HYDROLOGIC EVALUATION
PRENTER ROAD AREA
BOONE COUNTY, WV

Triad Engineering Project 04-10-0323

Prepared for:

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REFERENCES

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EXECUTIVE SUMMARY

On October 1, 2010, the West Virginia Department of Environmental Protection (WVDEP) issued Purchase Order DEP15223 to Triad Engineering, Inc. (Triad) to evaluate allegations of negative impacts to the quality of groundwater being used as a drinking source by residents along Laurel Creek and its tributaries in Boone County, WV. This area is commonly referred to as Prenter Road. Specifically, the WVDEP Request for Proposals indicated that the purpose of the study would be as follows:

"Determine what human activity, including coal mining and ancillary activity, may have negatively affected the quality of groundwater being used as a drinking water source by residents of the study area."

The investigation began December 1, 2010 and continued for approximately one year. This report represents the results of the study.

Triad completed extensive research into the geology and hydrology of the study area, including an in-depth review of published reports and previously collected water quality data. Triad personnel spent approximately ten days in the community and visited more than 100 homes across the study area and eventually were able to collect samples from 33 domestic wells. Two public meetings were held in the study area in association with WVDEP and local advocates to advise residents of our activities and to encourage participation in the study. Local media were present at these public meetings and broadcast coverage of the meetings. The WVDEP also published notices of the study in local newspapers encouraging residents to contact Triad to arrange to have their domestic well water sampled. Triad evaluated a number of human activities within the study area that could potentially have negative impacts on groundwater quality. Triad personnel collected samples from surface water streams, mine discharges, valley fill discharges, and coal slurry related samples. One of the mine discharges was located below the former Boone County Landfill.

Surface water within the study area is drained by Laurel Creek, which empties into the Coal River. The Laurel Creek watershed covers approximately 35,000 acres. The geology of the study area is comprised of relatively flat lying sedimentary rock with very gentle northeast-southwest trending folds. Rock units of the Kanawha Formation make up the majority of strata within the study area, including those which comprise the primary water-bearing zones. A number of mineable coals occur in the Kanawha Formation within the study area, including the Stockton, Coalburg, Winifrede, Chilton, Fire Clay, No. 2 Gas, Powellton and Eagle seams. Rock strata across a majority of the Laurel Creek watershed are essentially flat lying. Geologic structure is controlled by the Coalburg Syncline, which approximately follows the alignment of Laurel Creek and Sandlick Creek. Soils in the study area are sandy and contain sandstone fragments. Larger stream valleys are covered by alluvial and colluvial material that is less than 20 feet in thickness.

Groundwater flows within the study area by fracture-controlled secondary permeability, formed by bedding-plane partings, stress-relief fractures and joints. Abandoned underground coal mine voids also serve as conduit flow pathways. Groundwater flow in the study area is dominated by local flow systems, which are modeled as a series of “hydrologic islands” separated by surface water streams. Each local flow system is hydrologically separate from adjacent systems. Recharge to the local system comes from the ridge forming the hydrologic island and discharge occurs in the adjacent stream valley. A minor degree of leakage also moves from the local system to the underlying intermediate and regional groundwater flow systems. The majority of domestic wells derive their groundwater from the local flow system. Local groundwater systems typically contain calcium bicarbonate water.

Underground mine voids also provide groundwater flow pathways. The underground excavation acts as a large sink which draws in groundwater. Several underground mines in the study area were used for the disposal of coal slurry in the past. Potentially impacted groundwater in these mines moves via conduit flow and discharges at down dip mine openings or seeps along the coal outcrop. A minor portion of groundwater in these openings may move downward to lower mine voids, where it can once again move laterally to a mine opening or outcrop seep or migrate again to a lower mine void. The No. 2 Gas coal seam provides the lowest mine void groundwater transport system in the watershed. Very large quantities of water are pumped from the No. 2 Gas in the Lavinia Fork watershed to facilitate mining. Water not pumped from the No. 2 Gas seam discharges to Robinson Fork and Coal River, south of the study area, where it outcrops above drainage.

Intermediate and regional groundwater flow systems operate independently of the shallower local systems. Recharge to the regional system comes from major drainage basin divides and leakage from multiple local and intermediate systems. The regional groundwater systems discharge to larger, master stream valleys. Flow rates are very slow and groundwater residence time is probably measured in decades or centuries. Regional systems are rich in sodium chloride, while intermediate flow systems contain sodium bicarbonate waters.

A Sampling and Analysis Plan (April 2011) describing methods for collection of all water samples was submitted to WVDEP for review and approval. This included quality assurance/quality control procedures that were followed for all water and coal slurry sampling. Quality assurance/quality control procedures included using latex gloves, collecting samples in clean and appropriate containers supplied by the laboratory, using distilled water to rinse equipment between samples, using chemical preservatives when necessary, keeping samples chilled to 4 degrees Centigrade, and completing chain-of-custody for each sample.

Care was taken to ensure that domestic well samples were collected from a source as close to the well as possible, an unfiltered and/or untreated source, and from the cold water supply. Filters, softeners, treatment systems and hot water tanks can cause significant impacts to natural groundwater quality and their effects should be avoided where a representative groundwater sample is desired.

Triad contracted with REI Consultants, Inc. (REIC) of Beaver, WV to analyze the samples that were collected for this study. REIC is an approved WVDEP laboratory and followed appropriate EPA approved laboratory methods when conducting tests on all study samples.

Water samples collected during our study were analyzed for metals referenced in the primary drinking water standards, total and fecal Coliform, all secondary drinking water standards, indicators of mine drainage such as acidity/alkalinity, iron, manganese, aluminum and sulfate, and volatile organic compounds, which are frequently found in petroleum products, paints, paint thinners and industrial solvents. Also, samples were analyzed for major anions and cations such as calcium, magnesium, sodium, potassium, chloride, carbonate and bicarbonate.

Primary drinking water standards are legally enforceable standards that apply to public water systems. Although the domestic wells sampled are not part of a public system, these standards are typically used for purposes of comparison to a uniform standard. Primary standards are established by USEPA based on potential health effects associated with consumption of drinking water containing levels of the primary contaminants that exceed the recommended levels (referred to as maximum contaminant levels or MCLs).

Secondary drinking water standards (SMCLs) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. These contaminants are not considered to present a risk to human health at the SMCL. The USEPA recommends secondary standards to public water systems but does not require those systems to comply.

The results from all water samples were plotted on Piper diagrams for comparison. Surface water samples, valley fill samples, and most mine drainage and slurry related samples plotted in the upper portion of the Piper diagram, which is generally associated with mine-related impacts. Conversely, most domestic well samples did not plot in this zone. Three samples (DW-14, DW-15 and DW-25) did plot within the upper portion of the Piper diagram.

One domestic well sample exceeded the MCL for lead. The resident is connected to the public water supply and does not use well water for drinking. Sample DW-32 contained 0.0338 mg/L total lead, compared to the MCL of 0.0150 mg/L. Lead found in tap water usually comes from the corrosion of older fixtures or from the solder that connects pipes. The most common problem is with brass or chrome-plated brass faucets and fixtures which can leach significant amounts of lead into water. Homes built before 1986 are more likely to have lead pipes, fixtures and solder.

High levels of lead in tap water can cause health effects if the lead in the water enters the bloodstream and causes an elevated blood lead level. According to the Center for Disease Control (CDC), most studies show that exposure to lead-contaminated water alone would not be likely to elevate blood lead levels in most adults, even exposure to water with a lead content close to the MCL of 0.015 mg/L. Although the resident does not use groundwater for drinking, the source of elevated lead in DW-32 should be evaluated.

Samples were also plotted on Stiff diagrams. Surface water samples and valley fill drainage samples portrayed the strong magnesium sulfate pattern typically associated with mine-related impacts. Six of the eight mine drainage samples also exhibited a strong sulfate signature. Two of the slurry decant water samples exhibited calcium sulfate signatures, while the third sample exhibited a sodium sulfate signature. Domestic well samples were predominantly calcium bicarbonate and sodium bicarbonate in nature, which is generally indicative of shallow to intermediate depth naturally occurring groundwater. Four domestic well samples (DW-14, DW-15, DW-25 and DW-26) exhibited a sulfate-dominated signature.

Total manganese levels in domestic wells ranged from less than 0.002 to 0.496 mg/L and were above the secondary standard in 12 of the 33 wells sampled. The highest manganese concentration was measured at DW-25. Total iron levels in domestic wells ranged from less than 0.01 to 5.78 mg/L and exceeded the secondary standard in 12 of the 33 well samples.

Aluminum levels were generally low, ranging from less than .012 to 0.061 mg/L. Location DW-26 exceeded the secondary standard for aluminum.

According to the USEPA, manganese present in drinking water above the secondary standard is associated with black to brown color, black staining and a bitter metallic taste. Iron above the standard is associated with a rusty color, sediment in the water, a metallic taste, and reddish/orange staining of fixtures. Aluminum exceeding the SMCL can cause discoloration of drinking water. The USEPA does not associate these secondary drinking water parameters with health effects.

All volatile organic compounds (VOC) and all primary and secondary standards beyond those discussed above were present at concentrations less than the applicable standard in all samples from all domestic wells. Coliform bacteria (total and fecal) were not detected in any domestic well or surface water sample.

Our investigation did not identify evidence of widespread human-induced impacts to groundwater quality in the Prenter Road area. No evidence of impacts related to commercial/industrial activities was reflected in the analytical data. Also, our review of environmental database records did not reveal the presence of potential commercial/industrial contaminant sources other than coal mining. Our study also did not identify evidence of impacts from natural gas drilling and production. A sample collected from an underground mine located beneath the closed Boone County Landfill did not contain VOC or other parameters that would suggest that leachate from the landfill is impacting groundwater at that location.

Domestic wells DW-25 and DW-26, located in the Hopkins Fork A watershed, presented the strongest evidence of mine-related effects. Sulfate, iron and manganese were elevated in both wells, and aluminum was elevated in DW-26. Two wells located in the Hopkins Fork B watershed, DW-14 and DW-15, contained elevated sulfate concentrations, although none of the water quality parameters actually exceeded the primary or secondary drinking water standards. Water quality in these two wells is more closely allied with surface water quality than groundwater quality, due to their very shallow depths.

Approximately one-third of the domestic wells sampled (12 of 33) exceeded the secondary standard for iron concentration. The same number exceeded the secondary manganese standard. The US Geological Survey (USGS) found that in West Virginia, "concentrations of iron and manganese in ground water commonly exceed the secondary drinking-water standards". In their Evaluation of Ground-Water Quality in the Appalachian Plateaus, Kanawha River Basin, West Virginia (Sheets and Kozar, 2000), the USGS found that 40% of the sites sampled exceeded the secondary standard for iron and 57% exceeded the secondary standard for manganese. In the study area, 36% of the domestic wells sampled exceeded the secondary standard for iron and the same percentage exceeded for manganese. This suggests that concentrations of these two elements in groundwater are typical for the area. A comparison of data collected by Triad from the study area to data collected by the USGS from the Kanawha River basin illustrates that water quality in domestic wells in the Prenter Road area is typical of water quality found in the region by the USGS.

Nearly one-half of residents interviewed during our study reported that their water emitted a sulfur or rotten egg odor, and roughly one-fourth reported a red, orange or black color. A few residents also reported a slimy or greasy feel. Three residents reported black water or black particles in their water. One resident reported a gasoline odor. We found very poor correlation between resident complaints regarding sulfur odor and black or red appearance and laboratory analytical results. Of the 13 residents offering the strongest complaints regarding odor, only four of the samples actually contained elevated sulfate levels. Conversely, sulfate concentration at eight of those wells was very low or not detected.

The complaints regarding odors and coloration are most likely associated with bacterial causes. Iron and sulfate metabolizing bacteria are microorganisms widely distributed in nature. They do not generally cause disease in humans or animals, but are nuisance microorganisms. These bacteria can cause unpleasant tastes and odors, can foul dishwashers, washing machines and toilets, and can stain clothing and plumbing fixtures. They frequently cause reddish-orange, slimy-looking deposits inside toilet tanks. The bacteria obtain energy for growth by oxidizing dissolved iron and sulfate present in groundwater from soluble to insoluble forms. When the temperature of groundwater rises, as it does in toilet tanks and interior household plumbing, iron and sulfate bacteria grow faster and in greater quantities. Slimes and red water reported by domestic well users is most likely caused by the growth of iron and sulfate metabolizing bacteria.

Occasionally, hot water heaters can be a source of hydrogen sulfide odor. The magnesium corrosion control rod present in many hot water heaters can chemically reduce naturally occurring sulfates to hydrogen sulfide. Also, water softeners provide a convenient environment for these bacteria to grow and may produce a black slime inside water softeners.

Iron and sulfate bacteria can be controlled through disinfection processes such as chlorination. None of the residents reported that they had installed a chlorination system or had undertaken any water system maintenance activities such as well/system disinfection or well redevelopment in response to their observations.

Triad personnel did not observe any evidence of significant local sources of contamination during the course of our investigation. At two residential locations we observed that oil changes and other automobile maintenance had been performed. However, there was no direct evidence of impact to the wells.

The geologic literature indicates that groundwater flow within the study area is relatively localized, and that the vast majority of domestic wells derive their water from local flow systems. Cation and anion analyses conducted as a part of our study found that the vast majority of domestic wells contained calcium bicarbonate or sodium bicarbonate water typical of shallow to intermediate depth groundwater systems. Therefore, large scale impacts to groundwater quality across the study area are unlikely. Evidence of the local nature of groundwater quality was supported by the data from our investigation. In numerous settings across the study area domestic wells situated adjacent to each other exhibit very different water quality. Water quality within the study area is highly variable, due to the variability of fracture-related permeability and source rocks. Nearby wells often penetrate different stratigraphic units with different geochemical signatures, and therefore, yield different water quality. Also, different fracture character also can result in different water quality within fairly localized areas.

In summary, our investigation did not reveal evidence of widespread human-induced impacts to groundwater quality in the study area. Two wells, DW-25 and DW-26, exhibited the greatest evidence of mine-related impact. These wells are located in Hopkins Fork Watershed A, adjacent to a reclaimed surface mine operation situated immediately to the east, on the ridge separating Hopkins Fork and Big Coal River. These wells probably derive their water from the same groundwater flow system occupied by the reclaimed mining operation. Therefore, it is possible that elevated sulfate, iron, manganese and aluminum levels detected in those wells may be related to potential impacts from the mining operation.

1.0 INTRODUCTION

The purpose of our investigation was to evaluate reports of negative impacts to groundwater being used as a drinking source by residents along Laurel Creek and its tributaries in Boone County, WV. This area is commonly referred to as Prenter Road. Figure 1-1 depicts the study area in the context of the Williams Mountain 7.5 minute topographic quadrangle. More specifically, WVDEP asked that we determine what human activity, including coal mining and ancillary activity, may have negatively affected the quality of groundwater being used as a drinking water source by residents of the study area.

1.1 SCOPE OF WORK

The investigation encompassed three primary elements. First, our investigation fully characterized the geology and hydrology of the study area, including stratigraphy and geologic structure, surface water and groundwater hydrology, and known and inferred effects of underground coal mining on groundwater. This geologic/hydrologic characterization focused primarily on the potential for geologic strata and human activities to affect water quality and movement within the study area. It involved an in-depth review of existing information, including published reports regarding the geology and hydrology of the area and previously collected water quality data.

Second, our investigation characterized the quality of groundwater currently being used for residential water supplies in the area. In the past, all residents within the study utilized groundwater for their domestic needs, either through individual wells or through multi-family groundwater based systems. Recently, public water has been made available to residents within the northern portion of the study area. Public water is available to residents along Sandlick Creek, Laurel Creek and Hopkins Fork upstream to the community of Nolan. The availability of public water is shown on Figure 3-1. Also, drinking water is supplied in containers to many residents in the southern portion of the study area by a local coal company. Triad personnel spent approximately ten days in the community and visited more than 100 homes. Two public meetings were held in the study area to advise residents of our activities and to encourage participation in the study. A total of 33 samples were collected from domestic wells distributed across the entire study area.

Third, our investigation included an evaluation of areas of human impact within the study area that could possibly affect groundwater quality, including past and present human activities that can be considered potential causes of negative groundwater impacts. Coal mining, coal processing, and the disposal of coal processing waste have occurred extensively throughout the study area since approximately 1915. Natural gas extraction, gathering and transmission have also occurred within the study area. The study area also includes the former Boone County Landfill, where disposal of domestic, commercial and industrial waste occurred. Finally, given the long term history of human activity in the area, there is significant potential for the leakage, spillage and improper disposal of commercial and industrial wastes. Triad personnel visited numerous mining facilities across the study area and collected samples from surface water, mine discharges, valley fill discharges, and coal slurry related samples.

1.2 STUDY METHODOLOGY

Before beginning field work or collecting data, Triad conducted an extensive review of currently existing information regarding the study area. This included a review of previously collected water quality data, previous geologic and hydrologic reports prepared by others, environmental permits on file with the WVDEP, and extensive information published by various government agencies such as the US Geologic Survey and the WV Geologic and Economic Survey. A bibliography of many literature sources utilized in our study is provided at the conclusion of our report.

After researching the geology and hydrology of the study area, as well as the extent of mining, natural gas production, and industrial land use, Triad personnel performed extensive field reconnaissance that included interviews with local groundwater users and mining companies. Information collected from local groundwater users included descriptions of groundwater quality, well depths and ages, water system maintenance and repair efforts, and reports of changes in water quality. Triad personnel visited more than 100 homes across the study area and eventually were able to collect samples from 33 domestic wells. Two public meetings were held in the study area in association with the WVDEP and local advocates to advise residents of our activities and to encourage participation in the study. Local media were present at these public meetings and broadcast coverage of the meetings. The WVDEP also published notices of the study in local newspapers encouraging residents to contact Triad to arrange to have their domestic well water sampled.

During our field reconnaissance, Triad personnel confirmed the locations and nature of the various human activities that could negatively affect the quality of groundwater in the study area. This included a review of active and closed mining and coal processing operations, natural gas wells, and commercial and industrial activities.

To identify potential commercial and industrial activities that could impact water quality within the study area, Triad utilized the services of Environmental Data Resources, Inc. (EDR). EDR maintains current and historical records of numerous environmental databases that compile records of various commercial and industrial businesses that may reasonably be expected to use materials that may result in environmental contamination. These include environmental records from federal, state, and local databases that provide information regarding potential recognized environmental conditions and petroleum products within the study area.

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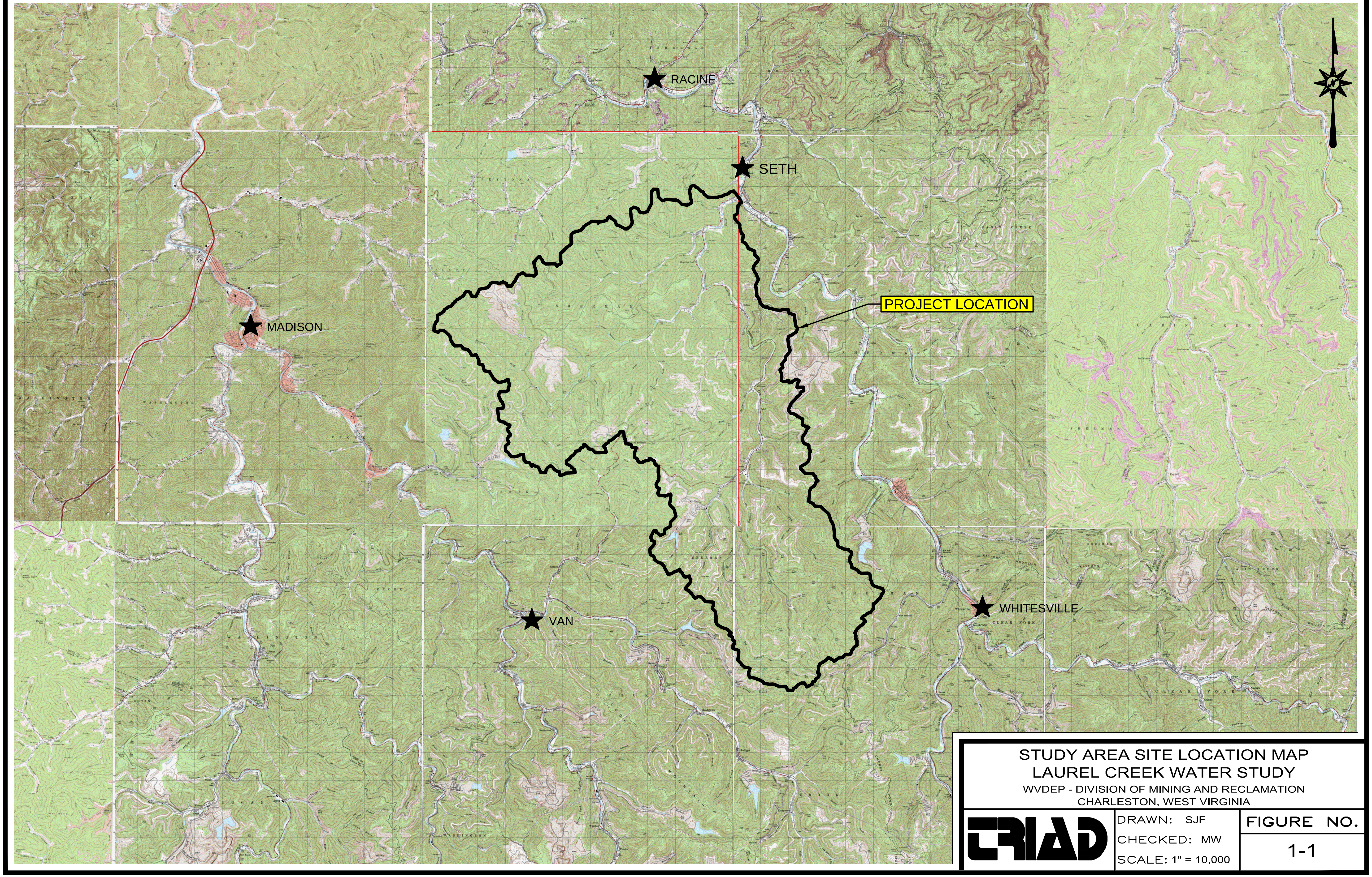
CAD FILE: 10-0323 SITE LOC.dwg



STUDY AREA SITE LOCATION MAP
LAUREL CREEK WATER STUDY
WVDEP - DIVISION OF MINING AND RECLAMATION
CHARLESTON, WEST VIRGINIA

TRIAD

DRAWN: SJF
CHECKED: MW
SCALE: 1" = 10,000

FIGURE NO.
1-1

2.0 REGIONAL GEOLOGIC AND HYDROLOGIC CHARACTERISTICS

The study area lies within the Appalachian Plateau physiographic province, which is underlain by very gently folded to horizontal beds of sedimentary rock of late Pennsylvanian age. Topography within the Appalachian Plateau consists of meandering ridges of generally concordant elevation that have been eroded by surface water flowing within a mature dendritic drainage pattern. Ridges and ridge-top knolls are usually underlain by resistant sandstone units. Total topographic relief within the study area is approximately 1400 feet. The lowest elevation within the study area is approximately 675 feet MSL, at the junction of Laurel Creek and Coal River at the northern extent of the area. The highest elevation is approximately 2080 feet MSL, at the headwaters of Big Jarrells Creek at the southern extent of the study area. Topography and surface water drainage of the study area is shown on Figure 2-1.

2.1 GEOLOGY

The rocks of the Appalachian Plateau are almost entirely sedimentary. Rock types consist of shale, sandstone, conglomerate, limestone, underclay, claystone, coal, and siltstone. The strata are relatively flat lying with gentle northeast-southwest trending folds.

Rocks across the Appalachian Plateau were deposited in a fluvial (river) delta setting and represent channel, backwater, swamp, delta and near-shore marine environments. The result is a complex, somewhat cyclical, relatively flat-lying mix of sedimentary rocks with a great deal of lateral variation and interwoven lithologies. Although generally referred to as cyclical, the depositional sequence is not regular when considered in three dimensions. Marine zones, coals, and underclays are the most aerially continuous units. However, these beds are occasionally interwoven, and locally replaced by sandstone channels. These thin, flat-lying, layered strata of contrasting permeability can result in a great degree of lateral and vertical heterogeneity.

2.1.1 Stratigraphy

Strata in the study area are comprised entirely of Pennsylvanian age sedimentary rock. The youngest strata in the study area include rocks of the Conemaugh Group, which are limited to a small area along ridge tops in the far southwestern portion of the study area. Rocks of the next youngest strata belong to the Allegheny Formation and outcrop along the higher ridge tops across the study area. Rocks of the Kanawha Formation make up the majority of strata within the study area, including the valley walls and the valley bottoms which comprise the primary water-bearing zones. The Kanawha Formation ranges up to 1000 feet thick in the study area and is defined as rock units extending downward from the top of the Homewood sandstone to the top of the Upper Nuttall sandstone. The Kanawha Formation is dominated by sandstone (approximately 50%) with lesser amounts siltstone, shale and coal. A number of mineable coals occur in the Kanawha Formation within the study area, including the Stockton, Coalburg, Winifrede, Chilton, Fire Clay, No. 2 Gas, Powellton and Eagle seams.

Due to the high percentage of sandstone occurring within Kanawha Formation, residual soils that weather from these strata are generally quite sandy and contain a large percentage of sandstone fragments. Where shale and siltstone bedrock occurs, soils are typically more fine-grained and cohesive, but still tend to contain a large percentage of rock fragments. Along the larger stream valleys, soils are primarily alluvial with a mix of colluvial material along the base of the ridges. These alluvial soils typically consist of a fining-upward sequence ranging from boulders and cobbles at the base to silty and clayey sand at the surface. Alluvial deposits along Laurel Creek and the major tributaries probably do not exceed 20 feet in thickness. Soils along ridge tops and valley walls are generally less than 10 feet in thickness.

2.1.2 Structural Geology

Rock strata in the vicinity of the study area are very gently folded, and are primarily influenced by a large regional structure; the Coalburg Syncline. The axis of the Coalburg Syncline trends southwest to northeast across the study area, approximately following the alignment of Laurel Creek and Sandlick Creek. Strata along the synclinal axis form a very broad trough and are nearly flat lying, with little consistent directional trend. The synclinal axis is also nearly horizontal in the vicinity of the study area, but plunges to the southwest at the southernmost extent of the study area. Therefore, rock strata across a majority of the Laurel Creek watershed are essentially flat lying. The Warfield Anticline lies immediately northwest from the Coalburg Syncline and causes strata to rise approximately 120 feet per mile in the area of Sandlick and upper Laurel Creek. In the southeastern portion of the study area, along the headwaters of Hopkins Fork, strata rise to the southeast at approximately 70 feet per mile away from the axis of the Coalburg Syncline. Structural contours are presented on the extent of underground mining maps presented in Figures 4-1 through 4-4.

2.2 SURFACE WATER HYDROLOGY

Surface water within the study area is drained by the Coal River. The Coal River drainage basin is located mostly within Boone and Raleigh Counties with small portions of the watershed in Kanawha, Lincoln, Logan, Putnam, and Fayette Counties. The watershed encompasses approximately 891 square miles. Major tributaries of the Coal River include Marsh Fork, Clear Fork, Pond Fork, Spruce Fork, Little Coal River, and Big Coal River. The watershed is dominated by forest land uses (91.5%) with minor urban/residential, pasture, and barren/mining land.

For purposes of our evaluation, the study area was limited to the drainage basin of Laurel Creek and its major tributaries, Sandlick Creek, Hopkins Fork, Lavinia Fork and Big Jarrells Creek. The Laurel Creek watershed comprises a drainage area of approximately 35,000 acres. Laurel Creek empties into the Coal River near Seth, WV. The Laurel Creek watershed is generally referred to as "Prenter Road" by local residents. The analysis and presentation of the hydrologic data collected as part of our study has been separated into sub-basins that occur within the Laurel Creek drainage basin. The following eight sub-basins were used to divide the study area.

- Laurel Creek Watershed A extends upstream from the mouth of Laurel Creek on Coal River to its junction with Hopkins Fork.

- Sandlick Creek Watershed extends upstream from the junction of Sandlick Creek with Laurel Creek, and includes the drainage area of Sandlick Creek and its major tributary, Three Fork Branch.

- Laurel Creek Watershed B extends upstream from its junction with Hopkins Fork, and includes the headwaters of Laurel Creek.

- Hopkins Fork Watershed A extends upstream from the junction of Hopkins Fork and Laurel Creek to the junction of Hopkins Fork with Lavinia Fork.

- Lavinia Fork Watershed includes the drainage area of Lavinia Fork.

- Hopkins Fork Watershed B extends upstream from the junction of Hopkins Fork and Lavinia Fork to its junction with Big Jarrells Creek.

- Hopkins Fork Watershed C extends upstream from its junction with Big Jarrells Creek and includes the headwaters of Hopkins Fork.

- Prenter Watershed includes the drainage area of Big Jarrells Creek.

All of the streams within the study area flow at relatively low gradients. In the central portion of the study area, along Hopkins Fork, the hydraulic gradient is approximately 40 feet per mile. Gradients of headwater streams and tributaries are significantly greater. The Laurel Creek watershed and sub-watersheds are shown on Figure 2-2.

2.3 GROUNDWATER HYDROLOGY

The traditional model for groundwater flow developed by Henry Darcy based on studies of water flow through columns of sand relies upon primary permeability, or the movement of fluid through intergranular pores. Although this model is generally dominant in unconsolidated sediments, it is far less important in the consolidated bedrock of the Appalachian Plateau, where the most significant permeability and porosity is secondary in nature. Bedding-plane partings, stress-relief fractures, joints and faults serve as pathways for fluid migration in this setting. Fracture zones (high concentrations of near vertical joints) are especially permeable. Within the Appalachian Plateau, these secondary features control the flow of groundwater. Without these secondary features, the Pennsylvanian age bedrock of the Appalachian Plateau would likely not be a significant aquifer.

High yielding aquifers in the Appalachian Plateau tend to be mainly sandstones, suggesting that primary permeability may be a factor in groundwater storage. However, it may also be that secondary permeability tends to develop more readily in sandstones than in shales. As a general rule, secondary permeability decreases with depth because fractures close due to overburden pressures and also decrease in frequency and distribution. Because secondary permeability features are less pronounced in deeper flow systems, the overall transmissivity of these deeper systems is also significantly lower than in shallow local flow systems.

The Appalachian Plateau contains substantial ranges of permeability that vary based on rock type and topographic setting. Permeability in sandstone units may be hundreds of times greater than in shale units. Also, permeability in stress-relief fractures along valley walls and floors can be hundreds of times greater than permeability found within the ridge cores.

Unconsolidated aquifers also occur on the Appalachian Plateau in major alluvial valleys and terraces. In contrast to consolidated bedrock, primary permeability dominates in unconsolidated sediments. These alluvial valley aquifers receive most of their recharge from the underlying bedrock aquifers, and subsequently discharge into surface water streams. The valleys located within the study area are generally too small to provide a reliable quantity of groundwater from the unconsolidated aquifers.

2.3.1 Effects of Mining

Over large areas of the Appalachian Plateau extensive underground mining has taken place, leaving as a remnant, substantial man-made aquifers (mine-void and subsidence-fracture zones) which can have a profound influence on groundwater flow. Impacts to local groundwater resources vary depending on myriad factors such as proximity to mining, geology, coal extraction percentage, thickness and strength of overburden, height of coal seam, topography, and the presence of preexisting fracture sets which can extend mining induced hydrologic impacts beyond the mined area.

Abandoned underground coal mine voids also serve as secondary permeability pathways. However, flow is very different from intergranular and fracture flow, especially if the mines are not full, and can be described as conduit flow. Conduit flow effectively reduces recharge to deeper aquifers and flow systems by allowing groundwater to discharge at mine openings. Dispersion of groundwater via intergranular and fracture flow is virtually eliminated by conduit flow. As a result, contaminants related to mining are more likely to move as a slug through discrete conduits rather than being dispersed over a larger area.

Underground mines typically impact the hydrology of a given locale much more profoundly than a surface mine. Underground mines have the potential to impact groundwater flow systems on a relatively large scale. During mining, the underground excavation acts as a large sink which draws in groundwater. Upon closure and flooding, it becomes a highly permeable aquifer which can permanently alter the pre-mining flow regime both physically and chemically. Interbasin transfer of groundwater is a common occurrence associated with underground mines, where the underground opening intercepts infiltrating groundwater that would otherwise have flowed to an adjacent basin and transports the discharge to a more distant, down dip discharge location.

Several underground mines in the study area were used for the disposal of coal slurry in the past. Three mines operated by Omar Coal Company are reported to have received coal slurry for disposal. These mines are reported to be in the No. 5 Block seam of the lower Allegheny Formation as well as the Stockton and Winifrede seams of the upper and middle Kanawha Formation. These mines are located well above drainage, near the ridge tops. Groundwater in these mine voids moves primarily via conduit flow to discharge at down dip mine openings or seeps along the coal outcrop. Depending on the underlying lithologies (sandstone versus shale/claystone) and the presence of naturally-occurring fractures or mine-related subsidence fractures, a minor portion of groundwater in these mine openings may move downward through the ridge to lower mine voids, where it will once again move laterally via conduit flow to a mine opening or outcrop seep or migrate again to an even lower mine void.

The No. 2 Gas coal seam has been mined by underground methods below the primary drainage basins, and therefore, represents the lowest mine void groundwater transport system in the watershed. Mines developed in the No. 2 Gas seam act as enormous sinks that drain groundwater from the intermediate and regional flow systems and direct that flow to various man-made outlets. Very large quantities of water are pumped from the No. 2 Gas in the Lavinia Fork watershed to facilitate mining. Water not pumped from the No. 2 Gas seam discharges to Robinson Fork and Coal River, south of the study area, where it outcrops above drainage.

2.3.2 Effects of Geologic Structure

A common misconception is that groundwater always flows down dip. Instead, groundwater flows from recharge areas to discharge areas. Flow is governed by the relative distribution of hydraulic head and not necessarily the geometric attitude of bedding planes. If the discharge area is in the up dip direction, groundwater will move counter to the control of dip. Results of field studies conducted by the US Geological Survey in the Appalachian Plateau indicate that structural orientation of the bedrock does little to control groundwater flow direction, except where flow is influenced by open voids, formed by mining or solution in limestone caves. Where underground mine voids are present within the study area, groundwater flow through these openings moves down dip.

As noted previously, fractures and bedding-plane partings are the main groundwater flow paths on the Appalachian Plateau. Fractures and joints have a direct and profound influence on groundwater flow rate due to the generally lower frictional resistance to groundwater flow within fractures versus intergranular pores.

A joint is a rock fracture along which displacement has not occurred. Joint spacing (distance between joints) and width (distance across a joint) are generally greatest in coarser, more resistant lithologies like sandstone. Closer joint spacing increases the number of joints available to serve as groundwater pathways. Greater joint width increases the ability of joints to transmit water. Joint permeability is dominant in shallow rock strata and may increase permeability values by hundreds of times when compared to intergranular permeability values.

Stress-relief fractures form a network that is unrelated to age and orientation to tectonic stresses. They are usually the most transmissive part of an aquifer. They were first documented while characterizing dam abutment hydrology prior to construction of dams in the Appalachian Plateau. Stress-relief fractures include vertical fractures parallel to valley walls and horizontal fractures along valley floors. Vertical valley wall fractures are caused by the release of stress as lateral rock support is removed during the erosion of stream valleys. Bedrock slumping occurs along the fractures on both sides of a valley, which causes compression in the center of the valley that results in arching, bedding-plane partings and vertical extension fractures above arches. Studies by Wyrick and Borchers (1981) describe a highly permeable, valley-related, shallow flow system which consists of interconnected valley-wall and valley-floor fracture sets.

2.3.3 Groundwater Flow Systems

As discussed previously, groundwater moves from recharge areas (generally topographic highs) to discharge areas (generally topographic lows). Flow systems within the Appalachian Plateau are typically classified as local, intermediate and regional. These descriptions characterize the areal extent of the flow system, groundwater travel time from recharge to discharge areas, and the proximity of the discharge area to the recharge area. In 1963, C.W. Poth proposed a relatively straightforward model for groundwater flow based on studies conducted in the Appalachian Plateau of Mercer County, Pennsylvania. This model has been refined and supported by more recent investigations.

The local groundwater flow system was described as circulating in a series of "hydrologic islands" separated by surface water streams. The dissected nature of the Appalachian Plateau has resulted in ridges that serve as surface water and groundwater divides that are surrounded by valleys containing streams. These ridges constitute the hydrologic islands postulated by Poth. A shallow, local groundwater flow system operates within each hydrologic island and is hydrologically separate from the local groundwater flow systems in adjacent ridges. The base of the local flow system is defined as the maximum depth from which groundwater originating within the ridge will flow upward to discharge into the adjacent stream valley. Recharge to the local system is completely from within the ridge forming the hydrologic island. Discharge is into the adjacent stream valley and to a lesser degree via leakage into the deeper intermediate and regional groundwater flow systems that will be discussed below.

The shallow flow system is the area of most active groundwater circulation and is the zone that contributes water to the vast majority of domestic wells. Because fractures decrease with increasing depth (and therefore, permeability), the vast majority of groundwater circulation occurs within the shallow zone. The local flow system can also be divided into subsystems that include the stress-relief fracture/weathered regolith zone and the ridge-core zone.

The stress-relief/weathered regolith subsystem exhibits distinctive groundwater flow characteristics when contrasted with the ridge-core subsystem and deeper flow systems. This is a highly transmissive zone consisting of soil, unconsolidated sediment, and fractured rock. Because of the open nature of the fractures within this zone, the groundwater flow time is short, and a significant portion of the recharge short circuits to local discharge points. Hydraulic conductivities within this zone tend to be one to two orders of magnitude greater than in zones which are only marginally deeper.

Recharge to the stress-relief/weathered regolith subsystem is through ridge-top and valley-wall fractures. Groundwater flows through the interconnected bedding-plane partings and fractures to springs flanking the hillsides (frequently located on coal outcrops) and into stream channels where the fractures are exposed. Much of the water that enters this shallow subsystem never penetrates to the ridge-core subsystem, nor to the deeper intermediate or regional flow systems. Residence time can be as short as days to a week. Flow in the stress relief fracture system moves down valley walls to the valley bottom, then moves coincidental with surface water flow. Therefore, generally, groundwater flow is a mirror of the surface water flow system.

Flow within the ridge-core subsystem is controlled by rock type and joints. The ridge-core subsystem receives recharge from the stress-relief/weathered regolith subsystem. Groundwater flow is through fractures, bedding-plane partings, and to a much lesser degree, through intergranular porosity. However, low permeability units such as claystone and shale do exert significantly more control within the ridge core subsystem due to the lack of stress-relief fractures and weathering. Because the integrity of these low permeability layers has not been compromised by stress relief fractures and weathering within the ridge cores, groundwater can become perched on these layers and either flow laterally to mix with groundwater within the stress-relief/weathered regolith subsystem or leak downward to an intermediate or regional flow system.

Groundwater residence times within the ridge cores are intermediate between those for the stress-relief/weathered regolith subsystem and deeper systems. The ridge-core subsystem is considered to be part of the local flow system because it is part of the hydrologic island that discharges into the valley adjacent to the local recharge area.

Intermediate groundwater flow systems lie below the local shallow flow systems but above the regional system. By definition, flow within an intermediate system passes beneath two or more ridges, or hydrologic islands (similar to regional systems), but discharges above the lowest level of the drainage basin. Although this zone contains some components of both the local and regional systems, the intermediate flow system has some distinctive features to separate it as a distinct zone. Primary controls on groundwater flow are regional joint sets, bedding-plane partings, rock type, and zones of fracture concentration. Recharge to intermediate systems comes from leakage from overlying local systems.

Flow rates and residence times are generally between those of local and regional groundwater flow systems, and probably vary from years to decades, depending on the size and the length of the flow path within the intermediate system. Also, in intermediate flow systems, regional structure tends to play a more important role in groundwater movement than with local flow systems. Important factors in controlling shallow flow systems, such as incised topography, weathering, and fracture enhanced permeability, are less important in intermediate systems.

The deep, regional groundwater flow system operates independently of the shallower systems. The base of the regional system lies at the fresh water/saline water contact. The vast majority of groundwater circulation is primarily at shallow to moderate depths (< 300 feet). Recharge to the regional system is from major drainage basin divides and leakage from multiple local and intermediate systems. Regional groundwater does not flow to the surface to discharge in the stream valleys bordering the ridges, but continues beneath adjacent hydrologic islands and intermediate flow system discharge points to larger, deeper, regional discharge areas. These discharge areas are usually in larger, master stream valleys.

These master stream valleys are commonly a major stream valley at the lowest level of the drainage basin. Within these regional groundwater systems flow rates are very slow and residence time is probably measured in decades or centuries.

Because of differences in rock mineralogy, residence time, and influence of the brine underlying the regional flow system, the chemistry of groundwater in different flow systems and subsystems varies. The deepest zone, directly affected by concentrated brines which exist at depth throughout all areas of the Appalachian Plateau, is rich in sodium chloride (NaCl). This zone is diluted with surface water that has leaked from shallower flow systems, but retains appreciable amounts of both sodium and chloride. This chemical signature is indicative of the more regional flow systems described above.

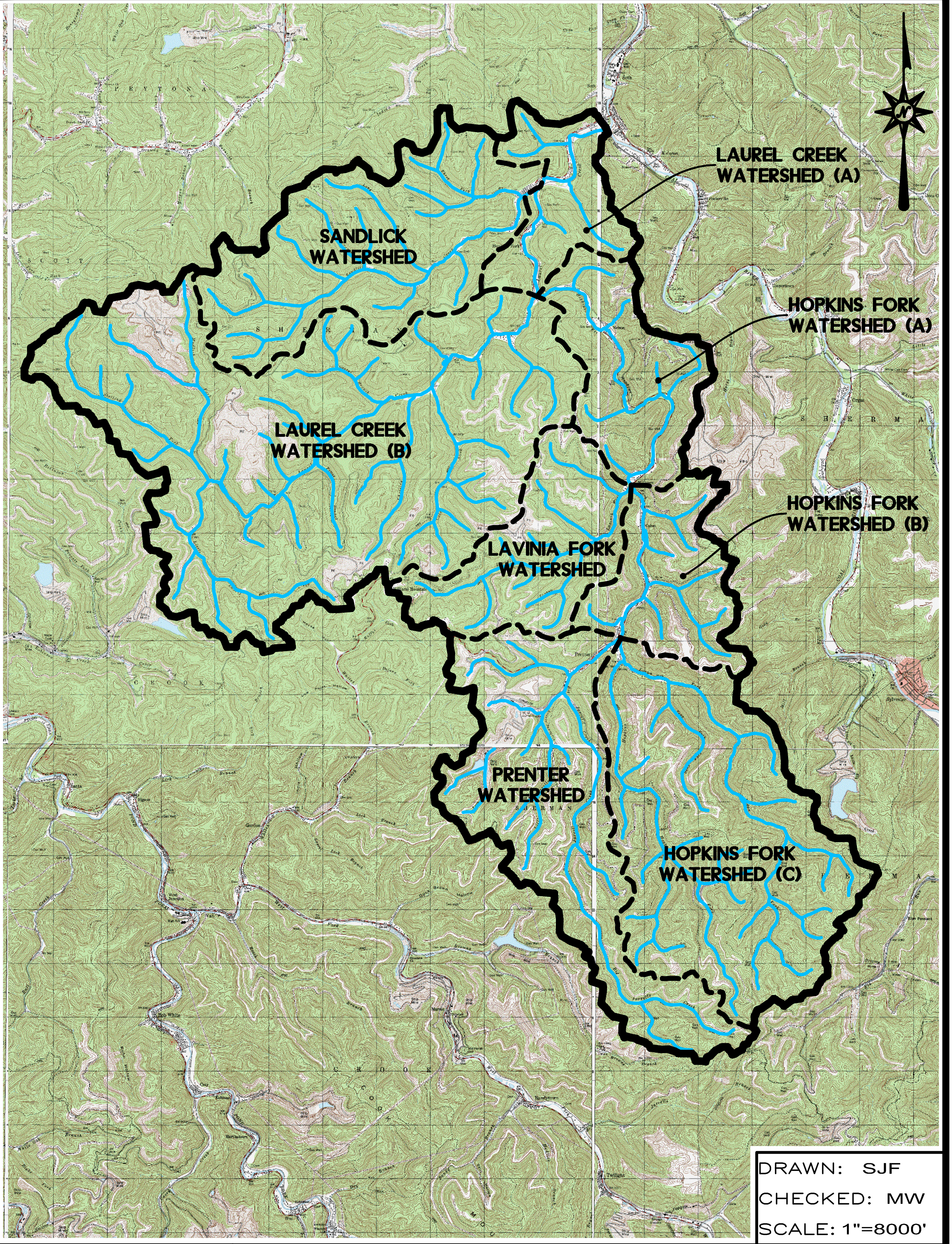
A shallower system (intermediate zone) exists in which chloride has been removed by flushing with surface waters, but considerable sodium remains adsorbed to clays and similar materials, leading to sodium bicarbonate ($NaHCO_3$) waters commonly found at intermediate depths.

In the uppermost zone, sodium is completely removed, leaving the calcium bicarbonate [$Ca(HCO_3)_2$] water typical of shallow groundwater. The shallow flow system is further divided into a low dissolved-solids zone associated with the stress-relief/weathered regolith subsystem, and a zone with higher dissolved solids associated with the unweathered ridge core subsystem. A schematic representation of the local, intermediate and regional flow systems is presented on Figure 2-3.

PROJECT No: 04-10-0323

DATE: JAN. 2011

CAD FILE: BASE-NEW SAMPLE LOC



DRAWN: SJF

CHECKED: MW

SCALE: 1"=8000'

TRIAD

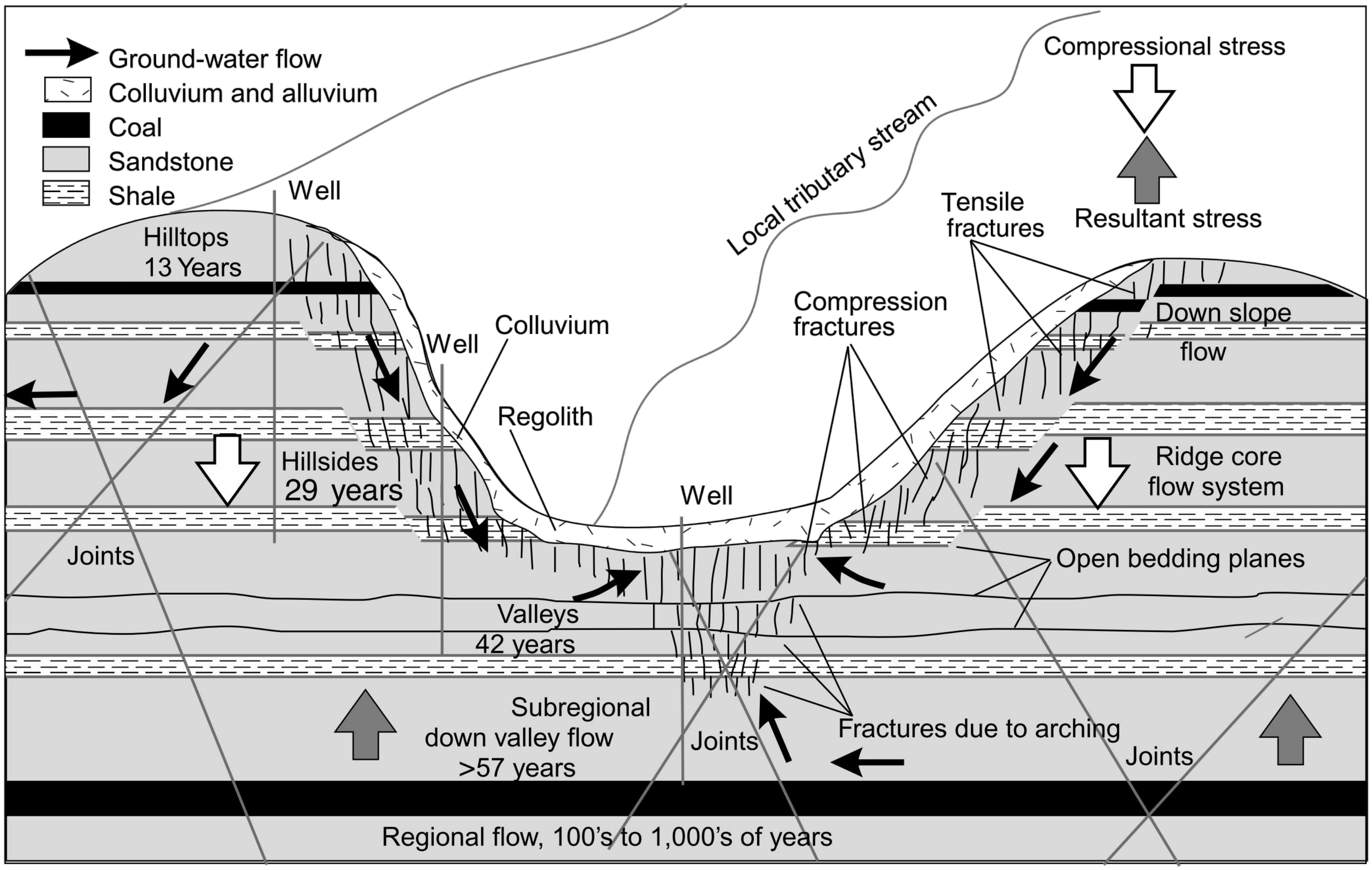
WATER DESIGNATIONS
LAUREL CREEK WATER STUDY

BOONE COUNTY, WEST VIRGINIA

FIGURE NO.

2-2

CAD FILE: 10-0323 GW FLOW.dwg DATE: NOV. 2011 PROJECT No: 04-10-0323



4980 TEAYS VALLEY ROAD
SCOTT DEPOT, WV 25560

GROUNDWATER FLOW SYSTEMS
LAUREL CREEK WATER STUDY
WVDEP - DIVISION OF MINING AND RECLAMATION
CHARLESTON, WEST VIRGINIA

DRAWN BY: SJF
CHECKED BY: MW
SCALE: NTS

FIGURE NO.
2-3

3.0 WATER QUALITY CHARACTERIZATION

Groundwater, surface water and mine-related sample locations and the related analytical parameters were designed to detect and evaluate any evidence of hydrologic impacts caused by commercial and industrial land use. This includes coal mining, coal preparation, coal preparation waste disposal, gas drilling and production, and the many other commercial activities that are required to support these efforts (e.g., fuel storage and dispensing, equipment repair and maintenance, metal plating, painting, etc.).

3.1 SAMPLE LOCATIONS AND ANALYTICAL PARAMETERS

Groundwater samples were obtained from domestic wells located across the entire Laurel Creek watershed to identify areas where groundwater quality may have been impacted by human activities. Surface water samples were obtained from Laurel Creek and all main tributaries of the primary watershed to identify sub-watershed areas where surface water quality has potentially been impacted by human activities. Mine-related samples were obtained from various sources for comparison to naturally-occurring water quality within the watershed. This included samples of discharges from deep mines that are known to or believed to have received coal slurry in the past. Additionally, samples were obtained from valley fill discharges, coal slurry decant water, coal storage run-off water, and coal slurry. Sample locations are shown on Figure 3-1.

Two sets of water quality standards have been promulgated by the Federal government under the Safe Drinking Water Act (SDWA). The first set of water quality standards is referred to as the National Primary Drinking Water Standards (primary standards) or Maximum Contaminant Levels (MCL). These are enforceable standards based on potential health risks. The second set of standards is referred to as the National Secondary Drinking Water Standards (secondary standards). Secondary standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. The US Environmental Protection Agency (EPA) at the Federal level and the WV Department of Environmental Protection (DEP) at the state level recommend secondary standards to water systems but do not require systems to comply. At the state level, the Groundwater Protection Rule (CSR §47-58-1 et seq.) establishes identical standards for groundwater quality.

Water samples from all sources were analyzed for several suites of parameters. Because groundwater is used extensively for domestic consumption, samples were analyzed for those metals referenced in the primary drinking water standards, as well as total and fecal Coliform, and all secondary drinking water standards. Because potential impacts from mining were to be evaluated, samples were analyzed for typical indicators of mine drainage such as acidity/alkalinity, iron, manganese, aluminum and sulfate. Because potential impacts from historical industrial activities were also evaluated, samples were analyzed for volatile organic compounds (VOC) found in petroleum products, paints, paint thinners and industrial solvents. And finally, because it was necessary to characterize the various types of water encountered across the study area using Piper ternary plots and Stiff diagrams, samples were analyzed for major anions and cations such as calcium, magnesium, sodium, potassium, chloride, carbonate and bicarbonate. Following is a brief discussion of the major field and laboratory parameters evaluated during our study:

pH: A measure of the hydrogen ion concentration and is typically in the range of 6.5 to 8.5 in natural waters. pH is measured on a unitless logarithmic scale.

Conductivity: The ability of a solution to conduct electrical current. Conductivity is an indirect measure of the amount of inorganic material dissolved in water and is quantified in micro-mho per centimeter (µmho/cm).

Total Dissolved Solids (TDS): A direct measure of the amount of dissolved material in the water. TDS is quantified in milligrams per litre (mg/L). TDS is related to conductivity and generally is recommended to be less than 500 mg/l.

Surfactants (MBAS): Essentially detergents that are used by natural gas drillers to create foam that will lift water and drill cuttings to the surface. The industry standard to analyze for surfactants is methylene blue active substances (referred to as MBAS). Surfactants are quantified in milligrams per litre (mg/L).

Coliform and Fecal Coliform: A measure of the number of bacterial colonies present in water. Coliform bacteria are found in the aquatic environment, in soil and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. The presence of Fecal Coliform in aquatic environments may indicate that the water has been contaminated with the fecal material of humans or other animals.

Alkalinity: The capacity of water to accept hydrogen ions (acids) without changing pH. Alkalinity is a measure of “buffering capacity”, and is generally due to the presence of the carbonate and bicarbonate anions (CO_3 and HCO_3).

Acidity: The capacity of water to accept hydroxide ions (bases) without changing pH. Acidity is the opposite of alkalinity and generally results from the presence of weak acids and acidic metal ions, particularly ferric iron (Fe^{3+}).

Calcium (Ca): The most common naturally occurring element in most freshwater systems and is measured in milligrams per litre (mg/L). Calcium minerals constitute the primary sources of the calcium ion in water.

Magnesium (Mg): The second most common naturally occurring element in most freshwater systems. Magnesium is closely associated with calcium and is measured in milligrams per litre (mg/L).

Sodium (Na): A naturally occurring element measured in milligrams per litre (mg/L). Elevated sodium in natural waters is usually attributed to human activities such as highway salting, water treatment, or oil and gas production.

Potassium (K): A naturally occurring element measured in milligrams per litre (mg/L). Elevated potassium in natural waters is usually attributed to human activities such as highway salting, water treatment, or oil and gas production.

Sulfate (SO4): A measure of the concentration of the sulfate anion in water and is an indicator of the presence of sulfide bearing rock, often associated with coal seams. Sulfate is a naturally occurring anion measured in milligrams per litre (mg/L).

Chloride (Cl): A measure of the concentration of the chloride anion in water and is an indicator of the presence of chloride bearing rock. Chloride is a naturally occurring anion measured in milligrams per litre (mg/L). Elevated chloride may indicate highway de-icing or liquids from oil and gas production.

Aluminum (Al): A naturally occurring element measured in milligrams per litre (mg/L). Elevated aluminum in natural waters is usually attributed to suspended clay particles or to dissolved aluminum where severe acid mine drainage is encountered.

Iron (Fe): A naturally occurring element measured in milligrams per litre (mg/L). Elevated dissolved iron in natural waters is frequently associated with the presence of coal seams and rocks deposited in association with coal seams.

Manganese (Mn): A naturally occurring element measured in milligrams per litre (mg/L). Elevated dissolved manganese in natural waters is frequently associated with the presence of coal seams and rocks deposited in association with coal seams.

3.2 SAMPLING METHODOLOGY

A complete description of sampling procedures for each of the media analyzed was provided in our Sampling and Analysis Plan (April 2011) submitted to the WVDEP for review and approval. This included quality assurance/quality control procedures for sampling of groundwater from domestic wells, surface water and mine-related samples. The sampling protocol was followed for all water and coal slurry sampling.

Quality assurance/quality control procedures included using latex gloves to prevent contamination of the samples and sampling equipment; collecting samples in clean and appropriate containers supplied by the laboratory; using distilled water to rinse sampling and field instruments between samples; using trip blanks and field duplicates; collecting matrix spike and matrix spike duplicates to monitor laboratory effects; using chemical preservatives when necessary; keeping samples chilled to 4 degrees Centigrade during storage and shipment; photographing the sampling sessions; and, completing and filing the chain-of-custody for each sample. Detailed descriptions of sampling procedures for each media, sample labeling, packaging and shipping, custody seals, chain-of-custody procedures, field documentation, quality control requirements, and decontamination procedures are provided in the approved SAP. Photos of each sample location are provided in Appendix A of this report.

Domestic well samples were obtained in accordance with "*Domestic Groundwater Supply Well Collection Standard Operating Procedure" Triad Engineering, Inc., April 2005.*
This Standard Operating Procedure (SOP) includes the following provisions:

1. Drinking water standards for metals are derived from total metals analyses; therefore, filtering of public groundwater supply wells for metals analyses is not recommended.

2. Samples will be collected from a tap source.

3. Allow the COLD WATER ONLY to run for a minimum of 60 seconds at full pressure in order to flush the lines of any stagnant water. You do not want any hot water in the sample as it may introduce contaminants as well as chemical or physical changes from the hot water tank.

4. Fill the appropriate container(s) and verify the appropriate preservative(s) has been used. Take care not to overfill and potentially dilute preservatives.

5. Seal each container, label, and place on ice.

Care was taken to ensure that samples were collected from a source as close to the well as possible, from an unfiltered and/or untreated source, and from the cold water supply. Natural groundwater quality is affected by varying degrees by flow through a typical domestic plumbing system. Filters, softeners, and other treatment systems can have both positive and negative impacts on natural groundwater quality. Well maintained systems can improve water quality, while poorly maintained systems can degrade water quality and introduce contaminants not present in the natural groundwater. Even relatively new hot water tanks cause significant impacts to natural water quality by changing water chemistry through heat and through reactions with the magnesium rods used to prevent corrosion of the tank and fixtures. Research has also shown that older hot water tanks cause naturally occurring compounds to settle and concentrate. Therefore, water samples from hot water tanks are not representative of naturally occurring groundwater and were not used in this study.

Triad contracted with REI Consultants, Inc. (REIC) of Beaver, WV to analyze the samples that were collected for this study. REIC is an approved WVDEP laboratory and followed appropriate EPA approved laboratory methods when conducting tests on all study samples.

3.3 RESIDENT INTERVIEWS

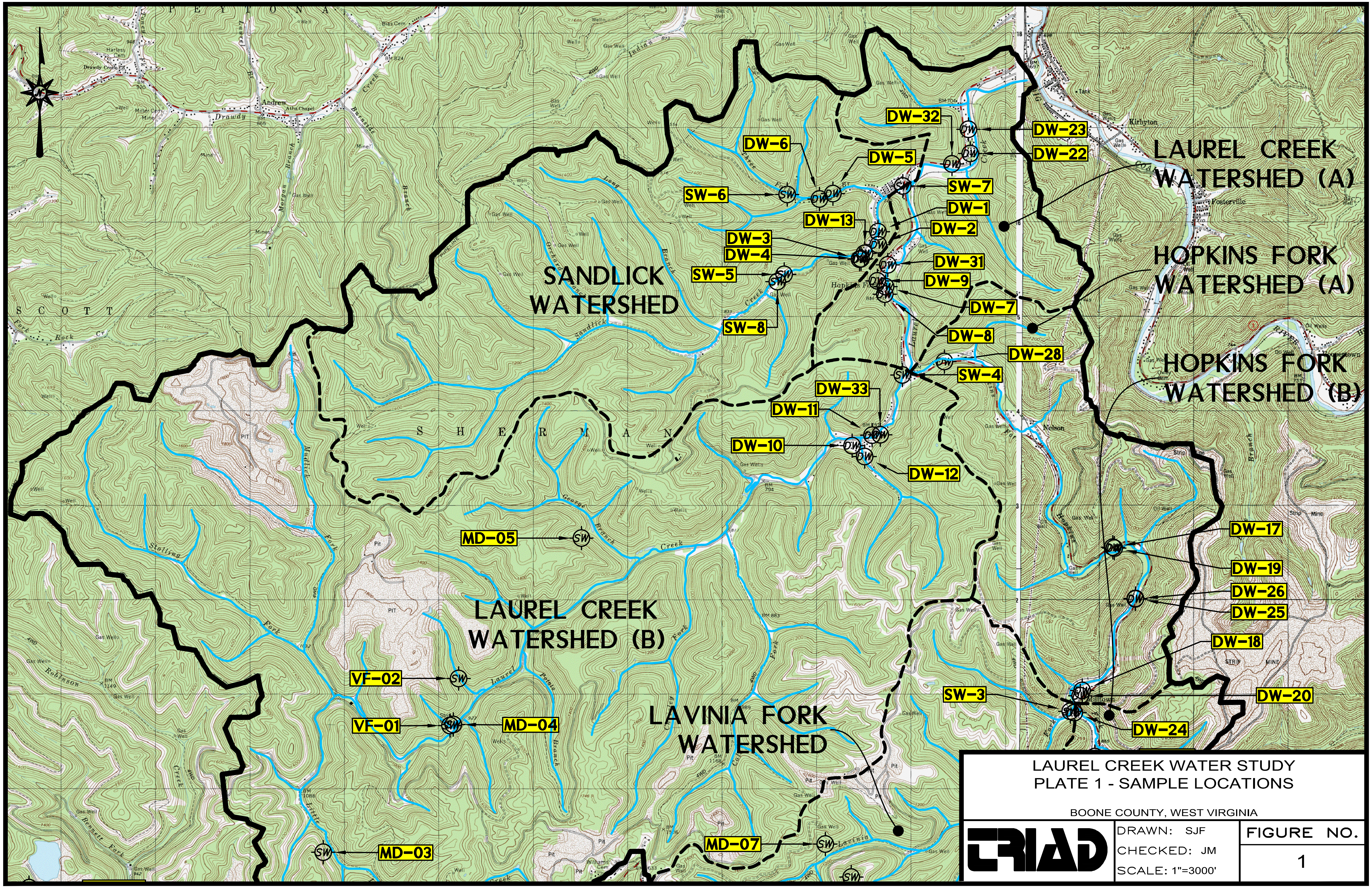
Prior to collecting domestic well samples, Triad personnel used a Domestic Water Well Inventory/Sample Form to interview each resident regarding details of their well and water system. The form included information such as sample ID, Triad field personnel, well location, resident contact information, water use, well depth, location of septic system, information regarding well and water system maintenance, and field measurements. Completed forms are provided in Appendix B.

Nearly one-half of the residents interviewed (16 of 33) reported that their water emitted a sulfur or rotten egg odor, and eight reported a red, orange or black color. A few residents reported a slimy or greasy feel. Three residents reported black water or particles in their water. One resident reported a gasoline odor. When asked what types of well and water system maintenance they had undertaken, none of the residents reported any maintenance activities such as well/system disinfection or well redevelopment.

Triad personnel also collected information regarding potential sources of local groundwater contamination, such as septic systems, waste disposal, chemical storage, etc. We did not observe any evidence of significant local sources of contamination during the course of our investigation. At two locations (DW-11 and DW-22), we observed that oil changes and other automobile maintenance has been performed. However, there was no direct evidence of impact to the residential well.

Public water is available to residents of the study area along Sandlick Creek and along Laurel Creek and Hopkins Fork from Seth upstream to the community of Nelson. The extent of public water supply is shown on Figure 3-1 – Sample Location Map.

CAD FILE: BASE-NEW SAMPLE LOC DATE: JAN. 2012 PROJECT No: 04-10-0323



LAUREL CREEK WATER STUDY
PLATE 1 - SAMPLE LOCATIONS

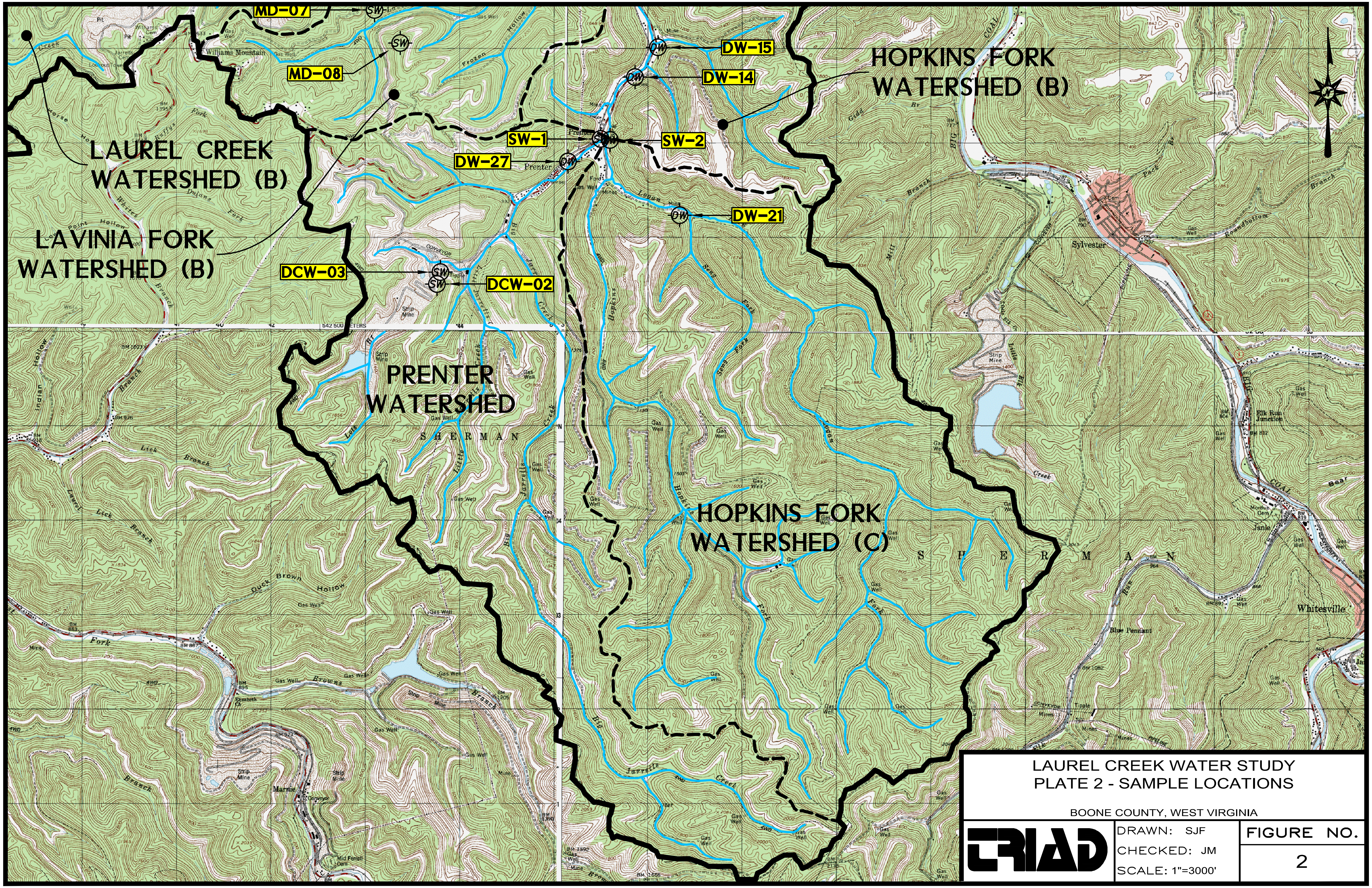
BOONE COUNTY, WEST VIRGINIA

TRIAD

DRAWN: SJF
CHECKED: JM
SCALE: 1"=3000'

FIGURE NO.
1

PROJECT No: 04-10-0323 DATE: JAN. 2012 CAD FILE: BASE-NEW SAMPLE LOC



LAUREL CREEK WATER STUDY
PLATE 2 - SAMPLE LOCATIONS

BOONE COUNTY, WEST VIRGINIA

TRIAD

DRAWN: SJF
CHECKED: JM
SCALE: 1"=3000'

FIGURE NO.
2

4.0 POTENTIAL SOURCES OF GROUNDWATER IMPACT

The purpose of the study was to determine what human activity, including coal mining and ancillary activity, may have negatively affected the quality of groundwater being used as a drinking water source by residents of the study area. Our investigation focused on coal mining related impacts, commercial/industrial activities, natural gas drilling, and waste disposal.

4.1 COAL MINING RELATED IMPACTS

Coal mining, coal processing, and disposal of coal processing waste have occurred extensively throughout the study area since approximately 1915. For purposes of our investigation, we considered potential impacts from surface mining, underground mining, and the disposal of refuse from coal processing activities.

Most surface mines and underground mines located above drainage are confined to the local hydrologic system (a single hydrologic island), although very large surface mines and underground mines below drainage can cross hydrologic borders. The majority of groundwater flow associated with any single surface mine is probably in the local system, and most of that is probably within the stress-relief/weathered regolith subsystem. Underground mines will also affect the ridge-core subsystem. Because a single hydrologic island comprises such a small part of the total recharge area for deeper flow systems, the effects of a single local flow system are probably insignificant to most of these deep systems. However, substantial recharge to regional and intermediate flow systems consists of leakage from local flow systems. Therefore, surface mines and underground mines can potentially affect deeper groundwater flow systems. Also, in cases where mines cover large portions of a regional flow system, more significant effects may be caused.

Mine drainage from surface mine operations ranges widely in composition, from acidic to alkaline, and often contains elevated concentrations of sulfate(SO_4), iron (Fe), manganese (Mn) and aluminum (Al), as well as common elements such as calcium, sodium, potassium and magnesium. A key parameter to identify mine related discharge is acidity, which is the amount of base required to neutralize the solution. In coal mine drainage, major contributors to acidity are from ferrous and ferric iron, aluminum, and manganese.

Acidic mine drainage (AMD) is formed by the oxidation of pyrite to release dissolved ferrous iron (Fe^{2+}), sulfate (SO_4^{2-}) and free hydrogen ions (H^+), followed by the further oxidation of the ferrous iron to ferric iron (Fe^{3+}) and the precipitation of iron as a hydroxide or similar substance, producing more free hydrogen. Neutralization of the acidic solution using limestone or sodium hydroxide can form neutral mine drainage with high SO_4, and possibly elevated Fe and Mn.

In contrast, neutral or alkaline mine drainage (NAMD) has alkalinity that equals or exceeds acidity but can still have elevated concentrations of SO_4, Fe, Mn and other solutes. NAMD can originate as AMD that has been neutralized by reaction with carbonate minerals, or can form from rock that contains very little pyrite. Dissolution of carbonate minerals produces alkalinity, which promotes the removal of Fe, Al and other metal ions from solution, and neutralizes acidity. However, neutralization of AMD does not usually affect concentrations of SO_4.

Many factors control the rate and extent of AMD formation in surface coal mines. More abundant pyrite in the overburden tends to increase the acidity of drainage, as does decreasing grain size of the pyrite. Iron-oxidizing bacteria and low pH values speed up the acid-forming reaction. Rates of acid formation tend to be slower if limestone or other neutralizers are present. Availability of air containing the oxygen needed for pyrite oxidation is commonly the limiting factor in rate of acid generation. Access to air and exposure of pyrite surfaces are promoted by breaking the pyrite-bearing rock.

Much of the study area has been mined using surface and underground methods in past years. Contour mine benches and abandoned mine entries were noted across the Laurel Creek watershed. The WVDEP inventory of known abandoned mine land (AML) sites lists 12 AML sites in the study area. However, the majority of AML sites are not listed in the WVDEP AML database.

A great number of mineable seams exist in the study area, most of which have been mined somewhere within the watershed. This includes the following major seams (in ascending order):

- Eagle
- Powellton
- No.2 Gas
- Peerless
- Williamson
- Cedar Grove
- Fire Clay
- Chilton
- Winifrede
- Coalburg
- Stockton
- No.5 Block
- No.6 Block

Many of these seams also include riders and splits that have been mined in conjunction with or separately from the main seam. The extent of mining in major coal seams is shown on Figures 4-1 through 4-4.

There is typically a considerable amount of disagreement over the naming of coal seams across the Appalachian coal basin. The primary area of disagreement and confusion appears to be with regard to the No. 2 Gas seam, which has been extensively mined below drainage across the basin. This seam is generally referred to as the Powellton, by some operators in the area and appears on many mine maps. Also, other seam names seams such as Buffalo, Dorothy, Hernshaw and Alma have also been used for mines in the area. Coal seam names used in this report are those endorsed by the WV Geologic and Economic Survey modern correlation system. Therefore, some of the seam names referenced in this report may conflict with seam names commonly used by coal companies in the area. In general, the reader should understand that the majority of the deep mined seams are within the Kanawha Formation, while most of the surface mining is high on the hills in the various 5 Block (or Kittanning) seams within the Allegheny Formation.

A limited amount of mining has occurred below drainage in the study area. Below drainage mining refers to underground mines that pass below major streams such as Laurel Creek and the main tributaries of Sandlick Creek and Hopkins Fork. Based on available information, mining has not occurred below drainage near any of the wells or communities within the study area. The largest below drainage mine by far is the Justice No.1 Mine in what is believed to be the No.2 Gas seam (also referred to as the Powellton seam by the mining company). This longwall mine is located east of the abandoned Quinland Mine. Most of this mining occurs in the southwestern portion of the study area near Williams Mountain, but we understand extensions are proposed into southern Laurel Creek and northern Lavinia Fork watersheds. Openings in this seam represent the primary mine void transport system in the watershed. Huge quantities of water are pumped from mines in the No. 2 Gas to facilitate mining. This causes mines developed in the seam to act as an enormous sink that drains groundwater from the intermediate and regional flow systems and directs that flow to man-made outlets. This prevents, or modifies the natural flow patterns that would otherwise be observed. This deep mining is occurring more than approximately 250 feet below drainage, and would not be expected to affect the shallow flow system feeding domestic wells.

Currently, upper Kanawha and Allegheny Formation seams are being extensively surface mined in the headwaters of Sandlick Creek and Laurel Creek.

4.2 FINE COAL REFUSE DISPOSAL

Fine coal refuse, or coal slurry, is typically disposed of either in surface impoundments or pumped into previously mined underground mine voids. Slurry is usually pumped from the thickener at a coal processing plant to either a surface impoundment or injection well. The solid portion of the slurry pumped to disposal impoundments is allowed to slowly settle away from the liquid fraction and remains in the impoundment. The remaining liquid portion (decant water) is discharged via a permitted outfall, injected into mine voids, or reused at the coal preparation plant. Slurry and decant water disposed of in underground mine voids is gravity fed or pumped into the underground mine via slurry pipelines and injection wells. The solid portion of slurry eventually settles to the lowest portions of the mine void, while the liquid portion pools within the void and eventually migrates in ways analogous to groundwater via the available pathways.

Historic records indicate that slurry injection occurred as early as the 1960s. During the late 1970s and early 1980s, more than 60 different preparation plants in WV injected slurry underground. Unfortunately, information about injection prior to 2000 is poor, and records prior to 1983 are generally unavailable.

Based on our research, it appears that coal slurry may have been injected into three or more mines in the vicinity of the study area. Chesterfield No.1, Chesterfield No.3 and Chesterfield No.5 mines, all operated by Omar Coal Company, are reported to have received coal slurry for disposal. The Chesterfield No.1 was reported to be in the Stockton seam, located in the upper Kanawha Formation. The Chesterfield No.3 was reported to be in the No. 5 Block seam in the lower Allegheny Formation. The Chesterfield No.5 was reported to be in the Winifrede seam of the middle Kanawha Formation. All three mines are situated along the surface water divide between at the headwaters of Laurel Creek and Robinson Creek, which forms the southwestern boundary of the study area. These locations were slightly more than a mile from the town of Prenter.

Groundwater that could potentially may transport slurry-related contaminants moves through the mine voids via conduit flow and discharges at down dip mine openings or seeps along the coal outcrop. A minor portion of groundwater in these mine openings may also move downward through the ridge to lower mine voids, where it will once again move laterally via conduit flow to a mine opening or outcrop seep or migrate again to a lower mine opening.

The No. 2 Gas coal seam has been mined below the primary drainage basins and represents the lowest mine void groundwater transport system in the watershed. Mines in the No. 2 Gas seam act sinks that collect groundwater draining from the intermediate and regional flow systems and directs that flow to various man-made outlets. Groundwater is pumped from a longwall mine in the No. 2 Gas seam and discharged to Lavinia Fork to allow mining of the seam below drainage. Any groundwater not pumped from the mine discharges to Robinson Fork and Coal River, south of the study area, where the No. 2 Gas seam outcrops above drainage.

The WVDEP Underground Injection Control (UIC) Program is currently responsible for regulating the injection of coal slurry into abandoned underground mines within the State. In the vicinity of the study area, Independence Coal Co. holds UIC Permit 0326-01-005, which includes two injection points listed as outlet 200 and outlet 205. These injection points are located more than three miles away from any residence in or near Prenter.

Applications for UIC permits require the Material Safety Data Sheet (MSDS) for each proposed chemical to be assessed and analyses to be performed on the proposed injectate to confirm that the substance is not hazardous as defined by the Resource Conservation and Recovery Act (RCRA). After issuance, UIC permits require regular monitoring to ensure that the injectate meets permit standards. Most permits specify monthly sampling and quarterly reporting of approximately 18 parameters. A Discharge Monitoring Report (DMR) is submitted quarterly by the permittee to the UIC office.

A previous study authorized by Senate Concurrent Resolution 15 (SCR-15) analyzed the solid portion of coal slurry for an extensive list of inorganic and organic parameters. The analyses showed that iron, sodium, aluminum, and calcium made up the greatest portion of the slurry solids. Silver, cyanide and thallium were not detected in any sample. Most samples did not contain selenium or antimony. All samples were alkaline with varying concentrations of chloride and sulfate values.

The majority of the organic compounds detected in slurry were Polycyclic Aromatic Hydrocarbon (PAH) compounds. These organic compounds are associated with coal, fuels, gas, oils and tars. They occur naturally in coal and are ubiquitous in the environment. The SCR-15 study found that most of the compounds detected in the coal were also detected in the slurry. Compounds detected in the slurry samples that were not also found in a coal sample were acetone, chloromethane, ethylbenzene, n-propylbenzene, butylbenzene, naphthalene, n-nitrosodiphenylamine, and pyrene.

The SCR-15 study reported that no universal tracer was found to indicate the presence of coal slurry as distinguished from other mining activities on surface and groundwater because slurry is similar to coal in its composition. Therefore, water quality effects typically associated with mining can also be expected to be associated with slurry disposal. Interestingly, the SCR-15 study reported that two public water supplies draw water from an underground mine receiving slurry injection. The report indicated that samples from both public water systems met the primary drinking water standards. The report concluded that samples collected during the study failed to document adverse effects to surface water or groundwater quality from slurry injection.

4.3 COMMERCIAL/INDUSTRIAL ACTIVITIES

A variety of commercial and industrial activities can sometimes result in negative impacts to groundwater and surface water quality. These impacts are primarily related to the inadvertent or purposeful release of chemicals and wastes associated with these activities. Common commercial and industrial activities that can result in negative impacts to groundwater and surface water include the following:

- Retail Petroleum Sales
- Bulk Petroleum Storage
- Vehicle and Equipment Repair
- Dry Cleaning Operations

Retail petroleum sales can result in the release of petroleum products (gasoline and diesel fuel) to the environment through leaks from underground storage tanks (UST) and associated piping and pumps, and from spills of product during delivery activities. Bulk petroleum storage generally occurs in above-ground storage tanks (AST). Releases of petroleum from these facilities generally occur from ASTs and associated piping and also during loading and unloading operations.

Vehicle equipment and repair can result in contamination of soil, groundwater and surface water from the release of lubricating oil, parts cleaning solvents, paint and paint thinners, acid from batteries and petroleum from fuel tanks. Dry cleaning operations use chlorinated and non-chlorinated solvents in lieu of water.

To evaluate the potential for impacts from these operations, Triad utilized the services of Environmental Data Resources, Inc. (EDR). EDR maintains current and historical records of numerous databases that compile records of various commercial and industrial businesses that may reasonably to be expected to use materials that may result in environmental contamination. These include environmental records from federal, state, and local databases that provide information regarding potential recognized environmental conditions and petroleum products within the study area. The EDR database report summary is included in Appendix C. Additionally, Triad personnel made numerous visits to the study area to inspect the area for evidence of commercial and industrial activities that could result in environmental contamination.

4.4 NATURAL GAS DRILLING

During the drilling and extraction of natural gas, large quantities of water and other fluids are used and produced. These typically contain complex mixtures of metal salts and organics, both from the natural formation and from additives used to enhance production. The gas well drill hole itself can also result in the movement of drilling fluids and formation water into near-surface groundwater. Drill casing and cement is used to prevent the flow of oil, gas or salt water between underground formations. However, contaminants can migrate between aquifers in the subsurface because of improperly grouted casings or casing leaks. Contaminants can include drilling fluids, including acids used for stimulating clogged formations; corrosion inhibitors, biocides, and other additives; organics and metals from the producing formation. The location of gas wells within the study area is shown on Figure 4-5.

4.5 WASTE DISPOSAL

The Boone County Landfill was previously operated in the southern portion of study area, in the vicinity of Williams Mountain. Landfills were often established in abandoned mining pits. Older, poorly designed or poorly managed landfills can create a number of adverse environmental impacts when water percolates through waste, picking up a variety of substances such as metals, organic chemicals, bacteria and other contaminants. If this leachate is not contained and reaches groundwater or surface water it could contaminate water supply wells.

5.0 WATER QUALITY ANALYSIS

Triad personnel visited more than 100 residences and collected samples from 33 domestic wells distributed across the entire study area. Also, Triad personnel collected eight samples from surface water, eight mine discharges, two valley-fill discharges, and five coal slurry related samples. One mine discharge sample was collected from beneath the former Boone County Landfill. Water samples from all sources were analyzed for several suites of parameters, including metals referenced in the primary drinking water standards, total and fecal Coliform, and secondary drinking water standards. Samples were also analyzed for typical indicators of mine drainage such as acidity/alkalinity, iron, manganese, aluminum and sulfate. To evaluate potential impacts from historical industrial activities, samples were analyzed for volatile organic compounds found in petroleum products, paints, paint thinners and industrial solvents. Finally, samples were analyzed for major anions and cations such as calcium, magnesium, sodium, potassium, chloride, carbonate and bicarbonate to allow the use of Piper and Stiff diagrams for comparing water samples. Laboratory reports are provided in Appendix D.

The Piper diagram is a tool used to illustrate water type, which is generally defined as the predominant cations and anions present in the sample. REIC Labs provided general chemistry analyses of each sample which indicates the concentration of cations such as sodium, potassium, calcium and magnesium, and anions such as chloride, carbonate, bicarbonate and sulfate. The relative concentrations of these cations and anions (expressed as percents) are plotted as a single point in the diagram. That location within the diagram is the water type signature of that sample in relation to other samples. Water samples with similar water chemistry are located near each other within the diagram.

Samples which are taken from nearby locations or from similar sources would be expected to plot in similar locations on the Piper diagram. When samples from nearby locations do not plot in similar locations on the diagram, it indicates that those samples were derived from different water sources. For example, a sample relatively high in sodium and chloride would typically be derived from a deeper groundwater source, perhaps within the intermediate or regional flow systems. Conversely, a sample relatively high in magnesium and sulfate would typically be derived from a shallow groundwater source, perhaps within the stress relief/regolith flow subsystem.

All samples were also plotted on Stiff diagrams. Stiff diagrams are a visualization tool that portrays cation and anion concentrations in a sample (expressed as milliequivalents per kilogram) in a unique shape that can easily be compared with other samples. Similar shapes indicate similar water types and therefore, probably represent a similar source or location.

5.1 DOMESTIC WELLS

Samples were collected from 33 domestic wells located across the study area. For purposes of discussion, samples have been grouped by watershed. All domestic well samples were analyzed for those metals included in the primary drinking water standards plus fecal and total Coliform bacteria; all secondary drinking water standards; a variety of mine related parameters; major cations and anions; and VOC. Analytical data from domestic wells is presented on Tables 5-1 through 5-6. Piper and Stiff diagrams are presented on Figures 5-1 through 5-40.

5.1.1 Sandlick Creek

A total of 11 samples were collected from seven locations in the Sandlick Creek watershed, including both the main stem of Sandlick Creek and Three Forks Branch. Three locations were re-sampled following the original sample event (DW-3, DW-4 and DW-5). A field duplicate was also collected during the resample of location DW-3.

Water types among the seven wells were somewhat variable, although all were dominated by the bicarbonate anion. All samples were either sodium bicarbonate or calcium bicarbonate, which suggests that these samples come from shallower, more local groundwater sources.

Domestic wells DW-1, DW-2, DW-3, DW-4 and DW-13 were located nearly adjacent to each other and well depths were reported by the owners to be similar. Samples DW-2, DW-3 and DW-4 were similar and samples DW-1 and DW-13 were similar. Locations DW-5 and DW-6 were located immediately adjacent to each other on Three Forks Branch of Sandlick Creek and water types were essentially the same in these two wells.

Iron and manganese were present above the secondary drinking water standards in samples from locations DW-1, DW-3, DW-4, DW-5 and DW-6 during the original sample event. However, both iron and manganese were less than the secondary drinking water standards in the re-sample from location DW-3 (DW-3R) and the re-sample field duplicate (DW-3RFD). Also, iron and manganese were significantly less in the resample from location DW-4, but still exceeded the secondary standard. Water systems at these two locations were allowed to run for a longer period during the resample, thus obtaining a more representative sample of actual groundwater quality at those locations.

Zinc (sample DW-3) and aluminum (sample DW-5) were also present at concentrations above the secondary drinking water standards during the original sample event. However, both zinc and aluminum were below the standards in the resample from these locations (DW-3R, DW-3RFD and DW-5R). These high level detections were most likely due to particulate matter in the samples derived from the domestic plumbing system. Although iron and manganese were elevated at about one-half of the Sandlick Creek domestic well locations, other mine drainage related parameters were not elevated. Acidity, sulfate and total dissolved solids were low, while alkalinity was moderate and pH was generally neutral to alkaline.

Carbon disulfide was detected at 8.1 ug/L in the original sample from location DW-3. The MCL for carbon disulfide is 1000 ug/L. Carbon disulfide is a common laboratory artifact that occasionally is detected in VOC samples. It was not detected in the resample from this location or in the re-sample field duplicate. No other VOC was detected in any sample from the Sandlick Creek domestic well locations.

No other primary or secondary drinking water parameter, including Coliform bacteria, was detected above the applicable standard in any sample from Sandlick Creek locations.

5.1.2 Laurel Creek Watershed A

A total of seven samples were collected from seven locations in Laurel Creek Watershed A. Locations DW-22, DW-23 and DW-32 were sampled from the downstream portion of the watershed, below the confluence of Sandlick Creek. Locations DW-7, DW-8, DW-9 and DW-31 were sampled from above the confluence with Sandlick Creek.

Water types among the seven wells were relatively similar, despite the fact that more than one mile separated the most aerially distant samples. Sodium was the dominant cation at all locations. Chloride and bicarbonate were the dominant anions at all locations. The prevalence of sodium and chloride suggests that these samples are somewhat aligned with intermediate or regional groundwater flow systems that would be expected to discharge in a major stream valley. Well depths were unknown at most locations, but two locations reported well depths of 70 and 80 feet.

Domestic wells DW-22, DW-23 and DW-32 were located within the same general area, though not adjacent to each other. Well depths were reported by the owners to be unknown. Locations DW-7, DW-8, DW-9 and DW-31 were located in close proximity to each other. Locations DW-7 and DW-8 reported similar well depths.

One domestic well sample collected in Laurel Creek Watershed A exceeded the MCL for lead. The resident is connected to the public water supply and does not use groundwater for drinking. Sample DW-32 contained 0.0338 mg/L total lead, compared to the MCL of 0.0150 mg/L. Lead found in tap water usually comes from the corrosion of older fixtures or from the solder that connects pipes. The most common problem is with brass or chrome-plated brass faucets and fixtures which can leach significant amounts of lead into water. Homes built before 1986 are more likely to have lead pipes, fixtures and solder. Although the resident does not use groundwater for drinking, the source of elevated lead in DW-32 should be evaluated.

Iron was present above the secondary drinking water standard in samples from locations DW-7, DW-31 and DW-32. Iron was significantly elevated in location DW-31. Acidity was elevated in sample DW-31 and pH was also somewhat acidic (6.27). Manganese was present above the secondary drinking water standard in samples from locations DW-7, DW-8 and DW-31.

Total dissolved solids were present above the secondary drinking water standard in samples from locations DW-23 and DW-32. Fluoride was very significantly elevated above the primary drinking water standard in DW-23 (206 mg/L). The source of this fluoride detection is unknown. Chloride was elevated in DW-32 (203 mg/L), but less than the secondary standard. No other primary or secondary drinking water parameter, including Coliform bacteria, was detected above the standard in any other sample from the Laurel Creek Watershed A locations.

Carbon disulfide was detected at 1.4 ug/L in sample DW-32. The MCL for carbon disulfide is 1000 ug/L. Carbon disulfide is a common laboratory artifact that occasionally is detected in VOC samples. Chloroform was detected at 3.7 ug/L in sample DW-9. Chloroform is a disinfection by-product commonly produced by the chlorination of public water supplies and is the most commonly detected VOC in public and domestic drinking water supply wells in the United States. The presence of chloroform in groundwater is most likely due to the leakage of chlorine treated water from a public water supply, from septic systems receiving treated water, and from the use of chlorine treated water for irrigation of lawns and gardens. No other VOC was detected in any sample from the Laurel Creek Watershed A locations.

5.1.3 Laurel Creek Watershed B

A total of four samples were collected from four locations in Laurel Creek Watershed B. Locations DW-10, DW-11, DW-12 and DW-33 were sampled from the Laurel Creek watershed, above the confluence of Hopkins Fork.

Water types among three of the four wells were very similar, while the water type at one well was different. Sodium bicarbonate water was found at locations DW-10, DW-11 and DW-33, while calcium bicarbonate was dominant at DW-12. Locations DW-10, DW-11 and DW-33 were situated along the main valley of Laurel Creek and exhibit more characteristics of intermediate groundwater flow, while DW-12 was located along a tributary valley and is more typical of local flow. Sulfate concentration was highest at DW-12, while dissolved solids and alkalinity were lowest.

Well depths at locations DW-10 and DW-33 were reported by the owners to be unknown. Well depths at locations DW-11 and DW-12 were reported by the owners to be 100 ft. and 58 ft., respectively.

Iron was present above the secondary drinking water standard in the sample from location DW-11. No other primary or secondary drinking water parameter, including Coliform bacteria, was detected above the standard in any other sample from the Laurel Creek Watershed B locations. No VOC was detected in any sample from the Laurel Creek Watershed B locations.

5.1.4 Hopkins Fork Watershed A

A total of seven samples were collected from seven locations in Hopkins Fork Watershed A, which extends from the confluence with Laurel Creek upstream to Lavinia Fork.

Water types among the eight wells were somewhat variable, although water types among closer wells were more similar. Locations DW-18, DW-20 and DW-24 plotted very closely on the Piper diagrams, as did locations DW-26, DW-28, DW-19 and DW-17. Sample DW-25 exhibited the most unique water quality signature, although it was located very close to sample DW-26. Samples DW-25 and DW-26 exhibited characteristics of shallower groundwater flow systems (higher proportions of magnesium and sulfate). Other samples were more typical of shallow to intermediate flow systems.

Iron and manganese were present above the secondary drinking water standards in samples from locations DW-28, DW-19, DW-25 and DW-26. Total dissolved solids and sulfate were elevated in DW-25 and DW-26, which contained the two highest sulfate concentrations measured during our study (224 and 90.6 mg/L, respectively). Aluminum concentration exceeded the secondary drinking water standard in DW-26 and was also the highest measured during our study.

No other primary or secondary drinking water parameter, including Coliform bacteria, was detected above the standard in any other sample from the Hopkins Fork Watershed A locations. No VOC was detected in any sample from the Hopkins Fork Watershed A locations.

5.1.5 Hopkins Fork Watershed B

A total of five samples were collected from five locations in Hopkins Fork Watershed B, which extends from the confluence with Lavinia Fork upstream to Big Jarrells Creek.

Water types among the five wells closely correlated to location. Locations DW-14 and DW-15 contained magnesium sulfate water typical of surface water. Locations DW-16, DW-29 and DW-30 contained sodium bicarbonate water more typical of local systems. Location DW-15 was reported to be a 25 ft. well that was hand bailed by our sampling personnel.

None of the parameters analyzed, including Coliform bacteria, were detected above the applicable drinking water standards in samples from the Hopkins Fork Watershed B locations. The sample from location DW-14 exhibited a pH value of 6.13, which is the most acidic pH value measured during our study.

No VOC was detected in any sample from the Hopkins Fork Watershed B locations.

5.1.6 Hopkins Fork Watershed C

One sample was collected from one location in Hopkins Fork Watershed C, which extends from the confluence with Big Jarrells Creek upstream to the headwaters.

Location DW-21 contained sodium bicarbonate water typical of intermediate flow systems.

None of the parameters analyzed, including Coliform bacteria, were detected above the applicable drinking water standards in the sample from the Hopkins Fork Watershed C location. No VOC was detected in the sample from the Hopkins Fork Watershed C location.

5.1.7 Prenter Watershed

One sample was collected from one location in the Prenter Watershed, which includes the drainage area of Big Jarrells Creek from the confluence with Hopkins Fork upstream to the headwaters.

Location DW-27 is an abandoned gas well that serves the Prenter community water system and is reportedly 2700 feet deep. However, the pump is reported to be located at a depth of 147 ft. The sample from location DW-27 contained sodium bicarbonate water typical of intermediate flow systems.

None of the parameters analyzed, including Coliform bacteria, were detected above the applicable drinking water standards in the sample from the Prenter Watershed. No VOC was detected in the sample from the Prenter Watershed.

5.2 SURFACE WATER

A total of nine samples were collected from seven surface water locations within the study area. All surface water samples were analyzed for those metals included in the primary drinking water standards plus fecal and total Coliform bacteria; all secondary drinking water standards; a variety of mine related parameters; major cations and anions; and VOC. Sample locations were selected to isolate water quality within the individual sub-watersheds, so that comparisons could be made between groundwater quality, surface water quality and mine-related discharges.

For purposes of our study, water quality at surface water locations were compared to primary and secondary drinking water standards. Although surface water quality standards have been developed under the Clean Water Act, the purpose of our study was to evaluate potential impacts to groundwater in the study area. Therefore, surface water quality values were compared to groundwater quality standards to identify any similarities with domestic groundwater quality. Analytical data is presented on Table 5-7. Piper and Stiff diagrams are presented on Figures 5-41 through 5-49.

5.2.1 Prenter Watershed (Big Jarrells Creek)

One sample was collected from one location on Big Jarrells Creek in the Prenter Watershed. Sample SW-1 was collected from Big Jarrells Creek immediately upstream from the confluence with Hopkins Fork. A significant amount of mining is occurring within the Prenter Watershed.

Sample SW-1 contained calcium sulfate water. Aluminum and manganese concentrations exceeded the secondary drinking water standards. No VOC was detected in the surface water sample from the Prenter Watershed.

5.2.2 Hopkins Fork Watershed C

One sample was collected from one location in Hopkins Fork Watershed C. Sample SW-2 was collected from Hopkins Fork immediately upstream from the confluence with Big Jarrells Creek. No significant mining is currently occurring within this watershed.

Sample SW-2 contained calcium sulfate water. None of the parameters analyzed were detected above the applicable drinking water standards. No VOC was detected in the sample from Hopkins Fork Watershed C.

5.2.3 Lavinia Fork

One sample was collected from one location in the Lavinia Fork Watershed. Sample SW-3 was collected from Lavinia Fork immediately upstream from the confluence with Hopkins Fork. A significant amount of mining has occurred within the Lavinia Fork Watershed, although most surface disturbance has been reclaimed.

Sample SW-3 contained magnesium sulfate water. Aluminum, manganese, sulfate and TDS concentrations exceeded the secondary drinking water standards. No VOC was detected in the sample from Lavinia Fork.

5.2.4 Laurel Creek Watershed B

One sample was collected from one location in Laurel Creek Watershed B. Sample SW-4 was collected from Laurel Creek immediately upstream from the confluence with Hopkins Fork. Significant mining is currently occurring within Laurel Creek Watershed B.

Sample SW-4 contained magnesium sulfate water. Aluminum, manganese, sulfate and TDS concentrations exceeded the secondary drinking water standards. No VOC was detected in the sample from Laurel Creek Watershed B.

5.2.5 Sandlick Creek Watershed Upstream

Three samples were collected from one location in Sandlick Creek Watershed upstream from all domestic wells. Sample SW-5 was collected on April 18, 2011 and samples SW-8 and SW-8FD (field duplicate) were collected from the same location August 17, 2011. Significant mining is currently occurring within the Sandlick Creek Watershed.

Samples from Sandlick Creek Watershed Upstream contained magnesium sulfate water. Aluminum and manganese concentrations exceeded the secondary drinking water standards in the April 18, 2011 samples. Aluminum, manganese, sulfate and TDS concentrations exceeded the secondary drinking water standards in the samples collected August 17, 2011. No VOC was detected in any sample from Sandlick Creek Watershed Upstream.

5.2.6 Three Forks Branch Upstream

One sample was collected from one location on Three Forks Branch upstream from all domestic wells. No significant mining is currently occurring within this watershed.

Sample SW-6 contained magnesium sulfate water. None of the parameters analyzed were detected above the applicable drinking water standards. No VOC was detected in the sample from Three Forks Branch Upstream.

5.2.7 Sandlick Creek Downstream

One sample was collected from one location in Sandlick Creek Watershed immediately upstream from the confluence with Laurel Creek on April 18, 2011. Water quality at the downstream location on Sandlick Creek closely mirrored the water quality at the upstream location. Sample SW-7 contained magnesium sulfate water. Aluminum and manganese concentrations exceeded the secondary drinking water standards. No VOC was detected in the sample from Sandlick Creek Watershed Upstream.

5.3 MINE RELATED SAMPLES

A total of 15 mine related samples were collected from 15 locations within the study area. Seven samples were collected from discharge from underground mines, several of which were known to have been used for disposal of coal slurry. Two samples were collected from discharge from valley fill locations. Three samples were collected from coal slurry impoundment decant water. One sample was collected from coal pile run-off that is injected into abandoned underground workings. One sample was collected of slurry directly from the thickener in the coal preparation plant.

All mine related samples were analyzed for those metals included in the primary drinking water standards; all secondary drinking water standards; a variety of mine related parameters; major cations and anions; and VOC. As with surface water samples, water quality from mine related sample locations was compared to primary and secondary drinking water standards for purposes of our study. Analytical data is presented on Table 5-8. Piper and Stiff diagrams are presented on Figures 5-50 through 5-66.

5.3.1 Mine Discharge Samples

Mine discharge samples were collected from underground mines developed in several seams across the Kanawha Formation stratigraphic section. The uppermost seam represented is the Coalburg (MD-4) and the lowermost seam represented is the No. 2 Gas (MD-7). The Coalburg seam mine received slurry via injection during the 1970s. The No. 2 Gas seam is currently being mined below drainage by longwall methods.

5.3.1.1 Davison Mine (Outlet 006) – Sample MD-1

Sample MD-1 was collected directly from the discharge from the former Davidson Mine, currently permitted as Outlet 006 by Independence Coal Company. The Davidson mine was developed in the No. 2 Gas seam. According to WVDEP UIC records, coal slurry was injected into the No. 2 Gas seam in the Quinland Mine.

Water from the Davison Mine is described as sodium bicarbonate. The concentration of TDS in sample MD-1 exceeded the secondary water quality standard, primarily due to contribution from bicarbonate. No other parameter was detected above the drinking water standards. No VOC was detected in the sample from the Davison Mine.

5.3.1.2 Stockton Seam – Sample MD-2

Sample MD-2 was collected from an unidentified Stockton seam mine discharge located in the Robinson Creek watershed. The Stockton is the uppermost coal seam being mined from the Kanawha Formation in the study area.

Water in sample MD-2 is described as calcium sulfate. Concentrations of aluminum, manganese and sulfate in sample MD-2 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-2.

5.3.1.3 Stockton Seam – Sample MD-3

Sample MD-3 was collected from an unidentified Stockton seam mine discharge located in the Laurel Creek watershed. Water in sample MD-3 is described as calcium sulfate. Manganese in sample MD-3 exceeded the secondary water quality standard. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-3.

5.3.1.4 Coalburg Seam – Sample MD-4

Sample MD-4 was collected from an unidentified Coalburg seam mine discharge located in the Laurel Creek watershed. Water in sample MD-4 is described as calcium sulfate. Concentrations of manganese, TDS and sulfate in sample MD-4 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-4.

5.3.1.5 Buffalo Seam – Sample MD-5

Sample MD-5 was collected from an unidentified Buffalo seam mine discharge located in the Laurel Creek watershed. Water in sample MD-5 is described as magnesium sulfate. The concentrations of manganese, TDS and sulfate in sample MD-5 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-5.

5.3.1.6 Ferrell Mine – Sample MD-6

Sample MD-6 was collected from the Ferrell (Quinland) Mine, developed in the No. 2 Gas seam. Water in sample MD-6 is described as sodium bicarbonate. The concentrations of aluminum, iron, manganese and TDS in sample MD-6 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-6.

5.3.1.7 Justice Mine – Sample MD-7

Sample MD-7 was collected from the Justice Mine, developed in the No. 2 Gas seam. Water in sample MD-7 is described as sodium sulfate. The concentrations of sulfate and TDS in sample MD-7 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-7.

5.3.1.8 Outlet 20 (Boone Co. Landfill) – Sample MD-8

Sample MD-8 was collected from Outlet 20 on Pine Ridge Coal Company property from the mine that underlies the former Boone Co. Landfill. Water in sample MD-8 is described as calcium sulfate. Concentrations of manganese, TDS and sulfate in sample MD-8 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample MD-8.

5.3.2 Slurry Related Samples

Fine coal slurry from the Revolution Coal Company preparation plant located on Robinson Run in Boone County is pumped to a slurry impoundment located near the plant. Water remaining on the impoundment surface after the fine coal slurry settles (decant water) is injected into abandoned underground workings via a permitted injection well.

5.3.2.1 Raw Slurry – Sample SL-1

Sample SL-1 was collected directly from piping inside the Revolution Coal Company preparation plant. Water in sample SL-1 is described as calcium bicarbonate. Concentrations of aluminum, iron, manganese, chloride, sulfate and TDS exceeded the secondary water quality standards. Concentrations of arsenic, beryllium, lead and mercury exceeded the primary standard. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample SL-1.

5.3.2.2 Revolution Coal Decant Water – Sample DWater-01

Sample DWater-01 was collected from discharge from the Revolution Coal slurry impoundment located on Robinson Run. Water in sample DWater-01 is described as sodium sulfate. The concentration of sulfate and TDS in sample DWater-01 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample DWater-01.

5.3.2.3 Pine Ridge Coal Company Decant Water – Sample DWater-02

Sample DWater-02 represents permitted NPDES discharge from the Pine Ridge Coal Lotts Fork slurry impoundment and was collected from the right groin ditch. Water in sample DWater-02 is described as calcium sulfate. Concentrations of sulfate and TDS in sample DWater-02 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample DWater-02.

5.3.2.4 Pine Ridge Coal Company Decant Water – Sample DWater-03

Sample DWater-03 represents seepage from the Pine Ridge Coal Lotts Fork slurry impoundment and was collected from a seep located at the toe of the embankment. Water in sample DWater-03 is described as calcium sulfate. Concentrations of iron, manganese, sulfate and TDS in sample DWater-03 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample DWater-03.

5.3.2.5 Injection Well Liquid – Sample IW-1

Sample IW-1 represents run-off water from the Revolution Coal Company coal storage pile that is injected into abandoned workings via a permitted injection well. Water in sample IW-1 is described as sodium sulfate. Concentrations of aluminum, iron and manganese in sample IW-1 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample IW-1.

5.3.3 Valley Fill Discharge Samples

Two samples were collected from seepage discharging from valley fills constructed from excess spoil related to mining in the upper Kanawha and Allegheny formations in the headwaters of Laurel Creek.

5.3.3.1 Valley Fill Discharge – Sample VF-1

Water in sample VF-1 is described as magnesium sulfate. Concentration of beryllium exceeded the primary standard. Concentrations of aluminum, manganese, sulfate and TDS in sample VF-1 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample VF-1.

5.3.3.2 Valley Fill Discharge – Sample VF-2

Water in sample VF-2 is described as magnesium sulfate. Concentration of beryllium exceeded the primary standard. Concentrations of aluminum, manganese, sulfate and TDS in sample VF-2 exceeded the secondary water quality standards. No other parameter was detected above the applicable drinking water standards. No VOC was detected in sample VF-2.

6.0 SUMMARY AND CONCLUSIONS

The purpose of our investigation was to evaluate reports of negative impacts to groundwater being used as a drinking source by residents along Laurel Creek and its tributaries in Boone County, WV. This area is commonly referred to as Prenter Road. More specifically, WVDEP asked that we determine what human activity, including coal mining and ancillary activity, may have negatively affected the quality of groundwater being used as a drinking water source by residents of the study area.

6.1 Summary

To accomplish the goals of the study, Triad completed extensive research into the geology and hydrology of the study area, including stratigraphy and geologic structure, surface water and groundwater hydrology, and known and inferred effects of underground coal mining on groundwater. This included an in-depth review of existing information, including published reports regarding the geology and hydrology of the area and previously collected water quality data.

After completing our review of available information, Triad collected samples from domestic wells being used for residential water supplies in the area. Triad personnel spent approximately ten days in the community, visited more than 100 homes across the study area, and collected samples from 33 domestic wells. Two public meetings were held in the study area in association with the WVDEP and local advocates to advise residents of our activities and to encourage participation in the study. Local media were present at these public meetings and broadcast coverage of the meetings. The WVDEP also published notices of the study in local newspapers encouraging residents to contact Triad to arrange to have their domestic well water sampled.

Finally, we evaluated areas of human impact within the study area that could possibly affect groundwater quality. Coal mining, coal processing, and the disposal of coal processing waste have occurred extensively throughout the study area since approximately 1915. Natural gas extraction, gathering and transmission have also occurred within the study area. The study area also includes the former Boone County Landfill, where domestic, commercial and industrial waste was placed in an unlined landfill. Given the long term history of human activity in the area, there is potential for the leakage, spillage and improper disposal of commercial and industrial wastes. Triad personnel collected samples from surface water, mine discharges, valley fill discharges, and coal slurry related samples.

The geology of the study area is comprised of sedimentary rock. Rock types consist of shale, sandstone, conglomerate, limestone, underclay, claystone, coal, and siltstone. The strata are relatively flat lying with very gentle northeast-southwest trending folds. Rock units of the Kanawha Formation make up the majority of strata within the study area, including those which comprise the primary water-bearing zones. The Kanawha Formation is dominated by sandstone with lesser amounts siltstone, shale and coal. A number of mineable coals occur in the Kanawha Formation within the study area, including the Stockton, Coalburg, Winifrede, Chilton, Fire Clay, No. 2 Gas, Powellton and Eagle seams.

Geologic structure in the vicinity of the study area is controlled by the Coalburg Syncline, which trends southwest to northeast across the study area, approximately following the alignment of Laurel Creek and Sandlick Creek. Rock strata across a majority of the Laurel Creek watershed are essentially flat lying. Strata rise approximately 120 feet per mile in the area of Sandlick and upper Laurel Creek, and rise to the southeast at approximately 70 feet per mile along the headwaters of Hopkins Fork.

Soils in the study area are generally sandy and contain a large percentage of sandstone fragments. Along the larger stream valleys, soils are primarily alluvial with a mix of colluvial material along the base of the ridges. Alluvial deposits along Laurel Creek and the major tributaries are probably less than 20 feet in thickness.

Surface water within the study area is drained by Laurel Creek, which empties into the Coal River near Seth, WV. The major tributaries to Laurel Creek are Sandlick Creek, Hopkins Fork, Lavinia Fork and Big Jarrells Creek. The Laurel Creek watershed covers approximately 35,000 acres. Laurel Creek and its main tributaries flow at relatively low gradients except in headwater streams and tributaries where gradients are significantly greater.

The primary pathway for groundwater migration within the study area is provided by secondary permeability, which results from bedding-plane partings, stress-relief fractures, joints and faults. Abandoned underground coal mine voids also serve as secondary permeability pathways (conduit flow). The underground excavation acts as a large sink which draws in groundwater. Groundwater in mines located above drainage (within the ridges) moves via conduit flow and discharges at down dip mine openings or at seeps along the coal outcrop. A minor portion of groundwater from these mines may move downward to lower mine voids, where it can once again move laterally to a discharge point or migrate vertically to a lower mine void. The No. 2 Gas coal seam is the lowest mine void groundwater transport system in the watershed. Very large quantities of water are pumped from the No. 2 Gas in the Lavinia Fork watershed to facilitate mining. Water not pumped from the No. 2 Gas seam discharges to Robinson Fork and Coal River, south of the study area, where it outcrops above drainage.

Groundwater flow systems within the Appalachian Plateau are typically classified as local, intermediate and regional. Local groundwater flow systems are a series of “hydrologic islands” separated by surface water streams. Shallow, local groundwater flow systems are hydrologically separate from the local groundwater flow systems present in adjacent ridges. Recharge to local flow systems comes from within the ridge forming the hydrologic island. Local systems discharge into the adjacent stream valleys and also leak into the underlying intermediate and regional groundwater flow systems. Flow rates are relatively fast and groundwater residence time is measured in years. Local flow systems contribute water to the vast majority of domestic wells.

Intermediate groundwater flow systems lie between the local, shallow flow systems and above the regional system. Primary controls on groundwater flow within intermediate flow systems are regional joint sets, bedding-plane partings, rock type, and zones of fracture concentration. Intermediate groundwater systems discharge to larger stream valleys like Laurel Creek and Hopkins Fork. Recharge comes through leakage from overlying local systems. Flow rates are moderate and groundwater residence time is measured in years or decades.

The deep, regional groundwater flow system operates independently of the shallower systems. Recharge to the regional system is from major drainage basin divides and leakage from multiple local and intermediate systems. Regional groundwater systems discharge to larger, master stream valleys like the Coal River. Flow rates are very slow and residence time is probably measured in decades or centuries.

The groundwater chemistry of flow systems varies. The deepest zone is rich in sodium chloride. Much of the chloride has been removed from intermediate flow systems by flushing, but considerable sodium remains, leading to sodium bicarbonate waters. Sodium is completely removed from the uppermost zone, the leaving calcium bicarbonate water typical of shallow groundwater.

Water samples collected during our study were analyzed for metals referenced in the primary drinking water standards, total and fecal Coliform, all secondary drinking water standards, indicators of mine drainage such as acidity/alkalinity, iron, manganese, aluminum and sulfate, and the volatile organic compounds frequently found in petroleum products, paints, paint thinners and industrial solvents. Also, samples were analyzed for major anions and cations such as calcium, magnesium, sodium, potassium, chloride, carbonate and bicarbonate.

Primary drinking water standards are legally enforceable standards that apply to public water systems. Although the domestic wells sampled are not part of a public system, these standards are typically used for purposes of comparison to a uniform standard. Primary standards are established by USEPA based on potential health effects associated with consumption of drinking water containing levels of the primary contaminants that exceed the recommended levels (referred to as maximum contaminant levels or MCLs).

Secondary drinking water standards (SMCLs) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. These contaminants are not considered to present a risk to human health at the SMCL. The USEPA recommends secondary standards to public water systems but does not require those systems to comply.

The results from all water samples were grouped by location (e.g., sub-watershed) or by source (e.g., surface water) and plotted on Piper diagrams. As can be seen from the diagrams, several sample types tend to plot within the upper portion of the diagram, which is generally associated with mine-related impacts. All surface water samples, all valley fill samples, and most mine drainage and slurry related samples plot in the upper portion of the diagram. Conversely, most of the domestic well samples do not plot in this zone. However, samples DW-14, DW-15 and DW-25 did plot within the upper portion of the Piper diagram.

Samples were also plotted on stiff diagrams for comparison. Surface water samples portray a strong magnesium sulfate pattern. Some surface water samples also contain more or less relative calcium, but are generally skewed to the upper portion of the diagram. Six of the eight mine drainage samples also exhibit a strong sulfate signature, although cation signatures were less consistent. Mine drainage samples MD-1 and MD-6 exhibited strong sodium bicarbonate signatures, which is less common in mine related drainage. Both drainage samples from valley fills plotted very strong magnesium sulfate signatures. Two of the slurry decant water samples exhibited calcium sulfate signatures, while the third sample showed a sodium sulfate signature.

Groundwater in domestic well samples was predominantly calcium bicarbonate and sodium bicarbonate in nature. Only samples DW-14, DW-15, DW-25 and DW-26 exhibited a sulfate-dominated signature.

One domestic well sample exceeded the MCL for lead. The resident is connected to the public water supply and does not use well water for drinking. Sample DW-32 contained 0.0338 mg/L total lead, compared to the MCL of 0.0150 mg/L. Lead found in tap water usually comes from the corrosion of older fixtures or from the solder that connects pipes. The most common problem is with brass or chrome-plated brass faucets and fixtures which can leach significant amounts of lead into water. Homes built before 1986 are more likely to have lead pipes, fixtures and solder.

High levels of lead in tap water can cause health effects if the lead in the water enters the bloodstream and causes an elevated blood lead level. According to the Center for Disease Control (CDC), most studies show that exposure to lead-contaminated water alone would not be likely to elevate blood lead levels in most adults, even exposure to water with a lead content close to the MCL of 0.015 mg/L. Although the resident does not use groundwater for drinking, the source of elevated lead in DW-32 should be evaluated.

pH values for the domestic wells sampled were primarily neutral or alkaline, and ranged from 6.13 to 8.5. The most acidic pH measured at any domestic well was at DW-14. Equipment failure prevented pH measurement at wells DW-25 and DW-26 which exhibited strong sulfate signatures. However, these wells also contained excess alkalinity and probably would not exhibit acidic pH values.

Total manganese levels in the domestic wells ranged from less than 0.002 to 0.496 mg/L and were elevated above the secondary standard of 0.05 mg/L in 12 of the 33 wells sampled. The highest concentration was measured at DW-25. Average manganese concentration among the samples was 0.076 mg/L, which also exceeds the secondary standard.

Total iron levels in the wells ranged from less than 0.01 to 5.78 mg/L and exceeded the secondary standard of 0.3 mg/L in 12 of the 33 well samples. Unusually high iron values were found at locations DW-4 and DW-5 during the initial sampling round (7.08 and 9.96 mg/L, respectively). Therefore, these locations were re-sampled approximately four months later. Re-sampled iron concentrations at these two locations remained above the secondary standard, and the concentration at well DW-5 remained unusually high (5.78 mg/L).

Aluminum levels in the domestic wells were generally low, ranging from less than .012 to 0.061 mg/L. One domestic well (DW-26) exceeded the secondary standard of 0.05 mg/L.

According to the USEPA, manganese present in drinking water above the secondary standard is associated with black to brown color, black staining and a bitter metallic taste. Iron above the standard is associated with a rusty color, sediment in the water, a metallic taste, and reddish/orange staining of fixtures. Aluminum exceeding the SMCL can cause discoloration of drinking water. These secondary parameters are not associated with health effects by the USEPA.

All metals listed under the primary drinking water standards and all other secondary standards beyond those discussed above were less than the applicable standard in all samples from all domestic wells.

6.1 Conclusions

Our investigation did not identify evidence of widespread human-induced impacts to groundwater quality in the Prenter Road area. Volatile organic compounds were generally not detected in any domestic well sample. Therefore, no evidence of commercial/industrial impact was found. Carbon disulfide was detected in two samples and chloroform was detected in one sample. Carbon disulfide is a common laboratory artifact and chloroform is an indicator of chlorinated water. Therefore, neither of these detections can be considered indicative of human-induced impact. Our review of environmental database records provided by EDR did not reveal the presence of potential commercial/industrial contaminant sources such as gasoline stations, drycleaners, or manufacturing facilities.

Similarly, our study did not identify evidence of impacts from natural gas drilling and production. Neither chloride nor surfactants (MBAS) were detected in surface water or groundwater at concentrations indicative of gas drilling impacts. The sample collected from beneath the closed Boone County Landfill did not contain VOC or other parameters that would suggest that leachate from the landfill is impacting groundwater at that location.

One domestic well sample did exceed the MCL for lead. The resident is connected to the public water supply and does not use well water for drinking. Sample DW-32 contained 0.0338 mg/L total lead, compared to the MCL of 0.0150 mg/L. Lead found in tap water usually comes from the corrosion of older fixtures or from the solder that connects pipes. The most common problem is with brass or chrome-plated brass faucets and fixtures which can leach significant amounts of lead into water. Homes built before 1986 are more likely to have lead pipes, fixtures and solder. Although the resident does not use groundwater for drinking, the source of elevated lead in DW-32 should be evaluated.

Sulfate concentration is a commonly used indicator of mine-related impact and is probably the most reliable differentiator of mine-related versus naturally occurring conditions. In surface waters, a sulfate concentration in excess of 50 to 100 mg/L has been used as a rule of thumb by some investigators to identify sites potentially influenced by mine drainage. The secondary drinking water standard for sulfate is 250 mg/L. Only two of the thirty-three domestic wells analyzed exceeded the 50 mg/L surface water threshold and only one exceeded the 100 mg/L value. None of the domestic wells exceeded the secondary drinking water quality standard for sulfate. By comparison, all five slurry related samples and both valley fill drainage samples exceeded 50 mg/L sulfate. All surface water samples except SW-6 (Three Forks Branch) and six of the eight mine drainage samples contained more than 50 mg/L sulfate. Of the mine-related samples analyzed, 11 of 15 exceeded the 250 mg/L secondary drinking water standard. Only two samples (MD-1 and MD-6) did not exhibit strong sulfate signatures.

Domestic wells DW-25 and DW-26, located in the Hopkins Fork A watershed, presented the strongest evidence of mine-related effects. Sulfate, iron and manganese were elevated in both wells, and aluminum was elevated in DW-26. Two other wells in the Hopkins Fork A watershed, DW-28 and DW-19, also contained iron and manganese concentrations in excess of the secondary standards, but sulfate concentrations in these wells were not significantly elevated.

Two wells located in the Hopkins Fork B watershed, DW-14 and DW-15, contained elevated sulfate concentrations, although none of the water quality parameters exceeded the primary or secondary drinking water standards. Water quality in these two wells is more closely allied with surface water quality than groundwater quality, due to their very shallow depths.

Approximately one-third of the domestic wells sampled (12 of 33) exceeded the secondary standard for iron concentration. The same number exceeded the secondary standard for manganese concentration. Although iron and manganese are typically elevated in mine drainage, they are also naturally occurring elements that are common in the rock strata that comprise the aquifers. Therefore, iron and manganese concentrations are not useful in confirming mine-related impacts. The US Geological Survey found that in West Virginia, "concentrations of iron and manganese in ground water commonly exceed the secondary drinking-water standards". In their Evaluation of Ground-Water Quality in the Appalachian Plateaus, Kanawha River Basin, West Virginia (Sheets and Kozar, 2000), the USGS found that 40% of the sites sampled exceeded the secondary standard for iron and 57% exceeded the secondary standard for manganese. In the study area, 36% of the domestic wells sampled exceeded the secondary standard for iron and the same percentage exceeded for manganese. This suggests that groundwater concentrations of these two elements are typical for the area. A comparison of data collected by Triad from the study area to data collected by USGS from the Kanawha River basin illustrates that water quality in domestic wells in the Prenter Road area is typical of water quality found in the region (Table 6-1).

Iron and manganese are metallic elements that are found in the earth's crust. When groundwater percolates through soil and rock, minerals containing iron and manganese are dissolved into the water. Iron and manganese are chemically similar. Iron is the more common and can be found in a water source without the presence of manganese; however, manganese is rarely found alone in a water source. Iron can be found in two forms:

- Ferrous iron - this form dissolved in water appears clear but develops black or rust colored particles that settle to the bottom of the container when the water is allowed to stand. These particles develop because the ferrous iron reacts with air, chlorine, or other oxidants to form ferric iron.

- Ferric iron - ferric iron is insoluble in water. Therefore, ferric iron is commonly present when the tap water appears rusty or has a red or yellow color.

During our interviews of residents, we found very poor correlation between resident complaints regarding sulfur odor and black or red appearance and actual analytical results. Of the 10 samples that contained the highest levels of sulfate, only four of the residents at those locations reported objectionable odors. Conversely, of the 13 residents offering the strongest complaints regarding odor, only four samples actually contained elevated sulfate levels. Concentrations of sulfate at eight of those 13 residential wells were very low or not detected.

The complaints regarding odors and coloration can be attributed to bacterial causes. Iron and sulfate metabolizing bacteria are microorganisms widely distributed in nature. They do not generally cause disease in humans or animals, but are nuisance microorganisms. These bacteria cause taste and odor problems, can foul dishwashers, washing machines and toilets, and stain clothing and plumbing fixtures. They frequently cause reddish-orange, slimy-looking deposits inside toilet tanks. The bacteria obtain energy for growth by oxidizing dissolved iron and sulfate present in groundwater from soluble to insoluble forms. When the temperature of groundwater rises, as it does in toilet tanks and interior household plumbing, iron and sulfate bacteria grow faster and in greater quantities. Slimes and red water reported by domestic well users is the result of the iron and sulfate metabolizing bacteria.

Hot water heater can also be a source of hydrogen sulfide odor. The magnesium corrosion control rod present in many hot water heaters can chemically reduce naturally occurring sulfates to hydrogen sulfide. Water softeners provide a convenient environment for these bacteria to grow and may produce a black slime inside water softeners.

Iron or sulfate bacteria can be controlled through a disinfection process such as chlorination. None of the residents reported that they had undertaken any water system maintenance activities such as well/system disinfection or well redevelopment in response to their observations.

Water samples from domestic wells were plotted on Piper diagrams. Samples DW-14, DW-15 and DW-25 plotted within the upper portion of the Piper diagram that is typical of mine-related water quality. As discussed above, sample DW-25 did exhibit the potential for mine-related impact. Samples DW-14 and DW-15 were derived from very shallow groundwater sources and are more reflective of surface water quality than groundwater quality.

Samples were also plotted on stiff diagrams for comparison. Groundwater in domestic well samples was predominantly calcium bicarbonate and sodium bicarbonate in nature. A few samples exhibited sodium chloride signatures. Samples DW-14, DW-15, DW-25 and DW-26 exhibited a sulfate-dominated signature that can indicate mine-related impacts.

As discussed in Section 2.3 – Groundwater Hydrology, groundwater flow within the study area is dominated by fractures, in the form of bedding-plane partings, stress-relief fractures and joints. Groundwater flow is typically local, existing as a series of “hydrologic islands” separated by surface water streams. These local groundwater systems are hydrologically separated from the systems present in adjacent ridges. Therefore, the vast majority of groundwater flow is localized. These local systems primarily discharge to adjacent stream valleys and do not travel long distances. To a much lesser degree, the local systems leak into underlying intermediate and regional groundwater flow systems, and therefore, cannot significantly affect water quality in those deeper systems. The vast majority of domestic wells derive their water from local flow systems.

Knowing that domestic wells are a measure of localized water quality, it is easy to understand that large scale impacts to groundwater quality are highly unlikely. Evidence of the local nature of groundwater quality is supported by the data from our investigation. A number of examples exist across the study area where domestic wells that are situated adjacent to each other exhibit very different water quality. For example, locations DW-1, DW-2, DW-3, DW-4 and DW-13 are located in very close proximity along Sandlick Creek, but their Piper and Stiff signatures are highly variable, as is the concentrations of many analytical parameters. Similar evidence is provided by samples DW-7, DW-8 and DW-9 in watershed Laurel Creek A, and DW-10, DW-11 and DW-12 in watershed Laurel Creek B. Therefore, water quality within the study area is highly variable, due to the variability of both fracture-related permeability and source rocks. As discussed in Section 2.1 – Geology, rocks within the study area were deposited in a deltaic environment during the Pennsylvanian period and are representative of river channel, backwater, swamp, delta, and near-shore environments. The result is a complex mix of interwoven sedimentary rock that exhibits a great deal of lateral variation. The near-shore zones (limestone) and swamp deposits (coals and underclay) are the most horizontally continuous units. However, the sandstone, siltstone, claystone and shale units display a great degree of lateral and vertical heterogeneity. This lithologic variance also results in a high degree of geochemical variance on a local scale. Because of this lateral variability, nearby wells can penetrate different stratigraphic units with different geochemical signatures and yield different water quality. Also, because groundwater flow is predominantly controlled by fracture permeability, different fracture spacing, density, orientation and width can also result in very different water quality within fairly localized areas.

In summary, our investigation did not reveal evidence of widespread human-induced impacts to groundwater quality. Two wells, DW-25 and DW-26, exhibited the greatest evidence of mine-related impact. These wells are located in Hopkins Fork Watershed A, adjacent to a reclaimed surface mine operation situated immediately to the east, on the ridge separating Hopkins Fork and Big Coal River. These wells probably derive their water from the same groundwater flow system occupied by the reclaimed mining operation. Therefore, it is not unreasonable to conjecture that elevated sulfate, iron, manganese and aluminum levels detected in those wells may be related to impacts from the mining operation.

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TABLES

Table 5-1. Sandlick Creek Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Sandlick - Main Stem**								**Sandlick - Three Forks**		
Sample ID			DW-1	DW-2	DW-3	DW-3R	DW-3RFD	DW-4	DW-4R	DW-13	DW-5	DW-5R	DW-6
Name													
Latitude			38.08916666	38.087916	38.086527	38.086527	38.086527	38.086527	38.086527	38.0876	38.09278	38.09278	38.09225
Longitude			81.64251666	81.6424722	81.644722	81.644722	81.644722	81.644722	81.644722	81.6437	81.648	81.648	81.64962
Source			Well/Pump Faucet	Well/Pump Faucet	Well House	Well House	Well House	Well/Pump Faucet	Well/Pump Faucet	Hose Bib	Well/Pump Faucet	Well/Pump Faucet	Well/Pump Faucet
Well Setting			Well House/Well Seal	Basement	Well House	Well House	Well House	Well House	Well House	Well House	Well House	Well House	Well House
Well Depth			80'	97'	100'	100'	100'	90'	90'	125'	36'	36'	90'
Conductivity			262	223	261	261	261	210	210	210	81	81	173
Temp. °C			15.4	18.5	17.8	17.8	17.8	18.5	18.5	*	19.1	19.1	17.5
pH			7.15	8.5	8.21	8.21	8.21	7.6	7.6	8	6.75	6.75	7.47
Analyte	**Units**	**MCL Values**											
Aluminum	mg/L	0.05	ND	ND	0.013	0.02	0.014	ND	ND	ND	**0.13**	0.025	ND
Antimony	mg/L	0.006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	0.01	ND	ND	0.001	ND	ND	0.0037	0.0011	ND	0.0024	0.0025	0.001
Barium	mg/L	2	0.46	0.174	0.204	0.125	0.0974	0.753	0.454	0.457	0.136	0.232	0.358
Beryllium	mg/L	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.005	ND	ND	0.0002	ND	ND	0.0002	ND	ND	0.0008	ND	ND
Calcium	mg/L	NA	30	5.32	7.98	4.98	3.63	23.9	16.7	21.7	8.02	14.6	22.8
Chromium	mg/L	0.1	ND	ND	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	ND	0.004	ND	0.005	ND	0.004	0.007	ND	ND
Copper	mg/L	1.3	0.0021	0.0107	ND	NA	NA	0.0022	ND	0.0016	0.0231	0.0026	0.0084
Iron	mg/L	0.3	**0.307**	0.048	**1.25**	0.152	0.116	**7.08**	**1.28**	0.227	**9.96**	**5.78**	**0.466**
Lead	mg/L	0.015	0.0011	0.0009	0.0044	ND	ND	0.0014	ND	0.0022	0.0011	ND	0.0023
Magnesium	mg/L	NA	7.48	1.31	2.13	1.37	1.01	5.84	3.98	5.62	2.68	4.22	5.02
Manganese	mg/L	0.05	**0.079**	0.007	**0.05**	0.032	0.021	**0.095**	**0.05**	**0.065**	**0.28**	**0.364**	**0.062**
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/L	NA	ND	ND	ND	0.0016	0.0012	ND	ND	0.0018	ND	0.0021	ND
Nickel	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/L	NA	1.61	1.56	1.65	1.58	1.5	1.89	1.74	1.76	1.26	1.24	1.16
Selenium	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	15.7	52.8	0.767	62.2	64.4	15.7	41.8	25.1	2.75	4.16	6.07
Strontium	mg/L	NA	0.706	0.275	0.288	0.177	0.133	0.828	0.574	0.762	0.0703	0.178	0.352
Thallium	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	0.0024	0.0011	ND
Uranium	mg/L	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	5	0.077	0.027	**54.6**	0.059	0.037	0.551	0.023	0.055	1.14	0.03	0.015
MBAS	mg/L	0.5	0.005	0.007	0.007	ND	ND	0.01	ND	ND	ND	ND	ND
Acidity, Total	mg/L	NA	13.3	ND	1.5	ND	ND	3.7	6.8	5.1	7.8	7.1	2.9
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	107	128	134	149	141	103	119	105	22.4	45.4	77.7
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	107	128	134	149	141	103	119	105	22.4	45.4	77.7
Chloride	mg/L	250	2.97	2.31	54.6	10.9	10.6	5.47	4.71	5.19	2.99	1.81	2.35
Fluoride	mg/L	4	0.06	0.23	0.204	0.49	0.52	0.08	0.26	0.14	ND	ND	0.04
Sulfate	mg/L	250	26.5	ND	0.288	1.25	1.01	4.61	2.54	11.8	12.9	9.86	10.3
Total Dissolved Solids	mg/L	500	170	146	174	190	196	131	151	144	75	75	112
Total Coliform	NA	5.0%	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-1. Sandlick Creek Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Sandlick - Main Stem**								**Sandlick - Three Forks**		
Sample ID			DW-1	DW-2	DW-3	DW-3R	DW-3RFD	DW-4	DW-4R	DW-13	DW-5	DW-5R	DW-6
Name													
Latitude			38.08916666	38.087916	38.086527	38.086527	38.086527	38.086527	38.086527	38.0876	38.09278	38.09278	38.09225
Longitude			81.64251666	81.6424722	81.644722	81.644722	81.644722	81.644722	81.644722	81.6437	81.648	81.648	81.64962
Source			Well/Pump Faucet	Well/Pump Faucet	Well House	Well House	Well House	Well/Pump Faucet	Well/Pump Faucet	Hose Bib	Well/Pump Faucet	Well/Pump Faucet	Well/Pump Faucet
Well Setting			Well House/Well Seal	Basement	Well House	Well House	Well House	Well House	Well House	Well House	Well House	Well House	Well House
Well Depth			80'	97'	100'	100'	100'	90'	90'	125'	36'	36'	90'
Conductivity			262	223	261	261	261	210	210	210	81	81	173
Temp. °C			15.4	18.5	17.8	17.8	17.8	18.5	18.5	*	19.1	19.1	17.5
pH			7.15	8.5	8.21	8.21	8.21	7.6	7.6	8	6.75	6.75	7.47
Analyte	**Units**	**MCL Values**											
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	8.1	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-2. Laurel Creek A Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Laurel Creek A - Lower**			**Laurel Creek A - Upper**			
Sample ID			DW-22	DW-23	DW-32	DW-7	DW-8	DW-9	DW-31
Name									
Latitude			38.0957	38.098	38.0957	38.08392	38.0832	38.08447	38.086
Longitude			81.6327	81.6315	81.6352	81.64156	81.64165	81.64256	81.6413
Source			Hose Bib	Well Pump/Faucet	Hose Bib	Well/ Pump Faucet	Hose Bib	Hose Bib	Hose Bib
Well Setting			Well House	Well House	Well Seal	Garage	Well House	Side of House	Basement
Well Depth			Unknown	Unknown	Unknown	70'	80'	Unknown	Unknown
Conductivity			680	920	730	378	367	347	430
Temp. °C			*	*	12	20.4	19.7	19	14
pH			7.54	7.7	7.67	6.73	7.08	7.91	**6.27**
Analyte	**Units**	**MCL Values**							
Aluminum	mg/L	0.05	0.014	ND	ND	0.03	ND	ND	ND
Antimony	mg/L	0.006	ND	ND	0.0002	ND	ND	ND	ND
Arsenic	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND
Barium	mg/L	2	0.427	0.632	1.01	0.571	0.539	0.453	0.119
Beryllium	mg/L	0.004	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	NA	5.24	7.67	14.1	16.4	15.8	13.1	26.2
Chromium	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Copper	mg/L	1.3	0.0093	0.001	0.138	0.002	ND	ND	0.0183
Iron	mg/L	0.3	0.065	0.079	**0.352**	**0.363**	0.072	0.079	**5.37**
Lead	mg/L	0.015	0.0009	0.0002	**0.0338**	0.0009	ND	ND	0.0017
Magnesium	mg/L	NA	1.36	1.97	3.65	14.4	4.03	3.8	4.93
Manganese	mg/L	0.05	0.011	0.012	0.015	**0.063**	**0.079**	0.023	**0.089**
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	NA	ND	ND	0.0038	ND	ND	ND	0.0021
Potassium	mg/L	NA	2.74	3.48	3.54	1.98	1.57	1.66	1.3
Selenium	mg/L	0.05	0.001	0.0013	0.0023	ND	ND	ND	0.0019
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	152	191	183	38.2	40.1	67.9	86.2
Strontium	mg/L	NA	0.451	0.698	1.15	0.573	0.556	0.578	0.112
Thallium	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	0.0014	ND	ND	ND	ND
Titanium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Uranium	mg/L	0.03	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/L	NA	0.0014	0.0012	ND	ND	ND	ND	ND
Zinc	mg/L	5	0.013	0.01	0.319	0.979	ND	0.005	0.017
MBAS	mg/L	0.5	ND	ND	ND	ND	0.005	0.009	ND
Acidity, Total	mg/L	NA	ND	5.6	9.2	36.3	27.1	1.7	40.9
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	154	67.8	147	89.8	126	145	108
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	154	67.8	147	89.8	126	145	108
Chloride	mg/L	250	141	0.59	203	54.4	59.8	26.7	95.5
Fluoride	mg/L	4	0.68	**206**	0.47	0.1	0.25	0.2	0.07
Sulfate	mg/L	250	1.02	1.2	1.46	25.7	ND	ND	11.1
Total Dissolved Solids	mg/L	500	416	**734**	**509**	223	244	227	314
Total Coliform	NA	5.0%	ND	ND	ND	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-2. Laurel Creek A Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Laurel Creek A - Lower**			**Laurel Creek A - Upper**			
Sample ID			DW-22	DW-23	DW-32	DW-7	DW-8	DW-9	DW-31
Name									
Latitude			38.0957	38.098	38.0957	38.08392	38.0832	38.08447	38.086
Longitude			81.6327	81.6315	81.6352	81.64156	81.64165	81.64256	81.6413
Source			Hose Bib	Well Pump/Faucet	Hose Bib	Well/ Pump Faucet	Hose Bib	Hose Bib	Hose Bib
Well Setting			Well House	Well House	Well Seal	Garage	Well House	Side of House	Basement
Well Depth			Unknown	Unknown	Unknown	70'	80'	Unknown	Unknown
Conductivity			680	920	730	378	367	347	430
Temp. °C			*	*	12	20.4	19.7	19	14
pH			7.54	7.7	7.67	6.73	7.08	7.91	**6.27**
Analyte	**Units**	**MCL Values**							
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	1.4	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	***3.7***	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-3. Laurel Creek B Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			Laurel Creek B			
Sample ID			DW-10	DW-11	DW-12	DW-33
Name						
Latitude			38.06871666	38.069722	38.06768	38.0698
Longitude			81.6454666	81.643055	81.64394	81.6421
Source				Hose Bib	Well	Indoor Faucet
Well Setting			N/A	Well House	Well	Well House
Well Depth			N/A	100'	58'	Unknown
Conductivity			380	724	200	410
Temp. °C			18.7	18.4	17.5	23.8
pH			8.08	8.2	8.43	8.01
Analyte	**Units**	**MCL Values**				
Aluminum	mg/L	0.05	ND	ND	ND	ND
Antimony	mg/L	0.006	ND	ND	ND	ND
Arsenic	mg/L	0.01	ND	0.001	ND	ND
Barium	mg/L	2	0.364	0.418	0.531	0.29
Beryllium	mg/L	0.004	ND	ND	ND	ND
Cadmium	mg/L	0.005	ND	ND	ND	ND
Calcium	mg/L	NA	11.2	9.09	24	7.42
Chromium	mg/L	0.1	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	ND	ND
Copper	mg/L	1.3	0.0021	0.0094	ND	0.0011
Iron	mg/L	0.3	0.078	**0.689**	0.015	0.087
Lead	mg/L	0.015	0.0005	0.0041	ND	ND
Magnesium	mg/L	NA	2.87	2.26	5.51	2.02
Manganese	mg/L	0.05	0.013	0.01	0.035	0.007
Mercury	mg/L	0.002	ND	ND	ND	ND
Molybdenum	mg/L	NA	ND	ND	ND	0.0016
Nickel	mg/L	NA	ND	ND	ND	ND
Potassium	mg/L	NA	1.77	2.12	1.36	2.02
Selenium	mg/L	0.05	ND	ND	ND	ND
Silver	mg/L	0.1	ND	ND	ND	ND
Sodium	mg/L	NA	40.6	168	10	96.3
Strontium	mg/L	NA	0.426	0.47	0.601	0.372
Thallium	mg/L	0.002	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	ND	ND
Titanium	mg/L	NA	ND	ND	ND	ND
Uranium	mg/L	0.03	ND	ND	ND	ND
Vanadium	mg/L	NA	ND	ND	ND	ND
Zinc	mg/L	5	0.01	0.153	0.015	0.007
MBAS	mg/L	0.5	ND	0.011	ND	ND
Acidity, Total	mg/L	NA	20.6	ND	4.1	2.9
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	175	260	83.3	181
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	175	260	83.3	181
Chloride	mg/L	250	20.4	97.5	1.18	41
Fluoride	mg/L	4	0.31	0.42	0.06	0.49
Sulfate	mg/L	250	ND	ND	20.1	1.38
Total Dissolved Solids	mg/L	500	249	417	126	254
Total Coliform	NA	5.0%	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND
Acrolein	µg/L	*0.04	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-3. Laurel Creek B Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Laurel Creek B**			
Sample ID			DW-10	DW-11	DW-12	DW-33
Name						
Latitude			38.06871666	38.069722	38.06768	38.0698
Longitude			81.6454666	81.643055	81.64394	81.6421
Source				Hose Bib	Well	Indoor Faucet
Well Setting			N/A	Well House	Well	Well House
Well Depth			N/A	100'	58'	Unknown
Conductivity			380	724	200	410
Temp. °C			18.7	18.4	17.5	23.8
pH			8.08	8.2	8.43	8.01
Analyte	**Units**	**MCL Values**				
Bromoform	µg/L	*8.5	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-4. Hopkins Fork A and Lavinia Fork Quality Data
Prenter Road Hydrologic Evaluation

Watershed			Hopkins Fk A							Lavinia
Sample ID			DW-28	DW-17	DW-18	DW-19	DW-20	DW-25	DW-26	DW-24
Name										
Latitude			38.0768	38.0591800	38.04547	38.0591	38.0449722	38.0561	38.0558	38.04335
Longitude			81.0011	81.61388	81.61746	81.6137	81.6176944	81.61	81.6103	81.6184
Source			Hose Bib	Pump Faucet	Well/Pump Faucet	Faucet	Hose Bib on Trailer	Hose Bib	Well Pump/ Faucet	Hose Bib
Well Setting			Well House	Open Well	Well House	N/A	Well House	Well Seal	Well House	Well Seal/Well House
Well Depth			Unknown	51	65'	30'	55'	~50	56'	>57'
Conductivity			170	165.8	369	374	298	680	390	336
Temp. °C			25.4	17.5	19.1	18.4	18.4	*	*	19.8
pH			6.65	7.34	8.34	7.46	7.92	*	*	8.05
Analyte	**Units**	**MCL Values**								
Aluminum	mg/L	0.05	ND	ND	ND	ND	ND	ND	**0.061**	ND
Antimony	mg/L	0.006	ND	ND	ND	0.0002	ND	ND	ND	0.0003
Arsenic	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND
Barium	mg/L	2	0.645	0.203	0.404	0.597	0.569	0.0391	0.12	0.591
Beryllium	mg/L	0.004	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	NA	23.4	13.7	10.7	28.1	17.7	74.7	42.4	13.9
Chromium	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	ND	ND	ND	0.004	ND	ND
Copper	mg/L	1.3	0.03	0.0045	ND	ND	ND	0.0251	0.004	0.0041
Iron	mg/L	0.3	**1.6**	0.18	0.033	**0.573**	0.263	**1.72**	**1.48**	0.112
Lead	mg/L	0.015	0.0061	0.0009	ND	0.0002	ND	0.0036	0.0026	0.0003
Magnesium	mg/L	NA	5.65	5.32	2.88	6.71	5.06	27.5	16.6	5.7
Manganese	mg/L	0.05	**0.134**	0.016	0.015	**0.068**	0.026	**0.496**	**0.359**	0.012
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/L	NA	0.0022	ND	ND	ND	ND	0.0017	ND	ND
Nickel	mg/L	NA	ND	0.0024	0.0022	ND	ND	0.0025	0.0029	ND
Potassium	mg/L	NA	1.67	1.61	1.71	1.69	1.97	2.44	2.31	2.29
Selenium	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	12.8	19.1	41.2	23	48	23	31.4	40.1
Strontium	mg/L	NA	0.521	0.192	0.346	0.572	0.576	1.22	0.766	0.95
Thallium	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/L	NA	ND	ND	ND	ND	ND	0.0043	0.0028	ND
Uranium	mg/L	0.03	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	5	0.115	0.009	ND	0.049	ND	0.069	0.151	0.01
MBAS	mg/L	0.5	ND	0.006	ND	ND	0.008	ND	ND	ND
Acidity, Total	mg/L	NA	6.1	4.8	28.4	16.4	1.1	6.9	5.2	38.6
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	73.1	45.6	150	94.9	136	104	124	157
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	73.1	45.6	150	94.9	136	104	124	157
Chloride	mg/L	250	16.4	16.9	30.6	7.71	19.9	8.42	10	8.36
Fluoride	mg/L	4	0.07	ND	0.25	0.05	0.09	0.11	0.14	0.49
Sulfate	mg/L	250	13.9	28.8	ND	42.8	ND	224	90.6	25.8
Total Dissolved Solids	mg/L	500	124	184	247	176	188	475	323	217
Total Coliform	NA	5.0%	ND	ND	ND	ND	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-4. Hopkins Fork A and Lavinia Fork Quality Data
Prenter Road Hydrologic Evaluation

Watershed			Hopkins Fk A							Lavinia
Sample ID			DW-28	DW-17	DW-18	DW-19	DW-20	DW-25	DW-26	DW-24
Name										
Latitude			38.0768	38.0591800	38.04547	38.0591	38.0449722	38.0561	38.0558	38.04335
Longitude			81.0011	81.61388	81.61746	81.6137	81.6176944	81.61	81.6103	81.6184
Source			Hose Bib	Pump Faucet	Well/Pump Faucet	Faucet	Hose Bib on Trailer	Hose Bib	Well Pump/ Faucet	Hose Bib
Well Setting			Well House	Open Well	Well House	N/A	Well House	Well Seal	Well House	Well Seal/Well House
Well Depth			Unknown	51	65'	30'	55'	~50	56'	>57'
Conductivity			170	165.8	369	374	298	680	390	336
Temp. °C			25.4	17.5	19.1	18.4	18.4	*	*	19.8
pH			6.65	7.34	8.34	7.46	7.92	*	*	8.05
Analyte	**Units**	**MCL Values**								
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-5. Hopkins Fork B/C and Prenter Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Hopkins Fork B**					**Hopkins Fk C**	**Prenter**
Sample ID			DW-14	DW-15	DW-16	DW-29	DW-30	DW-21	DW-27
Name									
Latitude			38.0244	38.02725	38.032583	38.0372	38.0392	38.011222	38.01628
Longitude			81.616833	81.6140830	81.6154722	81.6163	81.6159	81.611333	81.62486
Source			Indoor Faucet	Bailed Well	Hose Bib	Hose Bib	Indoor Faucet	Indoor Faucet	Kitchen Sink
Well Setting			Well House	Well House	Well House	Well House	Well House	Well Seal	Community Well
Well Depth			Unknown	25	Unknown	Unknown	Unknown	150'	Unknown
Conductivity			46	89.4	226	350	240	174.5	306
Temp. °C			17.2	16.8	18.5	13.2	15.6	17.2	17.8
pH			**6.13**	7.32	8.1	7.36	7.54	8.09	7.48
Analyte	**Units**	**MCL Values**							
Aluminum	mg/L	0.05	0.017	ND	ND	ND	ND	ND	ND
Antimony	mg/L	0.006	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	0.01	ND	ND	ND	ND	ND	0.001	ND
Barium	mg/L	2	0.0323	0.036	0.432	0.591	0.636	0.466	0.768
Beryllium	mg/L	0.004	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	NA	3.67	9.24	13.7	18.5	16.3	11.5	21.7
Chromium	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	ND	ND	0.006	ND	ND
Copper	mg/L	1.3	0.0111	ND	ND	0.0453	ND	0.0022	ND
Iron	mg/L	0.3	0.112	ND	0.033	0.065	0.07	0.06	0.017
Lead	mg/L	0.015	0.0004	0.0002	ND	0.0015	ND	0.0004	ND
Magnesium	mg/L	NA	2.47	5.97	3.69	5.77	4.84	2.87	5.71
Manganese	mg/L	0.05	0.006	ND	0.018	0.031	0.02	0.013	0.045
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/L	NA	ND	ND	ND	ND	ND	0.0021	ND
Nickel	mg/L	NA	ND	0.0067	ND	0.0023	0.0028	0.002	ND
Potassium	mg/L	NA	0.971	2.03	1.39	1.83	1.96	1.28	2.01
Selenium	mg/L	0.05	ND	ND	ND	0.0014	0.0014	ND	ND
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	0.606	1.65	45.7	52.3	53.6	31.8	35.9
Strontium	mg/L	NA	0.0383	0.0766	0.366	0.479	0.561	0.515	0.905
Thallium	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/L	NA	0.001	ND	ND	ND	ND	ND	ND
Uranium	mg/L	0.03	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	5	0.045	0.014	ND	0.023	0.011	0.006	ND
MBAS	mg/L	0.5	0.007	0.013	0.009	ND	ND	0.008	0.006
Acidity, Total	mg/L	NA	4.9	4.6	ND	7.9	6.8	1.4	2.4
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	5.4	9.8	141	168	154	105	117
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	5.4	9.8	141	168	154	105	117
Chloride	mg/L	250	0.45	1.1	5.83	7.46	10.4	2.53	18
Fluoride	mg/L	4	ND	ND	0.1	0.2	0.23	0.12	0.06
Sulfate	mg/L	250	14.4	34.1	1.41	7.23	2.36	1.95	9.59
Total Dissolved Solids	mg/L	500	42	72	160	192	193	149	183
Total Coliform	NA	5.0%	ND	ND	ND	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-5. Hopkins Fork B/C and Prenter Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Hopkins Fork B**					**Hopkins Fk C**	**Prenter**
Sample ID			DW-14	DW-15	DW-16	DW-29	DW-30	DW-21	DW-27
Name									
Latitude			38.0244	38.02725	38.032583	38.0372	38.0392	38.011222	38.01628
Longitude			81.616833	81.6140830	81.6154722	81.6163	81.6159	81.611333	81.62486
Source			Indoor Faucet	Bailed Well	Hose Bib	Hose Bib	Indoor Faucet	Indoor Faucet	Kitchen Sink
Well Setting			Well House	Well House	Well House	Well House	Well House	Well Seal	Community Well
Well Depth			Unknown	25	Unknown	Unknown	Unknown	150'	Unknown
Conductivity			46	89.4	226	350	240	174.5	306
Temp. °C			17.2	16.8	18.5	13.2	15.6	17.2	17.8
pH			**6.13**	7.32	8.1	7.36	7.54	8.09	7.48
Analyte	**Units**	**MCL Values**							
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND

Yellow Highlight indicates value exceeds standard
* WV VRP Groundwater Value
NA- Not Applicable

Table 5-7. Surface Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Surface Water**								
Sample ID			SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-8	SW-8FD
Name			Big Jarrells Creek	Hopkins Fork	Lavinia Fork	Laurel Creek Watershed B	Sandlick Creek Upstream	Three Forks Branch	Sandlick Creek	Sandlick Creek Upstream	Sandlick Creek Upstream Field Duplicate
Latitude			38.01846	38.01836	38.04347	38.0755	38.08503	38.09266	38.09354	38.0844	38.0844
Longitude			81.62093	81.6198	81.6189	81.63945	81.65382	81.65353	81.63956	81.0655	81.0655
Conductivity			474	296	652	806	391	300	295	1680	1680
Temp. °C			18	18	18.9	16.4	13.4	16.2	14.8	*	*
pH			7.3	7.5	7.7	7.94	7.6	7.6	7.48	6.86	6.86
Analyte	**Units**	**MCL Values**									
Aluminum	mg/L	0.05	**0.162**	0.028	**0.086**	**0.33**	**0.437**	**0.085**	**0.293**	**0.221**	**0.169**
Antimony	mg/L	0.006	0.0002	ND	ND	0.0002	ND	ND	ND	ND	ND
Arsenic	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	mg/L	2	0.0474	0.0439	0.0359	0.0382	0.033	0.0225	0.0321	0.0827	0.0838
Beryllium	mg/L	0.004	0.0003	ND	0.0002	0.0004	0.0006	ND	0.0004	0.0002	ND
Cadmium	mg/L	0.005	ND	ND	ND	ND	0.0002	ND	ND	0.0004	0.0004
Calcium	mg/L	NA	47.1	31.7	33.3	76	34	2	26.4	142	140
Chromium	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/L	NA	ND	ND	0.005	0.006	0.008	ND	0.005	0.013	0.038
Copper	mg/L	1.3	ND	ND	0.0015	ND	ND	ND	ND	0.0024	0.0023
Iron	mg/L	0.3	0.193	0.066	0.063	0.108	0.135	0.121	0.19	**0.607**	**0.463**
Lead	mg/L	0.015	0.0004	ND	ND	0.0002	0.0002	0.0003	0.0004	0.0005	0.0005
Magnesium	mg/L	NA	25.2	16.9	35.2	58.2	23.6	1.94	17.8	84.2	84.1
Manganese	mg/L	0.05	**0.132**	0.01	**0.732**	**0.581**	**0.839**	0.009	**0.482**	**3.1**	**3.48**
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	0.0032	0.0011
Nickel	mg/L	NA	0.0104	0.0021	0.0192	0.0174	0.0223	ND	0.0142	0.046	0.0462
Potassium	mg/L	NA	5.44	3.25	3.51	5.83	2.93	1.04	2.43	8.21	8.48
Selenium	mg/L	0.05	0.0035	0.0019	ND	0.0031	0.0025	ND	0.002	0.005	0.0051
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	8.04	3.37	38.9	12.7	2.41	0.61	2.18	8.68	8.49
Strontium	mg/L	NA	0.843	0.701	0.517	0.869	0.4	0.0173	0.337	1.25	1.28
Thallium	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/L	NA	0.0028	0.0017	0.0033	0.0045	0.003	0.002	0.0032	0.0177	0.0183
Uranium	mg/L	0.03	ND	ND	ND	0.0013	ND	ND	0.0012	ND	ND
Vanadium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	5	0.035	ND	0.018	0.019	0.038	0.004	0.021	0.044	0.041
MBAS	mg/L	0.5	0.008	0.016	0.013	0.014	0.007	ND	0.007	ND	ND
Acidity, Total	mg/L	NA	6.4	8.8	13	13.3	4.8	2.7	6.9	6.7	8.9
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	52.8	44.7	54.7	66.6	20.5	4.9	17.3	51.8	43.4
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alkalinity, Total (As CaCO3)	mg/L	NA	52.8	44.7	54.7	66.6	20.5	4.9	17.3	51.8	43.4
Chloride	mg/L	250	1.71	9.08	20.8	6.84	1.8	0.74	1.75	3.24	2.9
Fluoride	mg/L	4	ND	0.04	0.08	0.06	0.04	ND	ND	0.13	0.17
Sulfate	mg/L	250	104	194	**276**	**395**	170	10.5	124	**644**	**828**
Total Coliform	NA	5.0%	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fecal Coliform, as E. coli	NA	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Dissolved Solids	mg/L	500	218	362	**500**	**616**	276	23	223	**896**	**849**
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 5-7. Surface Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Surface Water**								
Sample ID			SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-8	SW-8FD
Name			Big Jarrells Creek	Hopkins Fork	Lavinia Fork	Laurel Creek Watershed B	Sandlick Creek Upstream	Three Forks Branch	Sandlick Creek	Sandlick Creek Upstream	Sandlick Creek Upstream Field Duplicate
Latitude			38.01846	38.01836	38.04347	38.0755	38.08503	38.09266	38.09354	38.0844	38.0844
Longitude			81.62093	81.6198	81.6189	81.63945	81.65382	81.65353	81.63956	81.0655	81.0655
Conductivity			474	296	652	806	391	300	295	1680	1680
Temp. °C			18	18	18.9	16.4	13.4	16.2	14.8	*	*
pH			7.3	7.5	7.7	7.94	7.6	7.6	7.48	6.86	6.86
Analyte	**Units**	**MCL Values**									
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 5-8. Mine Related Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			**Mine Discharge**								**Valley Fill**		**Slurry Related**				
Sample ID			MD-1	MD-2	MD-3	MD-4	MD-5	MD-6	MD-7	MD-8	VF-1	VF2	DW-01	DW-02	DW-03	SL-1	IW-1
Name			Davison Mine, Outlet 006	Stockton Seam	Stockton Seam	Coalburg Seam	Buffalo Seam	Ferrell Mine	Justice Mine	Outlet 20 - Boone Co. Landfill	Seep	Seep	Revolution Coal, Impoundment Decant Water	Pine Ridge Coal Co., Lotts Fork Impoundment	Pine Ridge Coal Co., Lotts Fork Impoundment	Revolution Coal Raw Slurry	Revolution Coal, Injectate
Latitude			38.0173	38.0173	38.0295	38.0425	38.0597	38.0001	38.0306	38.0275	38.0417	38.0462	38.0259	38.0045	38.00564	-	38.0259
Longitude			81.7537	81.7136	81.709	81.6927	81.6781	81.7411	81.6484	81.64522	81.6938	81.6928	81.7445	81.64059	81.64018	-	81.7445
Conductivity			NA	NA	NA	NA	NA	NA	NA	625	NA	NA	-	825	465	NA	NA
Temp. °C			NA	NA	NA	NA	NA	NA	NA	15	NA	NA	28.5	17.5	18.9	NA	NA
pH			NA	NA	NA	NA	NA	NA	NA	7.12	NA	NA	7.82	7.72	6.81	NA	NA
Analyte	**Units**	**MCL Values**															
Aluminum	mg/L	0.05	ND	**0.422**	ND	0.019	ND	**0.067**	ND	0.044	**2.81**	**24.1**	0.024	ND	ND	**27.8**	**0.415**
Antimony	mg/L	0.006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0014	0.0003	ND	0.0008	0.0013
Arsenic	mg/L	0.01	0.0011	0.0011	0.0011	ND	ND	0.001	0.003	ND	ND	ND	0.0013	ND	ND	**0.0248**	0.0016
Barium	mg/L	2	0.11	0.022	0.0496	0.0245	0.0214	0.292	0.0352	0.0282	0.0258	0.0221	0.105	0.0153	0.0194	0.255	0.123
Beryllium	mg/L	0.004	ND	0.0006	ND	0.0003	ND	ND	ND	0.0013	**0.0044**	**0.0206**	ND	ND	ND	**0.0347**	ND
Cadmium	mg/L	0.005	ND	0.0003	ND	ND	ND	ND	ND	0.0003	0.0018	0.0027	0.0002	ND	ND	0.001	ND
Calcium	mg/L	NA	18.7	70.8	58.5	171	175	10.2	17.1	85.1	103	169	37.8	95.9	101	755	36.5
Chromium	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0017	ND	ND	ND	0.0531	ND
Cobalt	mg/L	NA	ND	0.024	0.008	0.005	0.004	ND	0.003	0.011	0.036	0.663	0.01	0.004	0.007	0.18	0.007
Copper	mg/L	1.3	ND	0.0071	0.0013	0.0017	0.0014	0.0016	0.0091	0.0028	0.0027	0.014	0.0024	ND	ND	0.027	0.0105
Iron	mg/L	0.3	0.055	0.271	0.164	0.053	0.03	**0.484**	0.183	0.278	0.069	0.271	0.023	0.026	**1.85**	**179**	**0.486**
Lead	mg/L	0.015	ND	0.0004	ND	ND	ND	0.0009	0.0005	0.0005	0.0003	0.0081	0.0014	ND	ND	**0.0669**	0.0028
Magnesium	mg/L	NA	5.26	35.3	23.2	82.9	125	3.48	8.47	45.5	164	245	15.5	40.1	41.9	47.3	16.5
Manganese	mg/L	0.05	0.016	**0.543**	**0.181**	**0.103**	**0.532**	**0.053**	0.025	**0.89**	**10.1**	**44.3**	0.044	0.04	**1.52**	**5.68**	**0.258**
Mercury	mg/L	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.002**	ND
Molybdenum	mg/L	NA	0.0033	ND	ND	ND	0.0012	0.0075	0.0061	ND	ND	0.0019	0.0104	ND	ND	0.0031	0.0053
Nickel	mg/L	NA	ND	0.0504	0.0199	0.027	0.0217	0.0034	0.0088	0.0319	0.278	0.743	0.0136	0.0034	0.0064	0.215	0.0107
Potassium	mg/L	NA	5.82	8.31	7.16	12.2	9.03	8.75	11.1	10	9.64	10.4	11.8	13.5	14.2	57.1	8.22
Selenium	mg/L	0.05	ND	0.0022	0.0027	0.0058	0.0054	ND	0.0012	0.0051	0.0035	0.0151	0.0066	0.0011	ND	0.0179	0.0016
Silver	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	NA	214	9.53	5.57	9.3	9.25	427	59.7	6.49	3.19	5.32	182	33	33.5	454	94.6
Strontium	mg/L	NA	0.415	1.28	1.11	4.16	2.4	0.485	1.18	1.15	0.365	0.51	0.652	2.04	2.02	12.5	0.8
Thallium	mg/L	0.002	ND	0.0002	ND	0.0004	0.0002	ND	ND	0.0004	ND	0.0005	0.0003	ND	0.0002	0.0012	ND
Tin	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/L	NA	0.001	0.006	0.0036	0.0135	0.0152	ND	0.0082	0.0029	0.0198	0.04	0.006	0.0036	0.0064	0.0077	0.0063
Uranium	mg/L	0.03	ND	ND	ND	ND	ND	0.0018	0.0024	ND	ND	0.002	0.002	ND	ND	0.0034	0.001
Vanadium	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0629	ND
Zinc	mg/L	5	0.011	0.112	0.024	0.051	0.06	ND	0.007	0.059	0.362	0.962	0.013	ND	0.004	0.299	0.018
MBAS	mg/L	0.5	0.013	0.013	ND	ND	0.005	ND	0.116	0.02	ND	0.008	0.013	0.012	0.005	ND	0.007
Acidity, Total	mg/L	NA	10.4	13.9	10.5	9.9	4.9	10.2	4.8	6	37.5	183	2.7	5.9	32.2	28.9	ND
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	461	14.7	99.8	139	101	752	489	62.6	ND	ND	131	114	116	929	141
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.1
Alkalinity, Total (As CaCO3)	mg/L	NA	461	14.7	99.8	139	101	752	489	62.6	ND	ND	131	114	116	929	146
Chloride	mg/L	250	34.3	5.87	2.04	0.83	1.58	89	175	12.1	1.67	4.05	113	9.65	9.93	**270**	27.3
Fluoride	mg/L	4	1.2	0.13	0.12	0.15	0.14	1.39	0.95	0.09	0.2	0.76	0.33	0.05	0.05	0.68	0.29
Sulfate	mg/L	250	36.7	**260**	96.8	**578**	**705**	16.9	**521**	**340**	**968**	**1500**	**250**	**366**	**370**	**340**	153
Total Coliform	NA	5.0%	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	ND	NA	NA
Fecal Coliform, as E. coli	NA	0	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	ND	NA	NA
Total Dissolved Solids	mg/L	500	**623**	483	321	**1040**	**1160**	**1200**	**1740**	**643**	**1240**	**1760**	**663**	**722**	**749**	**795**	411
1,1,1,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	µg/L	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	µg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	µg/L	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromoethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Isopropyltoluene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	*5500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 5-8. Mine Related Water Quality Data
Prenter Road Hydrologic Evaluation

Watershed			Mine Discharge								Valley Fill		Slurry Related				
Sample ID			MD-1	MD-2	MD-3	MD-4	MD-5	MD-6	MD-7	MD-8	VF-1	VF2	DW-01	DW-02	DW-03	SL-1	IW-1
Name			Davison Mine, Outlet 006	Stockton Seam	Stockton Seam	Coalburg Seam	Buffalo Seam	Ferrell Mine	Justice Mine	Outlet 20 - Boone Co. Landfill	Seep	Seep	Revolution Coal, Impoundment Decant Water	Pine Ridge Coal Co., Lotts Fork Impoundment	Pine Ridge Coal Co., Lotts Fork Impoundment	Revolution Coal Raw Slurry	Revolution Coal, Injectate
Latitude			38.0173	38.0173	38.0295	38.0425	38.0597	38.0001	38.0306	38.0275	38.0417	38.0462	38.0259	38.0045	38.00564	-	38.0259
Longitude			81.7537	81.7136	81.709	81.6927	81.6781	81.7411	81.6484	81.64522	81.6938	81.6928	81.7445	81.64059	81.64018	-	81.7445
Conductivity			NA	NA	NA	NA	NA	NA	NA	625	NA	NA	-	825	465	NA	NA
Temp. °C			NA	NA	NA	NA	NA	NA	NA	15	NA	NA	28.5	17.5	18.9	NA	NA
pH			NA	NA	NA	NA	NA	NA	NA	7.12	NA	NA	7.82	7.72	6.81	NA	NA
Analyte	**Units**	**MCL Values**															
Acrolein	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	µg/L	*0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	µg/L	*0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	µg/L	*8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	µg/L	*8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	µg/L	*1000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	µg/L	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	µg/L	*3.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	*0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	µg/L	*190	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	µg/L	*0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	µg/L	*390	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/L	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	µg/L	*0.86	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodomethane	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl tert-butyl ether	µg/L	*17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	µg/L	*5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	µg/L	*61	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	µg/L	*370	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	µg/L	*6.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	µg/L	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	µg/L	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	µg/L	*22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	µg/L	*410	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	µg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 6-1. WATER QUALITY COMPARISON

TRIAD DATA vs USGS STUDY

Parameter	Units	MCL	USGS Maximum	TEI Maximum	USGS Median	TEI Median
Conductivity	umhos/cm	NA	1090	920	360	306
pH	s.u.	NA	8.9	8.5	7	7.6
Aluminum	ml/L	0.05	20	0.061	0.003	0.0225
Antimony	ml/L	0.006	<0.001	0.0003	<0.001	0.0002
Arsenic	ml/L	0.01	0.016	0.0025	<0.001	0.001
Barium	ml/L	2	1.2	1.01	0.206	0.453
Beryllium	mg/L	0.004	<0.001	<0.001	<0.001	<0.001
Cadmium	ml/L	0.005	<0.001	<0.001	<0.001	<0.001
Calcium	ml/L	NA	190	74.7	24	14.6
Chromium	ml/L	0.1	0.0067	<0.001	0.0029	<0.001
Cobalt	mg/L	NA	0.0089	0.006	<0.001	0.004
Copper	ml/L	1.3	0.085	0.138	<0.001	0.0045
Iron	ml/L	0.3	22200	5.78	0.145	0.132
Lead	ml/L	0.015	0.0012	0.0338	<0.001	0.0009
Magnesium	mg/L	NA	32	27.5	5.8	4.84
Manganese	mg/L	0.05	1530	0.496	0.0985	0.0285
Molybdenum	mg/L	NA	0.055	0.0022	<0.001	0.0018
Nickel	mg/L	NA	0.017	0.0067	<0.001	0.00245
Potassium	mg/L	NA	4.5	3.54	1.4	1.74
Selenium	mg/L	0.05	0.07	0.0023	<0.001	0.0014
Silver	mg/L	0.1		<0.001	<0.001	<0.001
Sodium	mg/L	NA	117	191	19	40.1
Uranium	mg/L	0.03	0.0039	<0.001	<0.001	<0.001
Zinc	ml/L	5	0.521	0.979	0.0032	0.023
Bicarbonate	mg/L $CaCO_3$	NA	419	260	168	119
Carbonate	mg/L $CaCO_3$	NA	18	<0.01	<1	<0.01
Alkalinity	mg/L $CaCO_3$	NA	344	260	138	119
Chloride	ml/L	250	95	203	3.3	10
Fluoride	ml/L	4	1.4	0.68	0.155	0.17
Sulfate	ml/L	250	410	224	8.6	10.7
Total Coliform	P/A	0.05	420	<1	<1	<1
Fecal Coliform	P/A	0	<1	<1	<1	<1
Total Dissolved Solids	ml/L	500	836	734	212	190

FIGURES

TRIAD ENGINEERING, INC.

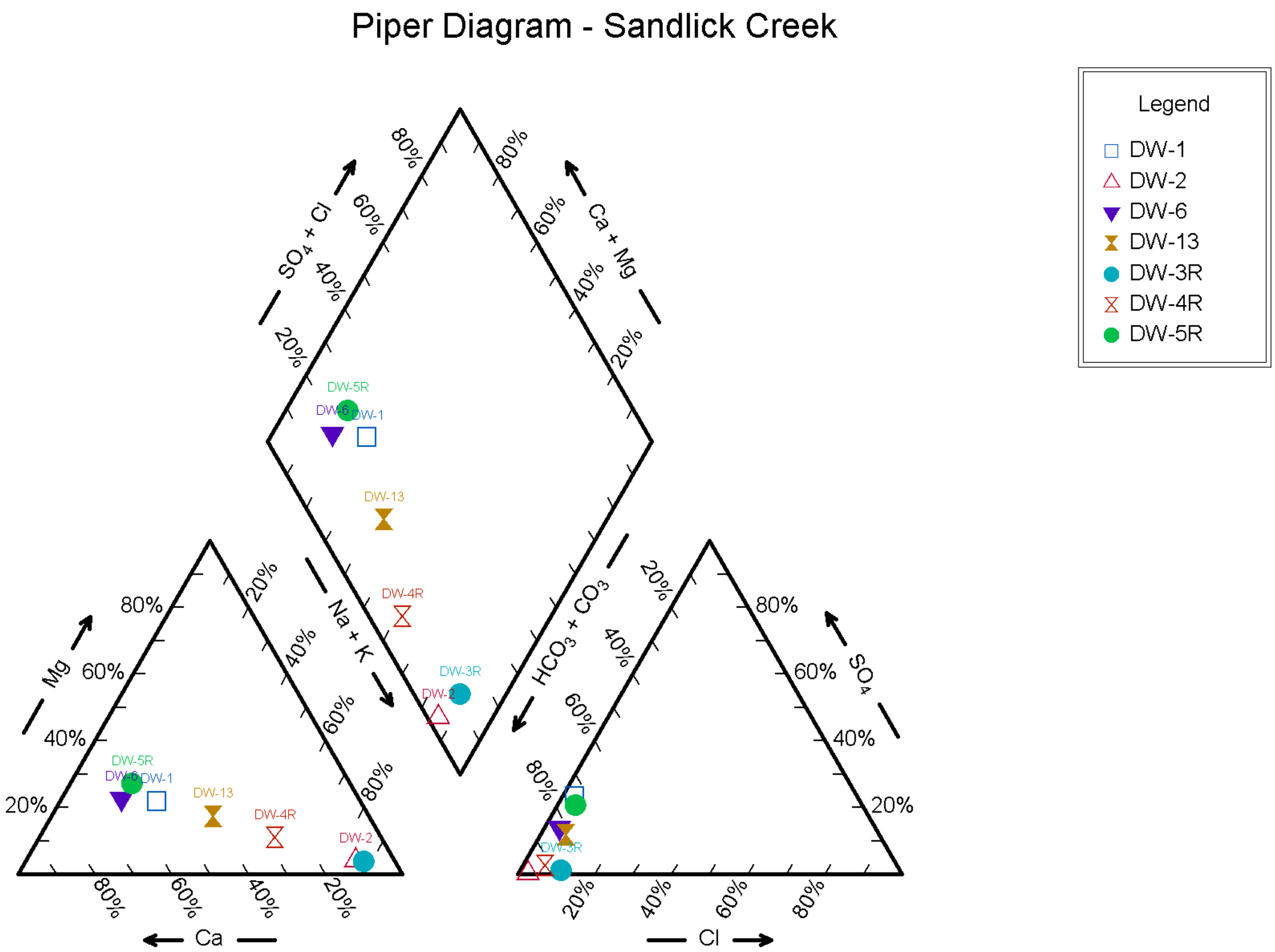

Piper Diagram - Sandlick Creek
Legend
□ DW-1
△ DW-2
▼ DW-6
⧗ DW-13
● DW-3R
⧖ DW-4R
● DW-5R
SO₄ + Cl
Ca + Mg
Na + K
HCO₃ + CO₃
Mg
Ca
Cl
SO₄
20%
40%
60%
80%
DW-5R
DW-6
DW-1
DW-13
DW-4R
DW-3R
DW-2

Figure 5-1

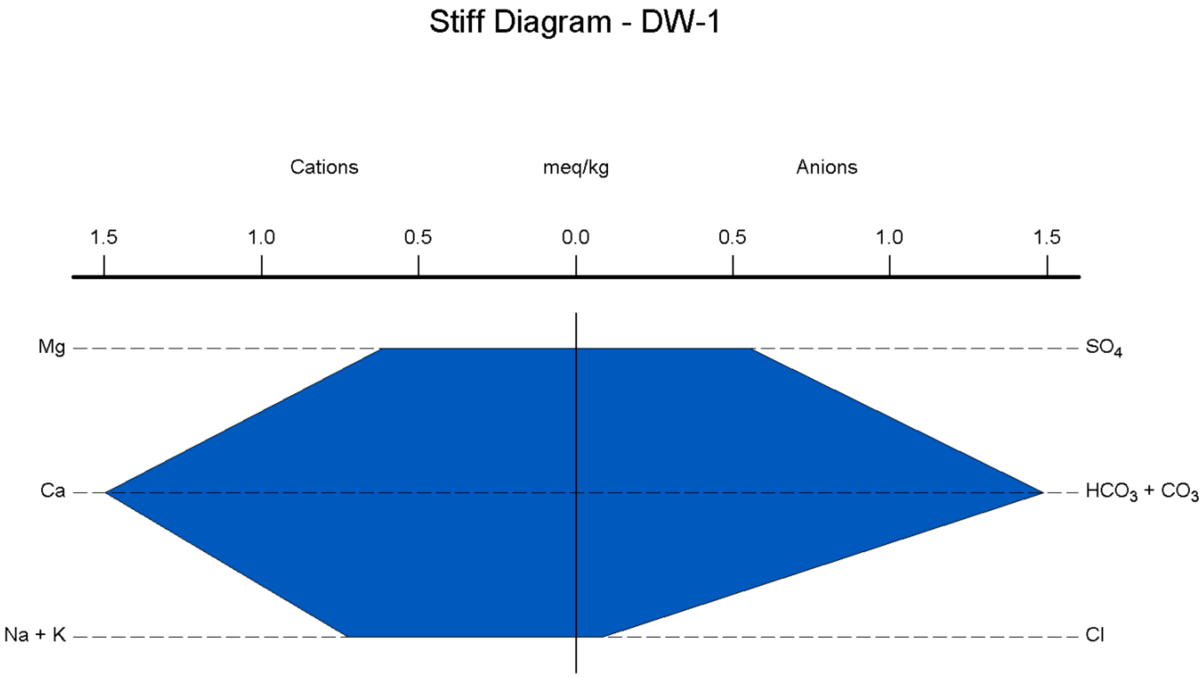


Figure 5-2

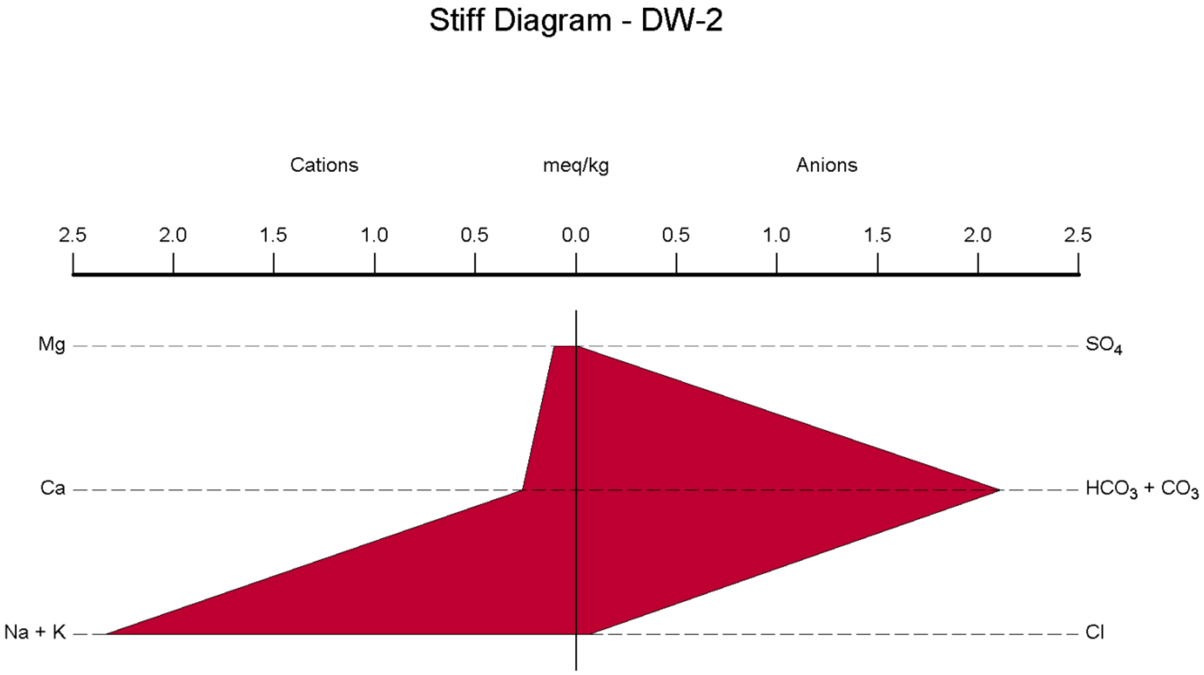


Figure 5-3

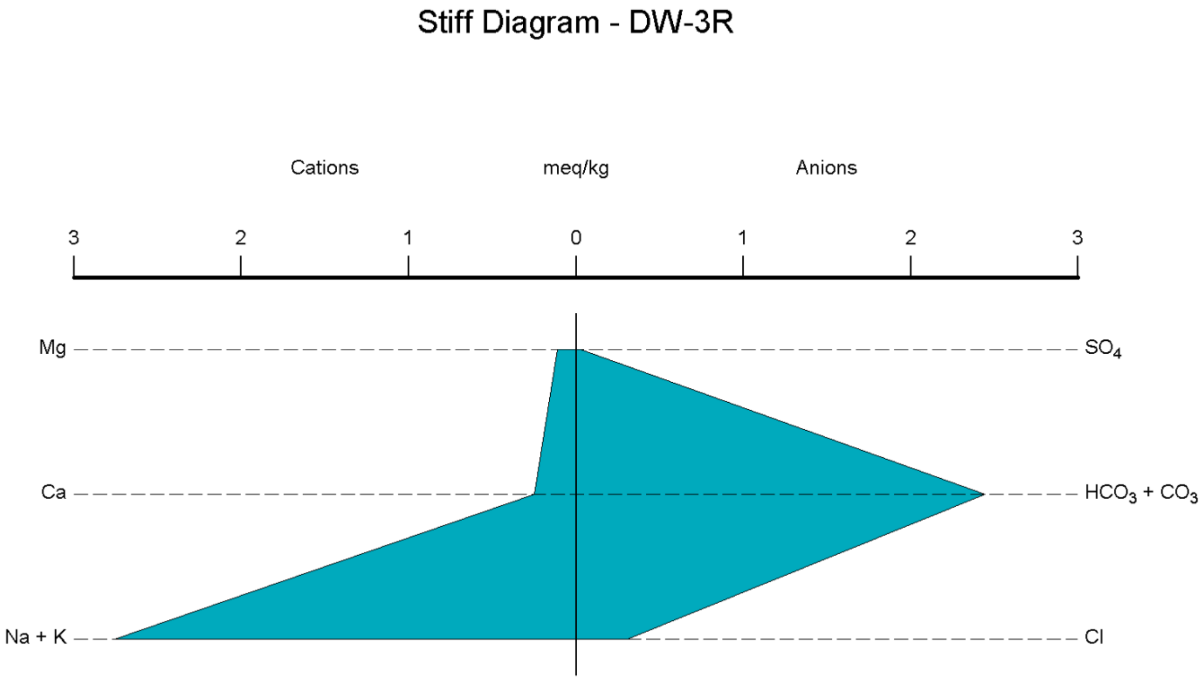


Figure 5-4

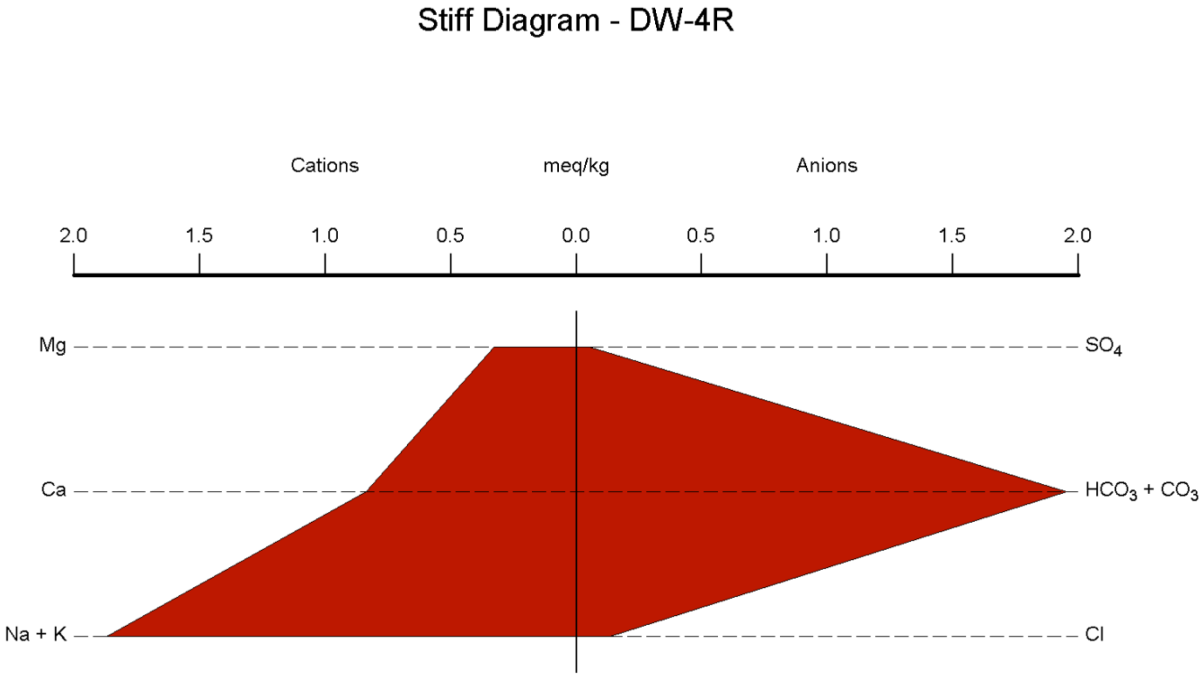


Figure 5-5

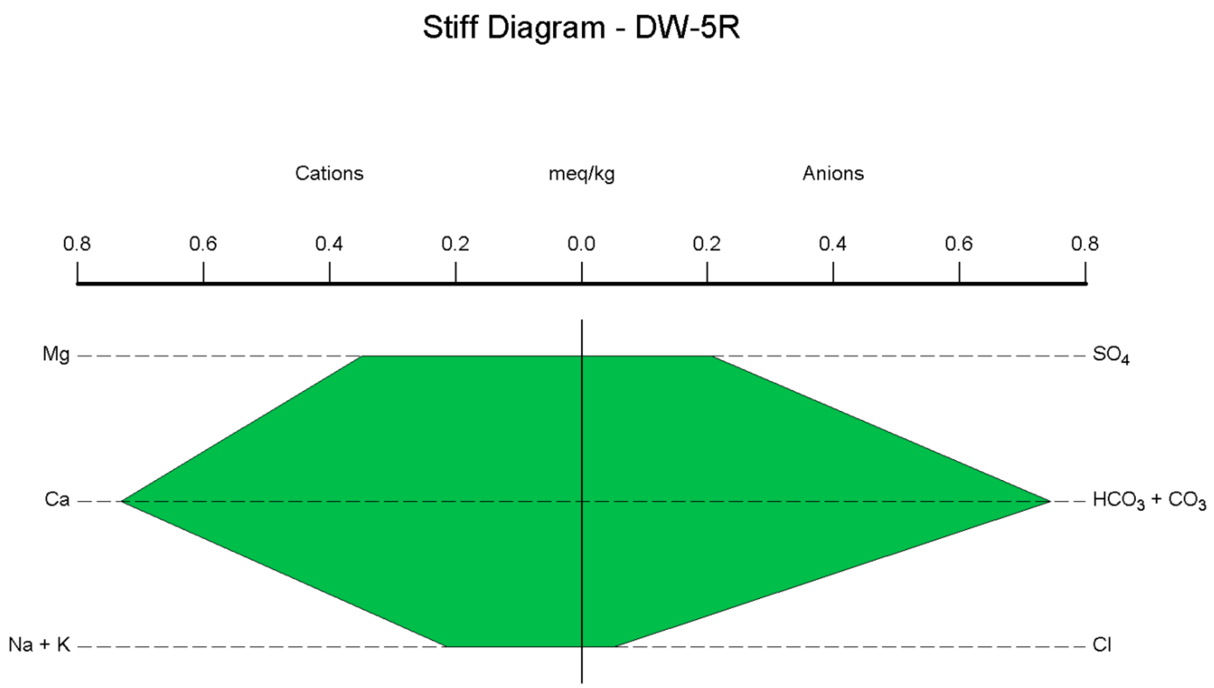


Figure 5-6

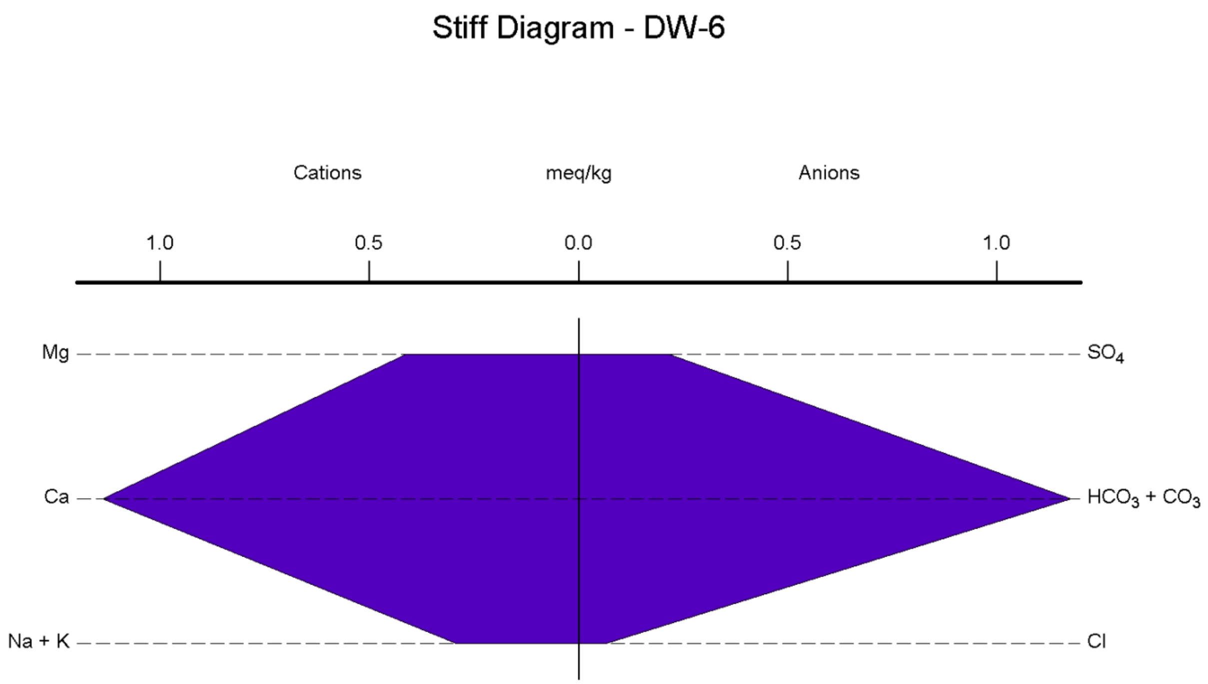


Figure 5-7

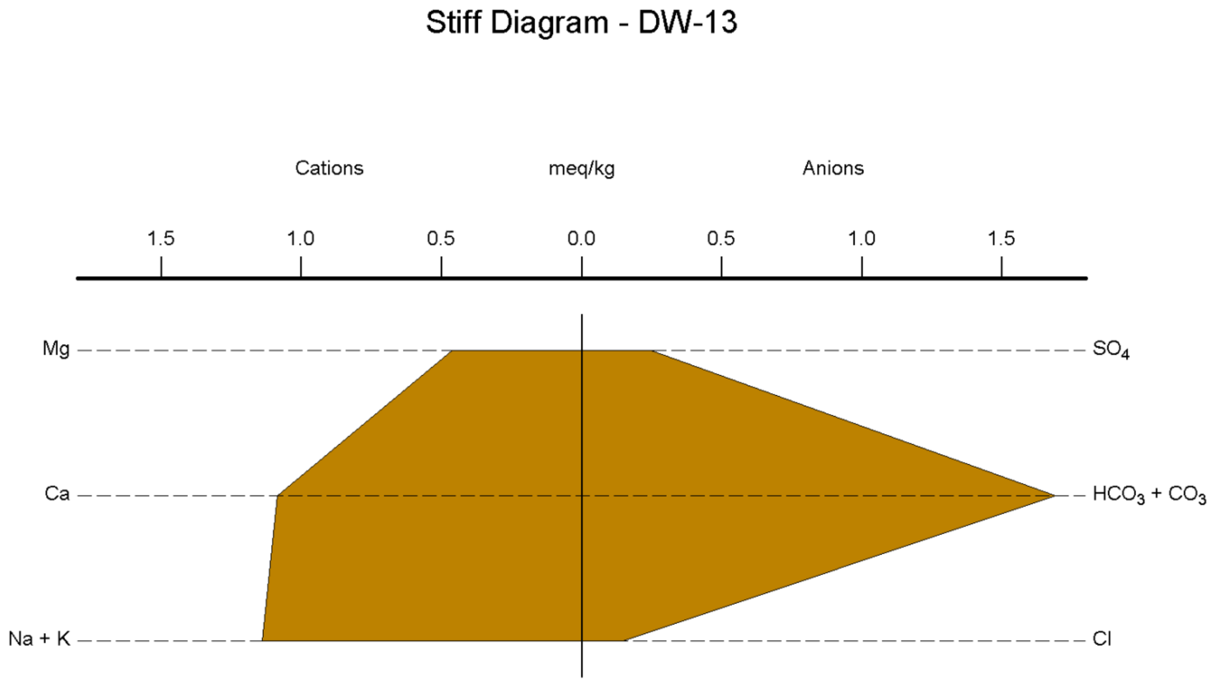

Stiff Diagram - DW-13
Cations
meq/kg
Anions
1.5
1.0
0.5
0.0
0.5
1.0
1.5
Mg
Ca
Na + K
SO_4
$HCO_3 + CO_3$
Cl

Figure 5-8

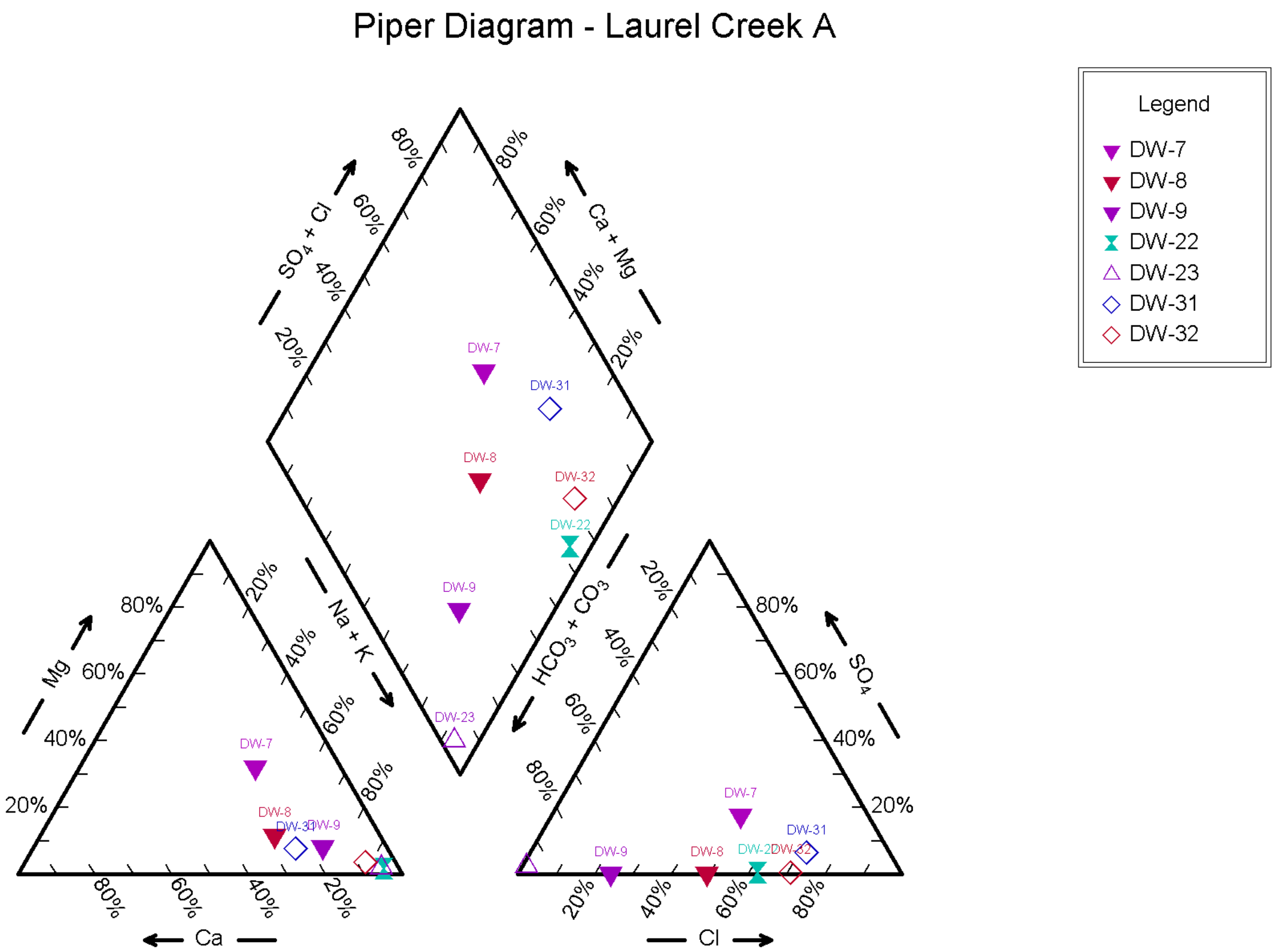

Piper Diagram - Laurel Creek A
Legend
▼ DW-7
▼ DW-8
▼ DW-9
⧗ DW-22
△ DW-23
◇ DW-31
◇ DW-32
SO$_4$ + Cl
Ca + Mg
Na + K
HCO$_3$ + CO$_3$
Mg
SO$_4$
Ca
Cl
20%
40%
60%
80%
DW-7
DW-8
DW-9
DW-22
DW-23
DW-31
DW-32

Figure 5-9

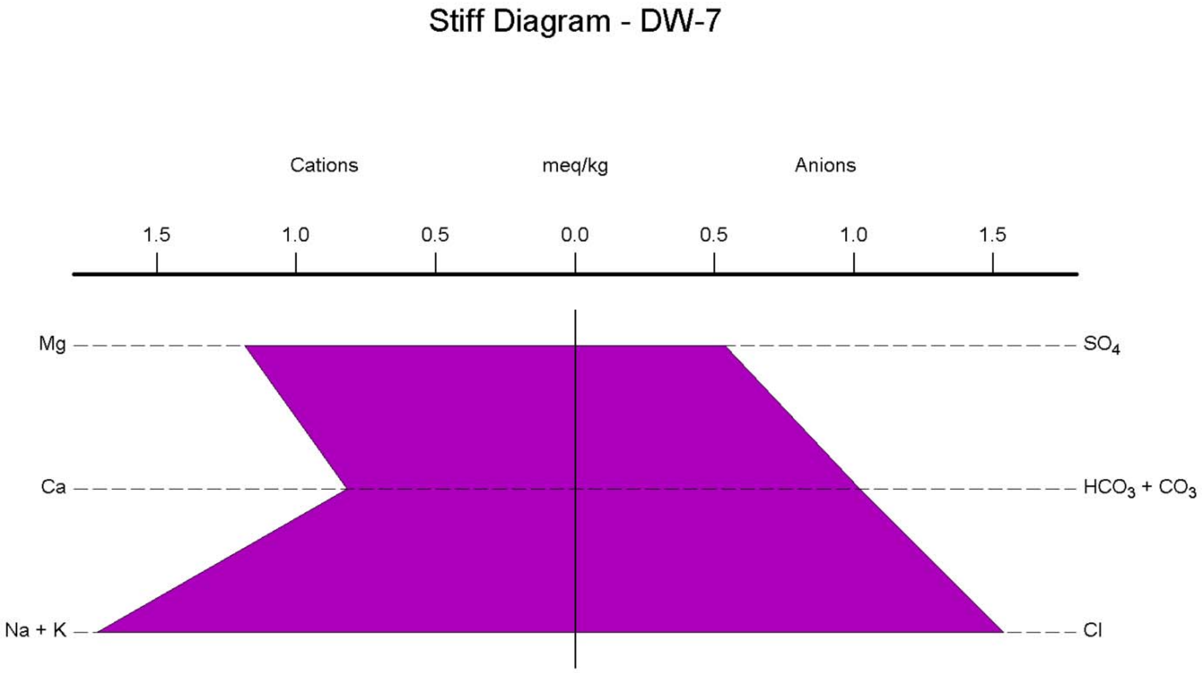


Figure 5-10

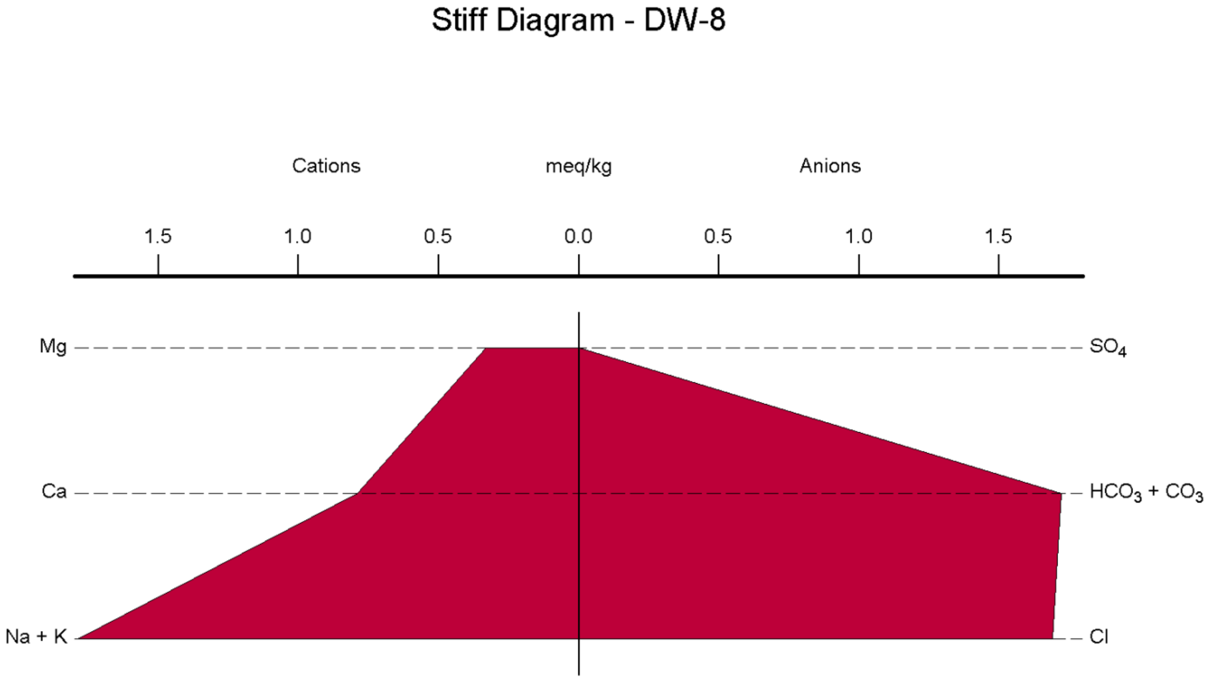


Figure 5-11

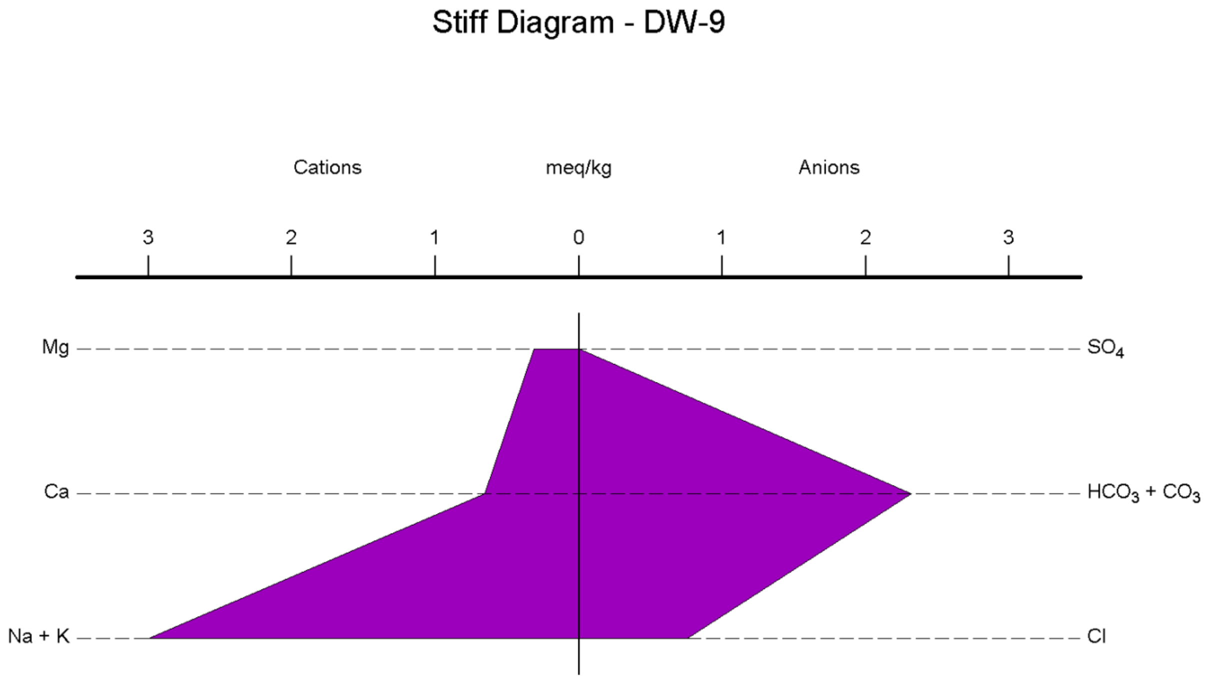


Figure 5-12

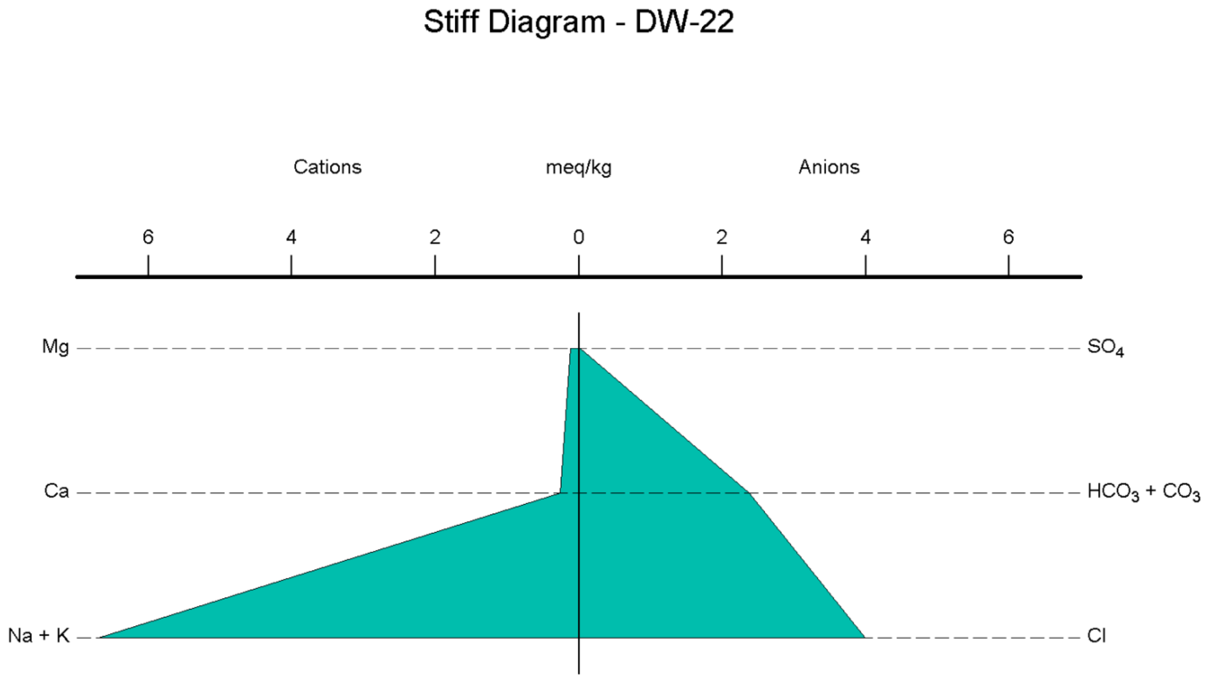


Figure 5-13

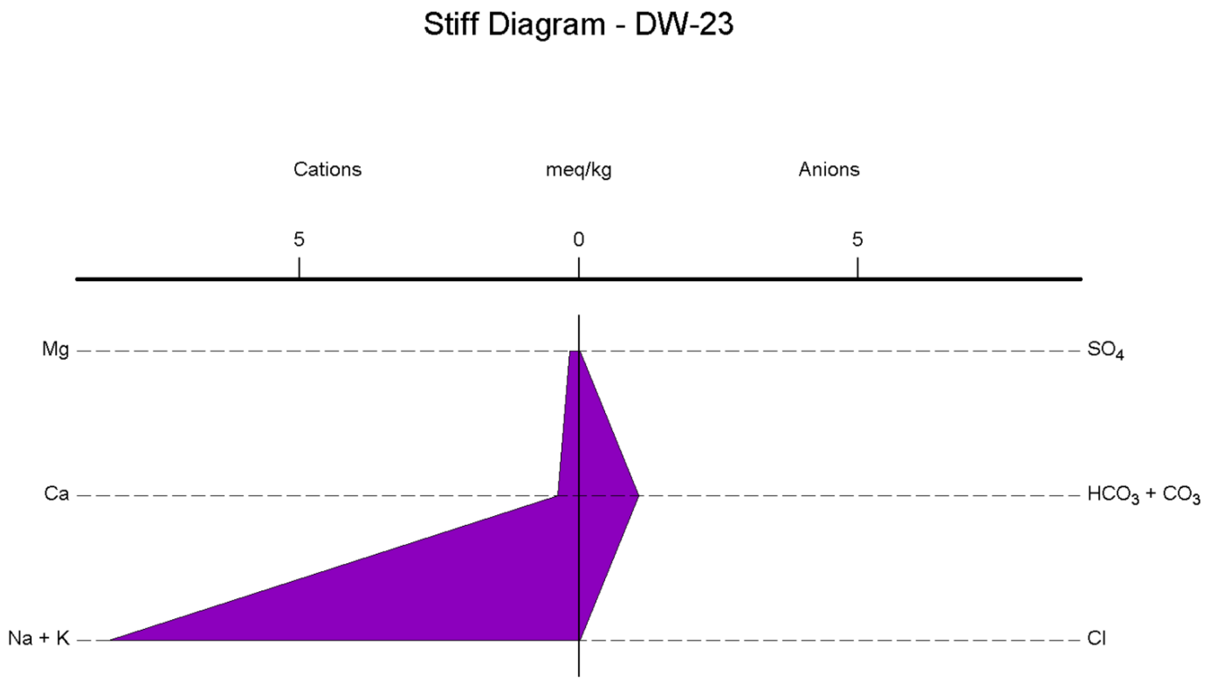


Figure 5-14

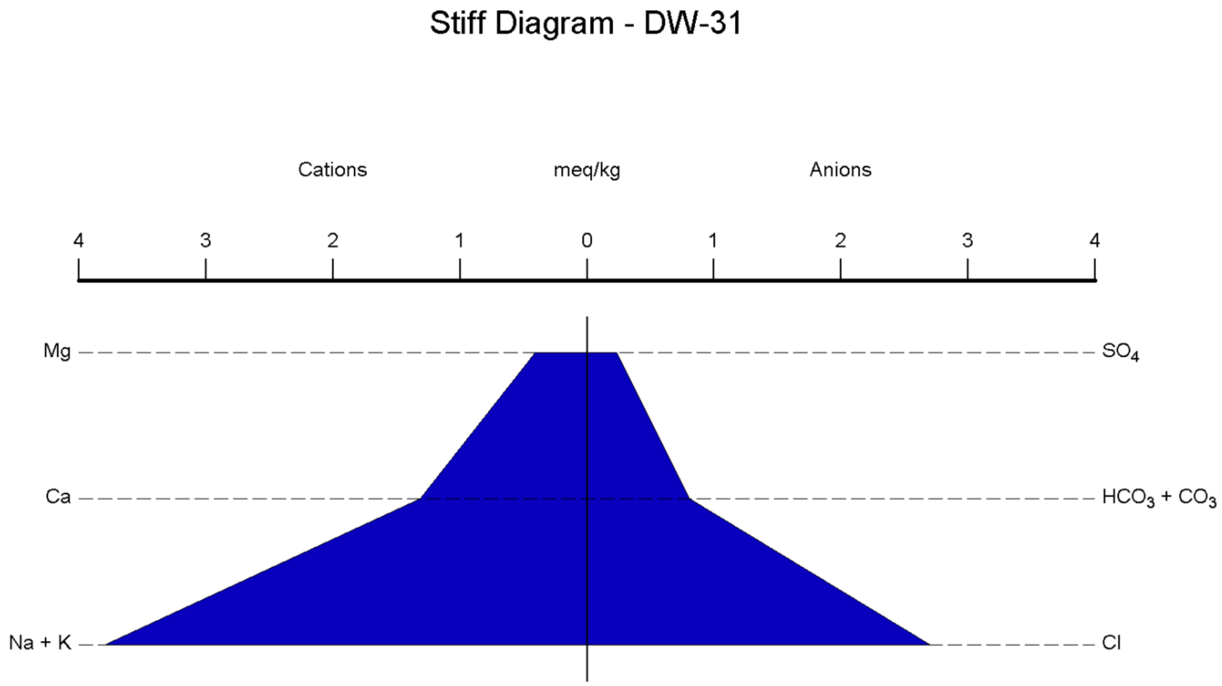


Figure 5-15

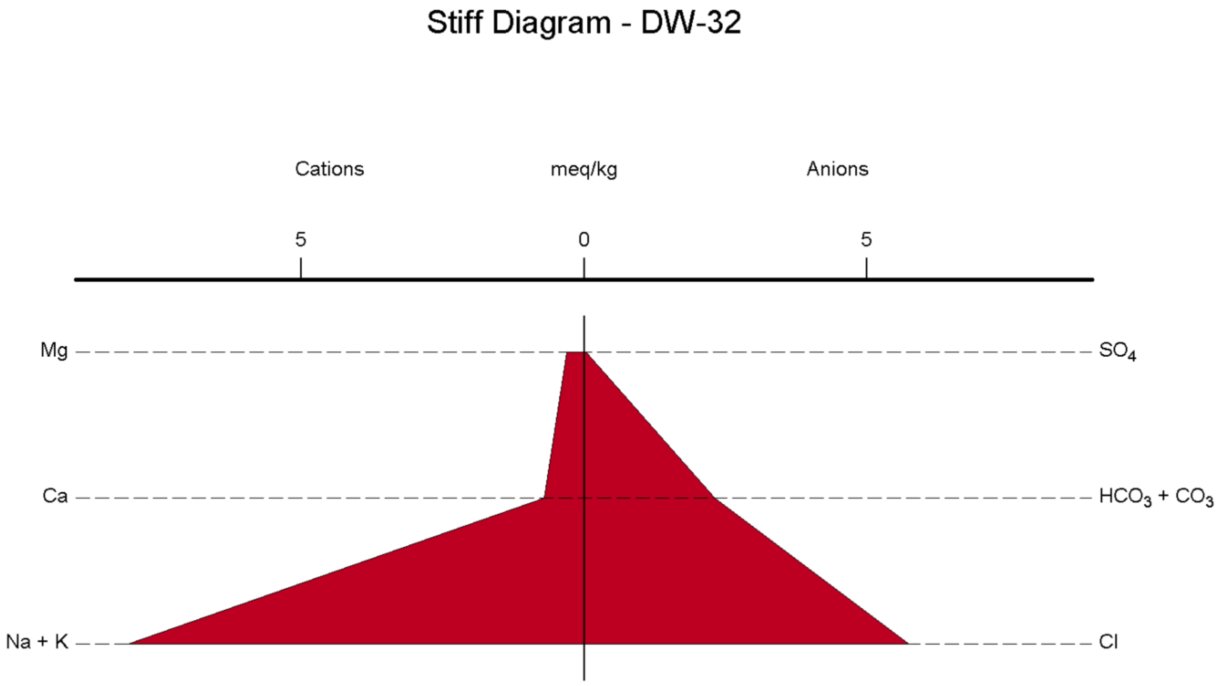

Stiff Diagram - DW-32
Cations
meq/kg
Anions
5
0
5
Mg
Ca
Na + K
SO4
HCO3 + CO3
Cl

Figure 5-16

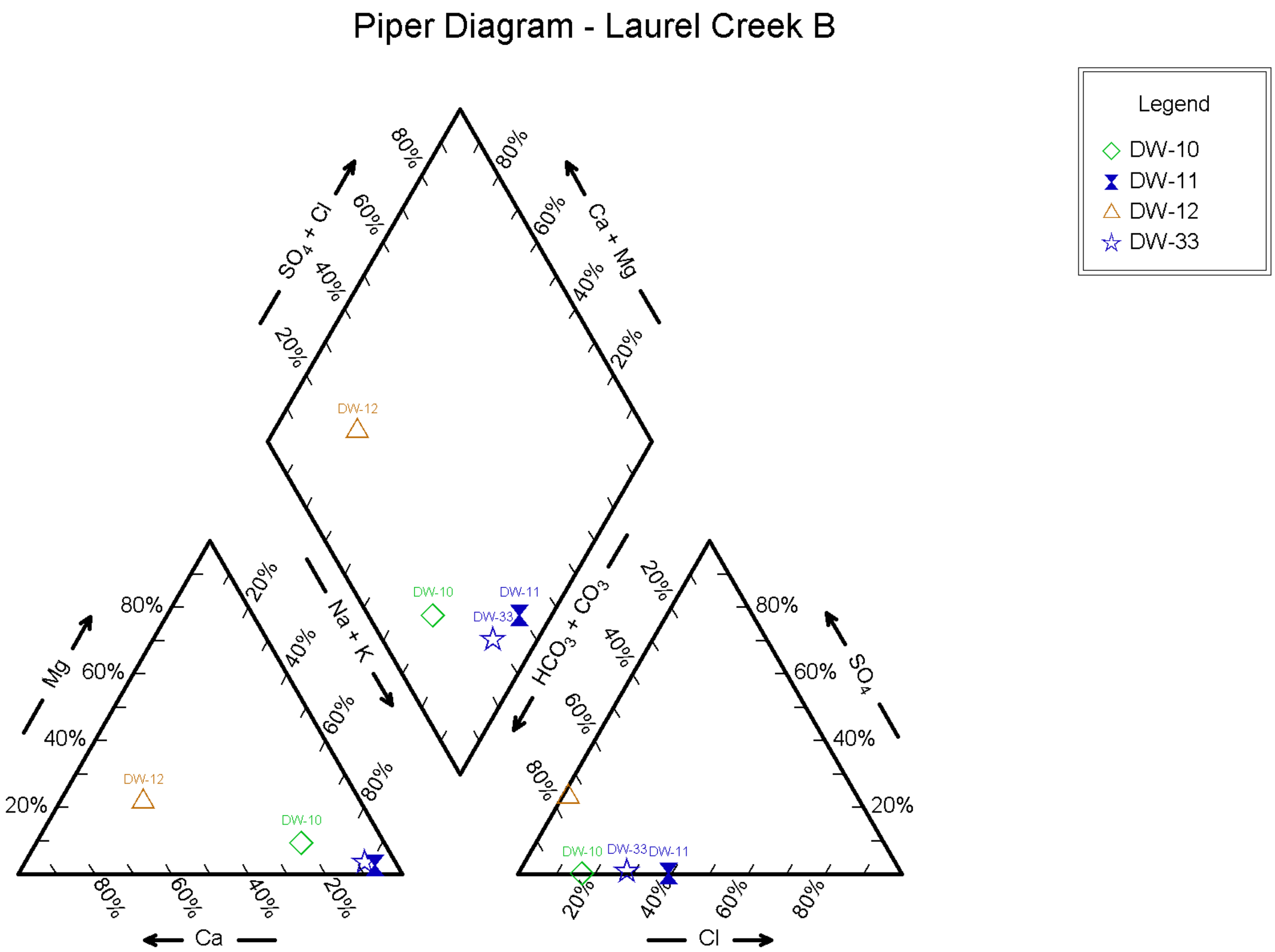

Piper Diagram - Laurel Creek B
Legend
◇ DW-10
⧗ DW-11
△ DW-12
☆ DW-33
SO₄ + Cl
Ca + Mg
Na + K
HCO₃ + CO₃
Mg
Ca
Cl
SO₄
20%
40%
60%
80%
DW-10
DW-11
DW-12
DW-33

Figure 5-17

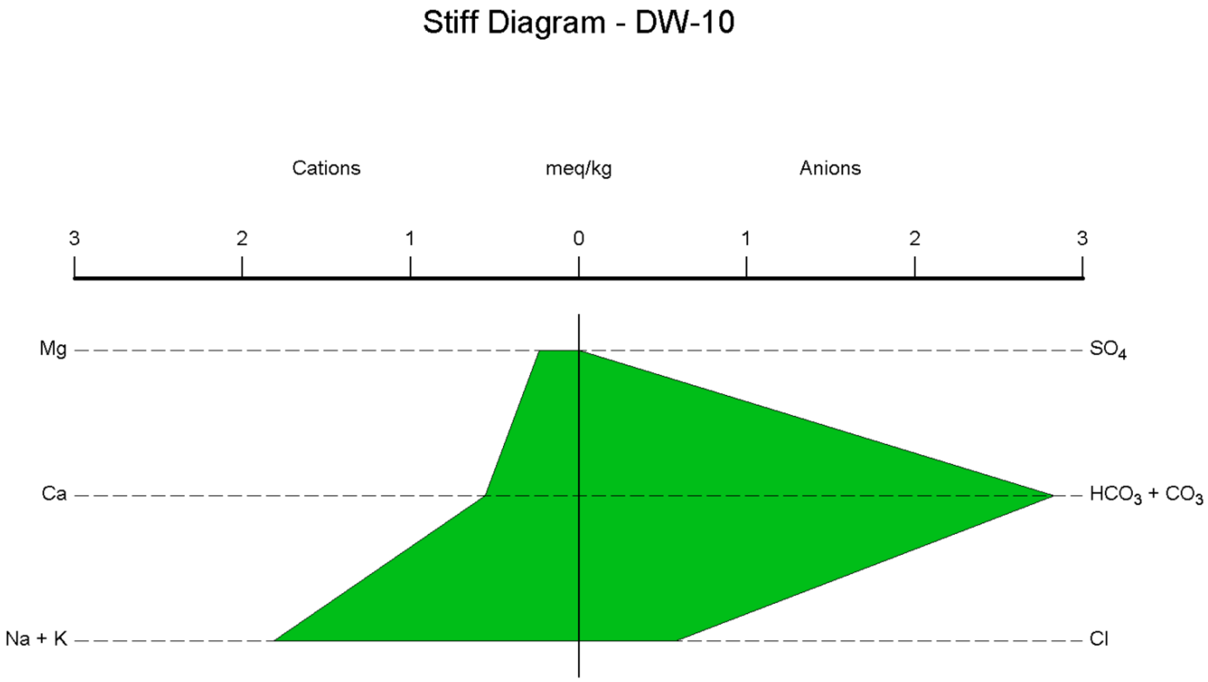


Figure 5-18

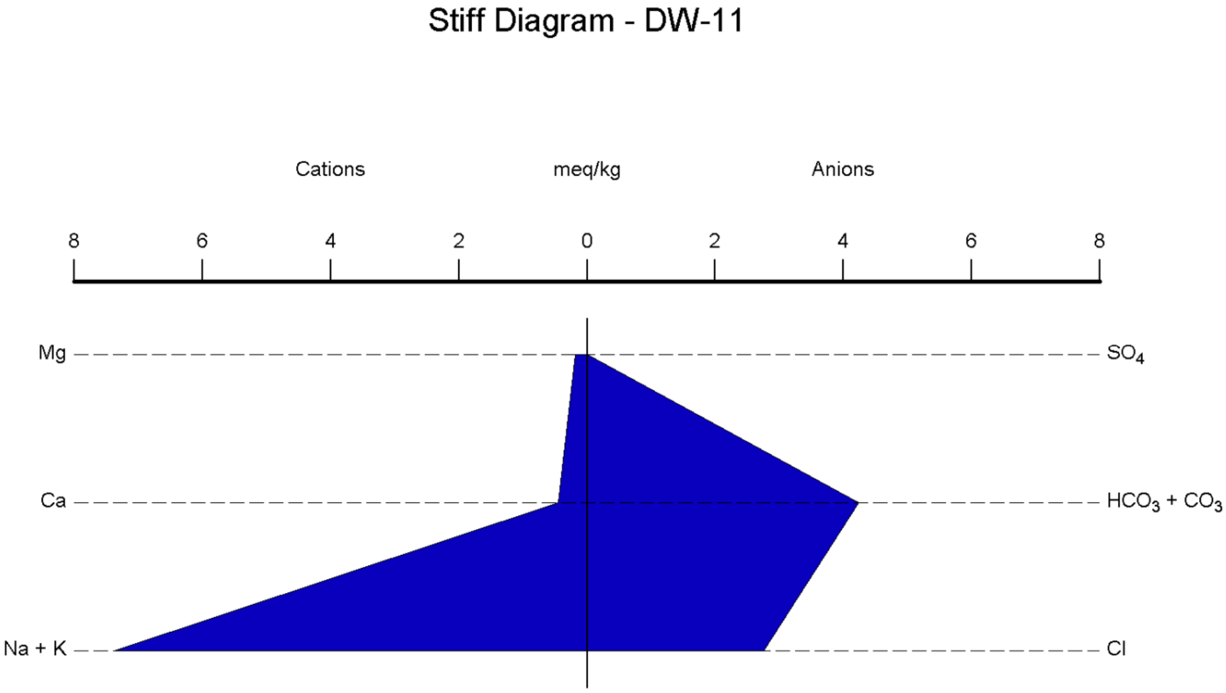


Figure 5-19

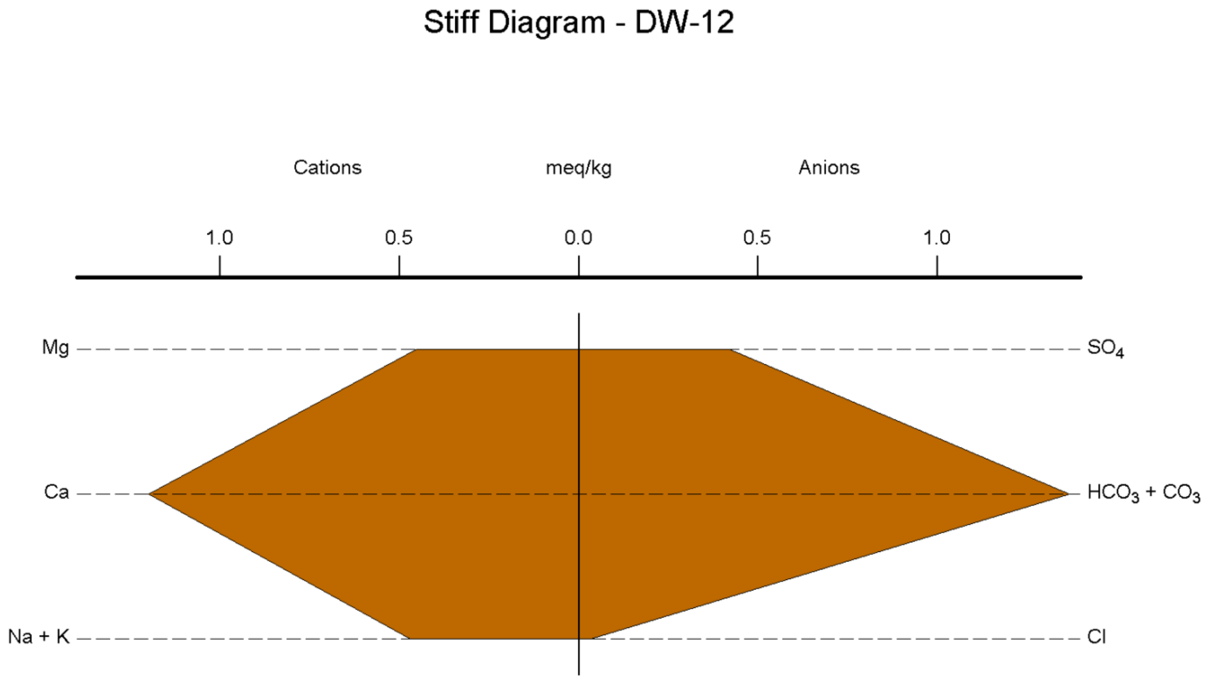


Figure 5-20

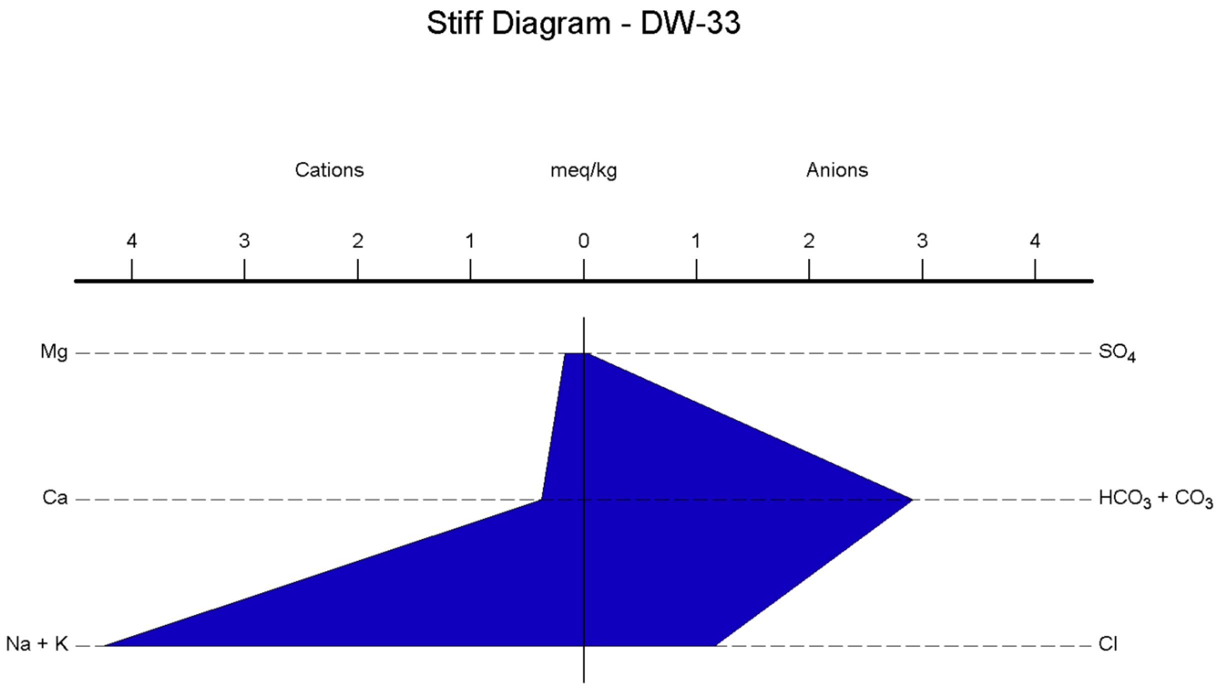


Figure 5-21

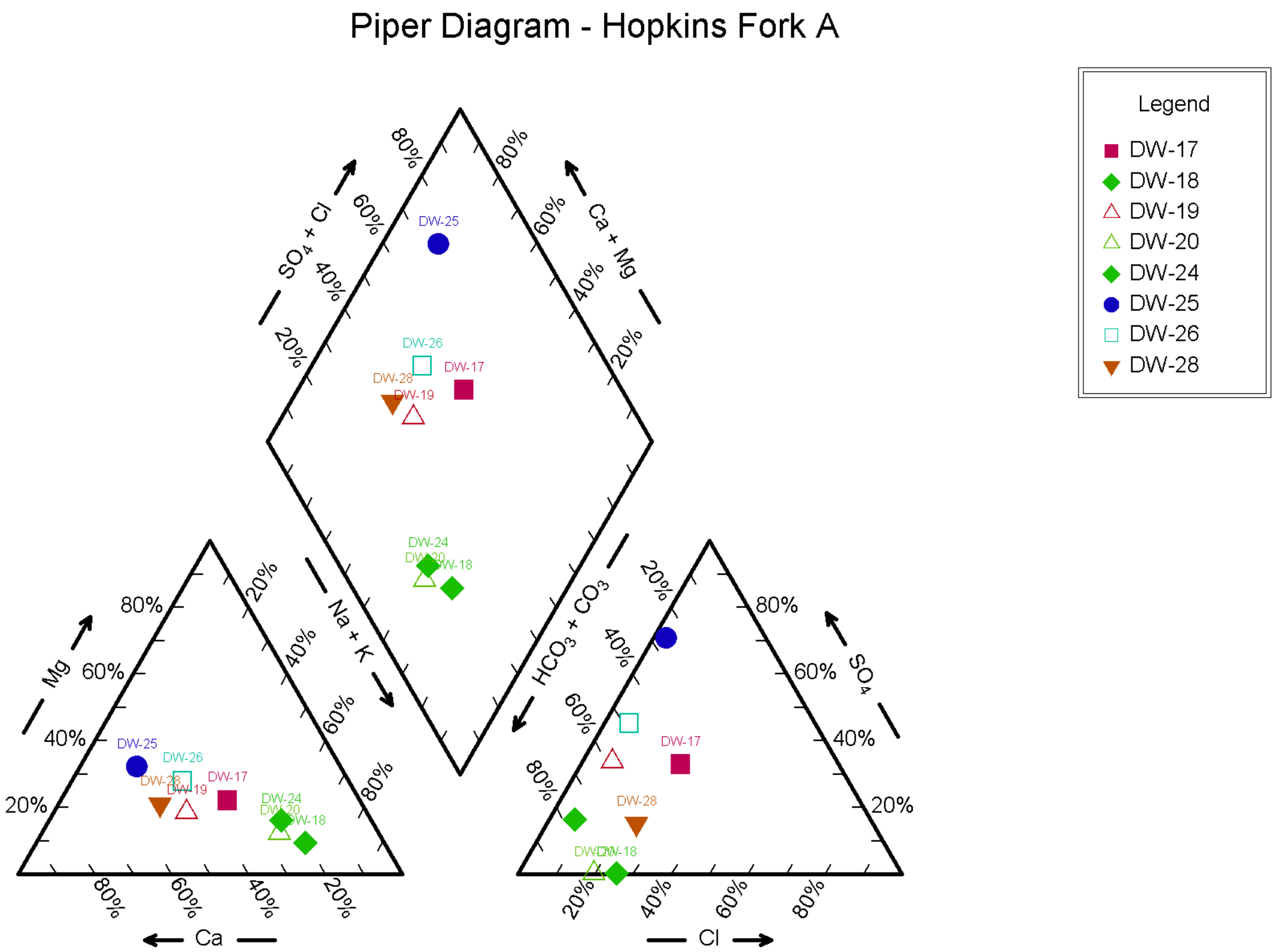

Piper Diagram - Hopkins Fork A
Legend
■ DW-17
◆ DW-18
△ DW-19
△ DW-20
◆ DW-24
● DW-25
□ DW-26
▼ DW-28
SO₄ + Cl
Ca + Mg
Na + K
HCO₃ + CO₃
Mg
Ca
Cl
SO₄
20%
40%
60%
80%
DW-25
DW-26
DW-17
DW-28
DW-19
DW-24
DW-20
DW-18

Figure 5-22

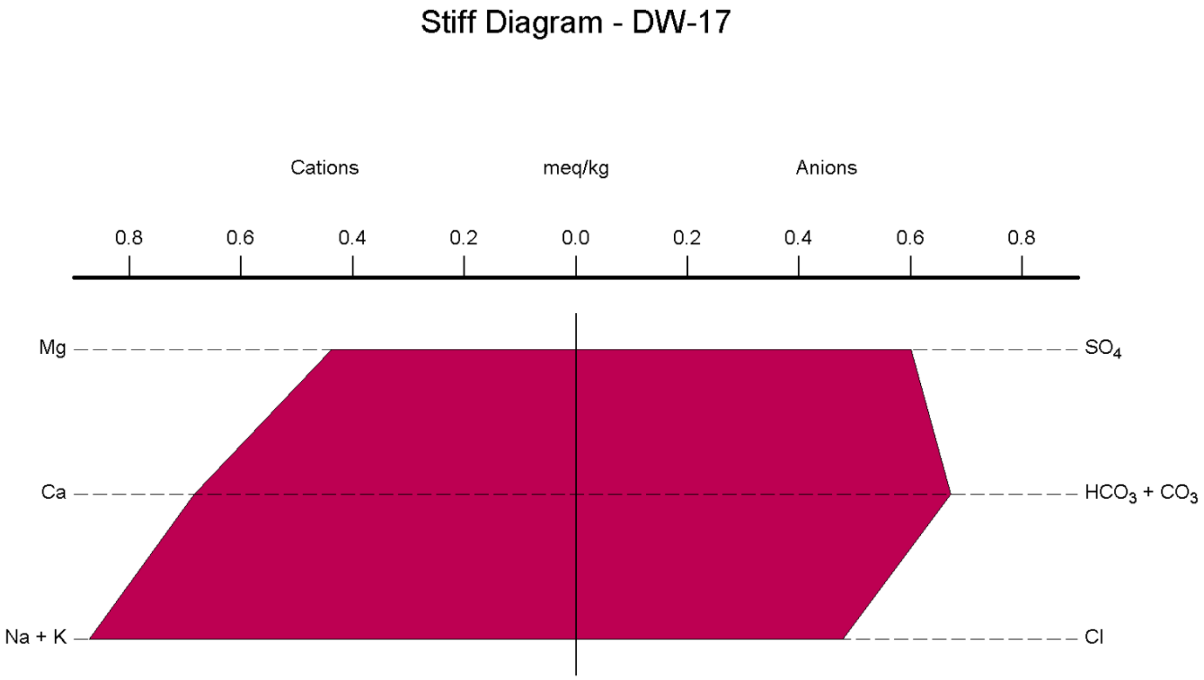


Figure 5-23

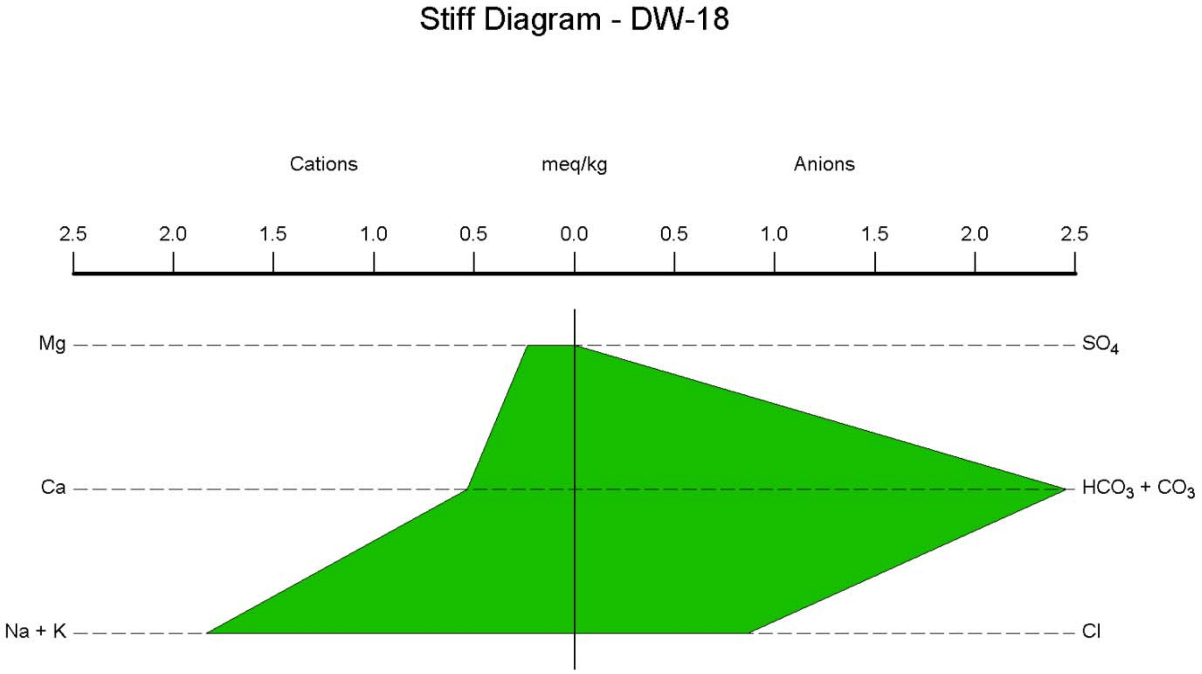


Figure 5-24

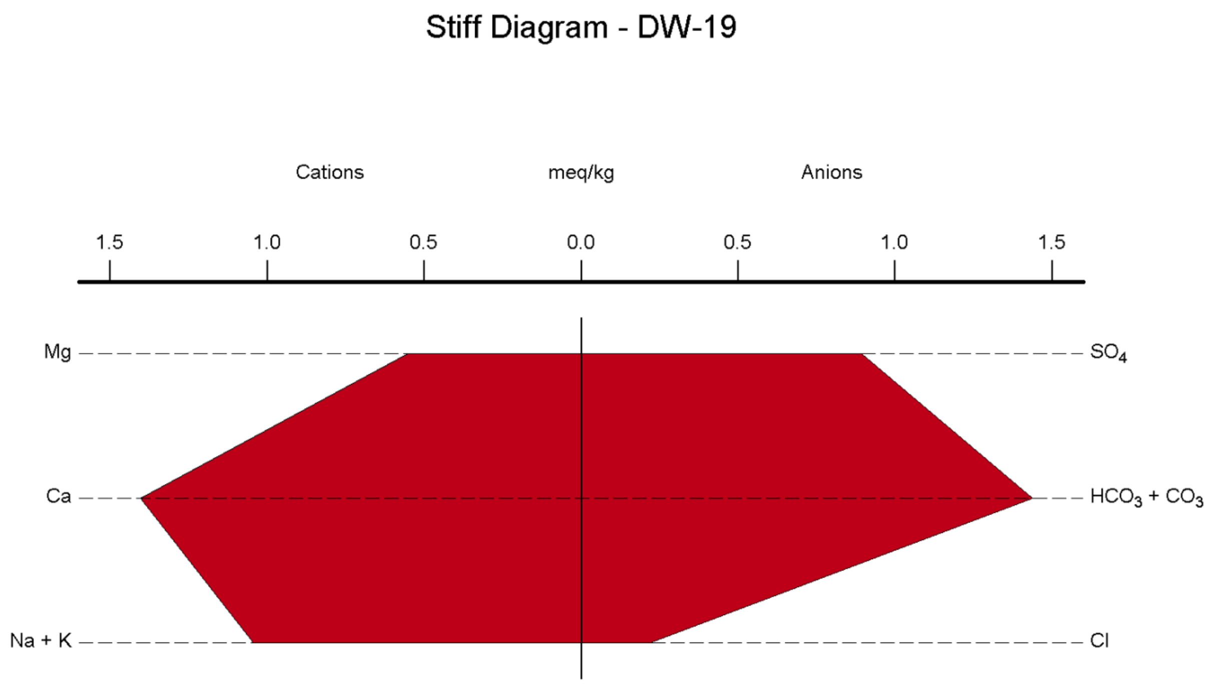


Figure 5-25

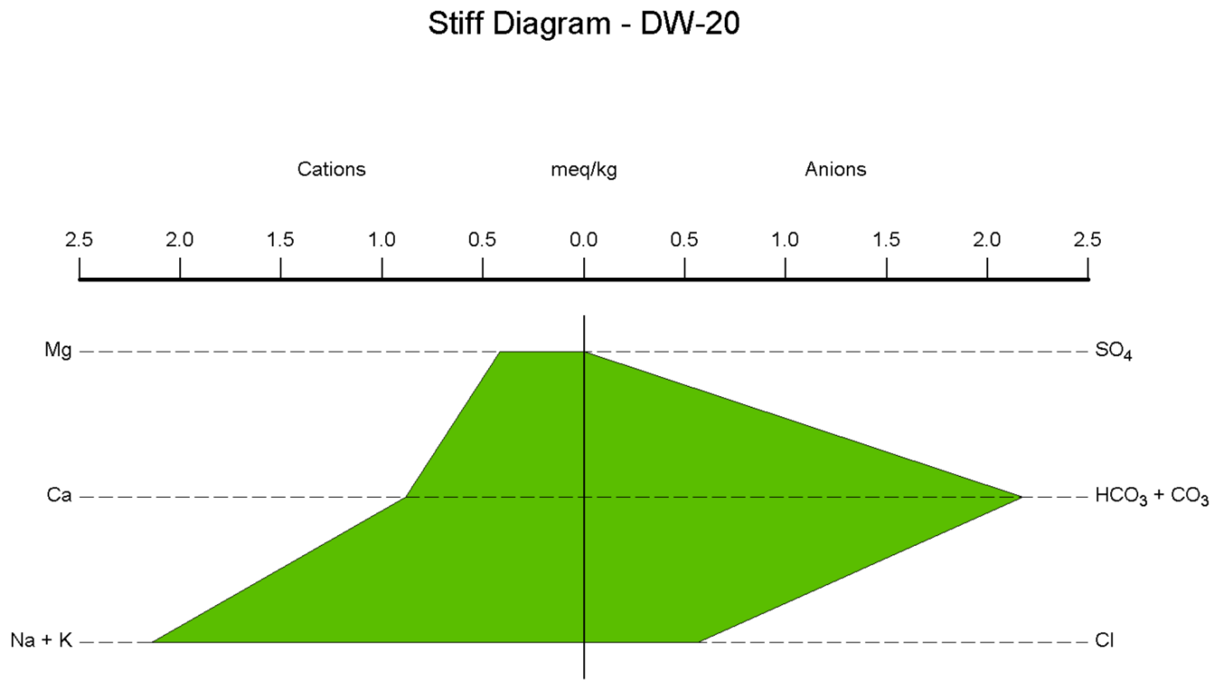


Figure 5-26

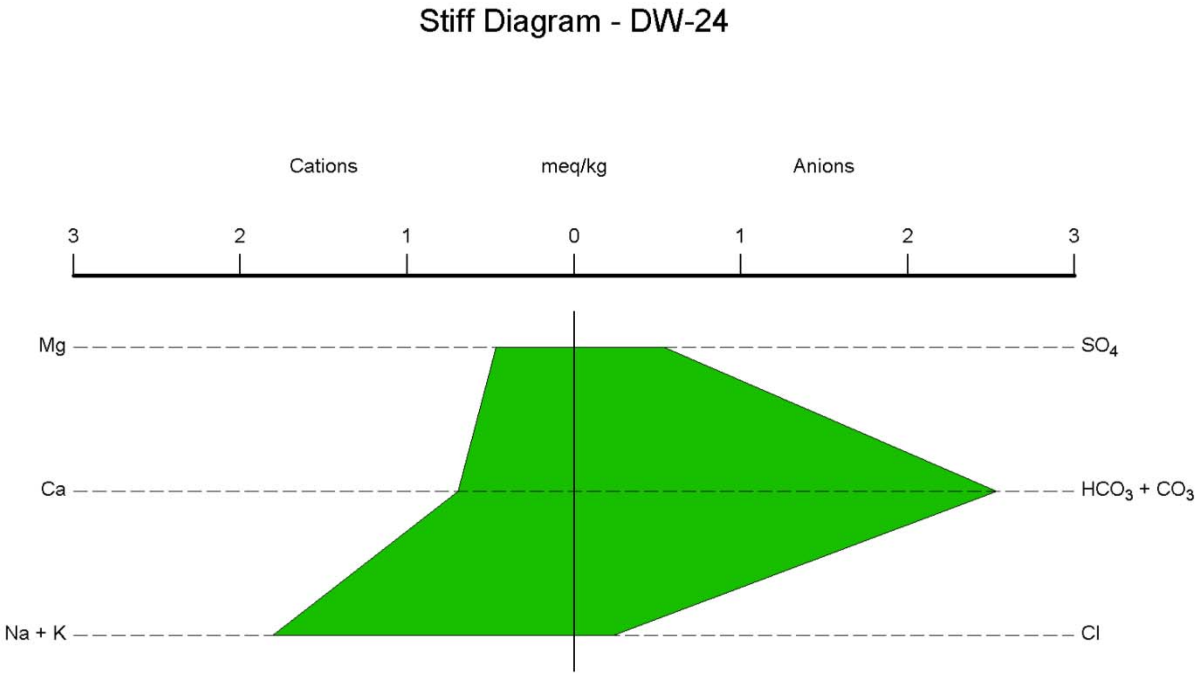


Figure 5-27

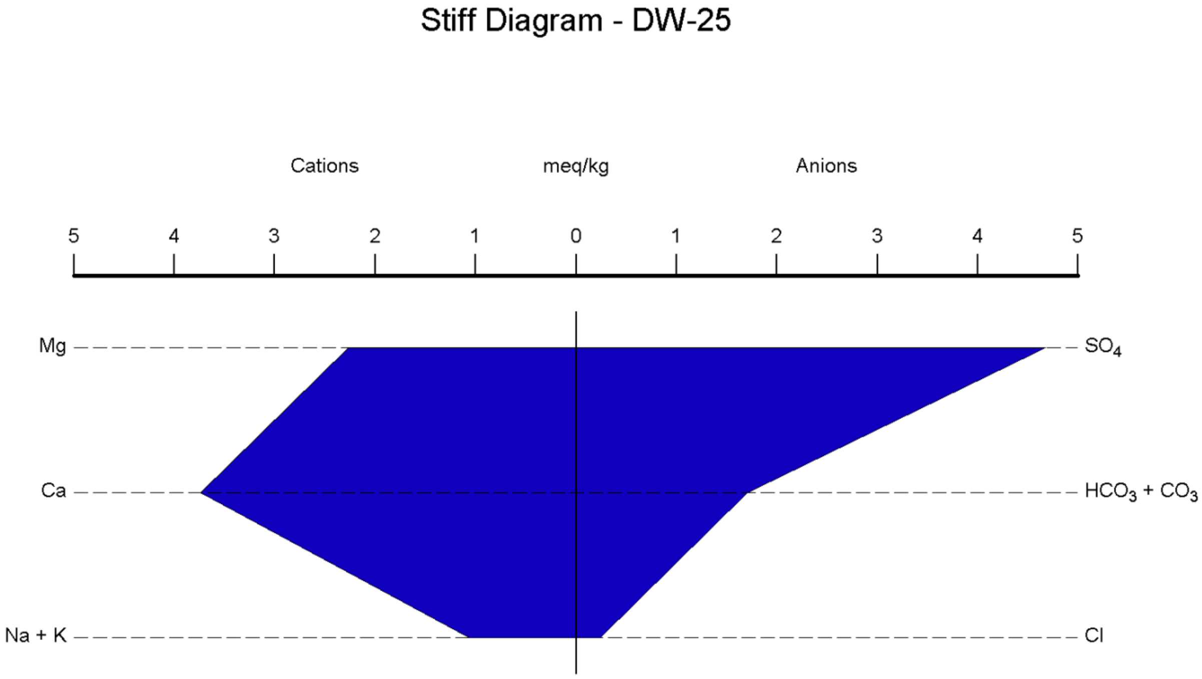


Figure 5-28

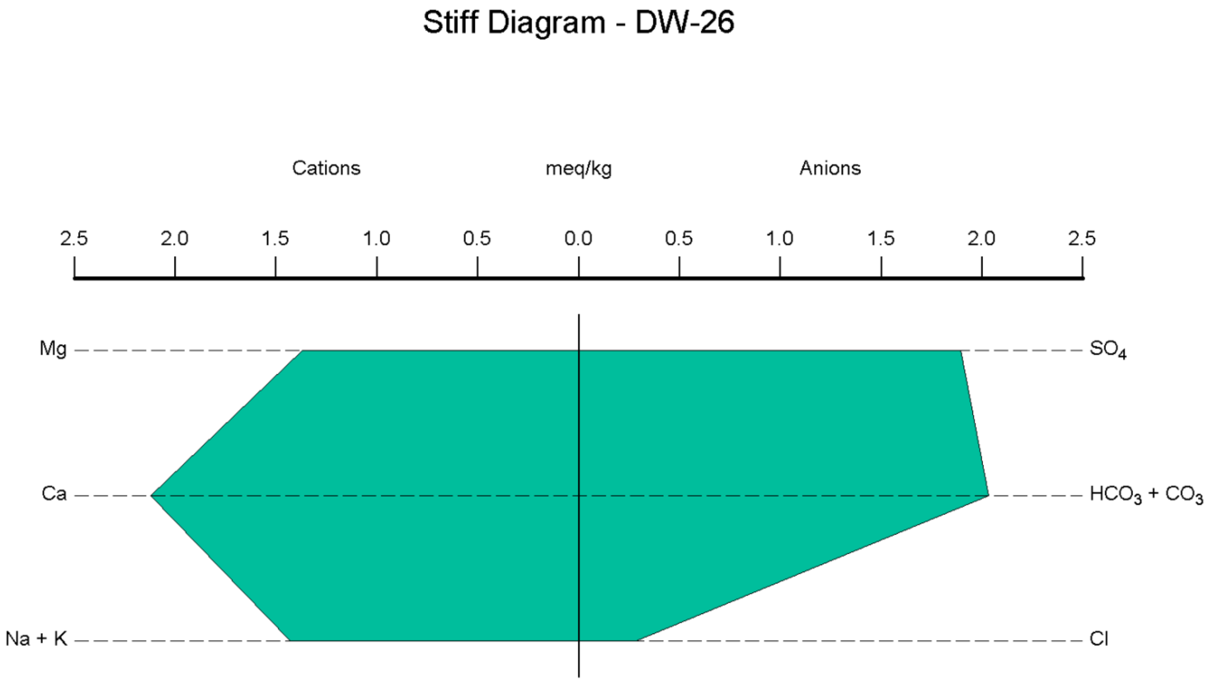


Figure 5-29

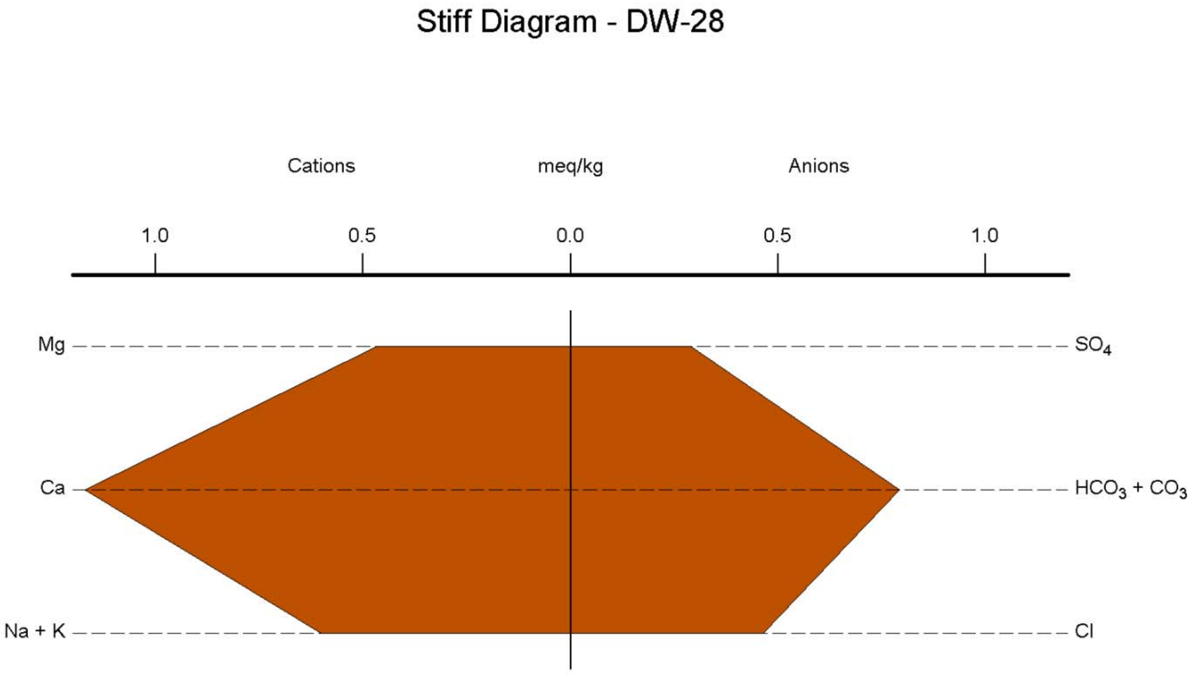


Figure 5-30

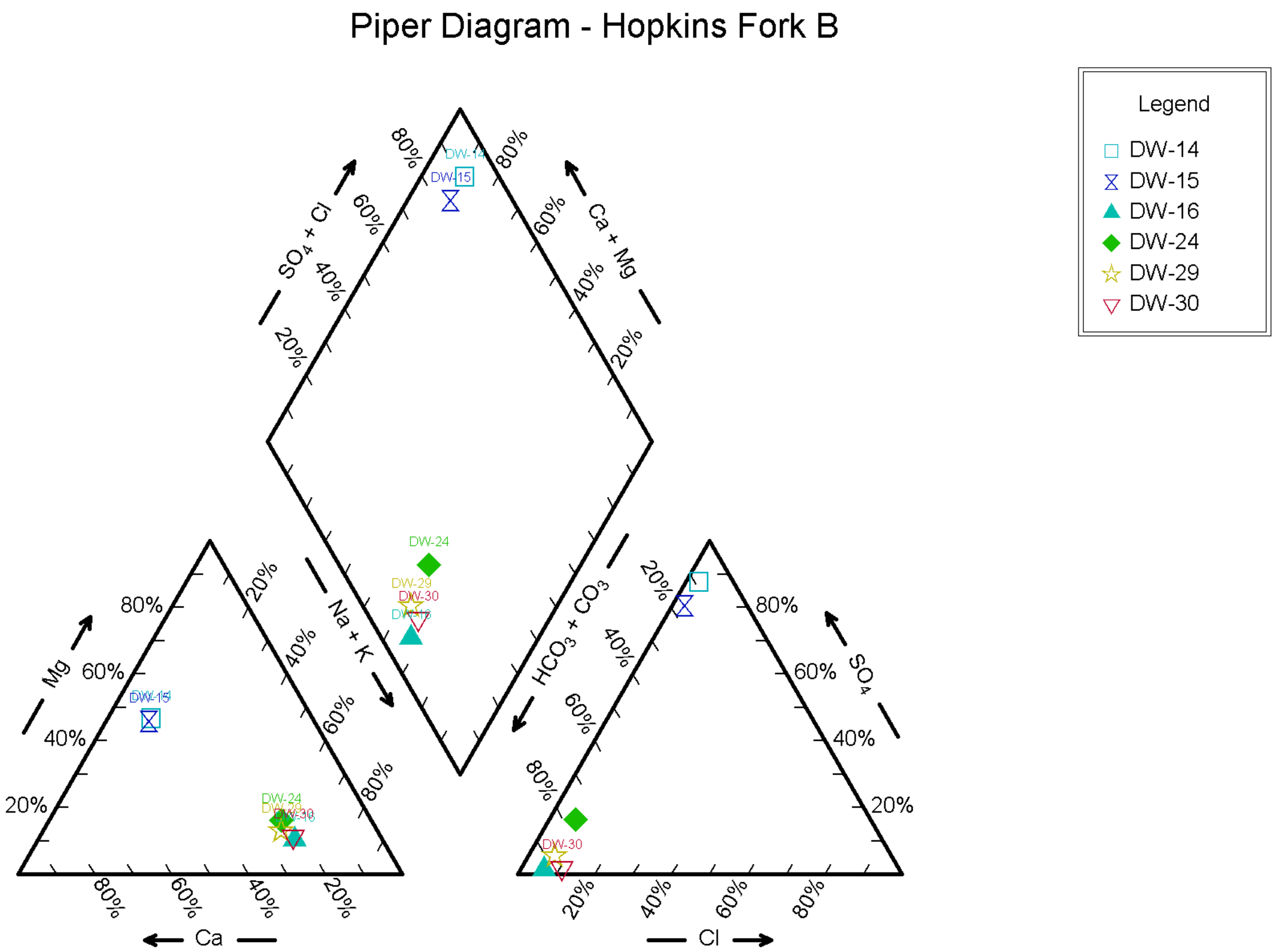

Piper Diagram - Hopkins Fork B
Legend
□ DW-14
⧗ DW-15
▲ DW-16
◆ DW-24
☆ DW-29
▽ DW-30
SO₄ + Cl
Ca + Mg
Na + K
HCO₃ + CO₃
Mg
Ca
Cl
SO₄
20%
40%
60%
80%
DW-14
DW-15
DW-16
DW-24
DW-29
DW-30

Figure 5-31

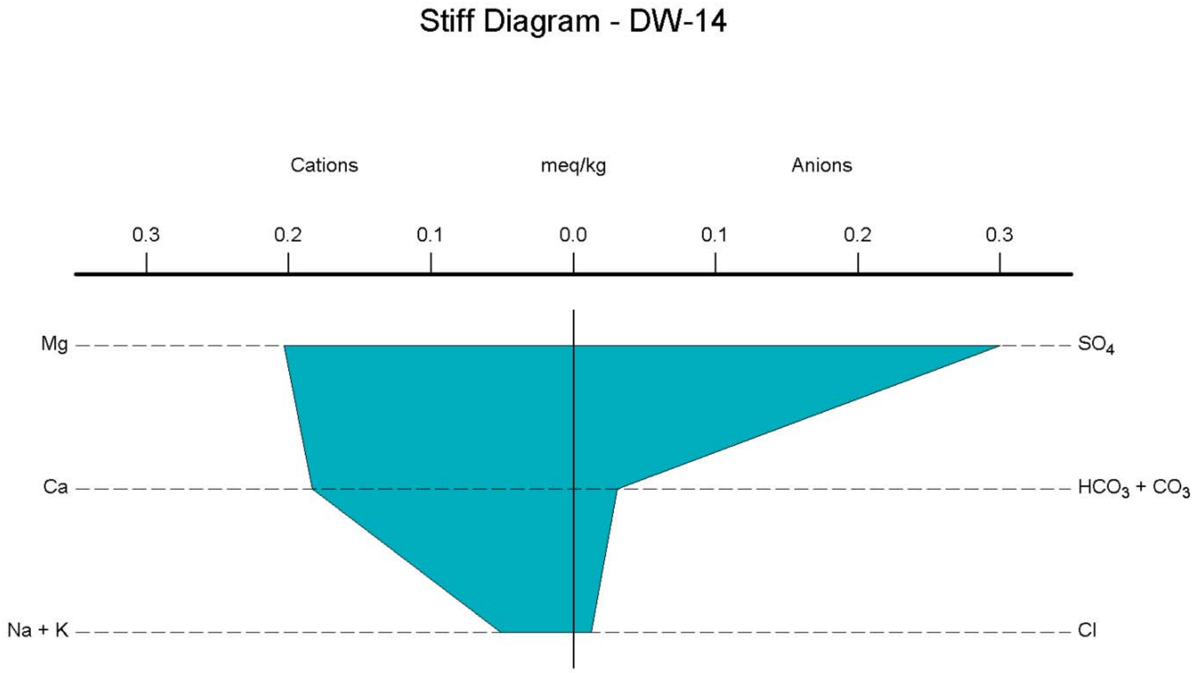


Figure 5-32

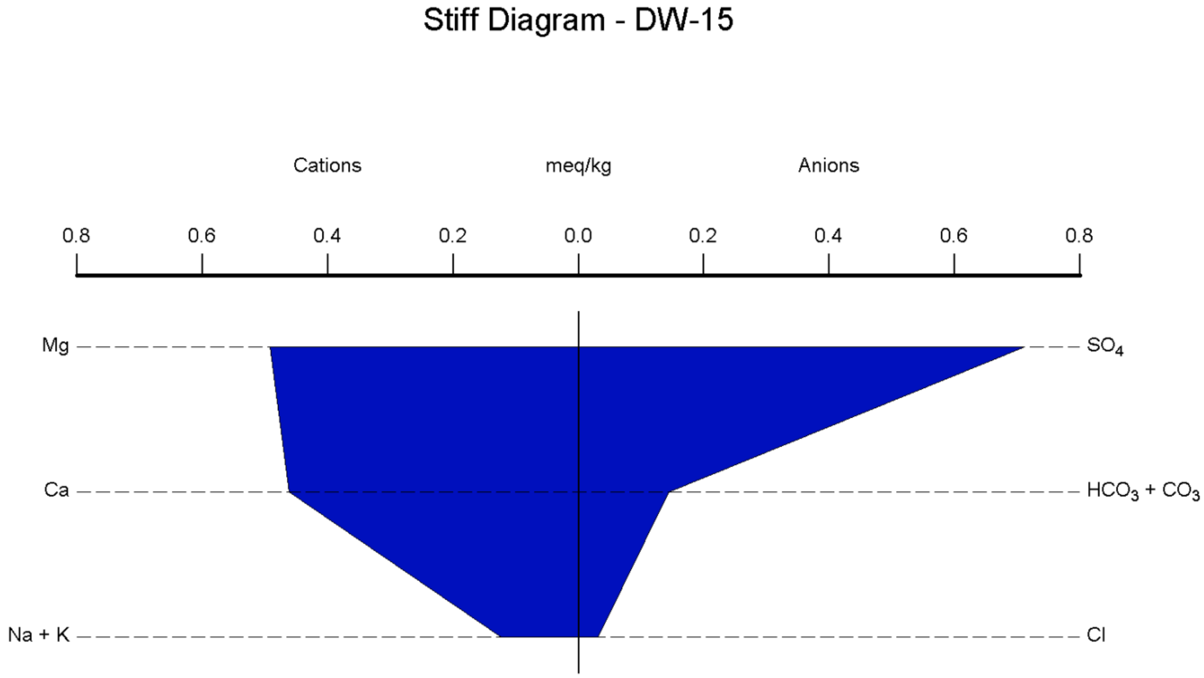


Figure 5-33

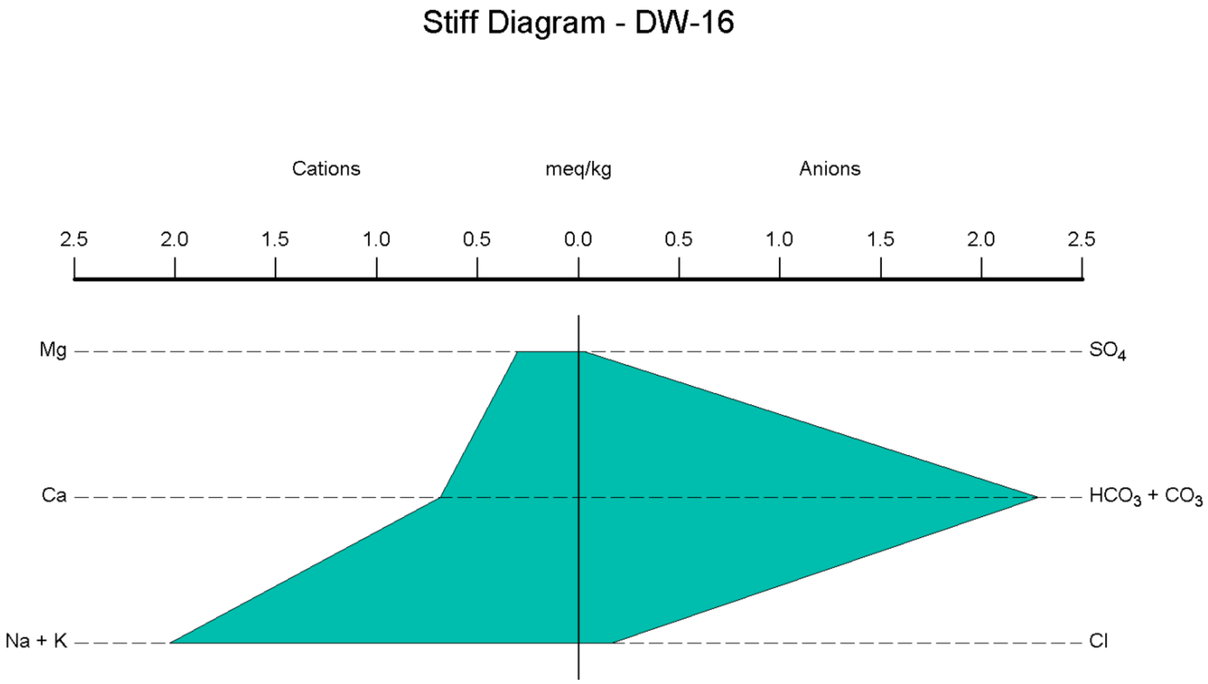


Figure 5-34

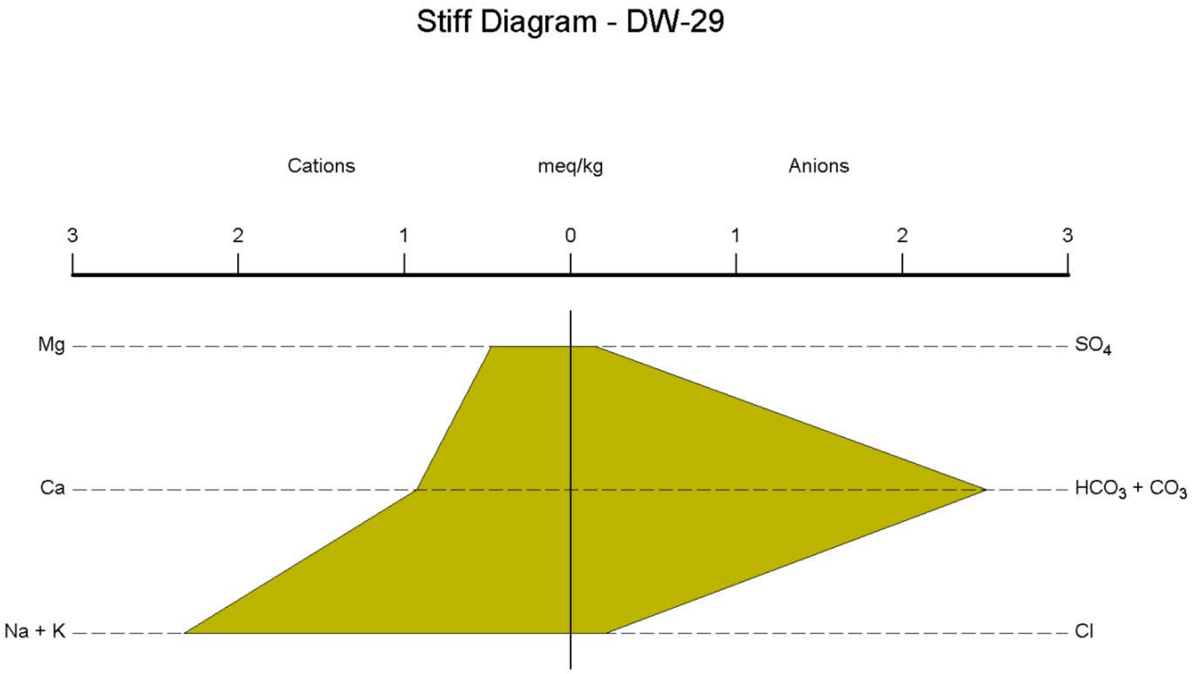


Figure 5-35

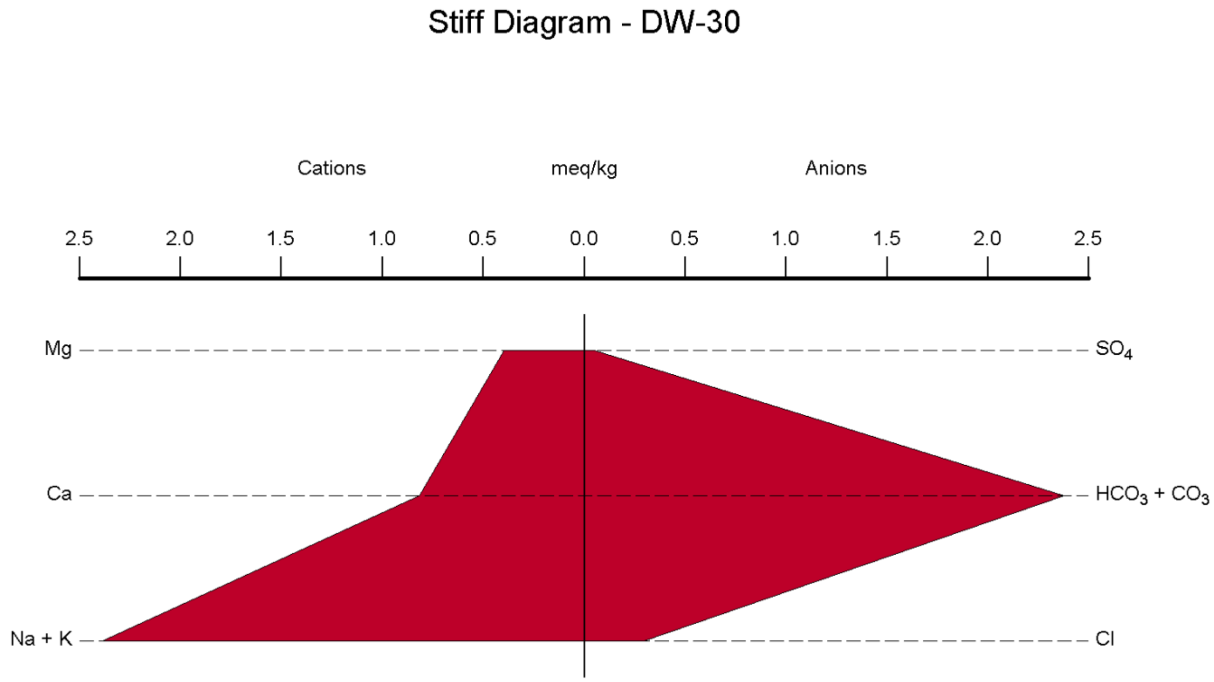

Stiff Diagram - DW-30
Cations
meq/kg
Anions
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
2.5
Mg
Ca
Na + K
SO_4
$HCO_3 + CO_3$
Cl

Figure 5-36

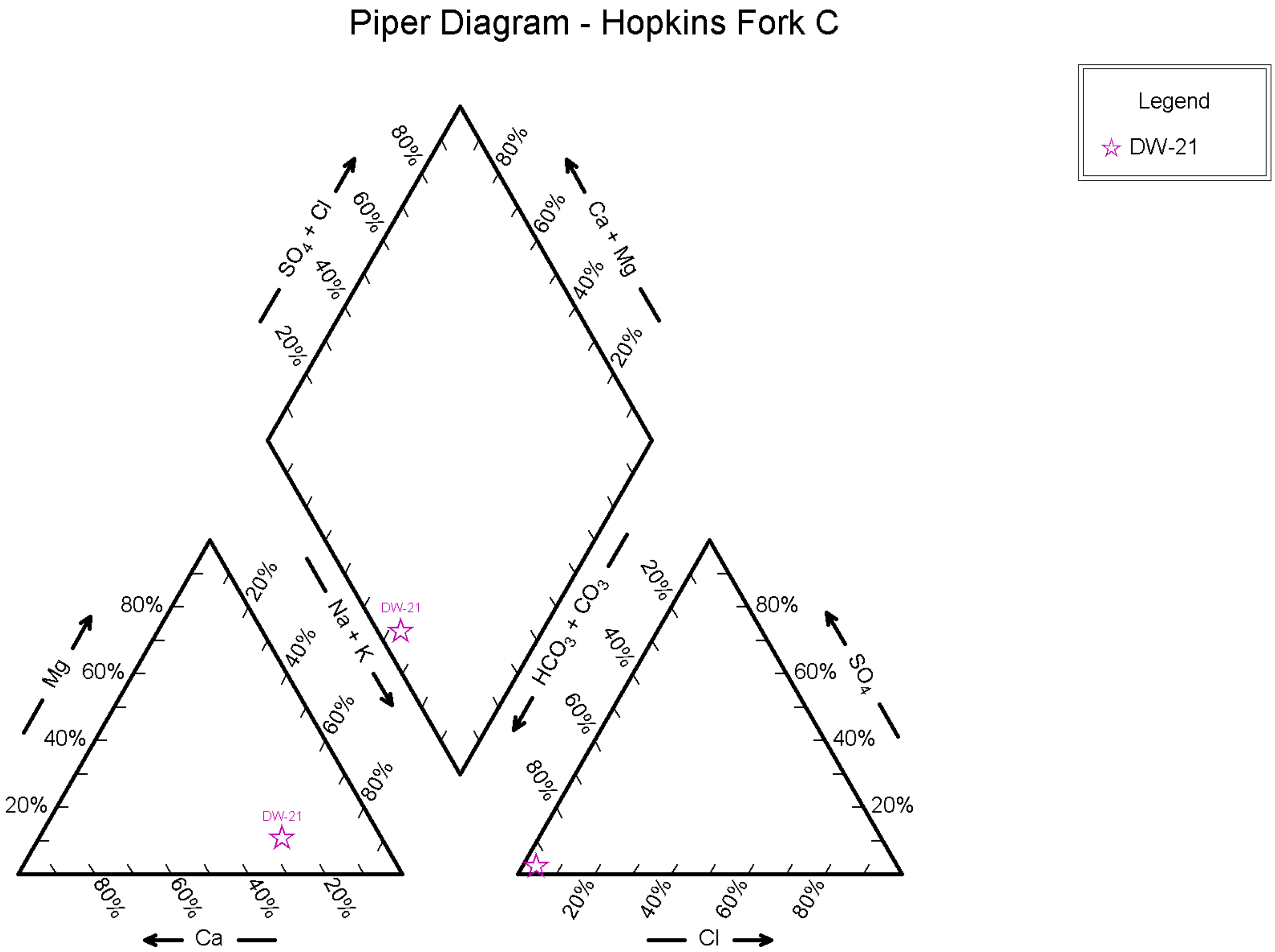

Piper Diagram - Hopkins Fork C
Legend
☆ DW-21
DW-21
DW-21
SO_4 + Cl
Ca + Mg
Na + K
HCO_3 + CO_3
Mg
Ca
Cl
SO_4
20%
40%
60%
80%

Figure 5-37

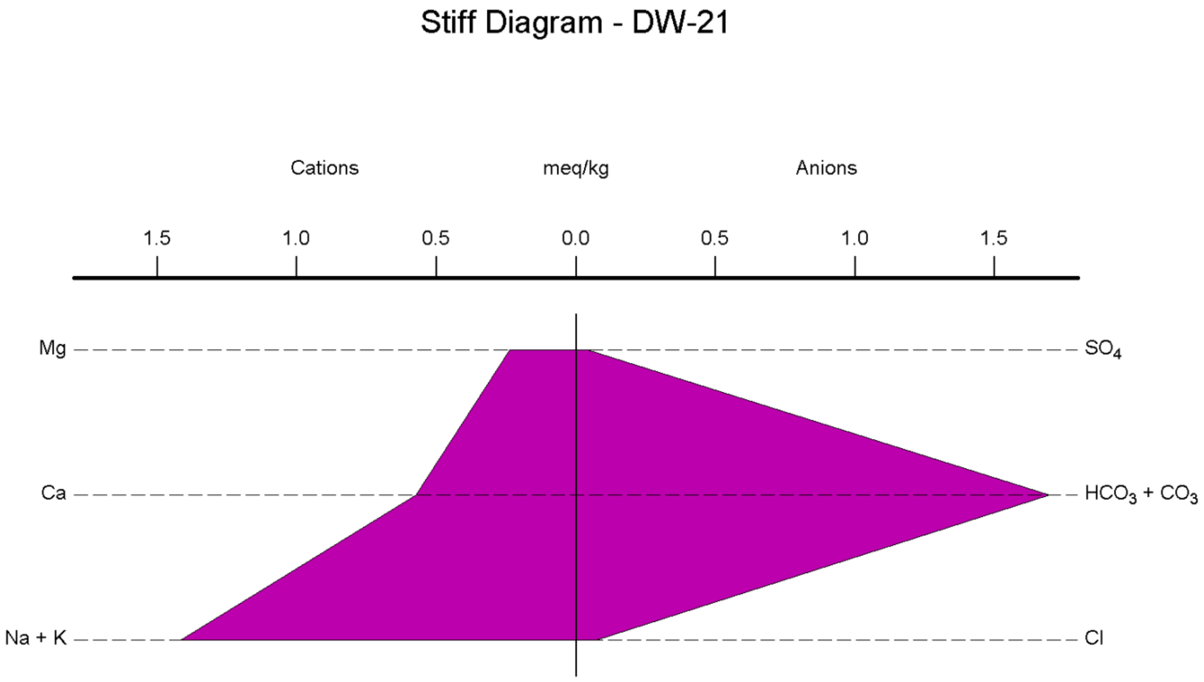


Figure 5-38

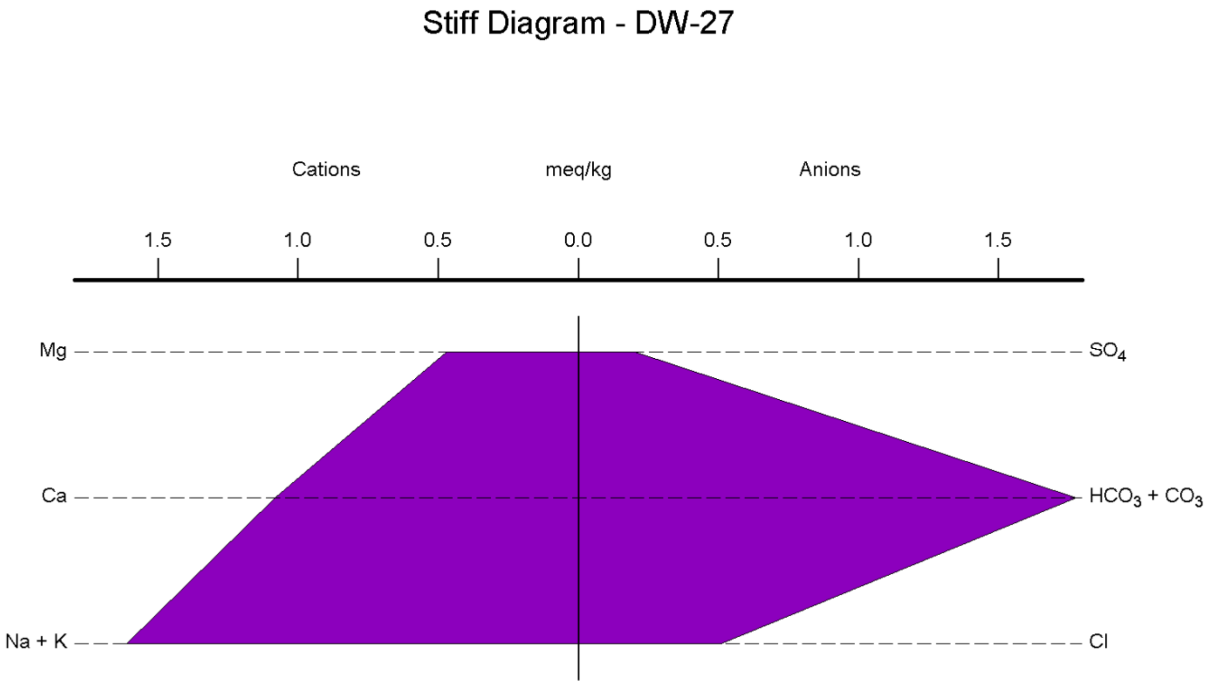
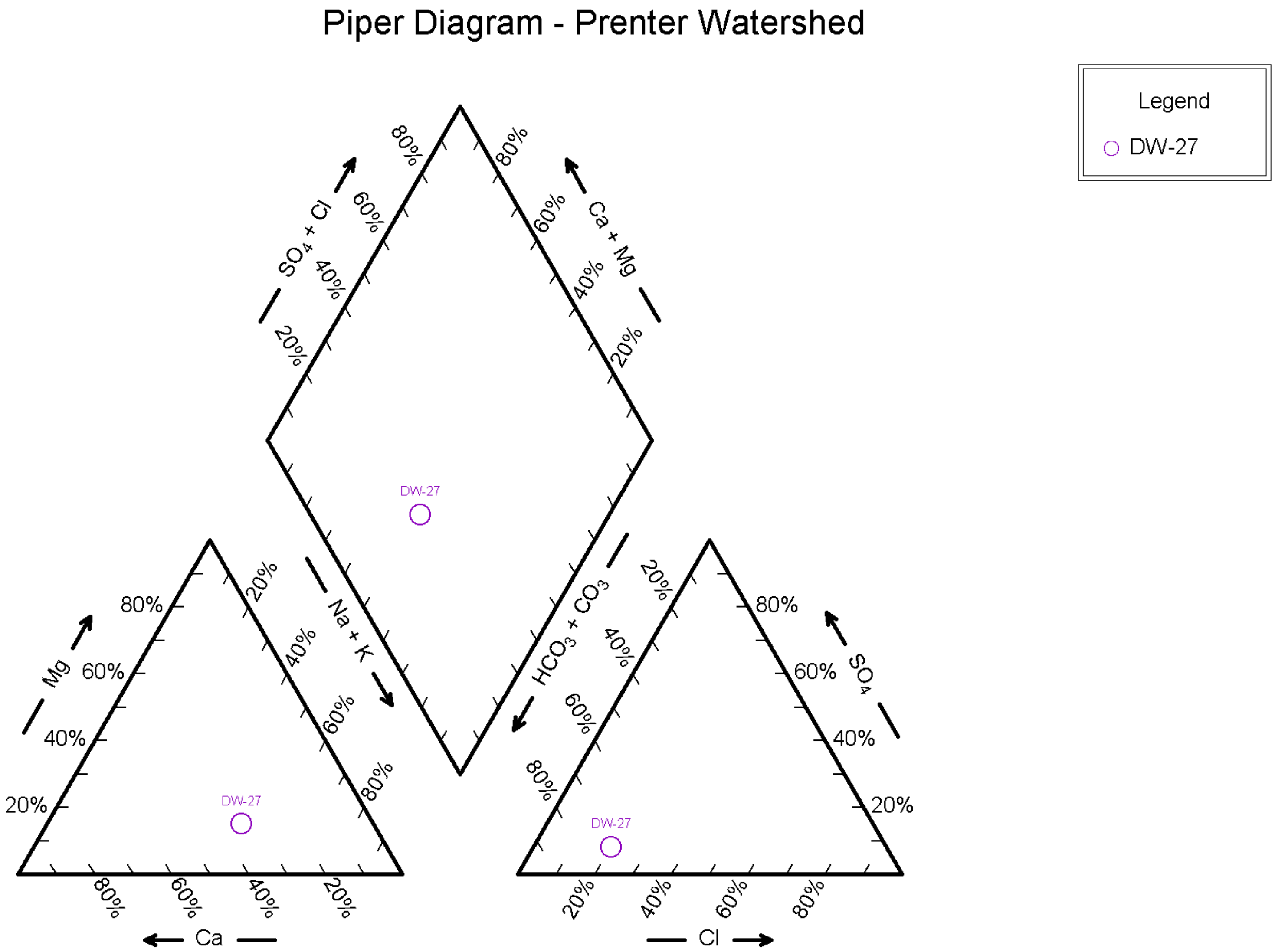


Figure 5-40



Piper Diagram - Prenter Watershed
Legend
○ DW-27
DW-27
DW-27
DW-27
$SO_4 + Cl$
Ca + Mg
Na + K
$HCO_3 + CO_3$
Mg
Ca
Cl
SO_4
20%
40%
60%
80%

Figure 5-39

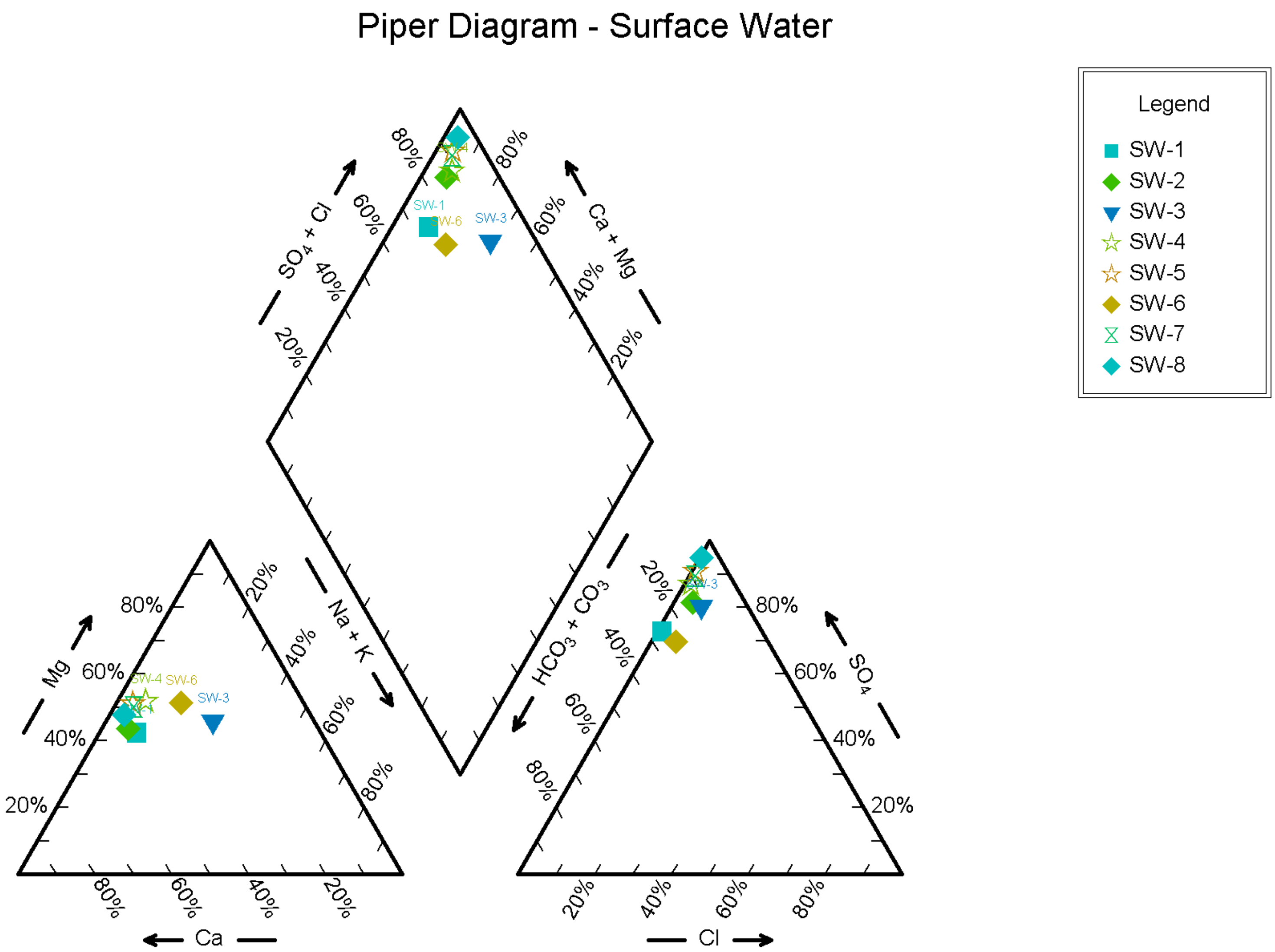

Piper Diagram - Surface Water
Legend
■ SW-1
◆ SW-2
▼ SW-3
☆ SW-4
☆ SW-5
◆ SW-6
⧖ SW-7
◆ SW-8
SW-1
SW-6
SW-3
SW-4
SO₄ + Cl
Ca + Mg
Na + K
HCO₃ + CO₃
Mg
Ca
Cl
SO₄
20%
40%
60%
80%

Figure 5-41

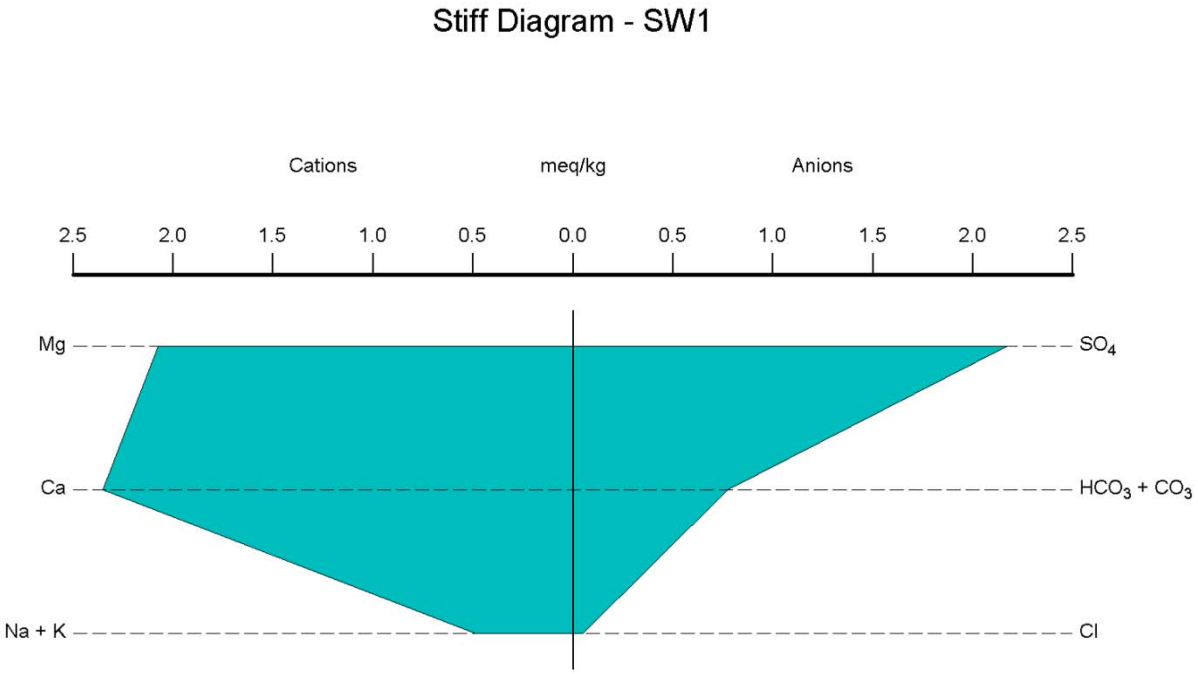


Figure 5-42

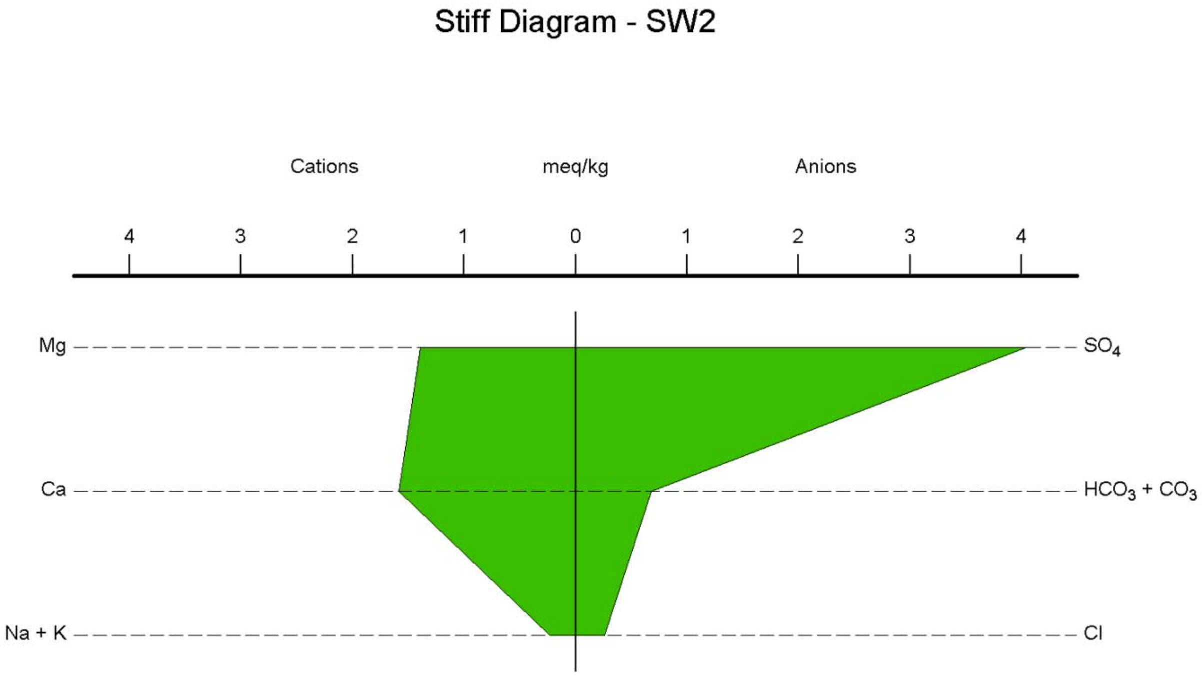


Figure 5-43

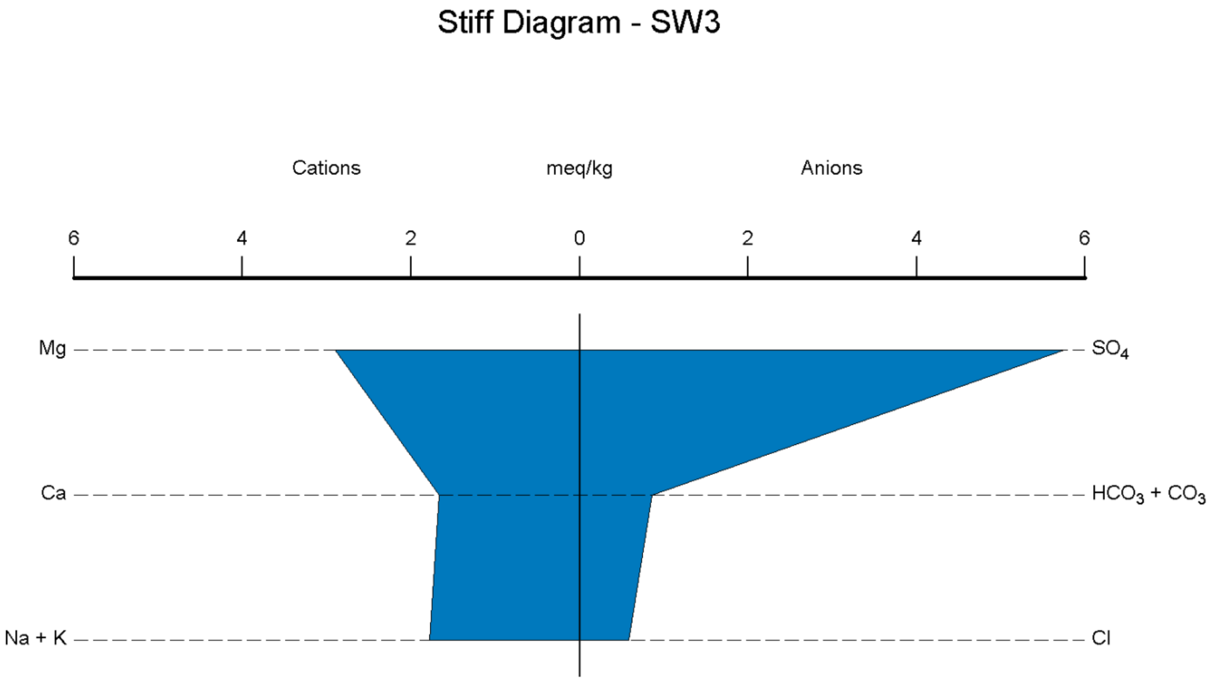


Figure 5-44

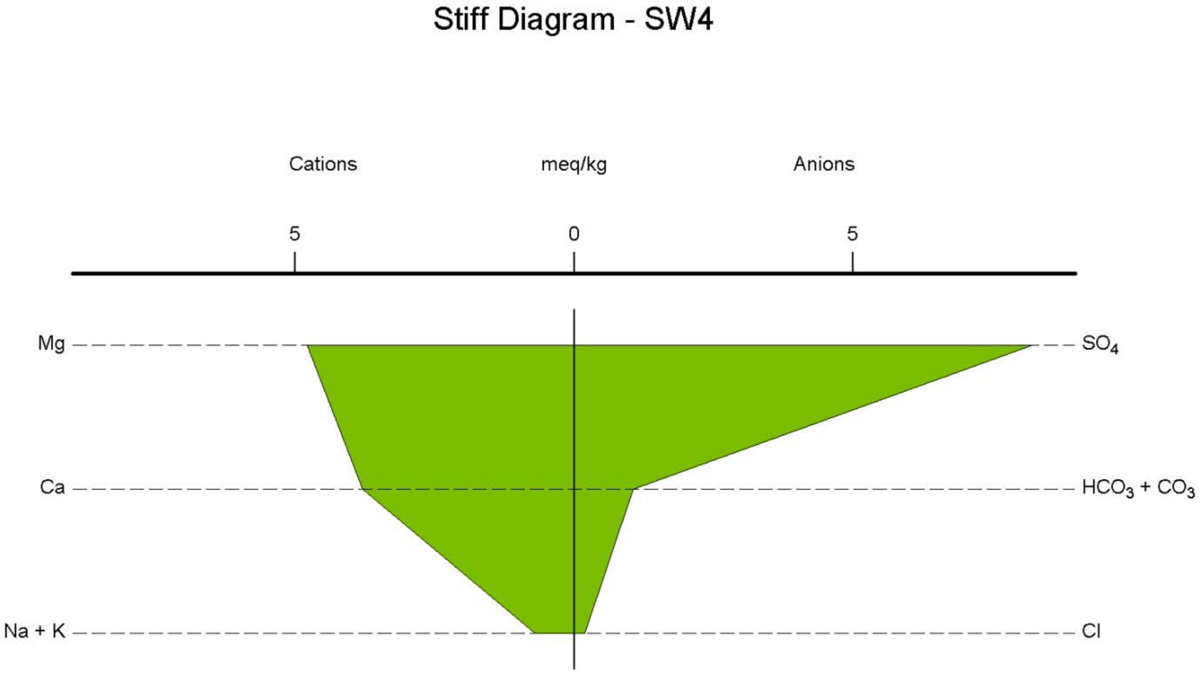


Figure 5-45

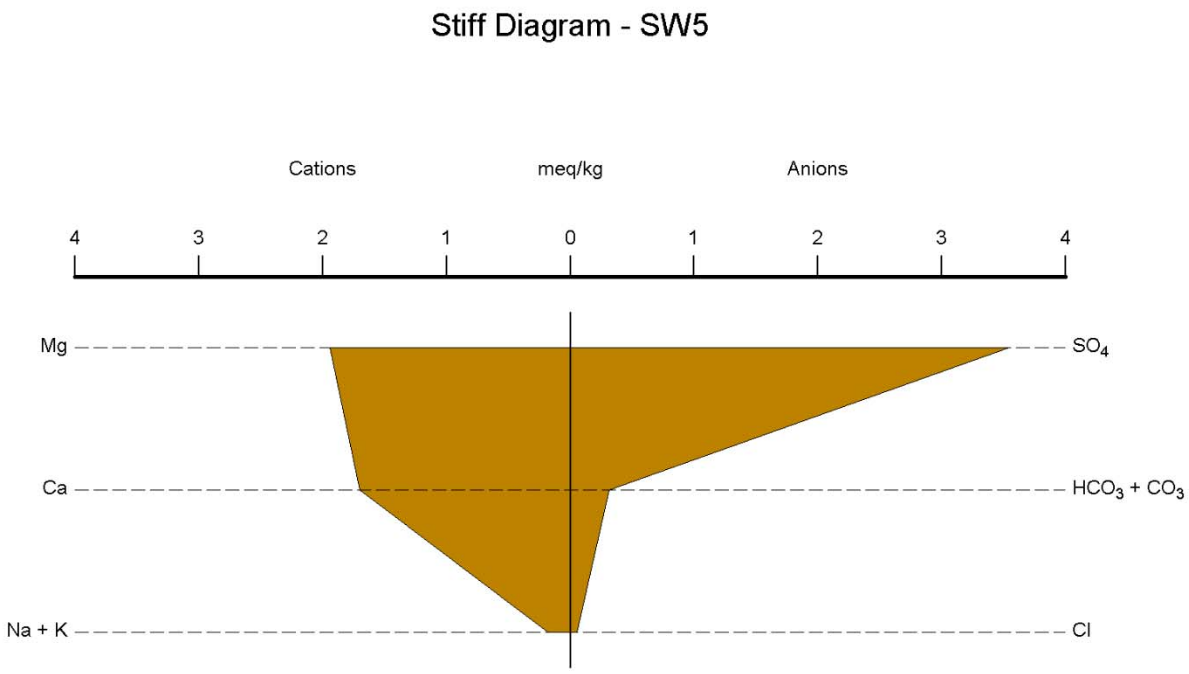


Figure 5-46

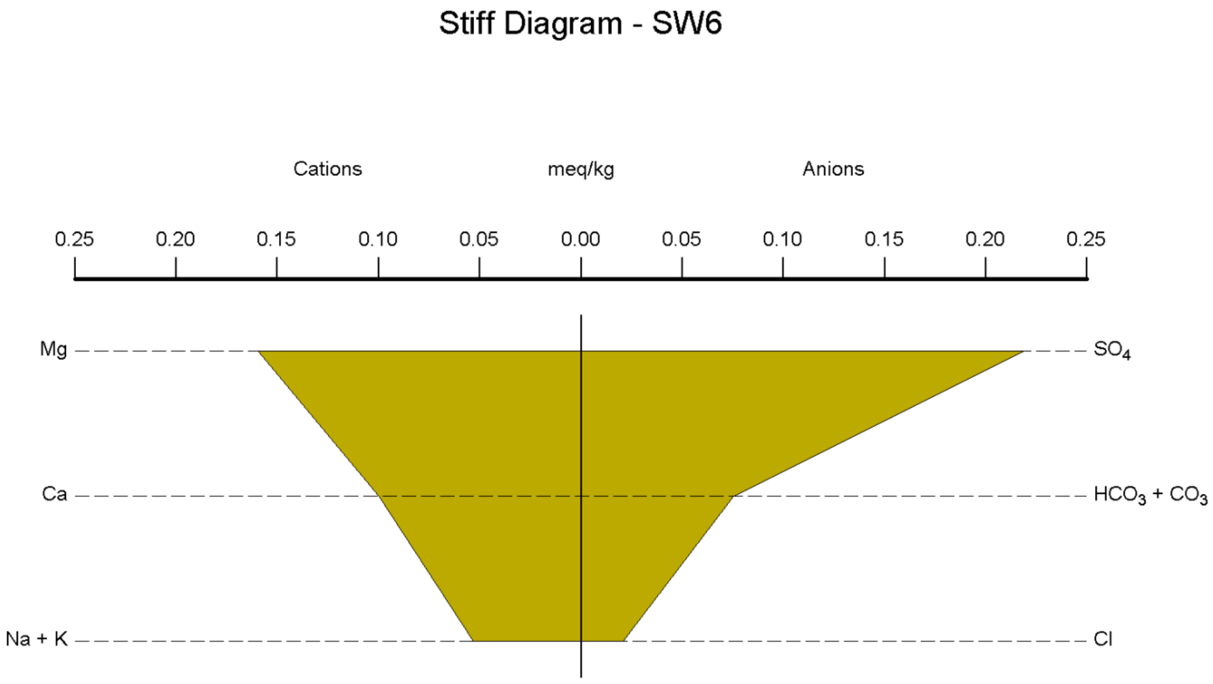


Figure 5-47

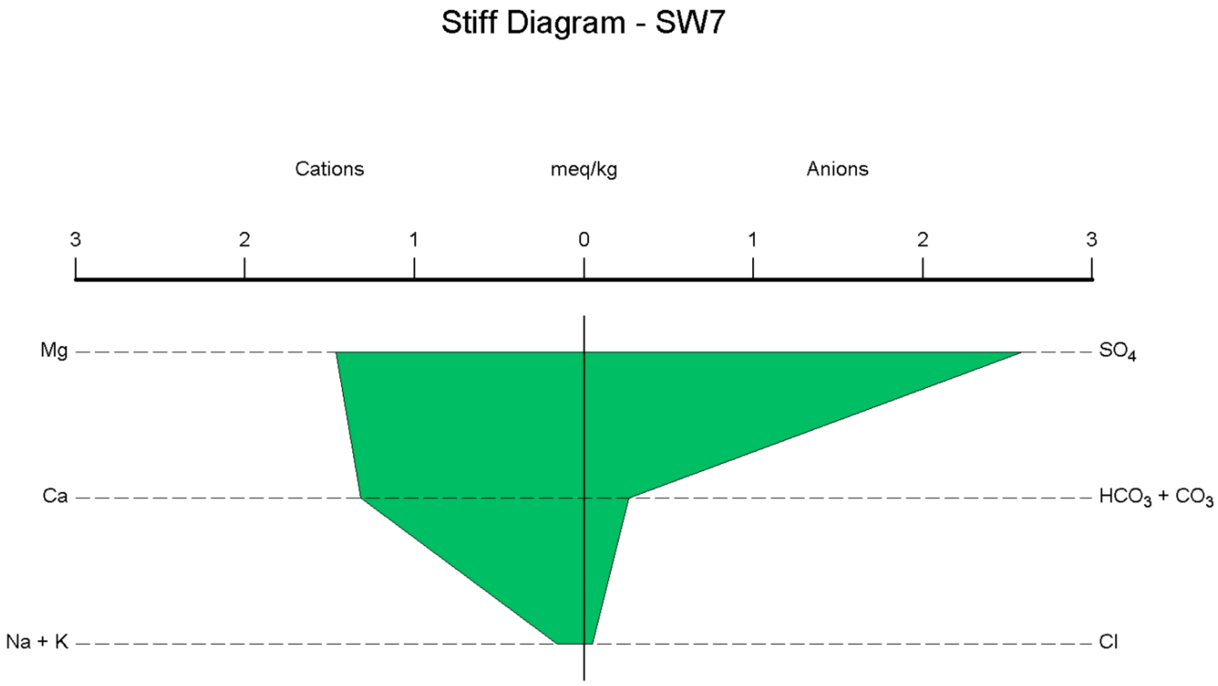


Figure 5-48

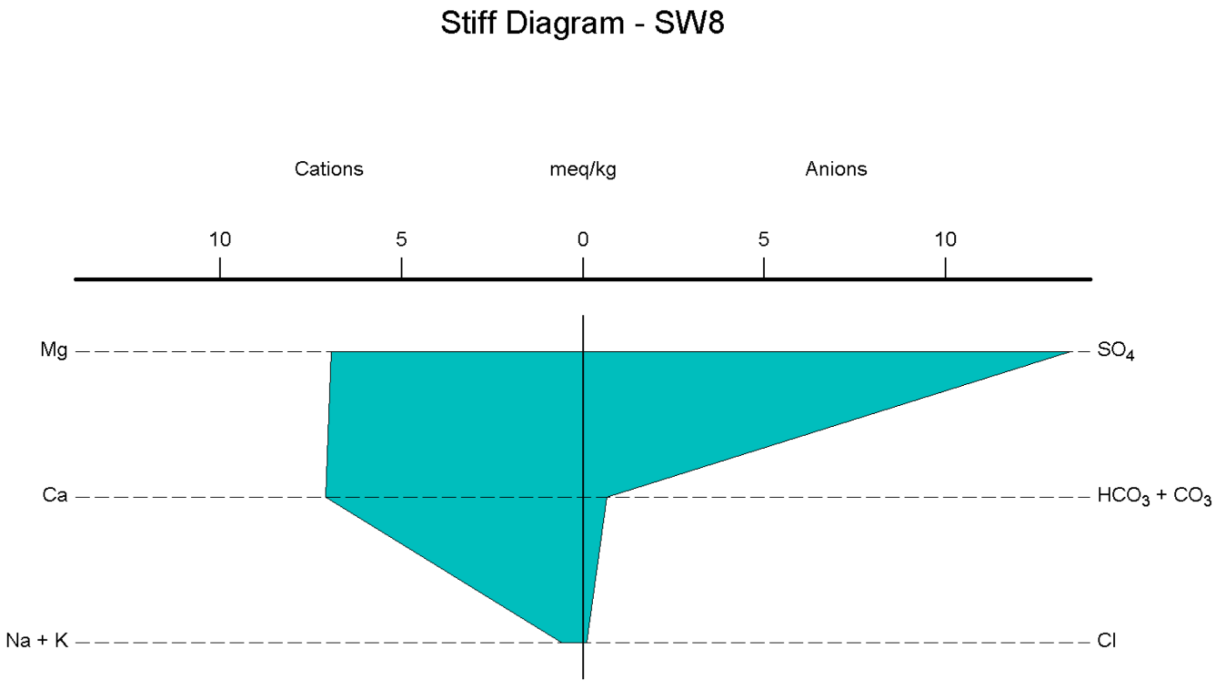
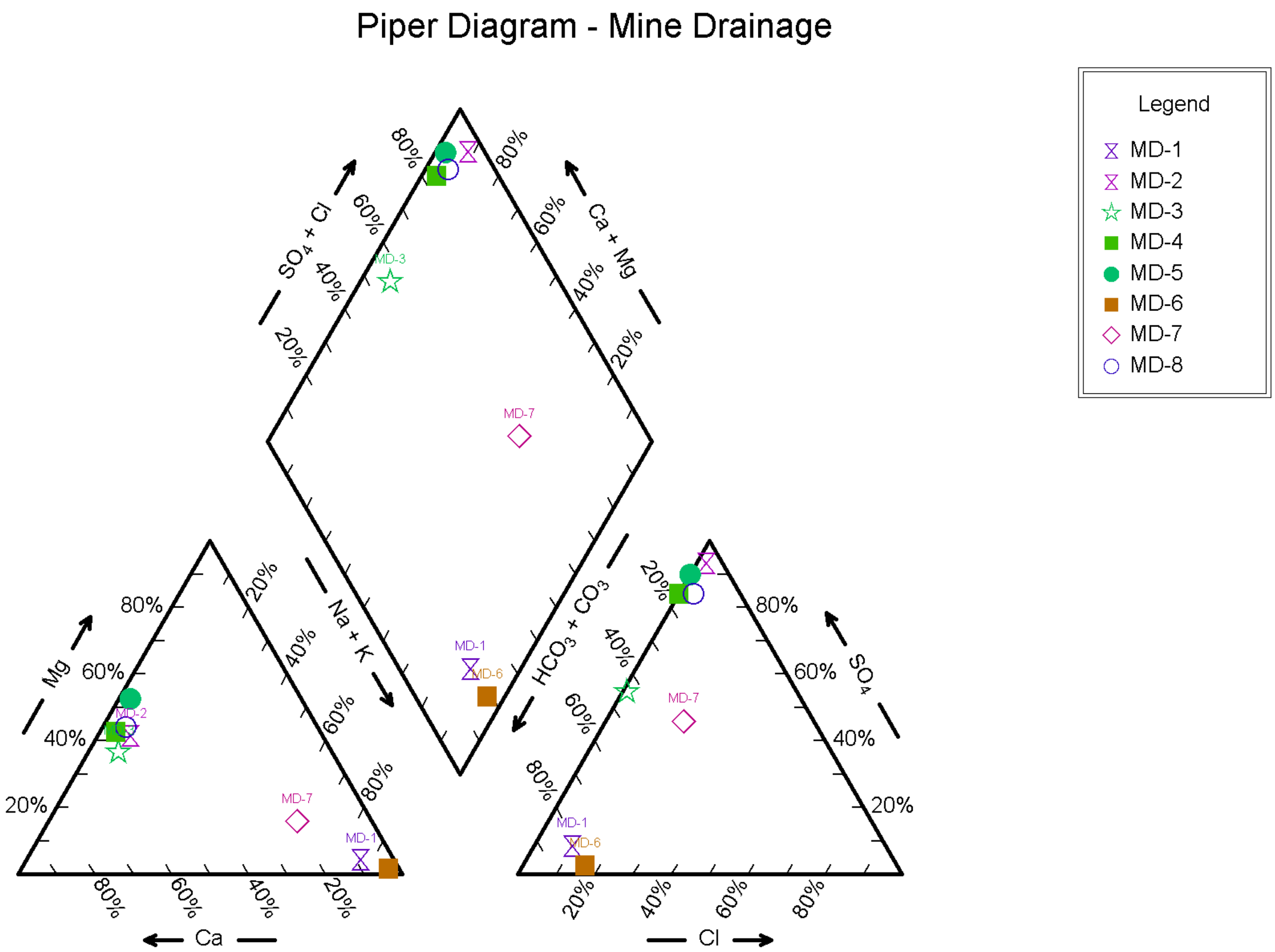


Figure 5-49



Piper Diagram - Mine Drainage
Legend
MD-1
MD-2
MD-3
MD-4
MD-5
MD-6
MD-7
MD-8
SO4 + Cl
Ca + Mg
Na + K
HCO3 + CO3
Mg
Ca
Cl
SO4
20%
40%
60%
80%

Figure 5-50

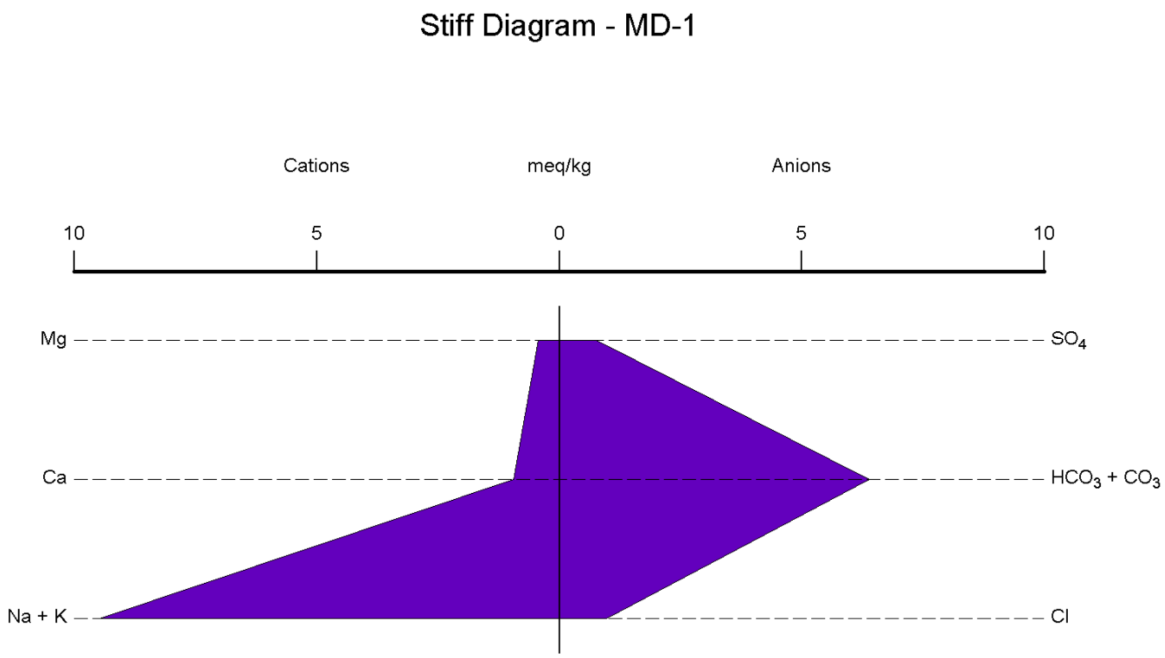


Figure 5-51

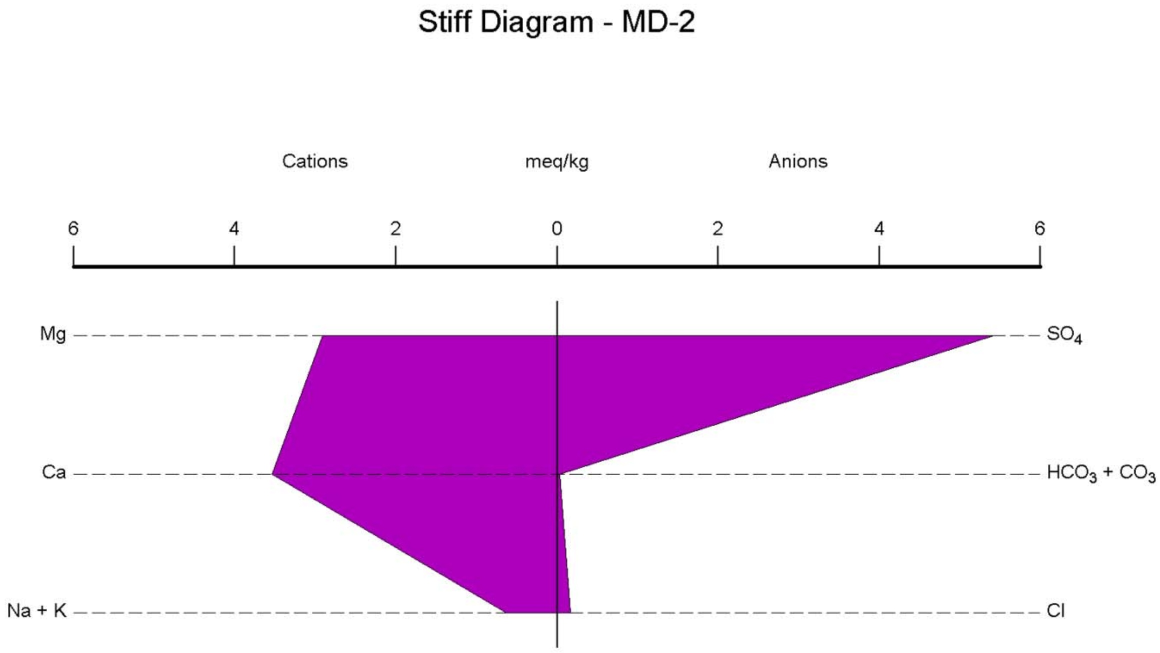


Figure 5-52

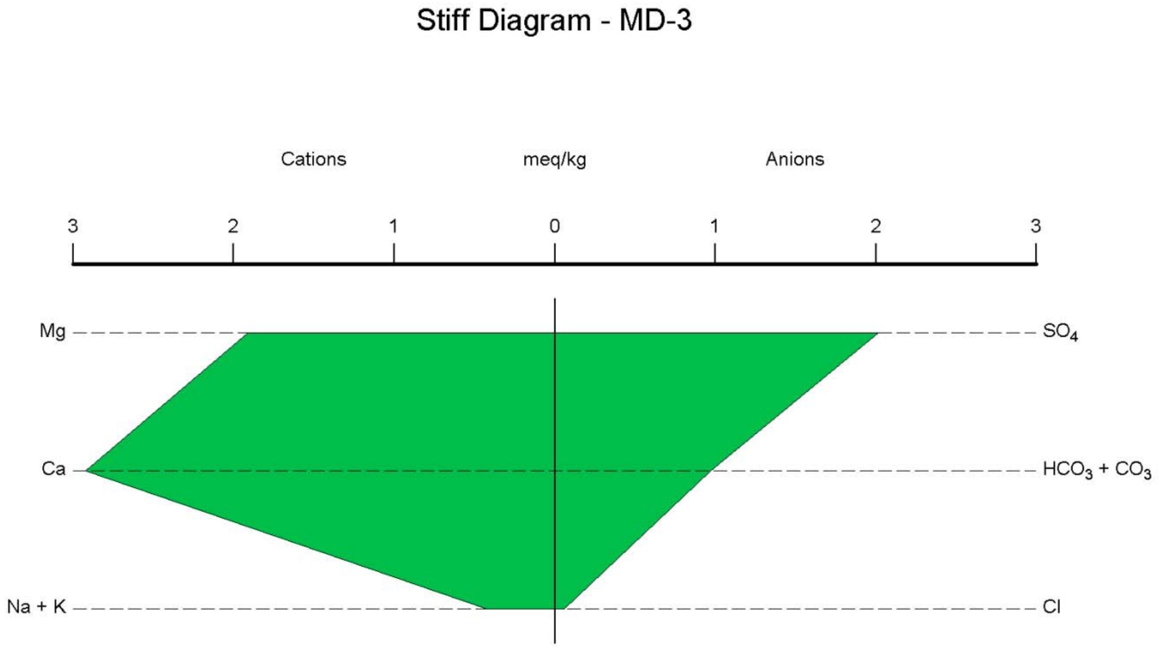


Figure 5-53

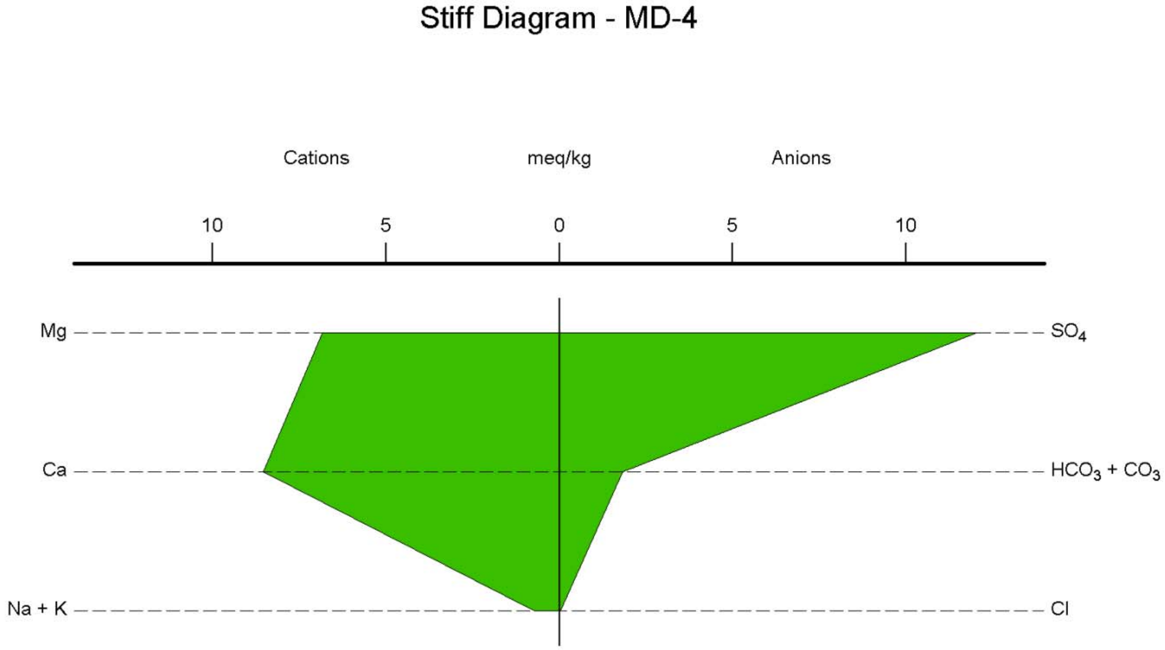


Figure 5-54

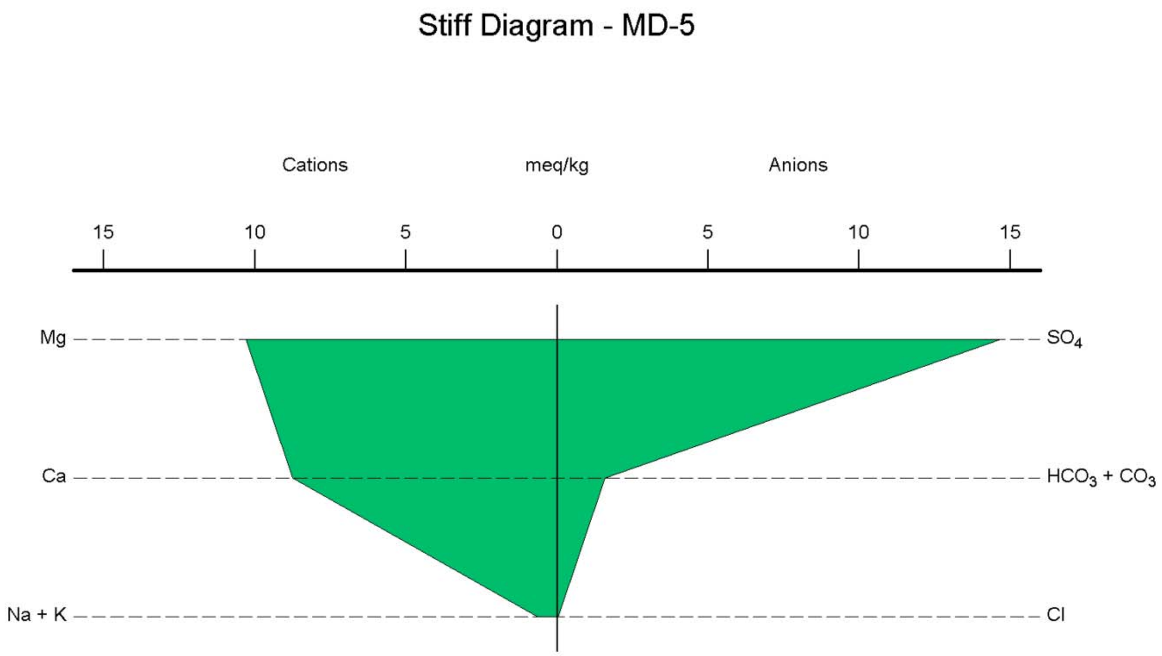


Figure 5-55

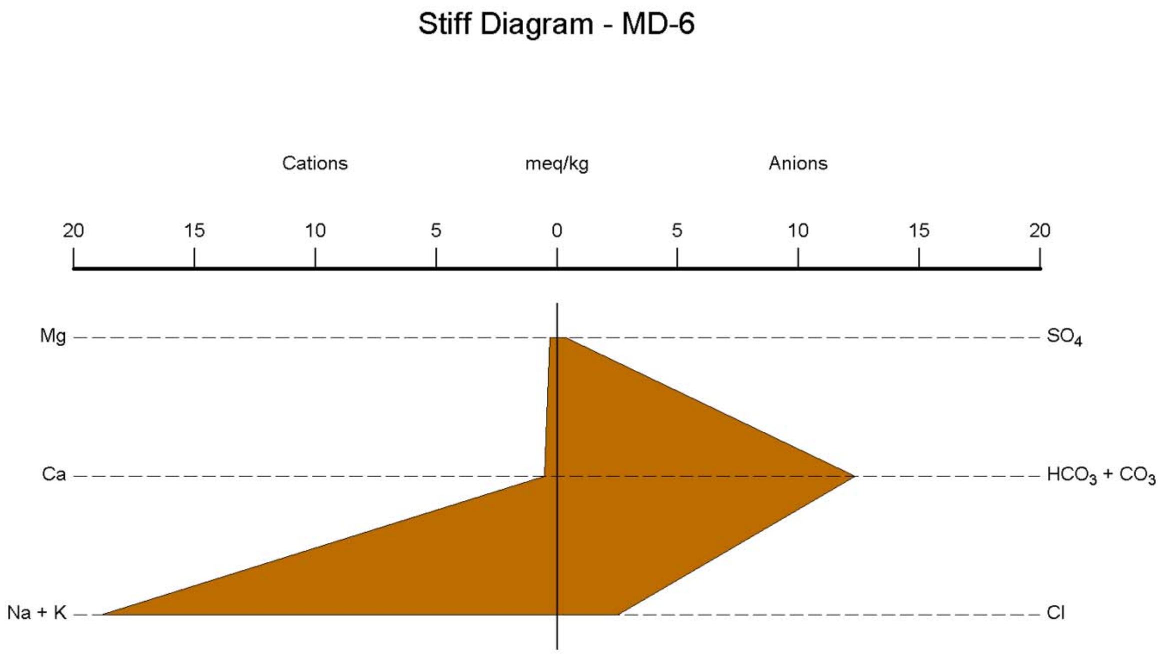


Figure 5-56

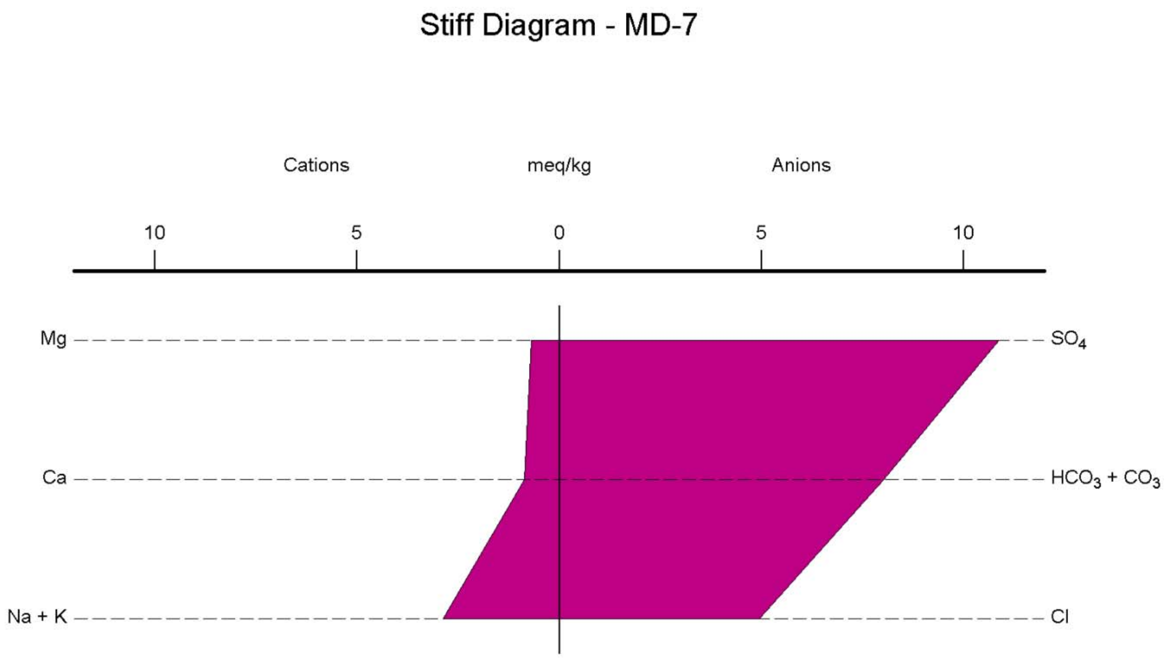


Figure 5-57

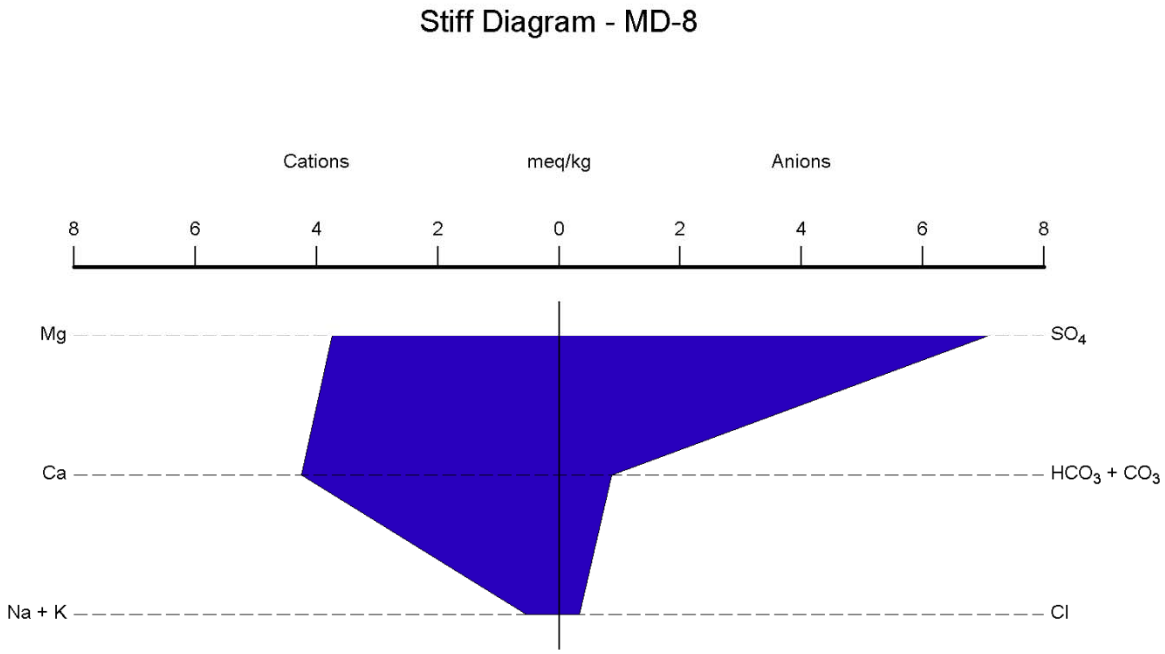


Figure 5-58

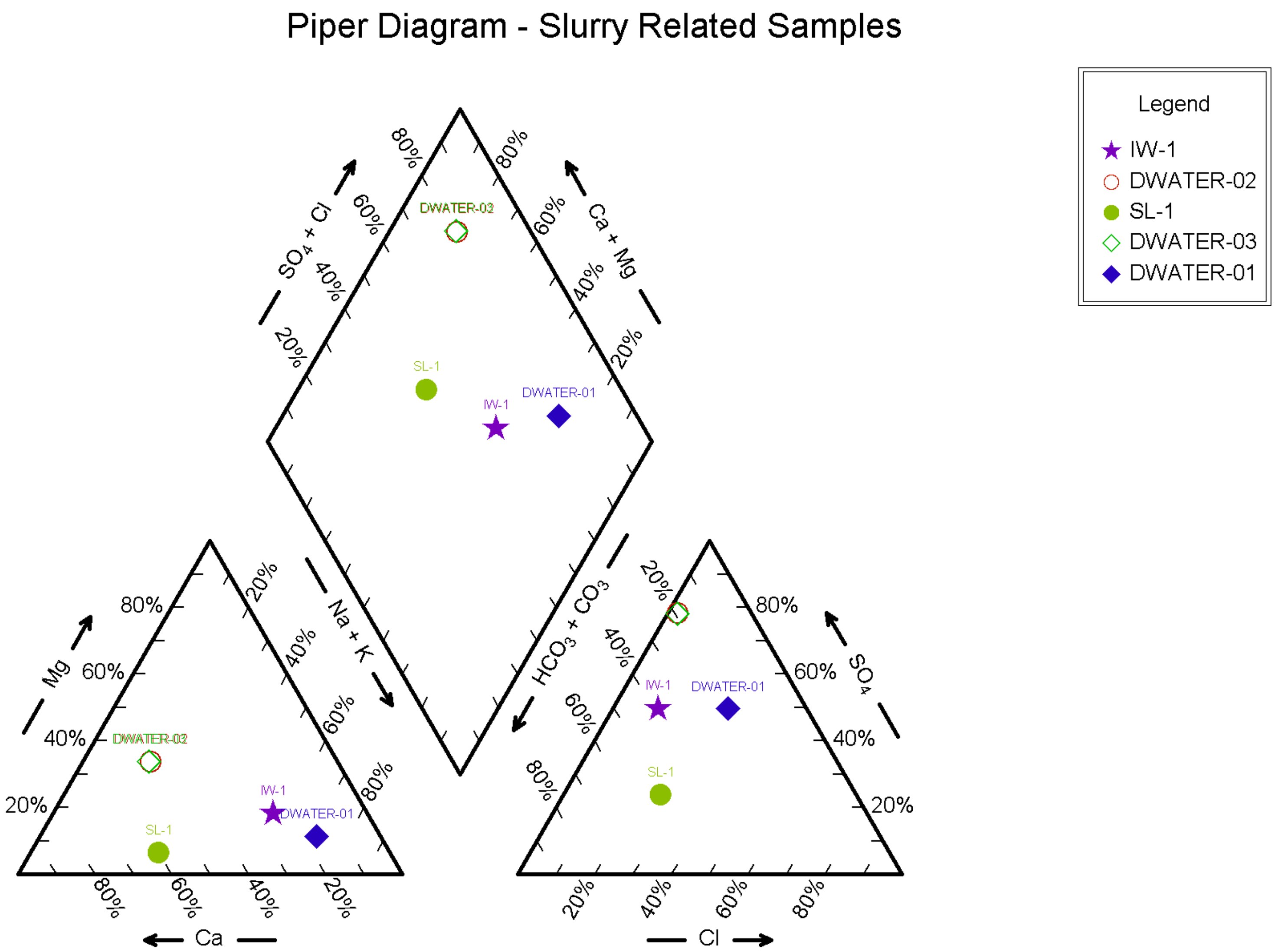

Piper Diagram - Slurry Related Samples
Legend
★ IW-1
○ DWATER-02
● SL-1
◇ DWATER-03
◆ DWATER-01
SO4 + Cl
Ca + Mg
Na + K
HCO3 + CO3
Mg
Ca
Cl
SO4
20%
40%
60%
80%
DWATER-02
DWATER-03
SL-1
IW-1
DWATER-01

Figure 5-59

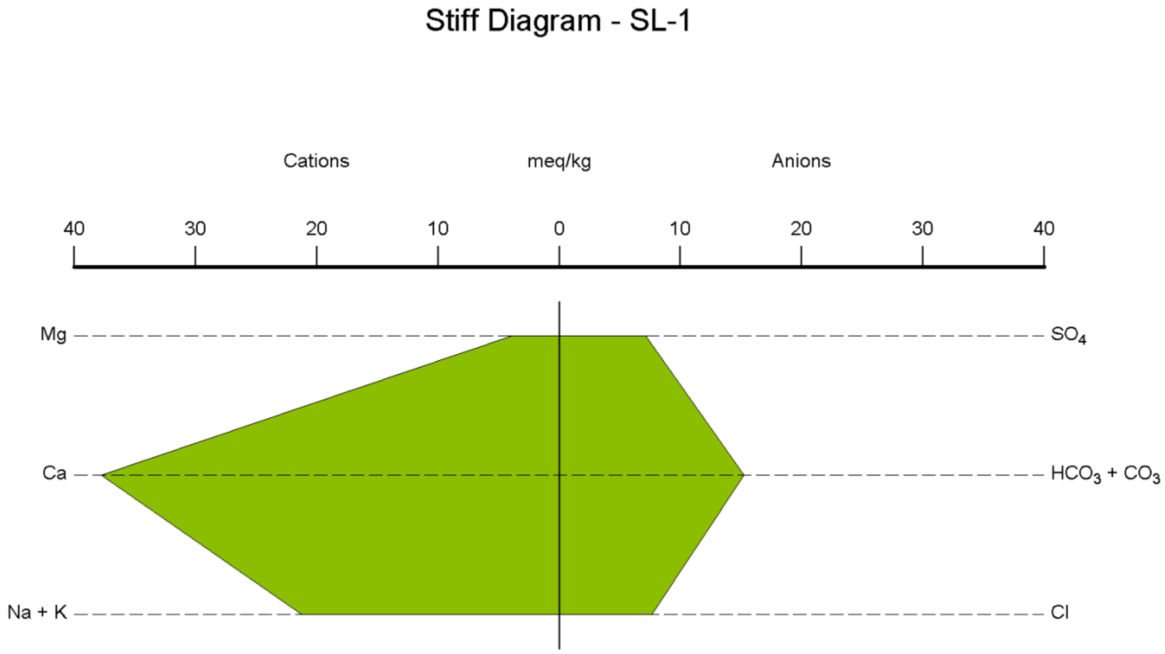


Figure 5-60

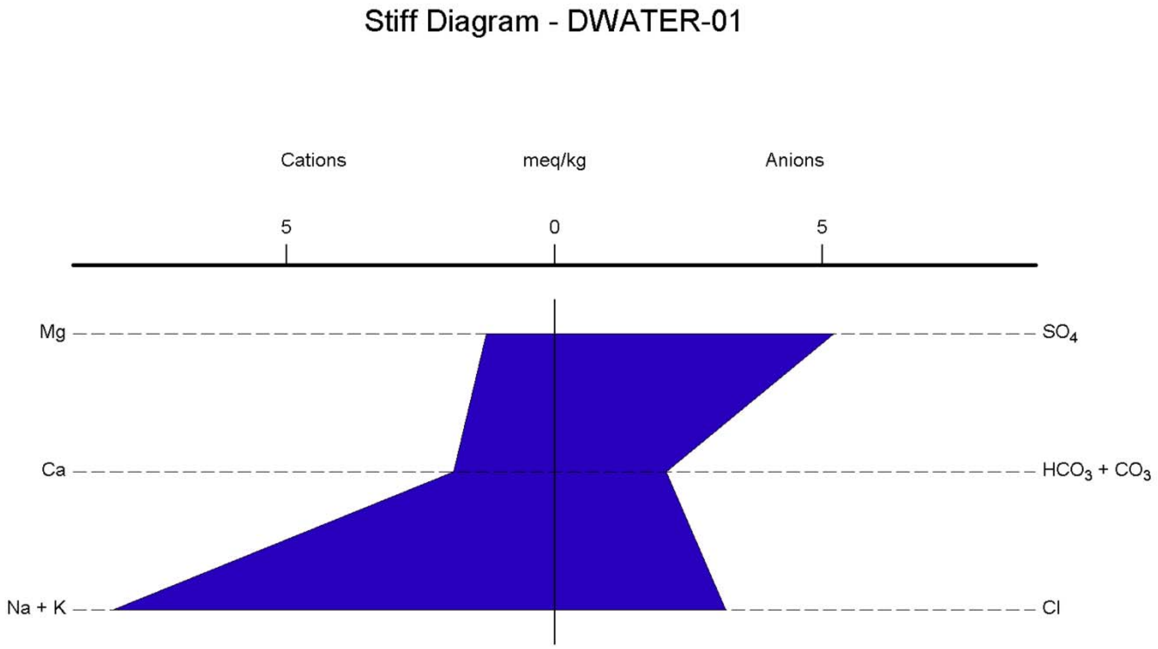


Figure 5-61

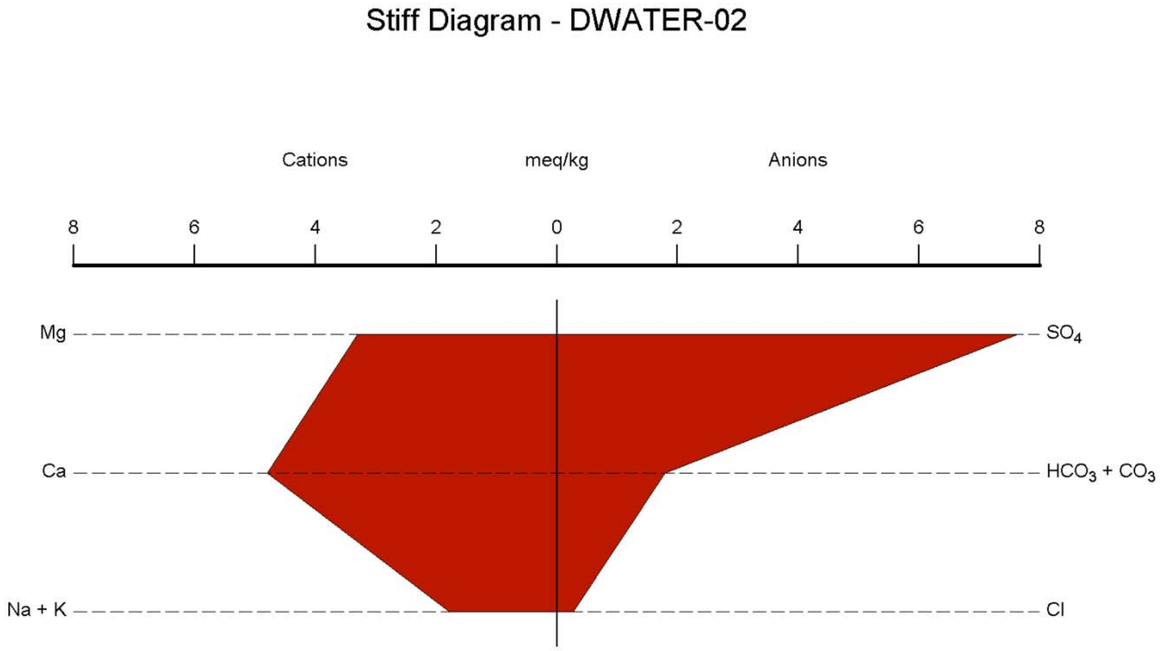


Figure 5-62

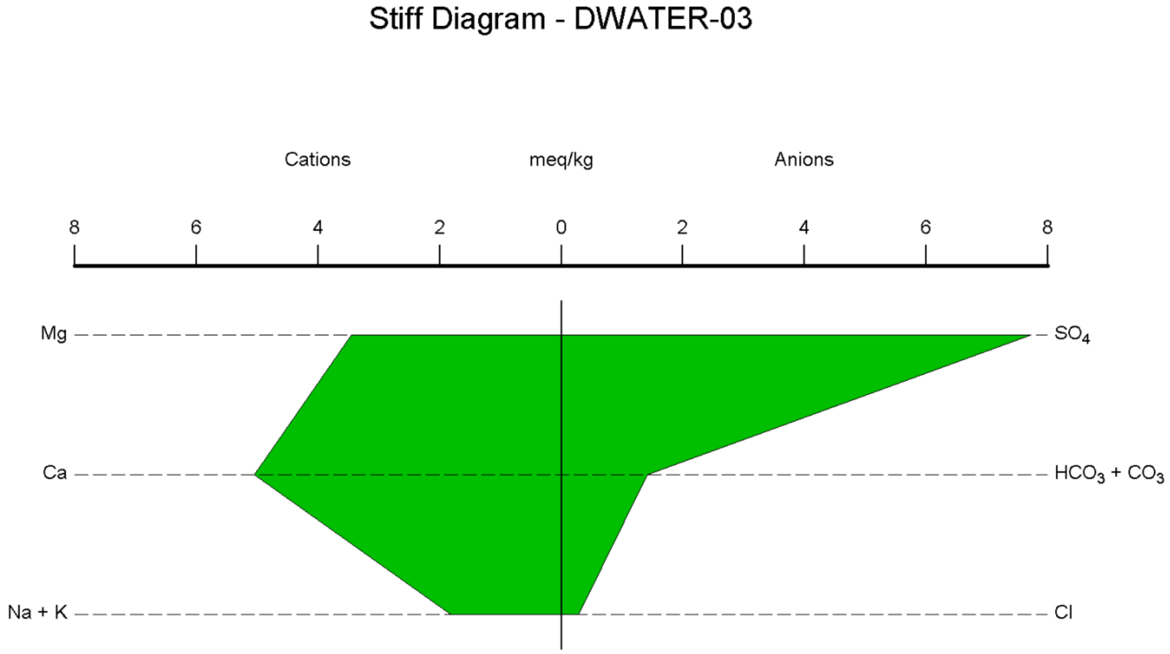


Figure 5-63

Piper Diagram - Valley Fill Discharge

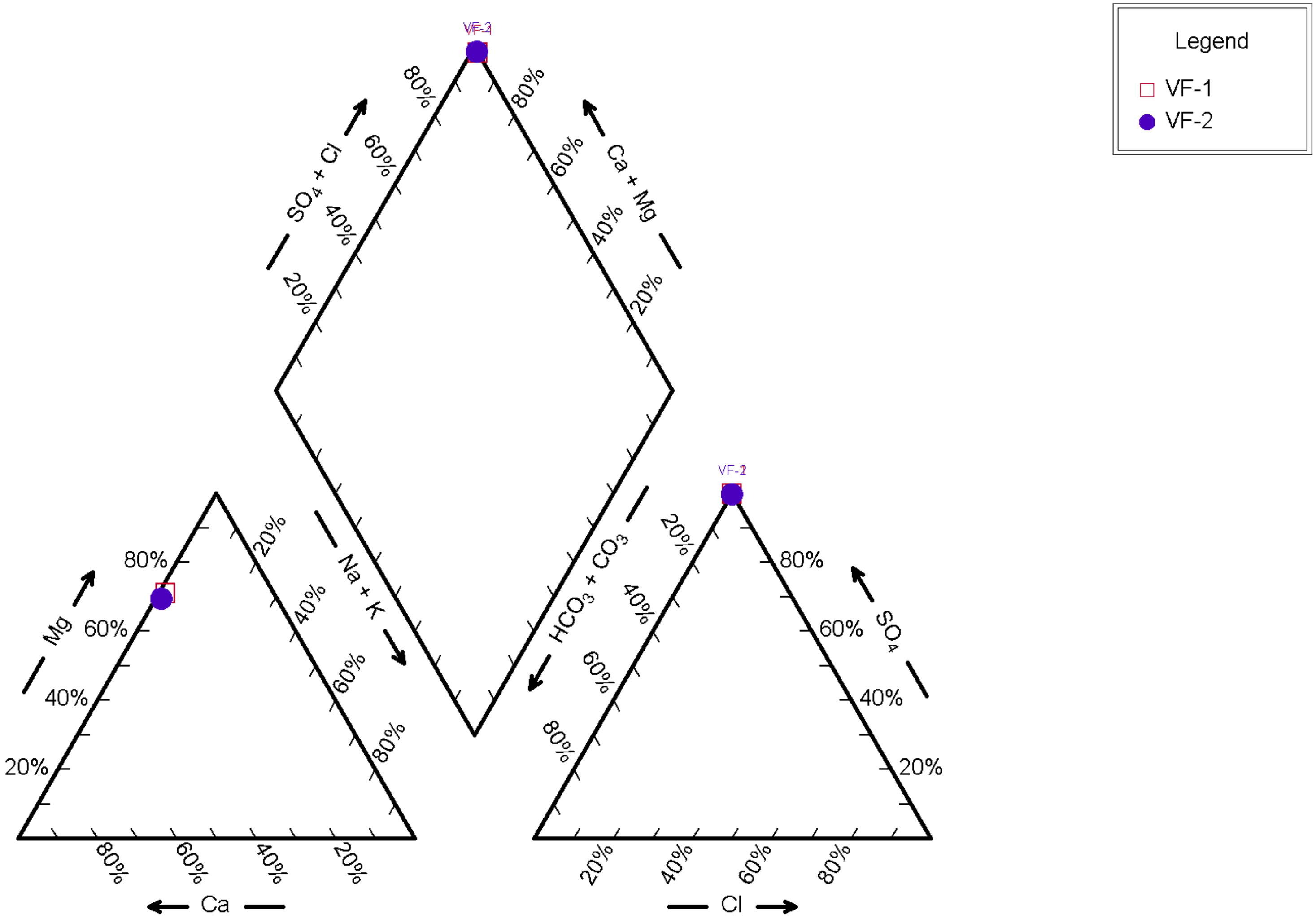


Figure 5-64

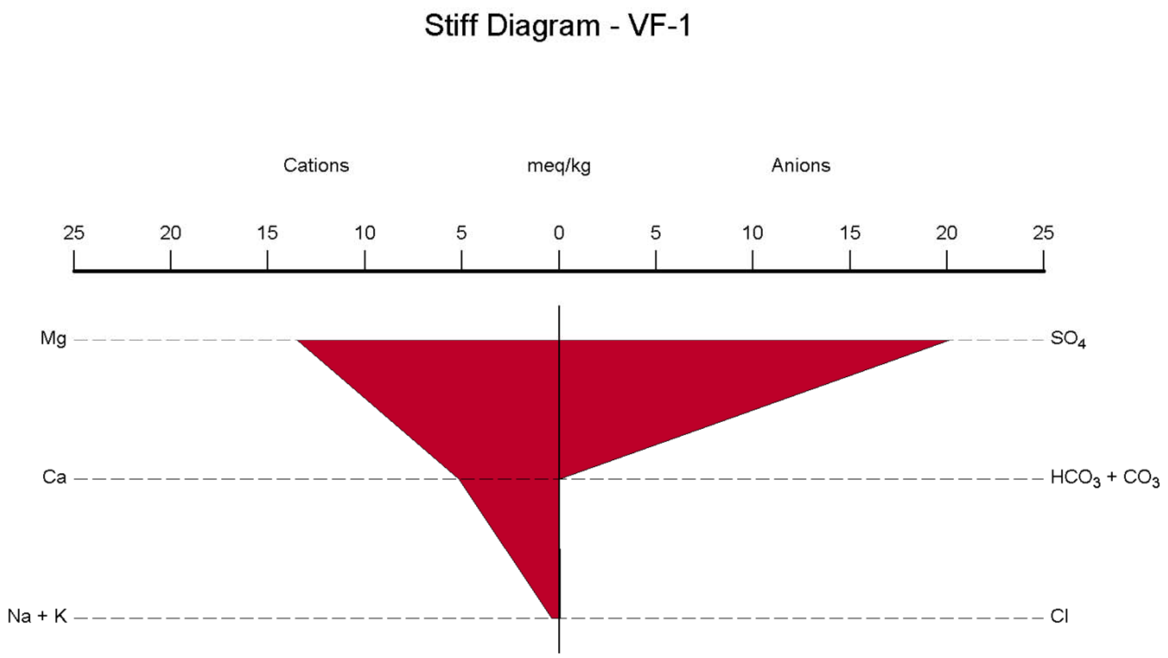


Figure 5-65

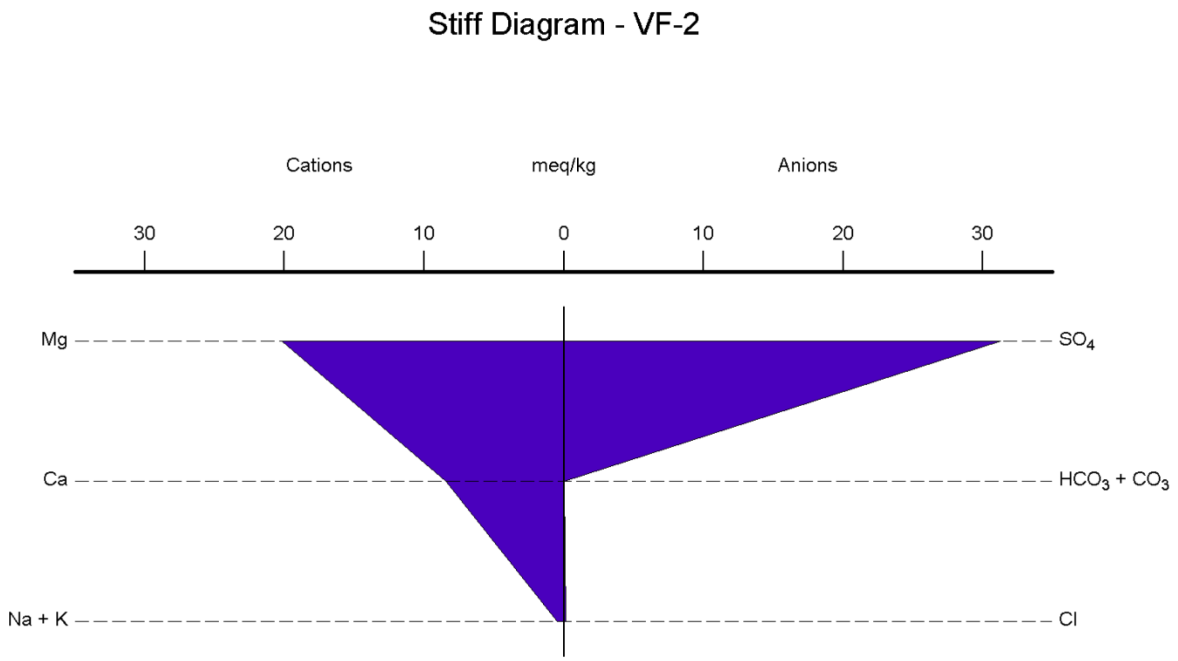


Figure 5-66