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Lawrence Livermore National Laboratory
Experimental Test Site 300

Compliance Monitoring Program for the Closed Building 829 Facility

Annual Report
2018

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Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.

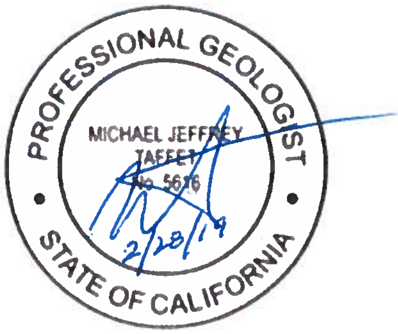

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Table of Contents

Tables

Figures

Appendices

1.0 General Description of the Building 829 (B829) Facility at Site 300

1.1 Description of Site 300

The Lawrence Livermore National Laboratory (LLNL) Experimental Test Site (Site 300) is owned by the U.S. Department of Energy (DOE) and, effective October 1, 2007, has been operated by Lawrence Livermore National Security, LLC (LLNS). This site is located in the southern Altamont Hills of the Diablo Range, which are part of the Coast Range Physiographic Province. It is situated about 20 km (12 mi) east of the LLNL Livermore Site (**Figure 1**). Site 300 covers an area of approximately 28.3 km^2 (10.9 mi^2) north of Corral Hollow Road (**Figure 2**). Its elevation ranges from about 150 m (490 ft) in the southeast corner to about 530 m (1740 ft) in the northwest area. The western one-sixth of the site lies in Alameda County; the remaining portion is in San Joaquin County. The surrounding land is primarily agricultural. Site 300 is an active Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site.

1.2 Description of the B829 Facility

As shown in **Figure 2**, the B829 Facility is located in the High-Explosives (HE) Chemistry Area in the south-central portion of Site 300. The B829 Facility, part of the B829 Complex, was used to thermally treat explosives process waste generated by operations at Site 300 and similar waste from explosives research operations at the LLNL Livermore Site. The B829 Facility was operated under the Resource Conservation and Recovery Act (RCRA) as an interim status treatment facility. Built in 1955, the B829 Facility consisted of three separate burn pits, which were constructed in unconsolidated sediments, and an open-air burn unit. The B829 Facility was closed in 1998, and an impervious cap was constructed over the burn pits as described in the *Final Closure Plan for the High-Explosives Open Burn Treatment Facility at Lawrence Livermore National Laboratory Experimental Test Site 300* (B829 Final Closure Plan) (Mathews and Taffet, 1997).

2.0 Post-Closure Monitoring and Inspection Activities

Monitoring and inspection of the closed burn pits during the post-closure period reflect the prime consideration: to protect human health and the environment by preventing any infiltration of rainwater that may cause the low concentrations of metals, radioactivity (i.e., gross alpha and gross beta), explosive compounds, and volatile organic compounds (VOCs) in near-surface soils to migrate to groundwater. The design of the post-closure plan was originally presented in Chapter 2 of the *B829 Final Closure Plan* (Mathews and Taffet, 1997).

In January 2002, LLNL submitted a revised *Post-Closure Permit Application for the B829 Facility* (LLNL, 2001) to the Department of Toxic Substances Control (DTSC). Subsequently, in February 2003, the DTSC issued the *Hazardous Waste Facility Post-Closure Permit for the B829 Facility* (DTSC, 2003), effective April 3, 2003 through April 2, 2013.

LLNL requested a permit modification in April 2005 (LLNL, 2005) to amend the text of the Building 829 Post Closure Operation Plan (formerly known as the "Post Closure Permit Application"). The revised operations plan reflected reductions in monitoring frequency for wells W-829-15 and W-829-22 as provided in Part III, 4(a) of the permit (DTSC, 2003), and wells W-829-15 and W-829-22 as provided in Part III, 4(a) of the permit (DTSC, 2003), and included statistical limits for constituents of concern consistent with the data contained in the LLNL Site 300 *Compliance Monitoring Program for the Closed Building 829 Facility* Annual Report 2004 (Revelli, 2005). On July 20, 2005, DTSC granted LLNL permission to implement these changes immediately (DTSC, 2005). A second modification was requested by LLNL in April 2008 (LLNL, 2008) to update current operations, and DTSC determined that LLNL could implement the five Class 1 changes that do not need DTSC's prior approval (DTSC, 2009).

On October 2, 2012, LLNL submitted to DTSC the Site 300 Building 829 (B829) Post-Closure Permit Renewal Application (LLNL, 2012) for this facility. The permit renewal application included a revised Operations Plan that reduced monitoring frequency of well W-829-1938 from quarterly to annually. In April 2017, DTSC renewed the *Hazardous Waste Facility Post-Closure Permit for the B829 Facility* (DTSC, 2017), effective April 27, 2017 through April 27, 2027, which included approval for the reduced monitoring frequency for well W-829-1938.

2.1 Groundwater Monitoring

Based on the analysis of groundwater samples recovered from boreholes, previous CERCLA remedial investigations determined that the perched groundwater near the B829 Facility was contaminated with VOCs, primarily trichloroethene (TCE), but that the deeper regional aquifer was free of any contamination stemming from operation of the facility (Webster-Scholten, 1994). Subsequent assays of soil samples obtained from shallow boreholes prior to closure revealed that low concentrations of HE compounds, VOCs, and metals existed beneath the burn pits (Mathews and Taffet, 1997). Conservative fate and transport modeling indicates that the shallow contamination will not adversely impact the regional aquifer, primarily because its downward movement is impeded and attenuated by more than 100 m (330 ft) of unsaturated Neroly Formation sedimentary rocks that include interbeds of claystone and siltstone. At this location, groundwater flow velocity in the regional aquifer is about 20 feet/year, and the direction of flow is approximately east-southeast.

Beginning in 1999, the dual-purpose, groundwater-monitoring program described in the *B829 Final Closure Plan* (Mathews and Taffet, 1997) was initiated for this area to track the fate of contaminants in the soil and perched water-bearing zone, and to monitor the deep regional aquifer for the unlikely appearance of any potential contaminants from the closed burn facility. This monitoring program remained in effect through the first quarter of 2003, at which time LLNL began implementation of the provisions specified in the *Hazardous Waste Facility Post-Closure Permit for the B829 Facility* (DTSC, 2003). Following the guidance outlined in the DTSC *Technical Completeness* (DTSC, 2002) assessment, LLNL installed one additional groundwater monitoring well (W-829-1938) at the point of compliance (POC) within 10 ft of the edge of the capped High Explosive Open Burn Treatment Facility. This well was screened in the regional aquifer, beneath the B829 Facility. From the first quarter of 2004 through the second quarter of 2017, well W-829-1938 was used for quarterly collection of groundwater samples from the regional aquifer as part of the permit-specified monitoring network (**Figure 3**). In the renewed permit issued in April 2017, DTSC approved a change from quarterly sampling to annual sampling of W-829-1938, effective on April 27, 2017 (DTSC, 2017). Also shown in **Figure 3** are two previously existing wells (W-829-15 and W-829-22), which were each sampled once in 2018, in accordance with the DTSC-approved change in sampling frequency (from quarterly to annually) for these two wells (DTSC, 2005). All samples collected from the B829 Facility monitoring network wells in 2018 were analyzed for the permit-specified constituents of concern. Constituents of concern, as defined by Title 23 of the California Code of Regulations (CCR), Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from the B829 burn pits. The data obtained during 2018 are discussed in **Section 3.1.**

LLNL uses statistical methods consistent with the state regulations [CCR Title 22, Section 66264.97(e)(8)(D)] to accomplish the monitoring and reporting provisions of the post-closure plan (Mathews and Taffet, 1997). The methodology relies on the ability to establish a background concentration, which is defined as the concentration limit (CL), for each constituent of concern. Additionally, statistically determined limits of concentration (SLs) for the constituents of concern have been calculated from the monitoring data.

The CL and SL values presented in **Table 1** replicate those limits documented in previous annual reports. For wells W-829-15 and W-829-22, established before the permit (DTSC, 2003) was issued, the limits were first included in the 2002 Annual Report (Revelli, 2003). For well W-829-1938, the CLs and SLs were developed in accordance with DTSC requirements (DTSC, 2002) and first included in the 2005 Annual Report (Revelli, 2006). These SL values (**Table 1**) served as the limits against which the analytical results from 2018 were compared. The SLs for most constituents of concern in **Table 1** are given as the analytical reporting limits (RLs) because historic concentrations are below the reporting limits for those constituents.

SLs provide the basis for comparison with constituent of concern measurements for subsequent years to identify potential releases to the deep regional aquifer. If a future measurement exceeds a SL, LLNL will implement a method of data verification that involves two discrete retests, in accordance with CCR Section 66264.97(e)(8)(E). If an exceedance is confirmed by either or both retests, these results will be interpreted and reported as "statistically significant evidence of a release of the constituent of concern to groundwater."

2.2 Inspection and Maintenance

The permit (DTSC, 2017) requires that LLNL perform quarterly inspections of the monitoring wells and monthly visual inspections of the closed B829 Facility (final cover cap, drainage and diversion ditches, groundwater monitoring system, signage, etc.). Additional inspections are required after major rainstorms, significant earthquakes, or other events that may cause substantial damage to the capped facility. Any deficiencies noted, such as erosion of the cover, fissures or low spots, burrowing by animals, and bare areas needing reseeding, are remediated. In addition to these inspections performed by LLNL staff, an independent, California-registered Professional Engineer (PE) must perform an annual engineering inspection. The PE prepares a written inspection report, which includes comments and recommendations, and submits that documentation to LLNL.

3.0 Results of Post-Closure Monitoring and Inspection for 2018

3.1 Discussion of Monitoring Results

The 2018 analytical results for wells W-829-15, W-829-22, and W-829-1938 are listed in **Tables 2, 3, and 4**, respectively. The annual sampling was conducted during the second quarter of 2018.

Note that all non-detections of constituents are shown in the data tables as being less than (<) each analytical reporting limit (RL).

Appendix A presents graphical depictions of groundwater elevations (GWE) and concentration trends for all confirmed constituent of concern detections above their respective RLs, for the permit-specified wells (W-829-15, W-829-22, and W-829-1938). Graphs for the two established wells (W-829-15 and W-829-22) present data accumulated since 2002. The graphs for well W-829-1938, which was installed during 2003, present quarterly data from the first quarter of 2004 to the second quarter 2017, and annual data from 2018.

In addition to the permit-required semi-annual GWE measurements plotted in **Appendix A**, LLNL collects quarterly GWE measurements for the wells in this network as part of a larger, site-wide study (**Tables 2, 3, and 4**). The GWEs for all three wells show little fluctuation (no more than three feet) across the four quarterly measurements. In accordance with permit requirements, LLNL also collects field data at least semi-annually for pH, temperature, and specific conductance (see **Tables 2, 3, and 4**). The 2018 field data for these parameters are consistent with results from recent years.

As in past years, the concentration trends shown in **Appendix A** generally reflect the natural background variability of the analytes detected at each of the three monitoring well locations. The metal concentrations are not significantly different from background concentrations (the CLs shown in **Table 1**) with the exception of barium in well W-829-15 (52 µg/L), which remains at approximately twice the calculated CL (CL=26 µg/L, SL=75 µg/L), and manganese in well W-829-1938 (38 µg/L), which is approximately 60% of the originally calculated background concentration (CL=63 µg/L, SL=150 µg/L). As shown in the corresponding **Appendix A** plot, the barium result for well W-829-15 and manganese result for W-829-1938 are consistent with previously reported values.

For several years, the plot for gross beta radioactivity at well W-829-15 has suggested that the more recent data (2003 to present) may indicate less variability and a slightly lower background value (as compared to the CL presented in **Table 1**) for this constituent. Similarly, chromium, nickel, and zinc concentrations at well W-829-1938 have remained below their typical reporting limits of 1 µg/L, 5 µg/L, and 20 µg/L, respectively, after initial detections in 2004 or 2005. LLNL will continue to monitor for similar trends in background concentrations as additional data become available.

As shown in Tables 2 and 3, zinc was initially detected above its statistical limit (SL=20 µg/L) in the routine second quarter 2018 groundwater samples collected at wells W-829-15 and W-829-22. The initial zinc concentrations for the second quarter 2018 samples were 31 µg/L and 28 µg/L for wells W-829-15 and W-829-22, respectively (**Tables 2 and 3**). During the routine second quarter sampling, the contract analytical laboratory reported zinc in the field blank at a concentration that exceeded both the SL of 20 µg/L and the zinc concentrations reported for wells W-829-15 and W-829-22. Nevertheless, LLNL initiated retests and reported these findings to the DTSC (LLNL, 2018a). To confirm the initial results, LLNL employed a method of data validation that utilizes discrete retests and is consistent with state regulations [CCR Title 22, Section 66264.97(e)(8)(E)]. Two retest samples were collected from each well during the second quarter, and all samples were analyzed for zinc using the same analytical test (EPA Method E200.7). For both wells, the zinc concentrations from the first retest were equal to, but did not exceed, the SL. The second retest resulted in zinc concentrations of 22 µg/L for both wells, which slightly exceeded the SL. Similar to the routine second quarter sample for zinc, the contract laboratory detected zinc in the field blanks poured at the sampling locations during the two independent retests (see footnotes in **Tables 2 and 3**). In the approximately 20-year history of sampling at W-829-15 and W-829-22, zinc was previously detected on only one occasion at each well, and the previous follow-up retests invalidated the initial detections. Based on the detection of zinc in the field blanks, LLNL concluded in a letter to the DTSC that the zinc data are inconclusive and do not constitute evidence of a release from the burn pit (LLNL, 2018b). LLNL will continue annual monitoring of zinc.

During the routine second quarter 2018 sampling, the manganese concentration at well W-829-22 was 13 µg/L (**Table 3**), which slightly exceeded the SL of 10 µg/L. LLNL initiated retest sampling and reported the results to the DTSC (LLNL, 2018a). The manganese concentration for the first retest sample collected at well W-829-22 was 14 µg/L, which exceeded the SL of 10 µg/L. The second retest concentration was below the method detection limit of 10 µg/L, and therefore was below the SL. According to the state-approved methodology, the detection of a constituent in one of two retest samples validates the initial detection of manganese. However, given the natural presence of manganese in the deep regional aquifer beneath the B-829 Facility, as well as the history of W-829-22 showing no previous detections of this constituent, LLNL concluded in a letter to the DTSC that the detection of manganese is from naturally occurring sources and not evidence of a release from the closed burn pit (LLNL, 2018b). LLNL will continue annual monitoring of manganese.

In summary, the only constituent of concern detections above their respective SLs were manganese and zinc detected in well W-829-22 and zinc detected in well W-829-15; however, LLNL concluded that these detections were not evidence of release. All results for gross alpha and gross beta (the radioactive constituents of concern) were below their SL values. Neither organic nor explosive constituents of concern were detected in any samples at concentrations above their respective RLs.

3.2 Inspection of the B829 Facility

During 2018, LLNL staff completed twelve post-closure inspections of the covered area at the B829 Facility and four quarterly inspections of the monitoring well network. The monthly inspection checklist form used during these LLNL inspections is provided in **Figure 4.** The checklist form used to document the monitoring well inspections, which are required quarterly, is shown in **Figure 5.** All completed forms are retained for three years in the Site 300 Manager's Office files.

The required annual cap inspection by a California-registered Professional Engineer was completed on April 30, 2018. [A copy of the *Building 829 Landfill Cap Annual Engineering Inspection* (Moore, 2018) is included in this report as **Appendix B**.] The inspection included a review of existing documentation on the cap as well as an on-site inspection. All items required to be inspected under Title 22 of the CCR, Part 66264.228(k) were noted to be in good condition, except for evidence of vegetative debris accumulation and minor damage in the caulking in the drainage ditch. The two recommendations made in the annual engineering report include removing the vegetative debris and repairing the caulking in the drainage ditch. The recommendations were implemented by the Site 300 Manager's Office during 2018.

4.0 References

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Table 1. Constituents of concern, typical analytical reporting limit (RL), background concentration limit (CL)[a], and statistical limit (SL)[b] for B829 Facility monitoring wells W-829-15, W-829-22, and W-829-1938.

Constituent of concern	Typical analytical RL	Unit of measure	Well W-829-15		Well W-829-22		Well W-829-1938	
			CL	SL	CL	SL	CL	SL
Antimony	5	µg/L	<RL	RL	<RL	RL	<RL	RL
Arsenic	2	µg/L	17	22	<2.9	2.9	26	42
Barium	25	µg/L	26	75	<RL	RL	22	30
Beryllium	0.5	µg/L	<RL	RL	<RL	RL	<RL	RL
Cadmium	0.5	µg/L	<RL	RL	<RL	RL	<RL	RL
Chromium	1	µg/L	2.2	7.8	0.9	1.5	0.8	3.9
Cobalt	25	µg/L	<RL	RL	<RL	RL	<RL	RL
Copper	10	µg/L	<RL	RL	<RL	RL	<RL	RL
Lead	2	µg/L	<RL	RL	<RL	RL	<RL	RL
Manganese	10	µg/L	<RL	RL	<RL	RL	63	150
Mercury	0.2	µg/L	<RL	RL	<RL	RL	<RL	RL
Molybdenum	25	µg/L	24	27	<RL	RL	23	32
Nickel	5	µg/L	<RL	RL	<RL	RL	4.9	19
Selenium	2	µg/L	<RL	RL	<RL	RL	<RL	RL
Silver	0.5	µg/L	<RL	RL	<RL	RL	<RL	RL
Vanadium	25	µg/L	<RL	RL	<RL	RL	<RL	RL
Zinc	20	µg/L	<RL	RL	<RL	RL	11	30
Perchlorate	4	µg/L	<RL	RL	<RL	RL	<RL	RL

(continued)

Table 1. Constituents of concern, typical analytical reporting limit (RL), background concentration limit (CL)[a], and statistical limit (SL)[b] for B829 Facility monitoring wells W-829-15, W-829-22, and W-829-1938.

Constituent of concern	Typical analytical RL	Unit of measure	Well W-829-15		Well W-829-22		Well W-829-1938	
			CL	SL	CL	SL	CL	SL
1,1,1-Trichloroethane	1	µg/L	<RL	RL	<RL	RL	<RL	RL
1,1-Dichloroethene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
1,2-Dichloroethane	1	µg/L	<RL	RL	<RL	RL	<RL	RL
cis-1,2-Dichloroethene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
trans-1,2-Dichloroethene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
1,2-Dichloroethene (total)	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Benzene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Carbon disulfide	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Chloroform	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Dichlorodifluoromethane	2	µg/L	<RL	RL	<RL	RL	<RL	RL
Ethylbenzene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Freon 113	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Tetrachloroethene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Toluene	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Total xylene isomers	2	µg/L	<RL	RL	<RL	RL	<RL	RL
Trichloroethene	0.5	µg/L	<RL	RL	<RL	RL	<RL	RL
Trichlorofluoromethane	1	µg/L	<RL	RL	<RL	RL	<RL	RL
Bis(2-ethylhexyl)phthalate	5	µg/L	<RL	RL	<RL	RL	<RL	RL
Phenols	5	µg/L	<RL	RL	<RL	RL	<RL	RL
HMX	1.0	µg/L	<RL	RL	<RL	RL	<RL	RL
RDX	1.0	µg/L	<RL	RL	<RL	RL	<RL	RL
TNT	5.0	µg/L	<RL	RL	<RL	RL	<RL	RL
Gross alpha	0.074	Bq/L	0	0.123	0	RL	0.01	0.11
Gross beta	0.11	Bq/L	1.81	3.77	0.27	0.43	0.42	0.55

[a] CL is defined as the average background concentration of a constituent of concern.

[b] SL is defined as the concentration of a constituent of concern, above which an exceedance occurs.

Table 2. B829 area deep well W-829-l5 monitoring results for 2018. Constituent detections printed in bold are discussed in the text.

Constituents	Sampling dates 2018			
	01/22/18[a]	**04/05/18**	**08/06/18[a]**	**10/09/18[b]**
Field Data (units)				
Groundwater elevation (feet)[c]	696.1	695.9	694.1	695.4
pH (pH Units)		8.19		8.24
Temperature (degrees Celsius)		25.4		24.1
Specific conductance (µmho/cm)		1027		1042
Inorganic (µg/L)				
Antimony		<5		
Arsenic		18		
Barium		**52**		
Beryllium		<0.5		
Cadmium		<0.5		
Chromium		<1		
Cobalt		<25		
Copper		<10		
Lead		<2		
Manganese		<10		
Mercury		<0.2		
Molybdenum		<25		
Nickel		<5		
Selenium		<2		
Silver		<0.5		
Vanadium		<25		
Zinc		**31**[d]		
Perchlorate		<4		
Turbidity (NT Units)		0.21		
Organic (µg/L)				
1,1,1-Trichloroethane		<1		
1,1-Dichloroethene		<1		
1,2-Dichloroethane		<1		
cis-1,2-Dichloroethene		<1		
trans-1,2-Dichloroethene		<1		
1,2-Dichloroethene (total)		<1		
Benzene		<1		
Carbon disulfide		<1		
Chloroform		<1		
Dichlorodifluoromethane		<2		
Ethylbenzene		<1		
Freon 113		<1		
Tetrachloroethene		<1		
Toluene		<1		
Total xylene isomers		<2		
Trichloroethene		<0.5		
Trichlorofluoromethane		<1		
Bis(2-ethylhexvl)phthalate		<5		
Phenol		<5		

(continued)

Table 2. B829 area deep well W-829-l5 monitoring results for 2018 (concluded). Constituent detections printed in bold are discussed in the text.

Constituents	Sampling dates 2018			
	01/22/18[a]	**04/05/18**	**08/06/18[a]**	**10/09/18[b]**
Explosives (µg/L)				
HMX		<1		
RDX		<1		
TNT		<5		
Radioactivity (Bq/L)[e]				
Gross alpha		-0.0032±0.044		
Gross beta		0.67±0.12		

[a] No sampling required, but groundwater elevation is measured as part of a larger, site-wide study.
[b] Only field measurements are required.
[c] Groundwater elevation (GWE) measurements are reported in units of feet above mean sea level.
[d] Analytical results from two discrete retests were 20 and 22 µg/L. During initial routine sampling and both retest sampling events, zinc was detected in the field blanks, therefore LLNL concluded that the results were inconclusive.
[e] Radioactivity results in Becquerels/liter (Bq/L) are shown as the reported sample radioactivity and associated 2 sigma counting errors. (Divide these values by 0.037 to convert them to picocuries/liter.)
The reported value is negative when the measured sample radioactivity is less than the measured background activity.
The result is zero when the measured sample radioactivity is equal to the measured background activity.

Table 3. B829 area deep well W-829-22 monitoring results for 2018. Constituent detections printed in bold are discussed in the text.

	Sampling dates 2018			
Constituents	**01/22/18[a]**	**04/09/18**	**08/06/18[a]**	**10/09/18[b]**
Field Data (units)				
Groundwater elevation (feet)[c]	655.4	655.3	655.6	655.3
pH (pH Units)		8.41		8.41
Temperature (degrees Celsius)		25.6		24.2
Specific conductance (µmhos/cm)		1062		1047
Inorganic (µg/L)				
Antimony		<5		
Arsenic		<2		
Barium		<25		
Beryllium		<0.5		
Cadmium		<0.5		
Chromium		<1		
Cobalt		<25		
Copper		<10		
Lead		<2		
Manganese		**13[d]**		
Mercury		<0.2		
Molybdenum		<25		
Nickel		<5		
Selenium		<2		
Silver		<0.5		
Vanadium		<25		
Zinc		**28[e]**		
Perchlorate		<4		
Turbidity (NT Units)		0.45		
Organic (µg/L)				
1,1,1-Trichloroethane		<1		
1,1-Dichloroethene		<1		
1,2-Dichloroethane		<1		
cis-1,2-Dichloroethene		<1		
trans-1,2-Dichloroethene		<1		
1,2-Dichloroethene (total)		<1		
Benzene		<1		
Carbon disulfide		<1		
Chloroform		<1		
Dichlorodifluoromethane		<2		
Ethylbenzene		<1		
Freon 113		<1		
Tetrachloroethene		<1		
Toluene		<1		
Total xylene isomers		<2		
Trichloroethene		<0.5		
Trichlorofluoromethane		<1		
Bis(2-ethylhexvl)phthalate		<5		
Phenol		<5		

(continued)

Table 3. B829 area deep well W-829-22 monitoring results for 2018 (concluded). Constituent detections printed in bold are discussed in the text.

Constituents	Sampling dates 2018			
	01/22/18[a]	**04/09/18**	**08/06/18[a]**	**10/09/18[b]**
Explosives (µg/L)				
HMX		<1		
RDX		<1		
TNT		<5		
Radioactivity (Bq/L)[f]				
Gross alpha		-0.012±0.052		
Gross beta		0.25±0.06		

[a] No sampling required, but groundwater elevation is measured as part of a larger, site-wide study.
[b] Only field measurements are required.
[c] Groundwater elevation (GWE) measurements are reported in units of feet above mean sea level.
[d] Analytical results from two discrete retests were 14 and 10 µg/L. LLNL concluded that the manganese detection is likely from naturally occurring sources.
[e] Analytical results from two discrete retests were 20 and 22 µg/L. During initial routine sampling and both retest sampling events, zinc was detected in the field blanks, therefore LLNL concluded that the results were inconclusive.
[f] Radioactivity results in Becquerels/liter (Bq/L) are shown as the reported sample radioactivity and associated 2 sigma counting errors. (Divide these values by 0.037 to convert them to picocuries/liter.)
The reported value is negative when the measured sample radioactivity is less than the measured background activity.
The result is zero when the measured sample radioactivity is equal to the measured background activity.

Table 4. B829 area deep well W-829-1938 monitoring results for 2018. Constituent detections printed in bold are discussed in the text.

Constituents	Sampling dates 2018			
	01/22/18[a]	**04/11/18**	**08/06/18[a]**	**10/10/18[b]**
Field Data (units)				
Groundwater elevation (feet)[c]	706.0	705.9	704.1	703.9
pH (pH Units)		7.69		8.03
Temperature (degrees Celsius)		20.9		19.8
Specific conductance (µmho/cm)		1075		1083
Inorganic (µg/L)				
Antimony		<5		
Arsenic		21		
Barium		<25		
Beryllium		<0.5		
Cadmium		<0.5		
Chromium		<1		
Cobalt		<25		
Copper		<10		
Lead		<2		
Manganese		**38**		
Mercury		<0.2		
Molybdenum		<25		
Nickel		<5		
Selenium		<2		
Silver		<0.5		
Vanadium		<25		
Zinc		<20		
Perchlorate		<4		
Turbidity (NT Units)		0.43		
Organic (µg/L)				
1,1,1-Trichloroethane		<1		
1,1-Dichloroethene		<1		
1,2-Dichloroethane		<1		
cis-1,2-Dichloroethene		<1		
trans-1,2-Dichloroethene		<1		
1,2-Dichloroethene (total)		<1		
Benzene		<1		
Carbon disulfide		<1		
Chloroform		<1		
Dichlorodifluoromethane		<2		
Ethylbenzene		<1		
Freon 113		<1		
Tetrachloroethene		<1		
Toluene		<1		
Total xylene isomers		<2		
Trichloroethene		<0.5		
Trichlorofluoromethane		<1		
Bis(2-ethylhexvl)phthalate		<5		
Phenol		<5		

(continued)

Table 4. B829 area deep well W-829-1938 monitoring results for 2018 (concluded). Constituent detections printed in bold are discussed in the text.

Constituents	Sampling dates 2018			
	01/22/18[a]	**04/11/18**	**08/06/18[a]**	**10/10/18[b]**
Explosives (µg/L)				
HMX		<1		
RDX		<1		
TNT		<5		
Radioactivity (Bq/L)[d]				
Gross alpha		0.081±0.055		
Gross beta		0.40±0.08		

[a] No sampling required, but groundwater elevation is measured as part of a larger, site-wide study.
[b] Only field measurements are required.
[c] Groundwater elevation (GWE) measurements are reported in units of feet above mean sea level.
[d] Radioactivity results in Becquerels/liter (Bq/L) are shown as the reported sample radioactivity and associated 2 sigma counting errors. (Divide these values by 0.037 to convert them to picocuries/liter.)
The reported value is negative when the measured sample radioactivity is less than the measured background activity.
The result is zero when the measured sample radioactivity is equal to the measured background activity.

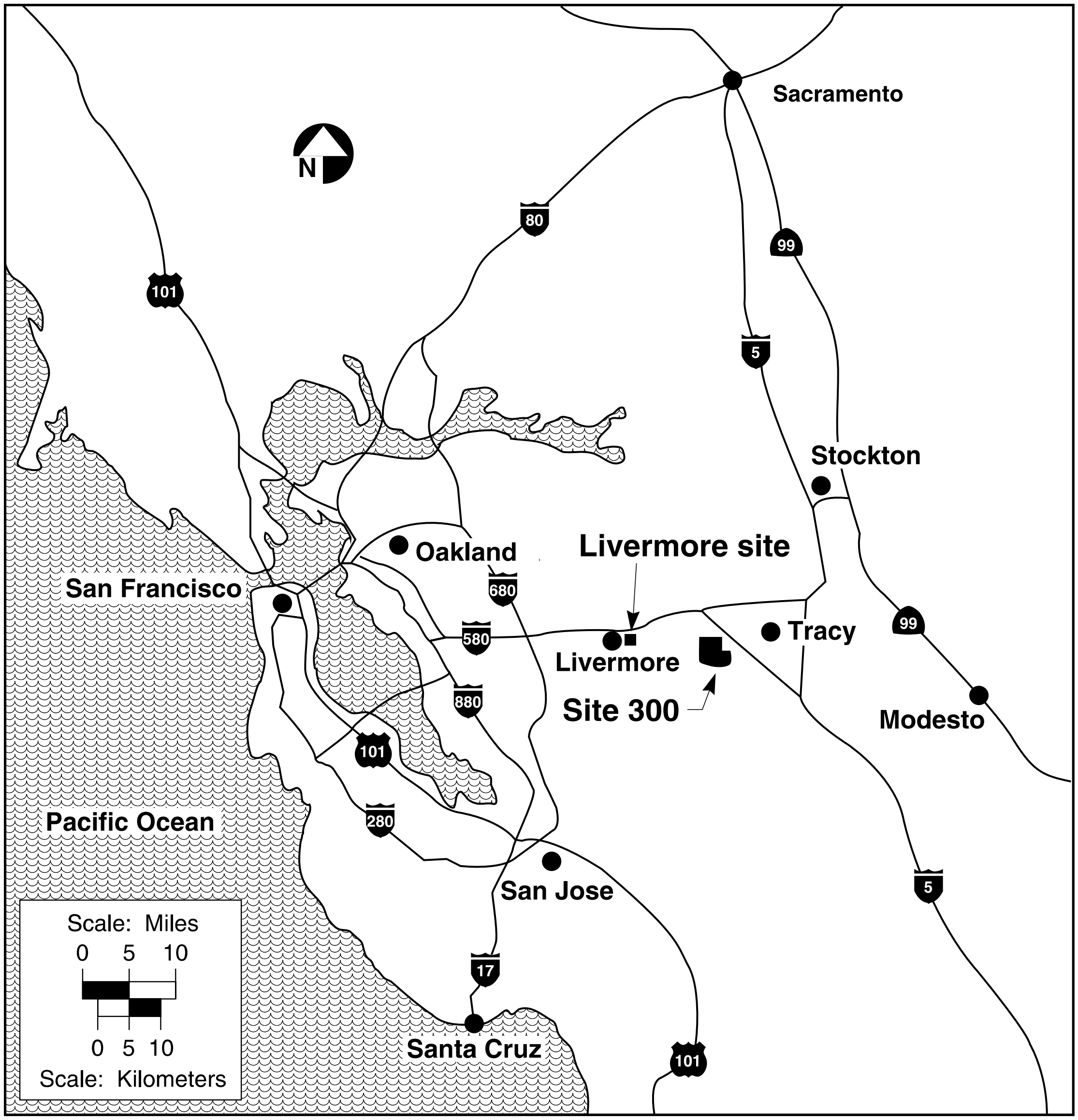


Figure 1. Locations of LLNL Livermore Site and Site 300.

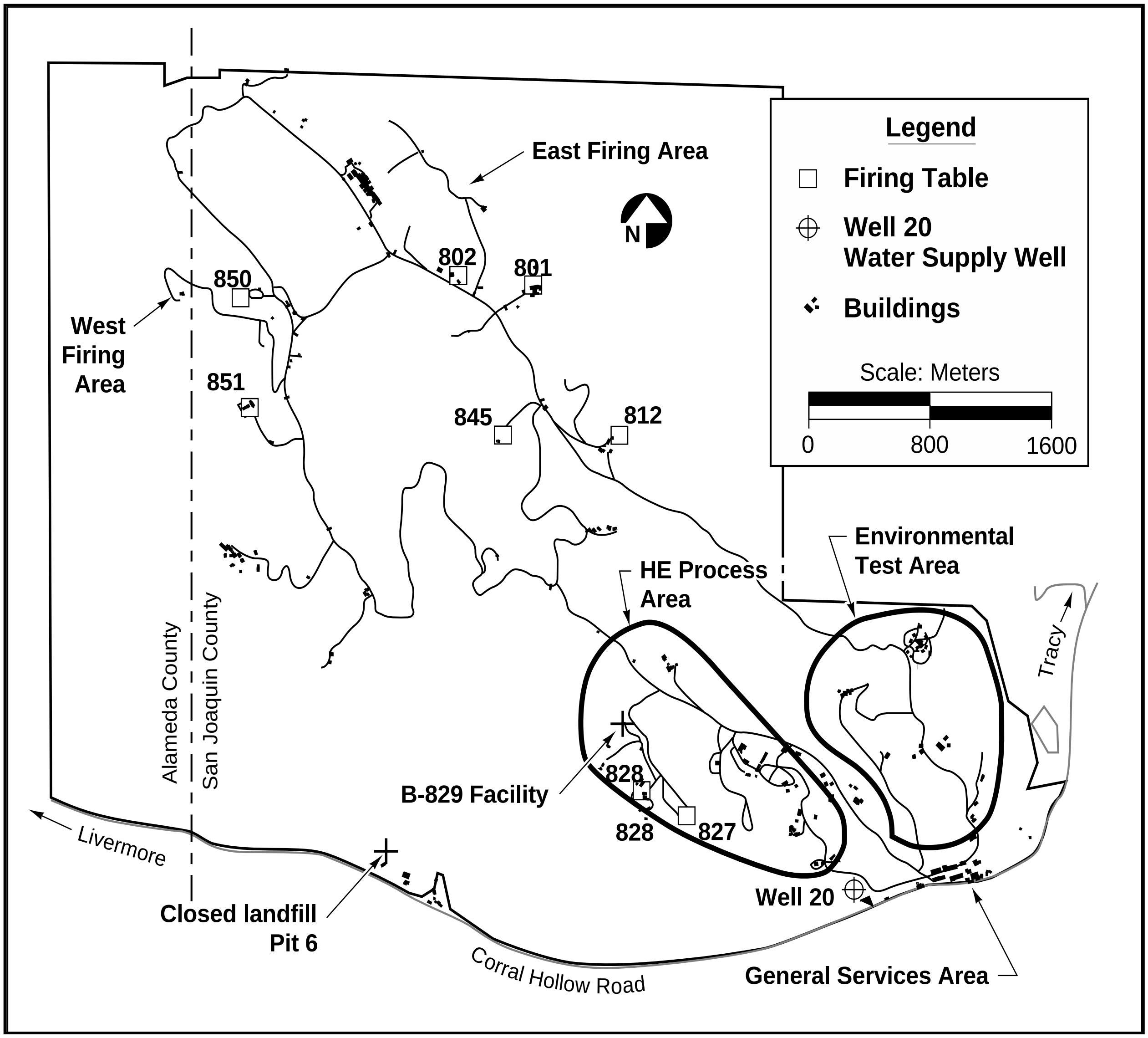


Figure 2. Location of the closed B829 Facility at LLNL Site 300.

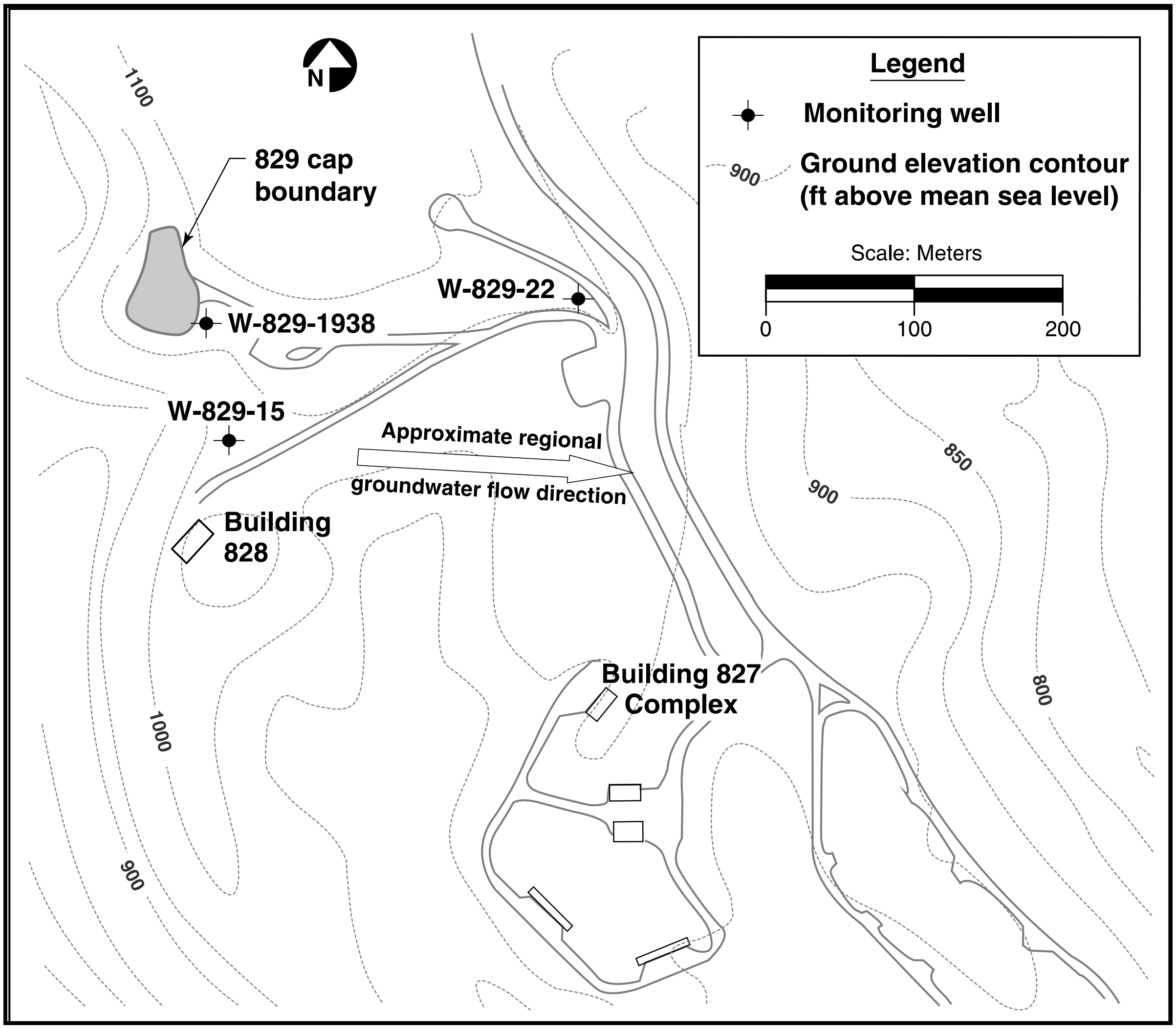


Figure 3. Location of the closed B829 Facility and monitoring wells at LLNL Site 300.

Post-Closure Inspection Checklist

Location:____________________ Inspector's name:________________________________

Date:______________________ Inspector's signature:_____________________________

Time:______________________ Site 300 EA signature and date:_____________________

Condition of the facility	Condition as described?	If correction needed, describe condition and needed repairs.	Corrections completed?	Date completed
DESCRIPTION	**Yes / No**	**INSPECTOR'S COMMENTS**	**Y/N**	**DATE**
1. Cap is in good condition.				
a. No settlement or gullying observed.				
b. No surface erosion visible.				
c. No fissures visible.				
d. No cracks visible.				
e. No low spots visible.				
f. No animal burrows visible.				
g. No bare spots observed.				
h. No subsidence observed.				
i. No vegetation beyond topsoil layer observed.				
2. Runoff is diverted away from the cap.				
3. Erosion controls are present and in good condition (i.e, grading, vegetation, and clear diversion channels).				
4. Permanent, surveyed benchmarks are present and maintained.				
5. Groundwater monitoring network is in good working order.				
a. Well label is intact and legible.				
b. Surface seal is intact.				
c. No evidence of damage (i.e, settlement, pipe tilting, poor protective pipe condition, standing water around the pipe, etc.) is observed.				
6. Warning sign is in place.				
7. Emergency Coordinator's name and phone number posted.				
8. Communications are in good working order.				
9. Access available to emergency vehicles.				
10. Copy of Post-Closure Plan is on file at Site 300.				
11. Other observations attached.				

Figure 4. B829 Facility post-closure inspection checklist.

B829 Monitoring Well Inspection Checklist

Well No.	Is Well No. clearly marked?	Is surface seal intact?	Is well capped & locked ?	Is there evidence of damage?	Is there settlement?	Is there standing water?	Is reference point marked?
829-15							
829-22							
829-1938							

Comment Log

Well No.	Comments/Repair(s) Needed	Nature of Repair	Date Repair Completed	Completed by (name)
829-15				
829-22				
829-1938				

Form date: 5/5/06, rev.1

Inspection date:__________________________________Time:____

Inspector name:__________________________________Signature:______________________________________

Figure 5. B829 Facility monitoring well inspection checklist.

Appendix A

Groundwater Elevation and Constituent of Concern Concentration Plots

Appendix A

Groundwater Elevation and Constituent of Concern Concentration Plots

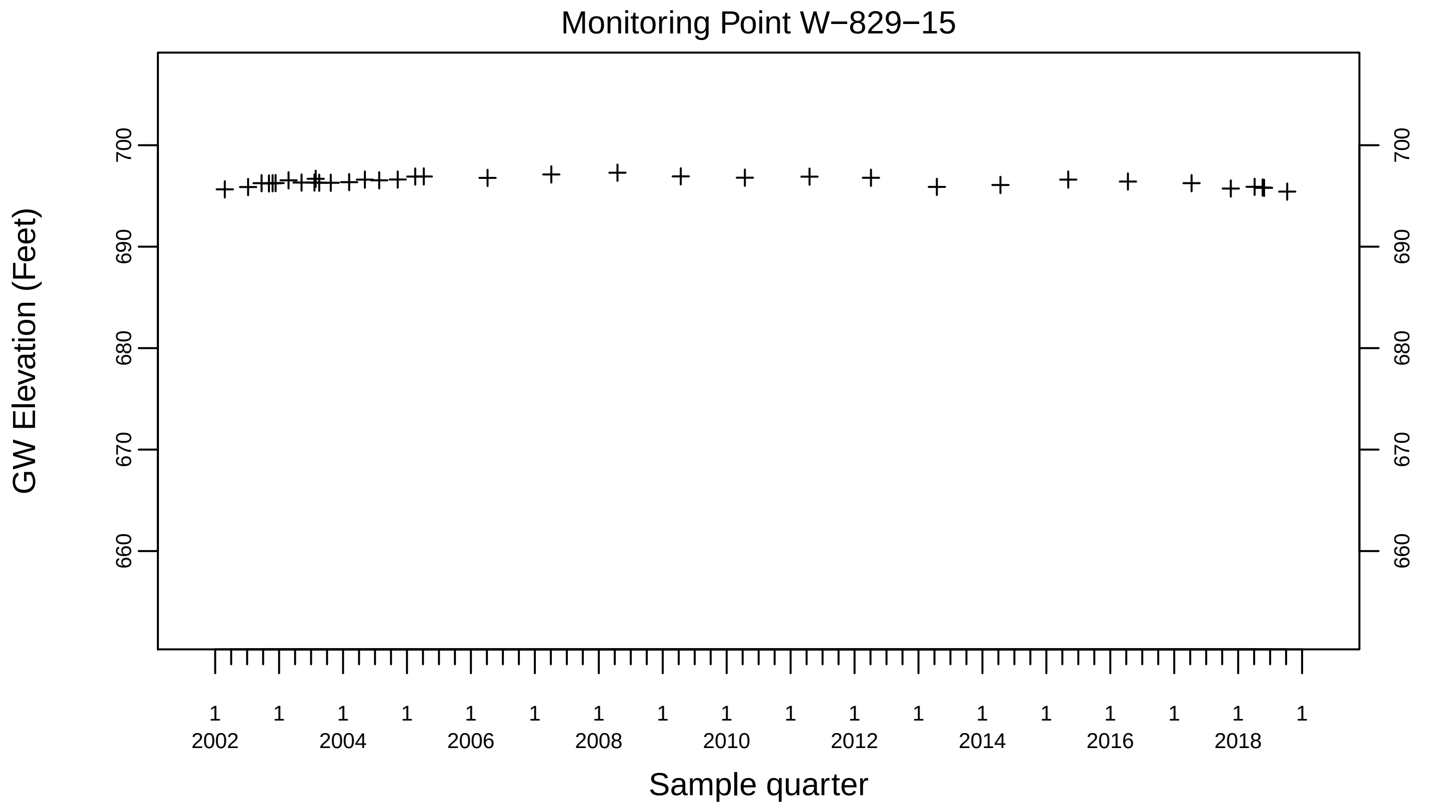
As required by the monitoring and reporting provisions of 22 CCR 66264.97(e), this appendix presents graphical depictions of groundwater elevations and concentration trends. Concentration-versus-time plots have been prepared for all confirmed constituent of concern (COC) detections above their respective analytical reporting limits (RLs), for the permit-specified wells. The graphs for the two established wells (W-829-15 and W-829-22) present data accumulated since 2002, and the graphs for well W-829-1938 present data accumulated since 2004.

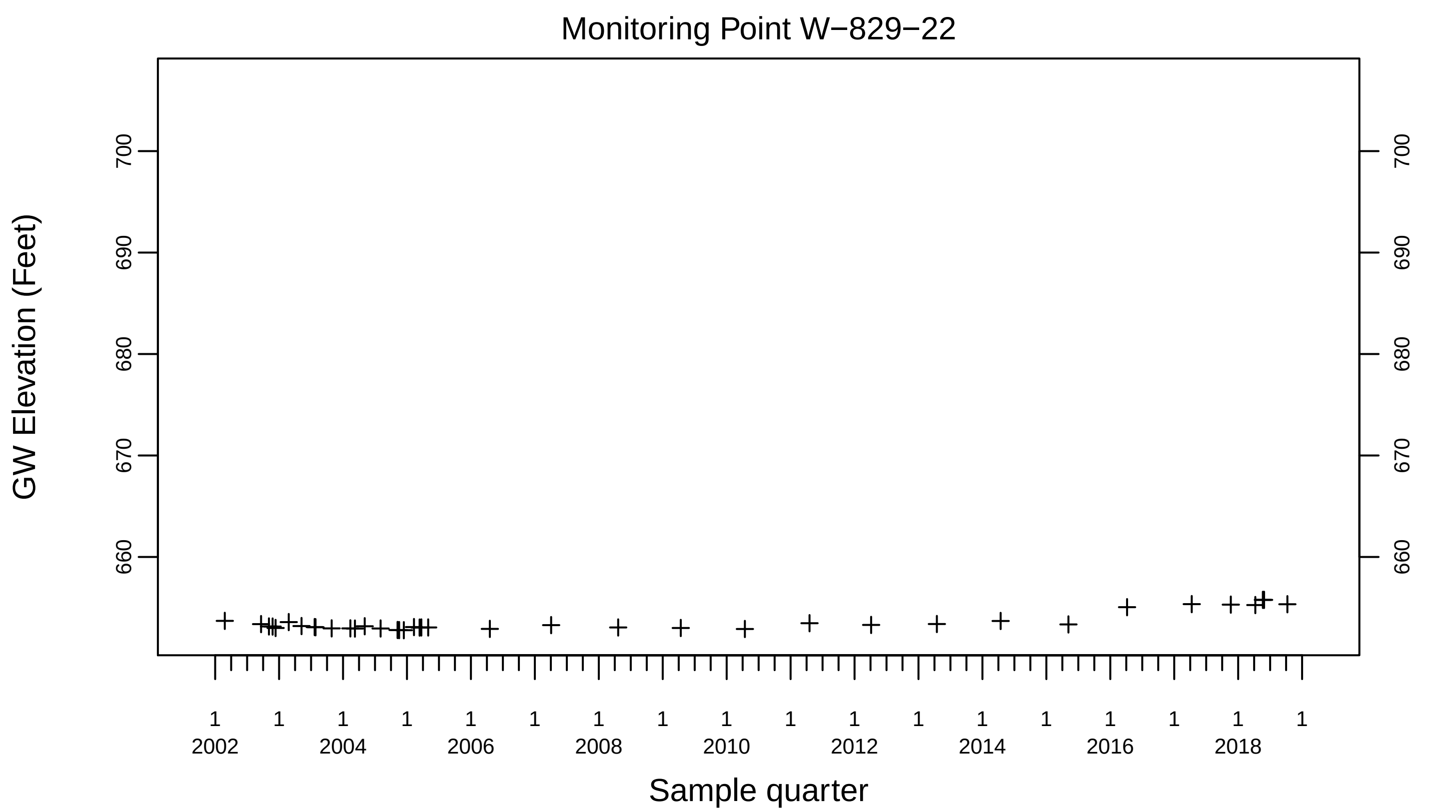
The sequence of graphs is by parameter (groundwater elevation, concentration, or activity) and by well. Graphs show the reported parameter on the y-axis, with time on the x-axis (time in years is divided into quarterly sample periods). The header and the vertical axis labels on each plot give the units of measurement. Statistical limits of concentration (SLs) are shown on the COC graphs as horizontal dotted lines. The numerical value of a SL is also given in the plot legend. Three different symbols are used to plot the COC data: a black diamond, an inverted white triangle, and a plus sign. Their different uses are explained below.

COC detections are plotted as black diamonds. Analytical laboratories report COC measurements above RLs as detections. (The RL for a COC is a contractual concentration value near zero.) COC concentrations below RLs are non-detections and are reported as “less than the RL.” For non-radioactive COCs, non-detections are assigned RL values and appear as inverted white triangles in the data graphs.

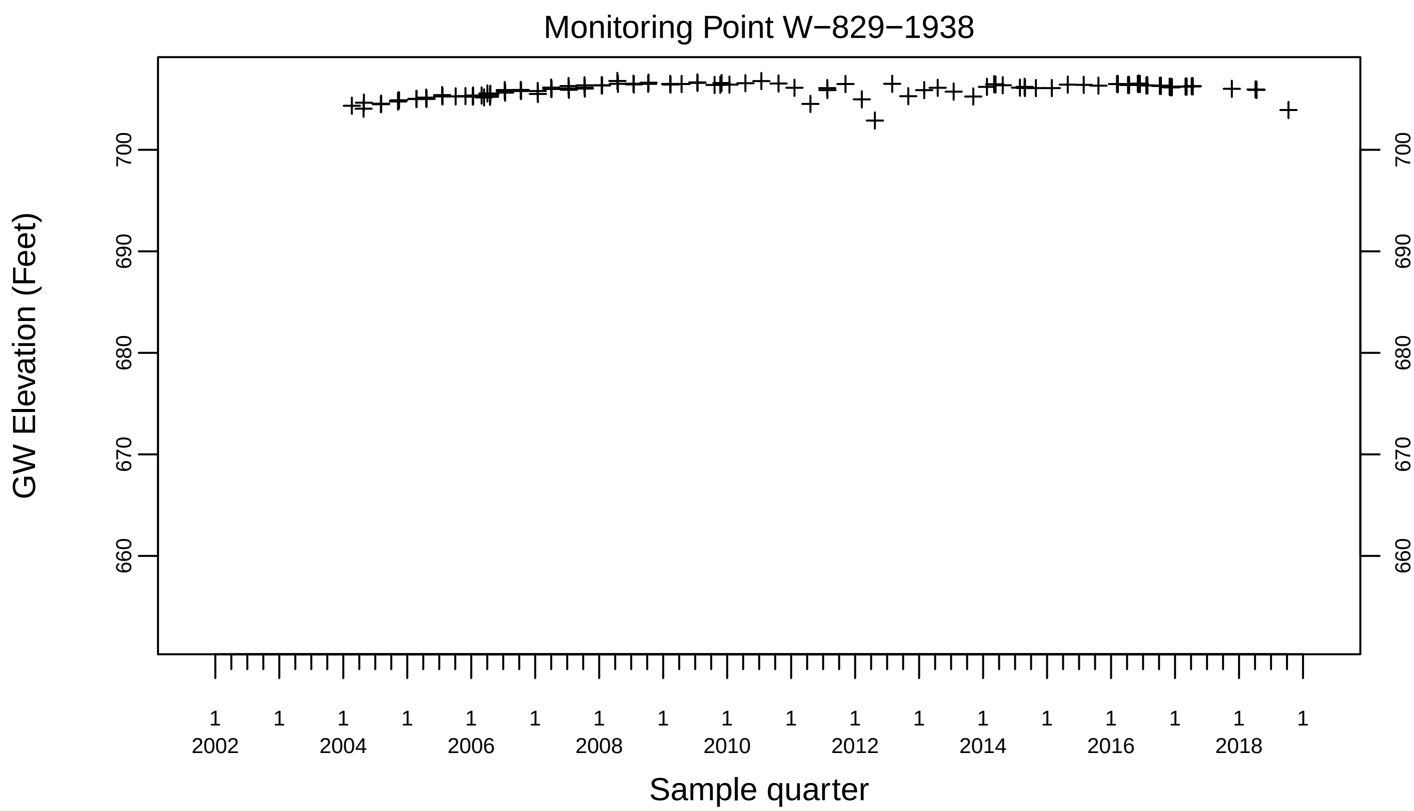
Non-detections of radioactive COCs, however, are treated differently. The reported value for radioactive COCs is the measured sample radioactivity minus the measured background radioactivity. When the result of this calculation is less than the RL, the value is plotted as a plus sign, indicating an estimated non-detection. (Note that the calculated value may be negative, or zero, if the measured sample radioactivity is less than, or equal to, the measured background activity.) When the reported activity is greater than the RL, the value is plotted as a black diamond, indicating a radioactive COC detection.

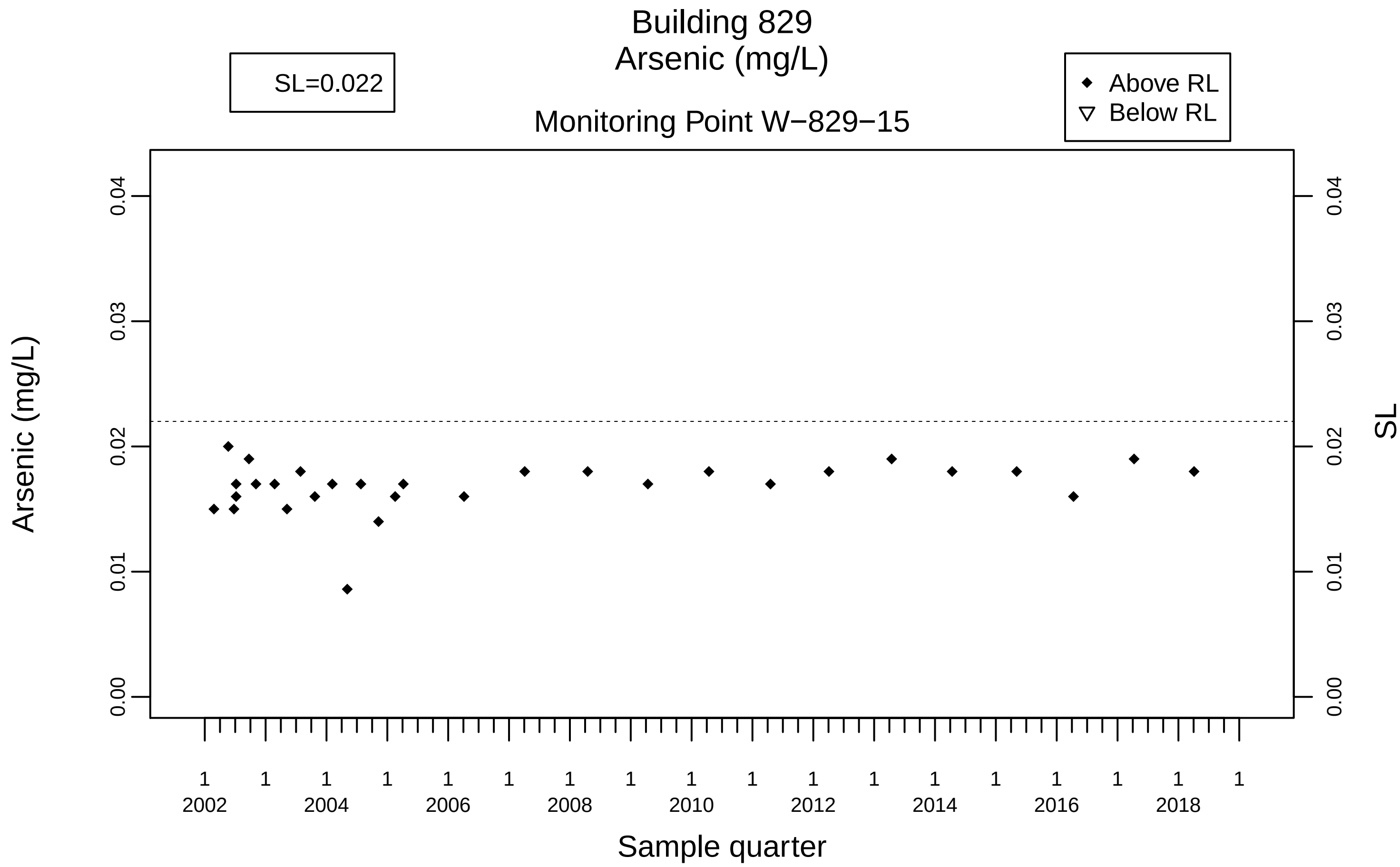
Building 829
GW Elevation (Feet)

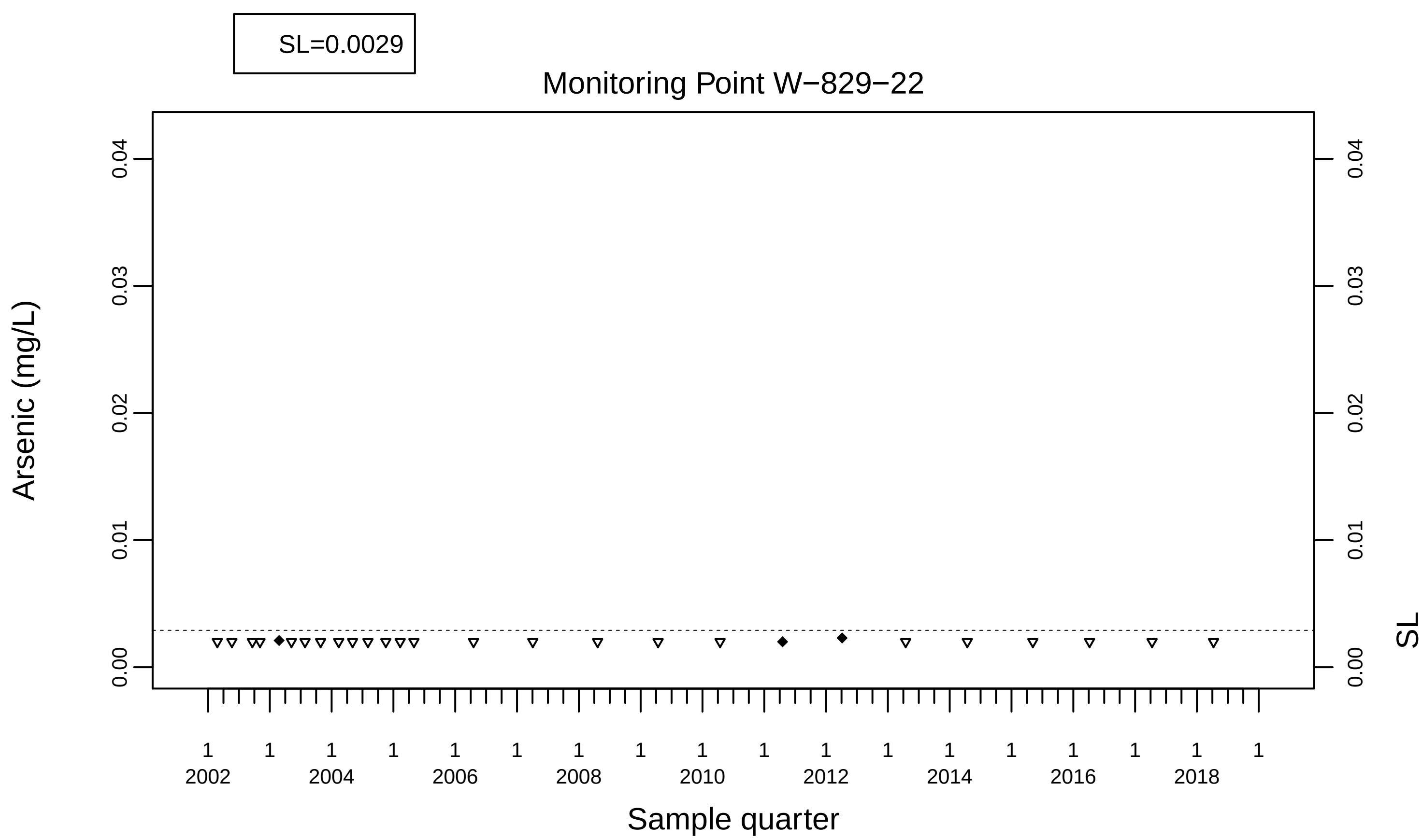


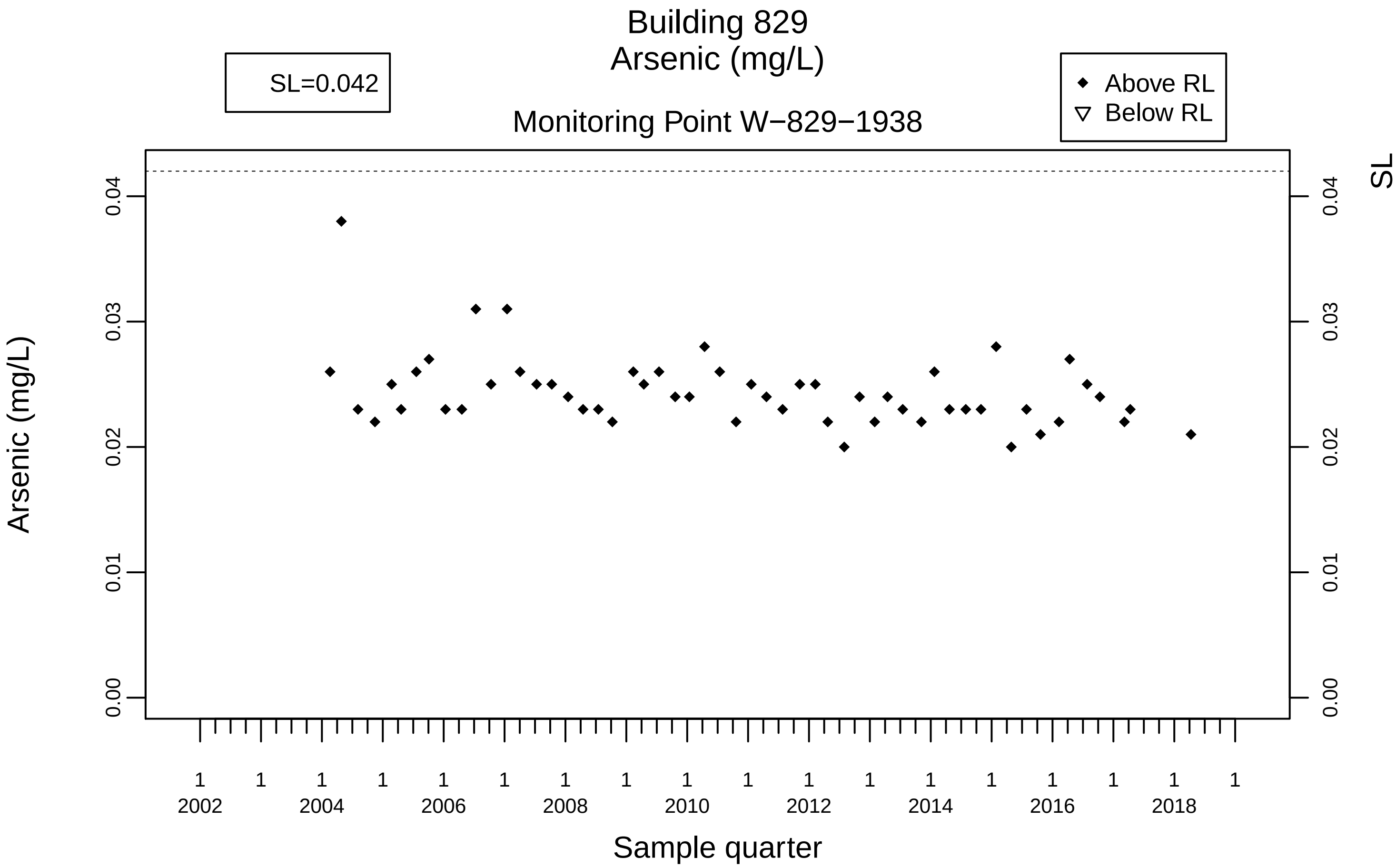


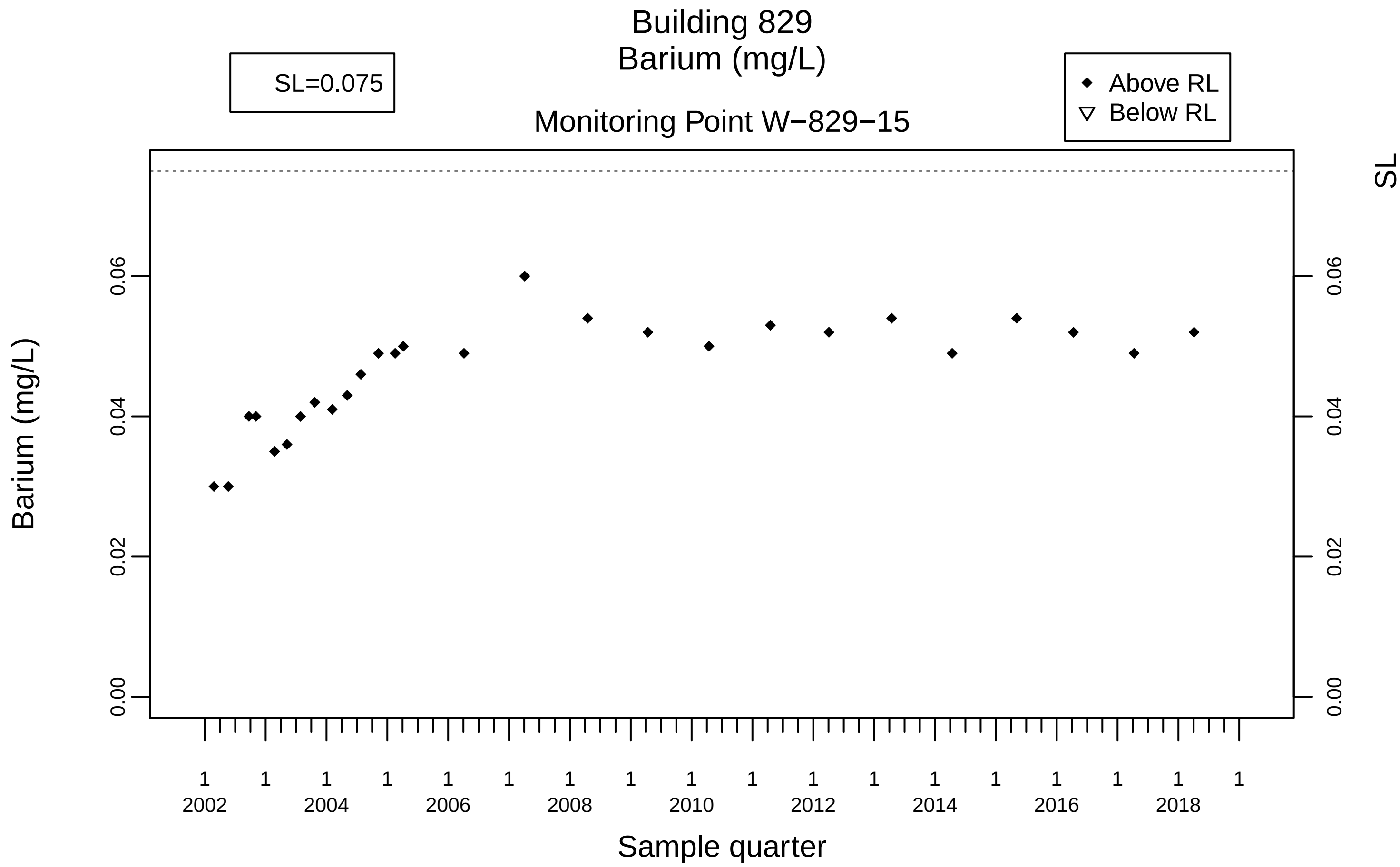
Building 829
GW Elevation (Feet)

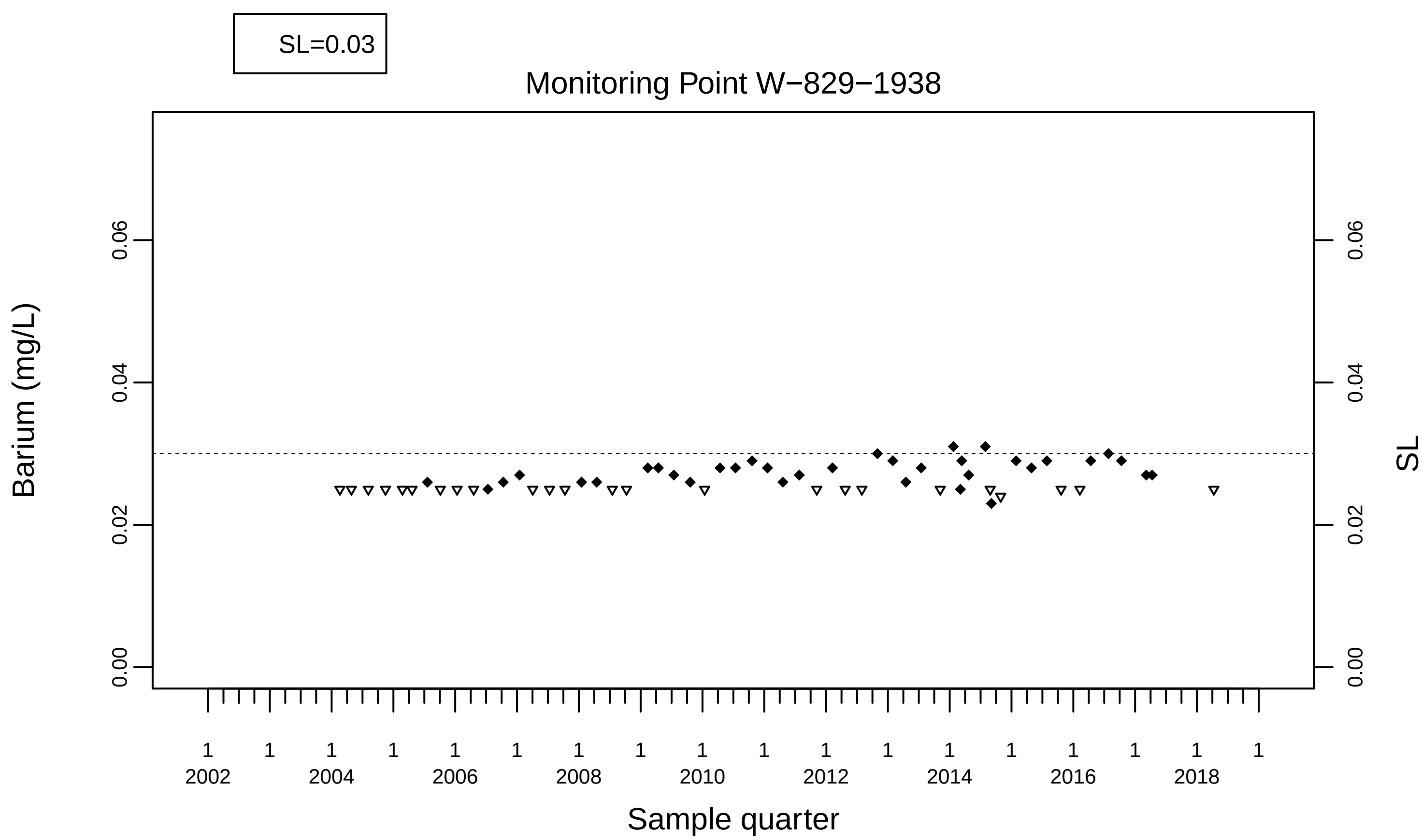


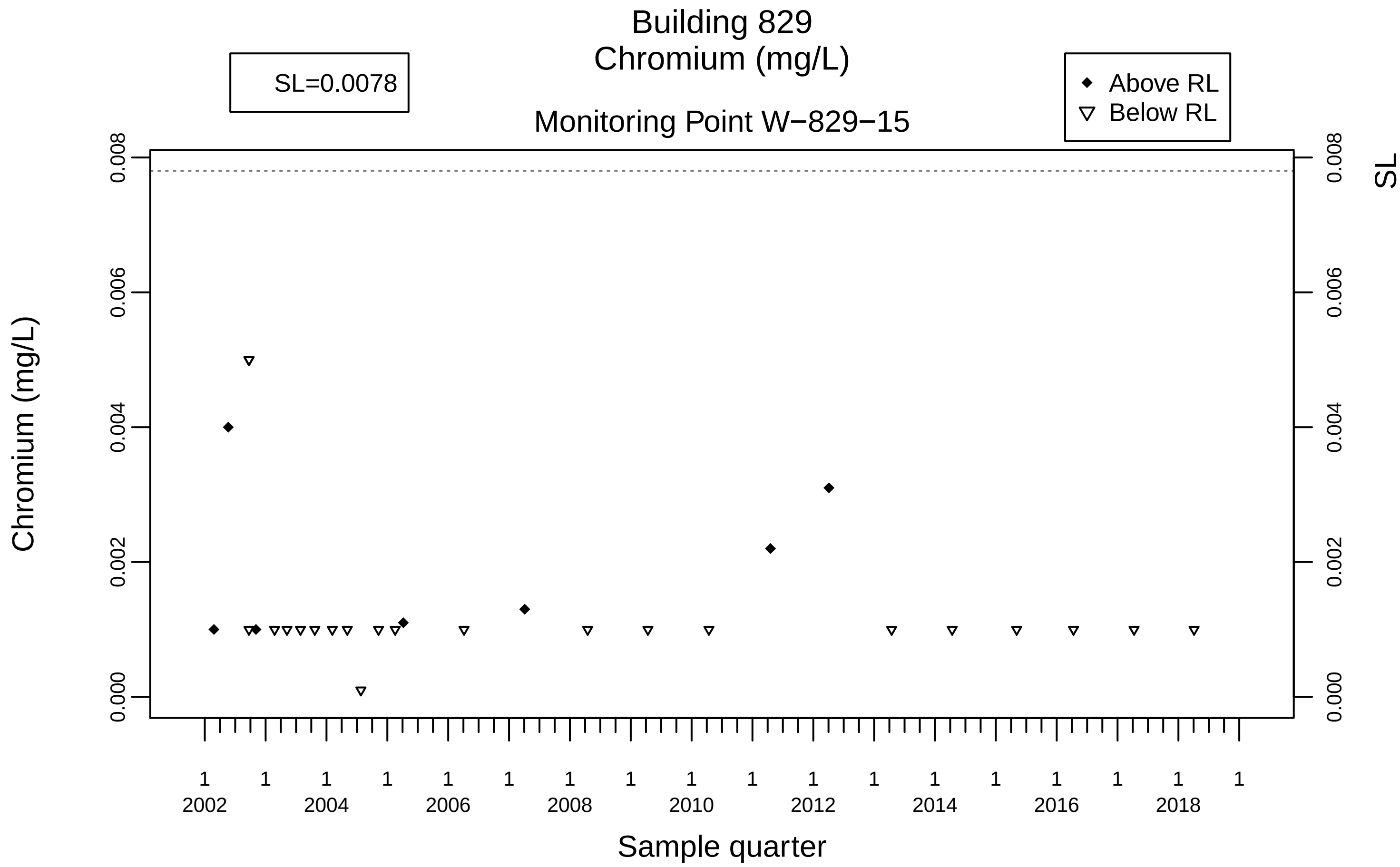

Building 829
Arsenic (mg/L)
SL=0.022
Above RL
Below RL
Monitoring Point W−829−15
Arsenic (mg/L)
0.00
0.01
0.02
0.03
0.04
SL
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

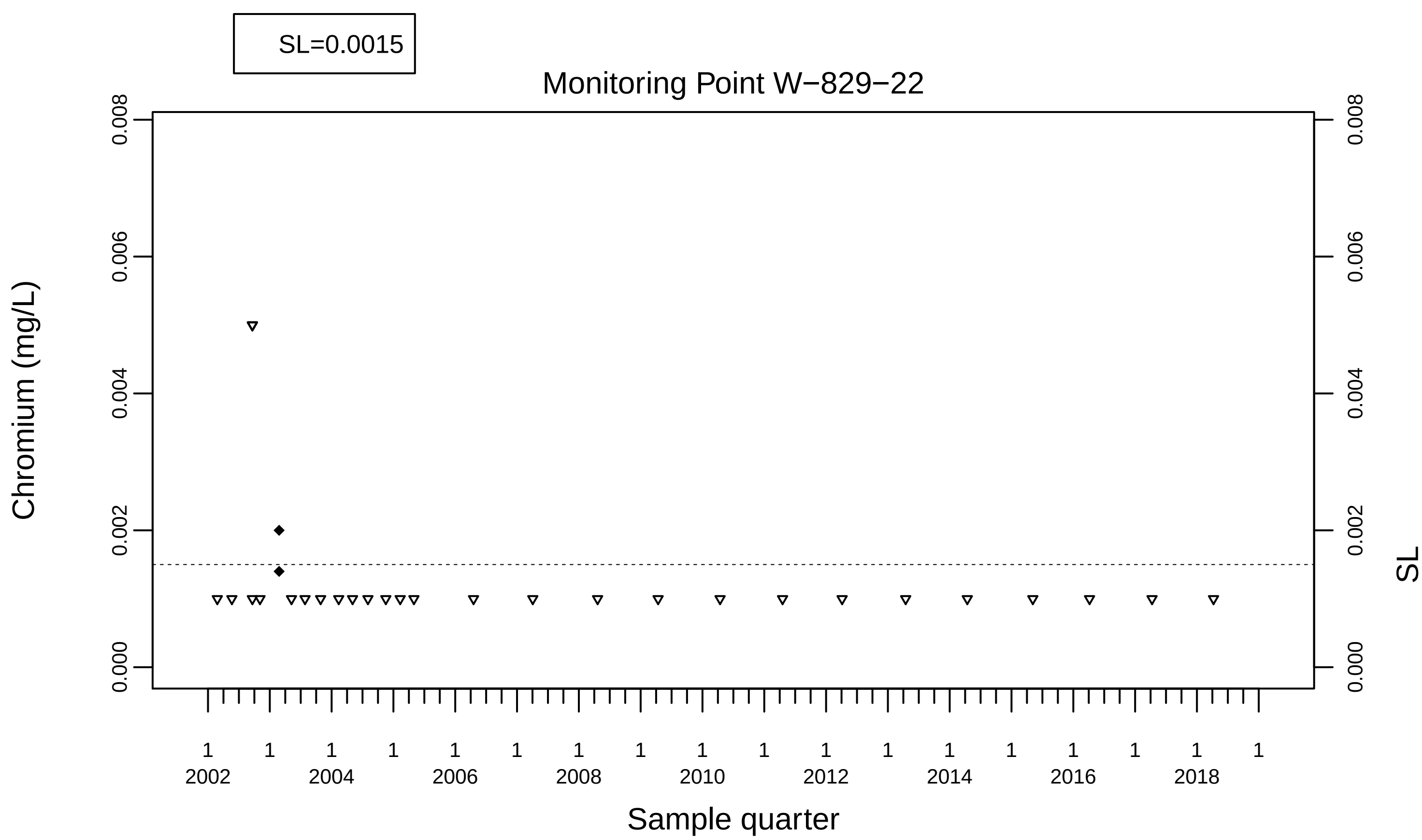

SL=0.0029
Monitoring Point W−829−22
Arsenic (mg/L)
0.00
0.01
0.02
0.03
0.04
SL
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

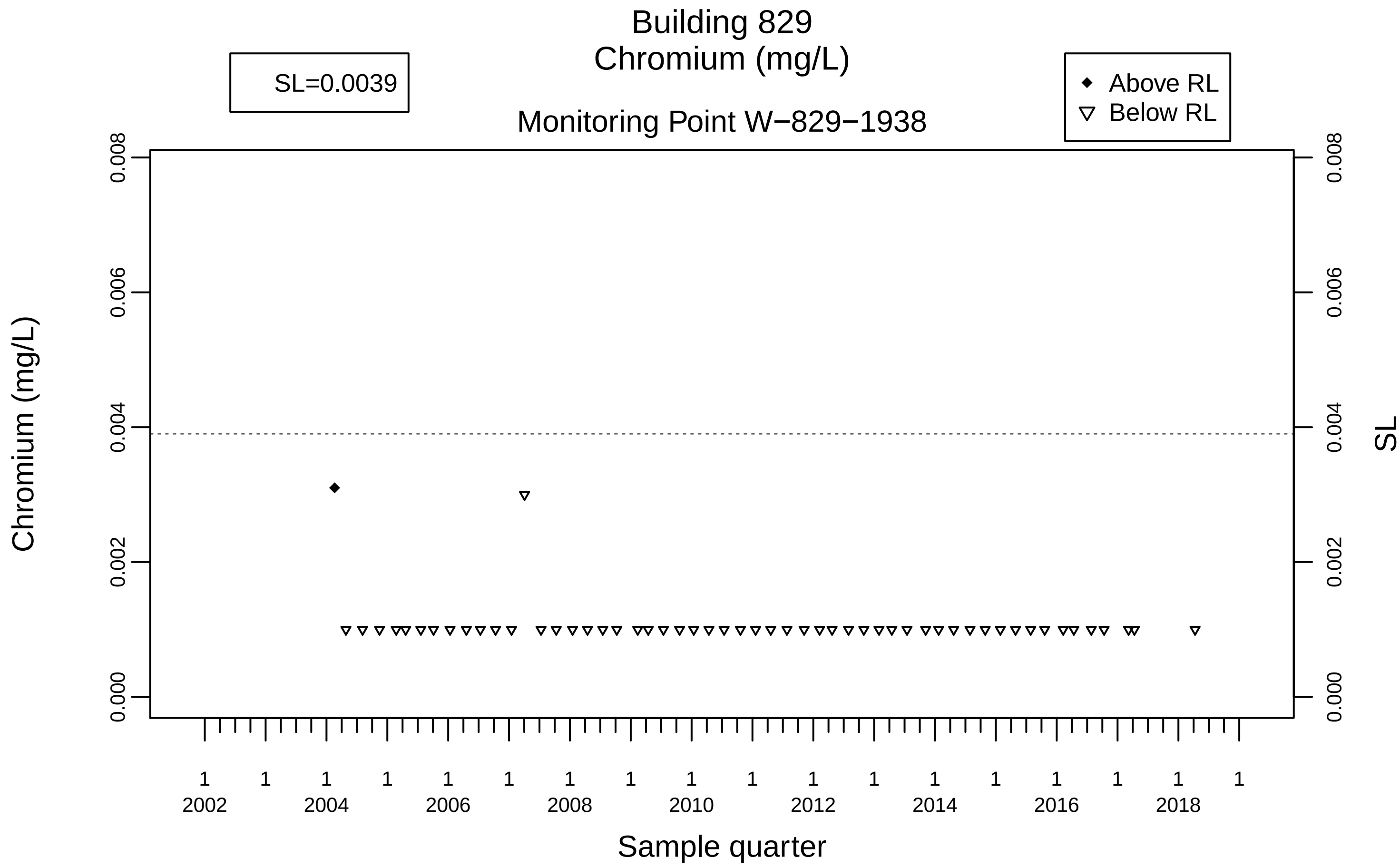

Building 829
Arsenic (mg/L)
SL=0.042
Monitoring Point W−829−1938
Above RL
Below RL
SL
Arsenic (mg/L)
0.00
0.01
0.02
0.03
0.04
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

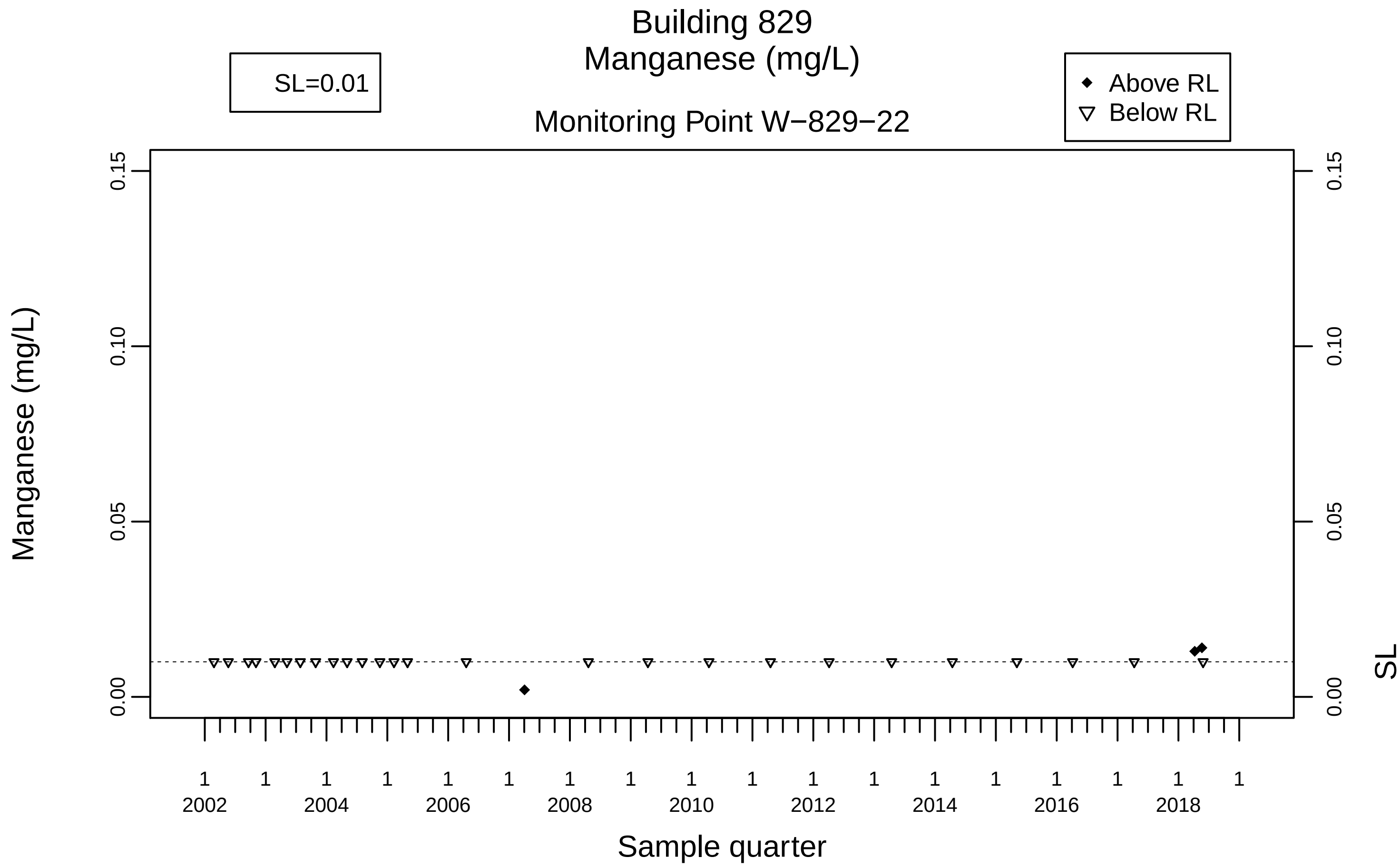

Building 829
Barium (mg/L)
SL=0.075
Above RL
Below RL
Monitoring Point W−829−15
SL
Barium (mg/L)
0.00
0.02
0.04
0.06
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

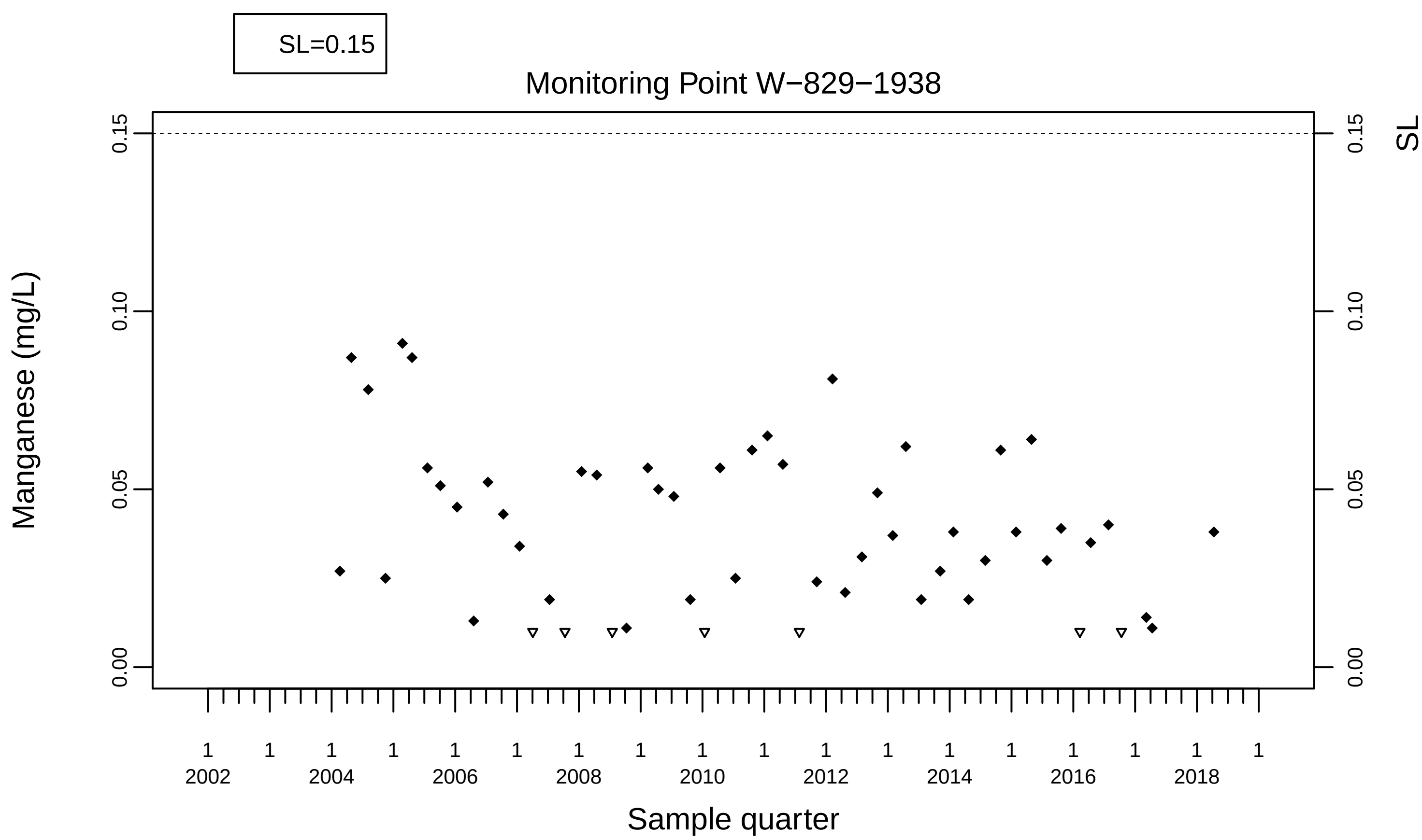

SL=0.03
Monitoring Point W−829−1938
SL
Barium (mg/L)
0.00
0.02
0.04
0.06
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter


Building 829
Chromium (mg/L)
SL=0.0078
Above RL
Below RL
Monitoring Point W−829−15
Chromium (mg/L)
0.000
0.002
0.004
0.006
0.008
SL
1 2002 1 1 2004 1 1 2006 1 1 2008 1 1 2010 1 1 2012 1 1 2014 1 1 2016 1 1 2018 1
Sample quarter

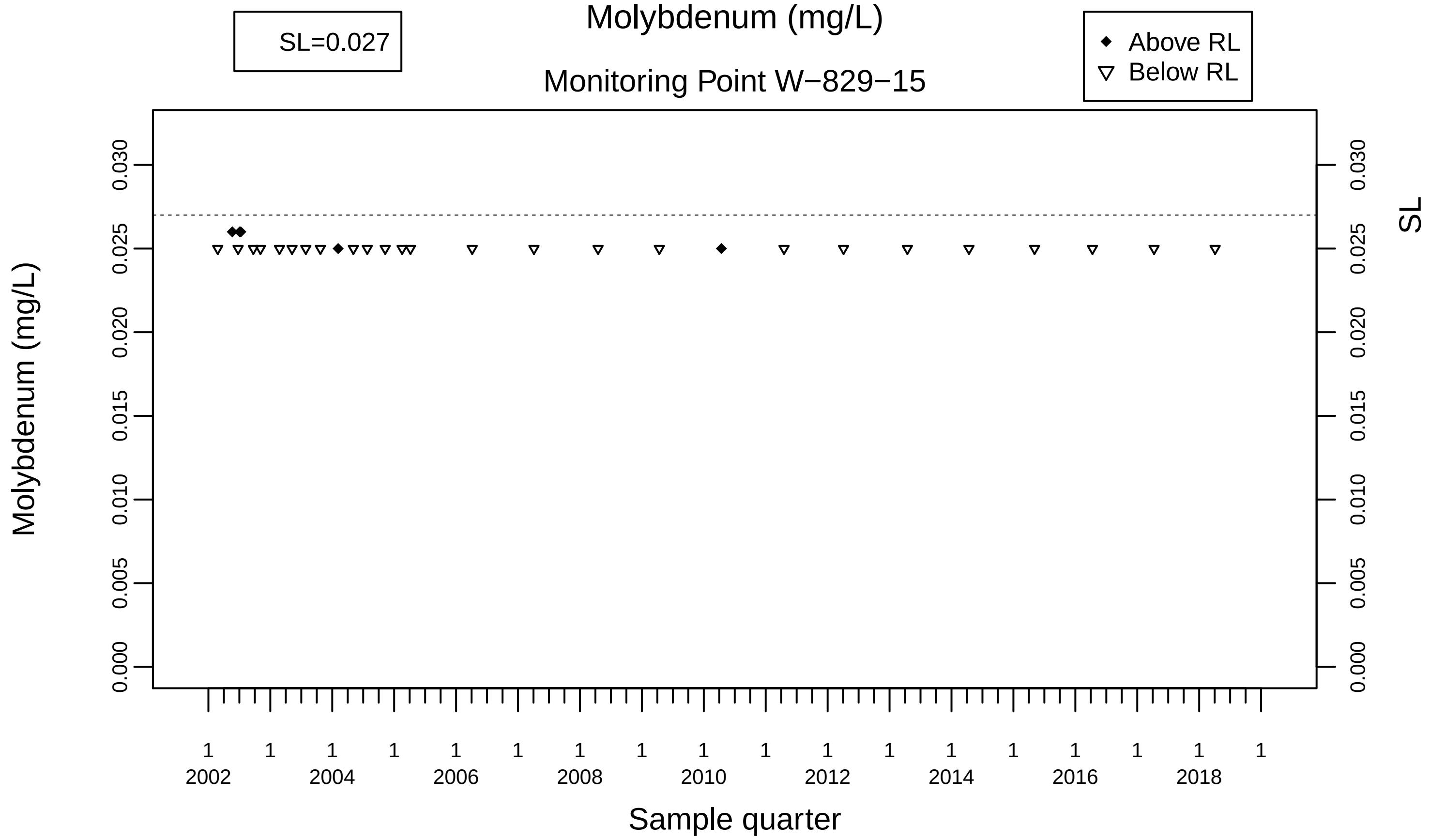

SL=0.0015
Monitoring Point W−829−22
Chromium (mg/L)
0.000
0.002
0.004
0.006
0.008
SL
1 2002 1 1 2004 1 1 2006 1 1 2008 1 1 2010 1 1 2012 1 1 2014 1 1 2016 1 1 2018 1
Sample quarter

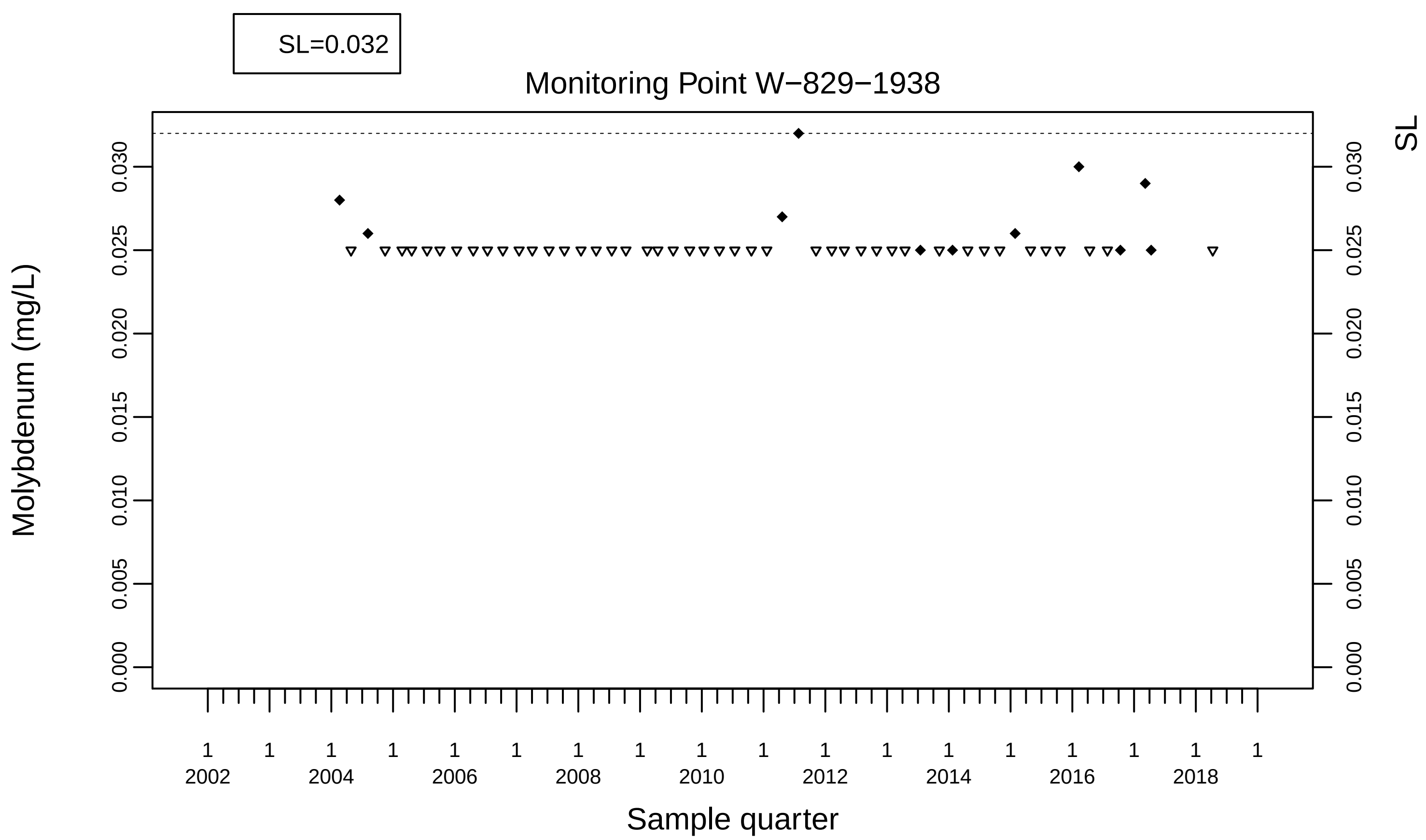

Building 829
Chromium (mg/L)
SL=0.0039
Above RL
Below RL
Monitoring Point W−829−1938
Chromium (mg/L)
SL
0.000
0.002
0.004
0.006
0.008
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

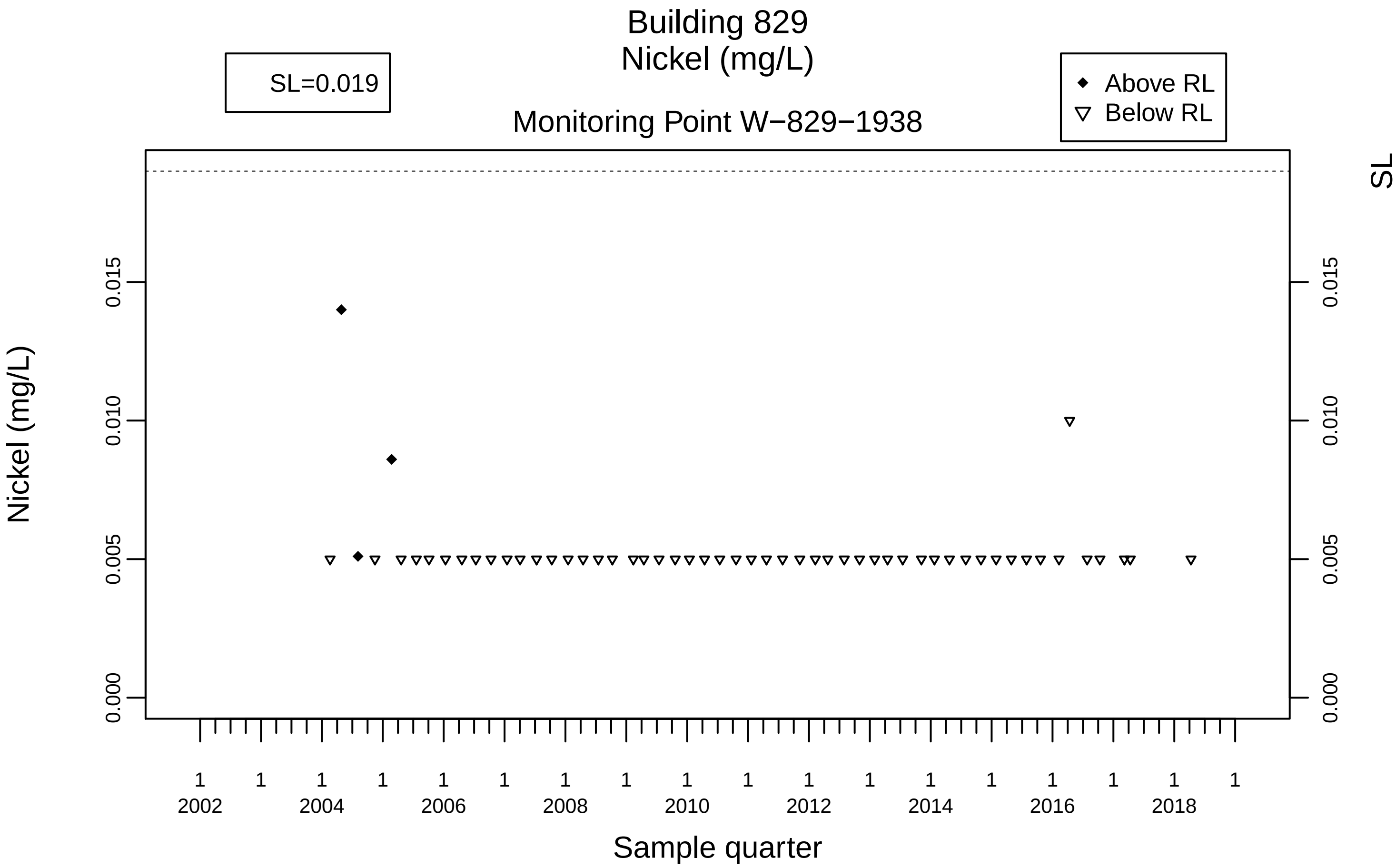

Building 829
Manganese (mg/L)
SL=0.01
Above RL
Below RL
Monitoring Point W−829−22
Manganese (mg/L)
0.00
0.05
0.10
0.15
SL
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

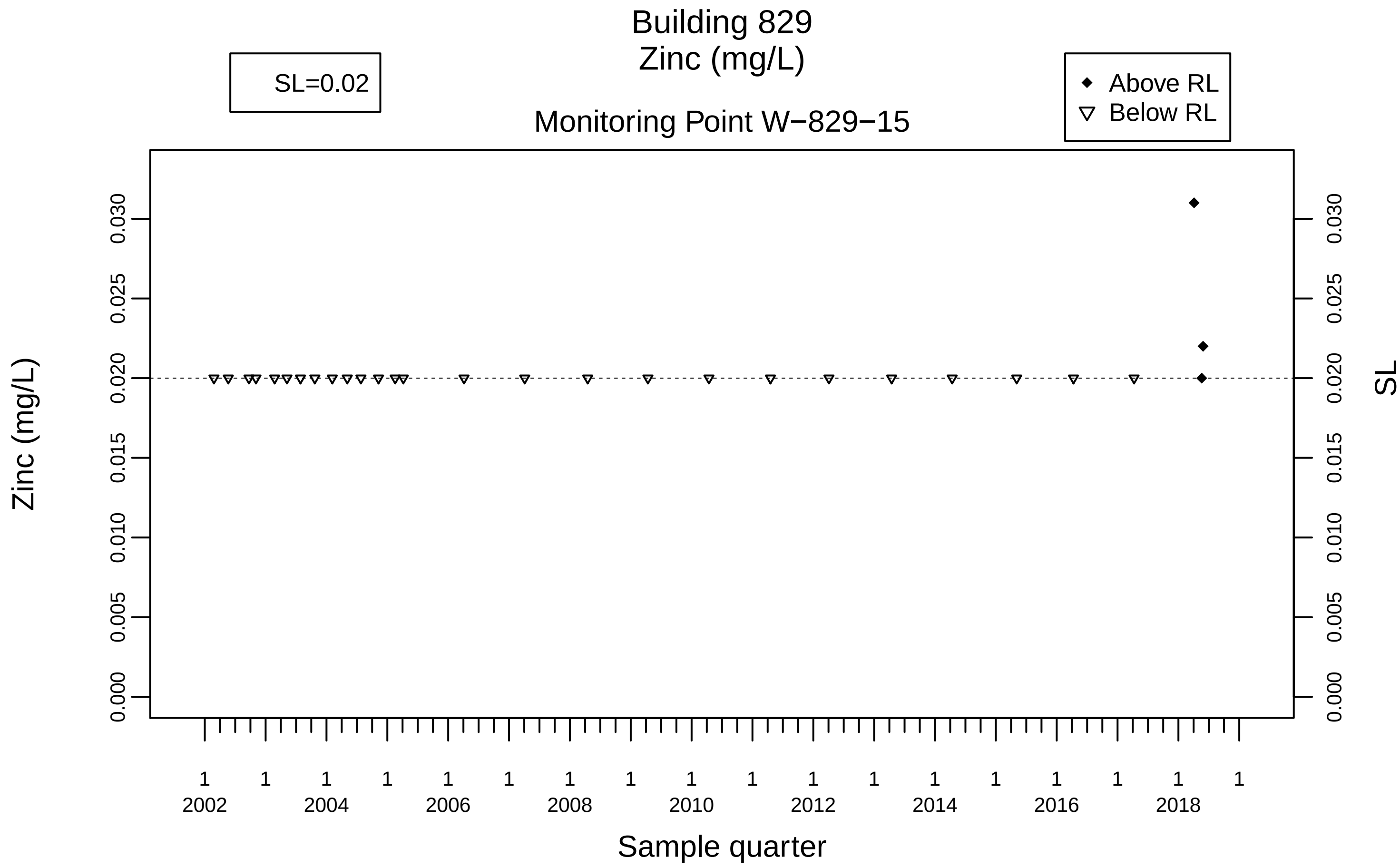

SL=0.15
Monitoring Point W−829−1938
Manganese (mg/L)
0.00
0.05
0.10
0.15
SL
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

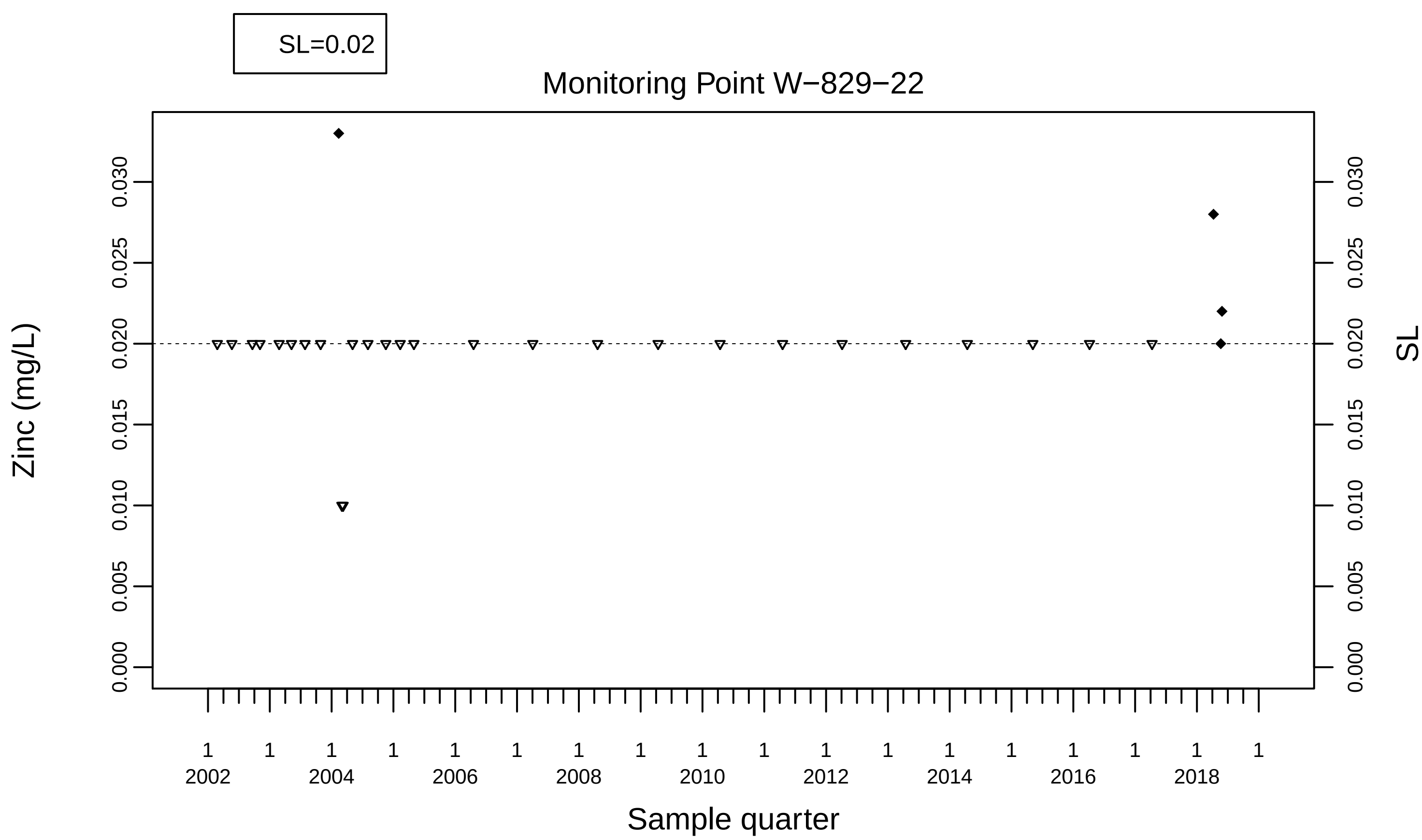
Building 829
Molybdenum (mg/L)

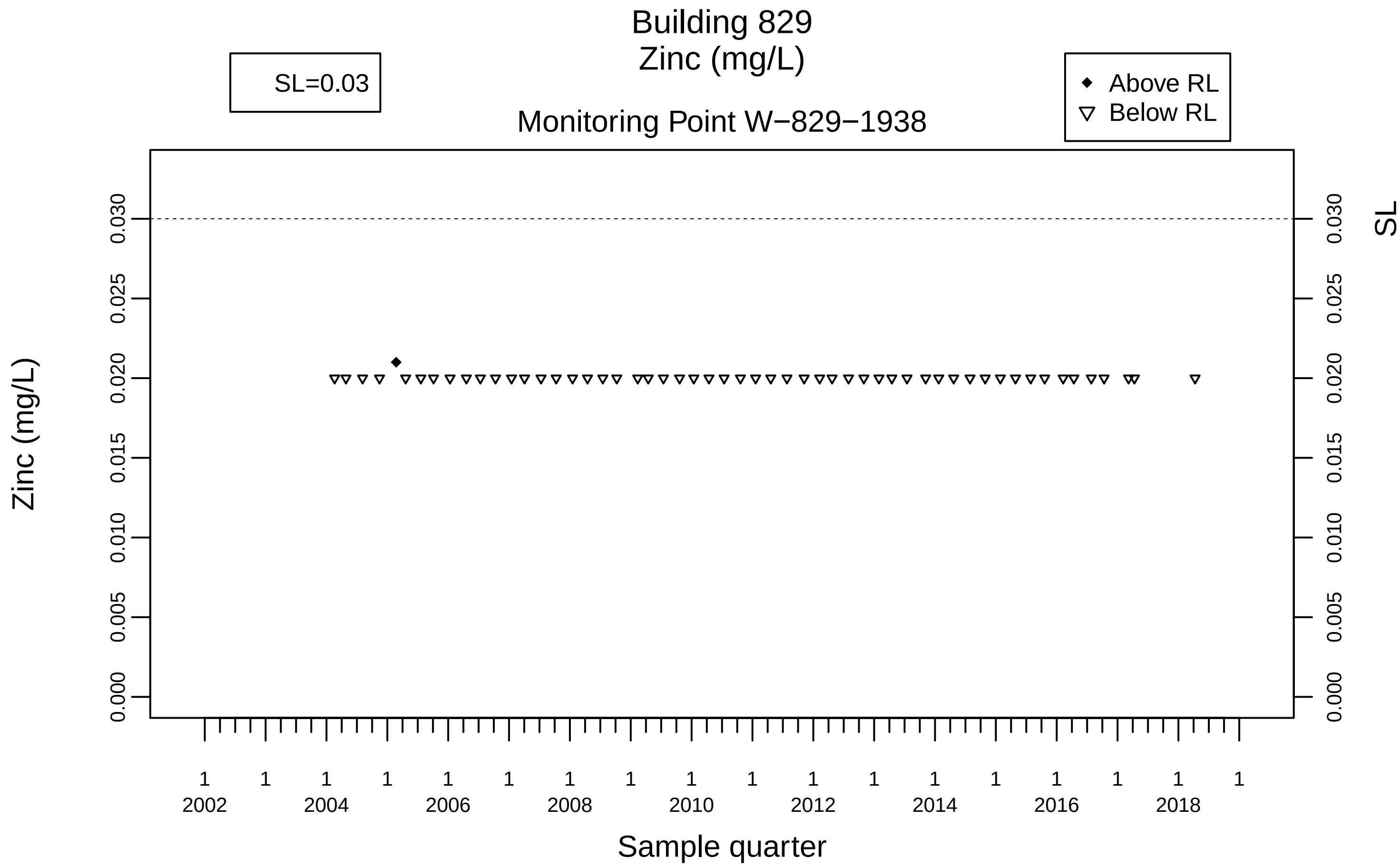


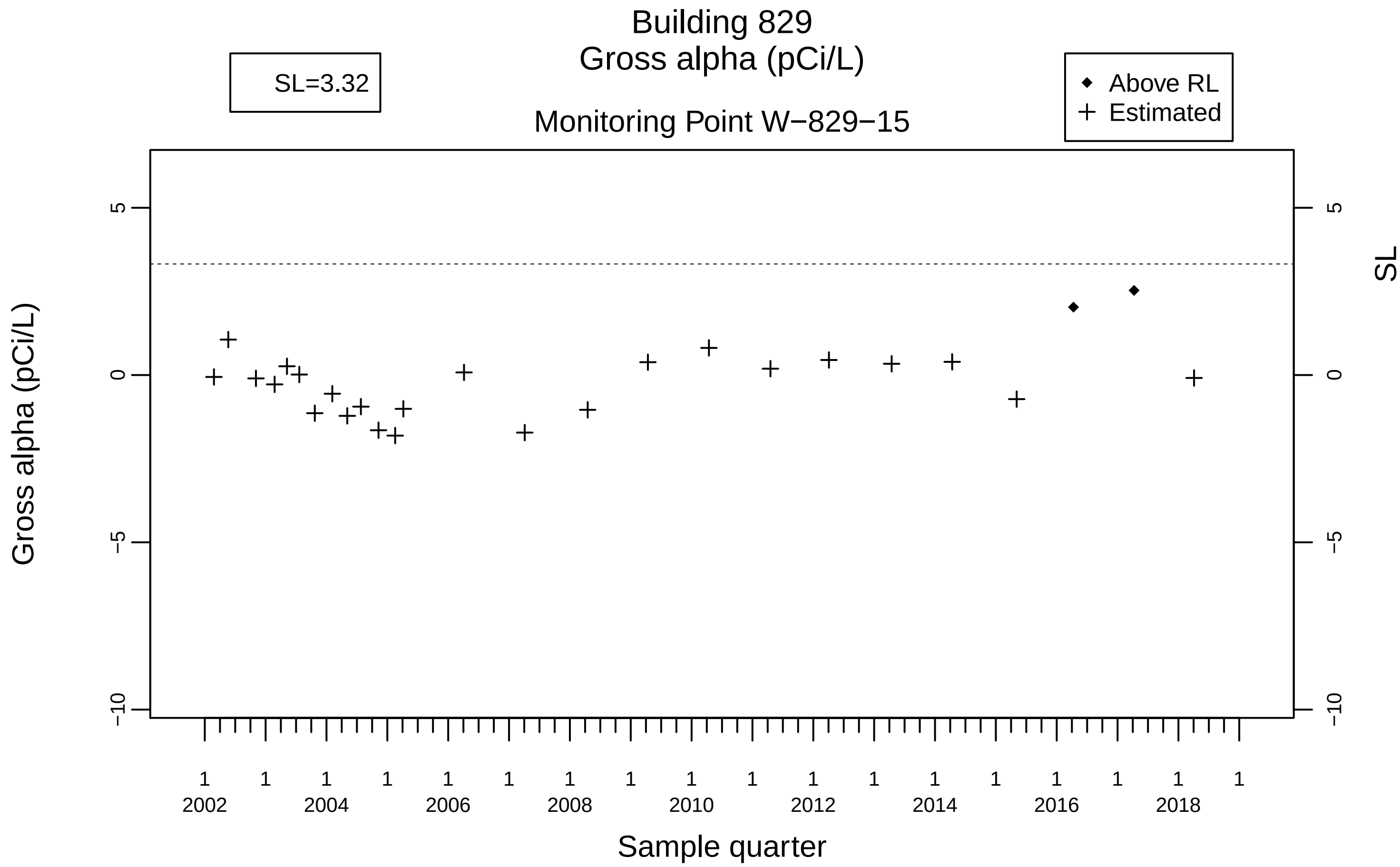


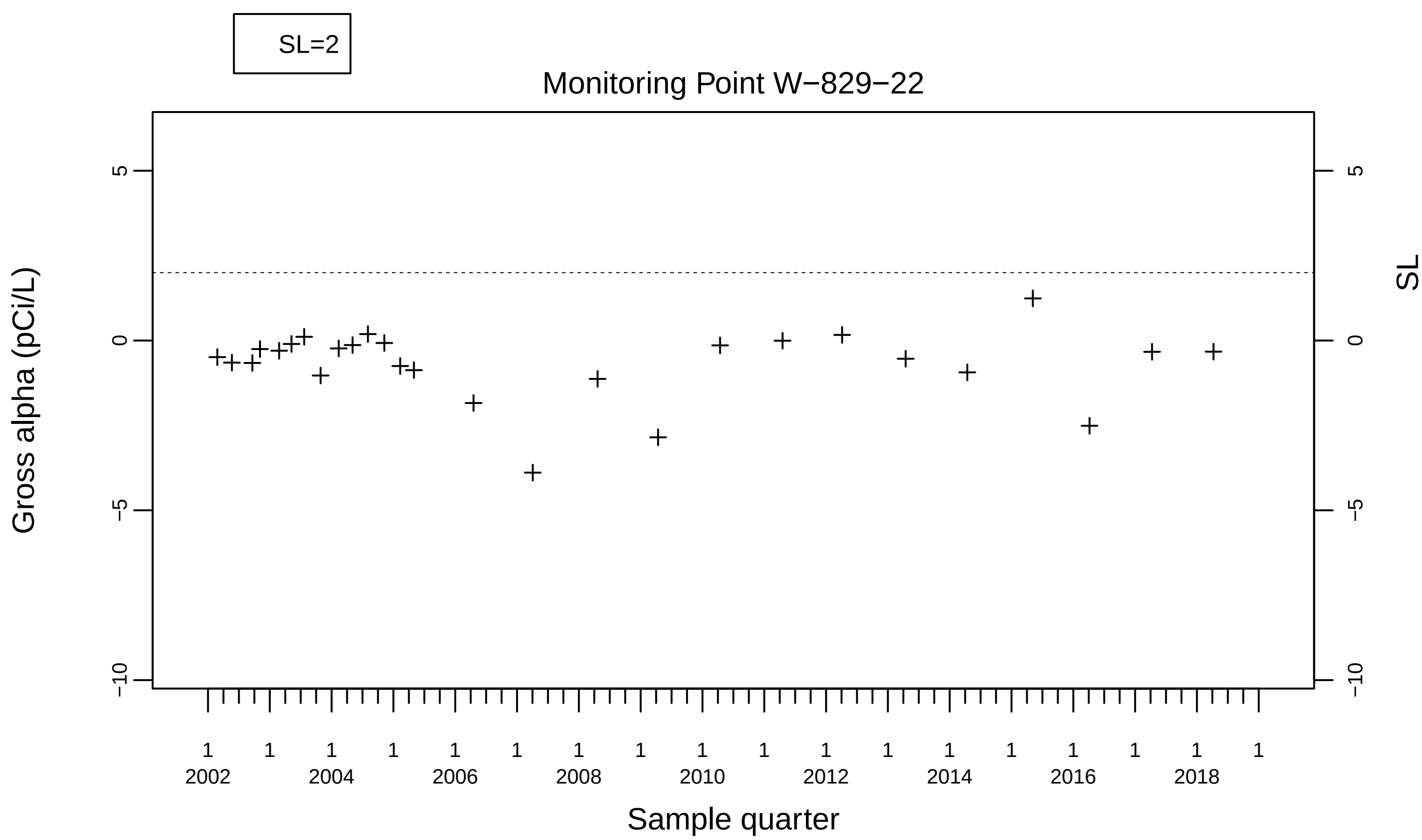

Building 829
Nickel (mg/L)
SL=0.019
Above RL
Below RL
Monitoring Point W−829−1938
SL
Nickel (mg/L)
0.000
0.005
0.010
0.015
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

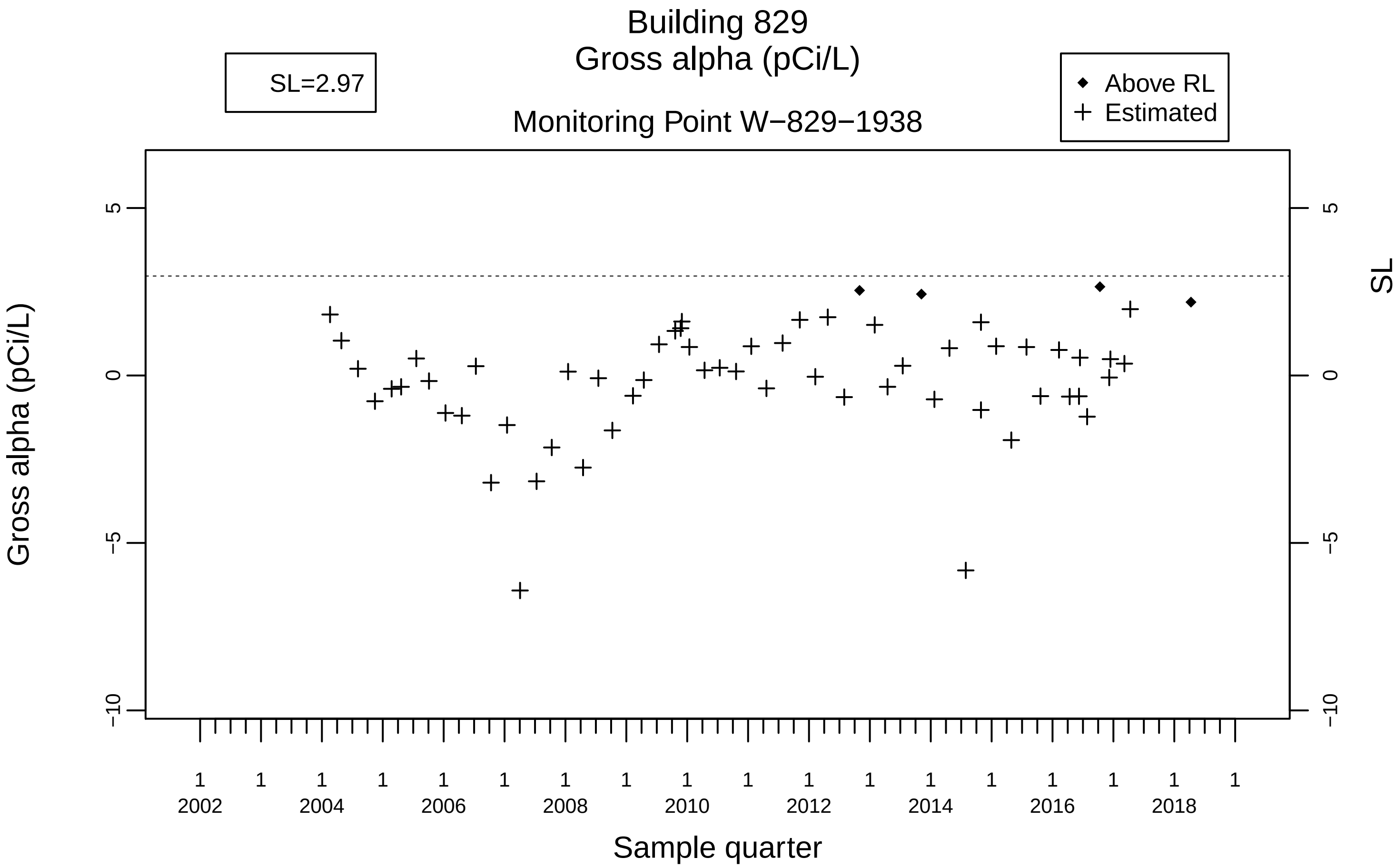

Building 829
Zinc (mg/L)
SL=0.02
Above RL
Below RL
Monitoring Point W−829−15
Zinc (mg/L)
SL
Sample quarter

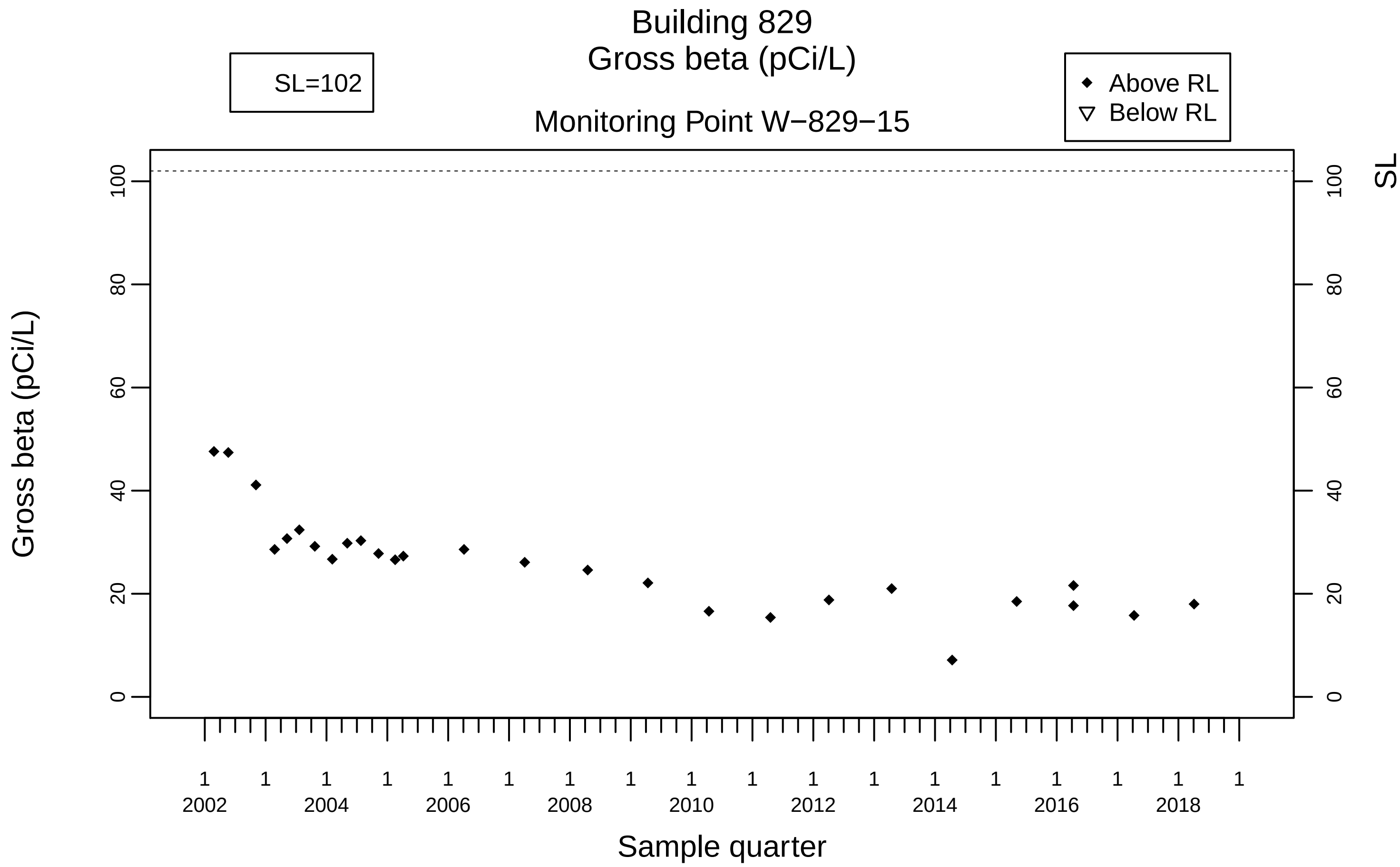

SL=0.02
Monitoring Point W−829−22
Zinc (mg/L)
SL
Sample quarter

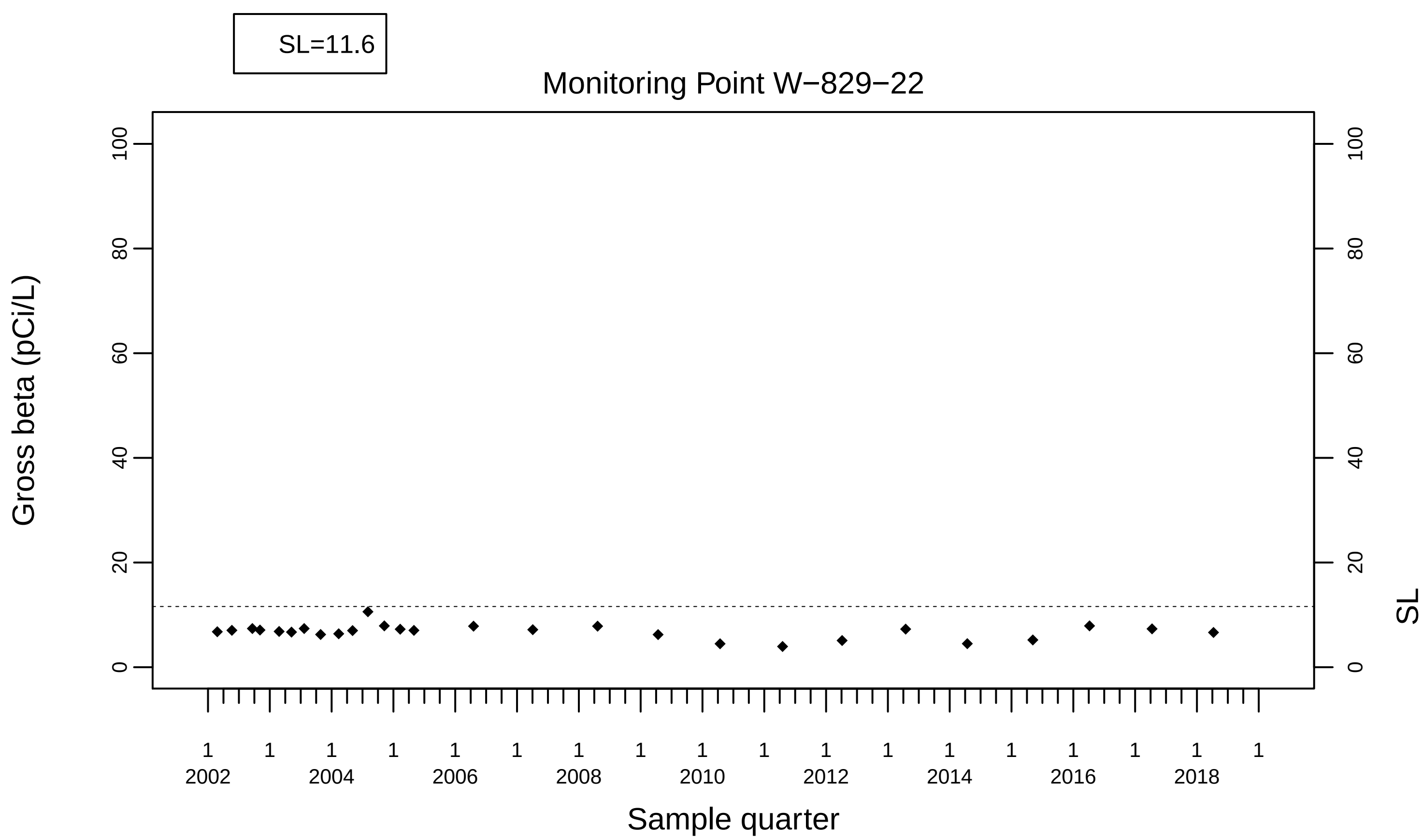

Building 829
Zinc (mg/L)
SL=0.03
Above RL
Below RL
Monitoring Point W−829−1938
Zinc (mg/L)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
SL
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

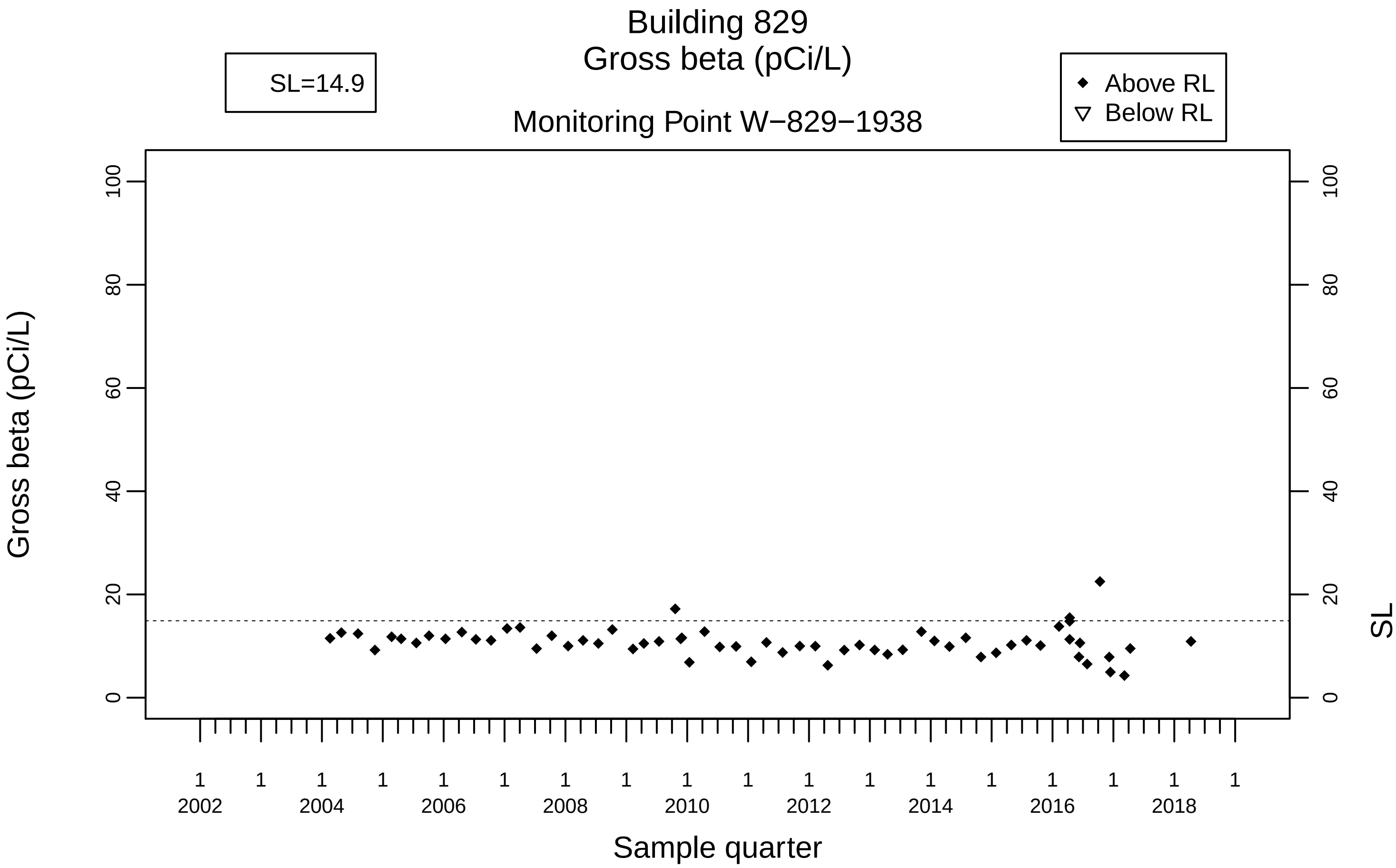

Building 829
Gross alpha (pCi/L)
SL=3.32
Above RL
Estimated
Monitoring Point W−829−15
Gross alpha (pCi/L)
SL
Sample quarter


SL=2
Monitoring Point W−829−22
Gross alpha (pCi/L)
SL
Sample quarter


Building 829
Gross alpha (pCi/L)
SL=2.97
Monitoring Point W−829−1938
Above RL
Estimated
Gross alpha (pCi/L)
SL
5
0
−5
−10
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter


Building 829
Gross beta (pCi/L)
SL=102
Above RL
Below RL
Monitoring Point W−829−15
Gross beta (pCi/L)
0
20
40
60
80
100
SL
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter


SL=11.6
Monitoring Point W−829−22
Gross beta (pCi/L)
0
20
40
60
80
100
SL
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter


Building 829
Gross beta (pCi/L)
SL=14.9
Above RL
Below RL
Monitoring Point W−829−1938
Gross beta (pCi/L)
SL
0
20
40
60
80
100
1
2002
2004
2006
2008
2010
2012
2014
2016
2018
Sample quarter

Appendix B

LLNL Site 300
Building 829 Landfill Cap
Annual Engineering Inspection

Abri Environmental Engineering, Inc.

Environmental Management and Compliance Consultants

LLNL SITE 300 BUILDING 829 LANDFILL CAP ANNUAL ENGINEERING INSPECTION

May 2018

CERTIFICATION

Based on the information reviewed, I certify that this annual inspection and evaluation report fairly describes the condition of the closed Building 829 Landfill.

I certify under penalty of law that this document and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate, and complete.

REGISTERED PROFESSIONAL ENGINEER
WILLIAM WEBBER MOORE
C18340
EXP. 6-30-19
CIVIL
STATE OF CALIFORNIA

4/30/2018

William W. Moore
California-Registered Professional Engineer
Abri Environmental Engineering, Inc.

Date

Table of contents

Figures

Executive Summary

Abri Environmental Engineering performed the annual inspection of the Building 829 landfill cap at the Lawrence Livermore National Laboratory (LLNL) Site 300 located near the City of Tracy. Mr. William W. Moore, P.E., conducted this annual inspection on April 9, 2018. Mr. Moore is a California Registered Civil Engineer, with extensive experience in civil engineering, and hazardous waste management.

This report has been prepared consistent with the scope of work, dated March 12, 2018 and in compliance with 22CCR Section 66264.228(K). The report is based on the observations made during the inspection and review of the documents listed in section 1.0.

Building 829 landfill cap is in good condition. The vegetation cover is thick and covers the soil cap over the pits; there is no visible erosion of the cap; and the drainage system is in good condition and appears to be functioning as intended. The groundwater monitoring system appears to be in good condition as well. Evidence of accumulation of some vegetative debris in the concrete lined drainage ditch was observed. Based on the inspection, recommendations are provided in section 2-14.

1.0 Introduction

LLNL Site 300, EPA ID Number CA2890090002, is owned by the U.S. Department of Energy (DOE) and is operated jointly by the Lawrence Livermore National Security, LLC (LLNS) and DOE. The site comprises approximately 7,000 acres of largely undeveloped land and is primarily used as an explosives test facility. Site 300 is located 15 miles southeast of the LLNL Livermore Site, and 6 miles southwest of downtown City of Tracy, California, see Figure 1. About one-sixth of the site is in Alameda County and the balance is in San Joaquin County.

Building 829 landfill area is located in the south-central quadrat of Site 300, See Figure 2. Building 829 area was used to burn explosives and explosive contaminated wastes at the HE Open Burn Treatment Facility. In 1997 LLNL closed the facility according to a DTSC approved RCRA closure plan. As a result, the area was closed as a landfill with an engineered cap consisting of a minimum of 2 ft compacted general fill, a layer of geosynthetic material and a minimum of 2 ft vegetative soil.

The inspection of the cap included walking the surface and perimeter of the cap. Weather conditions were sunny, temperatures in 60's degree F with winds of about 3-10 miles per hour.

In conjunction with the inspection, the following project files and documents were reviewed:

- Closure Plan for the High-Explosives Open Burn Treatment Facility at Lawrence Livermore National Laboratory, Experimental Test Site 300, dated July 1993,
- Specification PCS-1227, Site 300 Building 829 HE Burn Pits Closure, dated September 1997,
- Annual Pit Survey Data from 2001 to 2016,
- Monthly Post-Closure Inspection Checklists, dated 4/24/17, 5/9/17, 6/8/17, 7/11/17, 8/8/17, 9/13/17, 10/25/17, 11/13/17, 12/14/17, 1/18/18, 2/21/18, and 3/21/18.

2.0 Inspection Observations and Recommendations

The inspection of the cap included walking the surface and perimeter of the cap. The following sections describe the condition and recommendations.

The landfill has a 3 ft high retaining wall at the southwest corner of the cap. The wall appears to be in good condition and appears to be performing as intended.

2-1. Condition of Access Control (Fences, Gates and Warning Signs)

LLNL site 300 is a highly protected site with an around the clock security force and a perimeter fence. The entrance to the site is on Corral Hollow Road, which is protected by locking gates, fences and a security force. Warning signs in English are posted adjacent to the pit, see Figure 3.

2-2 Condition of Vegetation

The landfill is covered with thick and well-established vegetation, see Figure 4.

2-3 Erosion

There was no erosion visible on the site.

2-4 Cracking

No cracks or other desiccation of the cover was visible during the site visit.

2-5 Disturbance by Adverse Weather

No erosion or other evidence of disturbance/damage due to adverse weather (i.e. freezing and thawing) was observed at the site.

2-6 Seepage

No evidence of seepage or discharge was observed beyond the existing collection structures at the facility.

2-7 Slope Stability

No indication of slope instability was observed. There was no sign of slumping or shallow, localized failure.

2-8 Subsidence

No evidence of subsidence was observed over the pit.

2-9 Settlement

Results of the annual pit survey data from 2001 to 2017 showed maximum settlement of 0.23 feet.

2-10 Condition of Groundwater Monitoring System

No evidence of compromise in structural integrity of the groundwater monitoring wells was observed.

2-11 Condition of Run-On and Run-Off Control Systems

Surface runoff diversion structures consist of a perimeter drainage V-ditch. The V-ditch has expansion joints every 12 ft and every other one is caulked. The remaining expansion joints appear to be saw cuts partially onto the surface of the concrete. The structure also collects water from the "drainage layer" of the cap through a series of drainage pipes. The run-on and run-off control system appeared to be in good condition.

Vegetative debris was observed in the concrete lined drainage ditch, see Figure 5. It is recommended that the vegetative debris be removed. Evidence of minor damage in caulking was observed. It is recommended that the damage be repaired, see figure 6.

2-12 Condition of Surveyed Benchmarks

The settlement markers appeared to be in good condition.

2-13 Burrowing Animals

No evidence of burrowing animal holes were observed.

2-14 List of recommendations for Building 829 Landfill Cap

- Remove vegetative debris from the drainage ditch.
- Repair minor damage in the caulking in the drainage ditch.

Figure 1 LLNL Location Map

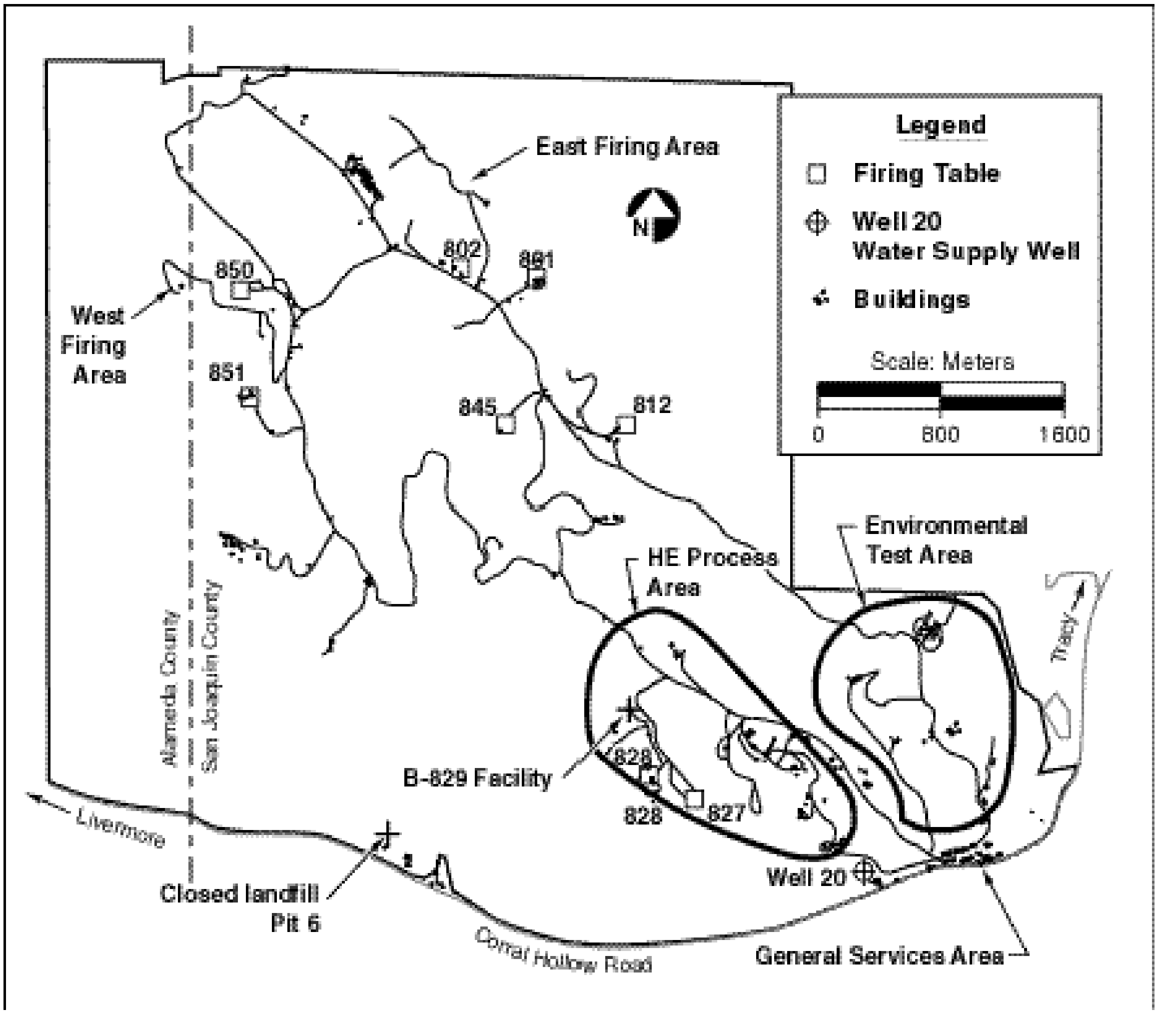


Figure 2 Building 829 Landfill Location Map

Figure 3 Building 829 Landfill Warning Signs

Figure 4 Building 829 Landfill Vegetation Cover Condition

Figure 5 Building 829 Vegetative Debris in Drainage Ditch

Figure 6 Building 829 Damaged caulking in Drainage Ditch

Appendix C

Acronyms and Abbreviations

Acronyms and Abbreviations

CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CL	concentration limit
COC	constituent of concern
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
GWE	groundwater elevation
HE	high explosives
LLC	Limited Liability Corporation
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
PE	Professional Engineer
POC	point of compliance
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
SL	statistically determined limit of concentration
TCE	trichloroethene
VOC	volatile organic compound