TEMPORAL AND SPATIAL NUTRIENT TRENDS OF THE LOWER BOISE RIVER, SOUTHWEST IDAHO

by

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ABSTRACT

Elevated nutrients, orthophosphate and nitrate, in the Lower Boise River (LBR) in southwest Idaho may be attributed to contamination from agriculture runoff draining into tributaries and/or waste water treatment plants (WWTP). To better understand the sources and associated spatial and temporal dynamics of nutrient loading to the LBR, a series of high resolution synoptic sampling events were conducted. Six separate synoptic sampling events were conducted along approximately 65 miles, from upstream near the city of Boise to the confluence with the Snake River, seasonally from July 2012 to October 2013 with a sampling increment of approximately 0.5 miles. The samples were then analyzed for the anions chloride, nitrate, orthophosphate, and sulfate. The resulting dataset shows overall trends of increasing concentrations for all anions with distance downstream, with chloride increasing an average of 17.2 mg L^{-1}, nitrate by 3.5 mg L^{-1}, orthophosphate by 0.15 mg L^{-1}, and sulfate by 33.1 mg L^{-1}. The most dramatic increases in nutrient concentrations are observed at WWTP discharges, with the greatest increases at the West Boise WWTP (Mile 17.1) with average increases of 0.32 mg L^{-1} for orthophosphate and 1.8 mg L^{-1} for nitrate, and the Caldwell plant (Mile 41.4) with average increases of 0.05 mg L^{-1} for orthophosphate and 1.7 mg L^{-1} for nitrate. Importantly, there was little evidence of significant increases in nutrient concentrations from any of the major tributaries not associated with WWTPs.

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LIST OF ABBREVIATIONS

IDEQ	Idaho Department of Environmental Quality
LBR	Lower Boise River
NWIS	National Water Information System
ODEQ	Oregon Department of Environmental Quality
SRHC	Snake River Hells Canyon
TMDL	Total Maximum Daily Load
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTP	Waste Water Treatment Plant

CHAPTER 1: INTRODUCTION

Problem Statement

Nutrient concentrations on the Lower Boise River (LBR) increase from Lucky Peak Reservoir (mile -2) to the confluence with the Snake River (mile 65) but the source of that increase is not well defined (MacCoy, 2004). A 2004 study by the U.S. Geological Survey (USGS) found concentrations increased from 0.02 mg L^{-1} to 0.23 mg L^{-1}. Additionally, a recent USGS study from 2012 to 2013 sampled 13 locations along the length of the LBR at three different times of the year, August, October, and March, and found similar results. Conclusions from the report show that orthophosphate concentrations increased downstream from approximately 0.005 mg L^{-1} to 0.25 mg L^{-1} for each sampling event. Even with the increased sample size, only one major increase was located, mile 18.7, where concentrations increased approximately 0.5 mg L^{-1} in March and 0.2 mg L^{-1} in August and October.

The downstream concentration increases exceed the U.S. Environmental Protection Agency (US EPA) recommended total phosphate concentration of 0.07 mg L^{-1}. Both the 2004 and 2012/2013 USGS studies determined that orthophosphate concentrations increased to almost four times the US EPA limit. The LBR exceeds the US EPA recommended limit but the source of this is not well defined.

Additionally, the total maximum daily load (TMDL) is violated downstream. A TMDL is the maximum amount of material mass allowed to leave a water system and is based off the sum of allotments from input sources plus a margin of safety. It is typically addressed as kilograms or pounds per 24 hours and is set by regulating agencies. The LBR 242 kg day^{-1} TMDL was developed through the Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ) cooperation for the Snake River Hells Canyon reach 2004 TMDL. The LBR daily load at Parma near the mount of the LBR was found to consistently surpass the TMDL.

Global Perspective

On a global scale, nutrient (nitrogen and phosphorus) related issues have become an increasing concern for communities and environmental protection organizations. An assessment of rivers in the United States shows the magnitude of nutrient contamination. Approximately 45% of the monitored rivers in the U.S. are contaminated by nutrients with only 20% of those rivers being addressed by a TMDL or restoration plan (US EPA, 2011). The input rate of bioavailable nitrogen that has entered the biosphere and hydrosphere has more than doubled in the past 50 years. Increases in fertilizer production, fossil fuel combustion, and crop cultivation has caused this accelerated nitrogen loading (Galloway et al., 2004). Phosphorus inputs, beyond natural weathering of phosphorus rich rocks, have also more than doubled in the past 50 years. This increase is due to a global need for fertilizers, livestock feed supplements, and wastewater treatment (Bennett et al., 2001; Mackenzie et al., 1998; USGS, 2008). Global increases in agriculture and the associated fertilizer use has caused massive nutrient inputs (Ignazi, 1993). Compounding the agricultural inputs, there has not been a parallel increase in wastewater production and wastewater treatment. Wastewater input has increased approximately 65% worldwide since 1980 with only an average 25% being treated

(OECD, 2010; Malik, 2013). Both of these contamination factors have led to an increase in water nutrient contamination.

Nutrient Contamination

The mechanism that causes a nutrient contaminated water system is eutrophication, massive algal blooms, which leads to hypoxic conditions. The excess nutrients shift the system out of equilibrium by creating a large amount of biomass. This biomass eventually dies and in the decay process uses a large amount of the available dissolved oxygen (Art, 1993). If left unchecked, it can lead to a host of problems including reduction or loss of beneficial uses, dominant species shifts, food web changes, and complete species disappearance (Janus & Vollenweider, 1981).

Nutrient Input Mechanisms: WWTP & Agricultural

There are two main delivery methods for nutrients to enter a water body, municipal WWTP and agricultural runoff. Municipal WWTPs, a major source for nutrient contamination, originate from a singular location and discharges directly to a water system (USGS, 2011). Approximately 90% of all waste water in the United States is processed through WWTPs (Selman & Greenhalgh, 2009), but with the current treatment methods, output consistently exceeds the EPA requirements for total phosphate and nitrogen removal. This problem is compounded with population growth, approximately 2.3 million people per year in the United states since 2010 (Census, 2014), which further increases WWTP output leading to detrimental impacts on rivers, lakes, and oceans.

The second major source of nutrients is from agricultural runoff, where nutrients are applied or released over broad areas and enter into the system through multiple sources (USGS, 2011). The field runoff enters into drainage channels through overland flow, carrying excess fertilizers, which are high in nitrate and orthophosphate. These nutrient rich drainage channels flow into streams and rivers.

Phosphorus Forms

The primary LBR contaminating nutrient, phosphate, is measured and discussed in a variety of forms including ‘total phosphate,’ ‘orthophosphate,’ or ‘orthophosphate as phosphorus’ depending on the specific use, test, monitoring, or regulation. US EPA and IDEQ regulation for TMDL development requires the total phosphate concentration, which is the sum of all suspended particulate and dissolved phosphate ions (APHA, 1992). More commonly used in nutrient analysis is the ion orthophosphate, PO_4^{3-}, and orthophosphate as phosphorus, PO_4^{3-} as P, which is the concentration of the PO_4^{3-} ion minus the mass of the four oxygen atoms. The PO_4^{3-} as P is often used when discussing nutrient behavior because this ‘free’ form of phosphorus (PO_4^{3-}) is considered the most biologically reactive (Boström et al., 1998).

Concentration vs. Daily Load

To fully understand how the LBR is changing with distance downstream, and throughout the year, it is important to recognize what is gained through the concentration analysis versus the daily load analysis. Concentration information is beneficial in determining the ecological health of the river (Withers & Jarvie, 2008) and provides information inputs. In contrast, the in stream biology is not affected by the daily load if concentrations are below the contamination limits. The daily load information is primarily of value when assessing impacts on downstream water bodies. This project addresses both, but focuses on concentration because the stream flow data is limited to select locations on the LBR.

Thesis Goal

Improving water quality by reducing elevated nutrient concentrations is a costly and time consuming endeavor. The purpose of this study is to investigate temporal and spatial trends for concentration and daily load to determine when and where nutrient, particularly orthophosphate, changes in the LBR occur. It is hoped this information can inform efforts to improve water quality.

Study Area

The area of study is the Lower Boise River and the associated watershed in southwest Idaho. The watershed area is approximately 1400 square miles and drains 442 square miles of rangeland, 597 square miles of irrigated agricultural, 142 square miles of urbanized areas (IDWR, 2007), and encompasses tributaries, canal diversions, and wastewater treatment plants. The Lower Boise River is approximately 65 miles long, flows from Lucky Peak Reservoir westward to the Snake River, and is the recipient of direct discharge from 12 tributaries. The majority of the watershed drainage can be attributed to these tributaries; listed from east to west, Freestone Creek, Eagle Drain, Dry Creek, 15 Mile Creek, Mill Slough, Willow Creek, Mason Slough, Mason Creek, Hartley Gulch Creek, Indian creek, Conway Gulch Creek, and Dixie Slough. In addition to tributary input there are four public WWTPs, which discharge directly into the LBR, Lander Street, West Boise, Middleton, and Caldwell. The West Boise WWTP is located on the southern channel of a major channel split around Eagle Island, and for this study the south channel was sampled to include direct input from the West Boise WWTP (Figure 1).

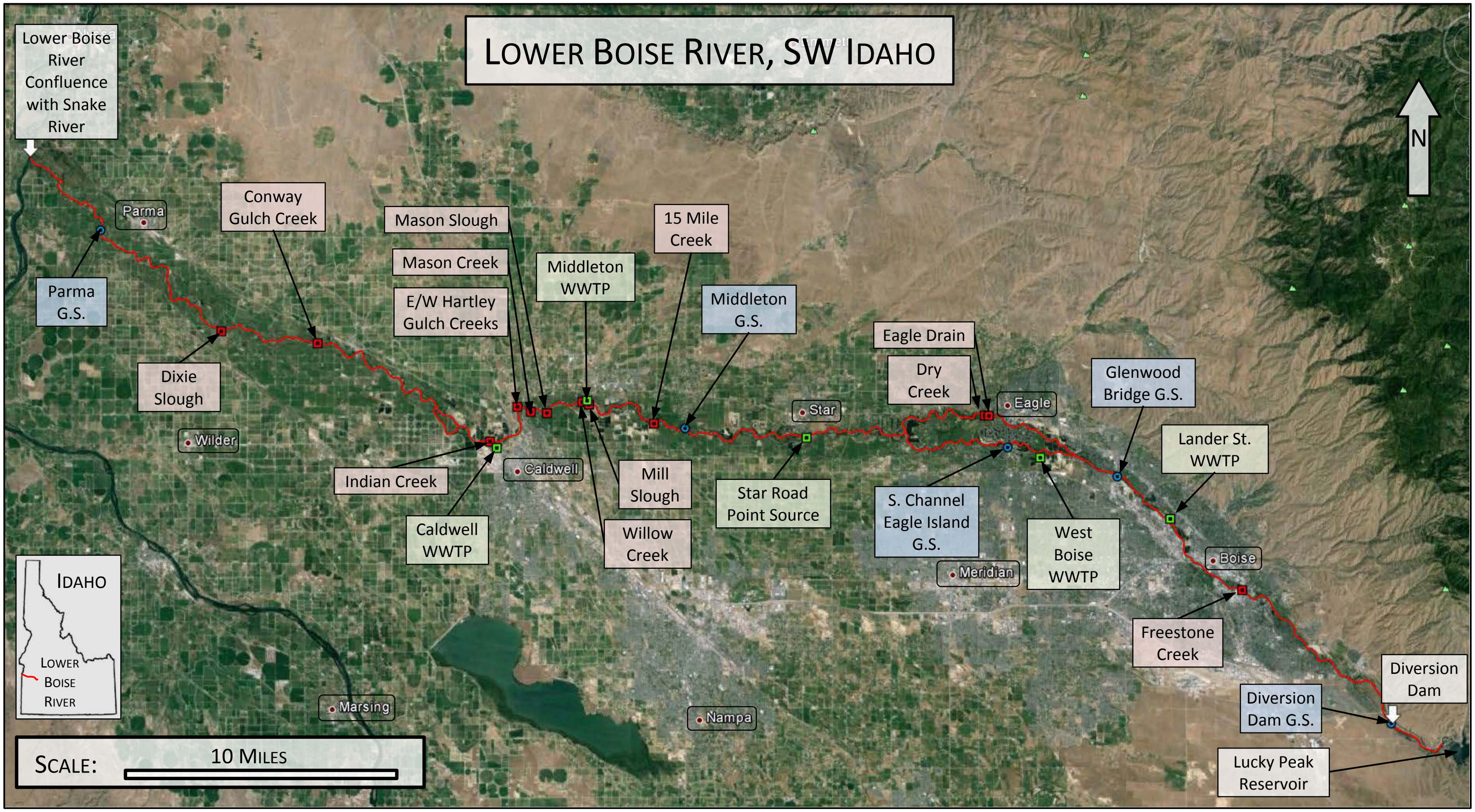


Figure 1. Project location map with main tributary and waste water treatment plant inputs.

Lower Boise River Hydrology

The hydrology of the LBR is strongly influenced by upstream control from the Army Corp. of Engineers at Lucky Peak Dam, summertime irrigation withdrawals, and summertime surface return flows of excess irrigation water (Figure 2). Seasonal variations in precipitation and water use divide the yearly river discharge into three flow classifications (IDEQ, 2001). The low flow period begins mid-October when irrigation diversions end and extends to the flood control period. The high discharge flood control period starts between January and March and continues until June or July when irrigation diversion begins. The irrigation period from July to mid-October has an intermediate discharge. Generally, the spring season has the highest discharge for the year while the fall and winter is the lowest.

Spatial variations in the hydrology are also present and are due to seasonal diversions and additions of the river (Figure 3). Downstream stations at Middleton and Parma show lesser discharge during irrigation seasons, June to October, due to irrigation diversions. Post irrigation season, October to February, shows higher discharge in the downstream stations than upstream stations due to a seasonal pause in diversions and the previous diverted water returning to the river. The high flow season, February to June, has almost constant discharge at each stations except for the South Channel Eagle Island station due to discharge being split between the North and South channels. During low and moderate flow periods, the majority of the water is diverted into the southern channel.

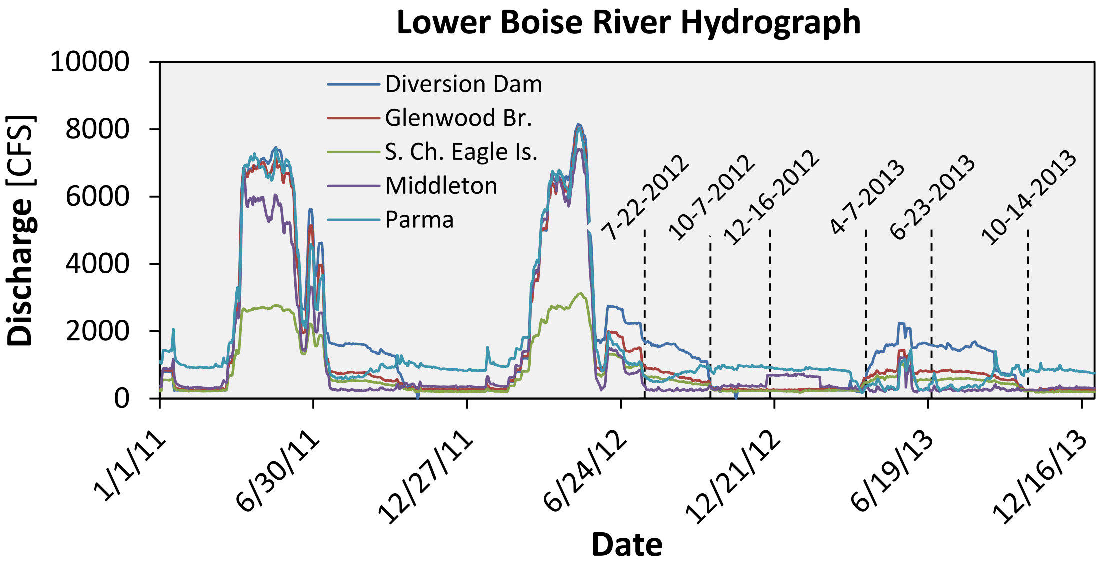


Figure 2. **Hydrograph of the LBR at the five continuous gauging stations from 2011 to 2013, and dates for the six sampling events.**

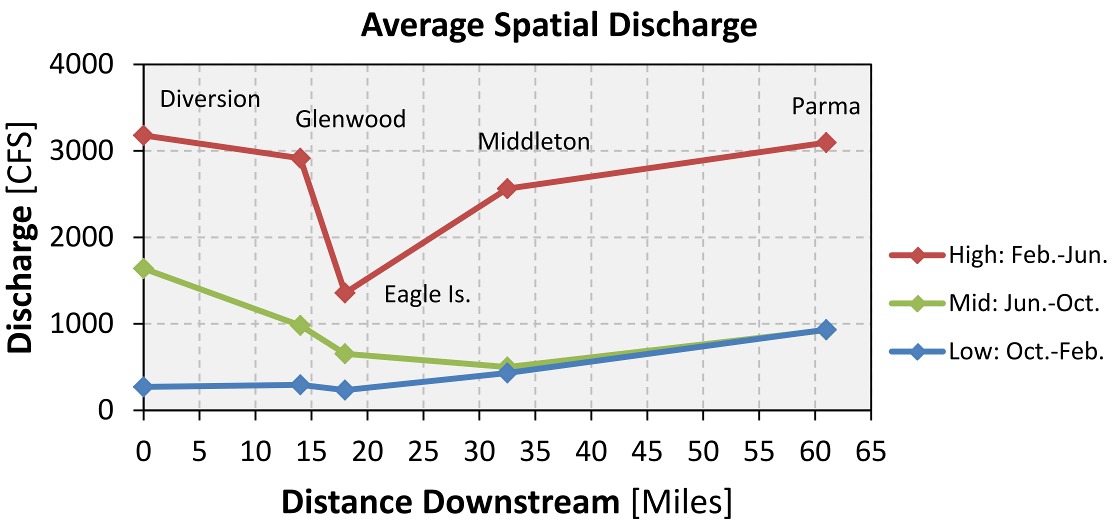


Figure 3. **LBR average spatial discharge for each flow regime from 2011 to 2013 at the five continuous gauging stations.**

Previous Quantification of Nutrients

The LBR has been continually monitored for orthophosphate concentrations since 1986 by the USGS, in cooperation with the Idaho Department of Environmental Quality (IDEQ) and the Lower Boise Watershed Council, to improve the water quality (Figure 4). The major aspects of this multi-decade study focus on nutrient loading attributed from tributaries, and nutrient loads at Parma, Idaho. Both the Parma site and the tributaries are monitored monthly, with Parma continuously sampled throughout the study, and the tributaries monitored on a rotating basis. The most recent tributary cycle, beginning in 2009 and scheduled to end in 2015, monitors one to three tributaries each water year. This sparse monitoring does not locate specific sources and has led to an incomplete understanding of the complex nutrient loading behavior in the LBR.

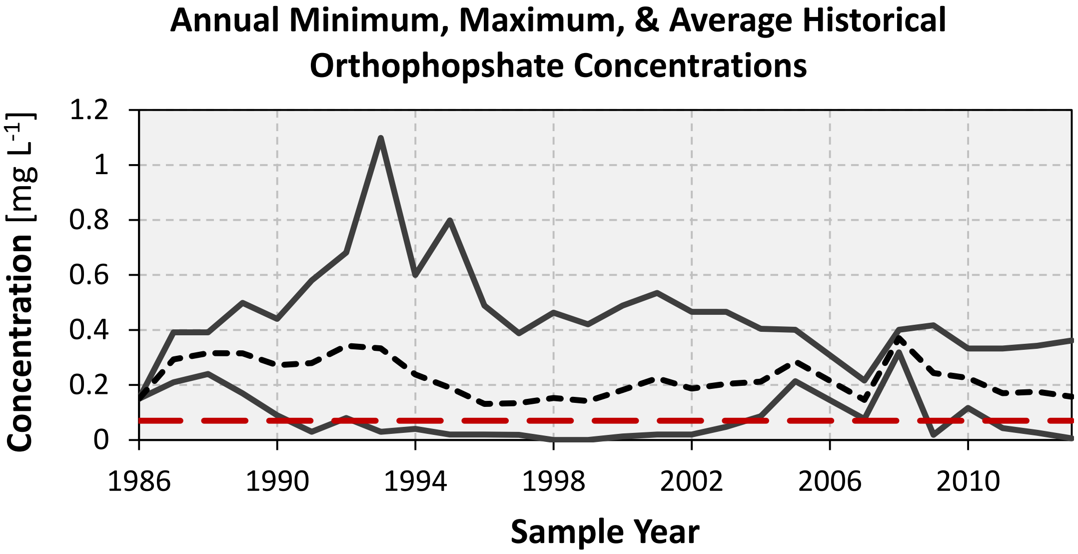


Figure 4. Historical Lower Boise River orthophosphate concentration minimum, maximum, and average collected by the USGS from 1986 to 2012. The majority of the data exceeds the US EPA recommended total phosphate limit of 0.07 mg L^{-1}, labeled as the red horizontal dashed line.

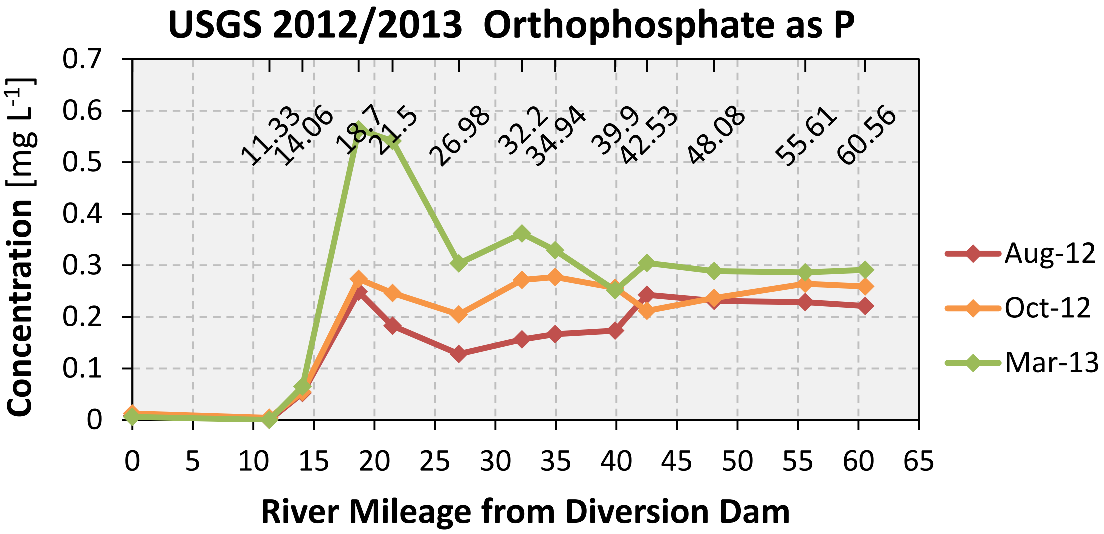


Figure 5. **USGS 2012-2013 synoptic orthophosphate data for the Lower Boise River from Diversion Dam at 0 miles to near Parma, Idaho at 60.5 miles. Sampling frequency is labeled in miles across the top for all three sampling events.**

In 2012 to 2013, the USGS undertook a project to obtain a more thorough orthophosphate dataset for the LBR. Three synoptic, whole river length, sampling events were conducted to correspond with specific irrigation seasons. The sampling events began in August 2012 with two additional events in October 2012 and March 2013; each collecting 13 sample points (Figure 5). The synoptic samples were collected at bridge crossings or wadable locations to ensure the correct sampling method of integrating the entire channel width and water column. This process is an accurate way to obtain a representative river chemistry sample at the specific location, but this method is time consuming and widely spaced. The samples for each event were separated by 5 to 10 mile gaps between points and required up to four days to collect using the approved USGS methods.

Lower Boise River Total Maximum Daily Load

The total maximum daily load for orthophosphate (TMDL) for the Lower Boise River is based off nutrient loads for the Snake River Hells Canyon Reach TMDL. The LBR is one of seven monitored direct discharge tributaries of the Snake River Hells Canyon reach, which spans from Adrian, Oregon to the confluence with the Salmon River. It has been assigned a TMDL of 242 kg day^{-1} from May to September for moderate flows in the Snake River. In comparison to the other six major tributaries and three non-tributary inputs, the LBR is allotted the second highest TMDL; it is preceded by the Payette River TMDL of 469 kg day^{-1} (IDEQ & ODEQ, 2004).

Current Remediation Efforts

Remediation efforts in the Lower Boise River are focused on both reducing input concentrations and removing orthophosphate from the river. Recent plant renovations at the Lander Street WWTP in 2012, and the Middleton WWTP in 2013, focused on decreasing the nutrient effluent concentrations, and future renovations to the West Boise WWTP plan to increase discharge while reducing concentrations. One popular future scenario to create a more efficient wastewater treatment system is to convert Lander Street WWTP to a liquids only plant and divert solid waste to an expanded West Boise WWTP, during which more efficient treatment systems would be installed (CH2MHILL & JUB, 2010). In addition to upgrading treatment processes, nutrient trading between the West Boise WWTP and the Dixie Slough through experimental total phosphate removal systems are planned for completion in the next several years. This would allow the West Boise WWTP to have an increased effluent concentration of orthophosphate from 0.07 mg L^{-1} to 0.35 mg L^{-1} and remove excess downstream. This means that any West Boise

WWTP orthophosphate concentration in excess of 0.07 mg L^{-1} is required to be removed by the Dixie Slough treatment process at a ratio of 1.5:1 (US EPA, 2012). Essentially for every kilogram of orthophosphate discharged into the LBR from West Boise with an effluent concentration over 0.07 mg L^{-1} requires the Dixie Slough to remove 1.5 kilograms.

Project Statement

Nutrient concentrations and loading increase with distance downstream. Previous monitoring has poorly defined the extent that and source from which the LBR becomes contaminated with the nutrients orthophosphate and nitrate. The objective of this project is to interpret WWTP and agricultural concentrations and daily load to establish the greatest sources of nutrient contamination. This was accomplished by utilizing existing data from the USGS, and supplementing with six high resolution field sampling campaigns. The combination of data was then used to identify and interpret important spatial and temporal trends as well as segregating WWTP and agricultural contributions to determine the primary mechanisms for nutrient contamination.

Historically, agricultural runoff is the primary nutrient contaminating input seen in rivers around the world, but in the LBR WWTPs are viewed as the main source for contamination. This project analyzed WWTP and tributaries (agricultural runoff) for both concentration and daily load. To do this is I determined the trends of input sources for both concentration and daily load by collecting high resolution concentration data and using it to calculate a low resolution daily load. The expected input signal for WWTP concentrations are a sharp increase followed by a less sharp decrease as the WWTP water mixes. The same is expected from the tributary concentrations, but with dampened increases. The daily load is expected to have large increases in reaches where WWTP are located and smaller increases in reaches where tributaries are entering. However, the daily load is expected to continually increase throughout the entire length of the river.

CHAPTER 2: METHODS

Prior Data Acquisition

Prior to this study, it was determined by the USGS (MacCoy, 2004) that orthophosphate concentration in the LBR is increasing from Lucky Peak Reservoir to the Snake River and exceeding the EPA recommendation of 0.07 mg L^{-1}. The orthophosphate data used to determine this was acquired from the USGS National Water Information System (NWIS) for the purpose of this study. There were seven field sites where the USGS collected data from the LBR in southwest Idaho, Diversion Dam, Glenwood Bridge, Star Road, Middleton, Highway 20-26 near Caldwell, near Notus, and Hexon Road near Parma. The Parma site is the only currently active collection site while Diversion Dam, Glenwood, and Middleton ended data collection in 2013, Star ended collection in 2002, and Highway 20-26 and Notus ended collection in 1972. The Parma site also contains the greatest amount of data from monthly monitoring since 2008, and due to its close proximity to the mouth of the LBR, it is a good indicator of downstream concentration trends. Downstream trends in conjunction with the upstream data from Diversion Dam, Glenwood Bridge, and Middleton lead to an overall low resolution trend for the LBR.

Field Sampling

Summary of Field Methods

A synoptic approach was taken to capture all the major trends as well as form an overall assessment of the LBR. The sampling campaigns were conducted over the 65 miles of the LBR over the course of one day via grab samples from boats. This allowed a large number of samples (100 to 150 samples) to be collected, leading to a high resolution snapshot of concentration data.

Sampling Challenges

Temporal Variation

The broad scope of this project required several assumptions in order to simplify the main problem. The more important factors were investigated to ensure the feasibility of the sampling campaigns. The greatest concern was the variation of anion concentrations throughout a sampling period. The main assumption for this project is that there is no significant concentration variation at any point over a daily sampling period. A sampling event typically started in the morning and ended in the early evening (8 to 12 hour period). If there was significant variation in concentrations over this period, the data would be skewed and unusable. It needed to be proven that there was no significant variation over 24 hours before the project moved forward with the sampling campaigns. Diurnal cycle data had been collected by the USGS in 2009 on the LBR near Parma, Idaho and on the Snake River at Adrian, Oregon and Nyssa, Oregon; it showed little variance for orthophosphate over 24 hours (Wood & Etheridge, 2011).

As part of this project, a 24-hour study of diel cycles was conducted on 7-13-2012 to 7-14-2012 to determine the validity of a sampling event that would last 8 to 12 hours. This study was conducted on the LBR immediately north of Hexon Road near Parma Idaho due to the historically higher concentration signals. 20 samples were collected, one every hour starting at 10:00AM on 7-13-2012 and ending at 10:00 AM on 7-14-2012, with the exception of 02:00 AM to 05:00 AM on 7-14-2012 where no samples were collected. Sample collection was approximately one meter from the east shore in an area where there was consistent flowing water and at a depth of approximately 30 centimeters (elbow depth). The grab samples were taken by triple rinsing clean 125 ml HDPE sample bottles with river water immediately before sampling and then preserving in a cooler with ice immediately following sampling.

Spatial Variation

Additional spatial concentration behavior was also assumed to simplify field sample collection. River channels are complex systems with eddies, pockets of stagnant water, and mixing issues. The benefit of high frequency sampling is the reduction of these effects. It was assumed that the river is homogeneous across transect and with depth and the sampling location in the channel as an accurate representation of the river chemistry. In March 2013, two transects were taken near Star Road and showed little variation in concentration between samples, orthophosphate transect samples did not vary greater than 6.3 % from the mean (Table 1).

Table 1 March 2013 LBR orthophosphate transects near Star Road.

Sample	West Transect [mg L^{-1}]	East Transect [mg L^{-1}]
1	0.23	0.18
2	0.22	0.18
3	0.21	0.20
4	0.21	0.20

Discharge Variation

Discharge also plays a major role in concentrations and was assumed constant over any section during sampling events. A changing discharge would dilute or concentrate the inputs into the LBR. This would create false decreases, causing sample data to misrepresent the true conditions. This factor was greatly reduced by selecting sampling event dates that were not during or after a major precipitation event and during stable discharge from Lucky Peak Reservoir. This was confirmed by weather and gauging station information for the sampling dates.

Date selection for sampling events was not only important for discharge, but also for representation of a specific irrigation season. There are four basic seasonal irrigation aspects that characterize a whole year, heavy summer irrigation, immediately prior to fall shutdown, winter non-irrigation, and spring start up. Each sampling event falls within one of these categories and is assumed to be an accurate representation of the entire season.

Sampling Procedures

There were six sampling events conducted from summer 2012 to fall 2013, each representing a different stage of the irrigation season. The first sampling was on 7-22-2012, which represented the heavy irrigation season; the second was on 10-7-2012, a week before the end of irrigation season; the third was on 12-16-2012, during non-irrigation season; the fourth was on 4-7-2013, at the beginning of irrigation season; the fifth was on 6-23-2013; and the sixth on 10-14-2013.

Conducting the high resolution synoptic sampling of the LBR required each team to sample their sections simultaneously. The teams were required to follow sampling procedures, collect samples within the specified timeframe of 8:00am to 8:00pm, and use commercial GPS devices to mark every sample location. Beginning at Diversion Dam in Boise, Idaho and moving downstream towards the Snake River, at the Idaho-Oregon border, the river length was divided into four sections with one sampling team per section (Table 2). Section breaks were decided by the availability of a launch site and ability to cover the required mileage in the 12-hour timeframe. Non-motorized transportation such as canoes or kayaks were used by the teams to move downstream directly on the river.

The sampling and preservation procedures are an adaptation of USGS methods for grab samples (USGS, 2006). The location of samples in the channel geometry was towards the center of the channel at approximately 30 cm depth (elbow depth). The samples were taken by first triple rinsing clean 125 ml HDPE sample bottles and caps with river water at the sample site, and then filling the bottle, integrating the water column from elbow depth to the surface. Samples were preserved immediately after collection in a cooler with ice bottles. The sampling campaigns yielded between 100 and 154 individual samples by collecting a sample approximately every 0.5 miles. Triplicate field sample sets were collected in the fourth section to test for bottle contamination and precision of field collection. A total of 789 samples, not including field replicates, were taken over the six sampling campaigns.

Table 2 Division of the Lower Boise River into four sampling sections with mileage between the start and end locations.

Section	Start Location	End Location	Mileage
1	Diversion Dam Boise, ID	Glenwood Br. Boise, ID	14
2	Glenwood Br. Boise, ID	Star Road Star, ID	14
3	Star Road Star, ID	W. Plymouth Br. Caldwell, ID	10
4	W. Plymouth Br. Caldwell, ID	Snake River OR-ID Border	26

Laboratory Analysis

Field samples were analyzed with an ion-chromatography method utilizing a Lachat Quikchem 8500 at the Boise State University Biogeochemistry Laboratory. This is an EPA 300.0 equivalent method using a carbonate eluent and sulfuric acid regenerate, which analyzes for the anions orthophosphate as P, nitrate as N, nitrite as N, chloride, sulfate, bromide, and fluoride. The recommended detection levels for all of the anions are 0.05 mg L^{-1} but concentrations as low as 0.02 mg L^{-1} can be separated from background noise by analyzing the chromatograph data for voltage peaks.

A six-point calibration curve was created using six standard calibration solutions and was performed for every sampling event. This calibration was used for multiple analytical runs of up to 55 samples each. The instrument accuracy was tested by running a standard calibration solution with similar concentrations to the sample water every 15 samples. Precision was tested by running a random field sample, with a concentration above the minimal detection level, multiple times. This was achieved by analyzing three test tubes with three sample pulls per test tube, totaling nine tests on a single sample.

All samples were tested within seven days of field collection, which exceeded the EPA holding times of 48 hours for orthophosphate and nitrate. To ensure there was no sample degradation, sample s2-1 was analyzed in multiple test runs. This sample number was chosen to be tested in each analytical run due to its early test time in a run and a concentration signal above the minimal detection level. Further preservation of samples was achieved by keeping them in the original sample bottles and refrigerated while not in queue for testing. Cross contaminations was eliminated by filtering the samples through single use disposable 0.45 micron nylon filters into clean and dry test tubes. The syringes used to push sample water through the filters were triple rinsed in DI water and dried with compressed air after every sample.

Daily Load Equation

The daily load analysis was used to determine the daily load at the five gauging stations, Diversion Dam, Glenwood Bridge, South Channel Eagle Island, Middleton, and Parma, for all of the sampling events. Daily load is a calculation of the mass of a particular constituent that moves past a point over 24 hours. It is calculated by multiplying a sampled concentration nearest to a gauging station by the discharge information provided by that station, and a conversion factor of 2.447. This yields the daily load in kg day^{-1}.

Equation 1. Daily Load Equation

$$[Concentration]\,\frac{mg}{L} \times Discharge\,\frac{ft.^3}{sec.} \times 2.447 = Daily\ Load\,\frac{kg}{Day}$$

CHAPTER 3: RESULTS

Historical Data: Concentration

The historical data collected by the USGS shows that overall orthophosphate concentrations are increasing from Diversion Dam to the Snake River and exceed the US EPA recommendation of 0.07 mg L^{-1}. Seasonal trends of peaks and troughs were also observed where the lowest concentrations are typically in the summer and highest concentrations are in the winter. Four of the seven collection sites were used to determine these trends, Diversion Dam, Glenwood Bridge, Middleton, and Parma, since they contain the most current data. Diversion Dam data ranges from 1990 to 2013, concentrations ranging from below detection to 0.083 mg L^{-1}, with the 2013 concentrations at 0.015 mg L^{-1}. Glenwood Bridge data ranges from 1972 to 2013, concentrations ranging from 3.37 mg L^{-1} to 0.018 mg L^{-1}, and the lowest concentrations in 2013 averaging approximately 0.08 mg L^{-1}. Middleton data ranges from 1991 to 2013, concentration range from 2.45 mg L^{-1} to 0.061 mg L^{-1}, with 2013 concentrations averaging around at 0.6 mg L^{-1}. The final collection site is Parma, which has been monitored discontinuously since 1970 and monthly since 2007. Concentrations at Parma range from 3.3 mg L^{-1} to 0.058 mg L^{-1}, with 1.23 mg L^{-1} to 0.058 mg L^{-1} for 2007 to 2013.

24 Hour Study: Concentration

Concentration data was collected near Parma, Idaho on 7-13-2012 to 7-14-2012 to determine the diel cycles of the LBR. Two main trends emerged, the first is erratic peaks and troughs and the second is a common sinusoidal function. Orthophosphate data ranged from 0.18 to 0.20 mg L^{-1} with a slightly increasing trend of peaks and troughs, where the frequencies of the peaks vary from one to four hours. Nitrate data ranged from 1.45 to 1.5 mg L^{-1} in a common sinusoidal trend with the lowest concentration around 12:00 PM and the highest concentrations around 03:00 AM. Chloride has a subdued sinusoidal trend combined with peaks and troughs ranging from 10.5 mg L^{-1} at 11:00 PM to 9.8 mg L^{-1} at 10:00 AM on 7-14-2012. Sulfate ranges from 21.5 mg L^{-1} at 12:00 PM to 20.7 mg L^{-1} at 10:00 AM on 7-14-2012 in a sinusoidal trend. Bromide, nitrite, and fluoride concentrations were below detection limits and were not included in the trend analysis.

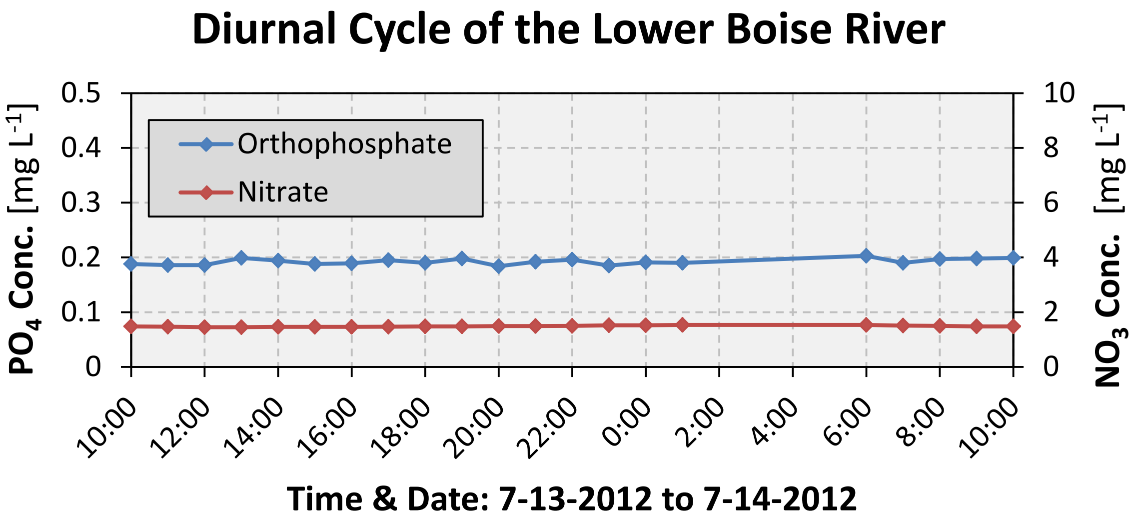


Figure 6. **Diurnal cycle of nutrients at the Parma Idaho USGS gauging station.**

Concentration Data

The temporal and spatial concentration and daily load trends in the LBR were identified for four major anions, chloride, orthophosphate, nitrate, and sulfate. The minor anions, bromide, nitrite, and fluoride were below detection level and did not yield significant concentration or load information. Chloride, orthophosphate, and nitrate contain similar concentration trends. Spatial trends show overall concentrations increase downstream with major increases at Lander Street WWTP, West Boise WWTP, the Star Road point source, and Caldwell WWTP, and a major decrease following the West Boise WWTP to approximately mile 25. The temporal trends are not as well defined as spatial trends but show fall and winter generally have greater concentrations than spring and summer. Sulfate has a consistent increase in concentration downstream with major increases at Lander Street WWTP, West Boise WWTP, Mason Creek, and Caldwell WWTP, but unlike the other major anions sulfate does not contain any major decreases. The seasonal trends are also poorly defined, generally showing fall and winter higher than spring and summer.

Loading trends, both spatially and temporally, were similar between orthophosphate, nitrate, chloride and sulfate. All loads had an overall increase downstream with major loading occurring between the Glenwood Bridge station and the South Channel Eagle Island station. Additional loading also occurred between the Middleton station and the Parma station. Seasonal variability in loading was also present for each major anion. The winter season had the greatest daily loads, intermediate loading occurred during the summer and fall, and the spring had the lowest daily loading.

Orthophosphate

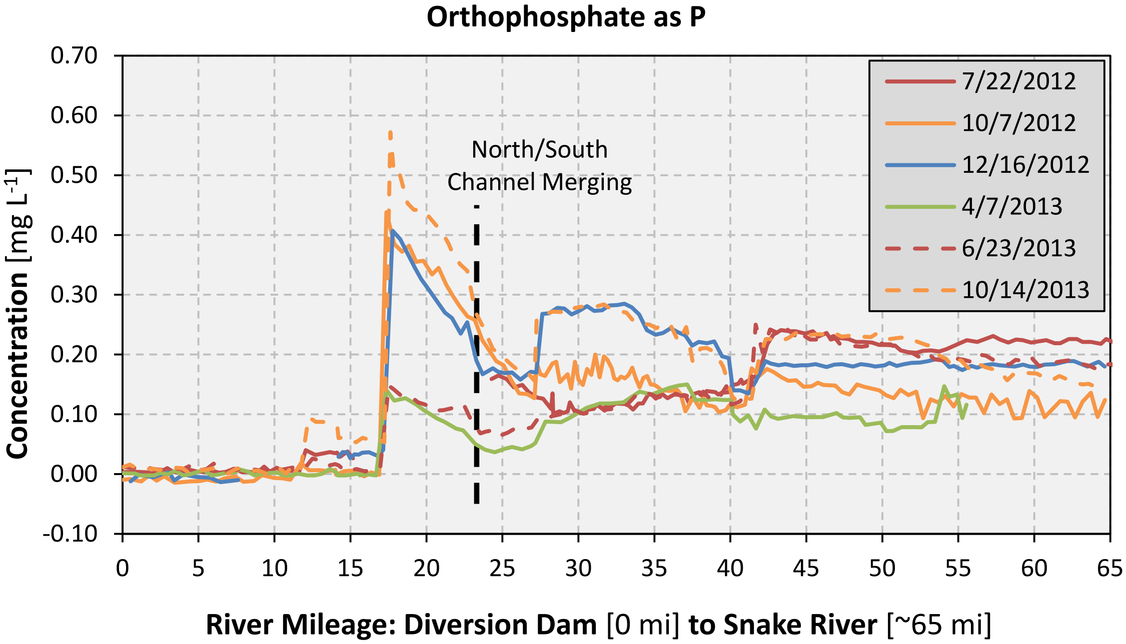


Figure 7. Orthophosphate concentration data for the six sampling events.

Spatial

Orthophosphate shows overall spatial trends of increasing concentration and exceeds the EPA limit of 0.07 mg L^{-1} for all six sampling events. Starting concentrations at diversion dam are at or near 0.0 mg L^{-1} and increase to a range of 0.12 mg L^{-1} to 0.23 mg L^{-1} at the Snake River. Four major concentration increases and one major decrease were located. The first major increase occurs at the Lander Street WWTP in Boise, Idaho at 11.6 miles. Concentration increases from base level noise or near detection levels to the first signals of 0.013 to 0.04 mg L^{-1}. The second major increase occurs at the West Boise WWTP in Boise Idaho at 17.2 miles. Concentrations increase from low levels, 0.0 to 0.035 mg L^{-1}, up to 0.15 to 0.44 mg L^{-1} depending on the time of year. This increase is the first time orthophosphate exceeds the EPA recommended limit of 0.07 mg L^{-1}. Following the West Boise WWTP increase is the first major decrease from 17.2 miles to approximately 27 miles at Star Road, Star, Idaho where concentrations gradually decrease to a range of 0.04 to 0.17 mg L^{-1}. At Star Road, there is the third major increase where concentrations increase up to 0.27 mg L^{-1}. The fourth major increase occurs at the Caldwell WWTP where concentrations increase 0.05 to 0.10 mg L^{-1}. Two minor trends were also located along the LBR. The first at the Middleton WWTP in Middleton, Idaho, mile 37.2, where there was inconclusive change even though the WWTP was operational, and the second is from approximately mile 45 to the Snake River where concentrations stabilize. These major spatial trends describe the overall behavior of the LBR, but within each trend there is temporal variation.

Temporal

Seasonality plays a major role in the magnitude of temporal variation at the key spatial locations. At the Lander Street WWTP, summer, fall, and winter increase by 0.03 mg L^{-1} or 200% over their base inputs, while spring shows no increase. The largest increase of orthophosphate in the LBR is at the West Boise WWTP during the fall and winter, where concentrations increase by 0.4 mg L^{-1} or 300%. Spring and summer have less dramatic increases, increasing by only 0.1 mg L^{-1}. Following the West Boise WWTP is a major decrease in concentration by approximately 50% for all seasons regardless of the starting concentration. At Star Road, there are major increases during the fall and winter, where winter is the largest increase year round, increasing by 0.1 mg L^{-1}. Minor increases occur during the summer 2013 and spring 2013. Caldwell WWTP has increases of 0.06 mg L^{-1} in the fall and winter and 0.10 mg L^{-1} during the summer, while there is a decrease of 0.02 mg L^{-1} in the spring. Concentrations level out at the end of the LBR from approximately mile 45 to the Snake River where spring concentrations are the lowest of the seasons at 0.10 mg L^{-1}, increasing to fall at 0.14 mg L^{-1}, winter at 0.18 mg L^{-1}, and finally summer at 0.20 mg L^{-1}. A few minor exceptions occur in the final reach from mile 45 to the Snake River. The first is an increase in the spring of 0.06 mg L^{-1} at the Dixie Slough, mile 53.7, and the second is in the fall where a series of increases and decreases occur approximately every mile varying around a magnitude of 0.04 mg L^{-1}.

Nitrate

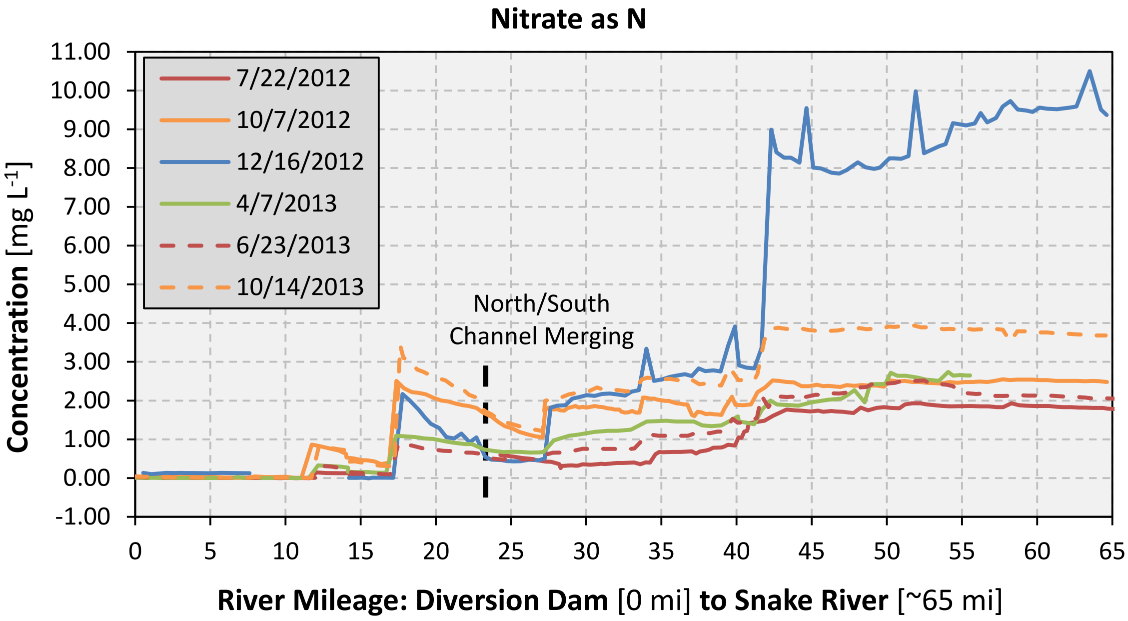


Figure 8. Nitrate concentration data for the six sampling events.

Spatial

Spatial trends for nitrate are similar to orthophosphate where there is an overall increase from Diversion Dam to the Snake River for all sampling events. Within the overall trend, four major increases, one major decrease, and several minor changes were identified. Concentrations for the overall nitrate trend enter at or less than the level of detection from Lucky Peak Reservoir and generally increase to 2.0 mg L^{-1} at the Snake River. The one exception is the winter sampling event where there is a large increase and concentrations increase to 10 mg L^{-1} at the Snake River. The first major increase occurs at the Lander Street WWTP where concentration increases from base input of 0.0 mg L^{-1} to a range of 0.31 to 0.87 mg L^{-1}. The second major increase occurs at the West Boise WWTP, with concentrations increasing between 0.8 and 2.1 mg L^{-1}. Following the West Boise WWTP increase is the first major decrease, from the West Boise WWTP (mile 17.2) to Star Road, Star Idaho (mile 27), concentrations gradually decrease to a range of 0.5 to 1.0 mg L^{-1}. The third major increase is at Star Road where concentrations increase to a range of 0.5 to 1.8 mg L^{-1}. The fourth major increase and the largest nitrate increase in the LBR occurred at the Caldwell WWTP where concentrations increase to a range of 1.5 to 9.0 mg L^{-1}. Several minor trends, such as step decreases or increases and localized increases, were also identified. A step decrease of 0.1 mg L^{-1} occurs at mile 14 near Glenwood Bridge, and smaller increases occur at 15 Mile Creek where concentration increases range from 0.4 to 1.1 mg L^{-1}, and Mason Creek increases range from 0.3 to 1.2 mg L^{-1}.

Temporal

The general spatial trends for nitrate also have seasonal variation. At the Lander Street WWTP, spring and summer have low increases, ~0.3 mg L^{-1}, while fall increases by 0.85 mg L^{-1}, and winter appears to have no increase. Winter data is missing for the Lander Street WWTP but samples downstream at mile 14.5 are below detection. West Boise WWTP has consistent increases year round with fall and winter increasing 1.5 mg L^{-1}, which is approximately 100% greater than the spring and summer increases of ~0.75 mg L^{-1}. Following the West Boise WWTP is a major concentration decrease of approximately 50% for all seasons regardless of starting concentration. At Star Road, there are major increases during the fall and winter, with the largest increase occurring in the winter which increases by 1.2 mg L^{-1}. Spring has minor increases of ~0.3 mg L^{-1} and there is inconclusive change during summer seasons. The largest increase for nitrate in the LBR occurs at the Caldwell WWTP during the winter season, increasing from 2.9 to 9.00 mg L^{-1}, a 200% increase. Spring, fall, and summer have smaller increases generally around 0.6 mg L^{-1}. Concentrations level out at the end of the LBR from approximately mile 45 to the Snake River in the spring, summer, and fall, remaining stable around 2.5 mg L^{-1}. Winter concentrations gradually increase approximately 0.1 mg L^{-1} per mile with localized 1.5 mg L^{-1} increases at miles 44.6, 51.9, and 63.5. The increase at mile 63.5 increases to 10.5 mg L^{-1} and is the only sample point where nitrate exceeds the US EPA limit of 10.0 mg L^{-1}.

Chloride

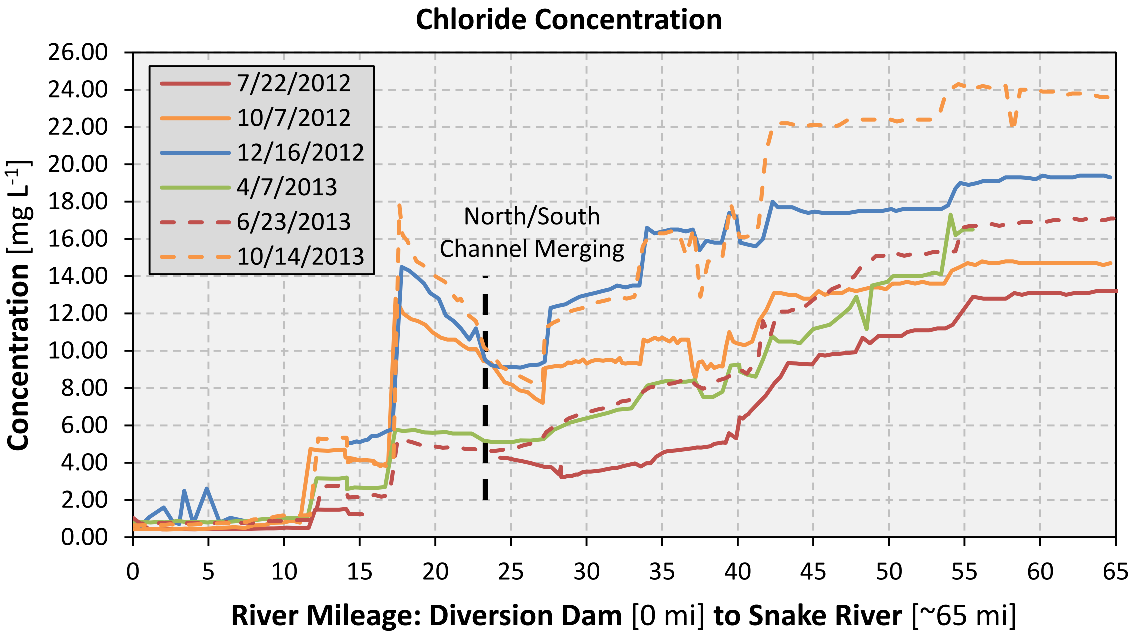


Figure 9. Chloride concentration data for the six sampling events.

Spatial

Chloride follows similar spatial trends to orthophosphate and nitrate. There is an overall increase from Diversion Dam to the Snake River for all sampling events, five major increases, one major decrease, and several minor changes. The base chloride concentrations entering from Lucky Peak Reservoir are approximately 0.5 mg L^{-1} and increase to a range of 13.1 to 24 mg L^{-1} at the Snake River. The first major increase occurs at the Lander Street WWTP where concentration increases from base input to a range of 2.7 to 4.7 mg L^{-1}. The second major increase occurs at the West Boise WWTP, with concentration increases ranging between 3.0 and 9.0 mg L^{-1}. Following the West Boise WWTP is the first major decrease, from mile 17.2 to approximately mile 27 at Star Road in Star, Idaho, where concentrations gradually decrease or do not have a significant change. At Star Road is the third major increase where concentrations increase 0.5 to 3.0 mg L^{-1}. The fourth major increase occurs at 15 Mile Creek where concentrations increase 1.0 to 3.0 mg L^{-1}. Finally the fifth major increase occurs at the Caldwell WWTP where concentrations increase approximately 2.0 mg L^{-1}. In addition to the major trends, several minor trends were identified at mile 14.5, Middleton WWTP, Mason Creek, and Dixie Slough. There is a step decrease at mile 14.5 of approximately 0.45 mg L^{-1}, a step decrease at Middleton WWTP of 1.0 to 2.0 mg L^{-1}, an increase at Mason Creek of approximately 1.5 mg L^{-1}, and an increase at Dixie slough of approximately 1.0 to 1.5 mg L^{-1}.

Temporal

The general spatial trends for chloride have a large amount of temporal variation, summer concentrations tend to be lower while winter is higher. At the Lander Street

WWTP, there is a consistent increase year round. Summer 2012 has the lowest increase, increasing only 1.75 mg L^{-1}, followed by spring and summer 2013 with a 2.0 mg L^{-1} increase, then fall and winter with the largest increase of ~4.0 mg L^{-1}. Again winter data is missing for the Lander Street WWTP but by extrapolating samples before and after the WWTP a clear increase is indicated. West Boise WWTP has consistent increases year round with fall and winter increasing 9.0 mg L^{-1}, which is approximately 200% greater than the spring and summer increases of 3.0 mg L^{-1}. Following the West Boise WWTP is a major decrease of approximately 50% for fall and winter seasons, while spring and summer have a slight gradual decrease of less than 1.0 mg L^{-1}. At Star Road, there are major increases during the fall and winter, increasing ~2.8 mg L^{-1}, while spring and summer have only slight increases of 1.0 mg L^{-1}.This trend, including the same magnitude, of fall and winter increases while spring and summer slightly increase is the same at 15 Mile Creek. The last major increase, at the Caldwell WWTP, is consistent year round. Increases are ~3.0 mg L^{-1} with spring, summer, and fall concentrations grouped together and winter at a higher concentration. Concentrations gradually increase to the Dixie Slough where there is a small increase of ~2.0 mg L^{-1} on an annual basis. The largest change is in the spring, increasing 3.2 mg L^{-1}, while the smallest change is in the fall, increasing 0.7 mg L^{-1}. Downstream from the Dixie Slough, from approximately mile 55.5 to the Snake River, concentrations level off.

Sulfate

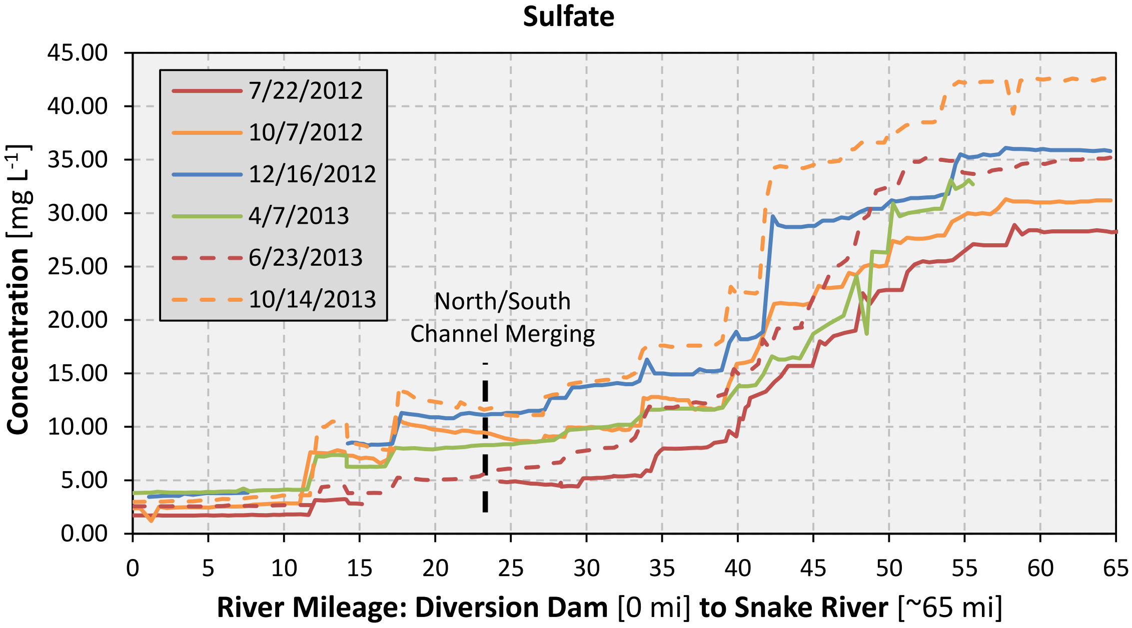


Figure 10. Sulfate concentration data for the six sampling events.

Spatial

Sulfate follows the same general trends as orthophosphate, nitrate, and chloride but does not have the dramatic increases and decreases. The overall trend is gradually increasing concentrations from ~2.0 mg L^{-1} at Diversion Dam to ~30.0 mg L^{-1} at the Snake River. There are three major increases along the length of the LBR and they occur at, Lander Street WWTP, West Boise WWTP, and Caldwell WWTP. In addition to the major increases in concentration, there are several minor increases and decreases. The first major increase at Lander Street WWTP had concentrations increasing in a range between 1.0 and 4.5 mg L^{-1}. The second major increase occurred at the West Boise WWTP, where concentrations increased in a range between 1.5 and 5.0 mg L^{-1}. The last major increase is at the Caldwell WWTP where concentrations increased in a range between 2.0 to 9.0 mg L^{-1}. Minor trends were also identified at several locations, mile

14.5, Star Road to mile 29, Mason Creek, Conway Gulch Creek, and Dixie Slough. There is a step decrease at mile 14.5 of approximately 0.6 mg L^{-1}, a two-step increase from mile 27 to mile 29 each step increasing ~1.0 mg L^{-1}, an increase at mason creek of ~2.5 mg L^{-1}, an increase at Conway Gulch Creek of ~2.5 mg L^{-1}, and an increase at Dixie Slough of ~1.0 mg L^{-1}.

Temporal

The amount of temporal variation for sulfate is similar to the other anions, summer concentrations tend to be lower while winter is higher. At the Lander Street WWTP, there is an increase year round. The concentrations in summer and spring have the lowest increase, increasing only 1.7 mg L^{-1}, followed by spring, increasing 3.1 mg L^{-1}, while fall and winter have a 4.4 mg L^{-1} increase. Again winter data is missing for the Lander Street WWTP but by extrapolating samples before and after the WWTP a clear increase is indicated. West Boise WWTP has consistent increases year round with fall and winter increasing ~3.0 mg L^{-1}, while spring and summer increase ~1.3 mg L^{-1}. Following the West Boise WWTP is where the sulfate trend differs from the other ions. Winter, spring, and summer increase gradually ~1.5 mg L^{-1} over the 10 miles downstream of the WWTP, while fall only slightly decreases, ~2.0 mg L^{-1} over 10 miles. The last major increase is located at the Caldwell WWTP and is consistent year round. Increases are ~2.5 mg L^{-1} in the spring and summer, 5.6 mg L^{-1} in the fall, and 10.8 mg L^{-1} in the winter. Following the Caldwell WWTP, concentrations gradually increase in a step function of 2.0 mg L^{-1} to 3.0 mg L^{-1} every mile to two miles until Conway Gulch Creek where there is a small increase of ~2.5 mg L^{-1} in the spring, summer, and fall. The final increase is at Dixie Slough where winter and spring increase

~2.5 mg L^{-1} while summer and fall increase ~1.0 mg L^{-1}. From approximately mile 55 to the Snake River concentrations level off. At the mouth of the LBR, winter had the highest concentration at 36 mg L^{-1} while the other seasons were as low as 28 mg L^{-1}.

Bromide, Nitrite, and Fluoride

Data for bromide, nitrite, and fluoride was near or below the level of detection or show few significant trends. Bromide data ranges from -0.02 0.05 mg L^{-1}, which is at or below the level of detection of 0.05 mg L^{-1}. Spring and summer 2013 data was not detected in the laboratory process, and there are no trends for the summer 2012, winter, or fall data. Nitrite data was below the level of detection of 0.05 mg L^{-1} for every sampling except the spring event. There is one notable trend in nitrite, which is an increase at mile 27 up to 0.05 mg L^{-1} with a gradual increase to 0.11 mg L^{-1} at mile 55.3. Fluoride was above detection for all sampling but only shows two significant trends. At Lander Street WWTP, there is an increase year round with fall having the greatest increase jumping ~0.3 mg L^{-1}, and a second trend at mile 27, Star Road, in the spring with a decrease of 0.06 mg L^{-1}. Overall bromide, nitrite, and fluoride were below detection or lost to background noise to discern any important trends.

Spatial Associations

There are several primary trend associations between the major anions orthophosphate, nitrate, chloride, and sulfate. These trends have been correlated between, location, concentration behavior, and time of the occurrence. Total associations, containing all four major anions, and partial associations, containing two or three major ions, have been identified. There are three universal trends in the LBR for orthophosphate, nitrate, chloride, and sulfate. The first is the water entering from Lucky

Peak Reservoir is clean with little or no concentration signal and is well below US EPA recommended contamination levels. The second is at the West Boise WWTP where concentrations increase and is generally the largest concentration increase for any of the anions. The third universal trend in the LBR is the increase at mile 27 where fall and winter have large concentration increases while spring and summer have lesser increases. In addition to the universal trends involving all four major anions, there are several trends between three anions.

The following correlated trends involve three of the anions in any combination of orthophosphate, nitrate, chloride, or sulfate. One major trend, which occurs year round and is immediately downstream of the West Boise WWTP and continues to Star Road, is the largest decrease in concentration for orthophosphate, nitrate, and chloride. There are also several trends that do not include orthophosphate but are spatially and temporally correlated between nitrate, chloride, and sulfate. Both concentration decreases and increases are present in the trends for these anions. There is only one decrease, occurring at mile 14, immediately before Glenwood Bridge and is a year round step decrease. There are three concentration increases, the first is located at 15 Mile Creek where an increase occurs year round but is greatest in the fall, winter, and spring. The second is at Mason Creek where there is an increase year round and is greatest in the winter. The final association between nitrate, chloride, and sulfate occurs at the Caldwell WWTP where there is an increase year round.

Daily Load Data

The daily load is an indication of the mass of material moving past a single point over a 24-hour period. For this study, it was calculated as the concentration of a sample point closest to each of the gauging stations multiplied by the average instantaneous daily discharge over a 24-hour period (Equation 1). The LBR daily load for the seven anions was calculated at five locations where the USGS and Bureau of Reclamation maintain continuous gauging stations. The USGS stations are located at Glenwood Bridge near Boise, South Channel Eagle Island near Eagle, and Hexon Road near Parma. The Bureau of Reclamation stations are located just below Diversion Dam near Boise, and near Middleton. The calculated load information provides a low resolution view of major loading sources and the overall accumulation of material from Diversion Dam to the Snake River (Figure 11).

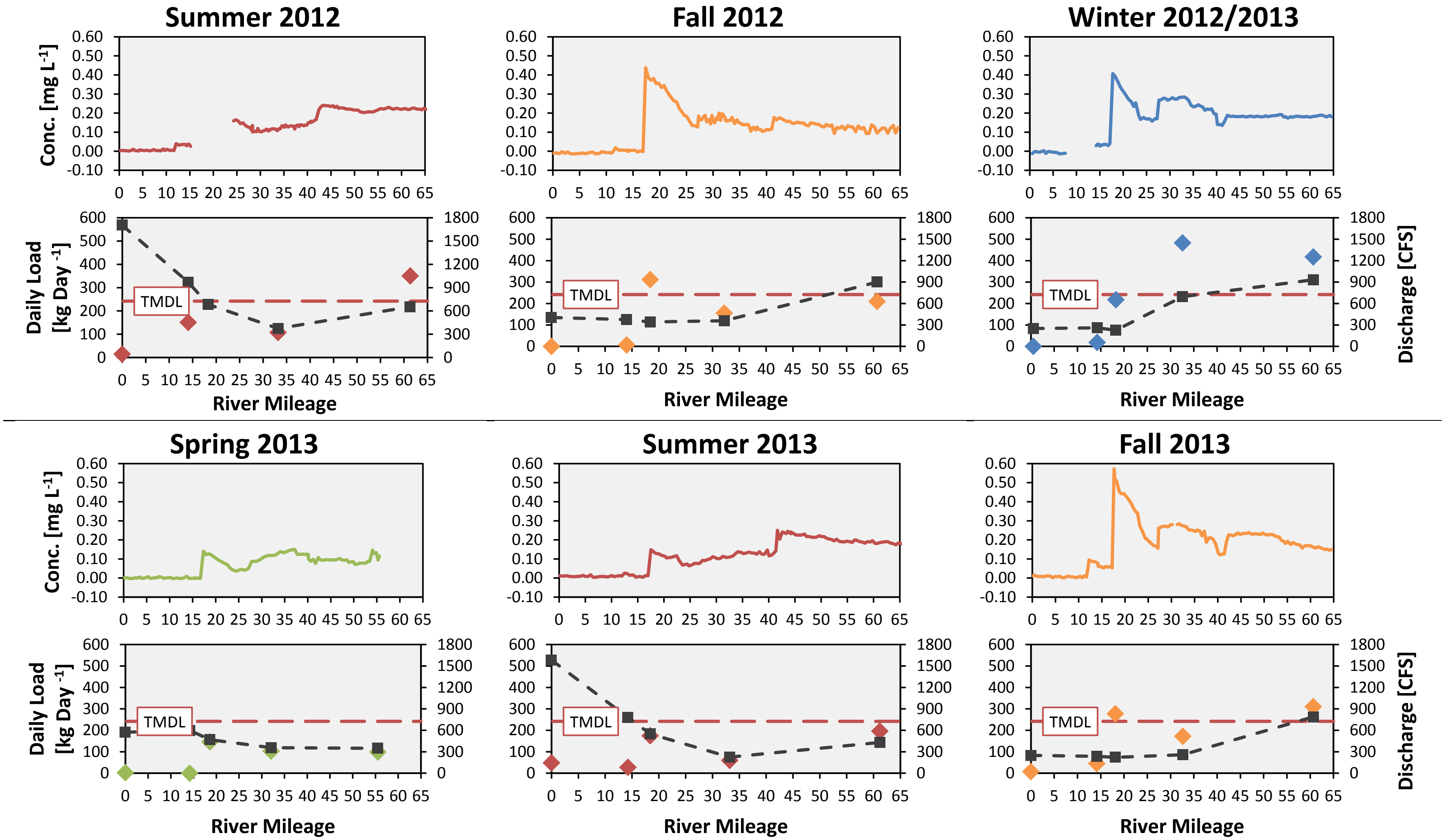


Figure 11. Comparison of orthophosphate concentration spatial data to load and discharge spatial data.

Orthophosphate

The overall temporal and spatial trends for orthophosphate are an increasing daily load from ~10 kg day^{-1} at Diversion Dam to an average of ~260 kg day^{-1} at the Parma site. Within the overall spatial trend, there are three key features that mimic the concentration data. The first is an increase in loads at the South Eagle Island channel gauging station to ~200 kg day^{-1}, the second is a decrease following the Eagle Island to the Middleton site ~100 kg day^{-1}, and the last is the recovery of load volume at the Parma site.

The main temporal trends are high summer loads upstream of the Eagle Island site, and high winter loads coupled with low spring loads downstream of the Eagle Island site. At Diversion Dam, daily summer loads were 14 kg day^{-1} in 2012 and 48 kg day^{-1} in 2013, while spring 2013 was 2 kg day^{-1}, Fall 2013 was 6 kg day^{-1}, and Fall 2012 and winter 2012 were below detection. The Glenwood Bridge site is similar to Diversion Dam where daily loads are low, averaging around 30 kg day^{-1}, and ranging from non-detect in Spring 2013 to 44 kg day^{-1} in Fall 2013. The one exception is Summer 2012 where the daily load was 400 % higher at 150 kg day^{-1}. At the eagle island site, loads average around 215 kg day^{-1}, with Fall 2012 and 2013 higher around 300 kg day^{-1}, and spring lower around 150 kg day^{-1}. The Middleton site is where there is a major change in temporal trends for winter daily loads; the spring, summer, and fall average around 120 kg day^{-1} while the winter load is at 482 kg day^{-1}. The Parma site exhibits a similar but less dramatic trend where winter is the highest load at 417 kg day^{-1}, followed by Summer 2012 and Fall 2013 at ~320 kg day^{-1}, then Summer 2013 and Fall 2012 at ~200 kg day^{-1}, and Spring 2013 at 98 kg day^{-1}.

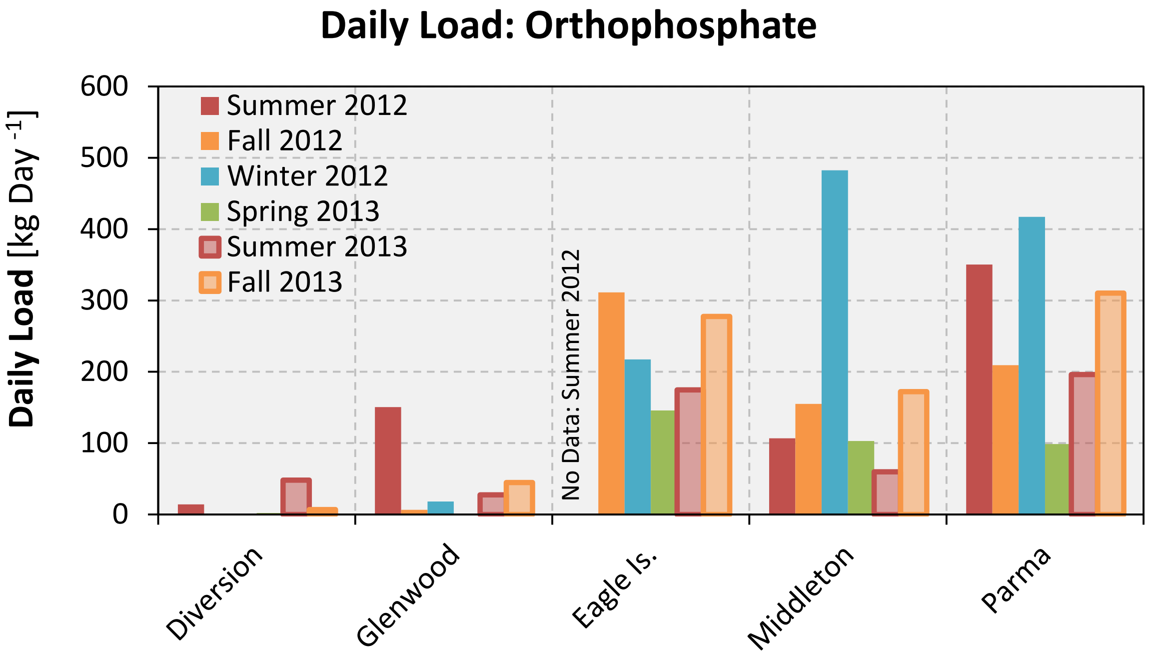


Figure 12. Orthophosphate daily load at the five continuous gauging stations.

Nitrate

Nitrate has an overall trend similar to orthophosphate where daily load is minimal at Diversion Dam, ~100 kg day^{-1}, and increases to ~4000 kg day^{-1} at the Parma site. The one exception to this is the Winter 2012 load, which is an extreme outlier of 21700 kg day^{-1}. Unlike the complex trends of orthophosphate, nitrate exhibits simple spatial trends over the length of the LBR. Summer 2012, Summer 2013, Fall 2012, Fall 2013, and Spring 2013 have increasing linear trends while Winter 2012/2013 is exponentially increasing.

The temporal variation at each site is minimal with exception of the last two sites, Middleton and Parma. The seasonal daily loads are closely grouped at the first three gauging stations, Diversion Dam, Glenwood Bridge, and Eagle Island at 100 kg day^{-1}, 200 kg day^{-1}, and 1000 kg day^{-1}, respectively. After Eagle Island, there is an exponential increase in nitrate daily load input during the Winter of 2012/2013. At the Middleton site, winter loads are at 3600 kg day^{-1}, while the average load for the rest of the seasons is ~1000 kg day^{-1}. This loading is even more prominent at the Parma site where average daily load without winter data is ~4000 kg day^{-1} while winter daily loads were ~22000 kg day^{-1}.

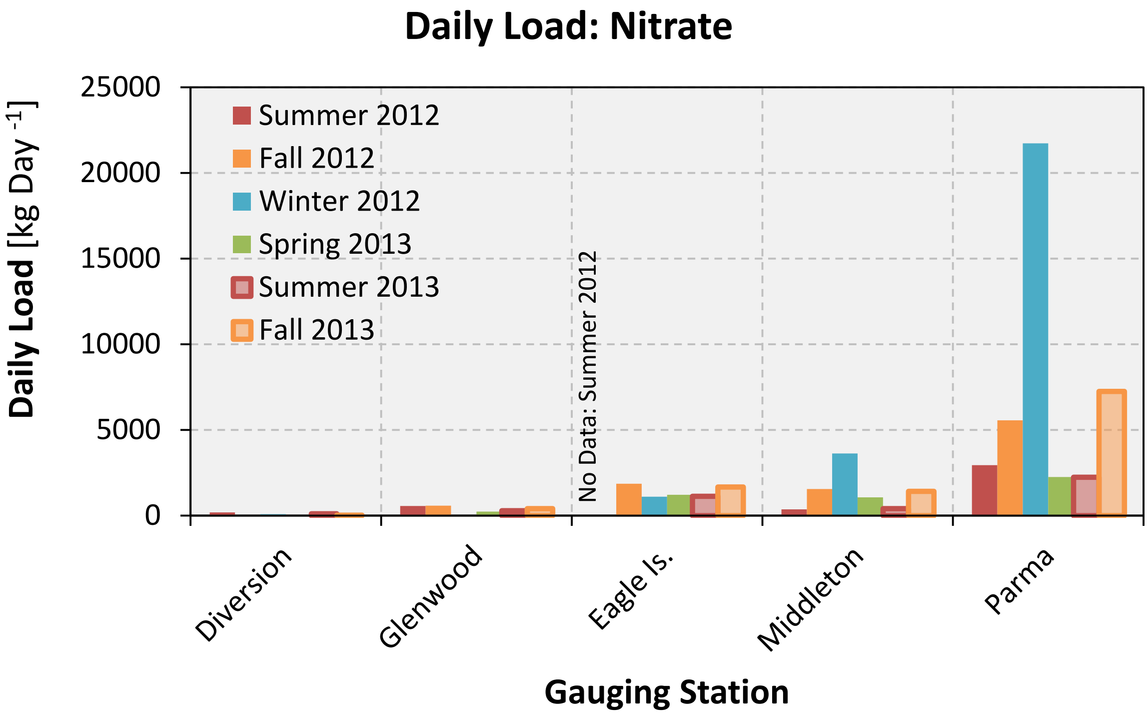


Figure 13. **Nitrate daily load at the five continuous gauging stations.**

<u>Chloride</u>

Chloride daily load trends were similar to nitrate with the exception of the winter load at the Parma station. The overall trend is an increasing load from ~2000 kg day^{-1} at Diversion Dam to ~30000 kg day^{-1} at the Parma station. Load increases linearly until the Eagle Island station, followed by a slight decrease to the Middleton station, and then a large increase to at the Parma station for the Summer 2012, Summer 2013, Fall 2012, Fall

2013, and Spring 2013 events. The Winter 2012/2013 event had increasing loads at every station downstream.

Like nitrate, the chloride temporal variation at each site is minimal with exception of the last two sites, Middleton and Parma. The seasonal daily loads are closely grouped at the first three gauging stations, Diversion Dam, Glenwood Bridge, and Eagle Island at 2000 kg day^{-1}, 4000 kg day^{-1}, and 8000 kg day^{-1}, respectively. After Eagle Island, there is a large increase in chloride daily load input during the winter at the Middleton site with a daily load of 23000 kg Day^{-1}. Average load for the other seasons at the Middleton station is ~8000 kg day^{-1}. The Parma station shows increases for all seasons with the Winter 2012/2013 and Fall 2013 events having the greatest chloride loads at ~45000 kg day^{-1}.

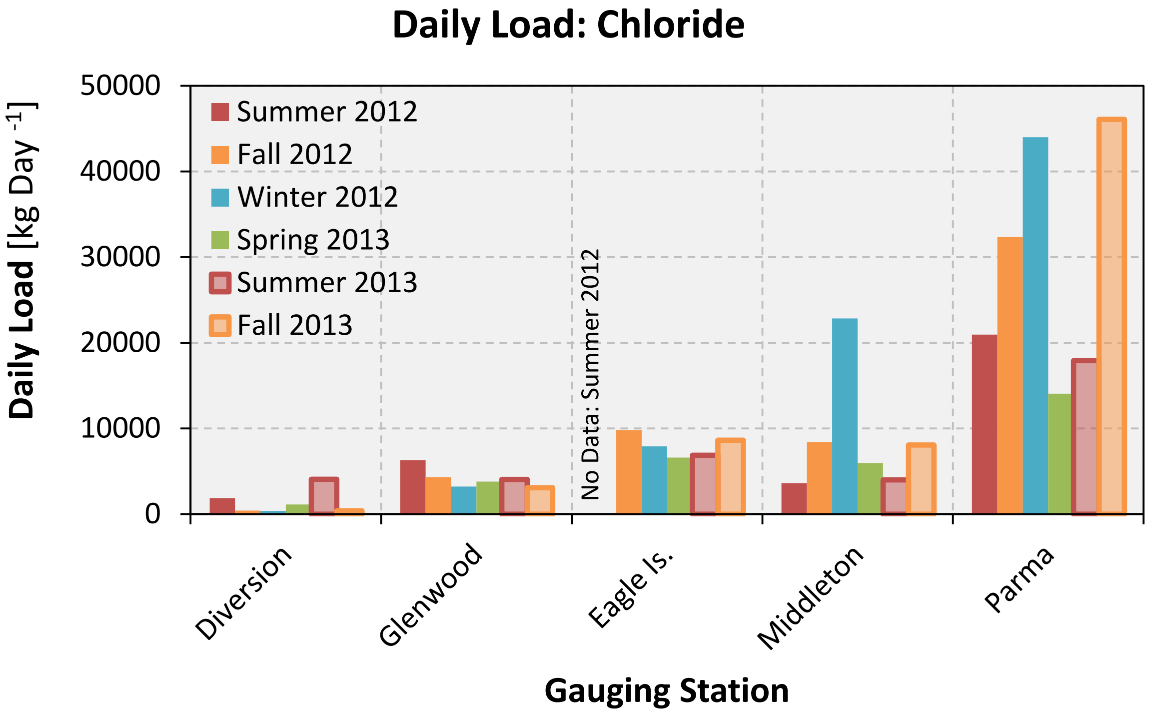


Figure 14. Chloride daily load at the five continuous gauging stations.

Sulfate

Sulfate daily load trends mirrored chloride. Daily load increases from ~5000 kg day^{-1} at Diversion Dam to ~60000 kg day^{-1} at Parma. Station to station trends show an increase from the Diversion Dam station, ~5000 kg day^{-1}, to the Glenwood Bridge station, 7000 kg day^{-1}, no change to the Eagle Island station, ~7000 kg day^{-1}, no change to the Middleton station except Winter 2012/2013, ~7000 kg day^{-1}, and a large increase to the Parma station, ~60000 kg day^{-1}. Temporal chloride daily load trends also mirrored chloride trends where the Diversion Dam, Glenwood Bridge, and Eagle Island stations had similar loads between seasons, Middleton station had a large winter load, and the Parma station had the highest loads in the winter and fall.

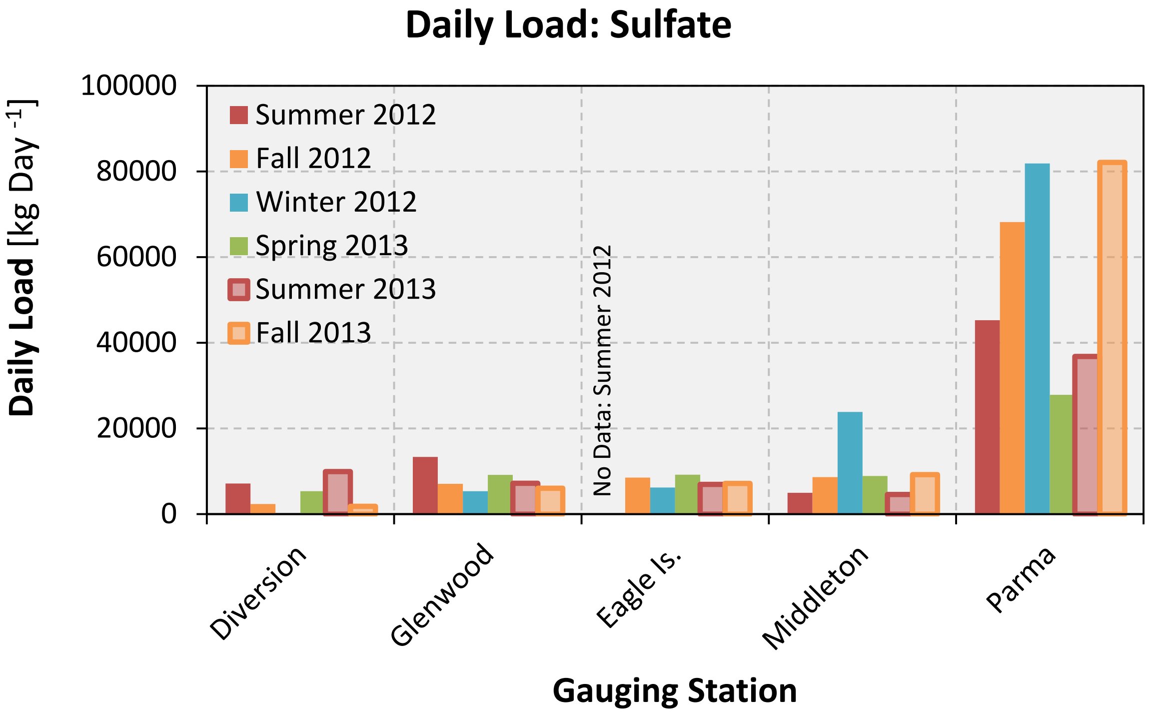


Figure 15. Sulfate daily load at the five continuous gauging stations.

Bromide, Nitrite, and Fluoride

The majority of the concentration data for bromide, nitrite, and fluoride was near or below the level of detection and could not be used for calculating daily load. Nitrite was the only analyte that had concentrations which could be used for calculating the daily load. Data for the first three gauging stations was below detection, but Middleton and Parma had discernible concentrations in the spring of 2013. The nitrite daily loads for the Spring 2013 sampling event were 50 kg day^{-1} at Middleton, and 88 kg day^{-1} at Parma.

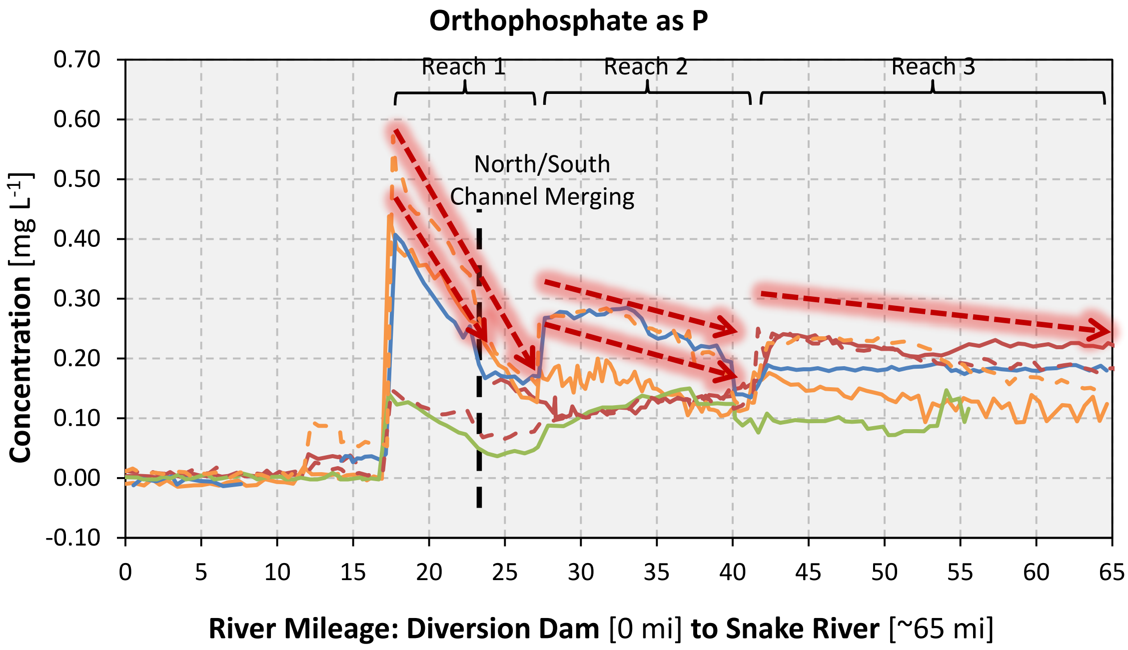
CHAPTER FOUR: DISCUSSION

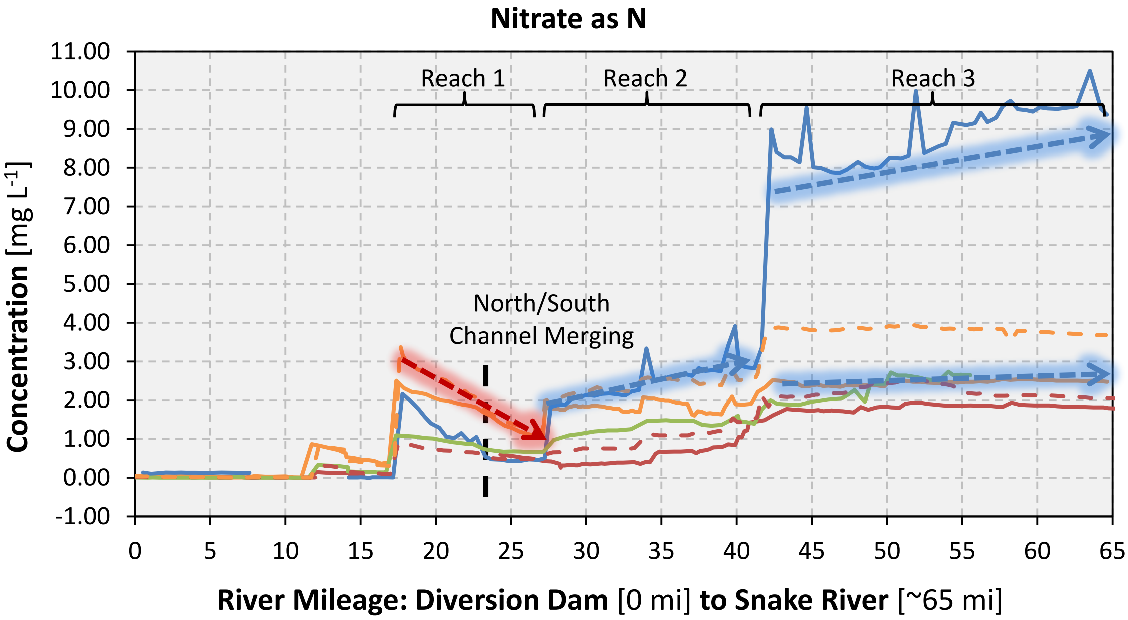
Concentration and Load Increases from Source to Confluence

The spatial concentration and daily load information exhibits an overall increase overlain by sharp increases with distance down river. The overall orthophosphate concentrations and daily loads increase from the source at Lucky Peak Reservoir, where orthophosphate is below detection, to the confluence at the Snake River, where concentration and daily load are ~0.18 mg L^{-1} and ~260 kg day^{-1}. This overall increase is mainly caused by the WWTPs, West Boise in particular, which causes the LBR orthophosphate concentrations to increase an average of 0.32 mg L^{-1}. Additional sources, Lander Street WWTP, Caldwell WWTP, and the Star Road point source were also main contributors to the orthophosphate increase. The overall spatial trends for the LBR contain major and minor increases and decreases, and a year-round concentration and daily load increases from the source at Lucky Peak Reservoir to the confluence at the Snake River.

Declines Due to Biological Consumption or Dilution/Mixing?

In addition to the increases, there were several sections of orthophosphate decreases, West Boise to Star Road (Reach 1), Star Road to Caldwell WWTP (Reach 2), and Caldwell WWTP to the Snake River (Reach 3). The data collected does not provide definitive causes but these decreases can be associated with specific mechanisms. We propose two potential main mechanisms for these declines: They may be produced by dilution or mixing with waters, surface or ground, containing lower concentrations of orthophosphate or nitrate, or these declines may be produced by biological uptake. It is illustrative to compare these declines with trends in chloride concentrations to evaluate these two possible mechanisms. Because chloride can be considered conservative and not actively assimilated by biomass, declines in chloride are indicative of mixing or dilution with waters containing lower chloride concentrations. In West Boise to Star Road (Reach 1), we observe nearly a 50% decline in phosphorous and a similar magnitude decline in chloride. This suggests that this decline can be attributed to mixing or dilution with smaller amounts of biological uptake. In contrast, the latter two declines, below Star Rd (Reach 2) and below the Caldwell WWTP (Reach 3), may be mainly attributed to biological attenuation since the non-biologically reactive chloride does not decrease over these reaches (Figure 16).





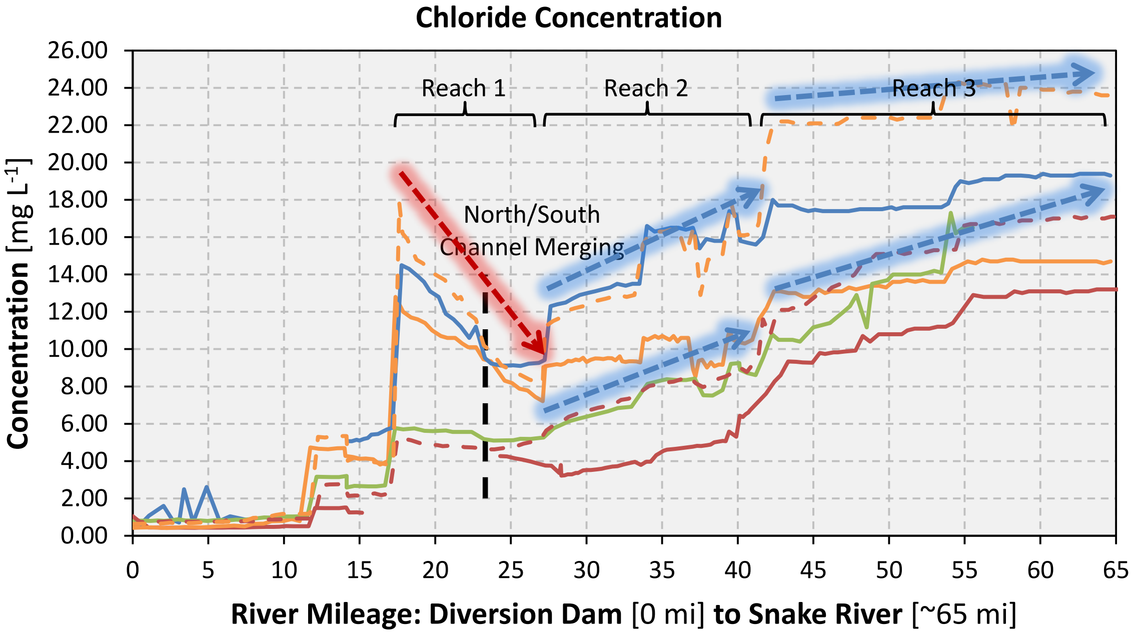


Figure 16. Orthophosphate, chloride, and nitrate concentration data comparison. Major increases (Blue Arrows) and decreases (Red Arrows).

West Boise WWTP Downstream Decline

Mixing or Dilution

The largest orthophosphate decrease in the LBR spans from the West Boise WWTP to the North/South Channel merging (mile 23) for spring, summer, and winter, and to Star Road (mile 27) for fall. Chloride concentrations also decrease in this section indicating that dilution or mixing is occurring. The constant and gradual decrease could suggest mixing issues as a dilution might cause a sharp decrease. The spring, summer, and winter concentrations level out at the channel merging but the fall concentrations never fully reach equilibrium and continue to decrease to the Star Road point source. It is possible that the physical characteristics of the channel and the sampling methods do not allow for the required distance to fully mix the West Boise WWTP input. Fall discharge is similar between the Glenwood, South Channel Eagle Island, and Middleton gauging stations, indicating that at the Eagle Island channel split (mile 15.7) there was a minimal amount of water diverted to the northern channel. Additionally, the southern channel physical characteristics differ from the main river. The channel width narrows from approximately 150 feet to 50 feet, the width-depth ratio increases, velocity increases, and the broad shallow riffle sections are absent. The sampling methods used for this study obtained grab samples close to the surface, approximately 30 cm deep, sampled the warmer WWTP water on the top of the water column. The extremely large input from the West Boise WWTP enters a fast, narrow, and deep channel requiring time and distance to fully mix with the water column. The spring, summer, and winter orthophosphate and chloride concentrations also gradually decrease but reach equilibrium at the north/south Eagle Island channel merging (mile 23.3). The gradual decrease is suggestive of the above mixing/sampling issues, and the sharp change to level concentrations could be due to dilution from the north and south channels merging.

Biological Attenuation

The mixing/dilution scenario only accounts for part of the total decrease seen in orthophosphate concentrations after the West Boise WWTP. The orthophosphate and chloride percent reductions were calculated to determine what possible percentage of orthophosphate can be attributed to dilution/mixing and what percentage can be attributed to biological attenuation (Table 3). Since chloride is non-biologically reactive in the LBR, its concentrations can indicate the amount of actual mixing/dilution. The percentage attributed dilution/mixing ranged from 9% in summer 2013 to 52% in Fall 2013, with the biological uptake ranging from 17% in fall 2013 up to 59% in Spring 2013. The orthophosphate concentration reduction percentages exceeded chloride for every season, leading to a constant percentage of the orthophosphate concentration reduction being attributed to biological uptake. This means that the decrease observed immediately downstream of the West Boise WWTP is most likely caused by both dilution/mixing and biological attenuation.

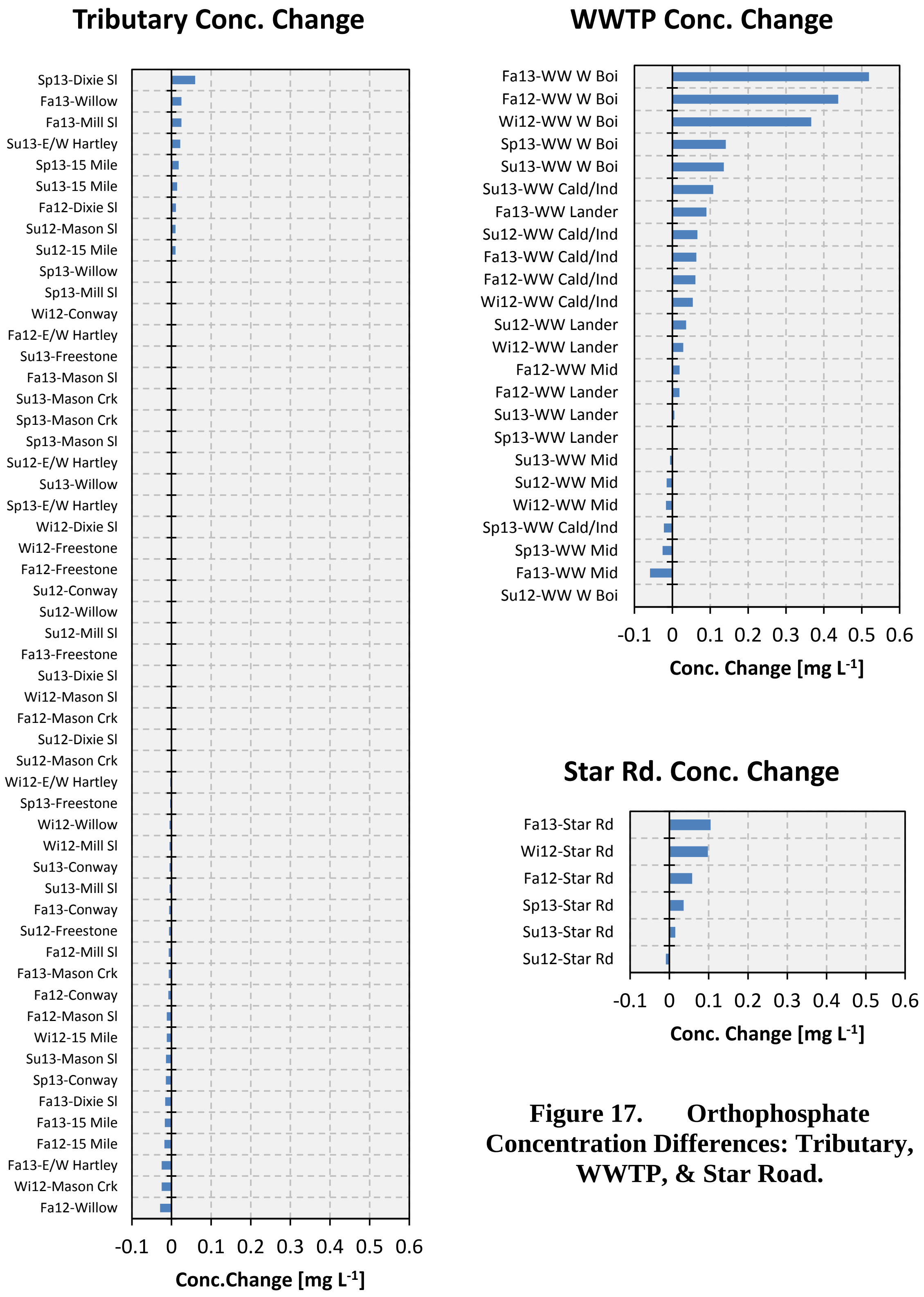
Table 3 Orthophosphate and chloride percent reductions downstream of the West Boise WWTP. Orthophosphate reduction separated into percent dilution/mixing and percent biological uptake.

Sampling Event	Orthophos. % Reduction	Chloride % Reduction	% Orthophos. Reduction: Dilution/Mixing	% Orthophos. Reduction: Biological Uptake
Summer 2012	NA	NA	NA	NA
Fall 2012	64	38	38	25
Winter 2012	58	37	37	21
Spring 2013	70	11	11	59
Summer 2013	53	9	9	44
Fall 2013	68	52	52	17

Major Sources for LBR Orthophosphate

WWTP Impact on Concentration

Orthophosphate concentrations in the LBR increase most dramatically after an input from a WWTP, with little evidence of concentration changes associated with tributary inputs. The high frequency sampling allowed the concentration difference to be calculated using data points immediately upstream and downstream of an input source. Separating this data into two categories, WWTP and tributaries, will determine which type of input has the greatest effect on the LBR orthophosphate concentrations (Figure 17).



Tributary Conc. Change

WWTP Conc. Change

Star Rd. Conc. Change

Figure 17. Orthophosphate Concentration Differences: Tributary, WWTP, & Star Road.

The upstream-downstream concentration differences at input sources contain 63 data points, 23 for WWTP, and 40 for tributaries/Star Road, which were separated and ranked in descending order of concentration difference. The WWTP data for the four facilities has differences ranging from -0.059 mg L^{-1} to 0.52 mg L^{-1} with an average increase of 0.087 mg L^{-1}. Within the four WWTPs, the West Boise facility clearly stood out as the primary sources for orthophosphate concentration increases in the LBR with an average year round concentration increase of 0.32 mg L^{-1} (Table 4). This was approximately 500% greater than the Caldwell, 1000% greater than the Lander Street, and modestly greater than the Middleton, year-round average concentration differences.

Table 4 WWTP range and average concentration changes in LBR.

	Range mg L^{-1}	**Average** mg L^{-1}
All WWTP	-0.059 to 0.52	0.087
West Boise	0.14 to 0.52	0.32
Caldwell	-0.022 to 0.11	0.055
Lander St.	-0.001 to 0.09	0.030
Middleton	-0.059 to 0.019	-0.017

WWTP Impact on Daily Load

The daily load data further reinforces that WWTP, specifically West Boise, are the most likely source for orthophosphate into the LBR. Load differences between a downstream gauging station and the immediate upstream station were calculated (Figure 18) and used in conjunction with the concentration data and input source location to determine the cause for increased loading. Load increases were observed in every gauging reach during at least one sampling event, but the Glenwood Bridge to Eagle Island section, which only input is the West Boise WWTP, had year-round load increases. Load increases were also observed in the Diversion Dam to Glenwood Bridge section, which are due to Lander Street WWTP, and in the Middleton to Parma section, which are due to the Caldwell WWTP.

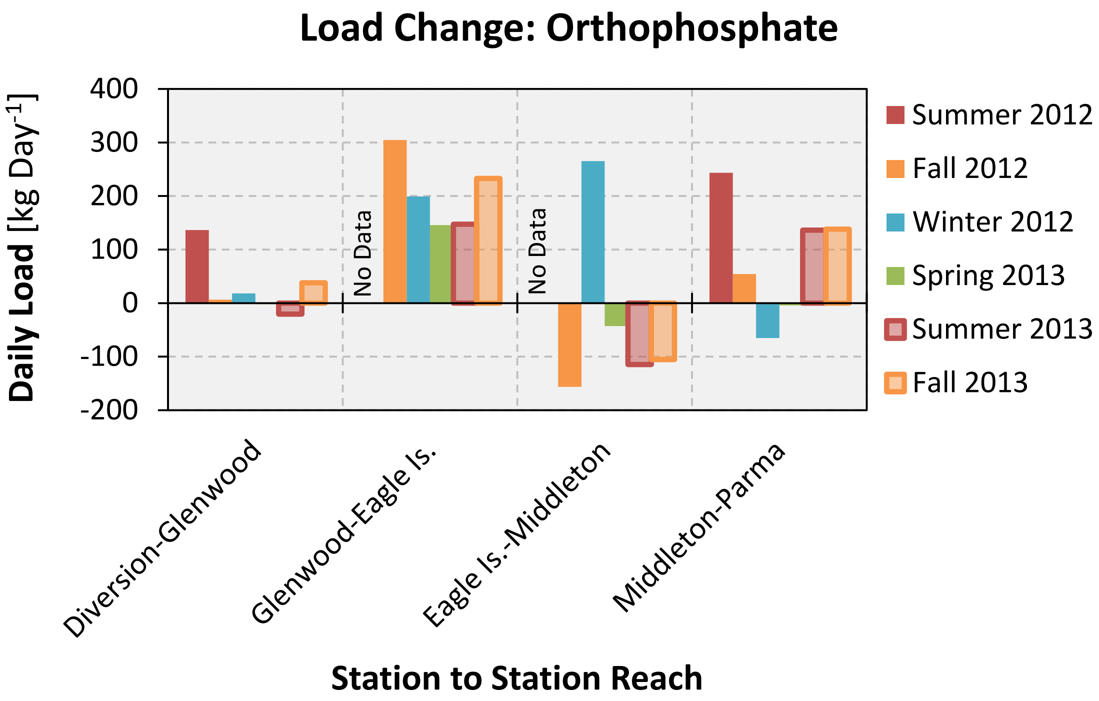


Figure 18. Difference in orthophosphate daily load between a downstream gauging station and its immediate upstream gauging station.

Star Road Point Source Impact on Concentration

The Star Road point source increases in both concentration and load, and originates from a source we cannot associate with a WWTP or tributary. This is an input that was not found by the 2012/2013 USGS synoptic study due to the spacing of the sampling locations. This source is seasonally active during the fall and winter where orthophosphate increases are approximately 0.10 mg L^{-1}; the year round average increase is 0.051 mg L^{-1}.

Star Road Point Source Impact on Daily Load

Load also increased significantly during the winter, leading to the only observed load increase in the South Eagle Island to Middleton section, increasing 270 kg day^{-1}. In comparison to the winter load increase, all other seasonal loads decreased by up to 150 kg day^{-1}. The non-WWTP and non-tributary Star Road point source is an important yet overlooked input for increases in both concentration and daily load of orthophosphate.

Tributary Impact on Concentration

The tributary data, yielding 54 data points, was similarly analyzed using upstream-downstream concentration differences, and covers the 12 major tributaries for all six sampling events. The orthophosphate concentration differences at a tributary input ranged from -0.029 to 0.060 mg L^{-1} with an average decrease of 0.001 mg L^{-1}. A direct comparison between WWTP and tributary data further illustrates that WWTP are most likely the major contributor to orthophosphate contamination. There are major differences between the concentration input sources, with WWTPs having a much higher magnitude of impact on the LBR than tributaries. The WWTP upper range limit is eight times higher than the tributaries, 0.52 mg L^{-1} for WWTP and 0.060 mg L^{-1} for tributaries. Averages are also much higher for WWTPs, where the average increase was 0.087 mg L^{-1} while tributaries had a decrease of 0.001 mg L^{-1}. Orthophosphate concentration differences immediately upstream and downstream of inputs show that major concentration increases were associated with WWTPs, while minor or no changes were associated with the tributaries. The conclusion from comparing upstream-downstream concentration differences for input sources is that the WWTPs have a far greater impact than tributaries for orthophosphate concentration increases in the LBR.

Tributary Impacts on Daily Load

Tributary inputs do not have a major effect on the concentration of the LBR since they enter an already contaminated system but can have effects on daily loading. If the tributary contains a similar elevated concentration to the LBR, there may be a large influx of orthophosphate mass with no change to concentration leading to an increase in daily load. Mason Creek (mile 38.9) and Dixie Slough (mile 53.7) input large amounts of water, Mason Creek ~150 cfs and Dixie Slough ~230 cfs, and enter the LBR at elevated total phosphorus concentrations. These concentrations are similar to the main channel, Mason Creek at 0.41 mg L-1 and Dixie slough at 0.38 mg L-1, leading to a large input of orthophosphate, Mason Creek at 150 kg day^{-1} (~21% of the average Parma daily load) and Dixie Slough at 220 kg day^{-1} (~31% of the average Parma daily load). Tributaries are not the sole loading source but are an addition to sources from WWTPs, which is observed in the daily load increases between Middleton G.S. and the Parma G.S (IDEQ, 2015).

Fall & Winter: Greatest Concentrations and Loading

Orthophosphate concentration and loading from input sources into the LBR are increased during the fall and winter seasons. The four seasons have been combined into fall/winter and spring/summer due to similar concentration trends and flow rates in the LBR. The fall/winter trend shows higher average concentrations in the river from approximately mile 11 to mile 40, after which it converges with the spring/summer confluence concentration (Figure 19).

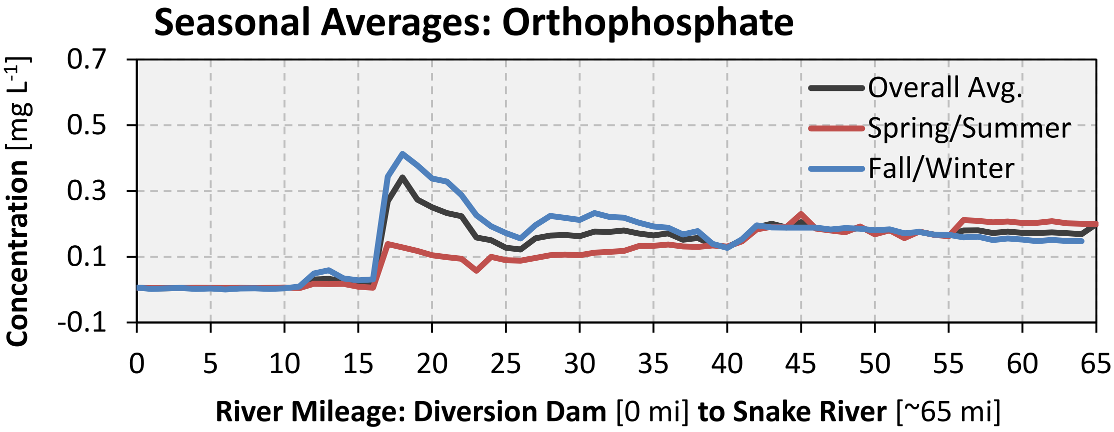


Figure 19. Average seasonal orthophosphate concentrations per mile.

In addition to seasonal averages, upstream-downstream concentration differences at inputs were also compared, with 41 spring/summer data points and 42 fall/winter data points (Figure 20). It was found that concentration differences from inputs were greater during the fall/winter seasons with differences ranging from -0.059 to 0.52 mg L^{-1} and an average of 0.041 mg L^{-1}. This was approximately three times higher than spring/summer, where differences range from -0.026 to 0.14 mg L^{-1}, with an average of 0.013 mg L^{-1}. The overall comparison from the upstream-downstream seasonal concentration differences shows fall/winter inputs have approximately three times the impact than the Spring/Summer inputs.

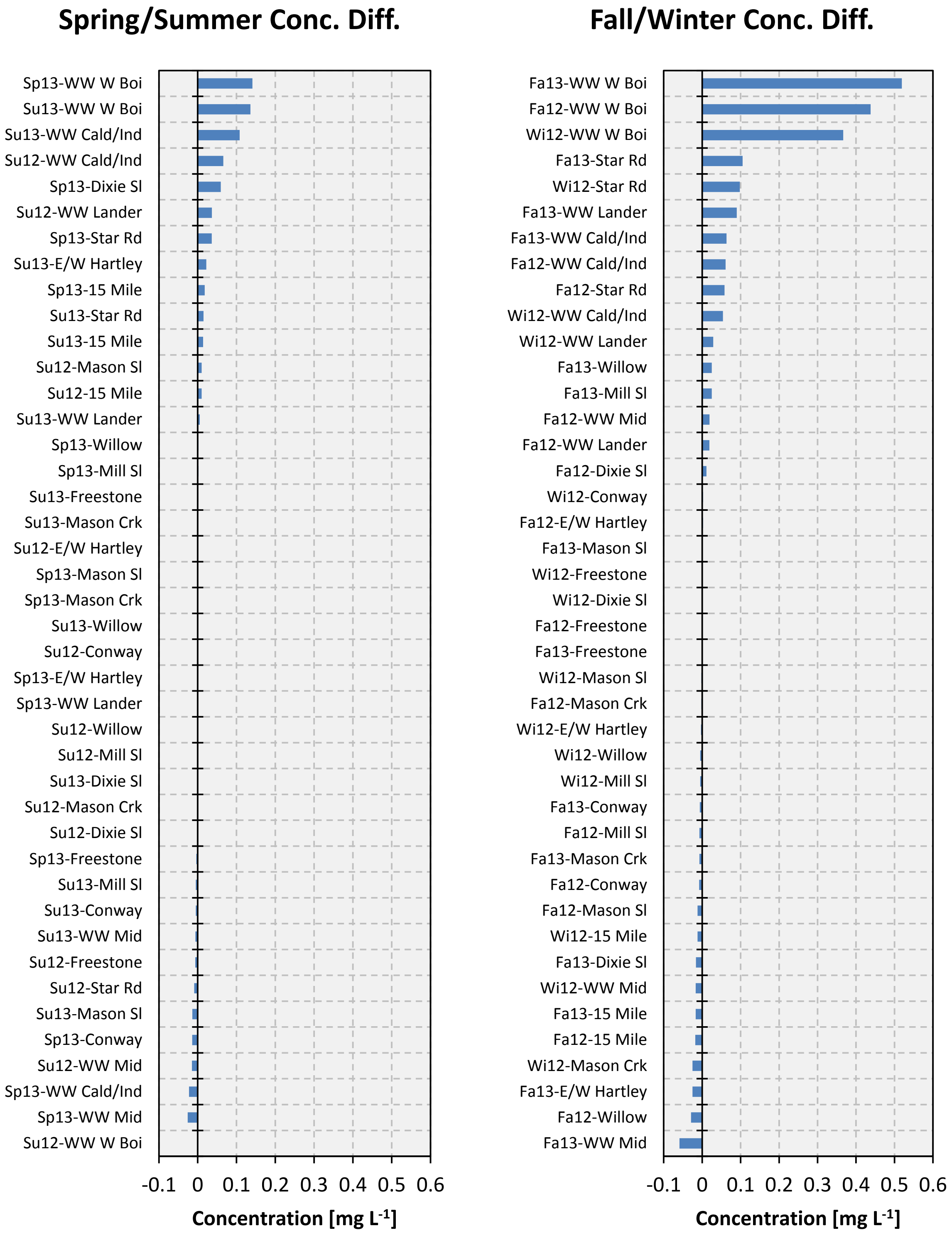


Figure 20. **Spring/Summer and Fall/Winter upstream-downstream concentration differences.**

Daily load seasonal trends were similar to the seasonal concentration trends where the winter season had the greatest amount of overall loading into the LBR while spring was the lowest. The average daily load for the winter 2012/2013 sampling was 230 kg day^{-1} and also had the greatest end load at the Parma gauging station, 420 kg day^{-1}. The spring average daily load of 70 kg day^{-1} and end load of 100 kg day^{-1} was far below the winter loading. These confined the intermediate average load and end load values for summer and fall (Figure 21). Orthophosphate concentration increases and daily loading varied seasonally, but generally fall and winter had the greatest increases.

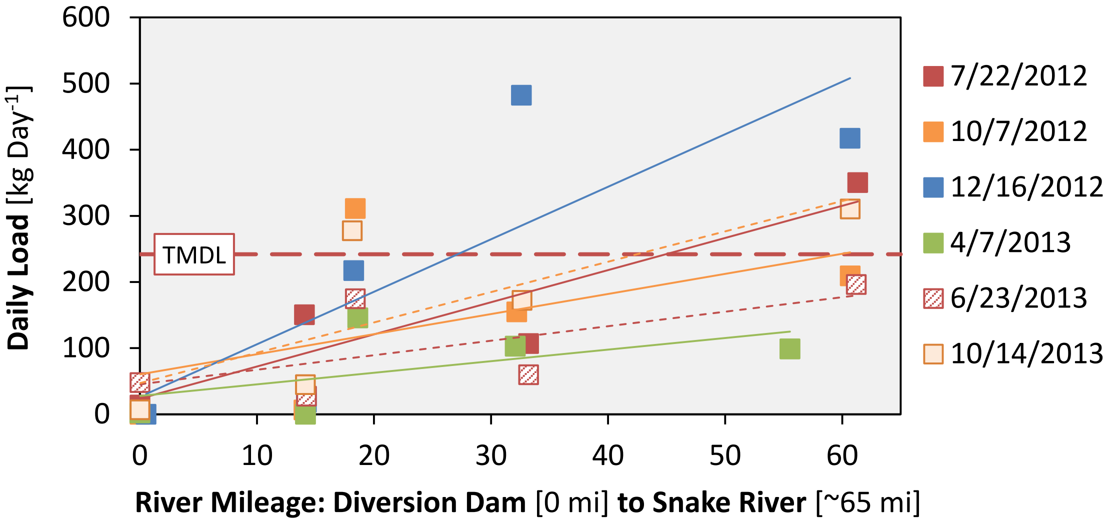


Figure 21. Daily load values at the five gauging stations for all sampling events, and average trend lines for each event. The marked TMDL dashed line is the Snake River Hells Canyon Reach TMDL of 242 kg Day^{-1}.

Total Phosphate TMDL Violated

The primary nutrient concern for the monitoring and regulating agencies, Idaho and Oregon Departments of Environmental Quality, U.S. EPA, and the USGS is the TMDL violations from Snake River tributaries. The regulation states that the Snake River Hells Canyon (SRHC) reach TMDL for the LBR tributary is not to exceed 242 kg day^{-1} of total phosphate for normal flow in the Snake River (IDEQ, 2004). The SRHC reach TMDL uses total phosphorus for its load calculations, whereas this study calculated the daily load from the sampled orthophosphate. By using orthophosphate, a conservative estimate of the daily load was calculated since approximately 70% in the summer to 90% in the winter of the total phosphate amount in the LBR is comprised of orthophosphate (Donato & MacCoy, 2005). This indicates that the actual total phosphate load associated with the calculated partial orthophosphate loads would be greater and could exceed the regulated TMDL more often than calculated. The daily load for each event was calculated at the Parma gauging station and was used as the end load into the Snake River due to its close proximity (5 miles) to the confluence. The orthophosphate TMDL exceedance ranges from 72% in the winter, which could be as high as 90% above if converted to total phosphate, to 59% below, 49% below if converted to total phosphate (Table 5). Additionally, if the summer and fall orthophosphate loads are converted to total phosphate loads, they would all exceed the SRHC TMDL. The orthophosphate daily loads exceeded the Idaho/Oregon responsibilities for the US EPA Clean Water Act in Winter 2012/2013, Summer 2012, and Fall 2013 while the estimated total phosphate loads exceeded the TMDL for every event except Spring 2013.

Table 5 Orthophosphate ranked % exceedance of the LBR 242 kg day^{-1} total phosphate TMDL for the end daily load at the Parma gauging station.

Sampling Event	Overall Load Average kg day^{-1}	End Load at Parma G.S. kg day^{-1}	Orthophosphate % TMDL Exceedance	Estimated Total Phosphate % Exceedance
Winter 2012/2013	227.1	417.3	72 %	90 %
Summer 2012	155.5	350.4	44 %	88 %
Fall 2013	162.3	310.4	28 %	54 %
Fall 2012	136.4	209.4	-13 %	38 %
Summer 2013	101.2	196.1	-19 %	5 %
Spring 2013	69.9	98.8	-59 %	-49 %

Proposed Future LBR TMDL

In response to the degraded water quality of the LBR, a new LBR TMDL is in the process of being finalized. It will specifically address the LBR loading and help protect the beneficial uses. The basis for the proposed LBR TMDL is still based off the SRHC 2004 TMDL, where the target concentration for total phosphate is 0.07 mg L^{-1} from May 1st to September 30th, but the total daily load has been adjusted to meet LBR flow fluctuations. The target total phosphate load will vary depending on flow rates in the LBR but will still meet the 0.07 mg L-1 concentration target. A 90th percentile flow of 383 cfs, to meet the concentration target 0.07 mg L^{-1}, will have a maximum daily load allotment of 65 kg day^{-1}, while a 10th percentile flow of 3268 cfs will be allotted up to 559 kg day^{-1}. An average flow, 40th percentile at 912 cfs, will be allowed up to 156 kg day^{-1} (IDEQ, 2015). Depending on flow rates, the new LBR TMDL would be lowered to 65 kg day^{-1} for low flows and 156 kg day^{-1} for moderate flows, which is far below the current 242 kg day^{-1} set by the 2004 SRHC TMDL. This new TMDL would cause an even greater violation for the daily loads calculated from the sampling events.

CHAPTER 5: CONCLUSIONS

Concentration and Load Increases from Source to Confluence

The spatial trends for the LBR include both major and minor increases and decreases, but an overall year round concentration and daily load increases from the source at Lucky Peak Reservoir to the confluence at the Snake River. Orthophosphate and nitrate enter the LBR near or below the detection level of 0.02 mg L^{-1} and less than 12 kg day^{-1} and 75 kg day^{-1}, respectively, and exit into the Snake River at ~0.18 mg L^{-1} and ~260 kg day^{-1} for orthophosphate, and ~2.5 mg L^{-1} and ~4000 kg day^{-1} for nitrate. Additionally, chloride, which is used as an indicator for certain nutrient behavior, exhibits concentration and load increases from ~0.60 mg L^{-1} and ~1800 kg day^{-1}at the source, to ~18.0 mg L^{-1} and 25000 kg day^{-1} at the confluence. Within these general increasing trends, all three anions exhibit sharp increases and decreases, as well as gradual increases and decreases due to the LBR interaction with the WWTP and tributary inputs.

Nutrient Decreases: Biological Attenuation, Mixing, and Dilution

There is evidence of both biological attenuation as well as mixing and dilution effects on nutrient concentrations within the LBR. Three major concentration decreases were identified for orthophosphate: West Boise WWTP (mile 17.2) to Star Road (mile 27), Star Road to Caldwell WWTP (mile 41.4), and from Caldwell WWTP to the Snake River (mile 65). Among these three decreases, the only similar chloride decrease is from West Boise WWTP to Star Road. This gradual concentration decrease of both orthophosphate and chloride follows the sharp increase from West Boise WWTP, and could be caused by several factors. These include incomplete mixing, where an input requires distance fully mix, mixing/dilution from interaction with the hyporheic zone, mixing/dilution from inputs and surface runoff, and biological attenuation. The following two decline reaches, Star to Caldwell and Caldwell to the Snake River, exhibit declines in orthophosphate but also exhibit increases in chloride. These trends may indicate orthophosphate removal through biological attenuation since the non-reactive chloride is accumulating while orthophosphate is being removed.

WWTP: Major Source for LBR Orthophosphate

Orthophosphate concentration differences immediately upstream and downstream of inputs show that major increases were associated with WWTPs, while minor or no changes were associated with the tributaries. Among the four WWTP that discharge directly into the Lower Boise River, the concentration increases at the West Boise facility were the highest, with increases ranging from 0.11 to 0.52 mg L^{-1}. In comparison to WWTP increases, the greatest tributary increase is 0.060 mg L^{-1}. Additionally, daily load has increased significantly due to WWTP discharge. A spatial comparison of concentration with daily load shows that all major daily load increases can be associated with an increase in concentration from a WWTP. The first major occurrence of loading is between the Glenwood Bridge and South Eagle Island gauging stations where the only input is the West Boise WWTP. Increases in this section range from 150 to 300 kg Day^{-1}. The second major loading location is at the Caldwell WWTP where daily loads have increases ranging from 54 to 240 kg Day^{-1}. Importantly, though the tributaries do not negatively impact concentrations in the LBR, they still may be bringing in large amounts of orthophosphate without changing concentrations. The WWTPs have a far greater impact than tributaries for orthophosphate concentrations in the LBR, but tributaries cannot be dismissed as a potential source for orthophosphate loading.

Fall & Winter: Greatest Concentrations and Loading

Orthophosphate concentration increases and daily loading varied seasonally, but generally fall and winter had the greatest increases with distance downstream. Spring/summer exhibited the lowest concentrations increases at input locations, while fall/winter exhibited both the greatest concentration increases at inputs and the higher overall average in the LBR. The average orthophosphate concentration change in the LBR due to inputs for fall/winter was 0.041 mg L^{-1} while spring/summer was only 0.013 mg L^{-1}. At the greatest input, the West Boise WWTP, Spring and Summer 2012 concentrations were both 0.14 mg L^{-1} , while fall and winter concentrations were greater (0.52 mg L^{-1} for Fall 2012, 0.44 mg L^{-1} for Fall 2013, and 0.37 mg L^{-1} for Winter 2012). Winter time sampling also exhibited the highest daily load (Average winter daily load of 230 kg day^{-1}, spring 140 kg day^{-1}, summer/fall daily loads range from 100 to 160 kg day^{-1}).

Total Phosphate TMDL Violated

Orthophosphate daily loads exceeded the US EPA Clean Water Act in Winter 2012/2013, Summer 2012, and Fall 2013, while the estimated total phosphate loads exceeded the TMDL for every event except Spring 2013. The trend of high winter loads, intermediate summer/fall loads, and low spring loads transfers to the TMDL violation. The Snake River Hells Canyon Reach TMDL for the LBR is set at 242 kg day^{-1} of total phosphate at moderate flows in the Snake River. This study measured orthophosphate, which makes up 70% to 90% of total phosphate, meaning the following daily loads are a conservative calculation of the actual load. The orthophosphate winter seasonal load exceeds the TMDL by 72%. The intermediate load seasons, summer and fall, range from 44% above to 19% below the TMDL, and the lower load season, spring, is 59% below the TMDL. Additionally, new LBR specific TMDL efforts are being developed that will further lower the target phosphate concentrations and loading. The future LBR TMDL will still maintain the current 0.07 mg L^{-1} required by the SRHC TMDL but will have a variable TMDL allotment based on the flows in the LBR.

Future Implications

The Lower Boise River exceeds US EPA recommendations for orthophosphate concentrations and violates TMDL limits. The average orthophosphate concentrations at the mouth of the LBR are 0.20 mg L^{-1}, almost three times the recommended limit. To meet EPA recommendations of 0.07 mg L^{-1} for orthophosphate concentrations, inputs must be reduced. For the West Boise WWTP, this would require lowering the average daily input of approximately 25 million GPD to 9 million GPD or decreasing input concentration levels from an average of 0.34 mg L^{-1} to 0.12 mg L^{-1}. Unfortunately, as populations continue to grow in the Treasure Valley, so will WWTP production.

There are active efforts to improve the water quality of the LBR. WWTPs are undergoing major renovations, Lander Street WWTP will be converting to liquid only and West Boise will be expanding operations and efficiency. A major total phosphate trading and removal project with Dixie Slough is hoped to remove an equivalent to 99% of the West Boise WWTP total phosphate output from the Dixie Slough, and is planned to be operational in 2016. And finally, the most important future plan is the development of a LBR-specific TMDL based on flow regimes which will be used to improve the beneficial uses in the LBR.

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APPENDIX A

Sample Concentration Data

Table A.1 7-22-2012 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0	-0.002	0.447	0.162	0.046	0.005	0.003	1.710
2	0.81	0.000	0.587	0.162	0.028	0.007	0.004	1.710
3	1.04	0.002	0.445	0.161	0.035	0.005	0.004	1.700
4	1.67	0.021	0.439	0.162	0.043	0.004	0.003	1.720
5	1.95	-0.002	0.426	0.162	0.016	0.004	0.001	1.690
6	2.42	0.001	0.432	0.163	0.027	0.005	0.003	1.690
7	2.95	0.007	0.429	0.171	0.023	0.000	0.010	1.690
8	3.36	0.012	0.430	0.167	0.019	0.001	0.003	1.690
9	4.11	0.000	0.426	0.168	0.014	-0.001	0.001	1.700
10	4.37	-0.006	0.429	0.169	0.015	0.001	0.008	1.710
11	4.86	-0.006	0.431	0.170	0.007	0.000	0.004	1.720
12	5.35	-0.003	0.435	0.171	0.006	0.000	0.003	1.700
13	5.92	0.013	0.435	0.166	0.005	0.000	0.005	1.720
14	6.35	0.004	0.437	0.169	0.006	0.001	0.002	1.700
15	6.79	0.004	0.445	0.166	0.023	0.001	0.004	1.720
16	7.34	-0.006	0.440	0.163	0.006	0.000	0.009	1.720
17	7.89	0.003	0.456	0.165	0.002	0.000	0.003	1.770
18	8.3	-0.001	0.468	0.166	0.006	0.000	0.004	1.740
19	8.86	0.002	0.474	0.174	0.005	-0.001	0.002	1.720
20	9.32	-0.003	0.476	0.162	0.002	0.000	0.013	1.770
21	9.7	0.012	0.481	0.173	-0.003	0.000	0.004	1.750
22	10.14	-0.004	0.517	0.166	0.012	0.000	0.011	1.800
23	10.63	0.000	0.508	0.176	-0.001	0.000	0.005	1.800
24	11.1	-0.003	0.510	0.170	0.000	0.000	0.005	1.810
25	11.63	0.003	0.507	0.167	-0.002	0.000	0.004	1.760
26	12.06	0.017	1.490	0.205	0.148	0.004	0.040	3.150
27	12.69	0.006	1.480	0.203	0.131	0.005	0.032	3.110
28	13.65	0.002	1.480	0.197	0.125	0.005	0.037	3.200
29	14.01	0.002	1.510	0.201	0.124	0.005	0.035	3.240
30	14.11	0.007	1.510	0.197	0.134	0.004	0.036	3.200
31	14.31	-0.001	1.250	0.188	0.085	0.003	0.029	2.830
32	14.81	-0.002	1.260	0.188	0.089	0.003	0.038	2.820
33	15.16	0.014	1.230	0.188	0.074	0.004	0.026	2.780
52	24.29	0.006	4.270	0.218	0.596	0.005	0.159	4.880
53	24.74	-0.001	4.250	0.222	0.577	0.004	0.165	4.820
54	25.28	-0.001	4.150	0.218	0.545	0.004	0.159	4.900
55	25.75	0.005	4.080	0.221	0.520	0.004	0.145	4.810
56	26.31	0.010	3.980	0.217	0.496	0.004	0.149	4.690
57	26.73	0.005	3.880	0.219	0.462	0.003	0.137	4.680

58	27.29	0.008	3.760	0.217	0.429	0.004	0.128	4.590
59	27.68	0.008	3.750	0.217	0.418	0.003	0.126	4.620
60	28.21	0.004	3.360	0.216	0.362	0.004	0.109	4.490
61	28.3	0.002	3.790	0.255	0.259	0.001	0.135	4.780
62	28.34	0.005	3.220	0.217	0.316	0.004	0.101	4.400
63	28.56	0.003	3.240	0.215	0.314	0.005	0.103	4.430
64	28.76	-0.001	3.290	0.218	0.323	0.003	0.105	4.460
65	29.03	0.007	3.290	0.216	0.328	0.004	0.102	4.460
66	29.3	0.003	3.370	0.213	0.318	0.003	0.105	4.440
67	29.44	0.000	3.360	0.214	0.320	0.004	0.120	4.420
68	29.77	0.004	3.500	0.219	0.358	0.004	0.104	5.180
69	30.06	0.009	3.520	0.223	0.348	0.005	0.102	5.200
70	30.28	0.012	3.520	0.219	0.345	0.004	0.102	5.180
71	30.68	0.013	3.560	0.220	0.356	0.004	0.108	5.230
72	31.01	0.001	3.590	0.221	0.370	0.004	0.109	5.230
73	31.23	0.011	3.630	0.221	0.359	0.004	0.116	5.260
74	31.73	0.005	3.710	0.222	0.378	0.006	0.106	5.350
75	31.79	-0.003	3.710	0.220	0.382	0.005	0.114	5.400
76	32.05	0.009	3.730	0.219	0.390	0.005	0.111	5.360
77	32.45	-0.006	3.820	0.219	0.390	0.005	0.118	5.360
78	33.2	0.002	3.960	0.222	0.404	0.006	0.117	5.460
79	33.6	-0.006	3.800	0.220	0.357	0.006	0.108	5.380
80	33.96	-0.002	3.963	0.227	0.407	0.005	0.118	5.923
81	34.24	-0.006	3.970	0.224	0.400	0.005	0.118	5.850
82	34.61	-0.006	4.320	0.240	0.619	0.008	0.134	7.300
83	34.87	0.000	4.440	0.244	0.673	0.010	0.132	7.740
84	35.09	-0.006	4.550	0.248	0.668	0.009	0.126	7.980
85	35.32	-0.002	4.610	0.248	0.672	0.009	0.138	7.970
86	35.86	-0.002	4.650	0.247	0.675	0.009	0.127	7.950
87	36.29	-0.003	4.700	0.246	0.675	0.009	0.133	7.970
88	37.03	-0.003	4.770	0.250	0.690	0.010	0.132	8.030
89	37.31	0.003	4.820	0.214	0.633	0.009	0.117	8.040
90	37.57	-0.003	4.810	0.249	0.687	0.010	0.134	8.030
91	37.97	0.002	4.850	0.250	0.710	0.011	0.137	8.090
92	38.21	-0.001	4.890	0.255	0.737	0.013	0.129	8.250
93	38.44	0.001	5.010	0.263	0.784	0.019	0.139	8.510
94	39.01	-0.006	5.080	0.266	0.790	0.020	0.137	8.620
95	39.2	-0.003	5.070	0.268	0.814	0.021	0.133	8.670
96	39.43	-0.002	5.580	0.278	0.862	0.020	0.136	9.610
97	39.9	-0.002	5.310	0.276	0.840	0.020	0.137	9.100
98	40.13	-0.006	6.430	0.291	1.050	0.020	0.149	10.800
99	40.34	0.000	6.360	0.290	1.040	0.020	0.150	10.700
100	40.52	-0.002	6.510	0.296	1.200	0.019	0.151	11.800

101	40.71	-0.006	6.610	0.301	1.220	0.020	0.158	12.000
102	40.82	0.016	6.730	0.304	1.420	0.031	0.151	12.700
103	41.86	0.021	7.610	0.315	1.480	0.027	0.167	13.300
104	42.43	0.022	8.270	0.320	1.610	0.025	0.217	14.200
105	42.83	0.022	8.600	0.323	1.680	0.025	0.233	14.700
106	43.33	0.028	9.340	0.327	1.770	0.023	0.241	15.700
107	43.87	0.023	9.320	0.325	1.750	0.023	0.239	15.700
108	44.28	0.024	9.290	0.328	1.740	0.022	0.239	15.700
109	44.93	0.022	9.270	0.327	1.720	0.022	0.235	15.700
110	45.43	0.032	9.790	0.333	1.740	0.021	0.239	18.000
111	45.77	0.025	9.740	0.332	1.710	0.020	0.230	17.700
112	46.33	0.030	9.830	0.334	1.730	0.020	0.236	18.500
113	46.61	0.033	9.830	0.337	1.720	0.020	0.225	18.600
114	47.06	0.028	9.870	0.336	1.710	0.019	0.228	18.800
115	47.78	0.031	9.920	0.334	1.680	0.019	0.226	19.000
116	48.26	0.039	10.700	0.339	1.820	0.020	0.221	22.500
117	48.75	0.035	10.400	0.338	1.750	0.019	0.221	21.500
118	49.32	0.034	10.800	0.338	1.810	0.020	0.220	22.700
119	49.8	0.035	10.800	0.336	1.830	0.019	0.216	22.800
120	50.3	0.039	10.800	0.342	1.810	0.020	0.216	22.800
121	50.84	0.039	10.800	0.333	1.800	0.020	0.215	22.800
122	51.21	0.039	11.000	0.343	1.900	0.018	0.207	24.500
123	51.69	0.042	11.100	0.345	1.930	0.019	0.204	25.200
124	52.24	0.044	11.100	0.344	1.930	0.019	0.203	25.500
125	52.66	0.039	11.100	0.338	1.900	0.018	0.206	25.400
126	53.2	0.036	11.200	0.349	1.880	0.018	0.207	25.500
127	53.74	0.040	11.200	0.348	1.860	0.018	0.205	25.500
128	54.22	0.042	11.400	0.350	1.850	0.018	0.209	25.600
129	55.56	0.047	12.900	0.382	1.860	0.020	0.224	27.100
130	56.25	0.049	12.800	0.379	1.850	0.019	0.221	27.000
131	56.76	0.047	12.800	0.380	1.850	0.019	0.226	27.000
132	57.3	0.040	12.800	0.378	1.830	0.019	0.231	27.000
133	57.74	0.049	12.800	0.380	1.830	0.019	0.225	27.000
134	58.29	0.048	13.100	0.376	1.930	0.019	0.220	28.900
135	58.8	0.050	13.000	0.385	1.880	0.019	0.225	28.000
136	59.24	0.048	13.100	0.386	1.870	0.018	0.224	28.400
137	59.79	0.043	13.100	0.385	1.860	0.018	0.220	28.400
138	60.24	0.049	13.100	0.384	1.860	0.018	0.222	28.200
139	60.8	0.048	13.100	0.386	1.860	0.018	0.224	28.300
140	61.33	0.047	13.100	0.385	1.840	0.017	0.219	28.300
141	61.71	0.048	13.000	0.386	1.830	0.017	0.219	28.300
142	62.27	0.047	13.100	0.389	1.830	0.017	0.226	28.300
143	62.81	0.053	13.100	0.386	1.820	0.018	0.226	28.300

144	63.18	0.050	13.100	0.392	1.820	0.017	0.221	28.300
145	63.73	0.049	13.200	0.390	1.810	0.017	0.221	28.400
146	64.39	0.050	13.200	0.384	1.810	0.018	0.218	28.300
147	64.72	0.045	13.200	0.391	1.790	0.017	0.226	28.200
148	65.27	0.058	13.200	0.388	1.780	0.017	0.220	28.300
149	65.67	0.045	13.200	0.391	1.780	0.017	0.216	28.300

Table A.2 10-7-2012 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0	-0.005	0.423	0.393	0.040	0.005	-0.010	2.370
2	0.51	-0.005	0.445	0.397	0.037	0.005	-0.008	2.390
3	1.23	-0.005	0.449	0.413	0.041	0.005	-0.012	1.190
4	1.76	-0.005	0.430	0.261	0.033	0.005	-0.002	2.530
5	2.25	-0.005	0.412	0.238	0.033	0.005	-0.011	2.400
6	2.74	-0.002	0.435	0.269	0.034	0.005	-0.004	2.440
7	3.44	0.004	0.469	0.248	0.044	0.005	-0.015	2.480
8	4.52	-0.001	0.448	0.240	0.024	0.005	-0.012	2.460
9	5.03	-0.002	0.464	0.236	0.030	0.005	-0.012	2.440
10	5.57	-0.005	0.503	0.256	0.023	0.005	-0.009	2.530
11	6.18	-0.005	0.520	0.278	0.006	0.005	-0.013	2.550
12	6.71	-0.002	0.541	0.345	0.006	0.005	-0.007	2.540
13	7.42	-0.005	0.497	0.286	0.007	0.005	-0.004	2.570
14	7.96	-0.005	0.640	0.283	0.042	0.005	-0.013	2.720
15	8.65	0.014	0.644	0.204	0.028	0.005	-0.012	2.760
16	9.18	0.003	0.775	0.206	0.026	0.005	-0.002	2.800
17	9.98	-0.001	0.795	0.204	0.034	0.005	-0.007	2.850
18	10.52	0.002	0.896	0.210	0.012	0.005	-0.007	2.840
19	11.05	-0.005	0.781	0.491	0.007	0.005	-0.009	2.840
20	11.75	0.004	4.730	0.436	0.866	0.005	0.019	7.620
21	12.28	0.014	4.660	0.430	0.823	0.005	0.006	7.560
22	12.92	-0.002	4.640	0.438	0.765	0.005	0.006	7.510
23	13.53	0.006	4.690	0.615	0.711	0.005	0.005	7.810
24	14.01	-0.005	4.700	0.431	0.630	0.005	0.007	7.670
25	14.06	0.000	4.280	0.451	0.530	0.005	-0.001	7.320
26	14.57	0.011	4.220	0.451	0.504	0.005	0.005	7.290
27	15.03	0.005	4.120	0.426	0.465	0.005	0.006	7.040
28	15.41	-0.005	4.140	0.435	0.461	0.005	0.005	7.110
29	15.9	0.007	4.100	0.427	0.433	0.005	-0.004	7.040
30	16.36	0.008	3.810	0.410	0.363	0.005	0.003	6.590
31	16.89	0.016	4.000	0.390	0.399	0.005	-0.001	6.960

32	17.37	0.012	12.800	0.442	2.510	0.005	0.438	10.900
33	17.88	0.019	12.000	0.448	2.320	0.005	0.385	10.400
34	18.4	0.011	11.700	0.468	2.220	0.005	0.372	10.200
35	18.85	0.014	11.600	0.434	2.200	0.005	0.382	10.100
36	19.33	0.010	11.400	0.428	2.160	0.005	0.355	10.000
37	19.8	0.008	11.000	0.412	2.080	0.005	0.357	9.770
38	20.37	0.009	10.700	0.430	2.000	0.005	0.334	9.690
39	20.8	0.004	10.600	0.411	1.980	0.005	0.345	9.600
40	21.32	0.002	10.600	0.499	1.920	0.005	0.316	9.440
41	21.79	0.003	10.300	0.457	1.880	0.005	0.296	9.650
42	22.18	0.001	10.100	0.416	1.860	0.005	0.281	9.620
43	22.7	0.005	10.100	0.504	1.810	0.005	0.264	9.470
44	23.18	0.008	9.460	0.425	1.680	0.005	0.258	9.470
45	23.68	-0.001	9.350	0.529	1.590	0.005	0.224	9.340
46	24.18	0.001	8.780	0.466	1.440	0.005	0.205	9.120
47	24.59	0.003	8.310	0.428	1.340	0.005	0.189	8.930
48	25.08	-0.005	8.180	0.495	1.280	0.005	0.182	8.820
49	25.56	-0.005	7.880	0.473	1.190	0.005	0.158	8.670
50	26.1	0.005	7.790	0.493	1.130	0.005	0.135	8.680
51	26.61	-0.005	7.440	0.481	1.080	0.005	0.134	8.580
52	27.11	-0.005	7.210	0.517	1.050	0.005	0.127	8.700
53	27.27	-0.009	9.080	0.503	1.760	0.002	0.185	9.170
54	27.5	-0.004	9.120	0.489	1.820	0.002	0.167	9.070
55	27.81	-0.009	9.160	0.504	1.770	0.002	0.164	9.120
56	28.04	-0.011	9.190	0.494	1.780	0.002	0.174	9.100
57	28.29	-0.006	9.160	0.494	1.750	0.002	0.185	9.080
58	28.54	-0.011	9.230	0.498	1.740	0.002	0.188	9.060
59	28.78	-0.007	9.370	0.510	1.810	0.002	0.154	9.960
60	29.02	0.001	9.350	0.500	1.830	0.002	0.160	9.950
61	29.29	-0.005	9.440	0.509	1.860	0.002	0.167	9.910
62	29.52	-0.011	9.400	0.506	1.820	0.004	0.143	9.940
63	29.77	-0.017	9.540	0.507	1.840	0.002	0.188	9.890
64	30.01	-0.011	9.310	0.492	1.820	0.002	0.158	9.930
65	30.29	-0.002	9.430	0.500	1.840	0.002	0.149	10.000
66	30.58	-0.003	9.500	0.508	1.860	0.002	0.176	9.960
67	30.85	-0.009	9.490	0.504	1.840	0.003	0.166	9.940
68	31.11	-0.011	9.470	0.503	1.830	0.002	0.200	9.810
69	31.4	-0.009	9.520	0.507	1.800	0.002	0.162	9.780
70	31.68	-0.010	9.510	0.507	1.790	0.002	0.197	9.660
71	31.91	-0.007	9.400	0.487	1.770	0.002	0.191	9.730
72	32.2	-0.005	9.610	0.513	1.770	0.002	0.177	9.860
73	32.36	-0.010	9.350	0.504	1.710	0.002	0.160	9.710
74	32.58	-0.011	9.310	0.498	1.690	0.002	0.157	9.700

75	32.81	-0.006	9.350	0.499	1.700	0.002	0.163	9.730
76	33.06	-0.004	9.350	0.492	1.730	0.002	0.160	10.200
77	33.3	-0.008	9.340	0.492	1.690	0.002	0.166	10.100
78	33.55	-0.011	9.290	0.488	1.690	0.002	0.178	10.100
79	33.78	-0.008	10.600	0.506	2.080	0.002	0.160	12.700
80	34.03	0.004	10.500	0.495	2.070	0.004	0.145	12.600
81	34.27	0.005	10.600	0.493	2.050	0.002	0.161	12.800
82	34.53	-0.007	10.700	0.502	2.050	0.002	0.164	12.800
83	34.76	-0.004	10.600	0.493	2.020	0.004	0.150	12.800
84	35.01	-0.007	10.700	0.506	2.010	0.002	0.149	12.700
85	35.25	-0.003	10.600	0.498	1.990	0.002	0.145	12.700
86	35.5	0.002	10.500	0.488	1.990	0.002	0.139	12.600
87	35.75	-0.004	10.700	0.495	1.960	0.002	0.140	12.600
88	36.02	-0.007	10.400	0.483	1.930	0.002	0.139	12.500
89	36.24	-0.002	10.600	0.497	1.920	0.002	0.140	12.500
90	36.5	-0.004	10.600	0.504	1.900	0.002	0.141	12.500
91	36.73	-0.007	10.600	0.497	1.900	0.002	0.134	12.500
92	37.04	0.003	8.910	0.487	1.630	0.002	0.105	11.700
93	37.2	-0.012	8.530	0.473	1.600	0.002	0.112	11.600
94	37.41	-0.009	9.370	0.483	1.710	0.002	0.124	11.800
95	37.65	-0.003	9.430	0.495	1.700	0.002	0.124	11.900
96	37.97	0.002	9.010	0.474	1.650	0.002	0.111	11.700
97	38.23	-0.009	9.300	0.499	1.660	0.002	0.127	11.700
98	38.45	-0.003	9.080	0.477	1.650	0.002	0.115	11.600
99	38.75	-0.006	9.180	0.483	1.640	0.002	0.114	11.800
100	39	-0.002	9.160	0.482	1.630	0.002	0.112	11.800
101	39.22	-0.004	10.200	0.495	1.810	0.002	0.104	13.200
102	39.45	-0.004	11.000	0.506	1.950	0.002	0.105	14.100
103	39.7	-0.006	10.500	0.505	2.100	0.002	0.107	14.900
104	39.93	0.016	10.400	0.454	1.890	0.008	0.115	15.900
105	40.46	0.019	10.300	0.454	1.880	0.008	0.112	16.000
106	40.96	0.020	10.500	0.456	1.900	0.008	0.116	16.200
107	41.4	0.026	11.600	0.466	2.220	0.008	0.177	17.500
108	41.9	0.023	12.200	0.473	2.340	0.008	0.164	19.500
109	42.4	0.024	13.100	0.471	2.520	0.008	0.176	21.500
110	42.83	0.027	13.100	0.472	2.510	0.008	0.171	21.600
111	43.36	0.030	13.000	0.468	2.480	0.008	0.162	21.500
112	43.82	0.025	13.000	0.470	2.470	0.008	0.156	21.500
113	44.33	0.032	12.800	0.471	2.370	0.008	0.157	21.400
114	44.83	0.025	12.800	0.473	2.370	0.008	0.146	21.600
115	45.35	0.027	13.200	0.477	2.410	0.008	0.147	23.200
116	45.76	0.035	13.000	0.474	2.370	0.008	0.153	23.000
117	46.11	0.028	13.100	0.476	2.380	0.008	0.149	23.000

118	46.9	0.031	13.100	0.471	2.350	0.012	0.148	23.100
119	47.35	0.027	13.300	0.477	2.400	0.008	0.137	24.400
120	47.83	0.025	13.200	0.476	2.380	0.008	0.133	24.200
121	48.33	0.028	13.300	0.477	2.400	0.008	0.150	25.000
122	48.82	0.028	13.400	0.482	2.390	0.008	0.146	25.200
123	49.32	0.028	13.400	0.481	2.390	0.008	0.143	25.000
124	49.81	0.029	13.300	0.477	2.360	0.008	0.140	25.100
125	50.24	0.032	13.600	0.480	2.520	0.008	0.132	27.400
126	50.75	0.040	13.600	0.478	2.490	0.008	0.127	27.200
127	51.19	0.032	13.700	0.484	2.510	0.008	0.141	27.700
128	51.73	0.033	13.600	0.483	2.480	0.008	0.132	27.600
129	52.23	0.032	13.700	0.481	2.480	0.008	0.138	27.600
130	52.68	0.031	13.600	0.486	2.460	0.008	0.094	27.700
131	53.18	0.037	13.600	0.485	2.450	0.008	0.125	27.900
132	53.66	0.032	13.600	0.487	2.440	0.008	0.120	27.900
133	54.16	0.034	14.300	0.497	2.480	0.008	0.131	29.200
134	54.7	0.040	14.500	0.521	2.460	0.008	0.113	29.600
135	55.2	0.031	14.700	0.520	2.480	0.008	0.134	30.000
136	55.72	0.032	14.600	0.514	2.480	0.008	0.128	29.900
137	56.16	0.039	14.800	0.517	2.490	0.008	0.128	30.000
138	56.69	0.040	14.700	0.518	2.480	0.008	0.102	29.900
139	57.18	0.040	14.700	0.511	2.510	0.008	0.133	30.400
140	57.72	0.039	14.800	0.524	2.550	0.008	0.117	31.300
141	58.2	0.030	14.800	0.523	2.530	0.008	0.125	31.100
142	58.68	0.034	14.700	0.522	2.540	0.008	0.093	31.100
143	59.18	0.030	14.700	0.506	2.540	0.008	0.094	31.100
144	59.68	0.040	14.700	0.502	2.540	0.008	0.139	31.000
145	60.2	0.032	14.700	0.511	2.530	0.008	0.128	31.000
146	60.68	0.037	14.700	0.503	2.530	0.008	0.095	31.000
147	61.25	0.033	14.700	0.504	2.510	0.008	0.110	31.100
148	61.7	0.035	14.700	0.511	2.510	0.008	0.122	31.000
149	62.19	0.036	14.700	0.512	2.510	0.008	0.121	31.000
150	62.68	0.044	14.700	0.508	2.510	0.008	0.095	31.100
151	63.18	0.029	14.700	0.507	2.500	0.008	0.121	31.100
152	63.72	0.045	14.700	0.504	2.510	0.008	0.136	31.200
153	64.17	0.046	14.600	0.496	2.500	0.008	0.096	31.200
154	64.65	0.040	14.700	0.517	2.480	0.008	0.124	31.200

Table A.3 12-16-2012 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0.53	0.018	0.618	0.348	0.135	0.000	-0.012	0.009
2	1.08	0.025	1.080	0.354	0.102	0.000	-0.001	3.450
3	2.04	0.014	1.600	0.345	0.132	0.001	-0.006	3.540
4	2.63	0.021	0.844	0.349	0.130	0.000	0.000	3.550
5	3.07	0.022	0.708	0.340	0.133	0.001	0.003	3.540
6	3.4	0.020	2.490	0.339	0.130	0.000	-0.011	3.740
7	4	0.018	0.715	0.343	0.131	0.000	-0.001	3.640
8	4.89	0.015	2.610	0.345	0.124	0.000	-0.005	3.810
9	5.75	0.015	0.794	0.341	0.134	0.000	-0.006	3.790
10	6.44	0.040	1.040	0.344	0.129	0.000	-0.014	3.790
11	7.61	0.014	0.834	0.353	0.124	0.000	-0.010	3.830
12	14.22	0.014	5.070	0.553	0.004	0.000	0.029	8.450
13	14.49	0.018	5.070	0.559	0.005	0.000	0.037	8.540
14	14.8	0.016	5.140	0.560	0.007	0.000	0.036	8.500
15	14.99	0.014	5.100	0.547	0.009	0.000	0.027	8.430
16	15.27	0.019	5.190	0.560	0.006	0.000	0.033	8.400
17	15.54	0.014	5.240	0.548	-0.005	0.000	0.033	8.250
18	15.78	0.016	5.420	0.536	0.011	0.000	0.036	8.340
19	16.22	0.017	5.450	0.538	0.011	0.000	0.037	8.320
20	16.8	0.019	5.690	0.532	0.009	0.000	0.030	8.370
21	17.16	0.026	5.790	0.527	0.006	0.000	0.040	8.430
22	17.78	0.019	14.500	0.558	2.170	0.000	0.407	11.300
23	18.27	0.021	14.300	0.553	2.000	0.000	0.393	11.200
24	18.86	0.021	13.900	0.561	1.760	0.000	0.364	11.100
25	19.26	0.020	13.600	0.573	1.570	0.000	0.344	11.000
26	19.66	0.019	13.100	0.573	1.400	0.000	0.326	10.900
27	20.23	0.021	12.800	0.563	1.290	0.000	0.306	10.900
28	20.7	0.021	11.900	0.564	1.060	0.000	0.289	10.800
29	21.22	0.018	11.600	0.558	1.020	0.000	0.270	10.800
30	21.69	0.021	11.200	0.570	1.150	0.000	0.261	11.200
31	22.25	0.018	10.600	0.562	0.924	0.002	0.235	11.300
32	22.69	0.021	11.200	0.566	1.050	0.001	0.254	11.200
33	23.29	0.019	9.520	0.560	0.544	0.001	0.190	11.100
34	23.7	0.018	9.230	0.553	0.478	0.001	0.167	11.200
35	24.37	0.018	9.120	0.574	0.465	0.001	0.177	11.200
36	24.72	0.014	9.120	0.564	0.439	0.000	0.171	11.300
37	25.15	0.022	9.130	0.574	0.431	0.000	0.169	11.300
38	25.64	0.022	9.100	0.564	0.436	0.001	0.170	11.300
39	26.18	0.016	9.220	0.568	0.473	0.000	0.158	11.500

40	26.86	0.022	9.260	0.564	0.460	0.000	0.171	11.500
41	27.24	0.016	9.420	0.567	0.506	0.000	0.170	11.600
42	27.63	0.027	12.300	0.587	1.820	0.000	0.268	12.700
43	28.07	0.014	12.400	0.576	1.870	0.001	0.269	12.700
44	28.62	0.024	12.500	0.583	1.880	0.000	0.278	12.700
45	29.07	0.021	12.700	0.588	2.050	0.002	0.277	13.700
46	29.55	0.020	12.900	0.592	2.090	0.001	0.267	13.700
47	30.05	0.025	13.000	0.576	2.140	0.000	0.273	13.800
48	30.56	0.021	13.100	0.578	2.120	0.001	0.281	13.900
49	31.04	0.018	13.200	0.588	2.170	0.000	0.273	13.900
50	31.56	0.023	13.300	0.586	2.180	0.000	0.274	14.000
51	32.03	0.039	13.500	0.588	2.160	0.000	0.282	14.100
52	32.59	0.022	13.400	0.585	2.130	0.000	0.283	14.000
53	33.03	0.021	13.500	0.586	2.230	0.000	0.285	14.000
54	33.5	0.018	13.500	0.583	2.270	0.000	0.279	14.300
55	34	0.023	16.600	0.573	3.340	0.000	0.267	16.300
56	34.5	0.024	16.300	0.538	2.510	0.000	0.241	15.000
57	35.07	0.023	16.400	0.536	2.550	0.000	0.233	15.000
58	35.57	0.022	16.500	0.538	2.610	0.000	0.236	14.900
59	36.07	0.021	16.500	0.531	2.650	0.000	0.244	14.900
60	36.57	0.022	16.400	0.534	2.680	0.000	0.237	14.900
61	37.03	0.022	16.500	0.532	2.630	0.000	0.232	14.900
62	37.48	0.020	15.400	0.514	2.830	0.000	0.215	15.400
63	37.92	0.021	15.900	0.515	2.760	0.000	0.221	15.200
64	38.46	0.020	15.800	0.517	2.780	0.001	0.219	15.200
65	38.94	0.024	15.800	0.512	2.750	0.001	0.222	15.300
66	39.45	0.020	17.400	0.517	3.430	0.000	0.197	17.900
67	39.9	0.023	17.200	0.509	3.910	0.000	0.194	18.900
68	40.17	0.020	15.800	0.504	2.910	0.000	0.140	18.200
69	40.66	0.025	15.700	0.505	2.850	0.000	0.140	18.200
70	41.19	0.024	15.600	0.503	2.830	0.000	0.135	18.400
71	41.67	0.024	16.000	0.511	3.360	0.000	0.155	18.900
72	42.31	0.031	18.000	0.488	8.990	0.000	0.189	29.700
73	42.66	0.034	17.700	0.489	8.410	0.000	0.185	28.900
74	43.17	0.031	17.700	0.496	8.270	0.000	0.182	28.700
75	43.62	0.034	17.700	0.493	8.270	0.000	0.184	28.700
76	44.19	0.035	17.500	0.493	8.140	0.000	0.181	28.700
77	44.66	0.033	17.400	0.491	9.550	0.000	0.182	28.800
78	45.1	0.032	17.467	0.499	8.013	0.000	0.182	28.800
79	45.61	0.033	17.400	0.494	7.990	0.000	0.184	29.300
80	46.33	0.033	17.400	0.491	7.880	0.000	0.179	29.300
81	46.84	0.035	17.400	0.490	7.860	0.000	0.183	29.600
82	47.34	0.033	17.400	0.499	7.950	0.000	0.184	29.500

83	48.07	0.033	17.500	0.494	8.150	0.000	0.180	30.100
84	48.59	0.033	17.500	0.500	8.020	0.000	0.184	30.400
85	49.16	0.033	17.500	0.497	7.980	0.000	0.182	30.400
86	49.54	0.032	17.500	0.491	8.010	0.000	0.180	30.400
87	50.17	0.036	17.600	0.499	8.250	0.000	0.182	31.200
88	50.46	0.033	17.500	0.492	8.250	0.000	0.186	31.100
89	50.95	0.033	17.600	0.499	8.240	0.000	0.181	31.200
90	51.44	0.036	17.600	0.491	8.310	0.000	0.184	31.400
91	51.92	0.035	17.600	0.507	9.980	0.000	0.186	31.400
92	52.48	0.032	17.600	0.498	8.383	0.000	0.187	31.467
93	53.01	0.034	17.600	0.496	8.480	0.000	0.189	31.500
94	53.47	0.035	17.600	0.497	8.560	0.000	0.192	31.700
95	53.91	0.035	17.800	0.502	8.620	0.000	0.192	31.800
96	54.4	0.038	18.700	0.510	9.160	0.000	0.179	34.600
97	54.71	0.035	19.000	0.504	9.140	0.000	0.181	35.500
98	55.27	0.035	18.900	0.501	9.100	0.000	0.174	35.200
99	55.85	0.036	19.000	0.503	9.150	0.000	0.181	35.300
100	56.24	0.036	19.100	0.506	9.420	0.000	0.178	35.500
101	56.68	0.037	19.100	0.504	9.180	0.000	0.182	35.400
102	57.26	0.032	19.100	0.502	9.290	0.000	0.184	35.500
103	57.71	0.036	19.300	0.503	9.590	0.000	0.182	36.100
104	58.22	0.037	19.300	0.506	9.730	0.000	0.181	36.000
105	58.71	0.039	19.300	0.506	9.510	0.000	0.180	36.000
106	59.27	0.037	19.267	0.507	9.487	0.000	0.183	35.967
107	59.7	0.037	19.200	0.502	9.450	0.000	0.180	35.900
108	60.17	0.037	19.400	0.516	9.560	0.000	0.179	36.000
109	60.67	0.038	19.300	0.511	9.530	0.000	0.183	35.900
110	61.33	0.036	19.300	0.513	9.520	0.000	0.184	35.900
111	62.17	0.037	19.300	0.506	9.560	0.000	0.189	35.900
112	62.61	0.036	19.400	0.513	9.590	0.000	0.189	35.900
113	63.5	0.036	19.400	0.507	10.500	0.000	0.180	35.800
114	64.24	0.039	19.400	0.505	9.510	0.000	0.188	35.900
115	64.63	0.036	19.300	0.505	9.370	0.000	0.180	35.800

Table A.4 4-7-2013 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0	0.016	0.804	0.360	0.007	0.004	0.001	3.810
2	0.82	0.016	0.811	0.375	0.002	0.004	0.001	3.840
3	1.17	0.016	0.797	0.376	0.005	0.019	-0.002	3.830
4	1.64	0.016	0.817	0.367	0.002	0.004	-0.002	3.930
5	2.07	0.016	0.803	0.373	0.001	0.019	-0.002	3.880
6	2.48	0.016	0.820	0.377	0.002	0.004	0.002	3.850
7	2.98	0.016	0.882	0.374	0.000	0.004	0.000	3.850
8	3.49	0.016	0.822	0.380	0.000	0.004	0.005	3.840
9	3.99	0.016	0.814	0.385	0.000	0.004	-0.002	3.860
10	4.48	0.016	0.822	0.377	0.001	0.004	0.000	3.850
11	4.94	0.016	0.791	0.363	0.000	0.004	0.004	3.910
12	5.37	0.016	0.827	0.377	0.001	0.004	0.007	3.900
13	5.85	0.016	0.844	0.382	0.000	0.004	-0.002	3.940
14	6.33	0.016	0.824	0.371	0.001	0.004	-0.001	3.960
15	6.84	0.016	0.863	0.381	0.025	0.004	0.002	3.940
16	7.32	0.016	0.856	0.377	0.000	0.004	0.002	4.230
17	7.73	0.016	0.890	0.384	0.002	0.004	0.008	3.970
18	8.25	0.016	0.942	0.382	0.000	0.004	0.004	4.050
19	8.7	0.016	0.980	0.380	0.001	0.007	-0.002	4.080
20	9.17	0.016	0.975	0.385	0.001	0.004	0.001	4.080
21	9.6	0.016	1.010	0.383	0.000	0.004	0.002	4.080
22	10.22	0.016	1.030	0.371	0.000	0.004	0.003	4.130
23	10.57	0.016	1.030	0.375	0.000	0.004	-0.002	4.110
24	11.11	0.016	1.040	0.374	0.001	0.004	-0.002	4.110
25	11.54	0.016	1.050	0.370	0.001	0.004	0.001	4.150
26	12.16	0.016	3.160	0.459	0.330	0.004	-0.002	7.240
27	12.64	0.016	3.150	0.444	0.314	0.004	-0.002	7.220
28	13.13	0.016	3.140	0.443	0.306	0.023	0.000	7.370
29	13.65	0.016	3.140	0.445	0.294	0.004	0.009	7.360
30	14.15	0.016	3.200	0.441	0.270	0.023	0.001	7.310
31	14.15	0.016	2.590	0.413	0.162	0.004	-0.002	6.270
32	14.66	0.016	2.670	0.409	0.155	0.021	-0.002	6.260
33	15.56	0.016	2.650	0.402	0.155	0.021	0.001	6.260
34	15.62	0.016	2.650	0.413	0.151	0.020	-0.002	6.270
35	16.11	0.016	2.650	0.397	0.140	0.004	0.000	6.260
36	16.69	0.016	2.700	0.412	0.138	0.004	-0.002	6.300
37	17.35	0.016	5.770	0.412	1.090	0.004	0.141	8.040
38	17.88	0.016	5.700	0.417	1.080	0.004	0.123	7.960
39	18.62	0.016	5.750	0.414	1.060	0.045	0.127	8.010

40	19.29	0.016	5.620	0.416	1.020	0.042	0.117	7.920
41	19.83	0.016	5.610	0.421	1.010	0.043	0.107	7.890
42	20.71	0.016	5.640	0.414	0.942	0.004	0.093	8.050
43	21.15	0.016	5.560	0.411	0.915	0.044	0.088	8.040
44	21.96	0.016	5.560	0.417	0.877	0.043	0.076	8.110
45	22.41	0.016	5.560	0.410	0.876	0.004	0.073	8.220
46	23.22	0.016	5.180	0.406	0.737	0.037	0.050	8.300
47	23.86	0.016	5.100	0.415	0.699	0.004	0.041	8.300
48	24.5	0.016	5.110	0.416	0.672	0.004	0.037	8.370
49	25.16	0.016	5.120	0.421	0.681	0.035	0.042	8.370
50	25.63	0.016	5.196	0.404	0.674	0.009	0.045	8.493
51	26.3	0.016	5.190	0.409	0.659	0.004	0.041	8.560
52	26.88	0.016	5.240	0.405	0.664	0.004	0.047	8.640
53	27.16	0.016	5.260	0.412	0.674	0.038	0.052	8.680
54	27.84	0.016	5.760	0.345	0.971	0.047	0.088	8.760
55	28.86	0.016	6.140	0.346	1.090	0.050	0.087	9.710
56	29.45	0.016	6.270	0.346	1.120	0.053	0.094	9.770
57	30.54	0.016	6.490	0.352	1.190	0.053	0.111	9.910
58	31.43	0.016	6.670	0.352	1.220	0.052	0.118	10.000
59	32.07	0.016	6.840	0.349	1.220	0.057	0.118	10.200
60	32.97	0.016	6.910	0.356	1.250	0.058	0.120	10.200
61	34.03	0.016	8.140	0.347	1.460	0.068	0.138	11.600
62	34.83	0.016	8.300	0.349	1.470	0.069	0.133	11.600
63	35.31	0.016	8.390	0.351	1.480	0.071	0.138	11.700
64	35.97	0.016	8.340	0.345	1.460	0.069	0.144	11.700
65	36.58	0.016	8.340	0.346	1.460	0.068	0.148	11.700
66	37.16	0.016	8.420	0.347	1.460	0.067	0.150	11.700
67	37.72	0.016	7.530	0.340	1.360	0.064	0.124	11.600
68	38.34	0.016	7.510	0.345	1.340	0.065	0.124	11.600
69	38.99	0.016	7.800	0.345	1.360	0.066	0.125	11.800
70	39.54	0.016	9.210	0.348	1.470	0.070	0.124	12.900
71	40.1	0.016	9.250	0.345	1.590	0.070	0.124	13.900
72	40.15	0.016	8.890	0.346	1.460	0.064	0.100	13.800
73	40.65	0.016	8.710	0.345	1.430	0.063	0.088	13.800
74	41.18	0.016	8.610	0.342	1.390	0.063	0.098	13.900
75	41.69	0.016	9.560	0.348	1.760	0.067	0.076	14.900
76	42.26	0.016	10.800	0.351	2.000	0.072	0.108	16.600
77	42.69	0.016	10.500	0.336	1.900	0.075	0.096	16.300
78	43.13	0.016	10.500	0.352	1.890	0.070	0.093	16.300
79	43.63	0.016	10.500	0.358	1.880	0.072	0.095	16.500
80	44.11	0.016	10.400	0.352	1.870	0.071	0.097	16.400
81	44.99	0.016	11.167	0.360	1.953	0.077	0.095	18.700

82	46.09	0.016	11.400	0.360	2.020	0.080	0.095	19.700
83	46.99	0.016	12.000	0.363	2.050	0.087	0.102	20.400
84	47.41	0.016	12.300	0.350	2.150	0.085	0.095	22.200
85	47.85	0.016	12.900	0.360	2.270	0.087	0.094	24.100
86	48.53	0.016	11.167	0.360	1.953	0.077	0.095	18.700
87	48.89	0.016	13.500	0.364	2.420	0.088	0.082	26.400
88	49.9	0.016	13.700	0.364	2.430	0.089	0.086	26.300
89	50.26	0.016	14.000	0.366	2.720	0.088	0.072	30.900
90	50.7	0.016	14.000	0.366	2.640	0.090	0.072	29.700
91	51.27	0.016	14.000	0.368	2.640	0.092	0.079	30.000
92	52.08	0.016	14.000	0.364	2.590	0.093	0.079	30.200
93	52.59	0.016	14.100	0.366	2.540	0.093	0.078	30.300
94	52.98	0.016	14.200	0.369	2.530	0.095	0.087	30.400
95	53.46	0.028	14.100	0.366	2.510	0.094	0.087	30.400
96	54.08	0.032	17.300	0.395	2.740	0.104	0.147	33.100
97	54.41	0.026	16.200	0.386	2.643	0.101	0.129	32.267
98	54.91	0.028	16.500	0.383	2.660	0.100	0.133	32.600
99	55.27	0.016	16.500	0.389	2.650	0.110	0.094	33.100
100	55.54	0.016	16.500	0.386	2.650	0.104	0.116	32.700

Table A.5 6-23-2013 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0	0.004	1.050	0.104	0.027	0.005	0.012	2.560
2	0.5	0.004	0.729	0.108	0.021	0.004	0.010	2.570
3	1	0.004	0.750	0.109	0.019	0.004	0.010	2.570
4	1.5	0.011	0.756	0.109	0.015	0.004	0.012	2.580
5	2	0.004	0.757	0.114	0.018	0.004	0.008	2.560
6	2.5	0.004	0.784	0.115	0.019	0.006	0.007	2.570
7	3	0.011	0.745	0.113	0.014	0.004	0.007	2.590
8	3.5	0.004	0.762	0.109	0.011	0.004	0.009	2.570
9	4	0.004	0.747	0.113	0.011	0.004	0.008	2.550
10	4.5	0.004	0.761	0.111	0.012	0.006	0.015	2.550
11	5	0.004	0.770	0.110	0.008	0.004	0.009	2.590
12	5.5	0.004	0.758	0.109	0.007	0.004	0.008	2.580
13	6	0.004	0.754	0.113	0.009	0.004	0.018	2.590
14	6.5	0.004	0.944	0.114	0.004	0.005	0.004	2.680
15	7	0.016	0.767	0.109	0.007	0.004	0.004	2.600
16	7.5	0.004	0.780	0.116	0.006	0.004	0.007	2.610
17	8	0.004	0.768	0.109	0.007	0.004	0.008	2.590
18	8.5	0.004	0.756	0.107	0.009	0.004	0.008	2.580

19	9	0.010	0.871	0.113	0.007	0.004	0.006	2.620
20	9.5	0.004	0.868	0.110	0.006	0.004	0.007	2.650
21	10	0.004	0.883	0.109	0.005	0.004	0.013	2.670
22	10.5	0.004	0.921	0.112	0.005	0.004	0.007	2.680
23	11.5	0.004	0.923	0.107	0.005	0.005	0.013	2.680
24	12	0.004	0.934	0.107	0.007	0.005	0.010	2.670
25	12.5	0.008	2.710	0.131	0.312	0.008	0.026	4.360
26	13	0.004	2.750	0.132	0.301	0.008	0.023	4.430
27	13.5	0.013	2.760	0.135	0.272	0.007	0.014	4.400
28	14	0.004	2.770	0.135	0.247	0.008	0.017	4.430
29	14.24	0.004	2.130	0.125	0.152	0.007	0.014	3.790
30	14.67	0.004	2.160	0.118	0.139	0.006	0.004	3.800
31	15.02	0.004	2.150	0.121	0.131	0.006	0.007	3.800
32	15.4	0.004	2.190	0.119	0.127	0.007	0.009	3.810
33	16	0.009	2.270	0.122	0.120	0.007	0.004	3.820
34	16.43	0.004	2.170	0.122	0.102	0.007	0.012	3.810
35	16.97	0.004	2.270	0.120	0.095	0.007	0.012	3.900
36	17.51	0.004	5.270	0.128	0.893	0.011	0.148	5.240
37	17.84	0.008	5.210	0.125	0.875	0.012	0.142	5.210
38	18.4	0.004	5.120	0.129	0.842	0.014	0.130	5.180
39	19.15	0.004	4.920	0.127	0.765	0.012	0.126	5.040
40	19.45	0.004	4.900	0.128	0.749	0.011	0.120	5.030
41	20.18	0.004	4.850	0.128	0.720	0.011	0.114	5.010
42	20.5	0.004	4.800	0.127	0.704	0.010	0.106	5.080
43	21.11	0.004	4.830	0.126	0.695	0.011	0.107	5.090
44	21.65	0.011	4.810	0.130	0.670	0.012	0.110	5.130
45	21.92	0.004	4.750	0.124	0.660	0.011	0.113	5.170
46	22.44	0.004	4.730	0.127	0.653	0.010	0.117	5.280
47	22.92	0.004	4.700	0.122	0.631	0.010	0.092	5.380
48	23.55	0.008	4.630	0.130	0.517	0.012	0.068	5.820
49	23.91	0.008	4.630	0.131	0.497	0.012	0.071	5.950
50	24.44	0.004	4.690	0.130	0.479	0.011	0.074	6.020
51	24.8	0.004	4.750	0.132	0.480	0.009	0.064	6.080
52	25.36	0.004	4.800	0.129	0.480	0.012	0.069	6.100
53	25.85	0.004	4.940	0.130	0.486	0.013	0.077	6.170
54	26.58	0.008	5.070	0.128	0.492	0.014	0.076	6.230
55	26.92	0.004	5.120	0.130	0.496	0.011	0.078	6.270
56	27.34	0.008	5.640	0.142	0.609	0.013	0.093	6.520
57	27.78	0.009	5.890	0.140	0.656	0.012	0.091	6.610
58	28.28	0.010	6.060	0.145	0.658	0.012	0.097	6.680
59	28.81	0.004	6.370	0.144	0.691	0.014	0.100	7.530
60	29.3	0.011	6.520	0.146	0.715	0.013	0.112	7.650

61	29.77	0.013	6.750	0.149	0.756	0.014	0.107	7.740
62	30.31	0.004	6.760	0.141	0.749	0.013	0.101	7.850
63	30.77	0.007	6.860	0.142	0.758	0.014	0.103	7.990
64	31.26	0.009	6.940	0.142	0.754	0.014	0.114	8.020
65	31.82	0.013	7.040	0.141	0.752	0.014	0.108	8.040
66	32.28	0.004	7.280	0.150	0.747	0.015	0.109	8.390
67	32.76	0.011	7.340	0.149	0.742	0.013	0.111	8.460
68	33.21	0.004	7.470	0.147	0.765	0.013	0.116	9.020
69	33.71	0.004	7.790	0.148	0.970	0.012	0.130	10.600
70	34.15	0.016	8.030	0.150	1.130	0.015	0.138	11.900
71	34.83	0.008	8.130	0.148	1.090	0.015	0.133	11.800
72	35.21	0.004	8.210	0.154	1.090	0.013	0.128	11.800
73	35.75	0.009	8.260	0.152	1.090	0.014	0.132	11.800
74	36.23	0.016	8.380	0.148	1.090	0.014	0.136	12.000
75	36.77	0.013	8.530	0.147	1.090	0.014	0.131	12.200
76	37.24	0.004	8.160	0.149	1.160	0.016	0.131	12.300
77	37.7	0.009	7.970	0.152	1.180	0.014	0.125	12.200
78	38.22	0.004	8.110	0.146	1.160	0.014	0.138	12.200
79	38.73	0.012	8.410	0.150	1.200	0.014	0.124	12.900
80	39.19	0.012	8.530	0.149	1.200	0.013	0.125	13.100
81	39.74	0.021	8.770	0.152	1.530	0.016	0.147	15.400
82	40.07	0.016	9.050	0.150	1.430	0.015	0.116	14.900
83	40.6	0.014	8.770	0.148	1.430	0.016	0.121	15.000
84	41.36	0.020	9.590	0.152	1.550	0.016	0.142	15.900
85	41.67	0.020	11.600	0.161	2.130	0.021	0.250	18.200
86	42.12	0.018	10.700	0.155	1.830	0.019	0.204	17.300
87	42.62	0.011	12.100	0.155	2.110	0.019	0.242	19.200
88	43.36	0.016	12.100	0.156	2.090	0.021	0.233	19.200
89	43.6	0.023	12.200	0.160	2.100	0.022	0.245	19.200
90	44.24	0.020	12.200	0.161	2.090	0.023	0.232	19.300
91	44.18	0.020	12.200	0.154	2.060	0.023	0.242	19.500
92	45.25	0.017	12.900	0.161	2.150	0.021	0.225	22.900
93	45.67	0.032	12.900	0.162	2.150	0.022	0.225	23.000
94	46.22	0.020	13.300	0.164	2.190	0.022	0.225	24.800
95	46.8	0.031	13.500	0.164	2.180	0.024	0.231	25.200
96	47.2	0.019	13.700	0.177	2.200	0.020	0.218	25.633
97	47.72	0.023	14.000	0.176	2.250	0.022	0.218	26.900
98	48.16	0.019	14.500	0.181	2.340	0.022	0.214	29.300
99	48.64	0.026	14.700	0.179	2.350	0.022	0.213	29.800
100	49.16	0.028	15.100	0.175	2.450	0.023	0.215	32.100
101	49.64	0.030	15.100	0.178	2.450	0.024	0.222	32.300
102	50.09	0.025	15.300	0.180	2.440	0.024	0.217	32.500
103	50.55	0.017	15.200	0.176	2.460	0.024	0.217	32.500

104	51.01	0.028	15.100	0.175	2.510	0.024	0.209	34.100
105	51.62	0.030	15.200	0.177	2.510	0.024	0.204	34.800
106	52	0.025	15.200	0.177	2.510	0.024	0.202	34.800
107	52.49	0.028	15.200	0.172	2.520	0.025	0.195	35.200
108	52.96	0.027	15.300	0.177	2.420	0.025	0.203	34.900
109	53.45	0.033	15.300	0.176	2.430	0.025	0.192	35.000
110	53.99	0.026	15.300	0.175	2.410	0.024	0.190	34.900
111	54.4	0.029	15.333	0.179	2.373	0.025	0.189	34.900
112	54.86	0.035	16.600	0.199	2.220	0.029	0.193	33.800
113	55.38	0.024	16.700	0.197	2.190	0.028	0.191	33.700
114	55.94	0.024	16.700	0.198	2.170	0.027	0.187	33.600
115	56.39	0.028	16.700	0.199	2.180	0.029	0.200	33.700
116	56.81	0.026	16.800	0.198	2.130	0.028	0.198	34.000
117	57.3	0.036	16.700	0.194	2.120	0.027	0.191	34.100
118	57.84	0.033	16.800	0.199	2.120	0.027	0.189	34.000
119	58.34	0.023	16.800	0.199	2.130	0.027	0.183	34.300
120	58.77	0.028	16.900	0.197	2.140	0.026	0.191	34.600
121	59.35	0.029	16.900	0.195	2.130	0.028	0.189	34.700
122	59.77	0.025	16.900	0.198	2.130	0.028	0.196	34.700
123	60.3	0.029	16.900	0.194	2.130	0.027	0.181	34.600
124	60.85	0.028	17.000	0.201	2.130	0.028	0.183	34.800
125	61.2	0.032	17.000	0.197	2.120	0.029	0.186	34.900
126	61.81	0.029	17.000	0.196	2.103	0.028	0.189	35.000
127	62.21	0.025	17.100	0.200	2.100	0.029	0.190	35.000
128	62.7	0.039	17.000	0.195	2.090	0.031	0.191	35.000
129	63.18	0.030	17.100	0.200	2.080	0.030	0.184	35.200
130	63.64	0.036	17.000	0.194	2.060	0.029	0.181	35.100
131	64.24	0.026	17.000	0.196	2.060	0.029	0.174	35.100
132	64.66	0.027	17.100	0.200	2.060	0.029	0.183	35.200
133	65.1	0.035	17.100	0.204	2.050	0.030	0.184	35.200
134	65.38	0.026	17.100	0.202	2.040	0.031	0.177	35.300

Table A.6 10-14-2013 Sampling

Sample Point	Distance Miles	Bromide (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	Phosphate-P (mg/L)	Sulfate (mg/L)
1	0	0.006	0.641	-0.012	0.036	0.003	0.011	2.963
2	0.48	0.006	0.641	0.030	0.029	0.003	0.016	2.990
3	0.92	0.006	0.659	0.025	0.034	0.003	0.009	3.000
4	1.49	0.006	0.642	-0.031	0.036	0.003	0.008	3.000
5	2	0.006	0.654	0.022	0.023	0.003	0.009	3.000
6	2.47	0.006	0.695	0.023	0.019	0.003	0.006	3.040
7	2.88	0.006	0.668	0.022	0.019	0.003	0.011	3.070
8	3.39	0.006	0.669	-0.032	0.014	0.003	0.011	3.020
9	3.95	0.006	0.683	-0.032	0.015	0.003	0.010	3.030
10	4.43	0.006	0.704	0.025	0.015	0.003	0.001	3.110
11	4.91	0.006	0.735	-0.032	0.014	0.003	0.008	3.120
12	5.4	0.006	0.739	0.026	0.009	0.003	0.007	3.130
13	5.93	0.006	0.753	0.029	0.009	0.003	0.009	3.250
14	6.43	0.006	0.759	0.030	0.007	0.003	0.001	3.240
15	6.92	0.006	0.781	0.026	0.007	0.003	0.001	3.220
16	7.54	0.006	0.827	0.027	0.007	0.003	0.009	3.340
17	7.97	0.006	0.959	-0.033	0.021	0.003	0.008	3.420
18	8.44	0.006	0.972	-0.034	0.017	0.003	0.006	3.440
19	8.97	0.006	1.020	-0.034	0.013	0.003	0.005	3.410
20	9.44	0.006	1.110	-0.033	0.012	0.003	0.001	3.450
21	9.9	0.006	1.170	-0.035	0.011	0.003	0.006	3.580
22	10.32	0.006	1.150	-0.033	0.008	0.003	0.010	3.560
23	10.74	0.006	1.180	0.033	0.004	0.003	0.001	3.580
24	11.16	0.006	1.170	-0.034	0.004	0.003	0.012	3.590
25	11.71	0.006	1.180	-0.034	0.007	0.003	0.006	3.590
26	12.25	0.010	5.300	0.090	0.865	0.003	0.096	10.000
27	12.72	0.015	5.260	-0.034	0.787	0.003	0.087	10.000
28	13.18	0.013	5.330	0.081	0.767	0.003	0.087	10.500
29	13.64	0.013	5.340	-0.034	0.736	0.003	0.085	10.500
30	14.14	0.013	5.340	-0.034	0.716	0.003	0.078	10.500
31	14.22	0.006	4.020	-0.038	0.422	0.003	0.060	8.330
32	14.62	0.006	4.170	-0.038	0.430	0.003	0.062	8.440
33	15.37	0.006	4.050	-0.038	0.379	0.003	0.053	8.230
34	15.8	0.006	3.970	0.049	0.347	0.003	0.061	7.980
35	16.3	0.011	3.900	-0.039	0.321	0.003	0.057	7.920
36	16.79	0.006	3.820	-0.039	0.311	0.003	0.059	7.850
37	17.23	0.013	3.830	-0.039	0.300	0.003	0.053	7.820
38	17.63	0.011	17.800	-0.038	3.420	0.003	0.572	13.900
39	17.84	0.006	16.200	-0.038	3.100	0.003	0.509	13.300

40	18.15	0.012	15.900	-0.038	3.070	0.003	0.511	13.200
41	18.76	0.006	14.800	-0.038	2.800	0.003	0.453	12.600
42	19.18	0.012	14.600	-0.038	2.740	0.003	0.442	12.500
43	19.79	0.006	14.100	-0.038	2.620	0.003	0.442	12.400
44	20.64	-4.110	13.700	-0.038	2.520	0.003	0.416	12.200
45	21.16	0.011	13.000	-0.039	2.370	0.003	0.399	11.900
46	21.46	0.012	12.700	-0.038	2.280	0.003	0.385	11.800
47	21.68	0.014	12.800	-0.039	2.330	0.003	0.372	12.300
48	22.21	0.006	11.900	-0.039	2.150	0.003	0.351	11.900
49	22.69	0.012	11.600	-0.039	2.080	0.003	0.340	11.900
50	23.22	0.012	10.200	-0.039	1.740	0.003	0.271	11.600
51	23.74	0.009	9.839	-0.038	1.639	0.003	0.246	11.757
52	24.37	0.012	9.130	-0.039	1.460	0.003	0.209	11.200
53	24.74	0.017	9.000	-0.039	1.430	0.003	0.203	11.100
54	25.62	0.016	8.630	-0.038	1.330	0.003	0.182	11.000
55	26.27	0.006	8.350	-0.039	1.270	0.003	0.169	11.100
56	26.74	0.015	8.270	-0.038	1.240	0.003	0.167	11.100
57	27.11	0.016	8.190	-0.039	1.210	0.003	0.156	11.100
58	27.26	0.013	11.200	-0.037	1.990	0.003	0.261	12.800
59	27.79	0.006	11.500	-0.038	2.050	0.003	0.267	13.000
60	28.31	0.014	11.700	-0.038	2.080	0.003	0.272	13.100
61	28.86	0.015	12.100	-0.037	2.160	0.003	0.271	14.000
62	29.25	0.014	12.200	-0.037	2.190	0.003	0.268	14.100
63	29.77	0.018	12.300	-0.037	2.220	0.003	0.278	14.200
64	30.22	0.020	12.500	-0.037	2.250	0.003	0.280	14.300
65	30.72	0.014	12.600	-0.037	2.340	0.003	N/A	14.300
66	31.27	0.016	12.700	-0.037	2.270	0.003	0.281	14.400
67	31.68	0.006	12.800	-0.037	2.280	0.003	0.284	14.400
68	32.16	0.016	12.900	-0.037	2.270	0.003	0.276	14.700
69	32.65	0.015	12.800	-0.037	2.240	0.003	0.273	14.600
70	33.17	0.016	12.900	-0.038	2.250	0.003	0.270	15.000
71	33.72	0.016	15.600	-0.038	2.550	0.003	0.253	17.200
72	34.08	0.013	16.100	-0.038	2.590	0.003	0.252	17.600
73	34.68	0.019	16.300	-0.038	2.560	0.003	0.250	17.600
74	35.15	0.016	16.300	-0.038	2.550	0.003	0.244	17.600
75	35.56	0.015	16.400	-0.038	2.560	0.003	0.252	17.500
76	36.08	0.014	16.400	-0.038	2.530	0.003	0.248	17.500
77	36.59	0.019	15.100	-0.038	2.460	0.003	0.221	17.600
78	37.1	0.017	16.600	-0.038	2.520	0.003	0.246	17.600
79	37.53	0.015	12.900	-0.039	2.420	0.003	0.187	17.600
80	38.04	0.014	14.800	-0.038	2.440	0.003	0.210	17.600
81	38.45	0.017	14.800	-0.038	2.410	0.003	0.211	17.600
82	38.98	0.014	15.000	-0.038	2.390	0.003	0.204	18.100

83	39.54	0.018	17.900	-0.038	2.860	0.003	0.179	23.100
84	40.12	0.020	16.100	-0.038	2.530	0.003	0.130	22.100
85	40.43	0.020	16.100	-0.038	2.530	0.003	0.122	22.600
86	41.17	0.020	16.200	-0.038	2.527	0.003	0.126	22.483
87	41.39	0.025	16.800	-0.038	2.680	0.003	0.126	22.700
88	41.86	0.035	20.600	-0.038	3.570	0.003	0.189	31.000
89	42.33	0.039	22.100	-0.038	3.860	0.003	0.226	34.200
90	42.79	0.045	22.200	-0.039	3.880	0.003	0.226	34.400
91	43.32	0.038	22.200	-0.039	3.850	0.003	0.222	34.300
92	43.84	0.039	22.100	-0.038	3.840	0.003	0.228	34.300
93	44.33	0.045	22.000	-0.038	3.860	0.003	0.236	34.200
94	44.79	0.044	22.100	-0.039	3.820	0.003	0.229	34.400
95	45.36	0.038	22.100	-0.039	3.800	0.003	0.233	34.700
96	45.72	0.041	22.100	-0.038	3.800	0.003	0.234	34.800
97	46.23	0.035	22.000	-0.038	3.800	0.003	0.234	34.800
98	46.71	0.042	22.100	-0.038	3.810	0.003	0.238	34.900
99	47.31	0.036	22.400	-0.038	3.850	0.003	0.230	35.900
100	47.72	0.044	22.400	-0.039	3.840	0.003	0.231	36.000
101	48.19	0.043	22.400	-0.038	3.870	0.003	0.233	36.600
102	48.66	0.037	22.400	-0.038	3.840	0.003	0.230	36.500
103	49.25	0.036	22.400	-0.038	3.860	0.003	0.229	36.600
104	49.68	0.036	22.400	-0.038	3.860	0.003	0.236	36.600
105	50.12	0.034	22.400	-0.038	3.910	0.003	0.230	37.800
106	50.52	0.038	22.300	-0.038	3.900	0.003	0.226	37.600
107	51.11	0.044	22.400	-0.038	3.930	0.003	0.228	38.200
108	51.76	0.041	22.400	-0.038	3.940	0.003	0.229	38.500
109	52.26	0.042	22.400	-0.038	3.890	0.003	0.222	38.500
110	52.89	0.036	22.400	-0.038	3.890	0.003	0.216	38.500
111	53.28	0.039	22.500	-0.038	3.880	0.003	0.214	38.700
112	53.76	0.041	23.800	-0.038	3.840	0.003	0.198	41.300
113	54.19	0.044	24.100	-0.038	3.850	0.003	0.193	41.900
114	54.6	0.042	24.300	-0.038	3.840	0.003	0.181	42.300
115	54.98	0.044	24.200	-0.038	3.840	0.003	0.192	42.200
116	55.26	0.043	24.300	-0.038	3.840	0.003	0.189	42.300
117	55.28	0.042	24.200	-0.038	3.860	0.003	0.187	42.200
118	55.77	0.046	24.100	-0.038	3.830	0.003	0.175	42.200
119	56.21	0.049	24.200	-0.038	3.840	0.003	0.186	42.300
120	56.75	0.042	24.100	-0.037	3.830	0.003	0.179	42.300
121	57.2	0.042	24.200	-0.038	3.850	0.003	0.176	42.500
122	57.72	0.044	24.200	-0.038	3.830	0.003	0.173	42.500
123	58.21	0.046	21.700	-0.039	3.520	0.003	0.157	39.300
124	58.68	0.049	24.000	-0.038	3.790	0.003	0.168	42.400
125	59.18	0.046	24.000	-0.038	3.790	0.003	0.170	42.500

126	59.66	0.045	24.000	-0.038	3.780	0.003	0.169	42.600
127	60.17	0.046	23.900	-0.038	3.760	0.003	0.168	42.500
128	60.68	0.047	23.900	-0.038	3.760	0.003	0.161	42.600
129	61.15	0.044	23.900	-0.038	3.740	0.003	0.157	42.500
130	61.65	0.043	23.700	-0.038	3.730	0.003	0.164	42.400
131	62.12	0.041	23.800	-0.038	3.720	0.003	0.159	42.600
132	62.62	0.043	23.800	-0.038	3.710	0.003	0.154	42.500
133	63.14	0.048	23.800	-0.038	3.700	0.003	0.150	42.500
134	63.58	0.039	23.700	-0.038	3.680	0.003	0.151	42.400
135	64.04	0.050	23.600	-0.038	3.680	0.003	0.146	42.600
136	64.56	0.048	23.600	-0.038	3.680	0.003	0.150	42.600

APPENDIX B

Sample Location

Table B.1 7-22-2012 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0	N43 32.333	W116 05.645
2	0.81	N43 32.950	W116 05.980
3	1.04	N43 33.123	W116 06.083
4	1.67	N43 33.545	W116 06.538
5	1.95	N43 33.652	W116 06.813
6	2.42	N43 33.658	W116 07.343
7	2.95	N43 33.866	W116 07.869
8	3.36	N43 34.157	W116 08.090
9	4.11	N43 34.403	W116 08.748
10	4.37	N43 34.506	W116 09.008
11	4.86	N43 34.814	W116 09.366
12	5.35	N43 35.157	W116 09.616
13	5.92	N43 35.427	W116 10.141
14	6.35	N43 35.704	W116 10.457
15	6.79	N43 36.031	W116 10.717
16	7.34	N43 35.986	W116 11.274
17	7.89	N43 36.313	W116 11.727
18	8.3	N43 36.323	W116 12.201
19	8.86	N43 36.638	W116 12.704
20	9.32	N43 36.826	W116 13.197
21	9.7	N43 37.042	W116 13.508
22	10.14	N43 37.270	W116 13.905
23	10.63	N43 37.640	W116 14.073
24	11.1	N43 37.956	W116 14.376
25	11.63	N43 38.325	W116 14.675
26	12.06	N43 38.537	W116 15.064
27	12.69	N43 38.836	W116 15.641
28	13.65	N43 39.435	W116 16.309
29	14.01	N43 39.606	W116 16.628
30	14.11	N43 39.636	W116 16.735
31	14.31	N43 39.733	W116 16.923
32	14.81	N43 39.801	W116 17.519
33	15.16	N43 39.986	W116 17.852
52	24.29	N43 40.222	W116 18.425
53	24.74	N43 40.377	W116 18.742
54	25.28	N43 40.548	W116 19.084
55	25.75	N43 40.688	W116 19.429
56	26.31	N43 40.901	W116 19.937
57	26.73	N43 41.048	W116 20.376
58	27.29	N43 41.137	W116 20.770

59	27.68	N43 41.239	W116 21.375
60	28.21	N43 41.431	W116 21.702
61	28.3	N43 41.451	W116 22.212
62	28.34	N43 41.345	W116 22.731
63	28.56	N43 41.484	W116 23.185
64	28.76	N43 41.577	W116 23.701
65	29.03	N43 41.389	W116 24.038
66	29.3	N43 41.415	W116 24.449
67	29.44	N43 41.379	W116 25.094
68	29.77	N43 41.246	W116 25.506
69	30.06	N43 40.990	W116 25.413
70	30.28	N43 40.849	W116 25.957
71	30.68	N43 40.990	W116 26.423
72	31.01	N43 40.970	W116 26.847
73	31.23	N43 41.006	W116 27.292
74	31.73	N43 40.993	W116 27.912
75	31.79	N43 41.073	W116 28.288
76	32.05	N43 40.944	W116 28.833
77	32.45	N43 40.873	W116 29.247
78	33.2	N43 40.841	W116 29.848
79	33.6	N43 40.843	W116 29.955
80	33.96	N43 40.876	W116 29.991
81	34.24	N43 40.876	W116 30.245
82	34.61	N43 40.772	W116 30.446
83	34.87	N43 40.888	W116 30.704
84	35.09	N43 40.903	W116 30.970
85	35.32	N43 40.838	W116 31.106
86	35.86	N43 40.791	W116 31.496
87	36.29	N43 41.002	W116 31.624
88	37.03	N43 41.003	W116 31.850
89	37.31	N43 40.927	W116 32.260
90	37.57	N43 40.692	W116 32.483
91	37.97	N43 40.671	W116 32.739
92	38.21	N43 40.950	W116 33.180
93	38.44	N43 40.947	W116 33.245
94	39.01	N43 40.915	W116 33.484
95	39.2	N43 40.892	W116 33.935
96	39.43	N43 40.982	W116 34.587
97	39.9	N43 41.098	W116 34.993
98	40.13	N43 41.251	W116 35.236
99	40.34	N43 41.318	W116 35.551
100	40.52	N43 41.315	W116 35.850
101	40.71	N43 41.332	W116 36.148

102	40.82	N43 41.506	W116 36.257
103	41.86	N43 41.687	W116 36.228
104	42.43	N43 41.806	W116 36.776
105	42.83	N43 41.730	W116 37.256
106	43.33	N43 41.486	W116 37.895
107	43.87	N43 41.706	W116 38.035
108	44.28	N43 41.768	W116 38.316
109	44.93	N43 41.844	W116 38.752
110	45.43	N43 41.744	W116 39.011
111	45.77	N43 41.766	W116 39.276
112	46.33	N43 41.706	W116 39.871
113	46.61	N43 41.568	W116 39.993
114	47.06	N43 41.563	W116 40.217
115	47.78	N43 41.599	W116 40.725
116	48.26	N43 41.659	W116 40.967
117	48.75	N43 41.700	W116 41.204
118	49.32	N43 41.564	W116 41.259
119	49.8	N43 41.395	W116 41.241
120	50.3	N43 41 19.4	W116 41 10
121	50.84	N43 40 45.9	W116 41 46.5
122	51.21	N43 40 41.5	W116 42 24.5
123	51.69	N43 40 38.4	W116 42 52.8
124	52.24	N43 40 56.3	W116 43 13.8
125	52.66	N43 41 10.2	W116 43 43.5
126	53.2	N43 41 25.3	W116 44 2.3
127	53.74	N43 41 45	W116 44 35
128	54.22	N43 41 51.3	W116 45 0.6
129	55.56	N43 42 2.6	W116 45 12.6
130	56.25	N43 42 11	W116 45 37
131	56.76	N43 42 7.6	W116 45 54
132	57.3	N43 42 29.2	W116 46 2.1
133	57.74	N43 42 48.5	W116 46 43.2
134	58.29	N43 42 48.1	W116 47 12.9
135	58.8	N43 43 7.7	W116 47 33.2
136	59.24	N43 43 13.3	W116 47 56.2
137	59.79	N43 43 17.1	W116 48 21.1
138	60.24	N43 43 33.8	W116 48 47.9
139	60.8	N43 43 34.8	W116 49 24
140	61.33	N43 43 37.4	W116 49 50.1
141	61.71	N43 43 43.6	W116 50 21.5
142	62.27	N43 43 38	W116 50 56.9
143	62.81	N43 43 37.6	W116 51 26.2
144	63.18	N43 43 50.8	W116 51 53.5

145	63.73	N43 43 58.2	W116 52 29.5
146	64.39	N43 44 0.5	W116 52 55.6
147	64.72	N43 44 15.5	W116 54 11
148	65.27	N43 44 39.2	W116 54 36.6
149	65.67	N43 44 50.1	W116 55 3.8

Table B.2 10-7-2012 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0	N43 32 21.52	W116 05 41.47
2	0.51	N43 32.731	W116 05.968
3	1.23	N43 33.292	W116 06.241
4	1.76	N43 33.571	W116 06.683
5	2.25	N43 33.587	W116 07.219
6	2.74	N43 33.754	W116 07.759
7	3.44	N43 34.209	W116 08.246
8	4.52	N43 34.627	W116 09.170
9	5.03	N43 34.933	W116 09.583
10	5.57	N43 35.321	W116 09.804
11	6.18	N43 35.639	W116 10.346
12	6.71	N43 36.007	W116 10.678
13	7.42	N43 36.075	W116 11.360
14	7.96	N43 36.320	W116 11.891
15	8.65	N43 36.563	W116 12.579
16	9.18	N43 36.791	W116 13.132
17	9.98	N43 37.236	W116 13.823
18	10.52	N43 37.618	W116 14.076
19	11.05	N43 37.987	W116 14.383
20	11.75	N43 38.428	W116 14.837
21	12.28	N43 38.677	W116 15.337
22	12.92	N43 39.063	W116 15.758
23	13.53	N43 39.408	W116 16.281
24	14.01	N43 39.608	W116 16.721
25	14.06	N43 39.641	W116 16.754
26	14.57	N43 39.781	W116 17.326
27	15.03	N43 39.941	W116 17.796
28	15.41	N43 40.145	W116 18.171
29	15.9	N43 40.254	W116 18.729
30	16.36	N43 40.355	W116 19.235
31	16.89	N43 40.420	W116 19.771
32	17.37	N43 40.438	W116 20.296
33	17.88	N43 40.552	W116 20.737

34	18.4	N43 40.526	W116 21.181
35	18.85	N43 40.651	W116 21.618
36	19.33	N43 40.555	W116 22.094
37	19.8	N43 40.724	W116 22.561
38	20.37	N43 40.658	W116 23.056
39	20.8	N43 40.644	W116 23.468
40	21.32	N43 40.484	W116 23.961
41	21.79	N43 40.427	W116 24.441
42	22.18	N43 40.417	W116 24.851
43	22.7	N43 40.683	W116 25.327
44	23.18	N43 40.862	W116 25.577
45	23.68	N43 40.871	W116 26.153
46	24.18	N43 41.114	W116 26.576
47	24.59	N43 40.915	W116 26.928
48	25.08	N43 40.989	W116 27.426
49	25.56	N43 40.980	W116 27.954
50	26.1	N43 41.079	W116 28.454
51	26.61	N43 40.967	W116 28.946
52	27.11	N43 40.852	W116 29.503
53	27.27	N43 40.851	W116 29.678
54	27.5	N43 40.860	W116 29.941
55	27.81	N43 40.865	W116 30.298
56	28.04	N43 40.774	W116 30.527
57	28.29	N43 40.924	W116 30.753
58	28.54	N43 40.884	W116 31.014
59	28.78	N43 40.792	W116 31.255
60	29.02	N43 40.806	W116 31.545
61	29.29	N43 41.015	W116 31.652
62	29.52	N43 41.020	W116 31.928
63	29.77	N43 40.982	W116 32.204
64	30.01	N43 40.821	W116 32.375
65	30.29	N43 40.677	W116 32.605
66	30.58	N43 40.760	W116 32.911
67	30.85	N43 40.930	W116 33.124
68	31.11	N43 40.880	W116 33.372
69	31.4	N43 40.953	W116 33.690
70	31.68	N43 40.866	W116 33.985
71	31.91	N43 40.936	W116 34.191
72	32.2	N43 41.085	W116 34.427
73	32.36	N43 40.992	W116 34.567
74	32.58	N43 41.072	W116 34.780
75	32.81	N43 41.095	W116 35.020
76	33.06	N43 41.191	W116 35.194

77	33.3	N43 41.306	W116 35.402
78	33.55	N43 41.250	W116 35.650
79	33.78	N43 41.310	W116 35.846
80	34.03	N43 41.329	W116 36.129
81	34.27	N43 41.513	W116 36.258
82	34.53	N43 41.709	W116 36.338
83	34.76	N43 41.809	W116 36.558
84	35.01	N43 41.776	W116 36.835
85	35.25	N43 41.703	W116 37.105
86	35.5	N43 41.702	W116 37.387
87	35.75	N43 41.516	W116 37.500
88	36.02	N43 41.454	W116 37.780
89	36.24	N43 41.574	W116 37.961
90	36.5	N43 41.761	W116 38.121
91	36.73	N43 41.792	W116 38.377
92	37.04	N43 41.851	W116 38.731
93	37.2	N43 41.791	W116 38.901
94	37.41	N43 41.724	W116 39.121
95	37.65	N43 41.786	W116 39.387
96	37.97	N43 41.752	W116 39.727
97	38.23	N43 41.619	W116 39.936
98	38.45	N43 41.523	W116 40.151
99	38.75	N43 41.633	W116 40.466
100	39	N43 41.600	W116 40.722
101	39.22	N43 41.660	W116 40.961
102	39.45	N43 41.697	W116 41.226
103	39.7	N43 41.489	W116 41.260
104	39.93	N43 41.314	W116 41.166
105	40.46	N43 40.900	W116 41.215
106	40.96	N43 40.766	W116 41.776
107	41.4	N43 40.664	W116 42.263
108	41.9	N43 40.643	W116 42.842
109	42.4	N43 40.919	W116 43.225
110	42.83	N43 41.135	W116 43.574
111	43.36	N43 41.425	W116 44.032
112	43.82	N43 41.594	W116 44.492
113	44.33	N43 41.926	W116 44.829
114	44.83	N43 42.017	W116 45.205
115	45.35	N43 42.188	W116 45.524
116	45.76	N43 42.181	W116 45.946
117	46.11	N43 42.458	W116 46.014
118	46.9	N43 42.814	W116 46.744
119	47.35	N43 42.798	W116 47.211

120	47.83	N43 43.125	W116 47.542
121	48.33	N43 43.262	W116 47.863
122	48.82	N43 43.223	W116 48.350
123	49.32	N43 43.537	W116 48.737
124	49.81	N43 43.540	W116 49.271
125	50.24	N43 43.618	W116 49.758
126	50.75	N43 43.735	W116 50.312
127	51.19	N43 43.699	W116 50.822
128	51.73	N43 43.626	W116 51.418
129	52.23	N43 43.828	W116 51.848
130	52.68	N43 43.939	W116 52.343
131	53.18	N43 44.024	W116 52.799
132	53.66	N43 43.946	W116 53.354
133	54.16	N43 44.068	W116 53.899
134	54.7	N43 44.314	W116 54.237
135	55.2	N43 44.644	W116 54.472
136	55.72	N43 44.850	W116 54.935
137	56.16	N43 44.797	W116 55.369
138	56.69	N43 45.216	W116 55.511
139	57.18	N43 45.610	W116 55.561
140	57.72	N43 45.797	W116 55.975
141	58.2	N43 46.018	W116 56.342
142	58.68	N43 45.984	W116 56.820
143	59.18	N43 46.236	W116 57.164
144	59.68	N43 46.386	W116 57.726
145	60.2	N43 46.625	W116 58.218
146	60.68	N43 47.002	W116 58.316
147	61.25	N43 47.330	W116 58.630
148	61.7	N43 47.603	W116 58.850
149	62.19	N43 47.691	W116 59.291
150	62.68	N43 47.916	W116 59.763
151	63.18	N43 48.242	W117 00.108
152	63.72	N43 48.498	W117 00.314
153	64.17	N43 48.733	W117 00.713
154	64.65	N43 48.919	W117 01.203

Table B.3 12-16-2012 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0.53	N43 32.648	W116 05.986
2	1.08	N43 33.099	W116 06.058
3	2.04	N43 33.654	W116 06.838
4	2.63	N43 33.672	W116 07.506
5	3.07	N43 33.910	W116 07.902
6	3.4	N43 34.147	W116 08.072
7	4	N43 34.261	W116 08.678
8	4.89	N43 34.805	W116 09.333
9	5.75	N43 35.350	W116 09.858
10	6.44	N43 35.709	W116 10.472
11	7.61	N43 36.101	W116 11.419
12	14.22	N43 39.639	W116 16.756
13	14.49	N43 39.742	W116 17.033
14	14.8	N43 39.789	W116 17.397
15	14.99	N43 39.837	W116 17.615
16	15.27	N43 39.995	W116 17.864
17	15.54	N43 40.130	W116 18.134
18	15.78	N43 40.203	W116 18.401
19	16.22	N43 40.282	W116 18.914
20	16.8	N43 40.291	W116 19.549
21	17.16	N43 40.391	W116 19.873
22	17.78	N43 40.571	W116 20.473
23	18.27	N43 40.660	W116 20.905
24	18.86	N43 40.620	W116 21.432
25	19.26	N43 40.543	W116 21.814
26	19.66	N43 40.581	W116 22.257
27	20.23	N43 40.631	W116 22.771
28	20.7	N43 40.713	W116 23.198
29	21.22	N43 40.635	W116 23.724
30	21.69	N43 40.441	W116 24.154
31	22.25	N43 40.419	W116 24.755
32	22.69	N43 40.587	W116 25.195
33	23.29	N43 40.891	W116 25.529
34	23.7	N43 40.844	W116 25.987
35	24.37	N43 41.108	W116 26.607
36	24.72	N43 40.928	W116 26.889
37	25.15	N43 41.015	W116 27.308
38	25.64	N43 40.998	W116 27.841
39	26.18	N43 41.075	W116 28.337
40	26.86	N43 40.940	W116 29.044

41	27.24	N43 40.875	W116 29.476
42	27.63	N43 40.853	W116 29.919
43	28.07	N43 40.795	W116 30.383
44	28.62	N43 40.926	W116 30.920
45	29.07	N43 40.790	W116 31.403
46	29.55	N43 41.015	W116 31.758
47	30.05	N43 40.919	W116 32.280
48	30.56	N43 40.666	W116 32.698
49	31.04	N43 40.930	W116 33.128
50	31.56	N43 40.932	W116 33.634
51	32.03	N43 40.871	W116 34.163
52	32.59	N43 40.983	W116 34.593
53	33.03	N43 41.091	W116 35.042
54	33.5	N43 41.300	W116 35.415
55	34	N43 41.318	W116 35.857
56	34.5	N43 41.531	W116 36.279
57	35.07	N43 41.822	W116 36.589
58	35.57	N43 41.707	W116 37.136
59	36.07	N43 41.495	W116 37.528
60	36.57	N43 41.607	W116 37.973
61	37.03	N43 41.796	W116 38.387
62	37.48	N43 41.802	W116 38.884
63	37.92	N43 41.787	W116 39.365
64	38.46	N43 41.634	W116 39.918
65	38.94	N43 41.623	W116 40.411
66	39.45	N43 41.660	W116 40.961
67	39.9	N43 41.527	W116 41.243
68	40.17	N43 41.301	W116 41.153
69	40.66	N43 40.907	W116 41.198
70	41.19	N43 40.759	W116 41.779
71	41.67	N43 40.676	W116 42.323
72	42.31	N43 40.695	W116 43.055
73	42.66	N43 40.957	W116 43.231
74	43.17	N43 41.165	W116 43.702
75	43.62	N43 41.433	W116 44.063
76	44.19	N43 41.716	W116 44.560
77	44.66	N43 41.891	W116 44.930
78	45.1	N43 42.050	W116 45.212
79	45.61	N43 42.174	W116 45.564
80	46.33	N43 42.465	W116 46.012
81	46.84	N43 42.660	W116 46.519
82	47.34	N43 42.855	W116 46.987
83	48.07	N43 43.153	W116 47.556

84	48.59	N43 43.232	W116 47.920
85	49.16	N43 43.332	W116 48.423
86	49.54	N43 43.547	W116 48.756
87	50.17	N43 43.572	W116 49.447
88	50.46	N43 43.614	W116 49.791
89	50.95	N43 43.733	W116 50.337
90	51.44	N43 43.682	W116 50.873
91	51.92	N43 43.625	W116 51.424
92	52.48	N43 43.857	W116 51.900
93	53.01	N43 43.986	W116 52.493
94	53.47	N43 44.011	W116 52.920
95	53.91	N43 43.957	W116 53.431
96	54.4	N43 44.108	W116 53.951
97	54.71	N43 44.279	W116 54.207
98	55.27	N43 44.649	W116 54.492
99	55.85	N43 44.824	W116 55.009
100	56.24	N43 44.798	W116 55.406
101	56.68	N43 45.155	W116 55.500
102	57.26	N43 45.625	W116 55.564
103	57.71	N43 45.825	W116 55.898
104	58.22	N43 45.989	W116 56.337
105	58.71	N43 45.971	W116 56.788
106	59.27	N43 46.234	W116 57.206
107	59.7	N43 46.372	W116 57.679
108	60.17	N43 46.599	W116 58.107
109	60.67	N43 46.949	W116 58.325
110	61.33	N43 47.363	W116 58.624
111	62.17	N43 47.652	W116 59.222
112	62.61	N43 47.851	W116 59.670
113	63.5	N43 48.383	W117 00.099
114	64.24	N43 48.761	W117 00.767
115	64.63	N43 48.894	W117 01.186

Table B.4 4-7-2013 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0	N43 32.350	W116 05.652
2	0.82	N43 32.962	W116 05.981
3	1.17	N43 33.224	W116 06.186
4	1.64	N43 33.523	W116 06.507
5	2.07	N43 33.677	W116 06.967
6	2.48	N43 33.715	W116 07.403
7	2.98	N43 33.887	W116 07.870
8	3.49	N43 34.211	W116 08.228
9	3.99	N43 34.310	W116 08.682
10	4.48	N43 34.562	W116 09.114
11	4.94	N43 34.859	W116 09.445
12	5.37	N43 35.163	W116 09.628
13	5.85	N43 35.419	W116 10.056
14	6.33	N43 35.706	W116 10.451
15	6.84	N43 36.066	W116 10.764
16	7.32	N43 35.986	W116 11.253
17	7.73	N43 36.219	W116 11.606
18	8.25	N43 36.320	W116 12.150
19	8.7	N43 36.560	W116 12.565
20	9.17	N43 36.747	W116 13.058
21	9.6	N43 37.012	W116 13.391
22	10.22	N43 37.297	W116 13.991
23	10.57	N43 37.585	W116 14.068
24	11.11	N43 37.962	W116 14.375
25	11.54	N43 38.244	W116 14.649
26	12.16	N43 38.603	W116 15.116
27	12.64	N43 38.799	W116 15.573
28	13.13	N43 39.125	W116 15.863
29	13.65	N43 39.430	W116 16.299
30	14.15	N43 39.614	W116 16.753
31	14.15	N43 39.657	W116 16.756
32	14.66	N43 39.778	W116 17.335
33	15.56	N43 40.170	W116 18.239
34	15.62	N43 40.185	W116 18.305
35	16.11	N43 40.274	W116 18.865
36	16.69	N43 40.276	W116 19.515
37	17.35	N43 40.381	W116 20.179
38	17.88	N43 40.598	W116 20.645
39	18.62	N43 40.519	W116 21.338
40	19.29	N43 40.584	W116 21.926

41	19.83	N43 40.715	W116 22.491
42	20.71	N43 40.659	W116 23.264
43	21.15	N43 40.639	W116 23.746
44	21.96	N43 40.469	W116 24.515
45	22.41	N43 40.450	W116 25.005
46	23.22	N43 40.890	W116 25.523
47	23.86	N43 40.886	W116 26.237
48	24.5	N43 41.056	W116 26.818
49	25.16	N43 40.998	W116 27.381
50	25.63	N43 40.994	W116 27.907
51	26.3	N43 41.069	W116 28.533
52	26.88	N43 40.914	W116 29.101
53	27.16	N43 40.880	W116 29.428
54	27.84	N43 40.889	W116 30.211
55	28.86	N43 40.789	W116 31.221
56	29.45	N43 41.023	W116 31.700
57	30.54	N43 40.672	W116 32.745
58	31.43	N43 40.929	W116 33.538
59	32.07	N43 40.942	W116 34.186
60	32.97	N43 41.090	W116 35.046
61	34.03	N43 41.331	W116 35.949
62	34.83	N43 41.755	W116 36.397
63	35.31	N43 41.748	W116 36.915
64	35.97	N43 41.522	W116 37.503
65	36.58	N43 41.678	W116 38.001
66	37.16	N43 41.852	W116 38.600
67	37.72	N43 41.753	W116 39.233
68	38.34	N43 41.669	W116 39.888
69	38.99	N43 41.640	W116 40.534
70	39.54	N43 41.700	W116 41.120
71	40.1	N43 41.329	W116 41.174
72	40.15	N43 41.293	W116 41.151
73	40.65	N43 40.901	W116 41.211
74	41.18	N43 40.748	W116 41.799
75	41.69	N43 40.695	W116 42.381
76	42.26	N43 40.686	W116 43.033
77	42.69	N43 41.009	W116 43.255
78	43.13	N43 41.163	W116 43.712
79	43.63	N43 41.437	W116 44.125
80	44.11	N43 41.680	W116 44.540
81	44.99	N43 42.000	W116 45.199
82	46.09	N43 42.303	W116 45.958

83	46.99	N43 42.788	W116 46.659
84	47.41	N43 42.806	W116 47.105
85	47.85	N43 43.010	W116 47.483
86	48.53	N43 43.239	W116 47.912
87	48.89	N43 43.174	W116 48.289
88	49.9	N43 43.541	W116 49.204
89	50.26	N43 43.573	W116 49.619
90	50.7	N43 43.658	W116 50.130
91	51.27	N43 43.741	W116 50.738
92	52.08	N43 43.602	W116 51.654
93	52.59	N43 43.909	W116 52.065
94	52.98	N43 43.982	W116 52.501
95	53.46	N43 44.008	W116 52.946
96	54.08	N43 44.039	W116 53.638
97	54.41	N43 44.128	W116 53.995
98	54.91	N43 44.476	W116 54.207
99	55.27	N43 44.650	W116 54.527
100	55.54	N43 44.782	W116 54.751

Table B.5 6-23-2013 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0	N43 32.352	W116 05.646
2	0.5	N43 32.746	W116 05.977
3	1	N43 33.068	W116 06.023
4	1.5	N43 33.435	W116 06.361
5	2	N43 33.669	W116 07.496
6	2.5	N43 33.753	W116 07.754
7	3	N43 34.008	W116 08.034
8	3.5	N43 34.190	W116 08.404
9	4	N43 34.494	W116 08.948
10	4.5	N43 35.668	W116 10.381
11	5	N43 35.969	W116 10.612
12	5.5	N43 36.209	W116 11.595
13	6	N43 36.449	W116 12.430
14	6.5	N43 36.764	W116 13.104
15	7	N43 37.004	W116 13.373
16	7.5	N43 37.232	W116 13.811
17	8	N43 37.422	W116 14.070
18	8.5	N43 37.779	W116 14.155
19	9	N43 38.081	W116 14.442
20	9.5	N43 38.438	W116 14.915

21	10	N43 38.440	W116 14.959
22	10.5	N43 38.798	W116 15.470
23	11.5	N43 39.145	W116 15.964
24	12	N43 39.574	W116 16.434
25	12.5	N43 39.704	W116 16.863
26	13	N43 39.773	W116 17.353
27	13.5	N43 39.901	W116 17.728
28	14	N43 40.098	W116 18.077
29	14.24	N43 40.254	W116 18.752
30	14.67	N43 40.355	W116 19.221
31	15.02	N43 40.418	W116 19.758
32	15.4	N43 40.458	W116 20.340
33	16	N43 40.609	W116 20.614
34	16.43	N43 40.580	W116 21.118
35	16.97	N43 40.541	W116 21.814
36	17.51	N43 40.526	W116 22.138
37	17.84	N43 40.586	W116 22.762
38	18.4	N43 40.679	W116 23.111
39	19.15	N43 40.637	W116 23.721
40	19.45	N43 40.445	W116 24.208
41	20.18	N43 40.455	W116 24.510
42	20.5	N43 40.482	W116 25.062
43	21.11	N43 40.830	W116 25.309
44	21.65	N43 40.857	W116 25.931
45	21.92	N43 40.913	W116 26.355
46	22.44	N43 41.067	W116 26.808
47	22.92	N43 40.929	W116 27.109
48	23.55	N43 40.930	W116 27.658
49	23.91	N43 40.950	W116 28.193
50	24.44	N43 40.941	W116 28.831
51	24.8	N43 40.875	W116 29.208
52	25.36	N43 40.856	W116 29.681
53	25.85	N43 40.893	W116 30.182
54	26.58	N43 40.876	W116 30.678
55	26.92	N43 40.796	W116 31.208
56	27.34	N43 40.976	W116 31.597
57	27.78	N43 41.033	W116 32.098
58	28.28	N43 40.682	W116 32.501
59	28.81	N43 40.801	W116 32.980
60	29.3	N43 40.891	W116 33.393
61	29.77	N43 40.851	W116 34.018
62	30.31	N43 41.088	W116 34.389

63	30.77	N43 41.114	W116 34.846
64	31.26	N43 41.239	W116 35.204
65	31.82	N43 41.217	W116 35.679
66	32.28	N43 41.325	W116 36.139
67	32.76	N43 41.768	W116 36.439
68	33.21	N43 41.768	W116 36.841
69	33.71	N43 41.671	W116 37.431
70	34.15	N43 41.452	W116 37.793
71	34.83	N43 41.786	W116 38.206
72	35.21	N43 41.853	W116 38.731
73	35.75	N43 41.757	W116 39.228
74	36.23	N43 41.733	W116 39.841
75	36.77	N43 41.588	W116 40.268
76	37.24	N43 41.633	W116 40.767
77	37.7	N43 41.579	W116 41.260
78	38.22	N43 41.312	W116 41.162
79	38.73	N43 40.900	W116 41.204
80	39.19	N43 40.663	W116 42.024
81	39.74	N43 40.693	W116 42.384
82	40.07	N43 40.641	W116 42.918
83	40.6	N43 40.975	W116 43.236
84	41.36	N43 40.936	W116 43.836
85	41.67	N43 40.890	W116 44.102
86	42.12	N43 41.348	W116 44.503
87	42.62	N43 41.790	W116 44.610
88	43.36	N43 41.844	W116 44.999
89	43.6	N43 42.113	W116 45.205
90	44.24	N43 42.131	W116 45.662
91	44.18	N43 42.424	W116 45.995
92	45.25	N43 42.564	W116 46.382
93	45.67	N43 42.862	W116 46.824
94	46.22	N43 42.836	W116 47.294
95	46.8	N43 43.197	W116 47.565
96	47.2	N43 43.206	W116 47.958
97	47.72	N43 43.302	W116 48.376
98	48.16	N43 43.561	W116 48.779
99	48.64	N43 43.541	W116 49.293
100	49.16	N43 43.623	W116 49.815
101	49.64	N43 43.702	W116 50.499
102	50.09	N43 43.654	W116 50.905
103	50.55	N43 43.622	W116 51.470
104	51.01	N43 43.838	W116 51.862
105	51.62	N43 43.932	W116 52.419

106	52	N43 44.016	W116 52.911
107	52.49	N43 43.948	W116 53.391
108	52.96	N43 44.063	W116 53.896
109	53.45	N43 44.301	W116 54.237
110	53.99	N43 44.662	W116 54.530
111	54.4	N43 44.852	W116 54.918
112	54.86	N43 44.781	W116 55.345
113	55.38	N43 45.148	W116 55.496
114	55.94	N43 45.589	W116 55.572
115	56.39	N43 45.822	W116 55.916
116	56.81	N43 45.932	W116 56.318
117	57.3	N43 45.967	W116 56.810
118	57.84	N43 46.241	W116 57.048
119	58.34	N43 46.361	W116 57.644
120	58.77	N43 46.618	W116 58.174
121	59.35	N43 46.867	W116 58.340
122	59.77	N43 47.266	W116 58.549
123	60.3	N43 47.551	W116 58.685
124	60.85	N43 47.661	W116 59.112
125	61.2	N43 47.821	W116 59.609
126	61.81	N43 48.061	W117 00.036
127	62.21	N43 48.414	W117 00.236
128	62.7	N43 48.666	W117 00.567
129	63.18	N43 48.811	W117 01.032
130	63.64	N43 48.992	W117 01.245
131	64.24	N43 32.352	W116 05.646
132	64.66	N43 32.746	W116 05.977
133	65.1	N43 33.068	W116 06.023
134	65.38	N43 33.435	W116 06.361

Table B.6 10-14-2013 Sampling

Sample Point	Distance Miles	Latitude	Longitude
1	0	N43 32.286	W116 05.598
2	0.48	N43 32.596	W116 05.973
3	0.92	N43 32.977	W116 05.981
4	1.49	N43 33.403	W116 06.321
5	2	N43 33.660	W116 06.795
6	2.47	N43 33.665	W116 07.316
7	2.88	N43 33.761	W116 07.771
8	3.39	N43 34.150	W116 08.067
9	3.95	N43 34.217	W116 08.673

10	4.43	N43 34.505	W116 08.993
11	4.91	N43 34.804	W116 09.346
12	5.4	N43 35.135	W116 09.597
13	5.93	N43 35.415	W116 10.066
14	6.43	N43 35.716	W116 10.470
15	6.92	N43 36.068	W116 10.765
16	7.54	N43 36.079	W116 11.358
17	7.97	N43 36.317	W116 11.739
18	8.44	N43 36.352	W116 12.279
19	8.97	N43 36.655	W116 12.749
20	9.44	N43 36.847	W116 13.232
21	9.9	N43 37.085	W116 13.641
22	10.32	N43 37.313	W116 14.010
23	10.74	N43 37.672	W116 14.072
24	11.16	N43 37.950	W116 14.375
25	11.71	N43 38.328	W116 14.677
26	12.25	N43 38.622	W116 15.138
27	12.72	N43 38.802	W116 15.585
28	13.18	N43 39.121	W116 15.855
29	13.64	N43 39.389	W116 16.242
30	14.14	N43 39.612	W116 16.689
31	14.22	N43 39.643	W116 16.762
32	14.62	N43 39.757	W116 17.197
33	15.37	N43 40.050	W116 17.966
34	15.8	N43 40.209	W116 18.427
35	16.3	N43 40.325	W116 18.995
36	16.79	N43 40.293	W116 19.546
37	17.23	N43 40.354	W116 19.962
38	17.63	N43 40.488	W116 20.390
39	17.84	N43 40.600	W116 20.545
40	18.15	N43 40.618	W116 20.832
41	18.76	N43 40.583	W116 21.387
42	19.18	N43 40.523	W116 21.756
43	19.79	N43 40.650	W116 22.424
44	20.64	N43 40.718	W116 23.172
45	21.16	N43 40.637	W116 23.694
46	21.46	N43 40.473	W116 23.946
47	21.68	N43 40.417	W116 24.184
48	22.21	N43 40.413	W116 24.755
49	22.69	N43 40.614	W116 25.228
50	23.22	N43 40.898	W116 25.505
51	23.74	N43 40.854	W116 26.092
52	24.37	N43 41.080	W116 26.659

53	24.74	N43 40.900	W116 26.973
54	25.62	N43 41.005	W116 27.874
55	26.27	N43 41.070	W116 28.496
56	26.74	N43 40.971	W116 28.957
57	27.11	N43 40.883	W116 29.365
58	27.26	N43 40.843	W116 29.542
59	27.79	N43 40.894	W116 30.129
60	28.31	N43 40.867	W116 30.657
61	28.86	N43 40.797	W116 31.200
62	29.25	N43 40.892	W116 31.580
63	29.77	N43 41.033	W116 32.056
64	30.22	N43 40.767	W116 32.413
65	30.72	N43 40.760	W116 32.910
66	31.27	N43 40.876	W116 33.375
67	31.68	N43 40.923	W116 33.840
68	32.16	N43 41.008	W116 34.258
69	32.65	N43 41.016	W116 34.740
70	33.17	N43 41.181	W116 35.196
71	33.72	N43 41.212	W116 35.671
72	34.08	N43 41.318	W116 36.035
73	34.68	N43 41.719	W116 36.358
74	35.15	N43 41.762	W116 36.852
75	35.56	N43 41.724	W116 37.319
76	36.08	N43 41.480	W116 37.721
77	36.59	N43 41.748	W116 38.088
78	37.1	N43 41.861	W116 38.656
79	37.53	N43 41.726	W116 39.135
80	38.04	N43 41.757	W116 39.713
81	38.45	N43 41.536	W116 40.069
82	38.98	N43 41.586	W116 40.637
83	39.54	N43 41.685	W116 41.246
84	40.12	N43 41.199	W116 41.117
85	40.43	N43 40.947	W116 41.149
86	41.17	N43 40.678	W116 41.920
87	41.39	N43 40.650	W116 42.180
88	41.86	N43 40.670	W116 42.722
89	42.33	N43 40.804	W116 43.199
90	42.79	N43 41.103	W116 43.463
91	43.32	N43 41.375	W116 43.920
92	43.84	N43 41.552	W116 44.457
93	44.33	N43 41.911	W116 44.753
94	44.79	N43 41.942	W116 45.197
95	45.36	N43 42.193	W116 45.471

96	45.72	N43 42.112	W116 45.876
97	46.23	N43 42.515	W116 46.071
98	46.71	N43 42.696	W116 46.553
99	47.31	N43 42.789	W116 47.145
100	47.72	N43 43.022	W116 47.490
101	48.19	N43 43.335	W116 47.709
102	48.66	N43 43.144	W116 48.187
103	49.25	N43 43.490	W116 48.685
104	49.68	N43 43.512	W116 49.117
105	50.12	N43 43.573	W116 49.623
106	50.52	N43 43.642	W116 50.092
107	51.11	N43 43.739	W116 50.733
108	51.76	N43 43.629	W116 51.455
109	52.26	N43 43.848	W116 51.882
110	52.89	N43 44.032	W116 52.546
111	53.28	N43 44.015	W116 52.907
112	53.76	N43 43.974	W116 53.467
113	54.19	N43 44.085	W116 53.927
114	54.6	N43 44.332	W116 54.256
115	54.98	N43 44.604	W116 54.383
116	55.26	N43 44.694	W116 54.678
117	55.28	N43 44.706	W116 54.688
118	55.77	N43 44.870	W116 55.127
119	56.21	N43 44.928	W116 55.456
120	56.75	N43 45.366	W116 55.596
121	57.2	N43 45.745	W116 55.585
122	57.72	N43 45.780	W116 56.149
123	58.21	N43 46.079	W116 56.470
124	58.68	N43 46.096	W116 56.882
125	59.18	N43 46.252	W116 57.348
126	59.66	N43 46.471	W116 57.825
127	60.17	N43 46.701	W116 58.327
128	60.68	N43 47.141	W116 58.288
129	61.15	N43 47.389	W116 58.611
130	61.65	N43 47.686	W116 58.923
131	62.12	N43 47.740	W116 59.374
132	62.62	N43 47.945	W116 59.885
133	63.14	N43 48.312	W117 00.027
134	63.58	N43 48.543	W117 00.347
135	64.04	N43 48.758	W117 00.764
136	64.56	N43 48.996	W117 01.254