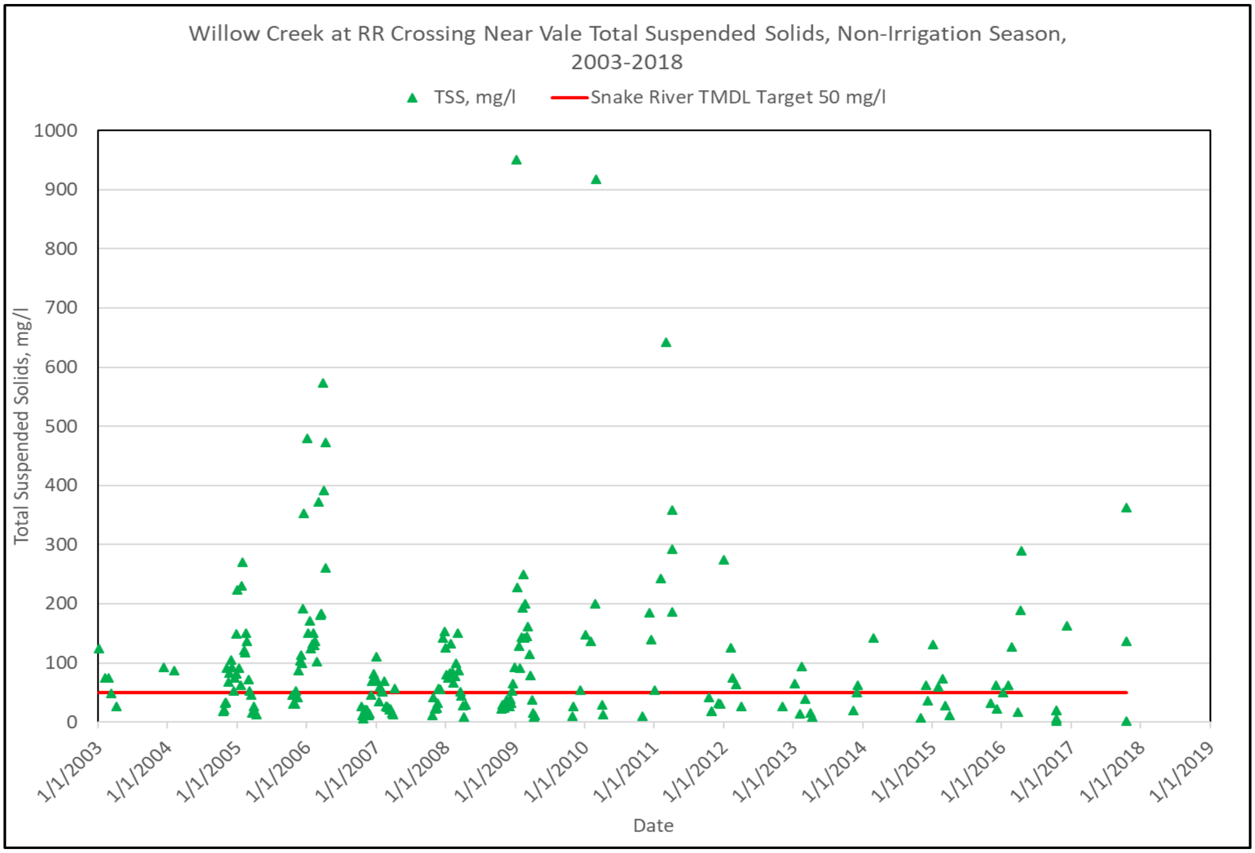
Willow Creek Total Suspended Solids During Irrigation Season by River Mile, 2016-2018
Willow Creek at Brogan Canyon
Willow Creek at 6th Avenue
Willow Creek at RR Crossing Near Vale
Snake River TMDL Target 50 mg/l
Total Suspended Solids, mg/l
400
350
300
250
200
150
100
50
0
35
30
25
20
15
10
5
0
-5
River Mile

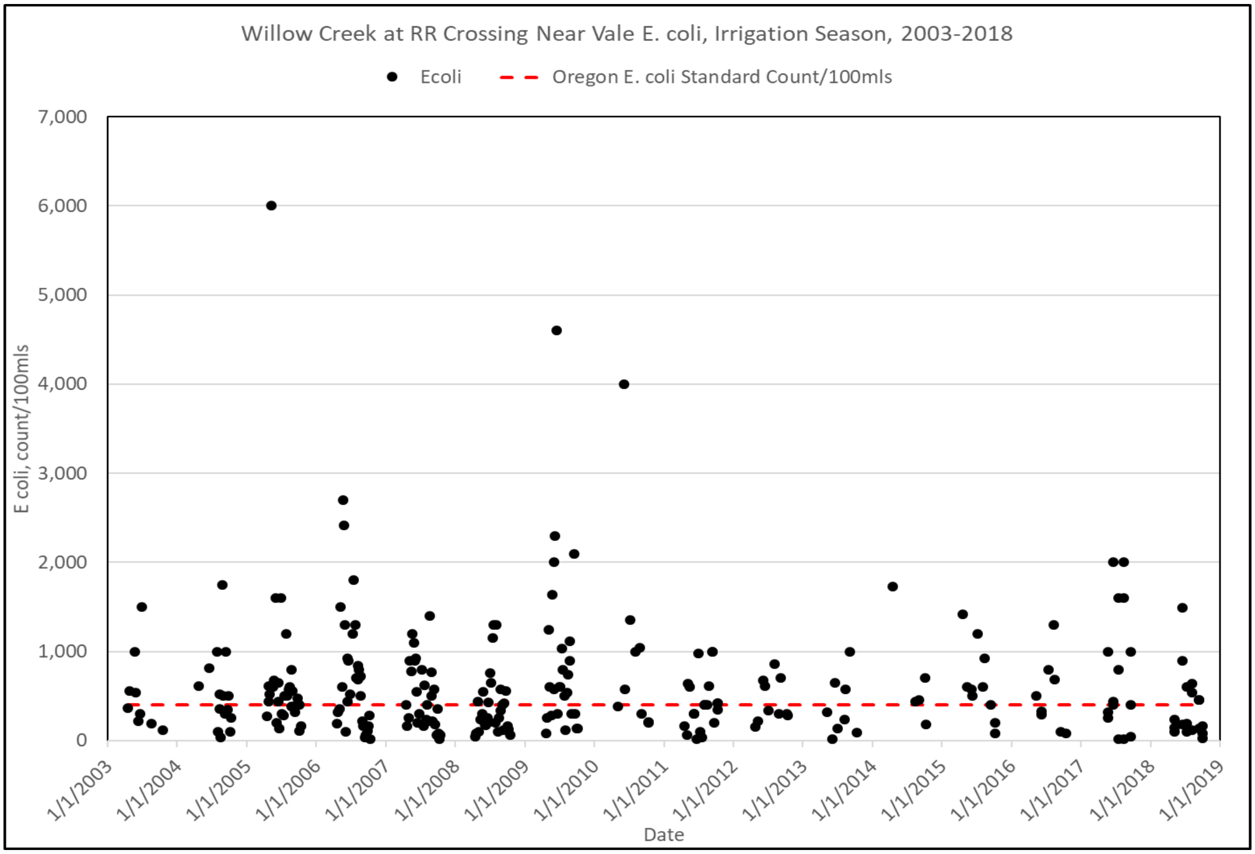

Willow Creek E. coli During Irrigation Season by River Mile, 2016-2018
Willow Creek at Brogan Canyon
Willow Creek at 6th Avenue
Willow Creek at RR Crossing Near Vale
Oregon E. coli Standard 406 Count/100mls
E. coli, Count/100mls
2500
2000
1500
1000
500
0
35
30
25
20
15
10
5
0
-5
River Mile


Willow Creek at RR Crossing Near Vale Total Phosphorus, Irrigation Season, 2003-2018
Total P, mg/l
Snake River TMDL Target 0.07 mg/l
Total Phosphorus as P, mg/l
0
0.5
1
1.5
2
2.5
3
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Willow Creek at RR Crossing Near Vale Total Phosphorus Non-Irrigation Season, 2003-2018
Total P, mg/l
Snake River TMDL Target 0.07 mg/l
Total Phosphorus as P, mg/l
0
0.5
1
1.5
2
2.5
3
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Willow Creek at RR Crossing Near Vale Total Suspended Solids, Irrigation Season, 2003-2018
TSS, mg/l
Snake River TMDL Target 50 mg/l
Total Suspended Solids, mg/l
0
100
200
300
400
500
600
700
800
900
1000
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Willow Creek at RR Crossing Near Vale Total Suspended Solids, Non-Irrigation Season, 2003-2018
TSS, mg/l
Snake River TMDL Target 50 mg/l
Total Suspended Solids, mg/l
0
100
200
300
400
500
600
700
800
900
1000
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Willow Creek at RR Crossing Near Vale E. coli, Irrigation Season, 2003-2018
Ecoli
Oregon E. coli Standard Count/100mls
E coli, count/100mls
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
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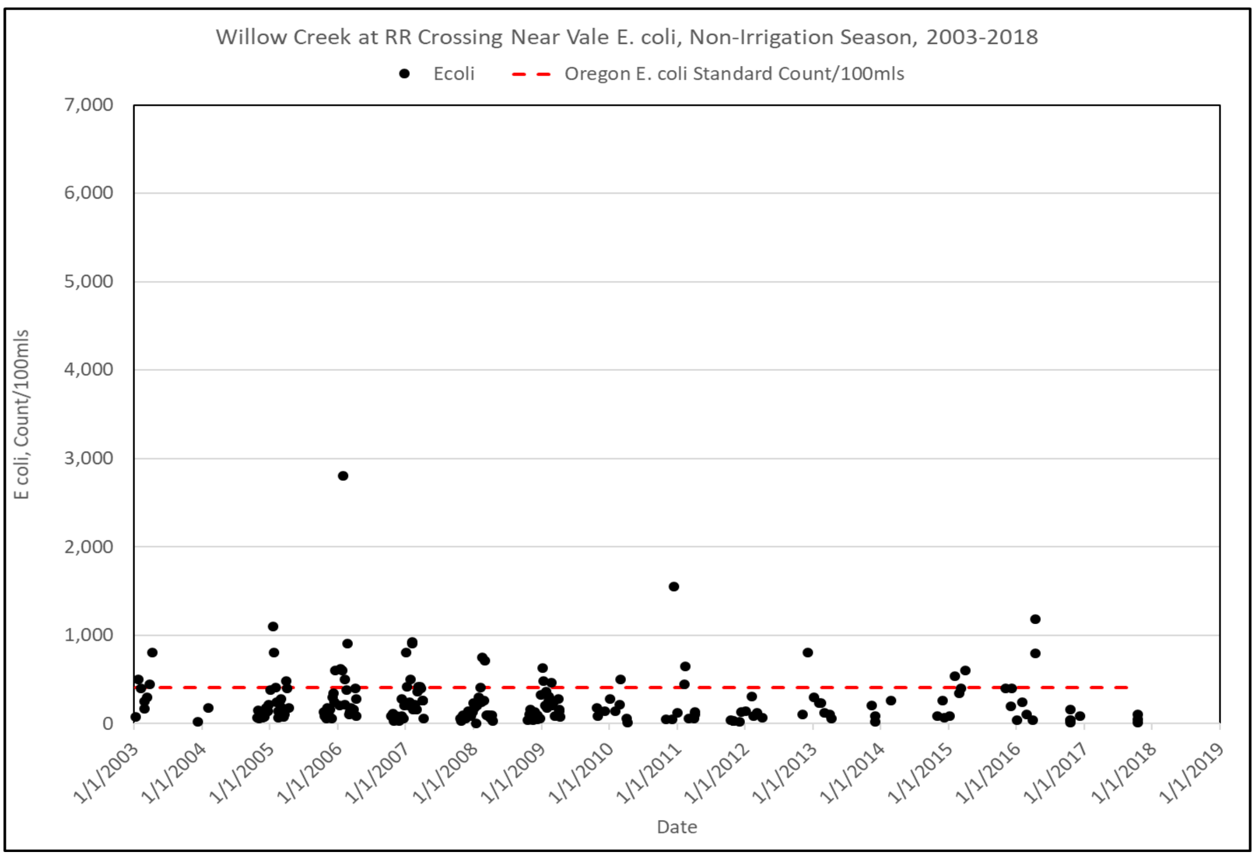
1/1/2018
1/1/2019
Date


Willow Creek at RR Crossing Near Vale E. coli, Non-Irrigation Season, 2003-2018
Ecoli
Oregon E. coli Standard Count/100mls
E coli, Count/100mls
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

Chapter 6 – Owyhee River

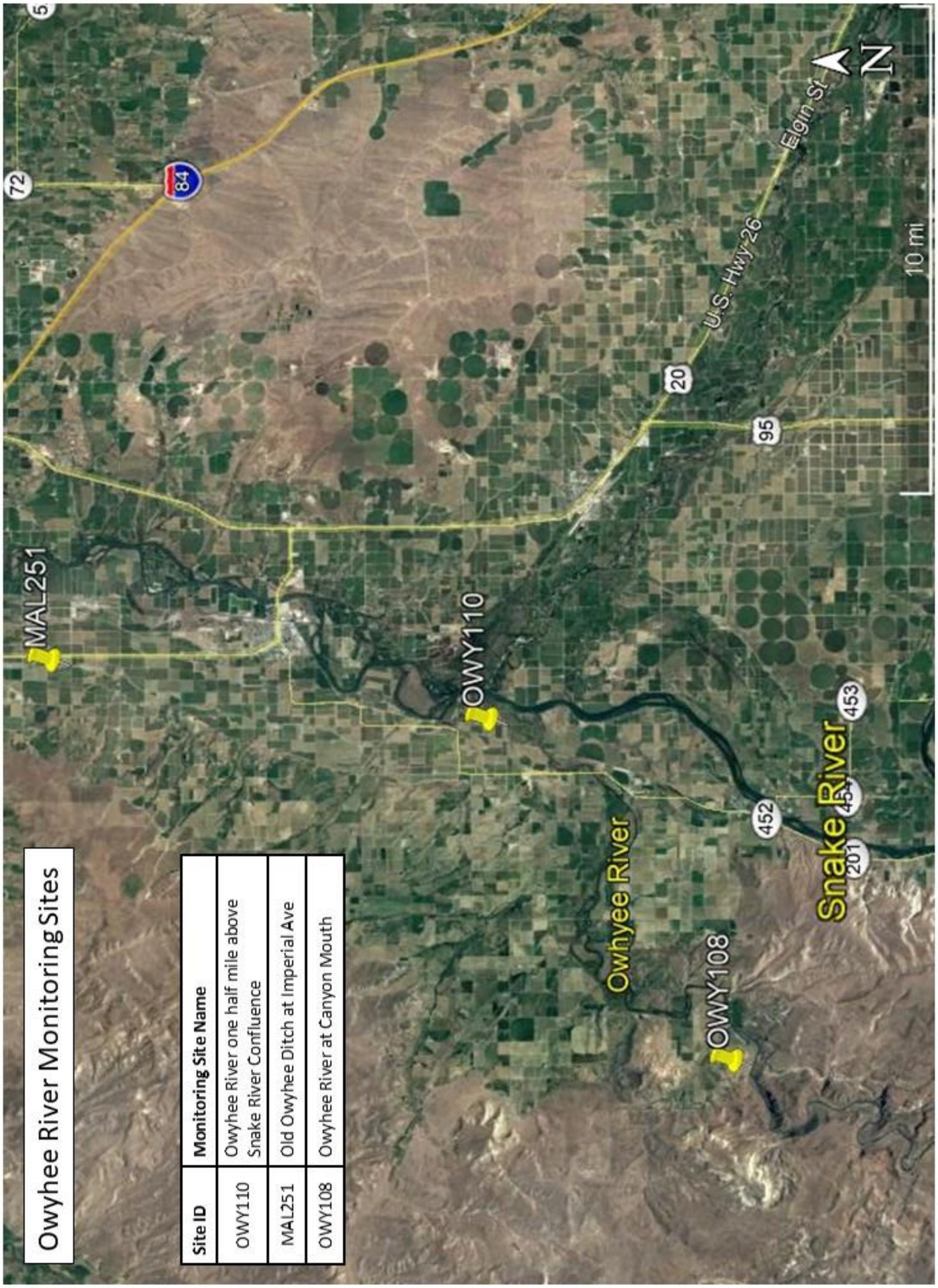
The Owyhee River is a tributary of the Snake River located in northern Nevada, southwestern Idaho and southeastern Oregon. It is 346 miles long. The river's drainage basin is 11,049 square miles in area, one of the largest subbasins of the Columbia Basin. The Owyhee drains a remote area of the arid plateau region on the north edge of the Great Basin, beginning in northeastern Nevada and flowing generally northward near the Oregon-Idaho border to the Snake River. Its watershed is very sparsely populated. The Owyhee River enters extreme southeast Oregon in southern Malheur County, flowing generally north in a zigzag course west of the Idaho border. It enters the Snake River from the west on the Oregon–Idaho border approximately 5 miles south of Nyssa, Oregon, and 2 miles south of the mouth of the Boise River. [9]

A Total Maximum Daily Load (TMDL) is a water quality management plan compiled by Oregon Department of Environmental Quality (DEQ) with public input. The plan sets water quality targets that, if achieved, will allow the water quality in rivers and streams to meet water quality standards. The Owyhee River TMDL is in progress at this time; water quality targets specific to the TMDL have not been established. The water quality targets set by the Snake River-Hells Canyon TMDL apply to the Owyhee River Basin. The targets are specific to water quality conditions at the mouth of the Owyhee River where the Owyhee flows into the Snake River. As the Owyhee River and the Old Owyhee Ditch water discussed in this chapter eventually discharge to the Snake River, the TMDL targets for phosphorus and total suspended sediment (TSS) identified in this chapter are specific to the Snake River – Hells Canyon TMDL and will be referred to as the “Snake River TMDL targets” in the following data graphs. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use.

The Malheur Watershed Council and Malheur SWCD have collected water quality samples at two (2) locations relative to the Owyhee River through OWEB grant funding (OWEB #216-5043); and at a third site farther upstream on the Owyhee River (Owyhee River at Canyon Mouth) under a separate grant agreement through DEQ. The following table provides information on the locations of the three (3) Owyhee River monitoring sites and the water quality data collected. A map of monitoring sites is included on the following page.

Site Location	Latitude	Longitude	Monitoring Period	Parameters Monitored
Owyhee River one half mile above Snake River Confluence	43.79250	117.04056	2008 - 2018	Ortho and Total Phosphorus, E. coli, and Total Suspended Solids for the entire period. NO2-NO3, lab pH, and Turbidity 2008-2014 only.
Old Owyhee Ditch at Imperial Ave	43.93808	117.01010	2008 - 2018 Irrigation Season only)	
Owyhee River at Canyon Mouth	43.73718	117.17601	2008 - 2018	

[9] Wikipedia


Owyhee River Monitoring Sites
Site ID | Monitoring Site Name
OWY110 | Owyhee River one half mile above Snake River Confluence
MAL251 | Old Owyhee Ditch at Imperial Ave
OWY108 | Owyhee River at Canyon Mouth
MAL251
OWY110
OWY108
Owyhee River
Snake River
U.S. Hwy 26
Elgin St
N
10 mi
72
84
20
95
452
453
201

The water quality data collected at each site are discussed in the following paragraphs. Data for the site located at the Owyhee River one half mile above its confluence with the Snake River were collected year-round and have been divided into separate graphs showing the irrigation season (April 15 – October 15) and the non-irrigation season (October 16-April 14) for the Owyhee Basin. In general, in the Owyhee River Basin, the irrigation season runs from April 15 to October 15. Depending on the river and irrigation storage conditions, however, the start and end of water delivery during the irrigation season may be adjusted as needed to accommodate wetter spring weather or drought conditions.

The graphs for ortho and total phosphorus for the Owyhee River one half mile above its confluence with the Snake River for both the irrigation season (April 15 to October 15) and the non-irrigation season (October 16 to April 14) for 2008 to 2018 are displayed on page 72. For comparison purposes, the vertical axes on the graphs are the same for both the irrigation and non-irrigation seasons for each parameter.

Ortho phosphorus concentrations measured during the irrigation season are generally higher than those measured during the non-irrigation season. Approximately half of the concentrations measured during the irrigation season are above the Snake River TMDL target of 0.07 mg/l, while most of the ortho phosphorus concentrations measured during the non-irrigation season are below the Snake River TMDL target of 0.07 mg/l. There are no obvious trends in either the irrigation or non-irrigation season ortho-phosphorus concentrations. Ortho phosphorus is one component of total phosphorus in the water column and represents that fraction of the total phosphorus that is most readily available to plant and algal growth. Excessive algal growth in drain and river water leads to reduced dissolved oxygen and changes in pH that can be detrimental to fish and other aquatic life and present maintenance delivery difficulties for water conveyance systems. Water quality data collected for these sites on the Owyhee River show that concentrations of ortho phosphorus measured in the river water are very often higher than the Snake River TMDL target of 0.07 mg/l for total phosphorus during both the irrigation and non-irrigation seasons.

For total phosphorus, measured irrigation season total phosphorus concentrations are much higher than those observed during the non-irrigation season. During the irrigation season, all measured total phosphorus concentrations are above the Snake River TMDL target of 0.07 mg/l. The measured total phosphorus concentrations collected during the irrigation season appear to show a slight decrease over time. During the non-irrigation season, all but three of the measured total phosphorus concentrations are above the Snake River TMDL target of 0.07 mg/l.

The graphs for TSS and E. coli for both the irrigation and non-irrigation seasons for the Owyhee River one half mile above its confluence with the Snake River for 2008 to 2018 are displayed on page 73. During the irrigation season, most of the measured TSS concentrations are greater than the Snake River TMDL TSS target of 50 mg/l before 2015-16. After 2016, many of the measured concentrations are less than the Snake River TMDL TSS target of 50 mg/l. Overall, during the irrigation season, the measured TSS concentrations appear to be decreasing over time. During the non-irrigation season, virtually all of the samples had measured concentrations that were less than the TMDL target.

For E. coli, the measured concentrations are higher during the irrigation season than the non-irrigation season, but, even during the irrigation season, most of the measured concentrations were below the Oregon water quality standard of 406 counts/100mls. Only one measured E. coli concentration exceeded the TMDL target during the non-irrigation season. There is no discernable change in concentration over time for E. coli in either season.

Pages 74 and 75 contain the graphs of data collected at the Old Owyhee Ditch at Imperial Avenue site and the Owyhee River at the Canyon Mouth site.

The Owyhee River at the Canyon Mouth is a site monitored under a Section 319 grant issued by the Oregon DEQ for water quality monitoring of agricultural drains that discharge into the Owyhee River. The data collected under this 319 grant were analyzed and summarized in a separate report entitled: Final Report for Owyhee River Improvement Project- Phase 4, Section 319 Grant # 092-1 (here after referred to as the ORIP Report, available through the Malheur Watershed Council). This site is located farthest upstream on the Owyhee River (of the three sites discussed in this chapter) and is considered to be representative of "baseline" conditions for the lower Owyhee Basin. The water quality data collected at this site should not be used to define reference or background conditions as there are some farming/cropping influences as well as livestock influences upstream of this monitoring site. The data collected at this site are included here to provide a better understanding of the differences in water quality at the upstream Owyhee River site (Owyhee River at the Canyon Mouth), the Owyhee River one half mile above its confluence with the Snake River (reflective of cumulative agricultural management effects within the basin) and the Old Owyhee Ditch site (which includes agricultural influences in the form of agricultural drain discharges).

The Old Owyhee Ditch is an irrigation water delivery canal that carries water diverted from the Owyhee River at river mile 12.5 and transports it to agricultural land between the diversion point and Ontario, Oregon. In addition to the water diverted from the Owyhee River, this ditch also receives water discharged from agricultural drains. The drain discharges mix with the diverted river water in the ditch, resulting in higher concentrations of pollutants in the delivered ditch water than were in the water diverted from the river.

Data for the Old Owyhee Ditch at Imperial Avenue were collected only during the irrigation season (April 15 – October 15). Because the graphs taken from the ORIP report (for the Owyhee River at the Canyon Mouth site) only included data from May through September, the graphs included here for the Old Owyhee Ditch are also only for May through September in order to allow a more direct comparison of water quality.

For comparison purposes, water quality data from the Owyhee River at the Canyon Mouth (the most upstream site on the Owyhee River and the site with the least potential for pollutant loading of the three sites discussed in this chapter) are displayed on page 75. It is recognized that the Canyon Mouth monitoring site is not the location where water is diverted into the Old Owyhee Ditch. It is also recognized that monitoring at this site is representative of the quality of water in the river and is not necessarily representative of the quality of the water that some producers receive (which has been used for irrigation, perhaps multiple times, and is therefore enriched before it is applied to their fields). In this section, the water quality data from the Owyhee River at the Canyon Mouth are compared with water quality data from the other Owyhee sites to measure the change in water quality from the river above intensive agricultural use and the runoff from agricultural fields.

Comparing the measured phosphorus data from the Old Owyhee Ditch with the phosphorus data from the Owyhee River at the Canyon Mouth shows that the measured total phosphorus concentrations are substantially higher in the Old Owyhee Ditch samples. Nearly all of the total phosphorus concentrations measured at the Canyon Mouth sites after 2013 are below the Snake River TMDL target of 0.07 mg/l. All but two (2) of the total phosphorus concentrations measured at the Old Owyhee Ditch site are well above the target.

All but two of the total phosphorus concentrations measured at the Old Owyhee Ditch exceed the Snake River TMDL target of 0.07 mg/l. Concentrations at this site range from about 0.06 mg/l to 1.1 mg/l. The maximum concentration measured in the ditch is about five times higher than the maximum concentration measured in the Owyhee River at the Canyon Mouth. The measured ortho phosphorus concentrations measured at both sites are similar and range from 0.01 mg/l to about 0.1 mg/l. The collected phosphorus data from both sites appears to show a slight decrease over time.

TSS concentration data collected at the Old Owyhee Ditch site are shown in the graph on page 74. Most of the measured TSS concentrations are well above the Snake River TMDL target of 50 mg/l. The maximum TSS concentration measured in the Old Owyhee Ditch water is approximately four times higher than the maximum concentration measured in the Owyhee River at the Canyon Mouth.

For E. coli (also on page 74), during the irrigation season, many of the concentrations measured at the Old Owyhee Ditch site are greater than the Oregon standard of 406 count/100mls, while all of the concentrations measured in the Owyhee River at the Canyon Mouth are below the standard. The maximum E. coli concentration measured at the Canyon Mouth is approximately one tenth of the maximum E. coli concentration measured in the Old Owyhee Ditch.

COMPARISON OF RIVER AND DRAIN WATER QUALITY

When the water quality data collected at the Old Owyhee Ditch site are compared to the data collected at the site on the Owyhee River one half mile from the mouth and at the Owyhee River at the Canyon Mouth, the ditch samples show consistently higher concentrations of phosphorus, TSS and E. coli; strongly indicative of substantial enrichment and higher pollutant loading in the ditch water. In general, the Canyon Mouth site had the highest water quality (although it did not meet the TMDL targets or state standards all the time), the site on the Owyhee River one half mile from the mouth had the second highest water quality of the three sites and the Old Owyhee Ditch samples showed the lowest water quality of the three sites. (Data displayed in the following table are from the irrigation season only.)

Site Location	Median Tot Phos (mg/l)	90th Percentile Tot Phos (mg/l)	Median TSS (mg/l)	90th Percentile TSS (mg/l)	Median E. coli (count/100ml)	90th Percentile E. coli (count/100ml)
Owyhee River at the Canyon Mouth	0.07	0.17	13	45	16	57
Owyhee River one half mile from the mouth	0.19	0.29	63	126	190	484
Old Owyhee Ditch	0.23	0.45	171	358	300	879

The data collected at the Owyhee River at the Canyon Mouth site are reflective of minimal farming/cropping influences as well as livestock influences. The data collected at the site on the Owyhee River one half mile from the mouth are reflective of a combination of river water and drain discharge as well as other land uses (urban and suburban inputs). The data collected at the Old Owyhee Ditch site are reflective of drain runoff from intensive agriculture (predominantly row crops).

COMPARISON OF HISTORIC AND CURRENT DATA

Historic water quality data (1980-1989) are available for the Owyhee River at Hwy 201 Bridge, a site located just upstream of the monitoring site on the Owyhee River one half mile from the mouth that has been discussed in this chapter. The historic data and the current data for the Highway 201 Bridge site were collected by Oregon DEQ as part of their ambient monitoring program.

There are some limitations to the data available. For this site, only a few (< 10) data points were available for the current time period (2016-2018). This site is very close to the mouth of the Owyhee River where it flows into the Snake River. When the Snake River is experiencing high flows, the water at the mouth of the Owyhee can back up due to back pressure from the water in the Snake. This may cause changes in water quality in the samples taken at the Highway 201 Bridge site on the Owyhee. Additionally, analytical methods have evolved from those used during the 1980s and may not be directly comparable with the analytical methods used today. Please keep these limitations in mind while reviewing the comparison of historic to current water quality presented here.

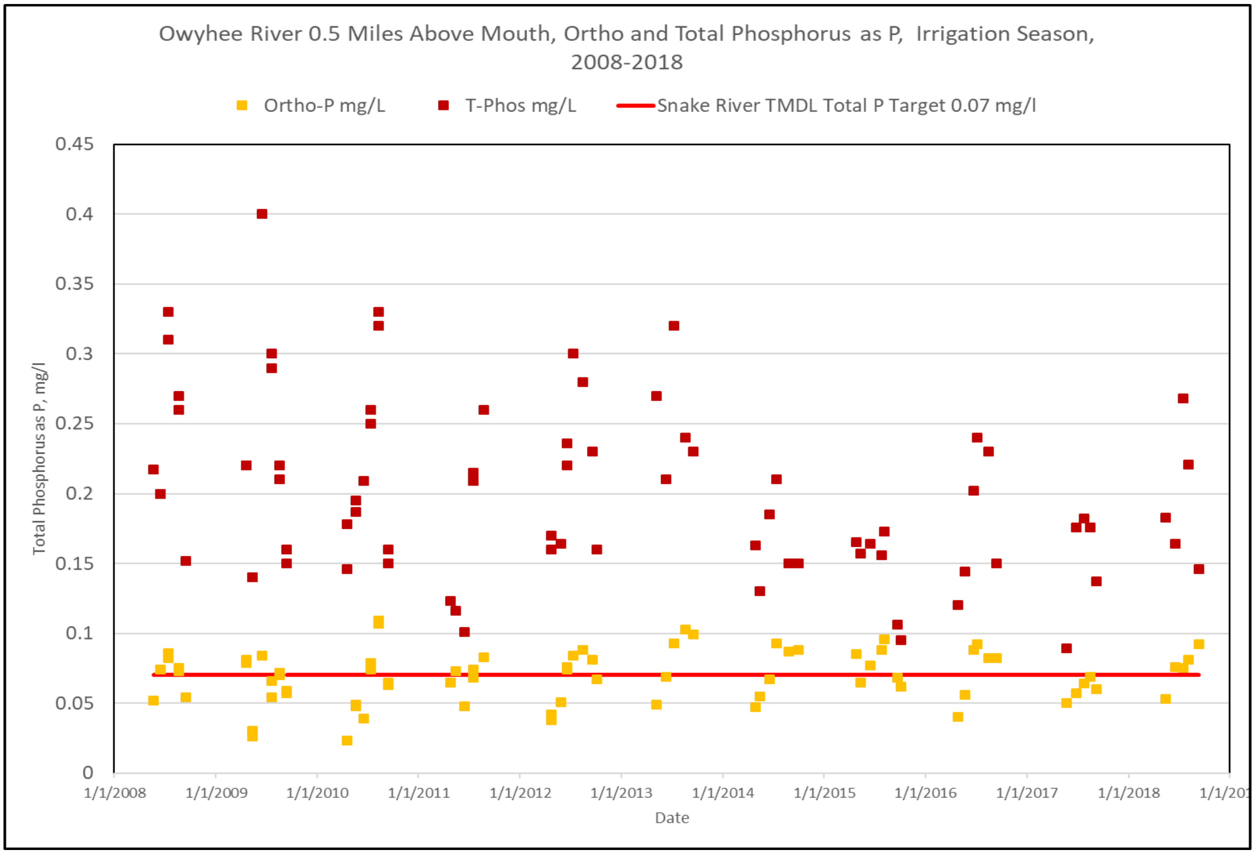
Data presented in the following tables shows the percent reduction in concentration from 1980-1989 to 2016-2018 for each site for both the irrigation season and the non-irrigation season.

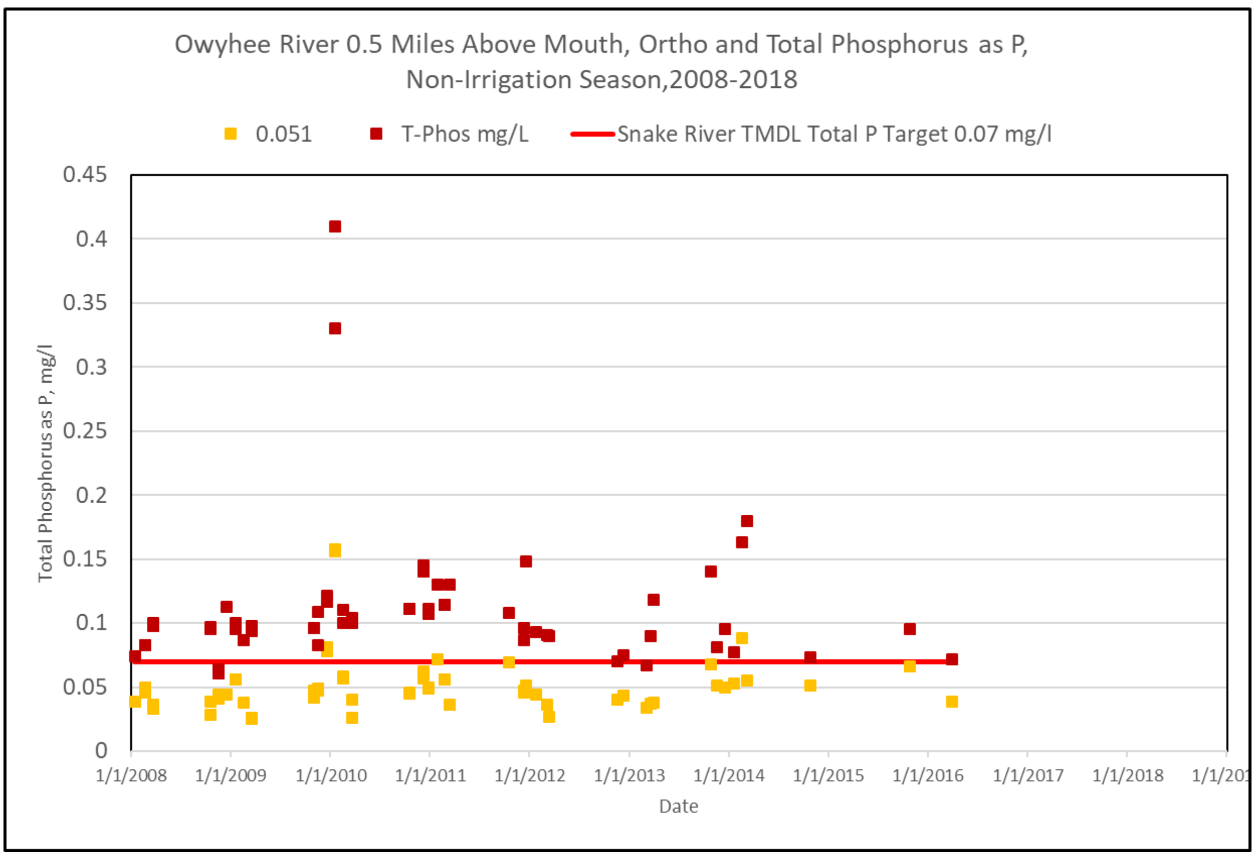
Total Phosphorus Concentration (mg/l), Owyhee River at Hwy 201 Bridge								
	Irrigation Season				**Non-Irrigation Season**			
Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
1980-1989	47	0.190	0.288	0.406	44.000	0.110	0.242	0.416
2016-2018	8	0.175	0.265	0.300	9.000	0.080	0.142	0.190

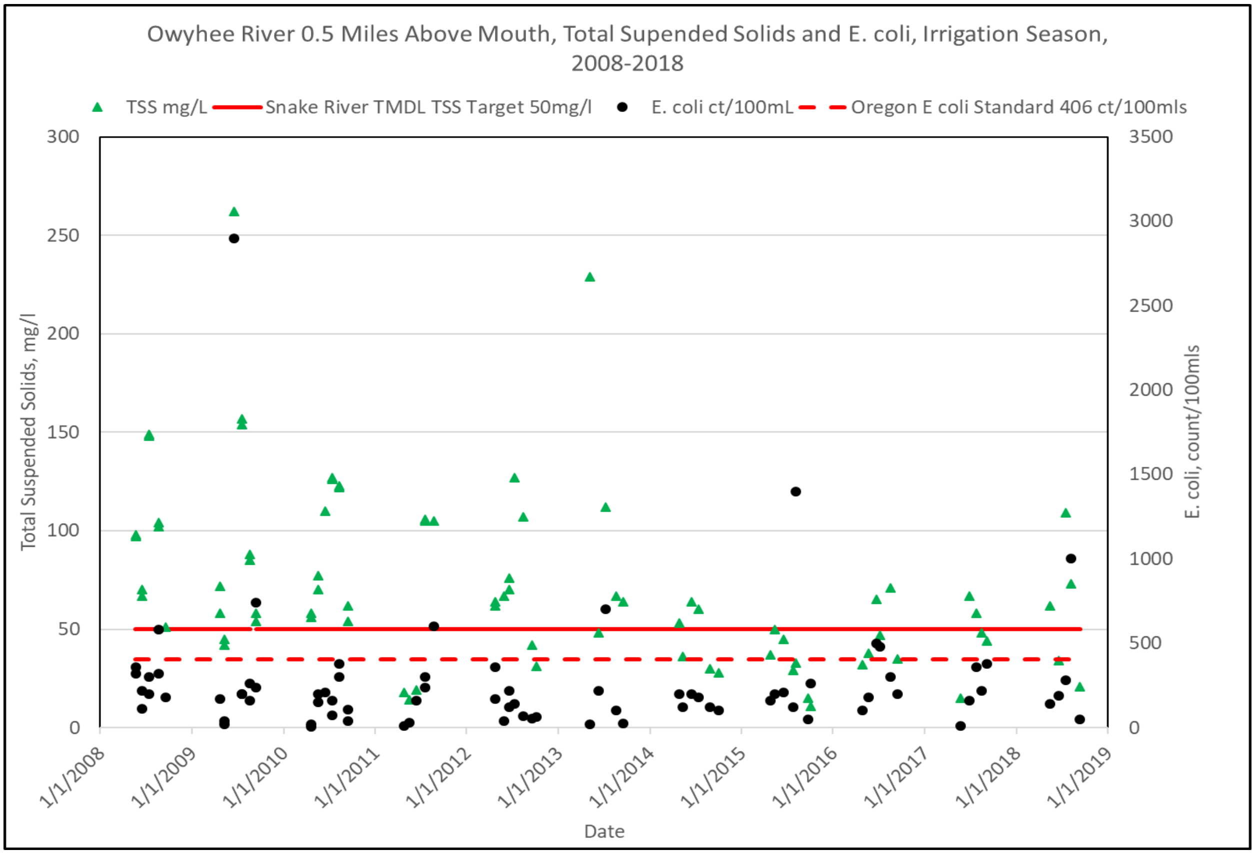
Total Suspended Solids Concentration (mg/l), Owyhee River at Hwy 201 Bridge								
	Irrigation Season				**Non-Irrigation Season**			
Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
1980-1989	42	96	162	237	50	32	103	439
2016-2018	8	45	77	99	9	11	29	58

Even with the limitations of the available data, it is clear that progress is being made over time in the Owyhee River Basin and water quality is improving. Concentrations of total phosphorus and total suspended solids have decreased in both the irrigation and non-irrigation seasons. Substantial reductions in total phosphorus and suspended solids have occurred in both the irrigation season and the non-irrigation season. In some cases (maximum total phosphorus concentrations at Highway 201 Bridge; 90th percentile and maximum TSS concentrations at Highway 201 Bridge, non-irrigation season) concentrations have realized a reduction of more than 50%.

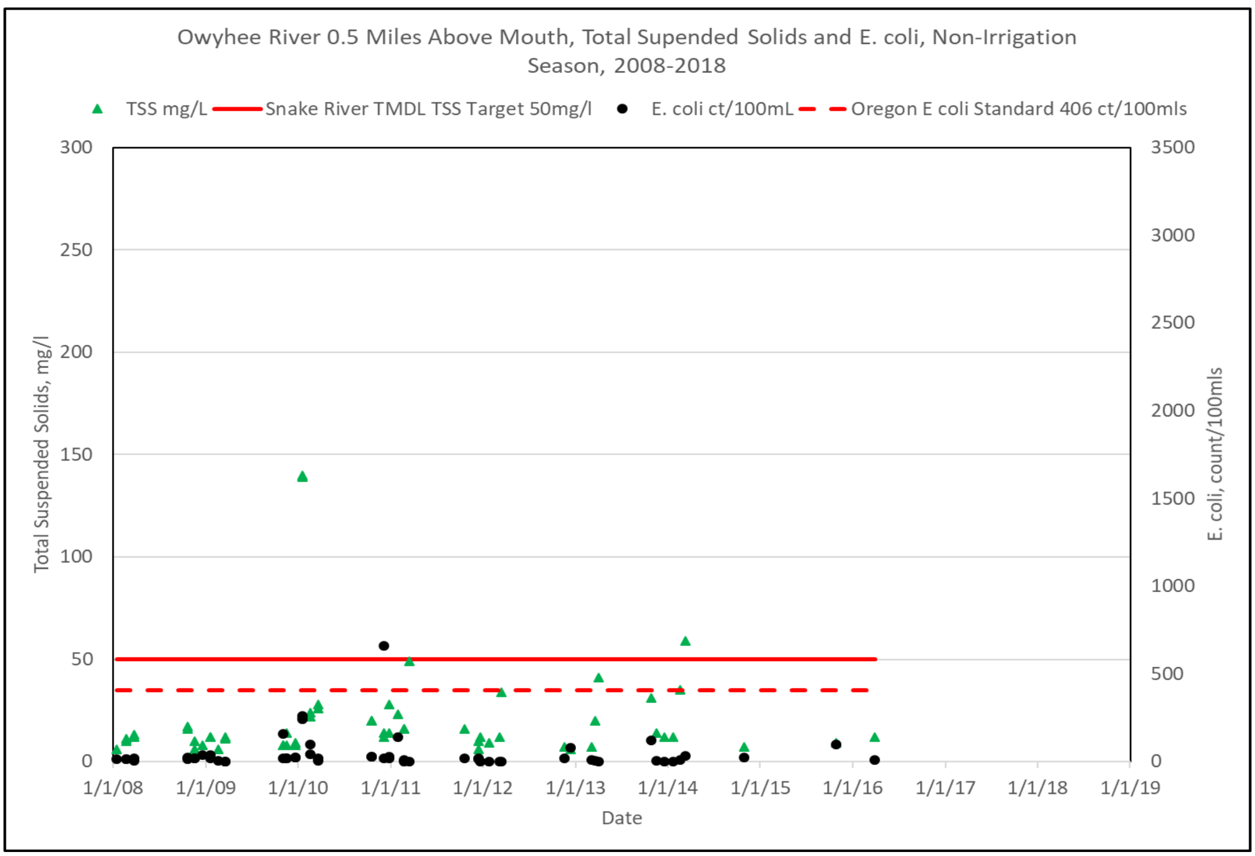
Additional information is provided in the more detailed tables of this historic to current data comparison in the final section of this report (please see pages 109-110.)


Owyhee River 0.5 Miles Above Mouth, Ortho and Total Phosphorus as P, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Total Phosphorus as P, mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
Date


Owyhee River 0.5 Miles Above Mouth, Ortho and Total Phosphorus as P, Non-Irrigation Season,2008-2018
0.051
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Total Phosphorus as P, mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
Date



Owyhee River 0.5 Miles Above Mouth, Total Supended Solids and E. coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E. coli, count/100mls
Date
0
50
100
150
200
250
300
500
1000
1500
2000
2500
3000
3500
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019



Owyhee River 0.5 Miles Above Mouth, Total Supended Solids and E. coli, Non-Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E. coli, count/100mls
Date
0
50
100
150
200
250
300
500
1000
1500
2000
2500
3000
3500
1/1/08
1/1/09
1/1/10
1/1/11
1/1/12
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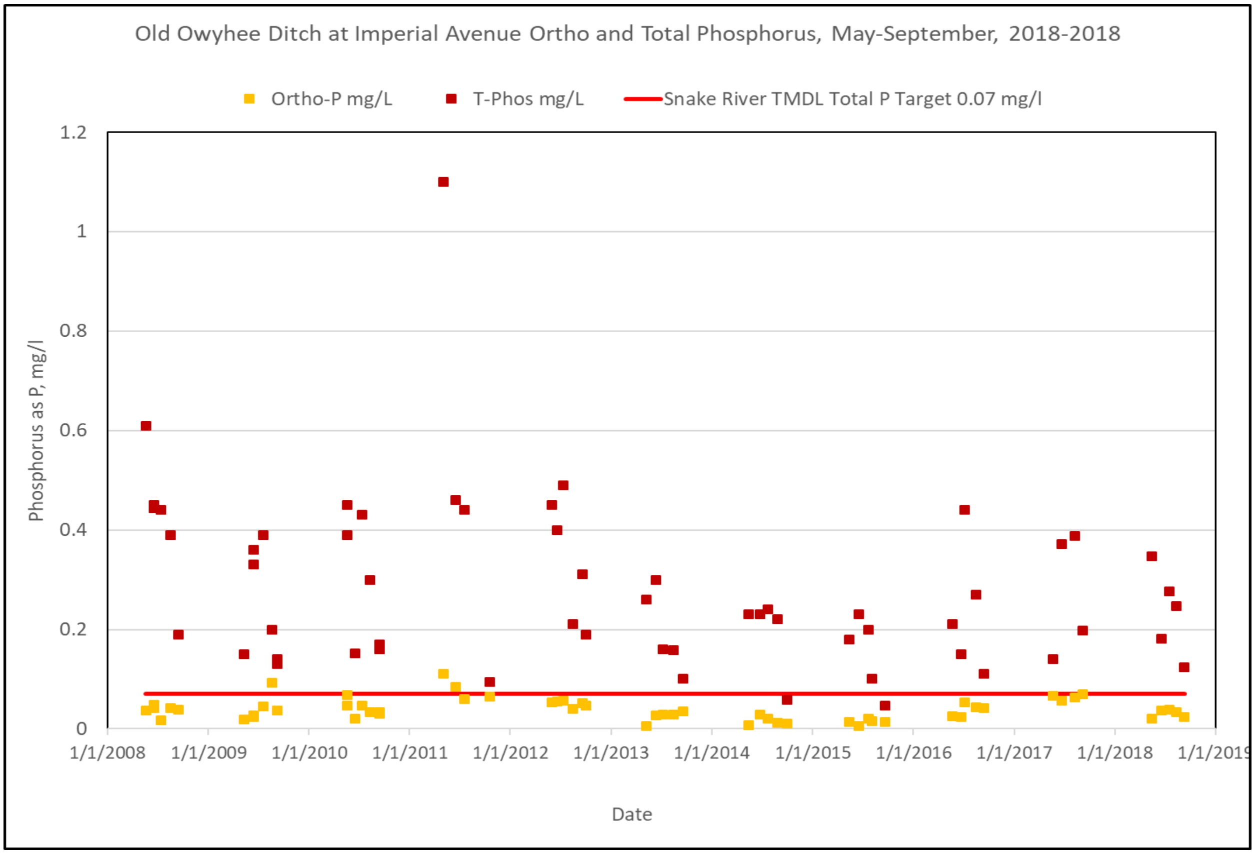
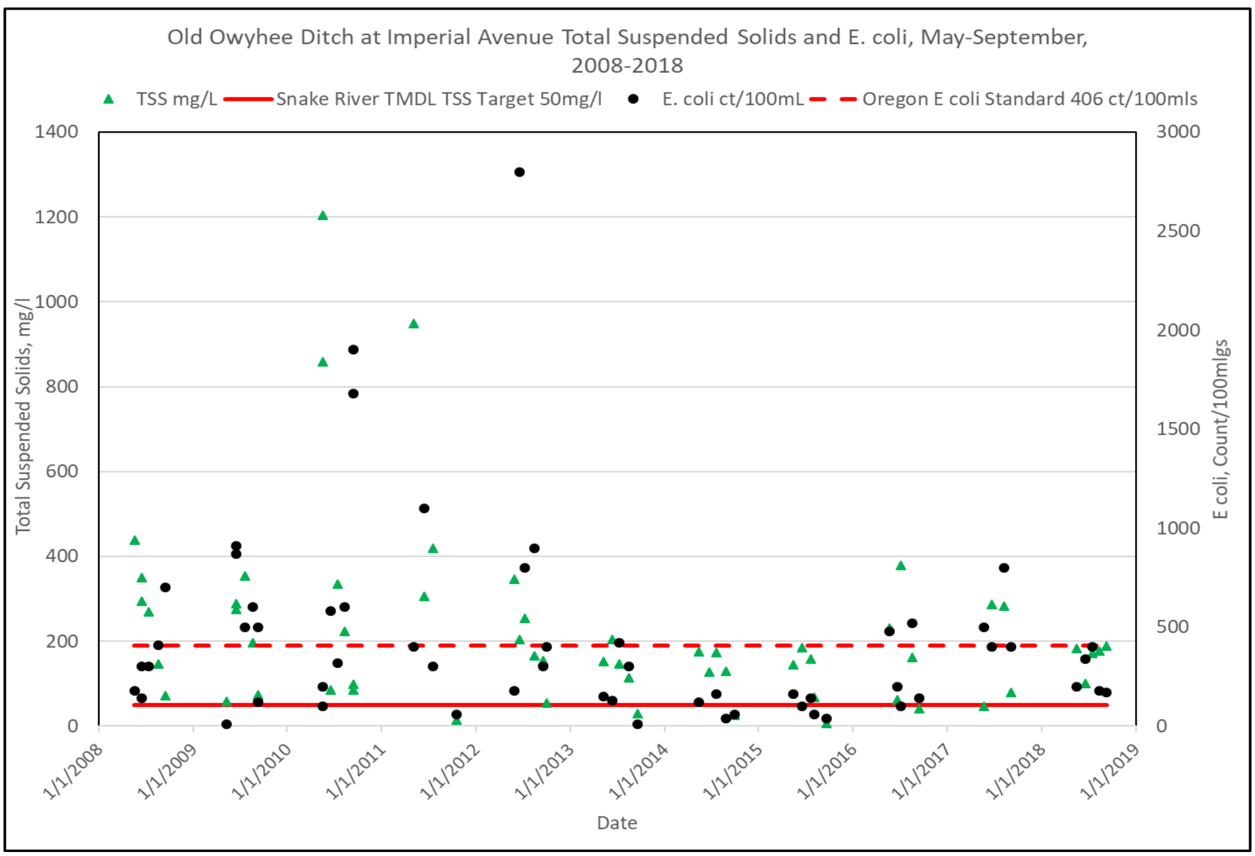
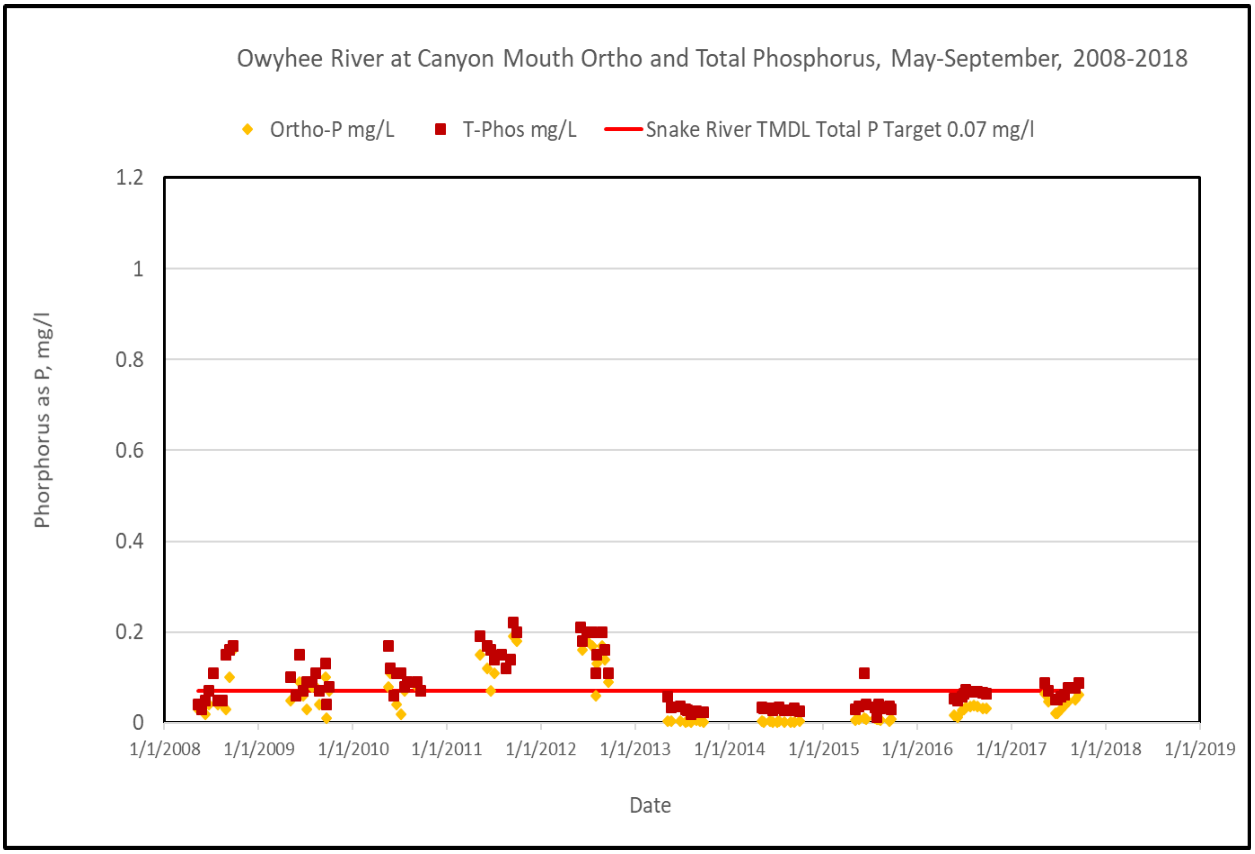
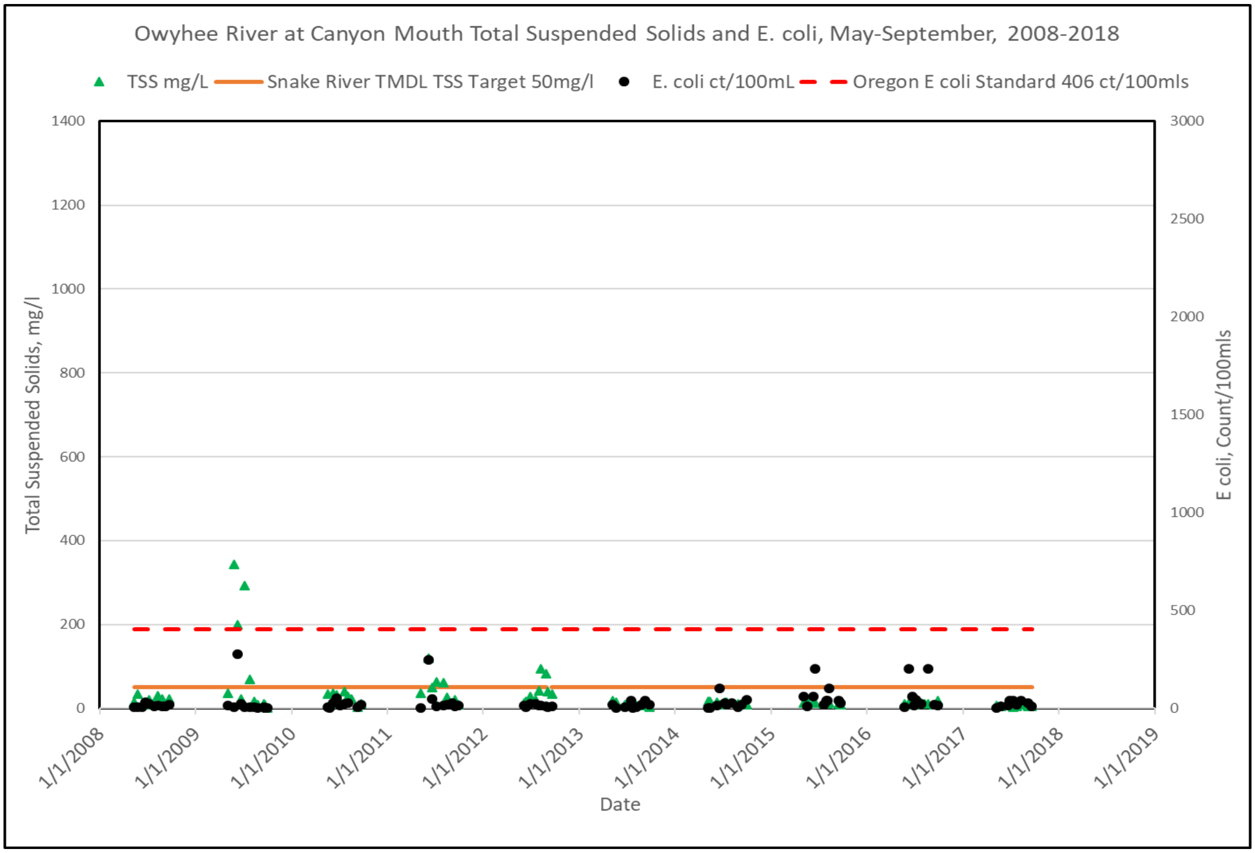
1/1/18
1/1/19


Old Owyhee Ditch at Imperial Avenue Ortho and Total Phosphorus, May-September, 2018-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
1.2
1
0.8
0.6
0.4
0.2
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Old Owyhee Ditch at Imperial Avenue Total Suspended Solids and E. coli, May-September, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
1400
1200
1000
800
600
400
200
0
E coli, Count/100mlgs
3000
2500
2000
1500
1000
500
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Owyhee River at Canyon Mouth Ortho and Total Phosphorus, May-September, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phorphorus as P, mg/l
1.2
1
0.8
0.6
0.4
0.2
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Owyhee River at Canyon Mouth Total Suspended Solids and E. coli, May-September, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
1400
1200
1000
800
600
400
200
0
E coli, Count/100mls
3000
2500
2000
1500
1000
500
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

Chapter 7 – Snake River Agricultural Drains

The Malheur River is located in southeast Oregon and is approximately 190 miles long. The Malheur Basin consists of approximately 5,000 square miles in southeastern Oregon drained by the Malheur River. Most of the basin is in Malheur and Harney counties and the northern areas are in Grant and Baker counties. The Malheur River is a tributary of the Snake River located in southeast Oregon. The Malheur River flows into the Snake River approximately two miles north of Ontario, Oregon. The inflow of the Malheur River is approximately at Snake River mile (RM) 370.

Approximately 70% of the Malheur Basin is under federal ownership, managed primarily by Bureau of Land Management (BLM). Topography consists of rolling hills with flat, alluvial valleys along major tributaries in the Vale-Nyssa-Ontario area. The hills are generally covered by sagebrush-grass communities and have multiple uses. The alluvial valleys are used primarily for irrigated crop and pasture land.[10] Irrigated farming in the basin produces sugar beets, onions, potatoes, corn, mint, grain, alfalfa seed, vegetable seed, hay and other crops.

Agricultural drains in the Malheur County contribute to impaired water quality in the Snake River. There are approximately 236,000 acres of irrigated agricultural in northern Malheur County that are drained by the Snake River system. About 80% of the farmland in Malheur County is irrigated with low-efficiency flood or furrow irrigation where 10 to 50 tons per acre of topsoil is lost annually as field runoff depending on slope and soil type. This eroded soil, along with all attached and entrained nutrients, bacteria and agricultural chemicals, is deposited in the area's rivers and streams where it contributes to elevated pollutant loads, high turbidities and water quality problems in local waterways and the Snake River.

During the irrigation season, irrigation water is delivered to fields in the Malheur Basin via flood, furrow and sprinkler irrigation practices. Agricultural drains in the area collect the runoff from these irrigated fields. In some cases, drain water is reused for irrigation of additional fields so water may be applied to the land surface multiple times before it is finally discharged to the river. The specific drains discussed in this section collect irrigation water runoff from fields in the Malheur Basin and discharge that water to the Snake River. Other drains in the area discharge to larger drains, to the Malheur River and to the Owyhee River, but all water eventually discharges into the Snake River.

The drains discussed in this section collect water from irrigated fields on the Oregon side of the Snake River near Ontario and Nyssa, Oregon. The irrigated land serviced by these drains is located in some of the most intensively farmed areas of the Treasure Valley. While there is some stormwater runoff that is conveyed to the Snake River via these drains, the majority of the water carried by the drains (and discharged to the Snake) is runoff from agricultural irrigation. In general, in the Malheur River Basin, the irrigation season runs from April 15 to October 15. The non-irrigation season is October 16 to April 14. Depending on the river and irrigation storage conditions, however, the start and end of water delivery during the irrigation season may be adjusted as needed to accommodate wetter spring weather or drought conditions.

[10] Wikipedia

This chapter includes a discussion of water quality data collected by the Malheur SWCD from nine (9) agricultural drains discharging to the Snake River under OWEB grant funding. In addition to the agricultural drain monitoring, it also includes two (2) irrigation water source sites where data were collected. These two irrigation sources provide water to the agricultural land that are drained by Jacobson Gulch, Sheperd Gulch and New Coyote Drains. Water quality data were collected from the drains with the goal of understanding whether or not drain water contributes to water quality exceedances in the Malheur Basin and in the Snake River, and in better characterizing the drainsheds where agricultural practices are improving water quality and those that would benefit from technical assistance in adjusting agricultural management practices.

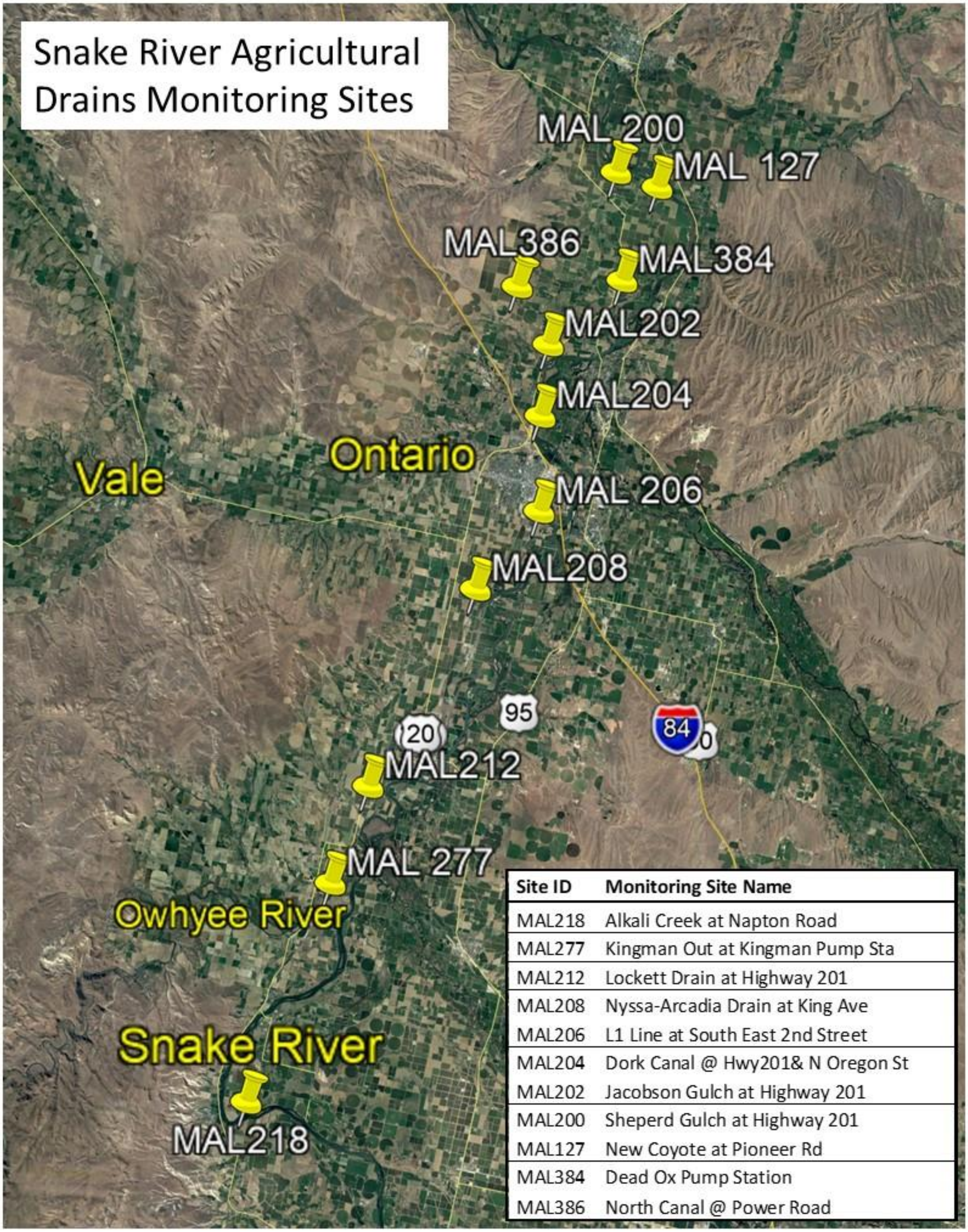
While the drains that were monitored under this project discharge to the Snake River, the drainsheds associated with these drains are located within the Malheur Basin (a drainshed is that area of irrigated land from which runoff water flows into a specific agricultural drain).

There are two Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin: the Malheur River TMDL and the Snake River-Hells Canyon TMDL. TMDLs are water quality management plans compiled by Oregon Department of Environmental Quality (DEQ) with public input. These plans set water quality targets that, if achieved, will allow the water quality in rivers and streams to meet state water quality standards.

In order to reduce complexity and maintain consistency, the total phosphorus target for the Malheur River Basin TMDL and Snake River-Hells Canyon TMDL, and the total suspended solids target for the Snake River-Hells Canyon TMDL will be collectively referred to as “Snake River TMDL targets” on all graphs of water quality data presented in this chapter. Please keep in mind that the Malheur River Basin TMDL target for total phosphorus (0.07 mg/L) applies to all perennial and intermittent streams within the Malheur Basin while the Snake River-Hells Canyon TMDL targets for total phosphorus and total suspended solids apply to waters of the Snake River and to water quality at the mouth of the Malheur River, where it flows into the Snake. The water quality standard for E. coli identified in this chapter is a state-wide standard that applies to all waters with contact recreation as a designated beneficial use. For additional information on the TMDLs, please see the text in the ‘Introduction’ section of this report.

All of the water discussed in this chapter (both from the Malheur River and the agricultural drains) eventually discharges to the Snake River. While the TMDL targets do not apply directly to these drains, when the water quality in the drain exceeds TMDL targets, the drain water is contributing to water quality exceedances in the river. When the water quality in the drain is below TMDL targets, the drain water is not contributing to water quality exceedances in the river.

A map of monitoring sites and tables showing the Snake River agricultural drains monitored by the Malheur SWCD, and the acres of irrigated land served by each of the drains is included on the following pages. Tables showing the median and 90th percentile concentration for the irrigation season and the non-irrigation season for the monitored drains are included on pages 88 and 89. A “90th percentile” concentration means that 90 percent of the data collected are less than this value. 90th percentile values are used in this chapter instead of maximum values because maximum values may represent one-time, uncontrollable events (like thunderstorm-induced runoff) and may not necessarily be reflective of the high concentrations that occur more routinely.



Site ID	Monitoring Site Name
MAL218	Alkali Creek at Napton Road
MAL277	Kingman Out at Kingman Pump Sta
MAL212	Lockett Drain at Highway 201
MAL208	Nyssa-Arcadia Drain at King Ave
MAL206	L1 Line at South East 2nd Street
MAL204	Dork Canal @ Hwy201& N Oregon St
MAL202	Jacobson Gulch at Highway 201
MAL200	Sheperd Gulch at Highway 201
MAL127	New Coyote at Pioneer Rd
MAL384	Dead Ox Pump Station
MAL386	North Canal @ Power Road

<table>
<tr><th>Site Location</th><th>Latitude</th><th>Longitude</th><th>River Mile</th><th>Monitoring Period</th><th>Parameters Monitored</th></tr>
<tr><td>Alkali Creek at Napton Road</td><td>43.67165</td><td>117.07182</td><td>401</td><td rowspan="9">2008 - 2018</td><td rowspan="11">Ortho and Total Phosphorus, E. coli, and Total Suspended Solids for the entire period. NO2-NO3, lab pH, and Turbidity 2008-2014 only.</td></tr>
<tr><td>Kingman Out at Kingman Pump Sta</td><td>43.78978</td><td>117.04695</td><td>392</td></tr>
<tr><td>Lockett Drain at Highway 201</td><td>43.84252</td><td>117.03593</td><td>388</td></tr>
<tr><td>Nyssa-Arcadia Drain at King Ave</td><td>43.95247</td><td>116.99217</td><td>374</td></tr>
<tr><td>L1 Line at South East 2nd Street</td><td>43.99823</td><td>116.95998</td><td>371</td></tr>
<tr><td>Dork Canal @ Hwy201& N Oregon St</td><td>44.04583</td><td>116.97392</td><td>366</td></tr>
<tr><td>Jacobson Gulch at Highway 201</td><td>44.08228</td><td>116.97935</td><td>363</td></tr>
<tr><td>Sheperd Gulch at Highway 201</td><td>44.17562</td><td>116.95868</td><td>352</td></tr>
<tr><td>New Coyote at Pioneer Rd</td><td>44.17271</td><td>116.92797</td><td>352</td></tr>
<tr><td>Dead Ox Pump Station</td><td>44.12233</td><td>116.93799</td><td>359</td><td>2014-2018</td></tr>
<tr><td>North Canal @ Power Road</td><td>44.10755</td><td>117.00997</td><td>N/A</td><td>2011-2018</td></tr>
</table>

Please note: The river mile listed in the table above is the river mile where the drains enter the Snake River. The Sheperd Gulch and New Coyote Drains combine prior to entering the Snake River (at river mile 352). Water quality data from each drain (above the confluence) were collected for this project. If the data from both these drains were displayed on the graphs at river mile 352, it would be difficult to compare or interpret the differences between the two drains. Therefore, on the following plots of water quality data, Sheperd Gulch Drain data are displayed as river mile 351 and New Coyote Drain data are displayed at river mile 352. When reading the water quality data plots, please keep in mind that the combined inflow of both drains is located at river mile 352.

Site ID	Name	Drained Acres	Discharges to	at GPS W	at GPS N
MAL 218	Alkali Creek	2521	Snake River	117 04 25.39	42 40 25.88
MAL 204	Dork	518	Snake River	116 58 23.65	44 02 5290
MAL 202	Jacobson	7212	Snake River	116 58 37.47	44 04 54.70
MAL 277	Kingman	2990	Snake River	117 02 00.28	43 46 44.63
MAL 206	L1	1909	Snake River	116 57 35.00	43 59 52.67
MAL 212	Lockett	1247	Snake River	117 01 44.38	43 50 20.88
MAL 127	New Coyote	1819	Snake River	116 56 20.97	44 11 29.37
MAL 208	Nyssa-Arcadia	8088	Snake River	116 58 36.07	43 58 25.98
MAL 200	Sheperd	1459	Snake River	116 56 20.97	44 11 29.37

AGRICULTURAL DRAIN MONITORING

The water quality data collected at each drain site are discussed in the following paragraphs. For each site, the data have been divided into separate graphs showing the irrigation season (April 15 – October 15) and the non-irrigation season (October 16-April 14) for the Malheur Basin. For comparison purposes, the vertical axes on each of the graphs are the same for both the irrigation and non-irrigation seasons for each parameter.

CONCENTRATION BY RIVER MILE

Drain flow data displayed by river mile for the monitored drains are shown on page 90 for the irrigation season and the non-irrigation season. As the two charts show, the flow in the non-irrigation season is substantially less than that during the irrigation season. The largest drain, from a flow perspective, is the Nyssa-Arcadia Drain with irrigation season flows often over 100 cfs. Even in the non-irrigation season, flows in this drain exceed 40 cfs. Drain flows during the irrigation season (other than the Nyssa-

Arcadia Drain) generally averaged 0 to 60 cfs, while non-irrigation season flows generally averaged less than 15 cfs. This is important from a pollutant transport perspective. A higher drain flow, especially when combined with higher pollutant concentrations, will discharge a greater pollutant load than a drain with a lower flow and lower pollutant concentrations. Data displayed in the statistical tables show that measured pollutant concentrations were generally lower during the non-irrigation season. These lower concentrations, combined with substantially lower drain flows, are a strong indication that the majority of the pollutant load being delivered to the Snake River by these drains occurs during the irrigation season. It strongly suggests that the majority of pollutant loading is directly associated with irrigation runoff water, not stormwater flows.

Graphs of measured ortho phosphorus concentrations by river mile for both the irrigation and non-irrigation seasons from 2008 to 2018 are shown on page 91 for the drain sites listed in the table above. Ortho phosphorus is one component of total phosphorus in the water column and represents that fraction of the total phosphorus that is most readily available to plant and algal growth. Excessive algal growth in drain and river water leads to reduced dissolved oxygen and changes in pH that can be detrimental to fish and other aquatic life and present maintenance delivery difficulties for water conveyance systems.

As displayed in the statistical tables, water quality data collected for these drains show that concentrations of ortho phosphorus measured in the drain water are very often higher than the Snake River TMDL target of 0.07 mg/l for total phosphorus during both the irrigation and non-irrigation seasons. The Alkali Creek Drain site shows the highest concentrations of ortho phosphorus of all the drains monitored (0.19 mg/l and 0.33 mg/l 90th percentile concentration for the irrigation and non-irrigation seasons respectively). The Lockett Drain site shows the lowest concentrations of ortho phosphorus of all the drains monitored (0.08 mg/l and 0.11 mg/l 90th percentile concentration for the irrigation and non-irrigation seasons respectively). While the TMDL target for total phosphorus does not apply directly to the drains, when the water quality in the drain exceeds TMDL targets, the drain water is contributing to water quality exceedances in the river. When the water quality in the drain is below TMDL targets, the drain water is not contributing to water quality exceedances in the river.

There does not appear to be any discernable pattern in ortho phosphorus concentrations as distributed by river mile for either the irrigation season or the non-irrigation season, however, the higher ortho phosphorus concentrations measured at each drain during the non-irrigation season are greater than those measured during the irrigation season for all of the monitored drains. The most probable explanation may be the growth of algae in the drains. Algae growth preferentially removes ortho phosphorus from the water column. Because of the lower water temperatures in the non-irrigation season, less algae growth would occur and therefore more ortho phosphorus would be present in the sampled drain water. These elevated non-irrigation season ortho phosphorus concentrations may also indicate the presence of one or more year-round sources of ortho phosphorus enrichment located within each drainshed. These sources may result in higher ortho phosphorus concentrations in the drain water due to the lower flows occurring in the non-irrigation season (less water in the drain means less opportunity for dilution). The source of these elevated non-irrigation season concentrations should be evaluated further.

Page 92 shows the graphs for total phosphorus concentrations by river mile collected in the same drains for both the irrigation and non-irrigation season. Only two of the total phosphorus concentrations measured during the irrigation and only four of the total phosphorus concentrations measured in the drains were lower than the TMDL target during the non-irrigation season. All other measured concentrations exceeded the target. All of the median total phosphorus concentrations measured in the drains were at least two times higher than the Snake River TMDL target of 0.07 mg/l for total phosphorus for both the irrigation and non-irrigation seasons. (The median value represents the middle point in the measured concentrations; half of the measured data will be less than the median value and half will be greater than the median value.) This means that more than half of the total phosphorus concentrations measured in all of the drains was more than double the TMDL target.

The New Coyote Drain site shows the highest concentrations of total phosphorus of all the drains monitored (1.00 mg/l 90th percentile concentration) for the irrigation season. The Kingman Drain (Kingman Out at Kingman Pump Station) site shows the highest concentrations of total phosphorus of all the drains monitored (0.64 mg/l 90th percentile concentration) for the non-irrigation season. The Jacobson Gulch Drain site shows the lowest concentrations of total phosphorus of all the drains monitored (0.30 mg/l and 0.23 mg/l 90th percentile concentration for the irrigation and non-irrigation seasons respectively). As for ortho phosphorus, the TMDL target for total phosphorus does not apply directly to the drains. However, when the water quality in the drain exceeds TMDL targets, the drain water is contributing to water quality exceedances in the river.

There does not appear to be any discernable pattern in total phosphorus concentrations as distributed by river mile for either the irrigation season or the non-irrigation season. The maximum total phosphorus concentrations measured during the non-irrigation season are greater than those measured during the irrigation season for the Kingman Drain site. These elevated non-irrigation season concentrations may indicate the presence excessive algal growth in the drains during the irrigation season or may be indicative of one or more year-round sources of phosphorus enrichment located within the drainshed. These sources may result in higher concentrations instream due to the lower flows occurring in the non-irrigation season (less water in the drain means less opportunity for dilution). The source of these maximum concentrations should be evaluated further.

The irrigation and non-irrigation season graphs by river mile for TSS concentrations measured in the drains are displayed on page 93. The vast majority of measured TSS concentrations in the irrigation season exceed the 50 mg/l Snake River TMDL target at all drain sites. Many measured TSS concentrations are more than 10 times greater than the TMDL target, over 500 mg/l. During the non-irrigation season, the measured TSS concentrations are lower but most still exceed the TMDL target. As displayed in the statistical tables, only two drain sites (Kingman and Jacobson Gulch) show median concentrations of TSS that are less than the Snake River TMDL TSS target of 50 mg/l during the irrigation season. All of the 90th percentile concentrations measured at all drain sites exceed the TMDL target of 50 mg/l during the irrigation season. Only two drain sites (Kingman and Lockett) show median concentrations of TSS that are greater than the Snake River TMDL TSS target of 50 mg/l during the non-irrigation season; these concentrations were very close to the target however (52 mg/l). Only three drain sites (L1 Line, Dork Canal and Jacobson Gulch) show 90th percentile TSS concentrations below the TMDL target during the non-irrigation season. There does not appear to be any discernable pattern in measured TSS phosphorus concentrations as distributed by river mile for either the irrigation season or the non-irrigation season.

The irrigation and non-irrigation season graphs by river mile for E. coli concentrations measured in the drains are displayed on page 94. The measured data show many exceedances of the Oregon standard of 406 count/100mls during the irrigation season at all drain sites. While measured E. coli concentrations are lower during the non-irrigation season, multiple samples at all drain sites show concentrations that exceed the Oregon standard. Two drain sites (Kingman and Jacobson Gulch) show median concentrations of E. coli that exceed the state standard during the irrigation season. The data collected at the Jacobson Gulch Drain site also show a median concentration of E. coli that exceeds the state standard during the non-irrigation season. All 90th percentile E. coli concentrations measured at all drain sites exceed the state standard during the irrigation season. The 90th percentile E. coli concentration measured at four drain sites (Alkali Creek, Kingman, Lockett and Jacobson Gulch) exceed the state standard during the non-irrigation season. There does not appear to be any discernable pattern in E. coli concentrations as distributed by river mile for either the irrigation season or the non-irrigation season.

CONCENTRATION OVER TIME

The preceding sections present data collected at each drain by river mile relative to the location of drain discharge to the Snake River; a display of data vs distance. There were no obvious spatial relationships that emerged from this evaluation. The concentrations measured in drains discharging to downstream locations on the Snake River are generally similar in distribution to the concentrations measured in drains discharging to upstream locations on the river.

The collected water quality data were also evaluated relative to time to better characterize temporal patterns or relationships within the data set.

The Nyssa-Arcadia Drain is one of the larger agricultural drains in the Malheur Basin and the largest (relative to flow) of the drains monitored as part of this project. The Jacobson Gulch Drain is a mid-sized drain (relative to flow). As these two drain sites represent both high flow and mid-flow conditions for the drains monitored as part of this project, and as the patterns observed in the data collected from these drains are generally representative of the patterns observed in the data collected from all of the drains discussed in this chapter, detailed graphs and discussion of only these two drains will be included in this chapter. (Please see the digital appendix of this report for graphs of ortho and total phosphorus, TSS, and E. coli concentrations for both the irrigation and non-irrigation season for the Alkali, Kingman, Lockett, L1 Line, Dork, Sheperd Gulch and New Coyote Drains) all of which discharge to the Snake River.)

Page 95 shows the single-measurement flow data for the Nyssa-Arcadia Drain for both the irrigation and non-irrigations seasons. (Note: this is called a single-measurement flow rate because it was a single (instantaneous) measurement taken at the time the water quality sample was taken, not a continuous measurement like would be recorded by a permanent gage site.) Flow data were only collected from 2013 to 2016. This data set is not sufficient to determine if flow is changing over time. Measured flows are highly variable, especially during the irrigation season. Flows measured during the non-irrigation season are much lower than those measured during the irrigation season.

Page 96 shows the ortho and total phosphorus collected for both the irrigation and non-irrigations seasons for the Nyssa-Arcadia Drain. For both seasons, all of the total phosphorus and the vast majority of the ortho phosphorus concentrations measured are above the Snake River TMDL target of 0.07 mg/l (median = 0.35 mg/l total phosphorus and 0.10 mg/l ortho phosphorus for the irrigation season; median

= 0.22 mg/l total phosphorus and 0.15 mg/l ortho phosphorus for the non-irrigation season). The measured total phosphorus concentrations are much higher during the irrigation season than the non-irrigation season. Measured ortho phosphorus concentrations are very similar in both seasons. While all measured total phosphorus concentrations in both seasons exceed the TMDL target, total phosphorus concentrations measured in the irrigation season appear to show a decrease over time. There is no discernable change in the ortho phosphorus concentrations over time for either season.

The graphs for E. coli and TSS for both the irrigation and non-irrigation seasons for the Nyssa-Arcadia Drain site are displayed on page 97. For TSS at the Nyssa-Arcadia Drain site during the irrigation season, all but two of the measured TSS concentrations are greater than the Snake River TMDL TSS target of 50 mg/l. Measured TSS concentrations appear to be decreasing over time during the irrigation season. During the non-irrigation season, the majority of the samples had measured concentrations that were less than the TMDL target.

For E. coli, the measured concentrations are much higher during the irrigation season than the non-irrigation season. While there are several measured concentrations that exceed the Oregon water quality standard of 406 counts/100mls during the irrigation season, the majority of the measured concentrations were below the standard. Only a few measured E. coli concentrations exceeded the Oregon water quality standard during the non-irrigation season. There is no discernable change in concentration over time for E. coli in either season.

Page 98 shows the single-measurement flow rates for the Jacobson Gulch Drain for both the irrigation and non-irrigation seasons. Measured flows are highly variable, especially during the irrigation season. Flows measured during the non-irrigation season are much lower than those measured during the irrigation season.

Page 99 shows the ortho and total phosphorus data collected for Jacobson Gulch Drain for both the irrigation season and non-irrigation season. During the irrigation season, approximately half of the measured ortho phosphorus concentrations exceeded the Snake River TMDL target of 0.07 mg/l for total phosphorus; all but three of the measured total phosphorus concentrations exceed the target. For the non-irrigation season, only three samples show concentrations of ortho phosphorus below the target and only one sample showed concentrations of total phosphorus below the target (median = 0.12 mg/l total phosphorus and 0.06 mg/l ortho phosphorus for the irrigation season; median = 0.16 mg/l total phosphorus and 0.13 mg/l ortho phosphorus for the non-irrigation season). There is no discernable change in either the ortho or total phosphorus concentrations over time for either season.

There does not appear to be any discernable pattern in total phosphorus concentrations as distributed by river mile for either the irrigation season or the non-irrigation season. Both the median total and ortho phosphorus concentrations measured during the non-irrigation season are greater than those measured during the irrigation season for the Jacobson Gulch Drain site. These elevated non-irrigation season concentrations may indicate the presence of one or more year-round sources of phosphorus enrichment located within the drainshed. These sources may result in higher concentrations instream due to the lower flows occurring in the non-irrigation season (less water in the drain means less opportunity for dilution). The source of these maximum concentrations should be evaluated further.

Page 100 shows the TSS and E. coli graphs for both seasons. For E. coli at the Jacobson Gulch Drain site, most of the measured concentrations exceed the Oregon standard of 406 count/100mls during both the irrigation and non-irrigation seasons. The information provided in the statistical tables shows that the median values measured during both seasons were higher than 406 count/100mls (680 count/100mls in the irrigation season, 500 count/100mls in the non-irrigation season). There is no discernable change in concentration over time for E. coli in either season at this site.

During the irrigation season, less than half of the measured TSS concentrations in Jacobson Gulch Drain exceeded the Snake River TMDL target of 50 mg/l (median = 30 mg/l irrigation season, 12 mg/l non-irrigation season). During the non-irrigation season, only one sampled concentration was higher than the target. However, measured concentrations for both seasons appear to be increasing over time at this site.

Irrigation Source Water Monitoring

The Malheur SWCD also collected water quality data during the irrigation season at the Dead Ox Pump Station and at the North Canal. The Dead Ox Pump Station (operated by the Owyhee Irrigation District) extracts water from the Snake River and distributes it for irrigation. The North Canal contains irrigation water diverted from the Owyhee River and delivered by Owyhee Irrigation District for irrigation. Both of these irrigation water sources provide water to agricultural lands from which the Jacobson Gulch, Sheperd Gulch, and New Coyote Drains collect runoff. The following pages contain the graphs for both the Dead Ox Pump Station and the North Canal site for the irrigation season. (Data were only collected during the irrigation season.) The vertical axes on the graphs for Dead Ox Pump Station and the North Canal sites have been set to the same ranges as those for the Jacobson Gulch Drain graphs so that the data from the two irrigation water sources can be compared directly to the Jacobson Gulch Drain data.

Water quality data from the Dead Ox Pump Station and the North Canal are displayed on pages 101 and 102. It is recognized that the source water from these two sites is not the source water for all drains monitored in this project. It is also recognized that monitoring at these sites is representative of the quality of water diverted directly from the Snake and Owyhee Rivers; it is not necessarily representative of the quality of the water that some producers receive (which has been used for irrigation, perhaps multiple times, and is therefore enriched when it is received, before it is applied to their fields). In this section, the water quality data from the Dead Ox Pump Station and the North Canal are used as a comparison to better understand the difference in water quality from the river to the water quality in the Jacobson Gulch, Shepard Gulch and New Coyote Drains, which collect runoff from land that has been irrigated.

The graphs shown on page 101 display the ortho and total phosphorus concentrations measured over time at the Dead Ox Pump Station during the irrigation season (2014 through 2018). As displayed in the statistical tables in this chapter, the median ortho phosphorus concentration measured at the Dead Ox Pump Station was 0.05 mg/l, indicating that well more than half of the measured ortho phosphorus concentrations at this site were below the Snake River TMDL target of 0.07 mg/l during the irrigation season. The 90th percentile ortho phosphorus concentration measured at this site (0.07 mg/l) is approximately two thirds of the 90th percentile concentration measured at the Jacobson Gulch Drain site (0.12 mg/l). The collected ortho phosphorus data from the Dead Ox Pump Station site do not appear to display any discernable pattern over time.

All but one of the measured total phosphorus concentrations at this site were above the Snake River TMDL target of 0.07 mg/l. The median total phosphorus concentration measured at the Dead Ox Pump

Station was 0.12 mg/l, the same as the median total phosphorus concentration measured in Jacobson Gulch Drain during the irrigation (0.12 mg/l). The 90th percentile total phosphorus concentration measured at this site (0.14 mg/l) is less than one half of the 90th percentile concentration measured at the Jacobson Gulch Drain site (0.30 mg/l). The collected total phosphorus data from the Dead Ox Pump Station site do not appear to display any discernable pattern over time.

All but four of the TSS concentrations measured at the Dead Ox Pump Station site (graphs on page 101) are well below the Snake River TMDL target of 50 mg/l. The median TSS concentration measured at the Dead Ox Pump Station site is slightly higher but very similar to the median concentration measured at the Jacobson Gulch Drain site during the irrigation season (35 mg/l and 30 mg/l respectively). Both are below the Snake River TMDL target. The 90th percentile TSS concentration measured at the Dead Ox Pump Station site (46 mg/l) is about one half of the 90th percentile TSS concentration measured at the Jacobson Gulch Drain site (107 mg/l). The collected TSS data from the Dead Ox Pump Station site do not appear to display any discernable pattern over time.

E. coli concentration data collected at the Dead Ox Pump Station site (irrigation season, 2014 through 2018) are shown in the graphs on page 101. For E. coli during the irrigation season, only two of the measured concentrations are greater than the Oregon standard of 406 count/100mls. The median E. coli concentration measured at the Dead Ox Pump Station site (60 counts/100ml) is less than one tenth of the median concentration measured at the Jacobson Gulch Drain site (680 counts/100ml). The 90th percentile E. coli concentration measured at the Dead Ox Pump Station site (116 count/100ml) is 25 times smaller than the 90th percentile E. coli concentration measured at the Jacobson Gulch Drain site (3000 count/100ml). The collected E. coli data from the Dead Ox Pump Station site do not appear to display any discernable pattern over time.

The graphs shown on page 102 display the ortho and total phosphorus concentrations measured over time at the North Canal site during the irrigation season (2014 through 2018). All but one of the measured ortho phosphorus concentrations at this site were below the Snake River TMDL target of 0.07 mg/l during the irrigation season. The median ortho phosphorus concentration measured at the North Canal site was 0.01 mg/l (six times lower than the median concentration measured in Jacobson Gulch Drain (0.06 mg/l)). The 90th percentile ortho phosphorus concentration measured at this site is 0.06 mg/l, approximately one half of the 90th percentile concentration measured at either the Jacobson Gulch Drain site (0.12 mg/l). The collected ortho phosphorus data from the North Canal site do not appear to display any discernable pattern over time.

The median total phosphorus concentration measured at the North Canal site was 0.06 mg/l (approximately one half of the median concentration measured at the Jacobson Gulch Drain site (0.12 mg/l)) indicating that well more than half of the measured total phosphorus concentrations at the North Canal site were below the Snake River TMDL target of 0.07 mg/l during the irrigation season. The 90th percentile total phosphorus concentration measured at the North Canal site (0.11 mg/l) is approximately one third of the 90th percentile concentration measured at the Jacobson Gulch Drain site (0.30 mg/l). The collected total phosphorus data from the North Canal site do not appear to display any discernable pattern over time.

The vast majority of the TSS concentrations measured at the North Canal site (also on page 102) are well below the Snake River TMDL target of 50 mg/l (only six concentrations exceed the target). The median TSS concentration measured at the North Canal site is about half of the median concentration measured at the Jacobson Gulch Drain site during the irrigation season (18 mg/l and 30 mg/l, respectively). Both are below the Snake River TMDL target. The 90th percentile TSS concentration measured at the North Canal site (68 mg/l), is about two thirds of the 90th percentile TSS concentration measured at the Jacobson Gulch Drain site (107 mg/l). The collected TSS data from the North Canal site appear to show a slight decrease in concentration over time but this is a very small data set. More data would be needed to be conclusive.

E. coli concentration data collected at the North Canal site (irrigation season, 2014 through 2018) are shown in the graphs on page 102. For E. coli during the irrigation season, six of the measured concentrations exceed the Oregon standard of 406 count/100mls. The median E. coli concentration at the North Canal site (120 counts/100ml) is less than one fifth of the median concentration measured at the Jacobson Gulch Drain site (680 counts/100ml). The 90th percentile E. coli concentration measured at the North Canal site (660 count/100ml) is 4 times smaller than the 90th percentile E. coli concentration measured at the Jacobson Gulch Drain site (3000 count/100ml). The collected E. coli data from the North Canal site do not appear to display any discernable pattern over time.

Comparison of river and drain water quality

Data collected at the North Canal site are reflective of water diverted from the Owyhee River. The water quality at this site is a combination of river water and (potentially) agricultural drain discharge as well as discharge from other land uses (rural and suburban inputs). This site is relatively far from the diversion site so the water in the canal may not be directly representative of the quality of water at the diversion point.

Data collected at the Dead Ox Pump Station site are reflective of water diverted directly from the Snake River and should be representative of water quality in the Snake at the diversion point. The water quality at this site is a combination of river water and agricultural drain discharge as well as discharge from other land uses (urban and suburban inputs). The Snake River is a very long river (1,078 miles) and travels through intensive agriculture for the majority of its length. It receives the discharge from numerous agricultural and stormwater drains, urban and suburban runoff and the discharge of permitted industrial and municipal waste waters in both Idaho and Oregon. Because of its greater length and the greater number of point and non-point discharges along that length, the potential for cumulative pollutant loading into the Snake is substantially greater than that for the Owyhee River.

Data collected at the site on the Jacobson Gulch Drain are reflective of drain runoff from intensive agriculture (predominantly row crops).

Relevant statistical data from these three sites are displayed in the table on the following page. (Data displayed in the table are from the irrigation season only.)

When the water quality data collected at both the Dead Ox Pump Station site (Snake River water) and the North Canal site (Owyhee River water) are compared to the data collected at the mouth of the Jacobson Gulch Drain, the consistently higher concentrations of phosphorus, TSS and E. coli measured at the mouth of the drains is strongly indicative of substantial enrichment and higher pollutant loading in the drain water. The only exception to this is the similar median concentrations of TSS measured at the Dead Ox Pump Station site and the Jacobson Gulch Drain site during the irrigation season (35 mg/l and 30 mg/l respectively). This pattern of higher pollutant concentrations in the drain flows than in the source water is generally representative of the patterns seen in the other monitored drains.

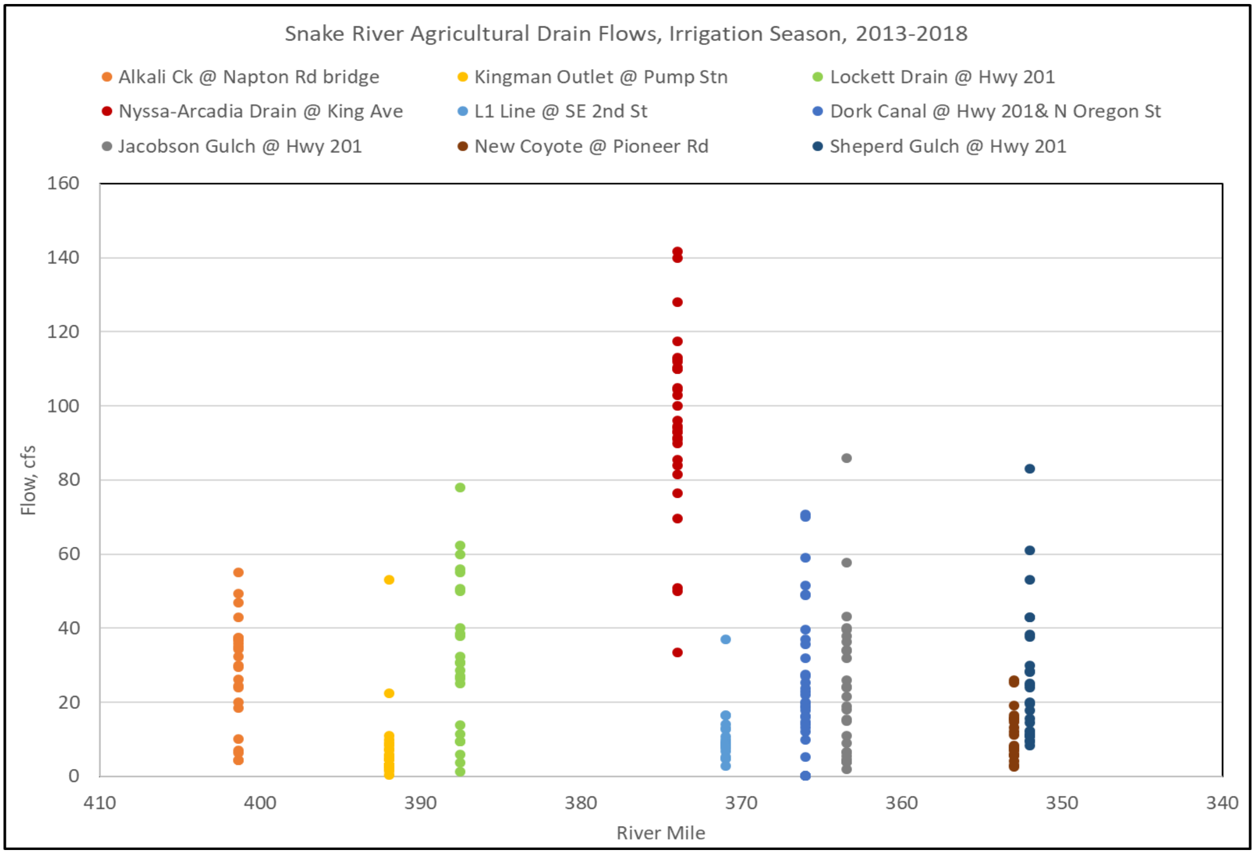
Site Location	Median Tot Phos (mg/l)	90th Percentile Tot Phos (mg/l)	Median TSS (mg/l)	90th Percentile TSS (mg/l)	Median E. coli (count/100ml)	90th Percentile E. coli (count/100ml)
North Canal (Owyhee River water)	0.06	0.11	18	68	120	660
Dead Ox Pump Station (Snake River water)	0.12	0.14	35	46	60	116
Jacobson Gulch Drain	0.12	0.30	30	107	680	3000

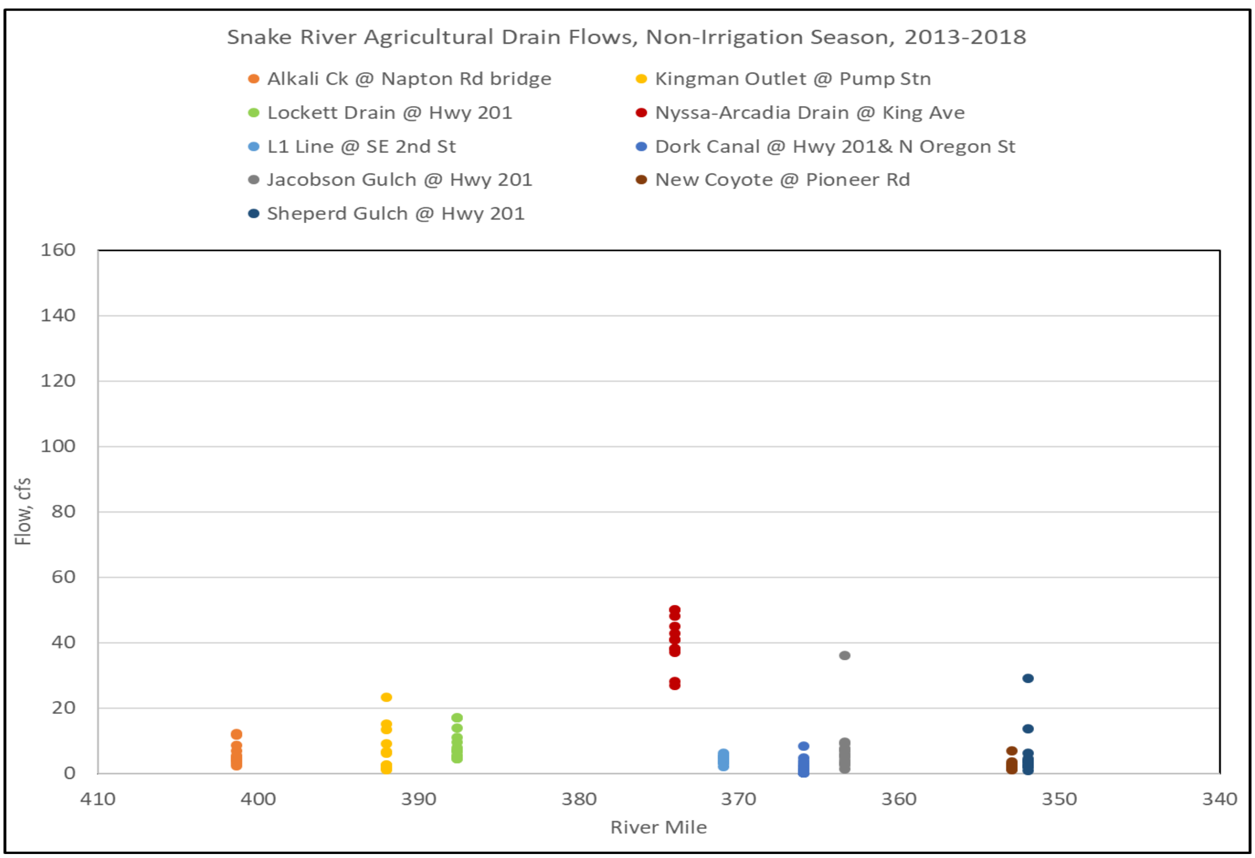
In general, the North Canal site (diverted Owyhee River water) has the highest water quality (although it did not meet the TMDL targets or state standards all the time), the site at the Dead Ox Pump Station (diverted Snake River water) has the second highest water quality of the three sites and the Jacobson Gulch Drain site shows the lowest water quality of the three sites.

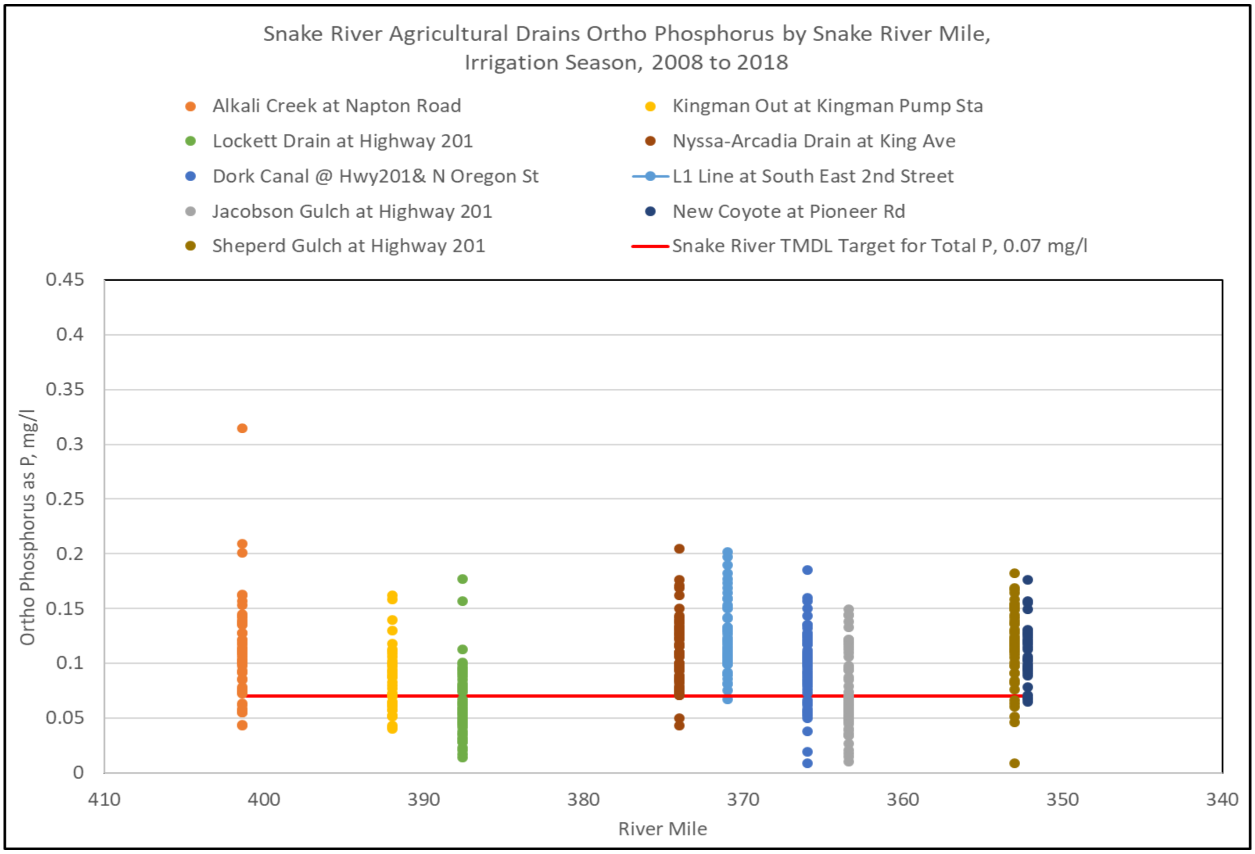
Please see the digital appendix of this report for graphs of ortho and total phosphorus, TSS, and E. coli concentrations for both the irrigation and non-irrigation season for the Alkali, Kingman, Lockett, L1 Line, Dork, Sheperd Gulch and New Coyote) all of which discharge to the Snake River.

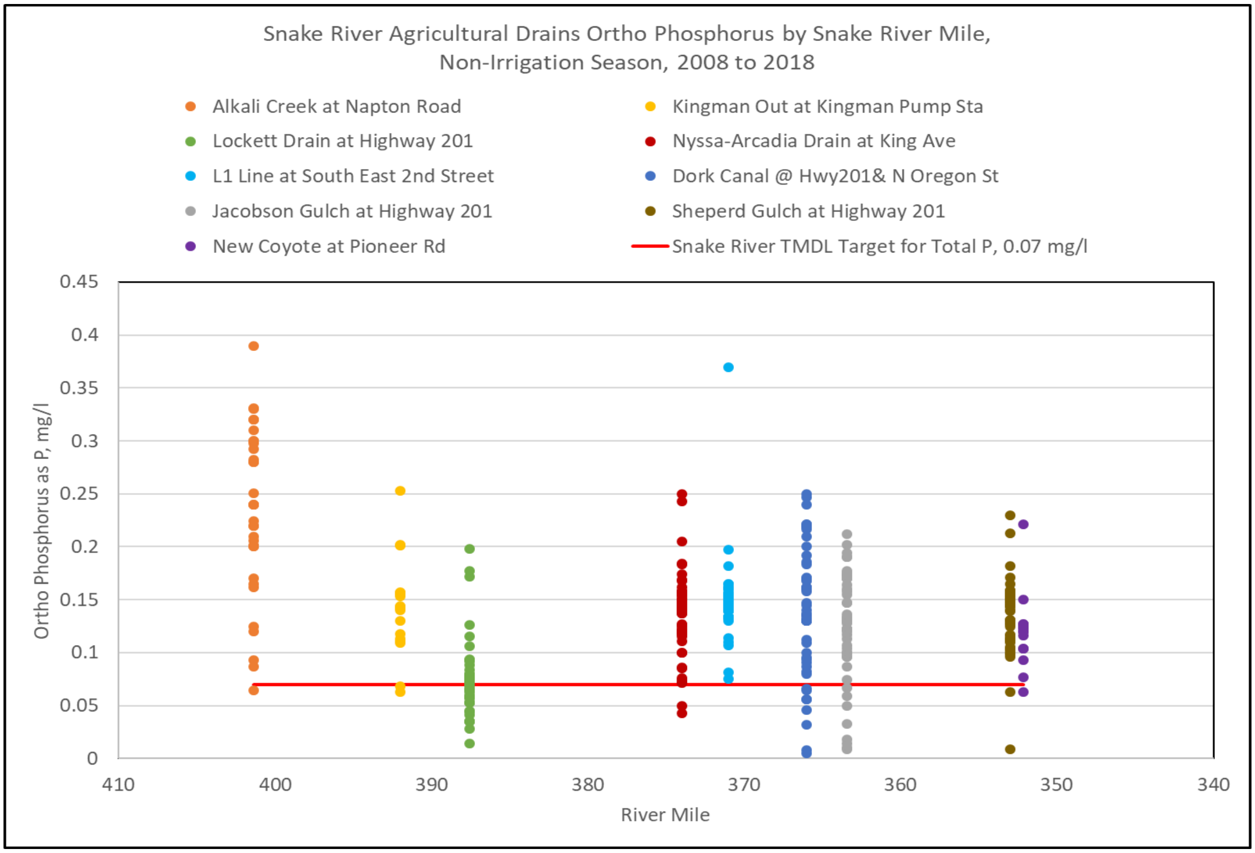
Water Quality data from Snake River Agricultural Drain monitoring **IRRIGATION SEASON**											
Site Location	**River Mile**	**Median Flow**	**90th Percentile Flow**	**Median ortho phos**	**90th Percentile ortho phos**	**Median total phos**	**90th Percentile total phos**	**Median TSS**	**90th Percentile TSS**	**Median E. coli**	**90th Percentile E. coli**
Alkali Creek at Napton Road	401	31	46	0.11	0.19	0.23	0.38	72	345	300	860
Kingman Out at Kingman Pump Sta	392	4.6	11	0.07	0.14	0.18	0.35	36	118	500	740
Lockett Drain at Highway 201	388	31	59	0.05	0.08	0.21	0.74	118	528	120	994
Nyssa-Arcadia Drain at King Ave	374	95	119	0.10	0.14	0.35	0.59	181	285	180	900
L1 Line at South East 2nd Street	371	8.8	16	0.11	0.14	0.35	0.63	134	262	200	700
Dork Canal @ Hwy201& N Oregon St	366	20	51	0.10	0.17	0.34	0.55	139	297	400	2040
Jacobson Gulch at Highway 201	363	19	41	0.06	0.12	0.12	0.30	30	107	680	3000
New Coyote at Pioneer Rd	352	9.8	19	0.12	0.15	0.48	1.00	302	605	360	700
Sheperd Gulch at Highway 201	352	20	47	0.12	0.15	0.45	0.95	234	412	280	900
Dead Ox Pump Station	359	-	-	0.05	0.07	0.12	0.14	35	46	60	116
North Canal @ Power Road	N/A	-	-	0.01	0.06	0.06	0.11	18	68	120	660

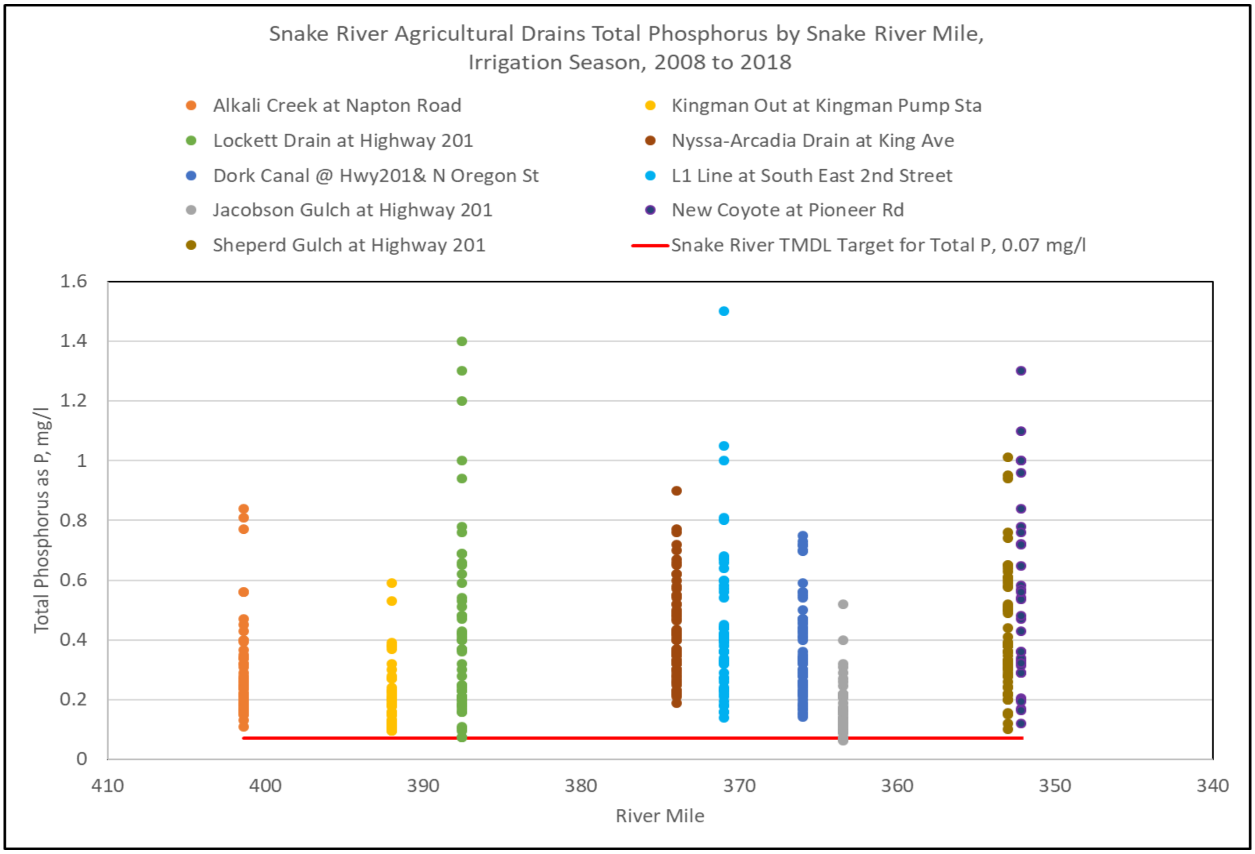
Water Quality data from Snake River Agricultural Drain monitoring NON-IRRIGATION SEASON											
Site Location	**River Mile**	**Median Flow**	**90th Percentile Flow**	**Median ortho phos**	**90th Percentile ortho phos**	**Median total phos**	**90th Percentile total phos**	**Median TSS**	**90th Percentile TSS**	**Median E. coli**	**90th Percentile E. coli**
Alkali Creek at Napton Road	401	4.9	12	0.16	0.33	0.27	0.40	10	105	100	2400
Kingman Out at Kingman Pump Sta	392	6.3	15	0.14	0.20	0.22	0.64	52	321	60	1000
Lockett Drain at Highway 201	388	7.1	16	0.07	0.11	0.13	0.52	52	409	116	832
Nyssa-Arcadia Drain at King Ave	374	41	50	0.15	0.24	0.22	0.34	31	52	50	370
L1 Line at South East 2nd Street	371	4.3	5.5	0.15	0.16	0.18	0.29	13	35	17	136
Dork Canal @ Hwy201& N Oregon St	366	1.1	4.3	0.18	0.26	0.23	0.38	13	38	70	360
Jacobson Gulch at Highway 201	363	6.0	9	0.13	0.17	0.16	0.23	12	37	500	1420
New Coyote at Pioneer Rd	352	2.3	3.4	0.12	0.16	0.15	0.27	23	58	60	272
Sheperd Gulch at Highway 201	352	3.8	12	0.15	0.16	0.18	0.25	31	64	60	200
Dead Ox Pump Station	359	-	-	-	-	-	-	-	-	-	-
North Canal @ Power Road	N/A	-	-	-	-	-	-	-	-	-	-

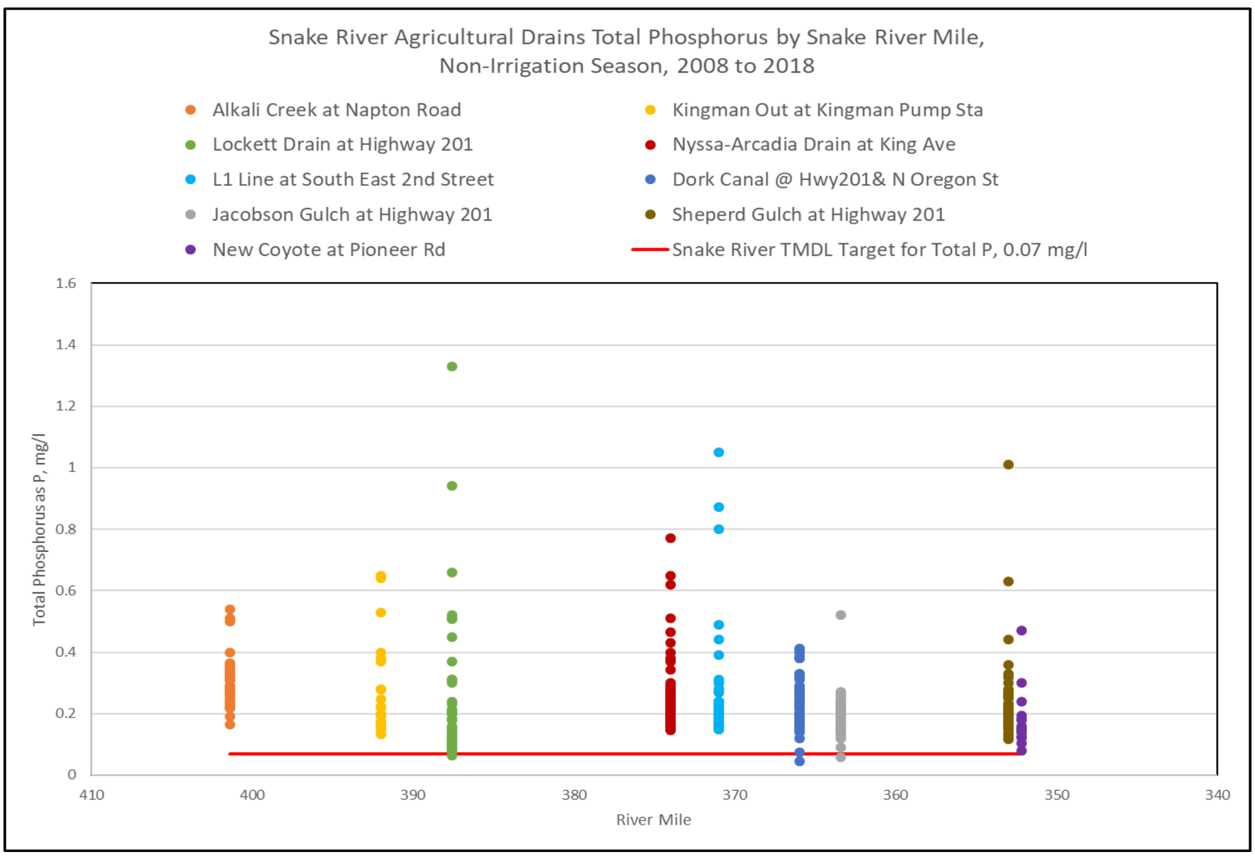

Snake River Agricultural Drain Flows, Irrigation Season, 2013-2018
Alkali Ck @ Napton Rd bridge
Kingman Outlet @ Pump Stn
Lockett Drain @ Hwy 201
Nyssa-Arcadia Drain @ King Ave
L1 Line @ SE 2nd St
Dork Canal @ Hwy 201& N Oregon St
Jacobson Gulch @ Hwy 201
New Coyote @ Pioneer Rd
Sheperd Gulch @ Hwy 201
Flow, cfs
0
20
40
60
80
100
120
140
160
410
400
390
380
370
360
350
340
River Mile

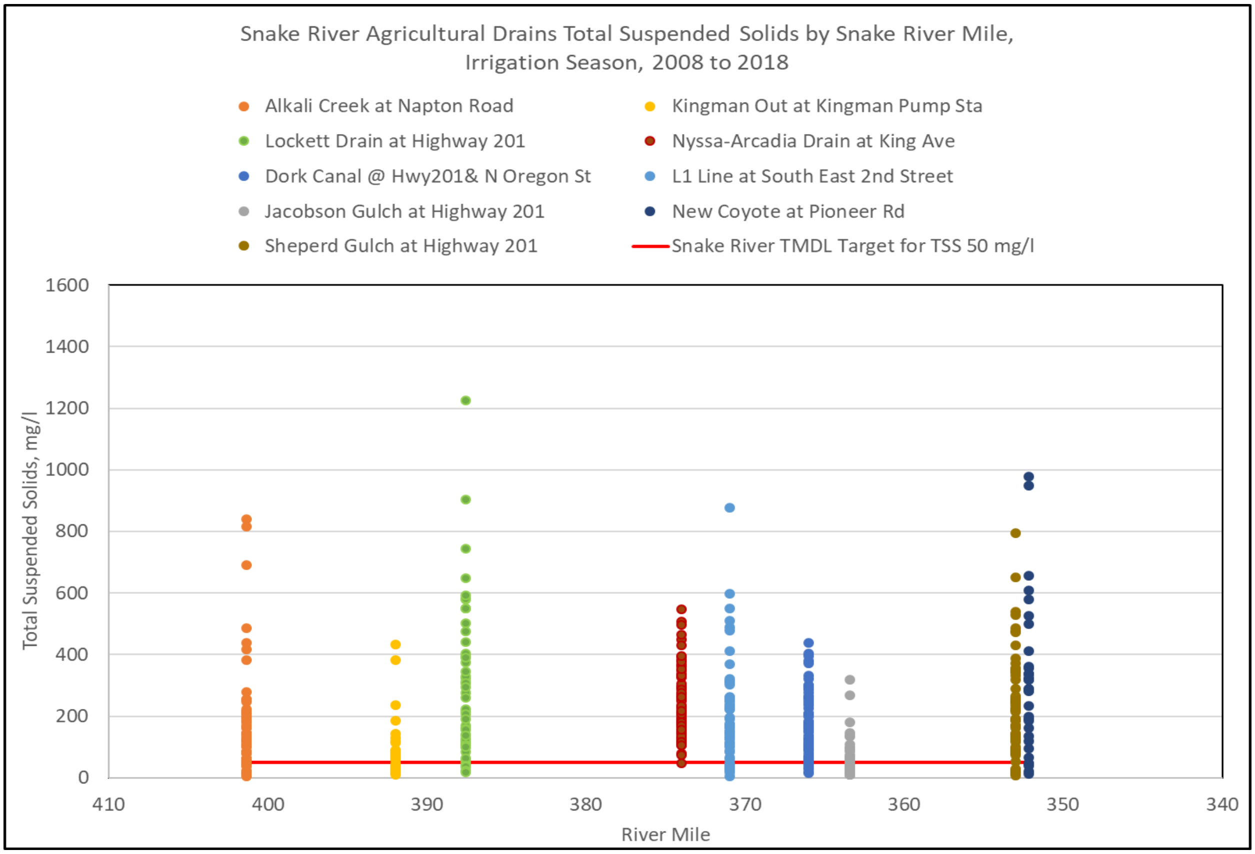

Snake River Agricultural Drain Flows, Non-Irrigation Season, 2013-2018
Alkali Ck @ Napton Rd bridge
Kingman Outlet @ Pump Stn
Lockett Drain @ Hwy 201
Nyssa-Arcadia Drain @ King Ave
L1 Line @ SE 2nd St
Dork Canal @ Hwy 201& N Oregon St
Jacobson Gulch @ Hwy 201
New Coyote @ Pioneer Rd
Sheperd Gulch @ Hwy 201
Flow, cfs
0
20
40
60
80
100
120
140
160
410
400
390
380
370
360
350
340
River Mile

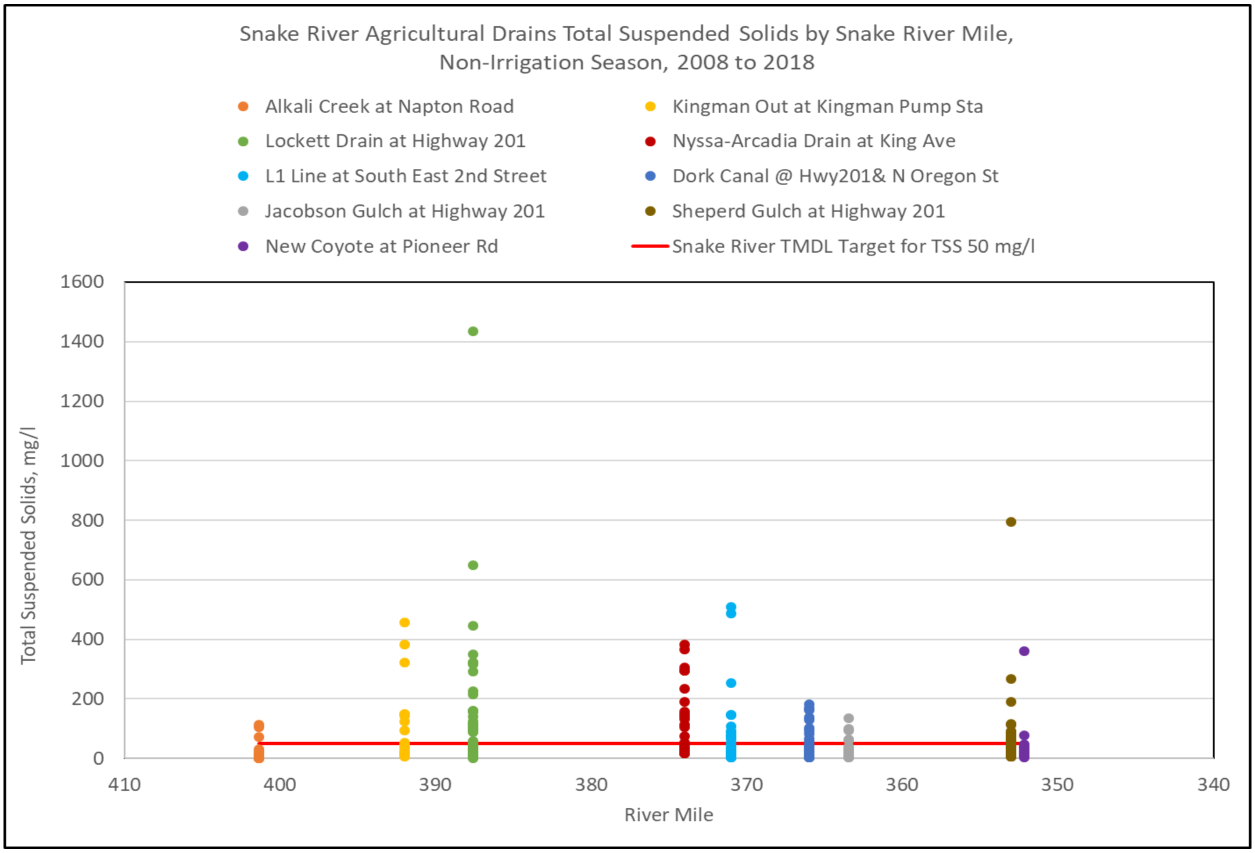

Snake River Agricultural Drains Ortho Phosphorus by Snake River Mile, Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
Dork Canal @ Hwy201& N Oregon St
L1 Line at South East 2nd Street
Jacobson Gulch at Highway 201
New Coyote at Pioneer Rd
Sheperd Gulch at Highway 201
Snake River TMDL Target for Total P, 0.07 mg/l
Ortho Phosphorus as P, mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
410
400
390
380
370
360
350
340
River Mile

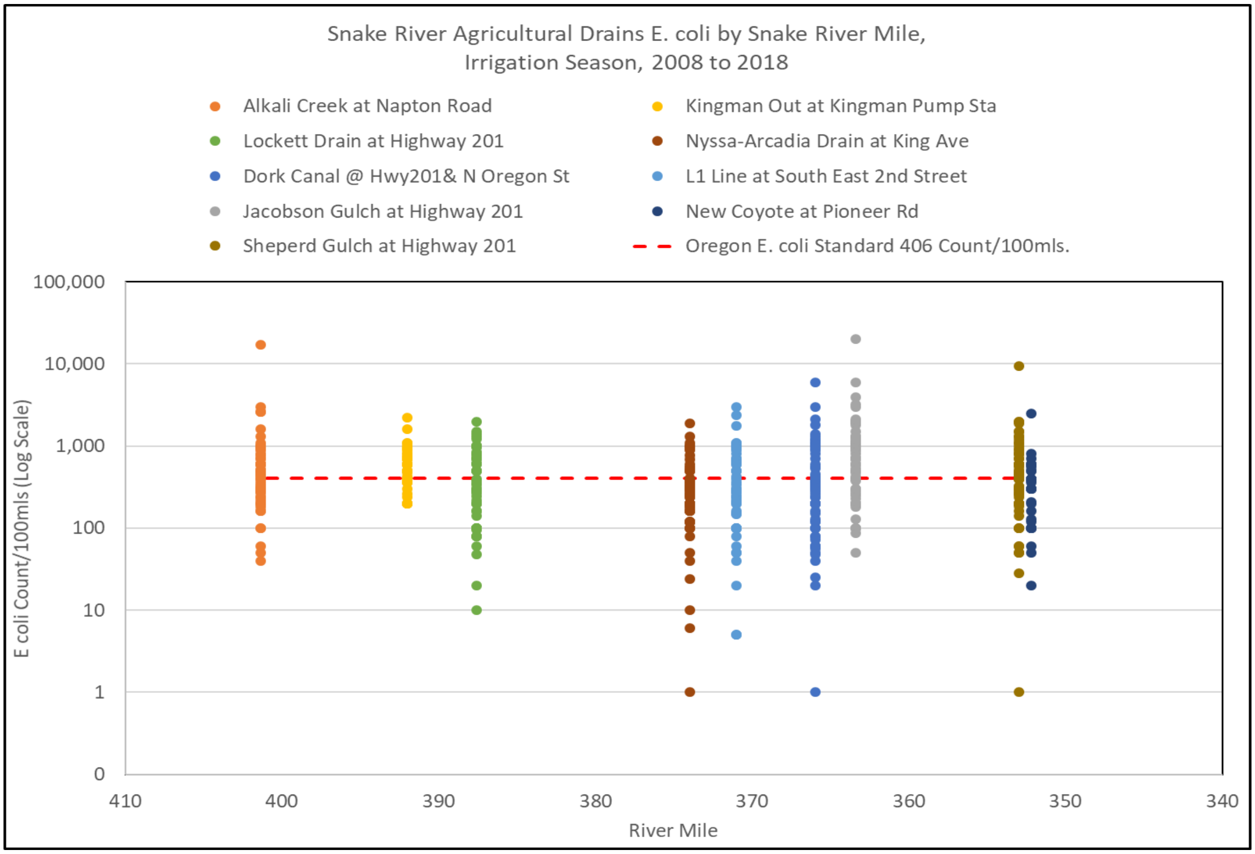

Snake River Agricultural Drains Ortho Phosphorus by Snake River Mile, Non-Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
L1 Line at South East 2nd Street
Dork Canal @ Hwy201& N Oregon St
Jacobson Gulch at Highway 201
Sheperd Gulch at Highway 201
New Coyote at Pioneer Rd
Snake River TMDL Target for Total P, 0.07 mg/l
Ortho Phosphorus as P, mg/l
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
410
400
390
380
370
360
350
340
River Mile

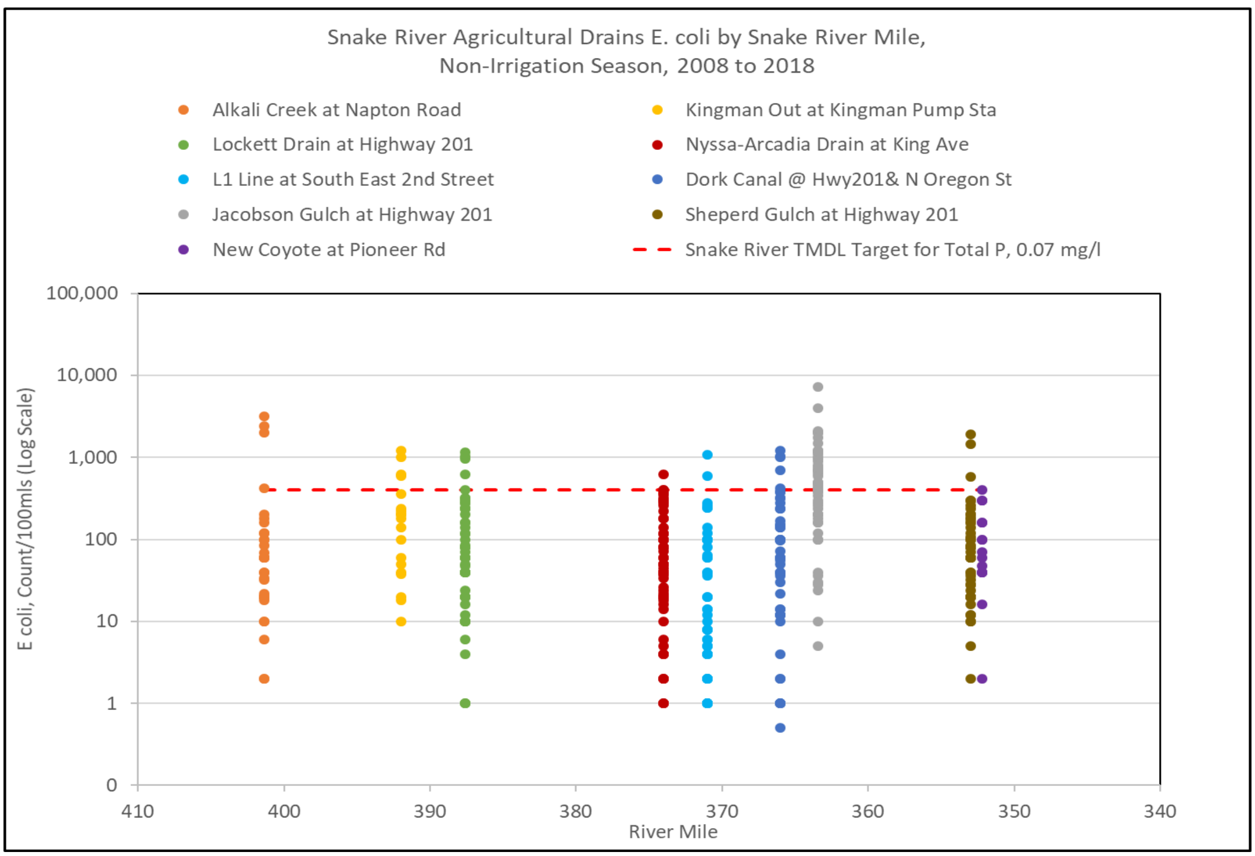

Snake River Agricultural Drains Total Phosphorus by Snake River Mile, Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
Dork Canal @ Hwy201& N Oregon St
L1 Line at South East 2nd Street
Jacobson Gulch at Highway 201
New Coyote at Pioneer Rd
Sheperd Gulch at Highway 201
Snake River TMDL Target for Total P, 0.07 mg/l
Total Phosphorus as P, mg/l
River Mile

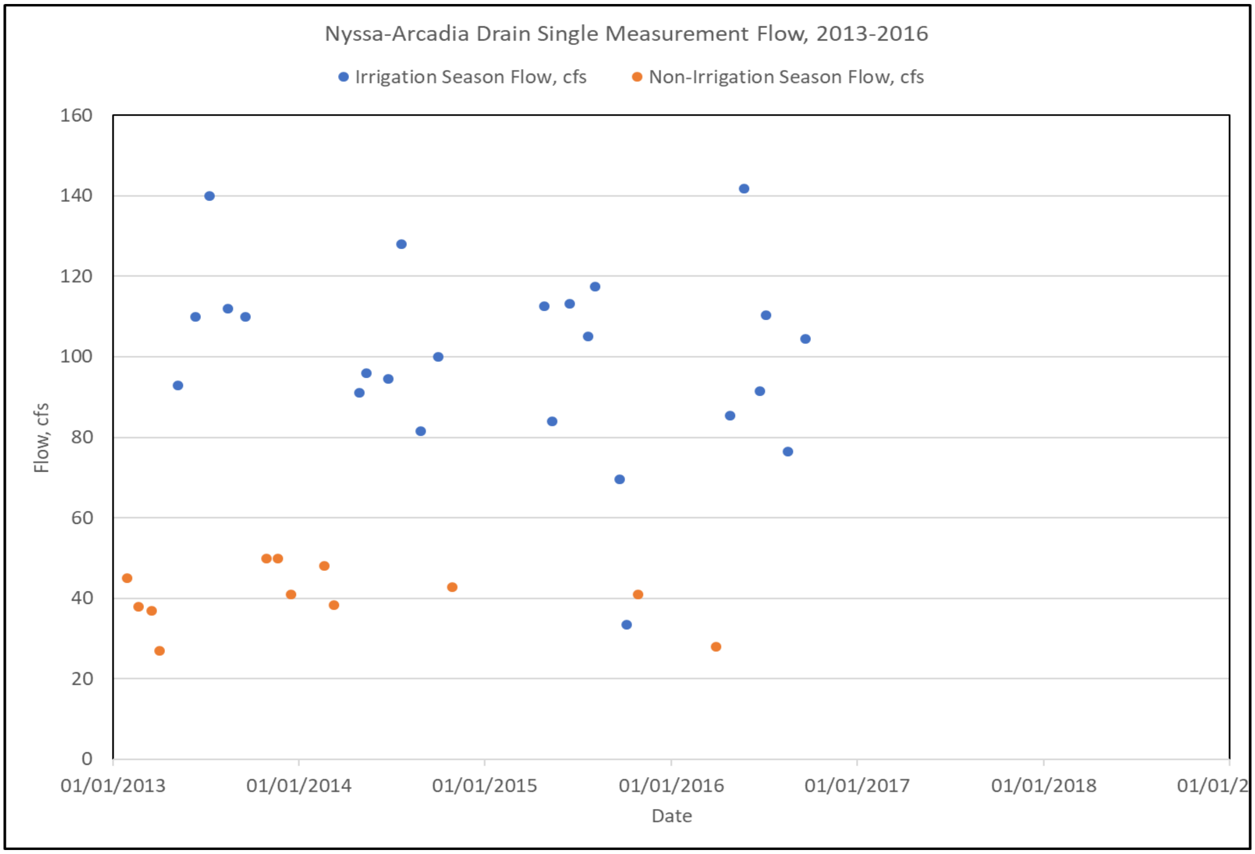

Snake River Agricultural Drains Total Phosphorus by Snake River Mile, Non-Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
L1 Line at South East 2nd Street
Dork Canal @ Hwy201& N Oregon St
Jacobson Gulch at Highway 201
Sheperd Gulch at Highway 201
New Coyote at Pioneer Rd
Snake River TMDL Target for Total P, 0.07 mg/l
Total Phosphorus as P, mg/l
River Mile

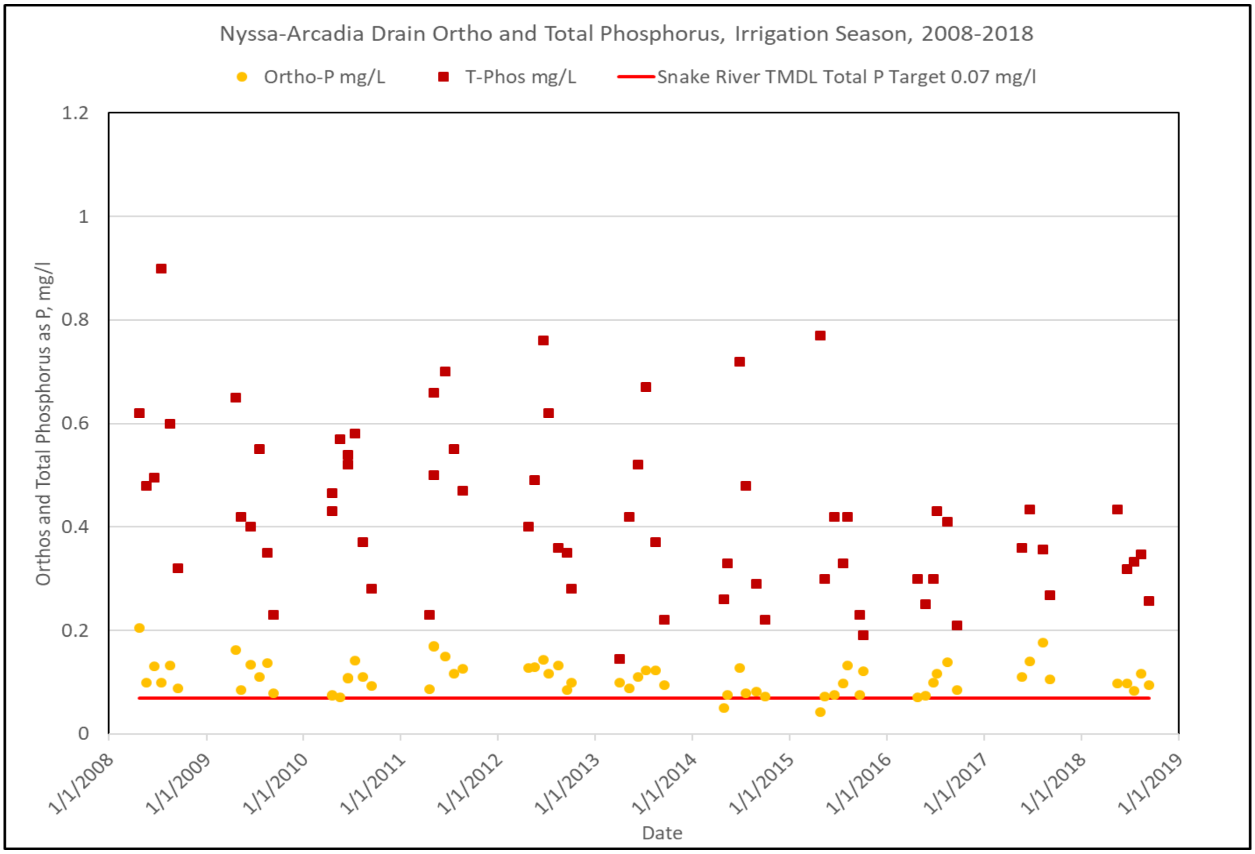

Snake River Agricultural Drains Total Suspended Solids by Snake River Mile, Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
Dork Canal @ Hwy201& N Oregon St
L1 Line at South East 2nd Street
Jacobson Gulch at Highway 201
New Coyote at Pioneer Rd
Sheperd Gulch at Highway 201
Snake River TMDL Target for TSS 50 mg/l
Total Suspended Solids, mg/l
0
200
400
600
800
1000
1200
1400
1600
410
400
390
380
370
360
350
340
River Mile


Snake River Agricultural Drains Total Suspended Solids by Snake River Mile, Non-Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
L1 Line at South East 2nd Street
Dork Canal @ Hwy201& N Oregon St
Jacobson Gulch at Highway 201
Sheperd Gulch at Highway 201
New Coyote at Pioneer Rd
Snake River TMDL Target for TSS 50 mg/l
Total Suspended Solids, mg/l
0
200
400
600
800
1000
1200
1400
1600
410
400
390
380
370
360
350
340
River Mile

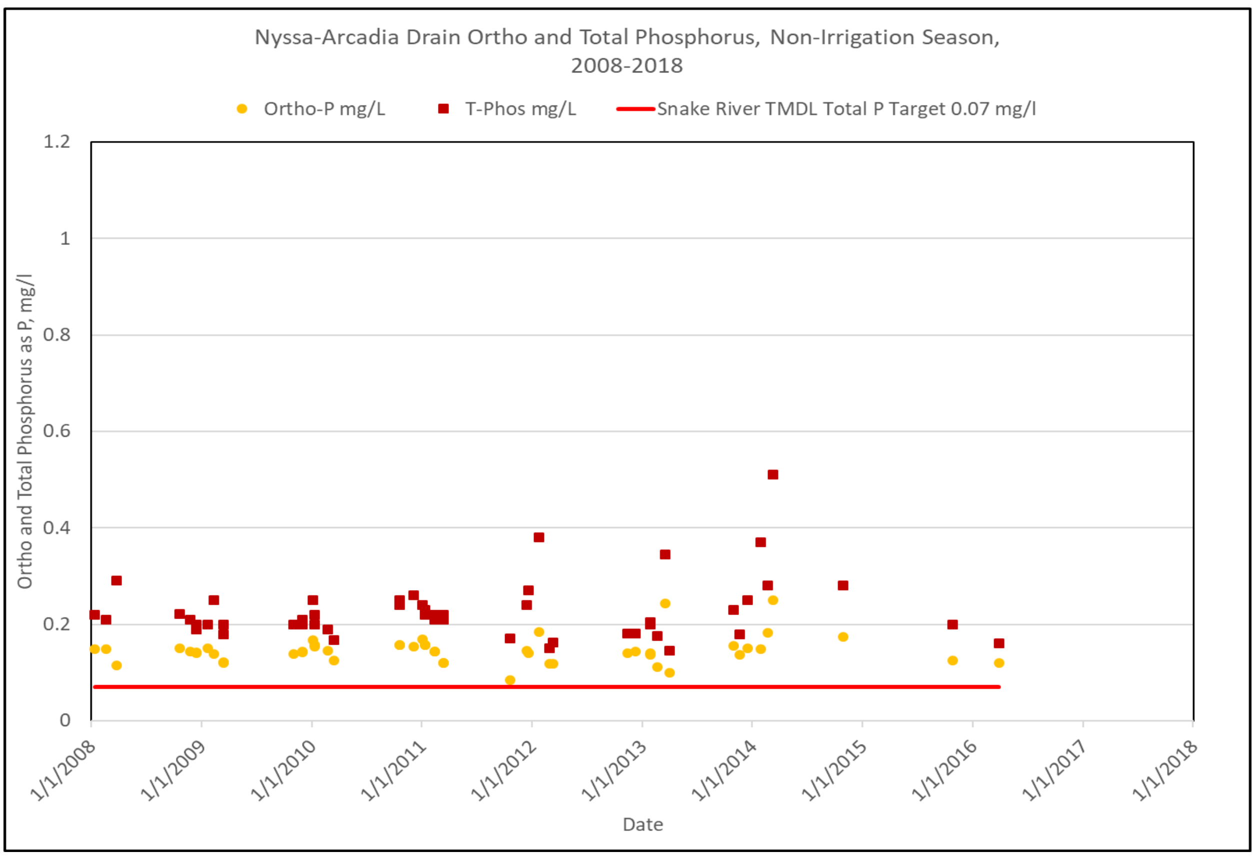

Snake River Agricultural Drains E. coli by Snake River Mile,
Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
Dork Canal @ Hwy201& N Oregon St
L1 Line at South East 2nd Street
Jacobson Gulch at Highway 201
New Coyote at Pioneer Rd
Sheperd Gulch at Highway 201
Oregon E. coli Standard 406 Count/100mls.
E coli Count/100mls (Log Scale)
100,000
10,000
1,000
100
10
1
0
410
400
390
380
370
360
350
340
River Mile


Snake River Agricultural Drains E. coli by Snake River Mile,
Non-Irrigation Season, 2008 to 2018
Alkali Creek at Napton Road
Kingman Out at Kingman Pump Sta
Lockett Drain at Highway 201
Nyssa-Arcadia Drain at King Ave
L1 Line at South East 2nd Street
Dork Canal @ Hwy201& N Oregon St
Jacobson Gulch at Highway 201
Sheperd Gulch at Highway 201
New Coyote at Pioneer Rd
Snake River TMDL Target for Total P, 0.07 mg/l
E coli, Count/100mls (Log Scale)
100,000
10,000
1,000
100
10
1
0
410
400
390
380
370
360
350
340
River Mile

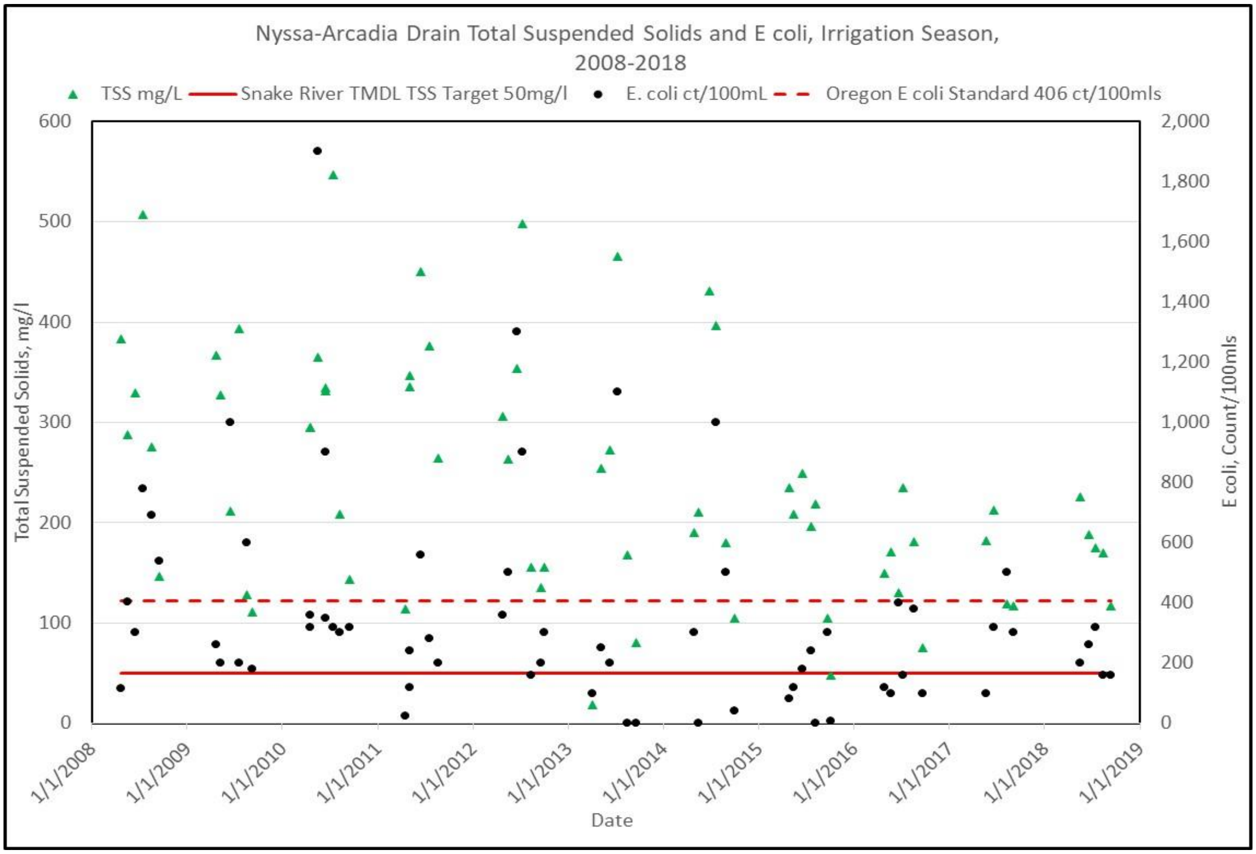

Nyssa-Arcadia Drain Single Measurement Flow, 2013-2016
Irrigation Season Flow, cfs
Non-Irrigation Season Flow, cfs
160
140
120
100
80
60
40
20
0
Flow, cfs
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2
Date

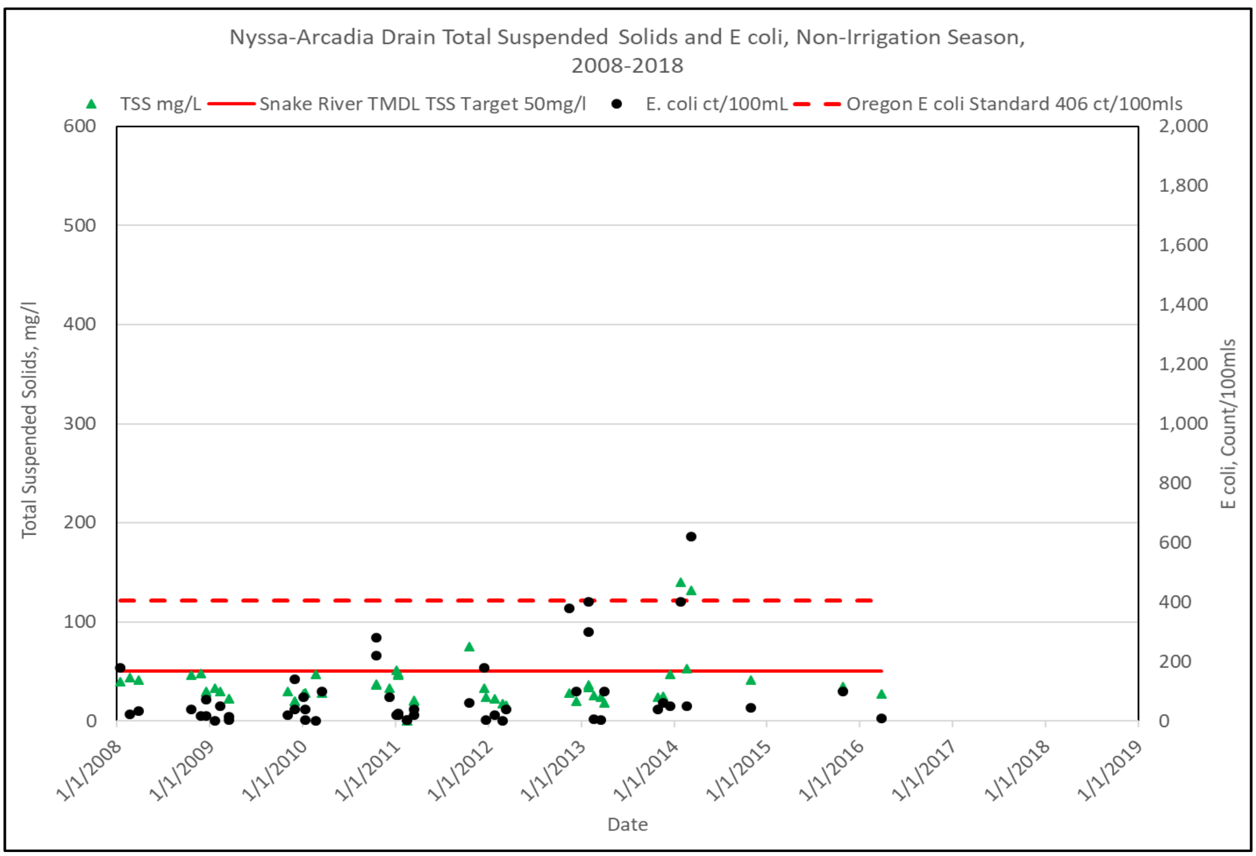


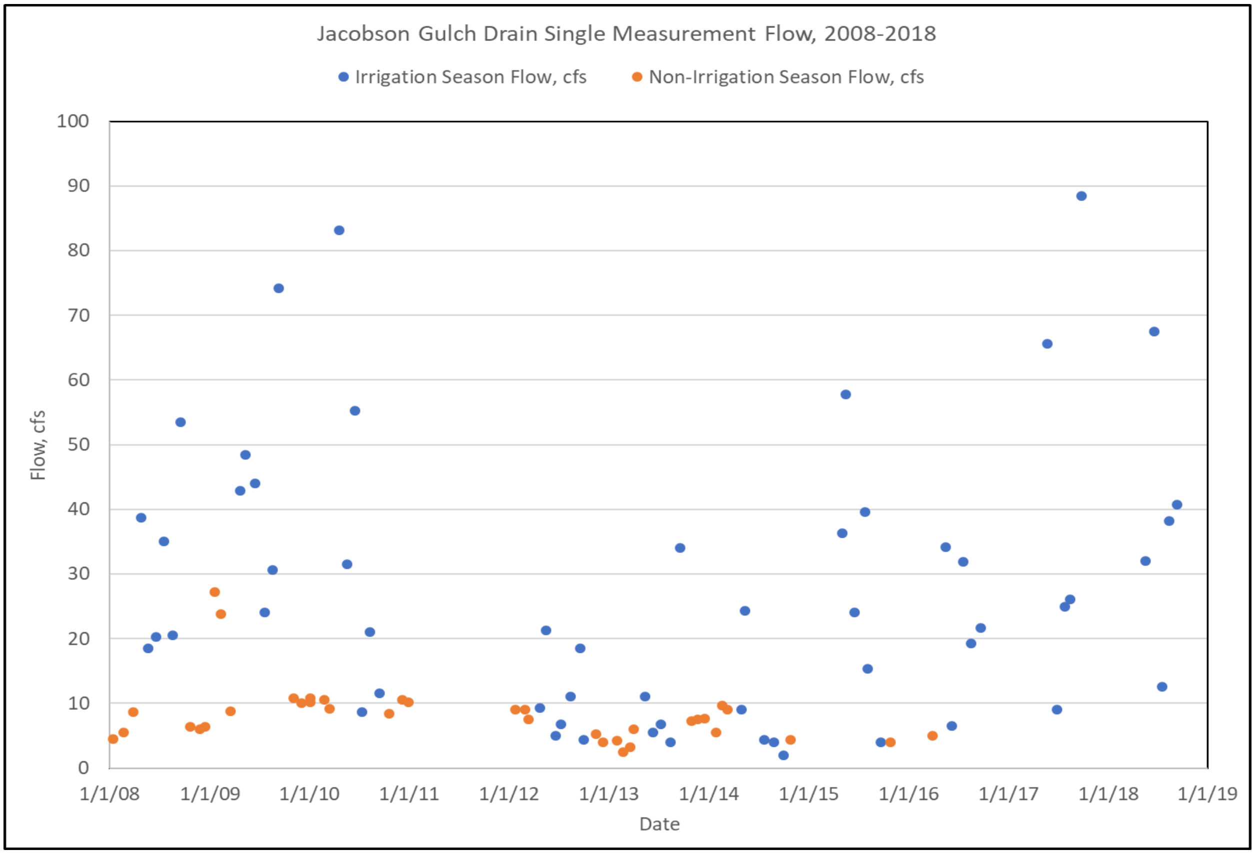
Nyssa-Arcadia Drain Ortho and Total Phosphorus, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Orthos and Total Phosphorus as P, mg/l
1.2
1
0.8
0.6
0.4
0.2
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

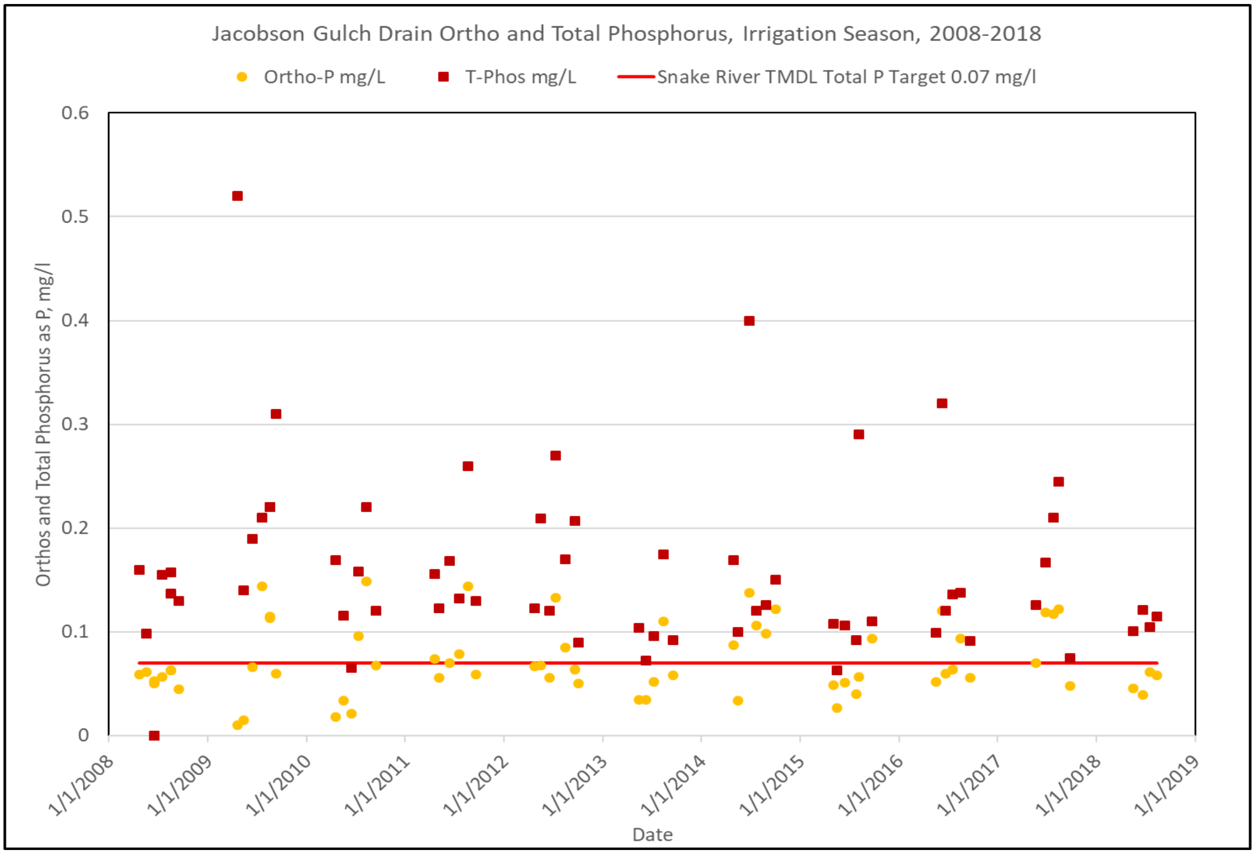


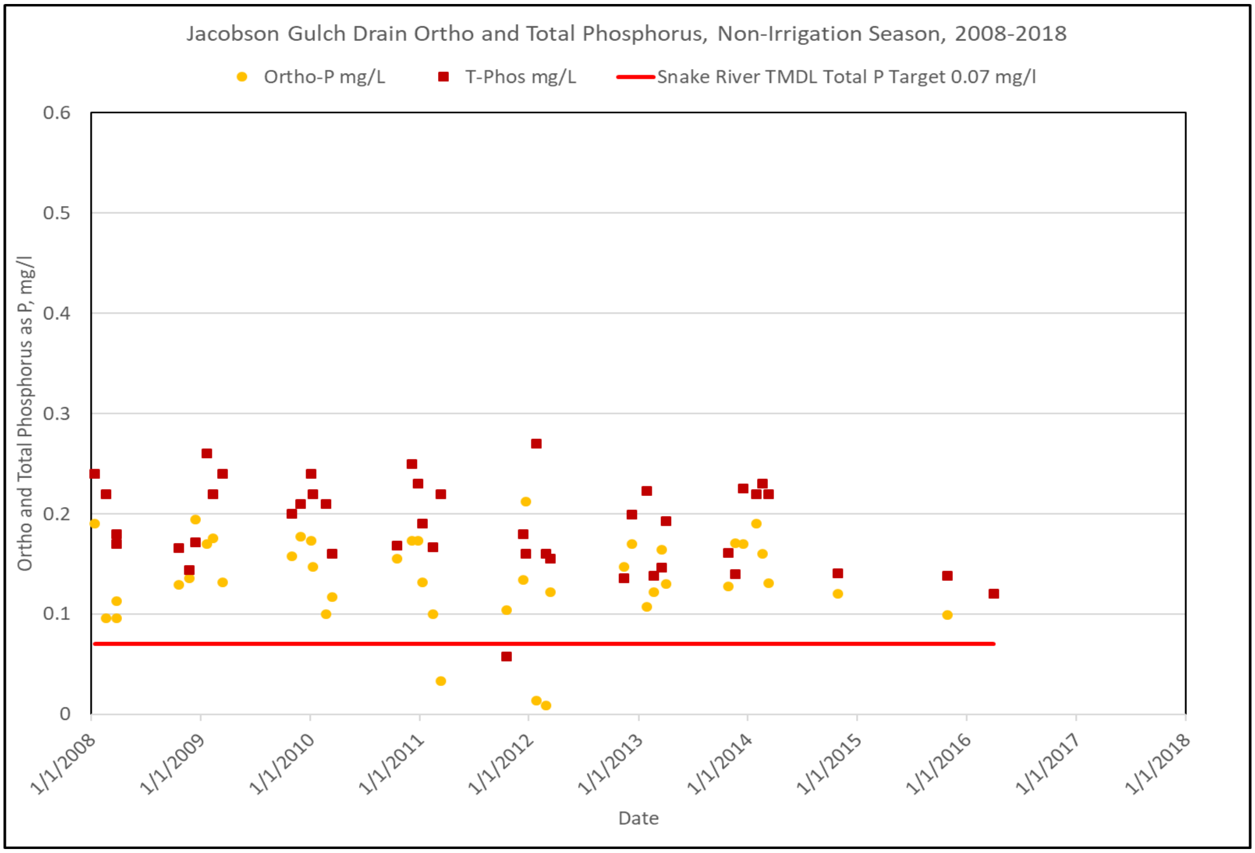
Nyssa-Arcadia Drain Ortho and Total Phosphorus, Non-Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
1.2
1
0.8
0.6
0.4
0.2
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
Date

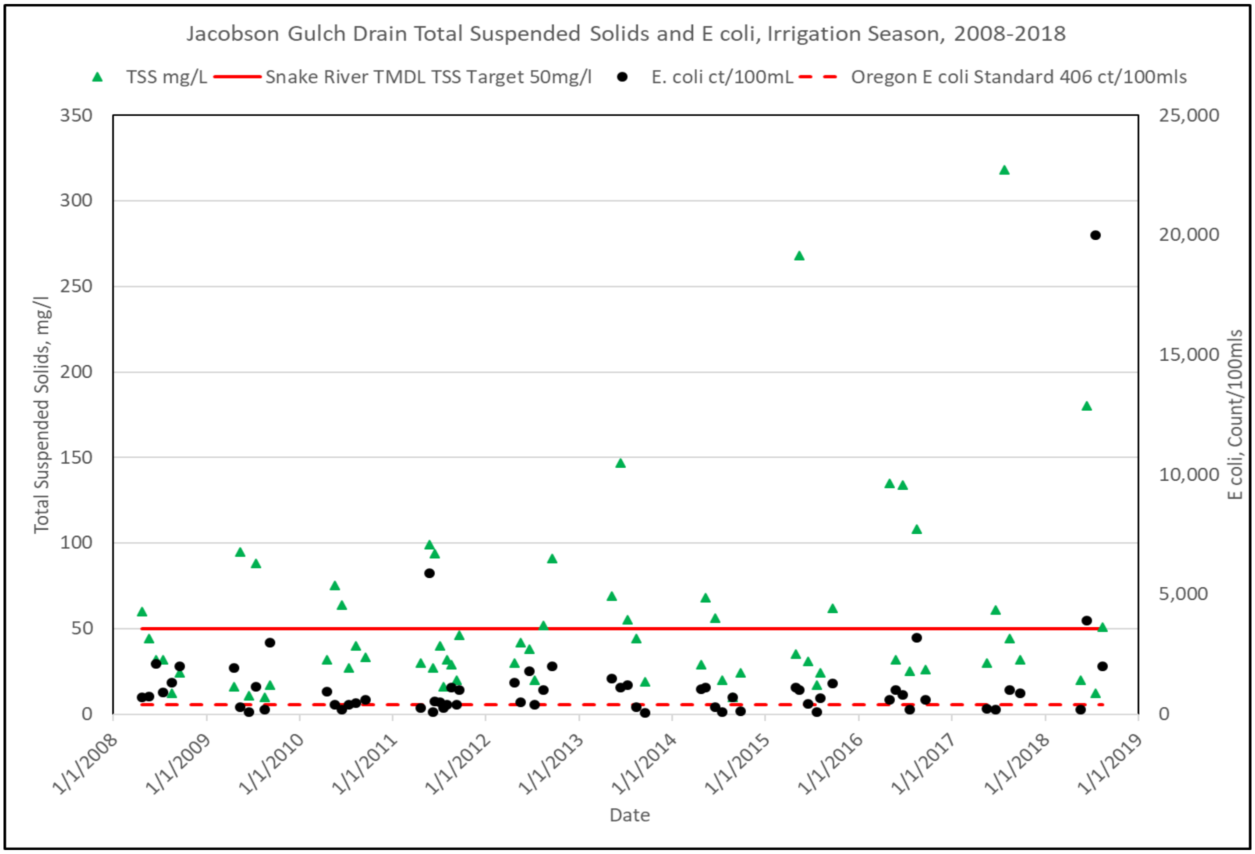

Nyssa-Arcadia Drain Total Suspended Solids and E coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date
0
100
200
300
400
500
600
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

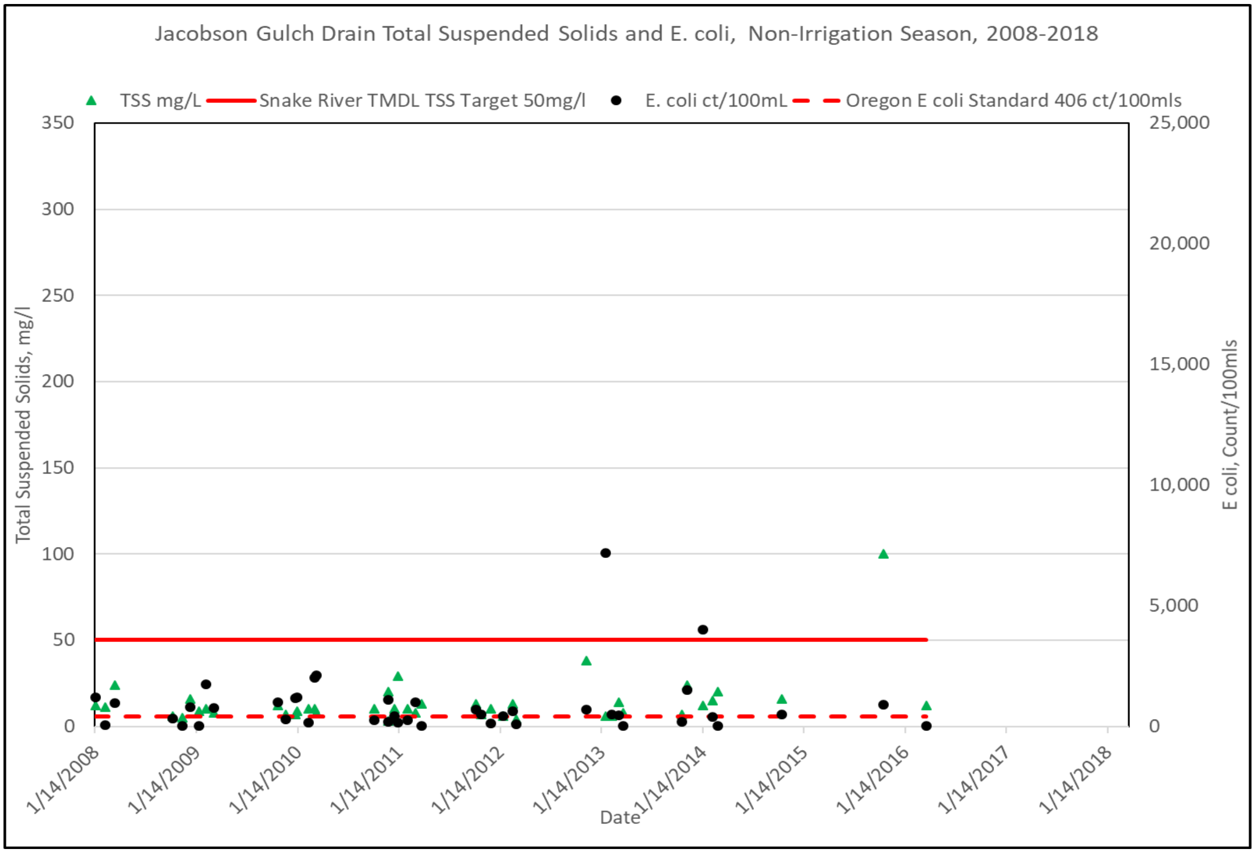

Nyssa-Arcadia Drain Total Suspended Solids and E coli, Non-Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date
0
100
200
300
400
500
600
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

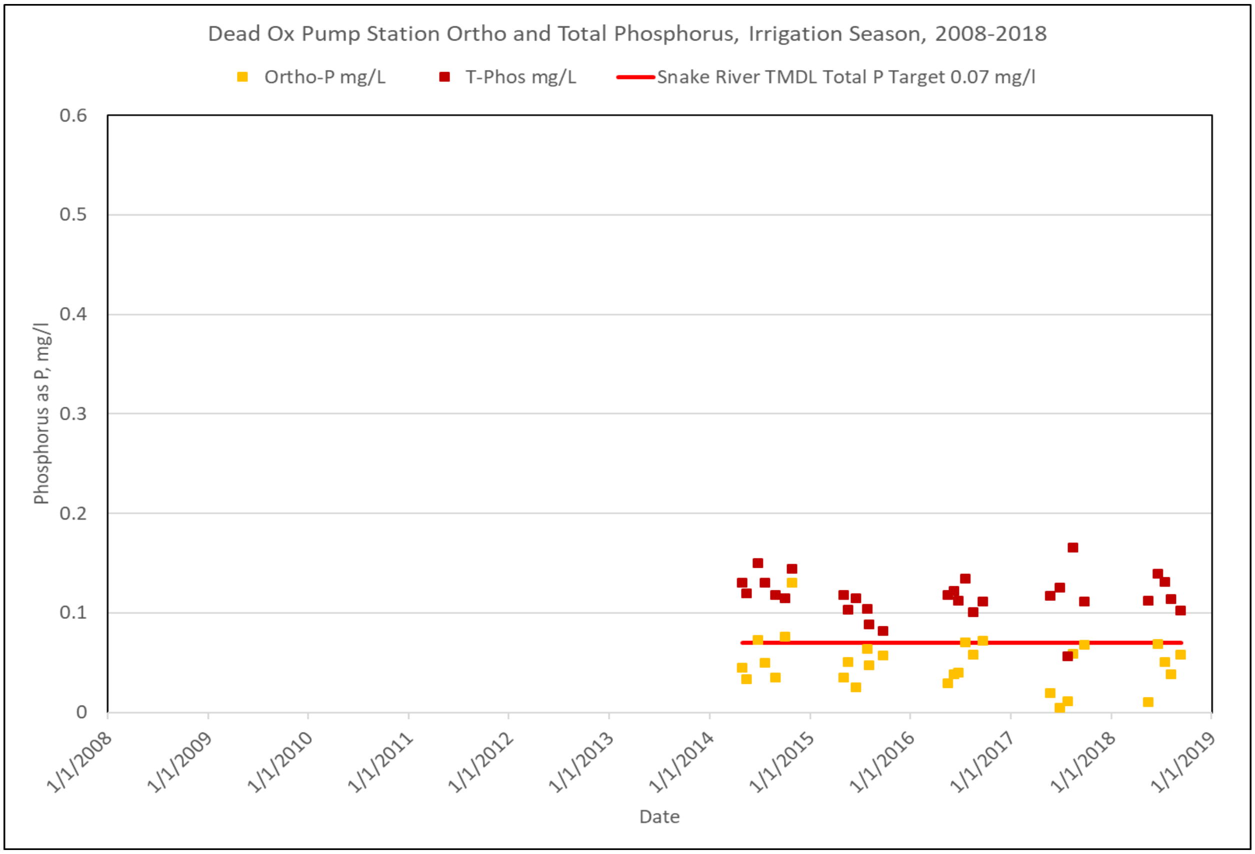

Jacobson Gulch Drain Single Measurement Flow, 2008-2018
Irrigation Season Flow, cfs
Non-Irrigation Season Flow, cfs
Flow, cfs
100
90
80
70
60
50
40
30
20
10
0
1/1/08
1/1/09
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18
1/1/19
Date

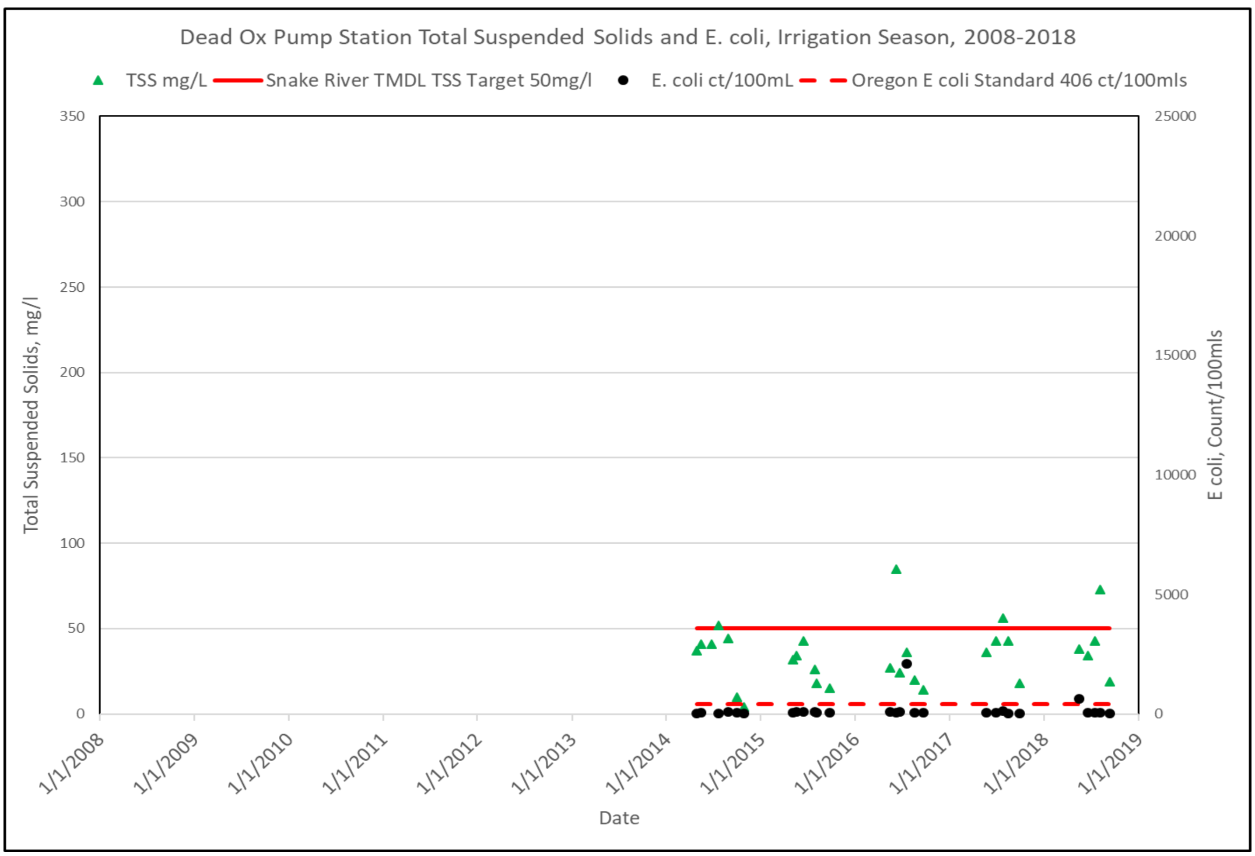

Jacobson Gulch Drain Ortho and Total Phosphorus, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Orthos and Total Phosphorus as P, mg/l
Date
0
0.1
0.2
0.3
0.4
0.5
0.6
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019

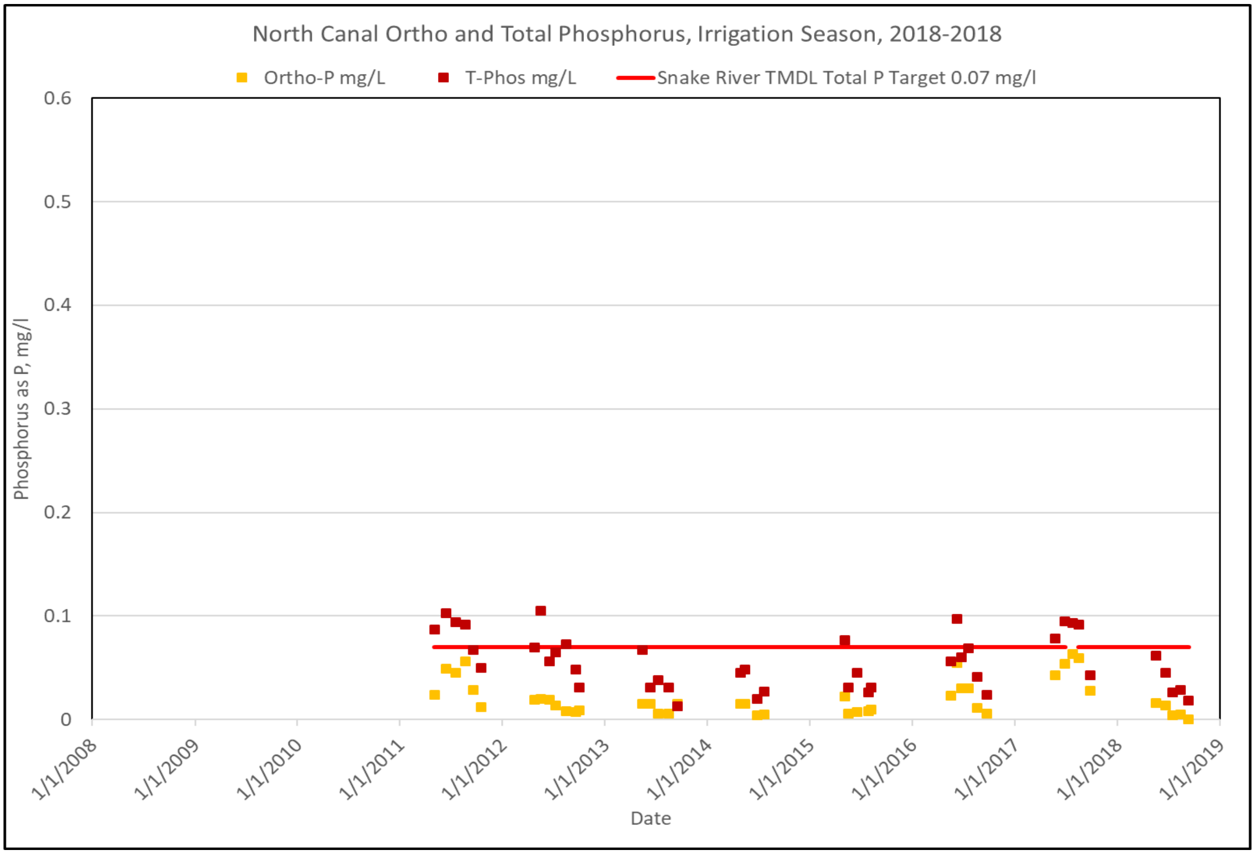

Jacobson Gulch Drain Ortho and Total Phosphorus, Non-Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Ortho and Total Phosphorus as P, mg/l
Date
0
0.1
0.2
0.3
0.4
0.5
0.6
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018

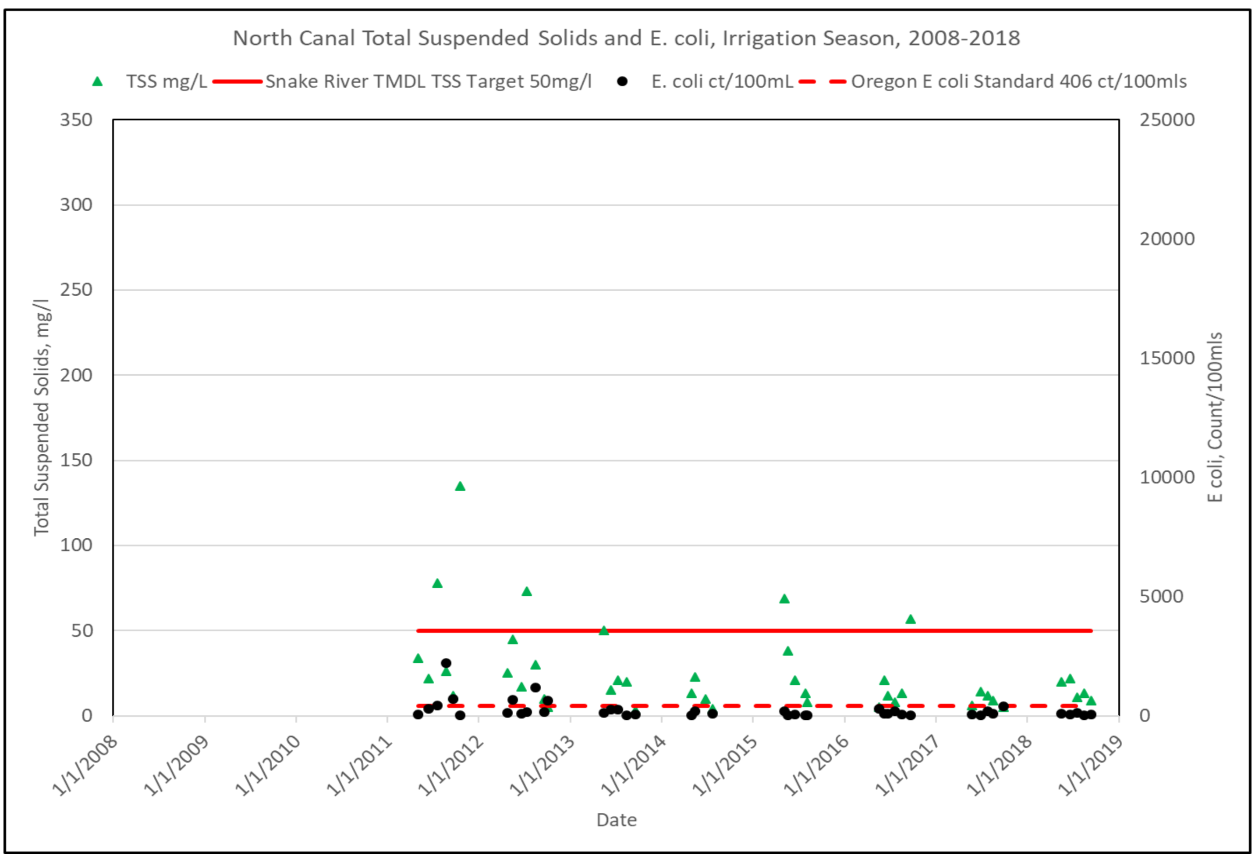

Jacobson Gulch Drain Total Suspended Solids and E coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date
350
300
250
200
150
100
50
0
25,000
20,000
15,000
10,000
5,000
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019


Jacobson Gulch Drain Total Suspended Solids and E. coli, Non-Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
E coli, Count/100mls
Date
350
300
250
200
150
100
50
0
25,000
20,000
15,000
10,000
5,000
0
1/14/2008
1/14/2009
1/14/2010
1/14/2011
1/14/2012
1/14/2013
1/14/2014
1/14/2015
1/14/2016
1/14/2017
1/14/2018


Dead Ox Pump Station Ortho and Total Phosphorus, Irrigation Season, 2008-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


Dead Ox Pump Station Total Suspended Solids and E. coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
350
300
250
200
150
100
50
0
E coli, Count/100mls
25000
20000
15000
10000
5000
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


North Canal Ortho and Total Phosphorus, Irrigation Season, 2018-2018
Ortho-P mg/L
T-Phos mg/L
Snake River TMDL Total P Target 0.07 mg/l
Phosphorus as P, mg/l
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date


North Canal Total Suspended Solids and E. coli, Irrigation Season, 2008-2018
TSS mg/L
Snake River TMDL TSS Target 50mg/l
E. coli ct/100mL
Oregon E coli Standard 406 ct/100mls
Total Suspended Solids, mg/l
350
300
250
200
150
100
50
0
E coli, Count/100mls
25000
20000
15000
10000
5000
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
Date

Findings and Conclusions

The findings and conclusions of this report are discussed below specific to the goals and objectives of the water quality monitoring activities. The objectives are stated in the introduction section (Chapter 1) of this report as listed in the grant application. These objectives are discussed below and have been grouped into categories with similar characteristics.

Document and Track Changes in Water Quality Relative to Implementation and Local Efforts

One of the objectives of the water quality monitoring was to document and track the progress of local efforts to improve water quality in Malheur Basin through documented changes in water quality.

The majority of the data collected did not show discernable change in concentration over time. This is not necessarily indicative that there is no effective implementation occurring in the areas monitored. It may be the result of data sets that are too short to show subtle changes in concentration. With continued monitoring, changes in water quality may become evident. It may also be due to complicating factors such as changes in crop rotation or water availability or may be the result of one or two "bad actors" overwhelming the good practices of the majority of a basin or drainshed.

However, the data do show that water quality is improving in some locations.

- Total phosphorus appears to be decreasing over time in Bully Creek below the dam in both the irrigation and non-irrigation seasons (small data set)
- TSS appears to be decreasing over time in Willow Creek at the railroad crossing during the irrigation season
- E. coli appears to be decreasing slightly over time in Willow Creek at the railroad crossing during the irrigation season
- Total phosphorus appears to be decreasing over time in the Owyhee River one half mile above the mouth during the irrigation season
- TSS appears to be decreasing over time in the Owyhee River one half mile above the mouth during the irrigation season
- Total phosphorus appears to be decreasing slightly over time in the Old Owyhee Ditch during the irrigation season
- Total phosphorus appears to be decreasing over time in the Owyhee River at the Canyon Mouth during the irrigation season
- Total phosphorus appears to be decreasing over time in the Nyssa-Arcadia Drain during the irrigation season
- TSS appears to be decreasing over time in the Nyssa-Arcadia Drain during the irrigation season
- TSS appears to be decreasing over time in the North Canal during the irrigation season (small data set)

These are all very promising results and the efforts of all those on-the-ground who helped to implement best management practices like flood/furrow to sprinkle conversions, conservation tillage, direct seeding, drip irrigation, PAM and straw mulch sediment practices and many others should be commended. The decrease in nutrient and sediment loading represented by these changes in concentration are directly beneficial to water quality.

Data on specific implementation practices within the Malheur and Owyhee Basins are collected by Oregon Department of Agriculture (ODA) or Natural Resources Conservation Service (NRCS), however, due to privacy concerns, ODA and NRCS cannot release these data for correlation with the improvements recognized above. Data were requested at a lower level of specificity (such as information on practices at a watershed or subbasin level) to avoid any privacy concerns but it was reported that data are not collected in a format where the information could be effectively grouped at a watershed or subbasin level.

ACCOUNT FOR THE EFFECTS OF THE RECENT DRY WEATHER (DROUGHT)

It was a stated objective of the monitoring in the grant application that data be reviewed to account for the effect of the recent dry weather (drought). The collected data were assessed specific to changes in water quality that could be attributed directly to drought or low water conditions. However, most of the data sets did not have sufficient temporal extent to determine specific changes resulting from dry weather conditions. The years of 2014, 2015 and 2016 were very low precipitation (and therefore low irrigation water delivery years in the Malheur and Owyhee Basins. Some of the effects of low precipitation may have been mitigated by stored water supplies in reservoirs and increasing dependence on ground water sources for irrigation supplies. However, in many cases, drought conditions were addressed by changes in cropping practices and fallowing. None of the data collected under this grant project showed discernable changes in water quality that were directly attributable to drought conditions. Year to year and season to season variation was too high to distinguish credible changes due to low precipitation conditions.

PROVIDE DATA TO HELP PRIORITIZE RESTORATION EFFORTS

One of the primary and express goals of the water quality monitoring, both under this grant and the monitoring conducted under previous grants (some funded by OWEB and some funded by other sources), was to provide monitoring data that could help to inform and prioritize restoration efforts in the Malheur Basin with special emphasis on the Willow Creek Focus Area and the Snake River Agricultural Drainsheds. This report is formatted specifically to support this effort.

This report is formatted to function as an outreach tool for both the Malheur Watershed Council and the Malheur SWCD. Each chapter of the report is formatted to be used separately. With long reports, it can be tedious for members of the agricultural community to find the results and data specific to their location or practices in the report document. The format of this report is intended to address this concern. As Watershed Council and SWCD staff meet with local producers and landowners, they can provide local landowners and producers with a copy of the individual chapter of the report that deals with their specific area or location, rather than paging through the full report document. This will put site-specific information and results directly in the hands of those interested in the findings. The full report document can be made available on request. Please keep in mind that in order to make the chapters function as stand-alone documents, some duplication of general information is required.

INFORM, COMPLEMENT AND SUPPORT TMDL PROCESSES FOR THE MALHEUR, SNAKE AND OWYHEE RIVERS

All of the systems monitored and discussed in this report eventually flow into the Snake River. The quality of water in the monitored rivers, tributaries and drains contributes to the quality of water in the Snake River. Because of the interconnected nature of these systems, reductions in pollution loading are necessary in these tributaries and drains and in the Malheur, Owyhee and Snake Rivers in order to meet water quality standards in the Snake River.

There are two approved Total Maximum Daily Loads (TMDLs) that apply to the Malheur Basin: the Malheur River TMDL (2010) and the Snake River-Hells Canyon TMDL (2004). TMDL targets that apply to both the Malheur and Snake Rivers, and affect practices on the tributaries and drains that discharge into these river systems, have been established. The Owyhee River TMDL is in progress at this time and water quality targets specific to the Owyhee River TMDL have not yet been established. TMDL water quality targets, if achieved, will allow the water quality in rivers and streams to meet state water quality standards. Because the Malheur River flows into the Snake River, Snake River TMDL targets were considered in the establishment of TMDL targets for the Malheur River. It is expected that Snake River TMDL targets will also be considered in the establishment of TMDL targets for the Owyhee River.

Water quality data collected under this grant work have been evaluated relative to the Snake River TMDL targets for phosphorus (0.07 mg/l) and total suspended sediment (TSS) (50 mg/l). The water quality standard for E. coli used to evaluate data in this report is a state-wide standard (406 count/100ml) that applies to all waters with contact recreation as a designated beneficial use.

All graphs displayed in this report show the applicable TMDL target and/or water quality standards. Although there are some monitoring sites where a short period of data collection made it inadvisable to draw conclusions on changes in water quality, in most cases, the data collected show, overwhelmingly, that the rivers, tributary and drain systems monitored throughout the Malheur Basin, Owyhee Basin (three locations), and in the Snake River do not meet TMDL targets or state standards for total phosphorus, TSS or E. coli much of the time. Exceedances of the targets and standards occurred very routinely and sometimes in all data collected, especially during the irrigation season. The most consistent exceedances were for total phosphorus.

The collected data (displayed in the graphs for each chapter and in the and statistical tables for the Snake River Agricultural Drains) show that measured pollutant concentrations are generally lower during the non-irrigation season and higher during the irrigation season. The lower non-irrigation season concentrations, combined with substantially lower river and drain flows, are a strong indication that the majority of the pollutant load being delivered to the Malheur, Owyhee and Snake Rivers by the monitored tributaries and drains occurs during the irrigation season. The collected data show that pollutant loading in the Malheur and Owyhee Basins is directly tied to irrigation water runoff, not to stormwater flows.

Similarly, the data collected under this grant project show, overwhelmingly, that the cumulative effect of enriched tributary and drain system inflows result in pollutant concentrations that increase from upstream to downstream. In several cases, where upstream water quality met (or only rarely exceeded) TMDL targets and/or state standards, downstream concentrations exhibited the effect of enrichment and routinely did not meet TMDL targets or state standards for total phosphorus and/or TSS. This pattern was frequently observed in the collected data, especially during the irrigation season.

As mentioned in the previous paragraphs, concentrations of total phosphorus, TSS and (in one case) E. coli appear to be decreasing over time at some of the sites monitored. While this is commendable and is most likely the result of very dedicated on-the-ground implantation efforts, it is not representative of the majority of sites monitored. It may be the result of data sets that are too short to show subtle changes in concentration. With continued monitoring, changes in water quality may become evident. This may also be the result of complicating factors or cases where one or two “bad actors” overwhelming the good practices of the majority of a basin or drainshed.

All of these data should help to inform the TMDL processes for the Malheur, Snake and Owyhee Rivers by providing additional data to supplement that collected for the TMDL process (for the Malheur and Snake TMDLs) and by providing real-time current condition information for evaluating TMDL targets and water quality needs for all three river systems. The decreases in total phosphorus and TSS observed in the data collected in the Owyhee Basin should be recognized in the process for setting the TMDL targets.

Specific to the Snake River TMDL target for total phosphorus, many residents of the Malheur Basin have expressed concern that the 0.07 mg/l target is lower even than natural background for the Malheur River system and therefore unattainable. One goal of the monitoring in the Upper Malheur River was to address this concern and provide data to DEQ relative to the TMDL target.

The monitoring in the Upper Malheur (Chapter 2) shows that in four of the six locations (Little Malheur River, NF Malheur at USF Road 18, WF Wolf Creek, and MF Wolf Creek), measured median concentrations are well below the TMDL target (0.06 mg/l, 0.04 mg/l, 0.03 mg/l, 0.03 mg/l respectively). Similarly, the data collected at the North Canal site (carrying water diverted from the Owyhee River) exhibited concentrations of total phosphorus that were very consistently lower than the TMDL target (median = 0.06 mg/l). These locations are not pristine, untouched locations do experience some level of human management and activities, and total phosphorus concentrations are still below the target the majority of the time. This is strong evidence that the TMDL target of 0.07 mg/l is attainable.

Two of the sites in the Upper Malheur (Calamity Creek and Beaverdam Creek) show concentrations of total phosphorus that are well above the TMDL target. The monitoring notes for these sites indicate that cattle were observed in both Calamity and Beaverdam Creeks. These activities may be contributing to the measured phosphorus enrichment. Further investigation of livestock and other anthropogenic activities in these watersheds is recommended to better characterize sources of enrichment and determine if the baseline total phosphorus concentrations (with implementation of best management practices) is supportive of the TMDL target.

COMPARE CURRENT WATER QUALITY MONITORING DATA TO HISTORIC WATER QUALITY DATA

Historic water quality data (1980-1989) are available for five (5) of the monitoring sites detailed in this chapter or sites located in close proximity.

- Malheur River at Hwy 201 Bridge (located downstream of the Malheur River at the 36th Street Bridge site)
- Malheur River at Little Valley
- Malheur River One Mile below Namorf
- Owyhee River at Hwy 201 Bridge (located about one half mile upstream of the Owyhee River one half mile above the mouth site)
- Willow Creek at RR Bridge near Vale

Both historic (1980-1989) and current (2016-2018) data are available for these five sites. The historic data for all five sites (and the current data for the two Highway 201 Bridge sites) were collected by Oregon DEQ as part of their ambient monitoring program.

There are some limitations to the data available. For some sites, only a few (< 10) data points were available for the current time period (2016-2018). For both the Highway 201 Bridge sites and the Willow

Creek at the railroad crossing site, the monitoring site is located very close to the mouth of the river or creek. High flows in the receiving river can cause the water in the inflowing stream to back up due to back pressure from the receiving water. This may cause changes in water quality in the samples taken at the Highway 201 Bridge site and the on the Willow Creek at the railroad crossing site during spring flows. Additionally, analytical methods have evolved from those used during the 1980s and may not be directly comparable with the analytical methods used today. Please keep these limitations in mind while reviewing the comparison of historic to current water quality presented here.

Data presented in the following tables shows the percent reduction in concentration from 1980-1989 to 2016-2018 for each site for both the irrigation season and the non-irrigation season. Additional detail and concentration information is provided in the more detailed tables on pages 109 and 110.

% REDUCTION IN TOTAL PHOSPHORUS CONCENTRATION HISTORIC (1980-1989) VS CURRENT DATA (2016-2018)						
	Irrigation Season			**Non-Irrigation Season**		
Site	Median	90th Percentile	Maximum	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	-2%	19%	23%	17%	74%	87%
Malheur River at Little Valley	12%	9%	13%	21%	28%	56%
Malheur River One Mile below Namorf	10%	1%	0%	N/A	N/A	N/A
Owyhee River at Hwy 201 Bridge	8%	8%	26%	27%	41%	54%
Willow Creek at RR Bridge near Vale	12%	3%	26%	2%	40%	88%

% REDUCTION IN TOTAL SUSPENDED SOLIDS CONCENTRATION HISTORIC (1980-1989) VS CURRENT DATA (2016-2018)						
	Irrigation Season			**Non-Irrigation Season**		
Site	Median	90th Percentile	Maximum	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	31%	29%	45%	11%	82%	95%
Malheur River at Little Valley	42%	67%	65%	28%	88%	95%
Malheur River One Mile below Namorf	24%	21%	43%	N/A	N/A	N/A
Owyhee River at Hwy 201 Bridge	53%	53%	58%	66%	72%	87%
Willow Creek at RR Bridge near Vale	15%	33%	64%	24%	61%	93%

Even with the limitations of the available data, it is clear that progress is being made over time in the Malheur River Basin and water quality is improving. With only two exceptions (median total phosphorus concentration during the irrigation season in the Malheur River at the Highway 201 Bridge and maximum total phosphorus concentration during the irrigation season in the Malheur River at Namorf), concentrations of total phosphorus and total suspended solids have decreased in both the irrigation and non-irrigation season at all three sites. Substantial reductions in total phosphorus and suspended solids have occurred in both the irrigation season and the non-irrigation season. In some cases concentrations have realized a reduction of more than 80%.

Total Phosphorus									
		Irrigation Season				Non-Irrigation Season			
Site	Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	1980-1989	41	0.37	0.61	0.66	25	0.37	1.37	3.01
	2016-2018	9	0.38	0.49	0.51	9	0.31	0.36	0.40
Malheur River at Little Valley	1980-1989	20	0.25	0.28	0.32	14	0.22	0.28	0.66
	2016-2018	19	0.22	0.25	0.28	9	0.17	0.20	0.29
Malheur River One Mile below Namorf	1980-1989	9	0.22	0.24	0.25	N/A	N/A	N/A	N/A
	2016-2018	16	0.20	0.24	0.25	N/A	N/A	N/A	N/A
Owyhee River at Hwy 201 Bridge	1980-1989	47	0.19	0.29	0.41	44	0.11	0.24	0.42
	2016-2018	8	0.18	0.27	0.30	9	0.08	0.14	0.19
Willow Creek at RR Bridge near Vale	1980-1989	27	0.42	0.52	0.76	19	0.42	0.85	4.49
	2016-2018	19	0.37	0.50	0.56	10	0.41	0.51	0.52

Total Suspended Solids									
		Irrigation Season				**Non-Irrigation Season**			
Site	Time Period	# of Samples	Median	90th Percentile	Maximum	# of Samples	Median	90th Percentile	Maximum
Malheur River at Hwy 201 Bridge	1980-1989	37	89	166	244	42	56	655	2579
	2016-2018	9	61	118	133	9	50	117	123
Malheur River at Little Valley	1980-1989	20	29	77	82	22	18	208	734
	2016-2018	8	17	26	29	7	13	26	34
Malheur River One Mile below Namorf	1980-1989	9	17	26	42	N/A	N/A	N/A	N/A
	2016-2018	16	13	21	24	N/A	N/A	N/A	N/A
Owyhee River at Hwy 201 Bridge	1980-1989	42	96	162	237	50	32	103	439
	2016-2018	8	45	77	99	9	11	29	58
Willow Creek at RR Bridge near Vale	1980-1989	29	78	196	457	19	125	504	3980
	2016-2018	19	66	131	164	10	95	199	289

ATTACHMENTS (PROVIDED IN DIGITAL FORMAT ONLY):

DIGITAL APPENDIX INCLUDING:

Appendix Graphs

Data Appendix

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MALHEUR WSC SAMPLING ANALYSIS PLAN (SAP)

DEQ E-MAIL ACCEPTING DATA SUBMISSION