Final Project Report

for

Prop 84 STORM WATER GRANT PROGRAM
Agreement # 12-425-550

ASSESSING THE EFFECT OF LONG-TERM STORMWATER INFILTRATION ON GROUNDWATER QUALITY; CONTINUED MONITORING OF THE LOS ANGELES BASIN WATER AUGMENTATION STUDY INFILTRATION BEST MANAGEMENT PRACTICES (BMPS)

Watershed: Los Angeles River

Project Type: Monitoring and Assessment

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Total Project Cost: $271,525 (as of 03/31/2016)

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EXECUTIVE SUMMARY

This Final Project Report presents the synthesized results of this long-term study, with a focus on Phase III results of the effort. This report is intended to provide a focused on a summary of the results of monitoring at the three long-term Phase III sites. This includes a summary of the results from the Phase III monitoring compared to previous phases for the long-term monitoring sites (Broadous Elementary School, Mid-City Iron and Metals, and Veterans Park). Results are compared to regulatory thresholds (California drinking water Maximum Contaminant Levels (MCLs) or Los Angeles Basin Plan Water Quality Objectives) to ascertain if a measurable reduction in pollutant concentrations, especially metals, nutrients, anions, volatile organic compounds, and sediment to the Los Angeles River was achieved.

Although capturing and infiltrating stormwater is an accepted and practiced means of reliably augmenting groundwater supplies in southern California, there has been lack of scientific data available to assess whether long-term infiltration of storm water-borne contaminants negatively impact groundwater quality and poses a risk to human health. To help address this, the Council for Watershed Health, in collaboration with its partners, initiated the Los Angeles Basin Water Augmentation Study (WAS) in 2000 to investigate the potential risk to groundwater quality posed by long-term infiltration of urban storm water, among many other related topics. Phase I of the WAS consisted of implementing pilot monitoring projects at Broadous Elementary School in Pacoima and the IMAX headquarters building in Santa Monica. Initiated in 2003, Phase II of the WAS expanded the number of study sites to six, to represent various land uses (residential, public parks, industrial, and commercial).

Based on initial project success, Phase III began with implementation of the Elmer Avenue Neighborhood Retrofit, a pilot project designed to demonstrate the feasibility of implementing a large-scale infiltration retrofit project in an existing neighborhood. New monitoring results documented in this report are part of Phase III activities, and include monitoring at Elmer Avenue and three of the original six project sites (Broadous Elementary School, Mid-City Iron and Metal in Los Angeles, and Veterans Park in Long Beach) with viable monitoring stations. In addition, a long-term infiltration project owned by Los Angeles County (Sun Valley Park) was monitored collaboratively with the County of Los Angeles.

Methodology

The monitored infiltration BMPs for this project are subsurface infiltration galleries, designed to capture at least the 85th percentile, 24-hour storm event of about ¾ of an inch. This design storm results in the capture of about 80% of annual average runoff.

Comprehensive monitoring systems installed at the project sites include surface monitoring stations to collect surface runoff samples, lysimeters to collect samples of captured storm water infiltrating though the vadose zone, and monitoring wells to collect samples of receiving groundwater. Collected samples were analyzed for approximately 80 constituents of concern including: metals, nutrients, organics, general water chemistry parameters, and emerging contaminants. In addition, monitoring at Elmer Avenue included biodiversity assessments and analysis of soil samples to assess the time trend of contaminant accumulation within the bioswales used to promote infiltration.

Results

The optimum means of assessing long-term impact to groundwater quality is to perform statistical time trend analysis of groundwater samples beneath long-term infiltration sites. Mann-Kendall trend analysis was performed for selected constituents of concern for monitoring stations with sufficient data for statistical analysis. Additional analysis performed includes comparison of results from up- and down-gradient wells, assessment of time-concentration charts, and other non-statistical methods.

Mann-Kendall trend analysis was performed for groundwater results for 157 constituents with a sufficient number of data points for statistical analysis. Concentrations of most constituents of concern in groundwater were stable (i.e. there was not a statistically significant trend) or decreasing. The strongest trends were observed at the Veterans Park site, which has the shallowest groundwater. Very few statistically significant increasing concentration trends for groundwater samples were detected (13 of the 157 constituents analyzed) and about half of these increasing trends were associated with an up-gradient or background well that are not impacted by infiltration. The other increasing trends are considered to result from factors other than infiltration (i.e. regional changes), or are not significant (i.e. concentration is below MCL). The increasing trends observed were related primarily to salts (chloride, nitrate, total dissolved solids (TDS) and certain metals (total aluminum, boron, cadmium and hexavalent chromium). Nutrients generally decreased with depth and volatile organic compounds (VOCs) have not been an issue.

Concentrations of some metals (chromium, copper, lead, nickel and zinc) and chloride showed increasing trends over time for the lysimeters at the Mid-City Iron and Metal site. Concentrations of these metals, other metals (aluminum, boron, and cadmium) and some other constituents (chloride and chemical oxygen demand) in the lysimeter samples collected at Mid-City Iron and Metal also were notably higher during the Phase III sampling than during previous sampling events conducted seven or more years earlier. The data available and reviewed to date do not indicate conclusively whether these increased concentrations represent actual subsurface conditions away and apart from the sampling systems or, if so, the cause(s) of the increased concentrations. Steps that could be considered to further evaluate these increased concentrations, and to assess whether continued infiltration at this site poses a significant risk of eventually degrading groundwater quality, include: continued monitoring of groundwater and soil moisture using existing facilities; collection and analysis of additional soil samples from various locations and depths in the vadose zone; construction and monitoring of additional vadose zone or groundwater sampling points; collection of surface water samples under first-flush and a range of other conditions; and, more detailed data analysis to estimate potential mass transfer of constituents from surface water and/or the vadose zone to groundwater.

None of the concentrations of constituents analyzed in soil samples from the bioswales at Elmer consistently increased over time (measured annually from 2010 to 2015). At Elmer Avenue in the first 12 months after BMP installation (2010-2011), a total of 22 animal species were observed. During the 2014-15 monitoring season (about 5 years post construction) 35 species were observed. The biggest improvement was seen in the insect diversity. In 2010-11 just two species were observed, whereas in 2014-15 fifteen unique native and beneficial insect species were observed, including a range of butterflies and bees.

Findings

Results of the Phase III monitoring for the Los Angeles Basin Water Augmentation Study are in agreement with results from previous phases of the project. Based on monitoring to date, there is no evidence of significant degradation of groundwater quality due to long-term infiltration of urban storm water. These results are not only significant from the aspects of human and watershed health, but are useful and practical for permit writers and city planners, as well as provide confidence that stormwater-based ordinances can safely encourage infiltration as means to augment groundwater supplies.

Funding for this project has been provided in full or in part through an agreement with the State Water Resources Control Board, Proposition 84 Stormwater Grant Program and by the following cost-sharing partners:

- *City of Los Angeles Bureau of Sanitation*
- *Water Replenishment District of Southern California*

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BACKGROUND

In January 2000, the Council for Watershed Health (Council), formerly the Los Angeles and San Gabriel Rivers Watershed Council, convened a workgroup made up of representatives from a variety of federal, state, and local agencies to discuss the potential benefits of conserving stormwater runoff and the barriers associated with such conservation. The availability of water resources in southern California were increasingly under pressure and there was a growing interest in the use of stormwater flows as a potential source of recharge for groundwater storage aquifers in order to increase local water supply. However, with the increased interest in the capture of stormwater, local water agencies also expressed concern that increased infiltration of runoff may simply transfer pollutants from surface water to groundwater, thereby exacerbating existing water quality problems.

These concerns initiated the Los Angeles Basin Water Augmentation Study (WAS), a long-term effort that set out to evaluate the practical potential to improve surface water quality and increase local groundwater supplies though infiltration of urban storm water runoff. In large part, the study was conceived as a direct response to a need to investigate the fate and transport of stormwater pollutants associated with various infiltration techniques and to determine whether capture and infiltration of stormwater at sites throughout the Los Angeles watershed was a viable means of augmenting water supply without adversely affecting groundwater quality.

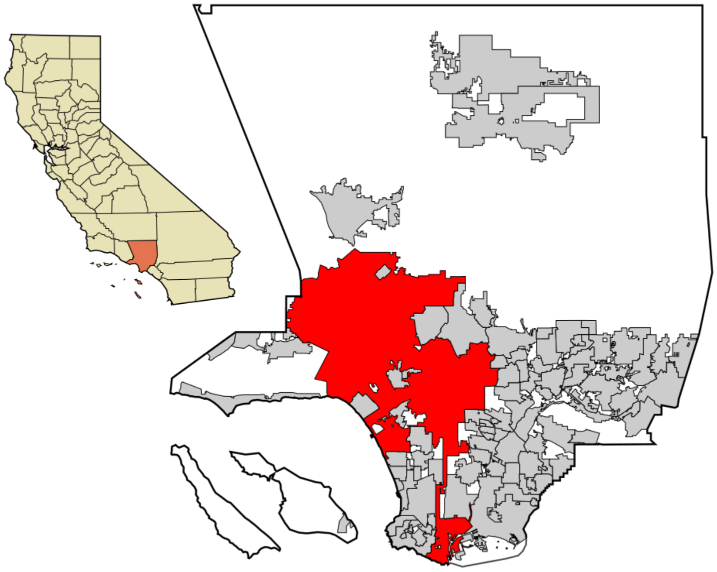
The overall WAS program was developed and implemented over time using phased approach. Phase I of the study was designed to monitor the fate and transport of runoff-borne pollutants by measuring stormwater quality at the surface as it infiltrates through the soil and as it mixes with groundwater, with a focus on water quality assessment on single parcels, utilizing infiltration structures. For Phase I, two locations were monitored for one wet season. Phase I also included performing a review of available literature relevant to assessing the impact of infiltrating urban storm water. Phase II expanded the spatial and temporal aspects of the monitoring, adding new sites with different land uses and infiltration techniques, and monitoring for several years. Phase III (the focus of this report) added subsurface vadose-zone and groundwater sampling to the program to monitor long-term impacts of infiltration, in addition to continuing to collect data on surface stormwater runoff.

a. City and County Information

As of the 2010 U.S. Census, the County of Los Angeles (County) has a population of 9,818,605, making it by far the most populous county in the United States. The County has 88 incorporated cities and many unincorporated areas. At 4,083 square miles (10,570 km^2), it is larger than the combined areas of the states of Rhode Island and Delaware. The County contains more than one quarter of all California residents and is one of the most ethnically diverse counties in the state and the country.

The County's administrative center is the City of Los Angeles (City), the second-largest city in the United States and the most populous city in California (Figure 1). Situated in Southern California, the City of Los Angeles is known for its Mediterranean climate and sprawling metropolitan area. The city lies in a large coastal basin surrounded on three sides by mountains reaching up to and over 10,000 feet (3,000 m).

Figure 1: Location of Los Angeles County and City (in red) in the state of California



b. Discussion of Watershed

The Los Angeles River is one of the primary watersheds in Los Angeles County. It encompasses 834 square miles from the San Gabriel Mountains on the northern end of the Los Angeles Basin to the Pacific Ocean. The watershed extends from the western edge in the Santa Susana and Simi Hills and curves southward around the intrusion of the Santa Monica Mountains to discharge into the Pacific Ocean at

Long Beach Harbor in San Pedro Bay (**Error! Reference source not found.**).The main stem of the river measures 51 miles, with the first 32 miles within the City of Los Angeles.

Figure 2. The Los Angeles River Watershed

MAP DESIGNED BY THE COUNCIL FOR WATERSHED HEALTH, 2013

Approximately one-third (272 square miles) of the Los Angeles River Watershed (upper watershed) remains in a relatively natural state and is within the boundary of the Angeles National Forest, largely managed by the United States Forest Service (USFS). This includes the western portion of the San

Gabriel Mountains, the Santa Susana Mountains, the Verdugo Hills, and the northern slope of the Santa Monica Mountains. Big Tujunga Creek is the largest natural perennial stream in the upper watershed.

The lower watershed, defined as the major tributaries to the Los Angeles River downstream of Sepulveda Dam, including the sub-watershed of the lower Tujunga Wash, Burbank Western Channel, Verdugo Wash, Arroyo Seco, Rio Hondo, and Compton Creek have been highly urbanized and now support primarily residential and industrial land uses. Since the 1990, agricultural and commercial uses have decreased slightly, while industrial uses have increased from 6% to 14% (LARWMP 2012).

Rich alluvial deposits characterize portions of the lower watershed in the San Gabriel Valley, the eastern portion of the San Fernando Valley, and a large part of the coastal plain. Closest to the mountains, coarse gravel predominates while the granularity of the deposits diminishes in size with distance from the San Gabriel Mountains, graduating from sand, silt, and clay. In the central and western portions of the San Fernando Valley, the deposits are fine-grained materials resulting from the erosion of shale, sandstone, and clay, with most of the material having been deposited by streams entering the valley from the southern slopes of the Santa Susana Mountains.

Surface Hydrology and Runoff

Annual stream flows in the Los Angeles River reflect a Mediterranean climate along with the effects of flood management and water conservation practices. Average monthly stream flows are characterized by dramatic seasonal and spatial variability. In general, flows increase from upstream to downstream in the watershed. Flows in the main stem of the Los Angeles River, Compton Creek, Verdugo Wash, and Burbank Western Channel have steadily increased since the 1940s as impervious cover has increased.

The typical dry-weather period from May through September is characterized by little or no rainfall and steady flows that range from 1 cubic feet per second (cfs) at the headwaters up to 194 cfs at the confluence with San Pedro Bay. In the upper watershed, natural springs feed Tujunga Wash, Pacoima Wash, Santa Anita and other tributaries above their respective dams. Flow in the lower watershed is sustained by treated effluents from three publicly-owned treatment works (POTWs): the City of Los Angeles' Glendale and Tillman POTWs, and the City of Burbank POTW. The POTWs proportion of total annual stream flow in the Los Angeles River varies both annually and seasonally, and can range from 19% during wet weather to 92% during dry weather. The Glendale Narrows, a seven-mile long soft-bottom section of the Los Angeles River adjacent to Griffith Park, is an area where rising groundwater also contributes significant dry-weather flows into the river. Historically this rising groundwater ensured that the river had year-round flow (LASGRWC 2001).

The typical wet period spans October through April and flows range from 1.34 CFS at the headwaters up to 1,592 CFS at the estuary. This period is marked by occasional storms and flows during storm events are flashy. Storms can increase runoff volume to 10 billion gallons (Sheng 2009).

Four sub-regions of the watershed can be loosely defined based on the source of flow:

- Upper Watershed tributary streams dominated by **natural** flows
- The Los Angeles River main stem (including the Burbank Western Channel) dominated by treatment plant **effluent** flows
- Lower watershed tributary streams dominated by **urban** runoff
- Los Angeles River estuary dominated by **tidal flow**

Tertiary-treated effluents from three publicly-owned treatment works (POTWs) dominate dry weather flows in the river's main stem on the coastal plain (see Figure 2). Their treatment capacities range from 9 million gallons per day (MGD) for the Burbank Water Reclamation Plant (WRP) to 20 MGD and 80 MGD for the Los Angeles Glendale and Los Angeles Tillman Water Reclamation Plants, respectively. Las Virgenes Municipal Water District's Tapia Plant is permitted to discharge 2 MGD to the Los Angeles River at certain times of year, but generally discharges much less. These facilities produce recycled water for landscape irrigation and industrial processes. The rest is discharged to surface waters, with the Tillman Plant's discharge first being used for recreation enhancement in Lake Balboa, Wildlife Lake, and Japanese Garden Lake, before flowing into the river.

c. Historical Uses

Prior to development, the Los Angeles River was typical of other watersheds in the US southwest. Water and debris from the mountains spread freely across the expansive alluvial plain of the lower watershed. The perennial flow in the Los Angeles River historically originated in large part as rising groundwater from the San Fernando Valley ground water basin. The basin is tilted southwards and overflow waters feed the Los Angeles River as it runs through the southern side of the valley. The river's channel was broad and often shifted location within the flood plain with the high sediment loads; the mouth of the river moved frequently between Long Beach and Ballona Creek. Between 1815 and 1825, the river turned southwest after leaving the Glendale Narrows, where it joined Ballona Creek and discharged into Santa Monica Bay in present Marina del Rey (LACDPW 2006). During a catastrophic flash flood in 1825, its course was diverted again close to its present one, flowing due south just east of present-day downtown Los Angeles and discharging into San Pedro Bay. At this time, the coastal plain was a network of creeks, springs, lakes, and wetlands, only remnants of which still remain today.

Following the damaging flood of 1914 and the creation of the Los Angeles County Flood Control District in 1915, a program of flood control and water conservation was initiated in the County. Local residents supported this effort through voter approved storm drain bond issues in 1952, 1958, 1964, and 1970 for a total of over $900 million (LACDPW, 1996). The County Board of Supervisors approved an additional $200 million bond issue in 1993. In the Los Angeles River Watershed this funded the construction of several dams. The Los Angeles County Flood Control District constructed three major dams which were completed between 1920 and 1931: Pacoima, Big Tujunga and Devil's Gate. In the Rio Hondo drainage area, several dams were constructed including Eaton Wash, Sierra Madre, Santa Anita and Sawpit. As the need outstripped the ability to fund further flood control efforts, the federal government stepped in during the Great Depression. The US Army Corps of Engineers constructed three major dams between 1940 and 1954: Hansen Dam, Sepulveda Dam, and Lopez Dam

The concrete sections of the Los Angeles River were constructed between the late 1930's and the 1950's in a trapezoidal or rectangular configuration of minimize the costly acquisition of rights-of-way. Most of the channel was lined in concrete to prevent erosion of the native soils and the system was designed to be a low maintenance, durable way to move flood waters through the coastal plain. Three significant portions of the river however, exist in a semi-natural or soft bottom state: Sepulveda Basin, Glendale Narrows and the inter-tidal estuary below Willow Street. In contrast to the concrete-lined portions, today these areas support a wide variety of habitat and wildlife

d. Problem Statement and Relevant Issues

The Los Angeles Coastal Plain and adjacent watersheds are home to more than 10 million people, or nearly one third of California's residents. The population is expected to grow another 15% by 2015 (California Department of Finance 2001). Approximately 4.5 million people live in the highly urbanized coastal plain of the lower Los Angeles watershed. This region depends on imported water from the Owens Valley, Northern California, and Colorado River for about two-thirds of its water supply, with the remaining one-third provided by local groundwater. The combination of growing urban and industrial demands as well as competition from environmental water users and other users outside the region puts increasing pressure on future water supplies and can compromise local surface and groundwater water quality. Impervious surfaces of the city cause over 50% of each year's rain to run off to the ocean, carrying many pollutants.

Non-point source urban runoff constitutes most of the dry season flow in many of the tributaries and channels of the lower watershed. Approximately 100 million gallons of runoff from landscape irrigation, car washing, and other inadvertent sources flows through the Los Angeles County storm drain system daily and into the flood control channels, including the Los Angeles River and its tributaries (Sheng 2009).

In terms of overall water quality, the majority of the Los Angeles River is considered impaired by a variety of point and nonpoint sources. Impairment may be a result of water column exceedances, excessive sediment levels of pollutants, or bioaccumulation of pollutants. The beneficial uses most often threatened or impaired by degraded water quality are aquatic life, recreation, groundwater recharge, and municipal water supply. The 2010 303(d) list implicates pH, ammonia, a number of metals, coliform, trash, odor, algae, oil, DDT as well as other pesticides, and volatile organics for a total of 116 individual impairments (reach/constituent combinations). Some of these constituents are of concern throughout the length of the river while others are of concern only in certain reaches. The Clean Water Act (CWA) requires a Total Maximum Daily Load (TMDL) be developed to restore impaired water bodies to their full beneficial uses by allocating allowable loadings from point sources and nonpoint sources. TMDLs have been established for trash (2001), and bacteria (2012) for the Los Angeles River, for nitrogen compounds and related effects for the Los Angeles River (2004), for metals for the Los Angeles River and its tributaries (2006), and for nitrogen, phosphorus, trash, organochlorine pesticides, and PCBs for Los Angeles Area Lakes (2012).

In general, historical activities and practices have degraded the groundwater quality in Los Angeles County over the past century. Reasons for this include seepage into the subsurface of fertilizers and pesticides from past agricultural uses, nitrogen and pathogenic bacteria from poorly sited and maintained septic tanks, and various hazardous substances from leaking aboveground and underground storage tanks and industrial operations. Overdraft of groundwater from coastal aquifers in the first half of the 20th Century resulted in not only a decline in groundwater levels, but also the intrusion of seawater into the aquifers.

Regulatory and Management Implications

Throughout the region, and especially within the Los Angeles River Watershed, many organizations and agencies have installed (and continue to install) stormwater Best Management Practices (BMPs) to capture and infiltrate stormwater. However, few of these systems are monitored for their long-term impacts to groundwater quality. Before WAS, there had been a general lack of scientific data available to assess whether long-term infiltration of storm water-borne contaminants would negatively impact groundwater quality and poses a risk to human health. WAS not only has important regulatory ramifications for the National Pollution Discharge Elimination System (NPDES) and TMDL compliance, but long-term management implications for infiltration on the vadose zone and groundwater quality and quantity and for the appropriate siting of infiltration BMPs based on geographic, geologic, and hydrologic conditions. In addition, WAS provided a means to begin to evaluate the costs and benefits of program implementation to determine the most effective strategy for developing this potentially significant source of water for southern California.

2.0 PROJECT DESCRIPTION

a. Project Type

Phase III of the WAS represents the final phase of this water quality monitoring program in its current form. This phase added subsurface vadose-zone and groundwater sampling to the program to monitor long-term impacts of infiltration, in addition to continuing to collect data on surface stormwater runoff.

This Final Project Report summarizes of the results of monitoring at the three long-term Phase III sites. This includes a synthesis of the results from the Phase III monitoring compared to the results from the long-term monitoring sites from previous phases (Broadous Elementary School, Mid-City Iron and Metals, and Veterans Park). Data from two additional sites, Elmer Avenue and Sun Valley Park, are also presented. Tables and graphs are provided to show trends in constituents of concern that were monitored for Phase III. A discussion of the goals and targets for this phase of the study, and whether they were achieved, are also discussed.

b. Project Cost

Grant funding for Phase III of this project in the amount of $255,292 was provided to the Council for Watershed Health through a contract with the State Water Resources Control Board (SWRCB) pursuant to the Proposition 84 Stormwater Grant Program. Matching funds were from the Council for Watershed Health, City of Los Angeles, and the Southern California Water Replenishment District for construction and monitoring and performance in the amount of $42,524. Other fund sources well as in-kind services in the amount of $1,158 for staff time related to direct administrative costs. The total cost for this project as of December 31, 2015 is $298,975.

c. Project Schedule

WAS Phase III was conducted from May 1, 2013 through March 31, 2016 (the full term of the grant agreement).

d. Project Goals

Phase III of WAS represents the final phase of the monitoring program to quantify the long-term effects of infiltrating urban stormwater on groundwater quality at sites in the Los Angeles River Watershed utilizing Best Management Practices (BMPs) For Phase III, a limited sampling program was conducted to continue the monitoring of subsurface water quality. The specific goals of Phase III were to assess the cumulative impact of infiltration on soil and groundwater, and to evaluate the effects of different land uses on pollutant types and concentrations. The intended outcome of Phase III was to observe a measurable reduction in pollutant concentrations, especially metals, nutrients, anions, volatile organic compounds, and sediment.

e. Project Methodology / CEQA / Permitting / Construction / Description / Pollutant Load

During Phase III (Grant Agreement # 12-425-550), a limited sampling program was conducted to continue monitoring subsurface water quality at selected sites described below. Data were collected by the Council for Watershed Health and its consultant, AMEC, with technical oversight by the WAS Technical Advisory Committee (TAC) that was assembled for the initial pilot study from an earlier phase of this effort (Montgomery Watson 2002; LASGRWC 2002).

Grant Agreement # 12-425-550 (Phase III) received a Notice of Exemption (NOE) from the State Water Board (SCH Number: 2013088109). The reason stated for this exemption was that this was for basic data collection and research with no disturbance to an environmental resource.

Site Selection

The 'open source' Structural BMP Prioritization and Analysis Tool (SBPAT), developed by Geosyntec (http://sbpat.net), was used to select appropriate priority BMPs for all phases of WAS. The prioritization methodology of this GIS-based water quality analysis tool is geared toward optimizing the water quality return on investment for user-defined priorities and multiple pollutant types. It takes into account variables such as available space, land ownership, and environmental priorities. It is intended to help link priorities to opportunities. BMP locations with porous soil types such as sandy loams were prioritized, since infiltration rates depend largely on particle size and porosity.

Five (5) sites representing different BMPs, land uses, soil types, and hydrogeology were monitored for Phase III (Figure 3):

- Broadous Elementary School in Pacoima
- Mid-City Iron and Metal in Downtown Los Angeles
- Veterans Park in Long Beach
- Sun Valley Park in Sun Valley (in collaboration with LADPW)
- Elmer Avenue in Sun Valley

During Phase III, three sites identified from the previous phases (Broadous Elementary School, Mid-City Iron and Metal , and Veterans Park) were re-sampled, and two new sites (Elmer Avenue and Sun Valley Park) were added. These sites incorporate different land uses (residential, school, commercial, and park) and are representative of typical in-situ stormwater conditions in the region. At each of the sampling locations, storm water LID BMPs had been previously installed. LID BMPs (vegetated bio swales, rain gardens, porous pavement, etc.) were present at the school (Broadous) and residential (Elmer Ave) sites. Engineered BMPs (pre-treatment systems and infiltration galleries) are installed at the industrial sites (Mid-City Iron) and the two municipal park sites (Veterans and Sun Valley). Detailed site maps for each of these sites are included in the Final Comprehensive Monitoring Report previously prepared for this agreement. The three sites monitored during Phases I and II were not monitored during Phase III due to either land ownership changes or that monitoring equipment had been destroyed or removed.

The monitoring conducted for Phase III was unique in that it incorporated a demonstration project on a neighborhood street- scale, the Elmer Avenue Neighborhood Retrofit Project. Elmer Avenue is located in Sun Valley, CA (City of Los Angeles) and was retrofitted with state of the art Best Management Practices to address storm water infiltration as well as water conservation, pollution reduction and treatment, flooding, and habitat restoration. In addition, native drought-tolerant landscapes were installed and use of irrigation controllers implemented. This demonstration project was monitored for water quality as well as for reduction of runoff and water use, changes in property values, and other potential benefits related to biodiversity and habitat. Elmer Avenue was intended as an in-situ demonstration for addressing existing infrastructure and continues to serve as a demonstration in the region of how to address flood management, water quality, water supply and environmental restoration. Elmer Avenue provides a template for how these approaches can be applied on a regional scale in Southern California.

At all Phase III sampling locations, water quality was assessed in three ways process:

1. Surface runoff was collected to characterize the quality of storm water that is entering each site to be captured for infiltration.
2. Soil pore moisture (vadose zone) was collected with lysimeters after a storm to evaluate the change in concentration of analytes as stormwater percolates through the vadose zone.
3. Groundwater was collected from the monitoring wells after a storm event to assess the long-term impact (if any) of urban stormwater infiltration on groundwater quality via the installed BMP

A monitoring and reporting plan (MRP) for Phase III that describes the procedures used to monitor stormwater run-off at the surface, while it is infiltrating, and in the groundwater, was produced (Daniels 2014). Surface runoff samples were collected as near as practical to the commencement of a runoff event. Lysimeters and shallow wells were sampled within 1-3 days after monitored rainfall events, allowing time for the water to infiltrate through the soil to the depth of sampling. Variables such as subsurface soil heterogeneity, infrequent rain events, evaporation, transpiration, and contaminant transport (dispersion, diffusion, chemical reactions) all tend to slow down actual storm event water travel times. Deep wells were sampled periodically, but not in response to any particular rainfall event. The timing for sampling of the lysimeters and monitoring wells was based on experience from the earlier phases.

At all Phase III sites, at least two years, and in some cases five years, of existing (baseline) monitoring data were available from prior studies. The one exception to this is for the lysimeter installed Elmer Avenue which was installed in 2012 by AMEC under contract to the Council for Watershed Health, with funding from the Water Replenishment District of Southern California. Mann-Kendall trend analysis was conducted for 157 analytes/sampling locations that had sufficient data for statistical analysis.

Figure 3. Los Angeles Basin Water Augmentation Study Phase III Site Location Map

Water Augmentation Study

★ Monitoring Locations

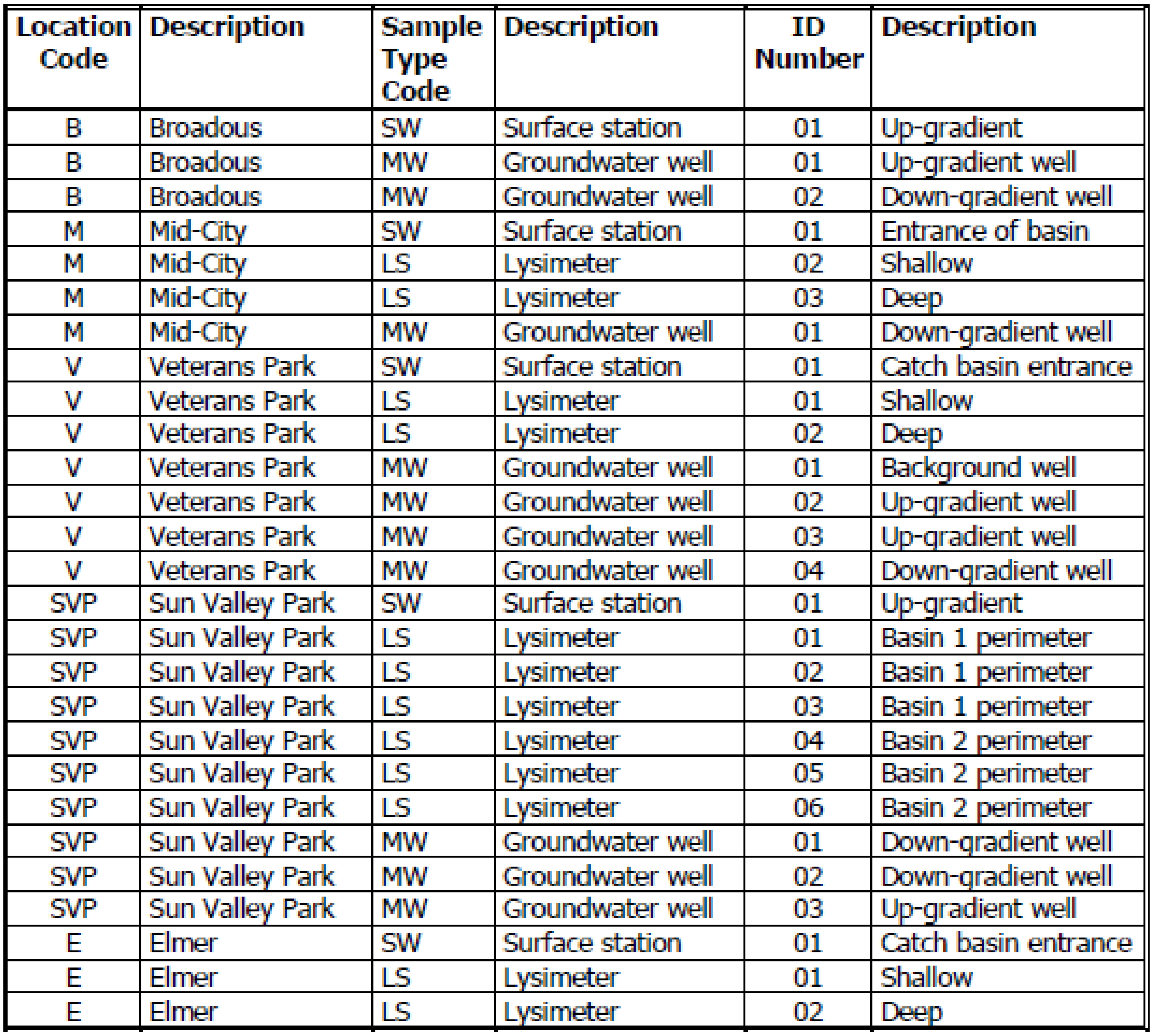
MAP DESIGNED BY THE COUNCIL FOR WATERSHED HEALTH, 2013

f. Data – Existing and New

The results from the Phase III monitoring compared to previous phases for the long-term monitoring sites (Broadous Elementary School, Mid-City Iron and Metals, and Veterans Park). Monitoring results for the two new sites (Sun Valley Park and Elmer Avenue) are also discussed, but analysis of this data was limited because less data were available. Results are compared to regulatory thresholds (California drinking water maximum contaminant levels (MCLs) or Los Angeles Basin Plan Water Quality Objectives). For Phase III, the analytical suite was limited to metals, general monitoring parameters, volatile organic compounds (VOCs) and glyphosate, as per the approved QAPP table. Because only limited sample volume can be obtained from lysimeters (in particular the Elmer Avenue lysimeters), the constituents analyzed in lysimeter samples during this monitoring phase were distributed over different sampling events. Each constituent was analyzed at least once during this phase. Laboratory reports are provided in the final comprehensive monitoring report for this project. Groundwater well and lysimeter monitoring locations for Phase III are included in Table 1.

Time concentration charts and depth-concentration charts for selected analytes, which show the spatial variation in concentrations at each sampling location by depth, for these sites are included as graphs for the Broadous Elementary School, Mid-City Iron and Metals, and Veterans Park sites. Additional analysis performed for these sites includes comparison of results from up- and down-gradient wells. To evaluate trends over time, Mann-Kendall trend analysis was conducted for selected constituents of concern for both the groundwater monitoring locations and lysimeters with sufficient data for statistical analysis. Detailed results of these Mann-Kendall analysis are included in Appendix A of this report. Mann-Kendall trend analysis indicates whether there is a statistically significant increasing or decreasing trend in concentrations for any given constituent at a given monitoring point. Significant trends detected in water quality constituents from groundwater wells and lysimeters are highlighted in Table 2. Although there are less data points for the lysimeter samples compared to the groundwater well samples, we wanted to present the observed trends for both. The Mann-Kendall trend analysis was performed for the lysimeters at Mid-City Metals and Veteran's Park sites only because there were no new lysimeter data for Phase III at Broadous Elementary School.

Table. 1 List of groundwater well and lysimeter monitoring locations for the Water Augmentation Study Phase III



Location Code	Description	Sample Type Code	Description	ID Number	Description
B	Broadous	SW	Surface station	01	Up-gradient
B	Broadous	MW	Groundwater well	01	Up-gradient well
B	Broadous	MW	Groundwater well	02	Down-gradient well
M	Mid-City	SW	Surface station	01	Entrance of basin
M	Mid-City	LS	Lysimeter	02	Shallow
M	Mid-City	LS	Lysimeter	03	Deep
M	Mid-City	MW	Groundwater well	01	Down-gradient well
V	Veterans Park	SW	Surface station	01	Catch basin entrance
V	Veterans Park	LS	Lysimeter	01	Shallow
V	Veterans Park	LS	Lysimeter	02	Deep
V	Veterans Park	MW	Groundwater well	01	Background well
V	Veterans Park	MW	Groundwater well	02	Up-gradient well
V	Veterans Park	MW	Groundwater well	03	Up-gradient well
V	Veterans Park	MW	Groundwater well	04	Down-gradient well
SVP	Sun Valley Park	SW	Surface station	01	Up-gradient
SVP	Sun Valley Park	LS	Lysimeter	01	Basin 1 perimeter
SVP	Sun Valley Park	LS	Lysimeter	02	Basin 1 perimeter
SVP	Sun Valley Park	LS	Lysimeter	03	Basin 1 perimeter
SVP	Sun Valley Park	LS	Lysimeter	04	Basin 2 perimeter
SVP	Sun Valley Park	LS	Lysimeter	05	Basin 2 perimeter
SVP	Sun Valley Park	LS	Lysimeter	06	Basin 2 perimeter
SVP	Sun Valley Park	MW	Groundwater well	01	Down-gradient well
SVP	Sun Valley Park	MW	Groundwater well	02	Down-gradient well
SVP	Sun Valley Park	MW	Groundwater well	03	Up-gradient well
E	Elmer	SW	Surface station	01	Catch basin entrance
E	Elmer	LS	Lysimeter	01	Shallow
E	Elmer	LS	Lysimeter	02	Deep

Broadous Elementary School: Monitoring Results

On September 10, 2014, the first dry weather monitoring event was conducted. Both groundwater wells B-MW-01 and B-MW-02 in the streets adjacent to Broadous Elementary School were sampled on that date. On November 1, 2014, the first wet weather monitoring event was conducted and included collecting a surface water sample, followed by sampling of the downgradient well B-MW-02 on November 10, 2014 to allow time for stormwater infiltration. The downgradient groundwater well was sampled again in response to a second rain event on March 5, 2015. The final dry weather monitoring event was conducted on June 10, 2015, with both groundwater wells sampled on this date. The samples were submitted to Weck Laboratories, Inc. on the same day as collection, and analyzed for the list of constituents in the approved QAPP.

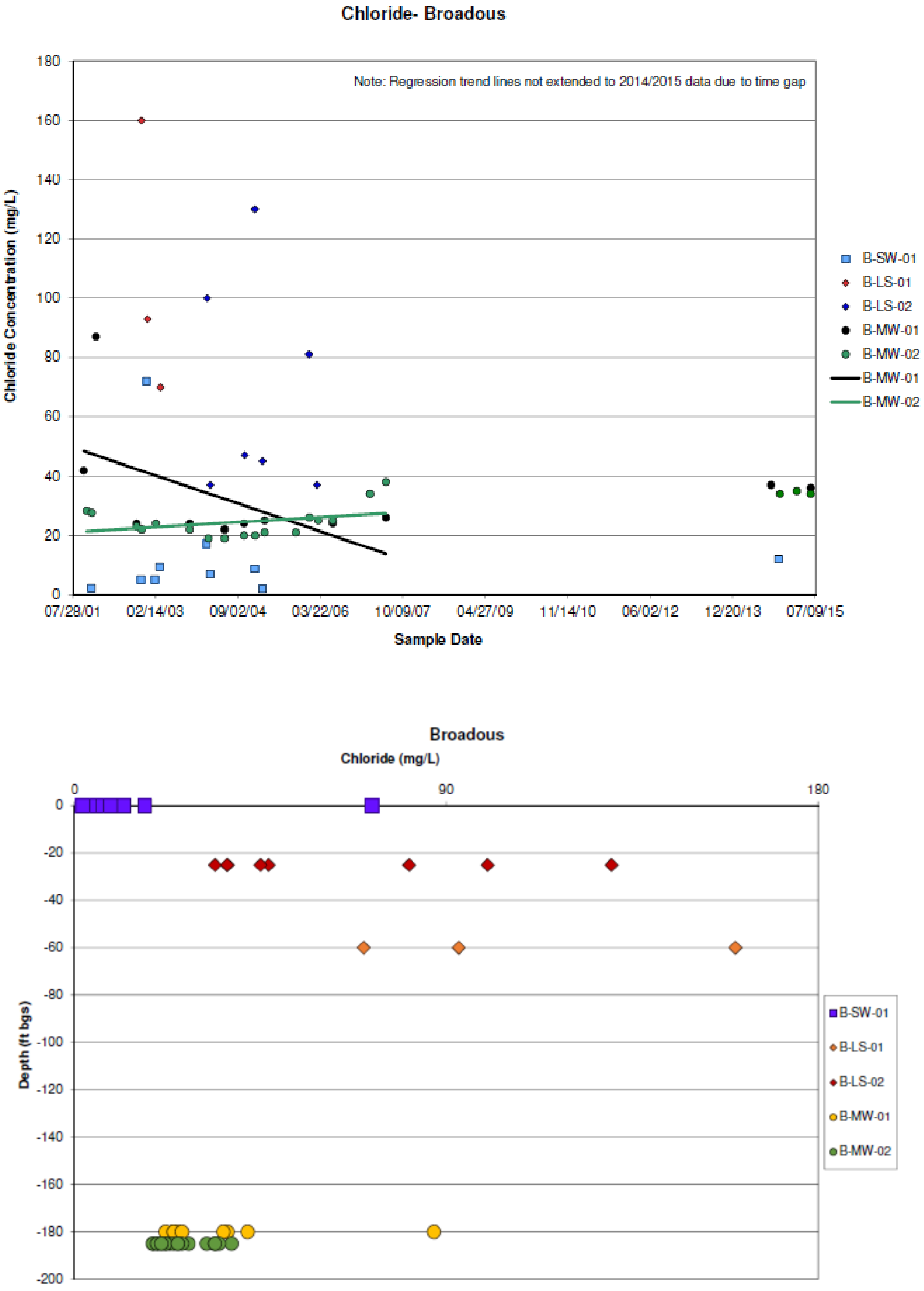
Broadous Elementary Schedule Tracking

Code	Description	Sample Type	Description	ID #	Description	Dry 1 2014	Rain 1 14/15	Rain 2 14/15	Dry 2 2015
B	Broadous	SW	Surface station	01	Up-gradient		√		
B	Broadous	MW	Groundwater well	01	Up-gradient well	√			√
B	Broadous	MW	Groundwater well	02	Down-gradient well	√	√	√	√

Anions:

At Broadous, two of the anions analyzed (bromide and fluoride) had relatively low concentrations in surface water and groundwater (less than 1 microgram per liter (mg/L)). No MCLs have been established for these compounds. For chloride in groundwater samples, when comparing current phase data to historical data, concentrations did not increase significantly, varying over the range of 19 to 34 mg/L, and all sample results were much lower than the MCL of 250 mg/L. Chloride was detected in surface water samples but at generally lower concentrations than in groundwater. A statistically significant increasing trend was calculated for chloride for the downgradient well (B-MW-02; though the magnitude of the increase is slight) and no statistically significant trend was calculated for the upgradient well (Figure 4).

Figure 4. Graphs of (top) concentrations over time and (bottom) depth-concentration for chloride from groundwater monitoring wells and lysimeters at Broadous Elementary School. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.



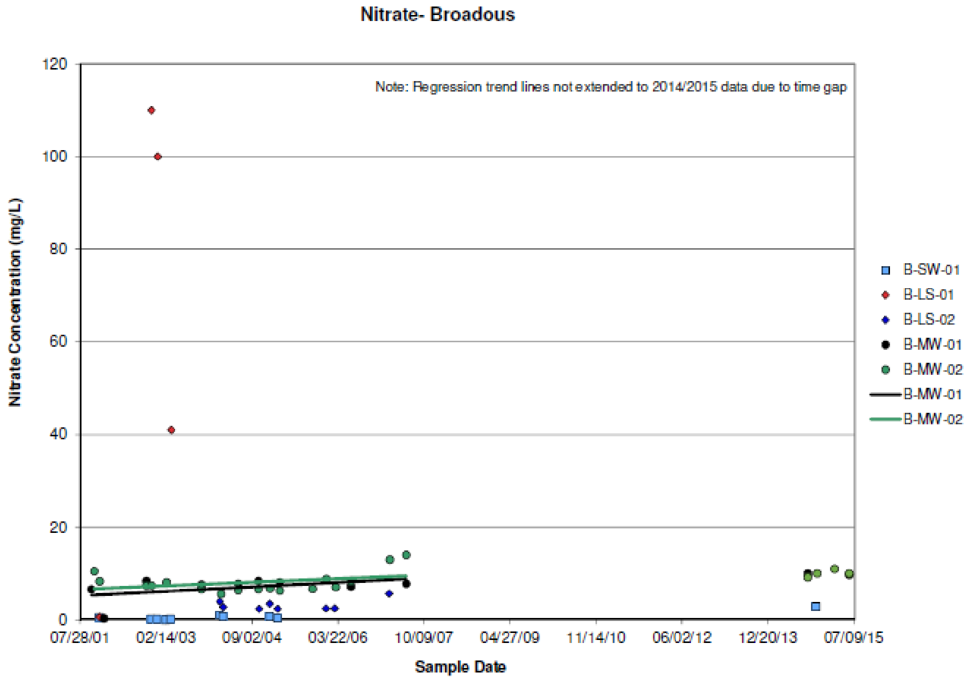
Because chloride is lower in concentration in surface water samples, it is not likely the increase in chloride at B-MW-02 is from infiltration of storm water. Lysimeter results showed higher concentrations of chloride in the initial part of the project indicating that salts may have accumulated in the soil and subsequently flushed out due to infiltration. By the last year of lysimeter monitoring (2007), chloride concentrations in the lysimeter were similar to groundwater concentrations and, over time, chloride concentrations may decrease for this well due to continued infiltration of relatively dilute surface runoff. Sulfate concentrations have shown no statistically significant trend for the upgradient well and a decreasing statistical trend for the downgradient well. All sulfate concentrations in groundwater samples were less than the regulatory threshold. Sulfate was detected in surface water samples but at generally lower concentrations than in groundwater.

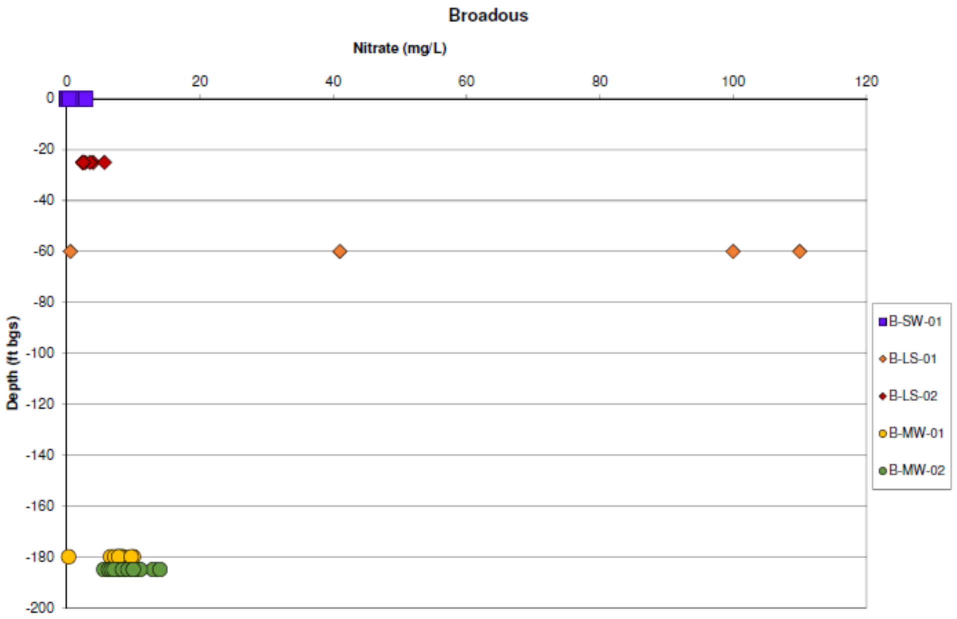
General Monitoring Parameters:
A summary of the general monitoring parameters include:

- Chemical oxygen demand (COD) in surface water for the current phase remained at comparable concentrations to previous surface water concentrations and surface water concentrations were generally higher than groundwater concentrations. COD was not detected in the groundwater wells for this phase of work. Over the course of the study, COD has statistically decreased at the downgradient well B-MW-02. For the upgradient well, insufficient detections were available to calculate a trend.

- Nitrate has been detected in surface water samples, but at slightly lower concentrations than groundwater samples. Over time, nitrate showed statistically significant increasing trends at both wells at concentrations ranging between 5.6 and 14 mg/L; the MCL for nitrate is 10 mg/L (Figure 5). Because the increasing trend in nitrate was in both wells, the increase is likely from regional groundwater effects rather than infiltration of storm water. For the downgradient well, nitrate periodically has been above the MCL, but is currently just at the MCL (similar to the baseline concentration).

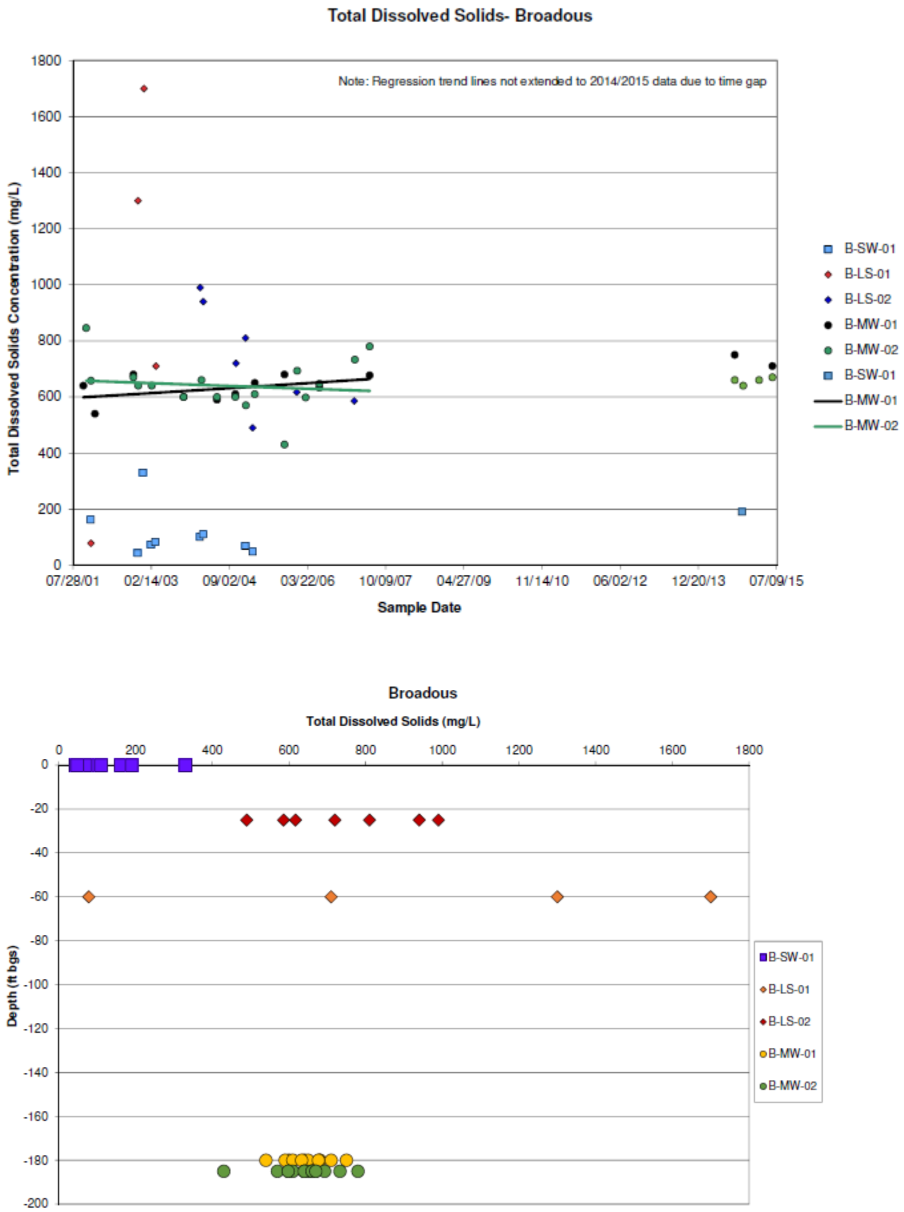
Figure 5. Graphs of (top) concentrations over time and (bottom) depth-concentration for nitrate from groundwater monitoring wells and lysimeters at Broadous Elementary School. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.





The concentration for total dissolved solids (TDS) during this phase remained within the previous range of concentrations observed for surface runoff samples. In groundwater samples from the upgradient well concentrations increased over time, while at the downgradient well the range of values was similar to the previous range. TDS concentrations are generally higher in groundwater than in surface water. Over time, a statistically significant increasing trend was detected for the upgradient well and no statistically significant trend was calculated for the downgradient well. (Figure 6). Therefore, it is likely that infiltration had a positive impact on TDS concentrations in groundwater.

Figure 6. Graphs of (top) concentrations over time and (bottom) depth-concentration for total dissolved solids (TDS) from groundwater monitoring wells and lysimeters at Broadous Elementary School. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.



- Concentrations of total Kjeldahl nitrogen (TKN) in Phase III surface water samples were higher than concentrations detected in surface water during earlier phases. TKN was not detected in either of the groundwater wells during this phase of monitoring.
- Dissolved and total phosphorus concentrations in groundwater were much lower (one to two magnitudes lower) than those in surface water. Concentration ranges observed at the downgradient well were slightly higher than the upgradient well but, in general, concentrations are very low (less than 1 mg/L). No MCL is established for phosphorus.
- Ammonia, nitrite, and organic nitrogen were detected in surface runoff samples but not detected in samples collected from either groundwater well.
- Total and dissolved organic carbon were detected at lower concentrations in groundwater than in surface water. Concentrations at the upgradient and downgradient wells were similar.
- The total suspended solids (TSS) concentrations measured during the current phase in surface water and groundwater were similar in concentration. TSS is not analyzed in subsurface samples.

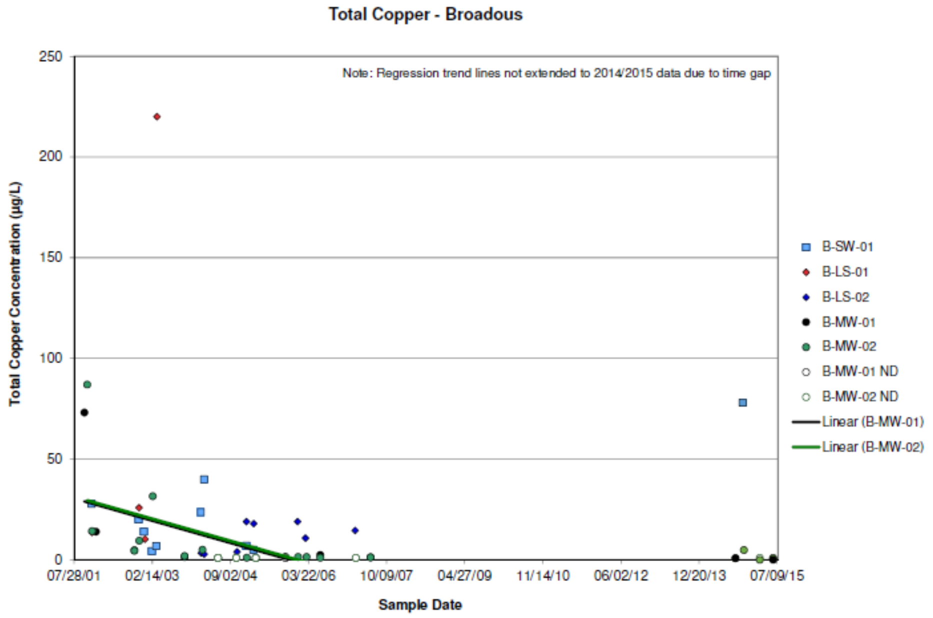
Metals:

- Dissolved aluminum has been detected only periodically in surface water and is currently at the lower end of the previous range detected. Dissolved aluminum was not detected in the monitoring wells during this phase and has generally been non-detect over the course of the project. When detected, the concentrations were within range of the surface water concentrations. Total aluminum in surface water was also detected at the lower end of the previous range of concentrations (up to one magnitude less than the previous highest concentration) and is generally higher in surface water than in groundwater, with the exception of some of the concentrations for the downgradient well. At the downgradient well, concentrations have fluctuated significantly over time, sometimes higher than the MCL of 1000 mg/L for aluminum and higher than the upgradient well. Total aluminum has shown a statistically significant increase for the upgradient well and no statistically significant trend was calculated for the downgradient well. Therefore, it is likely that infiltration had a positive impact on total aluminum concentrations in groundwater.

  Due to insufficient detections, no statistical trend was calculated for dissolved aluminum; the dissolved aluminum concentrations are well below MCLs.
- Dissolved and total arsenic in surface water were both detected at concentrations at the lower end of previous concentrations detected and are slightly higher in concentration than groundwater. Concentrations in the groundwater during this phase were lower than those previously observed. Insufficient data were available to calculate a statistical trend for total and dissolved arsenic for the upgradient well. For the downgradient well, a statistical no trend was calculated for the dissolved and total arsenic.

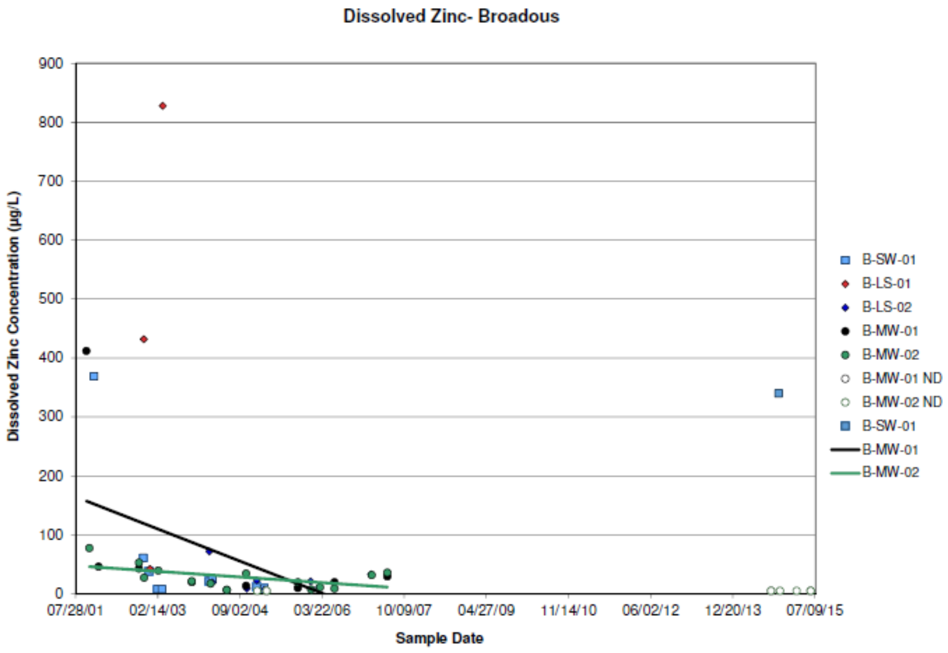
- Dissolved and total boron were present in surface water and concentrations were generally lower in surface water than in groundwater. Concentrations in each well were similar. However, boron concentrations were statistically stable over time for the downgradient well and for the upgradient well, total and dissolved boron showed statistically significant probably increasing and increasing trends, respectively. Based on these results, infiltration likely has had a positive effect on boron concentrations in groundwater.
- Total and dissolved cadmium were detected in surface water and continue to remain non-detect in both wells. Dissolved cadmium was detected in the surface water sample collected this phase but previously had not been detected in surface water.
- Total and dissolved chromium were detected in surface and groundwater. Surface water concentrations were less than groundwater concentrations for total chromium but greater than groundwater concentrations for dissolved chromium. The highest total chromium concentration was detected in the downgradient well (the downgradient well was sampled more frequently than the upgradient well), but the ranges for dissolved chromium concentrations were similar for the two wells. Statistical concentration trends were decreasing and probably decreasing for total and dissolved chromium for the upgradient well and no trend and decreasing for the downgradient well.
- Dissolved and total hexavalent chromium were present in surface water and groundwater at similar concentrations. Concentrations of dissolved and total hexavalent chromium have been slightly lower at the downgradient well compared to the upgradient well. Mann Kendall trends for dissolved hexavalent chromium were no trend to stable for the wells. Statistics were not performed for total hexavalent chromium because it was only analyzed during the current phase.
- Total and dissolved copper concentrations have increased in surface water and are higher in surface water than in groundwater, but the compounds have both decreased by about two orders of magnitude in groundwater compared to previous phases. Statistical concentration trends for both wells were decreasing for total and dissolved copper (Figure 7).

Figure 7. Graph of concentrations over time and for total dissolved solids (TDS) from groundwater monitoring wells and lysimeters at Broadous Elementary School. This graph compares the spatial variation in concentrations from up- and down-gradient wells.



- Total lead was observed in surface water on the lower end of the range previously detected while dissolved lead was similar in concentration. Dissolved lead was no longer detected in the upgradient or downgradient wells, and total lead was lower at both wells compared to previous phases. Overall, lead in groundwater is lower than in surface water. No statistical trend was calculated for total lead and insufficient data were available to calculate a statistical trend for dissolved lead for both wells.
- Dissolved and total nickel were detected in surface water and groundwater; surface water concentrations were higher than the upgradient well but lower than the downgradient well (concentrations were periodically higher at the downgradient well compared to the upgradient well). Concentration trends for both wells were decreasing (total nickel) or stable or no trend (dissolved nickel).
- Dissolved and total selenium were not detected in surface water but were present in groundwater. Statistical trends were stable for total selenium for the wells and probably decreasing for dissolved selenium.
- Total and dissolved zinc concentrations in surface water were similar to those previously observed. Dissolved zinc was not detected in groundwater during this phase. The total zinc concentrations were on the lower range of those previously detected. Zinc concentrations in groundwater were significantly lower than those in surface water. Statistical trends over time for both wells were decreasing for total and dissolved zinc (Figure 8).

Figure 8. Graph of concentrations over time and for dissolved zinc from groundwater monitoring wells and lysimeters at Broadous Elementary School. This graph compares the spatial variation in concentrations from up- and down-gradient wells.



Other constituents:
Glyphosate continued to not be detected in samples at this site.

Volatile organic compounds:

Of the suite of VOCs analyzed, none were detected in surface water during phase III. Only two VOCs (1,1-Dichloroethene (1,1-DCE) and Tetrachloroethene (PCE)) were detected in the upgradient well and no VOCs were detected in the downgradient well during the current phase. PCE and 1,1-DCE concentrations are statistically decreasing over time for the downgradient well and show no statistically significant trend to stable trend for these compounds, respectively, for the upgradient well. Trichloroethene (TCE) concentrations showed a “probably decreasing” trend over time for the upgradient well. Fuel hydrocarbon compounds such as benzene, toluene, ethylbenzene and xylenes (BTEX) and other chlorinated VOCs were detected earlier in the study at low concentrations in both wells but not in recent monitoring events. See Appendix B for full list of compounds tested.

See the table below for the schedule of monitoring completed at the Broadous Elementary school site:

Mid-City Iron and Metals: Monitoring Results

On September 16, 2014, the first dry weather groundwater monitoring event was conducted and consisted of sampling the single, deep groundwater well M-MW-01 located downgradient of the BMP at Mid-City Iron and Metal. On November 1, 2014, a surface runoff water sample was collected at this site and monitoring well M-MW-01 was sampled in response to this rain on November 10, 2014 to allow time for infiltration. The first collection of lysimeter samples was conducted on December 3 and 4, 2014 approximately 2 days following a rain event. The groundwater monitoring well was sampled again in response to rain on March 10, 2015, and a second batch of lysimeter samples was collected on March 2 and 3, 2015. The final dry weather monitoring event was conducted on June 9, 2015 and included sampling the single groundwater well on that date. The samples were all submitted to Weck Laboratories on the same day as collection and analyzed for the list of constituents in the approved QAPP. The water quality data for this site is provided in the Final Comprehensive Monitoring Report previously submitted for this project.

Mid-city Metals Schedule Tracking

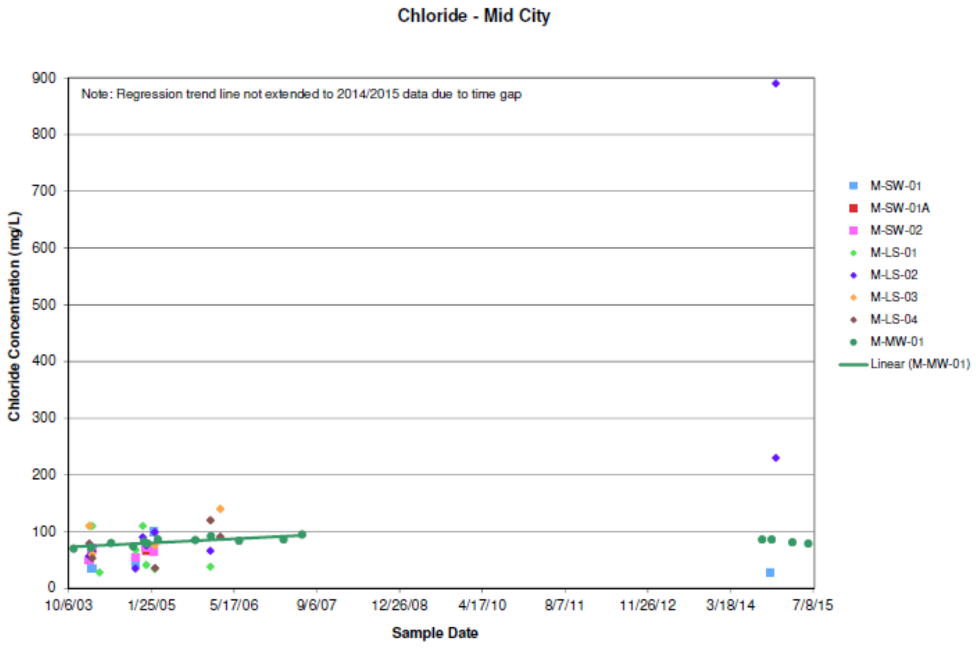
Code	Description	Sample Type	Description	ID #	Description	Dry 1 2014	Rain 1 14/15	Rain 2 14/15	Dry 2 2015
M	Mid-City	SW	Surface station	01	Entrance of basin		√		
M	Mid-City	LS	Lysimeter	02	Shallow		√	√	
M	Mid-City	LS	Lysimeter	03	Deep		√	√	
M	Mid-City	MW	Groundwater well	01	Down-gradient well	√	√	√	√

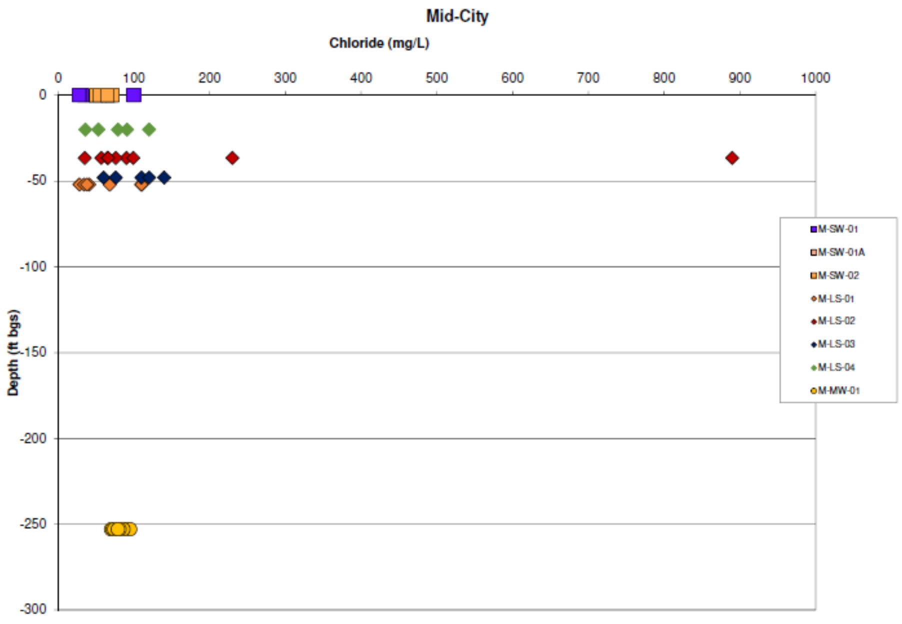
Since Phase I and II of the WAS, Mid-City Iron and Metal has upgraded its infiltration BMP through the addition of a pretreatment filtration system. The “Storminator” filtration system was purchased from Stormwater Online and Mid-City Environmental Managers have spent the past several years modifying the filters to improve functionality. The current filtration treatment train consists of two media filters (80% zeolite and 20% carbon, blended), followed by a unit with four, five-micron cartridge filters.

Anions:

At Mid-City Iron and Metal, bromide was detected in lysimeter and groundwater samples collected during this phase but not in the surface water sample; concentrations in the groundwater samples were over one magnitude less than the concentration in the lysimeter sample (bromide was only analyzed in one lysimeter sample). Concentrations in groundwater were generally low (less than 1 mg/L). Fluoride concentrations in the surface and groundwater samples were similar (less than 1 mg/L) and have ranged periodically higher in lysimeter samples. The chloride concentration in the surface water sample collected during the current phase was lower than concentrations detected in previous phases and is lower than groundwater concentrations. The current phase concentration of chloride at M-LS-02 (only one sample was collected this phase and chloride was not analyzed in the sample collected from M-LS-03 this phase) was notably higher than previous phase concentrations (as further discussed below) and much higher than surface water and the statistical trend is increasing over time (see Appendix E). Chloride concentrations in M-MW-01 have statistically increased over time although the magnitude of the increase is slight (Figure 9). The relationship, if any, between the increases in chloride concentrations in groundwater and at lysimeter M-LS-02 could not be resolved with the data available to date. Similar increasing trends were observed for COD and several metals as described below. The increasing trend is likely not from infiltration of storm water based on lower to similar concentrations in surface water. Chloride concentrations remain well below the regulatory threshold. Sulfate concentrations varied with depth, and concentrations were higher in lysimeter and groundwater samples than in surface water samples. Sulfate concentrations this phase are on the higher end of the range of concentrations detected previously but no statistical trend was calculated over time for sulfate. Sulfate concentrations were above the MCL prior to the study and have remained above the MCL.

Figure 9. Graphs of (top) concentrations over time and (bottom) depth-concentration for chloride from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.

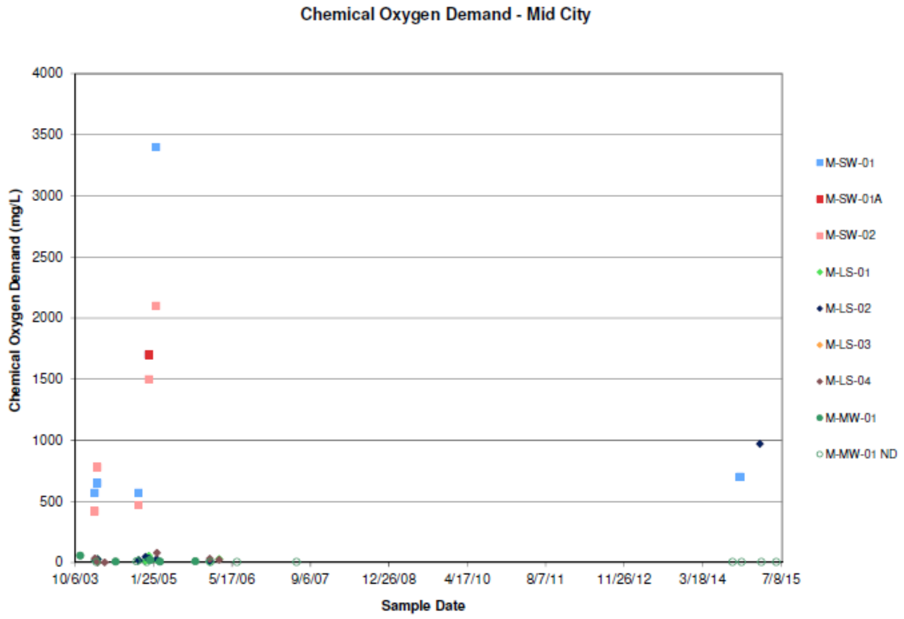




General Monitoring Parameters:

- Chemical oxygen Demand (COD) was detected in surface water and at M-LS-02 at similar concentrations this phase compared to previous phases. At M-LS-02, COD had previously been detected at lower concentrations than surface water in previous phases, but was higher during this phase (Figure 10). Concentrations were significantly lower at M-LS-03 this phase. The statistical trends in lysimeter concentrations were "no trend" and stable for M-LS-02 and M-LS-03, respectively. In groundwater, COD had been periodically detected in previous phases but was not detected during this phase. The statistical trend for COD for M-MW-01 was probably decreasing.

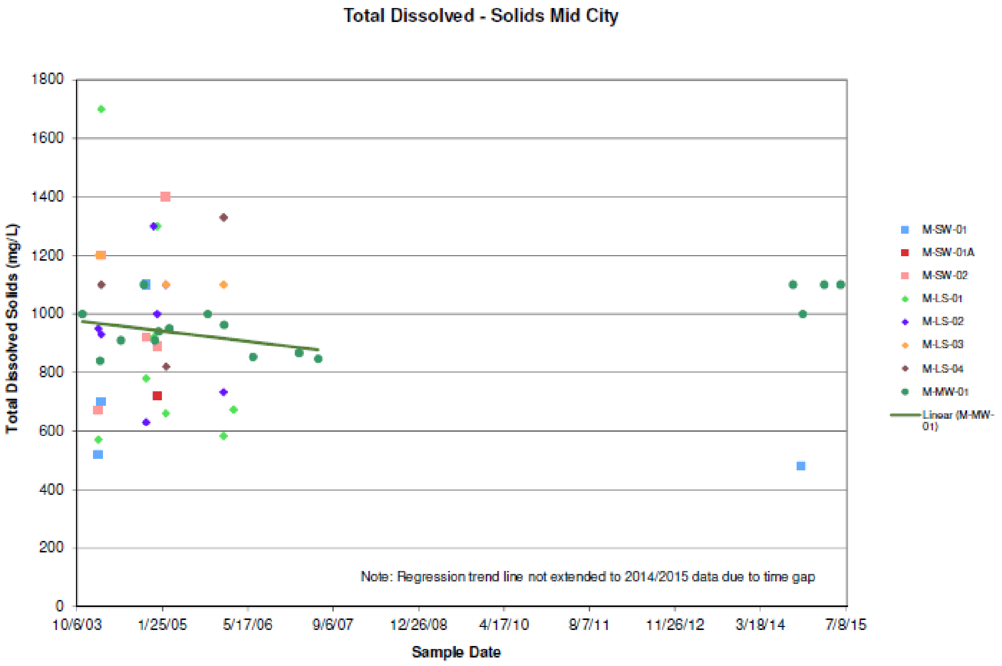
Figure 10. Graph of concentrations over time for chemical oxygen demand (COD) from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. This graph compare the spatial variation in concentrations from up- and down-gradient wells.

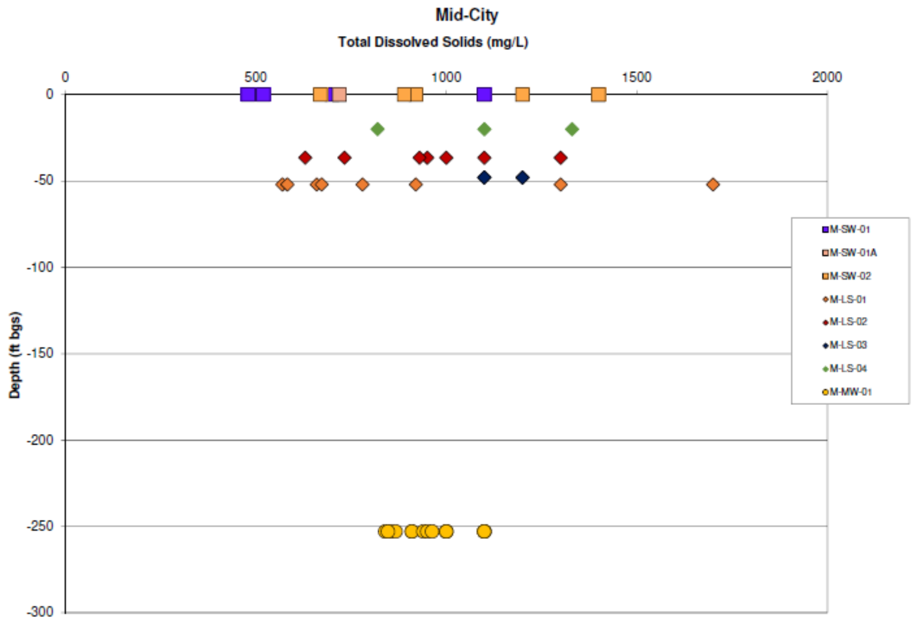


- Nitrate was detected in surface water and at M-LS-02 at slightly higher concentrations than in previous phases and were near or below the MCL. In groundwater, nitrate was detected only one time during the previous phases and was not detected during this phase. No statistical trend was calculated for nitrate for M-MW-01 due to insufficient detections.
- Nitrite was not detected in any of the monitoring samples.
- Organic nitrogen was present in surface water and at both lysimeters but was not detected in groundwater. No statistical trend was calculated for nitrogen for M-MW-01 due to insufficient detections.
- Dissolved and total phosphorus were both present in surface water. Concentrations decreased with depth and were generally less than 1 mg/L in lysimeter and groundwater samples.
- TDS during this phase was approximately two times higher in groundwater than in surface water. The TDS concentration for surface water for the current phase was on the lower end of the previous range of detections (Figure 11). In groundwater, concentrations of TDS prior to and over the course of the study have exceeded the MCL and MUN thresholds and the statistical trend over time is calculated as probably increasing (though the magnitude of the increase is slight). TDS was not analyzed in lysimeter samples this phase but previously, TDS in lysimeters was at a similar range of concentrations to surface water samples. Because the groundwater at

the site is quite deep, it is likely that the observed concentration increases are due to regional groundwater effects rather than infiltration.

Figure 11. Graphs of (top) concentrations over time and (bottom) depth-concentration for total dissolved solids (TDS) from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.





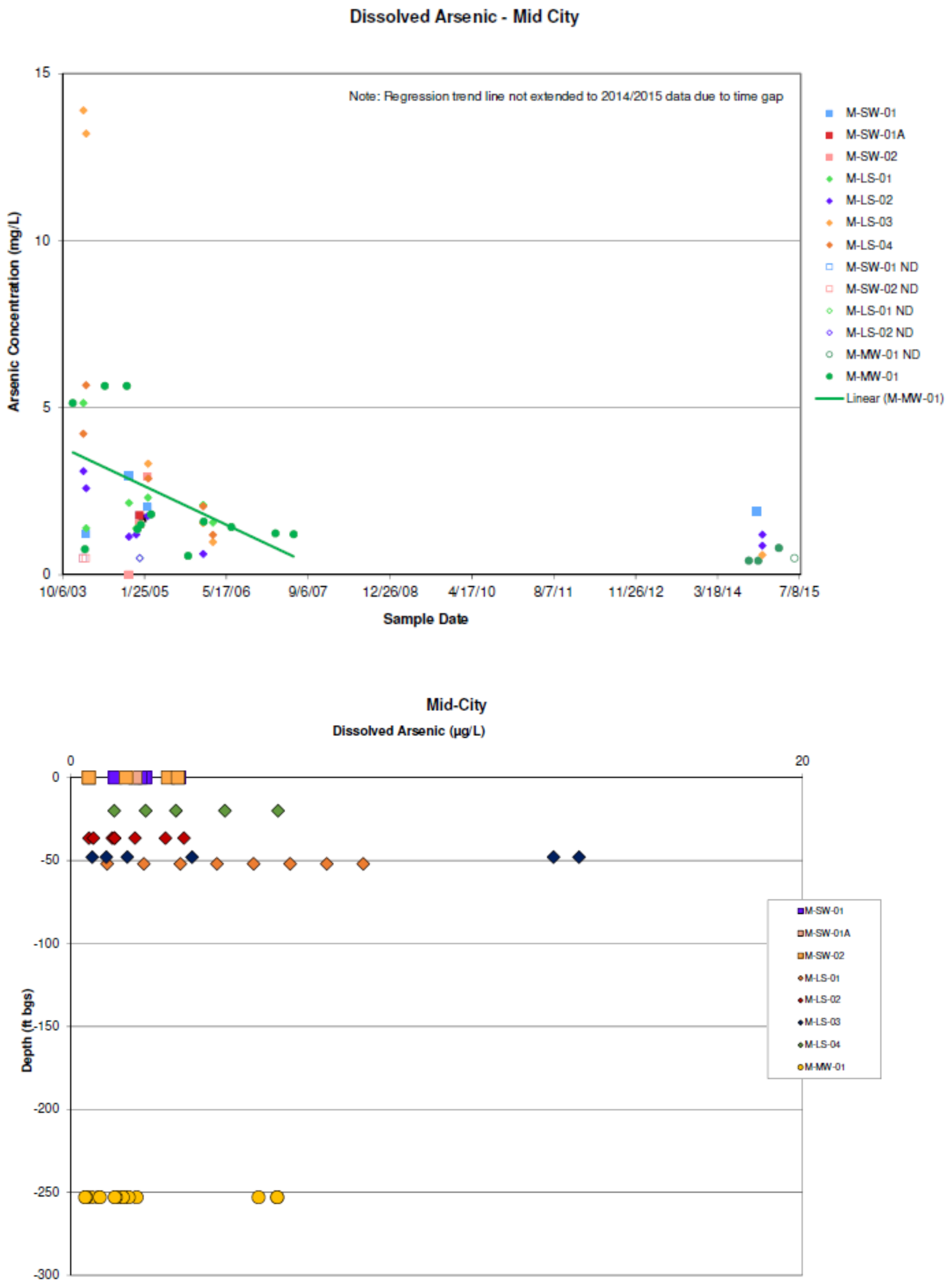
- TKN was present in surface water and at M-LS-02 at similar concentrations, but the concentration was over one magnitude lower at M-LS-03. Concentrations this phase were within range for the surface water sample compared to previous phases, higher for M-LS-02 but lower for M-LS-03 compared to previous phases. TKN was not detected in groundwater.
- Total and dissolved organic carbon and TSS were detected in surface water and groundwater, but concentrations in groundwater were much lower than surface water concentrations; concentrations at the upgradient and downgradient wells were similar.
- Ammonia was present in surface water, but concentrations were lower in concentration at M-LS-02 and ammonia was not detected at M-LS-03 and in groundwater.

Metals:

- Although total and dissolved aluminum were present in surface water, the maximum concentration of total aluminum in groundwater was almost one magnitude lower than the surface water concentration and at 590 micrograms per liter is below the regulatory threshold of 1 mg/L. Aluminum concentrations in lysimeter M-LS-03 were generally lower than the surface water concentration while concentrations in lysimeter M-LS-02 were similar to higher than the surface water concentration (and was significantly higher than previous concentrations which were non-detect). Total aluminum concentrations at M-MW-01 were generally similar in range to previous detections. Dissolved aluminum was not detected in groundwater. For M-MW-01, no statistically significant trend was calculated for total aluminum over time.
- Total and dissolved arsenic were detected in surface water but concentrations were lower in groundwater and generally lower at the lysimeters. Concentrations were below the MCL of 0.01

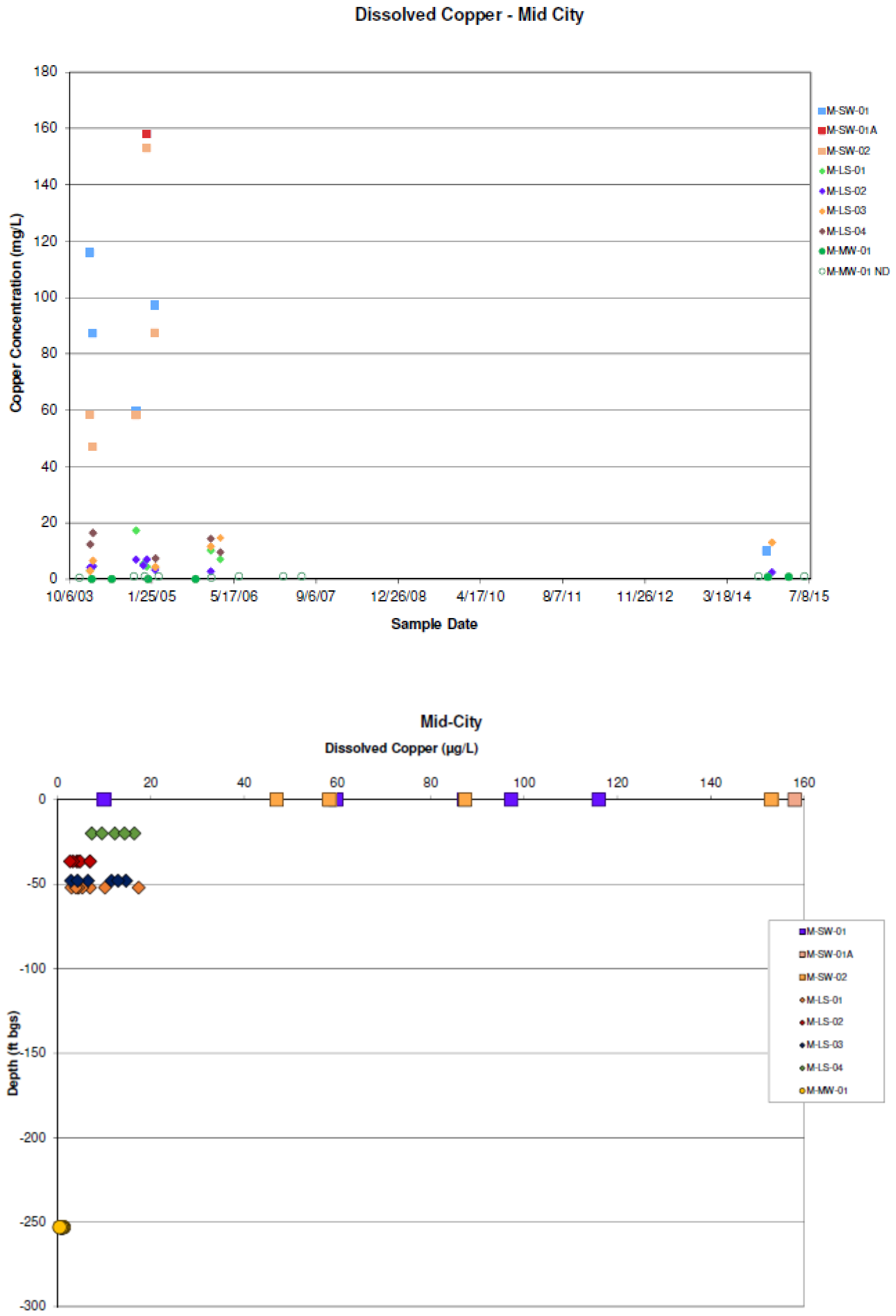
mg/L. Arsenic concentrations this phase were within range or lower than concentrations detected in previous phases. Statistical trends were decreasing over time for arsenic for M-MW-01 (Figure 12).

Figure 12. Graphs of (top) concentrations over time and (bottom) depth-concentration for dissolved arsenic from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.



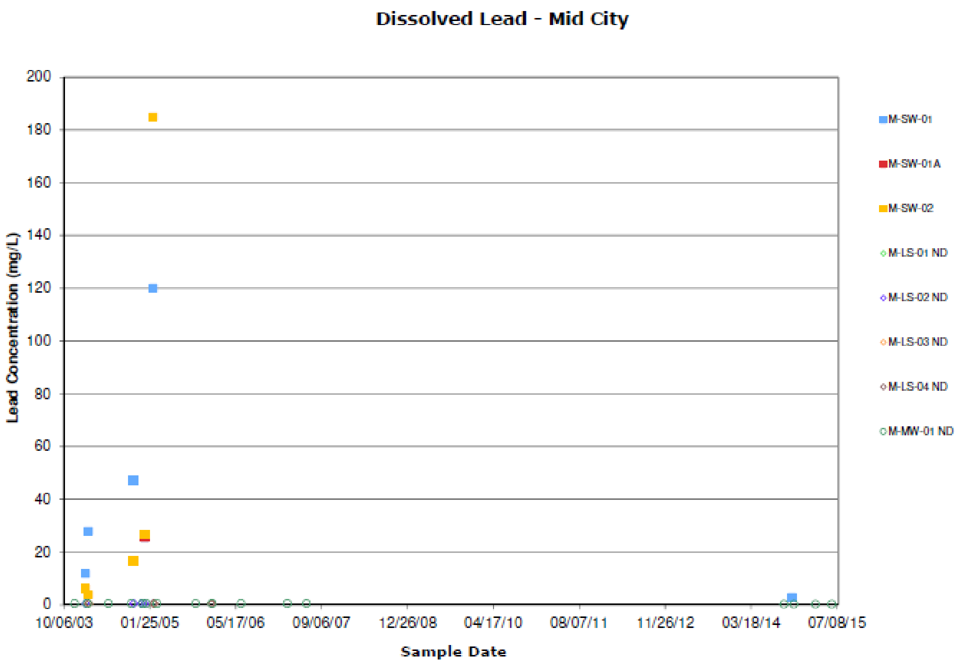
- Total and dissolved boron were detected in surface water and groundwater at similar concentrations and were under the MCL regulatory threshold; concentrations at M-LS-02 were higher and in excess of thresholds. Boron concentrations in groundwater this phase were slightly higher than concentrations in previous phases and statistical trends for total and dissolved boron in groundwater over time were increasing. Boron concentrations have been decreasing over time in surface water and lysimeters (with the exception of the increases during the current phase for lysimeter M-LS-02) and were higher in lysimeters in the initial part of the study, indicating that salts may have accumulated in the soil and have been flushed out. Over time, boron concentrations are likely to decrease for this well.
- Dissolved cadmium was present at lower concentrations in surface water than concentrations detected during previous study phases. The concentrations remained relatively stable at M-LS-02 and M-LS-03 while they continued to not be detected in groundwater. Concentrations in the lysimeters were similar to lower than surface water concentrations; total cadmium was only detected once in groundwater, at a very low concentration near the reporting limit during the current phase and previously was non-detect.
- Total and dissolved chromium were detected in surface water; concentrations of total chromium were significantly lower in groundwater and dissolved chromium was not detected in groundwater. Concentrations of total chromium at M-LS-02 were over two magnitudes higher than the surface water sample. Concentration trends in the lysimeters are increasing. For groundwater, total chromium concentrations were within range of previous concentrations and dissolved chromium concentrations remained non-detect. Over time, for groundwater, no trend was calculated for total chromium and statistical trends were not calculated for dissolved chromium due to insufficient detections.
- Total and dissolved hexavalent chromium were present in surface water, but were not detected in lysimeter samples. In groundwater, total and dissolved hexavalent chromium were only periodically detected and when detected were very low.
- Dissolved and total copper were present in surface water, and decreased with depth. Dissolved copper was only periodically detected in lysimeter and groundwater samples. Concentrations of total copper in lysimeters and groundwater were slightly higher than the concentrations detected during previous phases (and an increasing trend for total copper was calculated for the lysimeters) while concentrations were similar to lower for dissolved copper (Figure 13). Over time, for M-MW-01, no trend was calculated for total copper and a stable trend was calculated for dissolved copper.

Figure 13. Graphs of (top) concentrations over time and (bottom) depth-concentration for dissolved copper from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.



- Dissolved lead was present in surface water, generally lower in lysimeter samples and was not detected in groundwater in the current or previous phases of this study. Total lead was present in surface water and lysimeter samples (and an increasing trend was calculated for the lysimeters), and was detected in groundwater. Groundwater concentrations of total lead this phase were slightly higher than in previous phases but the concentrations were approximately two magnitudes lower than the current phase surface water concentration (Figure 14). Concentrations of total lead in surface water are currently on the lower range of previous concentrations detected but were similar to slightly higher for groundwater. "No trend" was calculated for M-MW-01 for total lead and a statistical trend could not be calculated for dissolved lead due to too few detections.

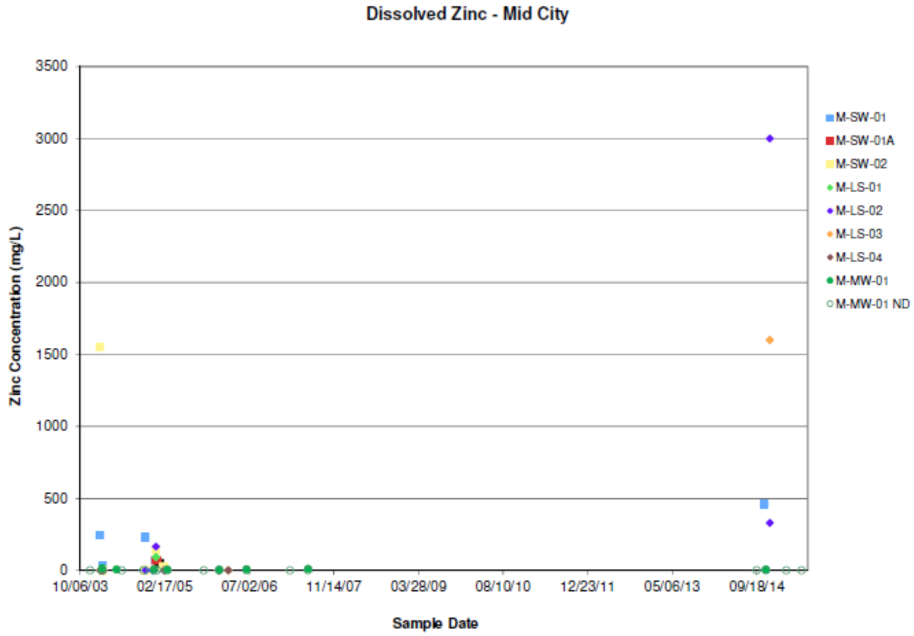
Figure 14. Graph of concentrations over time for dissolved lead from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. This graph compare the spatial variation in concentrations from up- and down-gradient wells.



- Dissolved and total mercury were detected in surface water and lysimeter samples but were not detected in groundwater during the four sampling events conducted during the current phase of this study. Mercury had only been detected once previously in groundwater at this site.

- Dissolved and total nickel were present in surface water but the concentration of total nickel in groundwater was over approximately one magnitude less than in surface water. The highest dissolved nickel concentration in groundwater was approximately half of the surface concentration. Both dissolved and total nickel in groundwater were below the MCL threshold value of 0.1 mg/L. Total and dissolved nickel concentrations were elevated at M-LS-02, sometimes over three magnitudes higher than the surface water concentration; concentrations at the other lysimeter M-LS-03 were much lower. Increasing trends were calculated for the lysimeters (with the exception of total nickel for M-LS-03 where “no trend” was calculated). Statistical trends for M-MW-01 over time were probably decreasing for total nickel and decreasing for dissolved nickel.
- Dissolved and total selenium were present in surface water and lysimeter samples, but they were not detected during three of the four sampling events in groundwater. Statistical trends over time for M-MW-01 were “no trend” for total selenium and a statistical trend could not be calculated for dissolved selenium due to insufficient detections.
- Total and dissolved zinc were present in surface water and were similar to higher at M-LS-02 and lower at M-LS-03 (and an increasing or probably increasing trend was calculated for the lysimeters). In groundwater, total and dissolved zinc were only periodically detected and when detected were at concentrations much lower than surface water. All groundwater concentrations were well below the MCL threshold. Statistical trends over time for M-MW-01 for total and dissolved zinc were stable (Figure 15).

Figure 15. Graph of concentrations over time for dissolved zinc from groundwater monitoring wells and lysimeters at Mid-City Iron and Metals. This graph compare the spatial variation in concentrations from up- and down-gradient wells.



As mentioned above, concentrations of some metals (chromium, copper, lead, nickel and zinc) showed increasing trends over time for the lysimeters. Concentrations of these metals, other metals (aluminum, boron, and cadmium) and some other constituents (chloride and COD) in the lysimeter samples also were notably higher during the Phase III sampling than during previous sampling events conducted seven or more years earlier. It was noted that the ratio of dissolved to total metals for these constituents for the lysimeters during the current phase of monitoring was much lower (approximately 1:100 for some constituents) than observed in previous samples (a minimum ratio of approximately 1:5 for older historical data for this site and for the other two sites). The available data did not allow us to conclude whether this difference in ratios resulted from changes in the water quality characteristics of vadose zone water during the 7-year gap in monitoring between Phase II and Phase III or from other factors.

Other constituents:

Glyphosate continued to not be detected in samples at this site.

Volatile organic compounds:

Of the suite of VOCs analyzed during the current phase, only naphthalene, 2-hexanone, Freon 113, styrene, and trichlorofluoromethane were detected in surface water. None of these compounds were detected in the lysimeter or groundwater samples. In lysimeter samples, 2-butanone and 4-methly-2-pentanone were detected at M-LS-02; the concentration of 2-butanone was generally lower than previous data and it was not detected at any other lysimeters. The compound 4-methly-2-pentanone had previously been detected at other lysimeters at this site but now is only detected from this lysimeter. No VOCs were detected during the current phase of the study at M-LS-03. No VOCs were detected in groundwater from this site during the current phase of this study. In previous phases, carbon disulfide and methylene chloride had been detected in groundwater at low concentrations. See Appendix B for full list of compounds tested.

Veteran's Park: Monitoring Results

Groundwater samples were collected from four monitoring wells. V-MW-01 is a background well more than 100 feet from the infiltration gallery. The other three wells are within about 30 feet of the infiltration gallery. Their current gradients are as follows: V-MW-02 (relatively cross-gradient), V-MW-03 (relatively upgradient), and V-MW-04 (relatively downgradient). There are also two lysimeters installed at this site.

On September 5, 2014, the first dry weather groundwater monitoring event was conducted and included sampling all four groundwater wells located at Veterans Park (Figure 9). The first wet weather sampling event for the two lysimeters and the downgradient well V-MW-04 was conducted on November 1, 2014. A surface runoff sample was collected on December 2, 2014. A second wet weather monitoring event was conducted with lysimeters sampled on March 2 and 3, 2015 and groundwater was sampled on March 5, 2015. The second dry weather groundwater monitoring event was conducted on June 8, 2015. The samples were submitted to Weck Laboratories on the same day as collection and analyzed for the list of constituents in the approved QAPP table shown in Appendix A. The water quality data for this site is provided in Appendix B.

Veterans Park Schedule Tracking

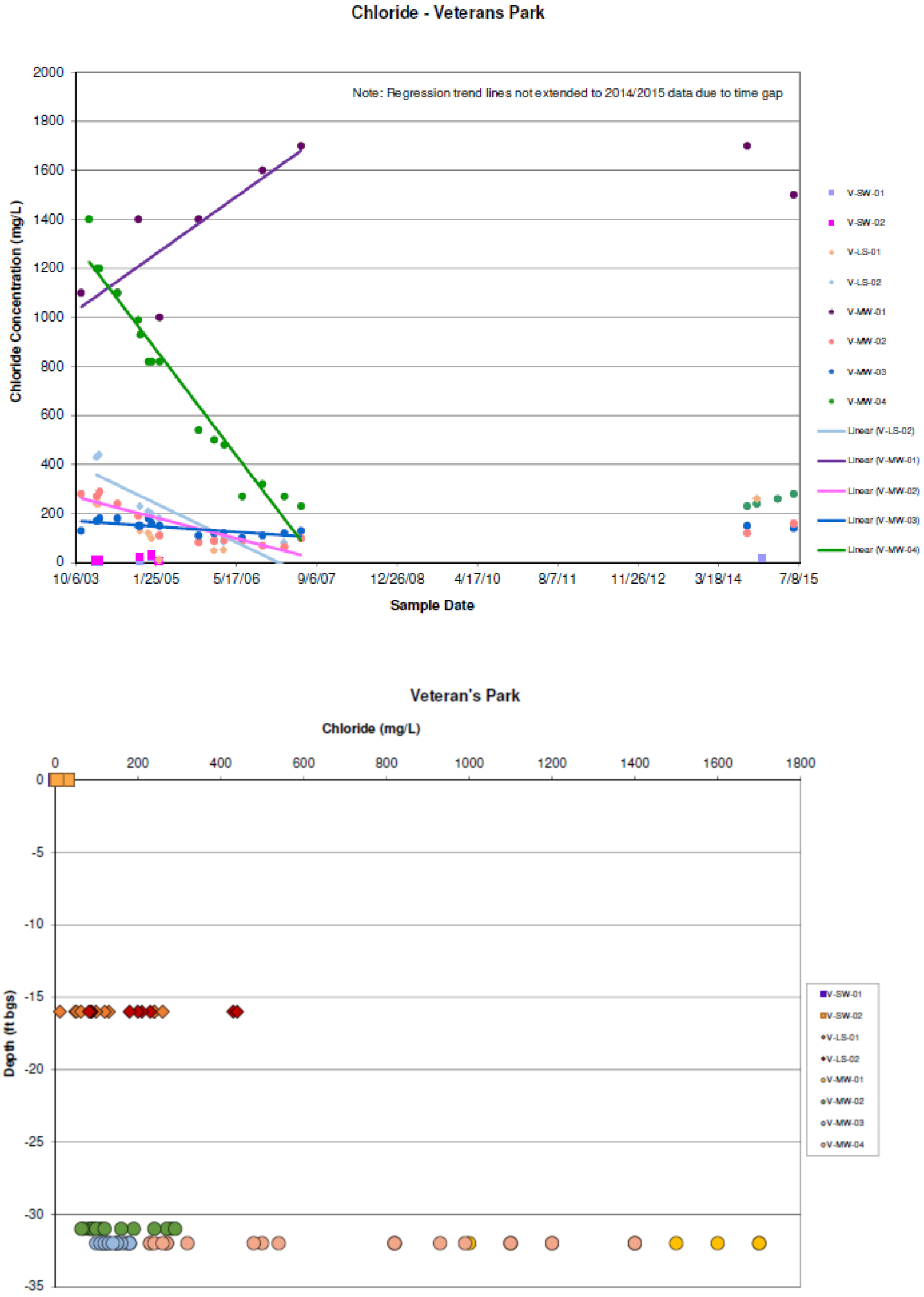
Code	Description	Sample Type	Description	ID #	Description	Dry 1 2014	Rain 1 14/15	Rain 2 14/15	Dry 2 2015
V	Veterans Park	SW	Surface station	01	At catch basin		√		
V	Veterans Park	LS	Lysimeter	01	Shallow		√	√	
V	Veterans Park	LS	Lysimeter	02	Deep		√	√	
V	Veterans Park	MW	Groundwater well	01	Background well	√			√

V	Veterans Park	MW	Groundwater well	02	Up-gradient well	√			√
V	Veterans Park	MW	Groundwater well	03	Up-gradient well	√			√
V	Veterans Park	MW	Groundwater well	04	Down-gradient well	√	√	√	√

Anions:

- Current phase chloride concentrations in surface water and the lysimeters have remained similar to previous ranges. Chloride concentrations are generally higher in lysimeters than in groundwater and the lowest concentrations are in surface water. Chloride concentrations measured for groundwater at the proximal wells V-MW-02 and V-MW-03 during this phase have been consistently below the regulatory MCL threshold and were similar to previous concentrations. Concentrations for proximal/downgradient well V-MW-04 have been lower than previous phase concentrations, and are near regulatory thresholds. Concentrations of chloride at V-MW-01 are higher than the other wells and increasing; this well was included to represent background water conditions at this site about 100 feet from the infiltrator, whereas the other three wells are within 30 feet of the infiltrator. Statistically, proximal wells V-MW-02, V-MW-03, and V-MW-04 have shown decreasing trends (Figure 16). Background well V-MW-01 has shown an increasing statistical trend over time. Because V-MW-01 is a background well, the increasing trend in groundwater concentrations is likely due to regional groundwater effects rather than infiltration. Based on these results, it appears that the infiltrator may be improving water quality with respect to chloride.

Figure 16. Graphs of (top) concentrations over time and (bottom) depth-concentration for chloride from groundwater monitoring wells and lysimeters at Veteran's Park. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.

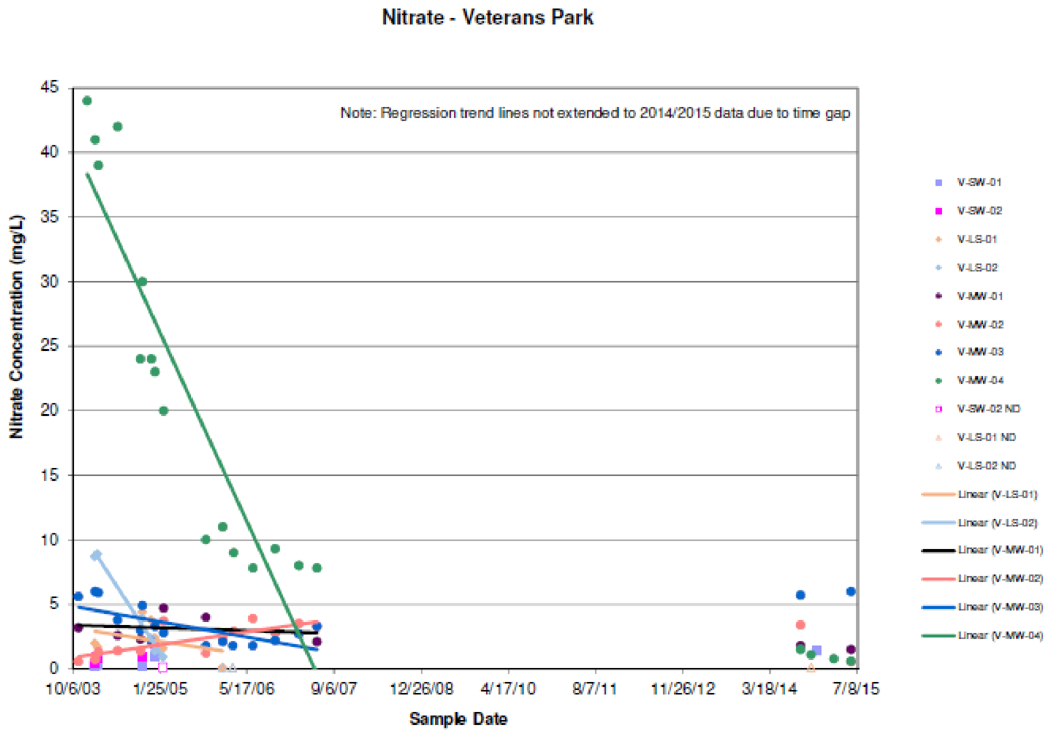


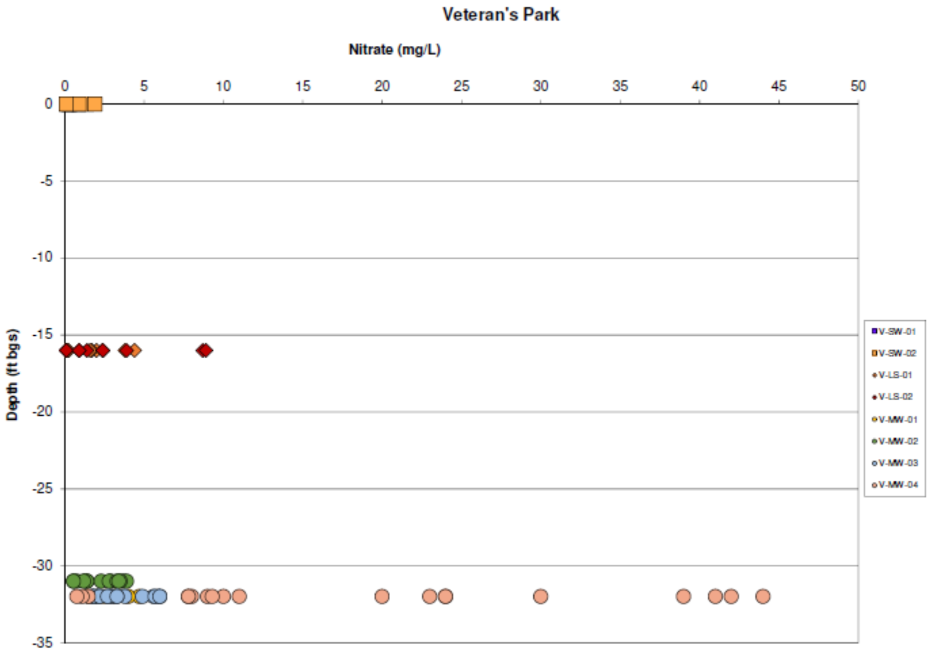
- Similarly sulfate concentrations were highest at the background well V-MW-01, with most of the concentrations below the regulatory threshold at V-MW-02 and V-MW-03 and concentrations at V-MW-04 and lysimeters slightly higher. Sulfate concentrations are lowest in surface water, similar in lysimeters and similar to higher in groundwater. Statistical trends were increasing for V-MW-01 and decreasing for the wells V-MW-02 through V-MW-04. Because V-MW-01 is a background well, the increasing trend in groundwater concentrations is likely due to regional groundwater effects rather than infiltration.
- Bromide concentrations were also highest at the background well V-MW-01; average concentrations at V-MW-02, V-MW-03, V-MW-04 and V-LS-01 were about a magnitude lower than the background well. Bromide was not detected in the surface water sample.
- Fluoride concentrations were generally low (2 mg/L or less).

General Monitoring Parameters:

- COD was detected in the surface water sample at approximately half the previous highest concentration. Concentrations in lysimeter and groundwater samples were on the lower end or lower than previous detections and over one magnitude less than the surface water concentration. Over time, statistical trends show decreasing trends for all wells except V-MW-01 (background well) which had a stable trend.
- Nitrate was present in surface water and groundwater but not detected in lysimeters for this current phase; the surface water concentration was within the range previously detected but concentrations in groundwater were lower than or similar to those previously detected in earlier phases. Surface water and groundwater concentrations were similar with the exception of V-MW-03 which showed slightly higher concentrations. Lysimeter concentrations were higher in previous phases than in groundwater or surface water but nitrate was not detected in the lysimeter sampled during this phase (Figure 17). All nitrate concentrations are currently less than the MCL. Statistical trends over time were decreasing for V-MW-01 and V-MW-04, increasing for V-MW-02, and stable for V-MW-03. Because nitrate is lower in concentration in surface water samples, it is not likely the increase in nitrate at V-MW-02 is due to infiltration. Current nitrate concentrations at V-MW-02 are similar to baseline concentrations. In addition, lysimeter results showed higher concentrations of nitrate in the initial part of the project (particularly at V-LS-02) indicating that salts may have accumulated in the soil and have been flushed out. In the current phase, nitrate concentrations in the lysimeter were lower than groundwater concentrations; therefore, over time, nitrate concentrations should decrease for this well.

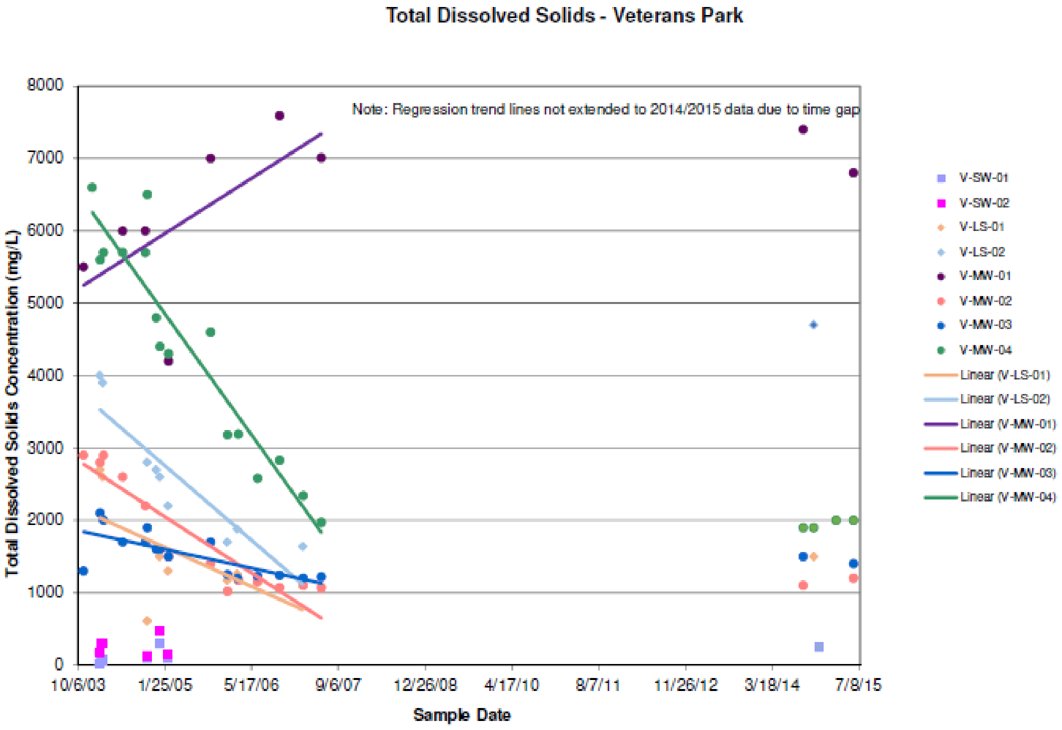
Figure 17. Graphs of (top) concentrations over time and (bottom) depth-concentration for nitrate from groundwater monitoring wells and lysimeters at Veteran's Park. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.

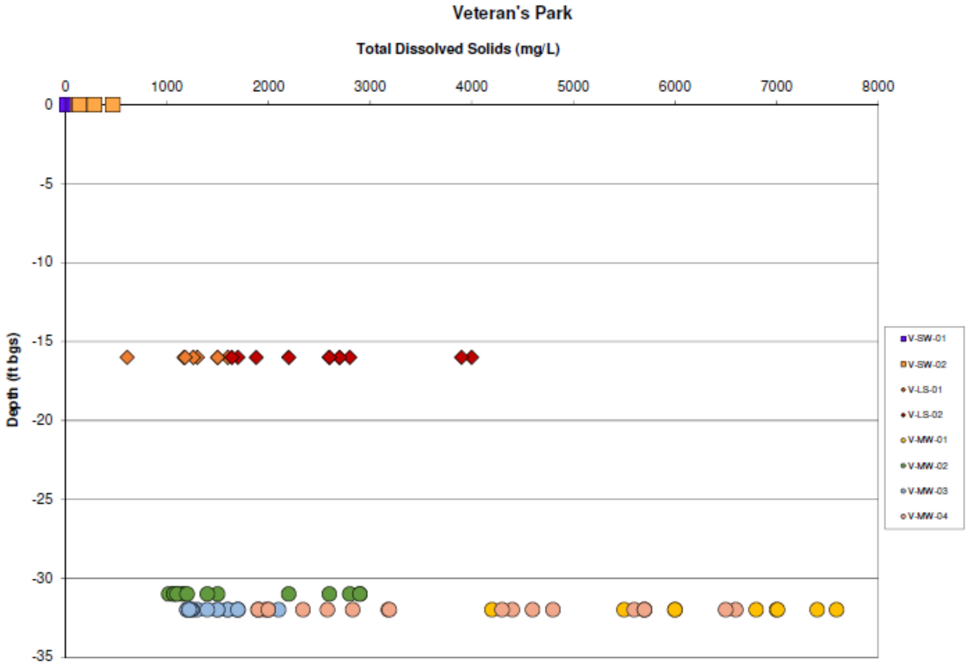




- Organic nitrogen concentrations were highest in surface water. Concentrations from lysimeter and groundwater samples were approximately one magnitude lower than the surface water concentration and periodically not detected at two of the three groundwater wells proximal to the infiltrator. Statistical trends over time were stable for wells V-MW-01 and V-MW-03, probably decreasing for V-MW-02 and decreasing for V-MW-04.
- Dissolved and total phosphorus concentrations were highest in surface water; concentrations in lysimeters or groundwater wells were approximately one magnitude or lower than the surface concentration and were relatively low (less than 1 mg/L).
- TDS concentrations were lowest in surface water and higher in lysimeter and groundwater; concentrations in surface water and in samples from V-LS-01, V-MW-01, V-MW-02 and V-MW-03 have remained within the previous ranges measured. The concentration measured from V-LS-02 was slightly higher than the previous range, and the concentrations from V-MW-04 were lower than previous concentrations. Statistical trends over time for TDS were decreasing for wells V-MW-02 through V-MW-04 and increasing for V-MW-01 (Figure 18). Because V-MW-01 is a background well, the increasing trend in groundwater concentrations is likely due to regional groundwater effects rather than infiltration and these results indicate that infiltration may have had a positive impact on TDS concentrations. Over time, concentrations of TDS have remained above the regulatory threshold at the lysimeters and groundwater monitoring wells.

Figure 18. Graphs of (top) concentrations over time and (bottom) depth-concentration for total dissolved solids (TDS) from groundwater monitoring wells and lysimeters at Veteran's Park. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.





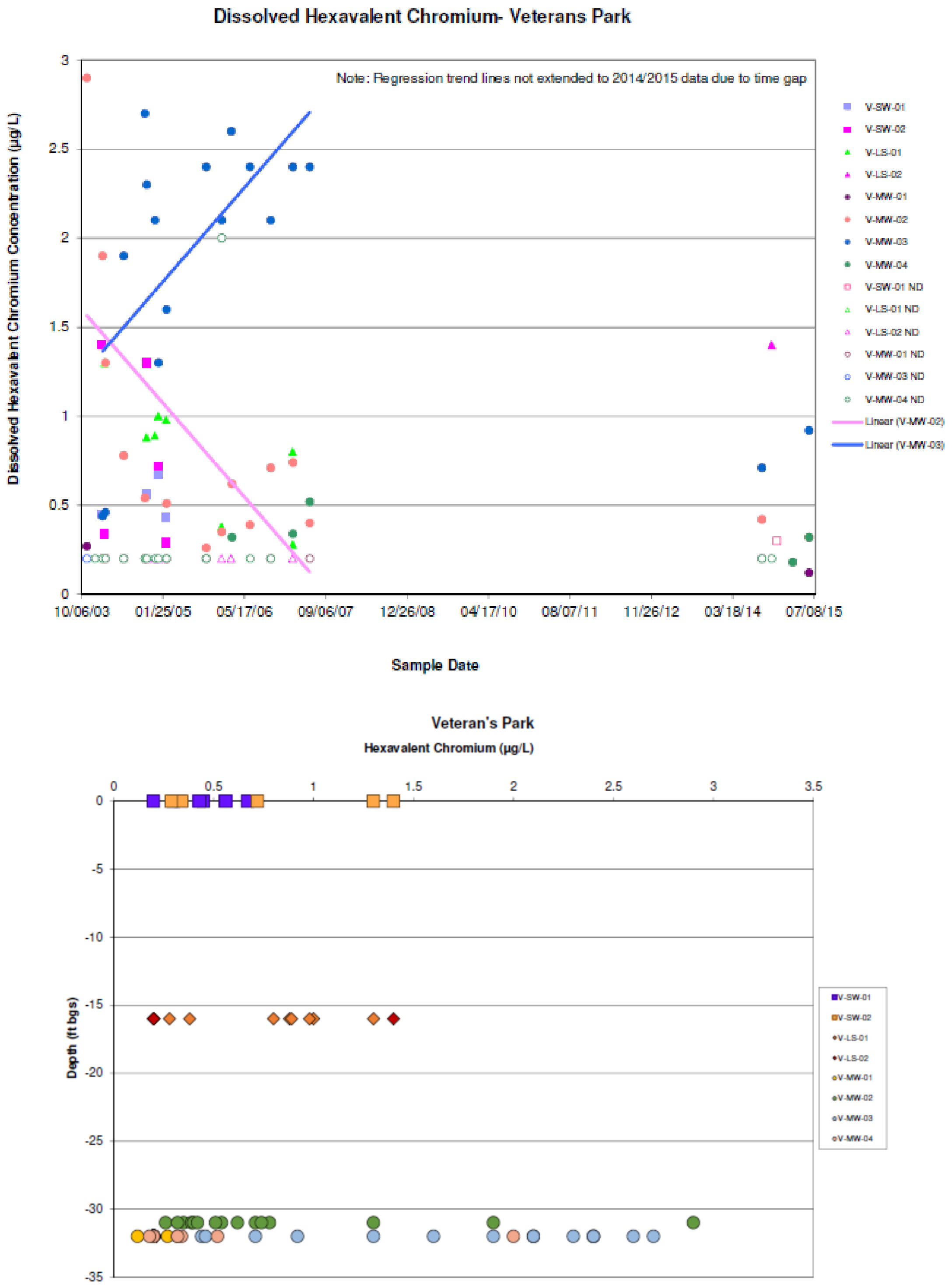
- The current surface water concentration of TKN is similar to previous ranges. TKN concentrations at V-LS-01, V-LS-02, V-MW-01, V-MW-02, V-MW-03 and V-MW-04 were near the lower end of the historical ranges and are relatively low (less than 1 mg/L) and approximately one magnitude less than the surface water concentration.
- Total organic carbon was detected in surface water and groundwater; concentrations in surface water were higher in lysimeters, and lowest in groundwater, with the proximal wells to the infiltrator having the lowest concentrations.
- Dissolved organic carbon concentrations were highest in surface water, followed by V-LS-02 and V-MW-01. Dissolved organic concentrations were lowest at V-LS-01, V-MW-02, V-MW-03 and V-MW-04.
- Current phase total suspended solids concentration in surface water was on the lower range previous measured at the site and was not analyzed in the other samples.
- Ammonia was detected in surface water but not in lysimeter or groundwater samples.

Metals:

- Total and dissolved aluminum in surface water were within the ranges previously recorded and are generally higher than other samples. During the current phase, dissolved aluminum was not detected in any lysimeter or groundwater samples but dissolved aluminum had previously been detected periodically in groundwater. Total aluminum had not previously been detected in lysimeter samples but is now present at concentrations about a magnitude lower than that in surface water. Phase III concentrations of total aluminum in groundwater were on the low end of the previous range (V-MW-02 and V-MW-03) or less than historical concentrations (V-MW-01 and V-MW-04). Statistically over time, total aluminum is decreasing for V-MW-01 and V-MW-02, probably decreasing for V-MW-04 and no trend was calculated for V-MW-03.
- Total and dissolved arsenic concentrations in surface water remain within previous ranges and are generally lower than other sample concentrations. Current phase concentrations in lysimeter samples were lower than the concentrations historically detected and concentrations at the four groundwater wells were similar to or less than historical concentrations. Statistically over time, total and dissolved arsenic are decreasing for V-MW-02 and V-MW-03, stable for V-MW-01 and stable and no trend, respectively, for V-MW-04.
- Dissolved and total boron concentrations were lowest in surface water and higher at lysimeters and groundwater wells. Concentrations at the background groundwater well are approximately twice as high as the other locations. A probably increasing trend was calculated for dissolved boron for V-LS-02 (no trend for total boron) but decreasing trends were calculated for boron for V-LS-01. For groundwater, statistically, no trend was calculated for V-MW-01 and a decreasing statistical trend was calculated for V-MW-02 through V-MW-04.

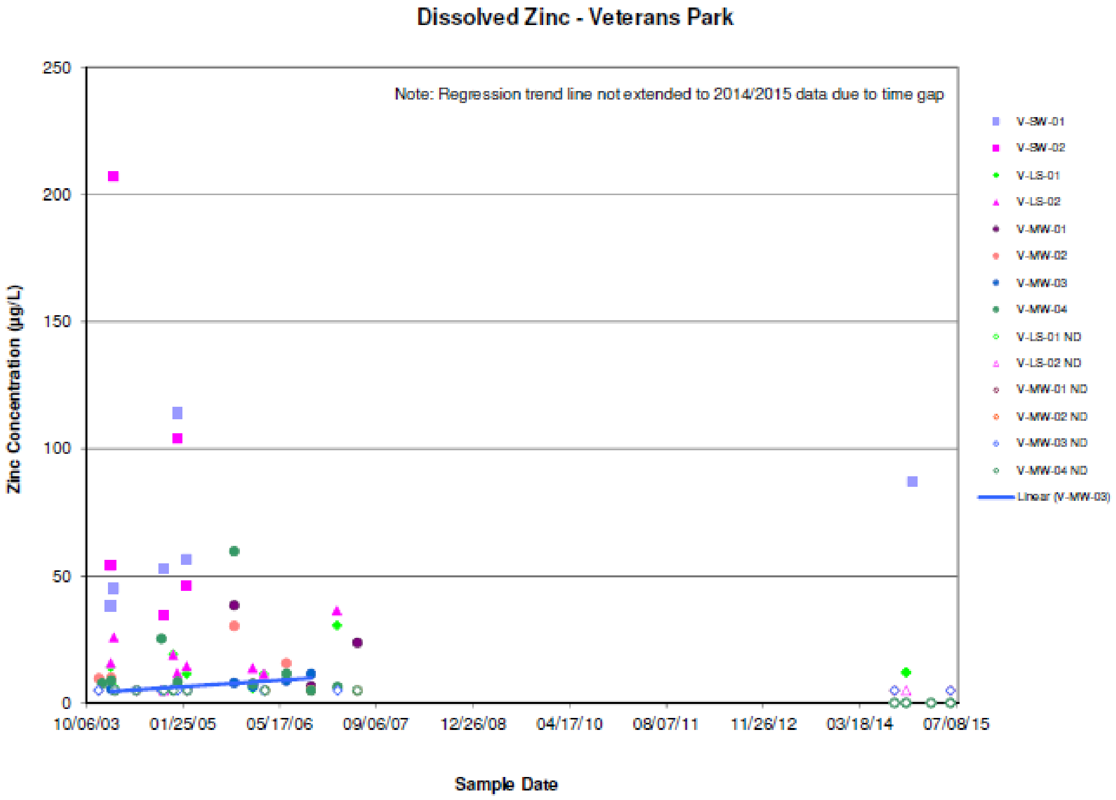
- The dissolved cadmium concentration in surface water was within the range of previous concentrations, but dissolved and total cadmium were not detected in lysimeters and in the wells were only detected at the background groundwater well. Insufficient detections were available to conduct statistics for wells V-MW-02 through V-MW-04. For background well V-MW-01, statistical trends were increasing and probably increasing for total and dissolved cadmium, respectively. Cadmium detections for all samples were generally low. Because V-MW-01 is a background well, the increasing trend in groundwater concentrations is likely due to regional groundwater effects rather than infiltration. These results indicate that infiltration may have a positive effect on TDS concentrations.
- Dissolved and total chromium were present in surface water, lysimeter samples and many groundwater samples but the concentrations were well below the MCL threshold. Statistical trends were no trend and decreasing for the background well and probably decreasing and decreasing for V-MW-03, for total and dissolved chromium, respectively. Statistical trends were decreasing for V-MW-02 and V-MW-04 for both compounds.
- Dissolved hexavalent chromium was not detected in surface water during this phase and it had previously been detected. Dissolved hexavalent chromium was periodically detected in lysimeter and groundwater samples at concentrations similar to historical ranges (Figure 19). Dissolved hexavalent chromium was decreasing for V-MW-02, probably increasing for V-MW-03, no trend for V-MW-04, and for V-MW-01 insufficient data were available to calculate a trend. Hexavalent chromium concentrations in surface water and lysimeter samples have been lower in range than groundwater at V-MW-03. Because hexavalent chromium is lower in concentration in surface water samples, it is not likely the increase in hexavalent chromium at V-MW-03 is due to infiltration. And, lysimeter results showed higher concentrations of hexavalent chromium in the initial part of the project (at V-LS-01, which is near V-MW-03) indicating that hexavalent chromium may have accumulated in the soil and has been flushed out. The concentrations should decrease over time since the current phase surface water detection of hexavalent chromium was non-detect.

Figure 19. Graphs of (top) concentrations over time and (bottom) depth-concentration for hexavalent chromium from groundwater monitoring wells and lysimeters at Veteran's Park. These graphs compare the spatial variation in concentrations from up- and down-gradient wells.



- Phase III concentrations of dissolved and total copper in surface water were similar to previous concentrations; the concentrations detected in lysimeter samples and V-MW-04 were lower than the previous range of concentrations. Concentrations at V-MW-01 and V-MW-03 were similar to historical concentrations and at V-MW-02 the concentrations were near the lower range or below the previous historical range. Statistical trends were no trend for V-MW-01, decreasing for V-MW-02 and V-MW-04, and no trend and stable for V-MW-03 for total and dissolved copper respectively.
- The dissolved lead concentration in surface water was within the previous range observed while total lead in surface water was below the previous range of concentrations detected in surface water; total lead was only detected at V-MW-03 and concentrations are on the lower range of those previously detected. Total and dissolved lead were not detected at any other lysimeters or groundwater wells this phase and had previously been detected at all locations with the exception of V-LS-02. Over time, statistics show no trend for V-MW-01, decreasing trend for V-MW-02 and V-MW-03, and probably decreasing trend for total lead for V-MW-04.
- Dissolved mercury had previously been detected in surface water, lysimeter and groundwater samples but was not detected in any of the samples this phase. Total mercury was also not detected in surface water, lysimeter samples or groundwater samples with the exception of periodic low concentrations at V-MW-03.
- Dissolved and total nickel were detected in surface water and periodically in lysimeter and groundwater samples at low concentrations, well below the MCL threshold. Over time, total and dissolved nickel statistical trends were stable for V-MW-01, stable and no trend for V-MW-02 and V-MW-03 for these compounds, respectively, and decreasing for V-MW-04.
- Dissolved and total selenium were not detected in surface water but were detected in lysimeter and groundwater samples; all concentrations were below the MCL threshold except for those at V-LS-02. The concentrations of selenium in groundwater at the background well V-MW-01 were approximately one magnitude higher than concentrations at the wells more proximal to the infiltrator. Statistical trends were decreasing for V-MW-02 through V-MW-04, and were decreasing and stable, respectively, for total and dissolved selenium for V-MW-01.
- Dissolved and total zinc were both detected in surface water similar to previous ranges for this site; concentrations at both lysimeters were all within the lower part of the range previously detected and dissolved zinc was not detected at V-LS-02. Dissolved and total zinc were not detected at any of the four groundwater wells during this phase but had previously been periodically detected at all four of the wells. Statistical trends were “no trend” for V-MW-01 and V-MW-03, probably decreasing for V-MW-04, and no trend and stable for V-MW-02 for total and dissolved zinc, respectively (Figure 20).

Figure 20. Graphs of concentrations over time for dissolved zinc from groundwater monitoring wells and lysimeters at Veteran's Park. This graph compare the spatial variation in concentrations from up- and down-gradient wells.



Other constituents:

Glyphosate was not detected in samples at this site during this phase. Previously, glyphosate was detected in one surface water sample.

Volatile organic compounds:

Of the suite of VOCs analyzed during phase III, no VOCs were detected in any of the samples. Several VOCs had been detected in surface water in previous phases but were not detected during this phase. Acetone, chloroform, methyl chloride and methylene chloride were detected in lysimeter and groundwater samples at low concentrations in previous phases, but were not detected in any samples during the current phase.

MONITORING RESULTS: SUN VALLEY PARK

CWH and Los Angeles County Department of Public Works Watershed Management Division prepared an MOU for joint water quality monitoring of Sun Valley Park. Los Angeles County Watershed

Management Division completed dry season monitoring of the three groundwater wells in May 15, 2014, and has shared this data with Council for Watershed Health. Los Angeles County Flood Control Division began monitoring water quality at this site in 2011. Although LA County analyzes samples for many of the same constituents, a more comprehensive list of constituents was analyzed for all other samples for the purpose of this project. Figure 10 shows pictures taken during summer 2014. On November 1, 2014 surface runoff water was collected at this site. Lysimeters were sampled November 1 and 2, 2014, and the downgradient wells SVP-MW-01 and SVP-MW-02 were sampled on November 11, 2014 in response to rain. A second wet weather monitoring event was conducted with lysimeters sampled on March 2 and 3, 2015 and groundwater sampled on March 10, 2015. The second dry weather event was conducted on May 15, 2015. The samples were submitted to Weck Laboratories on the same day as collection and analyzed for the list of constituents in the approved QAPP, table shown in Appendix A. The water quality data for this site is provided in Appendix B.

LA County staff informed CWH that during storm events they will select one of the infiltration galleries to be active, and lysimeter samples will be collected from the three lysimeters around the perimeter of the infiltration zone where water is being diverted to. During both storm events monitored, infiltration gallery 1 was made active.

Sun Valley Park Schedule Tracking

Code	Description	Sample Type	Description	ID #	Description	Dry 1 2014	Rain 1 14/15	Rain 2 14/15	Dry 2 2015
SVP	Sun Valley Park	SW	Surface station	01	Up-gradient		√		
SVP	Sun Valley Park	LS	Lysimeter	01	Basin 1 perimeter		Not active	Not active	
SVP	Sun Valley Park	LS	Lysimeter	02	Basin 1 perimeter		Not active	Not active	
SVP	Sun Valley Park	LS	Lysimeter	03	Basin 1 perimeter		Not active	Not active	
SVP	Sun Valley Park	LS	Lysimeter	04	Basin 2 perimeter		√	√	
SVP	Sun Valley Park	LS	Lysimeter	05	Basin 2 perimeter		√	√	
SVP	Sun Valley Park	LS	Lysimeter	06	Basin 2 perimeter			√	
SVP	Sun Valley Park	MW	Groundwater well	01	Down-gradient well	*	√	√	√
SVP	Sun Valley Park	MW	Groundwater well	02	Down-gradient well	*	√	√	√
SVP	Sun Valley Park	MW	Groundwater well	03	Up-gradient well	*			√

*Note: * indicates that groundwater data was shared by LA County for many of the constituents from their sampling conducted in May 2014.*

Anions:

At Sun Valley Park, bromide was not detected in surface water. Bromide was present in higher concentrations in the lysimeters and was up to a magnitude higher in concentration in groundwater compared to lysimeters. Fluoride concentrations were generally low (less than 1 mg/L). Fluoride was present in surface water, slightly lower in lysimeter samples, and the lowest in groundwater; current concentrations in groundwater at the wells were within the historical ranges. Chloride was detected at similar concentrations in surface and vadose zone water, but concentrations were generally higher in groundwater. Concentrations of chloride at downgradient well SVP-MW-01 measured during the current phase III were lower than historical concentrations; concentrations at the other two groundwater wells remained stable but were at the lower end of the historical ranges – all current chloride concentrations were much lower than the MCL. Sulfate was generally lowest in lysimeter samples, higher in surface water samples and then highest in groundwater. All phase III sulfate concentrations measured at the downgradient well SVP-MW-01 were lower than the historical range, while the average at SVP-MW-02 has remained relatively stable, and concentrations at SVP-MW-03 were on the lower end of the historical range. All phase III concentrations of sulfate were significantly lower than the MCL threshold.

General Monitoring Parameters:

- COD concentrations were highest in surface water; concentrations in lysimeter samples were approximately one magnitude lower than surface water concentrations and COD was not detected in any of the monitoring wells.
- Nitrate was detected in surface water and lysimeter samples at similar concentrations; in groundwater, concentrations were slightly higher for the downgradient well and lower in concentration for the other wells. However, the current concentration ranges at both the downgradient wells are below the historical ranges, while the current concentrations at the upgradient well are within the historical range.
- Organic nitrogen and TKN were present in surface water; in lysimeters, these compounds were approximately one magnitude lower than the surface water concentrations, and were not detected (SVP-MW-02 and SVP-MW-03) to just above detection limits (SVP-MW-01) in groundwater.

- TDS concentrations are higher in groundwater than in surface water and lysimeter samples; the current concentration ranges are below historical ranges and generally below MCLs. During the current phase, TDS concentrations are higher in the downgradient wells.
- Phosphorus was detected at lower concentrations in lysimeter and groundwater samples (approximately 1 mg/L or less) than in surface water (just under 2 mg/L). In the wells, the phosphorus concentration was highest in the upgradient well.
- Dissolved organic carbon concentrations were approximately one magnitude higher in surface water than in groundwater and was not analyzed in lysimeter samples. DOC concentrations were similar at the three groundwater wells.
- Total organic carbon was detected at the highest concentrations in surface water, followed by lysimeters and then groundwater; groundwater concentrations were near 1 mg/L or less.
- Total suspended solids were detected in surface water and was not analyzed in the other samples.
- Ammonia and nitrite were detected in surface water but not detected in groundwater or lysimeter samples.

Metals:

- Dissolved and total aluminum concentrations were highest in surface water. Concentrations in lysimeter samples were approximately one magnitude less than in surface water and aluminum was only periodically detected in groundwater. Detections when they occurred in groundwater were low and in the downgradient wells. Detections in groundwater only occurred during the current phase, most likely due to lower reporting limits during the current phase. The groundwater concentrations were well under the MCL regulatory threshold.
- Similarly, dissolved and total arsenic concentrations were highest in surface water, and lower in lysimeter and groundwater samples – all concentrations were significantly lower than the MCL regulatory threshold.
- Boron concentrations were highest in groundwater, followed by surface water and then lysimeters. Concentrations of total boron in groundwater appear to be relatively stable at SVP-MW-02 and SVP-MW-03 while the current range is lower at SVP-MW-01; current concentrations are much lower than the MCL level.
- Dissolved and total cadmium were present in surface water and at SVP-LS-05 at low concentrations, much lower than the regulatory threshold; dissolved and total cadmium were not detected in any other lysimeter or groundwater samples.
- Chromium was detected in surface water, at higher concentrations in lysimeter samples, but at lower concentrations in monitoring wells and was not detected at SVP-MW-03; all concentrations were below the MCL threshold.

- Hexavalent chromium was not detected in surface water but was present in groundwater at all three wells at similar concentrations; concentrations were well below the MCL.
- Copper was present in surface water; concentrations in lysimeter samples were almost one magnitude lower than those in surface water; dissolved and total copper were only periodically detected in groundwater at low concentrations. The new detections at SVP-MW-01 and SVP-MW-02 are likely due to lower reporting limits during this phase. All concentrations were well below the MCL.
- Dissolved lead was detected at a very low concentration in surface water but was not detected in lysimeter or groundwater samples. Total lead was detected in surface water and periodically detected in lysimeter and groundwater samples (with the exception of SVP-LS-06, SVP-MW-02 and SVP-MW-03). The detection in well SVP-MW-01 was just above the reporting limit and the new detection during this phase was likely due to lower reporting limits during this phase. Lead concentrations were well below the MCL threshold.
- Dissolved and total nickel were detected in surface water; concentrations were higher in lysimeter samples, but only periodically detected in groundwater at low concentrations (at SVP-MW-01 and SVP-MW-02). The new detections are likely due to lower reporting limits during this phase; the groundwater concentrations were well below the MCL.
- Dissolved selenium was not detected in surface water, lysimeter samples or groundwater. Total selenium was not detected in surface water or lysimeter samples, but was periodically detected in groundwater, at concentrations ranging to just above MCL in all three wells.
- Dissolved and total zinc concentrations were highest in surface water; lysimeter concentrations were approximately one magnitude lower than in surface water, and dissolved zinc was not detected in groundwater. Total zinc was only periodically detected in groundwater and concentrations are lower at the two downgradient wells compared to previous phases and slightly lower than the upgradient well concentration (SVP-MW-03).

Other constituents:
Glyphosate was not detected in surface runoff or at any of the three groundwater wells.

Volatile organic compounds:
Of the suite of VOCs analyzed, none were detected in surface water or lysimeter samples. Three compounds were previously detected in groundwater but were not detected during phase III (chloroform, dichlorodifluoromethane (Freon 12), and methyl tert-butyl ether); four compounds (1,1-dichloroethane, cis-1,2-DCE, PCE, and TCE) detected periodically previously were also periodically detected during the current phase but at similar to lower concentrations. All other VOC compounds were not detected. Current detected concentrations of VOCs are all below regulatory thresholds with the exception of PCE where concentrations have ranged to just above the MCL. See Appendix B for full

list of compounds tested. The presence of VOCs is likely due to historical industrial land uses in this area.

MONITORING RESULTS: ELMER AVENUE

During this project, water quality and soil sampling were conducted at Elmer Avenue, Sun Valley along with observations of biodiversity. Sections below summarize the results of this monitoring.

During the first sampling event at this site during phase III, water quality samples were collected for a storm event that occurred from February 28 to March 2, 2014. Staff collected samples at the surface and from the lysimeters at two depths to assess effectiveness of infiltration for removing stormwater pollutants. A second storm was monitored on November 1, 2014. Surface runoff water was collected at this site that event and the lysimeters were sampled later on November 1 and 2, 2014. The lysimeters were sampled again for a third and final storm monitoring event on March 2 and 3, 2015.

The purpose of the water quality monitoring was to characterize the type and concentration of pollutants entering the Elmer Avenue retrofit from the adjacent streets, and the pollutant concentration reduction attributable to the catch basins and the infiltration galleries. The latter is achieved by comparing the quality of the storm water prior to entering the BMP and after treatment in the BMP. This approach follows recommendations from the US EPA and ASCE Urban Stormwater BMP Database and the Technology Acceptance and Reciprocity Partnership (TARP).

Stormwater from the north enters catch basins located on the northeast and southeast ends of the street that convey water into infiltration galleries lengthwise underneath the street (Figure 6). Samples were collected on the street at the location where the run-on enters the system. To assess the performance of the soft-bottom catch basin to remove pollutants, samples were collected at the inlet to the north infiltration gallery. Lysimeters were also used to collect pore water samples from the vadose zone of the north infiltration gallery at two different depths to assess pollutant removal by the catch basins, infiltration gallery, and infiltration through the uppermost sediment.

Lysimeter and surface water samples were analyzed for conventional chemistry/physical parameters, nutrients, VOCs, and metals as per the constituent lists provided in the approved QAPP. The raw data from HTP laboratory is included in Final Comprehensive Monitoring Report previously submitted for this project.

Elmer Avenue Schedule Tracking

Code	Description	Sample Type	Description	ID #	Description	Rain 1 13/14	Rain 1 14/15	Rain 2 14/15
E	Elmer	SW	Surface station	01	Catch basin entrance	√	√	
E	Elmer	LS	Lysimeter	01	Shallow	√	√	√
E	Elmer	LS	Lysimeter	02	Deep	√	√	√

Note: there was no dry weather water monitoring at this site because there are no project groundwater wells, but 3 storm events were included.

Anions:

Concentrations of chloride were similar in lysimeter samples to the range observed in surface water; the concentrations were considerably lower than the MCL threshold. Similarly the concentrations of fluoride measured in surface water and in the lysimeters were similar. Overall, fluoride concentrations were very low (less than 2 mg/L). Concentrations of sulfate were higher in lysimeter samples than in surface water, but all concentrations measured were less than half of the MCL concentration.

General monitoring parameters:

- Ammonia was observed to reduce in concentration as water is infiltrated, and it was below reporting limits at both lysimeter depths.
- COD decreases in concentration as water infiltrates with concentrations highest in surface water, lower at the shallow lysimeter and lowest at the deep lysimeter.
- Nitrate concentrations increased slightly with depth, but the concentrations were below the MCL threshold.
- Nitrite was periodically detected in surface water, but was not detected in either lysimeter.
- Organic nitrogen was detected in surface water but not in lysimeter samples.
- Total and dissolved phosphorus were observed to decrease with depth; concentrations were highest in surface water, decreased at the shallow lysimeter and were lowest at the deep lysimeter.
- Total organic carbon was significantly higher in surface water than in the lysimeter samples; lysimeter samples were near reporting limits and the concentration for the deeper lysimeter was slightly higher than the shallow lysimeter.

No other general monitoring parameters were analyzed for the lysimeters.

Metals:

- Total aluminum concentrations in surface water were relatively high (more than twice the regulatory threshold) but dissolved aluminum concentrations were much lower. In the lysimeters, total and dissolved aluminum concentrations decreased with depth to non-detect concentrations.
- Total antimony concentrations decreased by about half between the surface water and the shallow lysimeter; concentrations decreased to below reporting limits at the deep lysimeter. Dissolved antimony concentrations were similar in surface and the shallow lysimeter but the concentration was below reporting limits at the deep lysimeter.
- Arsenic concentrations did not show a consistent trend with depth; some concentrations in lysimeter samples exceeded the regulatory threshold.
- Total barium decreased whereas dissolved barium increased in concentration with depth between the surface water sample and the shallow lysimeter; however, both showed the highest concentrations at the deeper lysimeter.
- Total and dissolved cadmium concentrations did not show a consistent trend with depth; the concentrations were well below the MCL threshold.
- Chromium concentrations were low in surface water, increased in the shallow lysimeter but decreased to very low concentrations much lower than the MCL threshold at the deep lysimeter.
- Dissolved and total copper concentrations were highest in surface water; the concentrations decreased significantly between surface and the shallow lysimeter, and decreased between the shallow and deep lysimeter.
- Dissolved iron was not present in any water samples at this site. While the concentrations of total iron in the surface water were high, total iron was not detected in the lysimeters.
- Lead concentrations were significantly higher in surface water than in lysimeter water, periodically exceeding the MCL threshold; however, lead was not detected in lysimeter samples.
- Total manganese concentrations were highest in surface water but decreased with depth.
- Total and dissolved molybdenum concentrations increased with depth.
- Total and dissolved nickel increased slightly with depth, and were periodically detected in the lysimeters at concentrations in exceedence of the MCL threshold.
- Selenium concentrations were generally low in surface water and increased slightly with depth; however, the concentrations were well below the MCL threshold.
- Only total silver was detected at a very low concentration at the deep lysimeter; neither dissolved or total silver were detected in the surface water or the shallow lysimeter samples.

- Zinc concentrations were highest in surface water; concentrations at the shallow lysimeter for total zinc were over a magnitude lower than those in surface water, and concentrations remained low at the deep lysimeter.

The metals beryllium, boron, cobalt, and thallium were not detected in any water samples at this site. Hexavalent chromium was not analyzed at this site.

Volatile organic compounds:
VOCs were only analyzed in one surface water sample and no VOCs were detected with the exception of toluene which was detected at a very low concentration between the method detection and reporting limit.

g. Data Evaluation/Pollutant Load Reduction

During Phase III, Mann-Kendall trend analysis was conducted for 157 analytes/sampling locations that had sufficient data for statistical analysis (Table 2). These results from the Phase III monitoring for the Los Angeles Basin Water Augmentation Study are in agreement with and support results from previous phases of the program with the overall evaluation that there is no evidence of significant degradation of groundwater quality due to long-term infiltration of urban storm water. A summary and evaluation of these results by site are presented below.

Summary of Monitoring Results at Broadous Elementary School

Monitoring at Broadous Elementary School has been conducted over a period of fourteen years since 2001, with a gap of about seven years prior to 2014. Over time, a statistically significant increasing trend has been observed for chloride in the downgradient well (B-MW-02), though the magnitude of the increase is slight. No statistically significant trend was detected for the upgradient well (B-MW-01). Because chloride in surface water samples is lower than in groundwater samples, it is not likely that the increase in chloride at B-MW-02 is from infiltration of storm water. Lysimeter results showed higher concentrations of chloride in the initial part of the project, suggesting that salts accumulated in the soil may have been dissolved and mobilized due to infiltration. By the last year of monitoring during Phase II (2007), chloride concentrations in the lysimeter were similar to groundwater concentrations. Chloride concentrations remain well below the regulatory thresholds. Sulfate concentrations have shown stable concentrations for the upgradient well and a statistically significant decreasing trend for the downgradient well. Sulfate concentrations in surface water are generally lower than in groundwater. Sulfate concentrations in all samples are less than the regulatory threshold.

Concentrations of metals in samples from both wells were stable or decreasing with the exception of boron and total aluminum in samples from the upgradient well. Based on Mann-Kendall trend analysis, concentrations of these two metals (see Table 2) were determined to be probably increasing and increasing (for total and dissolved boron, respectively) and increasing for total aluminum. Dissolved aluminum has not been detected in either well. Concentrations of all metals were below the regulatory thresholds. Based on these results, it appears that infiltration had a positive effect on site groundwater quality with respect to metals concentration.

For the general monitoring parameters, nitrate showed statistically significant increasing trends over time for both wells. Because the increase was observed in both wells, it is likely due to regional groundwater effects rather than infiltration. Nitrate has been detected in surface water samples, but at slightly lower concentrations than in groundwater samples. A statistically significant increasing trend has been observed for total dissolved solids (TDS) for the upgradient well, and no statistical trend has been observed for the downgradient well, indicating a possible positive impact on groundwater quality from infiltration. TDS has been detected in surface water samples but at lower concentrations than in groundwater. Concentration of the other analyzed nutrients and inorganic parameters were generally higher in surface water than in groundwater, and groundwater concentrations were generally low.

The volatile organic compounds (VOCs) tetrachloroethene (PCE) and 1,1-dichloroethene(1-1-DCE) were detected in the upgradient well during the current monitoring phase, but no VOCs were detected in the downgradient well. Over time, statistical trends have shown stable concentrations of PCE and 1,1-DCE, and a probable decreasing trend for trichlorethene (TCE) in the upgradient well; and statistically significant decreasing trends for PCE and 1,1-DCE for the downgradient well. VOCs (acetone, 2-butanone, and methylene chloride) were detected in surface water samples collected during the previous monitoring phase, but these VOCs generally have not been detected in groundwater samples. No VOCs were detected in surface water samples during Phase III monitoring.

For most analyzed constituents, storm water infiltration appears to have no discernible impact or a positive impact on groundwater quality. The exception was chloride, which exhibited a slight increase in concentrations observed in the downgradient well (which may be a result of short-term flushing of accumulated salts in soil). The highest chloride concentrations in any samples are significantly less than drinking water MCLs.

Monitoring Summary: Mid-City Metals

Monitoring at Mid-City Iron and Metals has been conducted over a period of twelve years since 2003, with a gap of about seven years prior to 2014. At Mid-City Iron and Metal, chloride concentrations showed a statistically significant increasing trend in groundwater well M-MW-01 over time (although the magnitude of the increase is slight), but concentrations remain much lower than the regulatory threshold for chloride. The increasing trend in groundwater chloride concentrations is likely the result of factors other than infiltration of storm water given the depth to groundwater at the site, and because concentrations of chloride in surface water are similar to or lower than those in groundwater. Lysimeter M-LS-02 showed a recent increase in chloride during Phase III monitoring as further discussed below; the relationship, if any, between the increases in chloride concentrations in groundwater and at this lysimeter could not be resolved with the data available to date. Sulfate concentrations in groundwater have been stable over time. Sulfate concentrations exceed groundwater regulatory thresholds, but this was also the case when the initial sample was collected prior to commencement of infiltration. Sulfate was detected in surface water samples at concentrations generally lower than in groundwater.

For the metals, most concentrations were higher in surface water and in vadose zone water (lysimeter samples) than in groundwater**.** Metals concentrations in groundwater have remained stable or decreased over the course of the project, indicating no negative impacts on groundwater quality, with the exception of boron, which showed a statistically significant increasing concentration. Boron has been detected in surface water samples at similar concentrations to groundwater, and in lysimeter samples at concentrations greater than in groundwater. With the exception of lysimeter M-LS-02, boron concentrations were significantly higher in lysimeters in the initial part of the study, indicating that salts accumulated in the soil may have been flushed out by infiltrating storm water. The concentrations of boron and other metals in groundwater are all below their regulatory thresholds. Although increasing trends for other metals were not observed for groundwater, it must be noted that concentrations of some of the metals (such as chromium, copper, lead, nickel and zinc) have increased in lysimeter samples over time. Concentrations of these metals, other metals including aluminum, boron, and cadmium and certain other compounds (chloride and chemical oxygen demand) showed a notable increase in samples from either or both of the lysimeters in the most recent phase of monitoring.
In addition, it was noted that the ratio of dissolved to total metals for these constituents for the lysimeters during the current phase of monitoring was much lower (approximately 1:100 for some constituents) than observed in previous samples (a minimum ratio of approximately 1:5 for older historical data for this site and for the other two sites). The available data did not allow us to conclude whether this difference in ratios resulted from changes in the water quality characteristics of vadose zone water during the 7-year gap in monitoring between Phase II and Phase III or from other factors.

Several potential causes of the higher concentrations of metals and certain other constituents in the Phase III lysimeter samples were considered. These included: 1) infiltration of storm water containing greater concentrations of these constituents than indicated by the surface water samples collected; 2) mobilization of metals from shallower in the vadose zone by infiltrating water; and 3) localized evaporative concentration of these constituents within or near the lysimeters. The data available did not allow us to conclude whether these or other factors caused or contributed to the higher concentrations noted.

In reviewing these data and considering potential causes, we noted that soil characterization was conducted in 2003 prior to the start of infiltration at the site, and included collection and analysis of soil samples from the depths where the lysimeters were installed, with the shallowest soil sample collected at 20 feet. The results of the sampling did not indicate the presence of elevated concentrations of metals at the locations and depths sampled. Shallow soil samples to assess potential metals accumulation due to long-term infiltration of storm water were not collected at this site.

For the general monitoring parameters, TDS concentrations show a probable increasing trend, though concentration magnitude did not increase significantly. TDS concentrations were above the regulatory thresholds prior to commencement of infiltration. TDS was detected in surface water samples at concentrations generally lower than in groundwater. Therefore, it is likely that the increasing concentration trend is due to factors other than infiltration of storm water. TDS concentrations in some of the lysimeters were initially higher in the beginning of the study (indicating flushing out of salts in the soil may have occurred) but have since decreased. Nitrate was detected in the initial groundwater sample and subsequently has not been detected. Similar to Broadous Elementary, the other nutrients and inorganic parameters were generally higher in surface water than in groundwater.

The VOCs detected in the surface water and lysimeter samples are generally not the same as those that have been detected in the groundwater samples (with the exception of methylene chloride). The VOCs detected in groundwater (carbon disulfide and methylene chloride) were only detected in the first several monitoring events and were not detected during Phase III monitoring.

In general, it appears that the infiltration has not had a negative impact on groundwater quality, with the exception of a slight increase in chloride, TDS, and boron concentrations. These increasing concentration trends may be from flushing accumulated salts from soil, which should be a short-term effect. However, because groundwater at the site is quite deep, we would expect that the effect of infiltration, if any, may not be evident for the duration of this study. Therefore, it is likely that the observed concentration increases are due to regional groundwater effects rather than infiltration.

Monitoring Summary: Veteran's Park

Monitoring at Veteran's Park has been conducted over a period of twelve years since 2003, with a gap of about seven years prior to 2014. For Veterans Park proximal wells V-MW-02 and V-MW-03, chloride concentrations have shown statistically significant decreasing trends, and concentrations are less than the regulatory thresholds. Concentrations for proximal well V-MW-04 have also shown a statistically decreasing trend in concentrations over time to near regulatory thresholds. Chloride concentrations are much higher for the background well, and have shown statistically significant increasing concentrations over time. Chloride in surface water was detected at similar to lower concentrations than in groundwater. It appears that infiltration has had a positive effect on chloride concentrations in groundwater at this site. Similar to trends in chloride concentration, sulfate concentrations have shown a statistically significant increasing trend over time for the background well, but statistically significant decreasing trends for the wells closer to the infiltration system. Sulfate concentrations are over the regulatory threshold for the background well, and below to just above the threshold for the other wells. Sulfate concentration was low in the only surface water sample collected during Phase III monitoring.

For the general monitoring parameters, nitrate concentrations showed a statistically significant increasing trend in one of the proximal wells (V MW-02), but current concentrations are similar to baseline concentrations. Statistical trends were stable or decreasing for the other wells. Because nitrate in groundwater is similar in concentration to surface water samples, it is not likely that the increase in nitrate at V-MW-02 is due to infiltration of storm water. In addition, lysimeter results showed higher concentrations of nitrate in the initial part of the project (particularly at V-LS-02) indicating that salts accumulated in the soil may have been dissolved and mobilized due to infiltration. During Phase III monitoring, nitrate concentrations in lysimeter samples were lower than groundwater concentrations. Current phase nitrate concentrations are less than the regulatory threshold for all groundwater samples. TDS concentrations in groundwater at the proximal wells have decreased since infiltration commenced, while in the background well TDS concentrations in groundwater have exhibited a statistically significant increasing trend. TDS is present in surface water samples at lower concentrations than groundwater. It appears likely that infiltration has had a positive effect on TDS concentrations at this site. TDS concentrations for the proximal wells are currently just above regulatory thresholds. The other nutrients and inorganic parameters were generally higher in surface water than in groundwater.

Concentrations of metals in groundwater samples were generally higher in the background well than the wells proximal to the infiltration BMP, indicating a likely positive effect on groundwater quality from the infiltration. Concentrations were stable or decreasing over time, with the exception of total and dissolved cadmium for the background well and hexavalent chromium for proximal well V-MW-03, which showed probable increasing or statistically significant increasing trends. Because the background well is relatively distant from the infiltrator, the increasing cadmium trends for this well are likely due to factors other than infiltration. Although an increasing trend for hexavalent chromium has been observed for well V-MW-03, the concentrations remain lower than regulatory thresholds. The other proximal wells exhibited stable or decreasing concentrations. Hexavalent chromium is lower in concentration in surface water samples, therefore it is not likely the increase in hexavalent chromium at V-MW-03 is due to infiltration of storm water. Analytical results for lysimeter V-LS-01, which is near well V-MW-03, showed higher concentrations of hexavalent chromium in the initial part of the project than during Phase III monitoring, indicating that salts accumulated in soil may have been flushed out due to infiltration.

VOCs were not detected in surface, lysimeter, and groundwater samples collected in the current phase of monitoring. In the previous phases, several VOCs were detected in surface water samples, and the compounds acetone, chloroform, methyl chloride and methylene chloride were detected in lysimeter and groundwater samples.

In general, with the exception of increases in nitrate and hexavalent chromium in proximal wells V-MW-02 and V-MW-03, respectively, concentrations of most constituents were stable or decreasing over time. It appears that infiltration of storm water had a generally positive impact on groundwater quality. Because groundwater is relatively shallow at this site, it appears that the impact of infiltration is more pronounced than at the sites with deeper groundwater.

Summary of Elmer Avenue Water Quality Monitoring, Soil Sampling, and Biodiversity Observations

For most metals, the concentration and ratio of total and dissolved fractions varied with depth. Some metals concentrations decreased significantly with depth (iron and lead), indicating the catch basin was likely effective at reducing the concentrations. Although the concentration of some metals such as selenium increased with depth, because surface water concentrations were low, the detections are not likely from infiltrated storm water and may be due to the presence of selenium in soil may have been dissolved and mobilized due to infiltration. Soils often contain relatively high concentrations of metals and soluble inorganic constituents due to evaporation. With the exception of arsenic and periodically nickel, metals were detected at concentrations below MCLs. Additional monitoring should be conducted to evaluate trends over time. Although arsenic and periodically nickel are detected above MCLs in the vadose zone, it is not likely that groundwater will be impacted given the depth to groundwater in this area.

At Elmer Avenue, none of the concentrations of constituents analyzed in soil samples (measured annually, from 2010 to 2015) from the bioswales consistently increased over time. In the first 12 months following BMP installation (2010-2011), a total of 22 animal species were observed, while in 2014/2015 (approximately 5 years post-construction,) 35 species were observed. The biggest improvement was seen in the insect diversity. In 2010-2011 just two species were observed, whereas in 2014-2015 fifteen unique native and beneficial insect species were observed, including a range of butterflies and bees.

Table 2. Significant Trends detected from Groundwater Well and Lysimeter Monitoring stations via Mann-Kendall analysis **(**see Appendix A for detailed analysis results**)**

Location	Constituent	Trend
M-MW-01	Chloride	**increasing**
M-MW-01	Total Dissolved Solids (TDS)	**probably increasing**
M-MW-01	Chemical Oxygen Demand (COD)	probably decreasing
M-MW-01	As-Total	decreasing
M-MW-01	As-Dissolved	decreasing
M-MW-01	B-Total	**increasing**
M-MW-01	B-Dissolved	**increasing**
M-MW-01	Ni-Total	probably decreasing
M-MW-01	Ni-Dissolved	decreasing
V-MW-01	TDS	**increasing**
V-MW-01	Chloride	**increasing**
V-MW-01	Nitrate	decreasing
V-MW-01	Sulfate	**increasing**
V-MW-01	Al-Total	decreasing
V-MW-01	Se-Total	decreasing
V-MW-01	Cr-Dissolved	decreasing
V-MW-01	Cd-Total	**increasing**
V-MW-01	Cd-Dissolved	**probably increasing**
V-MW-02	TDS	decreasing
V-MW-02	Nitrite	probably decreasing
V-MW-02	COD	decreasing
V-MW-02	Chloride	decreasing
V-MW-02	Nitrate	**increasing**
V-MW-02	Sulfate	decreasing
V-MW-02	Pb-Total	decreasing
V-MW-02	Cu-Total	decreasing
V-MW-02	Cu-Dissolved	decreasing
V-MW-02	Al-Total	decreasing
V-MW-02	B-Total	decreasing
V-MW-02	B-Dissolved	decreasing
V-MW-02	As-Total	decreasing

Location	Constituent	Trend
V-MW-02	As-Dissolved	decreasing
V-MW-02	Se-Total	decreasing
V-MW-02	Se-Dissolved	decreasing
V-MW-02	Cr-Total	decreasing
V-MW-02	Cr-Dissolved	decreasing
V-MW-02	Hex Cr Dissolved	decreasing
V-MW-03	TDS	decreasing
V-MW-03	COD	decreasing
V-MW-03	Chloride	decreasing
V-MW-03	Sulfate	decreasing
V-MW-03	Pb-Total	decreasing
V-MW-03	B-Total	decreasing
V-MW-03	B-Dissolved	decreasing
V-MW-03	As-Total	decreasing
V-MW-03	As-Dissolved	decreasing
V-MW-03	Se-Total	decreasing
V-MW-03	Se-Dissolved	decreasing
V-MW-03	Cr-Total	probably decreasing
V-MW-03	Cr-Dissolved	decreasing
V-MW-03	Hex Cr Dissolved	**probably increasing**
V-MW-04	TDS	decreasing
V-MW-04	Nitrite	decreasing
V-MW-04	COD	decreasing
V-MW-04	Chloride	decreasing
V-MW-04	Nitrate	decreasing
V-MW-04	Sulfate	decreasing
V-MW-04	Pb-Total	probably decreasing
V-MW-04	Cr-Total	decreasing
V-MW-04	Cr-Dissolved	decreasing
V-MW-04	Cu-Total	decreasing
V-MW-04	Cu-Dissolved	decreasing
V-MW-04	Zn-Total	probably decreasing
V-MW-04	Zn-Dissolved	probably decreasing
V-MW-04	Al-Total	probably decreasing
V-MW-04	B-Total	decreasing
V-MW-04	B-Dissolved	decreasing
V-MW-04	Se-Total	decreasing
V-MW-04	Se-Dissolved	decreasing
V-MW-04	Ni-Total	decreasing
V-MW-04	Ni-Dissolved	decreasing
B-MW-01	Cu-Total	decreasing
B-MW-01	Cu-Dissolved	decreasing
B-MW-01	Zn-Total	decreasing
B-MW-01	Zn-Dissolved	decreasing
B-MW-01	Al-Total	**increasing**
B-MW-01	B-Total	**probably increasing**
B-MW-01	B-Dissolved	**increasing**
B-MW-01	Se-Dissolved	probably decreasing
B-MW-01	Ni-Total	decreasing

Location	Constituent	Trend
B-MW-01	Cr-Total	decreasing
B-MW-01	Cr-Dissolved	probably decreasing
B-MW-01	Nitrate	**increasing**
B-MW-01	TDS	**increasing**
B-MW-01	Trichloroethene (TCE)	probably decreasing
B-MW-02	1,1-dichloroethene (1,1-DCE)	decreasing
B-MW-02	Tetrachloroethene (PCE)	decreasing
B-MW-02	COD	decreasing
B-MW-02	Chloride	**increasing**
B-MW-02	Nitrate	**increasing**
B-MW-02	Sulfate	decreasing
B-MW-02	Se-Dissolved	probably decreasing
B-MW-02	Zn-Dissolved	decreasing
B-MW-02	Cu-Dissolved	decreasing
B-MW-02	Cu-Total	decreasing
B-MW-02	Zn-Total	decreasing
B-MW-02	Ni-Total	decreasing
M-MW-02	Cr-Dissolved	decreasing
Lysimeters		
M-LS-02	Chloride	**increasing**
M-LS-02	Pb-Total	**probably increasing**
M-LS-02	Cu-Total	**probably increasing**
M-LS-02	Zn-Total	**increasing**
M-LS-02	Zn-Dissolved	**probably increasing**
M-LS-02	Cr-Total	**increasing**
M-LS-02	Cr-Dissolved	**increasing**
M-LS-02	Ni-Total	**increasing**
M-LS-02	Ni-Dissolved	**increasing**
M-LS-03	As-Dissolved	decreasing
M-LS-03	As-Total	decreasing
M-LS-03	B-Total	decreasing
M-LS-03	B-Dissolved	decreasing
M-LS-03	Cr-Total	**increasing**
M-LS-03	Cr-Dissolved	**increasing**
M-LS-03	Ni-Dissolved	**increasing**
M-LS-03	Pb-Total	**probably increasing**
M-LS-03	Cu-Total	**increasing**
M-LS-03	Cu-Dissolved	**increasing**
M-LS-03	Zn-Total	**increasing**
M-LS-03	Zn-Dissolved	**increasing**
V-LS-01	TDS	probably decreasing
V-LS-01	Nitrate	decreasing
V-LS-01	As-Total	probably decreasing
V-LS-01	As-Dissolved	decreasing
V-LS-01	B-Total	decreasing
V-LS-01	B-Dissolved	decreasing
V-LS-01	Cr-Total	decreasing
V-LS-01	Cr-Dissolved	decreasing
V-LS-01	Se-Total	decreasing

Location	Constituent	Trend
V-LS-01	Se-Dissolved	decreasing
V-LS-01	Cu-Dissolved	probably decreasing
V-LS-02	TDS	decreasing
V-LS-02	Chloride	decreasing
V-LS-02	Nitrate	decreasing
V-LS-02	As-Dissolved	decreasing
V-LS-02	As-Total	decreasing
V-LS-02	B-Dissolved	**probably increasing**
V-LS-02	Se-Total	probably decreasing
V-LS-02	Se-Dissolved	decreasing

Note on Table 2: Statistical trends were not performed this phase for alkalinity, ammonia, dissolved organic carbon, nitrogen, pH, phosphorus, specific conductance, Total Kjehdahl Nitrogen, total organic carbon, total suspended solids, calcium, hardness, magnesium, potassium, sodium, bromide, and fluoride. Statistical trends were not performed for volatile organic compounds (VOCs) unless there were detections in Phase III and statistical trends for VOCs were not performed for lysimeters this phase. See Table 1 for a list of monitoring locations and codes by site.

PUBLIC OUTREACH

Outreach on the results of WAS at its various phases was (and continues to be) an important component of this effort. This outreach was conducted via numerous presentations at meetings and conferences, as well as reports and publications. Presentations at two high-profile conferences were specifically conducted during Phase III of the program. Dr. Emily Daniels presented findings about the monitoring of WAS project site Elmer Avenue at the 2014 CASQA (California Stormwater Quality Association 2014) meeting in Garden Grove. Dr. Marty Spongberg and Katherine Howe, PG, with AMEC, shared findings of the WAS with the hydrogeology community at the Groundwater Resources Association Managed Aquifer Recharge conference in Orange.

An event focused on the Phase III WAS findings is scheduled for February 2016 to share the summary findings to-date and determine next steps for the program. The information learned from this event will be discussed and synthesized in the Final Project Report for Agreement.

Additional presentations, meetings, professional publications, and awards prepared for the study over the course of the entire program are listed below:

<u>List of WAS presentations and outreach activities by staff of the Council for Watershed Health:</u>

- 2/27/13 - Strategic Planning for Recharge Using Stormwater, LA County Department of Public Works, Alhambra, CA
- 5/8/13 - LA Basin Water Augmentation Study, State Water Resources Control Board and Strategic Growth Council, Sacramento, CA

- 7/25/13 - Tour of Elmer Avenue for USBR leadership
- 9/24/13 - Host at roundtable session, US Water Alliance, LA Basin Water Augmentation Study, Los Angeles, CA
- 10/3/13 - LA Basin Water Augmentation Study, Watersmart Innovations Conference, Las Vegas, NV
- 10/7/13 - Nancy Steele and Mike Antos had meetings with the five state water board members on this day, and shared WAS findings
- 10/16/13 - Office of LA County Supervisor Gloria Molina RE: stormwater capture and disadvantaged communities.
- 10/19 - 10/21/13 - US EPA Green Infrastructure Conference, part of Los Angeles delegation, Syracuse, NY
- 11/18/13 - Office of LA County Supervisor Mike Antonovich RE: stormwater capture, open space and disadvantaged communities.
- 2/20/14 Presentation about Elmer Avenue at Sun Valley Magnet Middle School (Emily)
- 6/4/14 - Clean Water for Life and Business (panelist), NextUp Business Forum, Los Angeles, CA

<u>List of selected WAS publications and presentations by AMEC:</u>

- “Green Storm Water Infrastructure Augments Sustainable Groundwater Objectives”, Groundwater Resources Association of California, 30th Biannual Groundwater Conference, Sacramento, October 2015.
- “Long-Term Subsurface Monitoring of Storm Water Infiltration for Groundwater Recharge”, WEFTEC, Annual Conference, Chicago, September 2015.
- “Long-term Subsurface Monitoring of Storm Water Infiltration for Groundwater Recharge”, Groundwater Resources Association of California, 14th Biannual Symposium on Managed Aquifer Recharge, Orange, August 2014.
- “Green Storm Water Management At Industrial Facilities”, StormCon Annual Conference, Portland, August 2014.
- Elmer Avenue LID Demonstration Project”, Nevada Water & Environment Association Conference, April 2014.
- “Sustainable Storm Water Management At Industrial Facilities”, California Stormwater Quality Association Annual Meeting, San Diego, November, 2012.
- “Costs and Benefits of Green Infrastructure”, Sustainable City Network, Western Regional Conference, Santa Rosa, May 2012.

- "Groundwater Recharge With Infiltrated Stormwater – Los Angeles Basin Water Augmentation Case Study", Groundwater Resources Association of California, Annual Meeting, Sacramento, October 2011.
- "Expanding Local Groundwater Supplies: Assessing the Impact of Stormwater Infiltration on Groundwater Quality", S. Dallman and M. Spongberg, Professional Geographer, August 2011.
- "Elmer Avenue Green Street Demonstration Project", E. Belden and M. Spongberg, California Stormwater Quality Association Annual Meeting, Rancho Mirage, 2010.
- "Long-Term Subsurface Monitoring Beneath Infiltration BMPs: Finding of the Los Angeles Basin Water Augmentation Study", M. Spongberg, StormCon Annual Conference, San Antonio, 2010.
- "Stormwater Infiltration for Sustainable Stormwater Infrastructure", ICMA Annual Conference, San Jose, 2010.
- "Fate of Contaminants in Infiltrated Runoff", Decentralized Stormwater Conference, Los Angeles, 2010.
- "Long-Term Subsurface Monitoring Beneath Infiltration BMPs – Findings of the Los Angeles Basin Water Augmentation Study", M. Spongberg et al., California Stormwater Quality Association Annual Meeting, San Diego, 2009.
- "Stormwater Infiltration – Case Studies", M. Spongberg, Industrial Environmental Association Annual Environmental Summit, San Diego, 2009.
- "Neighborhood Watershed Stormwater Management: The Elmer Avenue Neighborhood Retrofit Project", E. Belden and M. Spongberg, StormCon Annual Convention, Anaheim, 2009.
- "Stormwater Project Transforms Flooding Into Valuable Resource", M. Spongberg, WaterWorld, June 2009.
- "Local Water Supplies: Assessing the Impacts of Stormwater Infiltration on Groundwater Quality", Gatekeeper Conference, Phoenix, 2009.
- "Stormwater Project Transforms Flooding Into Valuable Resource", M. Spongberg, Urban Water Management, April 2009.
- "Impacts of Stormwater Infiltration: Findings of the Los Angeles Basin Water Augmentation Study", S. Dallman and M. Spongberg, StormCon Annual Conference, 2007.
- "Impacts of Stormwater Infiltration on the Vadose Zone and Groundwater", Dallman, S., M. Spongberg, and T. Simpson, Proceedings StormCon North American Surface Water Quality Conference & Exposition, Denver, CO, 2006.

Project Awards:

- CASQA Outstanding Regional Stormwater Research Project Award, Los Angeles & San Gabriel Rivers Watershed Council Water Augmentation Study, 2006.
- CASQA Outstanding Stormwater BMP Implementation Award, Los Angeles & San Gabriel Rivers Watershed Council Water Augmentation Study, 2010.

Project partners were also successful with publication and presentation of study findings at 3 regional meetings, and 1 state-wide conference (see above). In addition, a professional publication was submitted that describes new monitoring technique developed during this project to assess the growth and vitality of vegetation in bioswales:

- *Colcord, M., Antos, M., Daniels, E. (in review). Assessment of Vegetation Health in Urban Stormwater Management Project Using ImageJ. Environmental Monitoring and Assessment. Another professional publication is being prepared to present the water quality results of this study through this most recent phase.*

PROJECT EVALUATION AND EFFECTIVENESS

In order to appropriately evaluate the effectiveness of the WAS effort, it is important to recognize that this project was conducted in phases and that the knowledge base for each phase was built upon by the antecedent phase (i.e., Phase I informed Phase II findings; Phase I and II informed Phase III findings). Although Phase III (Agreement # 12-425-550) is the focus of this report, the overall WAS effort must be considered in the final evaluation of the program.

The overall goals of the WAS were to "quantify the long-term effects of infiltrating urban stormwater on groundwater quality at sites utilizing best management practices (BMPs) for stormwater runoff infiltration from a range of land use types in the Los Angeles River Watershed". The desired outcome of the study was to observe a measurable reduction in pollutant concentrations, especially metals, nutrients, anions, volatile organic compounds, and sediment, to the Los Angeles River.

The stated goals of the WAS Phase III can be articulated as follows:

- To collect water quality data from the subsurface (pore water and groundwater) and surface waters at infiltration BMPs installed during Phases II and III of the Los Angeles Basin Water Augmentation Study.
- To collect a complete set of representative, high quality samples to provide scientifically valuable data with broad implications for infiltration projects throughout California.
- Authorship and publication of a peer-reviewed paper describing this work and findings

The desired outcomes (products) of the WAS Phase III are as follows:

- To acquire additional data and analysis to supplement the earlier findings of the Water Augmentation Study and provide a greater understanding of the impacts from long-term stormwater capture for infiltration to groundwater in the Los Angeles Region.

- To build upon the successes of earlier study publications by helping the Los Angeles Region to move towards adoption of more stormwater capture infiltration projects.

With the above in mind, it is clear that the goals and targets of the project as stated in the original Project Evaluation and Assessment Plan (PAEP) were achieved (Table 3). Based on the Mann-Kendall trend analysis conducted for 157 analytes/sampling locations that had sufficient data for statistical analysis at Phase III, storm water infiltration appears to have no discernible impact or a positive impact on groundwater quality for most analyzed constituents i.e., there is no evidence of significant degradation of groundwater quality due to long-term infiltration of urban storm water**.** Veterans Park appears to show the greatest positive impact on groundwater quality from infiltration, possibly because this site has the shallowest groundwater.

Increasing concentration trends were calculated for only 13 of the constituents analyzed, and seven (7) of these increasing trends were associated with up-gradient or background wells that are not impacted by infiltration. The notable increasing trends for wells near or downgradient of an infiltration BMP include chloride at Broadous Elementary; chloride, TDS, and boron at Mid-City Iron and Metals; and nitrate and hexavalent chromium at Veterans Park. These increasing trends however are considered to be either due to factors other than infiltration (i.e. regional changes, short-term flushing of salts in soil), or are not significant (i.e. magnitude of the increase is small, or concentration is below the MCL).
At Mid-City Iron and Metal, concentrations of certain metals (chromium, copper, lead, nickel and zinc) and other constituents have increased over time in both lysimeters. Steps that could be considered to verify and evaluate the potential cause(s) and consequences of the increase in concentrations of certain metals and other constituents noted in the Phase III lysimeter samples include: 1) resampling of the lysimeters; 2) continued sampling of groundwater; 3) collection and analysis of additional soil samples from a range of depths near the infiltration system and lysimeters; 4) construction and monitoring of additional vadose zone or groundwater sampling points; 5) collection of surface water samples under first-flush and a range of other conditions; and, 6) more detailed data analysis to estimate potential mass transfer of constituents from surface water and/or the vadose zone to groundwater. As noted above, the depth to groundwater at the site is relatively great and groundwater quality does not appear to have been adversely impacted by infiltration. However, re-assessment of the suitability of the site for infiltration at the current location would be appropriate if further evaluation indicates transport of elevated concentrations of metals or other constituents from the surface or shallow vadose zone into the deeper vadose zone, and potentially to groundwater, is occurring.

Where increasing trends were seen at wells proximal to the infiltrator at the Veterans Park site, the increasing trend was limited to only one of the three wells and some of the results could be contributions from up-gradient groundwater.

There is insufficient data from the Elmer Avenue and Sun Valley Park sites to perform a robust trend analysis. At Elmer Avenue, with only a few years of monitoring data, arsenic and periodically nickel are the only compounds with concentrations in the lysimeter samples above their regulatory thresholds. The increasing trends were related primarily to salts (chloride, nitrate, TDS) and the metals total aluminum, boron, cadmium and hexavalent chromium. Nutrients generally decreased with depth and VOCs have not been an issue. Additional monitoring is recommended for these sites in order to obtain more long-term monitoring data. Additional monitoring is also recommended for the three long-term monitoring sites to further evaluate long-term trends (particularly at Mid-City Iron and Metals).

The project effort at Phase III was successful in its stated goal of acquiring additional data and conducting analyses to supplement the earlier findings of the WAS and provided a greater understanding of the impacts from long-term stormwater capture for infiltration to groundwater in the Los Angeles Region. For example, the recommendations that came out of experiences at Phase I included (1) continuing to monitor existing sites for additional seasons to develop a more robust data set and (2) expansion of the monitoring locations to include more land use types, BMP types, and soil types to address the fundamental questions raised by the Workgroup. All of this was implemented and achieved during Phase II of the program. Likewise, the recommendations at Phase II were implemented at Phase III by incorporating a demonstration project on a neighborhood scale, the Elmer Avenue Neighborhood Retrofit Project, and related management practices to address storm water infiltration as well as water conservation, pollution reduction and treatment, flooding, and community enhancement.

Over the course of the WAS program, up to nine study sites total were incorporated into the program. Specific sites changed out between the respective phases, but 100% completeness of planned sampling events at a minimum of seven (7) sites was achieved if the entire program is considered holistically over all its phases. We were able to collect high quality, representative data from five (5) sites at Phase III. The Hall residence, Sun Valley Paper Stock, and IMAX corporation sites monitored during Phases I and II were not monitored during Phase III due to either land ownership changes or that monitoring equipment had been destroyed or removed. This was beyond the control of the study and an inherent risk when conducting applied research in a highly urbanized area such as Los Angeles.

Some technical limitations were encountered during this study. The limited sample volume possible from lysimeters meant that not all constituents could be tested during all events (despite purging twice to maximize water volume). Concerted efforts were made to obtain data for as many constituents as possible at least once given the water volume constraint. This is a limitation of using lysimeters to quantify soli pore water that should be addressed in future studies.

These results achieved from Phase III are not only significant from the aspects of human and watershed health, but are useful and practical for permit writers and city planners, as well as provide confidence that stormwater-based ordinances can safely encourage infiltration as means to augment groundwater supplies. The information produced from the WAS has been useful for permit writers, and the results of the study have even been quoted in select MS4 permits. The information is further useful for discharges that want to comply with permits promoting infiltration, but don’t want to degrade receiving groundwater. Lastly, the information for the WAS has a practical application for city planners in that it provides confidence that water-related ordinances can safely encourage infiltration. These are specific, quantifiable changes that have resulted for the long-term finding of the WAS.

TABLE 3. PROJECT EVALUATION AND ASSESSMENT PLAN (PAEP)

<table>
<tr><th>Project Goal</th><th>Desired Outcomes</th><th>Output Indicators</th><th>Outcome Indicators</th><th>Measurement Tools and Methods</th><th>Targets</th></tr>
<tr>
<td>- Collect water quality data from the subsurface (pore waters and groundwater) and surface waters at infiltration BMPs installed during Phases II and III of the Los Angeles Basin WAS.
- Collect a complete set of representative, high quality samples to provide scientifically valuable data with broad implications for infiltration projects throughout California.
- Authorship and Publication of a peer-reviewed paper describing this work and findings</td>
<td>- Acquire additional data and analysis to supplement the earlier findings of the WAS and provide a greater understanding of the impacts from long-term stormwater capture for infiltration to groundwater in the Los Angeles Region.
- Build upon the successes of earlier study publications by helping the Region to move towards more Stormwater capture n infiltration projects.</td>
<td>Monitoring data from:
<table>
<tr><th>Site</th><th>Sensor / Sample</th><th>Sample Frequency</th></tr>
<tr><td>Public School</td><td>2 Monitoring Wells</td><td>3/wet season</td></tr>
<tr><td>Residential Property</td><td>1 Lysimeter</td><td>2/wet season</td></tr>
<tr><td>Metal Recycler</td><td>1 Monitoring Well</td><td>3/wet season</td></tr>
<tr><td>Paper Recycler</td><td>5 Lysimeters</td><td>2/wet season</td></tr>
<tr><td>Municipal Park</td><td>4 Monitoring Wells</td><td>3 /wet season</td></tr>
<tr><td></td><td>2 Lysimeters</td><td>2/ wet season</td></tr>
<tr><td></td><td>1 Lysimeter</td><td>3 /wet season</td></tr>
<tr><td>Elmer Avenue</td><td>5 Bioswales</td><td>1 following each wet season</td></tr>
<tr><td></td><td>2 Lysimeter
2 Surface</td><td>3 per wet season</td></tr>
</table>
</td>
<td>Data representativeness; data completeness; data quality, project reports, and peer-review publications made available via Council for Watershed Health website, or similar public source.</td>
<td>Data representativeness will be determined by comparing sampling to storm selection criteria and other monitoring protocols published in the Monitoring and Reporting Plan (MRP).
Data completeness will be determined by comparing the actual number of samples collected and analyzed to the number of samples described in the MRP and QAPP.
Data quality will be determined by comparison to the data quality objectives (DQO's) described in the project QAPP</td>
<td>1. 100% completeness of planned sampling events at a minimum of 7 sites
2.Collection of high quality and representative data at x sites
3 Publication and presentation of study findings at 3 regional meetings, and 1 state-wide conference
4. Submission of paper for peer-review publication to one journal, such as the Watershed Science Bulletin</td>
</tr>
</table>

CONCLUSIONS

The Water Augmentation Study presented a unique opportunity to collect long-term information about the efficacy and long-term impacts of infiltration BMPs from various stormwater capture BMPs on multiple land-uses throughout the region. The TAC assembled for this effort reflects a landmark level of collaboration, in that the Los Angeles Regional Water Control Board, the regulatory agency raising concerns over water quality, contributed to the study effort along with the water agencies that are directly affected by the study outcome. TAC membership comprises representation from multiple scientific disciplines, in addition to the engineering and geological expertise. Furthermore, the Elmer Avenue Neighborhood Retrofit project has been the site of performance monitoring and evaluation since the completion of Phase 1 of the project. Monitoring and evaluation at Elmer show that the conceptualized benefits of distributed stormwater capture have values that are observable and quantifiable, without significant evidence of unintended consequences like contaminant accumulation or resident apathy (GeoSyntech 2015).

Capturing and infiltrating stormwater is now an accepted and practiced means of reliably augmenting groundwater supplies in the region. In 2012, a new Municipal Separate Storm Sewer System (MS4) permit was issued that encourages the use of Low Impact Development (LID) solutions for stormwater quality mitigation, and many resource management agencies in the region continue to pursue long-range plans for stormwater capture to recharge drinking-water aquifers. Today, the City of Los Angeles is able capture approximately 29,000 acre-feet per year of stormwater (8.8 billion gallons), along with another 35,000 acre-feet per year infiltrating into the potable aquifers through incidental recharge. Water from groundwater basins fed by surface flows of the LA River and its tributaries provide a significant portion of the drinking water for the region. This water source represents approximately 10% of the City's annual water demand and enhances the reliability of the City of Los Angeles' water supply (Geosyntech 2015). The input of the WAS TAC and the long-term findings of the WAS have been instrumental in helping the Region to move towards its goal of having more stormwater capture infiltration projects in the region. This has been quite an accomplishment and the role that the WAS has played in this development process should not go unsung.

Expanding urban development and periodic droughts have only increased the need to infiltrate stormwater runoff to recharge groundwater basins. The Los Angeles Department of Water and Power 's (LADWP) Stormwater Capture Master Plan (SCMP) has demonstrated that an additional 68,000 to 114,000 acre-feet per year could be realistically captured through implementation of a suite of centralized projects and the adoption of distributed programmatic approaches over the next 20 years (Geosyntech 2015). Potential projects and programs to capture additional stormwater are particularly important to consider, not only because of the increasing economic value of this water supply but also because stormwater projects address a host of other challenges faced by the City of Los Angeles.

The Water Augmentation Study just completed its sixteenth and final year of the the study in its current form, but much work remains to be done and the WAS TAC should explore opportunities to elevate the program to the next level. Next steps for this program must consider evaluating the importance of proper operation and maintenance of BMPs relative to potential impacts on groundwater quality. Continued exploration of effective, economical BMPs to avoid long-term impacts of development could also be a fruitful avenue of research moving into the future.

Working together on projects that have collateral benefits for multiple agencies allows for the opportunity to cost-share and reduces the financial burden. All opportunities to enhance multi-beneficial aspects of increasing stormwater capture, including groundwater recharge, increased water conservation, potential open space alternatives, providing habitat, improved downstream water quality, and peak flow attenuation in downstream channels, creeks, and streams such as the Los Angeles River, should be continually identified and researched. Recommendations on stormwater capture projects, programs, policies, incentives, and ordinances throughout the entire City of Los Angeles should continue to be championed by the leadership on WAS TAC. The WAS program was able to build upon the successes of its earlier efforts and has real and lasting impacts in helping the greater Los Angeles Region to move towards more stormwater capture infiltration projects. A more comprehensive monitoring performance plan should be developed for the WAS Workgroup's review and approval to address these and other related questions.

On February 17th, 2016, a presentation on the final results of the Water Augmentation Study was presented to the WAS TAC and other members of the public in downtown Los Angeles. An outcome of this event was the identification of next steps for the program. The following recommendations cme out of this meeting:

1. **Continue subsurface monitoring at sites with viable monitoring systems**
    - Leverage the existing monitoring network to obtain scientifically valuable data at little incremental cost.
    - Continue to extend time line of "long-term" monitoring to assess whether breakthrough or other detrimental phenomena are relevant
2. **Assess quantitative recharge**
    - How quickly does captured storm water recharge groundwater?
    - Mapping aquitards and other barriers to vertical migration

- Role of infiltration wells to bypass migration barriers
- Development of modeling and other assessment tools
- Leveraging opportunities with Enhanced Watershed Management Plans (EWMPs)

3. **Siting studies**
    - Allowable levels (thresholds) of subsurface contamination through which storm water infiltrates
    - Anti-degradation policy
    - Implications of vadose zone data on leaching metals and other source rock issues
    - Magnitude and quality of dry weather flows
    - Role of infiltration wells to bypass contaminated zones

4. **Potential for storm water injection**
    - May be desirable when uppermost, unconfined aquifer is contaminated or otherwise unsuitable
    - Geochemistry factors
    - Energy and other cost factors

From a policy perspective, the WAS TAC also recommended that the policies and regulations that constrain or limit stormwater recharge due to liquefaction need attention and there is a need for more coordination on permitting by all the multiple agencies involved.

It is clear that more research is needed on the quantification of the cumulative benefits of distributed stormwater recharge facilities. There is currently limited data available for a composite of recharge volume (or available space for recharge) across the County of Los Angeles, especially data on recharge via distributed and passive infiltration. Most of the major groundwater basins have their own watermaster that tracks groundwater recharge amounts in its spreading basins, the data of which is reported to the respective watermasters by the County. Although the watermasters all technically track groundwater recharge and most report best estimates, these estimates are often just from centralized sources (i.e. large spreading basins). The Los Angeles Department of Water and Power (LADWP) has a model that calculates infiltration volume on a storm-by-storm event basis, but only for certain regions of the County (e.g., San Fernando Valley). Although there seems to be a number of efforts underway to model this better for the entire county, they tend not to emphasize actual data collection. Given all the various jurisdictions and disparate data sources, a coordinated countywide estimation of these amounts would allow for comparison of performance by groundwater basin on a larger scale.

Even if data are available, these data are not always publicly accessible and/or require a special request to the agency in question. For example, the Metropolitan Water District of Southern California (MWD) published a composite assessment from 2007 with these comparisons across LA County (and the whole

MWD service area), and they do regular updates, but these data are not usually available without requesting. This is more an issue of data availability, tracking, and management, but important none the less.

Finally, the Water Augmentation Study TAC acknowledges that over the past 16 years there has been a shift from a focus purely on "water supply and quality" to more holistic studies of “climate change resilience” and the evaporative cooling benefits from green infrastructure BMPs and other types of urban greening. These could provide lucrative avenues of research for future phases the WAS.

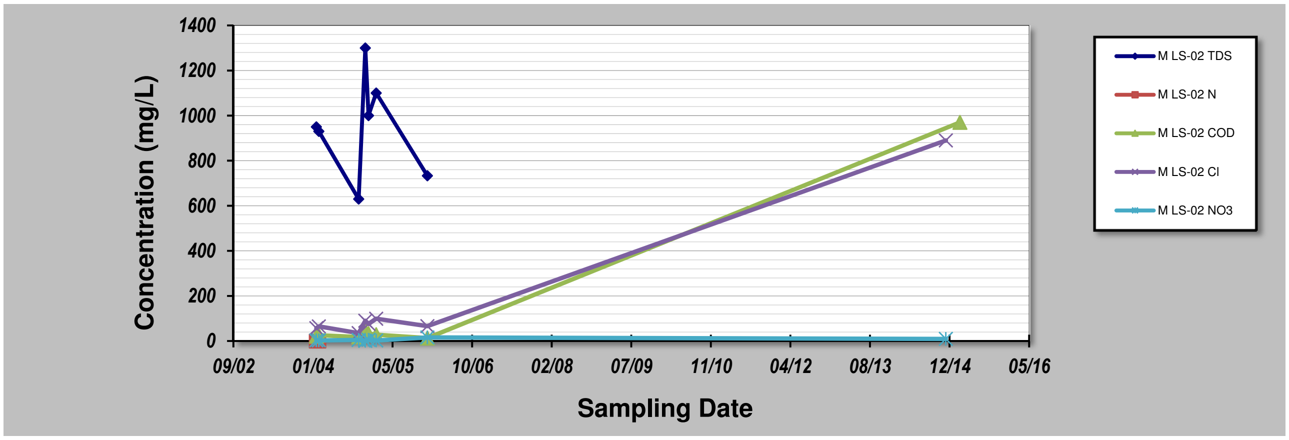
APPENDIX A

DETAILED MANN-KENDALL ANALYSIS RESULTS FOR GROUNDWATER AND LYSIMETER SAMPLES FOR MID-CITY IRON AND METAL AND VETERAN'S PARK

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	Job ID:	IR13164280
Facility Name:	Watershed Augmentation Study	Constituent:	M LS-02 Inorganics
Conducted By:	K. Howe	Concentration Units:	mg/L

	Sampling Point ID:	M LS-02 TDS	M LS-02 N	M LS-02 COD	M LS-02 Cl	M LS-02 NO3		
Sampling Event	Sampling Date	M LS-02 INORGANICS CONCENTRATION (mg/L)						
1	4-Feb-04	950	All concentrations	21	57	2.8		
2	20-Feb-04	930	non-detect	26	65	2.7		
3	3-Apr-04							
4	27-Oct-04	630		18	35	5		
5	8-Dec-04	1300		46	90	1		
6	28-Dec-04	1000		33	76	5.6		
7	14-Feb-05	1100		28	99	2.3		
8	2-Jan-06	733		13	66	16		
9	4-Dec-14				890	9.5		
10	2-Mar-15			970				
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.23		2.31	1.69	0.88		
Mann-Kendall Statistic (S):		1		6	16	10		
Confidence Factor:		50.0%		72.6%	96.9%	86.2%		
Concentration Trend:		No Trend		No Trend	Increasing	No Trend		



Notes:

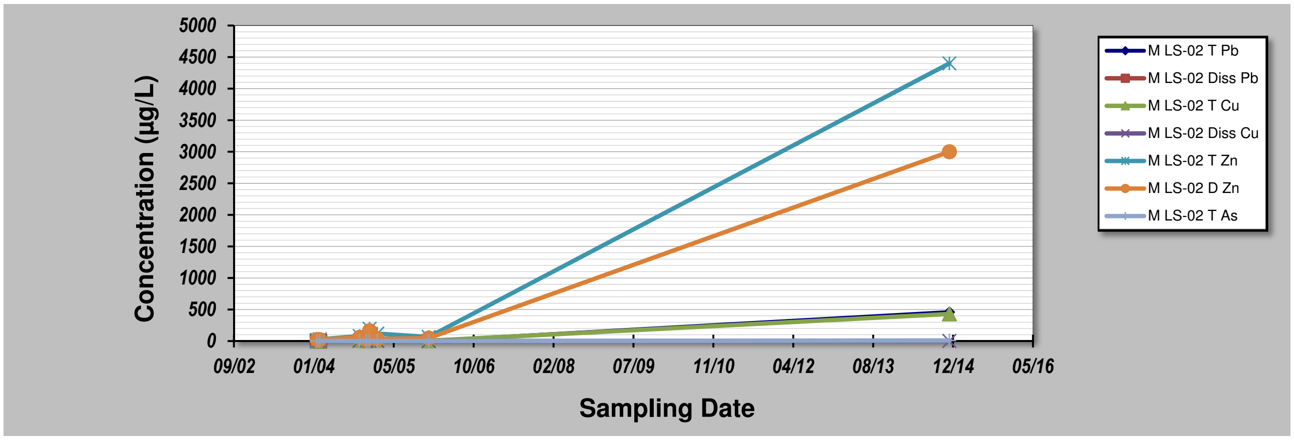
1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

GSI Environmental Inc., www.gsi-net.com

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-02 Metals
Concentration Units: µg/L

Sampling Point ID:		M LS-02 T Pb	M LS-02 Diss Pb	M LS-02 T Cu	M LS-02 Diss Cu	M LS-02 T Zn	M LS-02 D Zn	M LS-02 T As
Sampling Event	Sampling Date	M LS-02 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	0.872	Only 2 detections	4.17	4.14	18.5	24.9	2.77
2	20-Feb-04	2.45	no trend evaluated	8.24	4.54	28.1	22.9	2.98
3	3-Apr-04							
4	27-Oct-04	3.9		13.1	6.93	80.2	59.9	0.992
5	8-Dec-04	2.97		6.42	4.88	27.9	20.6	1.76
6	28-Dec-04	2.37		9.15	6.99	195	165	1.09
7	14-Feb-05	4.23		14.6	3.33	119	34.4	1.19
8	2-Jan-06	2.38		5.51	2.7	65.5	47.3	1.06
9	4-Dec-14	460		430	2.4	4400	3000	10
10	2-Mar-15							
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		2.70		2.43	0.39	2.48	2.47	1.11
Mann-Kendall Statistic (S):		12		12	-10	16	12	-2
Confidence Factor:		91.1%		91.1%	86.2%	96.9%	91.1%	54.8%
Concentration Trend:		Prob. Increasing		Prob. Increasing	Stable	Increasing	Prob. Increasing	No Trend



Notes:

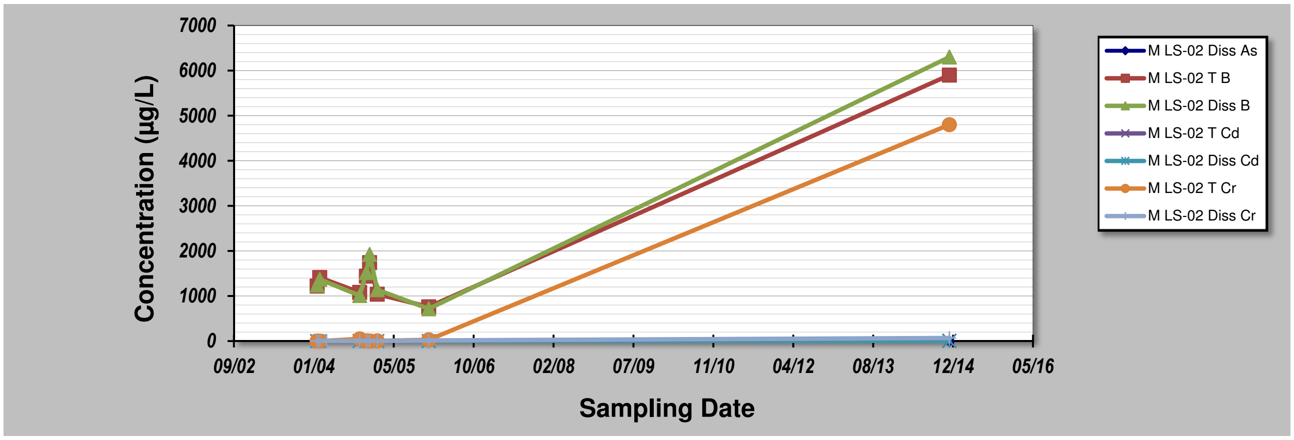
1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

GSI MANN-KENDALL TOOLKIT

for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-02 Metals
Concentration Units: µg/L

	Sampling Point ID:	M LS-02 Diss As	M LS-02 T B	M LS-02 Diss B	M LS-02 T Cd	M LS-02 Diss Cd	M LS-02 T Cr	M LS-02 Diss Cr
Sampling Event	Sampling Date	M LS-02 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	3.1	1220	1240	0.204	**0.1**	2.27	1.34
2	20-Feb-04	2.59	1410	1370	**0.2**	**0.1**	1.03	1.31
3	3-Apr-04							2.04
4	27-Oct-04	1.14	1080	1010	0.554	0.526	48.7	7.88
5	8-Dec-04	1.2	1440	1520	0.732	0.637	5.68	**1**
6	28-Dec-04	**0.5**	1740	1920	0.588	0.579	4.41	4.04
7	14-Feb-05	1.76	1040	1140	0.487	**0.1**	5.88	1.73
8	2-Jan-06	0.621	760	716	0.271	**0.1**	28	14.8
9	4-Dec-14	1.2	5900	6300	9.8	**0.1**	4800	69
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
	Coefficient of Variation:	0.61	0.92	0.95	2.07	0.89	2.77	1.92
	Mann-Kendall Statistic (S):	-11	2	4	10	-2	16	18
	Confidence Factor:	88.7%	54.8%	64.0%	86.2%	54.8%	96.9%	96.2%
	Concentration Trend:	Stable	No Trend	No Trend	No Trend	Stable	Increasing	Increasing



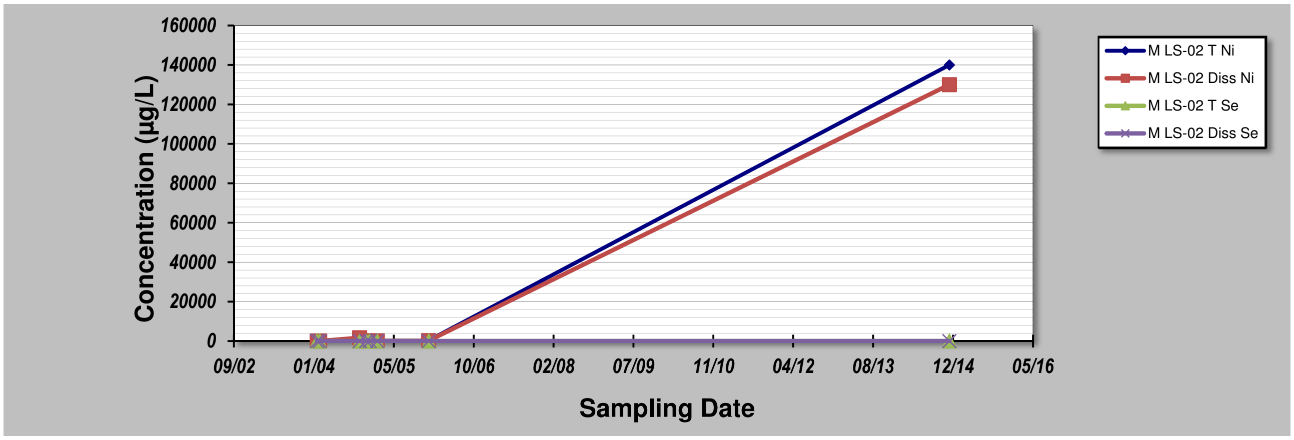
Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.
4. Non-detect results are shown in **bold**; the value shown for non-detect results is the lowest reporting limit value for the set of data.

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-02 Metals
Concentration Units: µg/L

Sampling Point ID:		M LS-02 T Ni	M LS-02 Diss Ni	M LS-02 T Se	M LS-02 Diss Se			
Sampling Event	Sampling Date	M LS-02 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	17	16	4.45	4.49			
2	20-Feb-04	45	27	5.21	5.11			
3	3-Apr-04							
4	27-Oct-04	1600	1700	2.82	3.4			
5	8-Dec-04	160	150	1.78	1.43			
6	28-Dec-04	66	57	2.08	**1**			
7	14-Feb-05	190	96	2.68	**1**			
8	2-Jan-06	350	220	5.41	3.53			
9	4-Dec-14	140000	130000	3.8	1.7			
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		2.77	2.77	0.40	0.60			
Mann-Kendall Statistic (S):		18	16	0	-11			
Confidence Factor:		98.4%	96.9%	45.2%	88.7%			
Concentration Trend:		Increasing	Increasing	Stable	Stable			



Notes:

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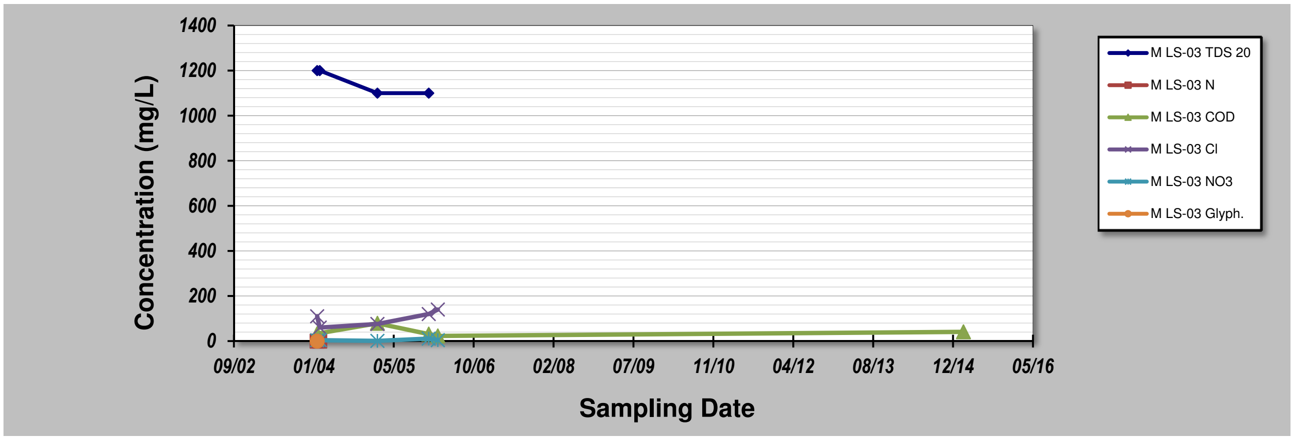
4. Non-detect results are shown in **bold**; the value shown for non-detect results is the lowest reporting limit value for the set of data.

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-03 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	M LS-03 TDS	M LS-03 N	M LS-03 COD	M LS-03 Cl	M LS-03 NO3	M LS-03 Glyph.	
Sampling Event	Sampling Date	M LS-03 INORGANICS CONCENTRATION (mg/L)						
1	4-Feb-04	1200	all concentrations	33	110	3.8	not analyzed	
2	20-Feb-04	1200	non-detect		60	3.8		
3	3-Apr-04							
4	15-Feb-05	1100		79	76	**1**		
5	2-Jan-06	1100		31	120	11		
6	28-Feb-06			23	140	4.1		
7	4-Dec-14							
8	2-Mar-15			41				
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
	Coefficient of Variation:	0.05		0.53	0.32	0.78		
	Mann-Kendall Statistic (S):	-4		-2	6	3		
	Confidence Factor:	83.3%		59.2%	88.3%	67.5%		
	Concentration Trend:	Stable		Stable	No Trend	No Trend		



Notes:

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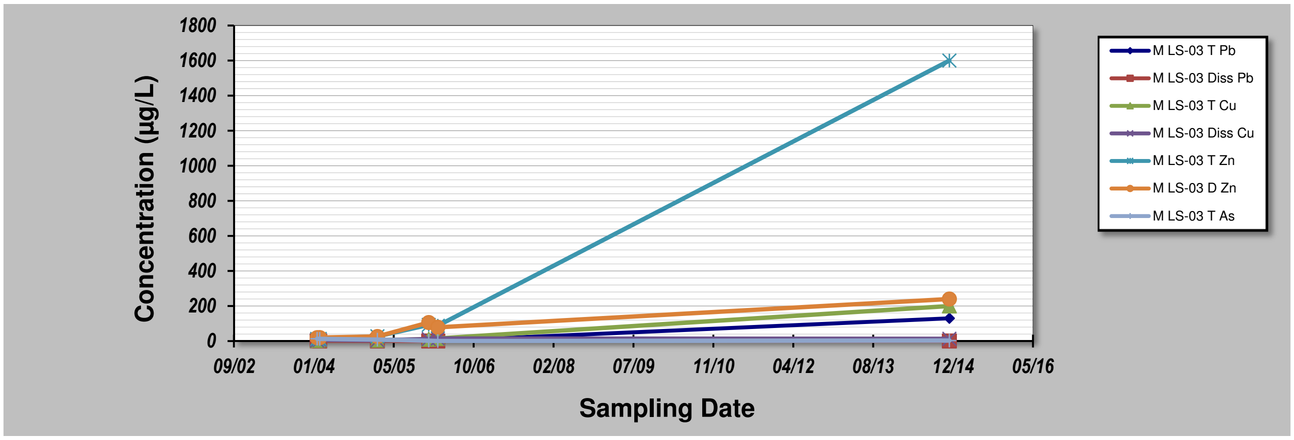
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: M LS-03 Metals
Concentration Units: µg/L

	Sampling Point ID:	M LS-03 T Pb	M LS-03 Diss Pb	M LS-03 T Cu	M LS-03 Diss Cu	M LS-03 T Zn	M LS-03 D Zn	M LS-03 T As
Sampling Event	Sampling Date	M LS-03 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	0.785	1.62	3.08	2.93	12.2	19.5	13.5
2	20-Feb-04	**0.5**	**0.5**	6.69	6.54	12.4	20	12.7
3	3-Apr-04							
4	15-Feb-05	0.534	**0.5**	4.94	4.32	27.2	26.3	8.52
5	2-Jan-06	0.58	**0.5**	10.4	11.6	92.5	106	2.38
6	28-Feb-06	0.868	0.504	15	14.7	87.6	78.7	**0.5**
7	4-Dec-14	130	0.41	200	13	1600	240	3
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
	Coefficient of Variation:	2.38	0.69	1.96	0.55	2.08	1.04	0.83
	Mann-Kendall Statistic (S):	9	-6	13	11	13	13	-11
	Confidence Factor:	93.2%	81.5%	99.2%	97.2%	99.2%	99.2%	97.2%
	Concentration Trend:	Prob. Increasing	Stable	Increasing	Increasing	Increasing	Increasing	Decreasing



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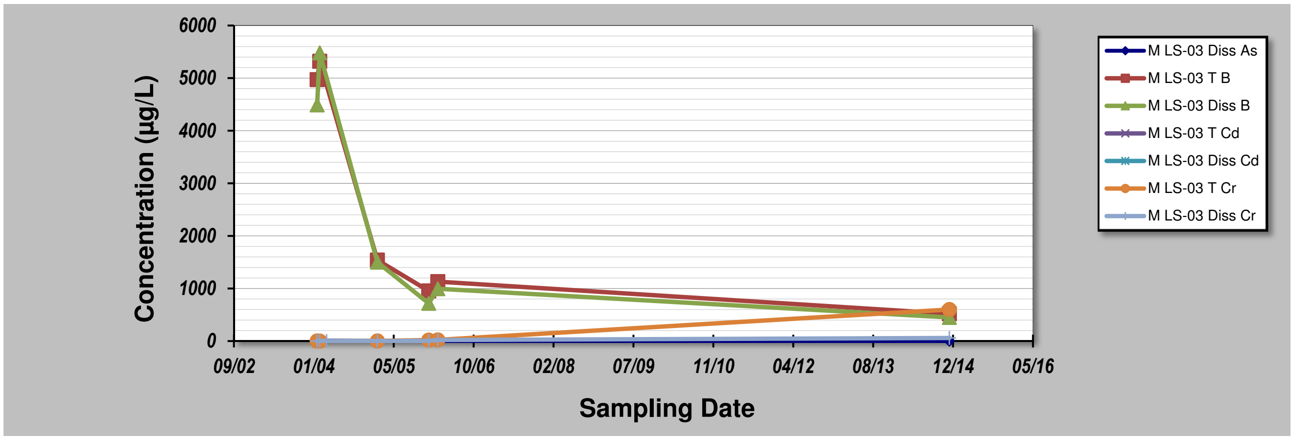
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-03 Metals
Concentration Units: µg/L

Sampling Point ID:		M LS-03 Diss As	M LS-03 T B	M LS-03 Diss B	M LS-03 T Cd	M LS-03 Diss Cd	M LS-03 T Cr	M LS-03 Diss Cr
Sampling Event	Sampling Date	M LS-03 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	13.9	4970	4490			2.7	1.35
2	20-Feb-04	13.2	5320	5480			**1**	**1**
3	3-Apr-04							2.67
4	15-Feb-05	3.32	1540	1500			3.54	2.35
5	2-Jan-06	1.55	954	718			18.9	4.31
6	28-Feb-06	0.979	1130	995			22.7	21.4
7	4-Dec-14	0.59	520	450			600	59
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18					Only three	Only three		
19					detections	detections		
20					trend not evaluated	trend not evaluated		
Coefficient of Variation:		1.12	0.89	0.95			2.23	1.63
Mann-Kendall Statistic (S):		-15	-11	-11			13	17
Confidence Factor:		99.9%	97.2%	97.2%			99.2%	99.5%
Concentration Trend:		Decreasing	Decreasing	Decreasing			Increasing	Increasing



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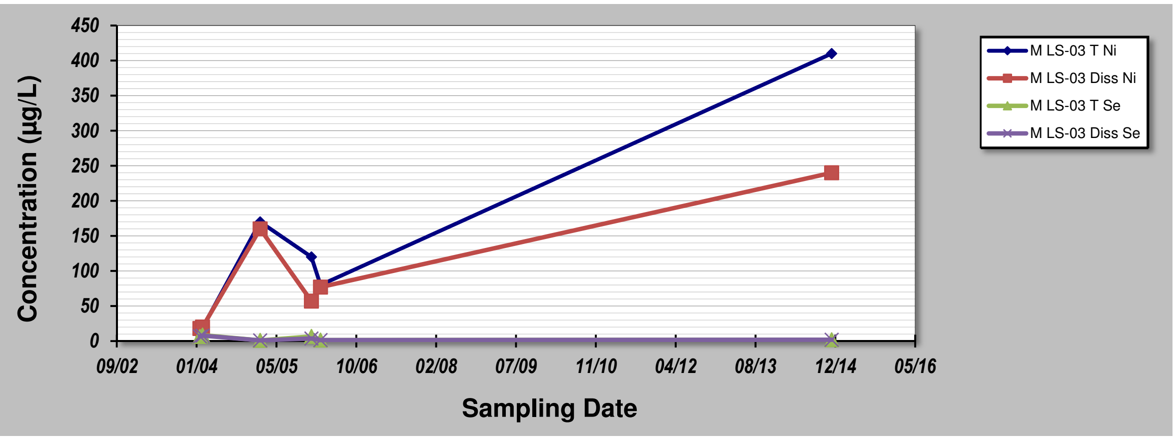
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M LS-03 Metals
Concentration Units: µg/L

	Sampling Point ID:	M LS-03 T Ni	M LS-03 Diss Ni	M LS-03 T Se	M LS-03 Diss Se		
Sampling Event	**Sampling Date**	**M LS-03 METALS CONCENTRATION (µg/L)**					
1	4-Feb-04	21	18	6.56	6.71		
2	20-Feb-04	19	20	8.51	7.79		
3	3-Apr-04						
4	15-Feb-05	170	160	**1**	**1**		
5	2-Jan-06	120	57	6.71	3.69		
6	28-Feb-06	80	77	1.42	1.42		
7	4-Dec-14	410	240	1.9	1.9		
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
Coefficient of Variation:		1.07	0.92	0.75	0.77		
Mann-Kendall Statistic (S):		7	11	-3	-5		
Confidence Factor:		86.4%	97.2%	64.0%	76.5%		
Concentration Trend:		No Trend	Increasing	Stable	Stable		



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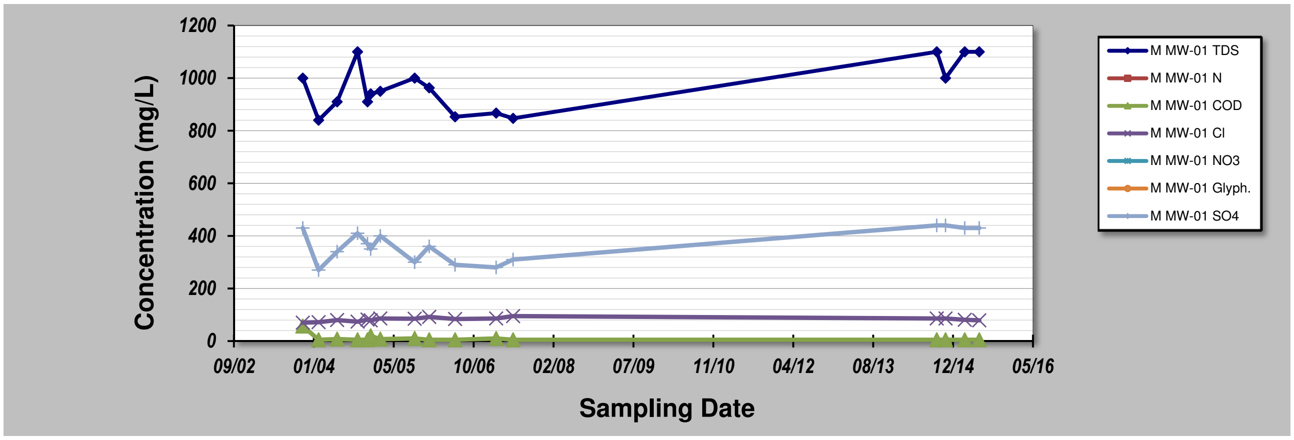
Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M MW-01 Inorganics
Concentration Units: mg/L

Sampling Point ID:		M MW-01 TDS	M MW-01 N	M MW-01 COD	M MW-01 Cl	M MW-01 NO3	M MW-01 Glyph.	M MW-01 SO4
Sampling Event	**Sampling Date**	**M MW-01 INORGANICS CONCENTRATION (mg/L)**						
1	6-Nov-03	1000		57	70			430
2	4-Dec-03							
3	13-Feb-04	840		**5**	72			270
4	8-Jun-04	910		7.7	80			340
5	14-Oct-04	1100		**5**	74			410
6	15-Dec-04	910		**5**	82			370
7	4-Jan-05	940		20	79			350
8	5-Mar-05	950		7.6	86			400
9	6-Oct-05	1000		10	85			300
10	5-Jan-06	963		**5**	92			360
11	16-Jun-06	853		**5**	84			290
12	28-Feb-07	867		10	86			280
13	14-Jun-07	847		**5**	95			310
14	16-Sep-14	1100		**5**	86			440
15	10-Nov-14	1000		**5**	86			440
16	10-Mar-15	1100		**5**	81			430
17	9-Jun-15	1100		**5**	79			430
18			Only three			Only one	All concentrations	
19			detections			detection	non-detect	
20			trend not evaluated			trend not evaluated		
Coefficient of Variation:		0.10		1.29	0.08			0.17
Mann-Kendall Statistic (S):		30		-34	49			20
Confidence Factor:		90.3%		93.0%	98.6%			80.1%
Concentration Trend:		Prob. Increasing		Prob. Decreasing	Increasing			No Trend



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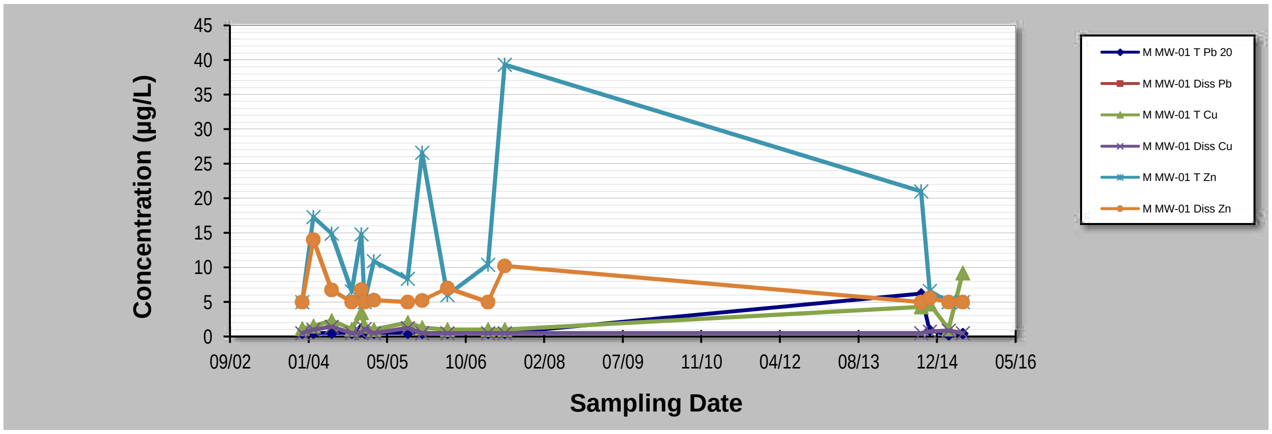
for Constituent Trend Analysis

Evaluation Date:	**6-Aug-15**	Job ID:	**IR13164280**
Facility Name:	**Watershed Augmentation Study**	Constituent:	**M MW-01 Metals**
Conducted By:	**K. Howe**	Concentration Units:	**µg/L**

Sampling Event	Sampling Date	M MW-01 METALS CONCENTRATION (µg/L)						
Sampling Point ID:		**M MW-01 T Pb**	**M MW-01 Diss Pb**	**M MW-01 T Cu**	**M MW-01 Diss Cu**	**M MW-01 T Zn**	**M MW-01 Diss Zn**	
1	6-Nov-03							
2	4-Dec-03	**0.5**		1.12	**0.5**	**5**	**5**	
3	13-Feb-04	**0.5**		1.49	1.01	17.3	14	
4	8-Jun-04	**0.5**		2.28	1.41	14.9	6.72	
5	14-Oct-04	**0.5**		1.05	**0.5**	6.55	**5**	
6	15-Dec-04	1.16		3.46	**0.5**	14.8	6.77	
7	4-Jan-05	**0.5**		1.51	1.11	**5**	**5**	
8	5-Mar-05	**0.5**		**1**	**0.5**	10.9	5.25	
9	6-Oct-05	**0.5**		2.02	1.24	8.35	**5**	
10	5-Jan-06	**0.5**		1.26	**0.5**	26.6	5.2	
11	16-Jun-06	**0.5**		1.01	**0.5**	6.02	7.03	
12	28-Feb-07	**0.5**		**1**	**0.5**	10.4	**5**	
13	14-Jun-07	**0.5**		**1**	**0.5**	39.3	10.2	
14	16-Sep-14	6.2		4.3	**0.5**	21	**5**	
15	10-Nov-14	0.9		4.7	0.74	6.6	5.6	
16	10-Mar-15	0.26		1.1	0.84	**5**	**5**	
17	9-Jun-15	0.44		9.2	**0.5**	**5**	**5**	
18			All concentrations					
19			non-detect					
20								
Coefficient of Variation:		**1.58**		**0.94**	**0.44**	**0.76**	**0.39**	
Mann-Kendall Statistic (S):		**-9**		**11**	**-11**	**-12**	**-16**	
Confidence Factor:		**63.9%**		**67.1%**	**67.1%**	**68.7%**	**74.7%**	
Concentration Trend:		No Trend		No Trend	Stable	Stable	Stable	



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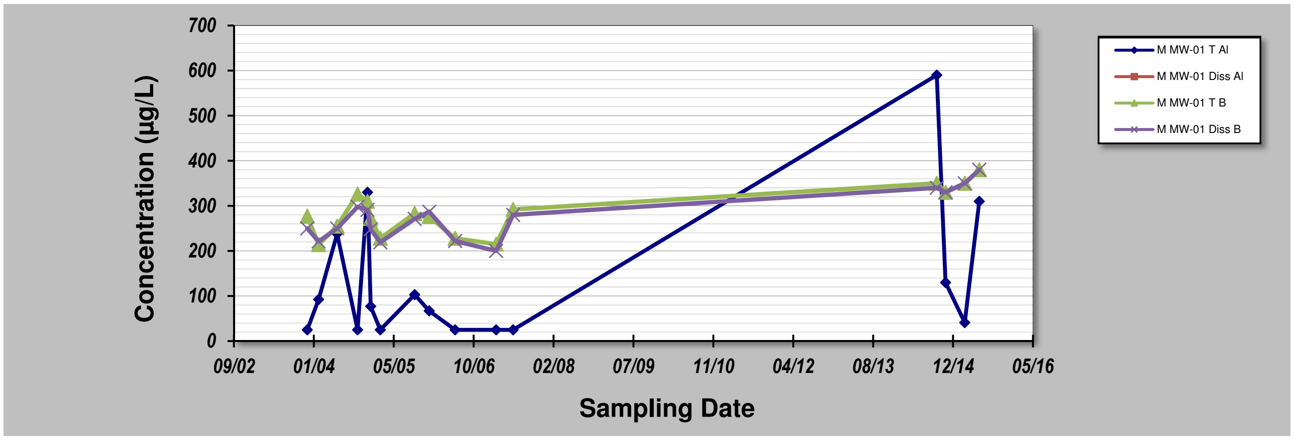
Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M MW-01 Metals
Concentration Units: µg/L

	Sampling Point ID:	**M MW-01 T Al**	**M MW-01 Diss Al**	**M MW-01 T B**	**M MW-01 Diss B**			
Sampling Event	**Sampling Date**	**M MW-01 METALS CONCENTRATION (µg/L)**						
1	6-Nov-03							
2	4-Dec-03	**25**		277	250			
3	13-Feb-04	92.4		214	221			
4	8-Jun-04	238		255	250			
5	14-Oct-04	**25**		326	298			
6	15-Dec-04	330		310	291			
7	4-Jan-05	77.1		272	248			
8	5-Mar-05	**25**		228	219			
9	6-Oct-05	103		283	271			
10	5-Jan-06	67		276	287			
11	16-Jun-06	**25**		228	222			
12	28-Feb-07	**25**		215	200			
13	14-Jun-07	**25**		292	280			
14	16-Sep-14	590		350	340			
15	10-Nov-14	130		330	330			
16	10-Mar-15	41		350	350			
17	9-Jun-15	310		380	380			
18			All concentrations					
19			non-detect					
20								
Coefficient of Variation:		1.19		0.18	0.19			
Mann-Kendall Statistic (S):		11		46	45			
Confidence Factor:		67.1%		97.9%	97.7%			
Concentration Trend:		No Trend		Increasing	Increasing			



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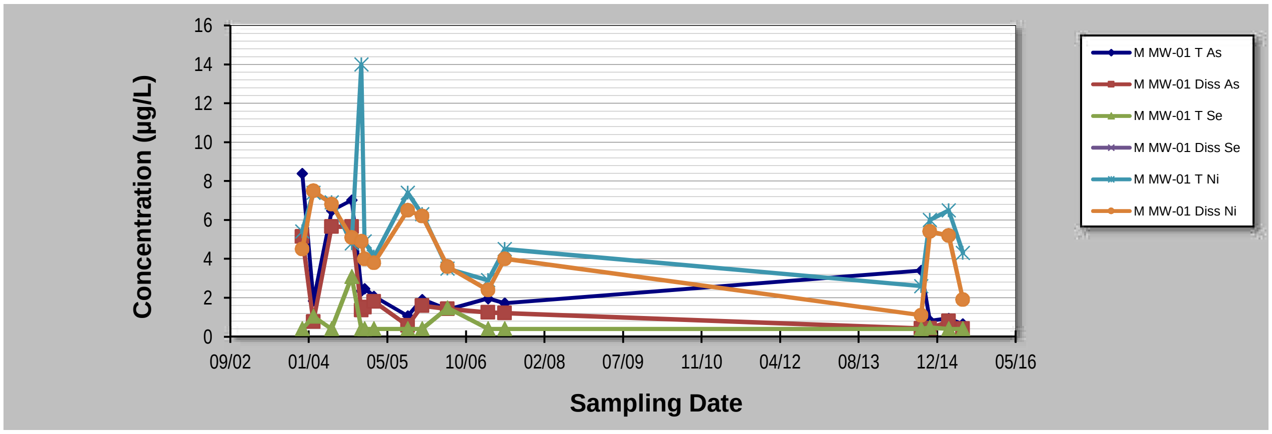
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **M MW-01 Metals**
Concentration Units: **µg/L**

Sampling Event	Sampling Date	M MW-01 METALS CONCENTRATION (µg/L)						
Sampling Point ID:		**M MW-01 T As**	**M MW-01 Diss As**	**M MW-01 T Se**	**M MW-01 Diss Se**	**M MW-01 T Ni**	**M MW-01 Diss Ni**	
1	6-Nov-03							
2	4-Dec-03	8.39	5.14	**0.4**		5.4	4.5	
3	13-Feb-04	1.83	0.765	1.04		7.4	7.5	
4	8-Jun-04	6.47	5.65	**0.4**		6.9	6.8	
5	14-Oct-04	7.02	5.65	3.08		4.8	5.1	
6	15-Dec-04	2.34	1.36	**0.4**		14	4.9	
7	4-Jan-05	2.47	1.5	**0.4**		4.9	4	
8	5-Mar-05	2.06	1.81	**0.4**		4.1	3.8	
9	6-Oct-05	1.07	0.566	**0.4**		7.4	6.5	
10	5-Jan-06	1.91	1.59	**0.4**		6.3	6.2	
11	16-Jun-06	1.39	1.43	1.48		3.5	3.6	
12	28-Feb-07	1.96	1.24	**0.4**		2.9	2.4	
13	14-Jun-07	1.72	1.21	**0.4**		4.5	4	
14	16-Sep-14	3.4	0.42	**0.4**		2.6	1.1	
15	10-Nov-14	0.81	0.42	0.47		6	5.4	
16	10-Mar-15	0.94	0.8	**0.4**		6.5	5.2	
17	9-Jun-15	0.65	**0.4**	**0.4**		4.3	1.9	
18					Only one			
19					detection			
20					no trend evaluated			
Coefficient of Variation:		**0.85**	**0.99**	**1.04**		**0.47**	**0.39**	
Mann-Kendall Statistic (S):		**-68**	**-68**	**-10**		**-37**	**-47**	
Confidence Factor:		**99.9%**	**99.9%**	**65.5%**		**94.7%**	**98.2%**	
Concentration Trend:		Decreasing	Decreasing	No Trend		Prob. Decreasing	Decreasing	



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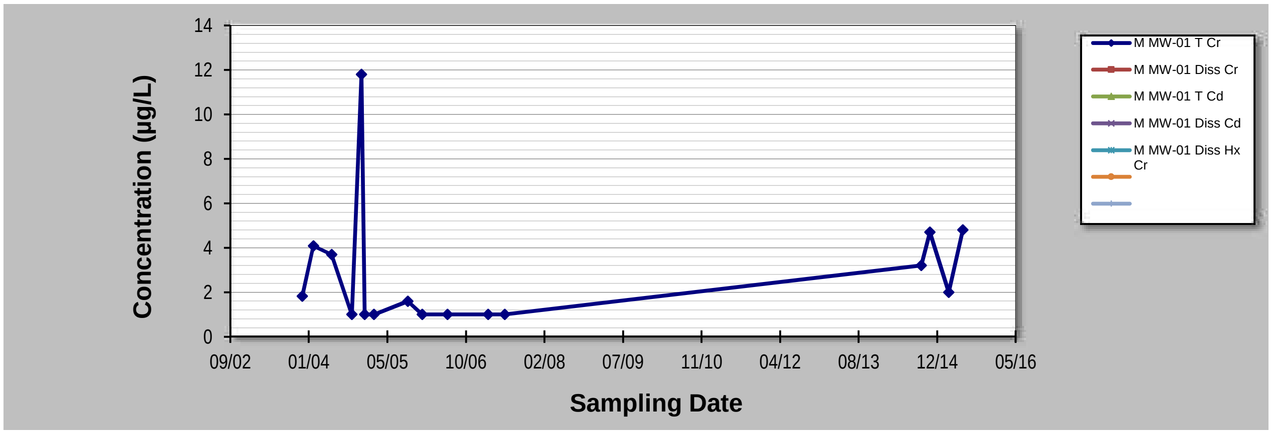
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **M MW-01 Metals**
Concentration Units: **µg/L**

Sampling Event	Sampling Date	M MW-01 T Cr	M MW-01 Diss Cr	M MW-01 T Cd	M MW-01 Diss Cd	MW-01 Diss Hx Cr		
		M MW-01 METALS CONCENTRATION (µg/L)						
1	6-Nov-03							
2	4-Dec-03	1.82						
3	13-Feb-04	4.09						
4	8-Jun-04	3.7						
5	14-Oct-04	**1**						
6	15-Dec-04	11.8						
7	4-Jan-05	**1**						
8	5-Mar-05	**1**						
9	6-Oct-05	1.59						
10	5-Jan-06	**1**						
11	16-Jun-06	**1**						
12	28-Feb-07	**1**						
13	14-Jun-07	**1**						
14	16-Sep-14	3.2						
15	10-Nov-14	4.7						
16	10-Mar-15	2						
17	9-Jun-15	4.8						
18			Only three	Only one	All concentrations	Only three		
19			detections	detection	are non-detect	detections		
20			no trend evaluated	no trend evaluated	no trend evaluated	no trend evaluated		
Coefficient of Variation:		**1.00**						
Mann-Kendall Statistic (S):		**7**						
Confidence Factor:		**60.5%**						
Concentration Trend:		No Trend						



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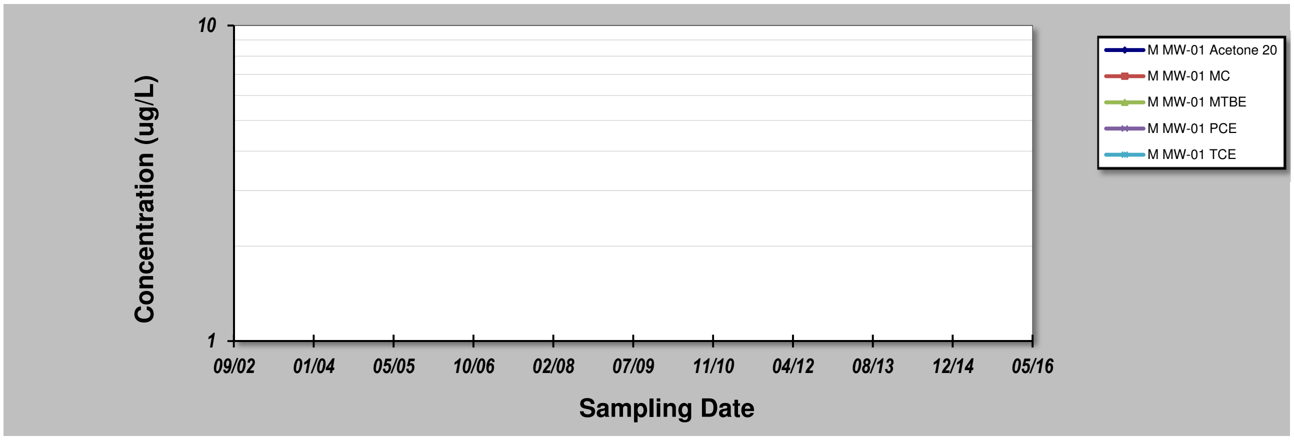
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: M MW-01 VOCs
Concentration Units: ug/L

	Sampling Point ID:	M MW-01 Acetone	M MW-01 MC	M MW-01 MTBE	M MW-01 PCE	M MW-01 TCE		
Sampling Event	**Sampling Date**	**M MW-01 VOCS CONCENTRATION (ug/L)**						
1	6-Nov-03	All concentrations	Only 3 detections	All concentrations	All concentrations	All concentrations		
2	4-Dec-03	non-detect	trend not evaluated	non-detect	non-detect	non-detect		
3	13-Feb-04							
4	8-Jun-04							
5	14-Oct-04							
6	15-Dec-04							
7	4-Jan-05							
8	5-Mar-05							
9	6-Oct-05							
10	5-Jan-06							
11	16-Jun-06							
12	28-Feb-07							
13	14-Jun-07							
14	16-Sep-14							
15	10-Nov-14							
16	10-Mar-15							
17	9-Jun-15							
18								
19								
20								
	Coefficient of Variation:							
	Mann-Kendall Statistic (S):							
	Confidence Factor:							
	Concentration Trend:							



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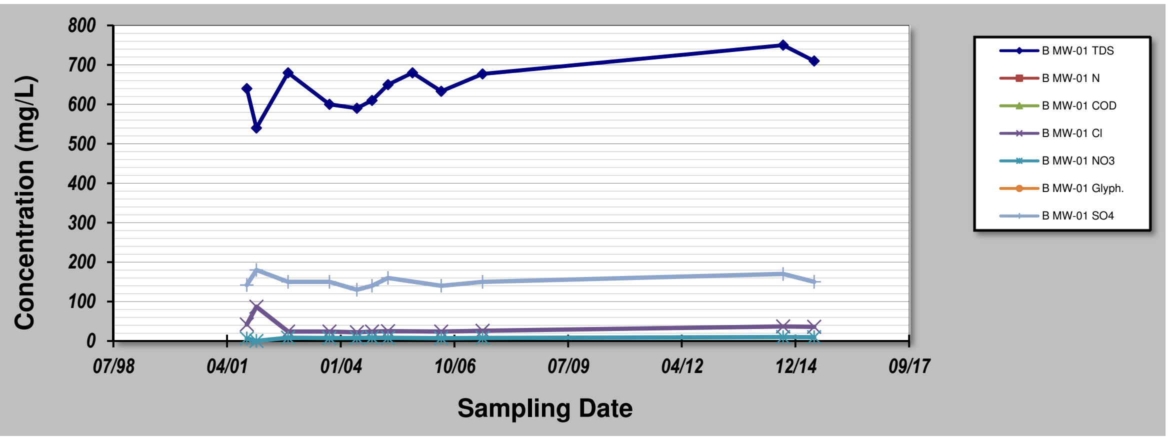
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: B MW-01 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	B MW-01 TDS	B MW-01 N	B MW-01 COD	B MW-01 Cl	B MW-01 NO3	B MW-01 Glyph.	B MW-01 SO4
Sampling Event	**Sampling Date**	**B MW-01 INORGANICS CONCENTRATION (mg/L)**						
1	10-Oct-01	640			41.89	6.59		142
2	2-Jan-02	540			87	0.3		180
3	8-Oct-02	680			24	8.4		150
4	7-Oct-03	600			24	7.6		150
5	4-Jun-04	590			22	7.8		130
6	15-Oct-04	610			24	8.4		140
7	5-Mar-05	650			25	8.1		160
8	6-Oct-05	680						
9	16-Jun-06	633			24	7.2		140
10	15-Jun-07	677			26	7.8		150
11	10-Sep-14	750			37	10		170
12	10-Jun-15	710			36	9.7		150
13			Only two	Only three			All concentrations	
14			detections	detections			non-detect	
15			trend not evaluated	trend not evaluated				
16								
17								
18								
19								
20								
Coefficient of Variation:		0.09			0.56	0.35		0.09
Mann-Kendall Statistic (S):		33			5	25		4
Confidence Factor:		98.7%			61.9%	97.0%		59.0%
Concentration Trend:		Increasing			No Trend	Increasing		No Trend



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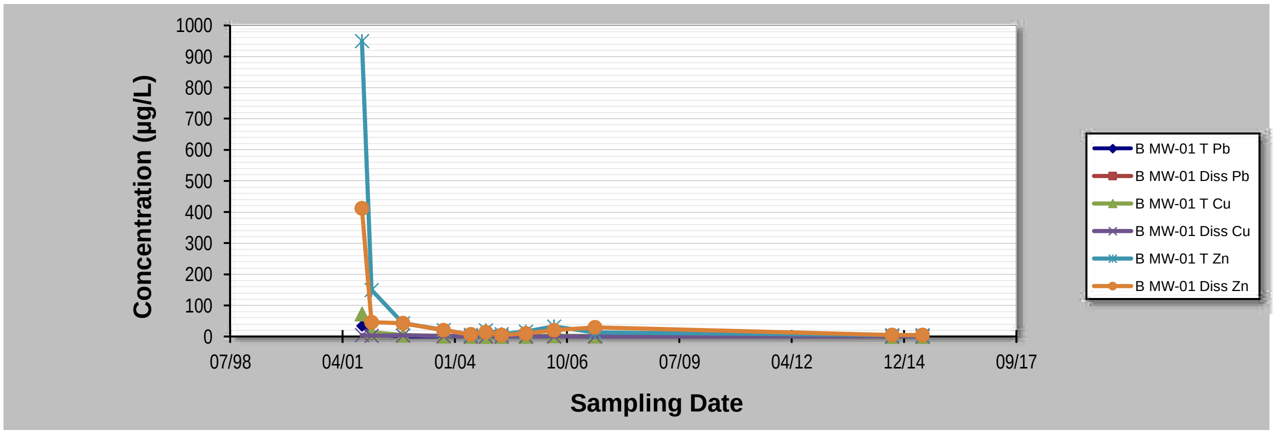
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-01 Metals**
Concentration Units: **µg/L**

Sampling Point ID:		**B MW-01 T Pb**	**B MW-01 Diss Pb**	**B MW-01 T Cu**	**B MW-01 Diss Cu**	**B MW-01 T Zn**	**B MW-01 Diss Zn**	
Sampling Event	Sampling Date	B MW-01 METALS CONCENTRATION (µg/L)						
1	10-Oct-01	34.7		73.1	5.27	950	412	
2	2-Jan-02	6.5		14	2.6	150	46	
3	8-Oct-02	**0.2**		4.77	4.17	42.5	42.8	
4	7-Oct-03	**0.2**		1.42	1.36	21.4	19.9	
5	4-Jun-04	**0.2**		**0.5**	**0.5**	5.69	6.54	
6	15-Oct-04	**0.2**		**0.5**	**0.5**	19.7	13.6	
7	5-Mar-05	**0.2**		**0.5**	**0.5**	7.44	**5**	
8	6-Oct-05	**0.2**		**0.5**	**0.5**	15.9	9.72	
9	16-Jun-06	1.17		2.44	1.02	32.8	19.7	
10	15-Jun-07	**0.2**		1.28	**0.5**	12.6	29.4	
11	10-Sep-14	0.39		0.74	**0.5**	**5**	**5**	
12	10-Jun-15	**0.2**		**0.5**	**0.5**	**5**	**5**	
13			All concentrations					
14			are non-detect					
15			no trend evaluated					
16								
17								
18								
19								
20								
Coefficient of Variation:		**2.69**		**2.48**	**1.10**	**2.54**	**2.24**	
Mann-Kendall Statistic (S):		**-12**		**-30**	**-35**	**-43**	**-37**	
Confidence Factor:		**77.0%**		**97.8%**	**99.2%**	**99.9%**	**99.5%**	
Concentration Trend:		No Trend		Decreasing	Decreasing	Decreasing	Decreasing	



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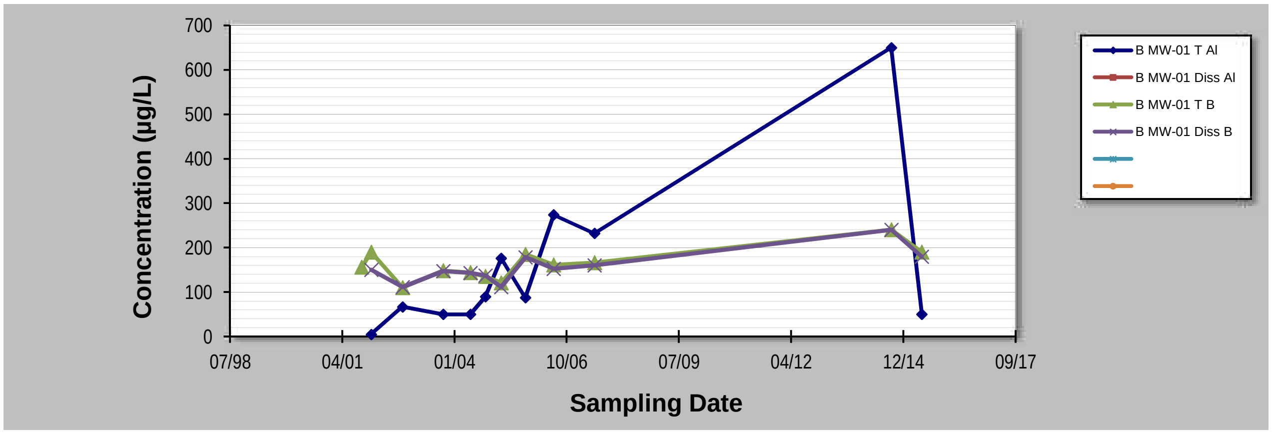
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-01 Metals**
Concentration Units: **µg/L**

Sampling Point ID:		**B MW-01 T Al**	**B MW-01 Diss Al**	**B MW-01 T B**	**B MW-01 Diss B**				
Sampling Event	Sampling Date	B MW-01 METALS CONCENTRATION (µg/L)							
1	10-Oct-01			156					
2	2-Jan-02	5.1		190	150				
3	8-Oct-02	67		110	111				
4	7-Oct-03	**50**		148	147				
5	4-Jun-04	**50**		144	143				
6	15-Oct-04	89.4		135	137				
7	5-Mar-05	176		121	111				
8	6-Oct-05	87.4		185	178				
9	16-Jun-06	274		161	152				
10	15-Jun-07	232		166	160				
11	10-Sep-14	650		240	240				
12	10-Jun-15	50		190	180				
13			All concentrations						
14			are non-detect						
15			no trend evaluated						
16									
17									
18									
19									
20									
Coefficient of Variation:		**1.17**		**0.22**	**0.23**				
Mann-Kendall Statistic (S):		**28**		**21**	**26**				
Confidence Factor:		**98.4%**		**91.3%**	**97.5%**				
Concentration Trend:		Increasing		Prob. Increasing	Increasing				



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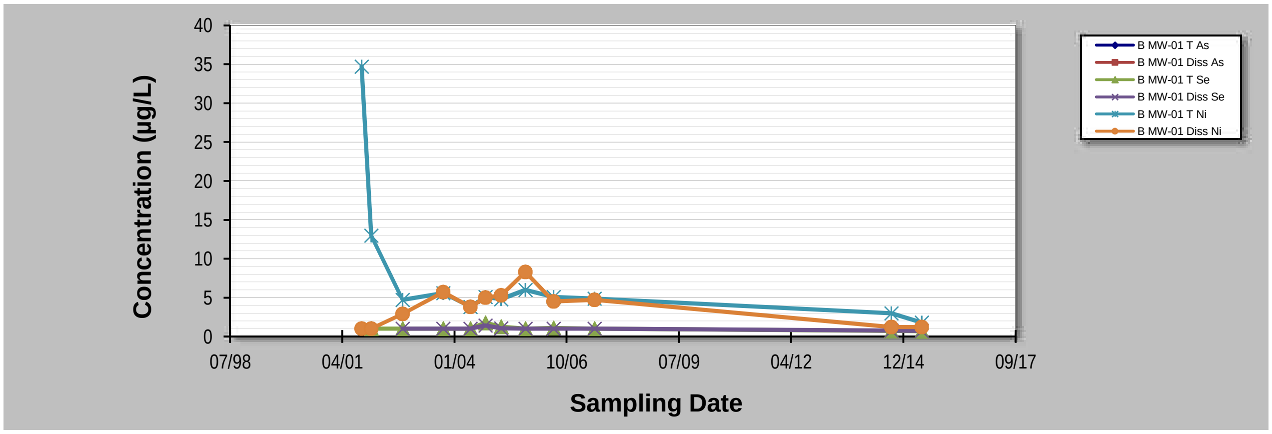
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-01 Metals**
Concentration Units: **µg/L**

Sampling Event	Sampling Date	B MW-01 METALS CONCENTRATION (µg/L)						
Sampling Point ID:		**B MW-01 T As**	**B MW-01 Diss As**	**B MW-01 T Se**	**B MW-01 Diss Se**	**B MW-01 T Ni**	**B MW-01 Diss Ni**	
1	10-Oct-01					34.7	**1**	
2	2-Jan-02			**1**		13	**1**	
3	8-Oct-02			**1**	**1**	4.7	2.89	
4	7-Oct-03			**1**	**1**	5.6	5.7	
5	4-Jun-04			**1**	**1**	3.8	3.8	
6	15-Oct-04			1.75	1.41	5.1	5	
7	5-Mar-05			1.27	1.06	4.8	5.3	
8	6-Oct-05			**1**	**1**	6	8.3	
9	16-Jun-06			1.08	**1**	5.1	4.5	
10	15-Jun-07			**1**	**1**	4.9	4.7	
11	10-Sep-14			0.74	0.76	3	1.2	
12	10-Jun-15			0.7	0.71	1.8	1.2	
13		Only two	Only three					
14		detections	detections					
15		no trend evaluated	no trend evaluated					
16								
17								
18								
19								
20								
Coefficient of Variation:				**0.27**	**0.19**	**1.16**	**0.62**	
Mann-Kendall Statistic (S):				**-14**	**-18**	**-33**	**10**	
Confidence Factor:				**84.0%**	**93.4%**	**98.7%**	**72.7%**	
Concentration Trend:				Stable	Prob. Decreasing	Decreasing	No Trend	



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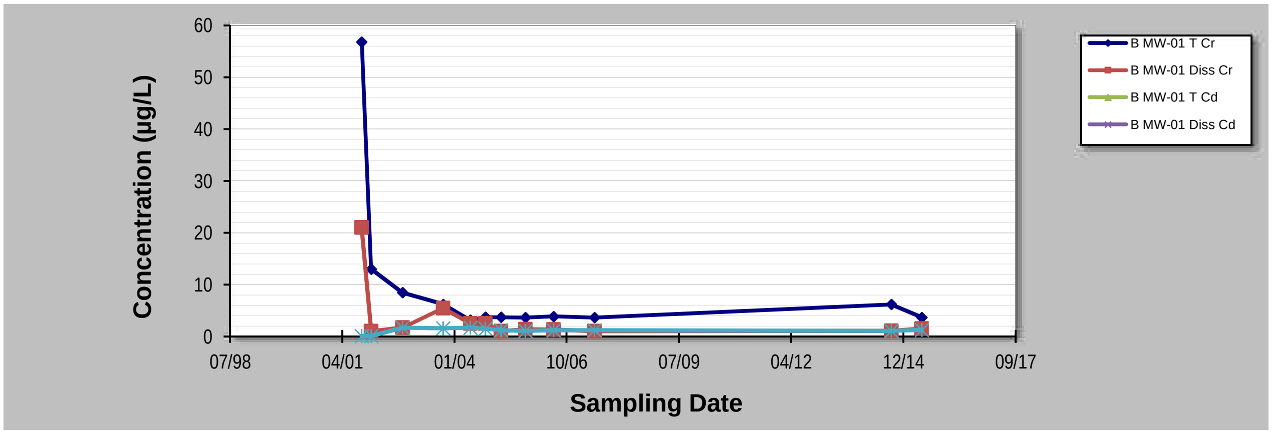
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-01 Metals**
Concentration Units: **µg/L**

Sampling Event	Sampling Date	B MW-01 T Cr	B MW-01 Diss Cr	B MW-01 T Cd	B MW-01 Diss Cd	MW-01 Diss Hex Cr		
		B MW-01 METALS CONCENTRATION (µg/L)						
1	10-Oct-01	56.8	21			**0.1**		
2	2-Jan-02	13	**1**			0.1		
3	8-Oct-02	8.48	1.68			1.7		
4	7-Oct-03	6.24	5.44			1.6		
5	4-Jun-04	3.17	2.52			1.7		
6	15-Oct-04	3.73	2.51			1.5		
7	5-Mar-05	3.74	**1**			1.2		
8	6-Oct-05	3.66	1.39			1.1		
9	16-Jun-06	3.87	1.32			1.2		
10	15-Jun-07	3.67	**1**			1.2		
11	10-Sep-14	6.2	1.1			1.1		
12	10-Jun-15	3.7	1.5			1.3		
13				Only one	All concentrations			
14				detection	are non-detect			
15				no trend evaluated	no trend evaluated			
16								
17								
18								
19								
20								
Coefficient of Variation:		1.56	1.64			0.47		
Mann-Kendall Statistic (S):		-28	-23			-4		
Confidence Factor:		96.9%	93.3%			58.0%		
Concentration Trend:		Decreasing	Prob. Decreasing			Stable		



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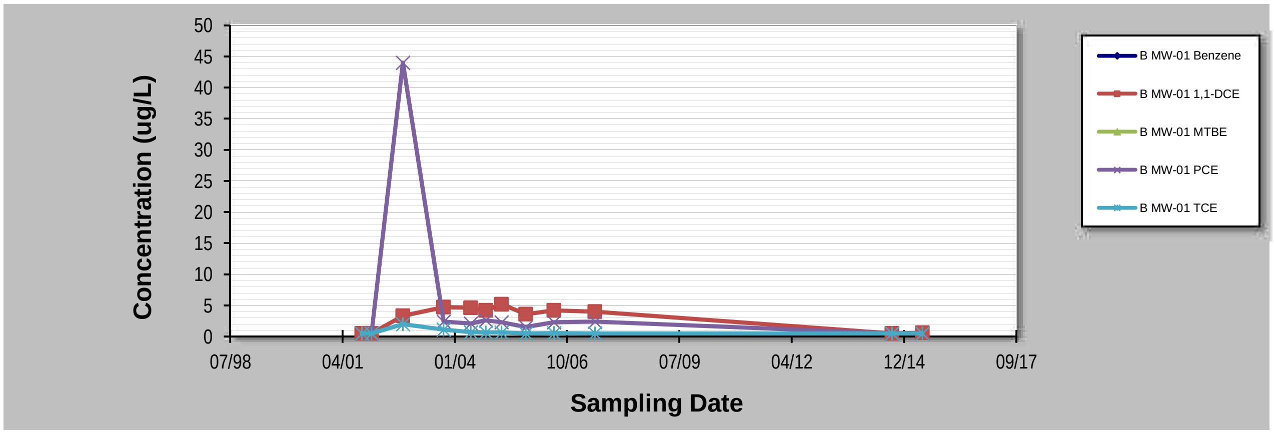
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **VOCs**
Concentration Units: **ug/L**

Sampling Point ID:		B MW-01 Benzene	B MW-01 1,1-DCE	B MW-01 MTBE	B MW-01 PCE	B MW-01 TCE		
Sampling Event	Sampling Date	VOCS CONCENTRATION (ug/L)						
1	10-Oct-01		**0.5**		**0.5**	**0.5**		
2	2-Jan-02		**0.5**		**0.5**	**0.5**		
3	8-Oct-02		3.3		44	2		
4	7-Oct-03		4.7		2.4	1.1		
5	4-Jun-04		4.6		2.1	0.68		
6	15-Oct-04		4.2		2.6	0.64		
7	5-Mar-05		5.2		2.3	0.64		
8	6-Oct-05		3.6		1.5	**0.5**		
9	16-Jun-06		4.2		2.3	0.56		
10	15-Jun-07		4		2.4	**0.5**		
11	10-Sep-14		**0.5**		**0.5**	**0.5**		
12	10-Jun-15		0.6		0.51	**0.5**		
13		Only 2 detections		All concentrations				
14		trend not evaluated		non-detect				
15								
16								
17								
18								
19								
20								
Coefficient of Variation:			**0.63**		**2.39**	**0.61**		
Mann-Kendall Statistic (S):			**0**		**-5**	**-24**		
Confidence Factor:			**47.3%**		**60.6%**	**94.2%**		
Concentration Trend:			Stable		No Trend	Prob. Decreasing		



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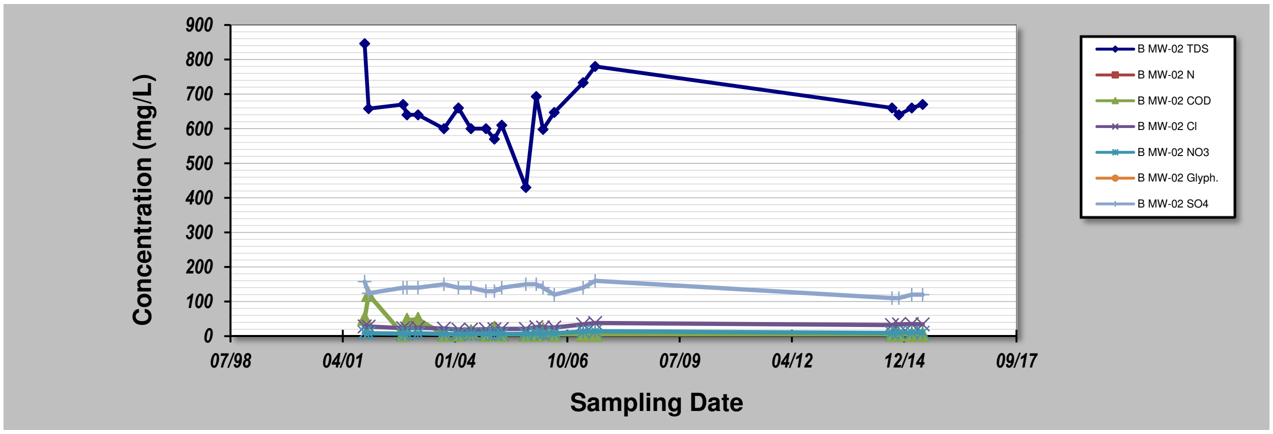
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: B MW-02 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	B MW-02 TDS	B MW-02 N	B MW-02 COD	B MW-02 Cl	B MW-02 NO3	B MW-02 Glyph.	B MW-02 SO4
Sampling Event	Sampling Date	B MW-02 INORGANICS CONCENTRATION (mg/L)						
1	31-Oct-01	846		51.3	28.28	10.509		157.72
2	5-Dec-01	658		120	27.6	8.33		124
3	8-Oct-02	670		**5**	23	7.4		140
4	12-Nov-02	640		46	22	7.4		140
5	18-Feb-03	640		49	24	8.1		140
6	7-Oct-03	600		**5**	22	6.6		150
7	13-Feb-04	660		5	19	5.6		140
8	4-Jun-04	600		13	19	6.4		140
9	15-Oct-04	600		**5**	20	6.6		130
10	30-Dec-04	570		23	20	6.8		130
11	5-Mar-05	610		5.1	21	6.3		140
12	6-Oct-05	430		5	21	6.7		150
13	6-Jan-06	693		**5**	26	8.8		150
14	8-Mar-06	598		18	25	7.1		140
15	16-Jun-06	647		**5**	25	8.4		120
16	28-Feb-07	733		**5**	34	13		140
17	15-Jun-07	780		**5**	38	14		160
18	10-Sep-14	660		**5**	32	9.2		110
19	10-Nov-14	640		**5**	34	10		110
20	5-Mar-15	660		**5**	35	11		120
21	10-Jun-15	670		**5**	34	10		120
22			Only one				all concentrations	
23			detection				non-detect	
24			trend not evaluated				no trend evaluated	
25								
	Coefficient of Variation:	0.13		1.51	0.23	0.27		0.11
	Mann-Kendall Statistic (S):	10		-84	78	67		-56
	Confidence Factor:	60.6%		99.5%	99.1%	97.7%		95.1%
	Concentration Trend:	No Trend		Decreasing	Increasing	Increasing		Decreasing



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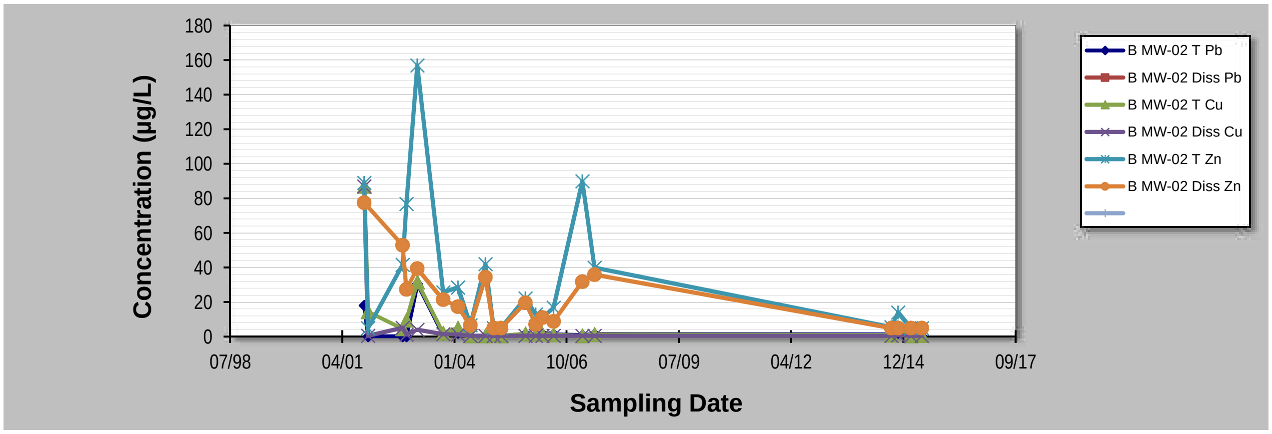
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-02 Metals**
Concentration Units: **µg/L**

	Sampling Point ID:	**B MW-02 T Pb**	**B MW-02 Diss Pb**	**B MW-02 T Cu**	**B MW-02 Diss Cu**	**B MW-02 T Zn**	**B MW-02 Diss Zn**	
Sampling Event	Sampling Date	B MW-02 METALS CONCENTRATION (µg/L)						
1	31-Oct-01	18		87	87	88.9	77.5	
2	5-Dec-01	**0.2**		14.3	**0.5**	**5**		
3	8-Oct-02	**0.2**		4.56	5.14	41.6	52.8	
4	12-Nov-02	**0.2**		9.51	1.26	76.8	27.3	
5	18-Feb-03	30.4		31.6	4.01	157	39.3	
6	7-Oct-03	0.777		1.89	1.46	25.6	21.4	
7	13-Feb-04	2.21		5.02	1.2	28.5	17.4	
8	4-Jun-04	**0.2**		**0.5**	**0.5**	6.51	6.51	
9	15-Oct-04	**0.2**		**0.5**	**0.5**	41.9	34.3	
10	30-Dec-04	0.599		1.06	**0.5**	**5**	**5**	
11	5-Mar-05	**0.2**		**0.5**	**0.5**	**5**	**5**	
12	6-Oct-05	1.68		1.52	**0.5**	22.2	19.6	
13	6-Jan-06	1.06		1.44	**0.5**	12.9	7.24	
14	8-Mar-06	1.68		1.46	**0.5**	10.8	11	
15	16-Jun-06	1.37		1.08	**0.5**	16.7	8.78	
16	28-Feb-07	0.866		**0.5**	**0.5**	89.9	31.7	
17	15-Jun-07	1.42		1.26	**0.5**	40	35.9	
18	10-Sep-14	1.3		0.82	**0.5**	5.5	**5**	
19	10-Nov-14	2.2		4.9	0.79	14	**5**	
20	5-Mar-15	**0.2**		**0.5**	**0.5**	**5**	**5**	
21	10-Jun-15	0.28		0.63	**0.5**	**5**	**5**	
22			only 1 detection					
23			no trend evaluated					
24								
25								
	Coefficient of Variation:	**2.35**		**2.39**	**3.66**	**1.17**	**0.93**	
	Mann-Kendall Statistic (S):	**14**		**-94**	**-81**	**-64**	**-91**	
	Confidence Factor:	**65.1%**		**99.8%**	**99.3%**	**97.2%**	**99.9%**	
	Concentration Trend:	No Trend		Decreasing	Decreasing	Decreasing	Decreasing	



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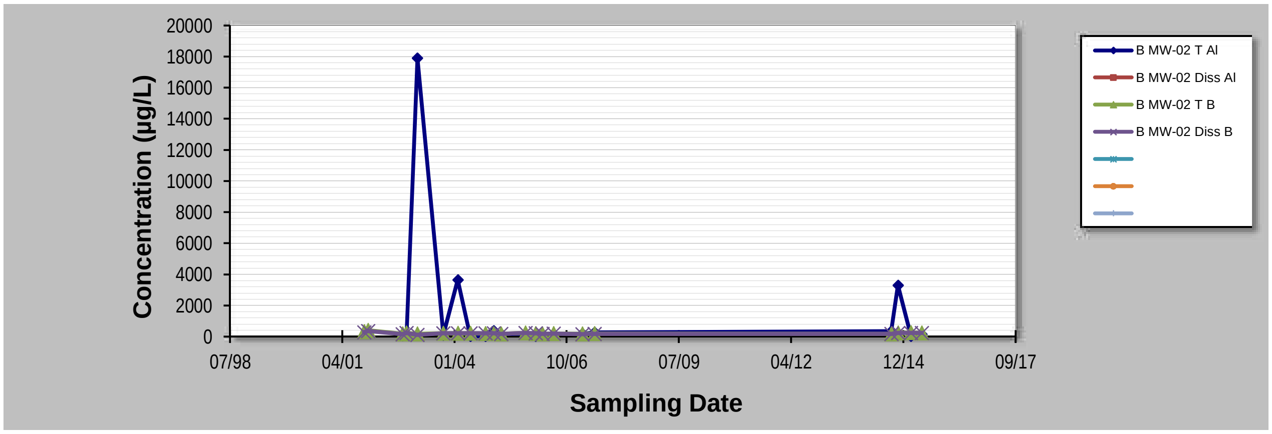
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**
Job ID: **IR13164280**
Constituent: **B MW-02 Metals**
Concentration Units: **µg/L**

	Sampling Point ID:	**B MW-02 T Al**	**B MW-02 Diss Al**	**B MW-02 T B**	**B MW-02 Diss B**			
Sampling Event	Sampling Date	B MW-02 METALS CONCENTRATION (µg/L)						
1	31-Oct-01			328	282			
2	5-Dec-01			405	360			
3	8-Oct-02	66.3		176	150			
4	12-Nov-02	130		234	231			
5	18-Feb-03	17900		180	123			
6	7-Oct-03	103		225	224			
7	13-Feb-04	3650		218	217			
8	4-Jun-04	**25**		211	213			
9	15-Oct-04	**25**		205	212			
10	30-Dec-04	378		208	209			
11	5-Mar-05	171		178	170			
12	6-Oct-05	162		245	235			
13	6-Jan-06	**25**		193	218			
14	8-Mar-06	176		184	173			
15	16-Jun-06	171		204	188			
16	28-Feb-07	190		170	166			
17	15-Jun-07	278		196	183			
18	10-Sep-14	360		180	180			
19	10-Nov-14	3300		230	230			
20	5-Mar-15	26		260	240			
21	10-Jun-15	160		240	240			
22			Only one detection					
23			no trend evaluated					
24								
25								
Coefficient of Variation:		**2.87**		**0.25**	**0.23**			
Mann-Kendall Statistic (S):		**21**		**-27**	**-15**			
Confidence Factor:		**75.5%**		**78.1%**	**66.2%**			
Concentration Trend:		No Trend		Stable	Stable			



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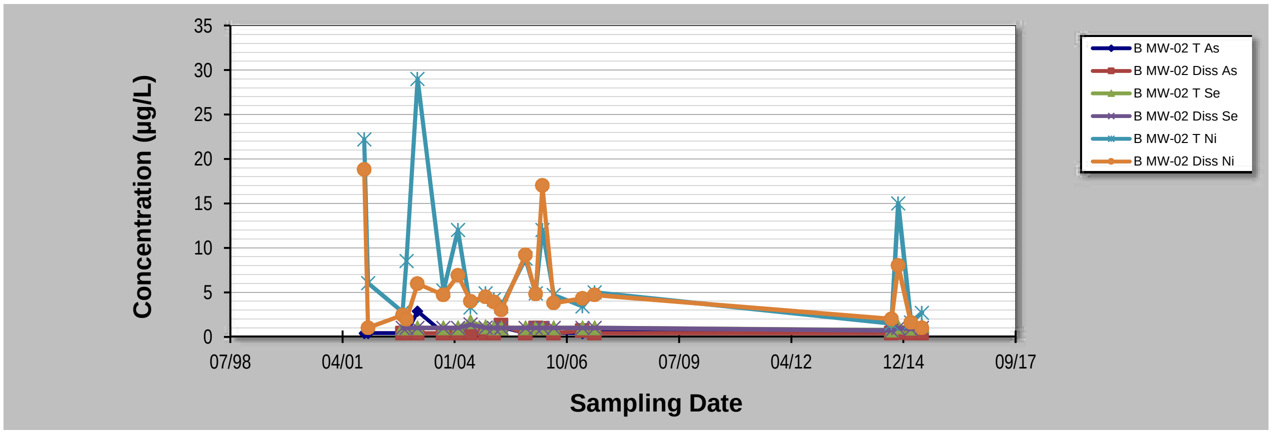
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-02 Metals**
Concentration Units: **µg/L**

Sampling Event	Sampling Date	B MW-02 METALS CONCENTRATION (µg/L)						
	Sampling Point ID:	**B MW-02 T As**	**B MW-02 Diss As**	**B MW-02 T Se**	**B MW-02 Diss Se**	**B MW-02 T Ni**	**B MW-02 Diss Ni**	
1	31-Oct-01	**0.4**				22.2	18.8	
2	5-Dec-01	**0.4**				6.02	**1**	
3	8-Oct-02	**0.4**	**0.4**	**1**	**1**	2.8	2.44	
4	12-Nov-02	**0.4**	**0.4**	**1**	**1**	8.5	1.95	
5	18-Feb-03	2.86	**0.4**	**1**	**1**	29	5.96	
6	7-Oct-03	**0.4**	**0.4**	**1**	**1**	5.2	4.7	
7	13-Feb-04	0.613	**0.4**	**1**	**1**	12	6.9	
8	4-Jun-04	**0.4**	**0.4**	1.69	1.38	3.3	4	
9	15-Oct-04	**0.4**	**0.4**	1.1	1.04	4.9	4.5	
10	30-Dec-04	**0.4**	**0.4**	**1**	**1**	4.2	3.9	
11	5-Mar-05	1.1	1.29	**1**	**1**	3.4	3	
12	6-Oct-05	**0.4**	**0.4**	**1**	**1**	8.8	9.2	
13	6-Jan-06	0.901	0.958	**1**	**1**	4.9	4.8	
14	8-Mar-06	0.782	0.912	**1**	**1**	12	17	
15	16-Jun-06	**0.4**	**0.4**	**1**	**1**	4.7	3.8	
16	28-Feb-07	**0.4**	0.683	**1**	**1**	3.4	4.3	
17	15-Jun-07	0.61	**0.4**	**1**	**1**	5	4.7	
18	10-Sep-14	**0.4**	**0.4**	0.76	0.71	1.5	2	
19	10-Nov-14	0.89	0.45	1.1	1	15	8	
20	5-Mar-15	**0.4**	**0.4**	0.95	0.89	1.6	1.6	
21	10-Jun-15	**0.4**	**0.4**	1.2	1	2.7	1	
22								
23								
24								
25								
	Coefficient of Variation:	**0.87**	**0.49**	**0.17**	**0.12**	**0.92**	**0.87**	
	Mann-Kendall Statistic (S):	**9**	**16**	**-8**	**-38**	**-61**	**-20**	
	Confidence Factor:	**59.5%**	**69.8%**	**59.6%**	**90.1%**	**96.6%**	**71.5%**	
	Concentration Trend:	No Trend	No Trend	Stable	Prob. Decreasing	Decreasing	Stable	



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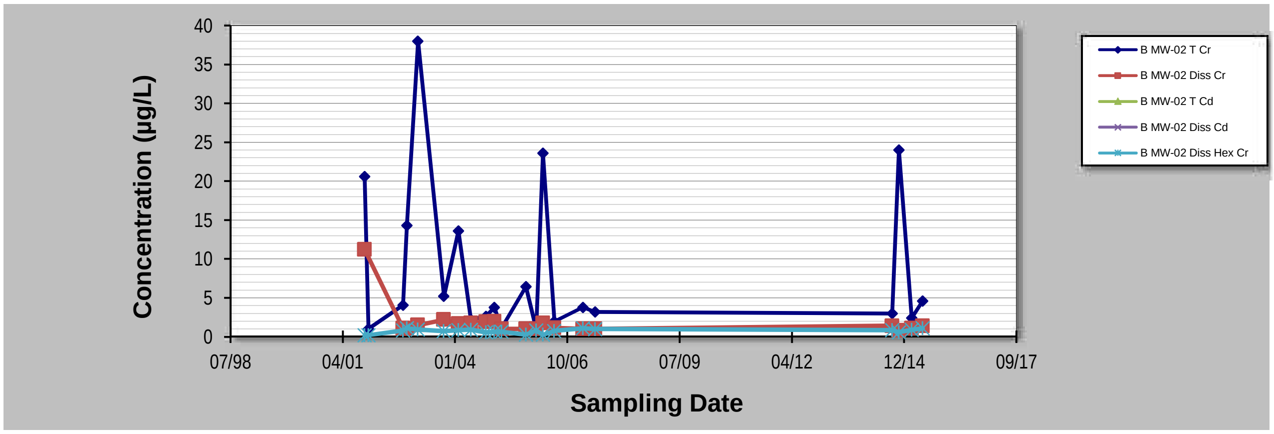
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**
Job ID: **IR13164280**
Constituent: **B MW-02 Metals**
Concentration Units: **µg/L**

	Sampling Point ID:	**B MW-02 T Cr**	**B MW-02 Diss Cr**	**B MW-02 T Cd**	**B MW-02 Diss Cd**	**MW-02 Diss Hex Cr**		
Sampling Event	Sampling Date	B MW-02 METALS CONCENTRATION (µg/L)						
1	31-Oct-01	20.6	11.2			**0.2**		
2	5-Dec-01	**1**				**0.2**		
3	8-Oct-02	4.06	1.08			0.79		
4	12-Nov-02	14.3	**1**			1.1		
5	18-Feb-03	38	1.49			0.92		
6	7-Oct-03	5.19	2.22			0.72		
7	13-Feb-04	13.6	1.67			0.85		
8	4-Jun-04	2.22	1.76			0.91		
9	15-Oct-04	2.61	1.9			0.55		
10	30-Dec-04	3.76	1.95			0.65		
11	5-Mar-05	1.14	**1**			0.65		
12	6-Oct-05	6.45	**1**			0.27		
13	6-Jan-06	**1**	**1**			0.79		
14	8-Mar-06	23.6	1.75			0.26		
15	16-Jun-06	1.94	1.12			0.74		
16	28-Feb-07	3.79	**1**			1.1		
17	15-Jun-07	3.2	**1**			0.99		
18	10-Sep-14	3	1.4			0.86		
19	10-Nov-14	24	0.82			0.58		
20	5-Mar-15	2.4	1.1			0.9		
21	10-Jun-15	4.6	1.4			1.1		
22				All concentrations	All concentrations			
23				non-detect	non-detect			
24								
25								
	Coefficient of Variation:	**1.17**	**1.21**			**0.40**		
	Mann-Kendall Statistic (S):	**-21**	**-52**			**42**		
	Confidence Factor:	**72.5%**	**95.1%**			**89.1%**		
	Concentration Trend:	No Trend	Decreasing			No Trend		



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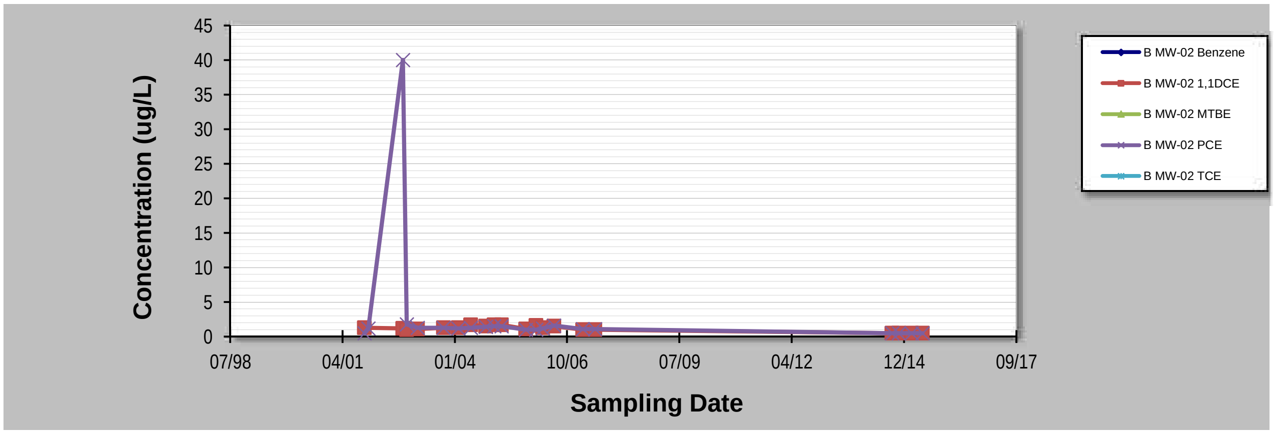
Evaluation Date: **6-Aug-15**
Facility Name: **Watershed Augmentation Study**
Conducted By: **K. Howe**

Job ID: **IR13164280**
Constituent: **B MW-02 VOCs**
Concentration Units: **ug/L**

	Sampling Point ID:	**B MW-02 Benzene**	**B MW-02 1,1DCE**	**B MW-02 MTBE**	**B MW-02 PCE**	**B MW-02 TCE**		
Sampling Event	Sampling Date	B MW-02 VOCS CONCENTRATION (ug/L)						
1	31-Oct-01		1.3		**0.5**			
2	5-Dec-01				1.2			
3	8-Oct-02		1.2		40			
4	12-Nov-02		0.98		1.8			
5	18-Feb-03		1.1		1.3			
6	7-Oct-03		1.3		1.3			
7	13-Feb-04		1.3		1.2			
8	4-Jun-04		1.7		1.3			
9	15-Oct-04		1.5		1.4			
10	30-Dec-04		1.7		1.5			
11	5-Mar-05		1.7		1.5			
12	6-Oct-05		1.1		1			
13	6-Jan-06		1.6		1			
14	8-Mar-06		1.3		1.2			
15	16-Jun-06		1.5		1.6			
16	28-Feb-07		1		1.1			
17	15-Jun-07		0.99		1.1			
18	10-Sep-14		**0.5**		**0.5**			
19	10-Nov-14		**0.5**		**0.5**			
20	5-Mar-15		**0.5**		**0.5**			
21	10-Jun-15		**0.5**		**0.5**			
22		Only 2 detections		All concentrations		Only 1 detection		
23		trend not		non-detect		trend not		
24		evaluated				evaluated		
25								
Coefficient of Variation:			**0.35**		**2.88**			
Mann-Kendall Statistic (S):			**-61**		**-79**			
Confidence Factor:			**97.5%**		**99.2%**			
Concentration Trend:			Decreasing		Decreasing			



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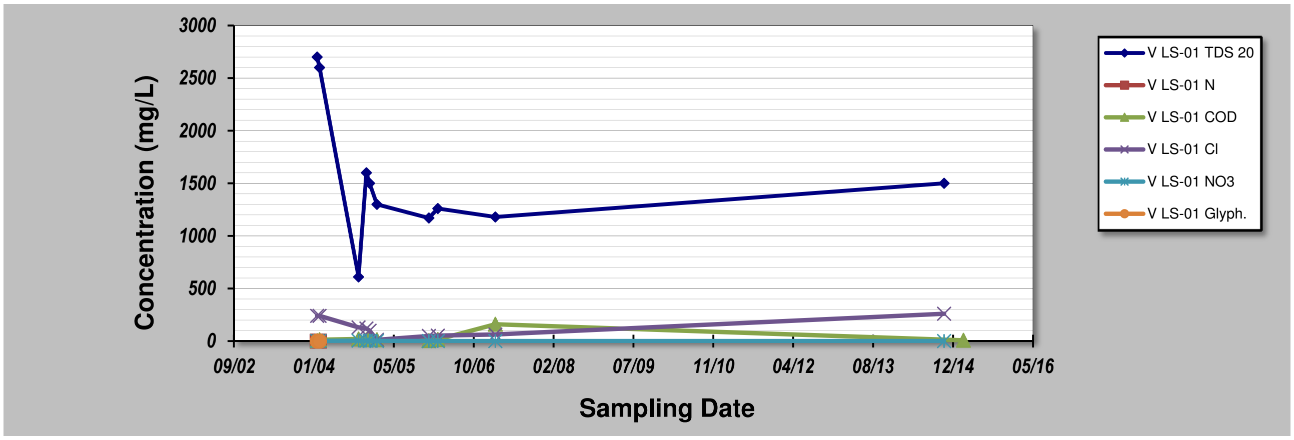
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-01 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	V LS-01 TDS	V LS-01 N	V LS-01 COD	V LS-01 Cl	V LS-01 NO3	V LS-01 Glyph.	
Sampling Event	**Sampling Date**	**V LS-01 INORGANICS CONCENTRATION (mg/L)**						
1	4-Feb-04	2700	All concentations	**5**	240	2	All concentrations	
2	19-Feb-04	2600	non-detect	13	240	1.7	non-detect	
3	20-Oct-04	610		20	130	4.4		
4	8-Dec-04	1600		13	120	3.8		
5	28-Dec-04	1500		23	99	2.4		
6	12-Feb-05	1300		13	12	1.6		
7	3-Jan-06	1170		**5**	49	0.12		
8	28-Feb-06	1260		15	52	**0.1**		
9	23-Feb-07	1180		160	63	0.24		
10	1-Nov-14	1500			260	**0.1**		
11	2-Mar-15			7.6				
12								
13								
14								
15								
16								
17								
18								
19								
20								
	Coefficient of Variation:	0.42		1.71	0.71	0.95		
	Mann-Kendall Statistic (S):	-18		7	-14	-28		
	Confidence Factor:	93.4%		70.0%	87.3%	99.4%		
	Concentration Trend:	Prob. Decreasing		No Trend	Stable	Decreasing		



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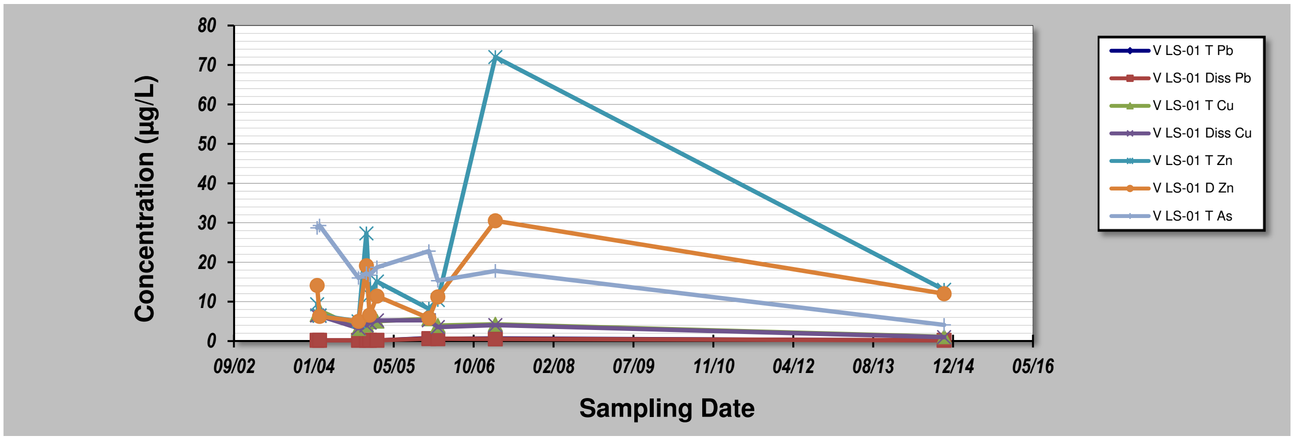
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V LS-01 Metals
Concentration Units: µg/L

Sampling Event	Sampling Date	V LS-01 T Pb	V LS-01 Diss Pb	V LS-01 T Cu	V LS-01 Diss Cu	V LS-01 T Zn	V LS-01 D Zn	V LS-01 T As
		V LS-01 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	**0.2**	**0.2**	6.71	6.49	9.34	14.1	28.7
2	19-Feb-04	**0.2**	**0.2**	7.76	6.4	6.52	6.26	29.3
3	20-Oct-04	**0.2**	**0.2**	3.18	3.26	**5**	**5**	16
4	8-Dec-04	**0.2**	**0.2**	4.1	3.99	27.3	19.1	17.2
5	28-Dec-04	**0.2**	**0.2**	4.89	4.68	11.6	6.56	16.7
6	12-Feb-05	**0.2**	**0.2**	5.05	5.25	15.1	11.4	18.7
7	3-Jan-06	0.816	0.631	5.65	5.28	8.19	5.81	22.8
8	28-Feb-06	0.642	0.608	3.95	3.55	10.4	11.2	15.3
9	23-Feb-07	0.719	0.553	4.27	4.05	72	30.5	17.8
10	1-Nov-14	**0.2**	**0.2**	1.1	1	13	12	4.1
11	2-Mar-15							
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.72	0.60	0.40	0.37	1.12	0.64	0.39
Mann-Kendall Statistic (S):		14	12	-15	-17	15	9	-17
Confidence Factor:		87.3%	83.2%	89.2%	92.2%	89.2%	75.8%	92.2%
Concentration Trend:		No Trend	No Trend	Stable	Prob. Decreasing	No Trend	No Trend	Prob. Decreasing



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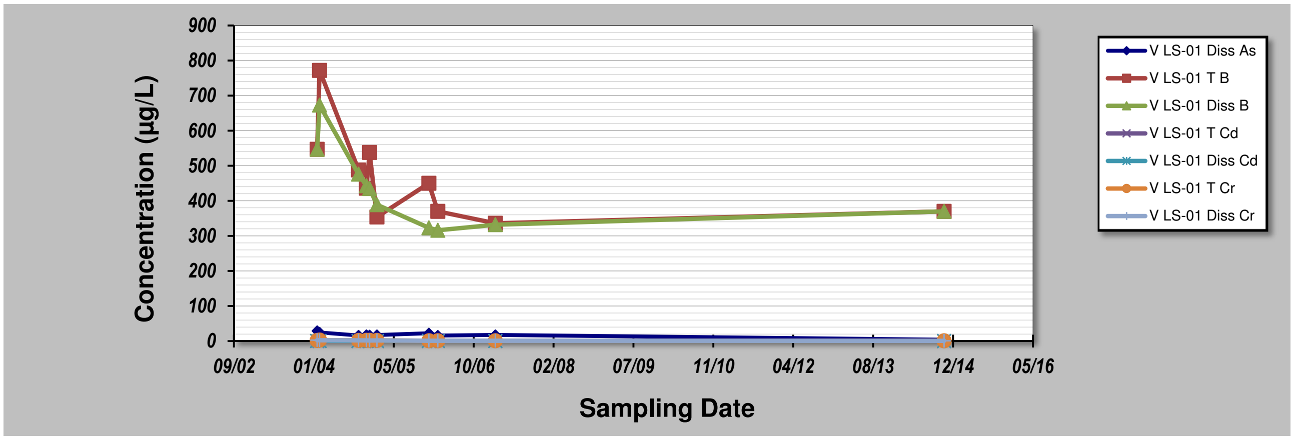
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-01 Metals
Concentration Units: µg/L

Sampling Point ID:		V LS-01 Diss As	V LS-01 T B	V LS-01 Diss B	V LS-01 T Cd	V LS-01 Diss Cd	V LS-01 T Cr	V LS-01 Diss Cr
Sampling Event	Sampling Date	V LS-01 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	29	547	547	0.352	0.401	1.92	2.77
2	19-Feb-04	24.7	772	673	0.435	0.355	2.91	2.41
3	20-Oct-04	16.1	488	476	0.259	0.25	2.01	2.03
4	8-Dec-04	17.5	436	443	0.253	0.248	2.24	1.91
5	28-Dec-04	16.6	538	435	0.247	0.23	2.34	1.71
6	12-Feb-05	17.3	354	389	0.248	0.24	1.98	1.93
7	3-Jan-06	22.4	450	323	0.434	0.399	**1**	**1**
8	28-Feb-06	15.8	370	316	0.434	0.4	**1**	**1**
9	23-Feb-07	17.5	336	332	0.331	0.301	**1**	**1**
10	1-Nov-14	4.1	370	370	**0.1**	**0.1**	0.92	0.8
11	2-Mar-15							
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.36	0.28	0.26	0.35	0.33	0.41	0.41
Mann-Kendall Statistic (S):		-20	-28	-33	-12	-13	-26	-38
Confidence Factor:		95.5%	99.4%	99.9%	83.2%	85.4%	98.9%	>99.9%
Concentration Trend:		Decreasing	Decreasing	Decreasing	Stable	Stable	Decreasing	Decreasing



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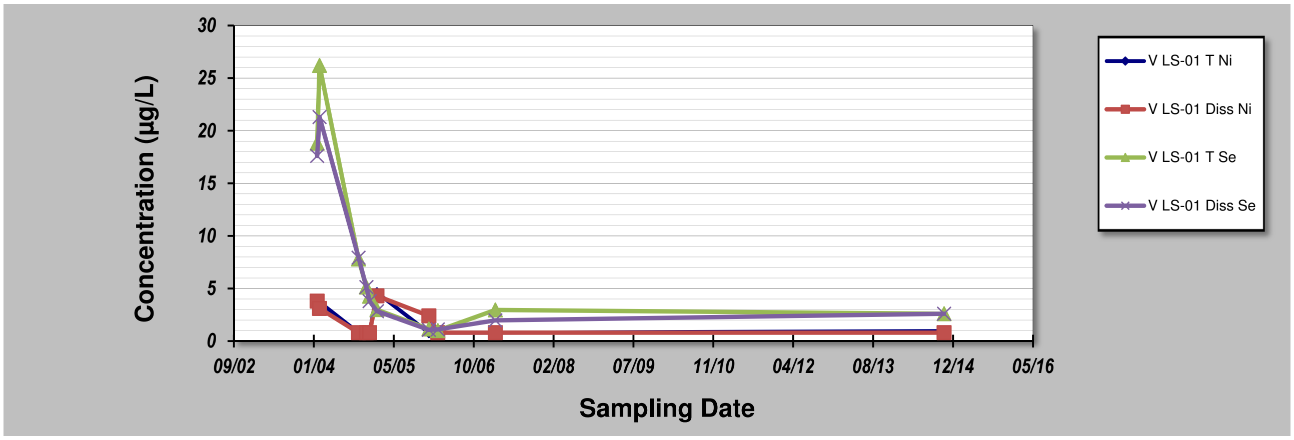
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-01 Metals
Concentration Units: µg/L

Sampling Point ID:		**V LS-01 T Ni**	**V LS-01 Diss Ni**	**V LS-01 T Se**	**V LS-01 Diss Se**			
Sampling Event	**Sampling Date**	**V LS-01 METALS CONCENTRATION (µg/L)**						
1	4-Feb-04	3.6	3.8	18.8	17.6			
2	19-Feb-04	3.7	3.1	26.2	21.3			
3	20-Oct-04	**0.8**	**0.8**	7.8	7.93			
4	8-Dec-04	**0.8**	**0.8**	5.13	5.13			
5	28-Dec-04	**0.8**	**0.8**	4.26	3.8			
6	12-Feb-05	4.6	4.3	2.99	2.84			
7	3-Jan-06	**0.8**	2.4	1.15	1.07			
8	28-Feb-06	**0.8**	**0.8**	**1**	1.11			
9	23-Feb-07	**0.8**	**0.8**	2.96	1.97			
10	1-Nov-14	0.96	**0.8**	2.6	2.6			
11	2-Mar-15							
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.87	0.77	1.16	1.10			
Mann-Kendall Statistic (S):		-6	-14	-35	-31			
Confidence Factor:		66.8%	87.3%	100.0%	99.8%			
Concentration Trend:		Stable	Stable	Decreasing	Decreasing			



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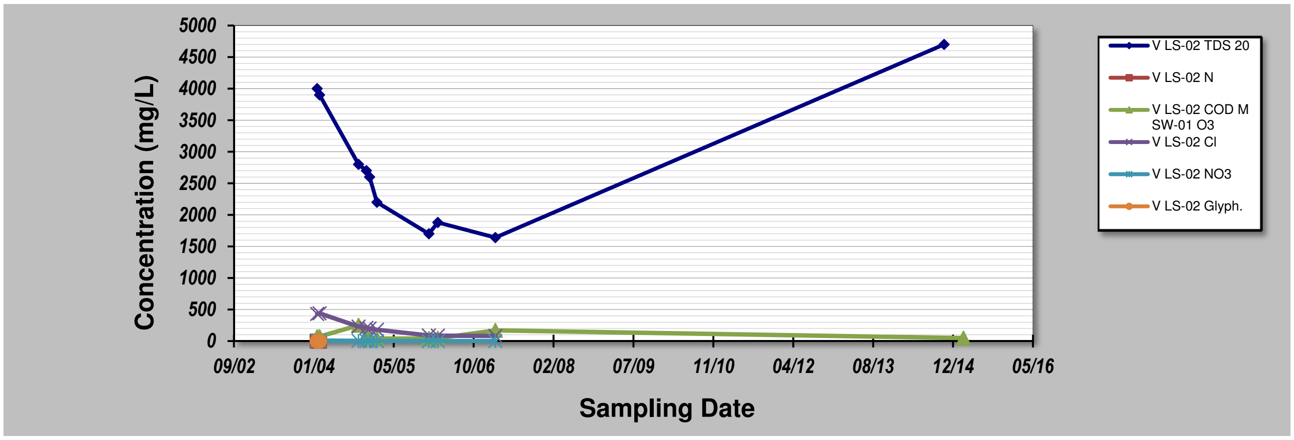
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-02 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	V LS-02 TDS	V LS-02 N	V LS-02 COD	V LS-02 Cl	V LS-02 NO3	V LS-02 Glyph.	
Sampling Event	Sampling Date	V LS-02 INORGANICS CONCENTRATION (mg/L)						
1	4-Feb-04	4000	All concentrations	69	430	8.7	All concentrations	
2	19-Feb-04	3900	non-detect	72	440	8.9	non-detect	
3	20-Oct-04	2800		250	230	3.9		
4	8-Dec-04	2700		94	210	2.4		
5	28-Dec-04	2600		56	200	1.4		
6	12-Feb-05	2200		41	180	0.91		
7	3-Jan-06	1700		41	89	**0.1**		
8	28-Feb-06	1880		46	86	**0.1**		
9	23-Feb-07	1640		170	82	0.91		
10	1-Nov-14	4700						
11	2-Mar-15			48				
12								
13		Non-detect						
14		concentrations						
15		are in **bold**						
16								
17								
18								
19								
20								
	Coefficient of Variation:	0.38		0.77	0.63	1.14		
	Mann-Kendall Statistic (S):	-25		-10	-34	-28		
	Confidence Factor:	98.6%		78.4%	>99.9%	99.9%		
	Concentration Trend:	Decreasing		Stable	Decreasing	Decreasing		



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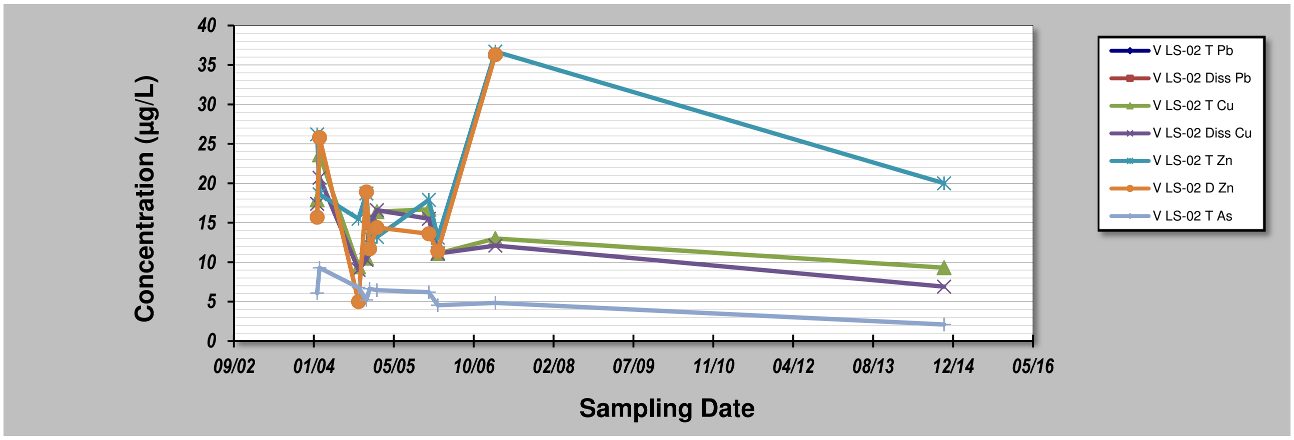
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-02 Metals
Concentration Units: µg/L

	Sampling Point ID:	V LS-02 T Pb	V LS-02 Diss Pb	V LS-02 T Cu	V LS-02 Diss Cu	V LS-02 T Zn	V LS-02 D Zn	V LS-02 T As
Sampling Event	**Sampling Date**	**V LS-02 METALS CONCENTRATION (µg/L)**						
1	4-Feb-04			17.9	17.4	26.2	15.7	6.09
2	19-Feb-04			23.6	20.7	18.6	25.8	9.28
3	20-Oct-04			9.41	9.03	15.5	**5**	6.78
4	8-Dec-04			10.5	10.3	18.7	18.9	5.22
5	28-Dec-04			15.2	14.6	13.2	11.7	6.63
6	12-Feb-05			16.4	16.6	13.2	14.4	6.45
7	3-Jan-06			16.7	15.5	17.9	13.6	6.2
8	28-Feb-06			11.1	11.1	13.1	11.4	4.55
9	23-Feb-07			13	12.1	36.7	36.3	4.84
10	1-Nov-14			9.3	6.9	20		2.1
11	2-Mar-15							
12								
13								
14								
15								
16								
17								
18		All concentrations	All concentrations					
19		non-detect	non-detect					
20								
Coefficient of Variation:				0.32	0.32	0.38	0.54	0.32
Mann-Kendall Statistic (S):				-13	-15	-4	-2	-27
Confidence Factor:				85.4%	89.2%	60.3%	54.0%	99.2%
Concentration Trend:				Stable	Stable	Stable	Stable	Decreasing



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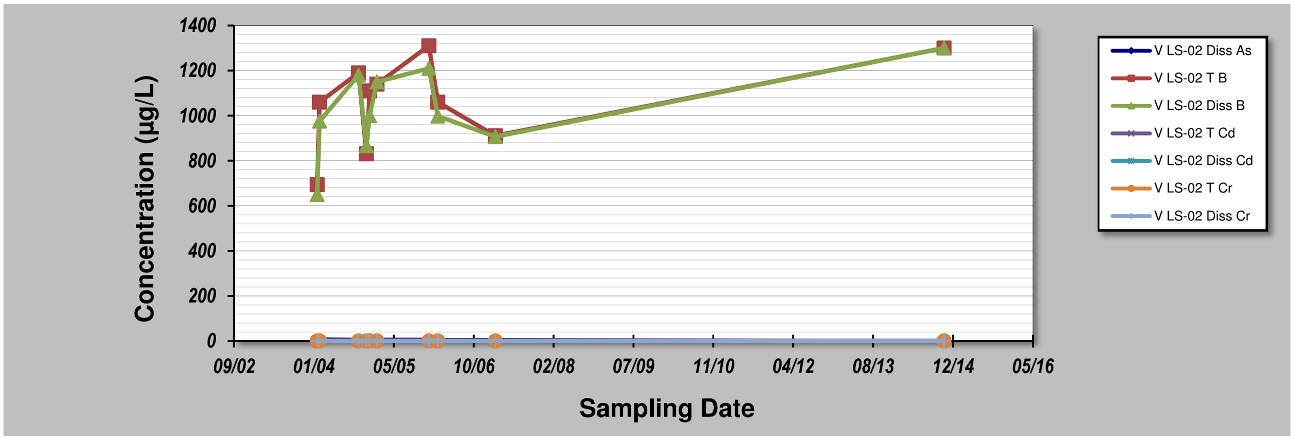
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V LS-02 Metals
Concentration Units: µg/L

	Sampling Point ID:	V LS-02 Diss As	V LS-02 T B	V LS-02 Diss B	V LS-02 T Cd	V LS-02 Diss Cd	V LS-02 T Cr	V LS-02 Diss Cr
Sampling Event	Sampling Date	V LS-02 METALS CONCENTRATION (µg/L)						
1	4-Feb-04	7.56	694	650			**1**	1.25
2	19-Feb-04	8.16	1060	976			1.27	1.18
3	20-Oct-04	5.76	1190	1180			**1**	**1**
4	8-Dec-04	5.34	831	867			1.07	**1**
5	28-Dec-04	6.41	1110	1000			1.4	**1**
6	12-Feb-05	6.37	1140	1150			1.13	1.15
7	3-Jan-06	6.29	1310	1210			**1**	**1**
8	28-Feb-06	4.7	1060	998			**1**	**1**
9	23-Feb-07	5.01	911	907			**1**	**1**
10	1-Nov-14	2.1	1300	1300			1.4	1.4
11								
12								
13								
14								
15								
16								
17								
18					Only two	Only two		
19					detections	detections		
20					trend not evaluated	trend not evaluated		
Coefficient of Variation:		0.29	0.19	0.19			0.15	0.13
Mann-Kendall Statistic (S):		-29	14	17			2	-6
Confidence Factor:		99.5%	87.3%	92.2%			53.5%	66.8%
Concentration Trend:		Decreasing	No Trend	Prob. Increasing			No Trend	Stable



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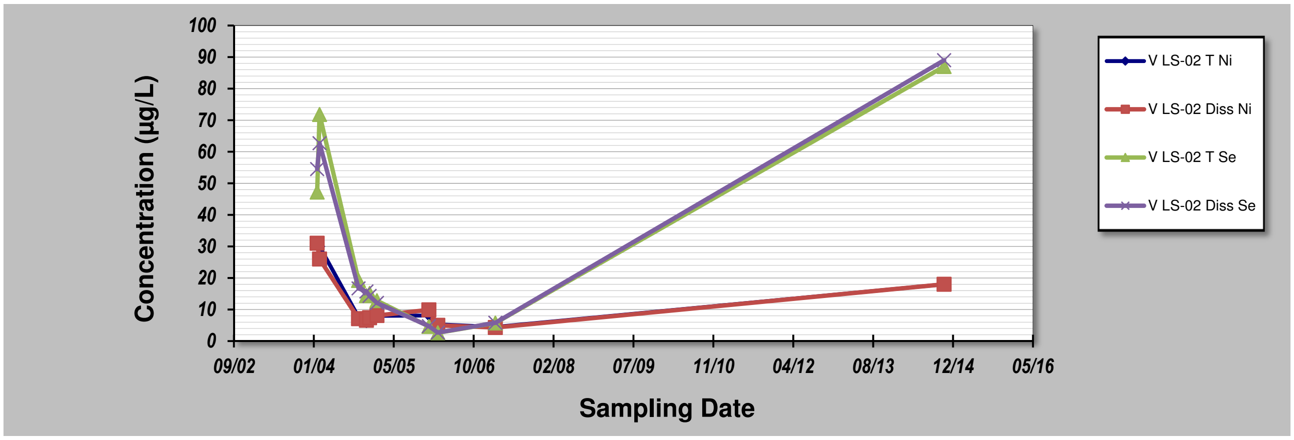
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	**Job ID:**	IR13164280
Facility Name:	Watershed Augmentation Study	**Constituent:**	V LS-02 Metals
Conducted By:	K. Howe	**Concentration Units:**	µg/L

		Sampling Point ID:	V LS-02 T Ni	V LS-02 Diss Ni	V LS-02 T Se	V LS-02 Diss Se			
Sampling Event	**Sampling Date**	**V LS-02 METALS CONCENTRATION (µg/L)**							
1	4-Feb-04	31	31	47.2	54.5				
2	19-Feb-04	30	26	71.8	62.7				
3	20-Oct-04	7.6	7.1	19.2	16.7				
4	8-Dec-04	5.9	6.6	14.4	15.7				
5	28-Dec-04	7.6	7.4	15.1	14.3				
6	12-Feb-05	8	8.1	12.8	12.1				
7	3-Jan-06	8.1	9.9	4.63	4.74				
8	28-Feb-06	5.3	5	2.62	2.7				
9	23-Feb-07	4.5	4.3	5.73	5.8				
10	1-Nov-14	18	18	87	89				
11	2-Mar-15								
12									
13									
14									
15									
16									
17									
18									
19									
20									
Coefficient of Variation:			0.80	0.76	1.07	1.07			
Mann-Kendall Statistic (S):			-14	-13	-19	-21			
Confidence Factor:			87.3%	85.4%	94.6%	96.4%			
Concentration Trend:			Stable	Stable	Prob. Decreasing	Decreasing			



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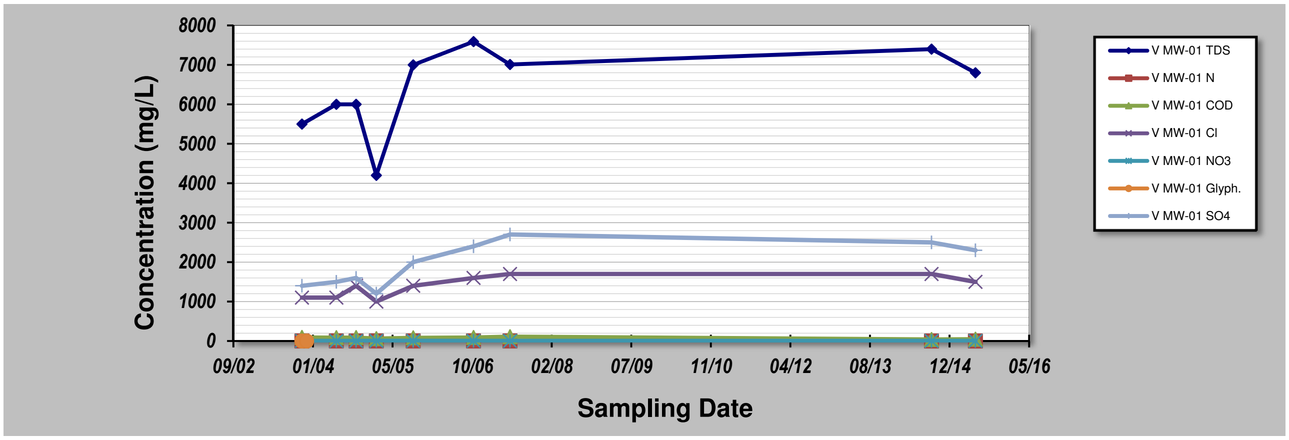
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-01 Inorganics
Concentration Units: mg/L

Sampling Point ID:		V MW-01 TDS	V MW-01 N	V MW-01 COD	V MW-01 Cl	V MW-01 NO3	V MW-01 Glyph.	V MW-01 SO4
Sampling Event	**Sampling Date**	**V MW-01 INORGANICS CONCENTRATION (mg/L)**						
1	6-Nov-03	5500	0.7	90	1100	3.2	All concentrations	1400
2	5-Dec-03						non-detect	
3	9-Jun-04	6000	0.84	84	1100	2.6		1500
4	11-Oct-04	6000	**0.5**	86	1400	2.3		1600
5	15-Feb-05	4200	0.7	61	1000	4.7		1200
6	5-Oct-05	7000	0.98	80	1400	4		2000
7	19-Oct-06	7590	0.84	88	1600	2.9		2400
8	5-Jun-07	7010	0.91	110	1700	2.1		2700
9	5-Sep-14	7400	0.53	38	1700	1.8		2500
10	8-Jun-15	6800	0.44	46	1500	1.5		2300
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.17	0.27	0.30	0.19	0.37		0.28
Mann-Kendall Statistic (S):		17	-4	-10	21	-20		22
Confidence Factor:		95.1%	61.9%	82.1%	98.3%	97.8%		98.8%
Concentration Trend:		Increasing	Stable	Stable	Increasing	Decreasing		Increasing



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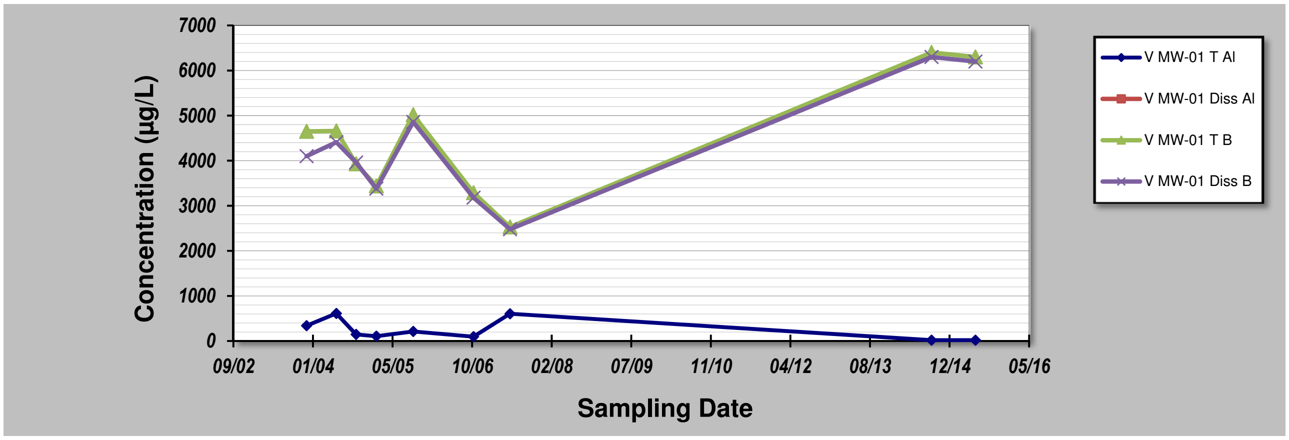
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V MW-01 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-01 T Al	V MW-01 Diss Al	V MW-01 T B	V MW-01 Diss B			
Sampling Event	**Sampling Date**	**V MW-01 METALS CONCENTRATION (µg/L)**						
1	6-Nov-03							
2	5-Dec-03	340		4650	4100			
3	9-Jun-04	612		4660	4410			
4	11-Oct-04	147		3930	3960			
5	15-Feb-05	108		3440	3380			
6	5-Oct-05	212		5020	4860			
7	19-Oct-06	96.4		3290	3180			
8	5-Jun-07	605		2530	2480			
9	5-Sep-14	19		6400	6300			
10	8-Jun-15	20		6300	6200			
11								
12								
13								
14								
15			Only one detection					
16			no trend evaluated					
17								
18								
19								
20								
	Coefficient of Variation:	0.96		0.30	0.30			
	Mann-Kendall Statistic (S):	-18		2	2			
	Confidence Factor:	96.2%		54.0%	54.0%			
	Concentration Trend:	Decreasing		No Trend	No Trend			



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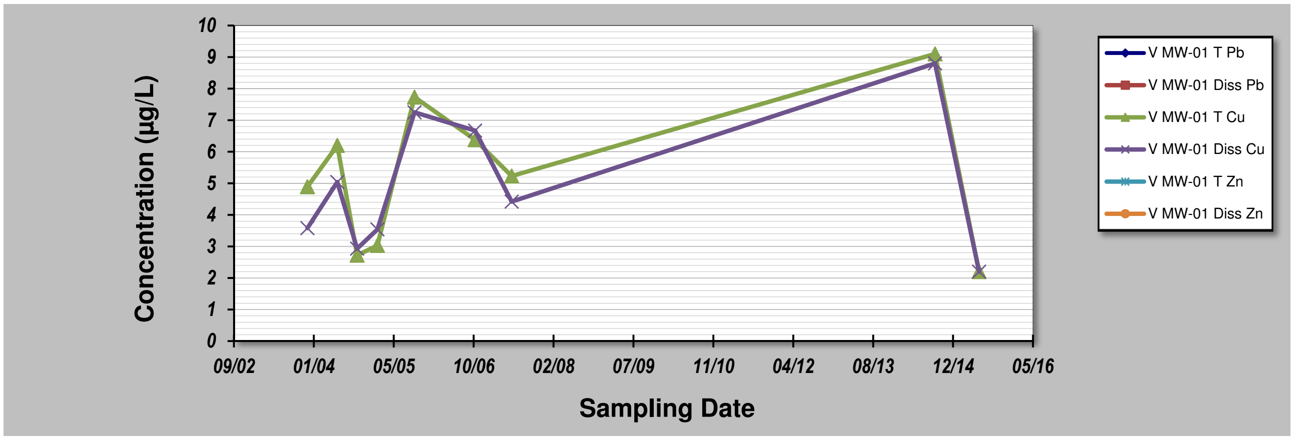
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-01 Metals
Concentration Units: µg/L

Sampling Event	Sampling Date	V MW-01 METALS CONCENTRATION (µg/L)						
	Sampling Point ID:	V MW-01 T Pb	V MW-01 Diss Pb	V MW-01 T Cu	V MW-01 Diss Cu	V MW-01 T Zn	V MW-01 Diss Zn	
1	6-Nov-03							
2	5-Dec-03			4.89	3.58			
3	9-Jun-04			6.2	5.04			
4	11-Oct-04			2.72	2.93			
5	15-Feb-05			3.03	3.54			
6	5-Oct-05			7.73	7.25			
7	19-Oct-06			6.38	6.67			
8	5-Jun-07			5.23	4.42			
9	5-Sep-14			9.1	8.8			
10	8-Jun-15			2.2	2.2			
11								
12								
13								
14								
15		Only two detections	All concentrations			Only three	Only three	
16		no trend evaluated	non-detect			detections	detections	
17						no trend evaluated	no trend evaluated	
18								
19								
20								
	Coefficient of Variation:			0.44	0.45			
	Mann-Kendall Statistic (S):			4	4			
	Confidence Factor:			61.9%	61.9%			
	Concentration Trend:			No Trend	No Trend			



Notes:

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3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.
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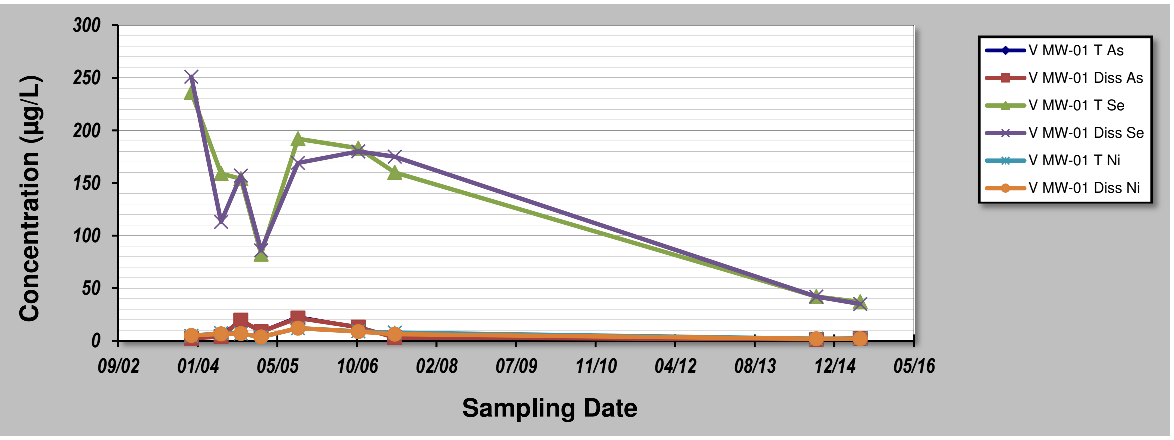
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-01 Metals
Concentration Units: µg/L

Sampling Event	Sampling Date	V MW-01 T As	V MW-01 Diss As	V MW-01 T Se	V MW-01 Diss Se	V MW-01 T Ni	V MW-01 Diss Ni	
		V MW-01 METALS CONCENTRATION (µg/L)						
1	6-Nov-03							
2	5-Dec-03	4.85	2.41	236	251	4.7	5.1	
3	9-Jun-04	4.92	3.99	159	113	7.3	6.5	
4	11-Oct-04	19.6	19.6	154	157	6.8	6.9	
5	15-Feb-05	8.65	8.63	82.3	86	3.5	3.6	
6	5-Oct-05	22.5	21.6	192	169	12	12	
7	19-Oct-06	12.6	13	183	180	9	8.7	
8	5-Jun-07	3.6	3.06	160	175	7.8	6.3	
9	5-Sep-14	1.5	1.4	42	42	2	1.9	
10	8-Jun-15	2.3	2.3	37	35	2.1	2	
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.86	0.93	0.50	0.53	0.55	0.55	
Mann-Kendall Statistic (S):		-10	-8	-18	-12	-6	-8	
Confidence Factor:		82.1%	76.2%	96.2%	87.0%	69.4%	76.2%	
Concentration Trend:		Stable	Stable	Decreasing	Stable	Stable	Stable	



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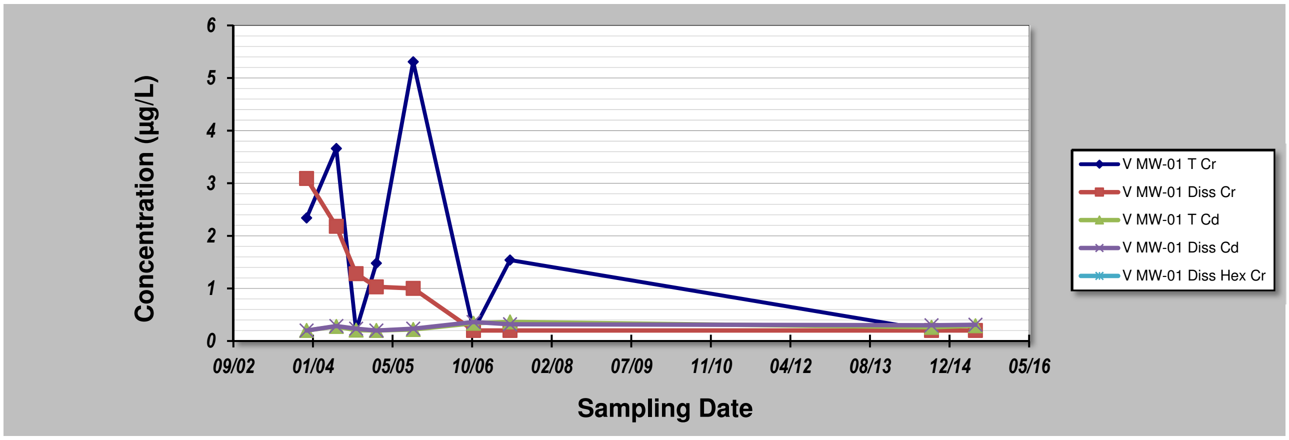
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	Job ID:	IR13164280
Facility Name:	Watershed Augmentation Study	Constituent:	V MW-01 Metals
Conducted By:	K. Howe	Concentration Units:	µg/L

	Sampling Point ID:	V MW-01 T Cr	V MW-01 Diss Cr	V MW-01 T Cd	V MW-01 Diss Cd	MW-01 Diss Hex Cr		
Sampling Event	Sampling Date	V MW-01 METALS CONCENTRATION (µg/L)						
1	6-Nov-03							
2	5-Dec-03	2.34	3.09	**0.2**	**0.2**			
3	9-Jun-04	3.66	2.18	0.277	0.285			
4	11-Oct-04	**0.2**	1.28	0.206	0.235			
5	15-Feb-05	1.48	1.03	**0.2**	0.2			
6	5-Oct-05	5.31	1	0.218	0.235			
7	19-Oct-06	**0.2**	**0.2**	0.338	0.361			
8	5-Jun-07	1.54	**0.2**	0.363	0.319			
9	5-Sep-14	**0.2**	**0.2**	0.26	0.3			
10	8-Jun-15	**0.2**	**0.2**	0.29	0.31			
11								
12						Only two detections		
13						no trend evaluated		
14								
15								
16								
17								
18								
19								
20								
	Coefficient of Variation:	1.08	0.98	0.23	0.21			
	Mann-Kendall Statistic (S):	-12	-30	17	16			
	Confidence Factor:	87.0%	100.0%	95.1%	94.0%			
	Concentration Trend:	No Trend	Decreasing	Increasing	Prob. Increasing			



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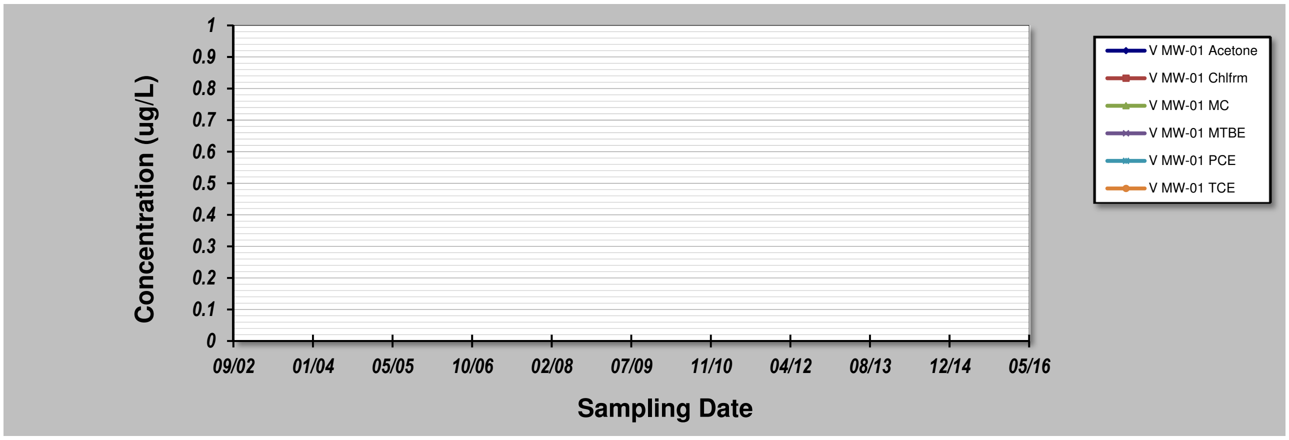
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-01 VOCs
Concentration Units: ug/L

Sampling Point ID:		V MW-01 Acetone	V MW-01 Chlfrm	V MW-01 MC	V MW-01 MTBE	V MW-01 PCE	V MW-01 TCE	
Sampling Event	**Sampling Date**	**V MW-01 VOCS CONCENTRATION (ug/L)**						
1	6-Nov-03							
2	5-Dec-03							
3	9-Jun-04							
4	11-Oct-04							
5	15-Feb-05							
6	5-Oct-05							
7	19-Oct-06							
8	5-Jun-07							
9	5-Sep-14							
10	8-Jun-15							
11								
12								
13		All concentrations	All concentrations	Only 2 detections	All concentrations	All concentrations	All concentrations	
14		non-detect	non-detect	trend not	non-detect	non-detect	non-detect	
15				evaluated				
16								
17								
18								
19								
20								
Coefficient of Variation:								
Mann-Kendall Statistic (S):								
Confidence Factor:								
Concentration Trend:								



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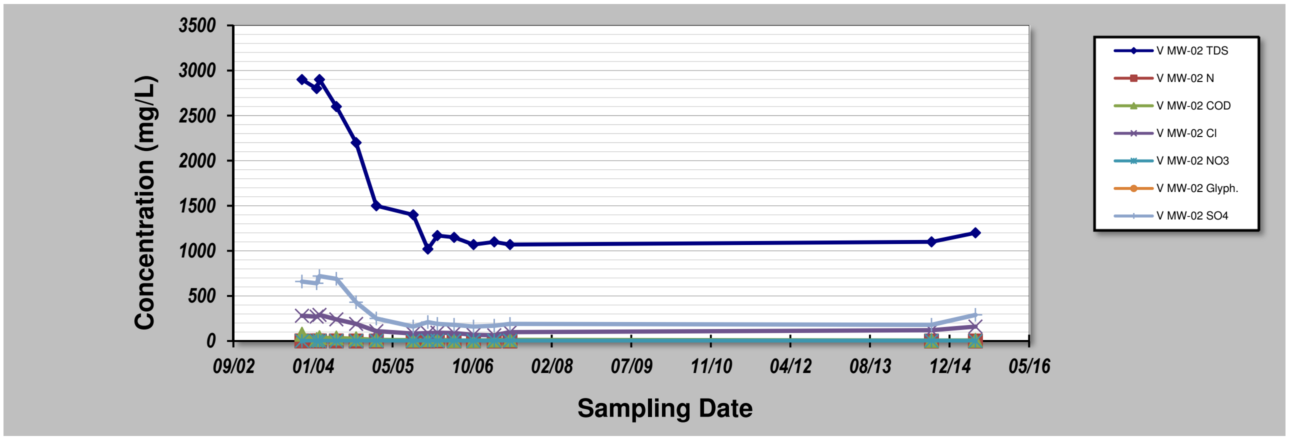
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V MW-02 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	V MW-02 TDS	V MW-02 N	V MW-02 COD	V MW-02 Cl	V MW-02 NO3	V MW-02 Glyph.	V MW-02 SO4
Sampling Event	**Sampling Date**	**V MW-02 INORGANICS CONCENTRATION (mg/L)**						
1	6-Nov-03	2900	0.98	75	280	0.56		660
2	8-Dec-03							
3	6-Feb-04	2800	0.7	15	270	0.76		640
4	24-Feb-04	2900	0.7	36	290	1.3		720
5	9-Jun-04	2600	0.7	33	240	1.4		690
6	11-Oct-04	2200	**0.1**	25	190	1.4		430
7	15-Feb-05	1500	**0.1**	13	110	3.7		250
8	5-Oct-05	1400	**0.1**	10	83	1.2		160
9	5-Jan-06	1020	0.84	13	89	2.3		210
10	6-Mar-06	1170	1.3	18	93	2.9		190
11	19-Jun-06	1150	0.84	**5**	89	3.9		180
12	19-Oct-06	1070	0.56	**5**	69	2.8		160
13	26-Feb-07	1100	**0.1**	9	64	3.5		170
14	5-Jun-07	1070	**0.1**	13	99	3.3		190
15	5-Sep-14	1100	**0.1**	**5**	120	3.4		180
16	8-Jun-15	1200	0.17	6.9	160	0.55		290
17							All concentrations	
18							non-detect	
19								
20								
Coefficient of Variation:		0.45	0.82	0.97	0.55	0.56		0.65
Mann-Kendall Statistic (S):		-68	-28	-65	-46	42		-52
Confidence Factor:		>99.9%	90.8%	100.0%	98.8%	98.0%		99.5%
Concentration Trend:		Decreasing	Prob. Decreasing	Decreasing	Decreasing	Increasing		Decreasing



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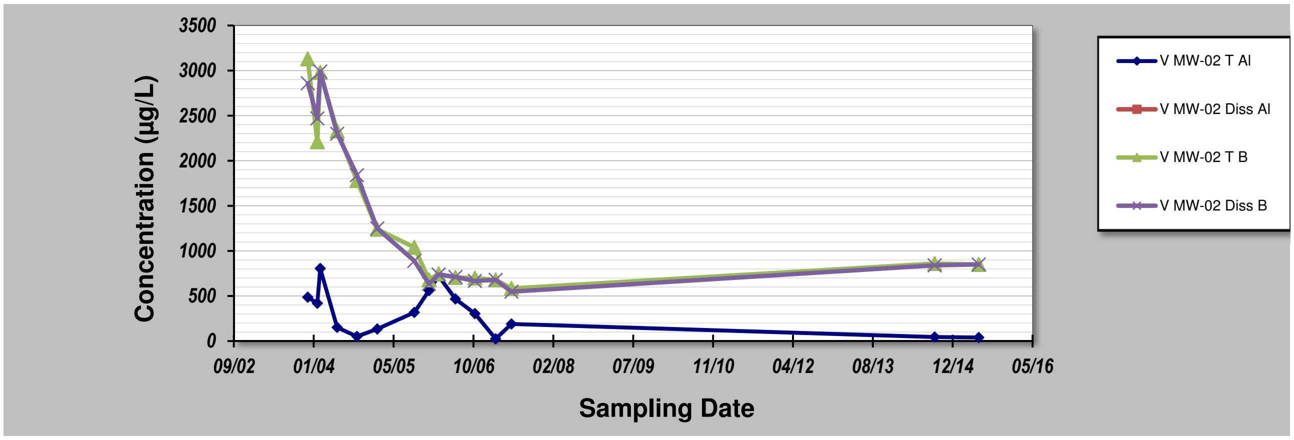
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-02 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-02 T Al	V MW-02 Diss Al	V MW-02 T B	V MW-02 Diss B		
Sampling Event	**Sampling Date**	**V MW-02 METALS CONCENTRATION (µg/L)**					
1	6-Nov-03						
2	8-Dec-03	487		3130	2860		
3	6-Feb-04	420		2210	2470		
4	24-Feb-04	805		2980	2990		
5	9-Jun-04	152		2330	2300		
6	11-Oct-04	51.4		1780	1840		
7	15-Feb-05	134		1240	1250		
8	5-Oct-05	318		1040	889		
9	5-Jan-06	561		679	635		
10	6-Mar-06	722		746	738		
11	19-Jun-06	468		706	711		
12	19-Oct-06	305		699	667		
13	26-Feb-07	**25**		679	679		
14	5-Jun-07	190		584	548		
15	5-Sep-14	45		860	840		
16	8-Jun-15	40		850	850		
17			All concentrations				
18			non-detect				
19							
20							
	Coefficient of Variation:	0.81		0.65	0.65		
	Mann-Kendall Statistic (S):	-39		-70	-65		
	Confidence Factor:	97.1%		>99.9%	100.0%		
	Concentration Trend:	Decreasing		Decreasing	Decreasing		



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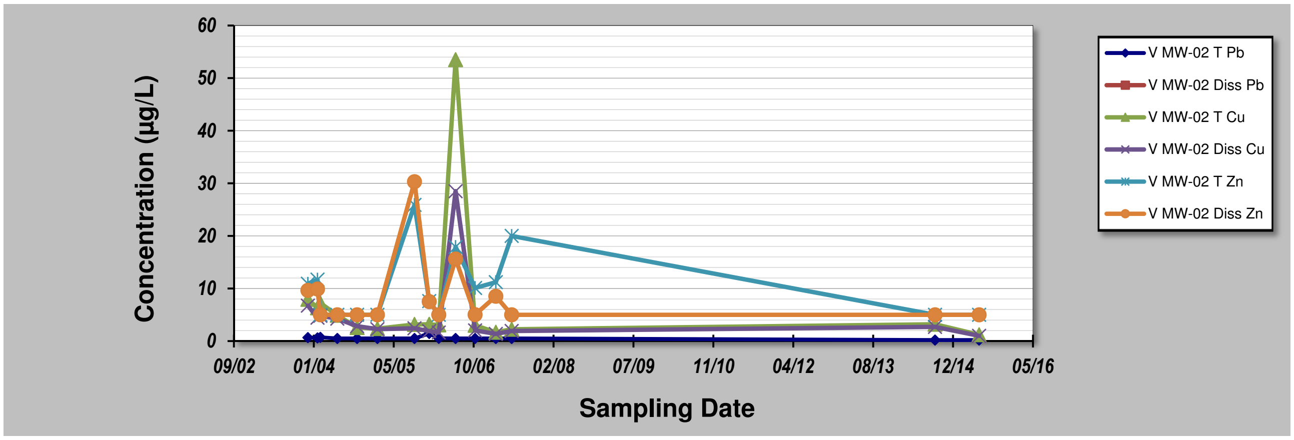
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	**Job ID:**	IR13164280
Facility Name:	Watershed Augmentation Study	**Constituent:**	V MW-02 Metals
Conducted By:	K. Howe	**Concentration Units:**	µg/L

Sampling Event	Sampling Date	V MW-02 METALS CONCENTRATION (µg/L)						
Sampling Point ID:		V MW-02 T Pb	V MW-02 Diss Pb	V MW-02 T Cu	V MW-02 Diss Cu	V MW-02 T Zn	V MW-02 Diss Zn	
1	6-Nov-03							
2	8-Dec-03	0.668		7.94	6.74	10.9	9.64	
3	6-Feb-04	0.61		6.32	4.45	11.7	9.9	
4	24-Feb-04	0.712		7.23	4.82	**5**	**5**	
5	9-Jun-04	**0.5**		4.91	4.27	**5**	**5**	
6	11-Oct-04	**0.5**		2.57	2.84	**5**	**5**	
7	15-Feb-05	**0.5**		2.37	2.27	**5**	**5**	
8	5-Oct-05	**0.5**		3.16	2.43	25.9	30.3	
9	5-Jan-06	1.45		3.19	1.9	7.61	7.51	
10	6-Mar-06	0.526		3.07	1.64	**5**	**5**	
11	19-Jun-06	**0.5**		53.5	28.5	17.9	15.6	
12	19-Oct-06	**0.5**		3	2.03	10.1	5.03	
13	26-Feb-07	**0.5**		1.68	1.37	11.2	8.52	
14	5-Jun-07	**0.5**		2.25	1.92	20	**5**	
15	5-Sep-14	**0.2**		3.2	2.7	**5**	**5**	
16	8-Jun-15	**0.2**		1.2	1	**5**	**5**	
17			All concentrations					
18			non-detect					
19								
20								
Coefficient of Variation:		0.51		1.85	1.48	0.65	0.80	
Mann-Kendall Statistic (S):		-50		-49	-59	4	-15	
Confidence Factor:		99.3%		99.2%	99.9%	55.8%	75.2%	
Concentration Trend:		Decreasing		Decreasing	Decreasing	No Trend	Stable	



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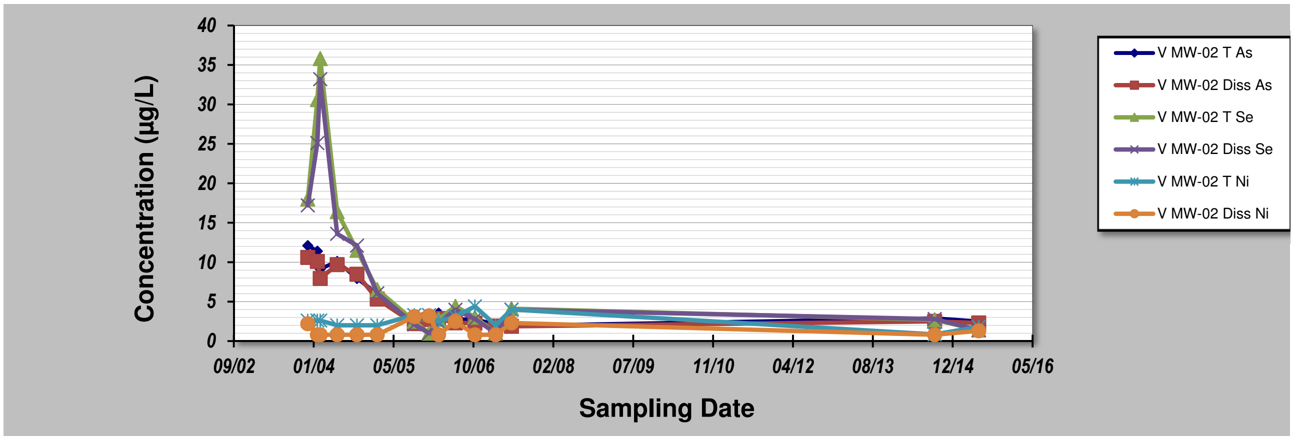
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-02 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-02 T As	V MW-02 Diss As	V MW-02 T Se	V MW-02 Diss Se	V MW-02 T Ni	V MW-02 Diss Ni	
Sampling Event	**Sampling Date**	**V MW-02 METALS CONCENTRATION (µg/L)**						
1	6-Nov-03							
2	8-Dec-03	12.1	10.6	18	17.2	2.6	2.2	
3	6-Feb-04	11.4	10.1	30.6	25.1	2.6	**0.8**	
4	24-Feb-04	9.14	7.94	35.8	33.2	2.6	**0.8**	
5	9-Jun-04	10.1	9.69	16.4	13.6	**2**	**0.8**	
6	11-Oct-04	7.94	8.47	11.5	12.1	**2**	**0.8**	
7	15-Feb-05	6.03	5.32	6.52	6.06	**2**	**0.8**	
8	5-Oct-05	2.56	2.21	2.51	2.11	3.3	3.1	
9	5-Jan-06	2.81	2.73	**1**	**1**	3.3	3.2	
10	6-Mar-06	3.55	2.86	2.76	2.34	2.5	**0.8**	
11	19-Jun-06	2.78	2.31	4.4	3.97	3.1	2.5	
12	19-Oct-06	2.75	2.28	3.03	2.81	4.4	**0.8**	
13	26-Feb-07	2.15	1.9	1.01	**1**	**2**	**0.8**	
14	5-Jun-07	1.95	1.87	4.11	3.97	4	2.3	
15	5-Sep-14	2.9	2.5	2.7	2.8	0.85	**0.8**	
16	8-Jun-15	2.5	2.3	1.4	1.4	1.8	1.3	
17								
18								
19								
20								
	Coefficient of Variation:	0.69	0.70	1.17	1.15	0.35	0.64	
	Mann-Kendall Statistic (S):	-77	-73	-61	-59	-7	7	
	Confidence Factor:	>99.9%	>99.9%	99.9%	99.9%	61.5%	61.5%	
	Concentration Trend:	Decreasing	Decreasing	Decreasing	Decreasing	Stable	No Trend	



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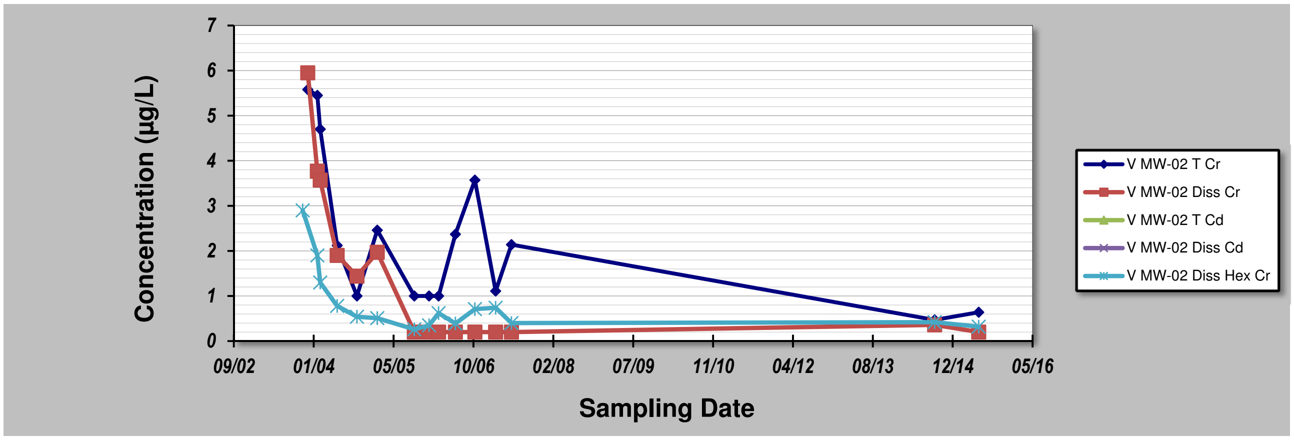
GSI Environmental Inc., www.gsi-net.com

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	Job ID:	IR13164280
Facility Name:	Watershed Augmentation Study	Constituent:	V MW-02 Metals
Conducted By:	K. Howe	Concentration Units:	µg/L

Sampling Event	Sampling Date	V MW-02 METALS CONCENTRATION (µg/L)						
Sampling Point ID:		V MW-02 T Cr	V MW-02 Diss Cr	V MW-02 T Cd	V MW-02 Diss Cd	MW-02 Diss Hex Cr		
1	6-Nov-03					2.9		
2	8-Dec-03	5.58	5.95					
3	6-Feb-04	5.45	3.77			1.9		
4	24-Feb-04	4.7	3.57			1.3		
5	9-Jun-04	2.12	1.9			0.78		
6	11-Oct-04	**1**	1.44			0.54		
7	15-Feb-05	2.46	1.97			0.51		
8	5-Oct-05	**1**	**0.2**			0.26		
9	5-Jan-06	**1**	**0.2**			0.35		
10	6-Mar-06	**1**	**0.2**			0.62		
11	19-Jun-06	2.37	**0.2**			0.39		
12	19-Oct-06	3.57	**0.2**			0.71		
13	26-Feb-07	1.11	**0.2**			0.74		
14	5-Jun-07	2.14	**0.2**			0.4		
15	5-Sep-14	0.47	0.36			0.42		
16	8-Jun-15	0.64	**0.2**			0.32		
17				All concentrations	All concentrations			
18				non-detect	non-detect			
19								
20								
Coefficient of Variation:		0.75	1.30			0.89		
Mann-Kendall Statistic (S):		-49	-59			-49		
Confidence Factor:		99.2%	99.9%			99.2%		
Concentration Trend:		Decreasing	Decreasing			Decreasing		



Notes:

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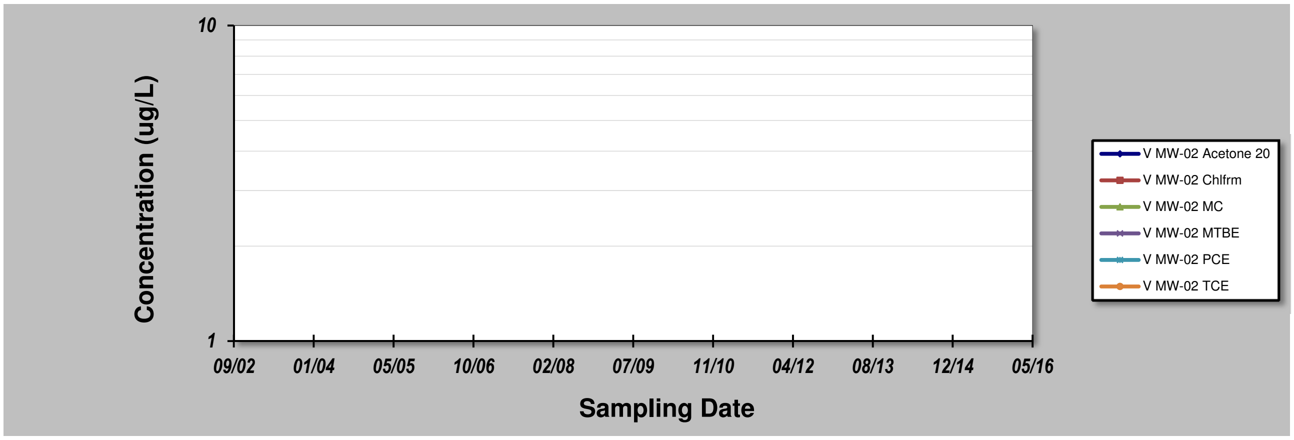
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-02 VOCs
Concentration Units: ug/L

Sampling Point ID:		V MW-02 Acetone	V MW-02 Chlfrm	V MW-02 MC	V MW-02 MTBE	V MW-02 PCE	V MW-02 TCE	
Sampling Event	**Sampling Date**	**V MW-02 VOCS CONCENTRATION (ug/L)**						
1	6-Nov-03	Only two	Only one	Only two	All concentrations	All concentrations	All concentrations	
2	8-Dec-03	detections	detection	detections	non-detect	non-detect	non-detect	
3	6-Feb-04	no trend evaluated	no trend evaluated	no trend evaluated				
4	24-Feb-04							
5	9-Jun-04							
6	11-Oct-04							
7	15-Feb-05							
8	5-Oct-05							
9	5-Jan-06							
10	6-Mar-06							
11	19-Jun-06							
12	19-Oct-06							
13	26-Feb-07							
14	5-Jun-07							
15	5-Sep-14							
16	8-Jun-15							
17								
18								
19								
20								
Coefficient of Variation:								
Mann-Kendall Statistic (S):								
Confidence Factor:								
Concentration Trend:								



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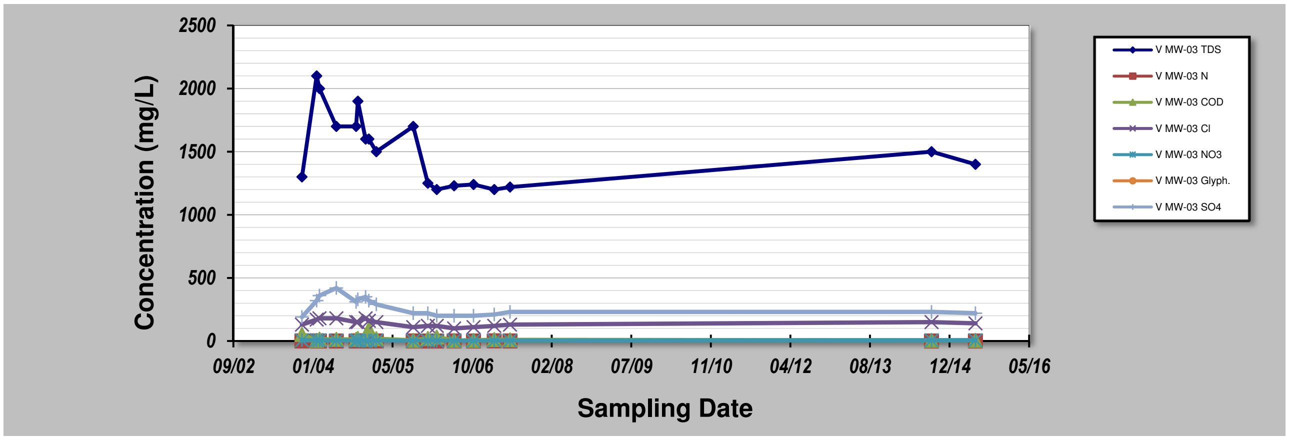
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-03 Inorganics
Concentration Units: mg/L

Sampling Point ID:		V MW-03 TDS	V MW-03 N	V MW-03 COD	V MW-03 Cl	V MW-03 NO3	V MW-03 Glyph.	V MW-03 SO4
Sampling Event	Sampling Date	V MW-03 INORGANICS CONCENTRATION (mg/L)						
1	6-Nov-03	1300	0.56	52	130	5.6		190
2	5-Dec-03							
3	6-Feb-04	2100	0.56	**5**	170	6		320
4	24-Feb-04	2000	**0.1**	15	180	5.9		360
5	9-Jun-04	1700	**0.1**	13	180	3.8		420
6	11-Oct-04	1700	**0.1**	13	150	3		310
7	22-Oct-04	1900	0.98	20	150	4.9		330
8	10-Dec-04	1600	0.56	13	180	2.1		350
9	30-Dec-04	1600	**0.1**	94	160	3.3		320
10	15-Feb-05	1500	0.56	18	150	2.8		290
11	5-Oct-05	1700	0.56	**5**	110	1.8		220
12	5-Jan-06	1250	**0.1**	20	120	2.1		220
13	2-Mar-06	1200	**0.1**	31	120	1.8		200
14	19-Jun-06	1230	0.8	**5**	100	1.8		200
15	19-Oct-06	1240	**0.1**	**5**	110	2.2		200
16	26-Feb-07	1200	0.84	11	120	2.7		210
17	5-Jun-07	1220	0.56	9	130	3.3		230
18	5-Sep-14	1500	0.11	**5**	150	5.7		230
19	8-Jun-15	1400	**0.1**	**5**	140	6		220
20							No detections	
Coefficient of Variation:		0.19	0.81	1.17	0.18	0.45		0.26
Mann-Kendall Statistic (S):		-81	-2	-46	-53	-31		-55
Confidence Factor:		99.9%	51.5%	95.6%	97.6%	87.0%		98.0%
Concentration Trend:		Decreasing	Stable	Decreasing	Decreasing	Stable		Decreasing



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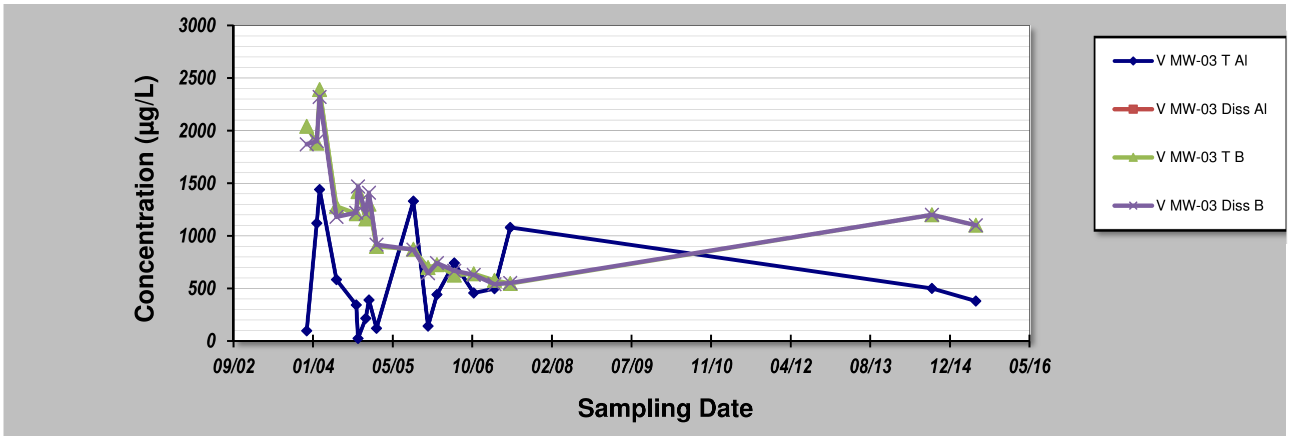
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	6-Aug-15	**Job ID:**	IR13164280
Facility Name:	Watershed Augmentation Study	**Constituent:**	V MW-03 Metals
Conducted By:	K. Howe	**Concentration Units:**	µg/L

	Sampling Point ID:	V MW-03 T Al	V MW-03 Diss Al	V MW-03 T B	V MW-03 Diss B			
Sampling Event	**Sampling Date**	**V MW-03 METALS CONCENTRATION (µg/L)**						
1	6-Nov-03							
2	5-Dec-03	97		2040	1870			
3	6-Feb-04	1120		1880	1900			
4	24-Feb-04	1440		2390	2320			
5	9-Jun-04	584		1280	1180			
6	11-Oct-04	343		1210	1220			
7	22-Oct-04	**25**		1420	1470			
8	10-Dec-04	216		1160	1210			
9	30-Dec-04	390		1300	1410			
10	15-Feb-05	121		899	916			
11	5-Oct-05	1330		872	869			
12	5-Jan-06	142		698	645			
13	2-Mar-06	442		725	741			
14	19-Jun-06	742		626	668			
15	19-Oct-06	457		639	629			
16	26-Feb-07	498		576	540			
17	5-Jun-07	1080		547	552			
18	5-Sep-14	500		1200	1200			
19	8-Jun-15	380		1100	1100			
20			No trend evaluated (only 2 detections)					
Coefficient of Variation:		0.78		0.46	0.45			
Mann-Kendall Statistic (S):		17		-101	-93			
Confidence Factor:		72.5%		>99.9%	>99.9%			
Concentration Trend:		No Trend		Decreasing	Decreasing			



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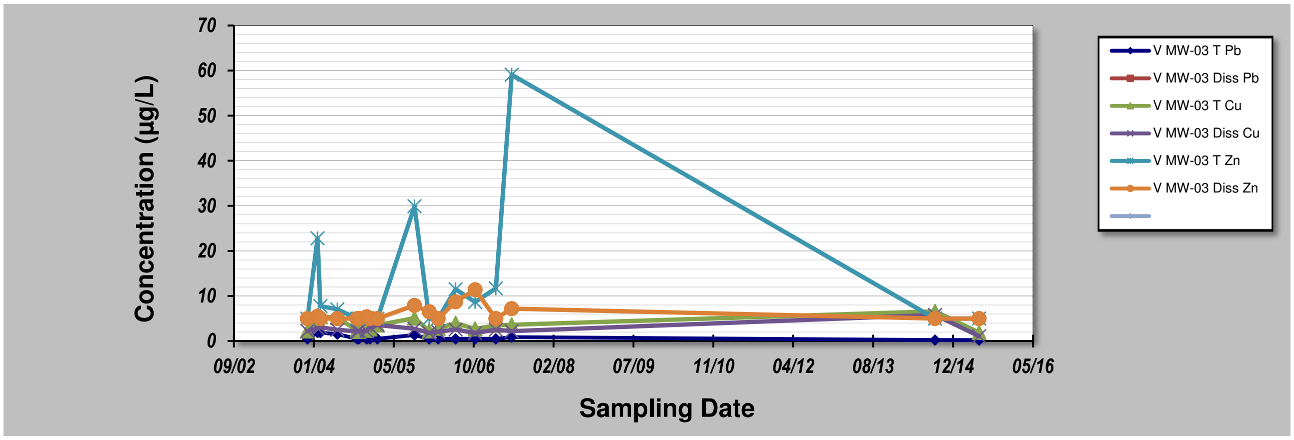
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-03 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-03 T Pb	V MW-03 Diss Pb	V MW-03 T Cu	V MW-03 Diss Cu	V MW-03 T Zn	V MW-03 Diss Zn	
Sampling Event	**Sampling Date**	**V MW-03 METALS CONCENTRATION (µg/L)**						
1	6-Nov-03							
2	5-Dec-03	**0.5**		2.23	2.23	**5**	**5**	
3	6-Feb-04	1.89		4.73	2.83	22.8	5.51	
4	24-Feb-04	1.87		5.39	3.06	7.77	**5**	
5	9-Jun-04	1.53		5.21	2.51	7.05	**5**	
6	11-Oct-04	**0.5**		2.37	2.14	**5**	**5**	
7	22-Oct-04	**0.5**		2.13	2.25	**5**	**5**	
8	10-Dec-04	**0.5**		2.37	2.22	5.14	5.41	
9	30-Dec-04	**0.5**		2.68	3.15	**5**	**5**	
10	15-Feb-05	**0.5**		3.54	3.57	**5**	**5**	
11	5-Oct-05	1.35		5.1	2.74	29.9	7.92	
12	5-Jan-06	**0.5**		2.22	1.82	**5**	6.52	
13	2-Mar-06	**0.5**		2.83	2.07	**5**	**5**	
14	19-Jun-06	**0.5**		3.96	2.57	11.5	8.72	
15	19-Oct-06	**0.5**		2.7	1.79	8.68	11.4	
16	26-Feb-07	**0.5**		3.49	2.52	11.7	**5**	
17	5-Jun-07	0.875		3.62	2.21	59.1	7.2	
18	5-Sep-14	0.23		6.6	5.8	**5**	**5**	
19	8-Jun-15	0.22		1.9	1.1	**5**	**5**	
20			No detections					
Coefficient of Variation:		0.71		0.39	0.38	1.18	0.30	
Mann-Kendall Statistic (S):		-58		6	-27	7	24	
Confidence Factor:		98.6%		57.4%	83.5%	58.9%	80.6%	
Concentration Trend:		Decreasing		No Trend	Stable	No Trend	No Trend	



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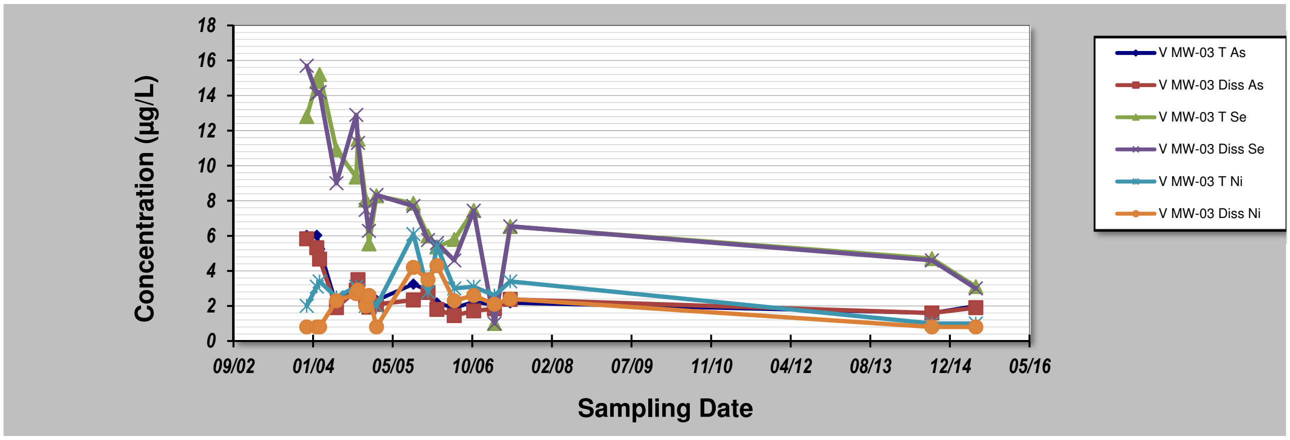
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-03 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-03 T As	V MW-03 Diss As	V MW-03 T Se	V MW-03 Diss Se	V MW-03 T Ni	V MW-03 Diss Ni	
Sampling Event	Sampling Date	V MW-03 METALS CONCENTRATION (µg/L)						
1	6-Nov-03							
2	5-Dec-03	6.02	5.83	12.8	15.7	**2**	**0.8**	
3	6-Feb-04	6.03	5.32	14.8	14.1	3.1	**0.8**	
4	24-Feb-04	5.25	4.67	15.2	14.2	3.4	**0.8**	
5	9-Jun-04	2.03	1.9	10.9	9	2.5	2.3	
6	11-Oct-04	3.22	2.9	9.35	12.9	3.1	2.7	
7	22-Oct-04	3.61	3.5	11.5	11.3	2.9	2.9	
8	10-Dec-04	2.51	2.4	8.05	7.48	**2**	2	
9	30-Dec-04	1.96	1.93	5.54	6.28	2.4	2.6	
10	15-Feb-05	2.32	2.09	8.28	8.33	**2**	**0.8**	
11	5-Oct-05	3.25	2.34	7.85	7.7	6.1	4.2	
12	5-Jan-06	2.87	2.77	5.99	5.76	2.8	3.5	
13	2-Mar-06	2.17	1.8	5.36	5.59	5.4	4.3	
14	19-Jun-06	1.89	1.45	5.79	4.6	3	2.3	
15	19-Oct-06	2.23	1.72	7.44	7.43	3.1	2.6	
16	26-Feb-07	2.07	1.84	**1**	**1**	2.6	2.1	
17	5-Jun-07	2.18	2.37	6.53	6.54	3.4	2.4	
18	5-Sep-14	1.6	1.6	4.7	4.6	1	**0.8**	
19	8-Jun-15	2	1.9	3.1	3	1	**0.8**	
20								
Coefficient of Variation:		0.48	0.49	0.48	0.51	0.44	0.54	
Mann-Kendall Statistic (S):		-87	-86	-109	-116	-13	12	
Confidence Factor:		>99.9%	>99.9%	>99.9%	>99.9%	67.3%	66.0%	
Concentration Trend:		Decreasing	Decreasing	Decreasing	Decreasing	Stable	No Trend	



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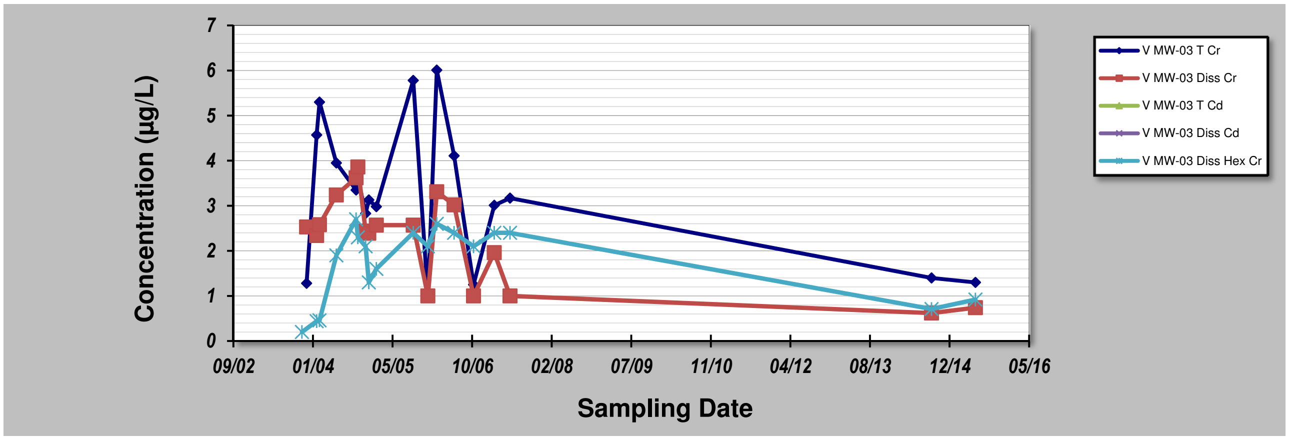
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-03 Metals
Concentration Units: µg/L

Sampling Event	Sampling Date	V MW-03 T Cr	V MW-03 Diss Cr	V MW-03 T Cd	V MW-03 Diss Cd	MW-03 Diss Hex Cr		
		V MW-03 METALS CONCENTRATION (µg/L)						
1	6-Nov-03					**0.2**		
2	5-Dec-03	1.28	2.53					
3	6-Feb-04	4.57	2.34			0.44		
4	24-Feb-04	5.3	2.58			0.46		
5	9-Jun-04	3.95	3.24			1.9		
6	11-Oct-04	3.35	3.62			2.7		
7	22-Oct-04	3.62	3.86			2.3		
8	10-Dec-04	2.83	2.44			2.1		
9	30-Dec-04	3.13	2.39			1.3		
10	15-Feb-05	2.98	2.57			1.6		
11	5-Oct-05	5.78	2.57			2.4		
12	5-Jan-06	**1**	**1**			2.1		
13	2-Mar-06	6.01	3.31			2.6		
14	19-Jun-06	4.11	3.02			2.4		
15	19-Oct-06	1.25	**1**			2.1		
16	26-Feb-07	3.01	1.96			2.4		
17	5-Jun-07	3.17	**1**			2.4		
18	5-Sep-14	1.4	0.62			0.71		
19	8-Jun-15	1.3	0.74			0.92		
20				No detections to conduct trend				
Coefficient of Variation:		0.49	0.45			0.48		
Mann-Kendall Statistic (S):		-35	-61			38		
Confidence Factor:		90.0%	98.9%			91.8%		
Concentration Trend:		Prob. Decreasing	Decreasing			Prob. Increasing		



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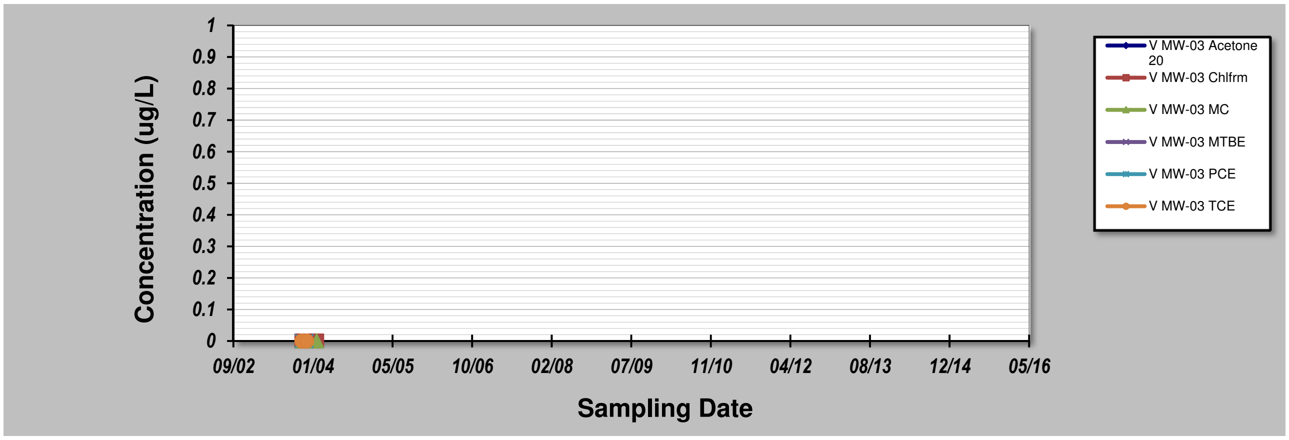
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-03 VOCs
Concentration Units: ug/L

	Sampling Point ID:	V MW-03 Acetone	V MW-03 Chlfrm	V MW-03 MC	V MW-03 MTBE	V MW-03 PCE	V MW-03 TCE	
Sampling Event	**Sampling Date**	**V MW-03 VOCS CONCENTRATION (ug/L)**						
1	6-Nov-03	All concentrations	Only one	Only three	All concentrations	All concentrations	All concentrations	
2	5-Dec-03	non-detect	detection	detections	non-detect	non-detect	non-detect	
3	6-Feb-04		no trend evaluated	no trend evaluated				
4	24-Feb-04							
5	9-Jun-04							
6	11-Oct-04							
7	22-Oct-04							
8	10-Dec-04							
9	30-Dec-04							
10	15-Feb-05							
11	5-Oct-05							
12	5-Jan-06							
13	2-Mar-06							
14	19-Jun-06							
15	19-Oct-06							
16	26-Feb-07							
17	5-Jun-07							
18	5-Sep-14							
19	8-Jun-15							
20								
	Coefficient of Variation:							
	Mann-Kendall Statistic (S):							
	Confidence Factor:							
	Concentration Trend:							



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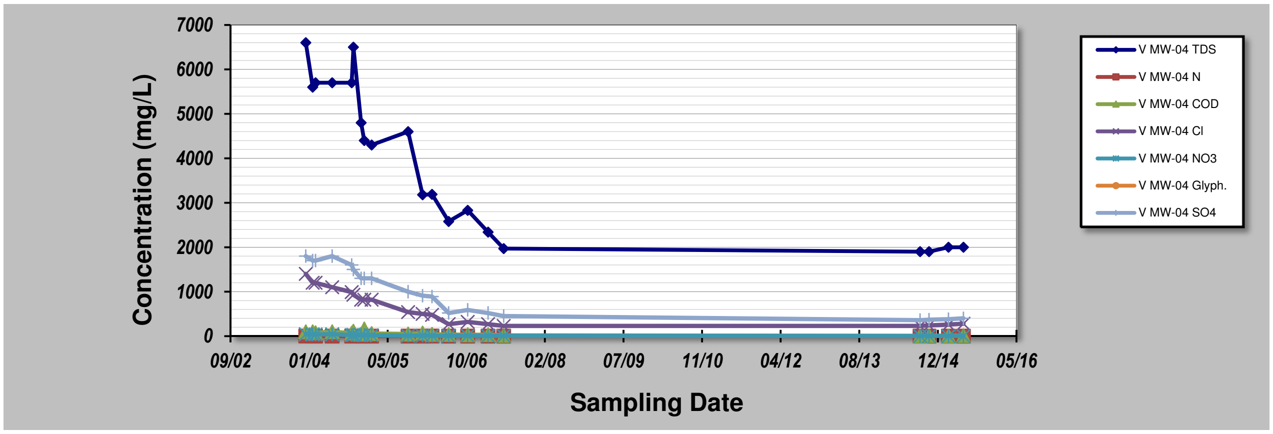
GSI Environmental Inc., www.gsi-net.com

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V MW-04 Inorganics
Concentration Units: mg/L

	Sampling Point ID:	V MW-04 TDS	V MW-04 N	V MW-04 COD	V MW-04 Cl	V MW-04 NO3	V MW-04 Glyph.	V MW-04 SO4
Sampling Event	**Sampling Date**	**V MW-04 INORGANICS CONCENTRATION (mg/L)**						
1	24-Dec-03	6600	1.5	98	1400	44		1800
2	6-Feb-04	5600	1.7	98	1200	41		1700
3	24-Feb-04	5700	1.3	77	1200	39		1700
4	9-Jun-04	5700	1.1	97	1100	42		1800
5	11-Oct-04	5700	0.98	68	990	24		1600
6	22-Oct-04	6500	1.5	110	930	30		1500
7	10-Dec-04	4800	0.98	46	820	24		1300
8	30-Dec-04	4400	0.98	160	820	23		1300
9	15-Feb-05	4300	0.98	59	820	20		1300
10	5-Oct-05	4600	1.1	47	540	10		1000
11	5-Jan-06	3180	0.84	69	500	11		910
12	6-Mar-06	3190	1.9	41	480	9		890
13	20-Jun-06	2580	0.7	36	270	7.8		520
14	19-Oct-06	2830	0.84	28	320	9.3		590
15	26-Feb-07	2340	1.1	32	270	8		520
16	5-Jun-07	1970	0.7	15	230	7.8		450
17	5-Sep-14	1900	0.26	**5**	230	1.5		360
18	1-Nov-14	1900	0.21	9.9	240	1.1		370
19	5-Mar-15	2000	0.22	6.3	260	0.77		380
20	8-Jun-15	2000	0.16	12	280	0.59		400
21							All concentrations	
22							non-detect	
23								
24								
25								
Coefficient of Variation:		0.43	0.52	0.74	0.61	0.84		0.53
Mann-Kendall Statistic (S):		-151	-122	-139	-160	-174		-166
Confidence Factor:		>99.9%	>99.9%	>99.9%	>99.9%	>99.9%		>99.9%
Concentration Trend:		Decreasing	Decreasing	Decreasing	Decreasing	Decreasing		Decreasing



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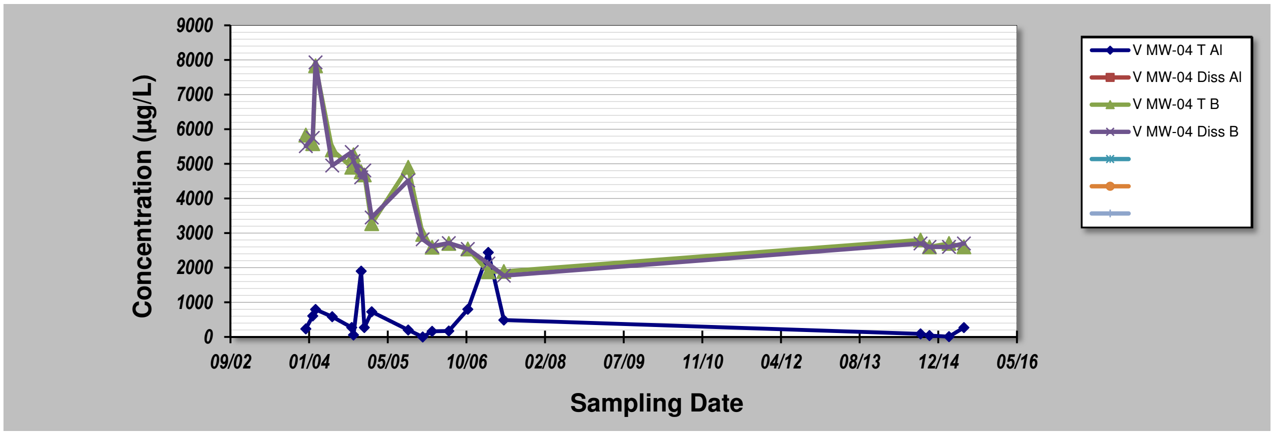
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-04 Metals
Concentration Units: µg/L

Sampling Point ID:		V MW-04 T Al	V MW-04 Diss Al	V MW-04 T B	V MW-04 Diss B			
Sampling Event	**Sampling Date**	**V MW-04 METALS CONCENTRATION (µg/L)**						
1	24-Dec-03	232		5830	5510			
2	6-Feb-04	607		5580	5750			
3	24-Feb-04	794		7830	7930			
4	9-Jun-04	584		5400	4950			
5	11-Oct-04	272		4900	5340			
6	22-Oct-04	55.7		5260	5080			
7	10-Dec-04	1900		4770	4610			
8	30-Dec-04	271		4680	4810			
9	15-Feb-05	727		3270	3450			
10	5-Oct-05	201		4900	4520			
11	5-Jan-06	**0.025**		2960	2820			
12	6-Mar-06	162		2590	2620			
13	20-Jun-06	171		2700	2710			
14	19-Oct-06	798		2540	2540			
15	26-Feb-07	2440		1880	2120			
16	5-Jun-07	488		1890	1770			
17	5-Sep-14	88		2800	2700			
18	1-Nov-14	40		2600	2600			
19	5-Mar-15	8.8		2700	2600			
20	8-Jun-15	270		2600	2700			
21			Only one					
22			detection					
23			no trend evaluated					
24								
25								
Coefficient of Variation:		1.25		0.42	0.42			
Mann-Kendall Statistic (S):		-46		-135	-140			
Confidence Factor:		92.7%		>99.9%	>99.9%			
Concentration Trend:		Prob. Decreasing		Decreasing	Decreasing			



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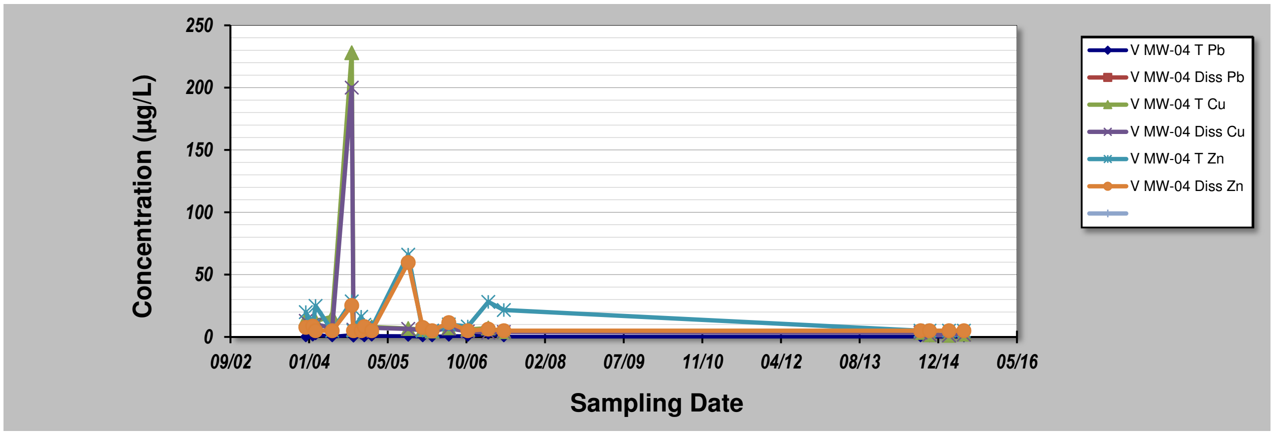
GSI MANN-KENDALL TOOLKIT

for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-04 Metals
Concentration Units: µg/L

Sampling Point ID:		V MW-04 T Pb	V MW-04 Diss Pb	V MW-04 T Cu	V MW-04 Diss Cu	V MW-04 T Zn	V MW-04 Diss Zn	
Sampling Event	**Sampling Date**	**V MW-04 METALS CONCENTRATION (µg/L)**						
1	24-Dec-03	**0.2**		14.4	12.9	19.9	7.68	
2	6-Feb-04	0.832		8.93	9.74	8.95	8.71	
3	24-Feb-04	1.86		12.8	10.1	24.9	**5**	
4	9-Jun-04	**0.2**		16.2	7.31	**5**	**5**	
5	11-Oct-04	1.54		228	200	28.5	25.3	
6	22-Oct-04	<0.5		6.01	5.85	**5**	**5**	
7	10-Dec-04	2.24		8.06	4.82	16.2	**5**	
8	30-Dec-04	**0.2**		6.77	7.09	9.71	8.3	
9	15-Feb-05	0.777		7.99	7.29	7.27	**5**	
10	5-Oct-05	0.623		6.74	6.44	66	59.7	
11	5-Jan-06	**0.2**		5.85	5.32	**5**	7.57	
12	6-Mar-06	**0.2**		4.68	5.01	**5**	**5**	
13	20-Jun-06	0.732		7.26	6.88	10	11.5	
14	19-Oct-06	0.593		5.97	4.45	8.34	5	
15	26-Feb-07	2.4		7.13	3.54	28.1	6.27	
16	5-Jun-07	**0.2**		4.18	4	21.6	**5**	
17	5-Sep-14	**0.2**		3.6	3.5	**5**	**5**	
18	1-Nov-14	**0.2**		1.7	1.7	**5**	**5**	
19	5-Mar-15	**0.2**		1.3	1.2	**5**	**5**	
20	8-Jun-15	**0.2**		2.2	1.8	**5**	**5**	
21			Only 1 detection					
22			no trend evaluated					
23								
24								
25								
Coefficient of Variation:		1.03		2.76	2.82	1.02	1.30	
Mann-Kendall Statistic (S):		-44		-134	-146	-46	-42	
Confidence Factor:		93.3%		>99.9%	>99.9%	92.7%	90.7%	
Concentration Trend:		Prob. Decreasing		Decreasing	Decreasing	Prob. Decreasing	Prob. Decreasing	



Notes:

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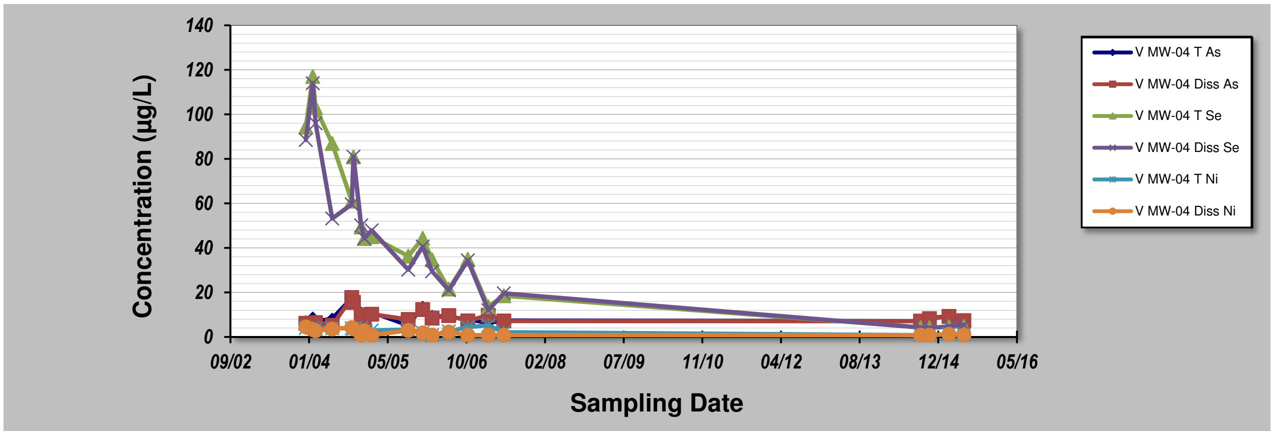
GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V MW-04 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-04 T As	V MW-04 Diss As	V MW-04 T Se	V MW-04 Diss Se	V MW-04 T Ni	V MW-04 Diss Ni	
Sampling Event	**Sampling Date**	**V MW-04 METALS CONCENTRATION (µg/L)**						
1	24-Dec-03	7.17	6.11	94.3	88.5	4	4.5	
2	6-Feb-04	8.88	5.76	117	114	4.1	3.3	
3	24-Feb-04	6.98	6.41	103	96	3.6	2.8	
4	9-Jun-04	8.37	5.17	86.9	53.2	3.9	3.6	
5	11-Oct-04	17.5	17.7	61	59.6	3.9	4.2	
6	22-Oct-04	15.8	15.5	80.9	81	3.6	3.6	
7	10-Dec-04	11.1	9.93	49.4	50.1	4.2	**0.8**	
8	30-Dec-04	5.79	6.22	44.2	44.3	2.6	2.7	
9	15-Feb-05	11	10.2	45	47.9	2.9	**0.8**	
10	5-Oct-05	5.1	7.82	36.3	30.2	3.3	2.9	
11	5-Jan-06	13.7	12.3	44.3	40.6	1.9	1.8	
12	6-Mar-06	9.68	8.45	34.7	29.5	**0.8**	**0.8**	
13	20-Jun-06	9.13	9.59	21.5	21	2.5	2.2	
14	19-Oct-06	7.92	7.19	34.9	34.4	4.4	**0.8**	
15	26-Feb-07	6.1	9.72	13.6	12	5.2	**0.8**	
16	5-Jun-07	7.46	7.14	18.5	19.6	2.1	**0.8**	
17	5-Sep-14	7.2	7.1	4.3	4.2	**0.8**	**0.8**	
18	1-Nov-14	8.5	8.2	4.2	4	0.8	**0.8**	
19	5-Mar-15	9.4	9.2	4.6	4.7	1.4	1.2	
20	8-Jun-15	7.9	7.3	4.7	5.4	1	**0.8**	
21								
22								
23								
24								
25								
	Coefficient of Variation:	0.35	0.36	0.78	0.77	0.48	0.66	
	Mann-Kendall Statistic (S):	-22	12	-162	-158	-87	-101	
	Confidence Factor:	75.0%	63.8%	>99.9%	>99.9%	99.8%	>99.9%	
	Concentration Trend:	Stable	No Trend	Decreasing	Decreasing	Decreasing	Decreasing	



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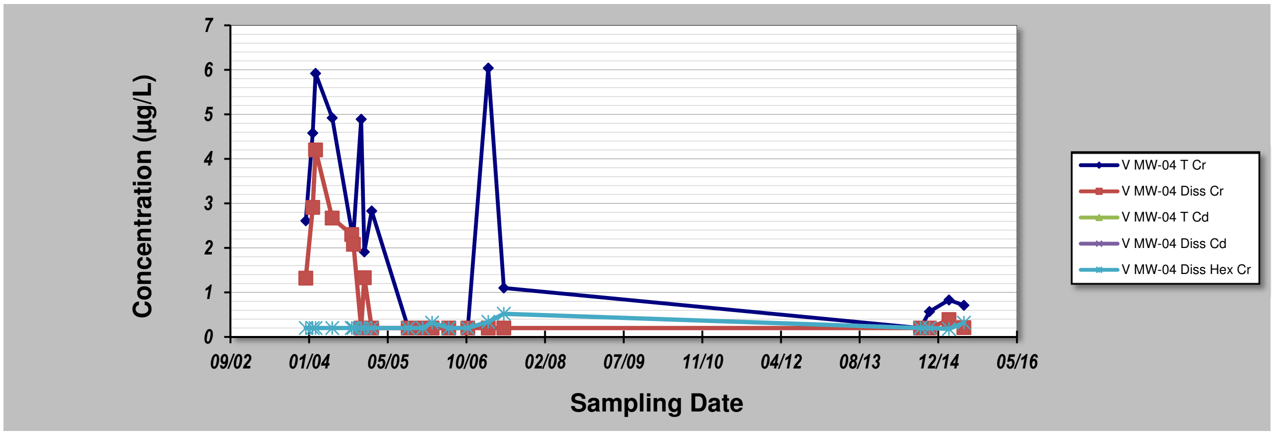
Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe

Job ID: IR13164280
Constituent: V MW-04 Metals
Concentration Units: µg/L

	Sampling Point ID:	V MW-04 T Cr	V MW-04 Diss Cr	V MW-04 T Cd	V MW-04 Diss Cd	MW-04 Diss Hex Cr		
Sampling Event	**Sampling Date**	**V MW-04 METALS CONCENTRATION (µg/L)**						
1	24-Dec-03	2.61	1.32			**0.2**		
2	6-Feb-04	4.58	2.91			**0.2**		
3	24-Feb-04	5.92	4.2			**0.2**		
4	9-Jun-04	4.92	2.67			**0.2**		
5	11-Oct-04	2.38	2.3			**0.2**		
6	22-Oct-04	2.31	2.08			**0.2**		
7	10-Dec-04	4.89	**0.2**			**0.2**		
8	30-Dec-04	1.91	1.33			**0.2**		
9	15-Feb-05	2.83	**0.2**			**0.2**		
10	5-Oct-05	**0.2**	**0.2**			**0.2**		
11	5-Jan-06	**0.2**	**0.2**			**0.2**		
12	6-Mar-06	**0.2**	**0.2**			0.32		
13	20-Jun-06	**0.2**	**0.2**			**0.2**		
14	19-Oct-06	**0.2**	**0.2**			**0.2**		
15	26-Feb-07	6.04	**0.2**			0.34		
16	5-Jun-07	1.1	**0.2**			0.52		
17	5-Sep-14	**0.2**	**0.2**			**0.2**		
18	1-Nov-14	0.57	**0.2**			**0.2**		
19	5-Mar-15	0.83	0.39			0.18		
20	8-Jun-15	0.71	0.21			0.32		
21				All concentrations	All concentrations			
22				non-detect	non-detect			
23								
24								
25								
	Coefficient of Variation:	0.97	1.23			0.35		
	Mann-Kendall Statistic (S):	-71	-75			28		
	Confidence Factor:	98.9%	99.3%			80.7%		
	Concentration Trend:	Decreasing	Decreasing			No Trend		



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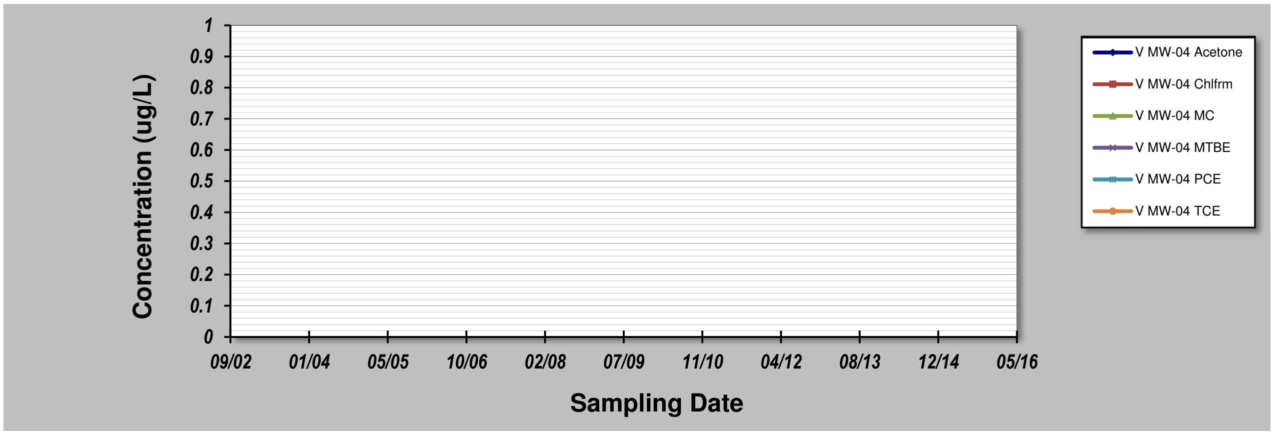
Evaluation Date: 6-Aug-15
Facility Name: Watershed Augmentation Study
Conducted By: K. Howe
Job ID: IR13164280
Constituent: V MW-04 VOCs
Concentration Units: ug/L

	Sampling Point ID:	V MW-04 Acetone	V MW-04 Chlfrm	V MW-04 MC	V MW-04 MTBE	V MW-04 PCE	V MW-04 TCE	
Sampling Event	**Sampling Date**	**V MW-04 VOCS CONCENTRATION (ug/L)**						
1	24-Dec-03							
2	6-Feb-04							
3	24-Feb-04							
4	9-Jun-04							
5	11-Oct-04							
6	22-Oct-04							
7	10-Dec-04							
8	30-Dec-04							
9	15-Feb-05							
10	5-Oct-05							
11	5-Jan-06							
12	6-Mar-06							
13	20-Jun-06							
14	19-Oct-06							
15	26-Feb-07							
16	5-Jun-07							
17	5-Sep-14							
18	1-Nov-14							
19	5-Mar-15							
20	8-Jun-15							
21		Only two detections	All concentrations	Only two detections	All concentrations	All concentrations	All concentrations	
22		No trend evaluated	non-detect	No trend evaluated	non-detect	non-detect	non-detect	
23								
24								
25								
	Coefficient of Variation:							
	Mann-Kendall Statistic (S):							
	Confidence Factor:							
	Concentration Trend:							



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