Benton Conservation District

Water Quality Monitoring – Final Report for 2020 to 2023

Badger Coulee, Benton County, Focus Area: Ground and Surface Water Nitrate Monitoring

Agreement Number (s): WQC-2018-BentCD-00080

EIM Study ID Number: WQC2020BentCD00080

Report Begin / End Date: January 01, 2022, to December 30, 2022

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Final Report – November 2023

Study and Data Information

Each study, funded in whole or in part by the Washington State Department of Ecology (Ecology), must follow an approved Quality Assurance Project Plan. This plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website: https://www.ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database. Search on Study ID WQC2020BentCD00080.

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Cover photo: Badger Coulee Canyon by Melissa Pierce, Benton Conservation District.

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Water Quality Monitoring – Final Report

Badger Coulee, Benton County, Focus Area: Ground and Surface Water Nitrate Monitoring

November 2023

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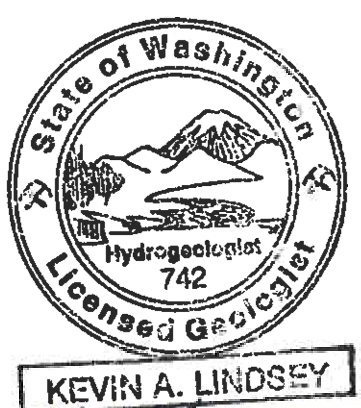

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2.0 Abstract

Recommendations from the Benton County Groundwater Nitrate Community Action Plan included expanding monitoring and analysis in the Badger Coulee Focus Area (Badger Coulee) in Benton County, with implementation of best management practices (BMPs) to decrease nitrate levels and improve drinking water safety.

The primary objective for this sampling effort was to sample and report on groundwater nitrate concentrations in private drinking water wells in Badger Coulee to assess potential human health issues. Monitoring results will be used to inform local residents of drinking water nitrate concerns and aid in landowner recruitment for implementing BMPs for groundwater protection.

This final report provides the sample results collected over the course of the project, documents the adherence to the Quality Assurance Project Plan (QAPP) (Appel and others, 2020), and provides statistical trend analyses and hydrogeological context for the observed occurrence of nitrate in the Badger Coulee.

3.0 Acknowledgements

The authors of this report thank the following people and/or groups for their contributions to this study:

- The Benton Conservation District (BCD) for community involvement, obtaining access, data collection, and data management.
- The Washington Department of Ecology (Ecology) for providing funding and guidance via document review for this project.

4.0 Introduction

4.1 Introduction and Problem Statement

Elevated nitrate concentrations in groundwater are a concern for Benton County (the County) in both urban and rural areas. The U.S. Environmental Protection Agency (USEPA) and Washington State Department of Health (WDOH) have established a maximum contaminant level of nitrate in drinking water at 10 mg/L for public supply wells. Washington Department of Ecology (Ecology) has established a groundwater standard also set at 10 mg/L.

The presence of nitrate in groundwater can come from irrigation processes, agricultural fertilization (both inorganic and organic), and lawn fertilization and watering practices for residential, community and recreational areas (e.g., golf courses and parks). Dairies, feedlots, and other livestock practices can also contribute to the presence of nitrate in the groundwater along with septic tanks and wastewater treatment. Although all these activities can introduce nitrate to groundwater, they also are part of the County's socio-economic fabric.

Previous studies have found concentrations above the state and federal maximum contaminant level (MCL) of 10 milligrams per liter (mg/L) or parts per million (ppm) in groundwater in much of the County, including Badger Coulee. Drinking water with high nitrates reduces the ability to carry oxygen in the blood, a condition called methemoglobinemia. In pregnant women, it increases the risk of spontaneous abortion or birth defects.

Building on the previous county-wide groundwater nitrate monitoring the County established a groundwater and surface water nitrate baseline and long-term monitoring program for Badger Coulee in 2020 to 2022, under Ecology Grant (WQC-2018-BentCD-00080). This area is of concern because it has a relatively high-density rural and mixed rural/urban population that is not serviced by a public water supply system.

Monitoring results described herein will be used to assess current nitrate conditions and trends in Badger Coulee. This will support BCD in its assessment/selection of Best Management Practices (BMPs) adopted to reduce groundwater nitrate concentrations. In addition, the results will be used to guide future groundwater protection efforts.

4.1.1 Background

Groundwater in predominantly agricultural areas, such as Badger Coulee often contains nitrate, potassium, chloride, calcium, and magnesium concentrations elevated above normal background conditions (Nolan et al. 1997). Nitrogen from inorganic and organic fertilizers, animal manure, and lime that is not taken up by plants is converted to nitrate via the nitrogen cycle. This nitrate can leach into groundwater where it can accumulate for years, resulting in high nitrate concentrations, especially in areas where nitrogen sources are continually active. All nitrogen applied to the soil becomes nitrate unless it is lost through volatilization (Nolan et al. 1997).

There are multiple potential sources of nitrate found in groundwater. Agricultural fertilizers, both inorganic and organic, are generally the most widespread. Examples of organic fertilizers include plant waste left in the field; land-applied food-processing discharge; land-applied manure solids, liquids, and compost; and seepage from leaking corrals and manure storage lagoons (Center for Watershed Sciences UC, Davis, 2012). Potential non-agricultural groundwater nitrate sources commonly include fertilizers applied to urban parks, residential landscaping, golf courses; and leachate from septic systems (Center for Watershed Sciences

UC, Davis, 2012). The nitrate needs of crops varies based on the type of crop, the soil type, and climate and the season. Any nitrogen/nitrate application above the amount taken up by crops, landscaping, and/or denitrification processes has the potential to lead to increased nitrate in groundwater (Herman et al 2015).

4.1.2 Goals and Objectives

The project goals for the monitoring portion of this study were to:

1. Identify nitrate concentration levels from 45 privately owned drinking wells in Badger Coulee.
2. Continue the nitrate monitoring efforts started under previous grant work (WQC-2015-BentCD-00102) in Badger Coulee to maintain a record of nitrate levels in the area.
3. Investigate nitrate levels in irrigation laterals that provide surface water to Badger Coulee as a potential added source of nitrate.
4. Investigate nitrate levels in surface water runoff, including Amon Creek, as potential return of nitrate sources to the Yakima River.
5. Use collected nitrate data to inform the community and help landowners in Badger Coulee implement best management practices for the reduction of nitrate loading to local groundwater.

The project objectives for this study were to:

1. Collect groundwater samples from a subset of privately owned wells within Badger Coulee on a quarterly basis for two years in order to determine nitrate levels that may cause negative health impacts on local drinking water.
2. Collect surface water from multiple locations within the Badger Coulee (including irrigation laterals, drainage ditches, and Amon Creek) and analyze for nitrate concentrations three times per year for two years.
3. Report data to EIM for hydrogeologists to compare to previously collected data to help monitor groundwater health and changes with respect to nitrate levels over time.

4.2 Study Area and Surroundings

Benton County is in the south-central portion of Washington covering an area of 1,760 square miles (mi^2) (4,600 square kilometers [km^2]). It is bounded by the Columbia River on three sides. The Yakima River passes through the middle of the County from west to east. It has a semi-arid climate with an average annual rainfall of 7.6 inches. The study area for this report is shown in Figure 1. Most of the area is occupied by agricultural and urban/suburban development (Figure 2). Rural residencies depend on individual wells, which are unregulated by the WDOH.

4.2.1 Irrigation and Surface Water

The primary source of surface water is irrigation water drawn from the Yakima River and delivered to residents through a series of pipelines and canals. Applied irrigation water returns to the shallow groundwater system and feeds several surface water drains and creeks. The surface drainage in Badger Coulee only appeared after extensive urban development in the Badger Coulee Area. Surface drainage exits the western part of Badger Coulee to the west into the Yakima River via an unnamed drainage. In the eastern part of Badger Coulee surface discharge is to the north via Amon Creek Wasteway (also referred to as Amon Creek) (Figure 1) and into the Yakima River. Amon Creek is the lowest drain in the Yakima Basin. Flowing all year, Amon Creek contributes a source of cooler water to the warmer Yakima River during summertime baseflow conditions and is identified as supporting migratory fish species. Over the past decade, with increased awareness of water conservation in the Yakima River, irrigation canals have been lined to prevent water seepage and loss. The long-term impact of lining irrigation canals in Benton County on groundwater levels and nitrate concentrations is not known.

4.2.2 Hydrogeologic Setting

Badger Coulee is located in the central portion of the Columbia River flood basalt province. The province comprises continental flood basalt flows collectively known as the Columbia River Basalt Group (CRBG), thin interbedded continental sedimentary units known as the Ellensburg Formation, and a thin discontinuous sequence of continental sedimentary units overlying the CRBG alternatively referred to as suprabasalt sediments or alluvial sediments. Groundwater is found in all these units. This section summarizes the basic hydrogeologic setting of Badger Coulee, the primary geologic units hosting the aquifer system (from youngest to oldest unit or shallowest to deepest), geologic structures which potentially influence groundwater occurrence, and basic aquifer system characteristics including recharge and discharge. Figure 3, a geologic map of Benton County, shows the basic geologic framework of the project area.

The primary groundwater systems underlying Benton County are found within alluvial sediments overlying the CRBG and within the CRBG. The CRBG aquifer system also is commonly subdivided into systems hosted primarily by the Saddle Mountains Basalt, the Wanapum Basalt and the Grande Ronde Basalt (Ely et al. 2014). Further subdivisions of these basalt aquifer systems have also been suggested, such as the upper (Priest Rapids and Roza) and lower (Frenchman Springs) Wanapum (GWMA 2011e). In the Benton County region, the Ecology Central Region Office also subdivides the Saddle Mountains Basalt into an upper and lower aquifer unit for the purpose of water rights management. Hydrologic characteristics of the CRBG and alluvial aquifer systems are summarized further in the following sections.

The CRBG groundwater system in Benton County is part of a regional system. Given that, the physical characteristics and properties of the CRBG effects their intrinsic hydraulic properties and influence potential distribution of groundwater within the CRBG. Based on both surface and subsurface data and mapping, the CRBG consists of multiple basalt layers, or flows, commonly classified as sheet flows (Beeson and Tolan 1990, 1996; Beeson et al. 1985, 1989; Reidel 1998; Reidel et al. 1994; USDOE 1988). As these reports show CRBG sheet flows exhibit a basic three-part internal arrangement of internal intraflow structures that originated during the emplacement and cooling of the lava flows. These three features are referred to as the flow top, flow interior, and flow bottom. Flow tops and flow bottoms are variously vesicular to rubbly. With increasing vesicles and rubble porosity and permeability will generally increase. Flow interiors tend to consist of massive, jointed rock which generally has very low permeability and porosity, even in the presence of joints. The combination of a flow top of one flow and the flow bottom of the overlying flow (with or without interbedded sediment) is commonly referred to as an interflow zone. Laterally continuous interflow zones host and transmit a large majority of the groundwater found in the CRBG aquifer system.

Groundwater within the CRBG aquifer system is typically confined. Where basalt flows are thick and laterally extensive, there is little vertical hydraulic connectivity between interflow zones. Conversely, where basalt flows thin, pinch out, or are disrupted, the degree of hydraulic continuity between interflow zones commonly increases. Where not fractured by faults and folding, the basalts typically exhibit high horizontal and vertical hydraulic conductivities in the vesicular/rubbly permeable interflow zones, and low horizontal and vertical hydraulic conductivities in the dense flow interiors. Basalt flow interiors exhibit much lower hydraulic conductivities compared to the interflow zones, generally 6 to 9 orders of magnitude less than those displayed by interflow zones (Reidel et al. 2002; USDOE 1988). Unconfined conditions may exist in permeable, uppermost portions of the basalt where exposed at the surface. The hydrogeology of the CRBG is discussed further in several reports, including Ely et al. (2014), GWMA (2009c, 2011b, 2011e) and Kahle et al. (2011).

Sedimentary interbeds found between the various CRBG formations, members, and flow units beneath Benton County belong to the Ellensburg Formation. These sedimentary interbeds vary in nature and composition, typically ranging between 1 and 100 feet thick, and while widespread, they can be locally absent (GWMA 2009a, 2011d). Within the Saddle Mountains Basalt there may be multiple Ellensburg Formation interbeds. Below the Saddle Mountains Basalt three primary Ellensburg Formation members are identified: the Quincy Member (predominantly claystone separating the Priest Rapids and Roza Members of the Wanapum Basalt), the Squaw Creek Member (predominantly claystone separating the Roza and Frenchman Springs Members), and the Vantage Member (predominantly claystone separating the Wanapum and Grande Ronde Basalts).

Benton County lies within the central portion of the Columbia Basin, a structural basin formed by regional subsidence and tectonic warping. Compressional and extensional tectonic stresses have led to the formation of regional fault and fold structures (e.g., anticlinal ridges and synclinal valleys) and four distinct structural subprovinces: Yakima Fold Belt, Blue Mountains, Palouse Slope, and the Clearwater Embayment (Myers and Price, 1979; Reidel et al. 1994). Of these, Benton County is located entirely within the Yakima Fold Belt which is characterized by a series of east-west-trending, anticlinal ridges, associated faults, and synclinal valleys. The major east-west oriented ridges cutting across Benton County, the Rattlesnake Hills, Horse Heaven Hills, and Columbia Hills are such features. In fact, the Badger Coulee project area is bounded on the north and south by two such structures. These ridges mark the locations of uplifts in which strata have been warped upwards hundreds to several thousand feet. Generally, the same units found at the tops of these ridges lie in the subsurface beneath adjacent valleys. Major fault systems have been mapped on the north sides of the Rattlesnake Hills and Horse Heaven Hills, and south side of the Columbia Hills. These faults abruptly truncate the rocks they crosscut, lifting them on one side and dropping them on the other. Fault/fold structures may present either barriers to groundwater movement or zones of enhanced groundwater flow (GWMA 2009c, 2011b, 2011e). In the Benton County area, the general assumption was that these fold and fault structures form barriers to groundwater flow much as suggested by Hansen et al. (1994).

Recharge to the basalt and alluvial aquifer systems is primarily from infiltration of precipitation, losing stream reaches, and seepage from canals and irrigation. The basalt aquifer system is recharged via more permeable sections of the basalt flows including vesicles, vertical joints, fractures and permeable interflow pathways. According to Hansen et al. (1994), groundwater recharge in the central Columbia Basin can range from as low as zero inches where annual precipitation is less than 8 inches up to several inches per year in heavily irrigated areas.

Discharge from the basalt and alluvial aquifer systems is generally toward topographic and structural lows, such as down dip in syncline axes and towards streams and lakes (Ely et al. 2014; Kahle et al. 2011). Shallow basalts commonly discharge to coulees and surface water systems while deeper units predominantly discharge into the major structural lows. The alluvial system can also discharge to and be a recharge source for the underlying basalts, primarily in areas where the suprabasalt deposits overlying the basalt are highly permeable and where the nature of the underlying basalt favors vertical flow.

Groundwater flow direction within basalt units exposed at the surface generally follows the land surface, flowing from topographic and structural uplands down-dip to low-lying areas. At depth, groundwater flow is less controlled by surface topography and is more generally down-dip to the south toward the Columbia River (GWMA 2009c, 2011e; Hansen et al. 1994). Sediments interbedded within the basalt can either enhance or inhibit groundwater flow. Groundwater flow directions in saturated portions of the alluvial aquifer system generally follow the land surface and discharge to surface drainage features or underlying basalt units. Alluvial aquifers tend to be localized by the numerous basalt outcrops that truncate these strata. Downward movement would be largely controlled by alluvial aquifer heterogeneities (e.g., cemented zones, caliche, and fine-grained overbank flood deposits) and the distribution of open joints and fractures in the underlying upper portions of the basalt aquifer system.

4.2.3 History of Study Area

Badger Coulee land use consists of relatively dense rural residential interspersed with irrigated farming (Figure 2). The primary potential anthropogenic (human caused) sources of nitrogen, and by association nitrate, in Badger Coulee are livestock agriculture, agricultural fertilization activities, urban wastewater, septic systems, and residential landscape fertilization, and urban landscape fertilization practices such as large area commercial landscaping including golf courses and parks. Of these, crop agriculture generally covers the largest area and likely contributes the largest amount of nitrogen. Croplands generally receive nitrogen from multiple inputs, including synthetic fertilizer, compost, solid and liquid animal manure, wastewater treatment plant and food processor effluent, wastewater treatment plant biosolids, atmospheric deposition, and nitrate in irrigation water sources. Potential natural sources of nitrate in groundwater include geologic minerals and atmospheric sources (nitrate and ammonia suspended in air and nitrate generated during lightning). However, the amount of nitrate in groundwater that may be attributed to natural sources is negligible compared with anthropogenic sources, especially the amounts applied to crops.

The primary source of water for irrigated areas in Badger Coulee is surface water drawn from the Yakima River and delivered via pipelines and canals. The primary delivery canal for the area flows from west to east down the coulee. The secondary source of water is groundwater pumping from the alluvial and basalt aquifer system. This water is used for both irrigation and in-house activity. Nitrate concentrations are generally expected to be elevated in irrigated areas such as those in Badger Coulee because irrigation seepage water moving out of the root zone to depth will carry nitrate with it. Dryland (non-irrigated) agriculture is most common on the Horse Heaven Hills in the south-central County (Figure 2).

Given the widespread occurrence of farming in the region, fertilizer application and irrigation can cause high nitrate in the aquifer systems. Shallow domestic wells generally have higher concentrations of nitrate (some exceeding 10 mg/L) than deeper wells (Williamson et al. 1998). Such groundwater quality conditions generally limit utilization of shallow groundwater sources, and most drinking water comes from deeper wells.

Given these generalizations, the presence of irrigation canals in irrigated areas has the potential to seasonally affect groundwater nitrate concentrations. Leaking irrigation canals can lower nitrate concentrations via dilution of the effected groundwater. Where this occurs, one will commonly see decreased groundwater nitrate concentrations during the irrigation season. After the irrigation season ends, nitrate concentrations will then increase as the diluting effect of canal leakage is removed. In dryland areas, elevated shallow groundwater nitrate is occasionally encountered because of the lack of irrigation dilution. However, the portion of the canal system in the Badger Coulee was lined in 2018, which could impact the distribution and concentrations of nitrate in area adjacent to the canals.

4.2.4 Summary of Previous Studies and Existing Data

Several agencies collected historical groundwater nitrate data in Benton County from the 1970s through 2011, including Ecology and the U.S. Geological Survey (USGS). These studies included:

- Ebbert et al. (1993) found approximately 10% of the wells sampled in the Kennewick and Finley areas of Benton County during the mid-1980s had nitrate concentrations exceeding the MCL of 10 mg/L.
- EES (2003) focused on the entire Yakima River valley and reported the presence of nitrate in some wells in this region indicating elevated nitrate levels in portions of the basin impair local groundwater quality.
- Aspect Consulting (2004), which focused on the Horse Heaven Hills (Glade/Fourmile Creeks sub-basin) and Kennewick portions of Benton County, summarized WDOH data for alluvial and basalt public water systems with nitrate concentrations exceeding 10 mg/L in 10 public water systems.
- Jones et al. (2006) showed the presence of wells containing elevated nitrate concentrations above 20 mg/Lin the lower Yakima River valley portion of Benton County.

In 2015 BCD began groundwater nitrate sampling and analysis in Benton County under Ecology Centennial Grant WQC-2015-BentCD-0010.2. This data was collected from drinking water wells from landowners who willingly volunteered to participate in Benton County's groundwater monitoring program. EA (2017) compared the previously identified nitrate concentrations in the county from sources listed above to the results from the BCD monitoring effort for 2015 - 2016. They determined that mixed rural urban areas like Badger Coulee, had higher levels of high nitrates, with the highest concentrations in shallow water producing zones. While the basic distribution of nitrates across the county were found to be relatively constant between the historical and current nitrate distributions, the average nitrate concentrations and highest values of nitrate levels increased between historical and current nitrate data sets. Nitrate concentration data from the 2017 report along with time series plots and maps are provided in Appendix A.

BCD continued groundwater sampling and monitoring seasonally from 2016-2018 in Benton County, including Badger Coulee, as part of grant funding WQC-2015-BentCD-00102. Over a third of the Badger Coulee area wells sampled had nitrate concentrations exceeding 10 mg/L. Some of the sampled wells in this area showed seasonal groundwater nitrate trends with decreasing nitrate concentrations in spring (presumably due to irrigation dilution) and rebounding at the end of irrigation season. Other wells in this area showed a continuous increase in nitrate concentrations over the sampling period regardless of seasonality. All data are available in Ecology's Environmental Information Management (EIM) database.

4.2.5 Parameters of Interest and Potential Sources

The parameter of interest for this study is nitrate (NO_3-N). The impacts of drinking high nitrates (> 10 mg/L) on public health are well documented. Methemoglobinemia, also known as "blue baby syndrome", occurs when high levels of nitrates reduce the capacity for red blood cells to carry oxygen. Populations at high risk are infants, pregnant women, individuals with a hereditary lack of methemoglobin reductase, and the elderly. Although treatable, methemoglobinemia can be lethal and the best solution is avoidance of high nitrates.

The parameter of interest for this report is:

- Groundwater nitrate concentrations in wells completed in various portions of the aquifer system underlying Badger Coulee.
- Surface water nitrate concentrations from Kennewick Irrigation District (KID) canals and flowing surface water features within the Badger Coulee area.

As previously discussed, there are several potential sources of nitrate both within and around Badger Coulee including livestock agriculture, agricultural fertilization activities, urban wastewater, septic systems, and residential landscape fertilization, and urban landscape fertilization practices such as large area commercial landscaping including golf courses and parks. The work described in this report was geared towards groundwater monitoring, it was not focused on determining point or non-point sources of nitrate in Badger Coulee.

4.2.6 Regulatory Criteria or Standards

The maximum contaminant level for nitrate in drinking water is 10 mg/L as nitrogen (40 CFR 141 Safe Drinking Water Act, and Chapter 246-290 WAC). The groundwater quality standards for Washington State also establish a criterion at 10 mg/L as nitrogen (Chapter 173- 200 WAC).

WDOH requires more frequent sampling when public drinking water supply system samples are over 5 mg/L for nitrates. Compliance orders, which can include remediation, to such systems are issued by the WDOH when samples are over 10 mg/L. Residents with privately owned wells are not regulated in the same manner as the public water supply system and are not required to sample their wells. As such, owners may not be aware of contaminated drinking water and when their source of drinking water is contaminated, options for alternative sources or remediation may be costly (Morgan 2014). Well testing by BCD as part of this study alerts residents and the community of concentrations of nitrates and health risks as well as providing data that continues to characterize and monitor groundwater nitrate contamination in Badger Coulee.

5.0 Methods

The approved Project Quality Assurance and Project Plan (Appel et al 2020) details the project sampling plan, data collection methods, and the required quality assurance and quality control metrics for the project. This section summarizes the methods described in the QAPP.

All sample results were reviewed promptly upon receipt from the laboratory for QA/QC, accuracy, and completeness. Any reporting issues were resolved immediately with the laboratory. After review, data was recorded electronically into the BCD database and uploaded into EIM for long term storage and retrieval.

5.1 Groundwater Sample Collection

Private drinking water well sampling occurred quarterly for the 2020 to 2022 sampling program using “The Benton County Nitrate Characterization Groundwater Method for Domestic Wells”. This method was used for the collection of samples under the previous grant WQC-2015-BentCD-00102. It was used to maintain consistency and comparability between projects and nitrate sampling (Appel et al 2020).

This method does not use acidification of samples, as acidification converts nitrites to nitrates and biases results (Personal communication between Benton Frankin Health Department (BFHD) laboratory and maximum exposure limit (MEL) auditor, dated January 2020). This method instead requires samples to be refrigerated at 4°C and analyzed within 48 hours of collection time using a nearby accredited laboratory for analysis (Rickert 1994). Field staff followed the sample collection procedures described in Appendix A which includes well purging, sample collection from the port closest to the well-head, and collection of required QA/QC samples as outlined by the Project QAPP.

BCD sampled 45 groundwater wells 2 times per year for two years between 2020 and 2022. These samples were collected from each well over a two-week period in Mid-March to April and Mid-September to October. These sampling periods bracket the irrigation season (March 15 – October 15) when larger amounts of applied irrigation water, along with increased fertilization practices, are likely to influence local groundwater nitrate concentrations.

BCD also monitored a subset of the wells (36 of the 45 selected drinking wells) in the winter and summer to investigate potential seasonal influences in nitrate concentrations. These samples were generally collected from mid-July to the end of August and mid-December to end of January. The set of wells monitored quarterly, and the corresponding sampling dates are provided in Table 1. The set of wells monitored twice per year are provided in Table 2.

5.2 Surface Water Sample Collection

BCD collected surface samples from 10 locations using grab sample methodology. The sample was collected from a single point near the surface, mid-stream of the creek, drain, or irrigation lateral. BCD collected samples using a sampling pole, with an attached empty 1-liter (L) polyethylene bottle. Ambient water was transferred into a smaller 125-mililiter mL polyethylene bottle for analysis. BCD cleaned the grab sample bottle between field sites to prevent cross contamination or transfer of invasive species following procedures outlined in the Project QAPP and documented by USGS 2018, Hartman 2019, and Ward 2016. All samples were immediately placed on ice to keep at a temperature of <4°C and analyzed by the accredited laboratory within 48 hours.

The surface water samples were collected 3 times per year in the spring, summer, and fall to accommodate the irrigation season each year. Samples were not collected when there was insufficient flow at the sample location. Sampling dates and source water descriptions are provided in Table 3.

5.3 Data Reporting

Data provided in this report was collected under the Badger Coulee, Benton County, Focus Area: Ground and Surface Water Nitrate Monitoring QAPP (Appel et al. 2020), Agreement Number WQC-2020-BentCD-00080. The EIM study ID is WQC2020BentCD00080. Interim reports for the data were prepared and delivered to the Department of Ecology for 2021 (Appel et al 2022) and 2022 (Appel et al 2023).

The groundwater trends analysis described in Section 7 of this report also included data from 2016 to 2018 for the Badger Coulee wells (grant funding WQC-2015-BentCD-00102) that were also sampled as part of the 2020-2022 monitoring effort. These data were retrieved from EIM by BCD.

5.4 Sampling Locations

Sampling locations for this monitoring effort included both groundwater well and surface water locations. Appendix B provides the latitude/longitude location for each sampling location.

5.4.1 Water Well Sampling Locations

For the purposes of this project, the Badger Coulee wells were grouped into major groundwater producing zones, including alluvial, shallow basalt, and intermediate basalt. For consistency, these groupings follow the classifications used in the previous nitrate monitoring study (EA 2015). Based on subsurface conditions described on an individual well log sampled wells are assigned to the zone(s) from which they are producing water. Wells without records are grouped together as "Unclassified Wells". Many of the sampled wells are open to more than one water producing interval. For example, several wells are reported to be open to a) alluvial and shallow basalt water producing zones or b) shallow and intermediate basalt water producing zones. As such, wells with multiple water producing intervals are graphed together. Unit identification was as follows:

- Alluvial wells are separated into two classifications as follows:
    - Wells completed shallower than 130-ft deep.
    - Well completed deeper than 130-ft deep.
- Basalt wells are classified based on the reported depth of the open interval below the top of basalt, as follows:
    - A shallow basalt well has a reported open interval between the top of basalt and 350 feet below the top of basalt.
    - An intermediate basalt well has a reported open interval between 350 and 1,000 below the top of basalt.

Although depth intervals were not assigned to specific hydrogeologic units, the shallow and intermediate basalt water producing zones generally correspond to the upper Saddle Mountains and lower Saddle Mountains, respectively. Figure 4 shows the location of the sampled wells within the project area.

5.4.2 Surface Water Sampling Locations

Surface water samples were collected from two KID irrigation laterals (canals) at several locations within Badger Coulee (Figure 5) that deliver water from the Yakima River. These canals provide irrigation water for Badger Coulee. Nitrate concentrations were also measured from flowing surface waters located within and downstream of the Badger Coulee boundaries (Figure 5). These sampling locations consisted of flowing drains, springs, and the Amon Creek basin.

The surface water locations were selected based on characteristics of physical accessibility, landowner access, and water availability (for example, a sufficient amount of flowing water to sample). Two of the selected sites are within KID laterals that supply irrigation water to Badger Canyon and as such do not flow year-round. The other sites are located in surface waters that are interpreted to be collecting groundwater discharging to the surface.

5.5 Quality Assurance Procedures

All water samples were analyzed by the Benton-Franklin Health District. Samples and analysis procedures are routinely checked according to their quality assurance and control. Routine laboratory quality control procedures maintained by the laboratory are adequate in estimating laboratory precision and accuracy for this project. Laboratory quality control samples consist of blanks, duplicates, matrix spikes, and check standards (laboratory control samples). The procedures were provided in the Project QAPP (Appel et al. 2020) and summarized below:

- Laboratory Duplicates were used to assess analytical precision.
- Matrix spikes were used to indicate bias due to matrix interferences.
- Check standards were used to estimate bias due to calibration.
- Laboratory blanks will be used to measure the response of the analytical system at a theoretical concentration of zero.

Field QC samples for both groundwater and surface water included field blanks, field duplicates, and performance evaluation samples. The field blanks are lab-provided inorganic-free water transported from Benton Franklin Health District in its original container and processed onsite identically to environmental samples and analyzed for dissolved nitrate. The field duplicates are a second identical sample from the same well to provide an estimate of overall sampling and analytical precision. The performance evaluation samples have nitrate concentrations known by BCD, but unknown by the laboratory when analyzed. These samples assess the accuracy of the measurement method.

Per the Project QAPP, field duplicates were collected at a rate of 10% of the total samples per sampling event. As such, 5 field duplicates were collected for the spring and fall well water sampling events, 4 field duplicates were collected for the winter and summer well water sampling events, and 1 field duplicate was collected for each surface water sampling event.

Four performance evaluation samples were provided to the lab for analysis per well water sampling event. The concentrations of the performance evaluation samples are 1.0 mg/L, 10 mg/L, 35 mg/L and 100 mg/L. Two performance evaluation samples were collected for each surface water sampling with concentrations of 1.0 mg/L and 35 mg/L.

5.6 Data Validation/Verification and Quality Control Procedures

The project manager worked closely with BFHD and ensured timely review of the data as it became available. If nitrate data fell outside of the measurement quality objectives (MQOs) criteria described in the QAPP or if data show anomalous results, the project manager either requested a rerun of the sample if still within the sample hold times or collected a new sample for analysis. Data validation and verification was presented in each interim report and is summarized in Table 4. The full data validation/QC effort is provided in Appendix C. Other potential impacts to data collection or data quality, where the actual conditions varied from what was described in the QAPP are provided in more detail in Section 6.

5.6.1 Water Wells QC

A total of 42 field groundwater duplicates were collected over the course of the project (Table 4 and Appendix C.1). All field duplicate and their respective parent samples were within the project data quality objective (DQO), a recovery percent difference (RPD) of 20%.

A total of 37 laboratory performance evaluation samples were evaluated for groundwater during the project (Table 4 and Appendix C.2). All performance evaluation samples met the MQO for percent recovery between 78 and 125%, apart from 7 samples. These 7 samples were for relatively low concentrations from <1.31 mg/L nitrate. Recovery percentages in the 7 cases were slightly above the 125% recovery target at approximately 130% recovery.

A total of 8 field blanks were collected in association with groundwater monitoring events (Table 4 and Appendix C.3), which satisfies the DQO of collecting one per field event. All field blanks were at or below the detection limit of 0.5 mg/L. Nitrate was detected in the field blank for winter 2021 at 0.63 mg/L.

5.6.2 Surface Water Samples QC

A total of 6 surface water field duplicates were collected over the course of the project (Table 4 and Appendix C.1). All field duplicates and their respective parent samples were within the project DQO, a recovery percent difference (RPD) of 20%, except for one sample BC03SW collected in April 2022, which had an RPD of approximately 46%. This difference was attributed to low concentrations for both the parent and duplicate sample, with nitrate concentrations of 0.8 and 0.5 mg/L, respectively.

A total of 16 laboratory performance evaluation samples were evaluated for surface water during the project (Table 4 and Appendix C.2). All performance evaluation samples met the MQO for percent recovery between 78% and 125%, apart from 3 samples. These 3 samples were for relatively low nitrate concentrations of less than 1.8 mg/L nitrate.

A total of 6 field blanks were collected in association with surface water monitoring events (Table 4 and Appendix C.3), which satisfies the DQO of collecting one per field event. All samples were below the method detection limit of 0.5 mg/L.

Quality control procedures for this project also included regular meetings between staff regarding field work and sampling updates, timely review of laboratory results including QA/QC samples, and timely entry of data results into BCD's ArcGIS® Pro database for comparison to previous and current nitrate results in Benton County.

5.7 Data Management

BFHD submitted electronic results to BCD. BCD project manager reviewed the results and once accepted the data was entered by the Field Technician into a pre-formatted project in

ArcGIS® Pro. Data was then downloaded from ArcGis Pro into the necessary EIM format for upload to the EIM database (EIM study ID WQC2020BentCD00080).

Prior to submitting the electronic results, BFHD reviewed and validated the results. Any samples that did not meet laboratory QA/QC were appropriately flagged in the final result package submitted to BCD. Any changes to the referenced method, failure to meet the MQOs by the laboratory, or problems that may affect results during analysis are discussed in the following section, Section 6.

All sample results were reviewed promptly upon receipt from the laboratory for QAQC, accuracy and completeness. Any reporting issues were resolved immediately with the laboratory. After review, data was recorded electronically into the BCD database and uploaded into EIM for long term storage and retrieval.

6.0 Results

Forty-five water wells in Badger Coulee were sampled for groundwater nitrate concentrations from fall 2020 to summer 2022. The monitoring locations are shown in Figure 4, and the list of wells and sampling dates are provided in Tables 1 and 2. The groundwater sampling results for nitrate are provided in Appendix D, Table D.1. The laboratory reports are provided in Appendix D.

Ten surface water locations were sampled four times during the project (fall 2020 to summer 2022). The sampling locations are shown in Figure 5, and the list of sampling dates for each location are provided in Table 3. The surface water sampling results for nitrate are provided in Appendix D, Table D.2. The laboratory reports are provided in Appendix D.

The project goal was to collect quality samples at each of the 45 water wells and the ten surface water monitoring locations for each sampling period. The project goal was met with the variances noted in Section 6.1.

6.1 Data QA/QC Assessment

The MQOs for nitrate in both the groundwater and surface water samples were met for the 2020 through 2022 monitoring events as described in the 2021 and 2022 interim reports. The QC data for the nitrate samples show that field sampling has no measurable contamination, with field replicates and performance evaluation samples returning results within the anticipated range, giving the data user confidence that the data is of excellent quality and suitable for use (Table 4 and Appendix C). BFHD provides internal analysis of all sample runs and their QC data for this project show that for nitrate analysis, the laboratory produces data with high precision and accuracy with low bias.

There is high confidence in the data presented and discussed in this report. It is of exceptionally high quality.

6.1.1 Variances in Groundwater Data Collection and Analysis

This section summarizes the decisions and actions taken by BCD when laboratory errors and/or changes in field conditions were encountered during data collection and analysis for groundwater nitrate monitoring events. Groundwater sampling events described in the 2021 interim report included the following variances:

- The summer 2021 sampling event required re-collection and re-analysis of several samples that turned brown upon the addition of the lab buffer prior to the run analysis. The samples had a matrix inference issue. The samples were re-collected and re-analyzed within a week of the initial samples. The nitrate values were similar between the two sample runs, indicating the sample matrix interference had not impacted the sample nitrate results.
- Four groundwater samples were removed from the January 2021 data set: BC607WW, BC606WW, BC603WW, and BC605WW due to a lab error. These values were pulled from reporting in EIM, and the landowners notified. The samples were unable to be re-collected within the same time frame, so the reported winter of 2021 batch results have 32 wells instead of 36. The data did not impact the analysis of whether the one-year monitoring results show the wells are above 10 mg/L, below 10 mg/L or variable given the multiple sampling events.

The groundwater sampling events described in the 2022 interim report included the following variances:

- Three samples from the July 2022 sampling event needed to be recollected and were analyzed 7/28/2022. These samples were collected from an irrigation water source instead of drinking water wells on the property. BCD management noted the issue immediately after receipt of the data package from Benton Franklin Health District, and the samples were recollected and analyzed the following week.
- Well BC603 was removed from the sampling program at the landowner's request.
- There was a sampling delay in the fall of 2021. The fall samples were collected in early November, after irrigation shutdown had already occurred. This was the only sampling event that deviated from the QAPP timeline.

6.1.2 Surface Water Sample Variances

This section summarizes the decisions and actions taken by BCD when laboratory errors and/or changes in field conditions were encountered during data collection and analysis for surface water nitrate monitoring events.

The surface water sampling events described in the 2021 interim report included the following variances:

- The fall 2021 sampling event was delayed and subsequently occurred after irrigation shut down. As such, the canal laterals had been drained and the samples from the KID canals could not be collected.
- Between the fall of 2020 and spring of 2021 sampling events, the BC005 sample location was relocated from a culvert at the intersection of Leslie Road to a location upstream at a culvert at the intersection of Lorraine J Blvd. The location was moved due to lack of flow downstream at the intended sampling site. All future samples were able to be collected from the original downstream location on Leslie Road.

The surface water sampling events described in the 2022 interim report included the following variance:

- Surface water samples collected in the Summer of 2022 were collected the same day as well water samples. They were analyzed within the same batch by the Benton Franklin Health District and as such separate PE samples, field blanks, and duplicates were not collected for this sampling period. The winter and fall 2022 sampling events had independent QA/QC samples collected for surface water and well water samples.
- One surface water sample, BC005SW, could not be collected in fall of 2022, which occurred after irrigation had shut down. As such, the KID lateral canal to be sampled had been drained.

6.2 Nitrate Monitoring Results

Groundwater and surface water sampling results are provided in tabular form in Appendix D. The following sections provide visual representation and descriptions summarizing the nitrate results.

6.2.1 Water Well Monitoring Results

As previously described, the water wells were grouped by their water producing units, including alluvial wells less than 130-feet deep, alluvial wells greater than 130-feet deep, shallow basalt wells, intermediate basalt well, and unclassified wells.

The MCL for nitrate in drinking water is 10 mg/L as nitrogen (40 CFR 141 Safe Drinking Water Act, and Chapter 246-290 WAC). The groundwater quality standards for nitrate in Washington State also establish a criterion at 10 mg/L as nitrogen (Chapter 173-200 WAC). For the purposes of viewing and discussing the results, three levels of nitrate concentration impact levels were established. The categories are as follows:

- “Low” are wells with concentrations below 10 mg/L, below the MCL.
- “Elevated” are wells with concentrations between 10 and 20 mg/L.
- “High” are wells with concentrations greater than 20 mg/L, twice the MCL.

The time series plots for groundwater nitrate results are presented in Figures 6 through 11. The drinking water limit is shown on the graphs (dashed black line) to indicate wells with nitrate concentration levels that are above or below the MCL. Figures 12 through 19 show the distribution of nitrate in the project area in plan view by each sampling event.

Ten alluvial wells less than 130 feet deep were sampled (Figure 6). In general, five wells had low nitrate levels during all sampling events. Five wells had elevated nitrate levels in all sampling events.

Nine alluvial wells greater than 131 feet deep were sampled (Figure 7). As previously noted, well BC603WW, dropped out of the program after three rounds of sampling. Of these wells, four had low nitrate concentrations during all sampling events. Three wells were elevated for all sampling events. Well BC127WW increased over the monitoring period.

Six alluvial and shallow basalt wells were monitored (Figure 8). Well BC117WW had high nitrate levels for all events. Elevated nitrate concentrations were detected in the five remaining wells for at least two events.

Nine wells producing water from the shallow basalt aquifers were sampled (Figure 9). Elevated nitrate concentrations were detected in four of the wells over the monitoring period, with wells BC607WW and BC611WW containing elevated nitrate concentrations for all sampling events. The remaining five wells had low concentrations (below the MCL) for all monitoring events.

There were two shallow and intermediate basalt wells, BC192WW and BC782321WW, sampled (Figure 10). Both wells had high nitrate levels over the monitoring period. Only one intermediate basalt well, BC601WW, was part of the monitoring program. Nitrate concentrations for this well were variable falling above (elevated) and below (low) the 10 mg/L threshold depending on the sampling event.

Seventeen wells were grouped as “unclassified” (Figure 11), with unknown water producing zone(s). With four of the wells, BC274WW, BC275WW, BC276WW, BC278WW dropping out of the program. Of the remaining 13 wells, three wells had elevated levels of nitrate, while the remaining nine had low levels of nitrate.

Trend analyses were completed on each time series with three or more data sets. The trend analysis is provided in more detail in Section 7.0.

6.2.2 Surface Water Monitoring Results

Surface water samples were collected during the irrigation season between fall 2020 to fall 2022. Samples were not collected in the winter months because the surface water canals were dry. The sample locations and corresponding nitrate values for the surface water samples within Badger Coulee are provided in Figures 20 and 21. Figure 20 shows the results for the 2020 to 2021 sampling events and Figure 21 shows the results for the 2022 sampling events.

Figure 22 shows a bar chart of the surface water results by sampling event and location. Although surface water samples, for reference purposes the nitrate drinking water MCL (10 mg/L) is represented as a black dashed line. Samples that could not be collected are discussed in Section 6 and represented as “NS” on the chart.

The surface water nitrate concentrations show minimal variability between the two sampling years in the KID laterals (BC002SW and BC003SW). Nitrate concentrations measured less than 2 mg/L for both years. Spring samples collected from the laterals in 2021 and 2022 had the lowest concentrations of nitrate (less than 0.9 mg/L), with consistently higher concentrations in the summer and fall.

The highest measured surface water nitrate concentrations were in sample BC005SW, which is collected from a topographic low in the bottom of a canyon that captures water from a spring created by irrigation induced seepage. This drain then flows into the headwaters of Amon Creek. The spring nitrate concentrations measured 47 mg/L in 2021 and 33.2 mg/L in 2022 from sample BC005SW.

Samples from Amon Creek (BC004SW, BC006SW, BC007SW, BC008SW and BC0010SW) had variable levels of nitrate depending on sample location, season, and year. BC004SW, was the furthest location upstream in the headwaters of the West Fork of Amon Creek. The majority of surface samples collected at this location had nitrate concentrations below 1.5 mg/L with the exception of the fall 2021 and Spring 2022 sampling events which had 4.3 mg/L nitrate and 9.8 mg/L, respectively.

Samples collected from the West Fork of Amon Creek (BC006SW) had higher concentrations of nitrate compared to all other Amon Creek sampling locations, including the samples collected from the East Fork of Amon Creek (BC007SW). BC006SW samples were collected from a wetland complex on the West Fork of the Amon Basin that receives discharge flows from Badger Coulee (e.g., BC005SW). Concentrations at BC006SW ranged from 6.4 mg/L to 11 mg/L in 2021 and from 7.2 mg/L – 10.4 mg/L in 2022. BC007SW, which is predominantly fed by irrigation source water from KID wastage flows, had lower concentrations ranging from 1.2 mg/L – 6.5 mg/L in 2021 and 0.6 mg/L – 1.3 mg/L in 2022.

Surface sample locations BC008SW and BC0010SW were collected at a point downstream of the West Fork/East Fork Confluence but upstream of Amon Creek’s confluence with the Yakima River. These two sites had similar concentrations for each sampling event, measuring within 0.3 mg/L of each other in 2021 and within 0.6 mg/L in 2022. The nitrate concentrations had greater variability between seasons in 2021 for BC008SW and BC0010SW than observed in 2022. For example, at BC0008SW, nitrate concentrations ranged from 2.0 – 6.6 mg/L in 2021 versus 1.1 mg/L to 2.5 mg/L in 2022.

Sample BC009SW is from man-made spring sourced from stormwater pipes and groundwater located just to the west of Amon Basin, on the Yakima Delta Habitat Management Unit. The spring is located under I-182 and flows into the Yakima River. The water from the spring outfall had nitrate concentrations greater than 10 mg/L for three of the four sampling events in 2021 and two of three sampling events in 2022.

7.0 Discussion

The purpose of the study was to collect water well nitrate data of sufficient and repeatable quality that could be used to evaluate ground water nitrate conditions in Badger Coulee. Surface water samples were also collected as part of this study to investigate potential nitrate inputs and exports within Badger Coulee. The data collected as part of this study was done in accordance with QAPP to the best extent possible. The data was determined to be of exceptional quality, determined to be usable, and uploaded to EIM (Section 5 and Section 6). Variances and issues with the data and actions taken to maintain data quality and meet the project goal are described in Section 6.1.

7.1 Data Analyses Methods

To further assess groundwater nitrate conditions in Badger Coulee, the nitrate data presented in Section 6.2 was used for statistical and trend analyses. The analyses were split into the following two groups:

- The 2020 to 2022 times series, to evaluate groundwater nitrate trends over the monitoring period, and
- A long term-trend analysis, which combined the data collected from 2020 to 2022 with the data collected from 2015 to 2018 for water wells that were evaluated under both projects.

Mann-Kendall trend analysis was used to evaluate whether nitrate concentrations have statistically significant increasing or decreasing trends over the data record. A detailed description of the analytical methods is provided in Appendix E.

7.2 General Statistics and Trend Analysis - 2020 to 2022 Series

The 2020 to 2022 data series had relatively high data density with respect to the monitoring period; therefore, general statistics were calculated. The general statistics included minimum nitrate concentrations, maximum nitrate concentrations, mean, geometric mean, and standard deviation. A summary of the general statistics by well is provided in Table 5. Wells with a lower standard deviation indicate that there is less variability in nitrated concentrations over the data set. Thirty-one wells within the sampling program had maximum nitrate concentrations greater than the 10 mg/L MCL. Of those 31, 20 had minimum concentrations above the MCL.

Figure 23 is a box and whisker plot of nitrate concentrations by unit. All sampling results from 2020 to 2022 from all sample locations in a specific unit were used for the generation of the unit specific box and whisker plot. The average nitrate concentration for each unit is represented by and “x” in the box. The median is represented by the horizontal line in the box. The nitrate drinking water MCL is represented as a black line at 10 mg/L.

General nitrate levels and variability within each unit can be visualized using Figure 23. For example, alluvial wells less than 130 feet deep (shown in blue) have nitrate concentrations with average and median values from 2020 to 2022 slightly above the 10 mg/L MCL, while wells completed in shallow basalt (shown in green) had average and median concentrations less than the MCL with a similar variability and spread as the shallow alluvial wells. The plot shows a high degree of variability in nitrate concentrations in each aquifer. It also indicates that each aquifer unit is impacted by elevated nitrate concentrations.

We do not have a high level of confidence in the intermediate and shallow + intermediate box and whisker representations, shown in yellow and purple respectively. This is due to the number of wells sampled from these units. Samples collected in the shallow and intermediate basalt had average values above 10 mg/L nitrate; however, it should be noted that this data only includes two wells. In addition, the intermediate basalt unit is only represented by one well.

A Mann-Kendal trend analysis was performed for each water well with three or more data points. The results are summarized in Table 6. The full ProUCL outputs, including the trend plots, are provided in Appendix E.

Two shallow alluvial wells (<130-ft deep), BC125WW and BC609 WW, had statistically significant decreasing nitrate trends. BC125WW decreased from above the MCL in 2021 to below the MCL for 2022. BC609WW remained below 5mg/L for the monitoring period. Water Well BC151WW had a statistically significant increasing trend but remained below the MCL for the monitoring period (Figure 6, Appendix E).

Two deep alluvial wells (>130-ft deep), BC127WW and BC604WW, had statistically significant trends (Table 6). BC604WW has been consistently above the MCL. BC127 steadily increased over the monitoring period. In 2020 is was below the MCL and increased to above the MCL in fall 2021 (Figure 7, Appendix E).

Two alluvial and shallow basalt wells had statistically significant trends, BC087WW and BC117WW. BC087WW was decreasing over the monitoring period starting above the MCL in 2020 and falling below the MCL in fall of 2021 (Figure 8, Appendix E). Well BC117WW had elevated to high nitrates over the monitoring period.

For the shallow basalt wells, two had statistically significant decreasing trends and three had increasing trends. Wells BC240WW, BC608WW, BC612WWWells had increasing trends. BC240WW and BC608WW increased over the monitoring period but remained below the MCL. BC612WW increase to above the MCL from spring to summer 2022. BC232WW and BC207WW had decreasing nitrate concentrations over the monitoring period. BC232WW had a decreasing trend over the monitoring period but remained above the MCL (Figure 9).

The wells in the intermediate and shallow and intermediate units did not have statistically significant trends, remaining relatively stable throughout the monitoring period.

Only one unclassified well, BC034WW, had a statistically significant trend, it increased, over the 2020 to 2022 monitoring period (Figure 11).

In general, there were few statistically significant trends identified within the 2020 to 2022 monitoring period. Many of the wells were relatively stable over this period. High variability (potentially seasonal) was observed in wells BC022WW and BC605WW.

7.3 Long-Term Trend Analysis – 2015 to 2022 Series

A long-term trend analysis was completed for the wells in the 2020 to 2022 monitoring program, which were also monitored under the previous grant, Ecology Centennial Grant WQC-2015-BentCD-00102. This data was retrieved from EIM. The full data set used for the long-term analysis is provided in Appendix F. The discussion of methods is provided in Appendix E.

There were four shallow alluvial wells (less than 130-ft deep), four deeper alluvial wells, five alluvial and shallow basalt wells, two shallow and intermediate basalt wells and three unclassified wells in both the older and recent data sets. Figures 24 through 28 show the nitrate concentration time series used for the analysis. The wells and a summary of the long-term trend analysis results are shown in Table 7. The full ProUCL tend analysis outputs including trend plots are provided in Appendix G.

Three of the four shallow alluvial wells had statistically significant trends. Wells BC088WW and BC125WW had decreasing nitrate concentrations over the long-term record. BC125WW decreased to below the MCL (Figure 24), while BC088WW is still above the MCL. Well BC151WW had a long-term increase in nitrate concentrations over the long-term record (Table 7).

Two of the four deep alluvial wells had statistically increasing nitrate trends, BC022WW and BC127WW. Nitrate concentrations in BC022WW have historically been at or above the MCL since 2015. Although there is variability in the record, the trend is increasing. Well BC127WW saw a steeper rise in nitrate concentrations beginning the fall of 2020, increasing to above the MCL (Figure 25).

Three of the five alluvial and shallow basalt wells, BC081WW, BC117WW, and BC128WW, had statistically significant long-term increasing trends. Well BC081 is increasing slowly compared to well BC117 (Figure 26), and both are above the MCL. BC128WW has an increasing trend, and some events sampled during the 2020 to 2022 monitoring period were above the MCL.

Well BC192WW, in the shallow and intermediate basalt unit, has a statistically significant increasing long term trend (Table 7). It increased about 10mg/L from 2016 to 2022, going from about 20mg/L to 30mg/L (Figure 27).

All three of the unclassified wells, BC012WW, BC034WW, and BC086WW, had statistically significant increasing long-term trends; however, all three remain below the MCL. It should be noted that BC034WW is approaching the MCL in recent sampling events.

Of the 18 water wells with long-term records, 12 had statistically significant trends, with the10 of the twelve seeing increasing trends. The decreasing trends were observed in the shallower alluvial wells BC088WW and BC125WW (Table 7).

7.4 Surface Water Data

With KID canal lining in Badger Coulee over the last decade, connectivity between the canal and groundwater has been lost, or significantly reduced. As such, the primary source of nitrogen in KID canal system water is from existing nitrates carried into the canals from Yakima River source water. The levels of nitrate measured in the KID canals were similar to ranges recently observed in the lower Yakima River by Sheibley and others (2022). For example:

- Continuous measurements of nitrate in the lower Yakima River from 2018 – 2020 showed the highest concentrations in the fall and winter months, with levels ranging from 1.2 – 1.8 milligrams of nitrogen per liter (mg-N/L) (Sheibley and others, 2022). Correspondingly, the measured nitrate concentrations in the KID canal samples were highest in the fall with levels just under 2 mg/L (Figure 22).
- Spring nitrate concentrations in the Yakima River reached a minimum with levels under 1.0 mg/L (Sheibley and others 2022). Similarly, canal surface water samples had the lowest levels of nitrate in the spring, also with values under 1.0 mg/L (Figure 22). The lower spring nitrate levels in the Yakima River were attributed to dilution with the onset of the spring freshet.

Sheibley and others (2022) noted that nitrate loads to the Yakima River increased steadily throughout the summer months without an increase in flow indicating a sustained input of nutrients to the Yakima River. The sustained inputs are likely from agricultural return flows and transport from nearby groundwater discharge. Further research of groundwater pathways in the lower Yakima River basin may help elucidate nitrate cycles and relationships between groundwater and surface water as basin wide irrigation water application, groundwater returns, and Yakima River source nutrients are intricately linked.

The surface water samples collected from the Amon Creek watershed in the eastern part of Badger Coulee as part of this study indicate longitudinal (upstream vs downstream), seasonal, and interannual variability. Specifically, nitrate concentrations in the Amon Creek basin were generally higher within the West Fork of Amon Creek versus the East Fork of Amon Creek. This is interpreted to show nitrate inputs from Badger Coulee drainages discharging into the West Fork may be a greater contributing factor than irrigation wasteway operations discharging into the East Fork (Figures 20 and 21).

Future studies should examine annual and interannual variations of nitrate concentrations along with flow measurements in both the East Fork and West Fork of Amon Creek to evaluate the relative nitrate loading in each tributary. Residential housing neighborhoods, a golf course, and a large city park also line Amon Creek downstream of the East Fork and West Fork confluence. Residential areas with large lawns are likely contributing sources of anthropogenic nitrate to the Amon Creek system beyond the incoming concentrations from upstream tributaries. Programs and education for urban landowners along Amon Creek are recommended to help reduce nonpoint source pollution from lawns, the golf course, and urban park landscaping.

While most samples in Amon Creek were largely below or near the 10 mg/L MCL threshold (Figure 22), this is a drinking water standard and is not indicative of protection for watershed health. The state of Washington has not established standards for nutrients in surface water, however, the USEPA has published suggested reference conditions to protect water bodies from nutrient enrichment (Wise 2009). The suggested reference condition for Yakima River basin streams (including Amon Creek) in the Xeric West Ecoregion (USEPA, 2000) is listed at 0.072 mg/L for Nitrate plus Nitrite as N. All samples in Amon Creek were above the USEPA reference conditions. The data from this project suggests nitrate levels in Amon Creek exceed acceptable levels for watershed health. Additionally, Amon Creek may be a source of added nitrate to the lower Yakima River delta. The current nitrate levels in the Yakima Delta are unknown and the relative proportion of incoming nitrates from Amon to the existing Yakima delta nitrates warrants additional study in the future.

8.0 Conclusions

BCD completed a nitrate monitoring program from 2020 to 2022 for both surface and groundwater nitrates within Badger Coulee, as part of a larger effort to implement best management practices in the project area to mitigate potential further nitrate impacts. Data collected under 2020 to 2022 monitoring efforts, as part of Ecology grant WQC-2018-BentCD-00080, was intended to further the understanding of groundwater nitrates and was used to evaluate the impacts of the BMP projects as they are implemented in Badger Coulee.

The data collected from 2020 to 2022 and provided in Section 6.0 were of exceptional quality and used for statistical and trend analyses (Section 7.0). The data indicated that 20 wells monitored had minimum nitrate concentrations above the MCL, with 31 water wells experiencing at least one event above the MCL (Table 5). As shown in Figure 23, nitrate distribution is highly variable within each aquifer unit, and all aquifer units are impacted by elevated and/or high nitrate concentrations. In general, there were few statistically significant trends identified within the 2020 to 2022 monitoring period (Table 6, Figures 6 through 11). A number of the wells were relatively stable over this shorter period; however, high variability (potentially seasonal) was observed.

8.1 Groundwater Conclusions

Groundwater nitrate concentrations in all the monitored aquifer units indicate anthropogenic impacts. There are a number of historic and current land use practices including irrigation processes, agricultural fertilization (both inorganic and organic), and lawn fertilization and watering practices for residential, community and recreational areas (e.g., golf courses and parks), dairies, feedlots, and other livestock practices that may have contributed to the current nitrate distribution in Badger Coulee.

The long-term trends indicated that nitrate concentrations in all units have generally increased since the 2016 study. However, long-term decreasing trends detected in two of the shallower alluvial wells may indicate that changes to long-term trends would be visible first in the shallower aquifer units. This is supported by previous studies that concluded that nitrate at depth was migrating down from land use practices (Table 7. Figure 24).

Groundwater nitrate sample collection and trend analysis is an appropriate way to evaluate short and long-term changes in groundwater nitrate due to changes in surface practices of application or mitigation. Although, it will likely take time to see the impacts, especially at depths. Improvements to groundwater nitrate concentrations due to BMPs will likely be observed in the shallower wells and aquifer units due to faster recharge rates.

8.2 Surface Water Data Conclusions

The surface water sampling conducted from 2021 and 2022 provided a preliminary picture of incoming and outgoing surface water nitrate levels in Badger Coulee. Nitrate is present in the source irrigation water displaying concentrations and trends similar to those observed in the lower Yakima River. Determining nutrient loads from the irrigation source water to Badger Coulee was outside the scope of this work but should be part of management planning when working with landowners to mitigate added nutrient application from irrigation water.

While irrigation source water may contribute to groundwater nitrate loads, over-application of irrigation water to heavily fertilized areas (e.g., lawns) is likely to be a larger contributor to groundwater nitrates within Badger Coulee than canal source water. Over-application of irrigation water can lead to excess nitrate in the groundwater as water carries nitrates deeper into the soil profile and groundwater. Recognizing this possibility, site specific nutrient management plans were created as part of the larger grant project (WQC-BentCD-00080) for multiple landowners in Badger Coulee. These plans provide a guide for fertilizer application and irrigation water application specific to each property in order to foster nutrient management stewardship and decrease excess nutrients applied to the groundwater system. For properties with large animals, manure composting facilities were recommended.

All surface water samples from Amon Creek had detectable levels of nitrates. Samples collected from the West Fork Amon Creek generally had higher concentration levels than those found in the East Fork Amon Creek indicating that irrigation wasteway operations may not be the primary contributing factor to nitrate levels within the basin. Amon Creek is a known native salmon spawning area and thermal refuge for adult salmonids. Amon Creek also contains an urban wetland preserve in the headwaters that provides important shrub steppe habitat. Managing incoming nonpoint sources of nitrates into Amon Creek is important to protect both the Amon Creek watershed health as well as the Yakima River Delta.

9.0 Recommendations

Based on the results and conclusions described above in Sections 6 and 7 we have the following recommendations:

- Continue quarterly groundwater monitoring. The quarterly groundwater monitoring performed between 2020 and 2022 picked up variability in nitrate concentrations, such as potential seasonal influence that was not visible in the older 2016 and 2018 data.
- Attempt to increase the number of monitored water wells within the Badger Coulee Area and within the intermediate basalt unit. There are only two shallow + intermediate wells and one intermediate basalt well. This is a narrow data set to apply within the larger project area.
- Conduct a larger groundwater study to investigate groundwater flow paths and connectivity between the Badger Coulee Area and the Yakima River. A larger study to investigate and better understand the nutrient fluxes between surface and groundwater sources would help land and water managers protect surface and groundwater in the basin.
- Implement targeted BMPs within Badger Coulee rural areas to mitigate nutrient transport to groundwater. These BMPs may include manure composting facilities, well head and septic drain field inspections, and improved irrigation and fertilizer practices.
- Develop site specific nutrient management plans for rural landowners in Badger Coulee with continued follow-up to ensure plan implementation success. These plans instruct landowners on fertilizer application rates, irrigation watering rates, and targeted manure management to decrease nutrient loading to groundwater.
- Develop collaborative programs with the local health district to connect Badger Coulee landowners with the high nitrates in their drinking water to state programs designed to provide alternatives for safe drinking water.
- Expand monitoring of the Amon Creek watershed to evaluate annual nitrate loads within the watershed as well as exports of nitrate to the Yakima River Delta. The predominant sources of nitrate loading to Amon basin should be further evaluated to ascertain inputs from the West Fork, East Fork, along with private and public land ownership inputs. These efforts will likely inform future urban BMPs, such as xeriscaping and filter strips, that may help decrease nutrient loadings to Amon.

10.0 References

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Tables

Table 1. Summary of Quarterly Groundwater Monitoring Frequency

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well	Fall 2020	Winter 2021	Spring 2021	Summer 2021	Fall 2021	Winter 2022	Spring 2022	Summer 2022	Fall 2022
Alluvial (less than 130-ft)									
BC088WW	10/6/2020	1/12/2021	3/23/2021	8/9/2021	11/9/2021	1/21/2022	4/6/2022	7/21/2022	9/27/2022
BC125WW	10/7/2020	1/11/2021	3/23/2021	8/10/2021	11/9/2021	1/20/2022	4/5/2022	7/21/2022	9/27/2022
BC151WW	10/6/2020	1/12/2021	3/23/2021	8/10/2021	11/9/2021	1/21/2022	4/6/2022	7/20/2022	9/29/2022
BC184WW	10/6/2020	1/11/2021	3/23/2021	8/10/2021	11/9/2021	1/20/2022	4/6/2022	7/20/2022	9/27/2022
BC254WW	10/8/2020	1/12/2021	3/24/2021	8/11/2021	11/10/2021	1/21/2022	4/6/2022	7/28/2022	9/29/2022
BC600WW	9/30/2020	1/11/2021	3/23/2021	8/11/2021	11/9/2021	1/20/2022	4/6/2022	7/20/2022	9/27/2022
BC609WW	9/28/2020	1/11/2021	3/23/2021	8/11/2021	11/9/2021	1/20/2022	4/5/2022	7/21/2022	9/29/2022
BC616WW	10/1/2020	1/11/2021	3/22/2021	8/13/2021	11/8/2021	1/20/2022	4/5/2022	7/28/2022	9/27/2022
Alluvial (greater than 130-ft)									
BC022WW	10/8/2020	1/11/2021	3/22/2021	8/9/2021	11/8/2021	1/20/2022	4/5/2022	7/19/2022	9/29/2022
BC100WW	10/7/2020	No Sample	3/22/2021	8/9/2021	11/8/2021	1/20/2022	4/5/2022	7/21/2022	9/29/2022
BC127WW	10/5/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	4/7/2022	7/20/2022	9/27/2022
BC194WW	10/5/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	4/7/2022	7/20/2022	9/27/2022
BC246WW	10/8/2020	1/13/2021	3/25/2021	8/10/2021	11/16/2021	1/19/2022	4/7/2022	7/19/2022	9/27/2022
BC268WW	10/5/2020	1/12/2021	3/24/2021	8/11/2021	10/8/2021	1/21/2022	4/6/2022	7/20/2022	9/27/2022
BC603WW	9/29/2020	1/13/2021	3/25/2021	Removed from Program					
BC604WW	10/2/2020	1/11/2021	3/22/2021	8/11/2021	11/8/2021	1/20/2022	4/5/2022	7/19/2022	9/27/2022
BC613WW	9/28/2020	1/12/2021	3/24/2021	8/11/2021	11/10/2021	1/21/2022	4/7/2022	7/20/2022	9/29/2022
Alluvial + Shallow Basalt									
BC087WW	10/6/2020	1/12/2021	3/23/2021	8/9/2021	11/9/2021	1/21/2022	4/6/2022	7/20/2022	9/29/2022
BC116WW	10/5/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	4/6/2022	7/20/2022	9/27/2022
BC117WW	10/5/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	No Sample	7/28/2022	9/27/2022
BC128WW	10/6/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	4/6/2022	7/20/2022	9/27/2022

Table 1. Summary of Quarterly Groundwater Monitoring Frequency

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well	Fall 2020	Winter 2021	Spring 2021	Summer 2021	Fall 2021	Winter 2022	Spring 2022	Summer 2022	Fall 2022
Shallow Basalt									
BC232WW	10/7/2020	1/11/2021	3/23/2021	8/10/2021	11/9/2021	1/20/2022	4/5/2022	7/20/2022	9/28/2022
BC239WW	10/8/2020	1/13/2021	3/25/2021	8/10/2021	11/16/2021	1/19/2022	4/7/2022	7/19/2022	9/27/2022
BC240WW	10/6/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/21/2022	4/6/2022	7/20/2022	9/29/2022
BC605WW	10/1/2020	1/11/2021	3/22/2021	8/10/2021	11/8/2021	1/20/2022	4/5/2022	7/28/2022	9/27/2022
BC606WW	9/30/2020	1/13/2021	3/25/2021	8/11/2021	11/16/2021	1/19/2022	4/7/2022	7/19/2022	9/29/2022
BC607WW	9/29/2020	1/13/2021	3/25/2021	8/11/2021	11/16/2021	1/19/2022	4/7/2022	7/19/2022	9/28/2022
BC608WW	9/29/2020	1/13/2021	3/25/2021	8/11/2021	11/16/2021	1/19/2022	4/7/2022	7/19/2022	9/27/2022
BC611WW	10/1/2020	1/11/2021	3/22/2021	8/11/2021	11/8/2021	1/20/2022	4/5/2022	No Sample	9/27/2022
BC612WW	9/28/2020	1/12/2021	3/23/2021	8/11/2021	11/9/2021	1/21/2022	4/6/2022	7/20/2022	9/27/2022
Shallow + Intermediate Basalt									
BC192WW	10/6/2020	1/12/2021	3/24/2021	8/10/2021	11/10/2021	1/19/2022	4/7/2022	7/21/2022	9/29/2022
BC782321WW	10/5/2020	1/13/2021	3/25/2021	8/13/2021	11/16/2021	1/21/2022	4/6/2022	7/21/2022	9/27/2022
Intermediate Basalt									
BC601WW	9/29/2020	1/11/2021	3/22/2021	8/11/2021	11/8/2021	1/20/2022	4/5/2022	7/21/2022	9/29/2022
Unclassified Wells									
BC034WW	10/7/2020	1/11/2021	3/23/2021	8/9/2021	11/9/2021	1/21/2022	4/5/2022	7/21/2022	9/27/2022
BC086WW	10/7/2020	1/11/2021	3/22/2021	8/9/2021	11/8/2021	1/19/2022	4/7/2022	7/19/2022	9/29/2022
BC235WW	10/1/2020	1/13/2021	3/25/2021	8/10/2021	11/16/2021	1/21/2022	4/5/2022	7/19/2022	9/29/2022
BC266WW	10/8/2020	1/11/2021	3/22/2021	8/11/2021	11/8/2021	1/20/2022	4/5/2022	7/28/2022	9/27/2022

Table 2. Summary of Semi Annual Groundwater Monitoring Frequency

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well	Fall 2020	Spring 2021	Fall 2021	Spring 2022	Fall 2022
Alluvial Wells (less than 130 feet deep)					
BC602WW	10/2/2020	3/25/2021	11/16/2021	4/7/2022	9/29/2022
BC273WW	No Sample	No Sample	No Sample	4/5/2022	No Sample
Alluvial and Shallow Basalt Wells					
BC081WW	10/7/2020	3/22/2021	11/8/2021	4/5/2022	9/28/2022
BC610WW	9/28/2020	3/22/2021	11/8/2021	4/5/2022	9/28/2022
Unclassified Wells					
BC012WW	10/8/2021	3/25/2021	11/16/2021	4/7/2022	9/30/2022
BC277WW	9/30/2020	3/23/2021	11/9/2021	4/6/2022	No Sample
BC278WW	9/30/2020	3/25/2021	No Sample	No Sample	No Sample
BC279WW	9/30/2020	3/24/2021	11/10/2021	4/7/2022	9/27/2022
BC500WW	10/6/2020	3/24/2021	11/10/2021	4/7/2022	9/29/2022
BC614WW	9/30/2020	3/24/2021	11/10/2021	4/6/2022	9/28/2022
BC615WW	9/29/2020	3/25/2021	11/16/2021	4/7/2022	9/27/2022
BC274WW	9/29/2020	3/25/2021	No Sample	No Sample	No Sample
BC275WW	10/1/2020	3/22/2021	No Sample	No Sample	No Sample
BC276WW	10/1/2020	3/22/2021	No Sample	No Sample	No Sample
BC325	No Sample	No Sample	No Sample	No Sample	9/29/2022

Table 3. Summary of Surface Water Monitoring Frequency

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Site	Source water	Fall 2020	Spring 2021	Summer 2021	Fall 2021	Spring 2022	Summer 2022	Fall 2022
BC001SW	Drain	10/9/2020	3/25/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC002SW	KID Canal	10/9/2020	4/12/2021	8/16/2021	No Sample	4/28/2022	7/21/2022	No Sample
BC003SW	KID Canal	10/9/2020	4/12/2021	8/16/2021	No Sample	4/28/2022	7/21/2022	10/3/022
BC004SW	Drain	10/9/2020	3/24/2021 4/12/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC005SW	Drain	10/9/2020	3/24/2021 4/12/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC006SW	Amon Creek	10/9/2020	3/24/2021 4/12/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC007SW	Amon Creek	10/9/2020	3/24/2021 4/12/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC008SW	Amon Creek	10/9/2020	3/24/2021 4/12/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC009SW	Spring	10/9/2020	3/23/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022
BC010SW	Amon Creek	10/9/2020	3/23/2021 4/2/2021	8/16/2021	11/15/2021	4/28/2022	7/21/2022	10/3/022

Table 4. Summary of Data Validation/Quality Control

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Parameter	Fiscal Year 2021 (Appel et al. 2022)			Fiscal Year 2022 (Appel et al. 2023)			Full Project 2020 Through 2022		
	Number of Verification Samples	Samples not meeting MQO	MQOs Met	Number of Verification Samples	Samples not meeting MQO	MQOs Met	Number of Verification Samples	Samples not meeting MQO	MQOs Met
Well Water Samples									
Field Duplicate	24	0	Y	18	0	Y	42	0	Y
Performance Evaluation	21	4*	Y*	16	3	Y*	37	7	Y*
Field Blank	5	0	Y	3	0	Y	8	0	Y
Surface Water Samples									
Field Duplicate	4	0	Y	2	1**	Y**	6	1**	Y**
Performance Evaluation	10	2	Y*	6	1*	Y*	16	3*	Y*
Field Blank	4	0	Y	3	0	Y	7	0	Y

Notes:

MQO = Method quality objective

QA/QC = Quality Assurance/Quality Control FY = Fiscal Year

* 1.0 mg/L PE samples did not meet the 125% threshold recovery limit due to the low concentrations analyzed. The difference between the measured samples and PE standard were within 0.5 mg/L for all results, but due to the low concentration, the results returned a RPD above 125%. For the purposes of the study, these results are considered acceptable as they do not impact the quality control of the sampling events.

** One FD sample did not meet the RPD threshold of <20% due to the low concentration of the sample and duplicate results. The sample and duplicate results were 0.8 mg/L and 0.5 mg/L, respectively and are considered acceptable as the results do not impact the quality control of the sampling events.

Table 5. 2020-2022 General Statistics

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Variable	NumObs.	Minimum	Maximum	Mean	Geo-Mean	Standard Deviation
Alluvial Wells (less than 130-ft)						
BC088WW	9	**14.5**	**16.6**	**15.7**	**15.7**	0.6
BC125WW	9	4.6	**11.6**	9.2	8.9	2.4
BC151WW	9	6.2	9.0	7.7	7.6	1.0
BC184WW	9	**15.1**	**21.0**	**19.1**	**19.0**	1.8
BC254WW	9	1.5	**18.7**	**15.5**	**13.1**	5.4
BC600WW	9	7.2	8.2	7.8	7.8	0.3
BC602WW	5	2.9	3.8	3.3	3.3	0.4
BC609WW	9	1.6	3.9	3.2	3.1	0.6
BC616WW	9	**12.5**	**14.4**	**12.9**	**12.9**	0.6
Alluvial Wells (greater than 130-ft)						
BC022WW	9	**16.4**	**29.6**	**21.8**	**21.3**	5.0
BC100WW	9	0.7	1.2	0.9	0.9	0.2
BC127WW	9	4.2	**23.4**	**11.4**	9.7	6.9
BC194WW	9	**11.4**	**14.3**	**13.2**	**13.1**	1.1
BC246WW	9	1.3	5.2	2.0	1.8	1.2
BC268WW	9	2.7	4.9	3.4	3.3	0.8
BC273WW	2	**13.4**	**13.7**	**13.6**	**13.6**	0.2
BC603WW	3	4.7	**16.4**	8.6	7.2	6.7
BC604WW	9	**16.5**	**18.3**	**17.4**	**17.4**	0.6
BC613WW	9	6.6	9.2	7.8	7.8	0.9
Alluvial+Shallow Basalt Wells						
BC081WW	5	**12.1**	**12.8**	**12.5**	**12.5**	0.3
BC087WW	9	6.5	**22.2**	**13.1**	**11.5**	6.8
BC116WW	9	1.6	**13.1**	9.0	8.0	3.3
BC117WW	8	**21.7**	**59.0**	**36.2**	**34.5**	12.3
BC128WW	9	3.4	14.3	9.6	8.6	4.3
BC610WW	5	18.0	25.3	21.0	20.8	3.0
Shallow Basalt Wells						
BC232WW	9	6.4	8.2	7.2	7.1	0.6
BC239WW	9	4.3	6.2	5.5	5.4	0.7
BC240WW	9	3.8	7.4	5.7	5.6	1.3
BC605WW	9	5.3	**20.9**	**12.3**	**10.9**	6.1
BC606WW	9	4.8	5.6	5.2	5.2	0.3
BC607WW	9	**12.9**	**23.4**	**18.6**	**18.2**	4.0
BC608WW	9	4.6	8.3	7.0	6.9	1.3
BC611WW	8	**14.2**	**17.3**	**16.1**	**16.1**	0.9
BC612WW	9	3.1	**18.7**	7.0	5.8	5.2

Table 5. 2020-2022 General Statistics

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Variable	NumObs.	Minimum	Maximum	Mean	Geo-Mean	Standard Deviation
Shallow + Intermediate Wells						
BC192WW	9	**24.9**	**30.8**	**28.8**	**28.8**	2.3
BC782321WW	9	**11.8**	**46.0**	**40.6**	**38.2**	10.9
Intermediate Wells						
BC601WW	9	7.5	12.5	9.689	9.221	1.9
Unclassified Wells						
BC012WW	5	2.6	6.6	4.0	3.7	1.8
BC034WW	9	6.6	9.9	7.9	7.9	1.0
BC086WW	9	3.0	4.6	3.7	3.7	0.4
BC235WW	9	1.7	**15.4**	**11.6**	**10.1**	4.2
BC266WW	9	**14.0**	**17.7**	**16.6**	**16.6**	1.2
BC274WW	2	**18.2**	**36.3**	**27.3**	**25.7**	12.8
BC275WW	2	**12.4**	**12.7**	**12.6**	**12.6**	0.2
BC276WW	2	**20.8**	**25.1**	**23.0**	**22.9**	3.0
BC277WW	4	4.8	5.3	5.0	5.0	0.2
BC278WW	2	**30.6**	**32.9**	**31.8**	**31.7**	1.6
BC279WW	5	**12.0**	**13.8**	**13.1**	**13.1**	0.8
BC325WW	1	9.9	9.9	9.9	9.9	N/A
BC500WW	5	5.7	6.7	6.1	6.0	0.5
BC614WW	5	1.3	3.2	1.9	1.8	0.8
BC615WW	5	0.9	1.9	1.6	1.5	0.4
BC617WW	1	1.0	1.0	1.0	1.0	N/A
BC618WW	2	4.8	5.4	5.1	5.1	0.4

Notes:

BOLD = Above the MCL of 10mg/L

Table 6. Summary of 2020-2022 Trend Analyses

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well ID	Number of Observations	First Recorded Spring WL	Last Recorded Spring WL	Trend direction[1]	M-K Test Value (S)	Approximate p-value	OLS Regression Slope
Alluvial (less than 130-ft)							
BC088WW	9	2020	2022	Insufficient	-14	0.0877	-0.0008
BC125WW	9	2020	2022	Decreasing	-24	0.00824	-0.0076
BC151WW	9	2020	2022	Increasing	31	8.31E-04	0.0036
BC184WW	9	2020	2022	Insufficient	-5	0.337	-0.0024
BC254WW	9	2020	2022	Insufficient	6	0.301	0.0101
BC273WW*	2	2022	2022	--			
BC600WW	9	2020	2022	Insufficient	-1	0.5	-0.0001
BC602WW	5	2020	2022	Insufficient	-6	0.11	-0.0009
BC609WW	9	2020	2022	Decreasing	-23	0.0105	-0.0018
BC616WW	9	2020	2022	Insufficient	-8	0.23	0.0003
Alluvial (greater than 130-ft)							
BC022WW	9	2020	2022	Insufficient	10	0.174	0.0025
BC100WW	9	2020	2022	Insufficient	9	0.189	0.0003
BC127WW	9	2020	2022	Increasing	36	1.32E-04	0.0261
BC194WW	9	2020	2022	Insufficient	-15	0.0682	-0.002
BC246WW	9	2020	2022	Insufficient	-9	0.197	-0.0022
BC268WW	9	2020	2022	Insufficient	8	0.23	0.0016
BC603WW	3	2020	2021	Insufficient	1	0.5	0.0091
BC604WW	9	2020	2022	Increasing	28	0.00244	0.0021
BC613WW	9	2020	2022	Insufficient	-8	0.233	-0.0016

Table 6. Summary of 2020-2022 Trend Analyses

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well ID	Number of Observations	First Recorded Spring WL	Last Recorded Spring WL	Trend direction[1]	M-K Test Value (S)	Approximate p-value	OLS Regression Slope
Alluvial and Shallow Basalt							
BC081WW	5	2020	2022	Insufficient	6	0.11	0.0008
BC087WW	9	2020	2022	Decreasing	-22	0.0143	-0.0235
BC116WW	9	2020	2022	Insufficient	-2	0.458	0.0014
BC117WW	8	2020	2022	Increasing	26	9.91E-04	0.0439
BC128WW	9	2020	2022	Insufficient	3	0.417	0.0037
BC610WW	5	2020	2022	Insufficient	2	0.403	-0.0018
Shallow Basalt							
BC232WW	9	2020	2022	Decreasing	-19	0.0296	-0.0016
BC239WW	9	2020	2022	Insufficient	-14	0.0853	-0.0016
BC240WW	9	2020	2022	Increasing	18	0.0382	0.003
BC605WW	9	2020	2022	Insufficient	-8	0.233	-0.0087
BC606WW	9	2020	2022	Insufficient	8	0.23	0.0003
BC607WW	9	2020	2022	Decreasing	-24	0.00824	-0.0113
BC608WW	9	2020	2022	Increasing	19	0.0296	0.0039
BC611WW	8	2020	2022	Insufficient	0	N/A	-0.0013
BC612WW	9	2020	2022	Increasing	30	0.00125	0.017
Intermediate Basalt							
BC601WW	9	2020	2022	Insufficient	-1	0.5	0
Shallow and Intermediate Basalt							
BC192WW	9	2020	2022	Insufficient	-14	0.0877	-0.0037
BC782321WW	9	2020	2022	Insufficient	1	0.5	0.0228

Table 6. Summary of 2020-2022 Trend Analyses

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Well ID	Number of Observations	First Recorded Spring WL	Last Recorded Spring WL	Trend direction[1]	M-K Test Value (S)	Approximate p-value	OLS Regression Slope
Unclassified							
BC012WW	5	2020	2022	Insufficient	0	N/A	-0.0008
BC034WW	9	2020	2022	Increasing	29	0.00167	0.0037
BC086WW	9	2020	2022	Insufficient	15	0.0711	0.0009
BC235WW	9	2020	2022	Insufficient	-13	0.104	0.0004
BC266WW	9	2020	2022	Insufficient	-3	0.417	-0.0011
BC274WW*	2	2020	2021	--			
BC275WW*	2	2020	2021	--			
BC276WW*	2	2020	2021	--			
BC277WW	4	2020	2022	Insufficient	3	0.235	0.0006
BC278WW	2	2020	2021	--			
BC279WW	5	2020	2022	Insufficient	-1	0.5	-0.0002
BC325WW*	1	2022	2022	--			
BC500WW	5	2020	2022	Insufficient	1	0.5	0.0005
BC614WW	5	2020	2022	Insufficient	5	0.156	0.0019
BC615WW	5	2020	2022	Insufficient	-3	0.307	-0.0009
BC617WW*	1	2021	2021	--			
BC618WW*	2	2022	2022	--			

Notes:

* Less than two data points. Trend analysis not conducted.

[1] Insufficient = not enough statistically significant evidence to establish a trend direction.

Table 7. Long-term Nitrate Trend Analyses

Groundwater and Surface Water Nitrate Monitoring

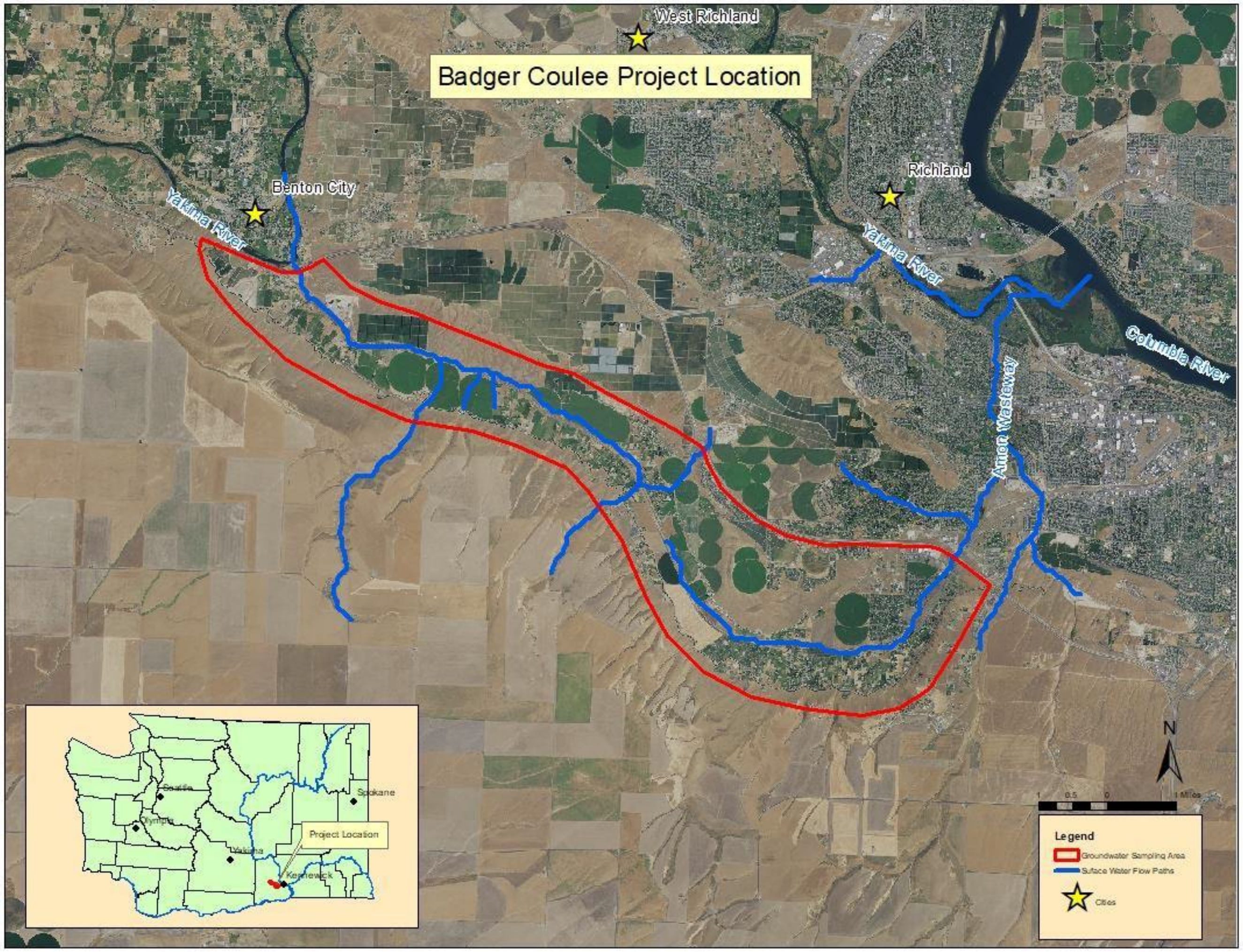
Badger Coulee, Bentron County, Washington

Well ID	Production Unit	Number of Observations	First Recorded Spring WL	Last Recorded Spring WL	Trend	M-K Test Value (S)	Approximate p-value	OLS Regression Slope
Alluvial <130-ft deep								
BC088WW	Alluvial	13	2016	2022	Decreasing	-44	0.0044	-0.2198
BC125WW	Alluvial	12	2016	2022	Decreasing	-46	0.001	-0.6003
BC151WW	Alluvial	13	2016	2022	Increasing	73	5.39E-06	0.4709
BC184WW	Alluvial	13	2016	2022	Insufficient	27	0.056	0.2527
Alluvial >130-ft deep								
BC022WW	Alluvial	13	2015	2022	Increasing	46	0.00302	0.9464
BC100WW	Alluvial	12	2016	2022	Insufficient	15	0.1629	-0.1609
BC127WW	Alluvial	13	2016	2022	Increasing	78	1.32E-06	1.7779
BC194WW	Alluvial	13	2016	2022	Insufficient	-15	0.0682	-0.002
Alluvial and Shallow Basalt								
BC081WW	Alluvial+Shallow Basalt	8	2016	2022	Increasing	19	0.0124	0.131
BC087WW	Alluvial+Shallow Basalt	14	2016	2022	Insufficient	-20	0.1488	-0.375
BC116WW	Alluvial+Shallow Basalt	13	2016	2022	Insufficient	-16	0.1792	-0.0399
BC117WW	Alluvial+Shallow Basalt	13	2016	2022	Increasing	45	1.20E-03	2.4815
BC128WW	Alluvial+Shallow Basalt	13	2016	2022	Increasing	31	0.038	0.6937
Shallow and Intermediate Basalt								
BC192WW	Shallow + Intermediate Basalt	13	2016	2022	Increasing	24	0.0803	0.6874
BC782321WW	Shallow + Intermediate Basalt	13	2015	2022	Insufficient	-21	0.1096	0.1687
Unclassified								
BC012WW	Unclassified	9	2015	2022	Increasing	20	0.0238	0.5138
BC034WW	Unclassified	13	2015	2022	Increasing	67	2.74E-05	0.5038
BC086WW	Unclassified	12	2016	2022	Increasing	45	0.0012	0.2644

Notes:

[1] Insufficient = not enough statistically significant evidence to establish a trend direction.

Figures



Source(s): Map generated by Benton Country Consecration District 2022

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Project Area Location Map –Badger Coulee

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

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Figure 1

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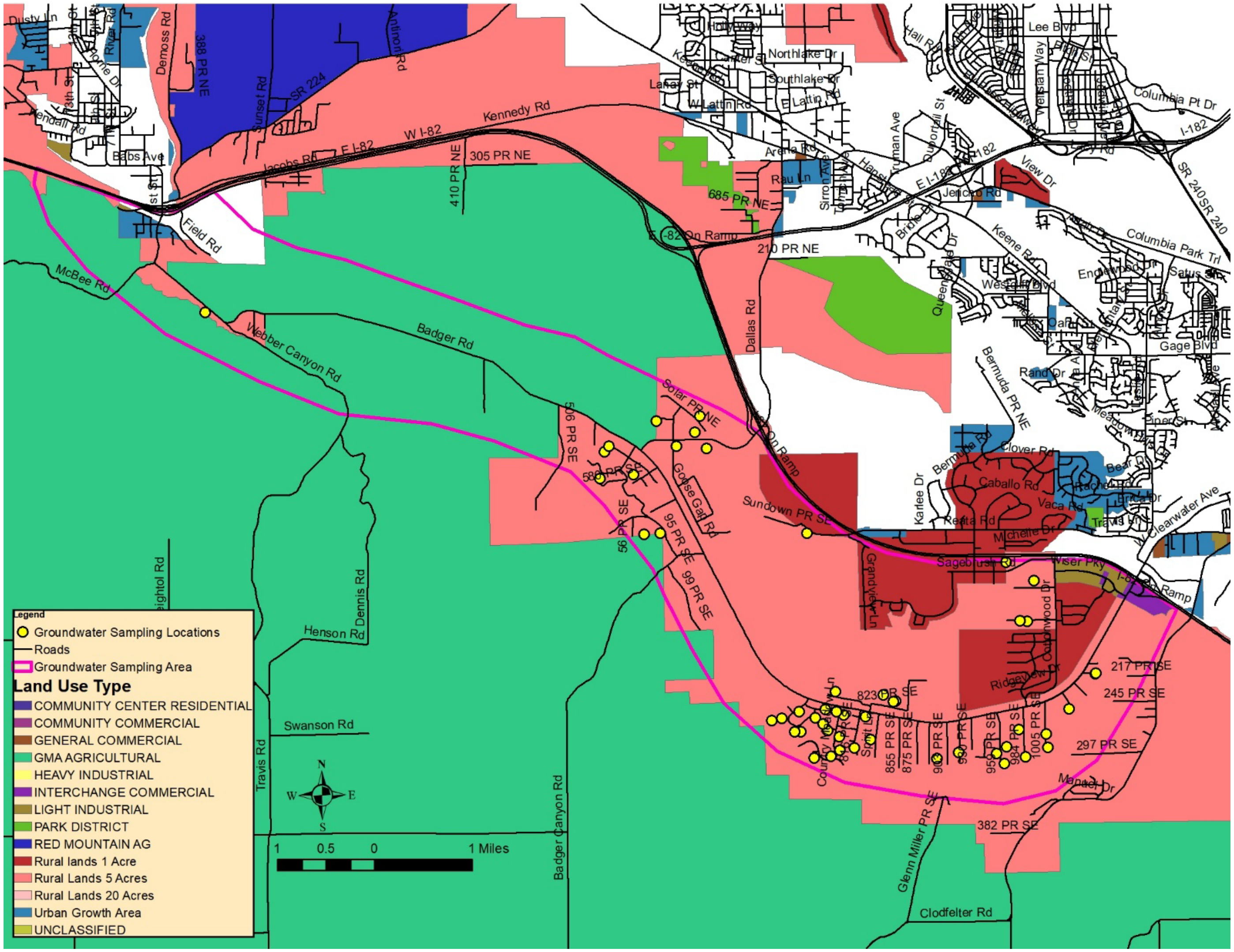

Note(s):

1. Data from Benton County Planning Department.

Source(s): Map generated by Benton Country Consecration District

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Land Use Map

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Badger Coulee, Benton County WA

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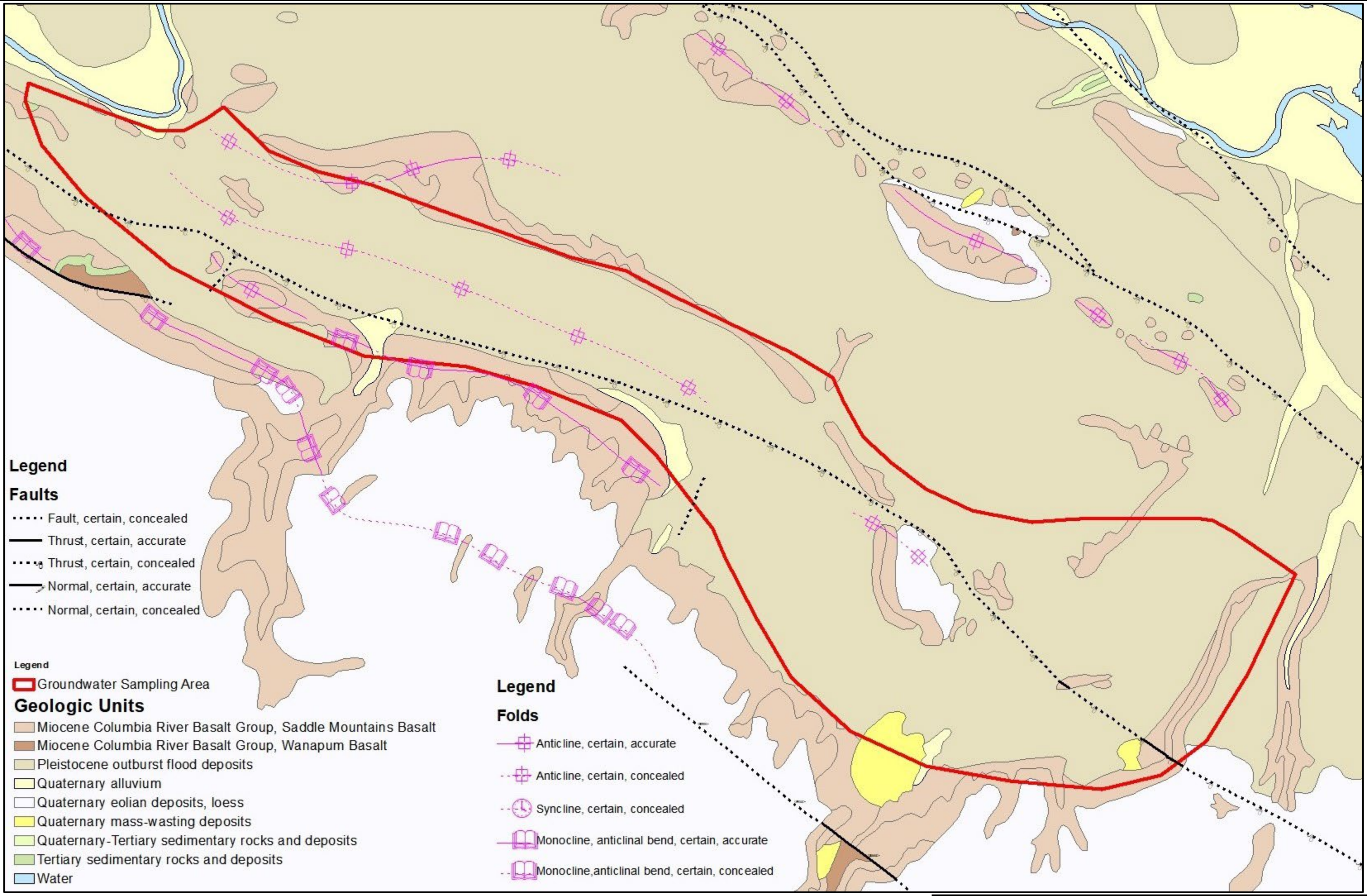
Figure 2



Note(s):

1. Surficial Geology data from WA DNR.

Source(s): Map generated by Benton Country Consecration District

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Geologic Map

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Badger Coulee, Benton County WA

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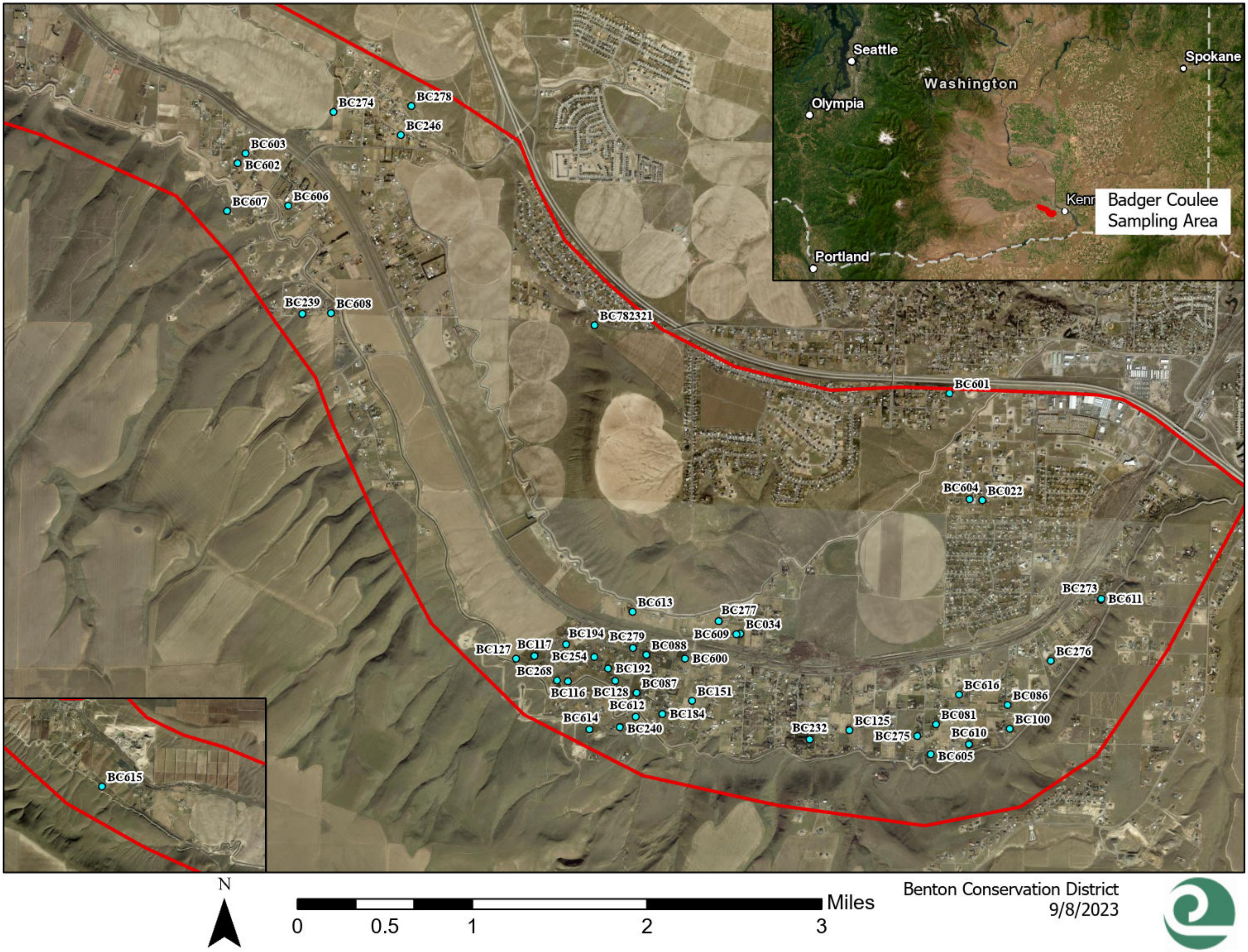
Figure 3

Figure 3 – Badger Coulee Area Groundwater Sampling Locations



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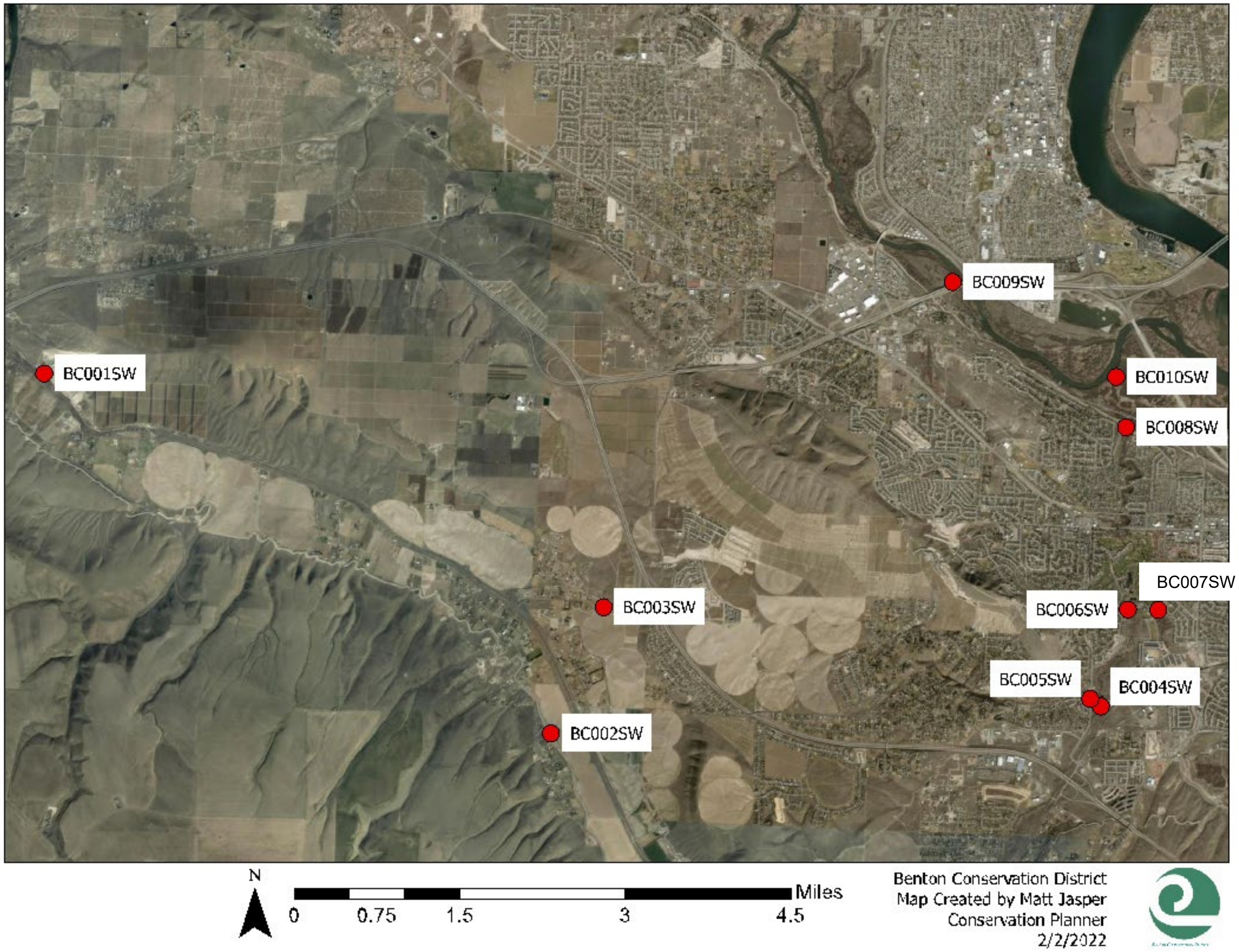
9/8/2023



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Surface Water Sampling Locations

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Badger Coulee, Benton County WA

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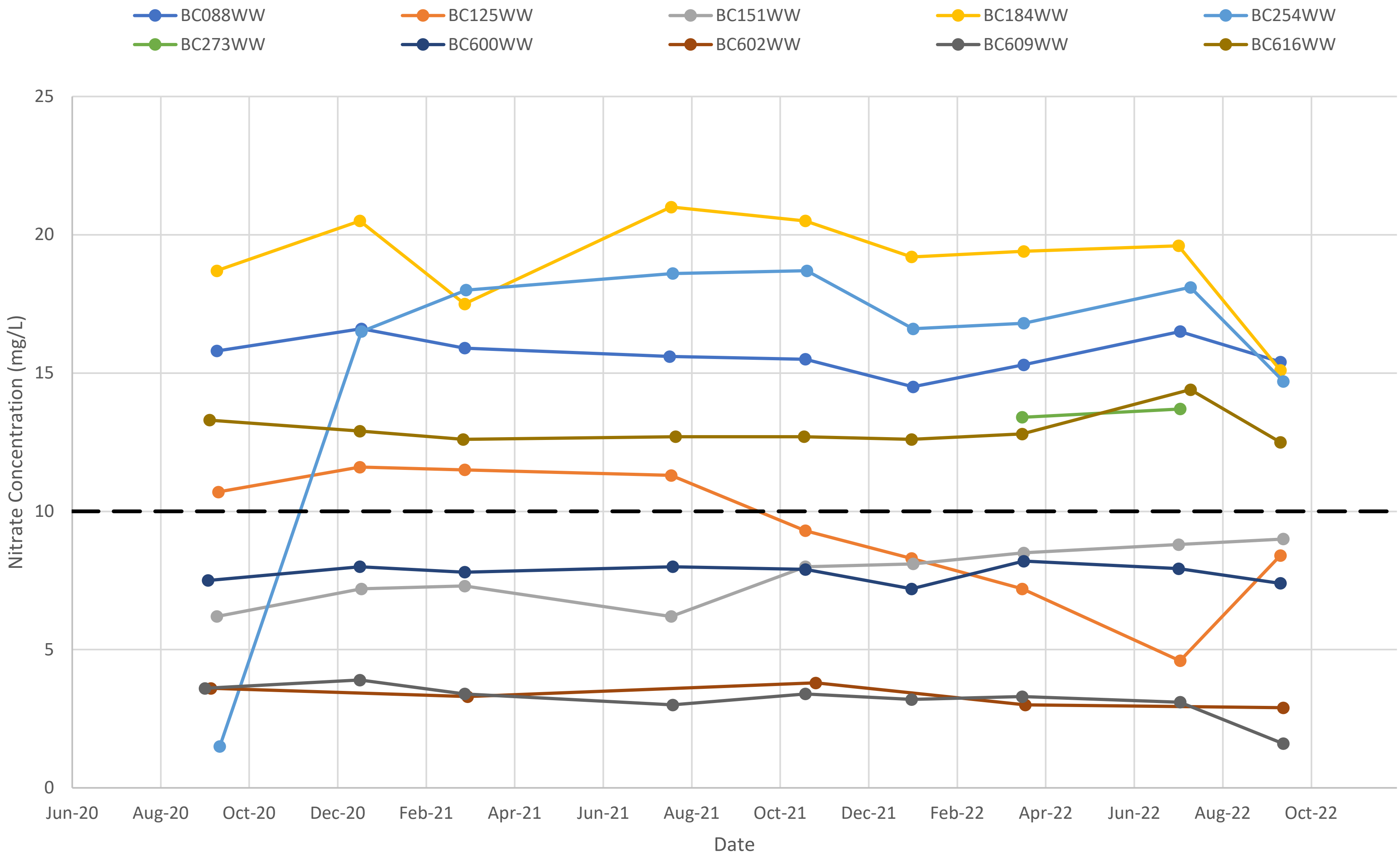
Figure 5

Note(s):
1. Figure notes here

Source(s): Map generated by Benton Country Consecration District



Note(s):
1. Figure notes here

Source(s):

Benton Conservation District

2020-2022 Nitrate Time Series - Alluvial Wells (<130-ft deep)

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Badger Coulee, Benton County WA

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Figure 6

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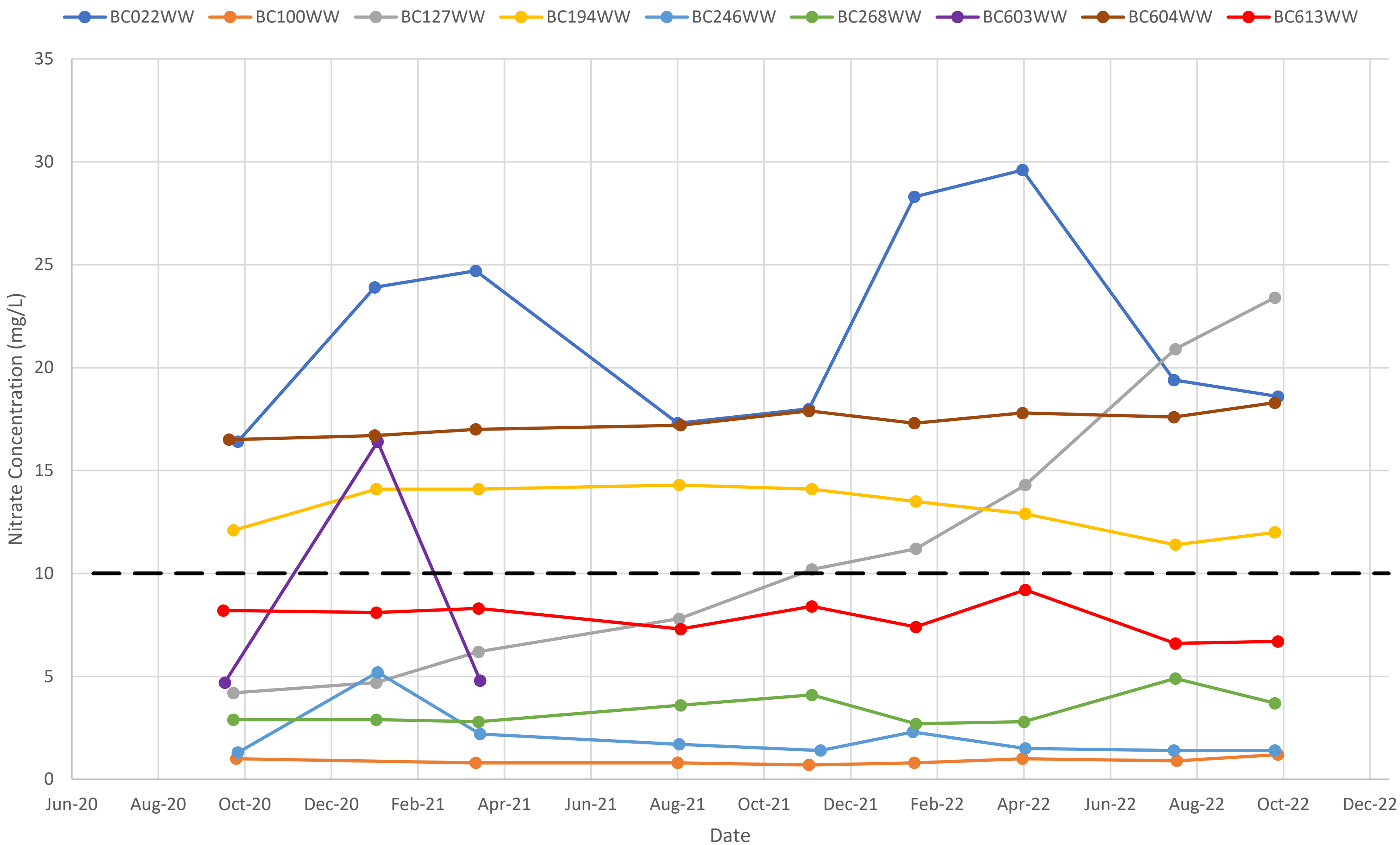

Note(s):
1. Figure notes here

Source(s):

Benton Conservation District

2020-2022 Nitrate Time Series - Alluvial Wells (>130-ft deep)

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Badger Coulee, Benton County WA

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Figure 7

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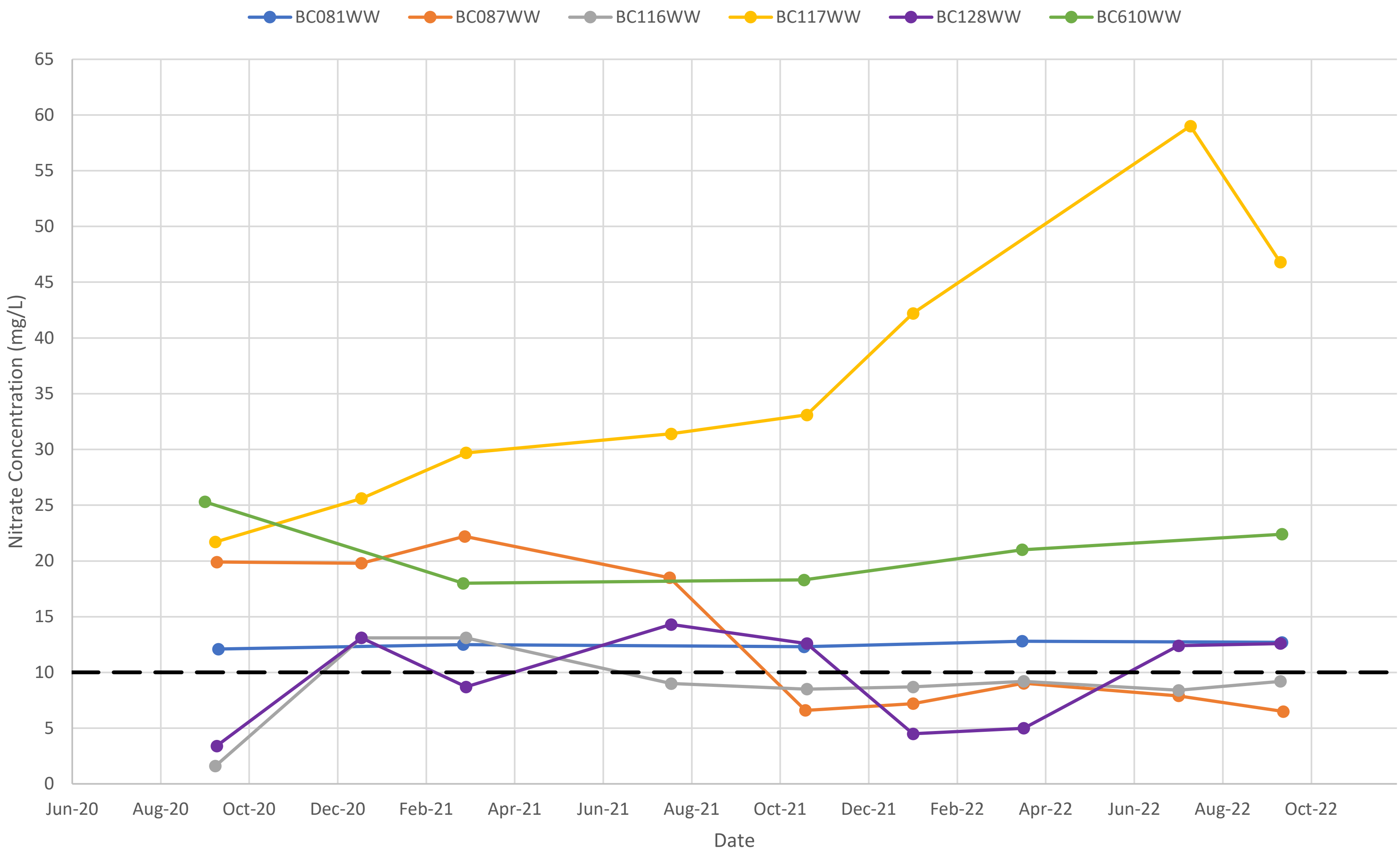

Note(s):

1. Figure notes here

Source(s):

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2020-2022 Nitrate Time Series - Alluvial + Shallow Basalt Wells

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Badger Coulee, Benton County WA

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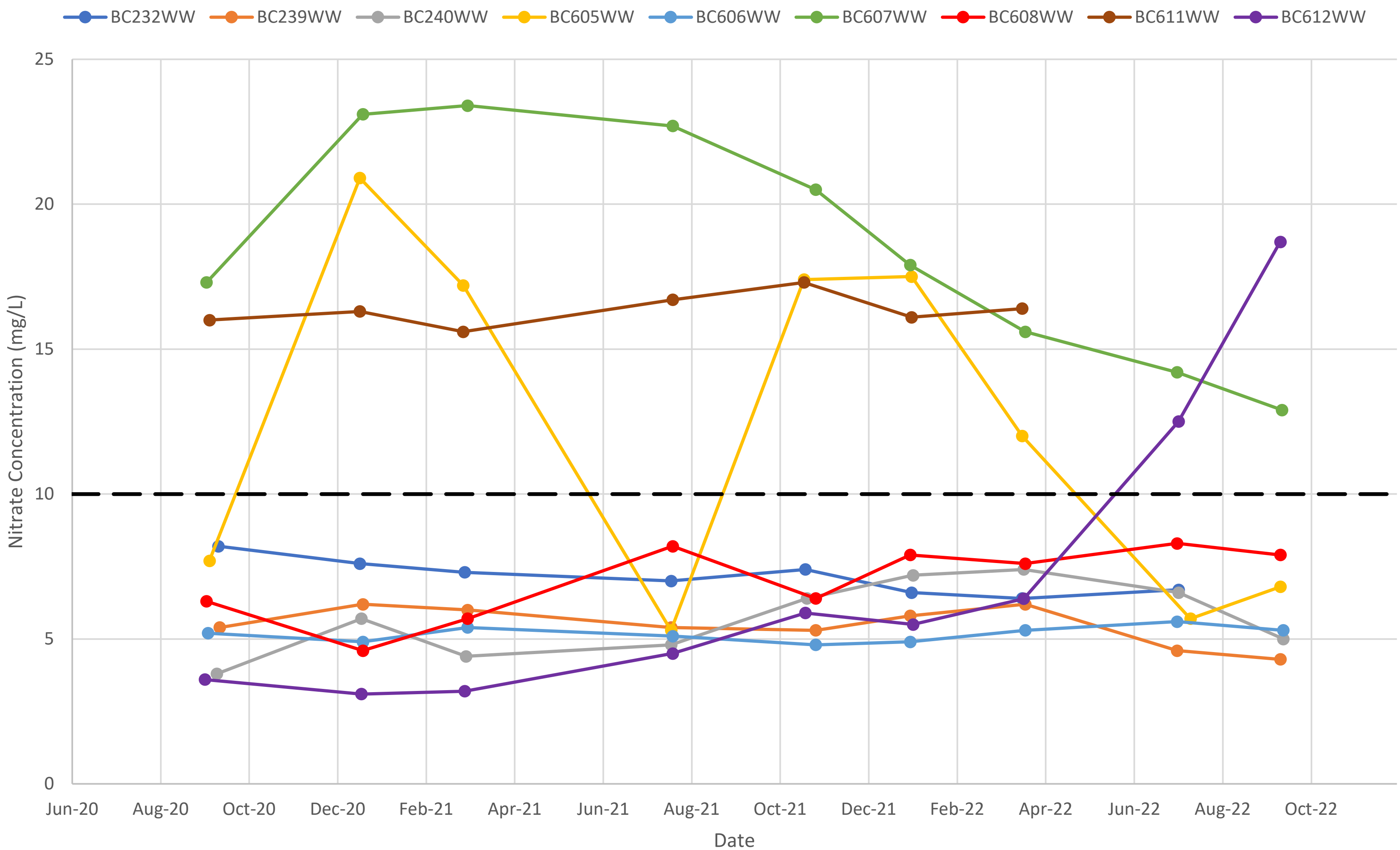
Figure 8



Note(s):

1. Figure notes here

Source(s):

2020-2022 Nitrate Time Series – Shallow Basalt Wells

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Badger Coulee, Benton County WA

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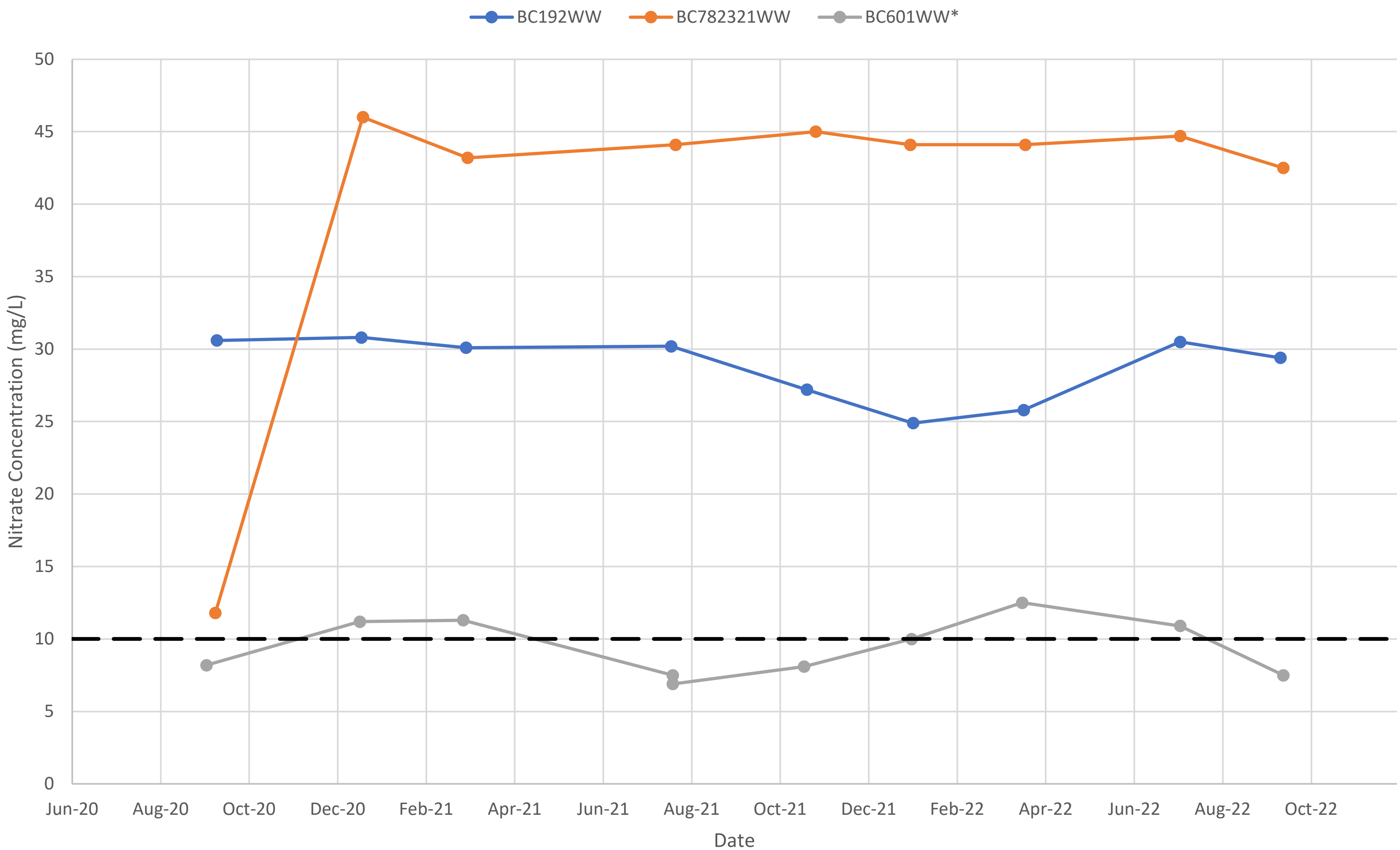
Figure 9



Note(s):
*Only open to the intermediate basalt

Source(s):

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2020-2022 Nitrate Time Series – Shallow + Intermediate Basalt and Intermediate Basalt Wells

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Badger Coulee, Benton County WA

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Figure 10

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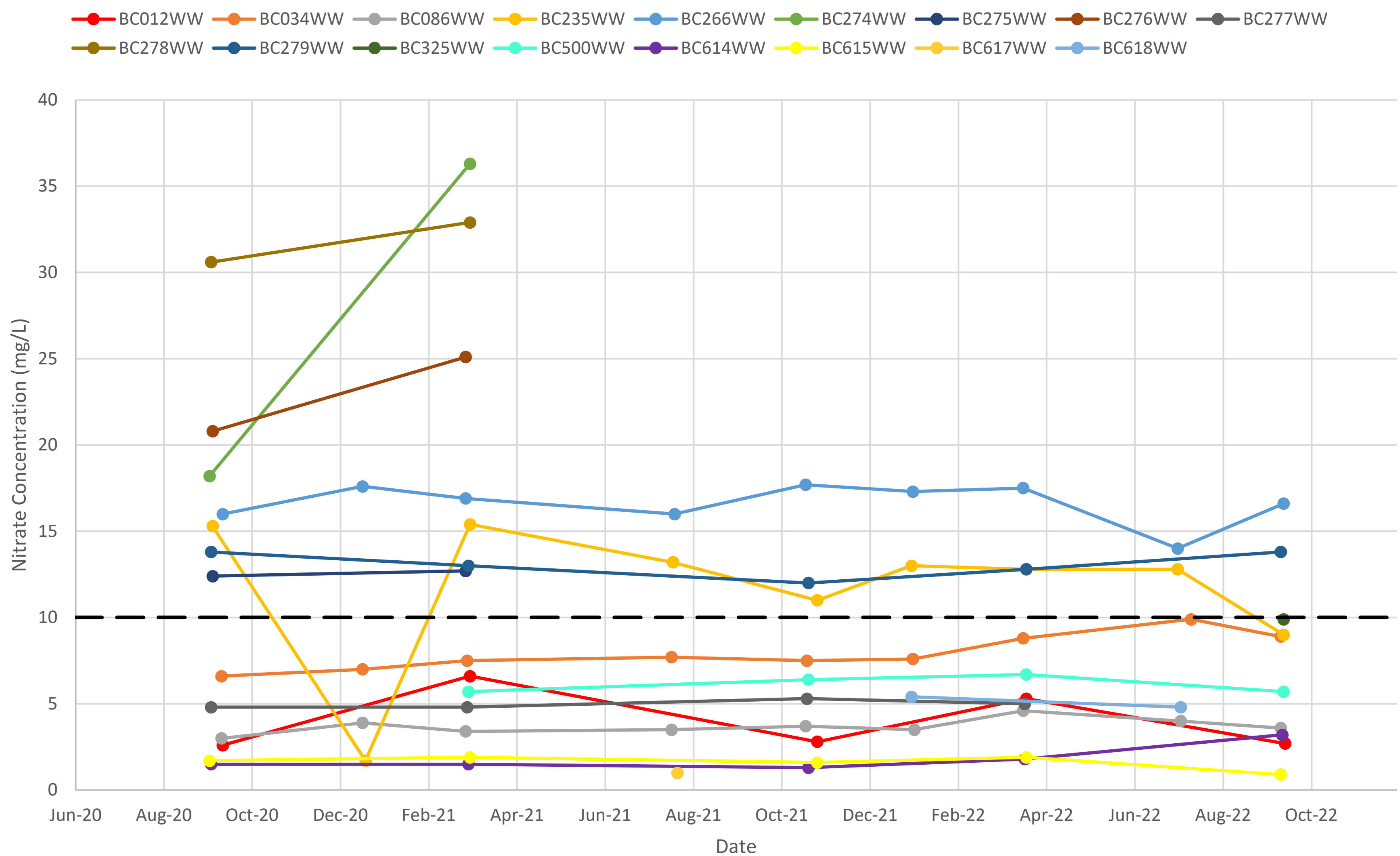

Note(s):

1. Figure notes here

Source(s):

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2020-2022 Nitrate Time Series – Unclassified Wells

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Badger Coulee, Benton County WA

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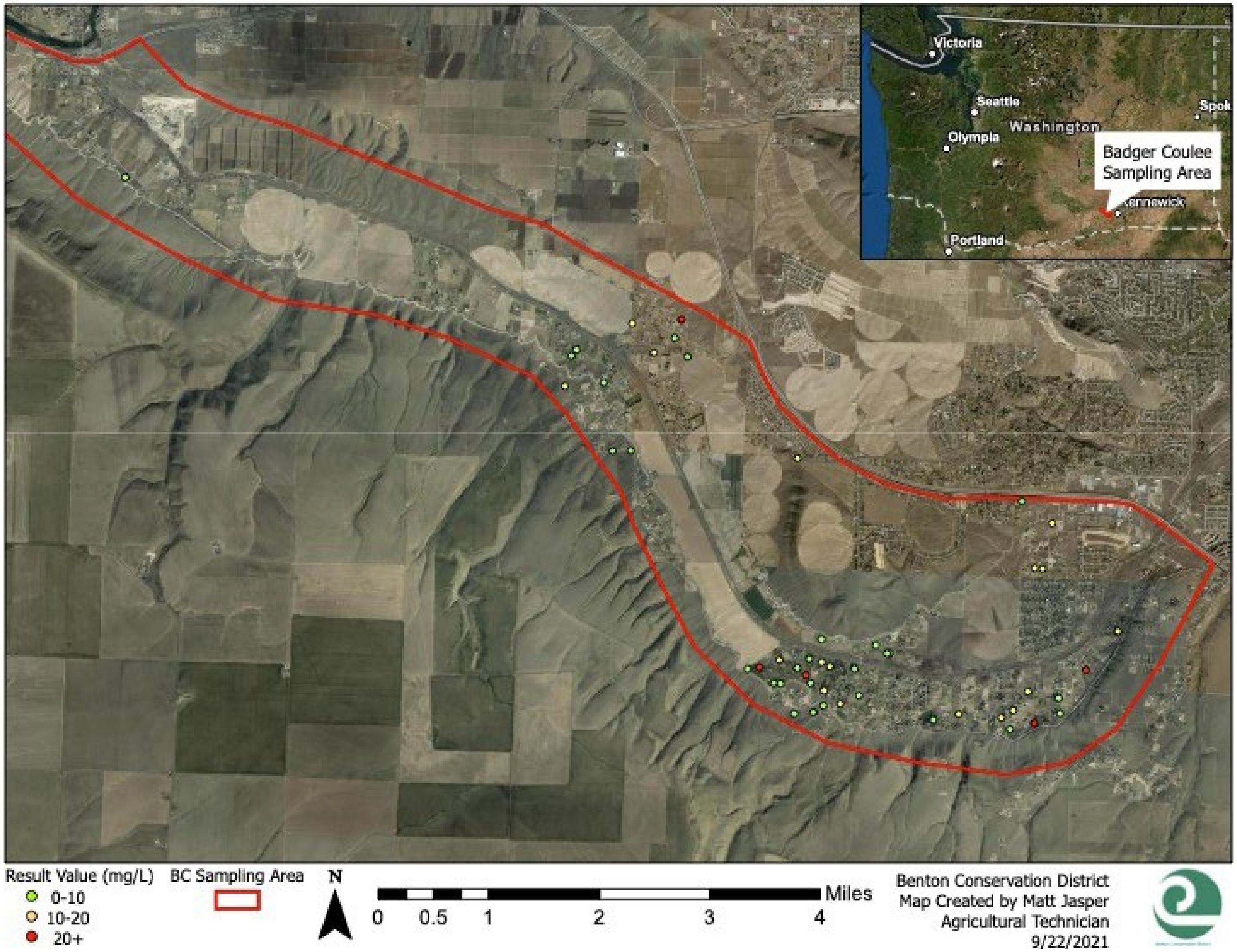
Figure 11



Source(s): Map generated by Benton Country Consecration District

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Fall 2020 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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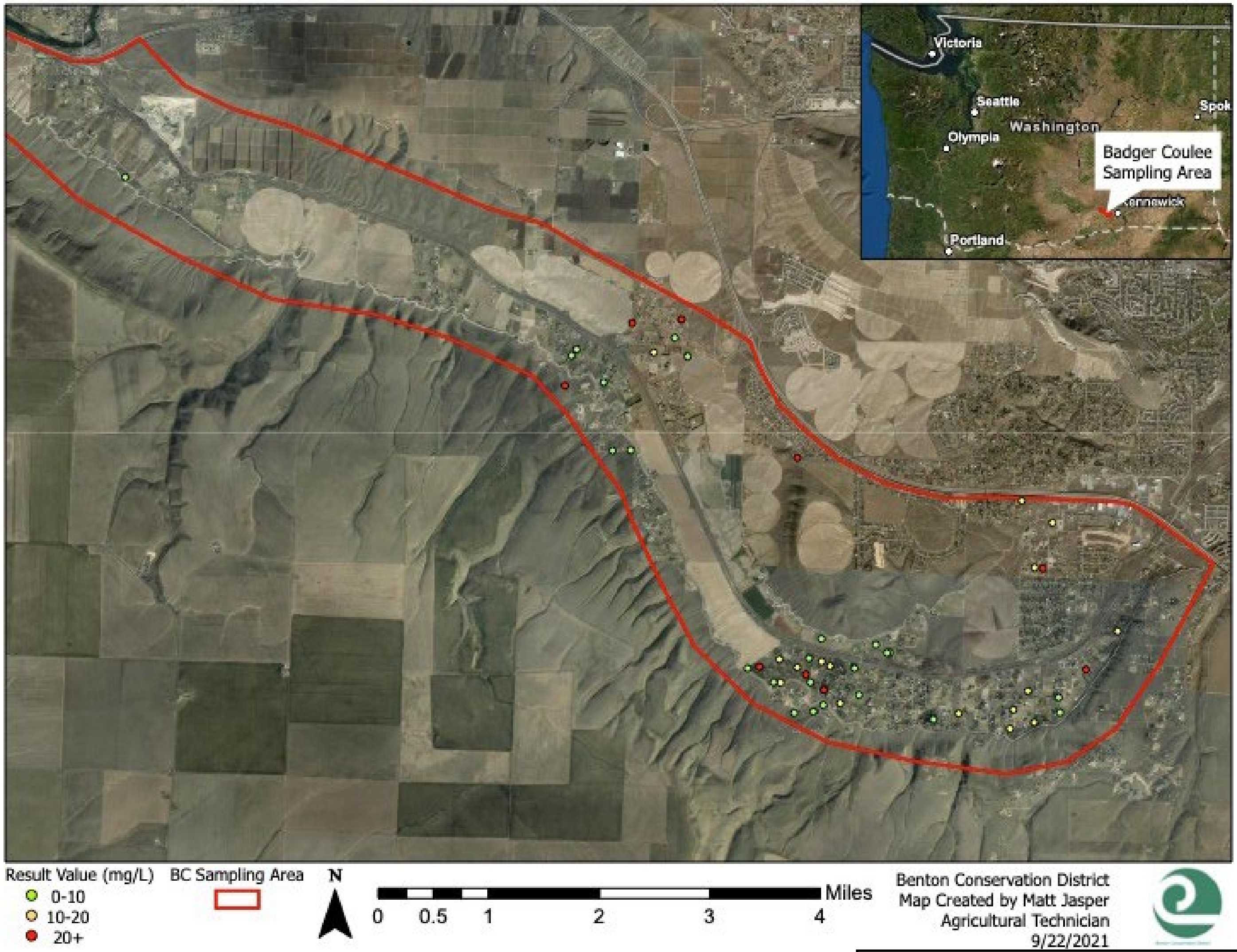
Figure 12



Spring 2021 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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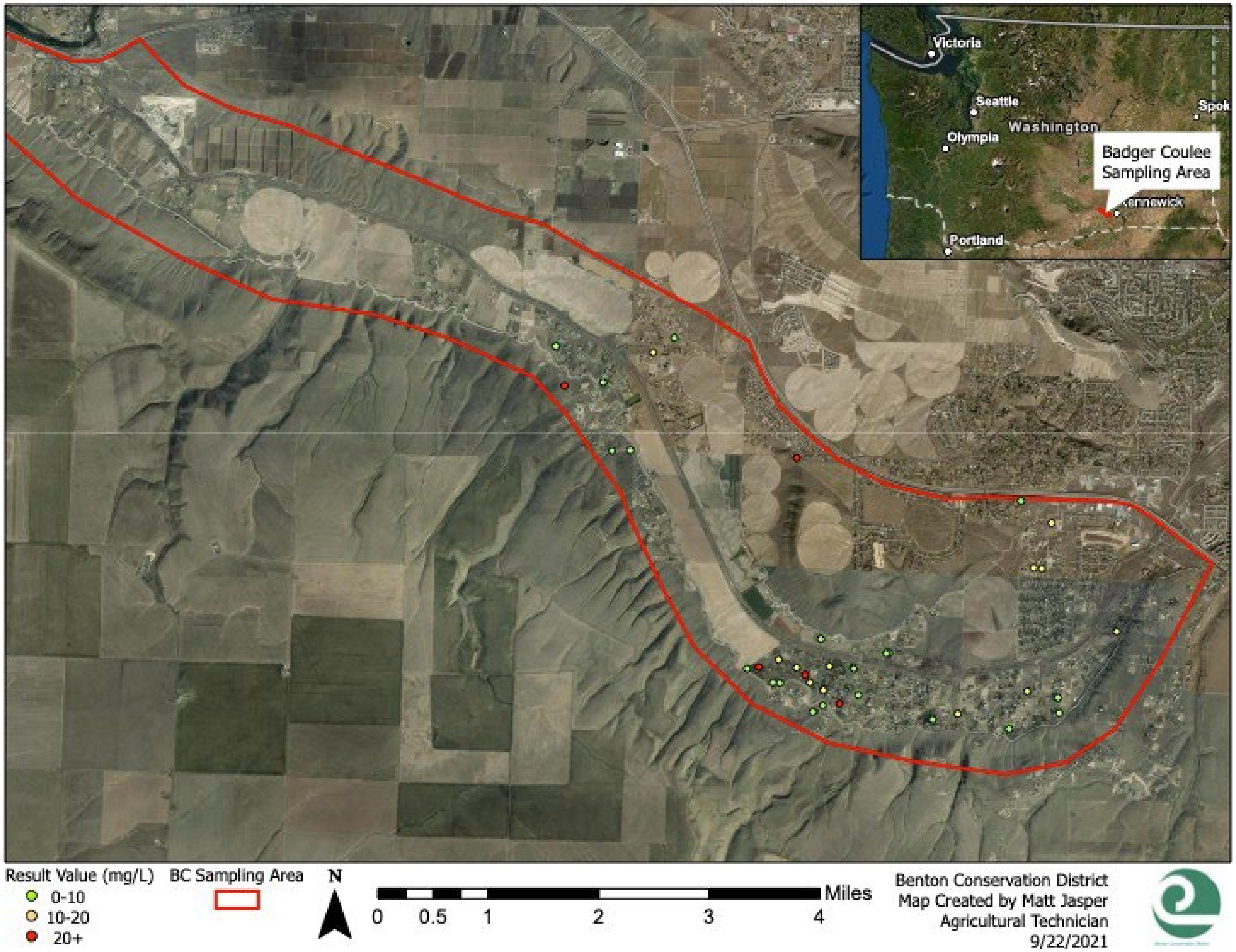
Figure 13

Source(s): Map generated by Benton Country Consecration District



Source(s): Map generated by Benton Country Consecration District

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Summer 2021 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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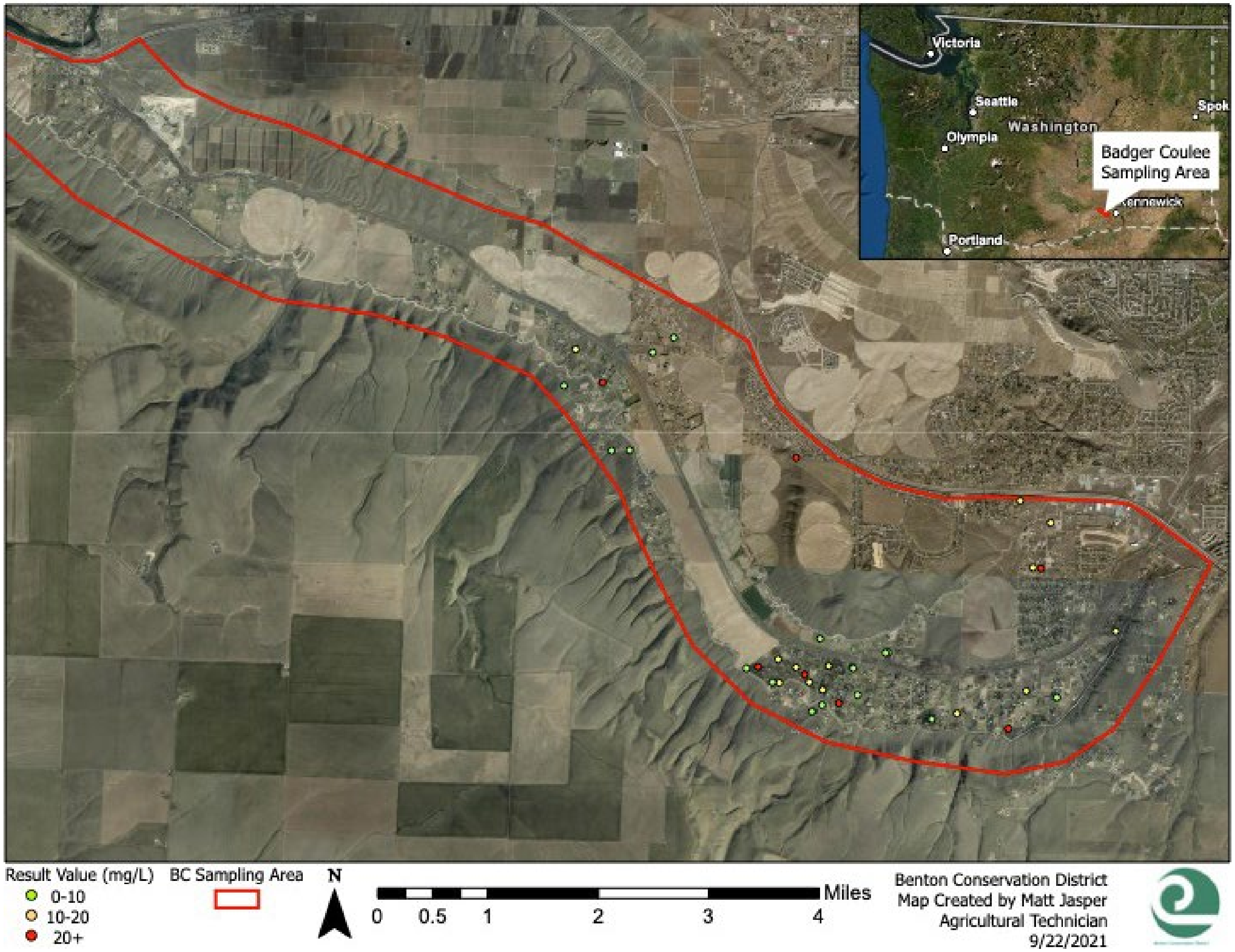
Figure 14



Benton Conservation District

Winter 2021 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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Figure 15

Source(s): Map generated by Benton Country Consecration District

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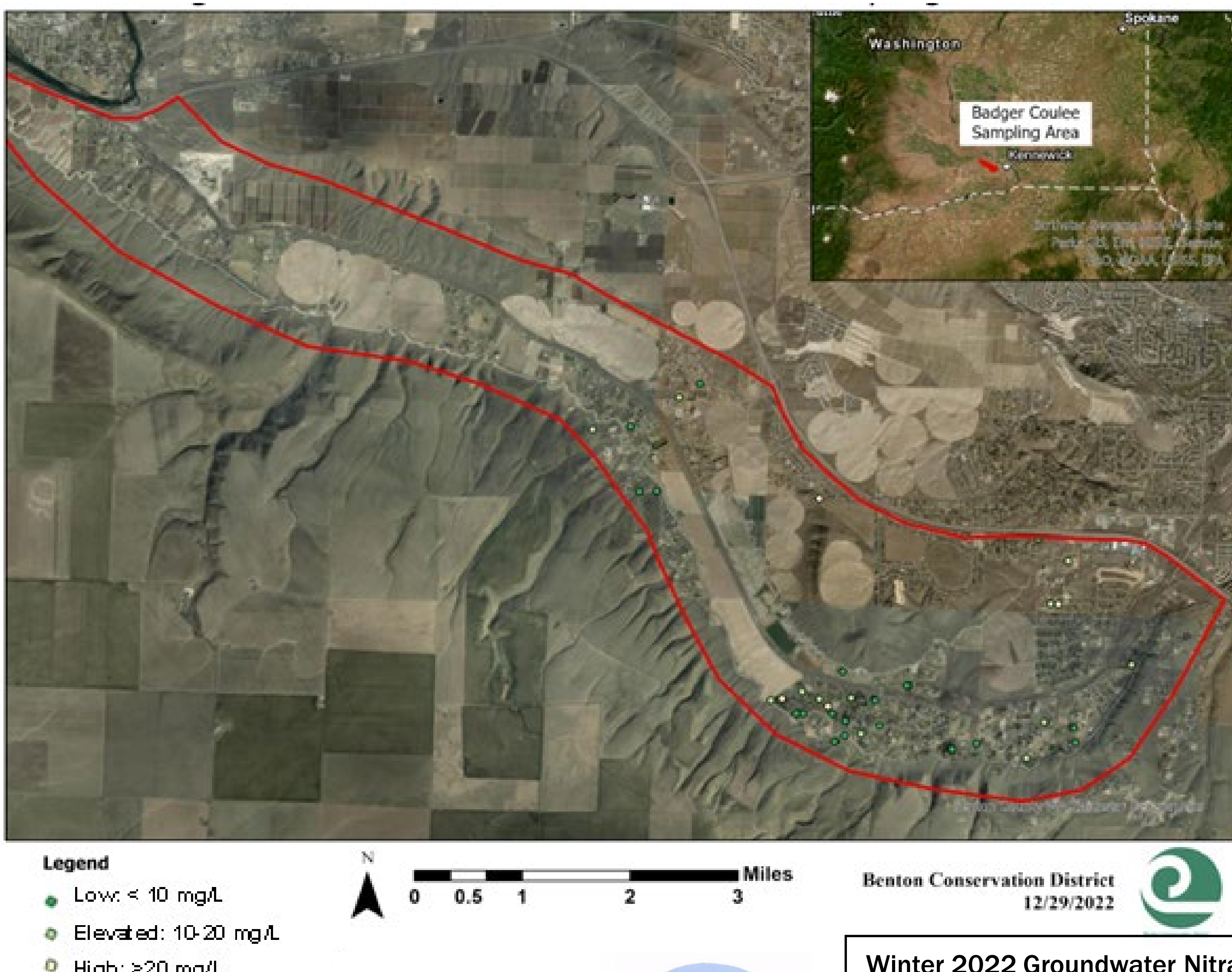

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Winter 2022 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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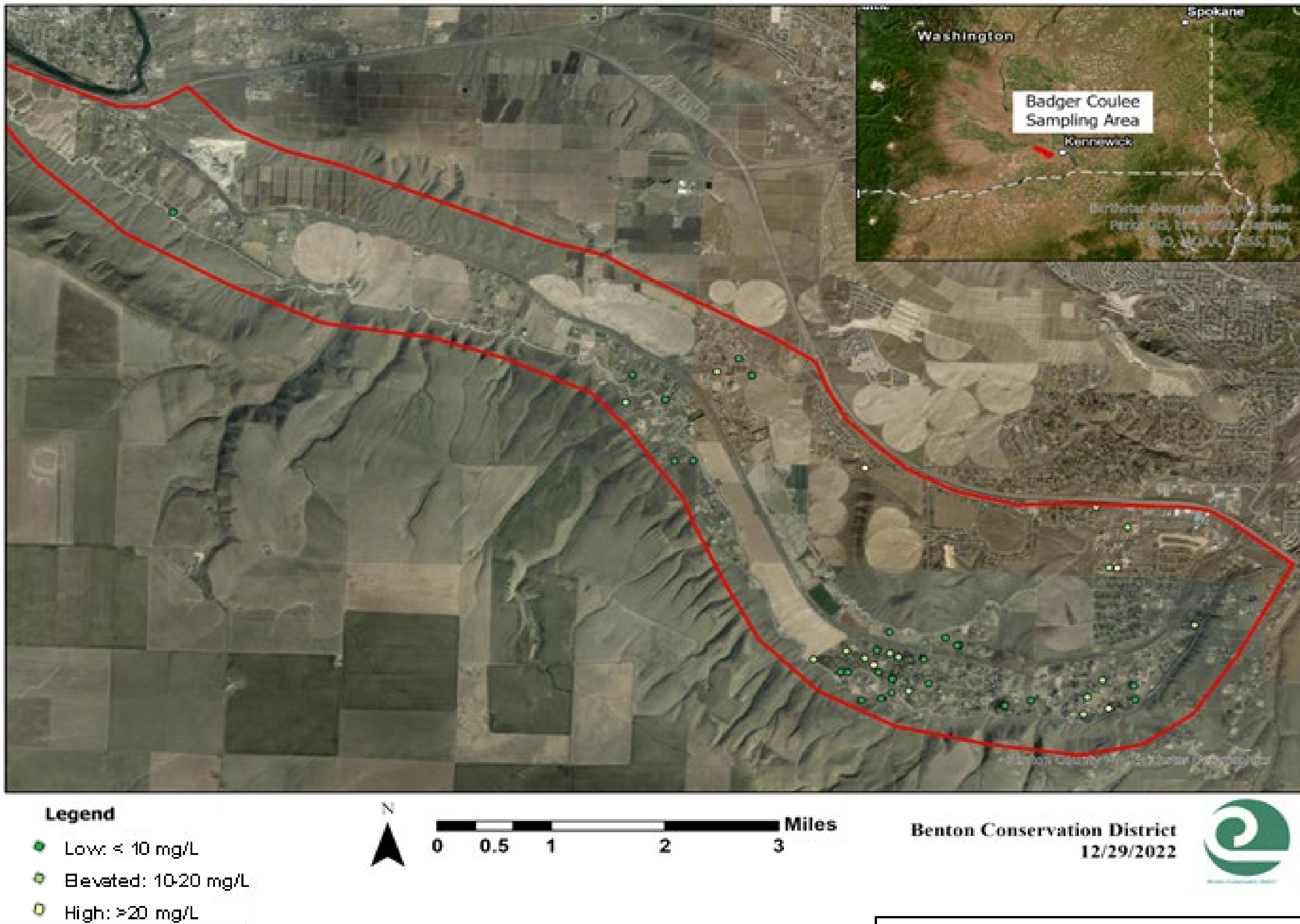
Figure 16



Source(s): Map generated by Benton Country Consecration District

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Benton Conservation District

Spring 2022 Groundwater Nitrate Distribution Map

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Badger Coulee, Benton County WA

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Figure 17

Legend

- Low: < 10 mg/L
- Elevated: 10-20 mg/L
- High: >20 mg/L

N

0 0.5 1 2 3 Miles

Benton Conservation District
12/29/2022

Benton Conservation District

Source(s): Map generated by Benton Country Consecration District

Summer 2022 Groundwater Nitrate Distribution Map

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

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Figure 18

Legend

- Low: < 10 mg/L
- Elevated: 10-20 mg/L
- High: >20 mg/L

N

0 0.5 1 2 3 Miles

Benton Conservation District
12/29/2022

Benton Conservation District

Source(s): Map generated by Benton Country Consecration District

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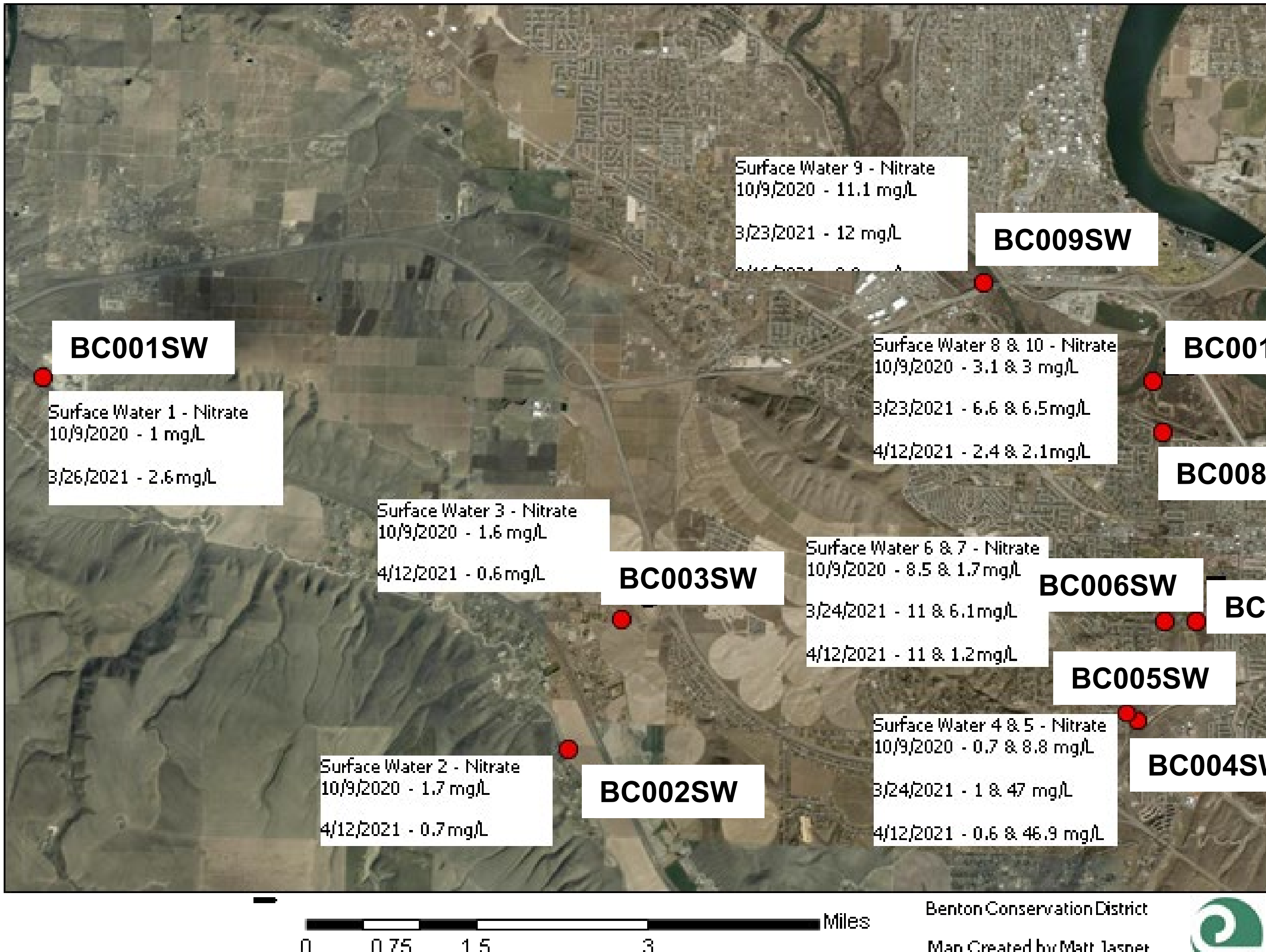
Fall 2022 Groundwater Nitrate Distribution Map	
BCCD Water Quality Monitoring Report Badger Coulee, Benton County WA	
GeoEngineers	**Figure 19**



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Map Created by Matt Jasper

Benton Conservation District

Source(s): Map generated by Benton Country Consecration District

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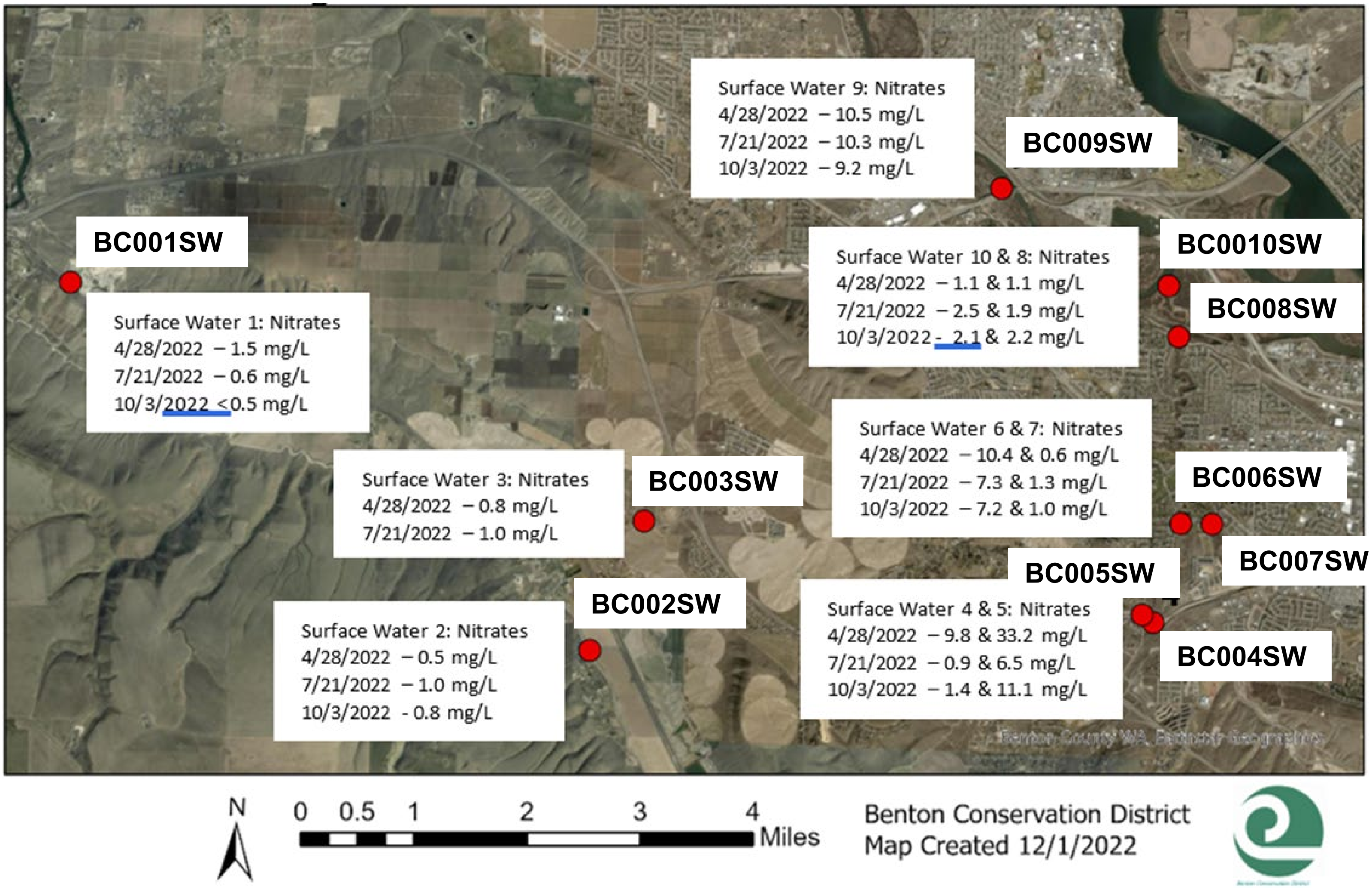
2020-2021 Surface Water Nitrate Sample Results

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

GEOENGINEERS

Figure 20



Source(s): Map generated by Benton Country Consecration District

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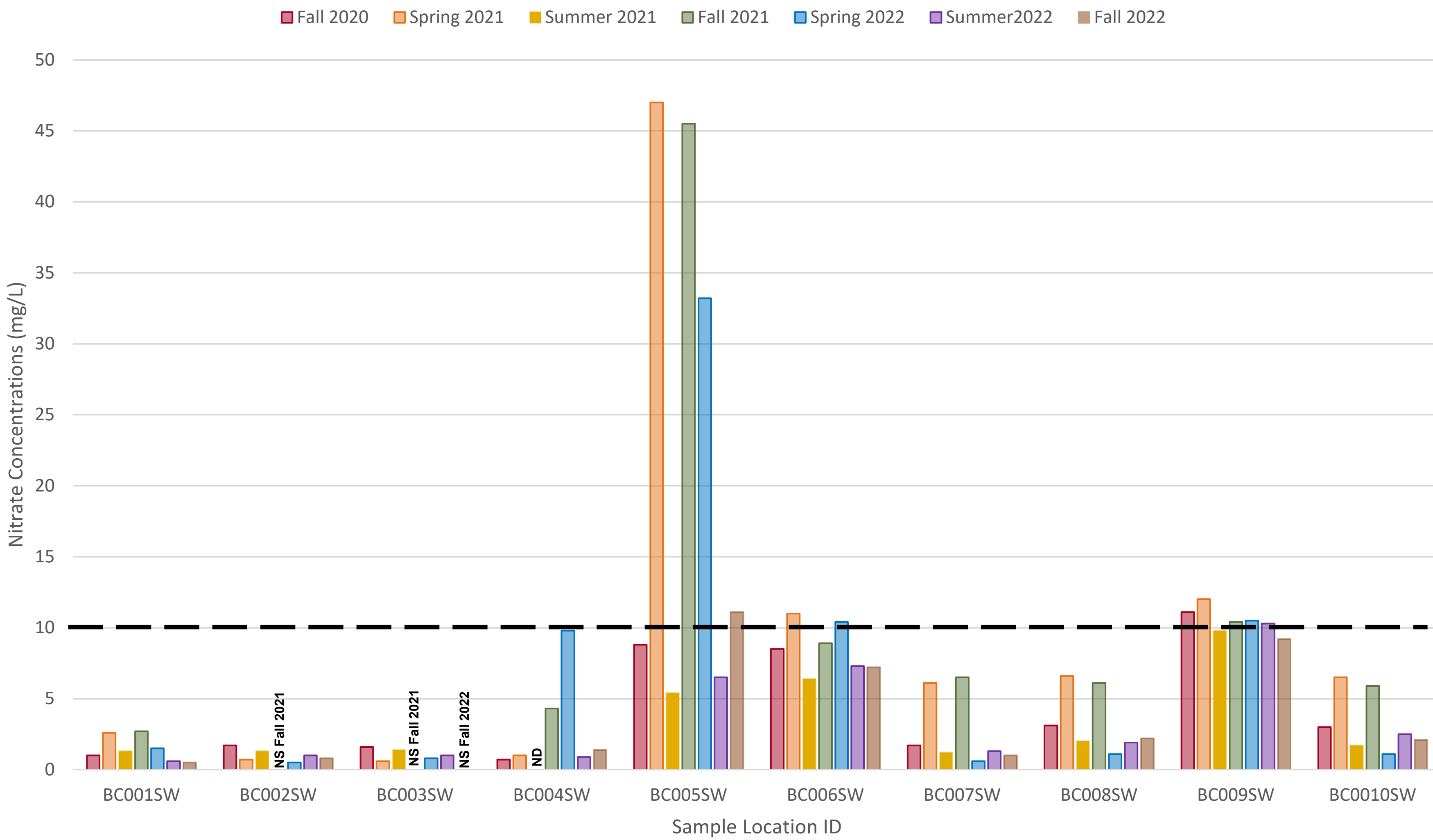
2022 Surface Water Nitrate Sample Results
BCCD Water Quality Monitoring Report Badger Coulee, Benton County WA
GEOENGINEERS — **Figure 21**



Note(s):
NS = Not Sampled.
ND = Non-detect

Source(s): Map generated by Benton Country Consecration District

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Surface Water Nitrate Bar Graph

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

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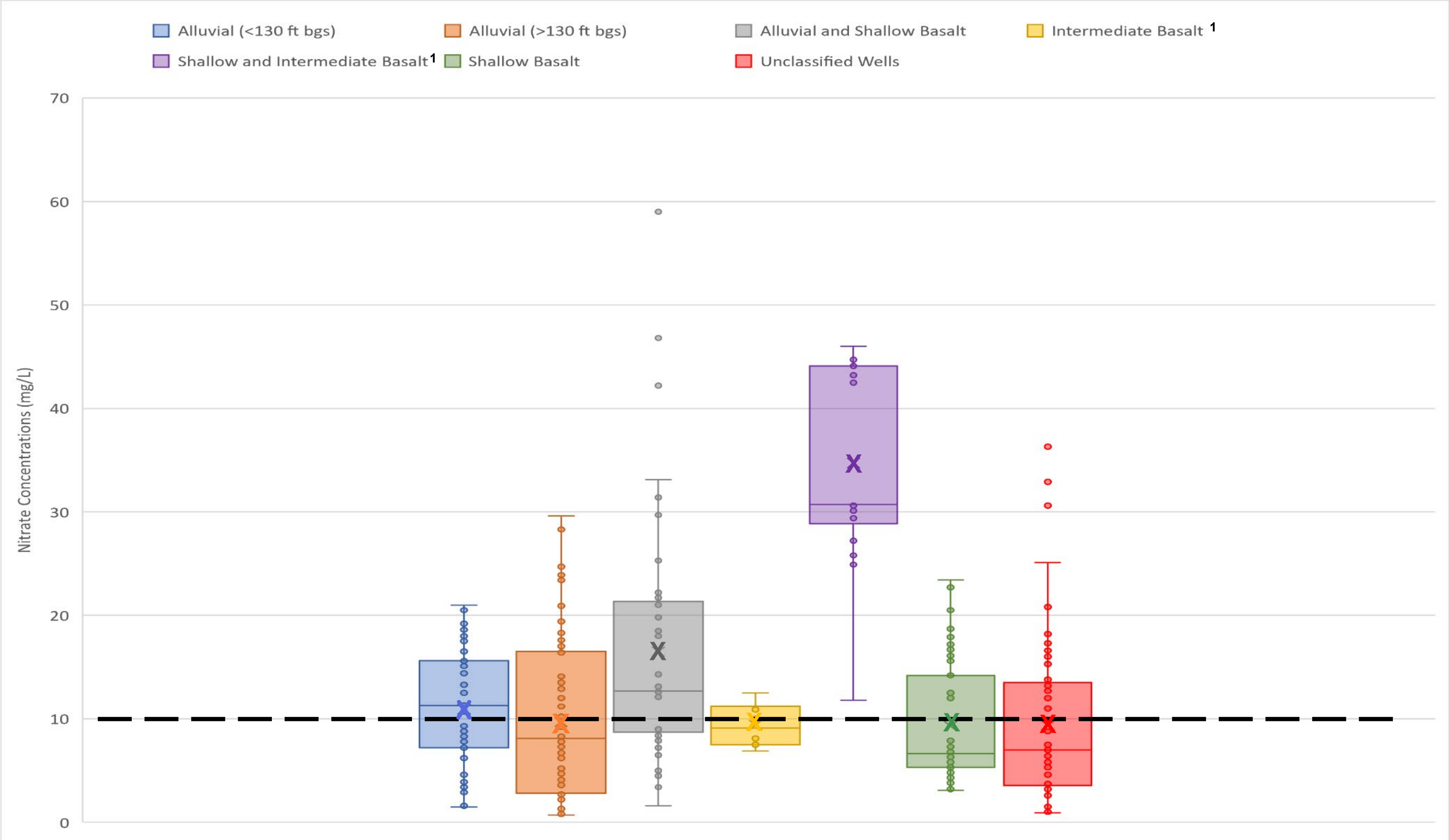
Figure 22



Note(s):

[1] Not considered a reasonable representation due to few sample locations.

Source(s): Map generated by Benton Country Consecration District

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2020 – 2022 Groundwater Nitrate Box and Whisker Plot

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

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Figure 23

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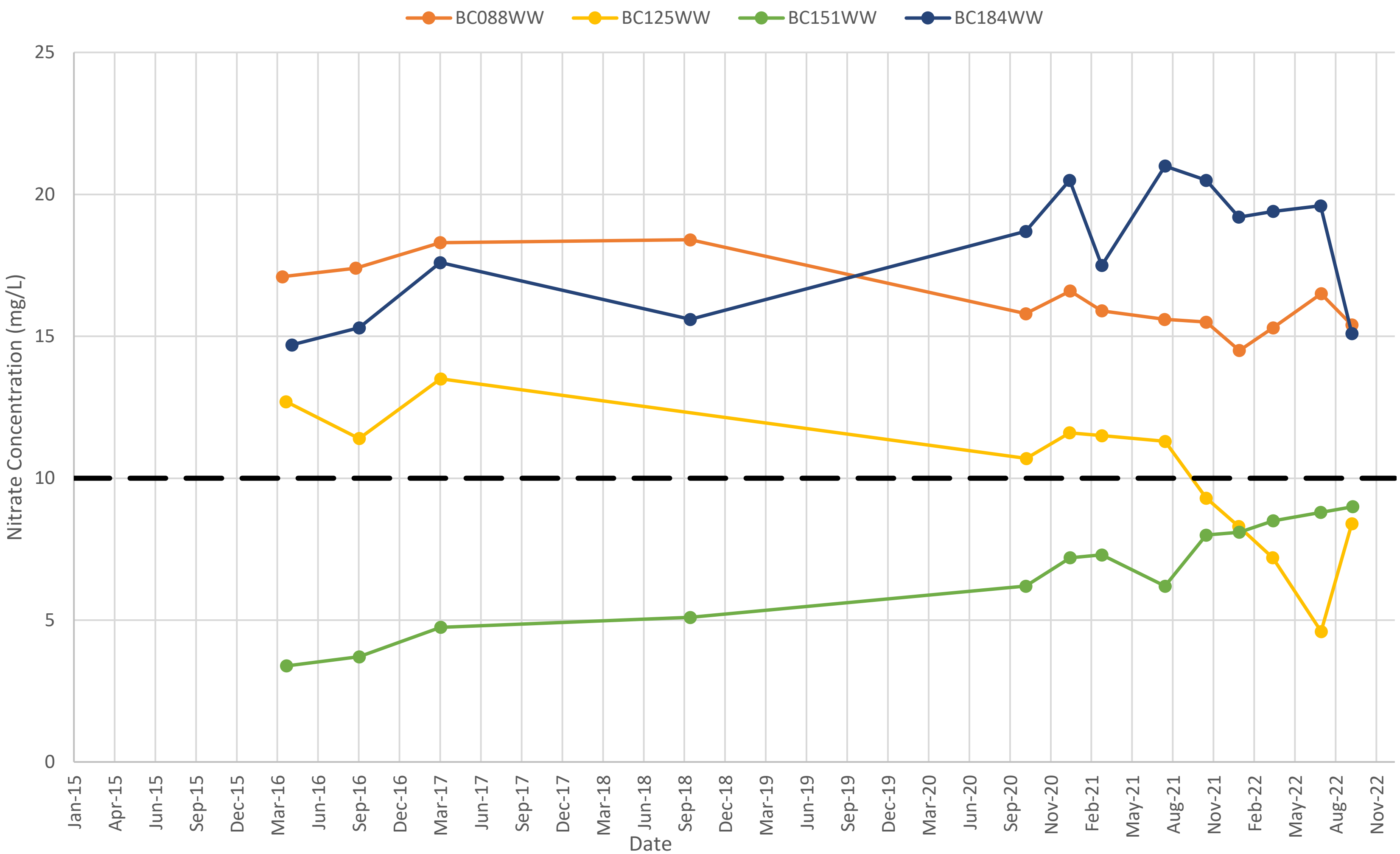

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Source(s): Map generated by Benton Country Consecration District

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2016-2022 Nitrate Time Series – Alluvial Wells (<130 ft deep)

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Badger Coulee, Benton County WA

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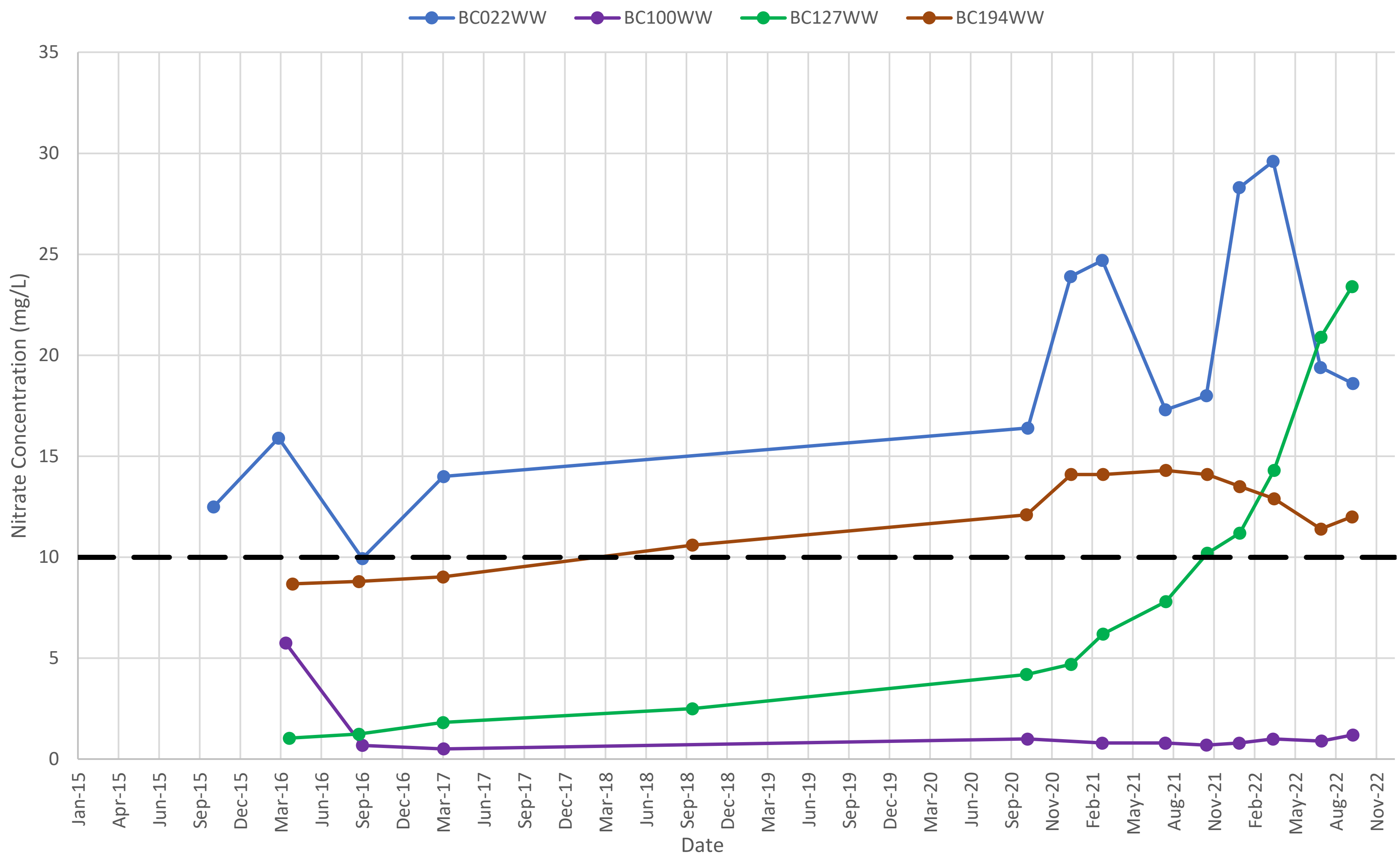
Figure 24



Source(s): Map generated by Benton Country Consecration District

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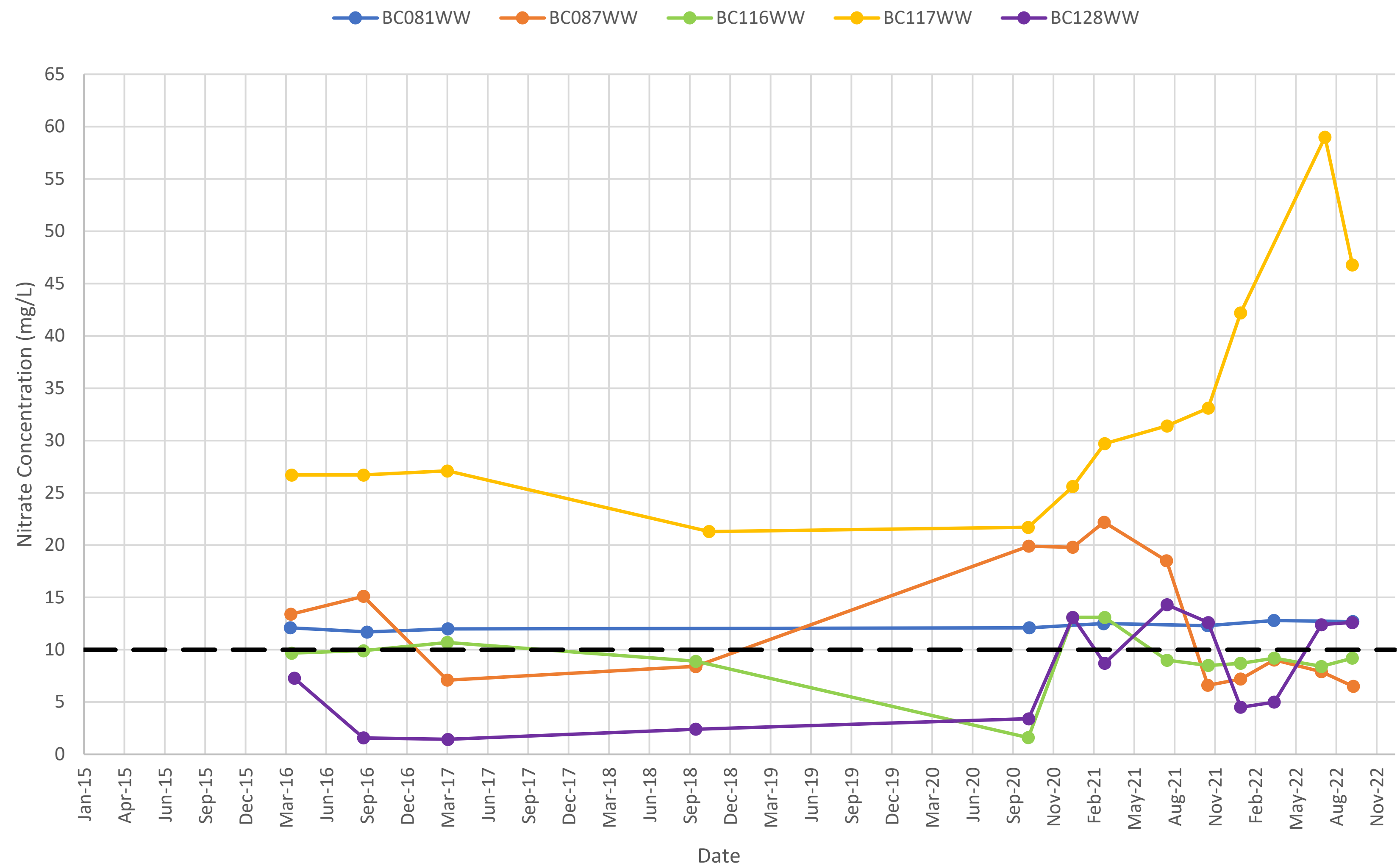
2016-2022 Nitrate Time Series – Alluvial Wells (>130 ft deep)

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

GeoEngineers

Figure 25



2016-2022 Nitrate Time Series – Alluvial + Shallow Basalt Wells

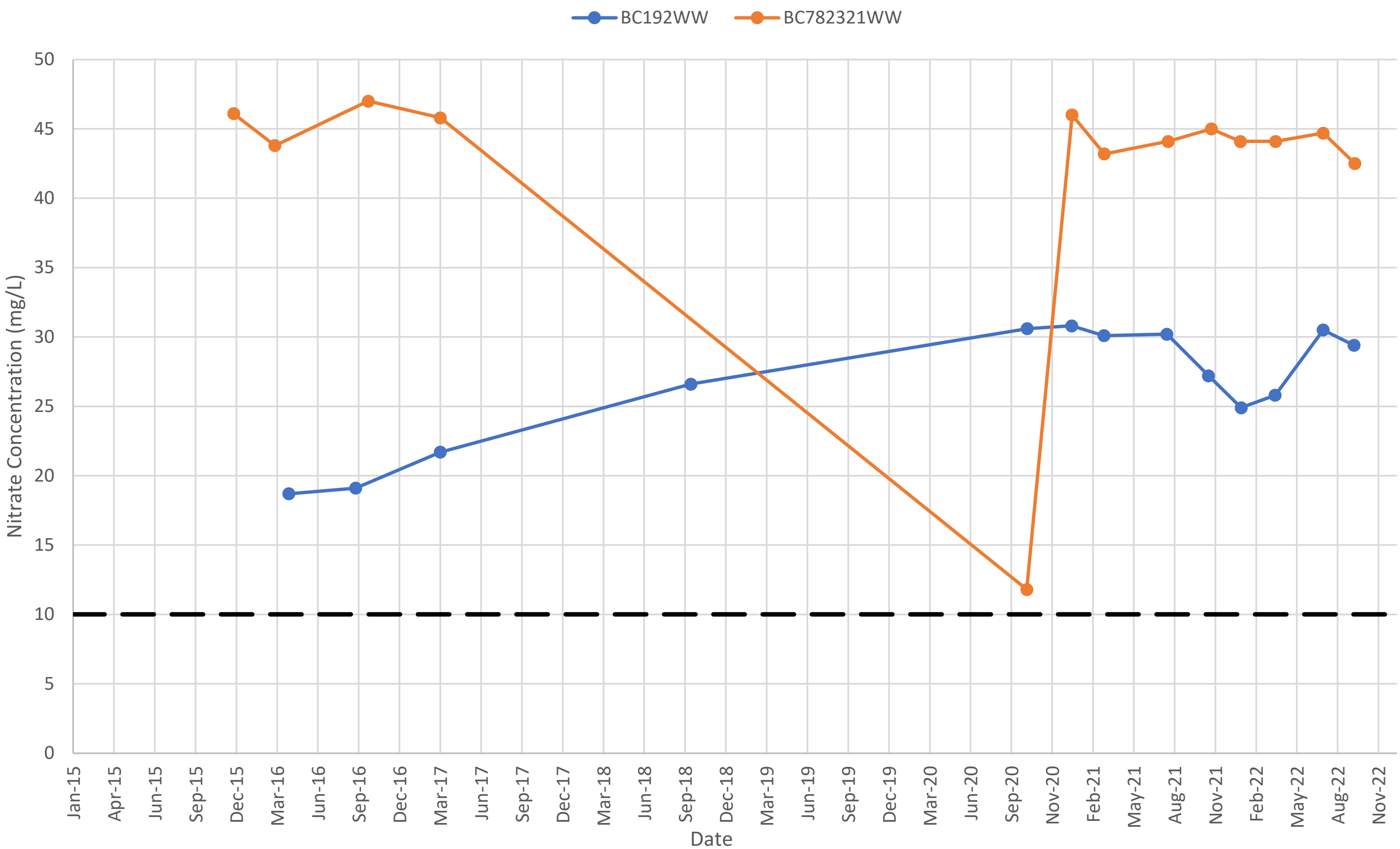
BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

GeoEngineers

Figure 26

Source(s): Map generated by Benton Country Consecration District

XXXXX-XXX-XX Date Exported: 07/31/23



Source(s): Map generated by Benton Country Consecration District

Disclaimer: This figure was created for a specific purpose and project. Any use of this figure for any other project or purpose shall be at the user's sole risk and without liability to GeoEngineers. The locations of features shown may be approximate. GeoEngineers makes no warranty or representation as to the accuracy, completeness, or suitability of the figure, or data contained therein. The file containing this figure is a copy of a master document, the original of which is retained by GeoEngineers and is the official document of record.

Benton Conservation District

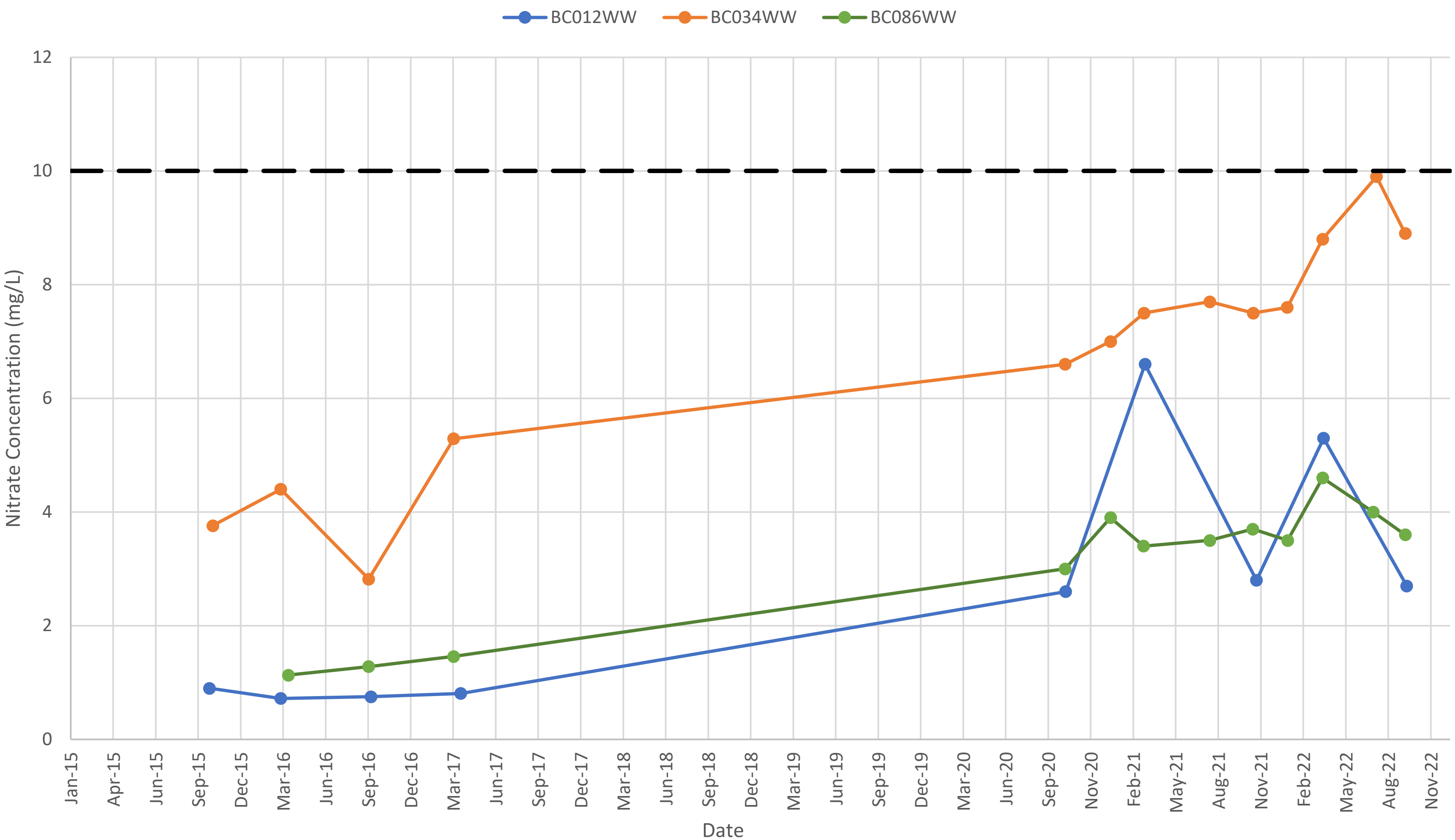
2016-2022 Nitrate Time Series – Shallow + Intermediate Basalt Wells

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

GEOENGINEERS

Figure 27

XXXXX-XXX-XX Date Exported: 07/31/23



Source(s): Map generated by Benton Country Consecration District

Disclaimer: This figure was created for a specific purpose and project. Any use of this figure for any other project or purpose shall be at the user's sole risk and without liability to GeoEngineers. The locations of features shown may be approximate. GeoEngineers makes no warranty or representation as to the accuracy, completeness, or suitability of the figure, or data contained therein. The file containing this figure is a copy of a master document, the original of which is retained by GeoEngineers and is the official document of record.

Benton Conservation District

2016-2022 Nitrate Time Series – Unclassified Wells

BCCD Water Quality Monitoring Report
Badger Coulee, Benton County WA

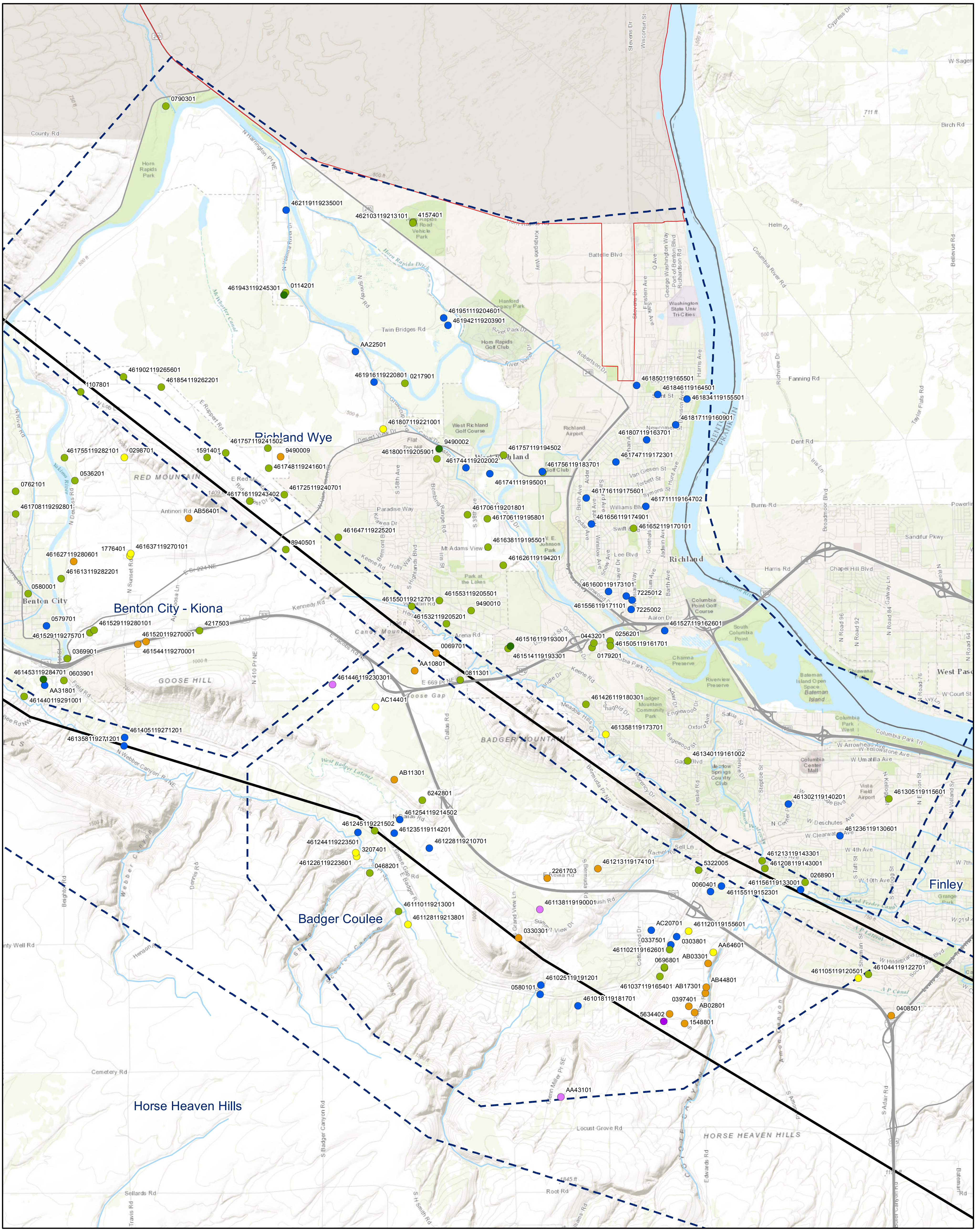
GeoEngineers

Figure 28

Appendices

Appendix A.

Previous Results



Legend

Well Hydrostratigraphy

- alluvial
- alluvial and shallow basalt
- shallow basalt
- shallow and intermediate basalt
- intermediate basalt
- intermediate and deep basalt
- deep basalt
- General Area Boundary
- Hanford
- Highways
- Simplified Major Structures
- Canals, Creeks, Canyons

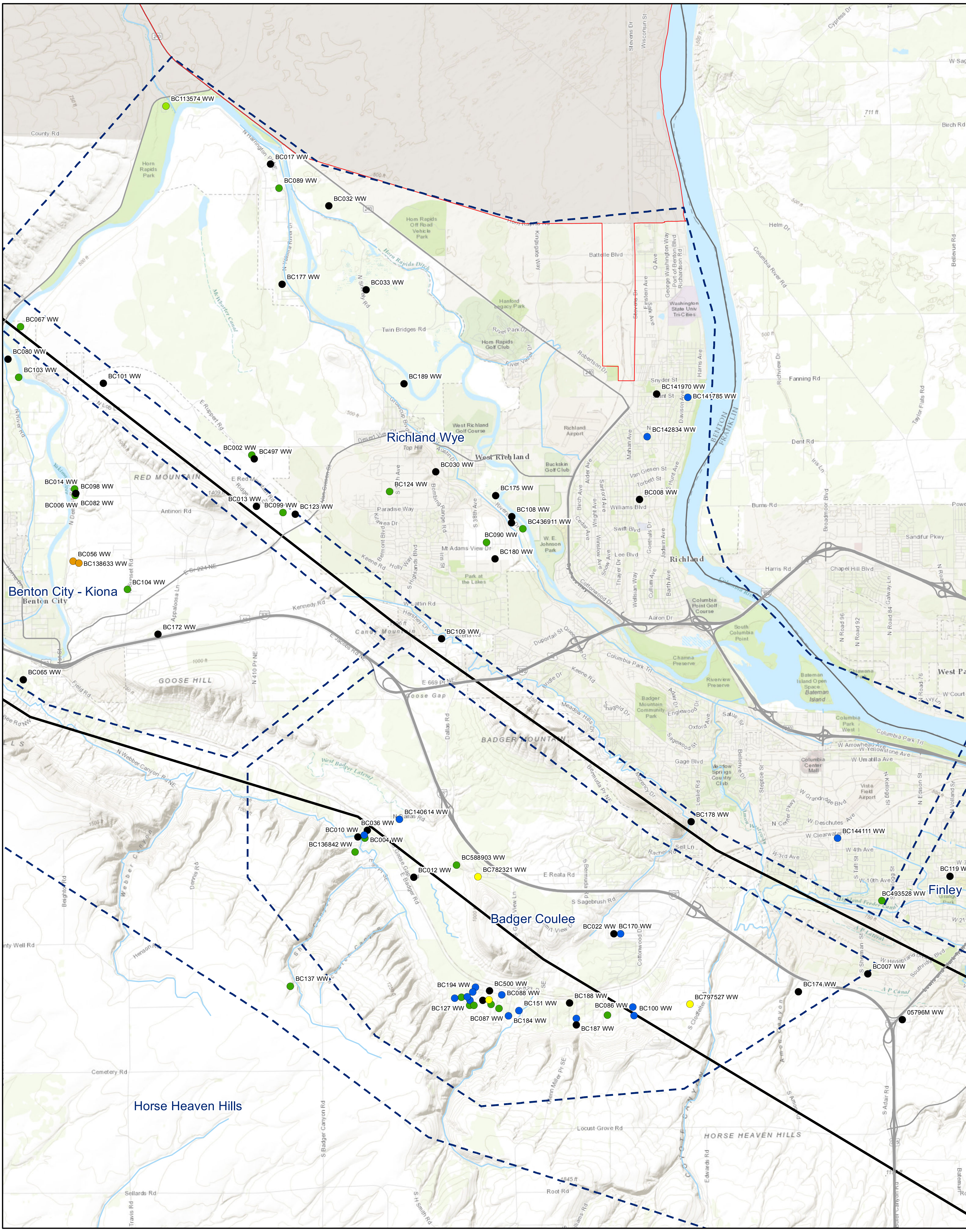
Figure 7.3.

Richland Wye and Badger Coulee Area Historically Sampled Wells (1971 - 2011) Benton County, WA

0 0.5 1 2
Miles

N

EA Engineering, Science, and Technology, Inc., PBC



Legend

Well Hydrostratigraphy

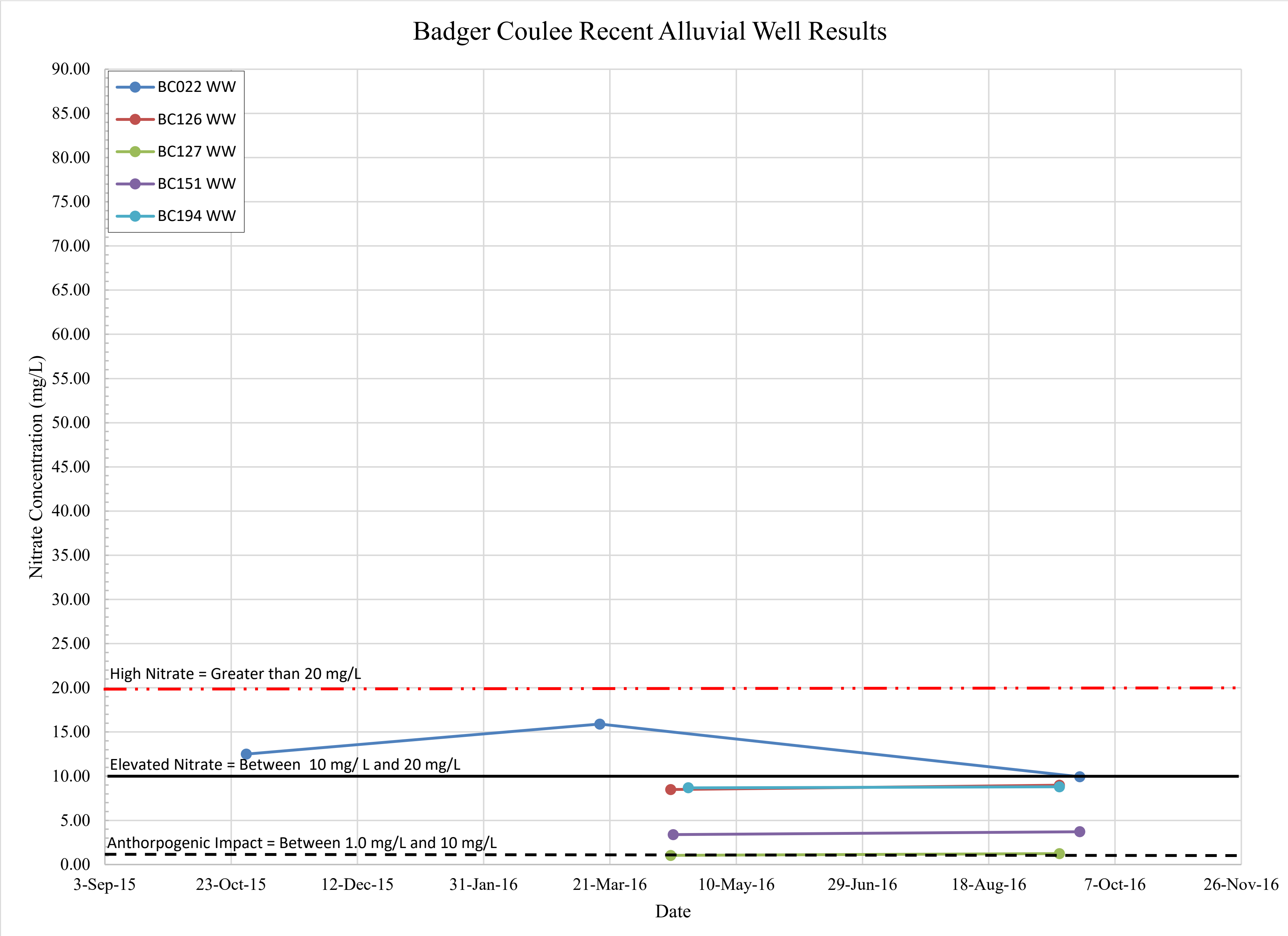
- unknown completion
- alluvial
- shallow basalt / shallow basalt & alluvial
- shallow basalt
- shallow & intermediate basalt
- intermediate basalt
- General Area Boundary
- Hanford
- Highways
- Simplified Major Structures
- Canals, Creeks, Canyons

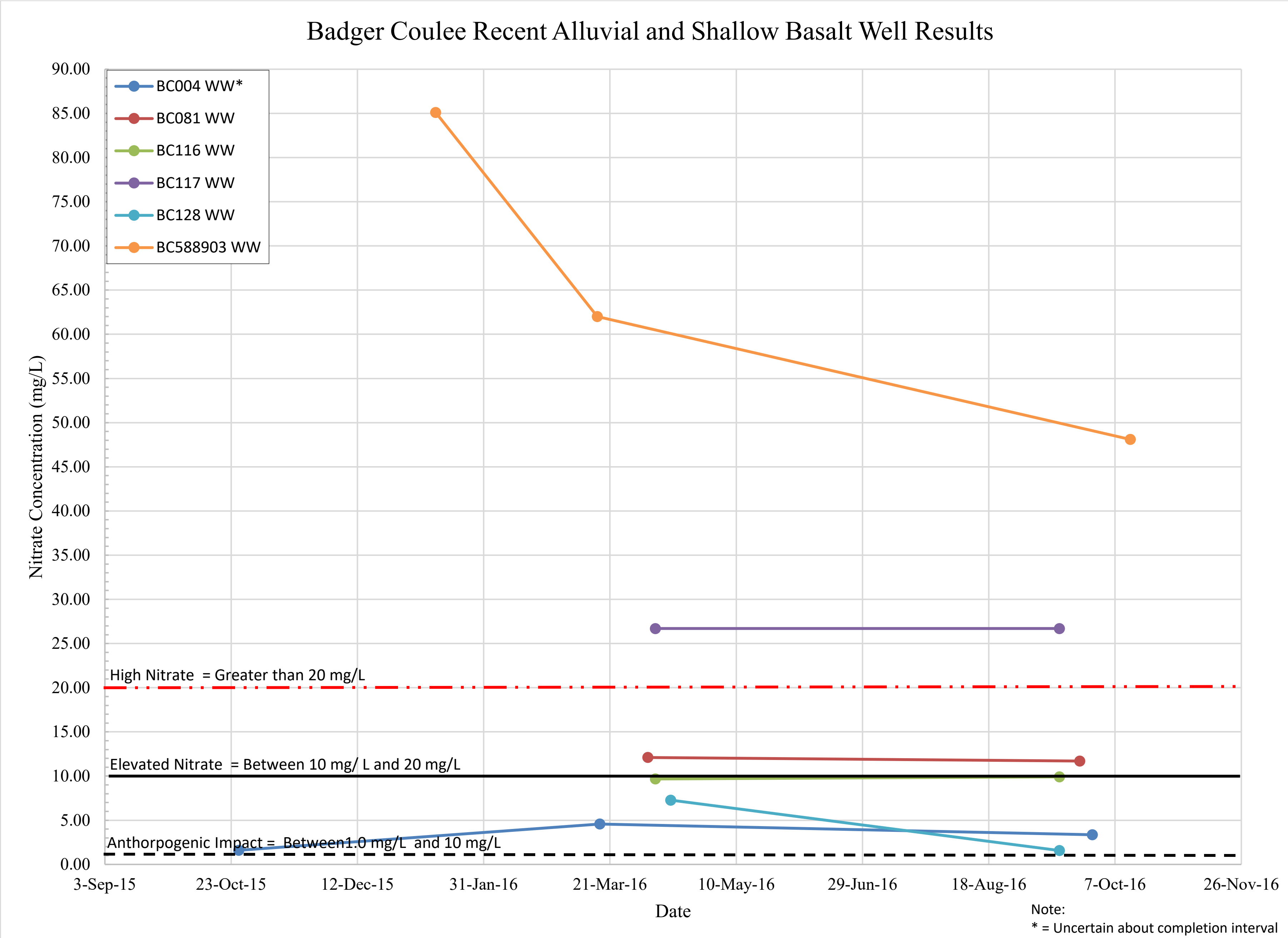
0 0.5 1 2
Miles

N

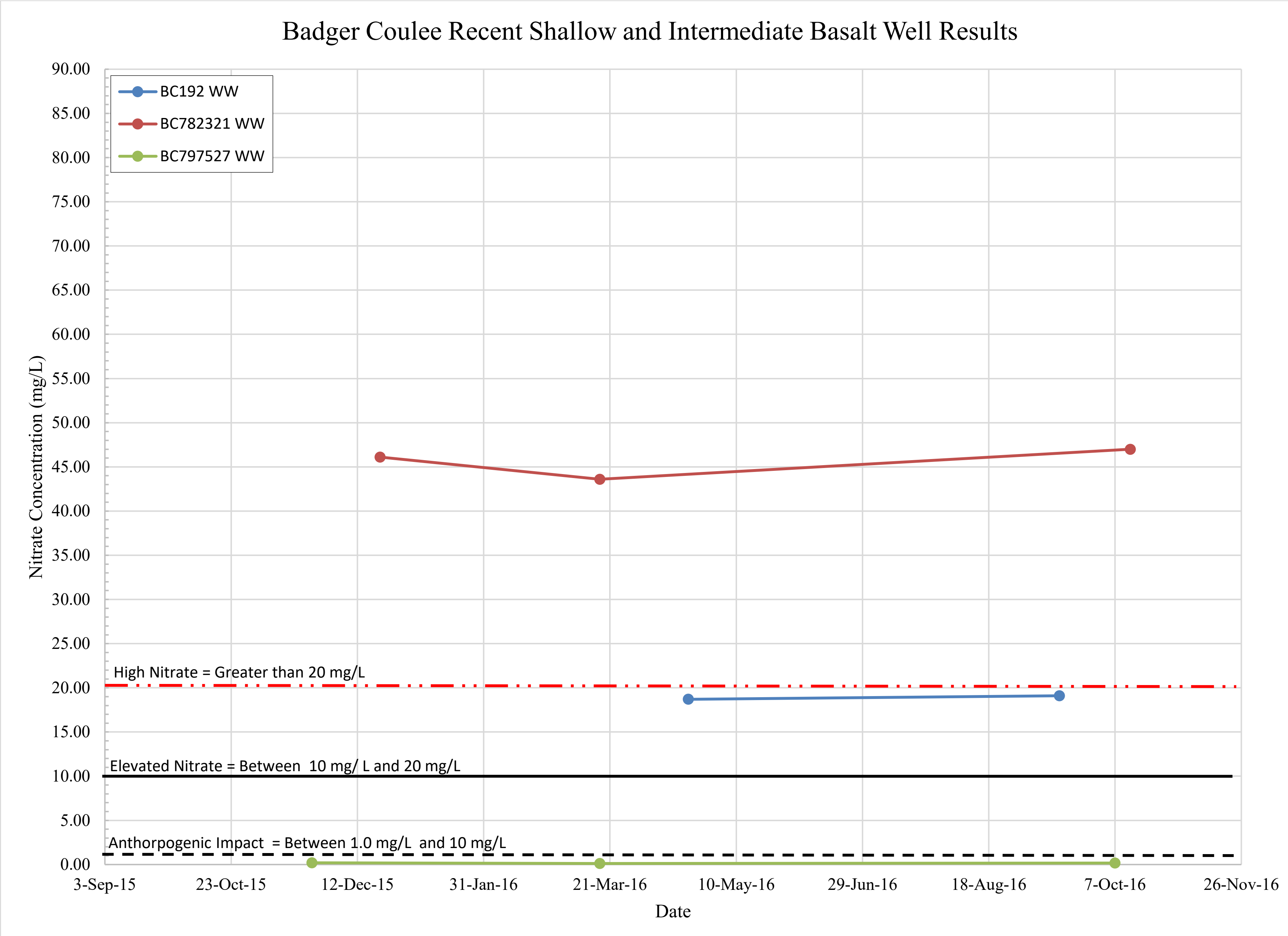
EA Engineering, Science, and Technology, Inc., PBC

Figure 8.3.
Richland Wye and Badger Coulee Area Recently Sampled Wells (2015 - 2016) Benton County, WA


Badger Coulee Recent Alluvial Well Results
BC022 WW
BC126 WW
BC127 WW
BC151 WW
BC194 WW
High Nitrate = Greater than 20 mg/L
Elevated Nitrate = Between 10 mg/ L and 20 mg/L
Anthorpogenic Impact = Between 1.0 mg/L and 10 mg/L
Nitrate Concentration (mg/L)
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
3-Sep-15
23-Oct-15
12-Dec-15
31-Jan-16
21-Mar-16
10-May-16
29-Jun-16
18-Aug-16
7-Oct-16
26-Nov-16
Date



Badger Coulee Recent Alluvial and Shallow Basalt Well Results
BC004 WW*
BC081 WW
BC116 WW
BC117 WW
BC128 WW
BC588903 WW
Nitrate Concentration (mg/L)
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
High Nitrate = Greater than 20 mg/L
Elevated Nitrate = Between 10 mg/ L and 20 mg/L
Anthorpogenic Impact = Between1.0 mg/L and 10 mg/L
3-Sep-15
23-Oct-15
12-Dec-15
31-Jan-16
21-Mar-16
10-May-16
29-Jun-16
18-Aug-16
7-Oct-16
26-Nov-16
Date
Note:
* = Uncertain about completion interval


Badger Coulee Recent Shallow and Intermediate Basalt Well Results
BC192 WW
BC782321 WW
BC797527 WW
Nitrate Concentration (mg/L)
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
High Nitrate = Greater than 20 mg/L
Elevated Nitrate = Between 10 mg/ L and 20 mg/L
Anthorpogenic Impact = Between 1.0 mg/L and 10 mg/L
3-Sep-15
23-Oct-15
12-Dec-15
31-Jan-16
21-Mar-16
10-May-16
29-Jun-16
18-Aug-16
7-Oct-16
26-Nov-16
Date

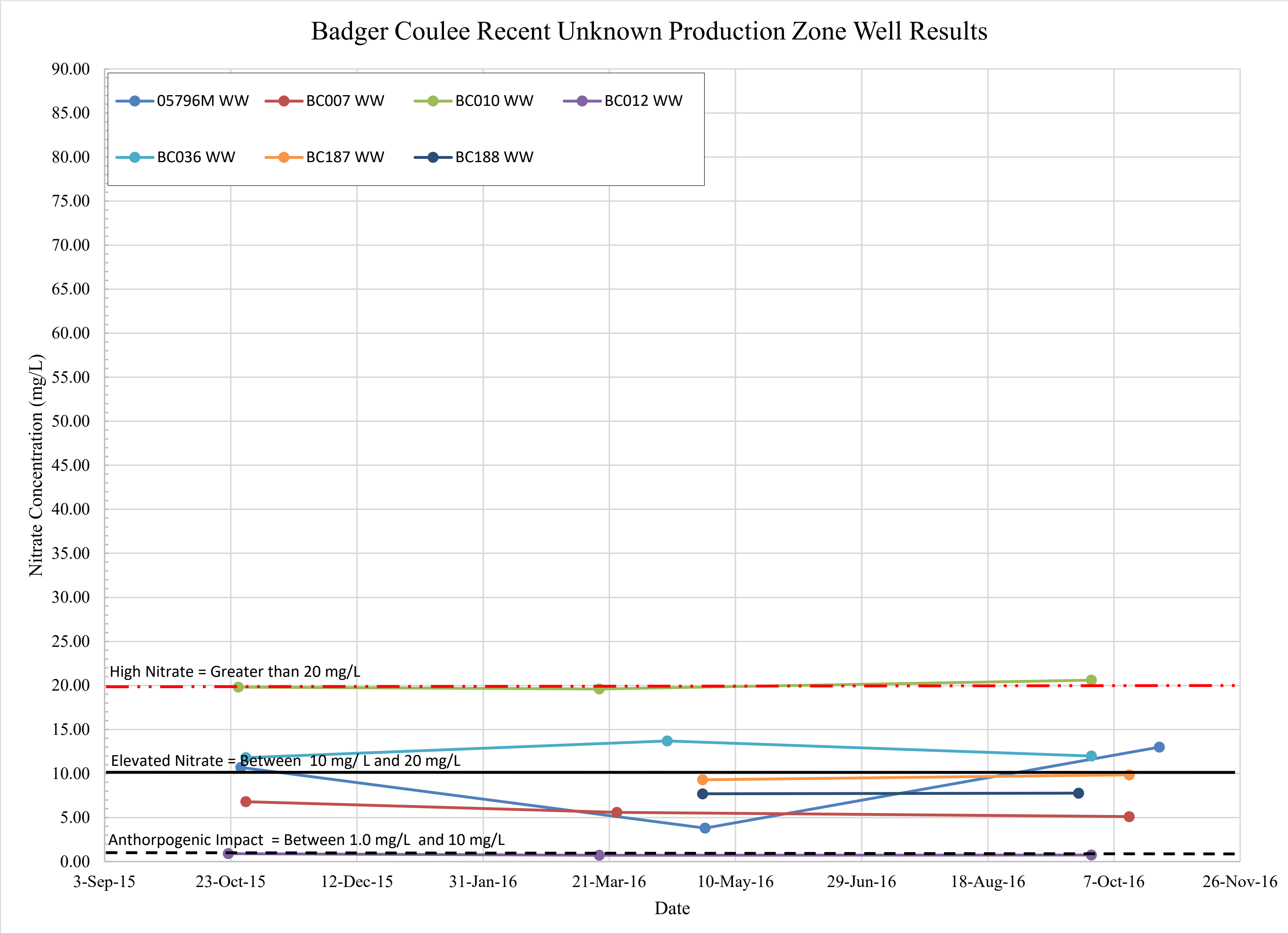
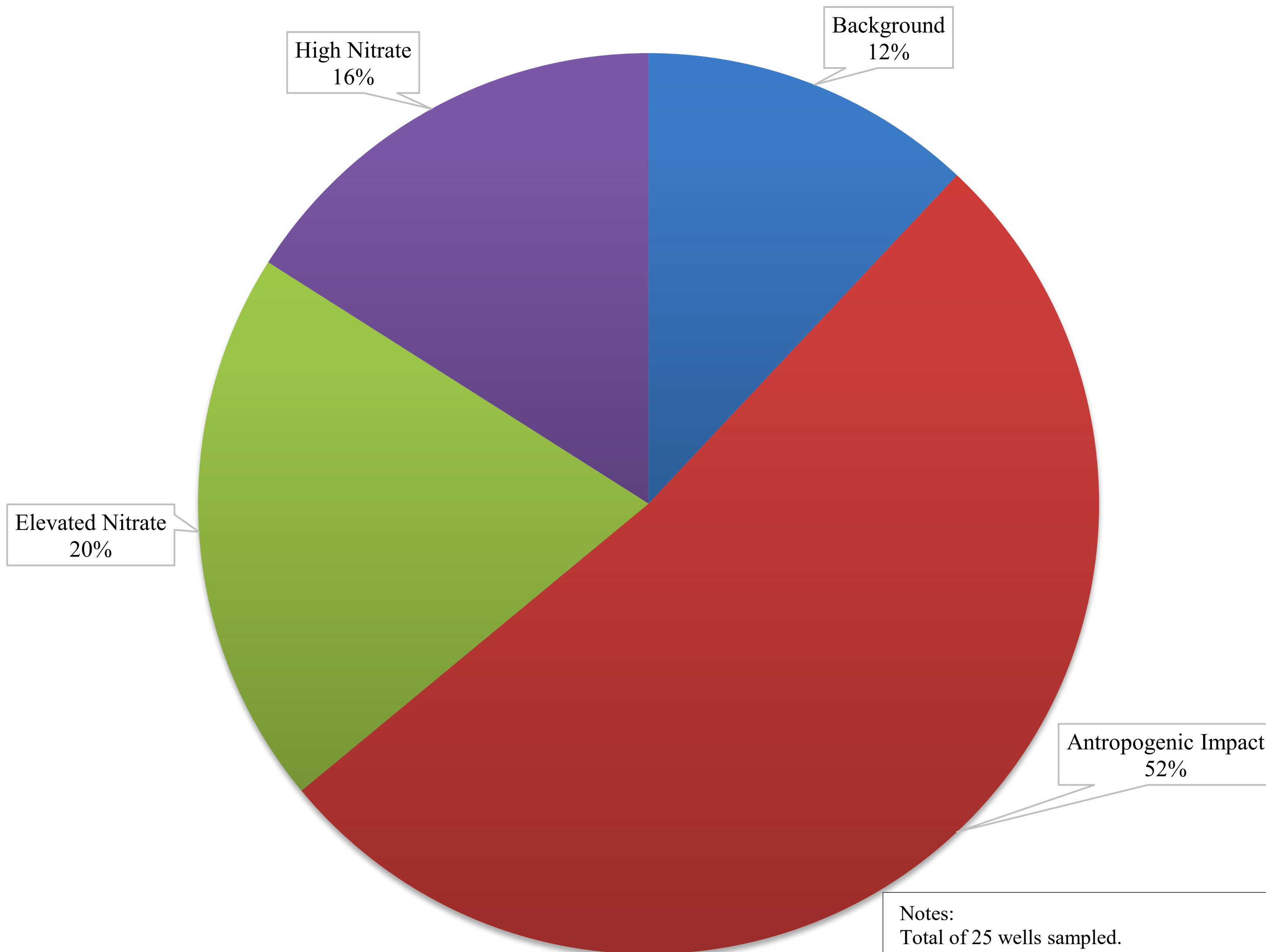

Badger Coulee Recent Unknown Production Zone Well Results
05796M WW
BC007 WW
BC010 WW
BC012 WW
BC036 WW
BC187 WW
BC188 WW
Nitrate Concentration (mg/L)
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
High Nitrate = Greater than 20 mg/L
Elevated Nitrate = Between 10 mg/ L and 20 mg/L
Anthorpogenic Impact = Between 1.0 mg/L and 10 mg/L
3-Sep-15
23-Oct-15
12-Dec-15
31-Jan-16
21-Mar-16
10-May-16
29-Jun-16
18-Aug-16
7-Oct-16
26-Nov-16
Date

Figure A.5. Badger Coulee 2015-2016 Well Percentages



Notes:
Total of 25 wells sampled.
Background = Nitrate less than 1.0 mg/L
Anthropogenic Impact = Nitrate between 1 mg/L and 10 mg/L
Elevated Nitrate = Nitrate between 10.0 mg/L and 20.0 mg/L
High Nitrate = Nitrate greater than 20.0 mg/L

Name	Sample ID	SampleDate	Nitrate ResultOrig (mg/L)	Water bearing Zone	Area
CLODFELTER HEIGHTS 1 & 2	AA64601	2/16/2004	2.300	Shallow Basalt and Intermediate Basalt	Badger Coulee
Two K Bross Well	AB02801	1/19/2005	3.400	Intermediate Basalt	Badger Coulee
Clodfelter Heights 7 & 8	AB03301	11/15/2004	2.900	Intermediate Basalt	Badger Coulee
Klinginsmith	AB11301	3/14/2005	0.800	Intermediate Basalt	Badger Coulee
Clodfelter Heights 13 & 14	AB17301	2/22/2005	0.400	Intermediate Basalt	Badger Coulee
Clodfelter Heights 11 & 12	AB44801	2/8/2004	0.500	Intermediate Basalt	Badger Coulee
Goose Ridge North	AC14401	7/3/2008	0.200	Shallow Basalt and Interr	Badger Coulee
J & B Construction	AC20701	10/14/2008	4.930	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/3/2010	3.500	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	6/1/2009	3.600	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/28/2008	3.600	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/23/2007	3.210	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/16/2006	3.200	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/25/2005	3.800	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/24/2004	3.570	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	11/24/2003	3.600	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	4/12/2002	4.100	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/30/2001	3.000	Alluvial	Badger Coulee
BADGER CANYON WATER ASSN	0060401	5/3/2000	3.780	Alluvial	Badger Coulee
HERITAGE ASSEMBLY OF GOD	0303801	7/27/2006	2.000	Alluvial	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	6/24/2010	0.400	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	6/24/2009	0.200	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	4/21/2009	0.500	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	3/20/2008	0.300	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	6/18/2007	0.200	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	3/29/2006	0.400	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	5/27/2005	0.200	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	12/21/2004	0.070	Intermediate Basalt	Badger Coulee
SUMMIT VIEW WATER SYSTEM	0330301	8/3/2001	0.200	Intermediate Basalt	Badger Coulee
HORST, JOE WATER SYSTEM	0337501	3/7/2001	4.000	Alluvial	Badger Coulee
SUNDANCE ESTATES	0397401	11/9/2007	0.300	Intermediate Basalt	Badger Coulee
SUNDANCE ESTATES	0397401	8/8/2004	0.200	Intermediate Basalt	Badger Coulee
SUNDANCE ESTATES	0397401	3/31/2003	0.400	Intermediate Basalt	Badger Coulee
SUNDANCE ESTATES	0397401	11/27/2001	0.200	Intermediate Basalt	Badger Coulee
SUNDANCE ESTATES	0397401	12/13/2000	0.300	Intermediate Basalt	Badger Coulee
CONNER WATER SYSTEM	0408501	12/4/2001	0.200	Intermediate Basalt	Badger Coulee
SHEEP CANYON NO 2	0468201	8/22/2004	0.700	Shallow Basalt	Badger Coulee
SHEEP CANYON NO 3	0468201	7/6/2000	0.300	Shallow Basalt	Badger Coulee
CANYON VILLAGE WATER SYSTEM INC	0580101	12/29/2009	0.500	Alluvial	Badger Coulee
DESERT ROSE H2O SUPPLY NO 1	0696701	1/11/2010	7.400	Shallow Basalt	Badger Coulee
DESERT ROSE H2O SUPPLY NO 1	0696701	9/7/2007	4.600	Shallow Basalt	Badger Coulee
DESERT ROSE H2O SUPPLY NO 1	0696701	7/2/2004	3.700	Shallow Basalt	Badger Coulee
DESERT ROSE H20 SUPPLY NO 2	0696801	1/11/2010	3.600	Shallow Basalt	Badger Coulee
DESERT ROSE H20 SUPPLY NO 2	0696801	7/7/2007	2.200	Shallow Basalt	Badger Coulee
DESERT ROSE H20 SUPPLY NO 2	0696801	7/2/2004	2.400	Shallow Basalt	Badger Coulee
MARCOUX, CHARLES	1548801	5/2/2008	0.200	Intermediate Basalt	Badger Coulee
MARCOUX, CHARLES	1548801	6/30/2005	0.200	Intermediate Basalt	Badger Coulee

Name	Sample ID	SampleDate	Nitrate ResultOrig (mg/L)	Water bearing Zone	Area
TUMBLE WEED ACRES WELL ASSOCIATION	2187701	5/28/2008	7.000	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	4/20/2010	0.200	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	12/4/2009	0.300	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	8/31/2009	0.200	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	12/18/2008	0.200	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	8/17/2007	0.300	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	8/29/2006	0.050	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	8/10/2005	0.050	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	6/17/2005	0.300	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	7/29/2004	0.200	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	12/30/2003	0.200	Intermediate Basalt	Badger Coulee
BADGER MOUNTAIN IRRIGATION DISTRICT	2261703	2/4/2002	0.050	Intermediate Basalt	Badger Coulee
BADGER CANYON RANCHETTES NO 2	3207401	1/13/2010	1.700	Shallow Basalt and Interi	Badger Coulee
BADGER CANYON RANCHETTES NO 3	3207401	8/10/2007	4.000	Shallow Basalt and Interi	Badger Coulee
KID - Lorayne J	5322005	7/7/2010	1.140	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	6/23/2009	1.200	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	4/1/2008	1.500	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	9/5/2007	0.820	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	12/4/2006	0.200	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	3/22/2005	1.900	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	12/28/2004	0.930	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	4/2/2003	1.980	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	5/22/2002	1.600	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	1/11/2001	0.700	Shallow Basalt	Badger Coulee
KID - Lorayne J	5322005	8/10/2000	1.300	Shallow Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	9/28/2010	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	9/29/2009	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/14/2008	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	12/7/2007	0.500	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/17/2006	0.300	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/4/2005	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	12/30/2004	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/21/2003	0.400	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	3/2/2003	0.500	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/14/2002	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/21/2001	0.200	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/9/2001	0.300	Deep Basalt	Badger Coulee
SOUTHGATE WATER COMPANY	5634402	11/12/2000	0.200	Deep Basalt	Badger Coulee
FARAGHER WATER SYSTEM	6242801	3/25/2004	1.900	Shallow Basalt	Badger Coulee
08N/28E-22D01	461018119181701	9/4/1986	8.100	Alluvial	Badger Coulee
08N/28E-16L01	461025119191201	9/4/1986	11.000	Alluvial	Badger Coulee
08N/28E-14L01	461037119165401	9/5/1986	2.500	Shallow Basalt	Badger Coulee
08N/29E-17G02	461044119122701	2/25/1987	2.600	Shallow Basalt	Badger Coulee
08N/29E-17G02	461044119122701	9/16/1986	2.500	Shallow Basalt	Badger Coulee
08N/29E-17G02	461044119122701	9/2/1986	2.600	Shallow Basalt	Badger Coulee
08N/29E-17G02	461044119122701	6/25/1982	1.800	Shallow Basalt	Badger Coulee
08N/28E-14C02	461102119162601	2/20/1988	2.800	Shallow Basalt	Badger Coulee
08N/28E-14C02	461102119162601	3/4/1987	3.000	Shallow Basalt	Badger Coulee

Name	Sample ID	SampleDate	Nitrate ResultOrig (mg/L)	Water bearing Zone	Area
08N/28E-14C02	461102119162601	9/4/1986	3.000	Shallow Basalt	Badger Coulee
08N/29E-17L01	461105119120501	9/2/1986	3.200	Shallow Basalt	Badger Coulee
08N/28E-07M01	461110119213001	9/15/1988	0.100	Shallow Basalt	Badger Coulee
08N/28E-11R01	461120119155601	9/12/1988	0.100	Shallow Basalt and Interi	Badger Coulee
08N/28E-11R01	461120119155601	2/17/1988	0.100	Shallow Basalt and Interi	Badger Coulee
08N/28E-11R01	461120119155601	9/4/1986	0.300	Shallow Basalt and Interi	Badger Coulee
08N/28E-07P01	461128119213801	8/27/1982	0.100	Shallow Basalt and Interi	Badger Coulee
08N/28E-09F01	461138119190001	9/5/2001	0.221	Shallow Basalt and Interi	Badger Coulee
08N/30E-04N02	461155119042201	9/6/1986	6.500	Alluvial	Badger Coulee
08N/28E-12C03	461155119152301	9/4/1986	5.000	Alluvial	Badger Coulee
08N/29E-07B01	461156119133001	2/17/1988	5.000	Alluvial	Badger Coulee
08N/29E-07B01	461156119133001	2/25/1987	5.600	Alluvial	Badger Coulee
08N/29E-07B01	461156119133001	9/2/1986	8.200	Alluvial	Badger Coulee
08N/28E-01R01	461208119143001	2/17/1988	0.100	Shallow Basalt	Badger Coulee
08N/28E-01R01	461208119143001	9/5/1986	0.100	Shallow Basalt	Badger Coulee
08N/28E-01R02	461213119143301	2/19/1988	5.100	Shallow Basalt	Badger Coulee
08N/28E-01R02	461213119143301	9/5/1986	5.300	Shallow Basalt	Badger Coulee
08N/28E-03P01	461213119174101	9/5/1986	0.100	Intermediate Basalt	Badger Coulee
08N/27E-01G01	461226119223601	2/20/1988	0.100	Shallow Basalt and Interi	Badger Coulee
08N/28E-06G01	461228119210701	9/23/1971	8.600	Alluvial	Badger Coulee
08N/28E-06G01	461235119114201	9/3/1986	16.000	Alluvial	Badger Coulee
08N/27E-01B01	461244119223501	2/17/1988	14.000	Alluvial	Badger Coulee
08N/27E-01B01	461244119223501	2/25/1987	16.000	Alluvial	Badger Coulee
08N/27E-01B01	461244119223501	9/2/1986	12.000	Alluvial	Badger Coulee
08N/27E-01A01D1	461245119221502	7/22/1983	11.000	Shallow Basalt	Badger Coulee
08N/27E-01A01D1	461245119221502	3/8/1983	7.900	Shallow Basalt	Badger Coulee
08N/27E-01A01D1	461245119221502	8/27/1982	11.000	Shallow Basalt	Badger Coulee
09N/29E-36N02	461254119075701	2/22/1988	6.000	Alluvial	Badger Coulee
09N/29E-36N02	461254119075701	9/6/1986	3.500	Alluvial	Badger Coulee
09N/28E-31P01D1	461254119214502	9/13/1988	17.000	Alluvial	Badger Coulee
09N/28E-31P01D1	461254119214502	2/22/1988	11.000	Alluvial	Badger Coulee
09N/28E-31P01D1	461254119214502	9/3/1986	24.000	Alluvial	Badger Coulee
09N/27E-24N01	461446119230301	9/5/2001	0.221	Intermediate Basalt and I	Badger Coulee

Appendix B.

Sample Locations

Table B1. Groundwater Sample Locations

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Location (WA)	Property Ownership	Well Log	Well Type	Latitude	Longitude
BC012WW	Private			46.21431732	119.3594284
BC022WW	Private	BCE649	Alluvial	46.1878891	119.2913055
BC034WW	Private			46.17625427	119.3197098
BC078WW	Private				
BC081WW	Private	AKO797	Alluvial and Shallow Basalt	46.16922379	119.2960587
BC086WW	Private	BHT466		46.1709938	119.2875671
BC087WW	Private	BNQ609	Alluvial and Shallow Basalt	46.17111206	119.3318634
BC088WW	Private	AKH804	Alluvial	46.17427826	119.3308334
BC100WW	Private		Alluvial	46.16902924	119.2872467
BC116WW	Private	AGM112	Alluvial and Shallow Basalt	46.17189026	119.3400803
BC117WW	Private	APG016	Alluvial and Shallow Basalt	46.17391586	119.3441696
BC125WW	Private		Alluvial	46.16852951	119.3063583
BC127WW	Private	APG021	Alluvial	46.17363739	119.3463593
BC128WW	Private	AHK208	Alluvial and Shallow Basalt	46.17205429	119.3344421
BC151WW	Private		Alluvial	46.17058182	119.3252182
BC184WW	Private	ABX320	Alluvial	46.16941833	119.3287201
BC192WW	Private	BCJ725	Shallow and Intermediate Basalt	46.17305374	119.33535

Table B1. Groundwater Sample Locations

Groundwater and Surface Water Nitrate Monitoring
Badger Coulee, Bentron County, Washington

Location (WA)	Property Ownership	Well Log	Well Type	Latitude	Longitude
BC194WW	Private	ALC739	Alluvial	46.17494965	119.3404388
BC500WW	Private			46.17519379	119.3348236
BC782321WW	Private	BBJ639	Shallow and Intermediate Basalt	46.2014389	119.3812027
BC232WW	Private	AEL588	Shallow Basalt	46.16820526	119.298233
BC235WW	Private			46.2149086	119.3660507
BC239WW	Private	AAL297	Shallow Basalt	46.20166779	119.3730545
BC240WW	Private	BAP194	Shallow Basalt	46.16822052	119.3337479
BC246WW	Private	AFH017	Alluvial	46.21672058	119.3619461
BC254WW	Private	AGM135	Alluvial	46.17397308	119.3370285
BC266WW	Private			46.19388962	119.2897186
BC268WW	Private	BLD098	Alluvial	46.17193985	119.3413773
BC609WW	Private		Alluvial	46.17623138	119.3201218
BC610WW	Private		Alluvial and Shallow Basalt	46.16765976	119.2919769
BC612WW	Private	BBJ622	Shallow Basalt	46.16915131	119.3318024
BC613WW	Private	AEG423	Alluvial	46.17784119	119.33255
BC615WW	Private			46.23556137	119.4664993
BC274WW	Private			46.21842957	119.369957
BC601WW	Private	AHG900	Intermediate Basalt	46.19681931	119.2954712
BC608WW	Private		Shallow Basalt	46.20182037	119.3696136
BC603WW	Private	APK165	Alluvial	46.21480942	119.3804016
BC607WW	Private		Shallow Basalt	46.21001053	119.3824081
BC277WW	Private			46.17481995	119.3323898
BC600WW	Private	AEL011	Alluvial	46.1740799	119.3261795
BC279WW	Private	AKH817		46.17481995	119.3323898
BC278WW	Private			46.21910858	119.3607101

Table B1. Groundwater Sample Locations

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Location (WA)	Property Ownership	Well Log	Well Type	Latitude	Longitude
BC614WW	Private	BHT510		46.16801834	119.3373337
BC606WW	Private	BLD141	Shallow Basalt	46.21062088	119.3751373
BC605WW	Private	BIF672	Shallow Basalt	46.16682816	119.2965164
BC275WW	Private			46.16820526	119.298233
BC611WW	Private	AEL422	Shallow Basalt	46.17993164	119.2767563
BC273WW	Private	AEL423		46.18001938	119.2767563
BC616WW	Private		Alluvial	46.17173004	119.2934189
BC276WW	Private			46.17501068	119.2826233
BC604WW	Private	BBJ801	Alluvial	46.18793106	119.2928314
BC602WW	Private	AKA079	Alluvial	46.21397018	119.3813019
BC325WW	Private			46.174235	119.290247

Table B1. Surface Water Sample Locations

Groundwater and Surface Water Nitrate Monitoring
Badger Coulee, Bentron County, Washington

Location (WA)	Adjacent Water Body	Water Type (canal, creek, ditch, etc?)	Latitude	Longitude
BC001SW	Yakima River	Creek	46.24343	-119.464
BC002SW	Amon Creek	Canal	46.19841	-119.366
BC003SW	Amon Creek	Canal	46.21499	-119.357
BC004SW	Amon Creek	Creek	46.20386	-119.262
BC005SW	Amon Creek	Creek	46.2048	-119.264
BC006SW	Amon Creek	Creek	46.21668	-119.258
BC007SW	Amon Creek	Creek	46.21672	-119.252
BC008SW	Amon Creek	Creek	46.24053	-119.259
BC009SW	Yakima River	Spring	46.25887	-119.292
BC0010SW	Yakima River	Creek	46.24705	-119.261

Appendix C.

Data Quality Control and Validation

Table C.1. Field Duplicate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample Source	Sample ID	Date Sampled	Date Analyzed	Parent Sample Nitrate (mg/L)	Field Duplicate Nitrate (mg/L)	RPD%	Meets QA Criteria (RPD ≤ 20)
Groundwater Wells							
Well	BC235 WW	10/1/2020	10/2/2020	15.3	15.1	1.32	Yes
Well	BC087 WW	10/6/2020	10/7/2020	19.9	19.9	0	Yes
Well	BC088 WW	10/6/2020	10/7/2020	15.8	15.9	0.63	Yes
Well	BC184 WW	10/6/2020	10/7/2020	18.7	18.9	1.06	Yes
Well	BC232 WW	10/7/2020	10/7/2020	8.2	8.3	1.21	Yes
Well	BC022 WW	10/8/2020	10/9/2020	16.4	16.2	1.23	Yes
Well	BC254 WW	10/8/2020	10/9/2020	1.5	1.5	0	Yes
Well	BC022WW	1/11/2021	1/13/2021	23.9	24.3	1.66	Yes
Well	BC604WW	1/11/2021	1/13/2021	16.7	16.9	1.19	Yes
Well	BC611WW	1/11/2021	1/13/2021	16.3	16.5	1.22	Yes
Well	BC125WW	3/23/2021	3/24/2021	11.5	11.7	1.72	Yes
Well	BC232WW	3/23/2021	3/24/2021	7.2	7.3	1.38	Yes
Well	BC609WW	3/23/2021	3/24/2021	3.4	3.3	2.99	Yes
Well	BC034WW	3/23/2021	3/24/2021	7.5	7.4	1.34	Yes
Well	BC277WW	3/23/2021	3/24/2021	4.8	4.8	0	Yes
Well	BC601WW	8/13/2021	8/13/2021	7.2	6.9	4.26	Yes
Well	BC022WW	8/13/2021	8/13/2021	16	16	0	Yes
Well	BC100WW	8/13/2021	8/13/2021	0.8	0.7	13.3	Yes
Well	BC782321WW	8/9/2021	8/11/2021	44.1	44.7	1.35	Yes
Well	BC601WW	11/8/2021	11/10/2021	8.1	8	1.24	Yes
Well	BC266WW	11/8/2021	11/10/2021	17.7	18.1	2.23	Yes
Well	BC022WW	11/8/2021	11/10/2021	18	18.3	1.65	Yes
Well	BC604WW	11/8/2021	11/10/2021	17.9	18.3	2.21	Yes
Well	BC611WW	11/8/2021	11/10/2021	17.3	17	1.75	Yes
Well	BC601WW	1/19/2022	1/19/2022	10	10.3	2.96	Yes
Well	BC266WW	1/20/2022	1/21/2022	17.3	17.5	1.15	Yes
Well	BC022WW	1/20/2022	1/21/2022	28.3	28.9	2.1	Yes
Well	BC782321WW	1/20/2022	1/21/2022	44.1	44.5	0.9	Yes
Well	BC601WW	4/5/2022	4/6/2022	12.5	12.6	0.8	Yes

Table C.1. Field Duplicate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample Source	Sample ID	Date Sampled	Date Analyzed	Parent Sample Nirate (mg/L)	Field Duplicate Nitrate (mg/L)	RPD%	Meets QA Criteria (RPD ≤ 20)
Well	BC266WW	4/5/2022	4/6/2022	17.5	17.8	1.7	Yes
Well	BC022WW	4/5/2022	4/6/2022	29.6	30.3	2.34	Yes
Well	BC604WW	4/5/2022	4/6/2022	17.8	18.1	1.67	Yes
Well	BC611WW	4/5/2022	4/6/2022	16.4	16.6	1.21	Yes
Well	BC612WW	7/20/2022	7/20/2022	12.5	12.2	2.43	Yes
Well	BC268WW	7/20/2022	7/20/2022	4.9	4.6	5.92	Yes
Well	BC151WW	7/20/2022	7/20/2022	8.8	9.1	2.46	Yes
Well	BC184WW	7/20/2022	7/20/2022	19.6	19.6	0	Yes
Well	BC194WW	9/27/2022	9/28/2022	12	11.9	0.84	Yes
Well	BC246WW	9/27/2022	9/28/2022	1.4	1.4	1.45	Yes
Well	BC279WW	9/27/2022	9/28/2022	13.8	13.5	2.2	Yes
Well	BC608WW	9/27/2022	9/28/2022	7.9	8	2.14	Yes
Well	BC610WW	9/28/2022	9/28/2022	22.4	23.6	5.22	Yes
Surface Water							
Surface	BC002SW	10/9/2020	10/9/2020	1.7	1.7	0	Yes
Surface	BC0105SW	3/25/2021	3/26/2021	6.5	6.1	6.35	Yes
Surface	BC010SW	8/16/2021	8/18/2021	1.7	1.7	0	Yes
Surface	BC004SW	11/15/2021	11/17/2021	4.5	4.3	4.32	Yes
Surface	BC003SW	4/28/2022	4/29/2022	0.8	0.5	46.15	No
Surface	BC009SW	10/3/2022	10/5/2022	9.2	9.2	0.54	Yes

Table C.2. Performance Evaluation Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Source Water	Sample ID	Date Collected	Date Analyzed	PE Nitrate Conc. (mg/L)	Reference Solution Nitrate Conc. (mg/L)	Perenct Recovery (%)	Meets QA Criteria? (78% –125%)
Groundwater Well							
Well	BC612 PE	9/28/2020	9/30/2020	1.3	1	130	No
Well	BC610 PE	9/28/2020	9/30/2020	10.9	10	109	Yes
Well	BC613 PE	9/28/2020	9/30/2020	36.2	35	103.43	Yes
Well	BC609 PE	9/28/2020	9/30/2020	99	100	99	Yes
Well	BC151PE	1/12/2021	1/13/2021	1.31	1	131	No
Well	BC088PE	1/12/2021	1/13/2021	11.3	10	113	Yes
Well	BC087PE	1/12/2021	1/13/2021	37	35	105.71	Yes
Well	BC612PE	1/12/2021	1/13/2021	103	100	103	Yes
Well	BC240PE	3/24/2021	3/24/2021	1.4	1	140	No
Well	BC614PE	3/24/2021	3/24/2021	10.3	10	103	Yes
Well	BC128PE	3/24/2021	3/24/2021	36.1	35	103.14	Yes
Well	BC192 PE	3/24/2021	3/24/2021	102	100	102	Yes
Well	BC232 PE	8/11/2021	8/11/2021	1.3	1	130	No
Well	BC088 PE	8/11/2021	8/11/2021	11.5	10	115	Yes
Well	BC087 PE	8/11/2021	8/11/2021	36	35	102.86	Yes
Well	BC151 PE	8/11/2021	8/11/2021	102	100	102	Yes
Well	BC601 PE	8/13/2021	8/13/2021	10.1	10	101	Yes
Well	BC240PE	11/10/2021	11/10/2021	1.3	1	130	No
Well	BC614PE	11/10/2021	11/10/2021	10.5	10	105	Yes
Well	BC128PE	11/10/2021	11/10/2021	36.1	35	103.14	Yes
Well	BC192PE	11/10/2021	11/10/2021	98.2	100	98.2	Yes
Well	BC194PE	1/21/2022	1/21/2022	1.3	1	130	No
Well	BC613PE	1/21/2022	1/21/2022	10.9	10	109	Yes
Well	BC117PE	1/21/2022	1/21/2022	34.8	35	99.43	Yes
Well	BC086PE	1/21/2022	1/21/2022	98.2	100	98.2	Yes
Well	BC127PE	4/7/2022	4/8/2022	1.3	1	129	No
Well	BC194PE	4/7/2022	4/8/2022	11.2	10	112	Yes
Well	BC500PE	4/7/2022	4/8/2022	36.2	35	103.43	Yes
Well	BC279PE	4/7/2022	4/8/2022	98.6	100	98.6	Yes
Well/Surface*	BC273PE1*	7/21/2022	7/22/2022	1.4	1	140	No
Well	BC034PE4	7/21/2022	7/22/2022	37.2	35	106.29	Yes
Well//Surface*	BC088PE3*	7/21/2022	7/22/2022	11.2	10	112	Yes

Table C.2. Performance Evaluation Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Source Water	Sample ID	Date Collected	Date Analyzed	PE Nitrate Conc. (mg/L)	Reference Solution Nitrate Conc. (mg/L)	Perenct Recovery (%)	Meets QA Criteria? (78% –125%)
Well	BC125PE2	7/21/2022	7/22/2022	102	100	102	Yes
Well	BC001PE	9/27/2022	9/28/2022	1	1	100	Yes
Well	BC002PE	9/27/2022	9/28/2022	10.6	10	106	Yes
Well	BC003PE	9/27/2022	9/28/2022	36.3	35	103.71	Yes
Well	BC004PE	9/27/2022	9/28/2022	100	100	100	Yes
Surface Water							
Surface	BC001 PE	10/9/2020	10/9/2020	1.2	1	120	Yes
Surface	BC001 PE	10/9/2020	10/9/2020	36	35	102.86	Yes
Surface	BC010 PE	3/23/2021	3/24/2021	1.5	1	150	No
Surface	BC009 PE	3/23/2021	3/24/2021	12	10	120	Yes
Surface	BC003 PE	4/12/2021	4/12/2021	1.1	1	110	Yes
Surface	BC002 PE	4/12/2021	4/12/2021	36.9	35	105.43	Yes
Surface	BC008 PE	8/16/2021	8/18/2021	1.1	1	110	Yes
Surface	BC009 PE	8/16/2021	8/18/2021	9.8	10	98	Yes
Surface	BC001PE	4/28/2022	4/29/2022	1.1	1	110	Yes
Surface	BC002PE	4/28/2022	4/29/2022	36	35	102.86	Yes
Surface	BC005	11/15/2021	11/17/2021	1.8	1	180	No
Surface	BC006	11/15/2021	11/17/2021	35.2	35	100.57	Yes
Surface	BC000PE1	10/3/2022	10/5/2022	0.6	1	60	No
Surface	BC000PE2	10/3/2022	10/5/2022	9.8	10	98	Yes

*Well water and surface water samples were collected and submitted to the laboratory on the same day. Only one set of PE samples were submitted to the laboratory.

Table C.3. Field Blank Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sampling Event	Field Blank Sample ID	Nitrate Conc. (mg/L)	Sample Collection Date	Sample Analyzed Date	Field Blank Solution Source
Groundwater Well Events					
Fall 2020/WW	BC615FB	0.4	9/29/2020	9/30/2020	BFHD
Winter 2021/WW	BC782321FB	0.63	1/13/2021	1/13/2021	BFHD
Spring 2021/WW	BC605FB	0.5	3/22/2021	3/24/2021	BFHD
Summer 2021/WW	BC612FB	NA	8/11/2021	8/11/2021	BFHD
Fall 2021/WW	BC125FB	< 0.5	11/9/2021	11/10/2021	BFHD
Winter 2022/WW	BC246FB	< 0.5	1/19/2021	1/20/2021	BFHD
Spring 2022/WW	BC268FB	< 0.5	4/6/2022	4/7/2022	BFHD
Fall 2022/WW	BC000FB	< 0.5	9/28/2022	9/28/2022	BFHD
Surface Water Well Events					
Fall 2020/SW	BC004BF	<0.5	10/9/2020	10/9/2020	BFHD
Spring 2021/SW	BC004FB	0.4	3/24/2021	3/24/1931	BFHD
Summer 2021/SW	BC0001SWFB	<0.5	8/16/2021	8/18/2021	BFHD
Fall 2021/SW	BC001SWFB	< 0.5	11/15/2021	11/17/2021	BFHD
Spring 2022/SW	BC004FB	< 0.5	4/28/2023	4/29/2023	BFHD
Summer 2022/WW+SW*	BC605FB	< 0.5	7/19/2022	7/20/2022	BFHD
Fall 2022/SW	BC000FB	< 0.5	10/3/2022	10/3/2022	BFHD

*Well water and surface water samples were collected and submitted to the laboratory on the same day. Only one set of FB samples were submitted to the laboratory.

NR = Not Reported

Appendix D.

2020-2022 Groundwater and Surface Water Nitrate Concentration Results and Laboratory Reports

Table D.1. Water Well Nitrate Results
Groundwater and Surface Water Nitrate Monitoring
Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC022WW	Alluvial	10/8/2020	16.4
BC022WW	Alluvial	1/11/2021	23.9
BC022WW	Alluvial	3/22/2021	24.7
BC022WW	Alluvial	8/9/2021	17.3
BC022WW	Alluvial	8/9/2021	16
BC022WW	Alluvial	11/8/2021	18
BC022WW	Alluvial	1/20/2022	28.3
BC022WW	Alluvial	4/5/2022	29.6
BC022WW	Alluvial	7/19/2022	19.4
BC022WW	Alluvial	9/29/2022	18.6
BC088WW	Alluvial	10/6/2020	15.8
BC088WW	Alluvial	1/12/2021	16.6
BC088WW	Alluvial	3/23/2021	15.9
BC088WW	Alluvial	8/9/2021	15.6
BC088WW	Alluvial	11/9/2021	15.5
BC088WW	Alluvial	1/21/2022	14.5
BC088WW	Alluvial	4/6/2022	15.3
BC088WW	Alluvial	7/21/2022	16.5
BC088WW	Alluvial	9/27/2022	15.4
BC100WW	Alluvial	10/7/2020	1
BC100WW	Alluvial	3/22/2021	0.8
BC100WW	Alluvial	8/9/2021	0.8
BC100WW	Alluvial	8/9/2021	0.8
BC100WW	Alluvial	11/8/2021	0.7
BC100WW	Alluvial	1/20/2022	0.8
BC100WW	Alluvial	4/5/2022	1
BC100WW	Alluvial	7/21/2022	0.9
BC100WW	Alluvial	9/29/2022	1.2
BC125WW	Alluvial	10/7/2020	10.7
BC125WW	Alluvial	1/11/2021	11.6
BC125WW	Alluvial	3/23/2021	11.5
BC125WW	Alluvial	8/10/2021	11.3
BC125WW	Alluvial	11/9/2021	9.3
BC125WW	Alluvial	1/20/2022	8.3
BC125WW	Alluvial	4/5/2022	7.2
BC125WW	Alluvial	7/21/2022	4.6
BC125WW	Alluvial	9/27/2022	8.4
BC127WW	Alluvial	10/5/2020	4.2
BC127WW	Alluvial	1/12/2021	4.7
BC127WW	Alluvial	3/24/2021	6.2
BC127WW	Alluvial	8/10/2021	7.8
BC127WW	Alluvial	11/10/2021	10.2
BC127WW	Alluvial	1/21/2022	11.2
BC127WW	Alluvial	4/7/2022	14.3
BC127WW	Alluvial	7/20/2022	20.9
BC127WW	Alluvial	9/27/2022	23.4

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC151WW	Alluvial	10/6/2020	6.2
BC151WW	Alluvial	1/12/2021	7.2
BC151WW	Alluvial	3/23/2021	7.3
BC151WW	Alluvial	8/10/2021	6.2
BC151WW	Alluvial	11/9/2021	8
BC151WW	Alluvial	1/21/2022	8.1
BC151WW	Alluvial	4/6/2022	8.5
BC151WW	Alluvial	7/20/2022	8.8
BC151WW	Alluvial	9/29/2022	9
BC184WW	Alluvial	10/6/2020	18.7
BC184WW	Alluvial	1/11/2021	20.5
BC184WW	Alluvial	3/23/2021	17.5
BC184WW	Alluvial	8/10/2021	21
BC184WW	Alluvial	11/9/2021	20.5
BC184WW	Alluvial	1/20/2022	19.2
BC184WW	Alluvial	4/6/2022	19.4
BC184WW	Alluvial	7/20/2022	19.6
BC184WW	Alluvial	9/27/2022	15.1
BC194WW	Alluvial	10/5/2020	12.1
BC194WW	Alluvial	1/12/2021	14.1
BC194WW	Alluvial	3/24/2021	14.1
BC194WW	Alluvial	8/10/2021	14.3
BC194WW	Alluvial	11/10/2021	14.1
BC194WW	Alluvial	1/21/2022	13.5
BC194WW	Alluvial	4/7/2022	12.9
BC194WW	Alluvial	7/20/2022	11.4
BC194WW	Alluvial	9/27/2022	12
BC246WW	Alluvial	10/8/2020	1.3
BC246WW	Alluvial	1/13/2021	5.2
BC246WW	Alluvial	3/25/2021	2.2
BC246WW	Alluvial	8/10/2021	1.7
BC246WW	Alluvial	11/16/2021	1.4
BC246WW	Alluvial	1/19/2022	2.3
BC246WW	Alluvial	4/7/2022	1.5
BC246WW	Alluvial	7/19/2022	1.4
BC246WW	Alluvial	9/27/2022	1.4
BC254WW	Alluvial	10/8/2020	1.5
BC254WW	Alluvial	1/12/2021	16.5
BC254WW	Alluvial	3/24/2021	18
BC254WW	Alluvial	8/11/2021	18.6
BC254WW	Alluvial	11/10/2021	18.7
BC254WW	Alluvial	1/21/2022	16.6
BC254WW	Alluvial	4/6/2022	16.8
BC254WW	Alluvial	7/28/2022	18.1
BC254WW	Alluvial	9/29/2022	14.7

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC268WW	Alluvial	10/5/2020	2.9
BC268WW	Alluvial	1/12/2021	2.9
BC268WW	Alluvial	3/24/2021	2.8
BC268WW	Alluvial	8/11/2021	3.6
BC268WW	Alluvial	11/10/2021	4.1
BC268WW	Alluvial	1/21/2022	2.7
BC268WW	Alluvial	4/6/2022	2.8
BC268WW	Alluvial	7/20/2022	4.9
BC268WW	Alluvial	9/27/2022	3.7
BC273WW	Alluvial	4/5/2022	13.4
BC273WW	Alluvial	7/21/2022	13.7
BC600WW	Alluvial	9/30/2020	7.5
BC600WW	Alluvial	1/11/2021	8
BC600WW	Alluvial	3/23/2021	7.8
BC600WW	Alluvial	8/11/2021	8
BC600WW	Alluvial	11/9/2021	7.9
BC600WW	Alluvial	1/20/2022	7.2
BC600WW	Alluvial	4/6/2022	8.2
BC600WW	Alluvial	7/20/2022	7.93
BC600WW	Alluvial	9/27/2022	7.4
BC602WW	Alluvial	10/2/2020	3.6
BC602WW	Alluvial	3/25/2021	3.3
BC602WW	Alluvial	11/16/2021	3.8
BC602WW	Alluvial	4/7/2022	3
BC602WW	Alluvial	9/29/2022	2.9
BC603WW	Alluvial	9/29/2020	4.7
BC603WW	Alluvial	1/13/2021	16.4
BC603WW	Alluvial	3/25/2021	4.8
BC604WW	Alluvial	10/2/2020	16.5
BC604WW	Alluvial	1/11/2021	16.7
BC604WW	Alluvial	3/22/2021	17
BC604WW	Alluvial	8/11/2021	17.2
BC604WW	Alluvial	11/8/2021	17.9
BC604WW	Alluvial	1/20/2022	17.3
BC604WW	Alluvial	4/5/2022	17.8
BC604WW	Alluvial	7/19/2022	17.6
BC604WW	Alluvial	9/27/2022	18.3
BC609WW	Alluvial	9/28/2020	3.6
BC609WW	Alluvial	1/11/2021	3.9
BC609WW	Alluvial	3/23/2021	3.4
BC609WW	Alluvial	8/11/2021	3
BC609WW	Alluvial	11/9/2021	3.4
BC609WW	Alluvial	1/20/2022	3.2
BC609WW	Alluvial	4/5/2022	3.3
BC609WW	Alluvial	7/21/2022	3.1

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC609WW	Alluvial	9/29/2022	1.6
BC613WW	Alluvial	9/28/2020	8.2
BC613WW	Alluvial	1/12/2021	8.1
BC613WW	Alluvial	3/24/2021	8.3
BC613WW	Alluvial	8/11/2021	7.3
BC613WW	Alluvial	11/10/2021	8.4
BC613WW	Alluvial	1/21/2022	7.4
BC613WW	Alluvial	4/7/2022	9.2
BC613WW	Alluvial	7/20/2022	6.6
BC613WW	Alluvial	9/29/2022	6.7
BC616WW	Alluvial	10/1/2020	13.3
BC616WW	Alluvial	1/11/2021	12.9
BC616WW	Alluvial	3/22/2021	12.6
BC616WW	Alluvial	8/13/2021	12.7
BC616WW	Alluvial	11/8/2021	12.7
BC616WW	Alluvial	1/20/2022	12.6
BC616WW	Alluvial	4/5/2022	12.8
BC616WW	Alluvial	7/28/2022	14.4
BC616WW	Alluvial	9/27/2022	12.5
BC081WW	Alluvial and Shallow Basalt	10/7/2020	12.1
BC081WW	Alluvial and Shallow Basalt	3/22/2021	12.5
BC081WW	Alluvial and Shallow Basalt	11/8/2021	12.3
BC081WW	Alluvial and Shallow Basalt	4/5/2022	12.8
BC081WW	Alluvial and Shallow Basalt	9/28/2022	12.7
BC087WW	Alluvial and Shallow Basalt	10/6/2020	19.9
BC087WW	Alluvial and Shallow Basalt	1/12/2021	19.8
BC087WW	Alluvial and Shallow Basalt	3/23/2021	22.2
BC087WW	Alluvial and Shallow Basalt	8/9/2021	18.5
BC087WW	Alluvial and Shallow Basalt	11/9/2021	6.6
BC087WW	Alluvial and Shallow Basalt	1/21/2022	7.2
BC087WW	Alluvial and Shallow Basalt	4/6/2022	9.03
BC087WW	Alluvial and Shallow Basalt	7/20/2022	7.9
BC087WW	Alluvial and Shallow Basalt	9/29/2022	6.5
BC116WW	Alluvial and Shallow Basalt	10/5/2020	1.6
BC116WW	Alluvial and Shallow Basalt	1/12/2021	13.1
BC116WW	Alluvial and Shallow Basalt	3/24/2021	13.1
BC116WW	Alluvial and Shallow Basalt	8/10/2021	9
BC116WW	Alluvial and Shallow Basalt	11/10/2021	8.5
BC116WW	Alluvial and Shallow Basalt	1/21/2022	8.7
BC116WW	Alluvial and Shallow Basalt	4/6/2022	9.2
BC116WW	Alluvial and Shallow Basalt	7/20/2022	8.4
BC116WW	Alluvial and Shallow Basalt	9/27/2022	9.2
BC117WW	Alluvial and Shallow Basalt	10/5/2020	21.7
BC117WW	Alluvial and Shallow Basalt	1/12/2021	25.6
BC117WW	Alluvial and Shallow Basalt	3/24/2021	29.7

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC117WW	Alluvial and Shallow Basalt	8/10/2021	31.4
BC117WW	Alluvial and Shallow Basalt	11/10/2021	33.1
BC117WW	Alluvial and Shallow Basalt	1/21/2022	42.2
BC117WW	Alluvial and Shallow Basalt	7/28/2022	59
BC117WW	Alluvial and Shallow Basalt	9/27/2022	46.8
BC128WW	Alluvial and Shallow Basalt	10/6/2020	3.4
BC128WW	Alluvial and Shallow Basalt	1/12/2021	13.1
BC128WW	Alluvial and Shallow Basalt	3/24/2021	8.7
BC128WW	Alluvial and Shallow Basalt	8/10/2021	14.3
BC128WW	Alluvial and Shallow Basalt	11/10/2021	12.6
BC128WW	Alluvial and Shallow Basalt	1/21/2022	4.5
BC128WW	Alluvial and Shallow Basalt	4/6/2022	5
BC128WW	Alluvial and Shallow Basalt	7/20/2022	12.4
BC128WW	Alluvial and Shallow Basalt	9/27/2022	12.6
BC610WW	Alluvial and Shallow Basalt	9/28/2020	25.3
BC610WW	Alluvial and Shallow Basalt	3/22/2021	18
BC610WW	Alluvial and Shallow Basalt	11/8/2021	18.3
BC610WW	Alluvial and Shallow Basalt	4/5/2022	21
BC610WW	Alluvial and Shallow Basalt	9/28/2022	22.4
BC601WW	Intermediate Basalt	9/29/2020	8.2
BC601WW	Intermediate Basalt	1/11/2021	11.2
BC601WW	Intermediate Basalt	3/22/2021	11.3
BC601WW	Intermediate Basalt	8/11/2021	7.5
BC601WW	Intermediate Basalt	8/11/2021	6.9
BC601WW	Intermediate Basalt	11/8/2021	8.1
BC601WW	Intermediate Basalt	1/20/2022	10
BC601WW	Intermediate Basalt	4/5/2022	12.5
BC601WW	Intermediate Basalt	7/21/2022	10.9
BC601WW	Intermediate Basalt	9/29/2022	7.5
BC192WW	Shallow and Intermediate Basalt	10/6/2020	30.6
BC192WW	Shallow and Intermediate Basalt	1/12/2021	30.8
BC192WW	Shallow and Intermediate Basalt	3/24/2021	30.1
BC192WW	Shallow and Intermediate Basalt	8/10/2021	30.2
BC192WW	Shallow and Intermediate Basalt	11/10/2021	27.2
BC192WW	Shallow and Intermediate Basalt	1/21/2022	24.9
BC192WW	Shallow and Intermediate Basalt	4/6/2022	25.8
BC192WW	Shallow and Intermediate Basalt	7/21/2022	30.5
BC192WW	Shallow and Intermediate Basalt	9/27/2022	29.4
BC782321WW	Shallow and Intermediate Basalt	10/5/2020	11.8
BC782321WW	Shallow and Intermediate Basalt	1/13/2021	46
BC782321WW	Shallow and Intermediate Basalt	3/25/2021	43.2
BC782321WW	Shallow and Intermediate Basalt	8/13/2021	44.1
BC782321WW	Shallow and Intermediate Basalt	11/16/2021	45
BC782321WW	Shallow and Intermediate Basalt	1/19/2022	44.1
BC782321WW	Shallow and Intermediate Basalt	4/7/2022	44.1

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC782321WW	Shallow and Intermediate Basalt	7/21/2022	44.7
BC782321WW	Shallow and Intermediate Basalt	9/29/2022	42.5
BC232WW	Shallow Basalt	10/7/2020	8.2
BC232WW	Shallow Basalt	1/11/2021	7.6
BC232WW	Shallow Basalt	3/23/2021	7.3
BC232WW	Shallow Basalt	8/10/2021	7
BC232WW	Shallow Basalt	11/9/2021	7.4
BC232WW	Shallow Basalt	1/20/2022	6.6
BC232WW	Shallow Basalt	4/5/2022	6.4
BC232WW	Shallow Basalt	7/20/2022	6.7
BC232WW	Shallow Basalt	9/28/2022	7.3
BC239WW	Shallow Basalt	10/8/2020	5.4
BC239WW	Shallow Basalt	1/13/2021	6.2
BC239WW	Shallow Basalt	3/25/2021	6
BC239WW	Shallow Basalt	8/10/2021	5.4
BC239WW	Shallow Basalt	11/16/2021	5.3
BC239WW	Shallow Basalt	1/19/2022	5.8
BC239WW	Shallow Basalt	4/7/2022	6.2
BC239WW	Shallow Basalt	7/19/2022	4.6
BC239WW	Shallow Basalt	9/27/2022	4.3
BC240WW	Shallow Basalt	10/6/2020	3.8
BC240WW	Shallow Basalt	1/12/2021	5.7
BC240WW	Shallow Basalt	3/24/2021	4.4
BC240WW	Shallow Basalt	8/10/2021	4.8
BC240WW	Shallow Basalt	11/10/2021	6.4
BC240WW	Shallow Basalt	1/21/2022	7.2
BC240WW	Shallow Basalt	4/6/2022	7.4
BC240WW	Shallow Basalt	7/20/2022	6.6
BC240WW	Shallow Basalt	9/29/2022	5
BC605WW	Shallow Basalt	10/1/2020	7.7
BC605WW	Shallow Basalt	1/11/2021	20.9
BC605WW	Shallow Basalt	3/22/2021	17.2
BC605WW	Shallow Basalt	8/10/2021	5.3
BC605WW	Shallow Basalt	11/8/2021	17.4
BC605WW	Shallow Basalt	1/20/2022	17.5
BC605WW	Shallow Basalt	4/5/2022	12
BC605WW	Shallow Basalt	7/28/2022	5.7
BC605WW	Shallow Basalt	9/27/2022	6.8
BC606WW	Shallow Basalt	9/30/2020	5.2
BC606WW	Shallow Basalt	1/13/2021	4.9
BC606WW	Shallow Basalt	3/25/2021	5.4
BC606WW	Shallow Basalt	8/11/2021	5.1
BC606WW	Shallow Basalt	11/16/2021	4.8
BC606WW	Shallow Basalt	1/19/2022	4.9
BC606WW	Shallow Basalt	4/7/2022	5.3

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC606WW	Shallow Basalt	7/19/2022	5.6
BC606WW	Shallow Basalt	9/29/2022	5.3
BC607WW	Shallow Basalt	9/29/2020	17.3
BC607WW	Shallow Basalt	1/13/2021	23.1
BC607WW	Shallow Basalt	3/25/2021	23.4
BC607WW	Shallow Basalt	8/11/2021	22.7
BC607WW	Shallow Basalt	11/16/2021	20.5
BC607WW	Shallow Basalt	1/19/2022	17.9
BC607WW	Shallow Basalt	4/7/2022	15.6
BC607WW	Shallow Basalt	7/19/2022	14.2
BC607WW	Shallow Basalt	9/28/2022	12.9
BC608WW	Shallow Basalt	9/29/2020	6.3
BC608WW	Shallow Basalt	1/13/2021	4.6
BC608WW	Shallow Basalt	3/25/2021	5.7
BC608WW	Shallow Basalt	8/11/2021	8.2
BC608WW	Shallow Basalt	11/16/2021	6.4
BC608WW	Shallow Basalt	1/19/2022	7.9
BC608WW	Shallow Basalt	4/7/2022	7.6
BC608WW	Shallow Basalt	7/19/2022	8.3
BC608WW	Shallow Basalt	9/27/2022	7.9
BC611WW	Shallow Basalt	10/1/2020	16
BC611WW	Shallow Basalt	1/11/2021	16.3
BC611WW	Shallow Basalt	3/22/2021	15.6
BC611WW	Shallow Basalt	8/11/2021	16.7
BC611WW	Shallow Basalt	11/8/2021	17.3
BC611WW	Shallow Basalt	1/20/2022	16.1
BC611WW	Shallow Basalt	4/5/2022	16.4
BC611WW	Shallow Basalt	9/27/2022	14.2
BC612WW	Shallow Basalt	9/28/2020	3.6
BC612WW	Shallow Basalt	1/12/2021	3.1
BC612WW	Shallow Basalt	3/23/2021	3.2
BC612WW	Shallow Basalt	8/11/2021	4.5
BC612WW	Shallow Basalt	11/9/2021	5.9
BC612WW	Shallow Basalt	1/21/2022	5.5
BC612WW	Shallow Basalt	4/6/2022	6.39
BC612WW	Shallow Basalt	7/20/2022	12.5
BC612WW	Shallow Basalt	9/27/2022	18.7
BC012WW	Unclassified Wells	10/8/2020	2.6
BC012WW	Unclassified Wells	3/25/2021	6.6
BC012WW	Unclassified Wells	11/16/2021	2.8
BC012WW	Unclassified Wells	4/7/2022	5.3
BC012WW	Unclassified Wells	9/30/2022	2.7
BC034WW	Unclassified Wells	10/7/2020	6.6
BC034WW	Unclassified Wells	1/11/2021	7
BC034WW	Unclassified Wells	3/23/2021	7.5

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC034WW	Unclassified Wells	8/9/2021	7.7
BC034WW	Unclassified Wells	11/9/2021	7.5
BC034WW	Unclassified Wells	1/20/2022	7.6
BC034WW	Unclassified Wells	4/5/2022	8.8
BC034WW	Unclassified Wells	7/28/2022	9.9
BC034WW	Unclassified Wells	9/27/2022	8.9
BC086WW	Unclassified Wells	10/7/2020	3
BC086WW	Unclassified Wells	1/11/2021	3.9
BC086WW	Unclassified Wells	3/22/2021	3.4
BC086WW	Unclassified Wells	8/9/2021	3.5
BC086WW	Unclassified Wells	11/8/2021	3.7
BC086WW	Unclassified Wells	1/21/2022	3.5
BC086WW	Unclassified Wells	4/5/2022	4.6
BC086WW	Unclassified Wells	7/21/2022	4
BC086WW	Unclassified Wells	9/27/2022	3.6
BC235WW	Unclassified Wells	10/1/2020	15.3
BC235WW	Unclassified Wells	1/13/2021	1.7
BC235WW	Unclassified Wells	3/25/2021	15.4
BC235WW	Unclassified Wells	8/10/2021	13.2
BC235WW	Unclassified Wells	11/16/2021	11
BC235WW	Unclassified Wells	1/19/2022	13
BC235WW	Unclassified Wells	4/7/2022	12.8
BC235WW	Unclassified Wells	7/19/2022	12.8
BC235WW	Unclassified Wells	9/29/2022	9
BC266WW	Unclassified Wells	10/8/2020	16
BC266WW	Unclassified Wells	1/11/2021	17.6
BC266WW	Unclassified Wells	3/22/2021	16.9
BC266WW	Unclassified Wells	8/11/2021	16
BC266WW	Unclassified Wells	11/8/2021	17.7
BC266WW	Unclassified Wells	1/20/2022	17.3
BC266WW	Unclassified Wells	4/5/2022	17.5
BC266WW	Unclassified Wells	7/19/2022	14
BC266WW	Unclassified Wells	9/29/2022	16.6
BC274WW	Unclassified Wells	9/29/2020	18.2
BC274WW	Unclassified Wells	3/25/2021	36.3
BC275WW	Unclassified Wells	10/1/2020	12.4
BC275WW	Unclassified Wells	3/22/2021	12.7
BC276WW	Unclassified Wells	10/1/2020	20.8
BC276WW	Unclassified Wells	3/22/2021	25.1
BC277WW	Unclassified Wells	9/30/2020	4.8
BC277WW	Unclassified Wells	3/23/2021	4.8
BC277WW	Unclassified Wells	11/9/2021	5.3
BC277WW	Unclassified Wells	4/6/2022	5
BC278WW	Unclassified Wells	9/30/2020	30.6
BC278WW	Unclassified Wells	3/25/2021	32.9

Table D.1. Water Well Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Sample	Well Type	Date	Nitrate Result (mg/L)
BC279WW	Unclassified Wells	9/30/2020	13.8
BC279WW	Unclassified Wells	3/24/2021	13
BC279WW	Unclassified Wells	11/10/2021	12
BC279WW	Unclassified Wells	4/7/2022	12.8
BC279WW	Unclassified Wells	9/27/2022	13.8
BC325WW	Unclassified Wells	9/29/2022	9.9
BC500WW	Unclassified Wells	10/6/2020	5.8
BC500WW	Unclassified Wells	3/24/2021	5.7
BC500WW	Unclassified Wells	11/10/2021	6.4
BC500WW	Unclassified Wells	4/7/2022	6.7
BC500WW	Unclassified Wells	9/29/2022	5.7
BC614WW	Unclassified Wells	9/30/2020	1.5
BC614WW	Unclassified Wells	3/24/2021	1.5
BC614WW	Unclassified Wells	11/10/2021	1.3
BC614WW	Unclassified Wells	4/6/2022	1.8
BC614WW	Unclassified Wells	9/28/2022	3.2
BC615WW	Unclassified Wells	9/29/2020	1.7
BC615WW	Unclassified Wells	3/25/2021	1.9
BC615WW	Unclassified Wells	11/16/2021	1.6
BC615WW	Unclassified Wells	4/7/2022	1.9
BC615WW	Unclassified Wells	9/27/2022	0.9
BC617WW	Unclassified Wells	8/13/2021	1
BC618WW	Unclassified Wells	1/19/2022	5.4
BC618WW	Unclassified Wells	7/21/2022	4.8

Table D.2. Surface Water Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

Fall 2020		
Sample Date	**Sample ID**	**Nitrate Result (mg/l)**
10/9/2020	BC001SW	1
10/9/2020	BC002SW	1.7
10/9/2020	BC003SW	1.6
10/9/2020	BC004SW	0.7
10/9/2020	BC005SW	8.8
10/9/2020	BC006SW	8.5
10/9/2020	BC007SW	1.7
10/9/2020	BC008SW	3.1
10/9/2020	BC009SW	11.1
10/9/2020	BC0010SW	3
Spring 2021		
3/25/2021	BC001SW	2.6
4/12/2021	BC002SW	0.7
4/12/2021	BC003SW	0.6
4/12/2021	BC004SW	1
3/24/2021	BC005SW	47
3/24/2021	BC006SW	11
3/24/2021	BC007SW	6.1
3/24/2021	BC008SW	6.6
3/23/2021	BC009SW	12
3/23/2021	BC0010SW	6.5
Summer 2021		
8/16/2021	BC001SW	1.3
8/16/2021	BC002SW	1.3
8/16/2021	BC003SW	1.4
8/16/2021	BC004SW	0
8/16/2021	BC005SW	5.4
8/16/2021	BC006SW	6.4
8/16/2021	BC007SW	1.2
8/16/2021	BC008SW	2
8/16/2021	BC009SW	9.8
8/16/2021	BC0010SW	1.7
Fall 2021		
11/15/2021	BC001SW	2.7

Table D.2. Surface Water Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

11/15/2021	BC004SW	4.3
11/15/2021	BC005SW	45.5
11/15/2021	BC006SW	8.9
11/15/2021	BC007SW	6.5
11/15/2021	BC008SW	6.1
11/15/2021	BC009SW	10.4
11/15/2021	BC0010SW	5.9
Fall 2022		
10/3/2022	BC001SW	0.5
10/3/2022	BC002SW	0.8
10/3/2022	BC004SW	1.4
10/3/2022	BC005SW	11.1
10/3/2022	BC006SW	7.2
10/3/2022	BC007SW	1
10/3/2022	BC008SW	2.2
10/3/2022	BC009SW	9.2
10/3/2022	BC0010SW	2.1
Summer 2022		
7/21/2022	BC001SW	0.6
7/21/2022	BC002SW	1
7/21/2022	BC003SW	1
7/21/2022	BC004SW	0.9
7/21/2022	BC005SW	6.5
7/21/2022	BC006SW	7.3
7/21/2022	BC007SW	1.3
7/21/2022	BC008SW	1.9
7/21/2022	BC009SW	10.3
7/21/2022	BC0010SW	2.5
Spring 2022		
4/28/2022	BC001SW	1.5
4/28/2022	BC002SW	0.5
4/28/2022	BC003SW	0.8
4/28/2022	BC004SW	9.8
4/28/2022	BC005SW	33.2
4/28/2022	BC006SW	10.4
4/28/2022	BC007SW	0.6
4/28/2022	BC008SW	1.1

Table D.2. Surface Water Nitrate Results

Groundwater and Surface Water Nitrate Monitoring

Badger Coulee, Bentron County, Washington

4/28/2022	BC009SW	10.5
4/28/2022	BC0010SW	1.1

Appendix E.

2020-2022 Trend Analysis Results and Plots

Description of Trend Analysis Methods

The Mann-Kendall trend analyses were used to evaluate whether nitrate concentrations have statistically significant increasing or decreasing trends over the data record for both recent and long-term data records.

It is a non-parametric test that identifies trends by comparing each later-measured value to all the earlier measured values. Non-parametric tests are used for datasets that do not follow normal distribution, which is typical of environmental datasets. In this study, a statistical data analysis software ProUCL version 5.2, developed by U.S Environmental Protection Agency is used. The Mann-Kendall trend analysis seeks to either confirm or reject the null hypothesis that no trend is present, and the data series are independent of time. It uses the Kendall score statistic (S) and the normalized Kendall score statistic (P-value).

The Kendall score, S, is computed by comparing the later-measured value to the previous values and assigning either a -1,0, or 1, based on whether there is a decrease between the values (-1), the values are equal (0), or there is an increase between the values (1). S is then computed as a summation of these assigned values. When S is a large positive number, there is an increasing trend in the data. When S is a large negative number the is a decreasing trend in the data, and when the absolute value S is small there is no trend in the data. The maximum and minimum values of S depend on the number of measured data points. Normalized or standardized Kendall score assumes a minimum of 20 sample points. Since all the wells sampled contained less than 20 measurements, normalized Kendall score is not reported in the results summary tables.

The critical value is used for comparison to a test statistic based on the sample size and selected confidence interval. When using the Mann-Kendall Analysis the test statistic is the Standardized Value of S, or the standardized Kendall Score. The critical value will be either negative or positive depending on whether the trend line is decreasing or increasing, respectively. Look up tables are preprogrammed into Pro-UCL 5.2 and are used for sample sizes greater than 20. If the standardized value of S is larger than the critical value, then the trend is statistically significant, and the data has a non-normal distribution. If the standardized value is less than the critical value, then there is insufficient evidence for a statistically significant trend.

P-value is a measurement of normality in the data and provides a measurement of statistical significance for a linear trend in the data. The p-value ranges from 0 to 1 and is a normalized function of the residual data measurements i.e., deviation from the data set's mean value. A p-value equal to 1 indicates a perfect normal distribution and indicates that the Mann-Kendal method of analysis is not appropriate. A small p-value near zero indicates a non-normal distribution and a possible statistically significant trend. Statistical significance depends on the level of the confidence interval selected for the analysis.

The time series data was entered into ProUCL, and the Mann-Kendall trend analysis was selected with a 95% confidence interval and 5% level of significance. For duplicate samples and samples with the same date and time from the EIM database, the higher of the two values was used.

ProUCL calculates general statistics including the mean and standard deviation, the values of S, normalized S, the variance of S (Var(S)), and the least squares trend line slope. In addition to Mann-Kendall statistics, the p-value provides another way to reject the null hypothesis.

Mann-Kendall Trend Test - BC088WW (Alluvial)

Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	-1.3553
M-K Test Value (S)	-14
Tabulated p-value	0.0900
Approximate p-value	0.0877

OLS Regression Line (Blue)

OLS Regression Slope	-0.0008
OLS Regression Intercept	50.5475

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test (Alluvial Well BC022WW)

Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	0.9383
M-K Test Value (S)	10
Tabulated p-value	0.1790
Approximate p-value	0.1740

OLS Regression Line (Blue)

OLS Regression Slope	0.0025
OLS Regression Intercept	-87.2964

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trnd Test - BC100WW (Alluvial)

Mann-Kendall Trend Analysis

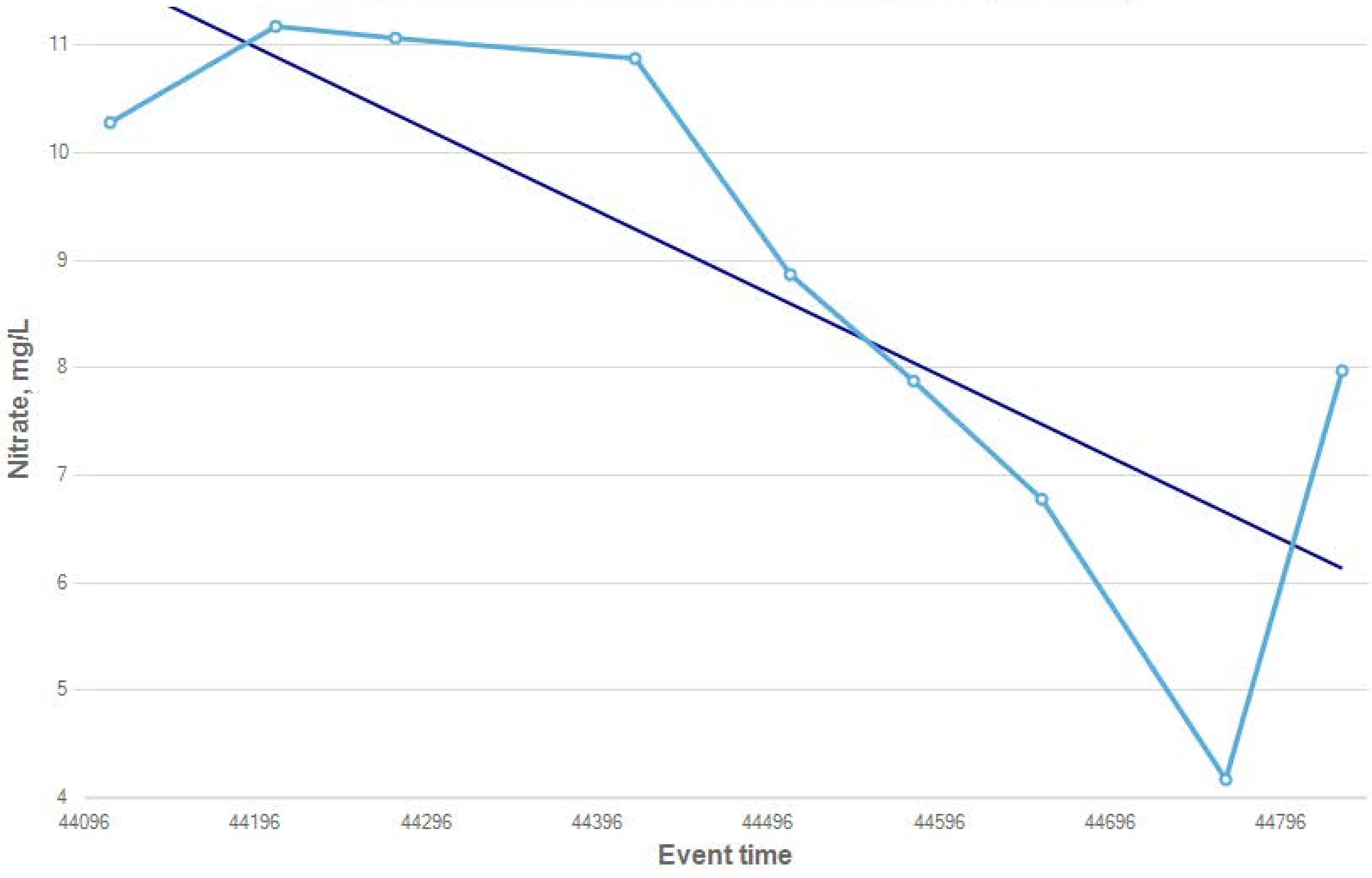
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.0738
Standardized Value of S	0.8817
M-K Test Value (S)	9
Tabulated p-value	0.2380
Approximate p-value	0.1890

OLS Regression Line (Blue)

OLS Regression Slope	0.0003
OLS Regression Intercept	-10.2534

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC125 WW (Alluvial)



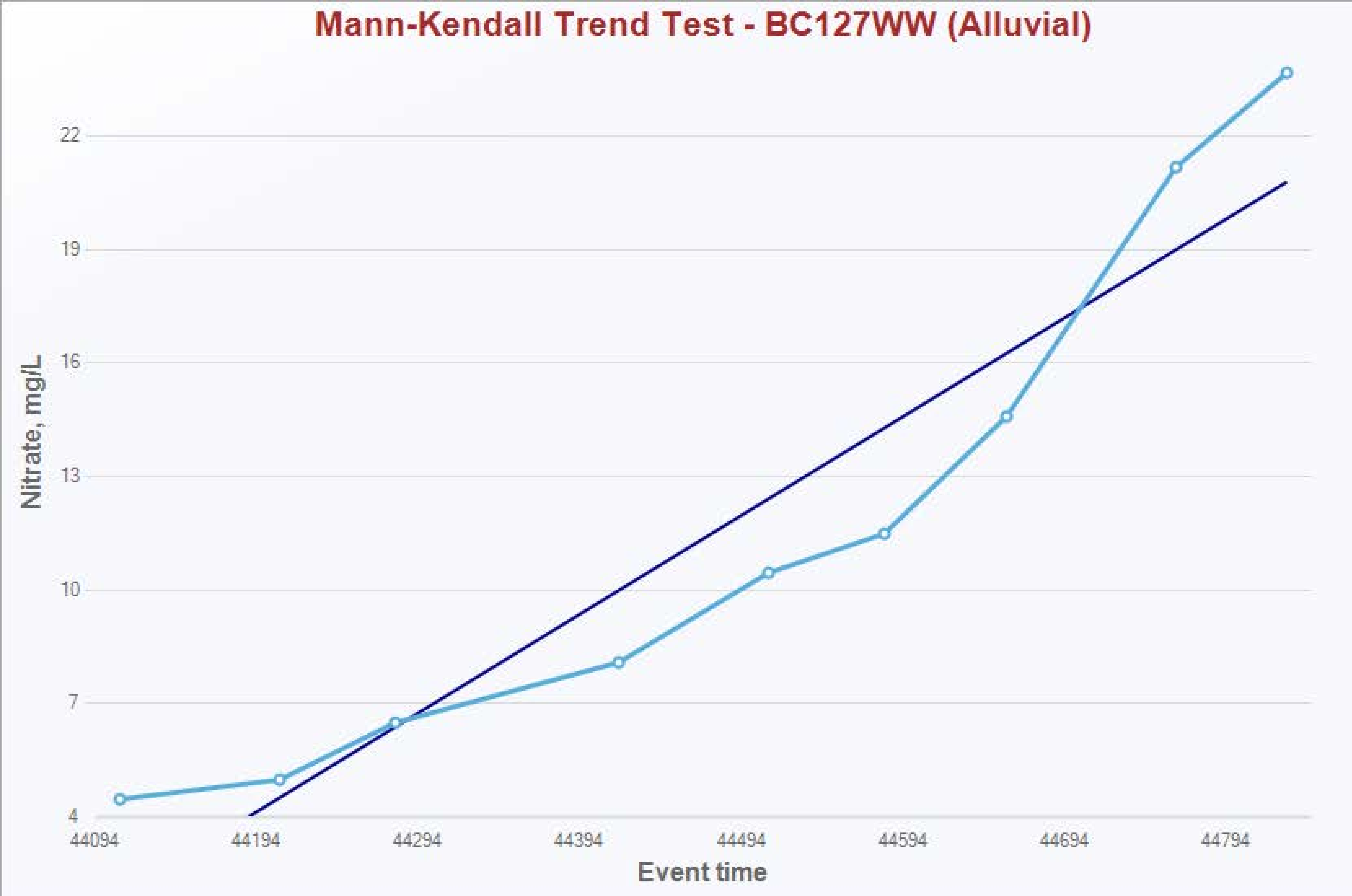
Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	-2.3979
M-K Test Value (S)	-24
Tabulated p-value	0.0060
Approximate p-value	0.0082

OLS Regression Line (Blue)

OLS Regression Slope	-0.0076
OLS Regression Intercept	349.2915

Statistically significant evidence of a decreasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	3.6490
M-K Test Value (S)	36
Tabulated p-value	0.0000
Approximate p-value	0.0001

OLS Regression Line (Blue)

OLS Regression Slope	0.0261
OLS Regression Intercept	-1,151.7507

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Trend Test - BC151WW (Alluvial)

Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	3.1449
M-K Test Value (S)	31
Tabulated p-value	0.0000
Approximate p-value	0.0008

OLS Regression Line (Blue)

OLS Regression Slope	0.0036
OLS Regression Intercept	-153.9921

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Trend Test - BC184WW (Alluvial)

Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	-0.4193
M-K Test Value (S)	-5
Tabulated p-value	0.3810
Approximate p-value	0.3375

OLS Regression Line (Blue)

OLS Regression Slope	-0.0024
OLS Regression Intercept	124.3966

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC194WW (Alluvial)

Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.3986
Standardized Value of S	-1.4896
M-K Test Value (S)	-15
Tabulated p-value	0.0900
Approximate p-value	0.0682

OLS Regression Line (Blue)

OLS Regression Slope	-0.0020
OLS Regression Intercept	102.6942

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC246WW (Alluvial)

Mann-Kendall Trend Analysis

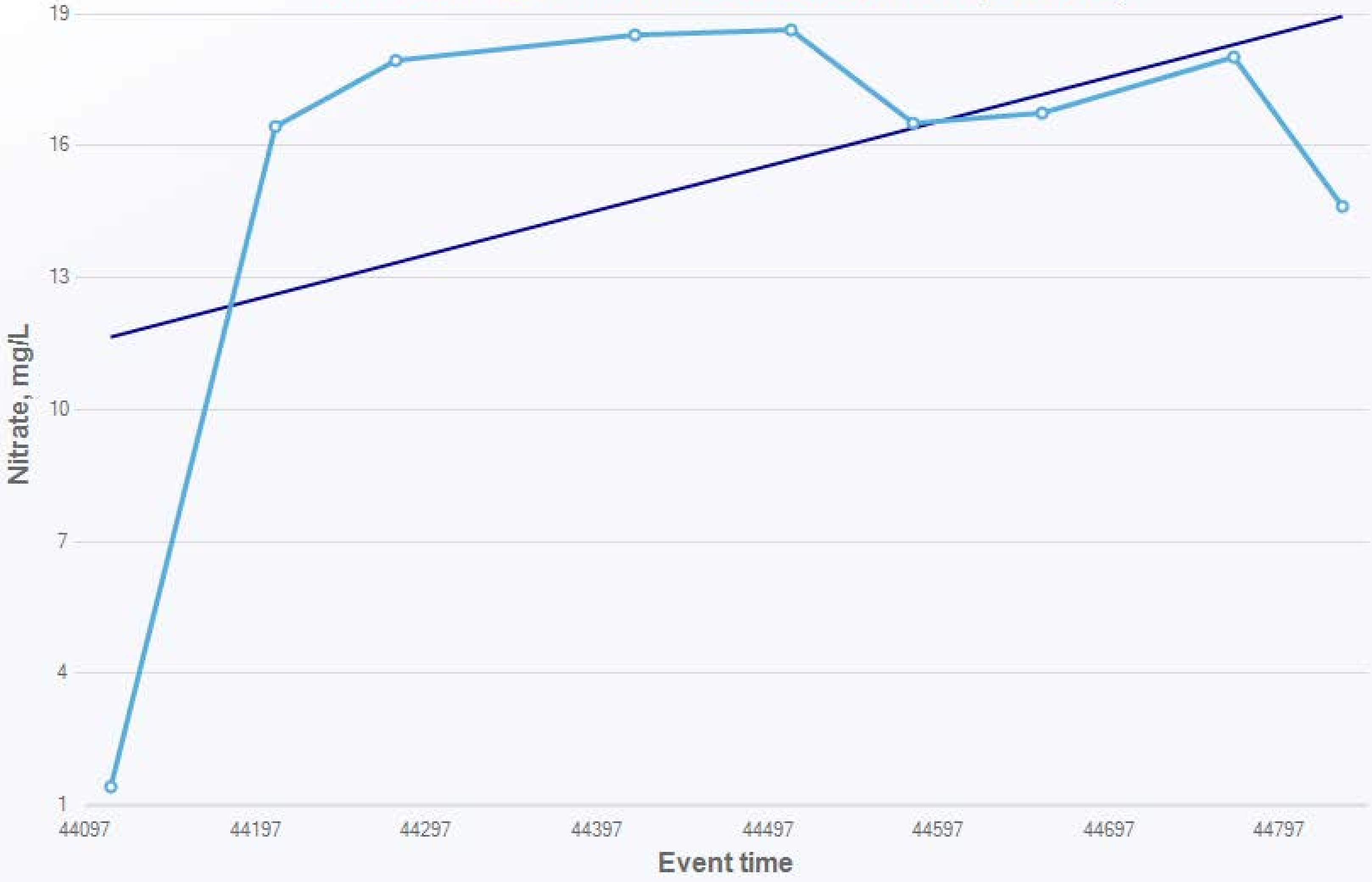
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.3986
Standardized Value of S	-0.8512
M-K Test Value (S)	-9
Tabulated p-value	0.2380
Approximate p-value	0.1973

OLS Regression Line (Blue)

OLS Regression Slope	-0.0022
OLS Regression Intercept	99.7347

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC254WW (Alluvial)



Mann-Kendall Trend Analysis

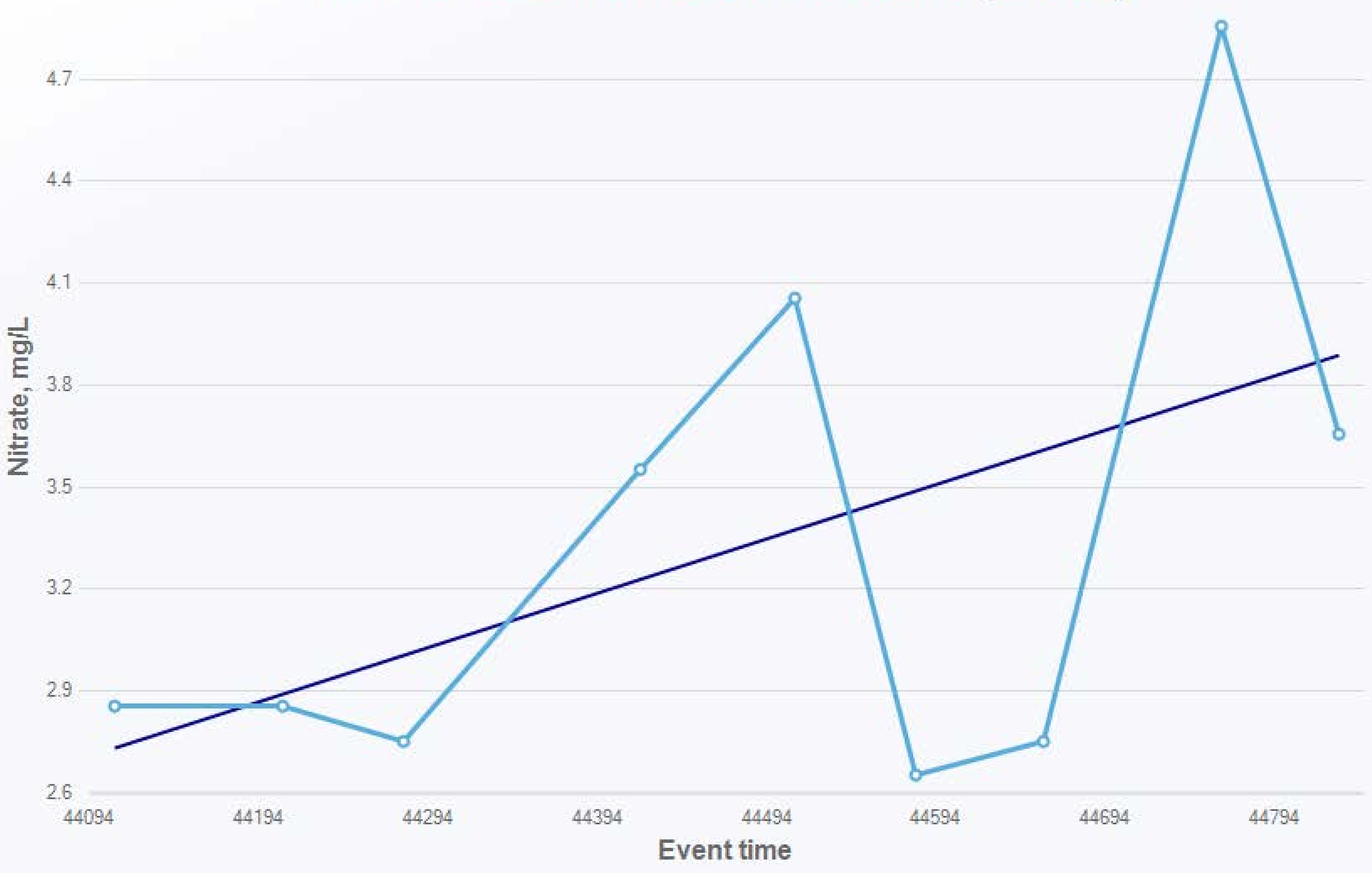
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	0.5213
M-K Test Value (S)	6
Tabulated p-value	0.3060
Approximate p-value	0.3011

OLS Regression Line (Blue)

OLS Regression Slope	0.0101
OLS Regression Intercept	-433.9715

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC268WW (Alluvial)



Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.4868
Standardized Value of S	0.7379
M-K Test Value (S)	8
Tabulated p-value	0.2380
Approximate p-value	0.2303

OLS Regression Line (Blue)

OLS Regression Slope	0.0016
OLS Regression Intercept	-67.8765

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC600WW (Alluvial)

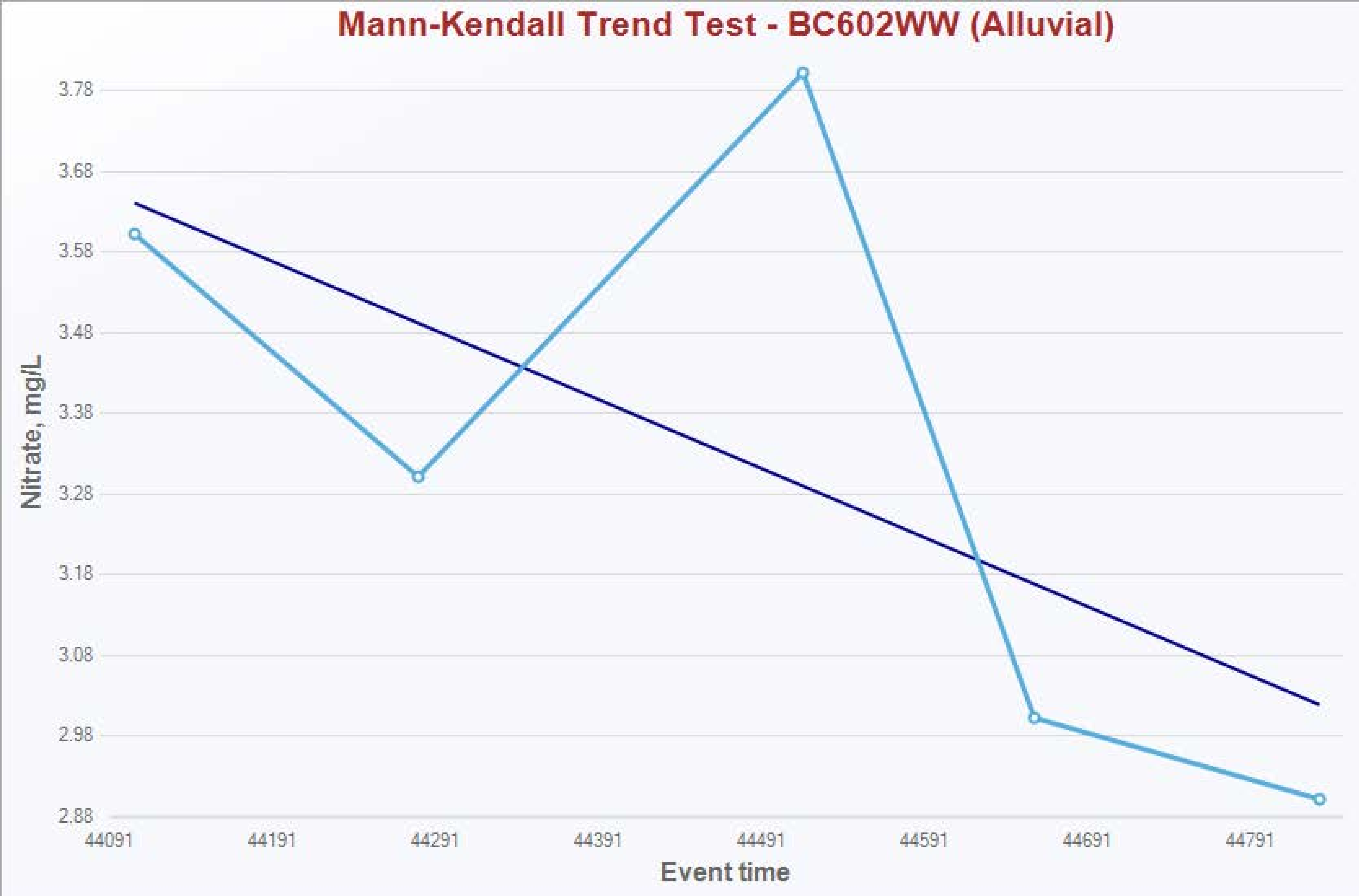
Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	0.0000
M-K Test Value (S)	-1
Tabulated p-value	0.5400
Approximate p-value	0.5000

OLS Regression Line (Blue)

OLS Regression Slope	-0.0001
OLS Regression Intercept	11.6248

Insufficient statistical evidence of a significant trend at the specified level of significance.



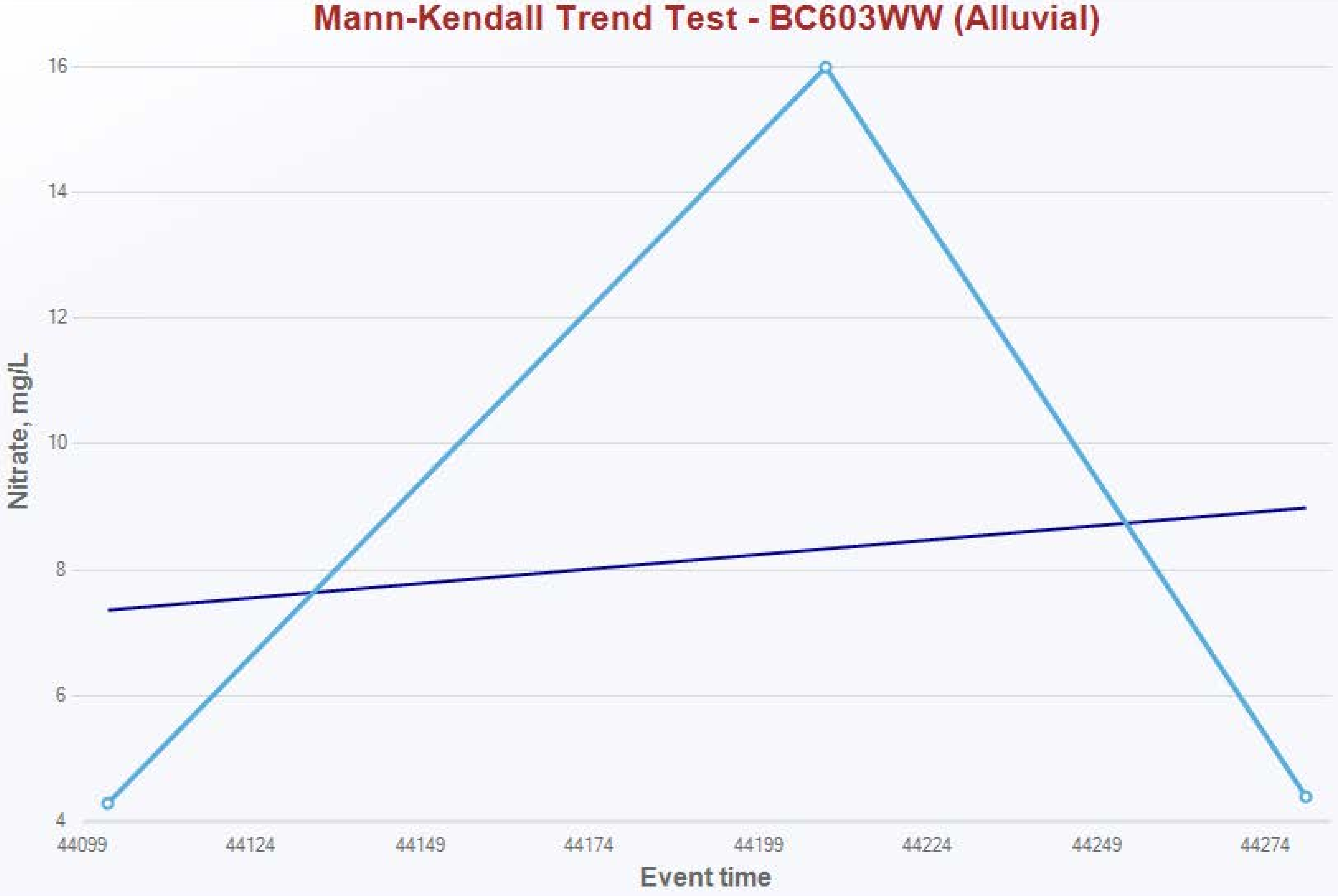
Mann-Kendall Trend Analysis

n	5
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	4.0825
Standardized Value of S	-1.2247
M-K Test Value (S)	-6
Tabulated p-value	0.1170
Approximate p-value	0.1103

OLS Regression Line (Blue)

OLS Regression Slope	-0.0009
OLS Regression Intercept	41.3671

Insufficient statistical evidence of a significant trend at the specified level of significance.



Mann-Kendall Trend Analysis

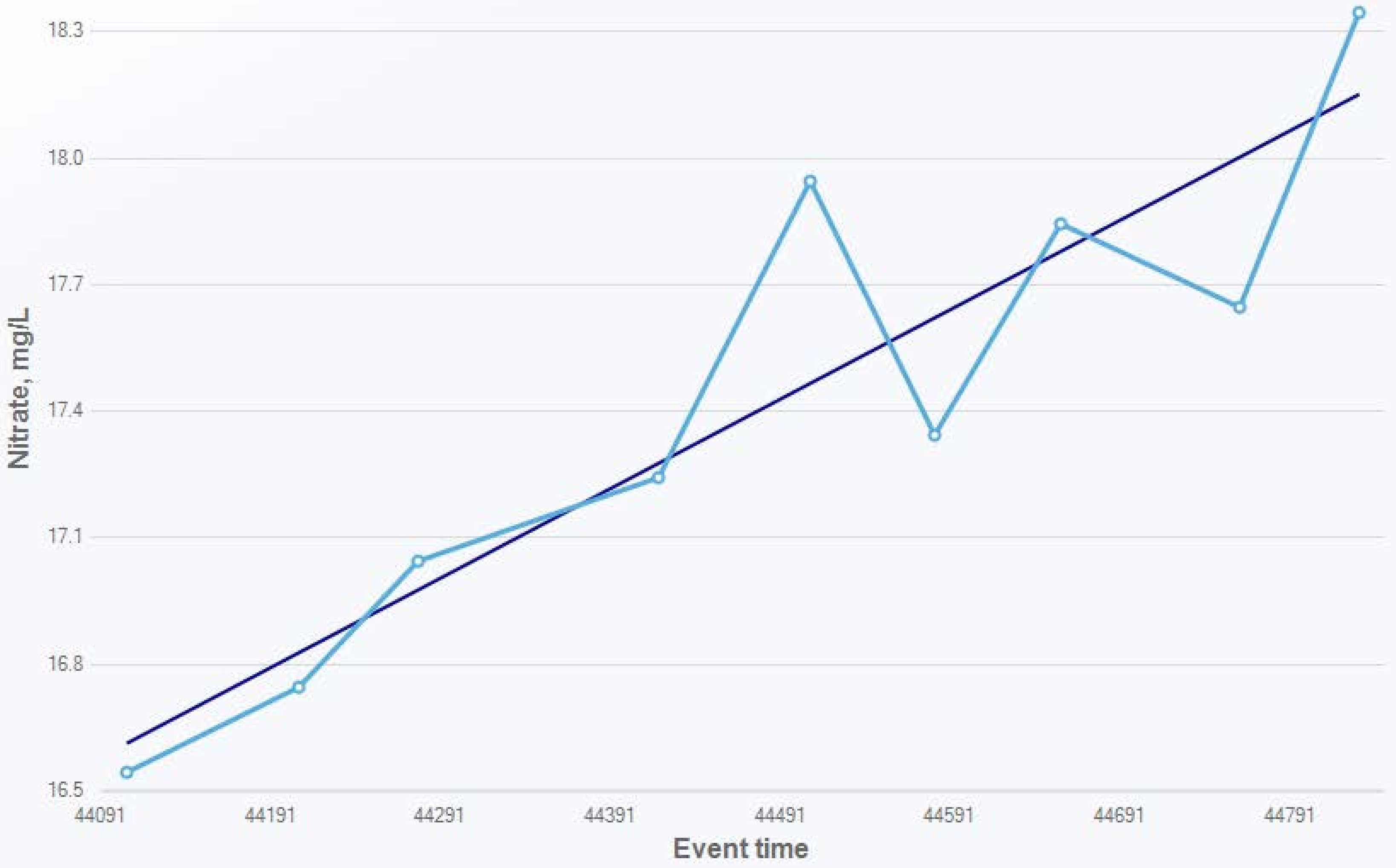
n	3
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	1.9149
Standardized Value of S	0.0000
M-K Test Value (S)	1
Tabulated p-value	
Approximate p-value	0.5000

OLS Regression Line (Blue)

OLS Regression Slope	0.0091
OLS Regression Intercept	-394.5701

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC604WW (Alluvial)



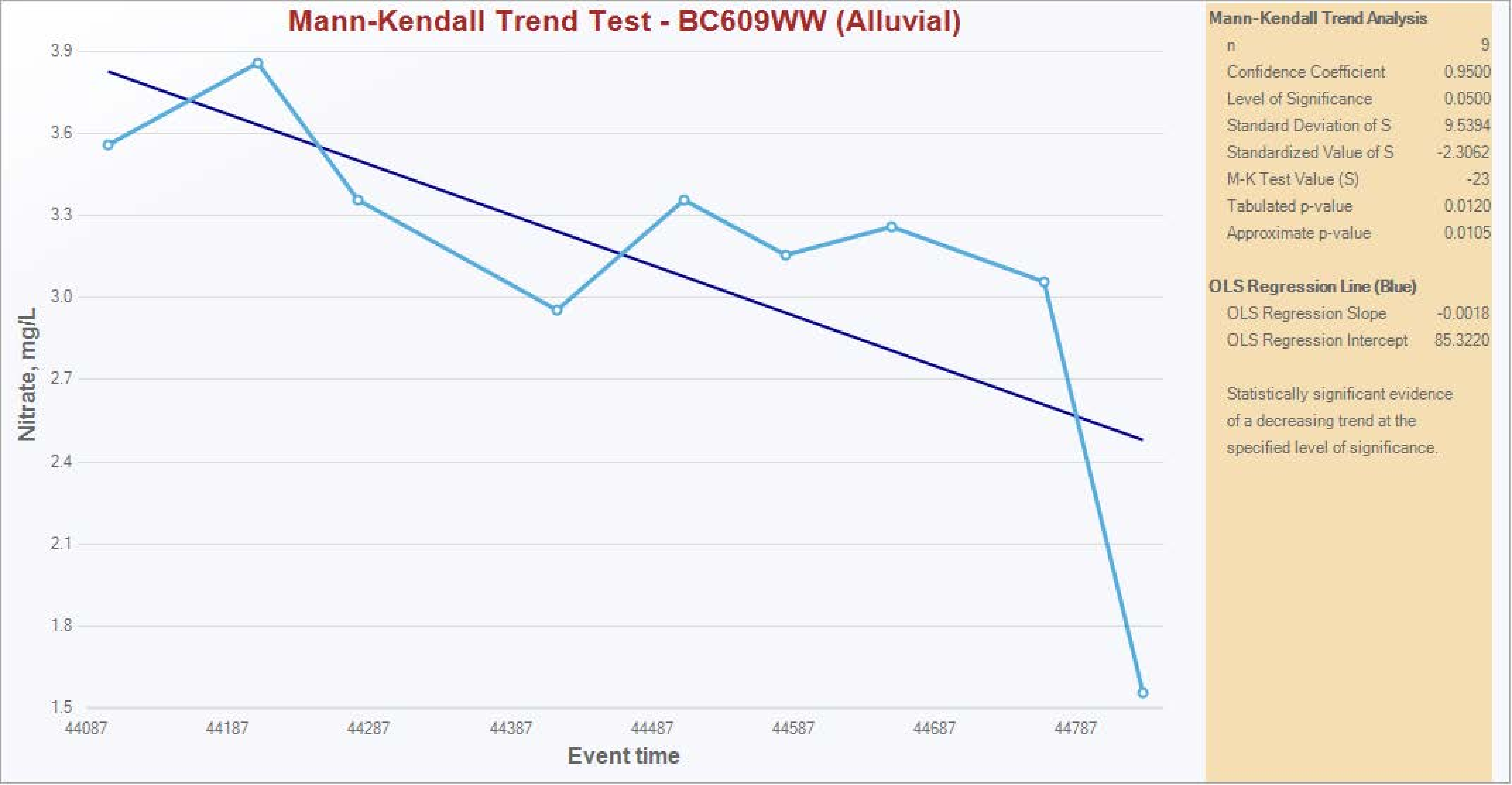
Mann-Kendall Trend Analysis

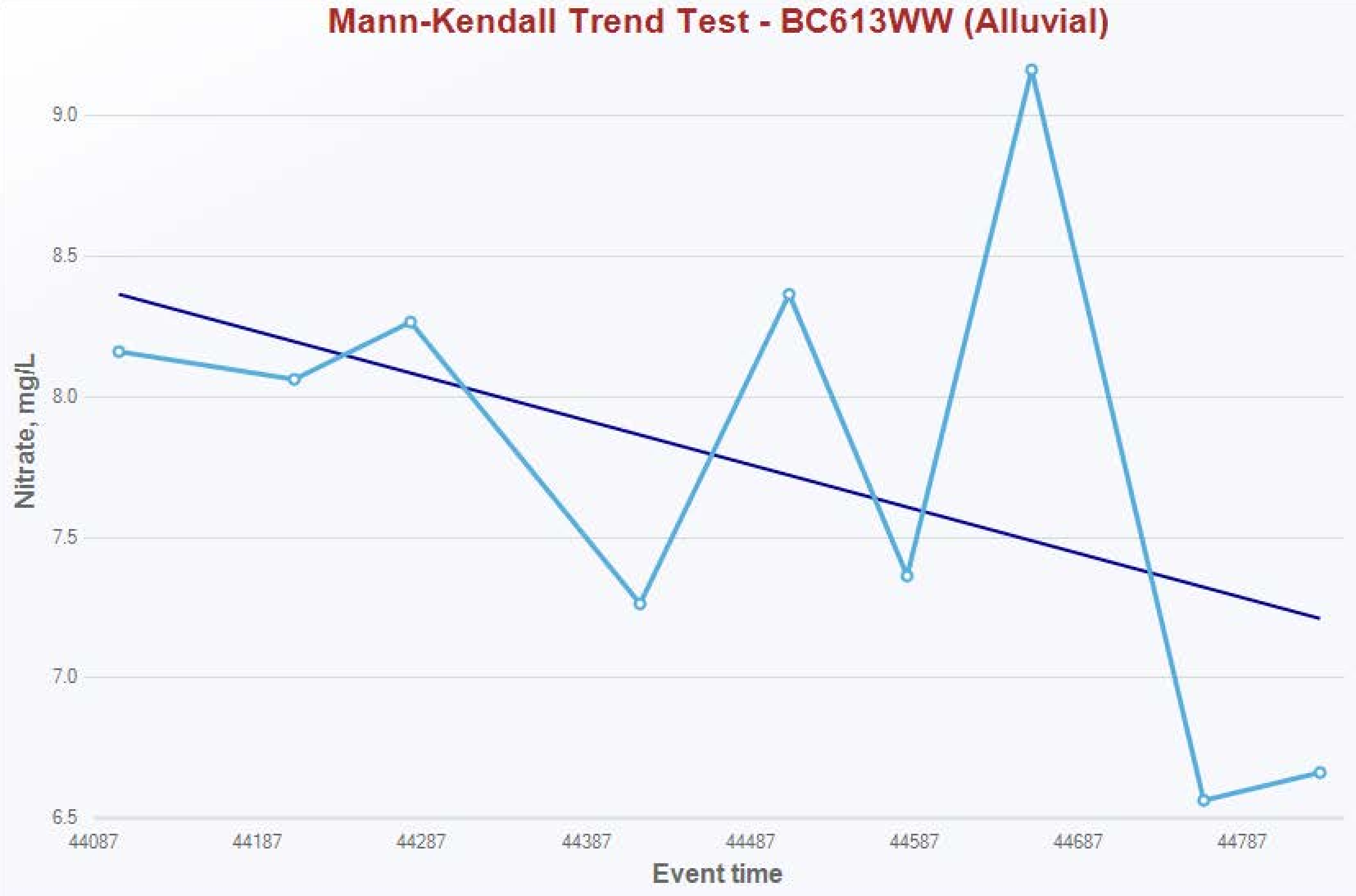
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	2.8149
M-K Test Value (S)	28
Tabulated p-value	0.0010
Approximate p-value	0.0024

OLS Regression Line (Blue)

OLS Regression Slope	0.0021
OLS Regression Intercept	-77.0427

Statistically significant evidence of an increasing trend at the specified level of significance.


Mann-Kendall Trend Test - BC609WW (Alluvial)
Nitrate, mg/L
Event time
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
44087
44187
44287
44387
44487
44587
44687
44787
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 9.5394
Standardized Value of S -2.3062
M-K Test Value (S) -23
Tabulated p-value 0.0120
Approximate p-value 0.0105
OLS Regression Line (Blue)
OLS Regression Slope -0.0018
OLS Regression Intercept 85.3220
Statistically significant evidence
of a decreasing trend at the
specified level of significance.



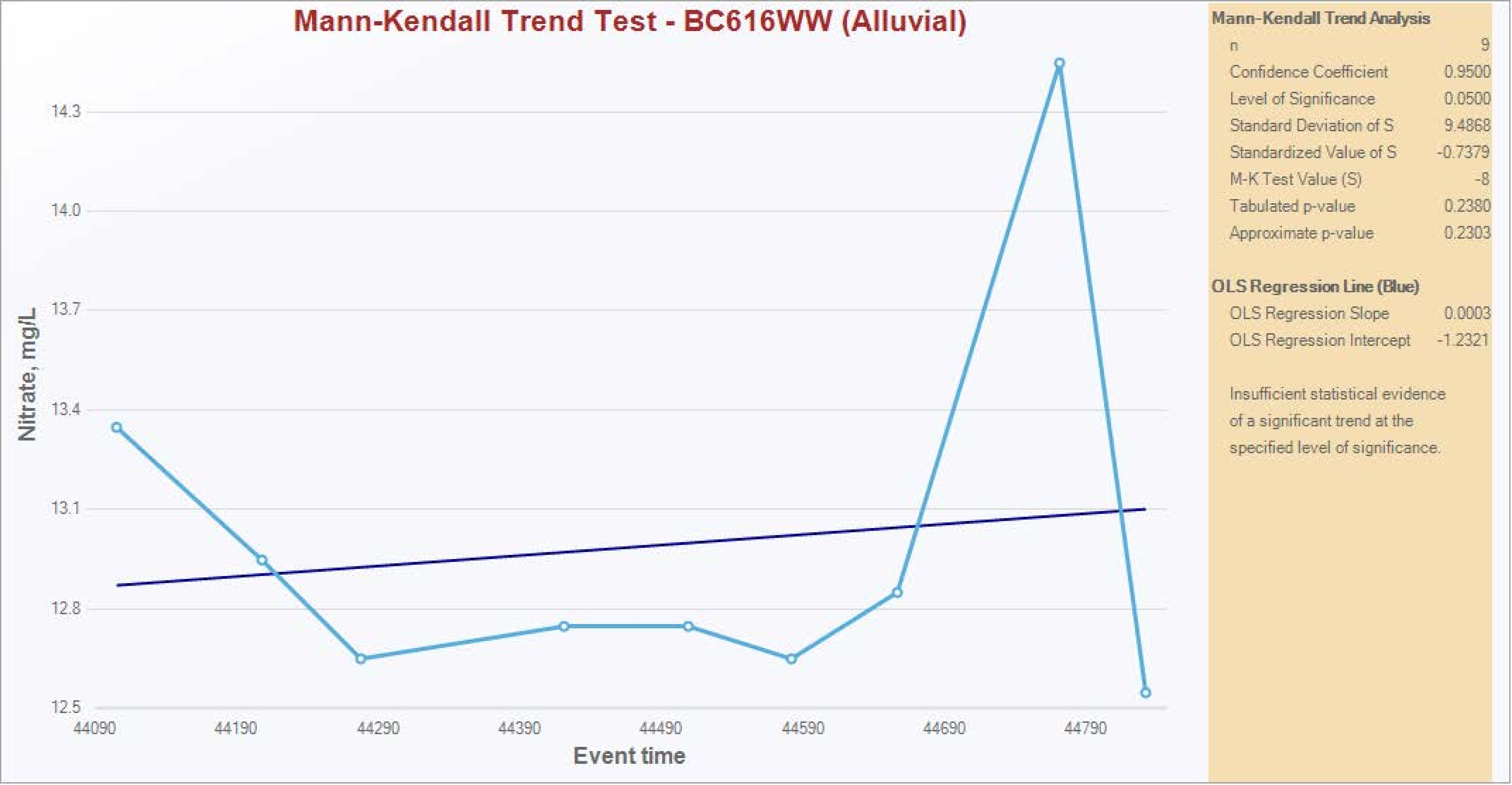
Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	-0.7298
M-K Test Value (S)	-8
Tabulated p-value	0.2380
Approximate p-value	0.2328

OLS Regression Line (Blue)

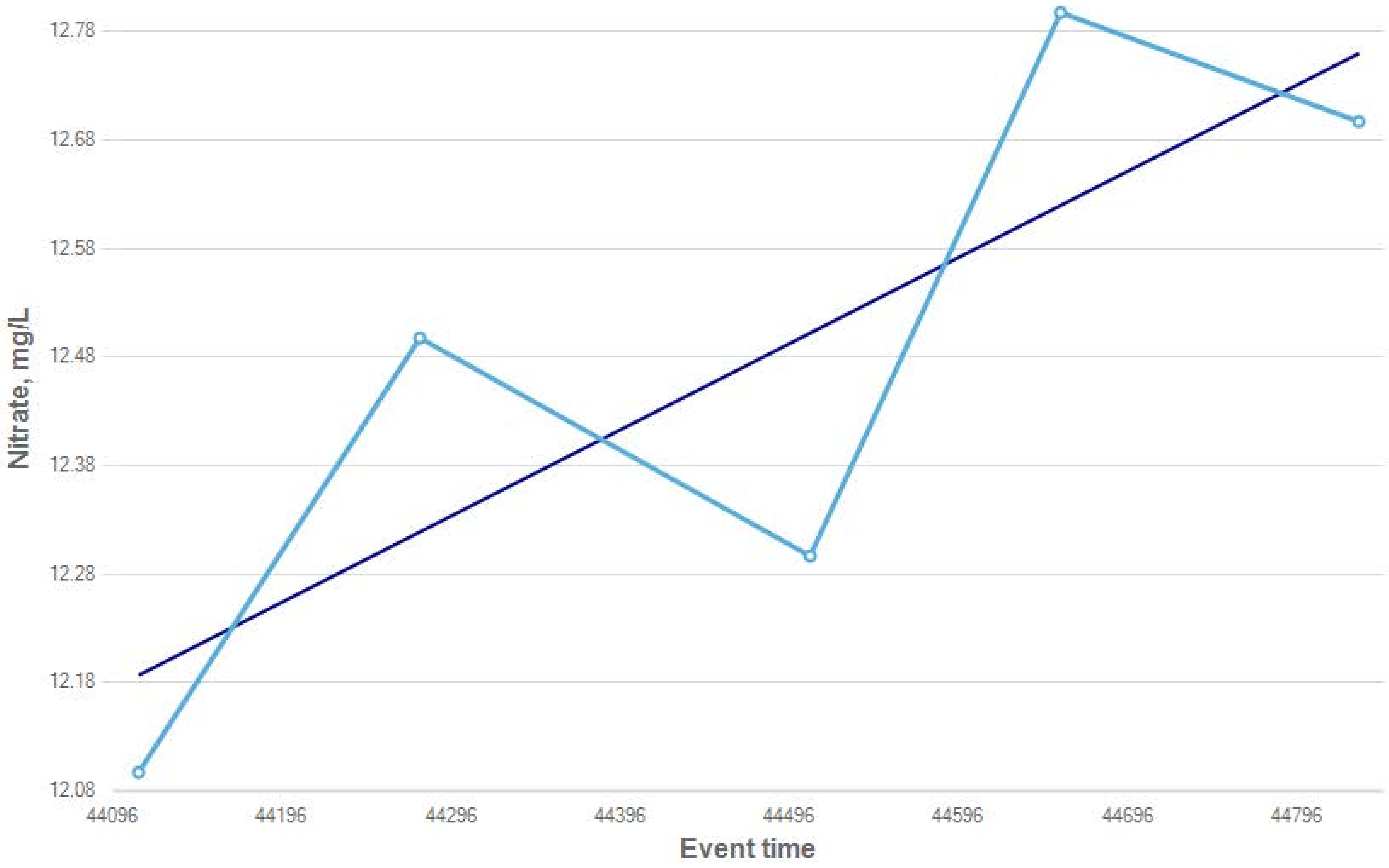
OLS Regression Slope	-0.0016
OLS Regression Intercept	78.1259

Insufficient statistical evidence of a significant trend at the specified level of significance.



Mann-Kendall Trend Test - BC616WW (Alluvial)
Nitrate, mg/L
14.3
14.0
13.7
13.4
13.1
12.8
12.5
44090
44190
44290
44390
44490
44590
44690
44790
Event time
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 9.4868
Standardized Value of S -0.7379
M-K Test Value (S) -8
Tabulated p-value 0.2380
Approximate p-value 0.2303
OLS Regression Line (Blue)
OLS Regression Slope 0.0003
OLS Regression Intercept -1.2321
Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC081WW (Alluvial and Shallow Basalt)



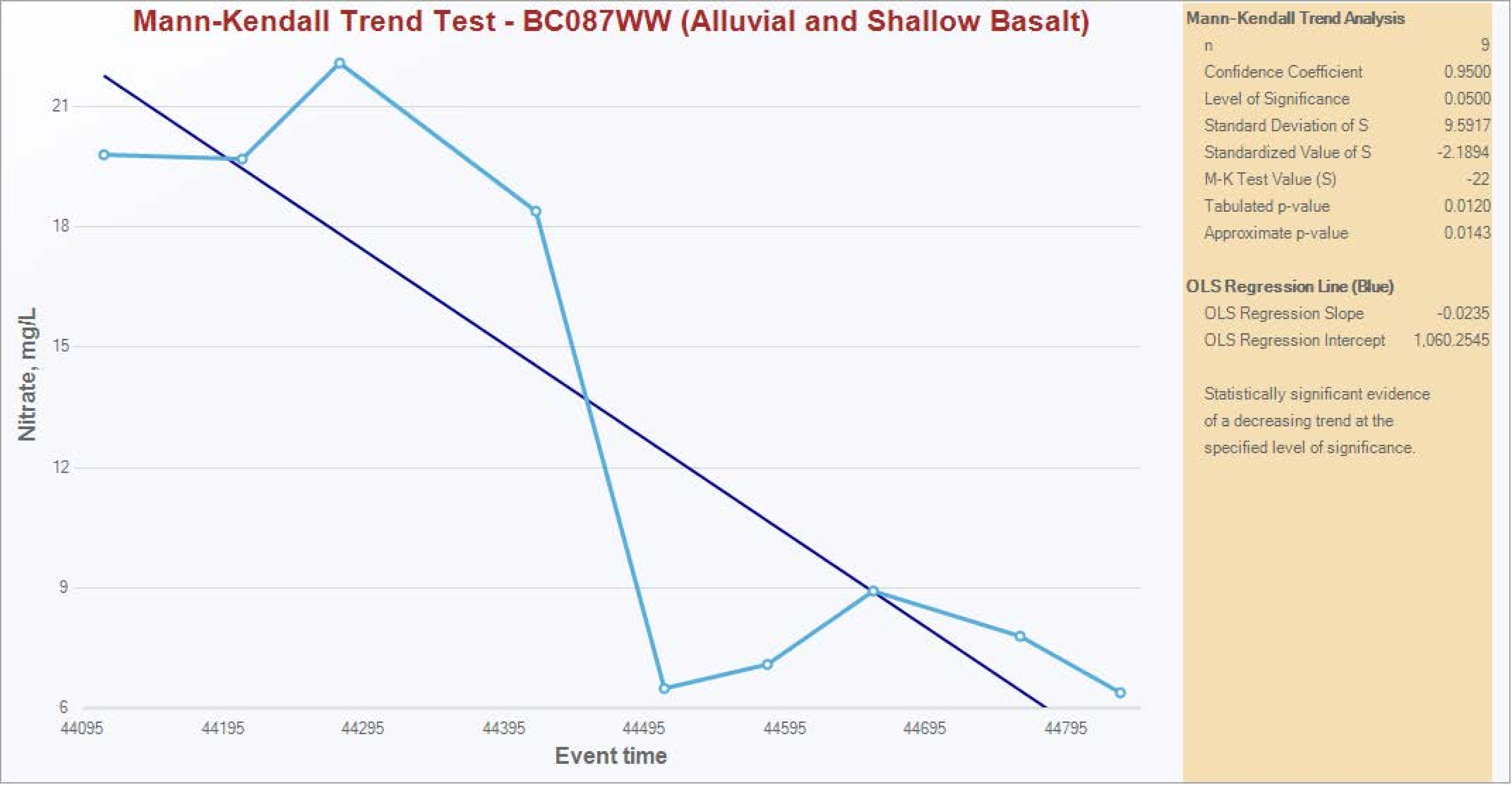
Mann-Kendall Trend Analysis

n	5
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	4.0825
Standardized Value of S	1.2247
M-K Test Value (S)	6
Tabulated p-value	0.1170
Approximate p-value	0.1103

OLS Regression Line (Blue)

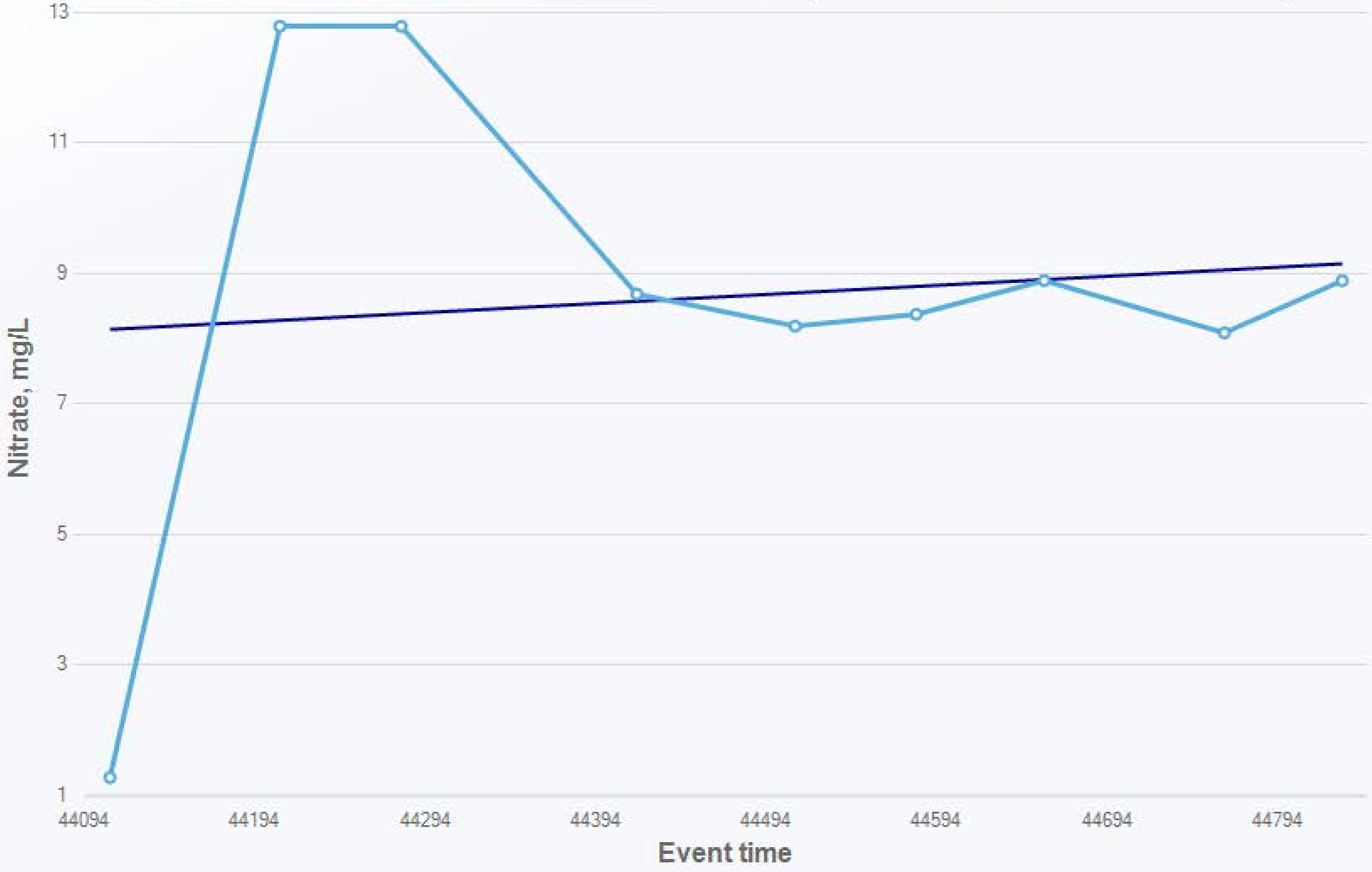
OLS Regression Slope	0.0008
OLS Regression Intercept	-22.9003

Insufficient statistical evidence of a significant trend at the specified level of significance.



Mann-Kendall Trend Test - BC087WW (Alluvial and Shallow Basalt)
Nitrate, mg/L
21
18
15
12
9
6
44095
44195
44295
44395
44495
44595
44695
44795
Event time
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 9.5917
Standardized Value of S -2.1894
M-K Test Value (S) -22
Tabulated p-value 0.0120
Approximate p-value 0.0143
OLS Regression Line (Blue)
OLS Regression Slope -0.0235
OLS Regression Intercept 1,060.2545
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

Mann-Kendall Trend Test - BC116WW (Alluvial and Shallow Basalt)



Mann-Kendall Trend Analysis

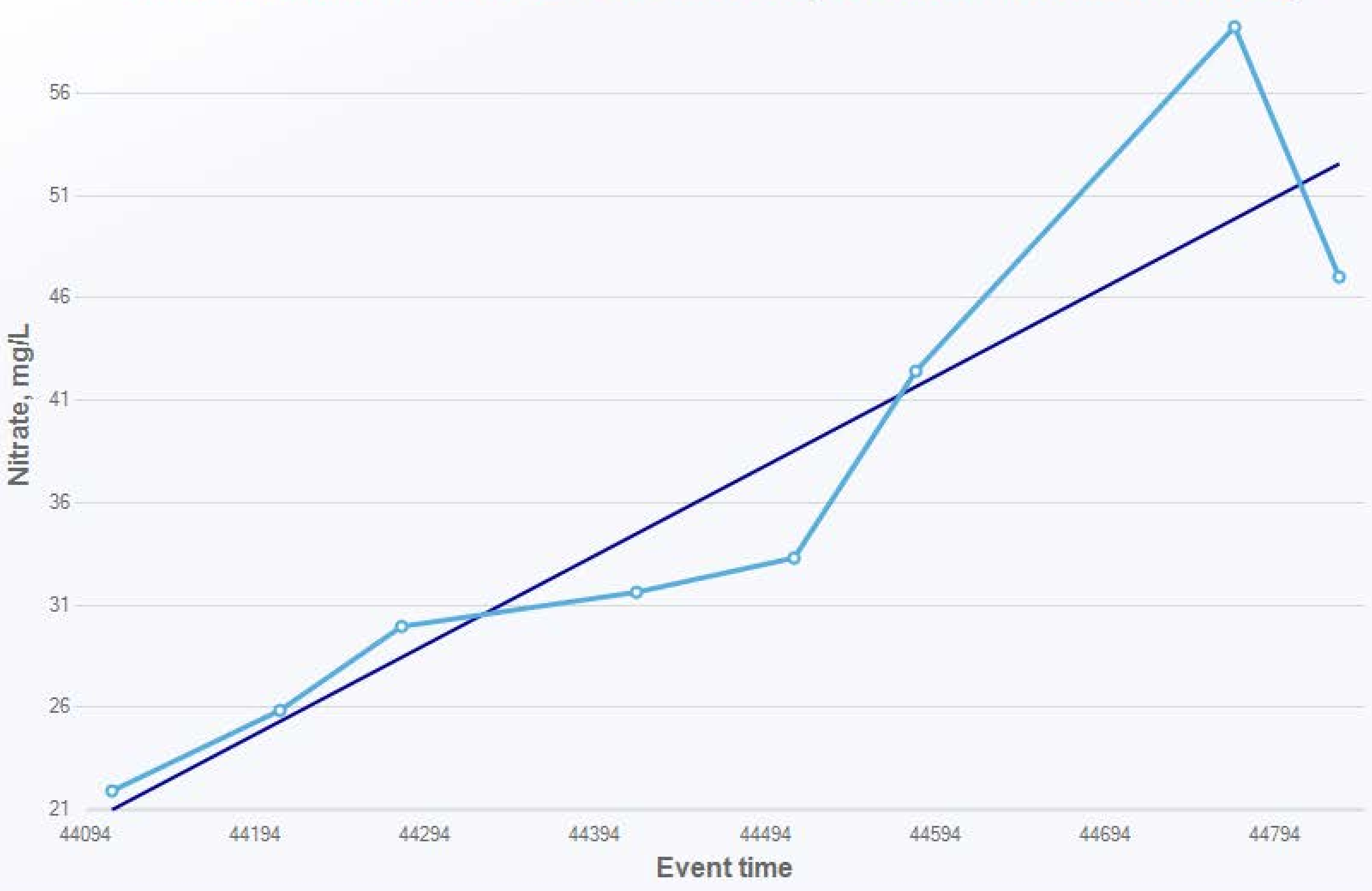
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.4868
Standardized Value of S	-0.1054
M-K Test Value (S)	-2
Tabulated p-value	0.4600
Approximate p-value	0.4580

OLS Regression Line (Blue)

OLS Regression Slope	0.0014
OLS Regression Intercept	-52.9609

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC117WW (Alluvial and Shallow Basalt)



Mann-Kendall Trend Analysis

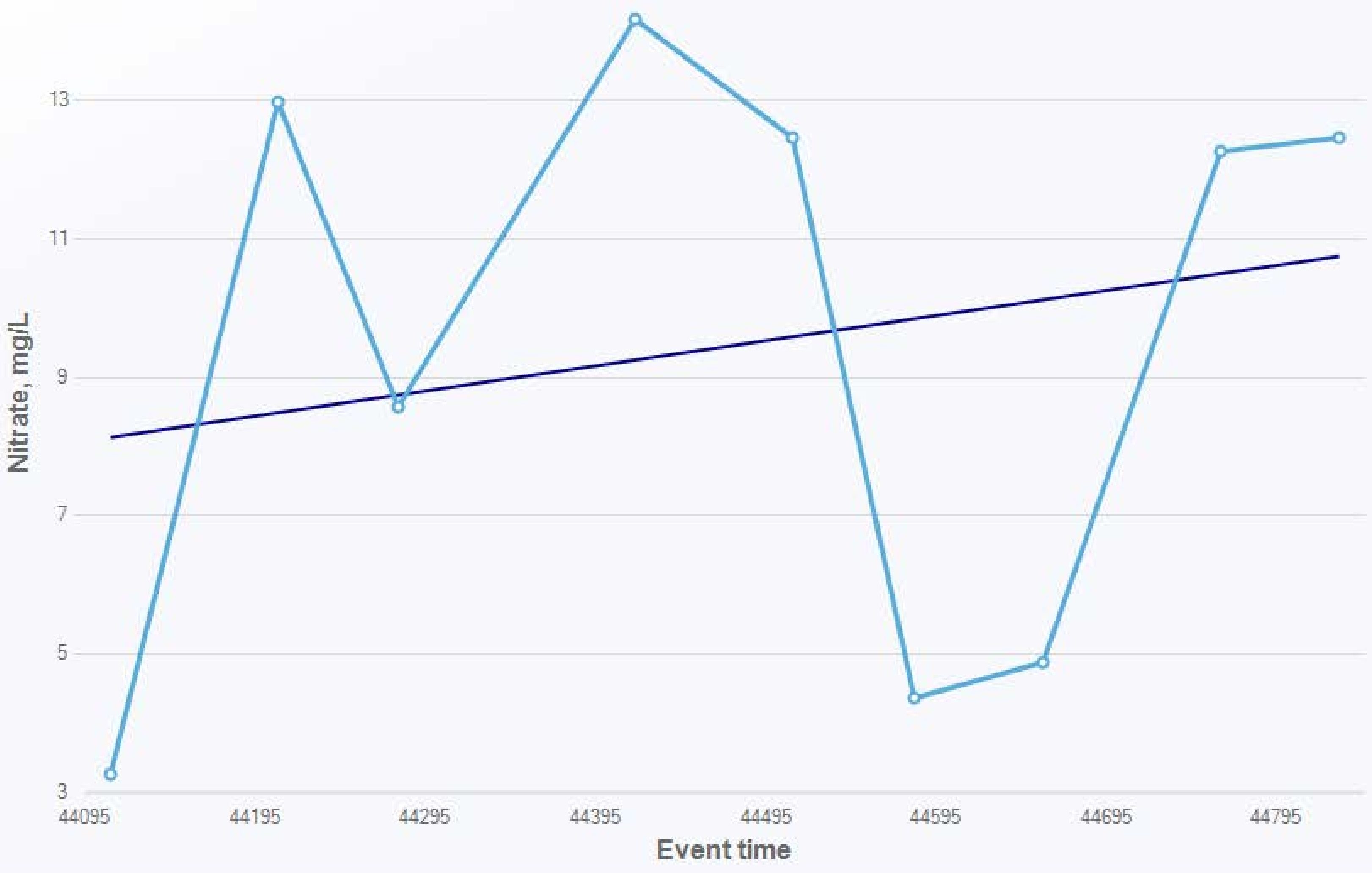
n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0829
Standardized Value of S	3.0929
M-K Test Value (S)	26
Tabulated p-value	0.0000
Approximate p-value	0.0010

OLS Regression Line (Blue)

OLS Regression Slope	0.0439
OLS Regression Intercept	-1,914.2815

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Trend Test - BC128WW (Alluvial and Shallow Basalt)



Mann-Kendall Trend Analysis

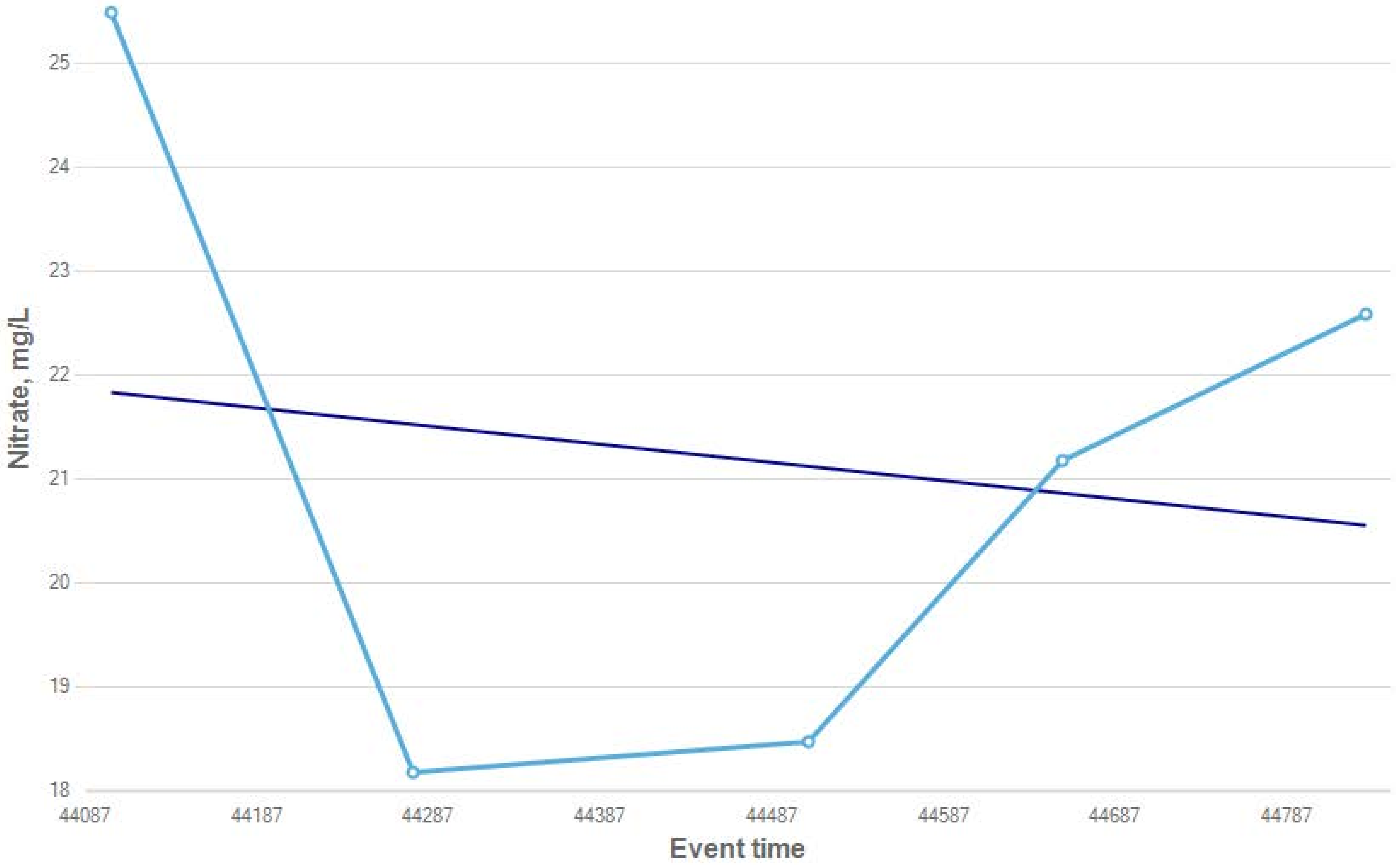
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	0.2097
M-K Test Value (S)	3
Tabulated p-value	0.4600
Approximate p-value	0.4170

OLS Regression Line (Blue)

OLS Regression Slope	0.0037
OLS Regression Intercept	-152.9809

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC610WW (Alluvial and Shallow Basalt)

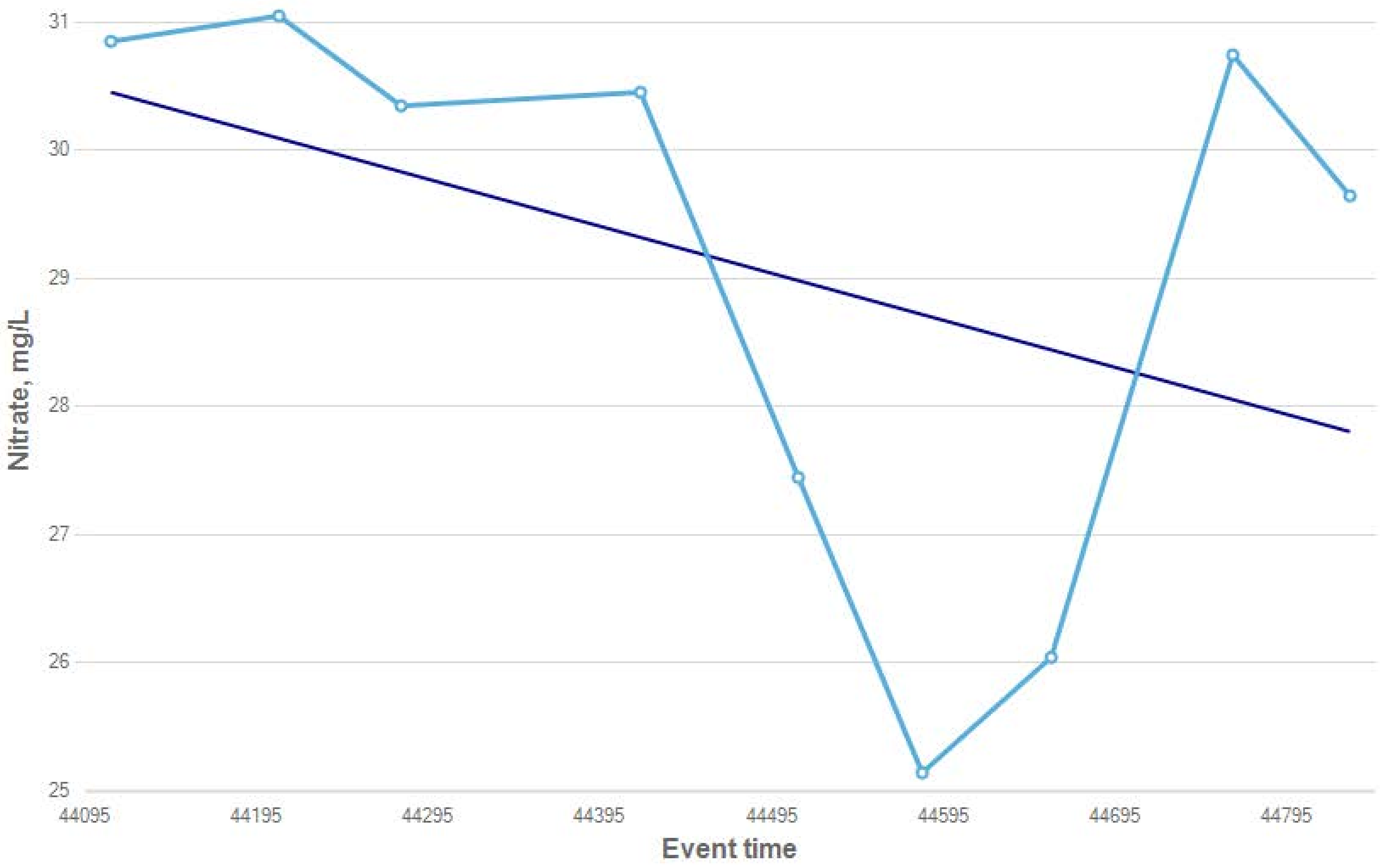


Mann-Kendall Trend Analysis	
n	5
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	4.0825
Standardized Value of S	0.2449
M-K Test Value (S)	2
Tabulated p-value	0.4080
Approximate p-value	0.4032

OLS Regression Line (Blue)	
OLS Regression Slope	-0.0018
OLS Regression Intercept	99.4656

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC192WW (Shallow and Intermediate Basalt)



Mann-Kendall Trend Analysis

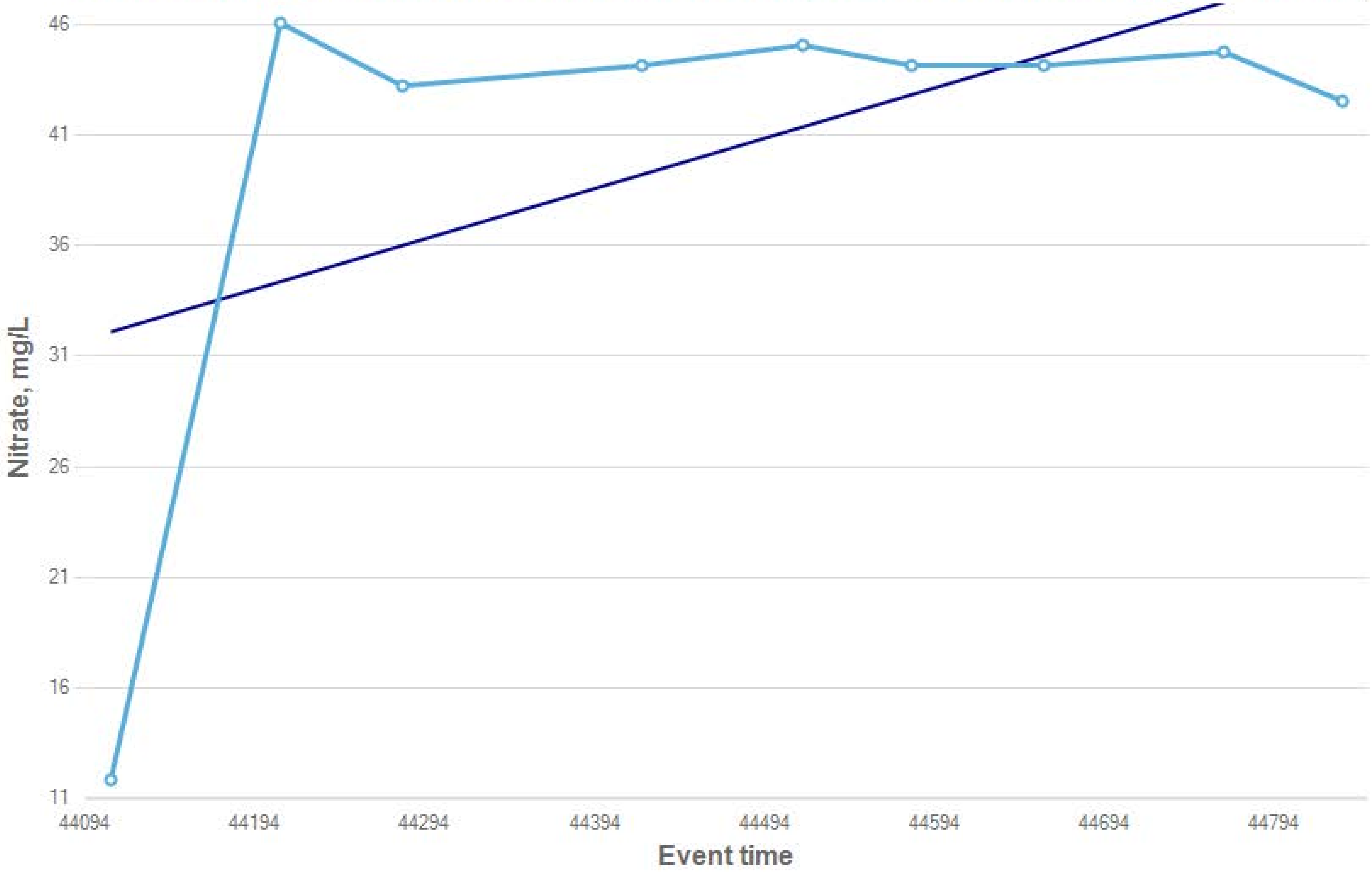
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	-1.3553
M-K Test Value (S)	-14
Tabulated p-value	0.0900
Approximate p-value	0.0877

OLS Regression Line (Blue)

OLS Regression Slope	-0.0037
OLS Regression Intercept	192.6406

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC782321WW (Shallow and Intermediate Basalt



Mann-Kendall Trend Analysis

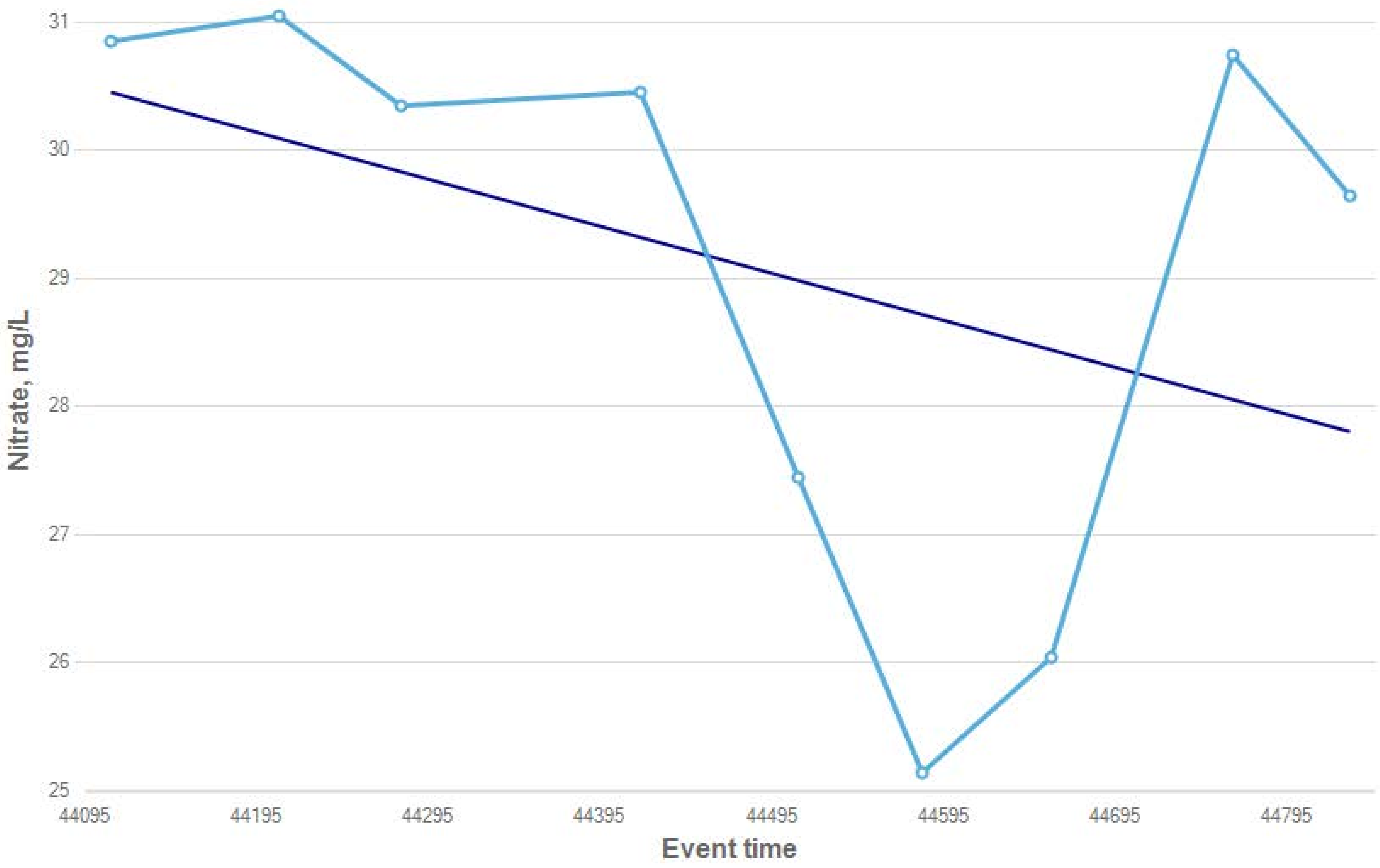
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.3986
Standardized Value of S	0.0000
M-K Test Value (S)	1
Tabulated p-value	0.5400
Approximate p-value	0.5000

OLS Regression Line (Blue)

OLS Regression Slope	0.0228
OLS Regression Intercept	-974.6977

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC192WW (Shallow and Intermediate Basalt)



Mann-Kendall Trend Analysis

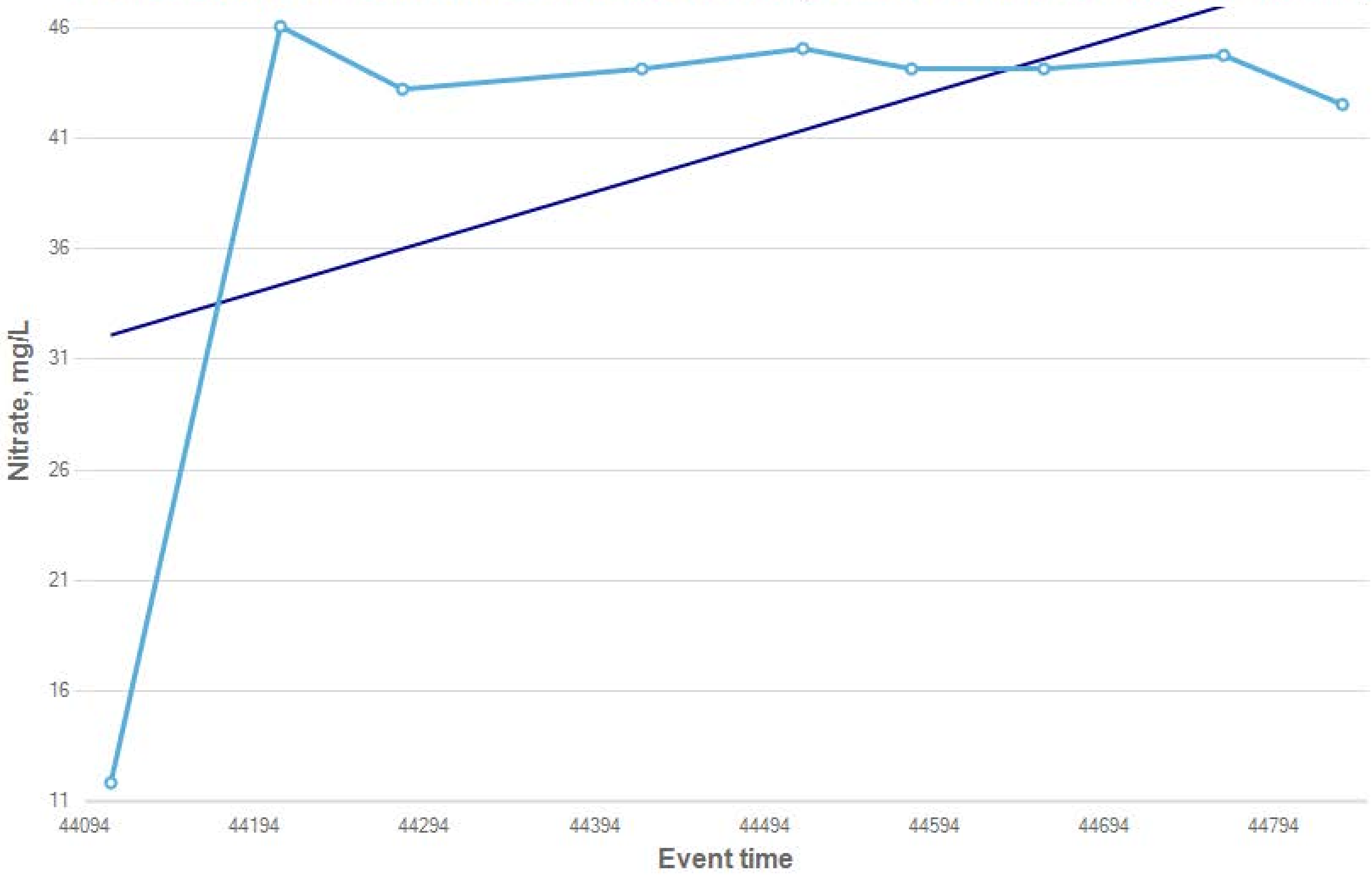
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	-1.3553
M-K Test Value (S)	-14
Tabulated p-value	0.0900
Approximate p-value	0.0877

OLS Regression Line (Blue)

OLS Regression Slope	-0.0037
OLS Regression Intercept	192.6406

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC782321WW (Shallow and Intermediate Basalt)



Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.3986
Standardized Value of S	0.0000
M-K Test Value (S)	1
Tabulated p-value	0.5400
Approximate p-value	0.5000

OLS Regression Line (Blue)

OLS Regression Slope	0.0228
OLS Regression Intercept	-974.6977

Insufficient statistical evidence of a significant trend at the specified level of significance.

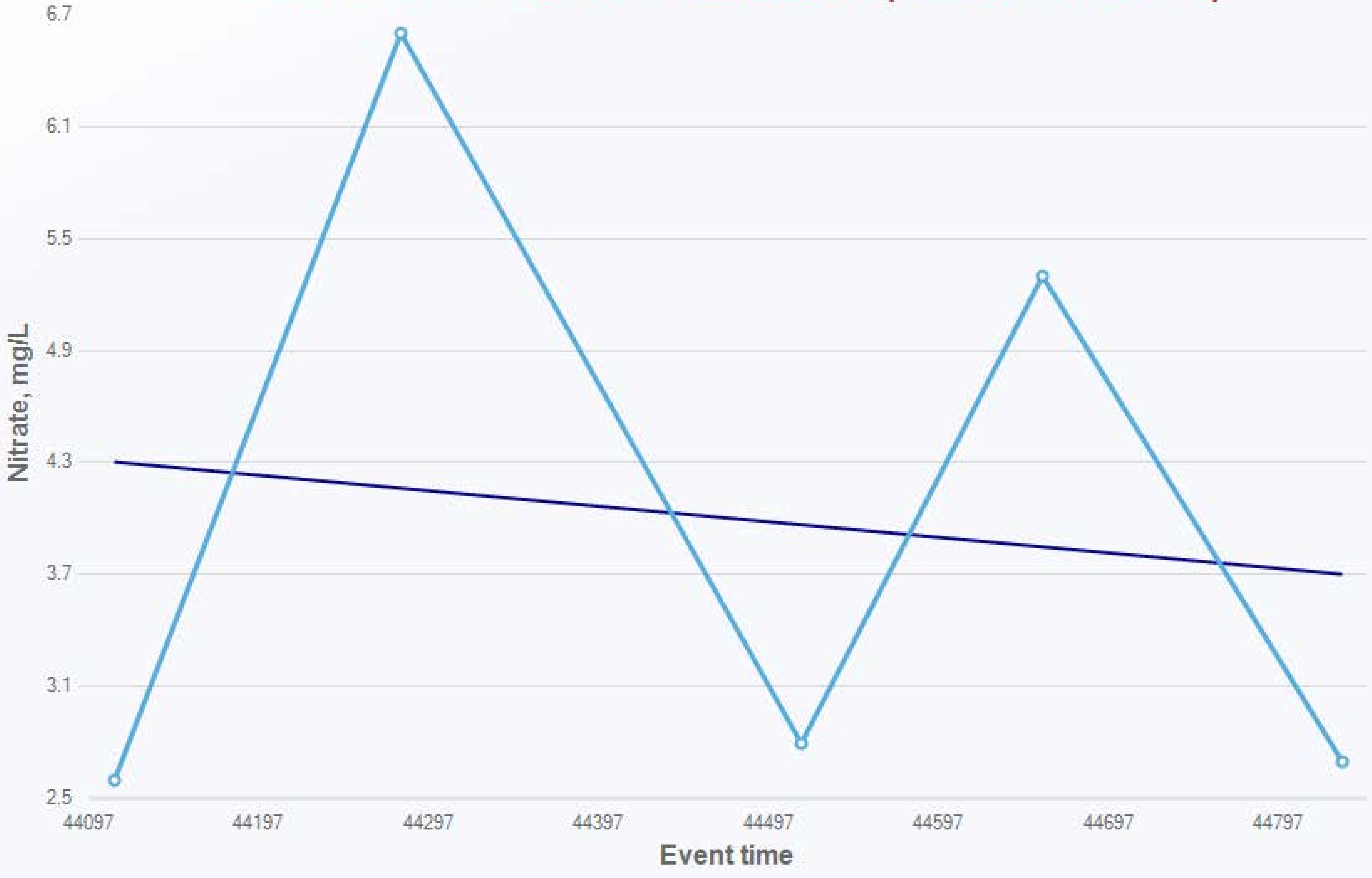
Mann-Kendall Trend Test - BC601WW (Intermediate Basalt)

Mann-Kendall Trend Analysis	
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	0.0000
M-K Test Value (S)	-1
Tabulated p-value	0.5400
Approximate p-value	0.5000

OLS Regression Line (Blue)	
OLS Regression Slope	0.0000
OLS Regression Intercept	9.0761

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC012WW (Unclassified Wells)



Mann-Kendall Trend Analysis

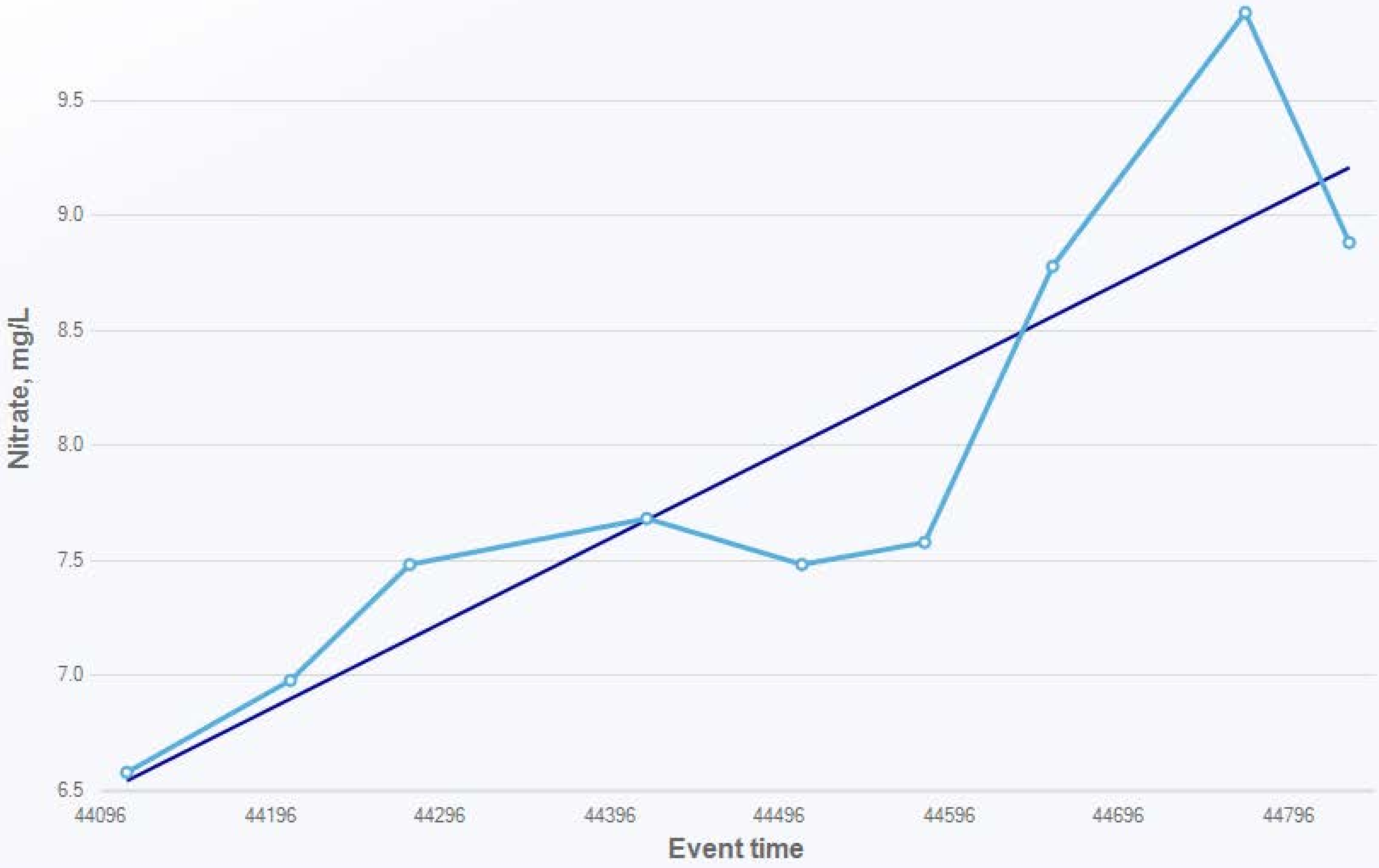
n	5
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	4.0825
Standardized Value of S	
M-K Test Value (S)	0
Tabulated p-value	0.5920
Approximate p-value	

OLS Regression Line (Blue)

OLS Regression Slope	-0.0008
OLS Regression Intercept	40.8934

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC034WW (Unclassified Wells)



Mann-Kendall Trend Analysis

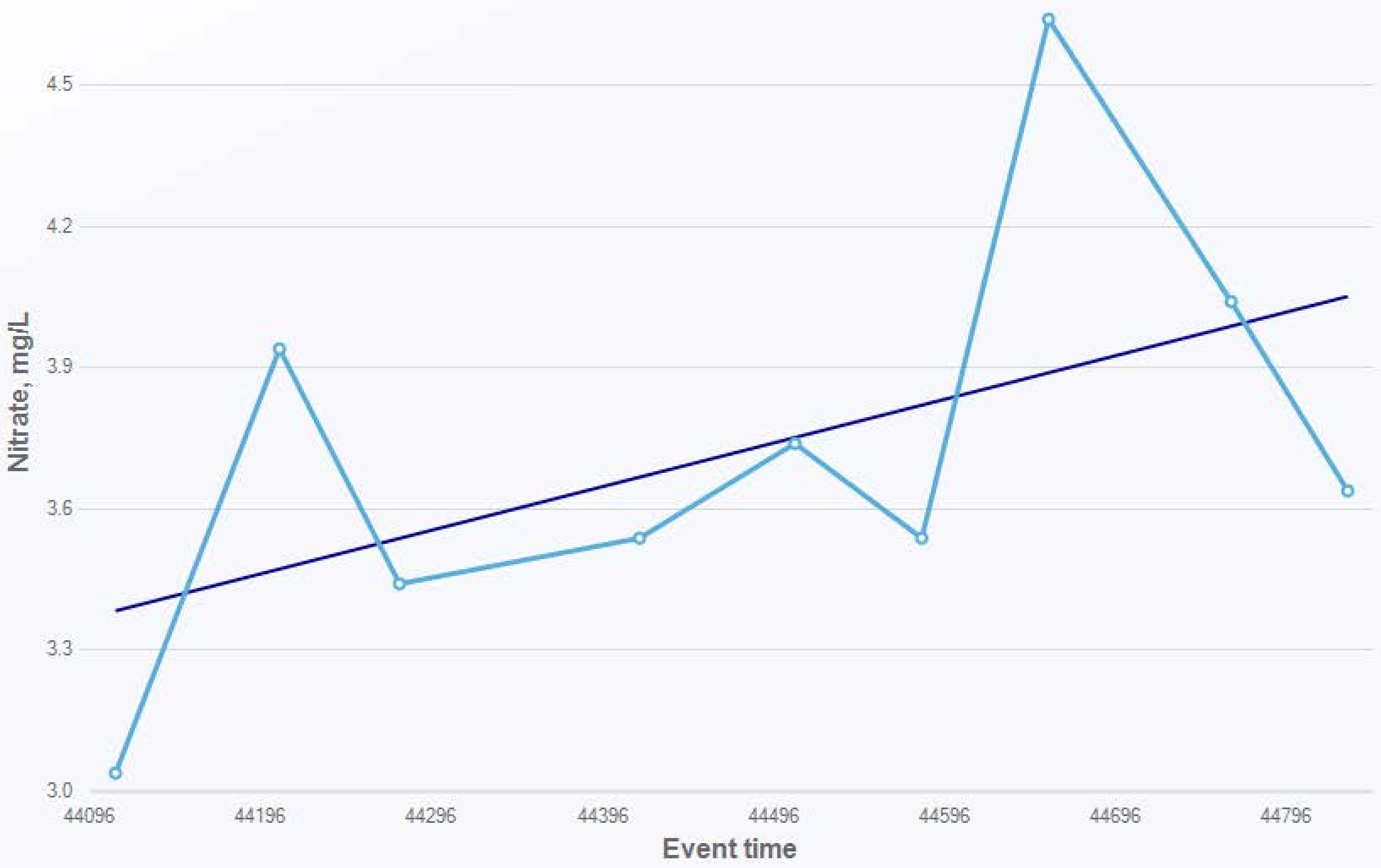
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	2.9352
M-K Test Value (S)	29
Tabulated p-value	0.0010
Approximate p-value	0.0017

OLS Regression Line (Blue)

OLS Regression Slope	0.0037
OLS Regression Intercept	-156.4264

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Trend Test - BC086WW (Unclassified Wells)



Mann-Kendall Trend Analysis

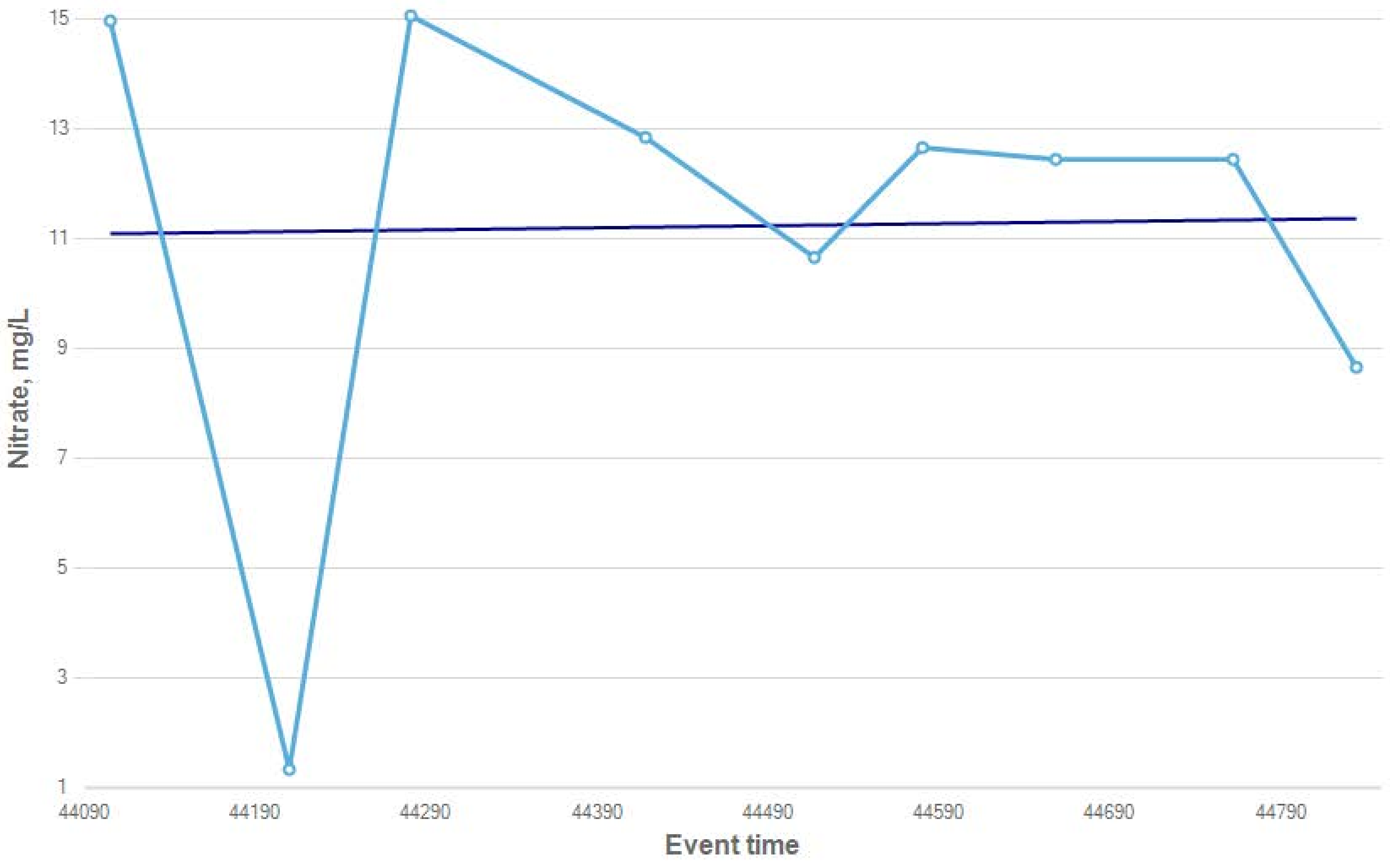
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	1.4676
M-K Test Value (S)	15
Tabulated p-value	0.0900
Approximate p-value	0.0711

OLS Regression Line (Blue)

OLS Regression Slope	0.0009
OLS Regression Intercept	-37.6126

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test -BC235WW (Unclassified Wells)



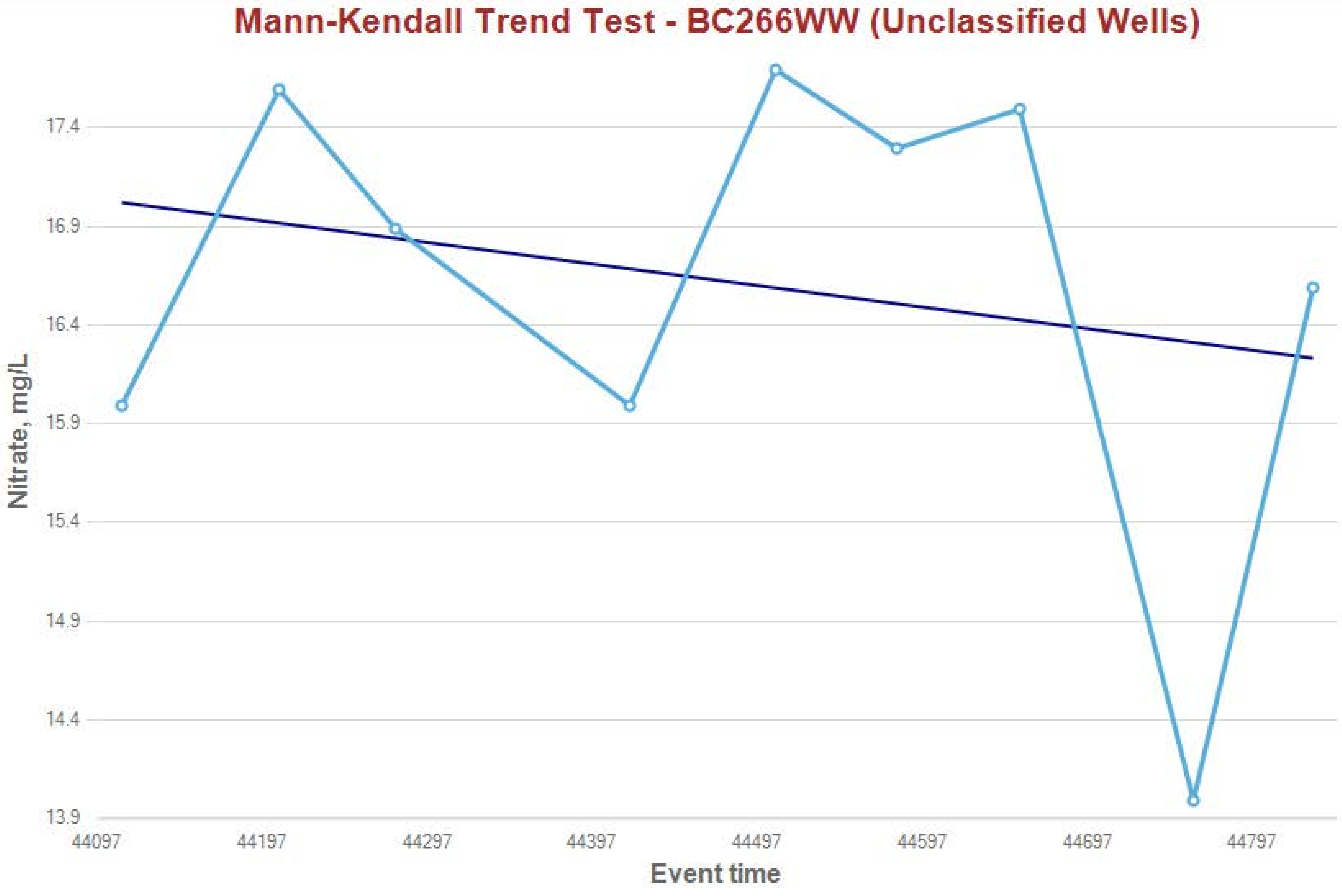
Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	-1.2579
M-K Test Value (S)	-13
Tabulated p-value	0.1300
Approximate p-value	0.1042

OLS Regression Line (Blue)

OLS Regression Slope	0.0004
OLS Regression Intercept	-5.0495

Insufficient statistical evidence of a significant trend at the specified level of significance.



Mann-Kendall Trend Analysis

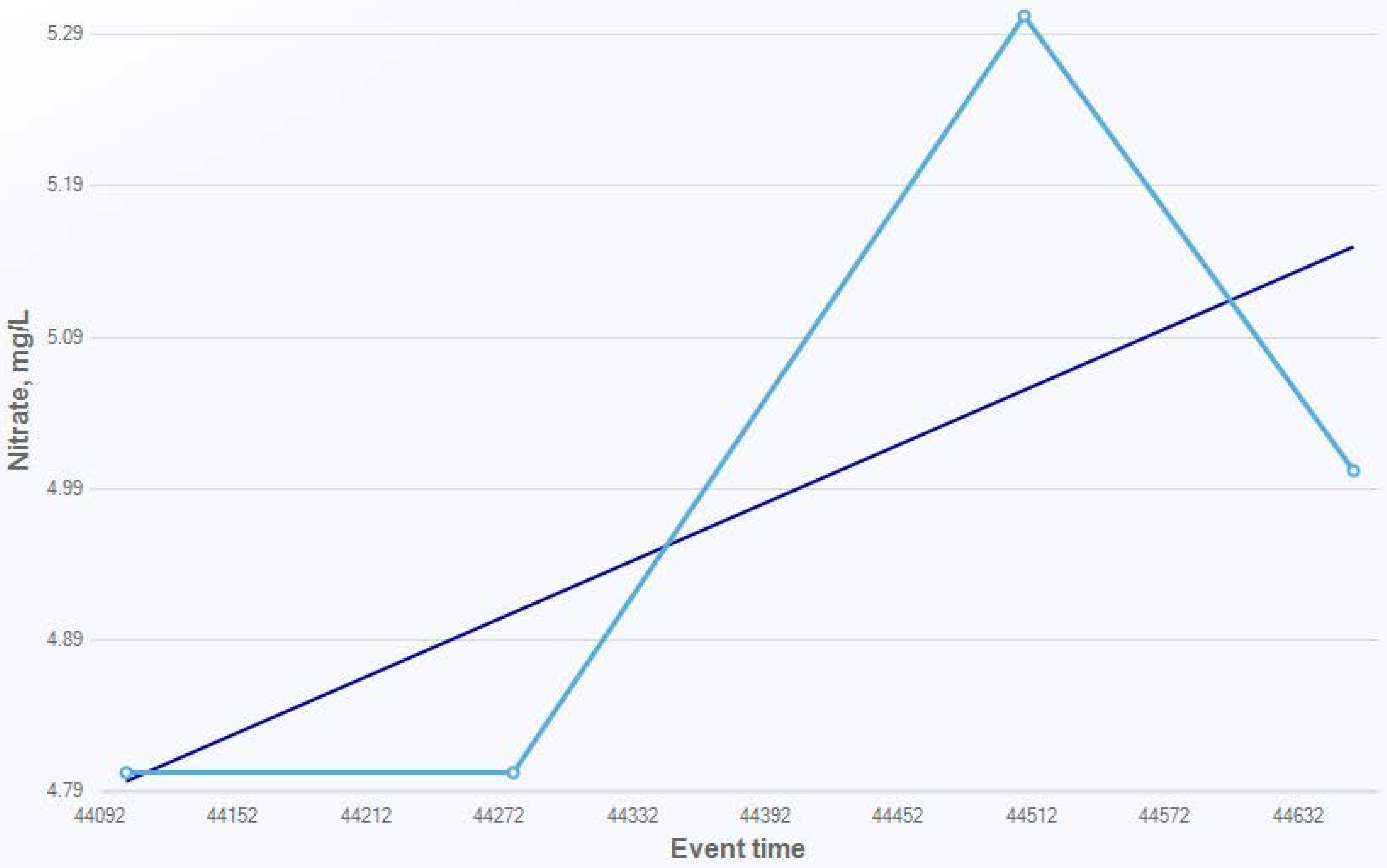
n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5394
Standardized Value of S	-0.2097
M-K Test Value (S)	-3
Tabulated p-value	0.4600
Approximate p-value	0.4170

OLS Regression Line (Blue)

OLS Regression Slope	-0.0011
OLS Regression Intercept	65.3447

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC277WW (Unclassified Wells)



Mann-Kendall Trend Analysis

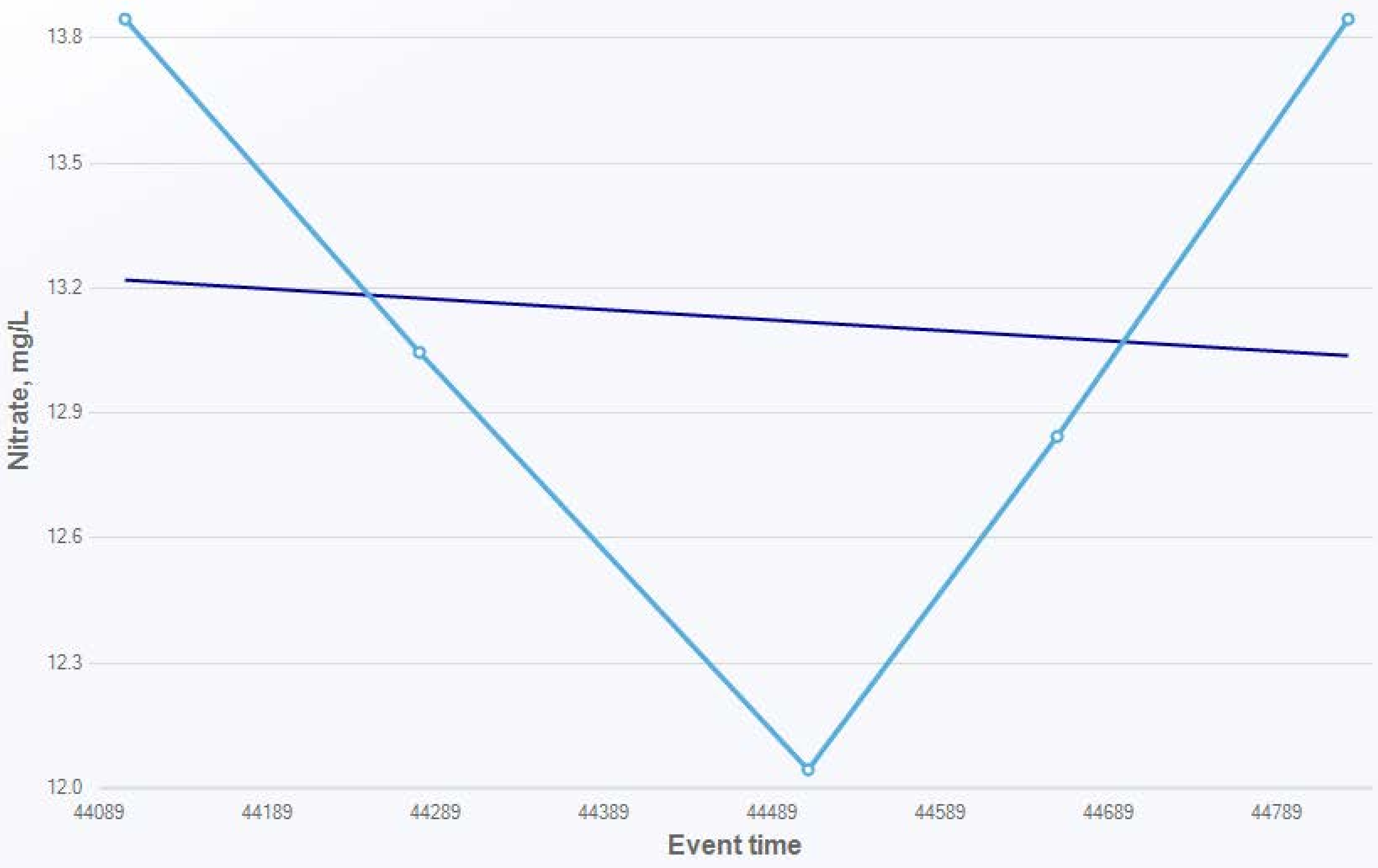
n	4
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	2.7689
Standardized Value of S	0.7223
M-K Test Value (S)	3
Tabulated p-value	0.3750
Approximate p-value	0.2351

OLS Regression Line (Blue)

OLS Regression Slope	0.0006
OLS Regression Intercept	-23.4222

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test - BC279WW (Unclassified Wells)



Mann-Kendall Trend Analysis

n	5
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	3.9581
Standardized Value of S	0.0000
M-K Test Value (S)	-1
Tabulated p-value	0.5920
Approximate p-value	0.5000

OLS Regression Line (Blue)

OLS Regression Slope	-0.0002
OLS Regression Intercept	24.1709

Insufficient statistical evidence of a significant trend at the specified level of significance.

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.2 8/3/2023 1:26:38 PM								
4			From File	BC022WW.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	0.95								
7			Level of Significance	0.05								
8												
9			**Result-bc022ww**									
10												
11			**General Statistics**									
12				Number or Reported Events Not Used	0							
13				Number of Generated Events	9							
14				Number Values Reported (n)	9							
15				Minimum	16.4							
16				Maximum	29.6							
17				Mean	21.8							
18				Geometric Mean	21.32							
19				Median	19.4							
20				Standard Deviation	4.947							
21				Coefficient of Variation	0.227							
22												
23			**Mann-Kendall Test**									
24				M-K Test Value (S)	10							
25				Tabulated p-value	0.179							
26				Standard Deviation of S	9.592							
27				Standardized Value of S	0.938							
28				Approximate p-value	0.174							
29												
30	**Insufficient evidence to identify a significant**											
31	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
33	Result-bc088ww											
34												
35	General Statistics											
36	Number of Events Reported (m)				9							
37	Number of Missing Events				0							
38	Number or Reported Events Used				9							
39	Number Values Reported (n)				9							
40	Minimum				14.5							
41	Maximum				16.6							
42	Mean				15.68							
43	Geometric Mean				15.67							
44	Median				15.6							
45	Standard Deviation				0.636							
46	Coefficient of Variation				0.0406							
47												
48	Mann-Kendall Test											
49	M-K Test Value (S)				-14							
50	Tabulated p-value				0.09							
51	Standard Deviation of S				9.592							
52	Standardized Value of S				-1.355							
53	Approximate p-value				0.0877							
54												
55	Insufficient evidence to identify a significant											
56	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
57	Result-bc100ww											
58												
59	General Statistics											
60	Number of Events Reported (m)				9							
61	Number of Missing Events				0							
62	Number or Reported Events Used				9							
63	Number Values Reported (n)				9							
64	Minimum				0.7							
65	Maximum				1.2							
66	Mean				0.889							
67	Geometric Mean				0.878							
68	Median				0.8							
69	Standard Deviation				0.154							
70	Coefficient of Variation				0.173							
71												
72	Mann-Kendall Test											
73	M-K Test Value (S)				9							
74	Tabulated p-value				0.238							
75	Standard Deviation of S				9.074							
76	Standardized Value of S				0.882							
77	Approximate p-value				0.189							
78												
79	Insufficient evidence to identify a significant											
80	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
81	Result-bc125ww											
82												
83	General Statistics											
84	Number of Events Reported (m)				9							
85	Number of Missing Events				0							
86	Number or Reported Events Used				9							
87	Number Values Reported (n)				9							
88	Minimum				4.6							
89	Maximum				11.6							
90	Mean				9.211							
91	Geometric Mean				8.889							
92	Median				9.3							
93	Standard Deviation				2.354							
94	Coefficient of Variation				0.256							
95												
96	Mann-Kendall Test											
97	M-K Test Value (S)				-24							
98	Tabulated p-value				0.006							
99	Standard Deviation of S				9.592							
100	Standardized Value of S				-2.398							
101	Approximate p-value				0.00824							
102												
103	Statistically significant evidence of a decreasing											
104	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
105	**Result-bc127ww**											
106												
107	**General Statistics**											
108	Number of Events Reported (m)				9							
109	Number of Missing Events				0							
110	Number or Reported Events Used				9							
111	Number Values Reported (n)				9							
112	Minimum				4.2							
113	Maximum				23.4							
114	Mean				11.43							
115	Geometric Mean				9.703							
116	Median				10.2							
117	Standard Deviation				6.9							
118	Coefficient of Variation				0.603							
119												
120	**Mann-Kendall Test**											
121	M-K Test Value (S)				36							
122	Tabulated p-value				0							
123	Standard Deviation of S				9.592							
124	Standardized Value of S				3.649							
125	Approximate p-value				1.3163E-4							
126												
127	**Statistically significant evidence of an increasing**											
128	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
129	**Result-bc151ww**											
130												
131	**General Statistics**											
132	Number of Events Reported (m)				9							
133	Number of Missing Events				0							
134	Number or Reported Events Used				9							
135	Number Values Reported (n)				9							
136	Minimum				6.2							
137	Maximum				9							
138	Mean				7.7							
139	Geometric Mean				7.635							
140	Median				8							
141	Standard Deviation				1.043							
142	Coefficient of Variation				0.135							
143												
144	**Mann-Kendall Test**											
145	M-K Test Value (S)				31							
146	Tabulated p-value				0							
147	Standard Deviation of S				9.539							
148	Standardized Value of S				3.145							
149	Approximate p-value				8.3085E-4							
150												
151	**Statistically significant evidence of an increasing**											
152	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
153	Result-bc184ww											
154												
155	General Statistics											
156	Number of Events Reported (m)				9							
157	Number of Missing Events				0							
158	Number or Reported Events Used				9							
159	Number Values Reported (n)				9							
160	Minimum				15.1							
161	Maximum				21							
162	Mean				19.06							
163	Geometric Mean				18.97							
164	Median				19.4							
165	Standard Deviation				1.823							
166	Coefficient of Variation				0.0957							
167												
168	Mann-Kendall Test											
169	M-K Test Value (S)				-5							
170	Tabulated p-value				0.381							
171	Standard Deviation of S				9.539							
172	Standardized Value of S				-0.419							
173	Approximate p-value				0.337							
174												
175	Insufficient evidence to identify a significant											
176	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
177	Result-bc194ww											
178												
179	**General Statistics**											
180	Number of Events Reported (m)				9							
181	Number of Missing Events				0							
182	Number or Reported Events Used				9							
183	Number Values Reported (n)				9							
184	Minimum				11.4							
185	Maximum				14.3							
186	Mean				13.17							
187	Geometric Mean				13.12							
188	Median				13.5							
189	Standard Deviation				1.101							
190	Coefficient of Variation				0.0836							
191												
192	**Mann-Kendall Test**											
193	M-K Test Value (S)				-15							
194	Tabulated p-value				0.09							
195	Standard Deviation of S				9.399							
196	Standardized Value of S				-1.49							
197	Approximate p-value				0.0682							
198												
199	**Insufficient evidence to identify a significant**											
200	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
201	Result-bc246ww											
202												
203	General Statistics											
204	Number of Events Reported (m)				9							
205	Number of Missing Events				0							
206	Number or Reported Events Used				9							
207	Number Values Reported (n)				9							
208	Minimum				1.3							
209	Maximum				5.2							
210	Mean				2.044							
211	Geometric Mean				1.838							
212	Median				1.5							
213	Standard Deviation				1.238							
214	Coefficient of Variation				0.606							
215												
216	Mann-Kendall Test											
217	M-K Test Value (S)				-9							
218	Tabulated p-value				0.238							
219	Standard Deviation of S				9.399							
220	Standardized Value of S				-0.851							
221	Approximate p-value				0.197							
222												
223	Insufficient evidence to identify a significant											
224	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
225	**Result-bc254ww**											
226												
227	**General Statistics**											
228	Number of Events Reported (m)				9							
229	Number of Missing Events				0							
230	Number or Reported Events Used				9							
231	Number Values Reported (n)				9							
232	Minimum				1.5							
233	Maximum				18.7							
234	Mean				15.5							
235	Geometric Mean				13.12							
236	Median				16.8							
237	Standard Deviation				5.401							
238	Coefficient of Variation				0.348							
239												
240	**Mann-Kendall Test**											
241	M-K Test Value (S)				6							
242	Tabulated p-value				0.306							
243	Standard Deviation of S				9.592							
244	Standardized Value of S				0.521							
245	Approximate p-value				0.301							
246												
247	**Insufficient evidence to identify a significant**											
248	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
249	**Result-bc268ww**											
250												
251	**General Statistics**											
252	Number of Events Reported (m)				9							
253	Number of Missing Events				0							
254	Number or Reported Events Used				9							
255	Number Values Reported (n)				9							
256	Minimum				2.7							
257	Maximum				4.9							
258	Mean				3.378							
259	Geometric Mean				3.31							
260	Median				2.9							
261	Standard Deviation				0.756							
262	Coefficient of Variation				0.224							
263												
264	**Mann-Kendall Test**											
265	M-K Test Value (S)				8							
266	Tabulated p-value				0.238							
267	Standard Deviation of S				9.487							
268	Standardized Value of S				0.738							
269	Approximate p-value				0.23							
270												
271	**Insufficient evidence to identify a significant**											
272	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
273	Result-bc273ww											
274												
275	**General Statistics**											
276	Number of Events Reported (m)				2							
277	Number of Missing Events				0							
278	Number or Reported Events Used				2							
279	Number Values Reported (n)				2							
280	Minimum				13.4							
281	Maximum				13.7							
282	Mean				13.55							
283	Geometric Mean				13.55							
284	Median				13.55							
285	Standard Deviation				0.212							
286	Coefficient of Variation				0.0157							
287	**Not enough reported values (n) to provide Mann-Kendall Statistics!**											
288												

	A	B	C	D	E	F	G	H	I	J	K	L
289	Result-bc600ww											
290												
291	General Statistics											
292	Number of Events Reported (m)				9							
293	Number of Missing Events				0							
294	Number or Reported Events Used				9							
295	Number Values Reported (n)				9							
296	Minimum				7.2							
297	Maximum				8.2							
298	Mean				7.77							
299	Geometric Mean				7.764							
300	Median				7.9							
301	Standard Deviation				0.33							
302	Coefficient of Variation				0.0424							
303												
304	Mann-Kendall Test											
305	M-K Test Value (S)				-1							
306	Tabulated p-value				0.54							
307	Standard Deviation of S				9.539							
308	Standardized Value of S				0							
309	Approximate p-value				0.5							
310												
311	Insufficient evidence to identify a significant											
312	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
313	Result-bc602ww											
314												
315	**General Statistics**											
316	Number of Events Reported (m)				5							
317	Number of Missing Events				0							
318	Number or Reported Events Used				5							
319	Number Values Reported (n)				5							
320	Minimum				2.9							
321	Maximum				3.8							
322	Mean				3.32							
323	Geometric Mean				3.302							
324	Median				3.3							
325	Standard Deviation				0.383							
326	Coefficient of Variation				0.115							
327												
328	**Mann-Kendall Test**											
329	M-K Test Value (S)				-6							
330	Tabulated p-value				0.117							
331	Standard Deviation of S				4.082							
332	Standardized Value of S				-1.225							
333	Approximate p-value				0.11							
334												
335	**Insufficient evidence to identify a significant**											
336	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
337	Result-bc603ww											
338												
339	**General Statistics**											
340	Number of Events Reported (m)				3							
341	Number of Missing Events				0							
342	Number or Reported Events Used				3							
343	Number Values Reported (n)				3							
344	Minimum				4.7							
345	Maximum				16.4							
346	Mean				8.633							
347	Geometric Mean				7.179							
348	Median				4.8							
349	Standard Deviation				6.726							
350	Coefficient of Variation				0.779							
351												
352	**Mann-Kendall Test**											
353	M-K Test Value (S)				1							
354	Tabulated p-value				N/A							
355	Standard Deviation of S				1.915							
356	Standardized Value of S				0							
357	Approximate p-value				0.5							
358												
359	**Insufficient evidence to identify a significant**											
360	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
361	**Result-bc604ww**											
362												
363	**General Statistics**											
364	Number of Events Reported (m)				9							
365	Number of Missing Events				0							
366	Number or Reported Events Used				9							
367	Number Values Reported (n)				9							
368	Minimum				16.5							
369	Maximum				18.3							
370	Mean				17.37							
371	Geometric Mean				17.36							
372	Median				17.3							
373	Standard Deviation				0.587							
374	Coefficient of Variation				0.0338							
375												
376	**Mann-Kendall Test**											
377	M-K Test Value (S)				28							
378	Tabulated p-value				0.001							
379	Standard Deviation of S				9.592							
380	Standardized Value of S				2.815							
381	Approximate p-value				0.00244							
382												
383	**Statistically significant evidence of an increasing**											
384	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
385	**Result-bc609ww**											
386												
387	**General Statistics**											
388	Number of Events Reported (m)				9							
389	Number of Missing Events				0							
390	Number or Reported Events Used				9							
391	Number Values Reported (n)				9							
392	Minimum				1.6							
393	Maximum				3.9							
394	Mean				3.167							
395	Geometric Mean				3.088							
396	Median				3.3							
397	Standard Deviation				0.646							
398	Coefficient of Variation				0.204							
399												
400	**Mann-Kendall Test**											
401	M-K Test Value (S)				-23							
402	Tabulated p-value				0.012							
403	Standard Deviation of S				9.539							
404	Standardized Value of S				-2.306							
405	Approximate p-value				0.0105							
406												
407	**Statistically significant evidence of a decreasing**											
408	**trend at the specified level of significance.**											

	A-D	E
409	Result-bc613ww	
410		
411	General Statistics	
412	Number of Events Reported (m)	9
413	Number of Missing Events	0
414	Number or Reported Events Used	9
415	Number Values Reported (n)	9
416	Minimum	6.6
417	Maximum	9.2
418	Mean	7.8
419	Geometric Mean	7.758
420	Median	8.1
421	Standard Deviation	0.857
422	Coefficient of Variation	0.11
423		
424	Mann-Kendall Test	
425	M-K Test Value (S)	-8
426	Tabulated p-value	0.238
427	Standard Deviation of S	9.592
428	Standardized Value of S	-0.73
429	Approximate p-value	0.233
430		
431	Insufficient evidence to identify a significant	
432	trend at the specified level of significance.	

	A	B	C	D	E	F	G	H	I	J	K	L
433	**Result-bc616ww**											
434												
435	**General Statistics**											
436	Number of Events Reported (m)				9							
437	Number of Missing Events				0							
438	Number or Reported Events Used				9							
439	Number Values Reported (n)				9							
440	Minimum				12.5							
441	Maximum				14.4							
442	Mean				12.94							
443	Geometric Mean				12.93							
444	Median				12.7							
445	Standard Deviation				0.594							
446	Coefficient of Variation				0.0459							
447												
448	**Mann-Kendall Test**											
449	M-K Test Value (S)				-8							
450	Tabulated p-value				0.238							
451	Standard Deviation of S				9.487							
452	Standardized Value of S				-0.738							
453	Approximate p-value				0.23							
454												
455	**Insufficient evidence to identify a significant**											
456	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.2 4/10/2023 12:31:47 PM								
4			From File	Data_c.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	0.95								
7			Level of Significance	0.05								
8												
9			**Result-bc081ww**									
10												
11			**General Statistics**									
12				Number of Events Reported (m)	5							
13				Number of Missing Events	0							
14				Number or Reported Events Used	5							
15				Number Values Reported (n)	5							
16				Minimum	12.1							
17				Maximum	12.8							
18				Mean	12.48							
19				Geometric Mean	12.48							
20				Median	12.5							
21				Standard Deviation	0.286							
22				Coefficient of Variation	0.0229							
23												
24			**Mann-Kendall Test**									
25				M-K Test Value (S)	6							
26				Tabulated p-value	0.117							
27				Standard Deviation of S	4.082							
28				Standardized Value of S	1.225							
29				Approximate p-value	0.11							
30												
31	**Insufficient evidence to identify a significant**											
32	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
33	Result-bc087ww											
34												
35	General Statistics											
36	Number of Events Reported (m)				9							
37	Number of Missing Events				0							
38	Number or Reported Events Used				9							
39	Number Values Reported (n)				9							
40	Minimum				6.5							
41	Maximum				22.2							
42	Mean				13.07							
43	Geometric Mean				11.52							
44	Median				9.03							
45	Standard Deviation				6.776							
46	Coefficient of Variation				0.518							
47												
48	Mann-Kendall Test											
49	M-K Test Value (S)				-22							
50	Tabulated p-value				0.012							
51	Standard Deviation of S				9.592							
52	Standardized Value of S				-2.189							
53	Approximate p-value				0.0143							
54												
55	Statistically significant evidence of a decreasing											
56	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
57	Result-bc116ww											
58												
59	General Statistics											
60	Number of Events Reported (m)				9							
61	Number of Missing Events				0							
62	Number or Reported Events Used				9							
63	Number Values Reported (n)				9							
64	Minimum				1.6							
65	Maximum				13.1							
66	Mean				8.978							
67	Geometric Mean				7.971							
68	Median				9							
69	Standard Deviation				3.338							
70	Coefficient of Variation				0.372							
71												
72	Mann-Kendall Test											
73	M-K Test Value (S)				-2							
74	Tabulated p-value				0.46							
75	Standard Deviation of S				9.487							
76	Standardized Value of S				-0.105							
77	Approximate p-value				0.458							
78												
79	Insufficient evidence to identify a significant											
80	trend at the specified level of significance.											

	A–D	E	F	G	H	I	J	K	L
81	**Result-bc117ww**								
82									
83	**General Statistics**								
84	Number of Events Reported (m)	8							
85	Number of Missing Events	0							
86	Number or Reported Events Used	8							
87	Number Values Reported (n)	8							
88	Minimum	21.7							
89	Maximum	59							
90	Mean	36.19							
91	Geometric Mean	34.48							
92	Median	32.25							
93	Standard Deviation	12.34							
94	Coefficient of Variation	0.341							
95									
96	**Mann-Kendall Test**								
97	M-K Test Value (S)	26							
98	Tabulated p-value	0							
99	Standard Deviation of S	8.083							
100	Standardized Value of S	3.093							
101	Approximate p-value	9.9089E-4							
102									
103	**Statistically significant evidence of an increasing**								
104	**trend at the specified level of significance.**								

	A	B	C	D	E	F	G	H	I	J	K	L
105	Result-bc128ww											
106												
107	General Statistics											
108	Number of Events Reported (m)				9							
109	Number of Missing Events				0							
110	Number or Reported Events Used				9							
111	Number Values Reported (n)				9							
112	Minimum				3.4							
113	Maximum				14.3							
114	Mean				9.622							
115	Geometric Mean				8.555							
116	Median				12.4							
117	Standard Deviation				4.281							
118	Coefficient of Variation				0.445							
119												
120	Mann-Kendall Test											
121	M-K Test Value (S)				3							
122	Tabulated p-value				0.46							
123	Standard Deviation of S				9.539							
124	Standardized Value of S				0.21							
125	Approximate p-value				0.417							
126												
127	Insufficient evidence to identify a significant											
128	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
129	Result-bc610ww											
130												
131	General Statistics											
132	Number of Events Reported (m)				5							
133	Number of Missing Events				0							
134	Number or Reported Events Used				5							
135	Number Values Reported (n)				5							
136	Minimum				18							
137	Maximum				25.3							
138	Mean				21							
139	Geometric Mean				20.83							
140	Median				21							
141	Standard Deviation				3.031							
142	Coefficient of Variation				0.144							
143												
144	Mann-Kendall Test											
145	M-K Test Value (S)				2							
146	Tabulated p-value				0.408							
147	Standard Deviation of S				4.082							
148	Standardized Value of S				0.245							
149	Approximate p-value				0.403							
150												
151	Insufficient evidence to identify a significant											
152	trend at the specified level of significance.											

	Mann-Kendall Trend Test Analysis	
User Selected Options		
Date/Time of Computation	ProUCL 5.2 4/10/2023 12:18:09 PM	
From File	Data_b.xls	
Full Precision	OFF	
Confidence Coefficient	0.95	
Level of Significance	0.05	
Result-bc232ww		
General Statistics		
Number of Events Reported (m)		9
Number of Missing Events		0
Number or Reported Events Used		9
Number Values Reported (n)		9
Minimum		6.4
Maximum		8.2
Mean		7.167
Geometric Mean		7.148
Median		7.3
Standard Deviation		0.559
Coefficient of Variation		0.078
Mann-Kendall Test		
M-K Test Value (S)		-19
Tabulated p-value		0.038
Standard Deviation of S		9.539
Standardized Value of S		-1.887
Approximate p-value		0.0296
Statistically significant evidence of a decreasing		
trend at the specified level of significance.		

	A	B	C	D	E	F	G	H	I	J	K	L
33	Result-bc239ww											
34												
35	General Statistics											
36	Number of Events Reported (m)				9							
37	Number of Missing Events				0							
38	Number or Reported Events Used				9							
39	Number Values Reported (n)				9							
40	Minimum				4.3							
41	Maximum				6.2							
42	Mean				5.467							
43	Geometric Mean				5.428							
44	Median				5.4							
45	Standard Deviation				0.673							
46	Coefficient of Variation				0.123							
47												
48	Mann-Kendall Test											
49	M-K Test Value (S)				-14							
50	Tabulated p-value				0.09							
51	Standard Deviation of S				9.487							
52	Standardized Value of S				-1.37							
53	Approximate p-value				0.0853							
54												
55	Insufficient evidence to identify a significant											
56	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
57			Result-bc240ww									
58												
59			General Statistics									
60				Number of Events Reported (m)	9							
61				Number of Missing Events	0							
62				Number or Reported Events Used	9							
63				Number Values Reported (n)	9							
64				Minimum	3.8							
65				Maximum	7.4							
66				Mean	5.7							
67				Geometric Mean	5.568							
68				Median	5.7							
69				Standard Deviation	1.277							
70				Coefficient of Variation	0.224							
71												
72			Mann-Kendall Test									
73				M-K Test Value (S)	18							
74				Tabulated p-value	0.038							
75				Standard Deviation of S	9.592							
76				Standardized Value of S	1.772							
77				Approximate p-value	0.0382							
78												
79	Statistically significant evidence of an increasing											
80	trend at the specified level of significance.											

	A–D	E
81	**Result-bc605ww**	
82		
83	**General Statistics**	
84	Number of Events Reported (m)	9
85	Number of Missing Events	0
86	Number or Reported Events Used	9
87	Number Values Reported (n)	9
88	Minimum	5.3
89	Maximum	20.9
90	Mean	12.28
91	Geometric Mean	10.85
92	Median	12
93	Standard Deviation	6.073
94	Coefficient of Variation	0.495
95		
96	**Mann-Kendall Test**	
97	M-K Test Value (S)	-8
98	Tabulated p-value	0.238
99	Standard Deviation of S	9.592
100	Standardized Value of S	-0.73
101	Approximate p-value	0.233
102		
103	**Insufficient evidence to identify a significant**	
104	**trend at the specified level of significance.**	

	A	B	C	D	E	F	G	H	I	J	K	L
105	Result-bc606ww											
106												
107	General Statistics											
108	Number of Events Reported (m)				9							
109	Number of Missing Events				0							
110	Number or Reported Events Used				9							
111	Number Values Reported (n)				9							
112	Minimum				4.8							
113	Maximum				5.6							
114	Mean				5.167							
115	Geometric Mean				5.161							
116	Median				5.2							
117	Standard Deviation				0.265							
118	Coefficient of Variation				0.0512							
119												
120	Mann-Kendall Test											
121	M-K Test Value (S)				8							
122	Tabulated p-value				0.238							
123	Standard Deviation of S				9.487							
124	Standardized Value of S				0.738							
125	Approximate p-value				0.23							
126												
127	Insufficient evidence to identify a significant											
128	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
129	**Result-bc607ww**											
130												
131	**General Statistics**											
132	Number of Events Reported (m)				9							
133	Number of Missing Events				0							
134	Number or Reported Events Used				9							
135	Number Values Reported (n)				9							
136	Minimum				12.9							
137	Maximum				23.4							
138	Mean				18.62							
139	Geometric Mean				18.23							
140	Median				17.9							
141	Standard Deviation				3.98							
142	Coefficient of Variation				0.214							
143												
144	**Mann-Kendall Test**											
145	M-K Test Value (S)				-24							
146	Tabulated p-value				0.006							
147	Standard Deviation of S				9.592							
148	Standardized Value of S				-2.398							
149	Approximate p-value				0.00824							
150												
151	**Statistically significant evidence of a decreasing**											
152	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
153	**Result-bc608ww**											
154												
155	**General Statistics**											
156	Number of Events Reported (m)				9							
157	Number of Missing Events				0							
158	Number or Reported Events Used				9							
159	Number Values Reported (n)				9							
160	Minimum				4.6							
161	Maximum				8.3							
162	Mean				6.989							
163	Geometric Mean				6.871							
164	Median				7.6							
165	Standard Deviation				1.295							
166	Coefficient of Variation				0.185							
167												
168	**Mann-Kendall Test**											
169	M-K Test Value (S)				19							
170	Tabulated p-value				0.038							
171	Standard Deviation of S				9.539							
172	Standardized Value of S				1.887							
173	Approximate p-value				0.0296							
174												
175	**Statistically significant evidence of an increasing**											
176	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
177	Result-bc611ww											
178												
179	General Statistics											
180	Number of Events Reported (m)				8							
181	Number of Missing Events				0							
182	Number or Reported Events Used				8							
183	Number Values Reported (n)				8							
184	Minimum				14.2							
185	Maximum				17.3							
186	Mean				16.08							
187	Geometric Mean				16.05							
188	Median				16.2							
189	Standard Deviation				0.91							
190	Coefficient of Variation				0.0566							
191												
192	Mann-Kendall Test											
193	M-K Test Value (S)				0							
194	Tabulated p-value				0.548							
195	Standard Deviation of S				8.083							
196	Standardized Value of S				N/A							
197	Approximate p-value				N/A							
198												
199	Insufficient evidence to identify a significant											
200	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
201	Result-bc612ww											
202												
203	General Statistics											
204	Number of Events Reported (m)				9							
205	Number of Missing Events				0							
206	Number or Reported Events Used				9							
207	Number Values Reported (n)				9							
208	Minimum				3.1							
209	Maximum				18.7							
210	Mean				7.043							
211	Geometric Mean				5.831							
212	Median				5.5							
213	Standard Deviation				5.225							
214	Coefficient of Variation				0.742							
215												
216	Mann-Kendall Test											
217	M-K Test Value (S)				30							
218	Tabulated p-value				0							
219	Standard Deviation of S				9.592							
220	Standardized Value of S				3.023							
221	Approximate p-value				0.00125							
222												
223	Statistically significant evidence of an increasing											
224	trend at the specified level of significance.											

	Mann-Kendall Trend Test Analysis	
User Selected Options		
Date/Time of Computation	ProUCL 5.2 4/10/2023 12:44:08 PM	
From File	Data_e.xls	
Full Precision	OFF	
Confidence Coefficient	0.95	
Level of Significance	0.05	
Result-bc192ww		
General Statistics		
Number of Events Reported (m)		9
Number of Missing Events		0
Number or Reported Events Used		9
Number Values Reported (n)		9
Minimum		24.9
Maximum		30.8
Mean		28.83
Geometric Mean		28.75
Median		30.1
Standard Deviation		2.261
Coefficient of Variation		0.0784
Mann-Kendall Test		
M-K Test Value (S)		-14
Tabulated p-value		0.09
Standard Deviation of S		9.592
Standardized Value of S		-1.355
Approximate p-value		0.0877
Insufficient evidence to identify a significant		
trend at the specified level of significance.		

	A	B	C	D	E	F	G	H	I	J	K	L
33	Result-bc782321ww											
34												
35	General Statistics											
36	Number of Events Reported (m)				9							
37	Number of Missing Events				0							
38	Number or Reported Events Used				9							
39	Number Values Reported (n)				9							
40	Minimum				11.8							
41	Maximum				46							
42	Mean				40.61							
43	Geometric Mean				38.17							
44	Median				44.1							
45	Standard Deviation				10.85							
46	Coefficient of Variation				0.267							
47												
48	Mann-Kendall Test											
49	M-K Test Value (S)				1							
50	Tabulated p-value				0.54							
51	Standard Deviation of S				9.399							
52	Standardized Value of S				0							
53	Approximate p-value				0.5							
54												
55	Insufficient evidence to identify a significant											
56	trend at the specified level of significance.											

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/3/2023 1:53:05 PM
From File	BC601WW Input.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Result-bc601ww

General Statistics

Number of Events Reported (m)	9
Number of Missing Events	0
Number or Reported Events Used	9
Number Values Reported (n)	9
Minimum	7.5
Maximum	12.5
Mean	9.689
Geometric Mean	9.523
Median	10
Standard Deviation	1.893
Coefficient of Variation	0.195

Mann-Kendall Test

M-K Test Value (S)	-1
Tabulated p-value	0.54
Standard Deviation of S	9.539
Standardized Value of S	0
Approximate p-value	0.5

Insufficient evidence to identify a significant trend at the specified level of significance.

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.2 4/10/2023 12:48:19 PM								
4			From File	Data_f.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	0.95								
7			Level of Significance	0.05								
8												
9			**Result-bc012ww**									
10												
11			**General Statistics**									
12				Number of Events Reported (m)	5							
13				Number of Missing Events	0							
14				Number or Reported Events Used	5							
15				Number Values Reported (n)	5							
16				Minimum	2.6							
17				Maximum	6.6							
18				Mean	4							
19				Geometric Mean	3.694							
20				Median	2.8							
21				Standard Deviation	1.84							
22				Coefficient of Variation	0.46							
23												
24			**Mann-Kendall Test**									
25				M-K Test Value (S)	0							
26				Tabulated p-value	0.592							
27				Standard Deviation of S	4.082							
28				Standardized Value of S	N/A							
29				Approximate p-value	N/A							
30												
31	**Insufficient evidence to identify a significant**											
32	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
33	**Result-bc034ww**											
34												
35	**General Statistics**											
36	Number of Events Reported (m)				9							
37	Number of Missing Events				0							
38	Number or Reported Events Used				9							
39	Number Values Reported (n)				9							
40	Minimum				6.6							
41	Maximum				9.9							
42	Mean				7.944							
43	Geometric Mean				7.886							
44	Median				7.6							
45	Standard Deviation				1.045							
46	Coefficient of Variation				0.132							
47												
48	**Mann-Kendall Test**											
49	M-K Test Value (S)				29							
50	Tabulated p-value				0.001							
51	Standard Deviation of S				9.539							
52	Standardized Value of S				2.935							
53	Approximate p-value				0.00167							
54												
55	**Statistically significant evidence of an increasing**											
56	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
57	Result-bc086ww											
58												
59	**General Statistics**											
60	Number of Events Reported (m)				9							
61	Number of Missing Events				0							
62	Number or Reported Events Used				9							
63	Number Values Reported (n)				9							
64	Minimum				3							
65	Maximum				4.6							
66	Mean				3.689							
67	Geometric Mean				3.665							
68	Median				3.6							
69	Standard Deviation				0.448							
70	Coefficient of Variation				0.122							
71												
72	**Mann-Kendall Test**											
73	M-K Test Value (S)				15							
74	Tabulated p-value				0.09							
75	Standard Deviation of S				9.539							
76	Standardized Value of S				1.468							
77	Approximate p-value				0.0711							
78												
79	**Insufficient evidence to identify a significant**											
80	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
81	Result-bc235ww											
82												
83	**General Statistics**											
84	Number of Events Reported (m)				9							
85	Number of Missing Events				0							
86	Number or Reported Events Used				9							
87	Number Values Reported (n)				9							
88	Minimum				1.7							
89	Maximum				15.4							
90	Mean				11.58							
91	Geometric Mean				10.12							
92	Median				12.8							
93	Standard Deviation				4.193							
94	Coefficient of Variation				0.362							
95												
96	**Mann-Kendall Test**											
97	M-K Test Value (S)				-13							
98	Tabulated p-value				0.13							
99	Standard Deviation of S				9.539							
100	Standardized Value of S				-1.258							
101	Approximate p-value				0.104							
102												
103	**Insufficient evidence to identify a significant**											
104	**trend at the specified level of significance.**											

	A-D	E	F	G	H	I	J	K	L
105	Result-bc266ww								
106									
107	General Statistics								
108	Number of Events Reported (m)	9							
109	Number of Missing Events	0							
110	Number or Reported Events Used	9							
111	Number Values Reported (n)	9							
112	Minimum	14							
113	Maximum	17.7							
114	Mean	16.62							
115	Geometric Mean	16.58							
116	Median	16.9							
117	Standard Deviation	1.177							
118	Coefficient of Variation	0.0708							
119									
120	Mann-Kendall Test								
121	M-K Test Value (S)	-3							
122	Tabulated p-value	0.46							
123	Standard Deviation of S	9.539							
124	Standardized Value of S	-0.21							
125	Approximate p-value	0.417							
126									
127	Insufficient evidence to identify a significant								
128	trend at the specified level of significance.								

	A	B	C	D	E	F	G	H	I	J	K	L
129	Result-bc274ww											
130												
131	**General Statistics**											
132	Number of Events Reported (m)				2							
133	Number of Missing Events				0							
134	Number or Reported Events Used				2							
135	Number Values Reported (n)				2							
136	Minimum				18.2							
137	Maximum				36.3							
138	Mean				27.25							
139	Geometric Mean				25.7							
140	Median				27.25							
141	Standard Deviation				12.8							
142	Coefficient of Variation				0.47							
143	**Not enough reported values (n) to provide Mann-Kendall Statistics!**											
144												

	A	B	C	D	E	F	G	H	I	J	K	L
145	**Result-bc275ww**											
146												
147	**General Statistics**											
148	Number of Events Reported (m)				2							
149	Number of Missing Events				0							
150	Number or Reported Events Used				2							
151	Number Values Reported (n)				2							
152	Minimum				12.4							
153	Maximum				12.7							
154	Mean				12.55							
155	Geometric Mean				12.55							
156	Median				12.55							
157	Standard Deviation				0.212							
158	Coefficient of Variation				0.0169							
159	**Not enough reported values (n) to provide Mann-Kendall Statistics!**											
160												

	A	B	C	D	E	F	G	H	I	J	K	L
161	Result-bc276ww											
162												
163	General Statistics											
164	Number of Events Reported (m)				2							
165	Number of Missing Events				0							
166	Number or Reported Events Used				2							
167	Number Values Reported (n)				2							
168	Minimum				20.8							
169	Maximum				25.1							
170	Mean				22.95							
171	Geometric Mean				22.85							
172	Median				22.95							
173	Standard Deviation				3.041							
174	Coefficient of Variation				0.132							
175	Not enough reported values (n) to provide Mann-Kendall Statistics!											
176												

	A–D	E
177	**Result-bc277ww**	
178		
179	**General Statistics**	
180	Number of Events Reported (m)	4
181	Number of Missing Events	0
182	Number or Reported Events Used	4
183	Number Values Reported (n)	4
184	Minimum	4.8
185	Maximum	5.3
186	Mean	4.975
187	Geometric Mean	4.971
188	Median	4.9
189	Standard Deviation	0.236
190	Coefficient of Variation	0.0475
191		
192	**Mann-Kendall Test**	
193	M-K Test Value (S)	3
194	Tabulated p-value	0.375
195	Standard Deviation of S	2.769
196	Standardized Value of S	0.722
197	Approximate p-value	0.235
198		
199	**Insufficient evidence to identify a significant**	
200	**trend at the specified level of significance.**	

	A	B	C	D	E	F	G	H	I	J	K	L
201	Result-bc278ww											
202												
203	General Statistics											
204	Number of Events Reported (m)				2							
205	Number of Missing Events				0							
206	Number or Reported Events Used				2							
207	Number Values Reported (n)				2							
208	Minimum				30.6							
209	Maximum				32.9							
210	Mean				31.75							
211	Geometric Mean				31.73							
212	Median				31.75							
213	Standard Deviation				1.626							
214	Coefficient of Variation				0.0512							
215	Not enough reported values (n) to provide Mann-Kendall Statistics!											
216												

	A	B	C	D	E	F	G	H	I	J	K	L
217	Result-bc279ww											
218												
219	General Statistics											
220	Number of Events Reported (m)				5							
221	Number of Missing Events				0							
222	Number or Reported Events Used				5							
223	Number Values Reported (n)				5							
224	Minimum				12							
225	Maximum				13.8							
226	Mean				13.08							
227	Geometric Mean				13.06							
228	Median				13							
229	Standard Deviation				0.756							
230	Coefficient of Variation				0.0578							
231												
232	Mann-Kendall Test											
233	M-K Test Value (S)				-1							
234	Tabulated p-value				0.592							
235	Standard Deviation of S				3.958							
236	Standardized Value of S				0							
237	Approximate p-value				0.5							
238												
239	Insufficient evidence to identify a significant											
240	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
241	Result-bc325ww											
242												
243	General Statistics											
244	Number of Events Reported (m)				1							
245	Number of Missing Events				0							
246	Number or Reported Events Used				1							
247	Number Values Reported (n)				1							
248	Minimum				9.9							
249	Maximum				9.9							
250	Mean				9.9							
251	Geometric Mean				9.9							
252	Median				9.9							
253	Standard Deviation				N/A							
254	Coefficient of Variation				N/A							
255	Not enough reported values (n) to provide Mann-Kendall Statistics!											
256												

	A	B	C	D	E	F	G	H	I	J	K	L
257	Result-bc500ww											
258												
259	General Statistics											
260	Number of Events Reported (m)				5							
261	Number of Missing Events				0							
262	Number or Reported Events Used				5							
263	Number Values Reported (n)				5							
264	Minimum				5.7							
265	Maximum				6.7							
266	Mean				6.06							
267	Geometric Mean				6.046							
268	Median				5.8							
269	Standard Deviation				0.462							
270	Coefficient of Variation				0.0762							
271												
272	Mann-Kendall Test											
273	M-K Test Value (S)				1							
274	Tabulated p-value				0.592							
275	Standard Deviation of S				3.958							
276	Standardized Value of S				0							
277	Approximate p-value				0.5							
278												
279	Insufficient evidence to identify a significant											
280	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
281	**Result-bc614ww**											
282												
283	**General Statistics**											
284	Number of Events Reported (m)				5							
285	Number of Missing Events				0							
286	Number or Reported Events Used				5							
287	Number Values Reported (n)				5							
288	Minimum				1.3							
289	Maximum				3.2							
290	Mean				1.86							
291	Geometric Mean				1.759							
292	Median				1.5							
293	Standard Deviation				0.77							
294	Coefficient of Variation				0.414							
295												
296	**Mann-Kendall Test**											
297	M-K Test Value (S)				5							
298	Tabulated p-value				0.242							
299	Standard Deviation of S				3.958							
300	Standardized Value of S				1.011							
301	Approximate p-value				0.156							
302												
303	**Insufficient evidence to identify a significant**											
304	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
305	Result-bc615ww											
306												
307	General Statistics											
308	Number of Events Reported (m)				5							
309	Number of Missing Events				0							
310	Number or Reported Events Used				5							
311	Number Values Reported (n)				5							
312	Minimum				0.9							
313	Maximum				1.9							
314	Mean				1.6							
315	Geometric Mean				1.546							
316	Median				1.7							
317	Standard Deviation				0.412							
318	Coefficient of Variation				0.258							
319												
320	Mann-Kendall Test											
321	M-K Test Value (S)				-3							
322	Tabulated p-value				0.408							
323	Standard Deviation of S				3.958							
324	Standardized Value of S				-0.505							
325	Approximate p-value				0.307							
326												
327	Insufficient evidence to identify a significant											
328	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
329	**Result-bc617ww**											
330												
331	**General Statistics**											
332	Number of Events Reported (m)				1							
333	Number of Missing Events				0							
334	Number or Reported Events Used				1							
335	Number Values Reported (n)				1							
336	Minimum				1							
337	Maximum				1							
338	Mean				1							
339	Geometric Mean				1							
340	Median				1							
341	Standard Deviation				N/A							
342	Coefficient of Variation				N/A							
343	**Not enough reported values (n) to provide Mann-Kendall Statistics!**											
344												

	A	B	C	D	E	F	G	H	I	J	K	L
345	Result-bc618ww											
346												
347	**General Statistics**											
348	Number of Events Reported (m)				2							
349	Number of Missing Events				0							
350	Number or Reported Events Used				2							
351	Number Values Reported (n)				2							
352	Minimum				4.8							
353	Maximum				5.4							
354	Mean				5.1							
355	Geometric Mean				5.091							
356	Median				5.1							
357	Standard Deviation				0.424							
358	Coefficient of Variation				0.0832							
359	**Not enough reported values (n) to provide Mann-Kendall Statistics!**											
360												

Appendix F.

Full Long-Term Data Set

Well Type	Sample	Date	Result
		Alluvial	
Alluvial	BC022WW	10/29/2015	12.5
Alluvial	BC022WW	3/21/2016	15.9
Alluvial	BC022WW	9/23/2016	9.94
Alluvial	BC022WW	3/22/2017	14
Alluvial	BC022WW	10/8/2020	16.4
Alluvial	BC022WW	1/11/2021	23.9
Alluvial	BC022WW	3/22/2021	24.7
Alluvial	BC022WW	8/9/2021	17.3
Alluvial	BC022WW	8/9/2021	16
Alluvial	BC022WW	11/8/2021	18
Alluvial	BC022WW	1/20/2022	28.3
Alluvial	BC022WW	4/5/2022	29.6
Alluvial	BC022WW	7/19/2022	19.4
Alluvial	BC022WW	9/29/2022	18.6
Alluvial	BC088WW	4/6/2016	17.1
Alluvial	BC088WW	9/15/2016	17.4
Alluvial	BC088WW	3/21/2017	18.3
Alluvial	BC088WW	9/25/2018	18.4
Alluvial	BC088WW	10/6/2020	15.8
Alluvial	BC088WW	1/12/2021	16.6
Alluvial	BC088WW	3/23/2021	15.9
Alluvial	BC088WW	8/9/2021	15.6
Alluvial	BC088WW	11/9/2021	15.5
Alluvial	BC088WW	1/21/2022	14.5
Alluvial	BC088WW	4/6/2022	15.3
Alluvial	BC088WW	7/21/2022	16.5
Alluvial	BC088WW	9/27/2022	15.4
Alluvial	BC100WW	4/6/2016	5.75
Alluvial	BC100WW	9/23/2016	0.69
Alluvial	BC100WW	3/22/2017	0.51
Alluvial	BC100WW	10/7/2020	1
Alluvial	BC100WW	3/22/2021	0.8
Alluvial	BC100WW	8/9/2021	0.8
Alluvial	BC100WW	8/9/2021	0.8
Alluvial	BC100WW	11/8/2021	0.7
Alluvial	BC100WW	1/20/2022	0.8
Alluvial	BC100WW	4/5/2022	1
Alluvial	BC100WW	7/21/2022	0.9
Alluvial	BC100WW	9/29/2022	1.2
Alluvial	BC125WW	4/14/2016	12.7
Alluvial	BC125WW	9/23/2016	11.4
Alluvial	BC125WW	3/22/2017	13.5
Alluvial	BC125WW	10/7/2020	10.7
Alluvial	BC125WW	1/11/2021	11.6
Alluvial	BC125WW	3/23/2021	11.5

Well Type	Sample	Date	Result
Alluvial	BC125WW	8/10/2021	11.3
Alluvial	BC125WW	11/9/2021	9.3
Alluvial	BC125WW	1/20/2022	8.3
Alluvial	BC125WW	4/5/2022	7.2
Alluvial	BC125WW	7/21/2022	4.6
Alluvial	BC125WW	9/27/2022	8.4
Alluvial	BC127WW	4/14/2016	1.04
Alluvial	BC127WW	9/15/2016	1.24
Alluvial	BC127WW	3/21/2017	1.82
Alluvial	BC127WW	9/25/2018	2.5
Alluvial	BC127WW	10/5/2020	4.2
Alluvial	BC127WW	1/12/2021	4.7
Alluvial	BC127WW	3/24/2021	6.2
Alluvial	BC127WW	8/10/2021	7.8
Alluvial	BC127WW	11/10/2021	10.2
Alluvial	BC127WW	1/21/2022	11.2
Alluvial	BC127WW	4/7/2022	14.3
Alluvial	BC127WW	7/20/2022	20.9
Alluvial	BC127WW	9/27/2022	23.4
Alluvial	BC151WW	4/15/2016	3.39
Alluvial	BC151WW	9/23/2016	3.71
Alluvial	BC151WW	3/22/2017	4.75
Alluvial	BC151WW	9/25/2018	5.1
Alluvial	BC151WW	10/6/2020	6.2
Alluvial	BC151WW	1/12/2021	7.2
Alluvial	BC151WW	3/23/2021	7.3
Alluvial	BC151WW	8/10/2021	6.2
Alluvial	BC151WW	11/9/2021	8
Alluvial	BC151WW	1/21/2022	8.1
Alluvial	BC151WW	4/6/2022	8.5
Alluvial	BC151WW	7/20/2022	8.8
Alluvial	BC151WW	9/29/2022	9
Alluvial	BC184WW	4/27/2016	14.7
Alluvial	BC184WW	9/23/2016	15.3
Alluvial	BC184WW	3/21/2017	17.6
Alluvial	BC184WW	9/25/2018	15.6
Alluvial	BC184WW	10/6/2020	18.7
Alluvial	BC184WW	1/11/2021	20.5
Alluvial	BC184WW	3/23/2021	17.5
Alluvial	BC184WW	8/10/2021	21
Alluvial	BC184WW	11/9/2021	20.5
Alluvial	BC184WW	1/20/2022	19.2
Alluvial	BC184WW	4/6/2022	19.4
Alluvial	BC184WW	7/20/2022	19.6
Alluvial	BC184WW	9/27/2022	15.1
Alluvial	BC194WW	4/21/2016	8.68

Well Type	Sample	Date	Result
Alluvial	BC194WW	9/15/2016	8.8
Alluvial	BC194WW	3/21/2017	9.03
Alluvial	BC194WW	9/25/2018	10.6
Alluvial	BC194WW	10/5/2020	12.1
Alluvial	BC194WW	1/12/2021	14.1
Alluvial	BC194WW	3/24/2021	14.1
Alluvial	BC194WW	8/10/2021	14.3
Alluvial	BC194WW	11/10/2021	14.1
Alluvial	BC194WW	1/21/2022	13.5
Alluvial	BC194WW	4/7/2022	12.9
Alluvial	BC194WW	7/20/2022	11.4
Alluvial	BC194WW	9/27/2022	12
Alluvial	BC246WW	10/8/2020	1.3
Alluvial	BC246WW	1/13/2021	5.2
Alluvial	BC246WW	3/25/2021	2.2
Alluvial	BC246WW	8/10/2021	1.7
Alluvial	BC246WW	11/16/2021	1.4
Alluvial	BC246WW	1/19/2022	2.3
Alluvial	BC246WW	4/7/2022	1.5
Alluvial	BC246WW	7/19/2022	1.4
Alluvial	BC246WW	9/27/2022	1.4
Alluvial	BC254WW	10/8/2020	1.5
Alluvial	BC254WW	1/12/2021	16.5
Alluvial	BC254WW	3/24/2021	18
Alluvial	BC254WW	8/11/2021	18.6
Alluvial	BC254WW	11/10/2021	18.7
Alluvial	BC254WW	1/21/2022	16.6
Alluvial	BC254WW	4/6/2022	16.8
Alluvial	BC254WW	7/28/2022	18.1
Alluvial	BC254WW	9/29/2022	14.7
Alluvial	BC268WW	10/5/2020	2.9
Alluvial	BC268WW	1/12/2021	2.9
Alluvial	BC268WW	3/24/2021	2.8
Alluvial	BC268WW	8/11/2021	3.6
Alluvial	BC268WW	11/10/2021	4.1
Alluvial	BC268WW	1/21/2022	2.7
Alluvial	BC268WW	4/6/2022	2.8
Alluvial	BC268WW	7/20/2022	4.9
Alluvial	BC268WW	9/27/2022	3.7
Alluvial	BC273WW	4/5/2022	13.4
Alluvial	BC273WW	7/21/2022	13.7
Alluvial	BC600WW	9/30/2020	7.5
Alluvial	BC600WW	1/11/2021	8
Alluvial	BC600WW	3/23/2021	7.8
Alluvial	BC600WW	8/11/2021	8
Alluvial	BC600WW	11/9/2021	7.9

Well Type	Sample	Date	Result
Alluvial	BC600WW	1/20/2022	7.2
Alluvial	BC600WW	4/6/2022	8.2
Alluvial	BC600WW	7/20/2022	7.93
Alluvial	BC600WW	9/27/2022	7.4
Alluvial	BC602WW	10/2/2020	3.6
Alluvial	BC602WW	3/25/2021	3.3
Alluvial	BC602WW	11/16/2021	3.8
Alluvial	BC602WW	4/7/2022	3
Alluvial	BC602WW	9/29/2022	2.9
Alluvial	BC603WW	9/29/2020	4.7
Alluvial	BC603WW	1/13/2021	16.4
Alluvial	BC603WW	3/25/2021	4.8
Alluvial	BC604WW	10/2/2020	16.5
Alluvial	BC604WW	1/11/2021	16.7
Alluvial	BC604WW	3/22/2021	17
Alluvial	BC604WW	8/11/2021	17.2
Alluvial	BC604WW	11/8/2021	17.9
Alluvial	BC604WW	1/20/2022	17.3
Alluvial	BC604WW	4/5/2022	17.8
Alluvial	BC604WW	7/19/2022	17.6
Alluvial	BC604WW	9/27/2022	18.3
Alluvial	BC609WW	9/28/2020	3.6
Alluvial	BC609WW	1/11/2021	3.9
Alluvial	BC609WW	3/23/2021	3.4
Alluvial	BC609WW	8/11/2021	3
Alluvial	BC609WW	11/9/2021	3.4
Alluvial	BC609WW	1/20/2022	3.2
Alluvial	BC609WW	4/5/2022	3.3
Alluvial	BC609WW	7/21/2022	3.1
Alluvial	BC609WW	9/29/2022	1.6
Alluvial	BC613WW	9/28/2020	8.2
Alluvial	BC613WW	1/12/2021	8.1
Alluvial	BC613WW	3/24/2021	8.3
Alluvial	BC613WW	8/11/2021	7.3
Alluvial	BC613WW	11/10/2021	8.4
Alluvial	BC613WW	1/21/2022	7.4
Alluvial	BC613WW	4/7/2022	9.2
Alluvial	BC613WW	7/20/2022	6.6
Alluvial	BC613WW	9/29/2022	6.7
Alluvial	BC616WW	10/1/2020	13.3
Alluvial	BC616WW	1/11/2021	12.9
Alluvial	BC616WW	3/22/2021	12.6
Alluvial	BC616WW	8/13/2021	12.7
Alluvial	BC616WW	11/8/2021	12.7
Alluvial	BC616WW	1/20/2022	12.6
Alluvial	BC616WW	4/5/2022	12.8

Well Type	Sample	Date	Result
Alluvial	BC616WW	7/28/2022	14.4
Alluvial	BC616WW	9/27/2022	12.5
	Alluvial and Shallow Basalt		
Alluvial and Shallo	BC081WW	4/5/2016	12.1
Alluvial and Shallo	BC081WW	9/23/2016	11.7
Alluvial and Shallo	BC081WW	3/22/2017	12
Alluvial and Shallo	BC081WW	10/7/2020	12.1
Alluvial and Shallo	BC081WW	3/22/2021	12.5
Alluvial and Shallo	BC081WW	11/8/2021	12.3
Alluvial and Shallo	BC081WW	4/5/2022	12.8
Alluvial and Shallo	BC081WW	9/28/2022	12.7
Alluvial and Shallo	BC087WW	4/6/2016	13.4
Alluvial and Shallo	BC087WW	9/15/2016	15.1
Alluvial and Shallo	BC087WW	3/21/2017	7.09
Alluvial and Shallo	BC087WW	9/25/2018	8.4
Alluvial and Shallo	BC087WW	9/25/2018	8.4
Alluvial and Shallo	BC087WW	10/6/2020	19.9
Alluvial and Shallo	BC087WW	1/12/2021	19.8
Alluvial and Shallo	BC087WW	3/23/2021	22.2
Alluvial and Shallo	BC087WW	8/9/2021	18.5
Alluvial and Shallo	BC087WW	11/9/2021	6.6
Alluvial and Shallo	BC087WW	1/21/2022	7.2
Alluvial and Shallo	BC087WW	4/6/2022	9.03
Alluvial and Shallo	BC087WW	7/20/2022	7.9
Alluvial and Shallo	BC087WW	9/29/2022	6.5
Alluvial and Shallo	BC116WW	4/8/2016	9.67
Alluvial and Shallo	BC116WW	9/15/2016	9.91
Alluvial and Shallo	BC116WW	3/21/2017	10.7
Alluvial and Shallo	BC116WW	9/25/2018	8.9
Alluvial and Shallo	BC116WW	10/5/2020	1.6
Alluvial and Shallo	BC116WW	1/12/2021	13.1
Alluvial and Shallo	BC116WW	3/24/2021	13.1
Alluvial and Shallo	BC116WW	8/10/2021	9
Alluvial and Shallo	BC116WW	11/10/2021	8.5
Alluvial and Shallo	BC116WW	1/21/2022	8.7
Alluvial and Shallo	BC116WW	4/6/2022	9.2
Alluvial and Shallo	BC116WW	7/20/2022	8.4
Alluvial and Shallo	BC116WW	9/27/2022	9.2
Alluvial and Shallo	BC117WW	4/8/2016	26.7
Alluvial and Shallo	BC117WW	9/15/2016	26.7
Alluvial and Shallo	BC117WW	3/21/2017	27.1
Alluvial and Shallo	BC117WW	10/25/2018	21.3
Alluvial and Shallo	BC117WW	10/5/2020	21.7
Alluvial and Shallo	BC117WW	1/12/2021	25.6
Alluvial and Shallo	BC117WW	3/24/2021	29.7
Alluvial and Shallo	BC117WW	8/10/2021	31.4

Well Type	Sample	Date	Result
Alluvial and Shallc	BC117WW	11/10/2021	33.1
Alluvial and Shallc	BC117WW	1/21/2022	42.2
Alluvial and Shallc	BC117WW	7/28/2022	59
Alluvial and Shallc	BC117WW	9/27/2022	46.8
Alluvial and Shallc	BC128WW	4/14/2016	7.28
Alluvial and Shallc	BC128WW	9/15/2016	1.57
Alluvial and Shallc	BC128WW	3/22/2017	1.43
Alluvial and Shallc	BC128WW	9/25/2018	2.4
Alluvial and Shallc	BC128WW	10/6/2020	3.4
Alluvial and Shallc	BC128WW	1/12/2021	13.1
Alluvial and Shallc	BC128WW	3/24/2021	8.7
Alluvial and Shallc	BC128WW	8/10/2021	14.3
Alluvial and Shallc	BC128WW	11/10/2021	12.6
Alluvial and Shallc	BC128WW	1/21/2022	4.5
Alluvial and Shallc	BC128WW	4/6/2022	5
Alluvial and Shallc	BC128WW	7/20/2022	12.4
Alluvial and Shallc	BC128WW	9/27/2022	12.6
Alluvial and Shallc	BC610WW	9/28/2020	25.3
Alluvial and Shallc	BC610WW	3/22/2021	18
Alluvial and Shallc	BC610WW	11/8/2021	18.3
Alluvial and Shallc	BC610WW	4/5/2022	21
Alluvial and Shallc	BC610WW	9/28/2022	22.4
	Shallow and Intermediate Basalt		
Shallow and Inter	BC192WW	4/21/2016	18.7
Shallow and Inter	BC192WW	9/15/2016	19.1
Shallow and Inter	BC192WW	3/21/2017	21.7
Shallow and Inter	BC192WW	9/25/2018	26.6
Shallow and Inter	BC192WW	10/6/2020	30.6
Shallow and Inter	BC192WW	1/12/2021	30.8
Shallow and Inter	BC192WW	3/24/2021	30.1
Shallow and Inter	BC192WW	8/10/2021	30.2
Shallow and Inter	BC192WW	11/10/2021	27.2
Shallow and Inter	BC192WW	1/21/2022	24.9
Shallow and Inter	BC192WW	4/6/2022	25.8
Shallow and Inter	BC192WW	7/21/2022	30.5
Shallow and Inter	BC192WW	9/27/2022	29.4
Shallow and Inter	BC782321WW	12/21/2015	46.1
Shallow and Inter	BC782321WW	3/21/2016	43.8
Shallow and Inter	BC782321WW	10/13/2016	47
Shallow and Inter	BC782321WW	3/21/2017	45.8
Shallow and Inter	BC782321WW	10/5/2020	11.8
Shallow and Inter	BC782321WW	1/13/2021	46
Shallow and Inter	BC782321WW	3/25/2021	43.2
Shallow and Inter	BC782321WW	8/13/2021	44.1
Shallow and Inter	BC782321WW	11/16/2021	45
Shallow and Inter	BC782321WW	1/19/2022	44.1

Well Type	Sample	Date	Result
Shallow and Inter	BC782321WW	4/7/2022	44.1
Shallow and Inter	BC782321WW	7/21/2022	44.7
Shallow and Inter	BC782321WW	9/29/2022	42.5
Intermediate Basalt			
Intermediate Bas	BC601WW	9/29/2020	8.2
Intermediate Bas	BC601WW	1/11/2021	11.2
Intermediate Bas	BC601WW	3/22/2021	11.3
Intermediate Bas	BC601WW	8/11/2021	7.5
Intermediate Bas	BC601WW	8/11/2021	6.9
Intermediate Bas	BC601WW	11/8/2021	8.1
Intermediate Bas	BC601WW	1/20/2022	10
Intermediate Bas	BC601WW	4/5/2022	12.5
Intermediate Bas	BC601WW	7/21/2022	10.9
Intermediate Bas	BC601WW	9/29/2022	7.5
Shallow Basalt			
Shallow Basalt	BC232WW	10/7/2020	8.2
Shallow Basalt	BC232WW	1/11/2021	7.6
Shallow Basalt	BC232WW	3/23/2021	7.3
Shallow Basalt	BC232WW	8/10/2021	7
Shallow Basalt	BC232WW	11/9/2021	7.4
Shallow Basalt	BC232WW	1/20/2022	6.6
Shallow Basalt	BC232WW	4/5/2022	6.4
Shallow Basalt	BC232WW	7/20/2022	6.7
Shallow Basalt	BC232WW	9/28/2022	7.3
Shallow Basalt	BC239WW	10/8/2020	5.4
Shallow Basalt	BC239WW	1/13/2021	6.2
Shallow Basalt	BC239WW	3/25/2021	6
Shallow Basalt	BC239WW	8/10/2021	5.4
Shallow Basalt	BC239WW	11/16/2021	5.3
Shallow Basalt	BC239WW	1/19/2022	5.8
Shallow Basalt	BC239WW	4/7/2022	6.2
Shallow Basalt	BC239WW	7/19/2022	4.6
Shallow Basalt	BC239WW	9/27/2022	4.3
Shallow Basalt	BC240WW	10/6/2020	3.8
Shallow Basalt	BC240WW	1/12/2021	5.7
Shallow Basalt	BC240WW	3/24/2021	4.4
Shallow Basalt	BC240WW	8/10/2021	4.8
Shallow Basalt	BC240WW	11/10/2021	6.4
Shallow Basalt	BC240WW	1/21/2022	7.2
Shallow Basalt	BC240WW	4/6/2022	7.4
Shallow Basalt	BC240WW	7/20/2022	6.6
Shallow Basalt	BC240WW	9/29/2022	5
Shallow Basalt	BC605WW	10/1/2020	7.7
Shallow Basalt	BC605WW	1/11/2021	20.9
Shallow Basalt	BC605WW	3/22/2021	17.2
Shallow Basalt	BC605WW	8/10/2021	5.3

Well Type	Sample	Date	Result
Shallow Basalt	BC605WW	11/8/2021	17.4
Shallow Basalt	BC605WW	1/20/2022	17.5
Shallow Basalt	BC605WW	4/5/2022	12
Shallow Basalt	BC605WW	7/28/2022	5.7
Shallow Basalt	BC605WW	9/27/2022	6.8
Shallow Basalt	BC606WW	9/30/2020	5.2
Shallow Basalt	BC606WW	1/13/2021	4.9
Shallow Basalt	BC606WW	3/25/2021	5.4
Shallow Basalt	BC606WW	8/11/2021	5.1
Shallow Basalt	BC606WW	11/16/2021	4.8
Shallow Basalt	BC606WW	1/19/2022	4.9
Shallow Basalt	BC606WW	4/7/2022	5.3
Shallow Basalt	BC606WW	7/19/2022	5.6
Shallow Basalt	BC606WW	9/29/2022	5.3
Shallow Basalt	BC607WW	9/29/2020	17.3
Shallow Basalt	BC607WW	1/13/2021	23.1
Shallow Basalt	BC607WW	3/25/2021	23.4
Shallow Basalt	BC607WW	8/11/2021	22.7
Shallow Basalt	BC607WW	11/16/2021	20.5
Shallow Basalt	BC607WW	1/19/2022	17.9
Shallow Basalt	BC607WW	4/7/2022	15.6
Shallow Basalt	BC607WW	7/19/2022	14.2
Shallow Basalt	BC607WW	9/28/2022	12.9
Shallow Basalt	BC608WW	9/29/2020	6.3
Shallow Basalt	BC608WW	1/13/2021	4.6
Shallow Basalt	BC608WW	3/25/2021	5.7
Shallow Basalt	BC608WW	8/11/2021	8.2
Shallow Basalt	BC608WW	11/16/2021	6.4
Shallow Basalt	BC608WW	1/19/2022	7.9
Shallow Basalt	BC608WW	4/7/2022	7.6
Shallow Basalt	BC608WW	7/19/2022	8.3
Shallow Basalt	BC608WW	9/27/2022	7.9
Shallow Basalt	BC611WW	10/1/2020	16
Shallow Basalt	BC611WW	1/11/2021	16.3
Shallow Basalt	BC611WW	3/22/2021	15.6
Shallow Basalt	BC611WW	8/11/2021	16.7
Shallow Basalt	BC611WW	11/8/2021	17.3
Shallow Basalt	BC611WW	1/20/2022	16.1
Shallow Basalt	BC611WW	4/5/2022	16.4
Shallow Basalt	BC611WW	9/27/2022	14.2
Shallow Basalt	BC612WW	9/28/2020	3.6
Shallow Basalt	BC612WW	1/12/2021	3.1
Shallow Basalt	BC612WW	3/23/2021	3.2
Shallow Basalt	BC612WW	8/11/2021	4.5
Shallow Basalt	BC612WW	11/9/2021	5.9
Shallow Basalt	BC612WW	1/21/2022	5.5

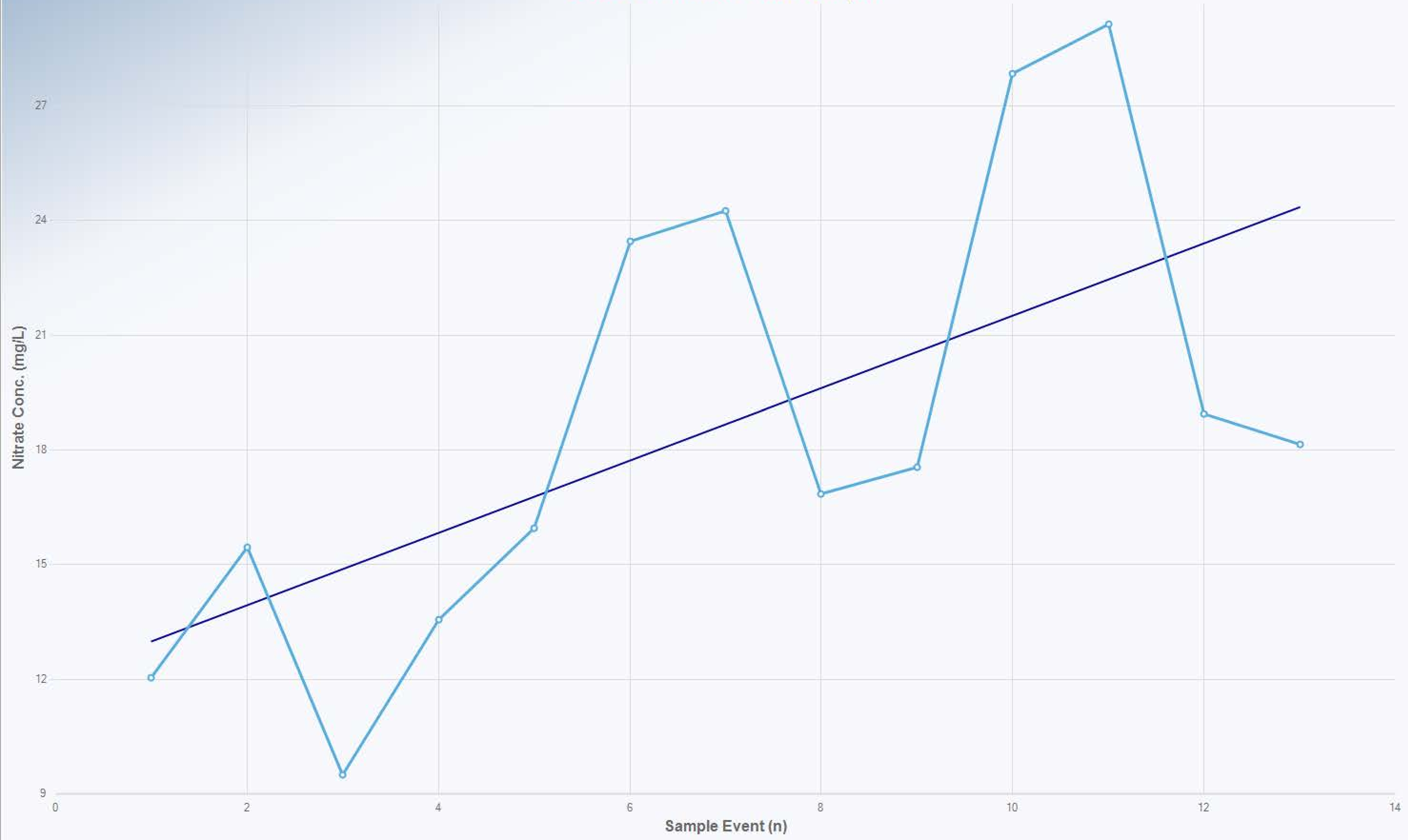
Well Type	Sample	Date	Result
Shallow Basalt	BC612WW	4/6/2022	6.39
Shallow Basalt	BC612WW	7/20/2022	12.5
Shallow Basalt	BC612WW	9/27/2022	18.7
		Unclassified Wells	
Unclassified Wells	BC012WW	10/22/2015	0.9
Unclassified Wells	BC012WW	3/21/2016	0.72
Unclassified Wells	BC012WW	9/28/2016	0.75
Unclassified Wells	BC012WW	4/6/2017	0.81
Unclassified Wells	BC012WW	10/8/2020	2.6
Unclassified Wells	BC012WW	3/25/2021	6.6
Unclassified Wells	BC012WW	11/16/2021	2.8
Unclassified Wells	BC012WW	4/7/2022	5.3
Unclassified Wells	BC012WW	9/30/2022	2.7
Unclassified Wells	BC034WW	10/29/2015	3.76
Unclassified Wells	BC034WW	3/21/2016	4.4
Unclassified Wells	BC034WW	9/23/2016	2.82
Unclassified Wells	BC034WW	3/22/2017	5.29
Unclassified Wells	BC034WW	10/7/2020	6.6
Unclassified Wells	BC034WW	1/11/2021	7
Unclassified Wells	BC034WW	3/23/2021	7.5
Unclassified Wells	BC034WW	8/9/2021	7.7
Unclassified Wells	BC034WW	11/9/2021	7.5
Unclassified Wells	BC034WW	1/20/2022	7.6
Unclassified Wells	BC034WW	4/5/2022	8.8
Unclassified Wells	BC034WW	7/28/2022	9.9
Unclassified Wells	BC034WW	9/27/2022	8.9
Unclassified Wells	BC086WW	4/6/2016	1.13
Unclassified Wells	BC086WW	9/23/2016	1.28
Unclassified Wells	BC086WW	3/22/2017	1.46
Unclassified Wells	BC086WW	10/7/2020	3
Unclassified Wells	BC086WW	1/11/2021	3.9
Unclassified Wells	BC086WW	3/22/2021	3.4
Unclassified Wells	BC086WW	8/9/2021	3.5
Unclassified Wells	BC086WW	11/8/2021	3.7
Unclassified Wells	BC086WW	1/21/2022	3.5
Unclassified Wells	BC086WW	4/5/2022	4.6
Unclassified Wells	BC086WW	7/21/2022	4
Unclassified Wells	BC086WW	9/27/2022	3.6
Unclassified Wells	BC235WW	10/1/2020	15.3
Unclassified Wells	BC235WW	1/13/2021	1.7
Unclassified Wells	BC235WW	3/25/2021	15.4
Unclassified Wells	BC235WW	8/10/2021	13.2
Unclassified Wells	BC235WW	11/16/2021	11
Unclassified Wells	BC235WW	1/19/2022	13
Unclassified Wells	BC235WW	4/7/2022	12.8
Unclassified Wells	BC235WW	7/19/2022	12.8

Well Type	Sample	Date	Result
Unclassified Well:	BC235WW	9/29/2022	9
Unclassified Well:	BC266WW	10/8/2020	16
Unclassified Well:	BC266WW	1/11/2021	17.6
Unclassified Well:	BC266WW	3/22/2021	16.9
Unclassified Well:	BC266WW	8/11/2021	16
Unclassified Well:	BC266WW	11/8/2021	17.7
Unclassified Well:	BC266WW	1/20/2022	17.3
Unclassified Well:	BC266WW	4/5/2022	17.5
Unclassified Well:	BC266WW	7/19/2022	14
Unclassified Well:	BC266WW	9/29/2022	16.6
Unclassified Well:	BC274WW	9/29/2020	18.2
Unclassified Well:	BC274WW	3/25/2021	36.3
Unclassified Well:	BC275WW	10/1/2020	12.4
Unclassified Well:	BC275WW	3/22/2021	12.7
Unclassified Well:	BC276WW	10/1/2020	20.8
Unclassified Well:	BC276WW	3/22/2021	25.1
Unclassified Well:	BC277WW	9/30/2020	4.8
Unclassified Well:	BC277WW	3/23/2021	4.8
Unclassified Well:	BC277WW	11/9/2021	5.3
Unclassified Well:	BC277WW	4/6/2022	5
Unclassified Well:	BC278WW	9/30/2020	30.6
Unclassified Well:	BC278WW	3/25/2021	32.9
Unclassified Well:	BC279WW	9/30/2020	13.8
Unclassified Well:	BC279WW	3/24/2021	13
Unclassified Well:	BC279WW	11/10/2021	12
Unclassified Well:	BC279WW	4/7/2022	12.8
Unclassified Well:	BC279WW	9/27/2022	13.8
Unclassified Well:	BC325WW	9/29/2022	9.9
Unclassified Well:	BC500WW	10/6/2020	5.8
Unclassified Well:	BC500WW	3/24/2021	5.7
Unclassified Well:	BC500WW	11/10/2021	6.4
Unclassified Well:	BC500WW	4/7/2022	6.7
Unclassified Well:	BC500WW	9/29/2022	5.7
Unclassified Well:	BC614WW	9/30/2020	1.5
Unclassified Well:	BC614WW	3/24/2021	1.5
Unclassified Well:	BC614WW	11/10/2021	1.3
Unclassified Well:	BC614WW	4/6/2022	1.8
Unclassified Well:	BC614WW	9/28/2022	3.2
Unclassified Well:	BC615WW	9/29/2020	1.7
Unclassified Well:	BC615WW	3/25/2021	1.9
Unclassified Well:	BC615WW	11/16/2021	1.6
Unclassified Well:	BC615WW	4/7/2022	1.9
Unclassified Well:	BC615WW	9/27/2022	0.9
Unclassified Well:	BC617WW	8/13/2021	1
Unclassified Well:	BC618WW	1/19/2022	5.4
Unclassified Well:	BC618WW	7/21/2022	4.8

Appendix G.

Long-Term Trend Analysis Results

BC022WW Nitrate Trend Analysis

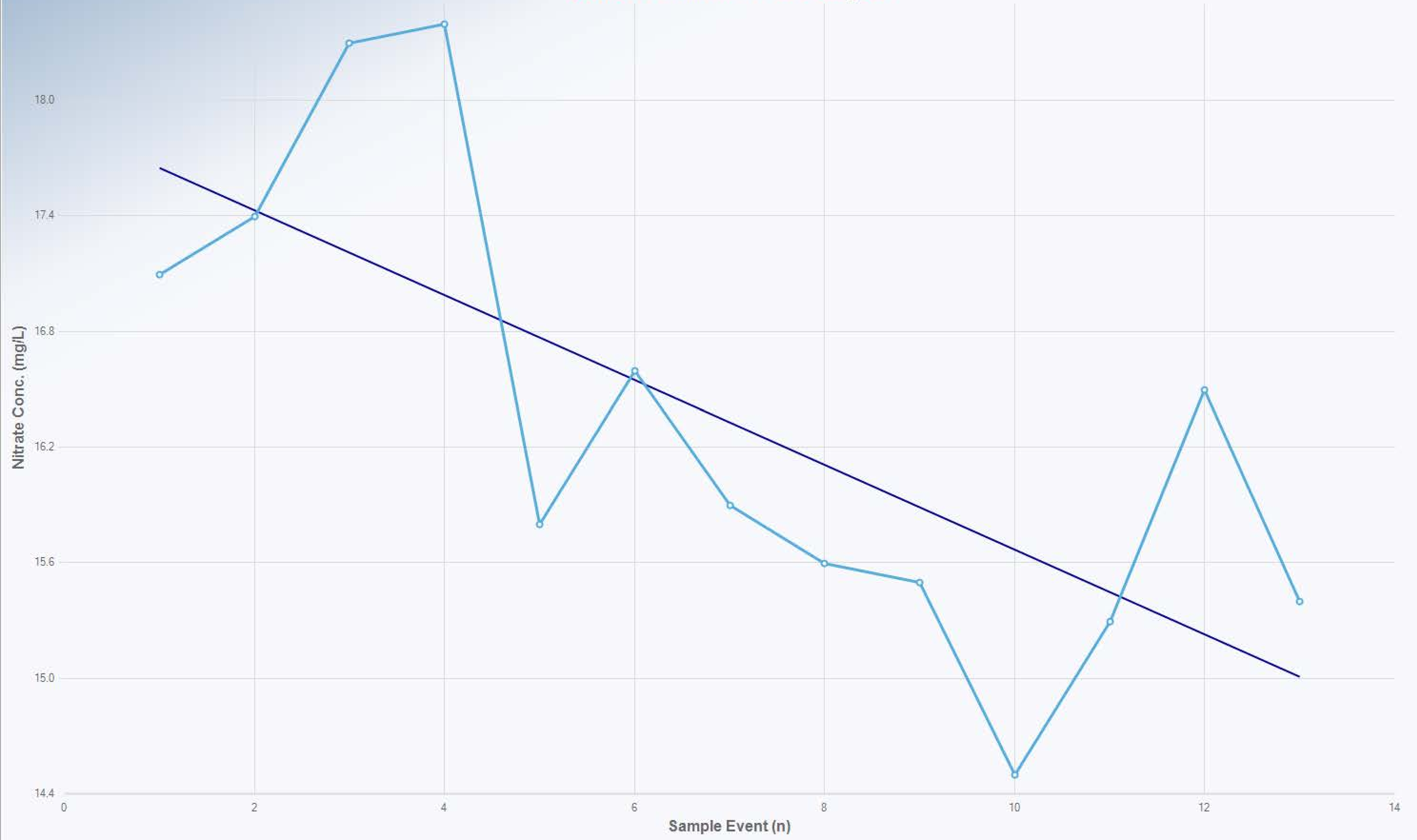


Mann-Kendall Trend Analysis	
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3911
Standardized Value of S	2.7454
M-K Test Value (S)	46
Tabulated p-value	0.0020
Approximate p-value	0.0030

OLS Regression Line (Blue)	
OLS Regression Slope	0.9464
OLS Regression Intercept	12.4938

Statistically significant evidence of an increasing trend at the specified level of significance.

BC088WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis	
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3911
Standardized Value of S	-2.6234
M-K Test Value (S)	-44
Tabulated p-value	0.0030
Approximate p-value	0.0044

OLS Regression Line (Blue)	
OLS Regression Slope	-0.2198
OLS Regression Intercept	17.8692

Statistically significant evidence of a decreasing trend at the specified level of significance.

BC100WW Nitrate Trend Analysis

Mann-Kendall Trend Analysis

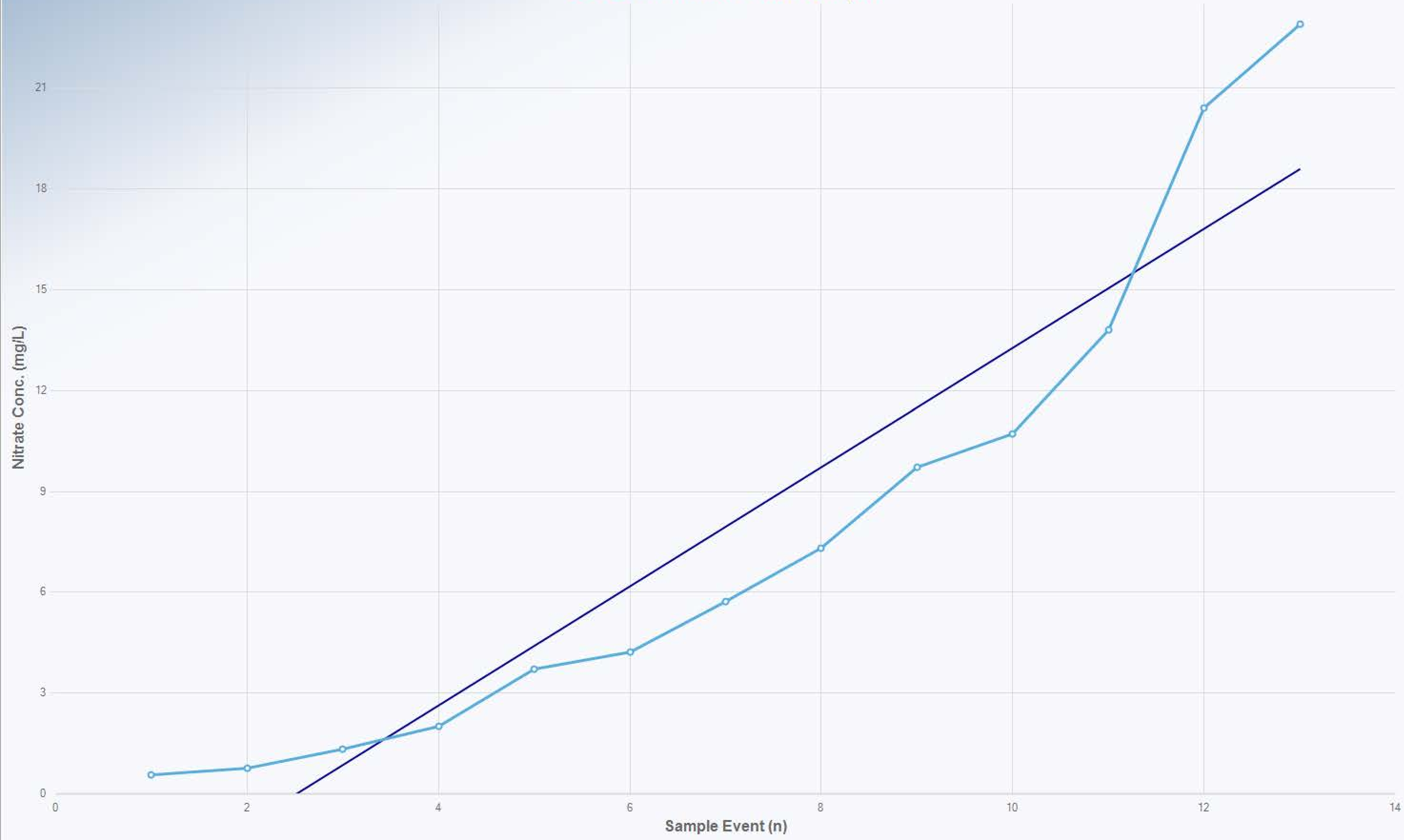
n	12
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	14.2478
Standardized Value of S	0.9826
M-K Test Value (S)	15
Tabulated p-value	0.1900
Approximate p-value	0.1629

OLS Regression Line (Blue)

OLS Regression Slope	-0.1609
OLS Regression Intercept	2.2920

Insufficient statistical evidence of a significant trend at the specified level of significance.

BC127WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

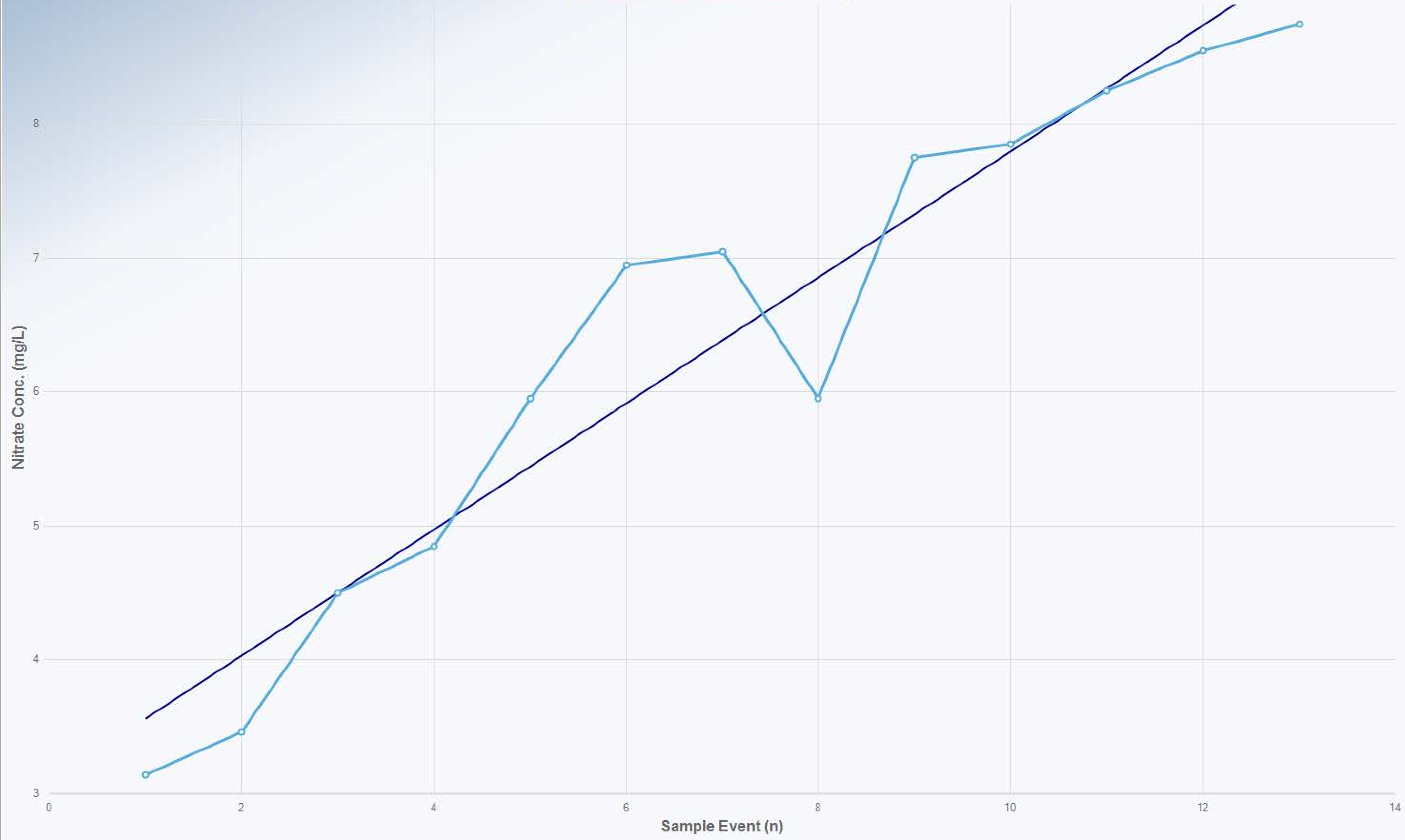
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3911
Standardized Value of S	4.6977
M-K Test Value (S)	78
Tabulated p-value	0.0000
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	1.7779
OLS Regression Intercept	-4.0223

Statistically significant evidence of an increasing trend at the specified level of significance.

BC151WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

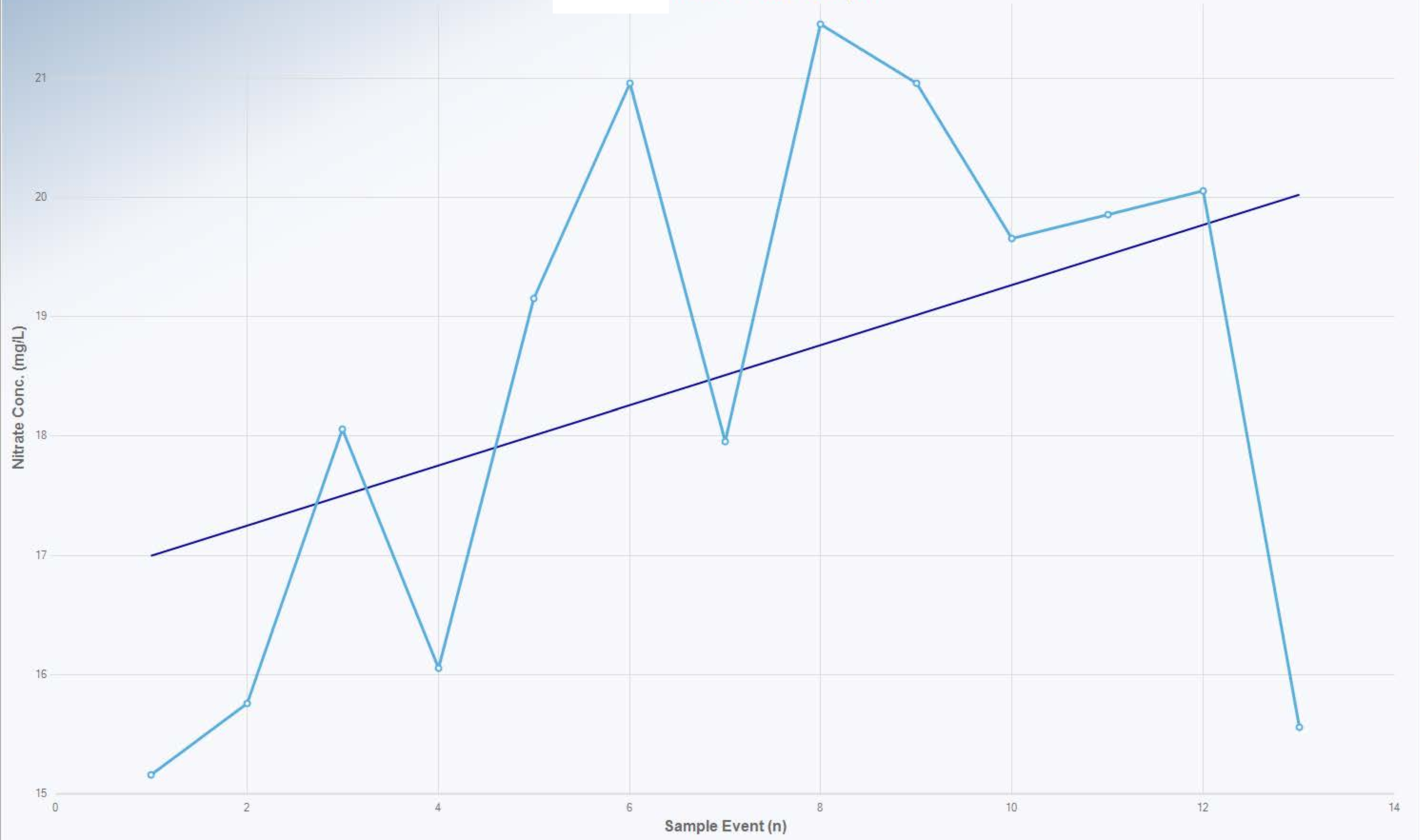
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3605
Standardized Value of S	4.4008
M-K Test Value (S)	73
Tabulated p-value	0.0000
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	0.4709
OLS Regression Intercept	3.3381

Statistically significant evidence of an increasing trend at the specified level of significance.

BC184WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

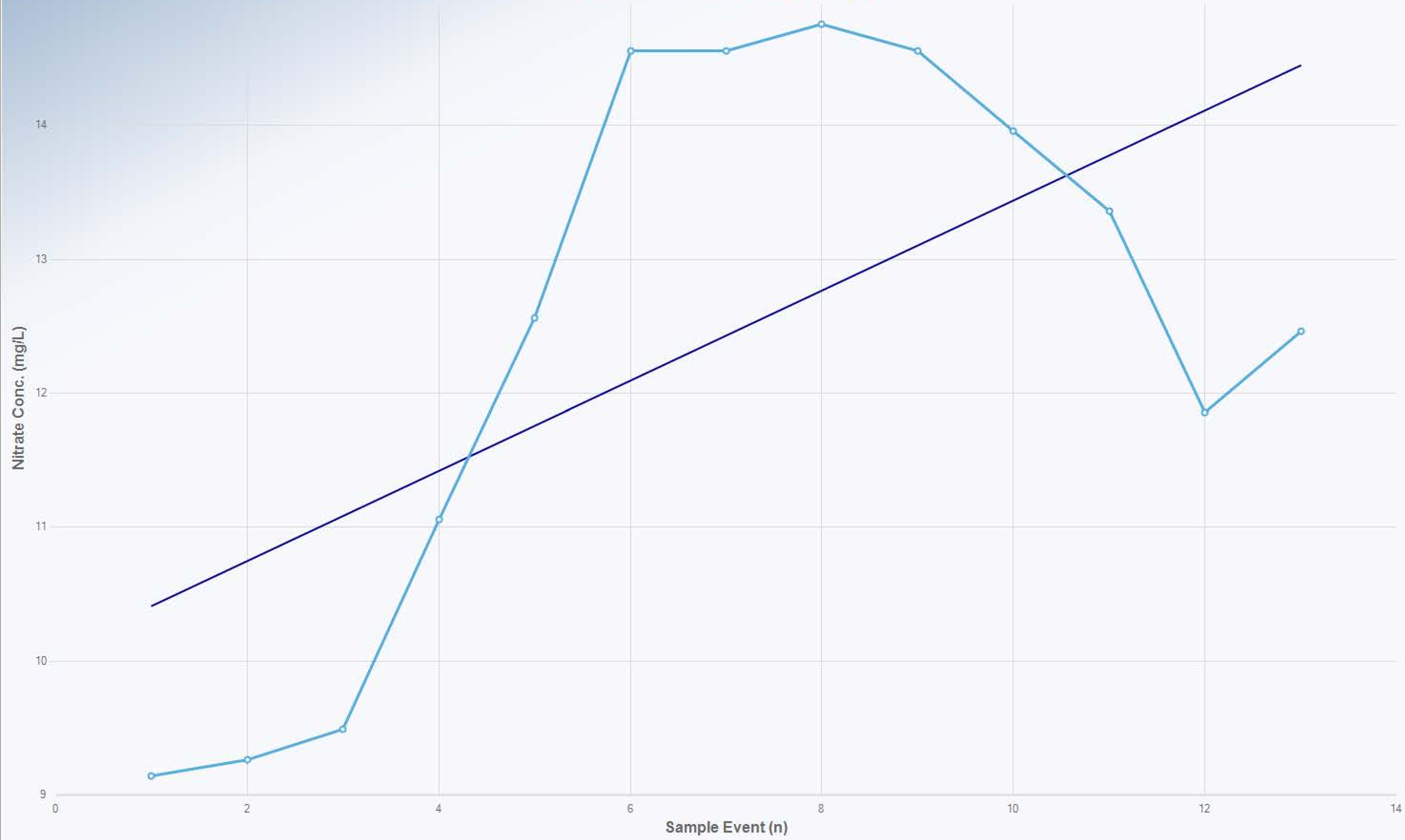
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3605
Standardized Value of S	1.5892
M-K Test Value (S)	27
Tabulated p-value	0.0640
Approximate p-value	0.0560

OLS Regression Line (Blue)

OLS Regression Slope	0.2527
OLS Regression Intercept	16.2846

Insufficient statistical evidence of a significant trend at the specified level of significance.

BC194WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

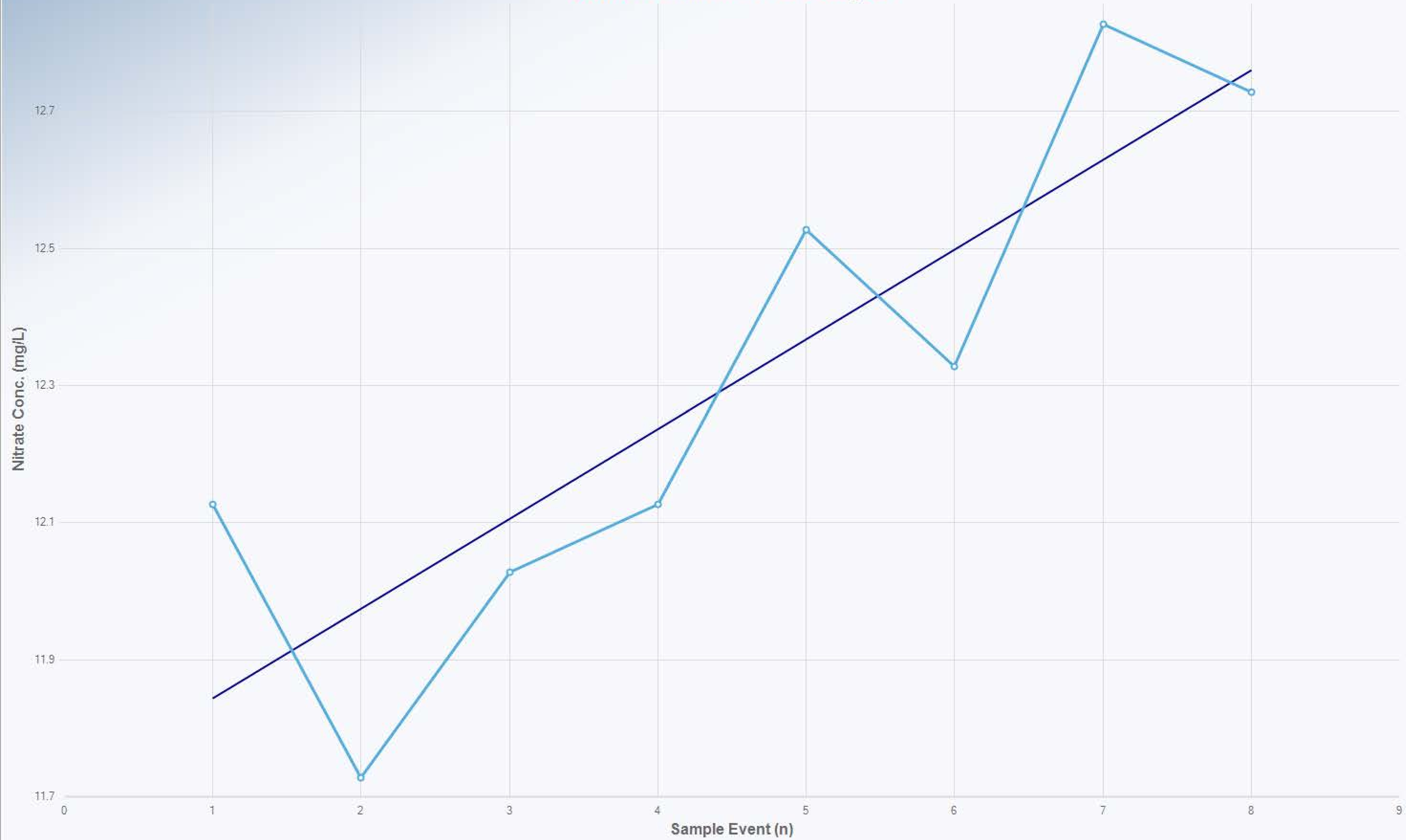
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.2788
Standardized Value of S	1.5972
M-K Test Value (S)	27
Tabulated p-value	0.0640
Approximate p-value	0.0551

OLS Regression Line (Blue)

OLS Regression Slope	0.3368
OLS Regression Intercept	9.6123

Insufficient statistical evidence of a significant trend at the specified level of significance.

BC081WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

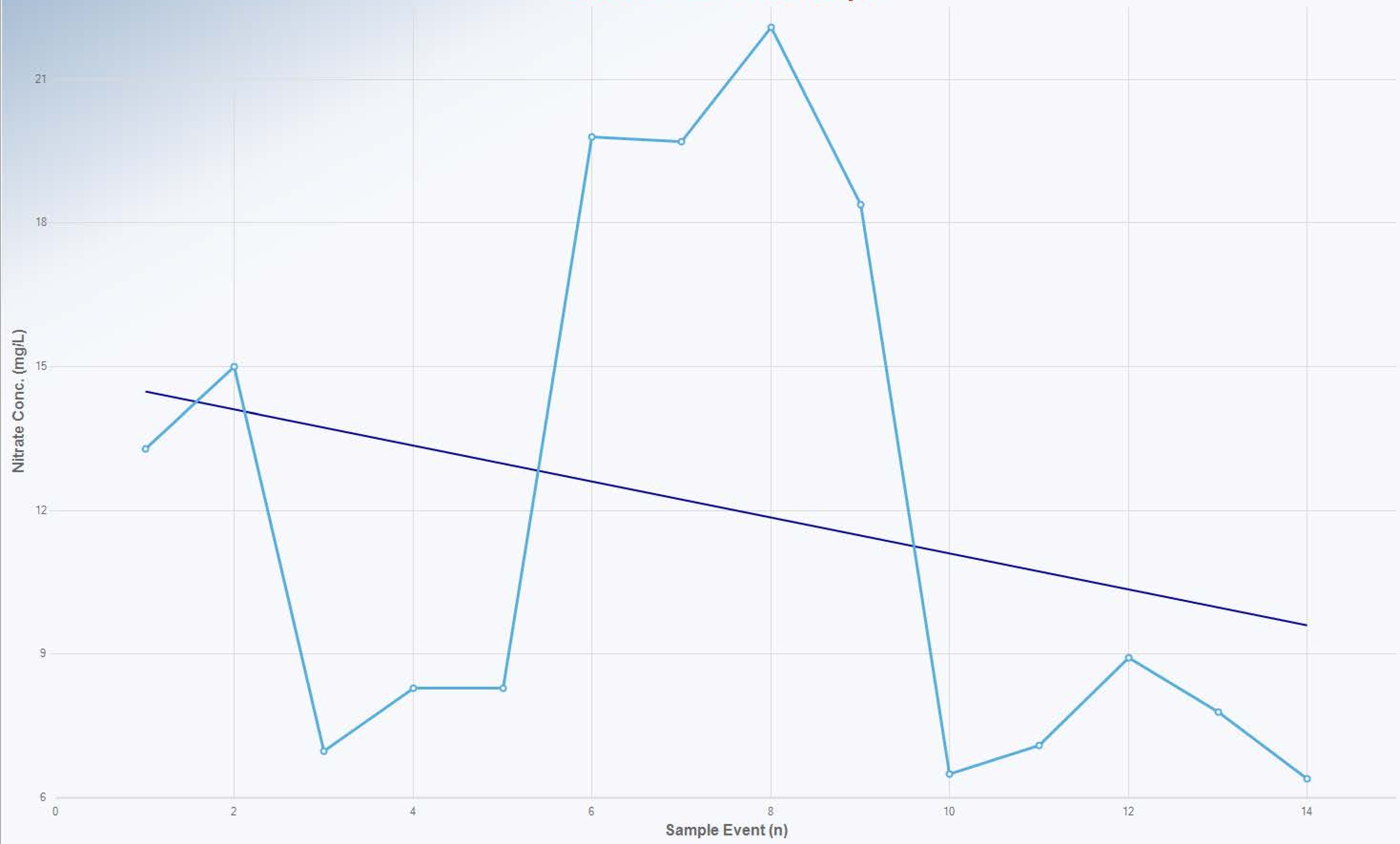
n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0208
Standardized Value of S	2.2442
M-K Test Value (S)	19
Tabulated p-value	0.0160
Approximate p-value	0.0124

OLS Regression Line (Blue)

OLS Regression Slope	0.1310
OLS Regression Intercept	11.6857

Statistically significant evidence of an increasing trend at the specified level of significance.

BC087WW Nitrate Trend Analysis



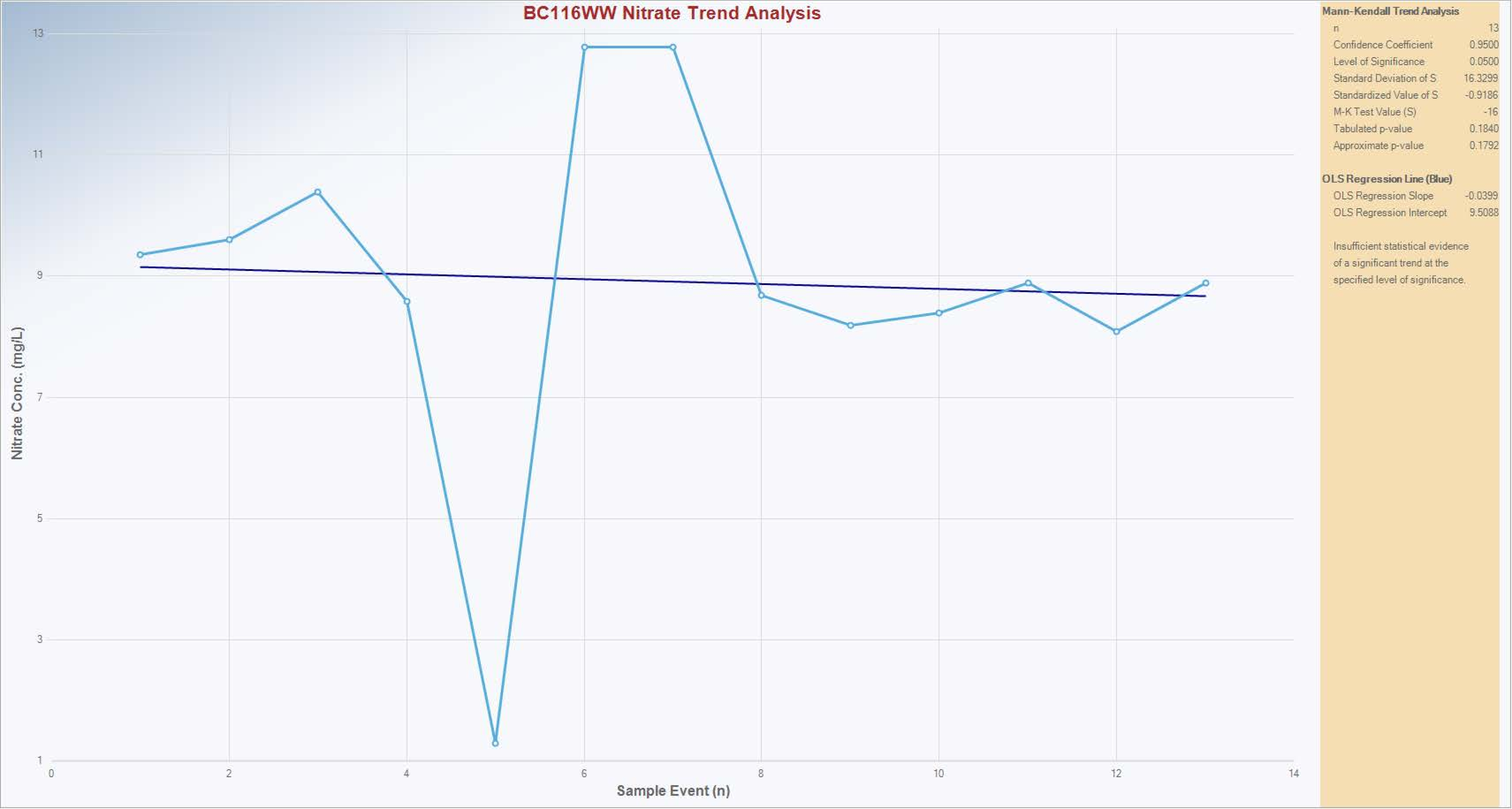
Mann-Kendall Trend Analysis

n	14
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	18.2392
Standardized Value of S	-1.0417
M-K Test Value (S)	-20
Tabulated p-value	0.1400
Approximate p-value	0.1488

OLS Regression Line (Blue)

OLS Regression Slope	-0.3750
OLS Regression Intercept	14.9570

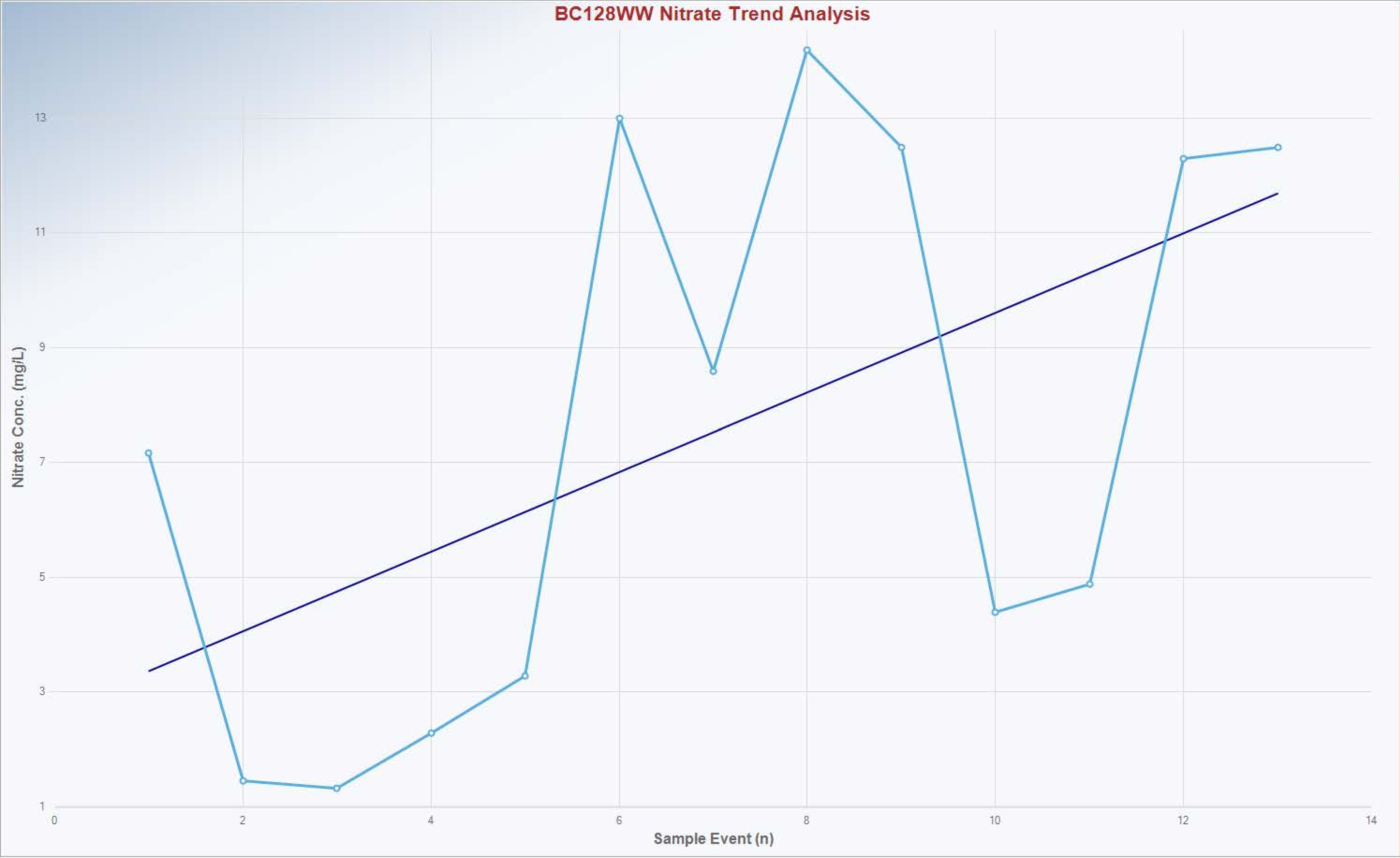
Insufficient statistical evidence of a significant trend at the specified level of significance.


BC116WW Nitrate Trend Analysis
Nitrate Conc. (mg/L)
13
11
9
7
5
3
1
0
2
4
6
8
10
12
14
Sample Event (n)
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 16.3299
Standardized Value of S -0.9186
M-K Test Value (S) -16
Tabulated p-value 0.1840
Approximate p-value 0.1792
OLS Regression Line (Blue)
OLS Regression Slope -0.0399
OLS Regression Intercept 9.5088
Insufficient statistical evidence of a significant trend at the specified level of significance.

BC117WW Nitrate Trend Analysis

Mann-Kendall Trend Analysis	
n	12
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	14.5488
Standardized Value of S	3.0243
M-K Test Value (S)	45
Tabulated p-value	0.0010
Approximate p-value	0.0012
OLS Regression Line (Blue)	
OLS Regression Slope	2.4815
OLS Regression Intercept	16.4788

Statistically significant evidence of an increasing trend at the specified level of significance.



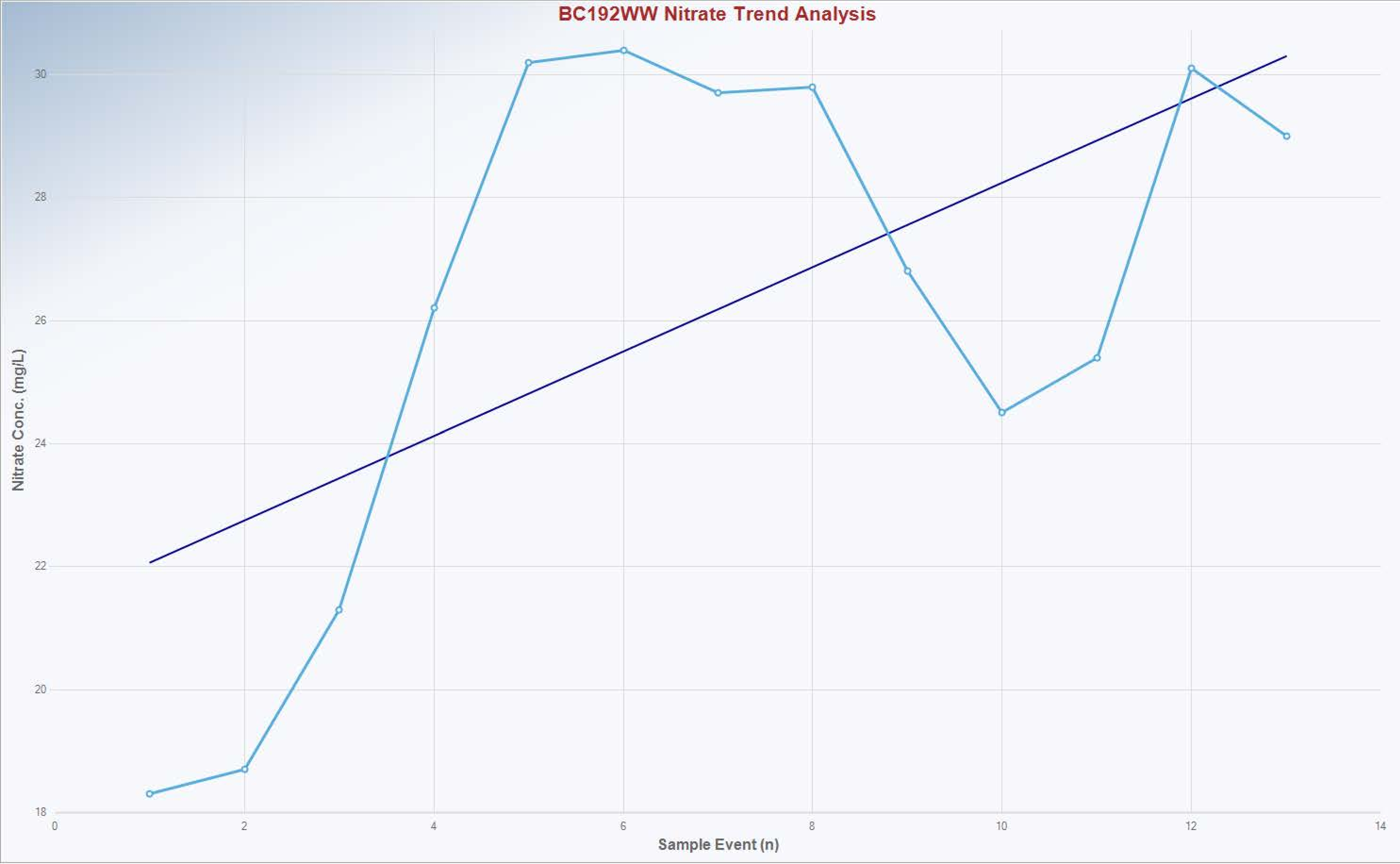
Mann-Kendall Trend Analysis

n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3605
Standardized Value of S	1.8337
M-K Test Value (S)	31
Tabulated p-value	0.0380
Approximate p-value	0.0334

OLS Regression Line (Blue)

OLS Regression Slope	0.6937
OLS Regression Intercept	2.7812

Statistically significant evidence of an increasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

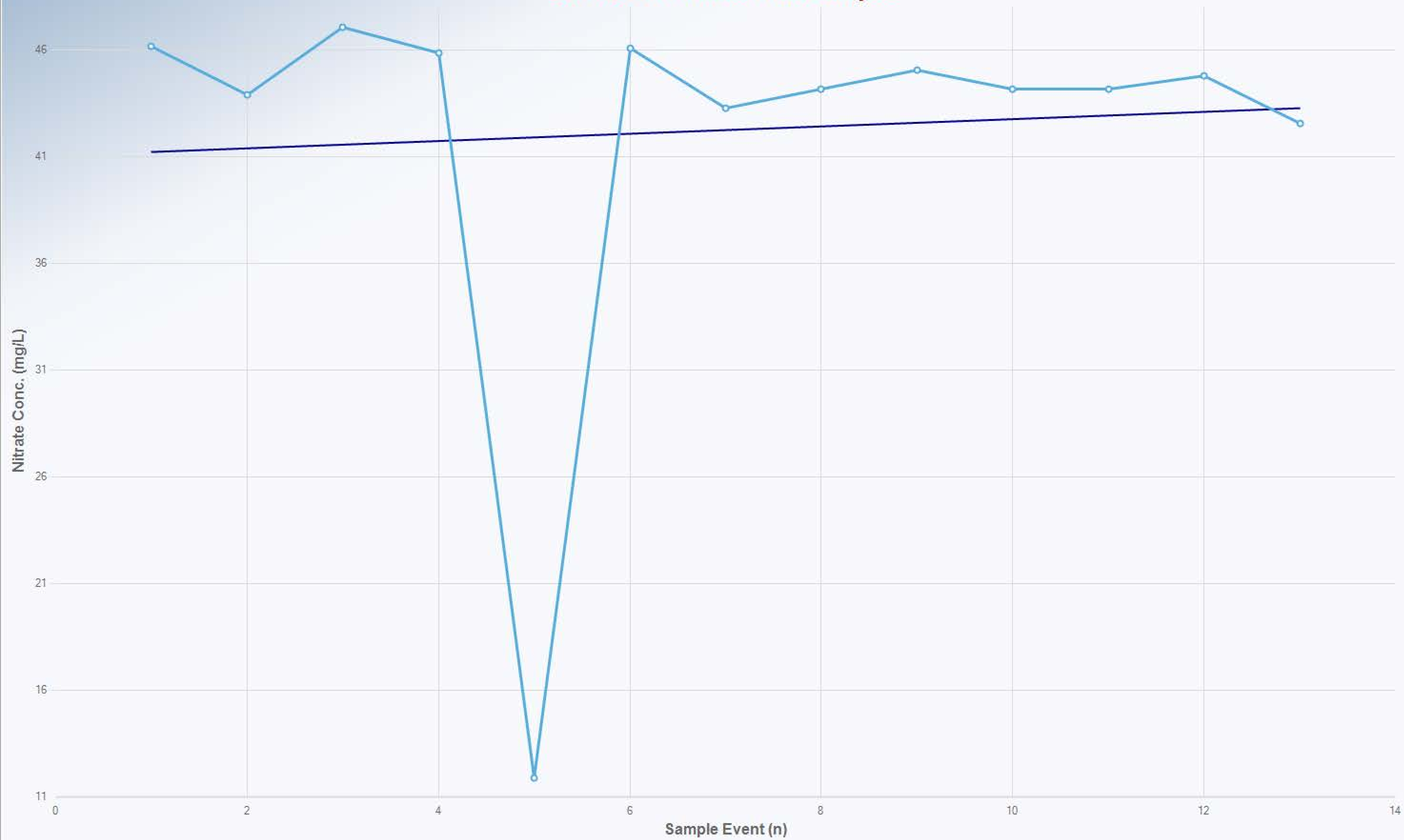
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3911
Standardized Value of S	1.4032
M-K Test Value (S)	24
Tabulated p-value	0.0820
Approximate p-value	0.0803

OLS Regression Line (Blue)

OLS Regression Slope	0.6874
OLS Regression Intercept	21.7731

Insufficient statistical evidence of a significant trend at the specified level of significance.

BC78232WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

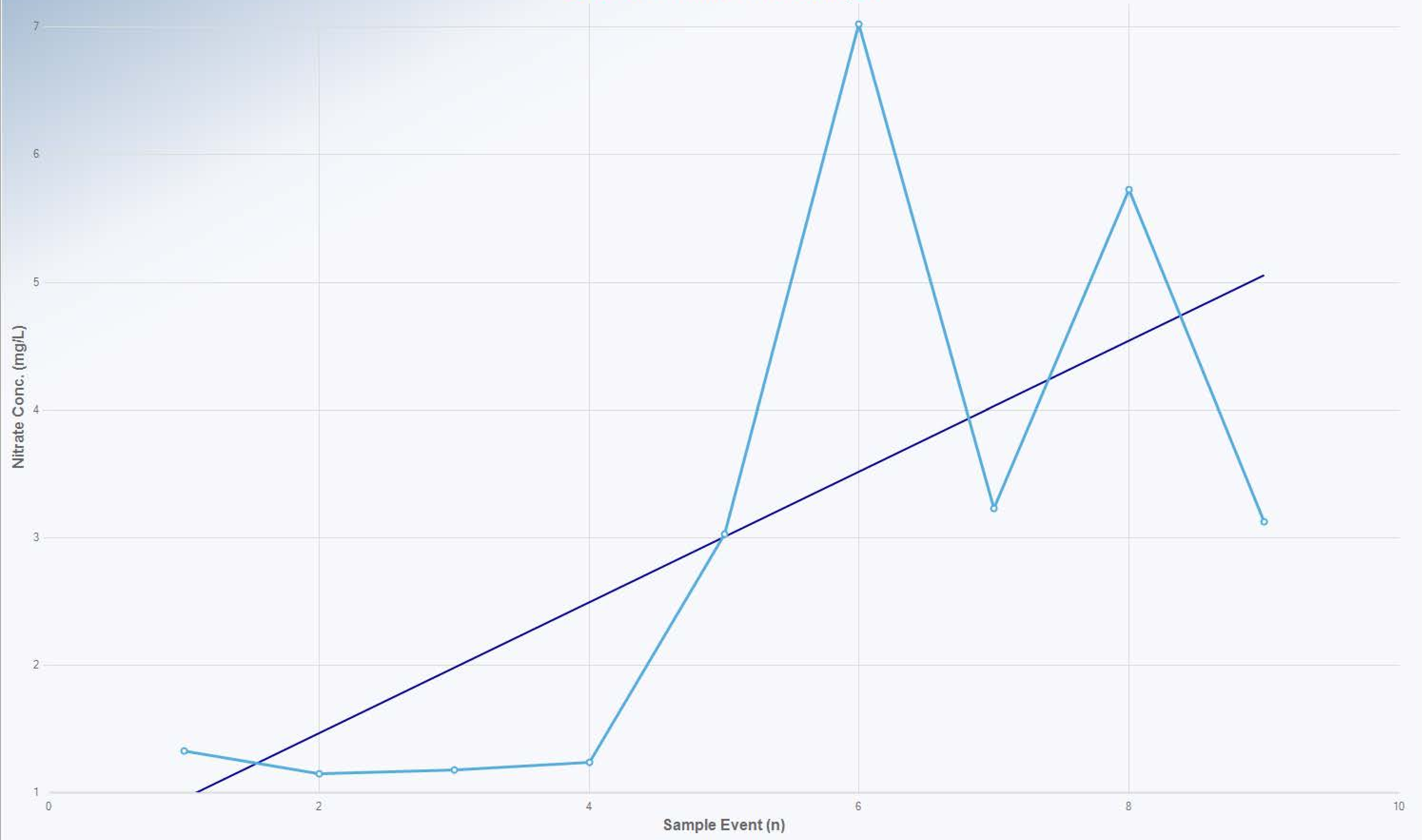
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.2788
Standardized Value of S	-1.2286
M-K Test Value (S)	-21
Tabulated p-value	0.1260
Approximate p-value	0.1096

OLS Regression Line (Blue)

OLS Regression Slope	0.1687
OLS Regression Intercept	40.9885

Insufficient statistical evidence of a significant trend at the specified level of significance.

BC012WW Nitrate Trend Analysis



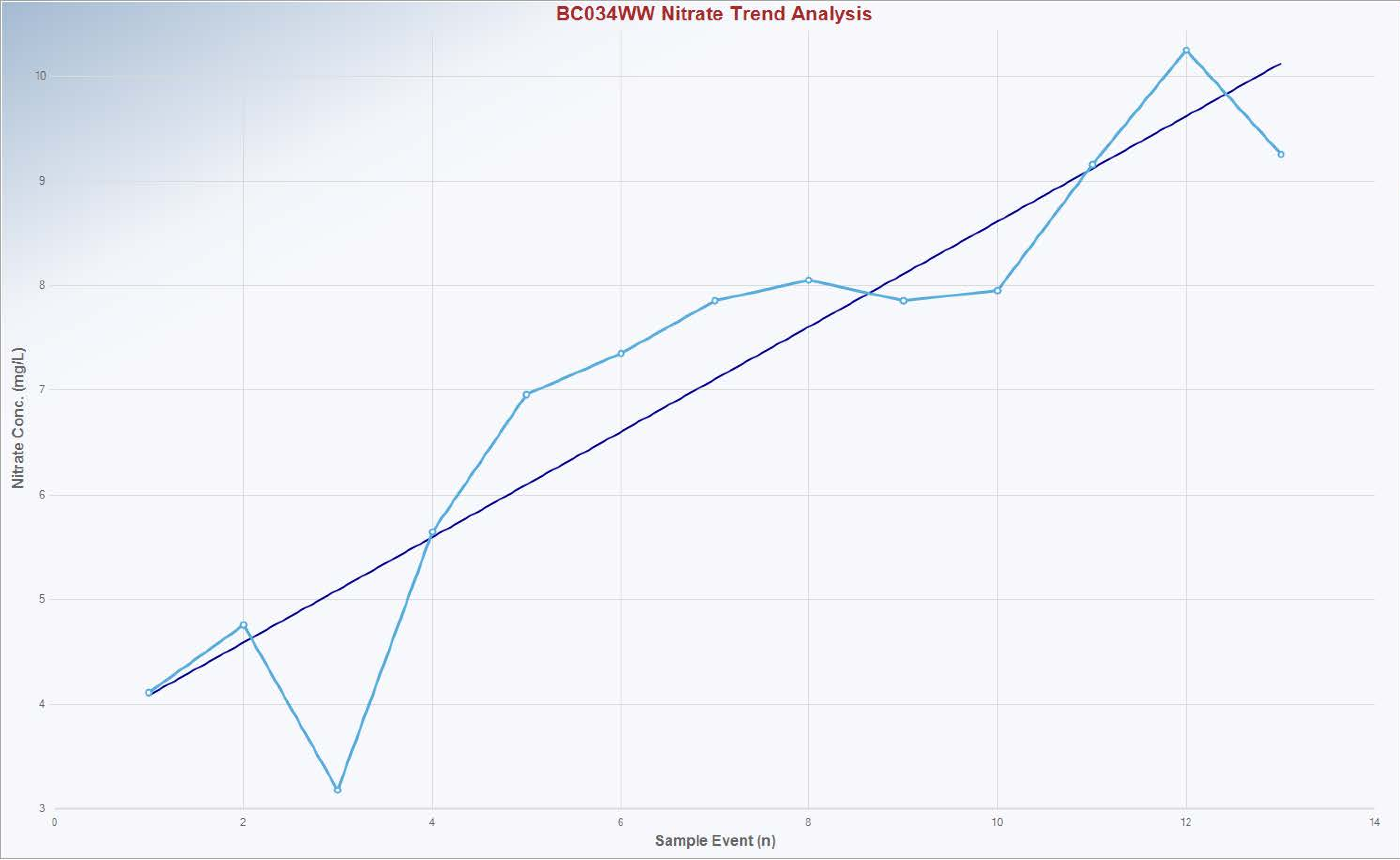
Mann-Kendall Trend Analysis

n	9
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	9.5917
Standardized Value of S	1.9809
M-K Test Value (S)	20
Tabulated p-value	0.0220
Approximate p-value	0.0238

OLS Regression Line (Blue)

OLS Regression Slope	0.5138
OLS Regression Intercept	0.0064

Statistically significant evidence of an increasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

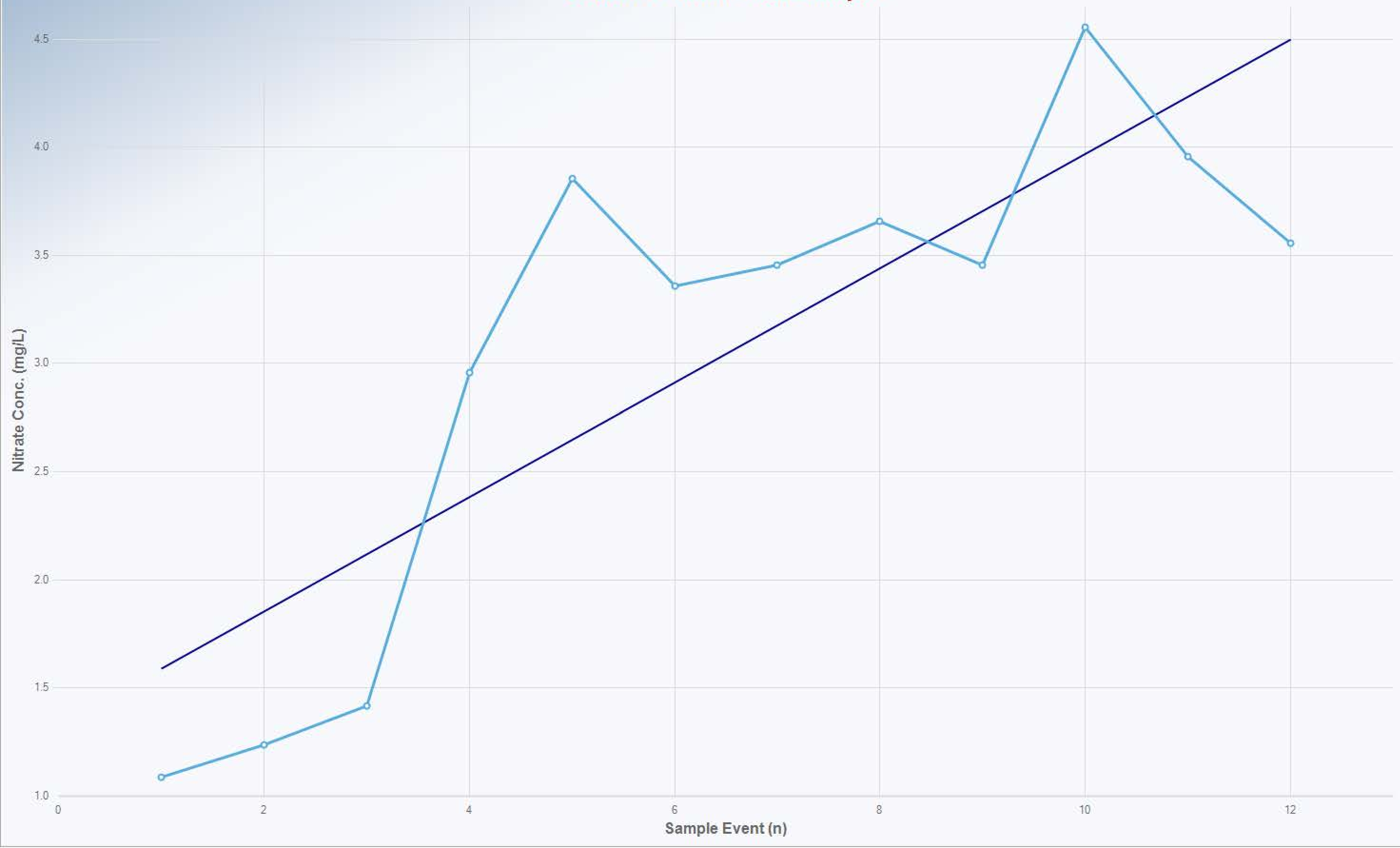
n	13
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	16.3605
Standardized Value of S	4.0341
M-K Test Value (S)	67
Tabulated p-value	0.0000
Approximate p-value	0.0000

OLS Regression Line (Blue)

OLS Regression Slope	0.5038
OLS Regression Intercept	3.2250

Statistically significant evidence of an increasing trend at the specified level of significance.

BC086WW Nitrate Trend Analysis



Mann-Kendall Trend Analysis

n	12
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	14.5488
Standardized Value of S	3.0243
M-K Test Value (S)	45
Tabulated p-value	0.0010
Approximate p-value	0.0012

OLS Regression Line (Blue)

OLS Regression Slope	0.2644
OLS Regression Intercept	1.3703

Statistically significant evidence of an increasing trend at the specified level of significance.

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.2 8/1/2023 2:02:49 PM								
4			From File	Alluvial Wells.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	0.95								
7			Level of Significance	0.05								
8												
9			**Result-bc022ww**									
10												
11			**General Statistics**									
12				Number or Reported Events Not Used	0							
13				Number of Generated Events	13							
14				Number Values Reported (n)	13							
15				Minimum	9.94							
16				Maximum	29.6							
17				Mean	19.12							
18				Geometric Mean	18.27							
19				Median	18							
20				Standard Deviation	5.952							
21				Coefficient of Variation	0.311							
22												
23			**Mann-Kendall Test**									
24				M-K Test Value (S)	46							
25				Tabulated p-value	0.002							
26				Standard Deviation of S	16.39							
27				Standardized Value of S	2.745							
28				Approximate p-value	0.00302							
29												
30	**Statistically significant evidence of an increasing**											
31	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
32	Result-bc088ww											
33												
34	**General Statistics**											
35	Number or Reported Events Not Used				0							
36	Number of Generated Events				13							
37	Number Values Reported (n)				13							
38	Minimum				14.5							
39	Maximum				18.4							
40	Mean				16.33							
41	Geometric Mean				16.29							
42	Median				15.9							
43	Standard Deviation				1.189							
44	Coefficient of Variation				0.0728							
45												
46	**Mann-Kendall Test**											
47	M-K Test Value (S)				-44							
48	Tabulated p-value				0.003							
49	Standard Deviation of S				16.39							
50	Standardized Value of S				-2.623							
51	Approximate p-value				0.00435							
52												
53	**Statistically significant evidence of a decreasing**											
54	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
55	Result-bc100ww											
56												
57	General Statistics											
58	Number or Reported Events Not Used				0							
59	Number of Generated Events				12							
60	Number Values Reported (n)				12							
61	Minimum				0.51							
62	Maximum				5.75							
63	Mean				1.246							
64	Geometric Mean				0.962							
65	Median				0.8							
66	Standard Deviation				1.429							
67	Coefficient of Variation				1.147							
68												
69	Mann-Kendall Test											
70	M-K Test Value (S)				15							
71	Tabulated p-value				0.19							
72	Standard Deviation of S				14.25							
73	Standardized Value of S				0.983							
74	Approximate p-value				0.163							
75												
76	Insufficient evidence to identify a significant											
77	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
78	Result-bc125ww											
79												
80	General Statistics											
81	Number or Reported Events Not Used				0							
82	Number of Generated Events				12							
83	Number Values Reported (n)				12							
84	Minimum				4.6							
85	Maximum				13.5							
86	Mean				10.04							
87	Geometric Mean				9.68							
88	Median				11							
89	Standard Deviation				2.548							
90	Coefficient of Variation				0.254							
91												
92	Mann-Kendall Test											
93	M-K Test Value (S)				-46							
94	Tabulated p-value				0							
95	Standard Deviation of S				14.58							
96	Standardized Value of S				-3.086							
97	Approximate p-value				0.00102							
98												
99	Statistically significant evidence of a decreasing											
100	trend at the specified level of significance.											

101	**Result-bc127ww**	
102		
103	**General Statistics**	
104	Number or Reported Events Not Used	0
105	Number of Generated Events	13
106	Number Values Reported (n)	13
107	Minimum	1.04
108	Maximum	23.4
109	Mean	8.423
110	Geometric Mean	5.525
111	Median	6.2
112	Standard Deviation	7.344
113	Coefficient of Variation	0.872
114		
115	**Mann-Kendall Test**	
116	M-K Test Value (S)	78
117	Tabulated p-value	0
118	Standard Deviation of S	16.39
119	Standardized Value of S	4.698
120	Approximate p-value	1.3156E-6
121		
122	**Statistically significant evidence of an increasing**	
123	**trend at the specified level of significance.**	

	A	B	C	D	E	F	G	H	I	J	K	L
124	Result-bc151ww											
125												
126	General Statistics											
127	Number or Reported Events Not Used				0							
128	Number of Generated Events				13							
129	Number Values Reported (n)				13							
130	Minimum				3.39							
131	Maximum				9							
132	Mean				6.635							
133	Geometric Mean				6.342							
134	Median				7.2							
135	Standard Deviation				1.913							
136	Coefficient of Variation				0.288							
137												
138	Mann-Kendall Test											
139	M-K Test Value (S)				73							
140	Tabulated p-value				0							
141	Standard Deviation of S				16.36							
142	Standardized Value of S				4.401							
143	Approximate p-value				5.3917E-6							
144												
145	Statistically significant evidence of an increasing											
146	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
147	**Result-bc184ww**											
148												
149	**General Statistics**											
150	Number or Reported Events Not Used				0							
151	Number of Generated Events				13							
152	Number Values Reported (n)				13							
153	Minimum				14.7							
154	Maximum				21							
155	Mean				18.05							
156	Geometric Mean				17.92							
157	Median				18.7							
158	Standard Deviation				2.249							
159	Coefficient of Variation				0.125							
160												
161	**Mann-Kendall Test**											
162	M-K Test Value (S)				27							
163	Tabulated p-value				0.064							
164	Standard Deviation of S				16.36							
165	Standardized Value of S				1.589							
166	Approximate p-value				0.056							
167												
168	**Insufficient evidence to identify a significant**											
169	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
170	Result-bc194ww											
171												
172	General Statistics											
173	Number or Reported Events Not Used				0							
174	Number of Generated Events				13							
175	Number Values Reported (n)				13							
176	Minimum				8.68							
177	Maximum				14.3							
178	Mean				11.97							
179	Geometric Mean				11.78							
180	Median				12.1							
181	Standard Deviation				2.121							
182	Coefficient of Variation				0.177							
183												
184	Mann-Kendall Test											
185	M-K Test Value (S)				27							
186	Tabulated p-value				0.064							
187	Standard Deviation of S				16.28							
188	Standardized Value of S				1.597							
189	Approximate p-value				0.0551							
190												
191	Insufficient evidence to identify a significant											
192	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2			User Selected Options									
3			Date/Time of Computation	ProUCL 5.2 8/1/2023 2:38:41 PM								
4			From File	Alluvial and SB Welle.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	0.95								
7			Level of Significance	0.05								
8												
9			**Result-bc081ww**									
10												
11			**General Statistics**									
12				Number or Reported Events Not Used	0							
13				Number of Generated Events	8							
14				Number Values Reported (n)	8							
15				Minimum	11.7							
16				Maximum	12.8							
17				Mean	12.28							
18				Geometric Mean	12.27							
19				Median	12.2							
20				Standard Deviation	0.373							
21				Coefficient of Variation	0.0304							
22												
23			**Mann-Kendall Test**									
24				M-K Test Value (S)	19							
25				Tabulated p-value	0.016							
26				Standard Deviation of S	8.021							
27				Standardized Value of S	2.244							
28				Approximate p-value	0.0124							
29												
30	**Statistically significant evidence of an increasing**											
31	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
32	**Result-bc087ww**											
33												
34	**General Statistics**											
35	Number or Reported Events Not Used				0							
36	Number of Generated Events				14							
37	Number Values Reported (n)				14							
38	Minimum				6.5							
39	Maximum				22.2							
40	Mean				12.14							
41	Geometric Mean				10.96							
42	Median				8.715							
43	Standard Deviation				5.811							
44	Coefficient of Variation				0.478							
45												
46	**Mann-Kendall Test**											
47	M-K Test Value (S)				-20							
48	Tabulated p-value				0.14							
49	Standard Deviation of S				18.24							
50	Standardized Value of S				-1.042							
51	Approximate p-value				0.149							
52												
53	**Insufficient evidence to identify a significant**											
54	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
55	**Result-bc116ww**											
56												
57	**General Statistics**											
58	Number or Reported Events Not Used				0							
59	Number of Generated Events				13							
60	Number Values Reported (n)				13							
61	Minimum				1.6							
62	Maximum				13.1							
63	Mean				9.229							
64	Geometric Mean				8.487							
65	Median				9.2							
66	Standard Deviation				2.779							
67	Coefficient of Variation				0.301							
68												
69	**Mann-Kendall Test**											
70	M-K Test Value (S)				-16							
71	Tabulated p-value				0.184							
72	Standard Deviation of S				16.33							
73	Standardized Value of S				-0.919							
74	Approximate p-value				0.179							
75												
76	**Insufficient evidence to identify a significant**											
77	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
78	Result-bc117ww											
79												
80	General Statistics											
81	Number or Reported Events Not Used				0							
82	Number of Generated Events				12							
83	Number Values Reported (n)				12							
84	Minimum				21.3							
85	Maximum				59							
86	Mean				32.61							
87	Geometric Mean				31.11							
88	Median				28.4							
89	Standard Deviation				11.27							
90	Coefficient of Variation				0.346							
91												
92	Mann-Kendall Test											
93	M-K Test Value (S)				45							
94	Tabulated p-value				0.001							
95	Standard Deviation of S				14.55							
96	Standardized Value of S				3.024							
97	Approximate p-value				0.00125							
98												
99	Statistically significant evidence of an increasing											
100	trend at the specified level of significance.											

	A	B	C	D	E	F	G	H	I	J	K	L
101	**Result-bc128ww**											
102												
103	**General Statistics**											
104	Number or Reported Events Not Used				0							
105	Number of Generated Events				13							
106	Number Values Reported (n)				13							
107	Minimum				1.43							
108	Maximum				14.3							
109	Mean				7.637							
110	Geometric Mean				5.861							
111	Median				7.28							
112	Standard Deviation				4.873							
113	Coefficient of Variation				0.638							
114												
115	**Mann-Kendall Test**											
116	M-K Test Value (S)				31							
117	Tabulated p-value				0.038							
118	Standard Deviation of S				16.36							
119	Standardized Value of S				1.834							
120	Approximate p-value				0.0334							
121												
122	**Statistically significant evidence of an increasing**											
123	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2	User Selected Options											
3	Date/Time of Computation			ProUCL 5.2 8/1/2023 2:51:52 PM								
4	From File			SB and IntB Wells.xls								
5	Full Precision			OFF								
6	Confidence Coefficient			0.95								
7	Level of Significance			0.05								
8												
9	**Result-bc192ww**											
10												
11	**General Statistics**											
12	Number or Reported Events Not Used				0							
13	Number of Generated Events				13							
14	Number Values Reported (n)				13							
15	Minimum				18.7							
16	Maximum				30.8							
17	Mean				26.58							
18	Geometric Mean				26.22							
19	Median				27.2							
20	Standard Deviation				4.363							
21	Coefficient of Variation				0.164							
22												
23	**Mann-Kendall Test**											
24	M-K Test Value (S)				24							
25	Tabulated p-value				0.082							
26	Standard Deviation of S				16.39							
27	Standardized Value of S				1.403							
28	Approximate p-value				0.0803							
29												
30	**Insufficient evidence to identify a significant**											
31	**trend at the specified level of significance.**											

	A–D	E
32	**Result-bc782321ww**	
33		
34	**General Statistics**	
35	Number or Reported Events Not Used	0
36	Number of Generated Events	13
37	Number Values Reported (n)	13
38	Minimum	11.8
39	Maximum	47
40	Mean	42.17
41	Geometric Mean	40.33
42	Median	44.1
43	Standard Deviation	9.212
44	Coefficient of Variation	0.218
45		
46	**Mann-Kendall Test**	
47	M-K Test Value (S)	-21
48	Tabulated p-value	0.126
49	Standard Deviation of S	16.28
50	Standardized Value of S	-1.229
51	Approximate p-value	0.11
52		
53	**Insufficient evidence to identify a significant**	
54	**trend at the specified level of significance.**	

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Mann-Kendall Trend Test Analysis**								
2	User Selected Options											
3	Date/Time of Computation			ProUCL 5.2 8/1/2023 3:05:59 PM								
4	From File			Unclassified Wells.xls								
5	Full Precision			OFF								
6	Confidence Coefficient			0.95								
7	Level of Significance			0.05								
8												
9	**Result-bc012ww**											
10												
11	**General Statistics**											
12	Number or Reported Events Not Used				0							
13	Number of Generated Events				9							
14	Number Values Reported (n)				9							
15	Minimum				0.72							
16	Maximum				6.6							
17	Mean				2.576							
18	Geometric Mean				1.863							
19	Median				2.6							
20	Standard Deviation				2.133							
21	Coefficient of Variation				0.828							
22												
23	**Mann-Kendall Test**											
24	M-K Test Value (S)				20							
25	Tabulated p-value				0.022							
26	Standard Deviation of S				9.592							
27	Standardized Value of S				1.981							
28	Approximate p-value				0.0238							
29												
30	**Statistically significant evidence of an increasing**											
31	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
32	**Result-bc034ww**											
33												
34	**General Statistics**											
35	Number or Reported Events Not Used				0							
36	Number of Generated Events				13							
37	Number Values Reported (n)				13							
38	Minimum				2.82							
39	Maximum				9.9							
40	Mean				6.752							
41	Geometric Mean				6.381							
42	Median				7.5							
43	Standard Deviation				2.114							
44	Coefficient of Variation				0.313							
45												
46	**Mann-Kendall Test**											
47	M-K Test Value (S)				67							
48	Tabulated p-value				0							
49	Standard Deviation of S				16.36							
50	Standardized Value of S				4.034							
51	Approximate p-value				2.7406E-5							
52												
53	**Statistically significant evidence of an increasing**											
54	**trend at the specified level of significance.**											

	A	B	C	D	E	F	G	H	I	J	K	L
55	**Result-bc086ww**											
56												
57	**General Statistics**											
58	Number or Reported Events Not Used				0							
59	Number of Generated Events				12							
60	Number Values Reported (n)				12							
61	Minimum				1.13							
62	Maximum				4.6							
63	Mean				3.089							
64	Geometric Mean				2.819							
65	Median				3.5							
66	Standard Deviation				1.153							
67	Coefficient of Variation				0.373							
68												
69	**Mann-Kendall Test**											
70	M-K Test Value (S)				45							
71	Tabulated p-value				0.001							
72	Standard Deviation of S				14.55							
73	Standardized Value of S				3.024							
74	Approximate p-value				0.00125							
75												
76	**Statistically significant evidence of an increasing**											
77	**trend at the specified level of significance.**											

Appendix H.

Acronyms and Abbreviations

BCD	Benton County Conservation District
BFHD	Benton Frankly Health District
BMP	best management practice
°C	degrees Celsius
CRBG	Columbia River Basalt Group
DQO	data quality objective
EIM	environmental information management
GWMA	groundwater management area
KID	Kennewick Irrigation District
km	kilometer
L	liter
MCL	maximum contaminant level
MEL	maximum exposure limit
mg	milligrams
mi	miles
ml	milliliter
MQO	measurement quality objective
N	Nitrogen
NO3	Nitrate
ppm	parts per million
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RPD	relative percent difference
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code
WDOH	Washington Department of Health