

Animas River Water Quality at Rotary Park, Durango, Colorado
Gold King Mine Release Monitoring



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1. Executive Summary

The Gold King Mine release occurred on August 5th, 2015 and caused mine wastewater containing high metal concentrations to enter Cement Creek and ultimately the Animas and San Juan Rivers. The incident occurred in a highly mineralized zone of the San Juan Mountains where high metal concentrations from natural and mine-related sources have contributed to a long history of degraded water quality in the Animas River watershed.

Mountain Studies Institute monitored water quality of the Animas River at Rotary Park in Durango, Colorado before, during, and after the Gold King Mine release. Rotary Park is located approximately 58 river miles (93 kilometers) downstream from the Gold King Mine, where the incident occurred.

Our monitoring objectives were to determine: 1) if metal concentrations during the Gold King Mine plume and subsequent fall storm events posed a risk to aquatic life, recreation, drinking water supply, or agricultural uses; 2) whether metal concentrations were elevated during fall storm events; and 3) whether metal concentrations in the Animas River returned to pre-release levels. We collected 130 water samples from the Animas River from August 6 to October 26 and analyzed samples for 24 different metals and minerals. Our data suggest the following conclusions:

- A substantial spike in total and dissolved concentrations of metals and minerals associated with the Gold King Mine release occurred at Rotary Park from approximately 10 PM on August 6 to midnight on August 7, 2015. Several metals increased in concentration by more than 500 percent during the plume.
- During the plume, on August 6 and 7th, we detected metal concentrations that surpassed water quality benchmarks. Aluminum concentrations from samples collected at 12 AM and 12:30 AM on August 7th were higher than the Colorado Department of Public Health and the Environment (CDPHE) Aquatic Life Acute Standard; lead concentrations from six samples collected on August 6th and August 7th surpassed the CDPHE Domestic Water Supply One-day Maximum Contaminant Level. We did not detect any metal concentrations that surpassed water quality standards or recreational screening levels from August 8th to October 26th.
 - These results suggest that during the plume, high concentrations of aluminum may have been detrimental to aquatic life in the Animas River at Rotary Park. However, observations from Colorado Parks and Wildlife and the Mountain Studies Institute confirmed that fish and benthic macroinvertebrates in the Durango stretch of the Animas River largely survived the Gold King Mine release. Sub-lethal impacts to aquatic life, such as reduced reproduction potential, are possible and should be examined by assessing the survival of subsequent generation of fish and benthic macroinvertebrates.

- The CDPHE Domestic Water Supply Maximum Contaminant Levels (MCL) are set to protect the use of surface water for use as domestic water supply. On August 6th and August 7th at Rotary Park in Durango, we detected concentrations of lead that surpassed the domestic water supply MCL for lead. However, during the August 6th and August 7th time period when we detected high concentrations of lead in the Animas River, the City of Durango had preemptively shut off its intake valve so that the city did not receive any drinking water from the Animas River during that time.
- We detected elevated total and dissolved concentrations of several metals during storm events, but concentrations during storm events were lower than those detected during the plume (except for dissolved aluminum). Metal concentrations during storm events did not surpass water quality standards or screening levels.
- During the post-plume time period (August 10 to October 26, 2015) at Rotary Park, total and dissolved concentrations of aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc returned to levels consistent, or lower than historic observed metal concentrations from the Animas River.
- When compared to historic 2001-2014 River Watch data from the Animas River, concentrations of total recoverable aluminum, copper, iron, lead, and zinc were clearly higher during the Gold King Mine plume than in any other sample since at least 2001. However, the historic River Watch data indicated that concentrations of total recoverable arsenic and selenium observed during the plume were not unprecedented; higher concentrations were documented in the 2001-2014 time period.

Further monitoring is necessary to determine the source of elevated metals observed during storm events, whether elevated metals will occur in the Animas River during spring runoff, and the downstream effectiveness of mine drainage treatment in the Upper Animas basin.

2. Introduction

Mountain Studies Institute (MSI) was financially supported by the Environmental Protection Agency (EPA) to conduct water quality monitoring at Rotary Park in Durango, Colorado following the Gold King Mine release that occurred on August 5, 2015. Due to the Gold King Mine release, mine wastewater containing high metal concentrations entered Cement Creek and ultimately the Animas and San Juan Rivers. Rotary Park is located approximately 58 river miles (93 kilometers) downstream from the Gold King Mine, where the incident occurred.

Extensive research has been conducted on the impacts to water quality and aquatic life from the legacy of historic mining in the Upper Animas watershed. Church and others (2007) provide a thorough overview of the complex interplay of natural geological and mining-related processes that drive impacts to water quality from historic mining in the Upper Animas watershed. The heavily mineralized Silverton region also contributes natural sources of metals to the Animas River. Wright and Janik (1995) found that a greater percentage of dissolved zinc in the Middle Fork of Mineral Creek was from mining-related sources while a greater percentage of aluminum, copper, and iron in the creek were from natural sources. The EPA (2015) recently evaluated the potential risks to the environment from metal contamination of water and sediments in the Upper Animas watershed. Their research concluded that due to elevated metal concentrations, fish have largely been eliminated in the Animas River from the confluence with Mineral Creek to the confluence with Elk Creek, and that benthic macroinvertebrate communities are impaired in most sections of the Animas River from Silverton to Baker's Bridge. Unfortunately, few studies have focused on the impact of metal contamination on sections of the Animas River located further downstream, such as in the Animas Valley or within the city of Durango.

There is an abundance of research describing the effects of metal-contaminated water on aquatic life (e.g., Besser and Leib 2001; Brinkman and Johnston 2012; Farag et al. 2007; Iwasaki et al. 2009; Nehring 1976; Schmidt et al. 2002; Vuori 1995; Warnick and Bell 1969; Yuichi et al. 2009). Elevated metal concentrations can cause direct and indirect effects on aquatic life. For example, the precipitation of iron on body surfaces of aquatic organisms can damage gills and interfere with respiration and osmoregulation (Vuori 1995). Aquatic organisms can also be exposed to metals through ingestion of sediment and suspended particles, or by uptake of metals dissolved in solution (John 1995; Luoma 1983). Toxicity varies greatly between metals, but dissolved metals are generally more biologically available and thus pose a greater threat to aquatic life than metals in a solid state (Luoma 1983). Precipitation of metals on river substrate can indirectly affect aquatic life by smothering potential habitat, filling interstitial spaces, preventing the growth of aquatic vegetation, and altering food resources (Vuori 1995).

Objective

The Gold King Mine release captured international attention as the Animas River, which is heavily used for recreational boating and fishing, turned an orange-color. Communities along the Animas River became immediately concerned with the potential impacts to human health and aquatic life from exposure to the mine wastewater in the river. Community members raised many concerns, wanting to know what was in the mine wastewater, what was the risk of exposure to water and sediments associated with the release, and whether sediments associated with the Gold King Mine release would be re-suspended and pose a threat during storm events.

In this report, we attempt to address the following questions:

In the Animas River at Rotary Park, what was the extent and duration of elevated metal concentrations associated with the Gold King Mine release and subsequent fall storm events?

- a. Did metal concentrations during the Gold King Mine plume and subsequent fall storm events pose a risk to aquatic life, recreation, or agricultural uses?
- b. Were metal concentrations elevated during fall storm events?
- c. Did metal concentrations return to pre-release levels following the Gold King Mine release?

3. Methods

Monitoring Location

We established a water quality monitoring site at Rotary Park in Durango Colorado and collected grab samples along the southern bank of the Animas River, just downstream of the pedestrian bridge. We installed an ISCO automated sampler on the southern bank of the Animas River, beneath the pedestrian bridge (Appendix A).

Sampling Methodology

Our water quality sampling methodology followed the EPA's Sampling and Analysis Plan for the Gold King Mine Release (EPA 2015). We employed quality control and quality assurance measures including collecting field blanks and duplicates, and submitting appropriate chain of custody forms with all samples.

On August 7, 2015, we installed an ISCO automated water sampler along the south bank of the Animas River beneath the pedestrian bridge at Rotary Park. We used rebar to secure the ISCO sampling hose so that water samples were pulled from the same point within the river current each time. Every 3-4 days, we transferred samples from the ISCO collection bottles to sterile one-liter polypropylene bottles provided by Test America Laboratories. After transferring samples, we triple rinsed ISCO collection bottles with deionized water, returned the bottles to the ISCO unit, and reset the ISCO unit to resume sampling. We did not filter or preserve ISCO samples in the field.

Although we collected most samples using the ISCO unit, we did collect grab samples on August 6th, August 7th, and for use as sample duplicates throughout the monitoring period. We collected grab samples in sterile, one-liter polypropylene bottles provided by Test America Laboratories. Prior to sampling we triple rinsed each bottle with river water. We then filled the sample bottle with river water from the river current. We capped sample

bottles and stored samples at room temperature. We did not filter or preserve grab samples in the field.

We altered the frequency of sampling depending on sampling objectives. For example, we collected samples at a greater frequency during the Gold King Mine plume (8/6-7), immediately following the plume (8/9-25), and during storm events. After August 25th, we only collected one sample per day unless there was a storm event. During October storm events, we programmed the ISCO to collect water samples every six hours for the duration of the storm event. We defined storm events as rain events that resulted in a visible rise in water level and a change in turbidity of the Animas River at Rotary Park. Our goal was to collect a sample prior to a rise in the river level, and every six hours until the river level had declined.

Prior to shipping samples to laboratories, we measured the pH of each sample using a hand held pH meter. Before each use, we calibrated the pH meter using buffers of 4, 7, and 10.

We established sample identification nomenclature as: **GKMSW** (*Gold King Mine Surface Water*), **AR** (*Animas River*), **RP** (*Rotary Park*), **-MMDDYY-HH** (*Date/Time: two digit month, two digit day, last two digits of year, two digit hour*). The last two digits of the sample identification reflect the type of sample. We indicate a regular sample as 00, a duplicate sample as 10, and a blank sample as 20 (Table 1).

Table 1. Example of sample identification nomenclature for each sample type.

Sample Type	Sample Identification
Regular Sample	GKMSWARRP-080915-1200
Duplicate Sample	GKMSWARRP-080915-1210
Blank	GKMSWARRP-080915-1220

Laboratory Methods

We shipped all samples to Test America Laboratories in Savannah, GA. We supplied chain of custody forms physically with each sample shipment as well as digitally via email. Test America used EPA analytical methods 200.7 and 200.8 for metals and minerals, and 245.1 for Mercury. Test America conducted all sample preservation and filtering in the laboratory.

Water Quality Benchmarks

We assessed Animas River metal concentrations in relation to four CDPHE water quality standards and the EPA recreational screening level (Table 2). In this report, we use water quality standards and recreational screening levels not in a regulatory context, but as

benchmarks to determine if metal concentrations likely posed a risk to aquatic life, recreation, drinking water supply, or agricultural uses. Henceforth, we refer to water quality standards and screening levels as ‘water quality benchmarks.’

To address concerns for the safety of recreational users in the Animas River, the EPA provided risk-based screening levels for surface water and sediment. The recreational screening level represents the level at which no adverse health effects are expected to occur in adults or children consuming two liters of per day, from the Animas, orally, for 64 days a year for 30 years (EPA 2015).

The Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Commission (WQCC) has set basic water quality standards to protect water quality for domestic water supplies, aquatic life, and agricultural uses (CDPHE 2013). For regulatory use, the WQCC often also sets different water quality standards for specific river segments. Since we are using water quality standards as benchmarks to assess potential risk, and not within a regulatory context, we focus our analysis on the basic water quality standards outlined by CDPHE in Table 3 of Reg. 31 Basic Standards and Methodologies for Surface Water (CDPHE 2013).

Table 2. Applicable water quality standards and screening levels used for perspective as water quality benchmarks in this report.

Water Quality Benchmarks
CDPHE WQCC Domestic Water Supply
CDPHE WQCC Agriculture – Chronic
CDPHE WQCC Aquatic Life – Acute
CDPHE WQCC Aquatic Life – Chronic
EPA Recreational Screening Level – long term exposure

4. Results

Water Quality Sampling

We collected a total of 130 water quality samples from the Animas River at Rotary Park. We collected samples on 62 different days from August 6th to October 26th, 2015. Our data from August and September were collected during a period of declining river levels with a few small storm events. We captured two larger monsoonal storm events that caused an increase in discharge and turbidity in the Animas River on October 5-9 and October 17-26. Due to equipment malfunction, we were not able to collect samples between September 3rd and September 9th. We submitted ten field duplicate samples and three field blank samples to Test America Laboratories.

Laboratory results included total and dissolved concentrations for 24 metals and minerals: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium, silver, thallium, vanadium, and zinc. Test America provided total concentrations of metals and minerals only for samples collected between 12PM on August 7th and 5PM on August 14th.

Gold King Mine Plume

At Rotary Park in Durango, the Animas River became visibly turbid at approximately 10 PM on August 6th, indicating the arrival of the Gold King Mine release. Sample results indicate a substantial spike of metal concentrations and a sharp decrease in pH occurred at approximately 10 PM on August 6th. The lowest pH that MSI sampled was at a low point of 6.78 at 12:30 AM on August 7th, but rebounded to 7.60 by 4:15 PM later that day (Figures 1-2 in Appendix B). Concentrations for most metals generally decreased from this spike by midnight on August 7th. Henceforth, we refer to the 26-hour time period from 10 PM on August 6th to midnight on August 7th as “*the plume*”; from August 8th to August 9th as the “*initial recovery*”; and from August 10th to October 26th as “*post-plume*” (Figure 1 in Appendix B).

During the plume, we detected an increase in total recoverable concentrations of all 24 metals and minerals except for sodium (Figures 3-50 in Appendix B; presented on logarithmic scale; Tables 3 and 4). Concentrations of total recoverable aluminum, arsenic, cobalt, copper, iron, lead, manganese, silver, vanadium, and zinc increased more than 500 percent during the plume. Total recoverable lead increased by more than 175,000 percent. Concentrations of dissolved cobalt, manganese, and zinc also increased by more than 500 percent during the plume (Table 3). However, we did not detect a change in dissolved arsenic, and dissolved metal concentrations were below method detection limits for many analytes including antimony, beryllium, iron, molybdenum, nickel, selenium, silver, thallium, and vanadium. The absence of the dissolved state of some metals could be due to solubility. For example, the lack of dissolved iron in the plume is likely due to iron’s propensity to precipitate out of solution at a very low pH. Since the minimum pH of the plume at Rotary Park was 6.78, dissolved iron may have already precipitated out of solution and was only present in a solid state at Rotary Park.

Post-plume Storm Events

Several storm events occurred in August, September, and October causing a rise in river levels. Animas River discharge (flow rate) increased 10-80 cubic feet per second (cfs) during smaller storms on August 9th, August 28th, September 16th, and September 24th. Larger storm events occurred on September 3-9, October 5-9, and October 17-26, resulting in an increase in discharge (flow rate) of more than 200 cfs.

We evaluated whether metal concentrations increased or decreased during storm events by comparing the metal concentration observed immediately prior to a storm event to the

maximum concentration observed during the storm event. We found that concentrations of metals and minerals followed three general patterns during storm events:

- a) After the plume, total and dissolved concentrations returned to low levels or decreased to levels below method detection limits and did not increase or decrease during storm events (e.g., antimony, beryllium, chromium, mercury, selenium, silver, and thallium).
- b) Total and dissolved concentrations decreased after the plume, but increased during some storm events (e.g., aluminum, cadmium, cobalt, copper, manganese, and zinc).
- c) Total and dissolved concentrations decreased during some storm events (e.g., barium, calcium, molybdenum, potassium, and sodium).

We observed elevated levels of several metals during storm events (i.e., the maximum metal concentration observed during the storm event was more than 100% higher than the metal concentration observed immediately before the storm event). During the larger storm events on October 5-9 and October 17-26, concentrations of total recoverable aluminum, copper, iron, lead, and manganese increased more than 500 percent and concentrations of dissolved cadmium, lead, and manganese increased by more than 200 percent (Table 3). However, concentrations of metals during storm events never reached the levels detected on August 6th and 7th, when the plume arrived at Rotary Park. The only exception was dissolved aluminum, which had higher concentrations during the October 17-26 storm event than during the plume. Several metals and minerals decreased in concentration during storm events, which could be due to dilution in the higher volume of water.

Elevated metals during storm events could be from a number of sources including the natural mineralization of the watershed; storm water runoff that occurs locally; storm water runoff that occurs higher in the watershed; the resuspension of river sediment associated with the legacy of mining in the Upper Animas basin; and the resuspension of river sediment associated with the Gold King Mine release. Since levels of pollutants in surface waters typically increase following storm events, it is possible that the pattern of elevated metal concentrations that we observed during storm events may not be unprecedented, and may not be directly related to the Gold King Mine release. Without historical data that was collected at a high frequency during storm events, it is difficult to conclusively determine if the elevated metal concentrations that we observed during storm events in 2015 differ from metal concentrations that have occurred in storm events prior to the Gold King Mine release.

Table 3. Summary of detected change in metal concentrations during the Gold King Mine plume and subsequent October storm events.

Metal	Plume*				Fall Storms**			
	Total Recoverable		Dissolved		Total Recoverable		Dissolved	
	Direction of Change	Percent Change	Direction of Change	Percent Change	Direction of Change	Avg Percent Change	Direction of Change	Avg Percent Change
Aluminum	Increase	9,982%	Increase	***	Increase	1,932%	Increase	177%
Antimony	Increase	336%	ND	-	ND	-	ND	-
Arsenic	Increase	3,400%	None	-	Increase	100%	Increase	26%
Barium	Increase	379%	Decrease	-56%	Decrease	-17%	Decrease	-16%
Beryllium	Increase	33%	None	-	ND	-	ND	-
Cadmium	Increase	470%	Increase	403%	Increase	461%	Increase	212%
Calcium	Increase	25%	Decrease	***	Decrease	-30%	Decrease	-25%
Chromium	Increase	57%	Increase	***	ND	-	ND	-
Cobalt	Increase	924%	Increase	536%	Increase	163%	ND	-
Copper	Increase	15,512%	Increase	***	Increase	544%	Increase	96%
Iron	Increase	79,505%	ND	-	Increase	1,560%	ND	-
Lead	Increase	175,738%	Increase	***	Increase	1,328%	Increase	200%
Magnesium	Increase	54%	Increase	13%	Decrease	-35%	Decrease	-31%
Manganese	Increase	1,376%	Increase	798%	Increase	560%	Increase	1,283%
Mercury	Increase	410%	NS	-	ND	-	ND	-
Molybdenum	Increase	416%	ND	-	Decrease	-43%	Decrease	-43%
Nickel	Increase	20%	ND	-	Decrease	-39%	Decrease	-34%
Potassium	Increase	182%	Decrease	***	Decrease	-49%	Decrease	-46%
Selenium	Increase	38%	ND	-	ND	-	ND	-
Sodium	Decrease	***	Decrease	***	Decrease	-56%	Decrease	-56%
Silver	Increase	552%	ND	-	ND	-	ND	-
Thallium	Increase	364%	ND	-	ND	-	ND	-
Vanadium	Increase	508%	ND	-	Increase	22%	Increase	117%
Zinc	Increase	1,590%	Increase	748%	Increase	240%	Increase	75%

*Plume: The change in metal concentrations from before the plume (8/6/15 8:05 PM) to the maximum observed concentration during the plume. For metals that had concentrations below the MDL before the plume, the MDL value was used as the pre-plume concentration.

**Fall Storms: The change in metal concentrations from before a storm event to the maximum observed concentration during the storm event. Values indicate the average percent change of the two fall storm events that occurred between October 5-9 and October 17-26. Pre-storm concentrations were from samples collected on 10/5/15 at 12:00 PM and 10/17/15 at 6:00 PM. For metals that had concentrations below the MDL before the storm, the MDL value was used as the pre-storm concentration.

***For these metals, it is difficult to conclusively calculate percent change due to data limitations. The earliest sample from Rotary Park is from 8PM on 8/6. Concentrations of these metals from 8/6 at 8 PM suggest that levels were already reduced or elevated in the immediate hours prior to the arrival of the plume. Since there is no data from Rotary Park prior to 8PM on 8/6, it is difficult to ascertain pre-plume conditions for these metals. In these cases, direction of change was estimated based on comparing concentrations observed during the plume to concentrations observed during the post-plume 8/10 to 8/31 time period.

ND = Concentrations during plume or storms were below MDLs. If a change occurred, it was below our ability to detect; None = Concentrations during the plume or storms were similar to concentrations observed during the 8/10 to 8/31 post-plume time period. Therefore, no change was detected; NS = We do not have data for dissolved mercury during the plume time period; Gold highlight indicates a percent change greater than 500%.

Table 4. Summary statistics for Animas River water quality data for select metals from 2015 at Rotary Park.

Metal	2015 Plume (Aug 6-7)					2015 Initial Recovery (Aug 8-9)				
	Mean	Median	95th Percentile	Min	Max	Mean	Median	95th Percentile	Min	Max
<i>all units are µg/L</i>										
Total Recoverable										
Aluminum	4228	2500	11219	160	12300	119	97.0	205.0	85.0	270
Arsenic	25.659	10.4	82.1	0.37	87.5	0.40	0.37	0.52	0.37	0.64
Cadmium	1.05	0.55	2.68	0.05	2.85	0.06	0.05	0.11	0.04	0.13
Copper	112.1	52	354.1	3.65	395	3.47	3.20	5.20	2.40	6.40
Iron	33954	12000	111375	670	121000	315	250	595	200	800
Lead	688.1	156	2403	10	2620	4.55	4.0	8.40	2.70	11.0
Manganese	427.4	217.5	1214	37	1330	59.0	54.0	93.5	24.0	94.0
Selenium	5.25	5.65	6.83	0.58	6.91	0.80	0.84	1.05	0.58	1.10
Zinc	329.1	203	900	26	980	25.3	24.0	39.0	16.0	48.0
Dissolved										
Aluminum	25.6	20.0	42.1	20	47.5	NS	NS	NS	NS	NS
Arsenic	0.5	0.5	0.5	0.5	0.5	NS	NS	NS	NS	NS
Cadmium	0.32	0.19	0.66	0.1	0.70	NS	NS	NS	NS	NS
Copper	3.79	3.68	4.23	3.5	4.32	NS	NS	NS	NS	NS
Iron	100	100	100	100	100	NS	NS	NS	NS	NS
Lead	0.32	0.23	0.72	0.12	0.82	NS	NS	NS	NS	NS
Manganese	302	158	633.6	81.0	676	NS	NS	NS	NS	NS
Selenium	1	1	1	1	1	NS	NS	NS	NS	NS
Zinc	25.0	10	69.8	10	84.8	NS	NS	NS	NS	NS

“NS” indicates that there is no data for dissolved metals during this time period.

Water Quality Benchmarks

In this report, we use water quality standards and screening levels not in a regulatory context, but as benchmarks to determine if metal concentrations likely posed a risk to aquatic life, recreation, domestic water supply, or agricultural uses. We refer to water quality standards and screening levels as ‘water quality benchmarks.’

At Rotary Park, we detected metal concentrations that surpassed water quality standards that have been set to protect aquatic life and domestic water supply. Aluminum concentrations from samples collected at 12 AM and 12:30 AM on August 7th were higher than the Colorado Department of Public Health and the Environment (CDPHE) Aquatic Life Acute Standard. Lead concentrations from six samples collected on August 6th and August 7th surpassed the CDPHE Domestic Water Supply Maximum Contaminant Level. We did not detect any metal concentrations that surpassed water quality benchmarks from August 8th to October 26th.







There were several instances where metal concentrations briefly surpassed chronic or 30-day standards during the plume and storm events. Chronic standards are set to protect aquatic life, humans, animals, etc. from persistent, frequent, long-term exposure to contaminants over an extended period of time. Chronic standards are typically assessed from multiple samples over a 30-day period using the 50th percentile (or 85th percentile depending on the standard). Concentrations of metals that surpass chronic water quality standards from one sample on one day do not necessarily indicate potential harm unless these levels persist continuously over a 30-day period (CDPHE 2013). Similarly, the EPA Recreational Screening Levels are also set to protect recreational users from persistent, long-term exposure to contaminants over an extended period of time. We did detect total metal concentrations that briefly surpassed EPA Recreational Screening Levels, but since these levels did not persist longer than a few hours, they do not indicate potential harm (see the *Recreation* section below for more details).

We have plotted total and dissolved concentrations for 24 metals and minerals with applicable water quality benchmarks as Figures 3-50 in Appendix B. For metals and minerals that do not have applicable water quality benchmarks, we present the Rotary Park water quality data with no associated water quality benchmark. We have summarized whether metal concentrations surpassed water quality benchmarks during the Gold King Mine plume and subsequent fall storm events in Table 5.

Aquatic Life

These results suggest that during the plume, high concentrations of aluminum may have been detrimental to aquatic life in the Animas River at Rotary Park. However, observations from Colorado Parks and Wildlife and the Mountain Studies Institute confirmed that fish and benthic macroinvertebrates in the Durango stretch of the Animas River largely survived the Gold King Mine release (MSI, unpublished; White 2016).

Table 5. Summary of whether metal concentrations surpassed water quality benchmarks during the Gold King Mine plume and subsequent October storm events.

Metal												
	CDPHE Domestic Water Supply Standard		CDPHE Agriculture Chronic		CDPHE Aquatic Life Acute Standard		CDPHE Aquatic Life Chronic Standard		CDPHE Aquatic Life Chronic Trout-specific		EPA Recreational Screening Level	
	Plume	Storms	Plume	Storms	Plume	Storms	Plume	Storms	Plume	Storms	Plume	Storms
Aluminum	-	-	-	-	Y	n	Y*	n	-	-	n	n
Antimony	Y*	n	-	-	-	-	-	-	-	-	n	n
Arsenic	Y*	n	n	n	n	n	n	n	-	-	Y**	n
Barium	n	n	-	-	-	-	-	-	-	-	n	n
Beryllium	n	n	n	n	-	-	-	-	-	-	n	n
Cadmium	n	n	n	n	n	n	Y*	n	n	n	n	n
Chromium (VI)	n	n	n	n	n	n	n	n	-	-	n	n
Cobalt	-	-	-	-	-	-	-	-	-	-	n	n
Copper	n	n	Y*	n	n	n	n	n	-	-	n	n
Iron	n	n	-	-	-	-	Y*	Y*	-	-	Y**	n
Lead	Y	n	Y*	n	n	n	n	n	-	-	Y**	n
Manganese	Y*	Y*	-	-	n	n	n	n	-	-	n	n
Mercury	n	n	-	-	-	-	Y*	Y*	-	-	n	n
Molybdenum	n	n	n	n	-	-	-	-	-	-	n	n
Nickel	n	n	n	n	n	n	n	n	-	-	n	n
Selenium	n	n	n	n	n	n	n	n	-	-	n	n
Silver	n	n	-	-	n	n	n	n	Y*	n	n	n
Thallium	Y*	n	-	-	-	-	n	n	-	-	Y**	n
Vanadium	-	-	-	-	-	-	-	-	-	-	n	n
Zinc	n	n	n	n	n	n	n	n	-	-	n	n

Y (with yellow highlight) = indicates that for the listed metal, at least one sample had a concentration that surpassed water quality benchmarks;

Y* = Indicates that for the listed metal, at least one sample briefly surpassed a chronic or 30-day water quality benchmark. However, the 50th percentile (or 85th percentile, depending on the standard) must be surpassed over a 30-day period in order to suggest cause for concern.

Y**= Indicates that when applied to the total recoverable metal concentration, at least one sample briefly surpassed the EPA Recreational Screening Level. However, similar to chronic water quality benchmarks, the EPA Recreational Screening Level represents risk from persistent prolonged exposure. Since concentrations only briefly surpassed the EPA Recreational Screening Level, it does not indicate potential harm. See the Recreation section of this report for more details.

n = indicates that for the listed metal, no samples had concentrations that surpassed water quality benchmarks.

- = indicates there is no water quality benchmark for this analyte at this geographic location.

Sub-lethal impacts to aquatic life, such as reduced reproduction potential, are possible and should be examined by assessing the survival of subsequent generation of fish and benthic macroinvertebrates.

Besser and Leib (2001) documented that dissolved copper and zinc are especially harmful to fish and macroinvertebrates in the upper Animas River. At Rotary Park, dissolved copper and zinc concentrations did not surpass CHPHE Acute or Chronic Aquatic Life Standards during the plume or storm events.

In addition to water quality standards, results from bioassays (toxicity experiments) can be used to judge potential impacts to aquatic life from elevated metal concentrations. Bioassays are typically used to determine the lethal concentration that causes 50% mortality of test organisms in the laboratory (LC50). We found that dissolved copper and zinc concentrations from the Animas River at Rotary Park did not surpass LC50s for Brook Trout, Colorado Cutthroat Trout, Mottled Sculpin, Amphipods, or several macroinvertebrate species (Appendix C). However, laboratory conditions are often different from real world conditions. For example, because the toxicity to aquatic life of copper and zinc depends on the hardness of the water, it is important to note the differences in water hardness between experimental conditions in the laboratory and natural conditions in a river. In Appendix C, we present dissolved copper and zinc detected at Rotary Park in context to results from toxicity experiments for several aquatic species. The toxicity thresholds presented in Appendix C were derived from bioassays using water hardness ranging from 42.3 to 144 mg/L (Besser and Leib 2007; Brinkman and Johnston 2012; Nehring 1976; Warnick and Bell 1969). The water hardness measured at Rotary Park from August to October of 2015 ranged from 157 to 280 mg/L. Since the toxicity of dissolved copper and zinc decreases with water hardness, it can be assumed that if anything, these toxicity thresholds are lower than they would be if bioassays would have been conducted using a water hardness more similar to the higher values observed in the Animas River at Rotary Park.

Domestic Water Supply

The CDPHE Domestic Water Supply Maximum Contaminant Levels (MCL) are set to protect the use of surface water for domestic water supply. Although some domestic water supply MCLs are set to represent chronic 30-day exposure, the MCL for lead is set to represent acute 1-day exposure. On August 6th and August 7th at Rotary Park in Durango, we detected concentrations of lead that surpassed the domestic water supply MCL for lead. However, during the August 6th and August 7th time period when we detected high concentrations of lead in the Animas River, the City of Durango had preemptively shut off its intake valve so that the city did not receive any drinking water from the Animas River during that time.

Recreation

The EPA Recreational Screening Levels were set to represent the level at which no adverse health effects are expected to occur in humans consuming two liters of water per day, from the Animas, orally, for 64 days each year for 30 years.

To account for intentional ingestion of *filtered* Animas River water by recreational users such as campers, hunters, or backpackers (i.e., users most likely to have a high level of exposure from ingesting large volumes of river water over a prolonged period of time), EPA Recreational Screening Levels are applied to dissolved metal concentrations. We did not detect any dissolved metal concentrations during the Gold King plume or subsequent storm events that surpassed EPA Recreational Screening Levels.

To account for unintentional ingestion of *unfiltered* Animas River water by recreational users such as boaters and tubers (e.g., accidentally swallowing water), or intentional ingestion by campers, EPA Recreational Screening Levels could also be applied to total metal concentrations. When applied to total metal concentrations, the EPA Recreational Screening Level threshold was briefly surpassed for arsenic, iron, lead, and thallium on August 6th and 7th, but those levels only lasted a few hours during the plume and did not persist over a 64 day period.

Therefore, according to the screening levels set by the EPA (*applied to either dissolved or total metal concentrations*), the Gold King Mine release did not pose a threat to recreationalists exposed to Animas River water at Rotary Park during or after the Gold King Mine release.

Agriculture

The CDPHE Agricultural Water Quality Standards were set to protect the use of surface water for crop irrigation and as a drinking water source for livestock. The CDPHE Agricultural Water Quality Standards represent the level at which no adverse effects are expected to occur from chronic prolonged exposure over a 30-day period. On August 6th and 7th, we detected concentrations of copper and lead that surpassed CDPHE Agricultural Water Quality Standards. However, the CDPHE Agricultural Water Quality Standards for copper and lead are not applicable to the type of acute short-term exposure that occurred on August 6th and 7th; they are based on the maximum concentrations that are recommended for long-term continuous use on agricultural soils (EPA 1972). Metal concentrations detected from August 8th to October 26th were below CDPHE Agricultural Water Quality Standards.

Rotary Park Water Quality in Context to Historic Data

Historic water quality data are available from The Rivers of Colorado Water Watch Network, commonly referred to as River Watch. River Watch volunteers have collected monthly water quality samples from several sites along the Animas River, including a

monitoring location at the Colorado Parks and Wildlife fish hatchery (37.2813, -107.8733), which is located approximately 400 meters (1,300 feet) upstream from Rotary Park. Monthly samples are available from the hatchery monitoring location from 2001-2014. River Watch data are publicly available from the Colorado Data Sharing Network (CDSN 2015).

In order to assess whether metal concentrations at Rotary Park following the Gold King Mine release had returned to levels consistent with historical observed metal concentrations, we compared dissolved and total metals from historical River Watch data to 2015 Rotary Park data. We were only able to assess metals that were analyzed in both Rotary Park and River Watch datasets: aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc. We define the post-Gold King Mine plume as the time period occurring from August 10 to October 26, 2015.

Direct comparisons between the 2015 data and historical data are problematic due to differences in flow conditions at the time of sampling. For example, River Watch samples were obtained throughout the year and were collected under a variety of flow conditions (e.g., low flow, high flow, base flow, storm flow). Conversely, 2015 Rotary Park data are only from August, September, and October. Additionally, during the month of October, 2015, we only collected samples before, during, and after storm events. Therefore, in order to make as direct a comparison as possible, we compared 2015 Rotary Park data to a subset of the historic data, using only samples collected during August, September, and October (Table 6). We present 2015 Rotary Park data in context of historic 2001-2014 River Watch data for total recoverable and dissolved aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc (Appendix D).

For all nine metals, mean total and dissolved concentrations from the post-plume time period at Rotary Park were lower than historic means. However, differences in method detection limits (MDLs) between the 2015 Rotary Park dataset and the historic dataset can skew average values. For example, the MDL for many total recoverable lead samples in the River Watch data was 3.0 ug/L, while the MDL for total recoverable lead in the 2015 Rotary Park data was 0.06 ug/L. Due to these differing MDLs, a total recoverable lead concentration of 1.0 ug/L could have been accurately recorded as 1.0 ug/L in the 2015 dataset, and recorded at the MDL of 3.0 ug/L in the historical dataset, thus inaccurately suggesting that the historic concentration was higher than the 2015 concentration (Figure 6 in Appendix D). Therefore, it may be more meaningful to compare 2015 data to historic minimums, maximums, medians, and 95th percentiles. We found that post-plume mean concentrations at Rotary Park were within the range of concentrations recorded in the historic data (i.e., 2015 mean was higher than the historic minimum and lower than the historic maximum). Additionally, we found that maximums and 95th percentiles for most metals were lower during the post-plume time period than historic maximums and 95th percentiles (Table 6). The only exceptions were for total cadmium (post-plume 95th percentile was 0.48 ug/L; historic 95th percentile was 0.44 ug/L) and dissolved aluminum (post-plume 95th percentile was 58.5 ug/L; historic 95th percentile was 56 ug/L).

Table 6. Summary statistics for Animas River water quality data from 2015 at Rotary Park and from historic River Watch data (1992-1997; 2001-2014) at the Colorado Parks and Wildlife fish hatchery monitoring site.

Metal	2015 Post-Plume (Aug 10 -Oct 26)					Historic (Aug-Oct)					Historic (all data)				
	Mean	Median	95th Percentile	Min	Max	Mean	Median	95th Percentile	Min	Max	Mean	Median	95th Percentile	Min	Max
<i>all units are µg/L</i>															
Total Recoverable															
Aluminum	103.5	64	282	24	840	326	171	852	26	3,555	380	203	1,071	3.8	3,555
Arsenic	0.44	0.37	0.73	0.37	0.94	11.3	8.15	21.25	1.3	103	14.6	8.15	19.9	1.3	270
Cadmium	0.17	0.14	0.48	0.04	0.5	0.29	0.23	0.44	0.1	1.83	0.32	0.27	0.71	0.1	4.38
Copper	2.69	1.8	5.74	1	14	5.3	4.1	10.4	1	53.9	7.3	4.1	19.7	1	70.8
Iron	159	75	424	17	1,300	612	277	1,008	66	9,770	711	374	2,518	3.2	9,770
Lead	1.21	0.68	3.66	0.07	6.2	6.8	3	9.9	1.3	124.3	7	3	27.55	1.3	124.3
Manganese	35.4	22	94.4	1.8	160	130.5	110	159.2	19.8	1,084	161.6	138.1	350.9	3.8	1,084
Selenium	1.3	0.58	6.26	0.58	8.4	5.9	5	17	0.6	48.4	4.4	5	7.4	0.6	89.5
Zinc	32	29	63	2.8	130	69	54	142	9	472	95	86	190	0.3	472
Dissolved															
Aluminum	29.8	24	58.5	24	91	120	22	122	3.8	3,306	47	21	56	3.8	3,306
Arsenic	0.42	0.37	0.62	0.37	0.83	8.5	1.3	15	1.3	41	11.1	1.3	15	1.3	305
Cadmium	0.16	0.15	0.32	0.043	0.39	0.22	0.18	0.36	0.1	1.18	0.22	0.21	0.39	0.1	1.18
Copper	1.6	1.2	2.2	0.98	21	3.7	2.3	4.7	1	42.3	2.6	2.2	4.1	1	42.3
Iron	17.1	17	17	17	22	252.8	17.5	177	3.2	7,929	80.1	18.5	78.6	3.2	7,929
Lead	0.07	0.06	0.13	0.06	0.3	5.4	3	5.2	1.3	108	3.1	3	4.7	1.3	108
Manganese	6.4	1.2	31.5	1.2	79	93.7	71.7	139.6	16.7	790.8	116.2	92.9	230	3.8	790.8
Selenium	0.96	0.58	2.1	0.58	3.2	4.9	5	9.1	0.6	48.4	3.8	4.5	5.2	0.6	79.7
Zinc	19.1	20	33.5	2.8	46	42.9	36.5	86.6	6.6	252.7	54.3	51.9	92.7	0.3	252.7

Concentrations of total recoverable aluminum, copper, iron, lead, and zinc were clearly higher at the peak of the Gold King Mine plume than in any other sample since at least 2001 (Appendix D). However, the historic River Watch data indicated that concentrations of total recoverable arsenic and selenium observed during the plume were not unprecedented; higher concentrations were documented in the 2001-2014 time period.

These data suggest that during the post-plume time period (August 10 to October 26, 2015) at Rotary Park, total and dissolved concentrations of aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc returned to levels consistent, or lower than, historical observed metal concentrations from the Animas River.

Rotary Park Water Quality in Context to Other Sites on the Animas River

Water quality data from the EPA indicate that elevated metal concentrations also occurred during the plume at sites upstream of Rotary Park. In Appendix E, we present total and dissolved iron and zinc concentrations during the Gold King Mine release at four sites: Animas River at Rotary Park; Animas River at Baker's Bridge, Animas River below Silverton (A72), and Cement Creek in Silverton (the locations of these four sites are included in Appendix A). The data clearly depict a spike in metal concentrations at each site, occurring first at Cement Creek, then at A72, then at Baker's Bridge, and finally at Rotary Park. Metal concentrations appear to follow a gradient with the highest concentrations occurring at the furthest upstream site, Cement Creek, and the lowest concentrations occurring at the furthest downstream site, Rotary Park.

Dissolved iron was detected at Cement Creek and at the Animas River below Silverton. Dissolved iron was not detected at all at Rotary Park and only in one sample during the height of the plume at Baker's Bridge. This is likely due to iron's solubility at a very low pH. The pH of Cement Creek and of the Animas River below Silverton is low enough that some iron remained in a dissolved state. The pH of the Animas River is higher at Baker's Bridge and Rotary Park, and thus, most iron had precipitated out and was no longer in a dissolved state. In contrast, zinc has a solubility at a relatively high pH, which is apparent by the presence of dissolved zinc at Baker's Bridge and at Rotary Park (Appendix E).

Conclusions, Research Recommendations, and Further Questions

Water quality data from the Animas River at Rotary Park suggest the following conclusions:

- A substantial spike in total and dissolved concentrations of metals and minerals associated with the Gold King Mine release occurred at Rotary Park from approximately 10 PM on August 6 to midnight on August 7, 2015. Several metals increased in concentration by more than 500 percent during the plume.
- During the plume, on August 6 and 7th, we detected metal concentrations that surpassed water quality benchmarks. Aluminum concentrations from samples collected at 12 AM and 12:30 AM on August 7th were higher than the Colorado

Department of Public Health and the Environment (CDPHE) Aquatic Life Acute Standard; lead concentrations from six samples collected on August 6th and August 7th surpassed the CDPHE Domestic Water Supply One-day Maximum Contaminant Level. We did not detect any metal concentrations that surpassed water quality standards or recreational screening levels from August 8th to October 26th.

- These results suggest that during the plume, high concentrations of aluminum may have been detrimental to aquatic life in the Animas River at Rotary Park. However, observations from Colorado Parks and Wildlife and the Mountain Studies Institute confirmed that fish and benthic macroinvertebrates in the Durango stretch of the Animas River largely survived the Gold King Mine release. Sub-lethal impacts to aquatic life, such as reduced reproduction potential, are possible and should be examined by assessing the survival of subsequent generation of fish and benthic macroinvertebrates.
- The CDPHE Domestic Water Supply Maximum Contaminant Levels (MCL) are set to protect the use of surface water for use as domestic water supply. On August 6th and August 7th at Rotary Park in Durango, we detected concentrations of lead that surpassed the domestic water supply MCL for lead. However, during the August 6th and August 7th time period when we detected high concentrations of lead in the Animas River, the City of Durango had preemptively shut off its intake valve so that the city did not receive any drinking water from the Animas River during that time.
- We detected elevated total and dissolved concentrations of several metals during storm events, but concentrations during storm events were lower than those detected during the plume (except for dissolved aluminum). Metal concentrations during storm events did not surpass water quality benchmarks.
- Water quality data from the EPA indicated that elevated metal concentrations also occurred during the plume at sites along the Animas River upstream of Rotary Park.
- During the post-plume time period (August 10 to October 26, 2015) at Rotary Park, total and dissolved concentrations of aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc returned to levels consistent, or lower than historic observed metal concentrations from the Animas River.
- When compared to historic 2001-2014 River Watch data from the Animas River, concentrations of total recoverable aluminum, copper, iron, lead, and zinc were clearly higher during the Gold King Mine plume than in any other sample since at least 2001. However, the historic River Watch data indicated that concentrations of total recoverable arsenic and selenium observed during the plume were not

unprecedented; higher concentrations were documented in the 2001-2014 time period.

Further monitoring is necessary to determine the source of elevated metals observed during storm events, whether elevated metals will occur in the Animas River during spring runoff, and the downstream effectiveness of mine drainage treatment in the Upper Animas Basin.

There are still many uncertainties regarding the water quality of the Animas River following the Gold King Mine release. We did detect elevated levels of several metals during fall storm events. However, we have very limited historic metal concentration data from fall storm events on the Animas River, so it is difficult to determine whether the elevated levels we observed during storm events were directly attributable to the Gold King Mine release. Further monitoring is needed to determine the source of elevated metal concentrations that were observed in the Animas River during higher flows. Elevated metals in the Animas River could be due to re-suspension of sediment during storm events that occur locally, or from metal sources mobilized by storm events that occur higher in the watershed. Further storm event monitoring should attempt to collect water quality data from the Animas River during a variety of storm events that occur at different spatial scales. For example, water samples could be collected concurrently during storm events at reference sites (such as Lime Creek, Cascade Creek, and Hermosa Creek) and at sites along the Animas River (such as above and below Silverton; at Baker's Bridge; above and below Durango) in an attempt to understand if metals originate from the Silverton area, the Animas River canyon, agricultural areas of the Animas Valley, or urban runoff in Durango. During storm events in 2015, we detected substantial increases in concentrations of total recoverable aluminum, copper, iron, lead, and manganese, and concentrations of dissolved cadmium, lead, and manganese. If analyzing the full suite of metals and minerals is cost-prohibitive for future monitoring efforts, it may be advantageous to focus on this subset of metals.

There is concern among local communities that elevated metal concentrations will occur in the Animas River as sediment that was deposited during the Gold King Mine release is re-suspended during the high flows of spring runoff. Monitoring in the spring of 2016 could verify whether or not a spike in metal concentrations does occur during high spring flows. It could then be determined whether concentrations are consistent with historic spring runoff data or if elevated concentrations in the spring could be attributable to the Gold King Mine release. Ideally, spring runoff monitoring would occur at multiple locations, similar to our site suggestions for storm event monitoring. It is also possible that monitoring may not detect an increase in metal concentrations during spring runoff, since the high volume of water typical of spring runoff could dilute any sediment-related increases in metal concentrations.

Mine drainage from the Gold King Mine is currently being treated to remove 85% of metals of concern. The downstream effectiveness of this treatment effort in the Animas River is currently unknown. Further monitoring is necessary to assess how the Gold King Mine

treatment and other restoration activities in the upper Animas watershed affect water quality further downstream at sites such as Baker's Bridge, James Ranch, and Rotary Park.

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Appendix A - Maps of Animas River water quality monitoring sites

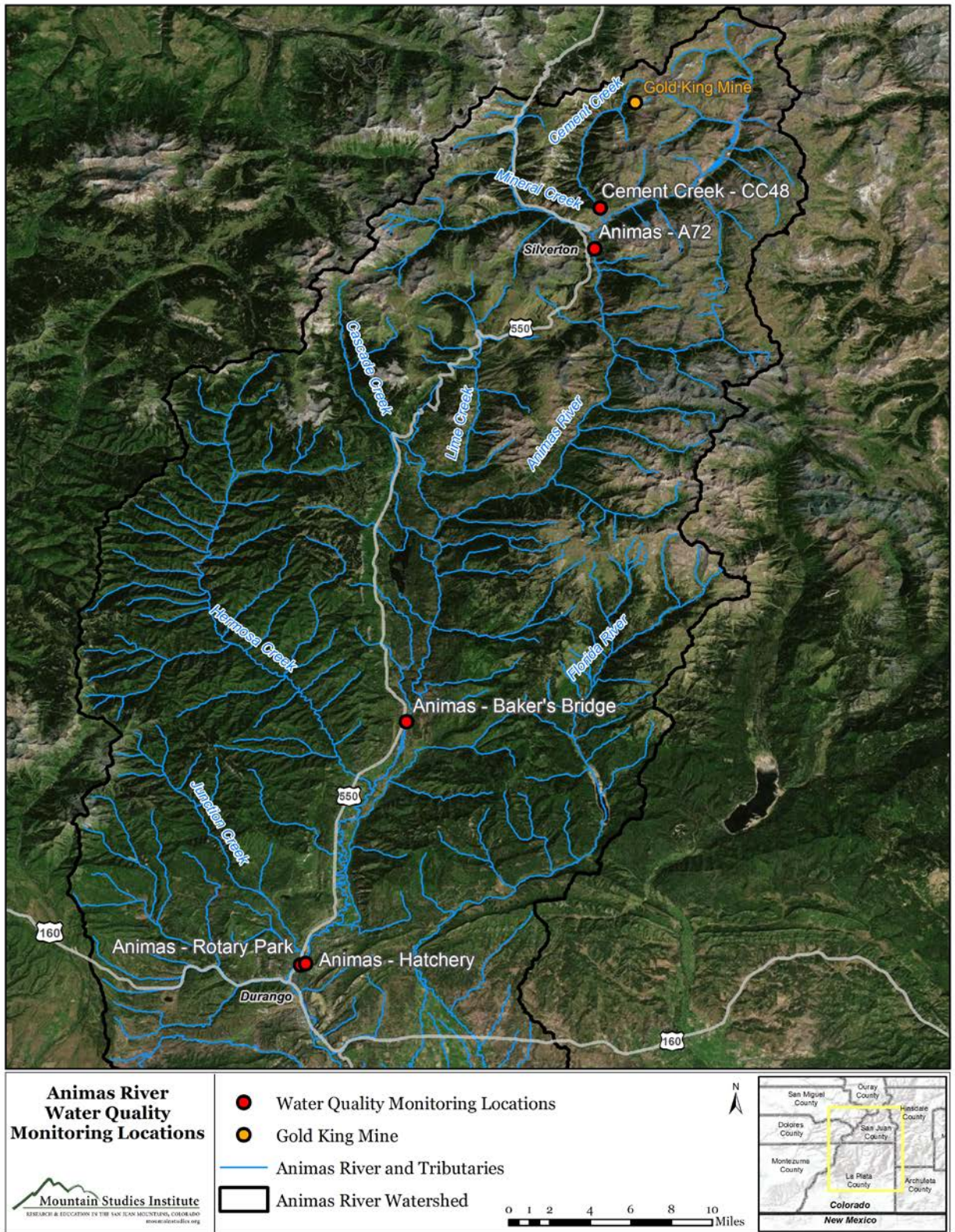


Figure 1: Animas River Water Quality Monitoring Locations

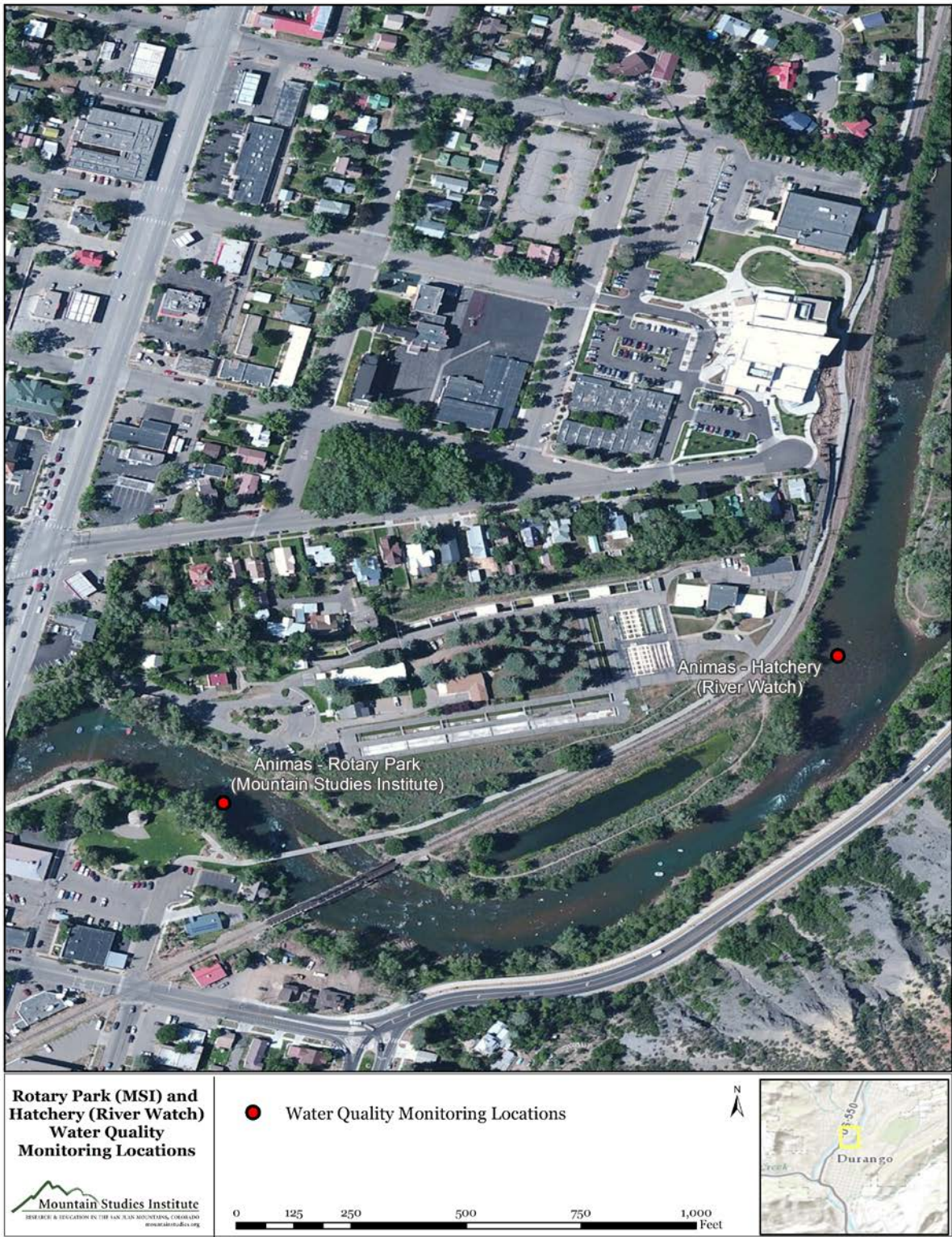


Figure 2: Rotary Park (Mountain Studies Institute) and Hatchery (River Watch) Monitoring Locations

**Appendix B - Water quality results from Rotary Park, Durango, CO
in context of appropriate water quality standards.**

Figure 1

Water Quality Time Series - Rotary Park, Durango, CO pH and Total Lead (Pb)

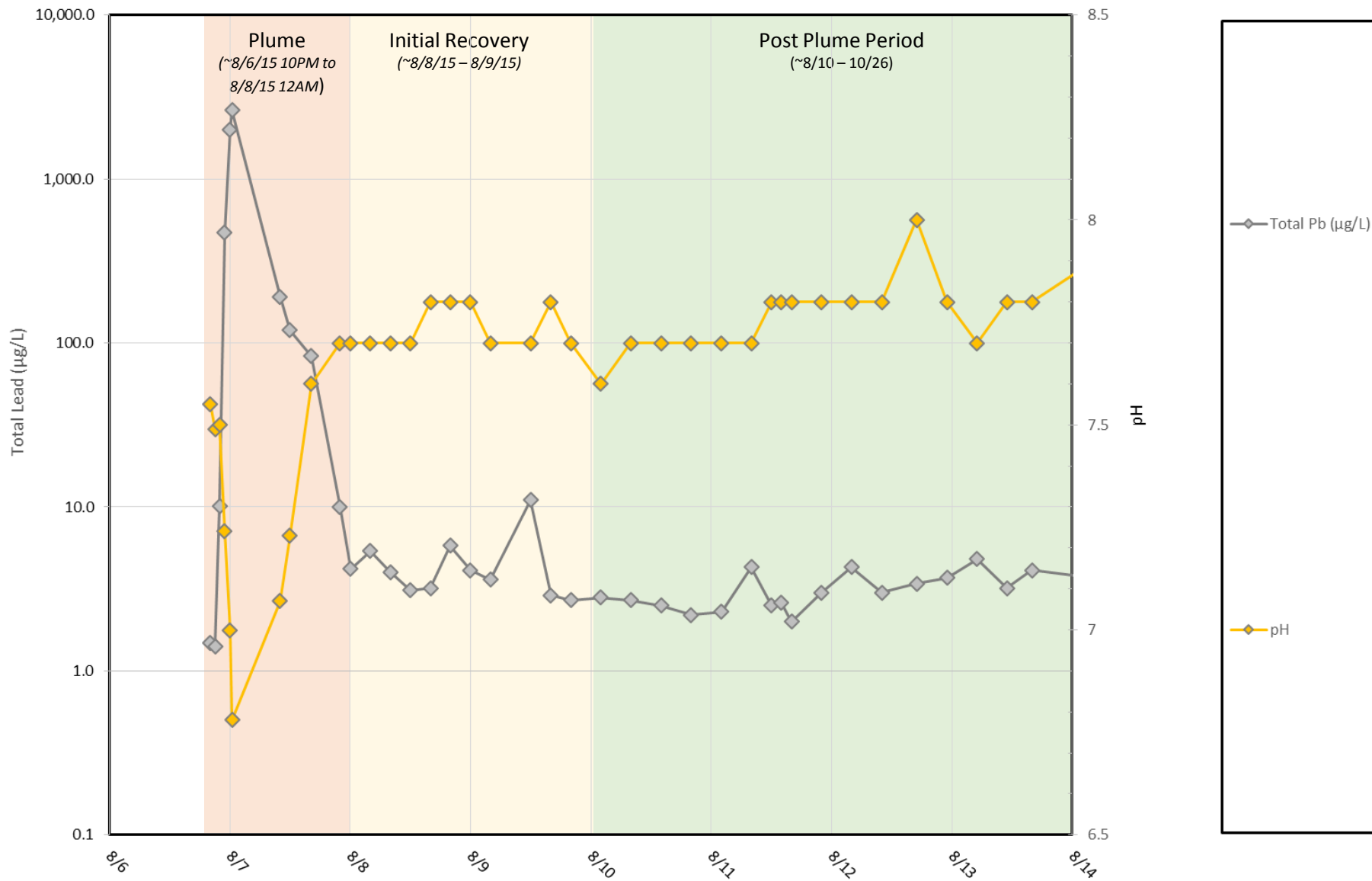


Figure 2

Water Quality Time Series - Rotary Park, Durango, CO

pH

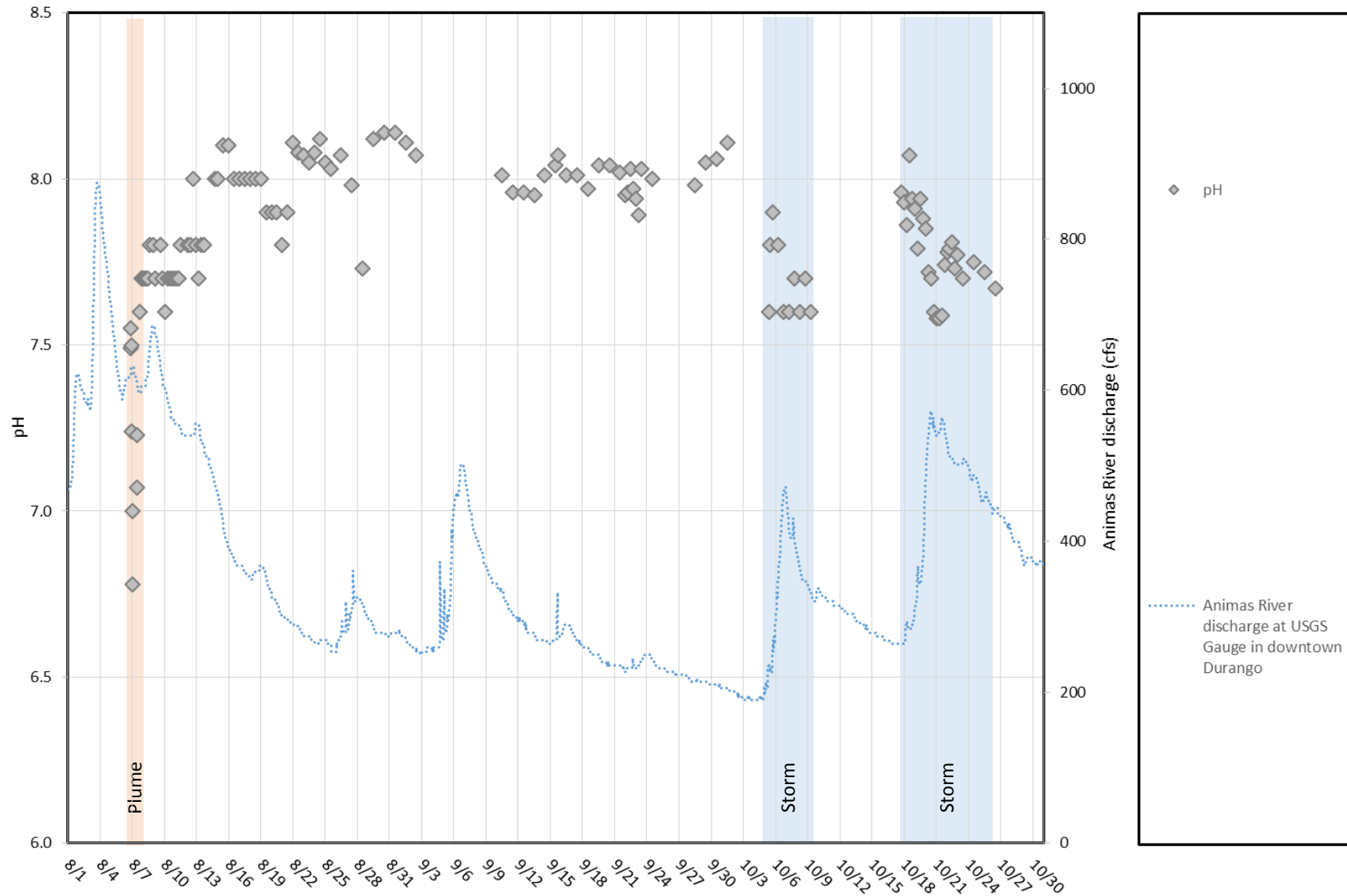
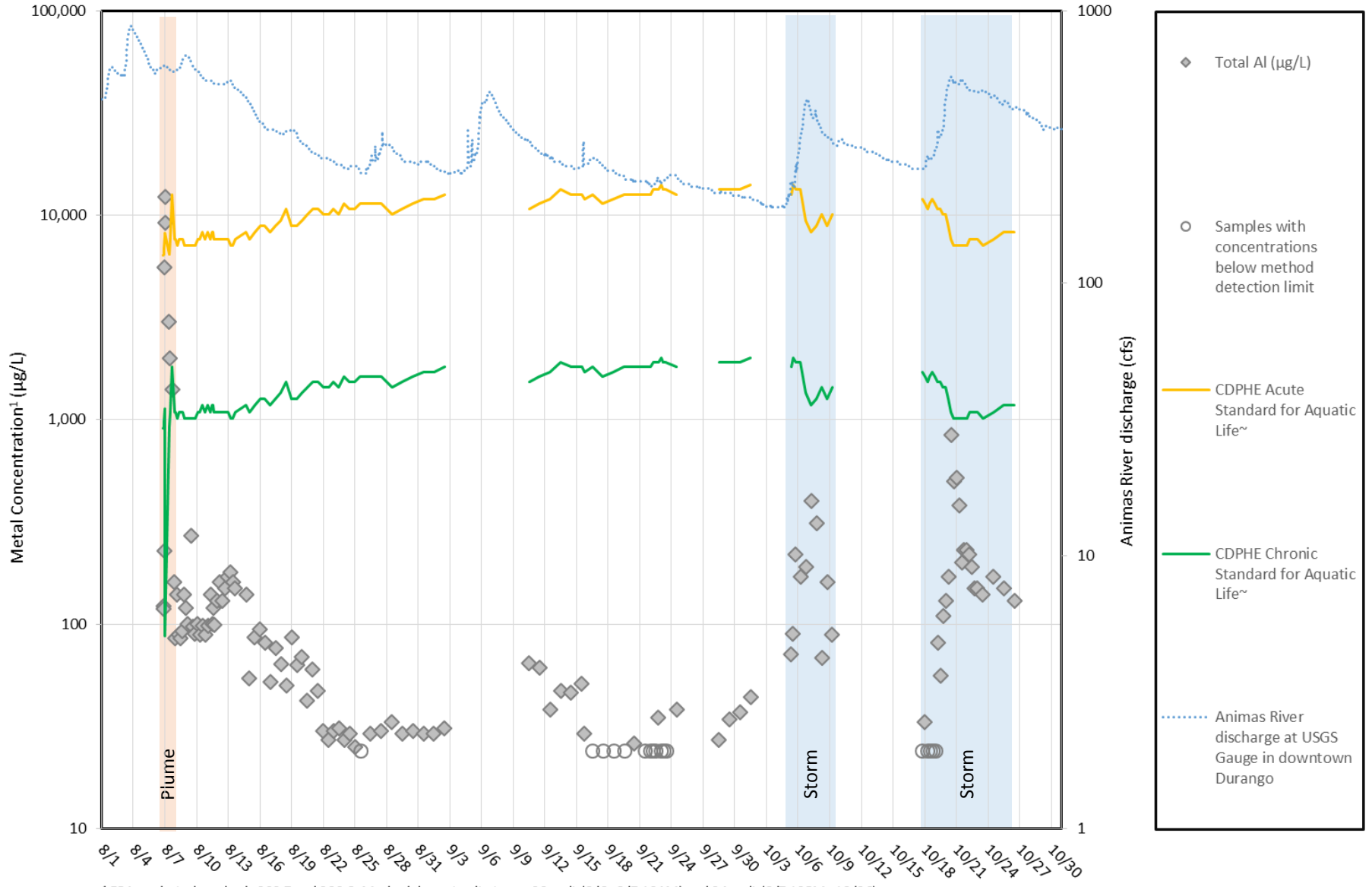


Figure 3

Water Quality Time Series - Rotary Park, Durango, CO Aluminum (Al), Total

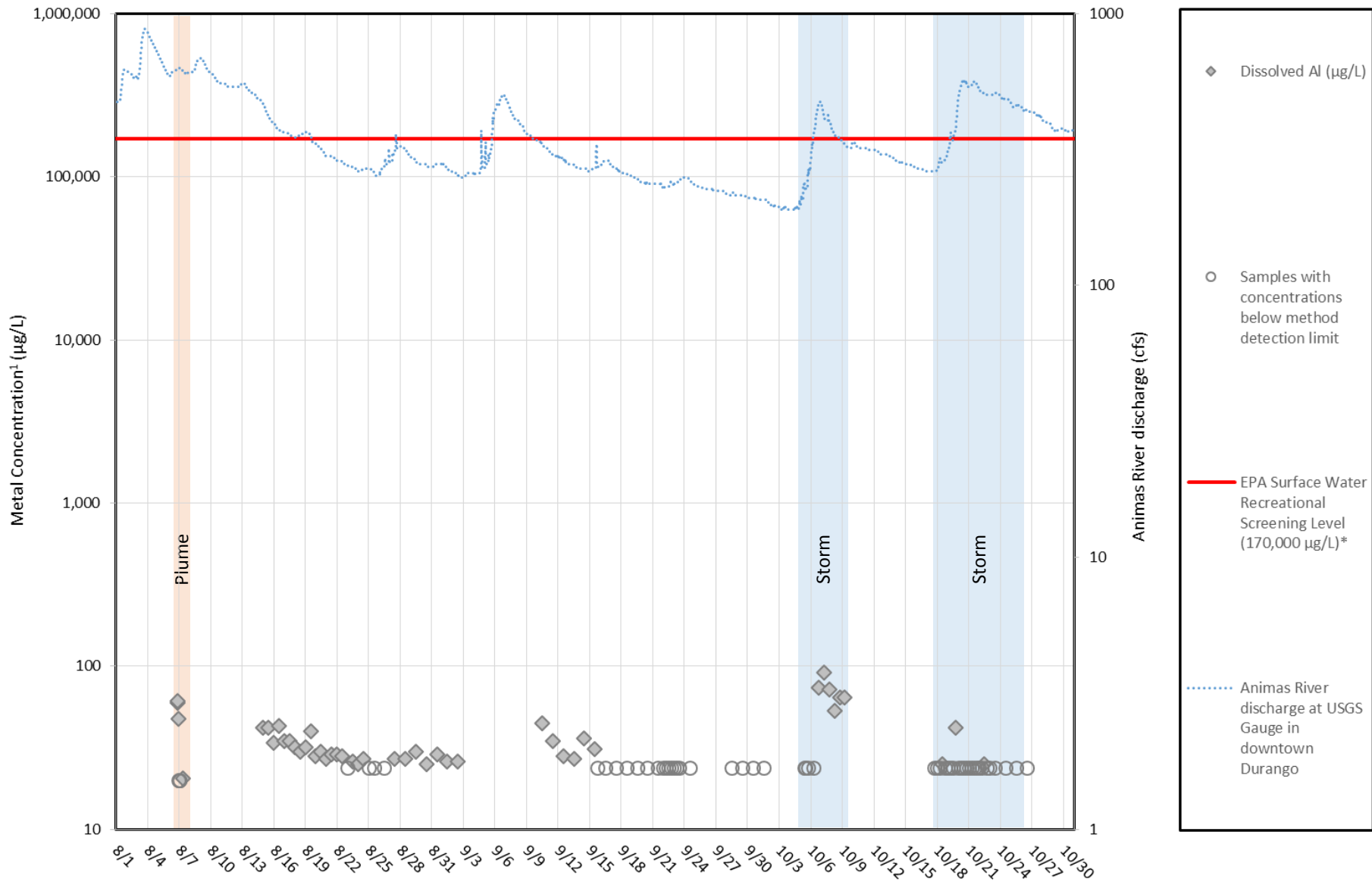


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 20 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 24 $\mu\text{g/L}$ (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness.

Figure 4

Water Quality Time Series - Rotary Park, Durango, CO Aluminum (Al), Dissolved

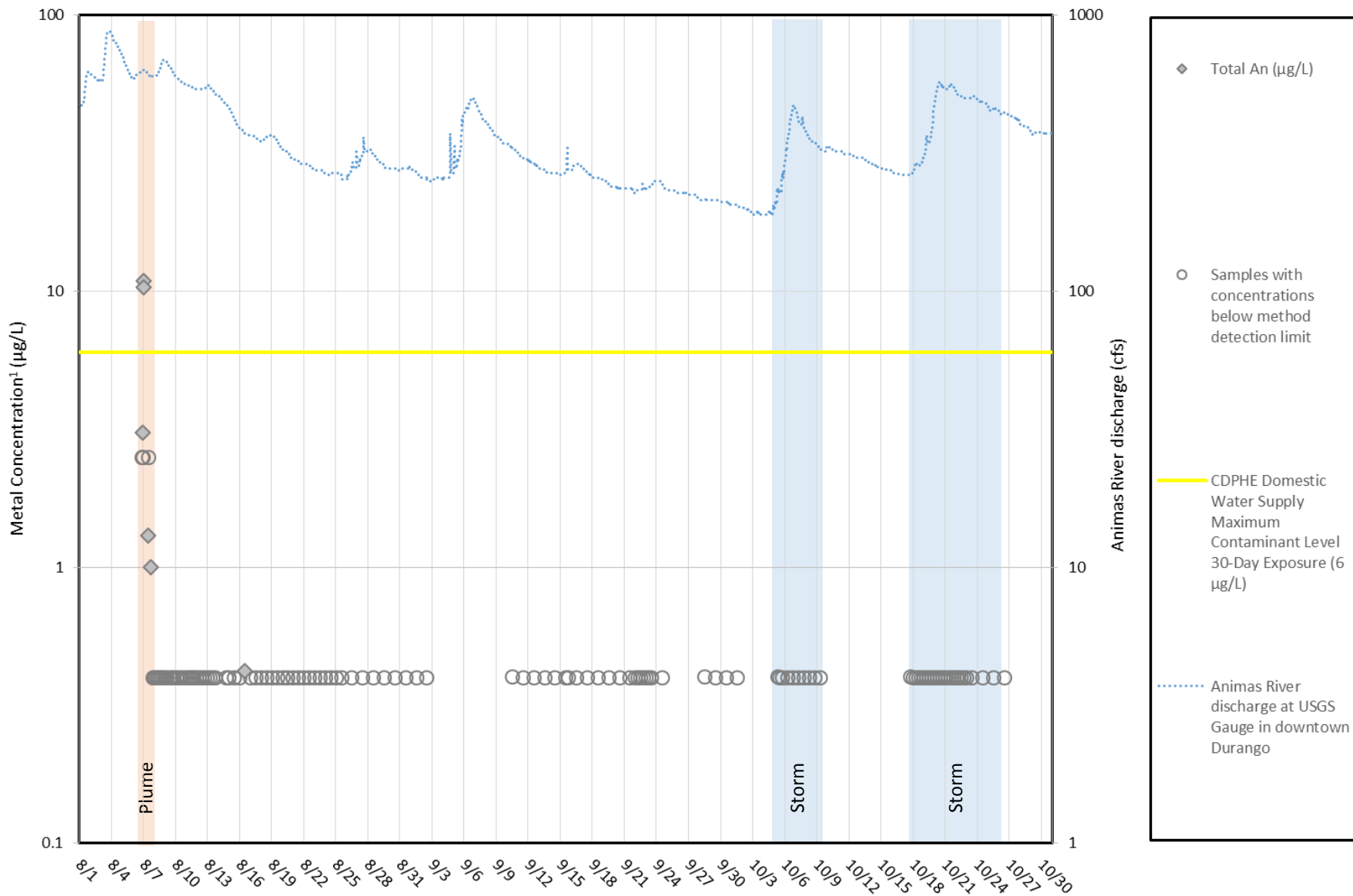


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 20 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 24 $\mu\text{g/L}$ (8/7 12PM - 10/26).

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 5

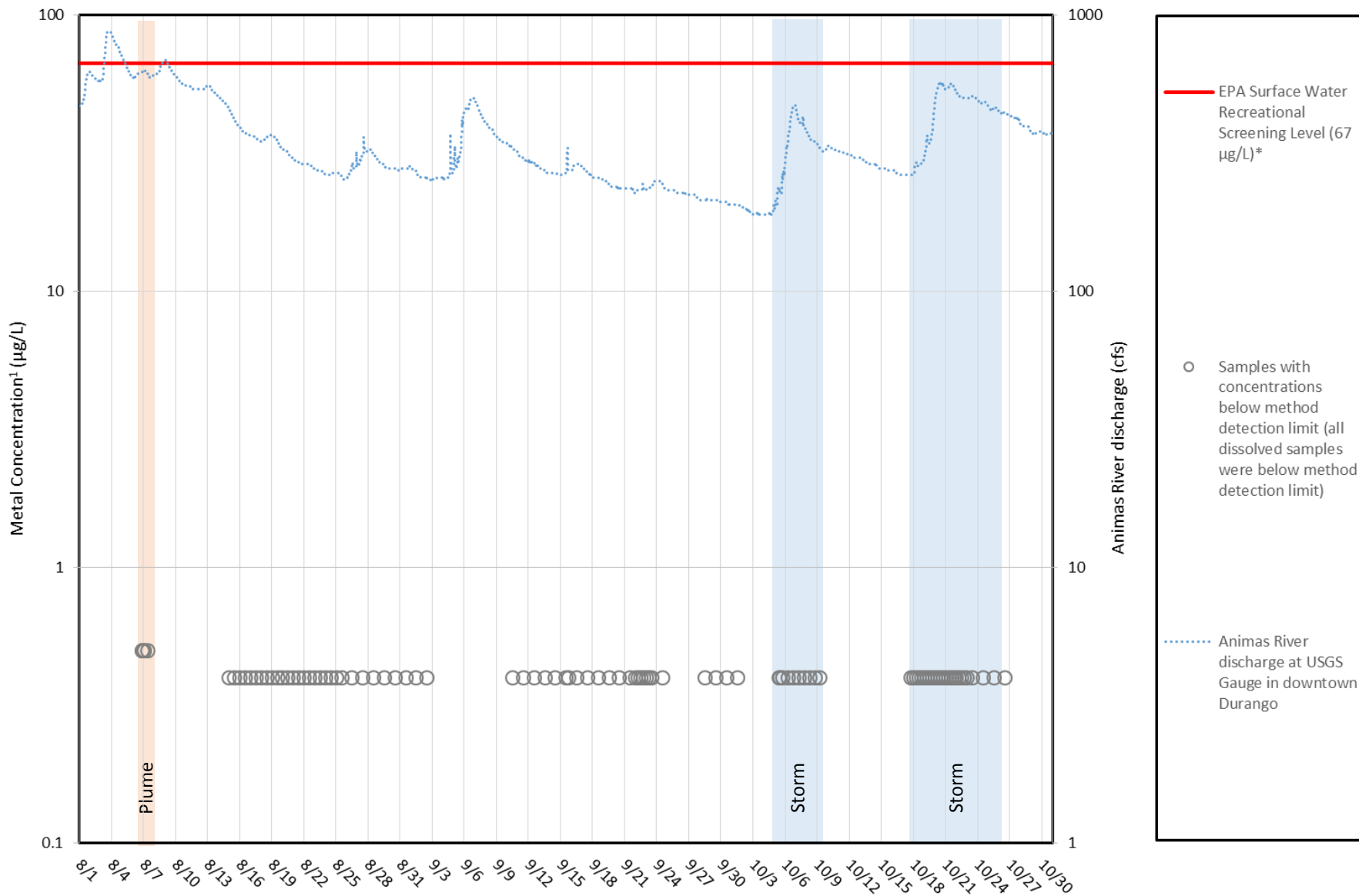
Water Quality Time Series - Rotary Park, Durango, CO Antimony (An), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6-8/7 10AM) and 0.4 µg/L (8/7 12PM - 10/26).

Figure 6

Water Quality Time Series - Rotary Park, Durango, CO Antimony (An), Dissolved

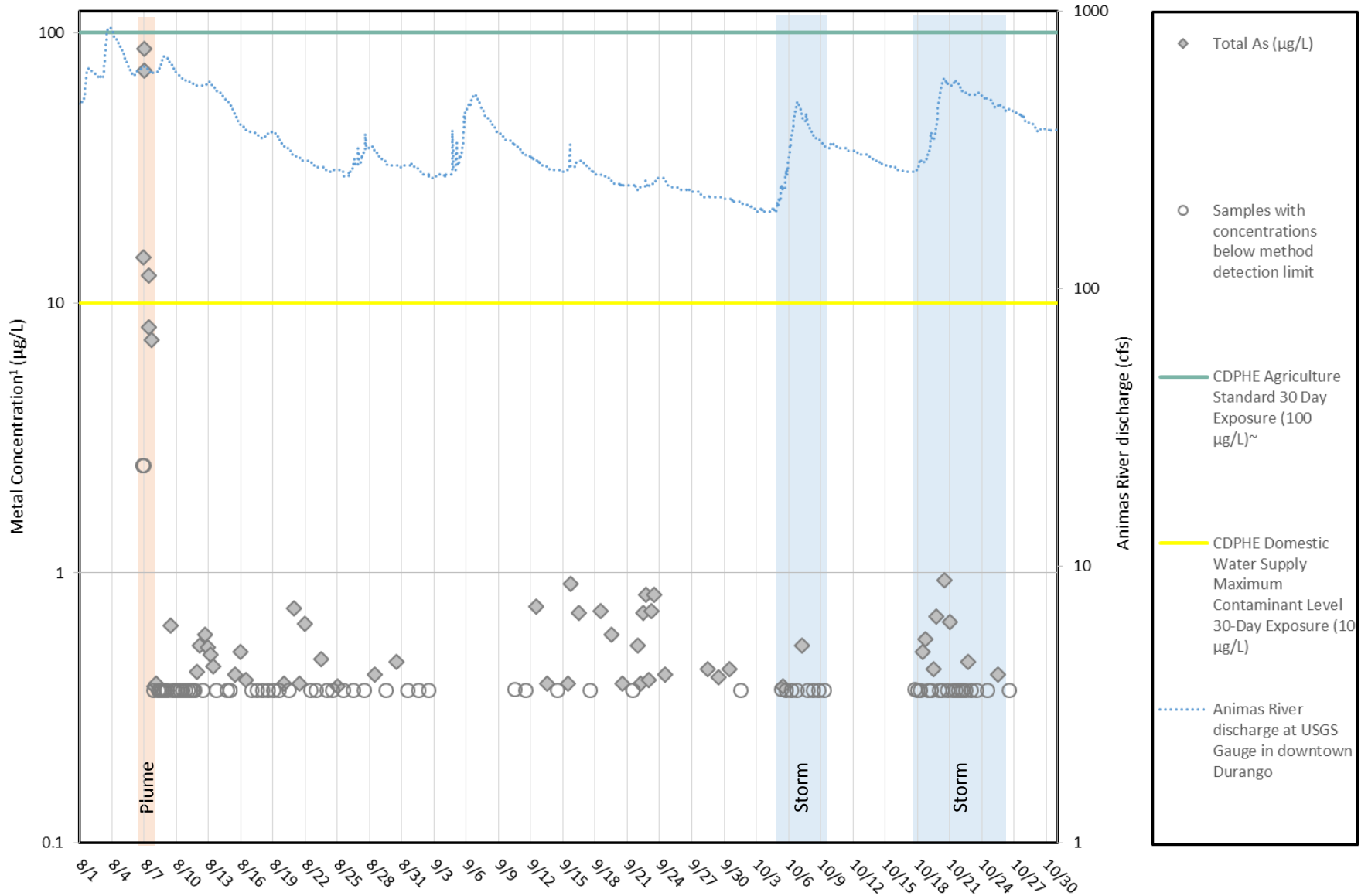


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L (8/6 - 8/7 10AM) and 0.4 µg/L (8/7 12PM - 10/26).

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 7

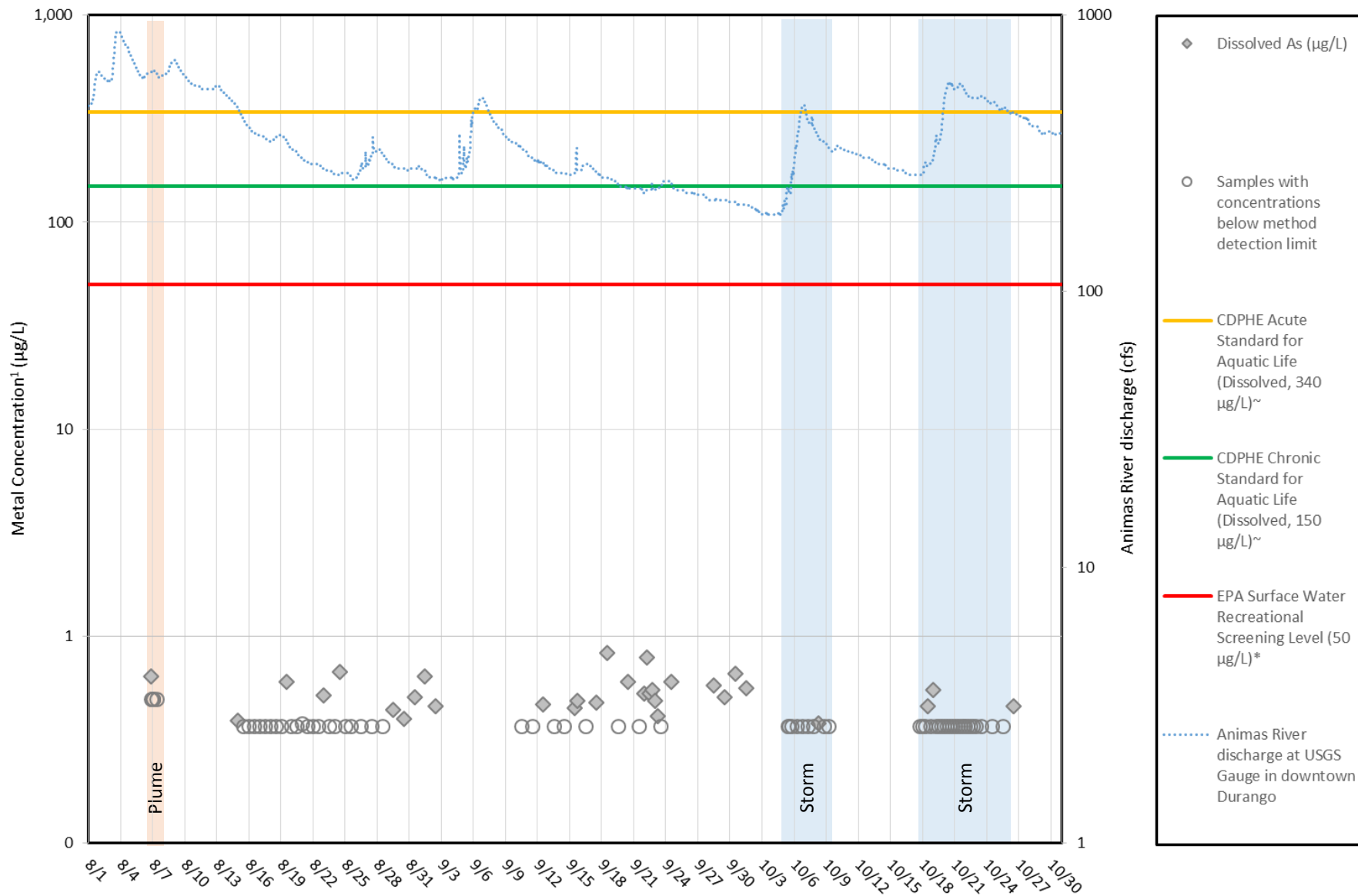
Water Quality Time Series - Rotary Park, Durango, CO Arsenic (As), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6 - 8/7 10AM) and 0.37 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 8

Water Quality Time Series - Rotary Park, Durango, CO Arsenic (As), Dissolved



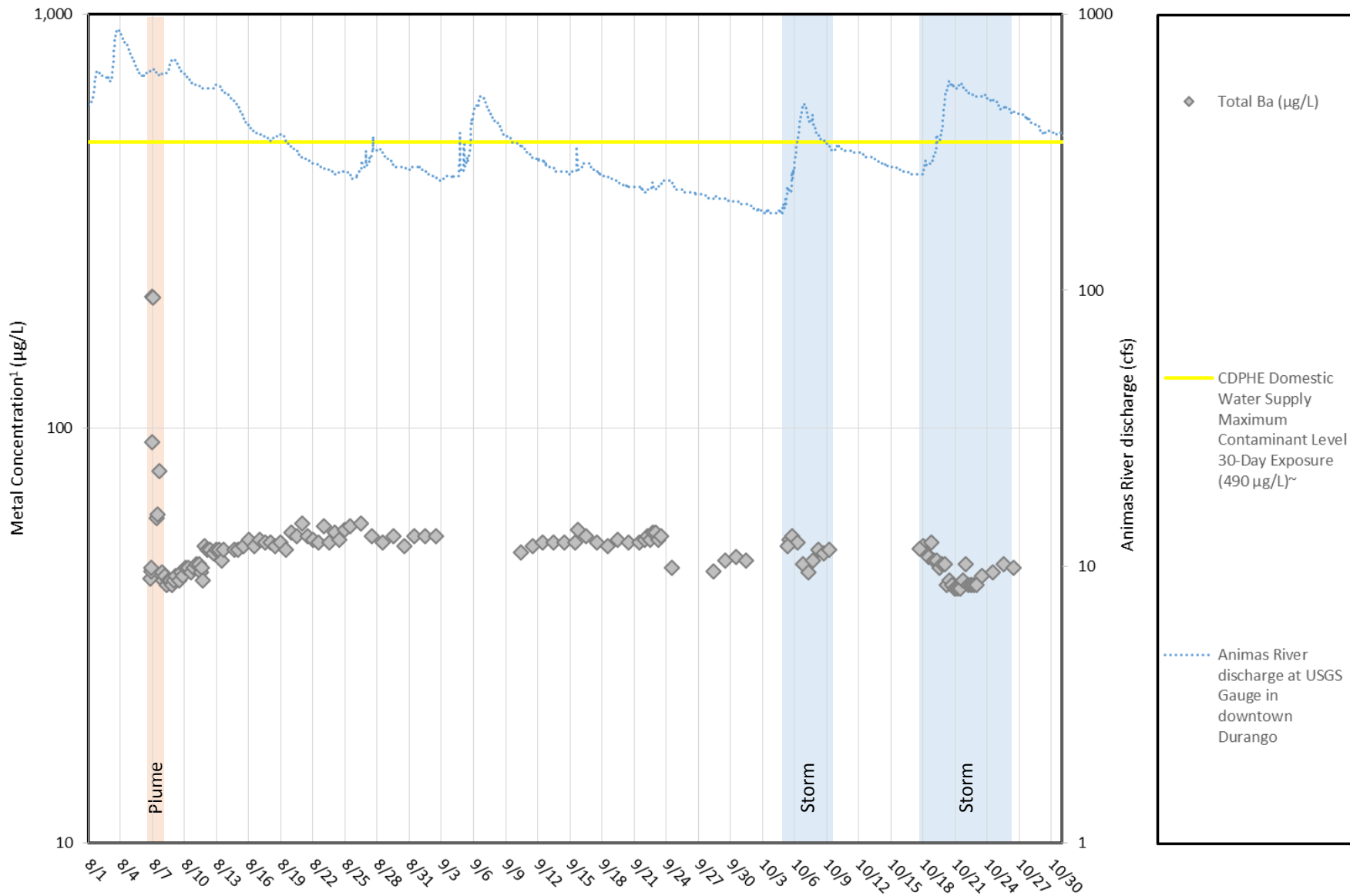
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 0.37 $\mu\text{g/L}$ (8/7 12PM - 10/26).

[~]CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

^{*} The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 9

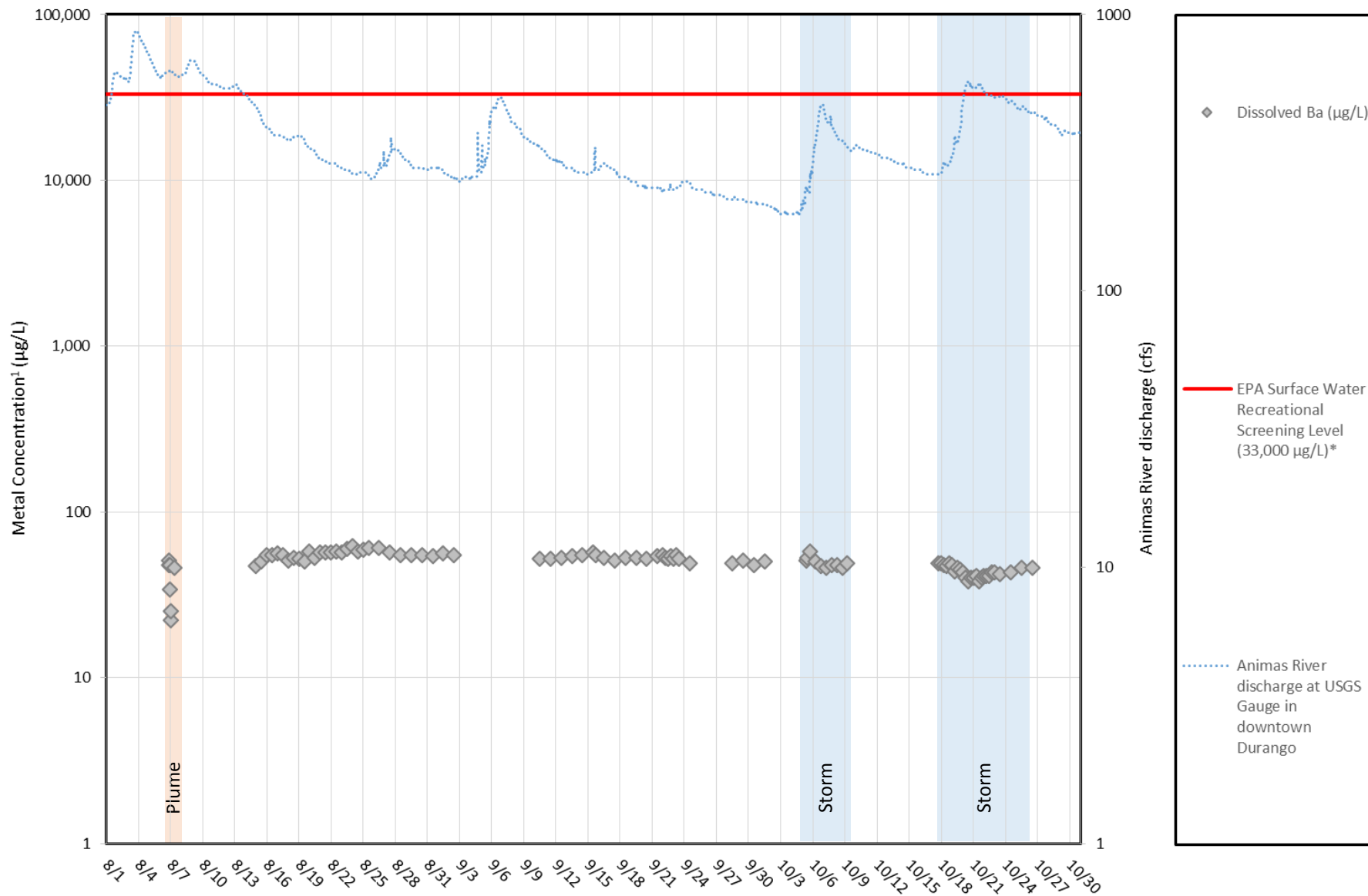
Water Quality Time Series - Rotary Park, Durango, CO Barium (Ba), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 25 µg/L (8/6-8/7 10AM) and 0.14 µg/L (8/7 12PM - 10/26).
~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 10

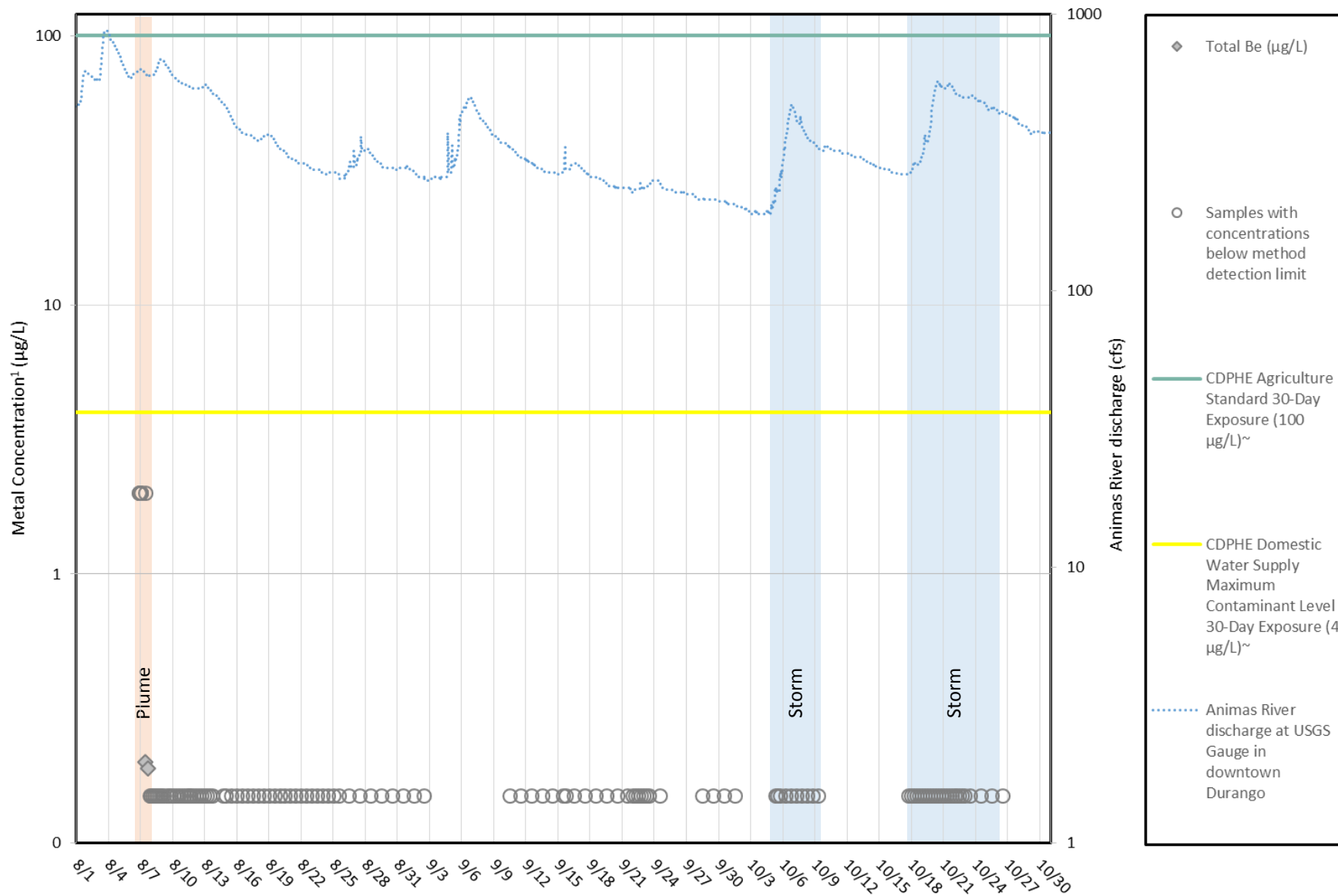
Water Quality Time Series - Rotary Park, Durango, CO Barium (Ba), Dissolved



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 5 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 0.14 $\mu\text{g/L}$ (8/7 12PM - 10/26).
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 11

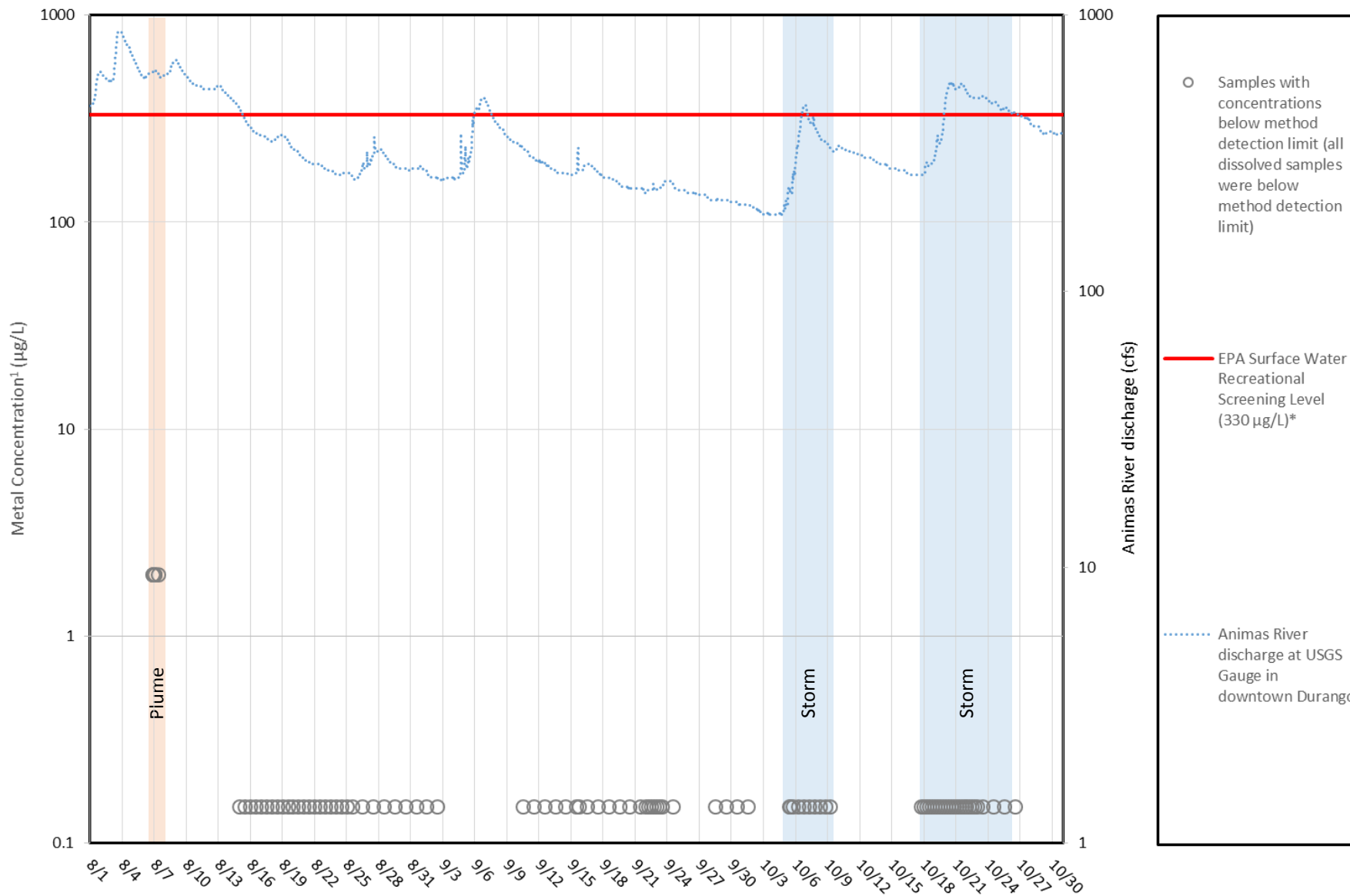
Water Quality Time Series - Rotary Park, Durango, CO Beryllium (Be), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2 µg/L (8/6 - 8/7 10AM) and 0.15 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 12

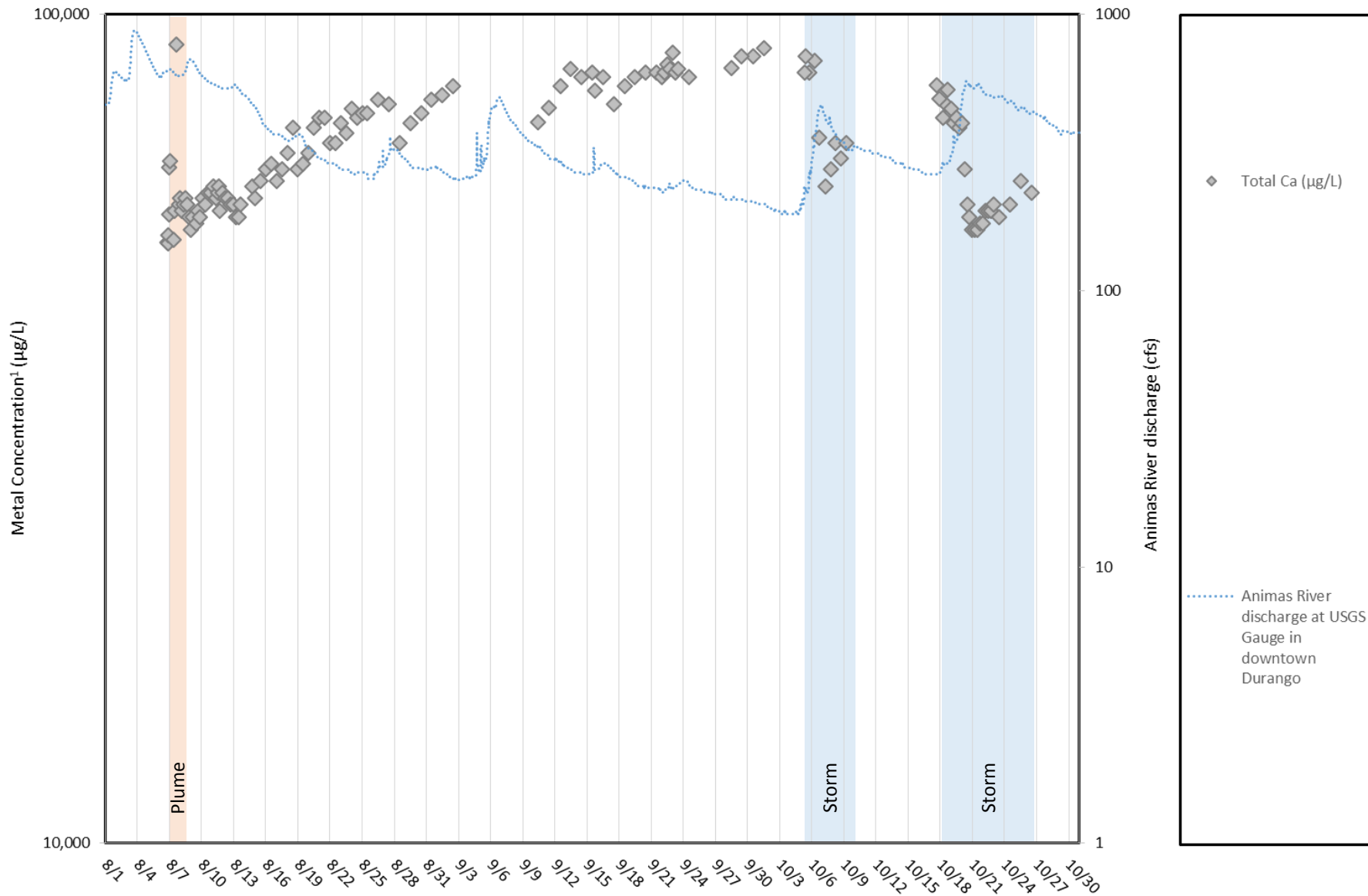
Water Quality Time Series - Rotary Park, Durango, CO Beryllium (Be), Dissolved



¹ EPA Analytical methods 200.7 and 200.8. Method detection limit was 2 µg/L (8/6 - 8/7 10AM) and 0.15 µg/L (8/7 12PM - 10/26).
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 13

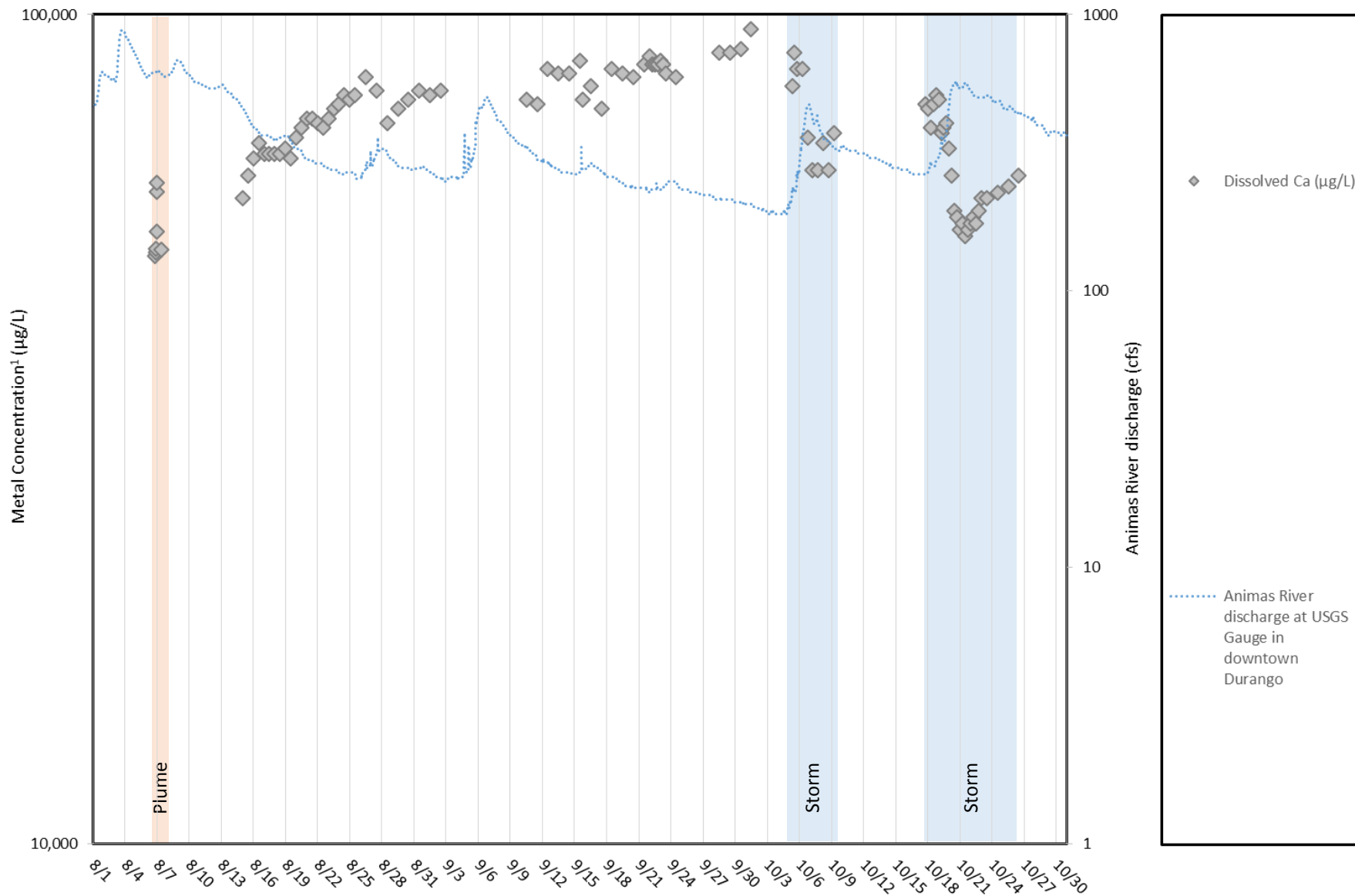
Water Quality Time Series - Rotary Park, Durango, CO Calcium (Ca), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 25 µg/L (8/7 12PM - 10/26).

Figure 14

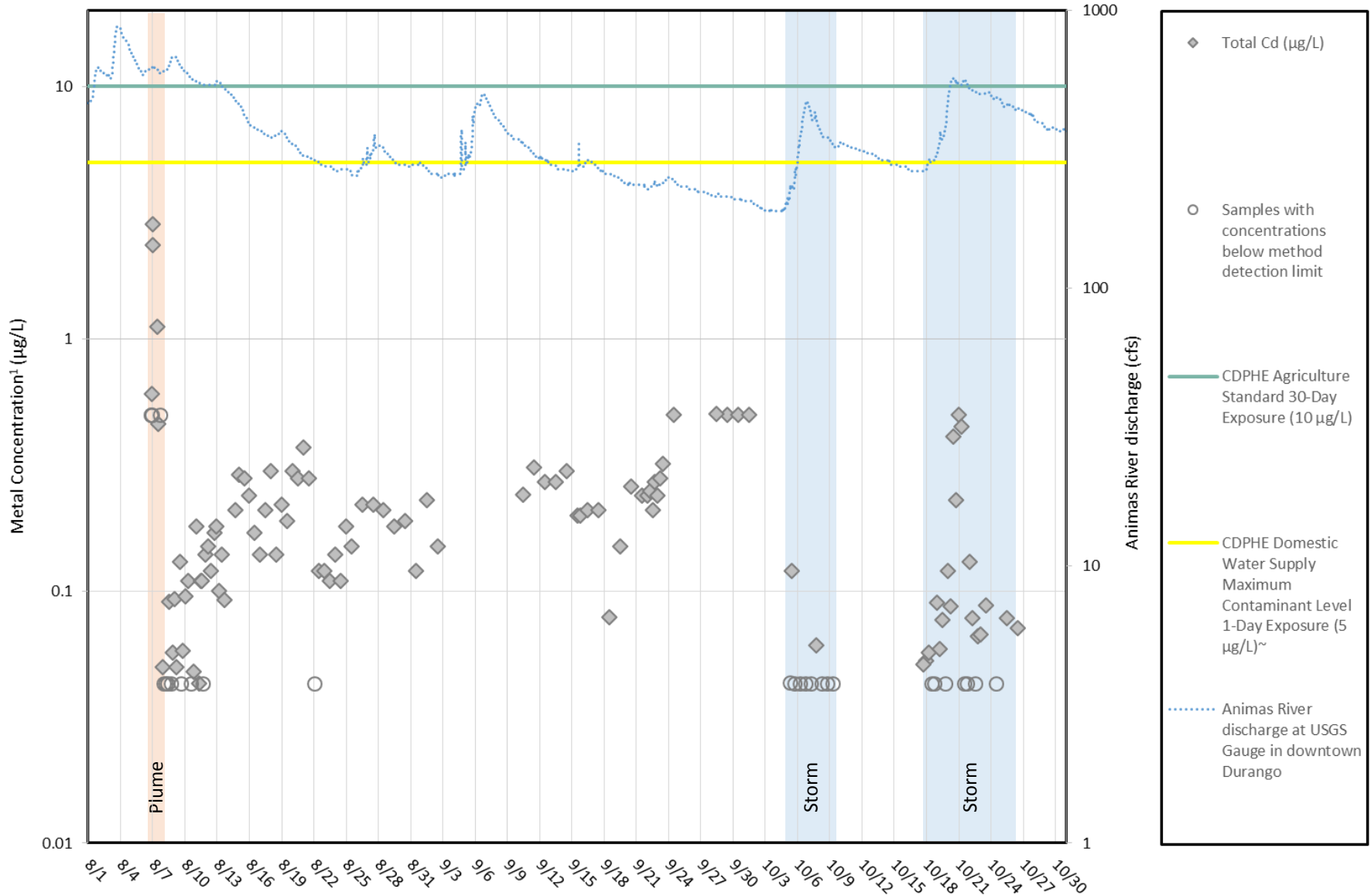
Water Quality Time Series - Rotary Park, Durango, CO Calcium (Ca), Dissolved



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 25 µg/L (8/7 12PM - 10/26).

Figure 15

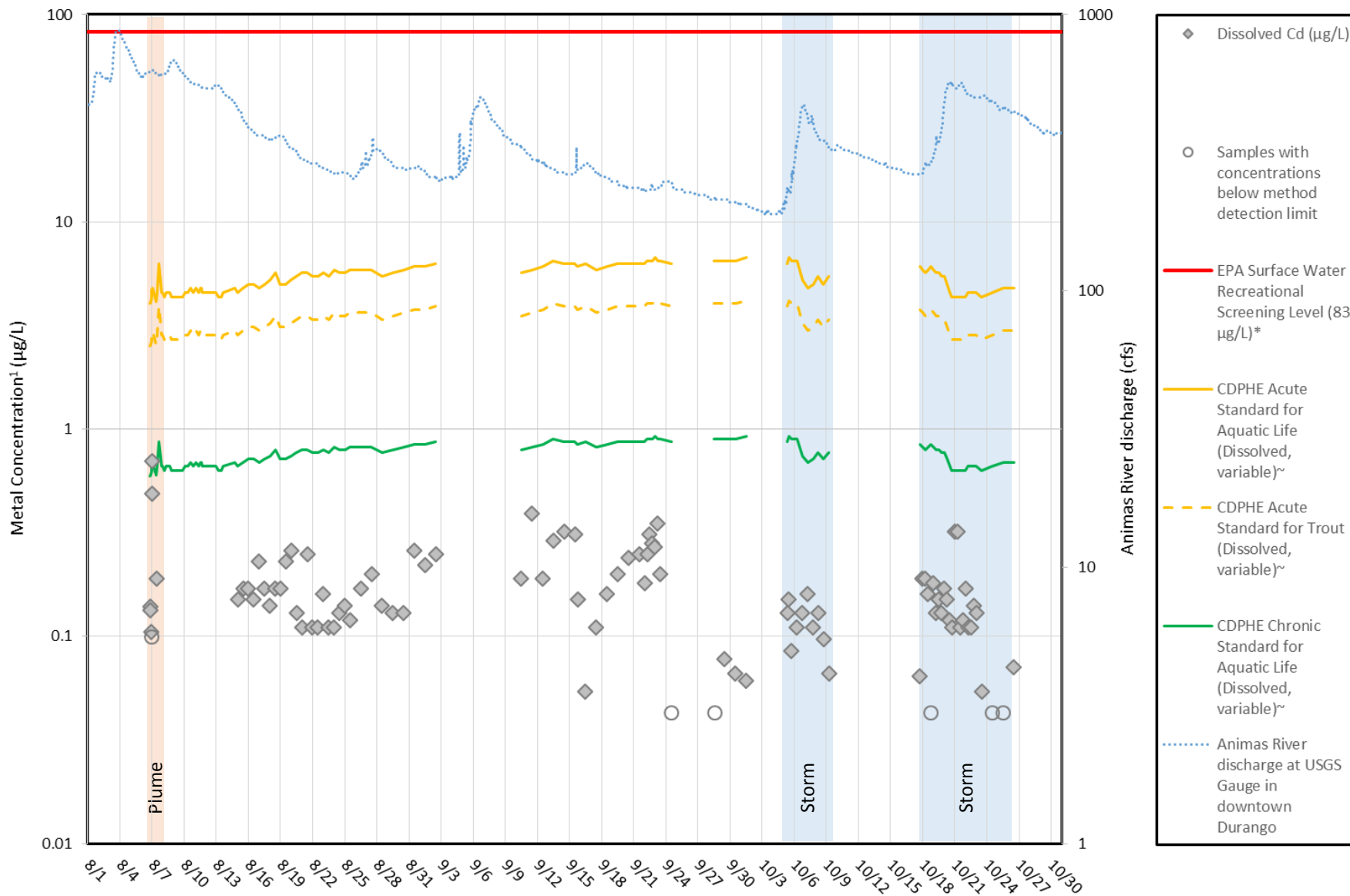
Water Quality Time Series - Rotary Park, Durango, CO Cadmium (Cd), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L (8/6 - 8/7 10AM) and 0.043 µg/L (8/7 12PM - 10/26).
~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 16

Water Quality Time Series - Rotary Park, Durango, CO Cadmium (Cd), Dissolved



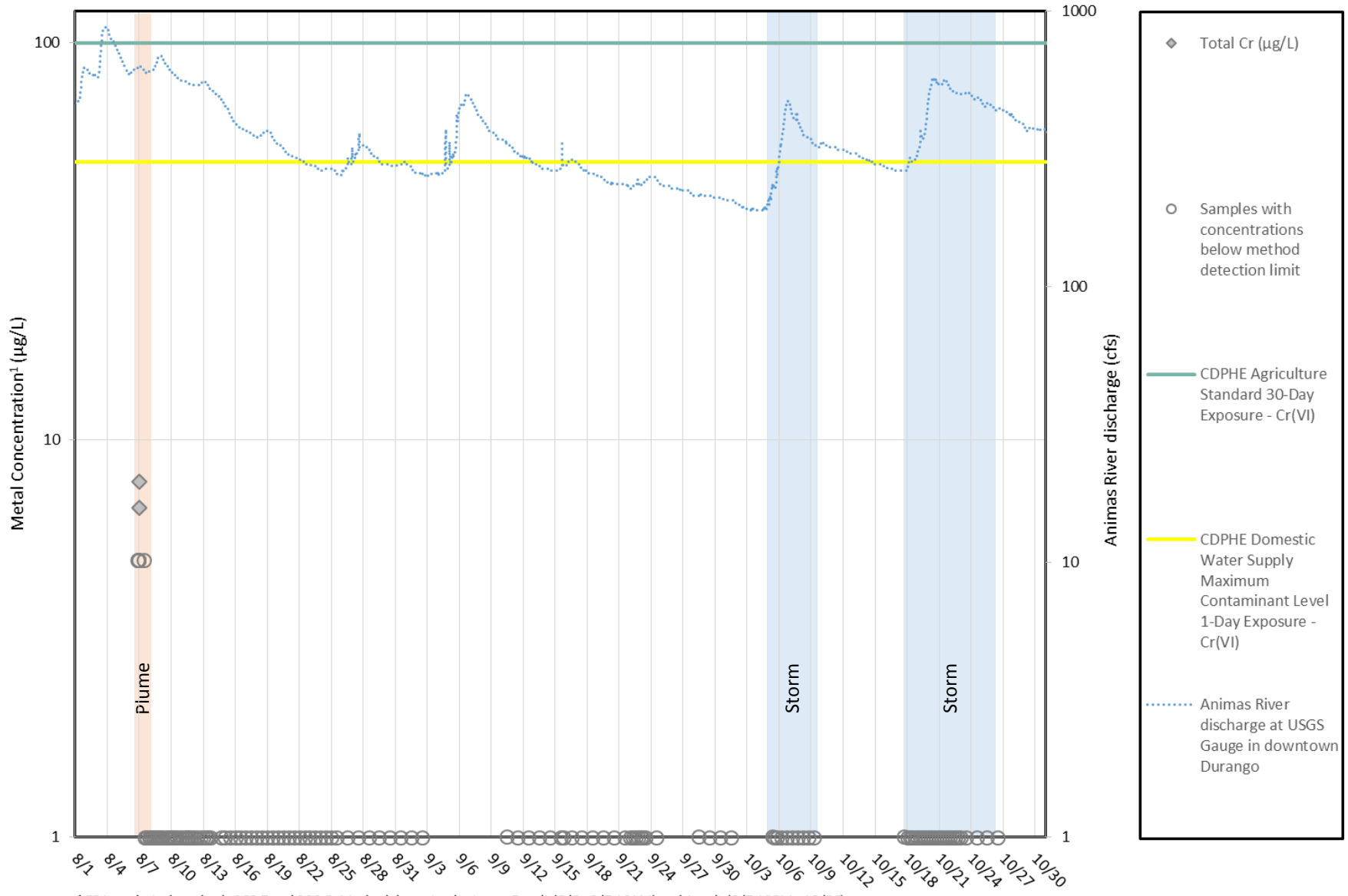
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.1 µg/L (8/6 - 8/7 10AM) and 0.043 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 17

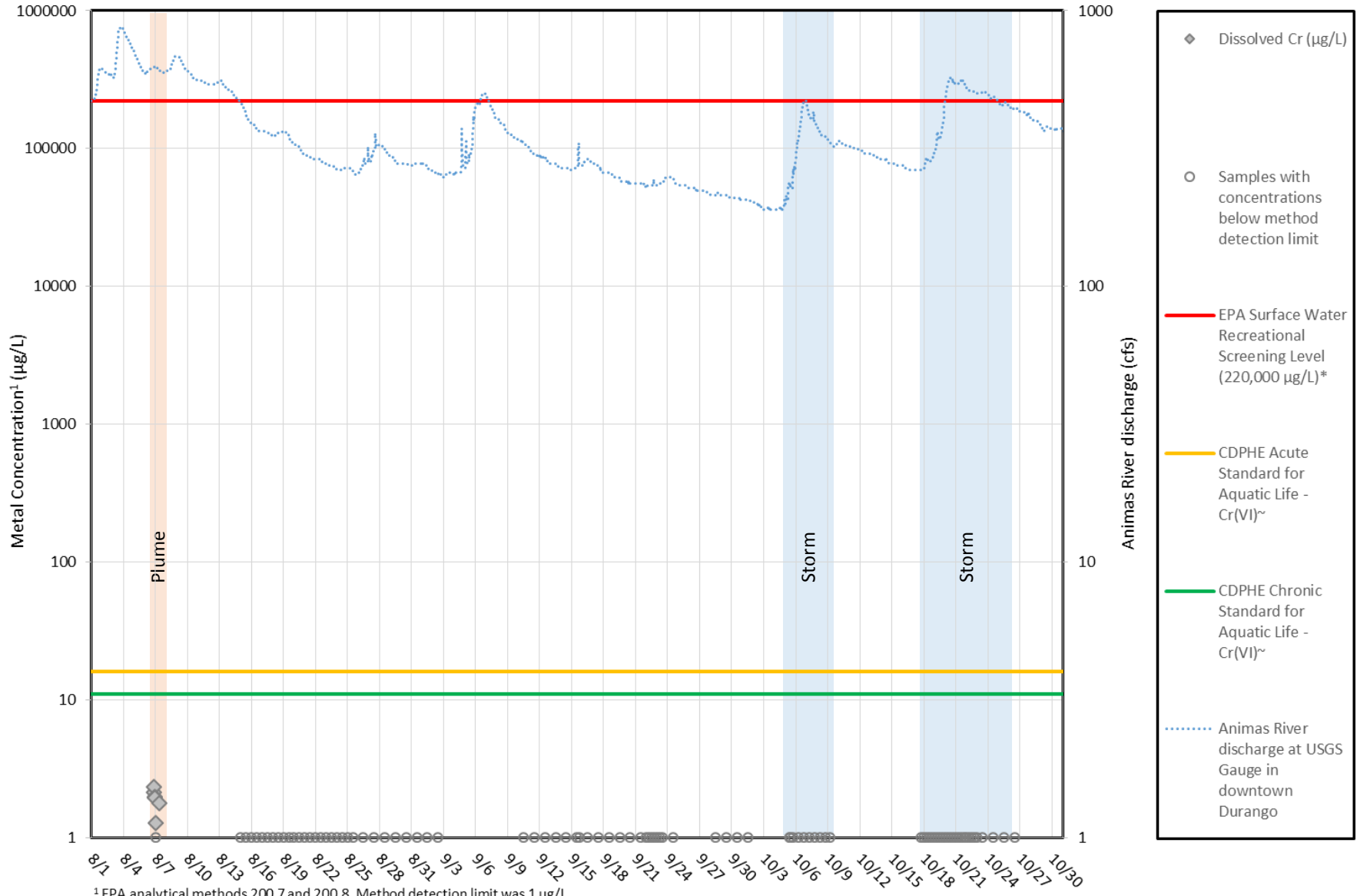
Water Quality Time Series - Rotary Park, Durango, CO Chromium (Cr), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 5 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 1 $\mu\text{g/L}$ (8/7 12PM - 10/26).

Figure 18

Water Quality Time Series - Rotary Park, Durango, CO Chromium (Cr), Dissolved



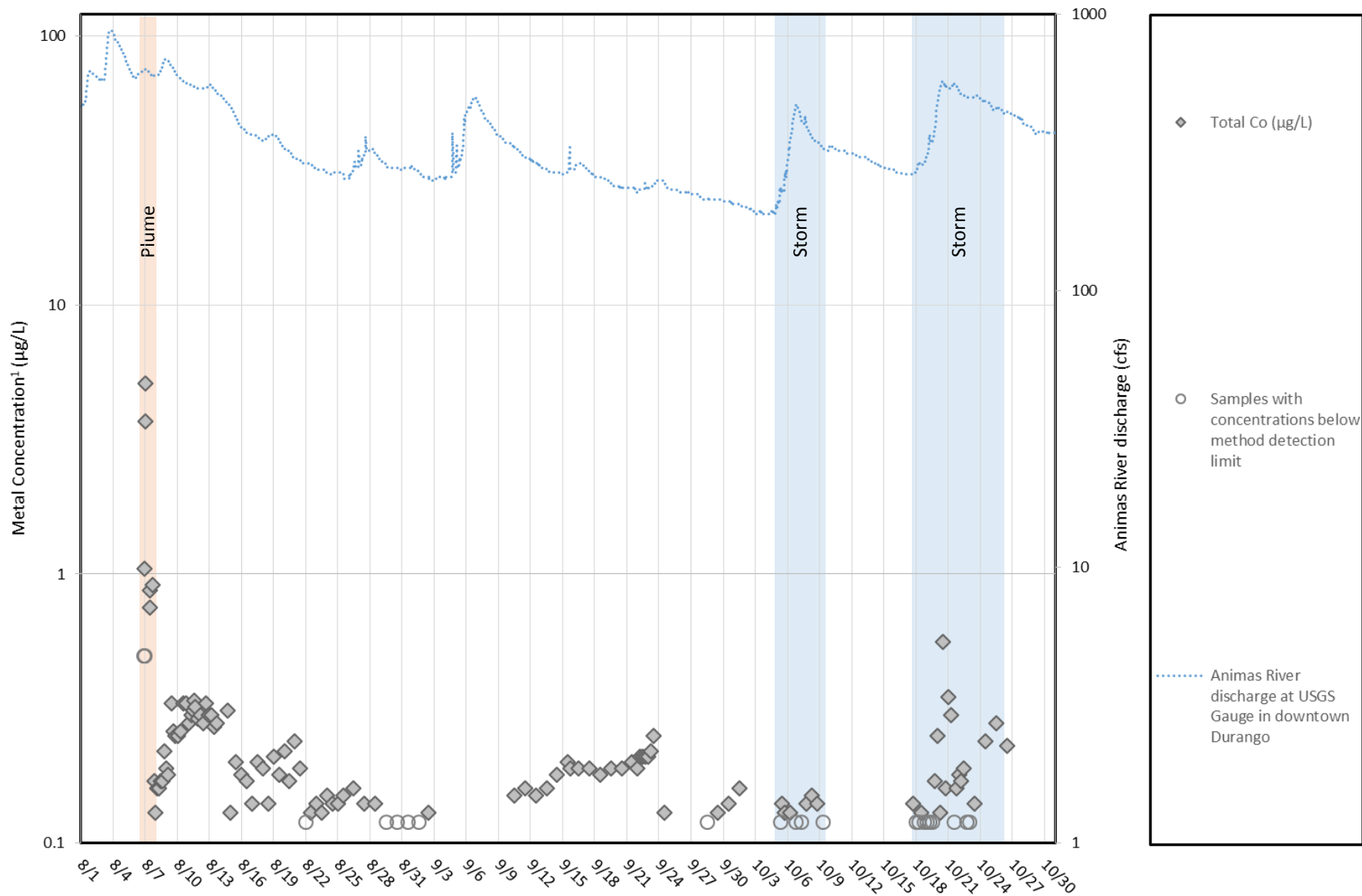
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was $1 \mu\text{g/L}$.

[~]CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 19

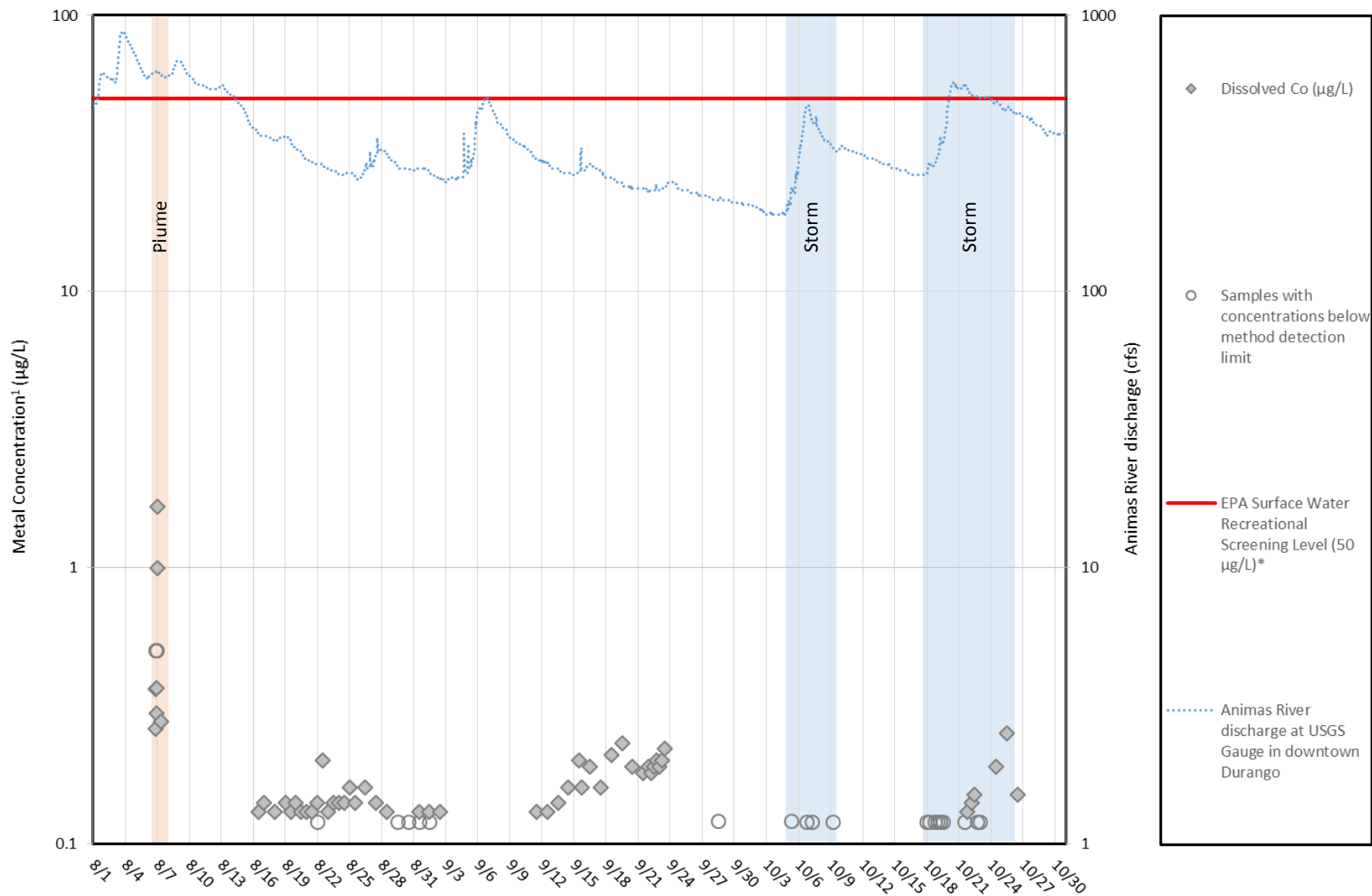
Water Quality Time Series - Rotary Park, Durango, CO Cobalt (Co), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 0.12 $\mu\text{g/L}$ (8/7 12PM - 10/26).

Figure 20

Water Quality Time Series - Rotary Park, Durango, CO Cobalt (Co), Dissolved

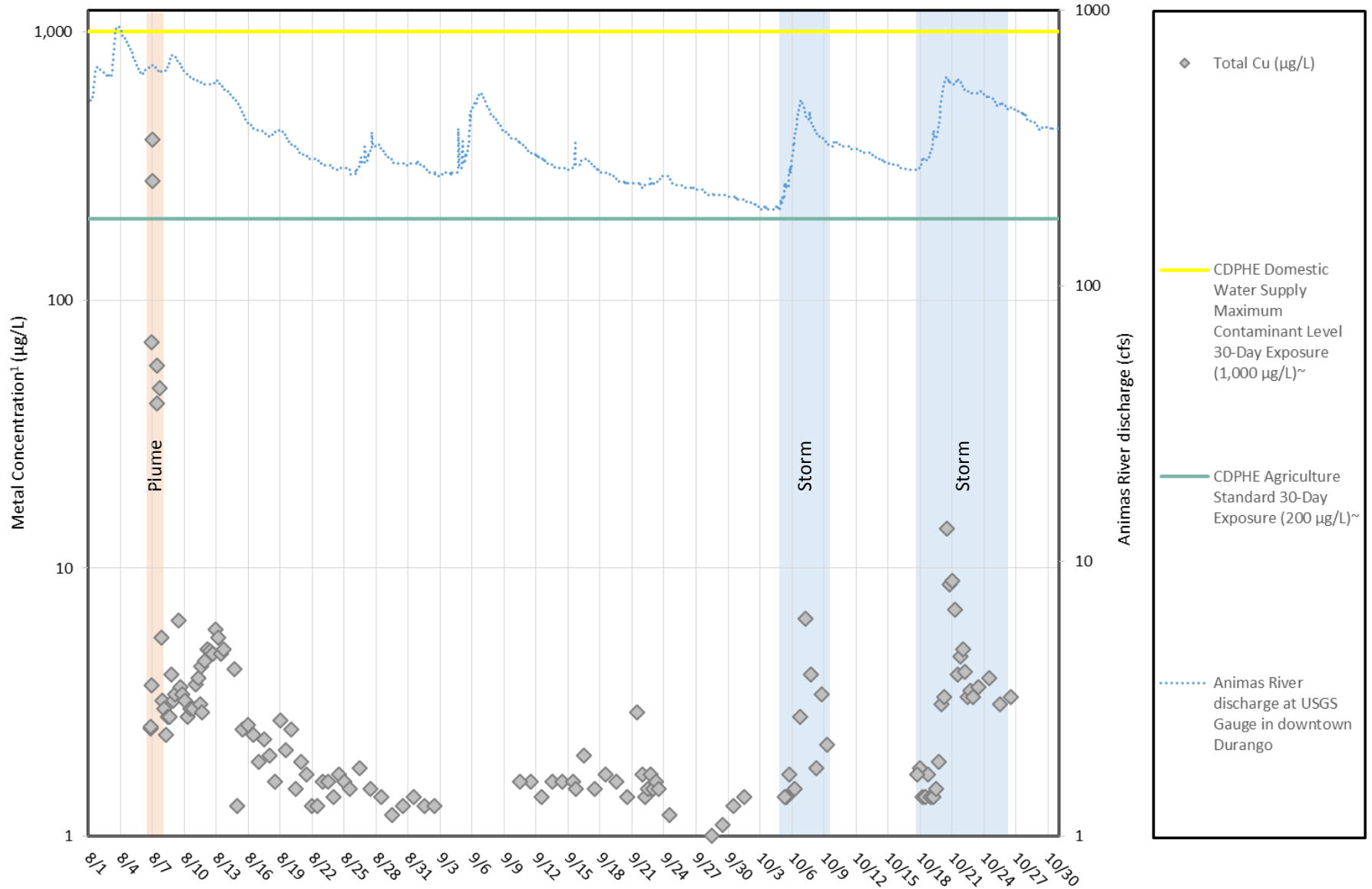


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.1 µg/L (8/6-8/7 10AM) and 0.12 µg/L (8/7 12PM - 10/26).

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 21

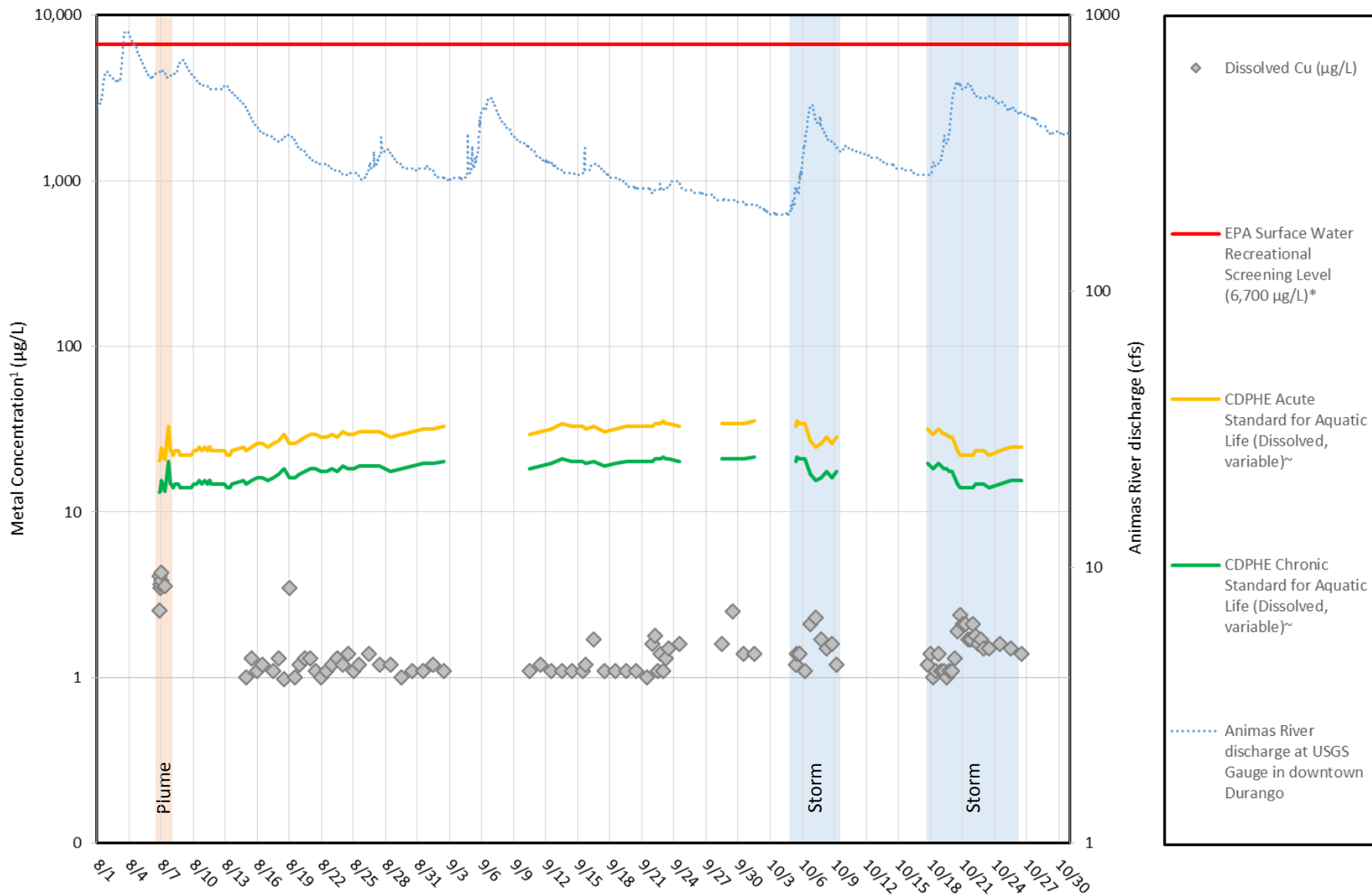
Water Quality Time Series - Rotary Park, Durango, CO Copper (Cu), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6 - 8/7 10AM) and 0.5 µg/L (8/7 12PM - 10/26).
~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 22

Water Quality Time Series - Rotary Park, Durango, CO Copper (Cu), Dissolved



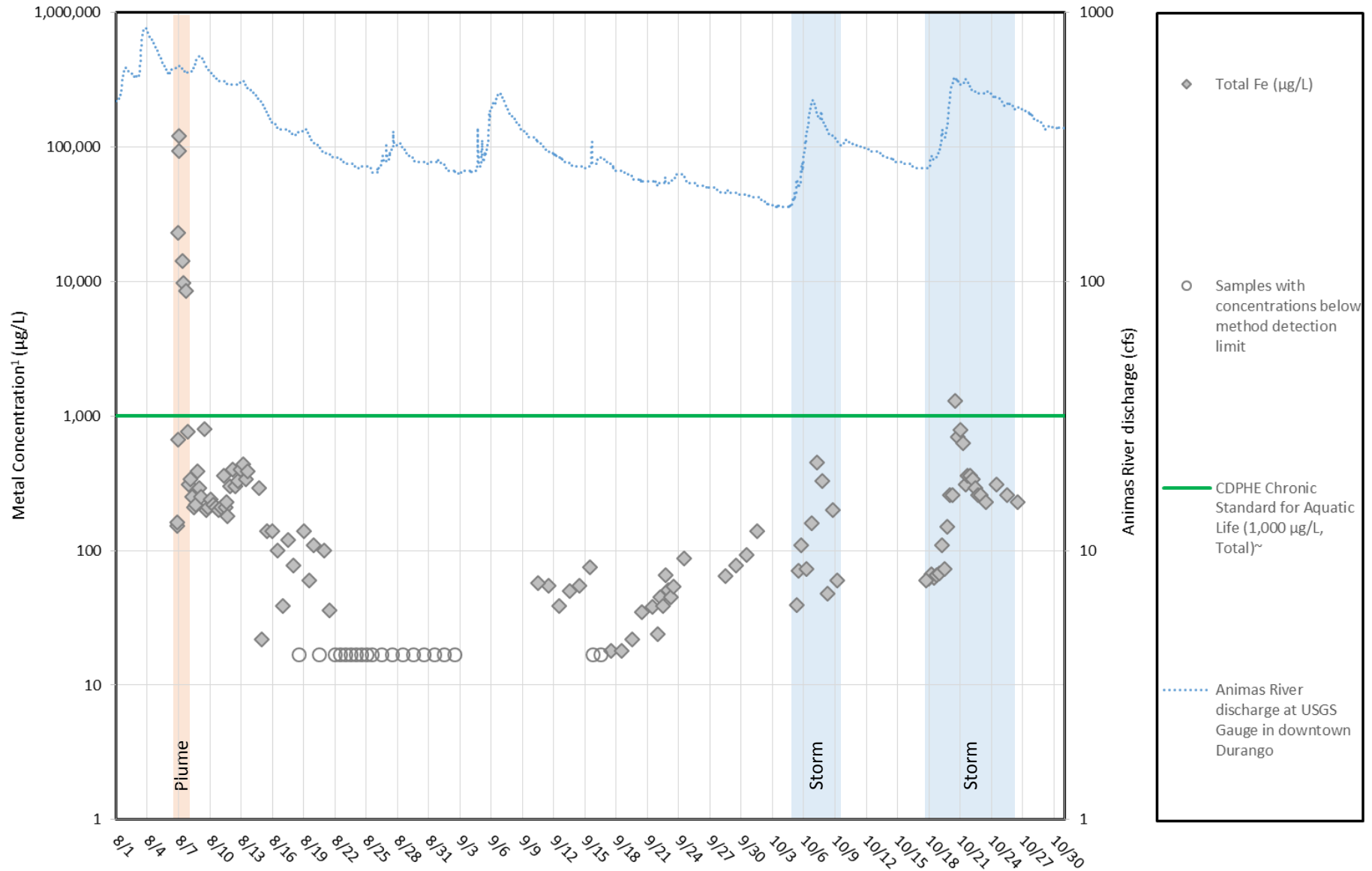
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L.

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 23

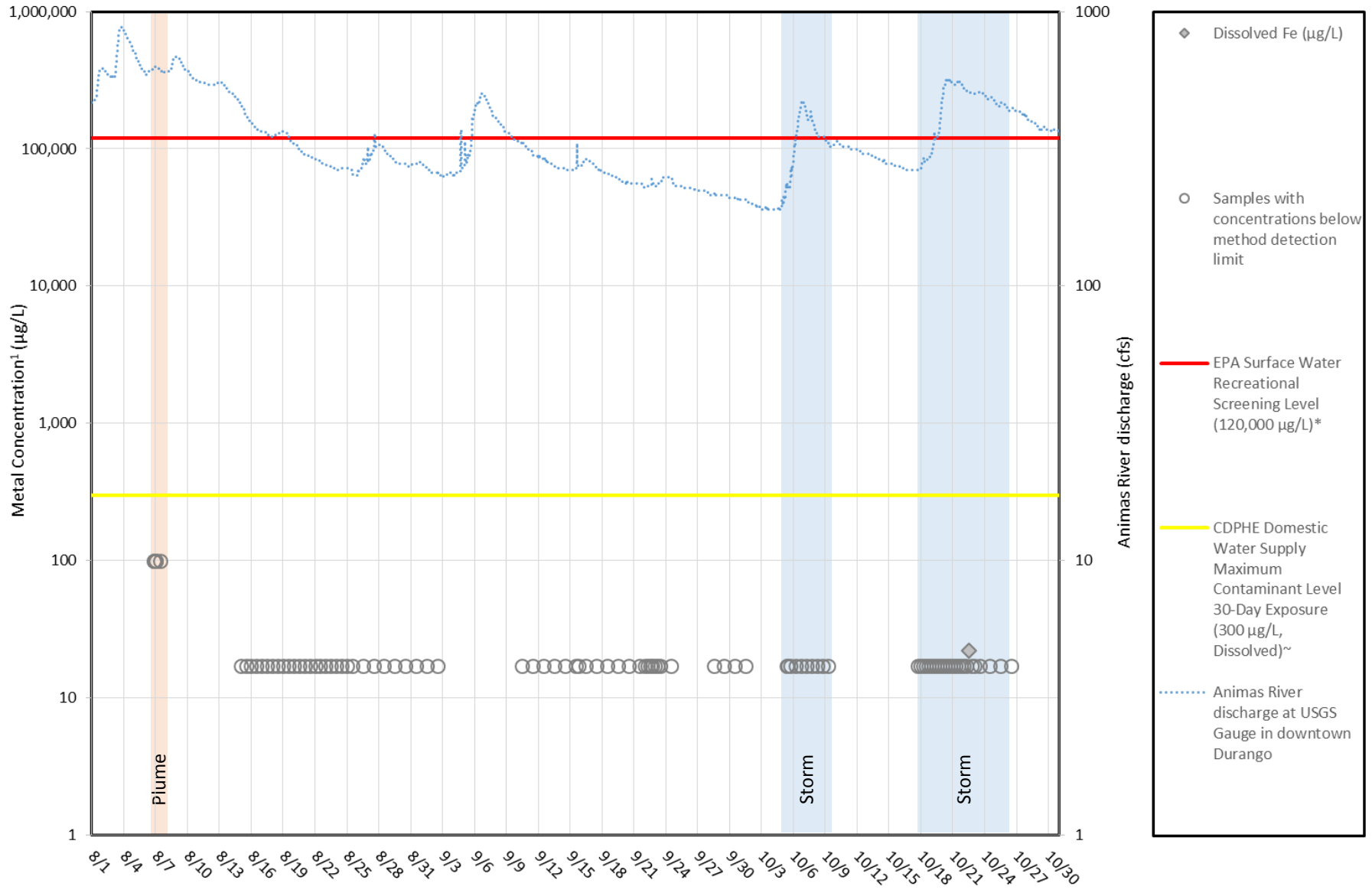
Water Quality Time Series - Rotary Park, Durango, CO Iron (Fe), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 17 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 24

Water Quality Time Series - Rotary Park, Durango, CO Iron (Fe), Dissolved



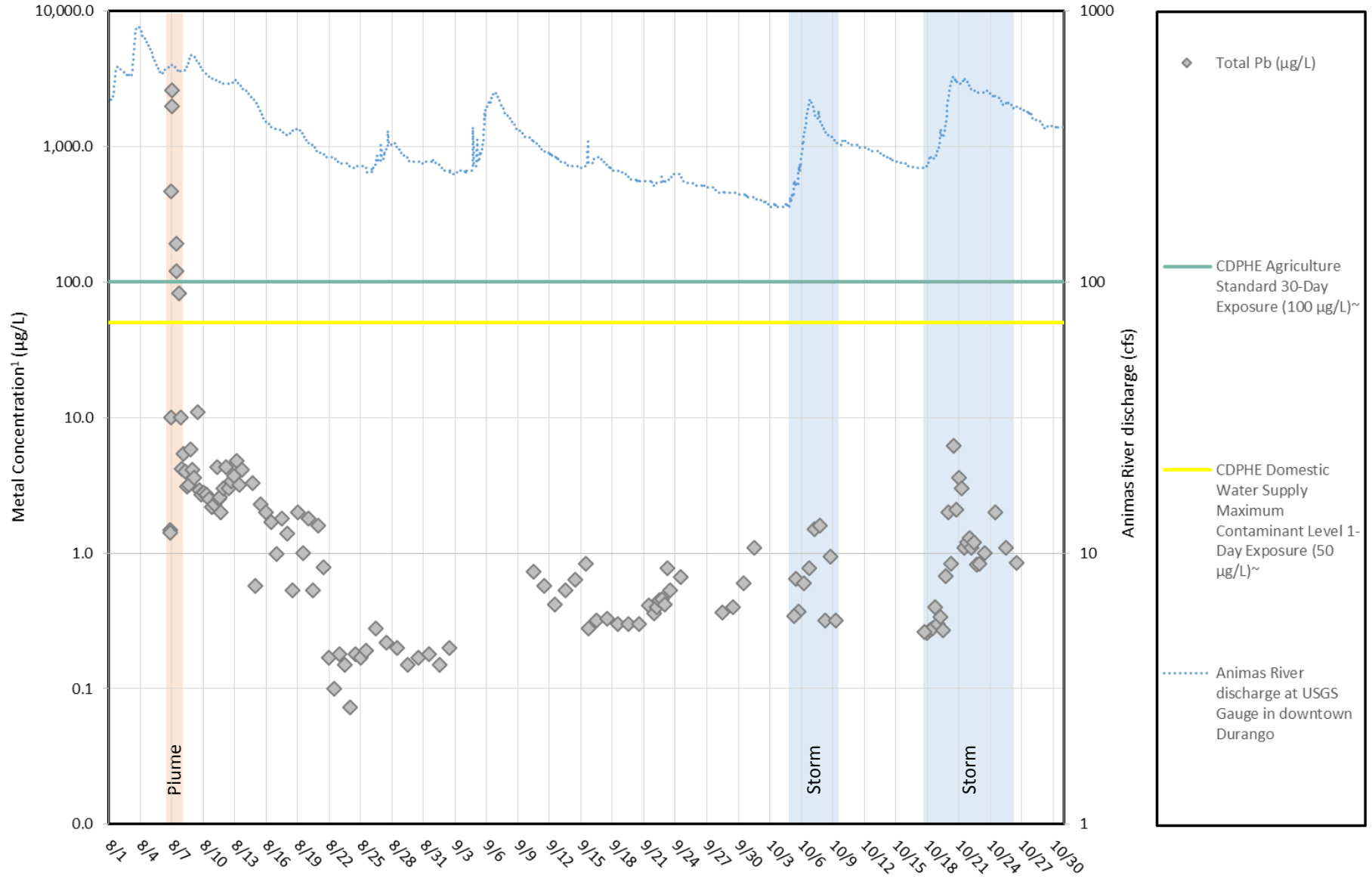
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 17 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 25

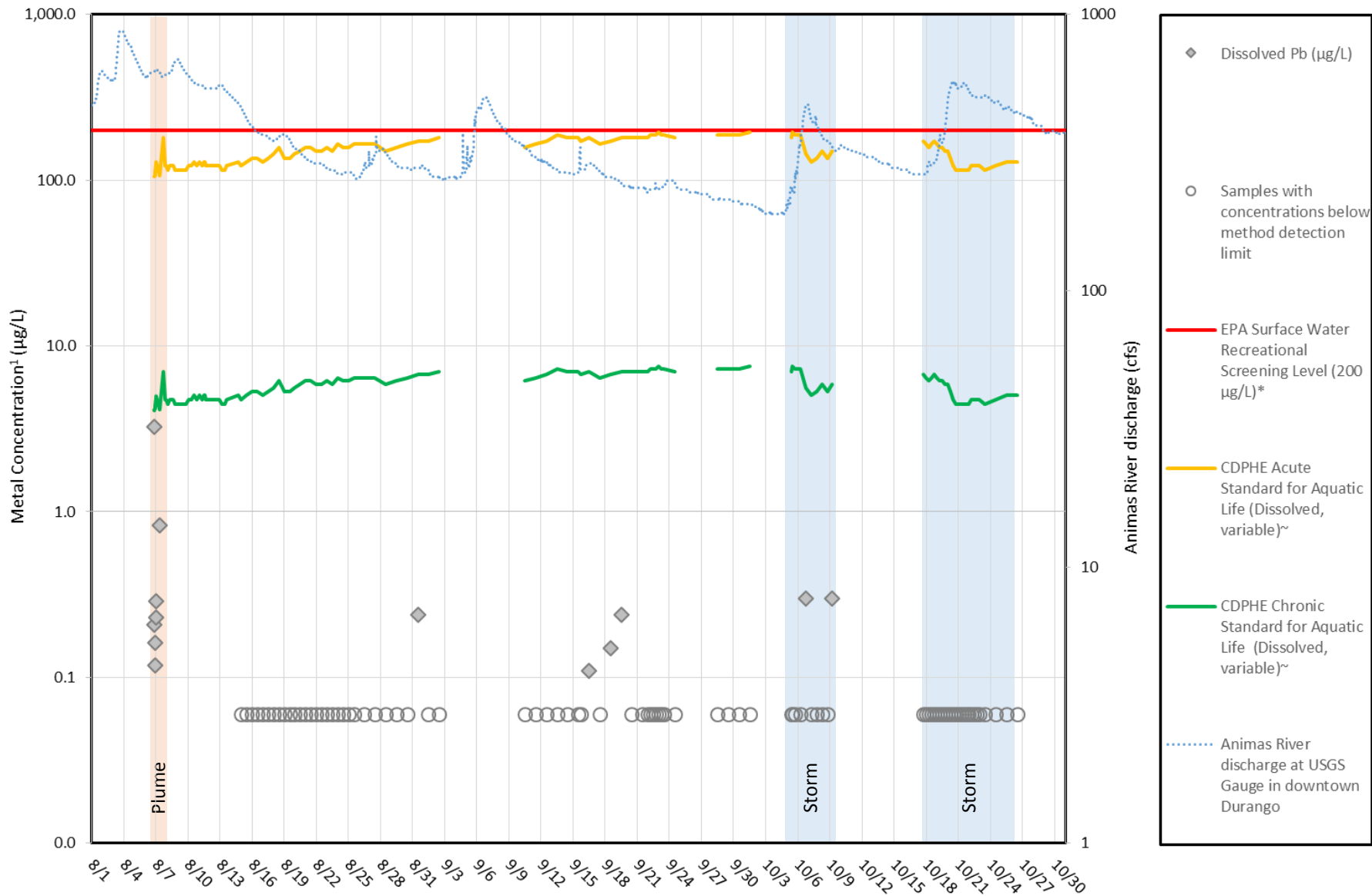
Water Quality Time Series - Rotary Park, Durango, CO Lead (Pb), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L (8/6 - 8/7 10AM) and 0.06 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 26

Water Quality Time Series - Rotary Park, Durango, CO Lead (Pb), Dissolved



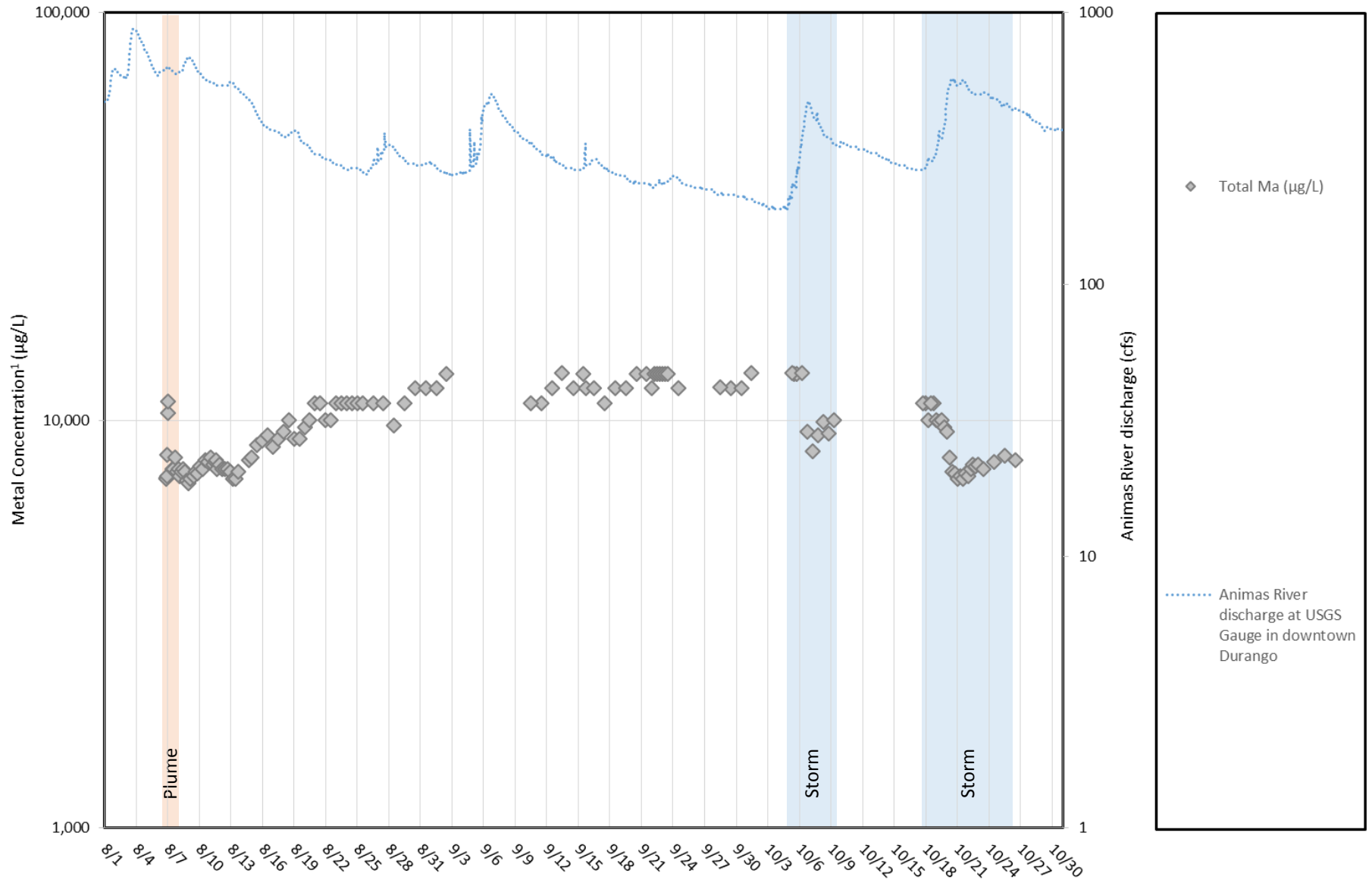
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.1 µg/L (8/6 - 8/7 10AM) and 0.06 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 27

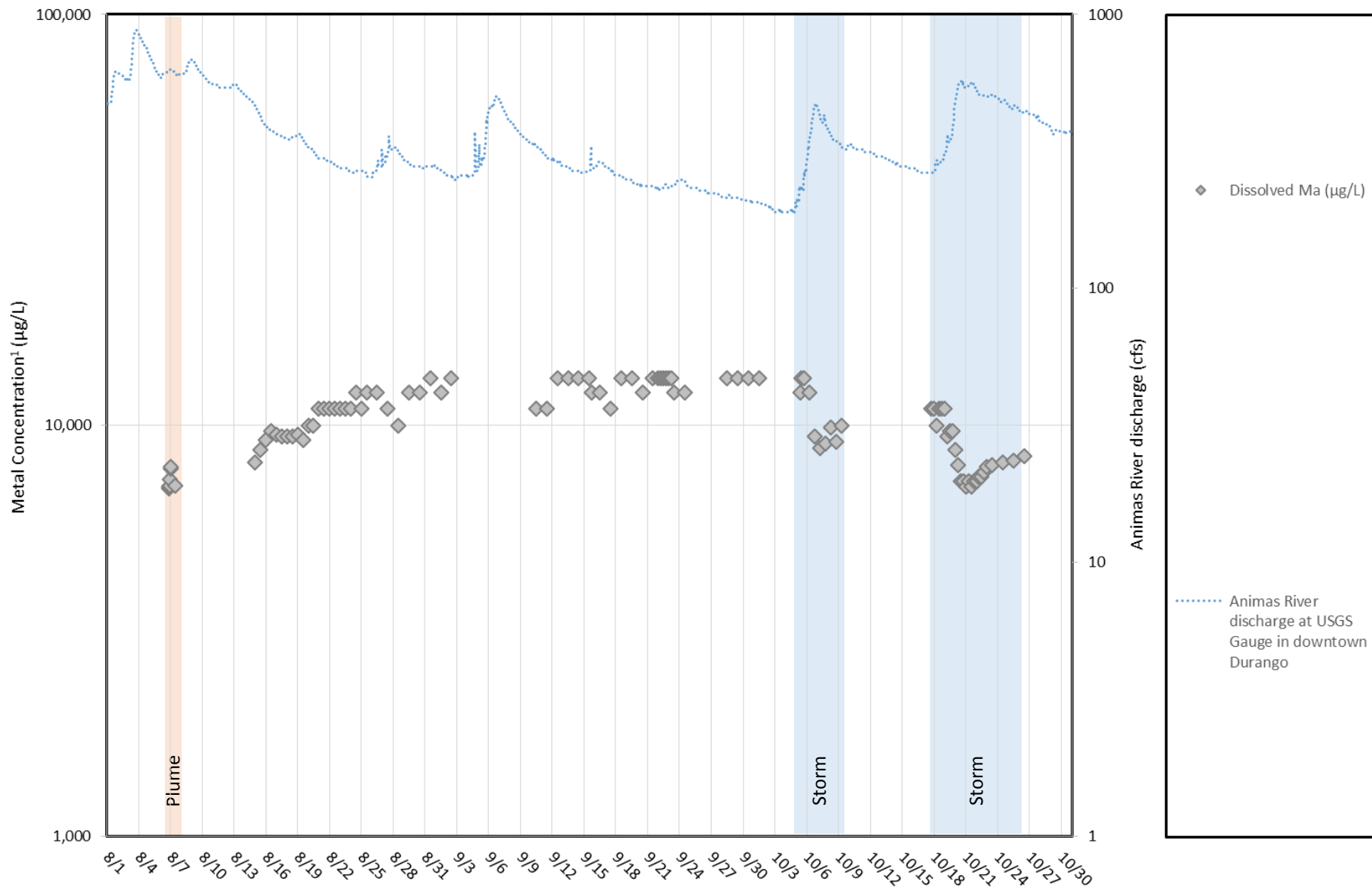
Water Quality Time Series - Rotary Park, Durango, CO Magnesium (Mg), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 33 µg/L (8/7 12PM - 10/26).

Figure 28

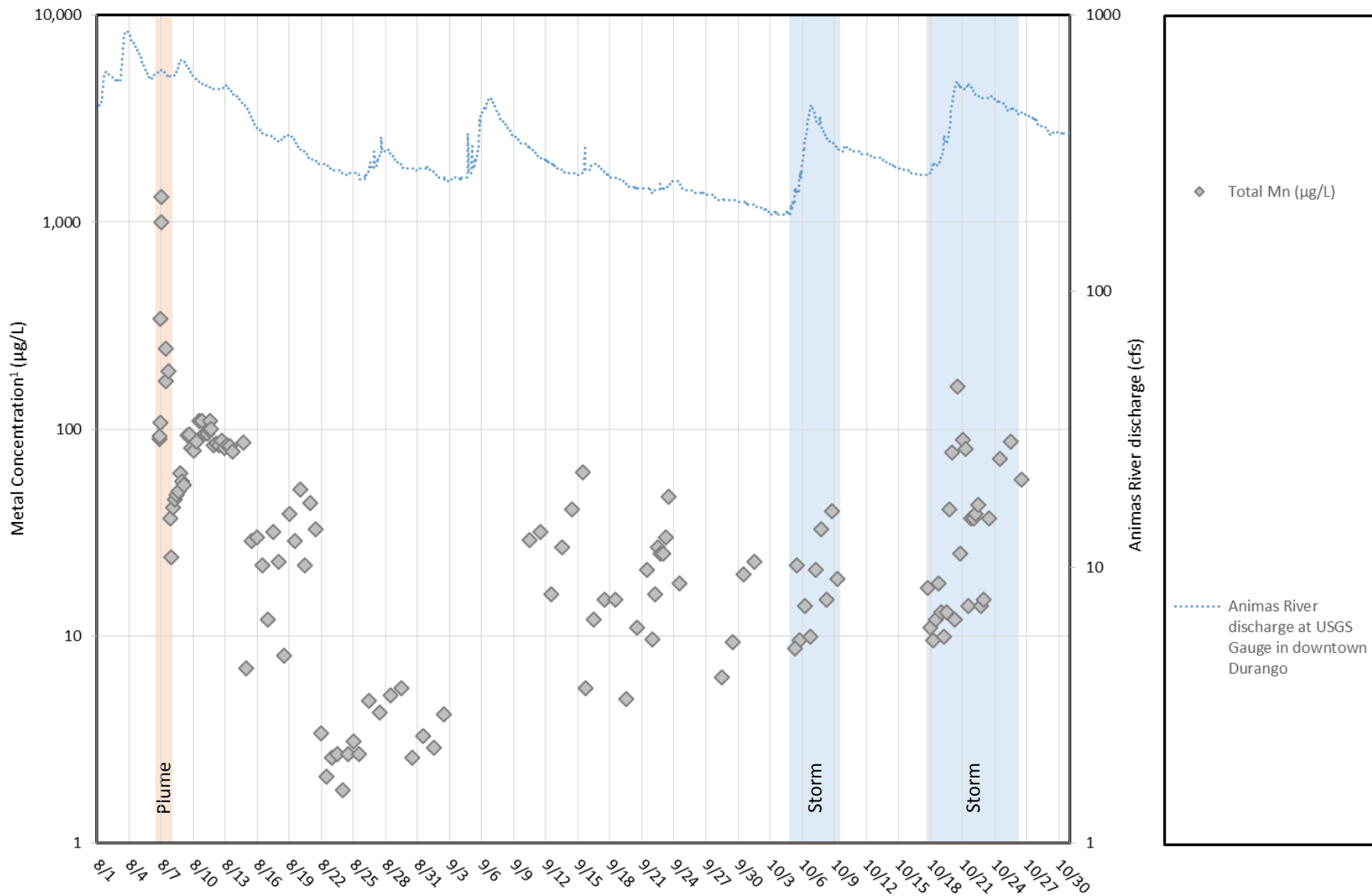
Water Quality Time Series - Rotary Park, Durango, CO Magnesium (Mg), Dissolved



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 100 µg/L (8/6 - 8/7 10AM) and 33 µg/L (8/7 12PM - 10/26).

Figure 29

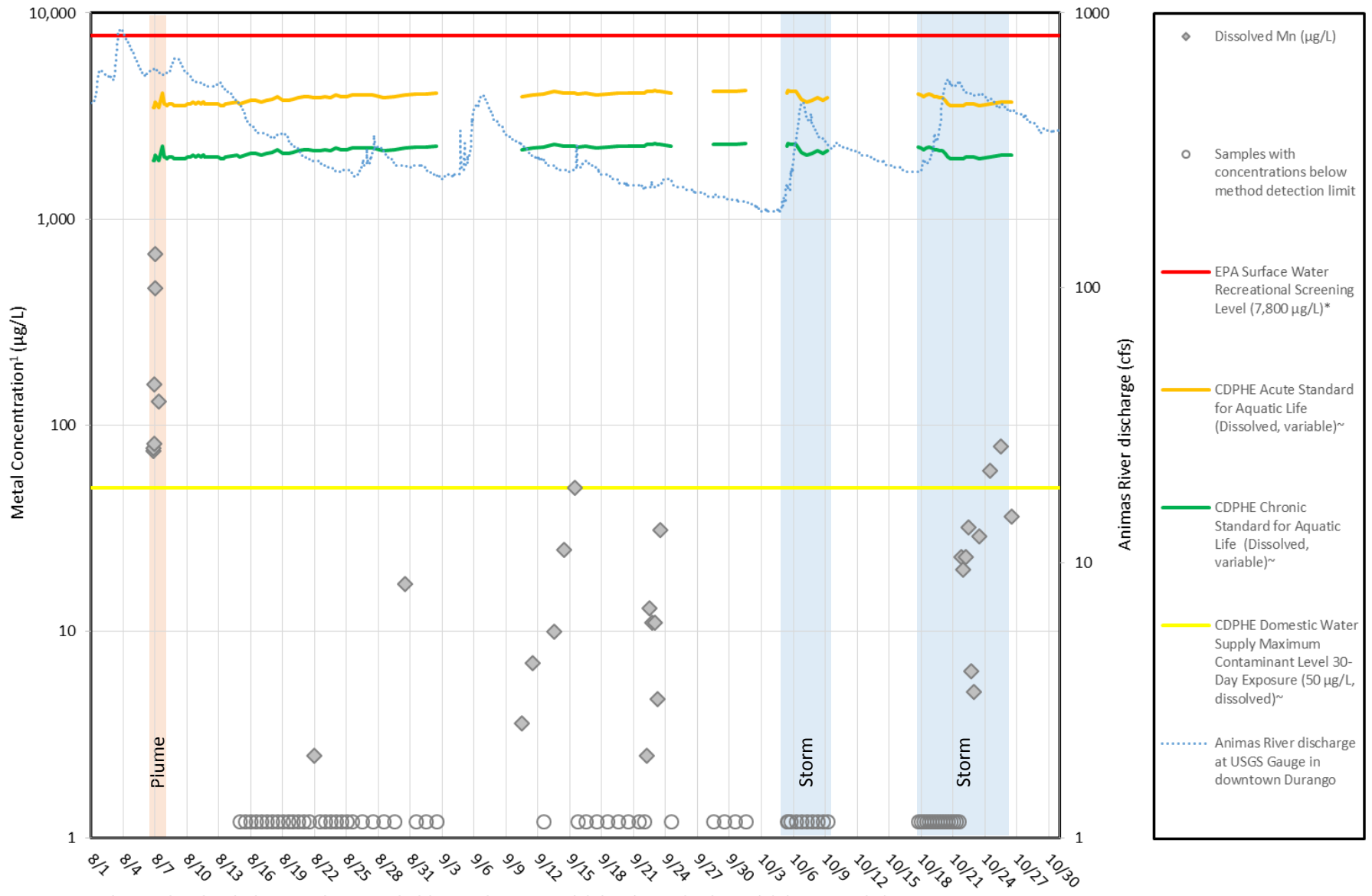
Water Quality Time Series - Rotary Park, Durango, CO Manganese (Mn), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2 µg/L (8/6 - 8/7 10AM) and 1.2 µg/L (8/7 12PM - 10/26).

Figure 30

Water Quality Time Series - Rotary Park, Durango, CO Manganese (Mn), Dissolved



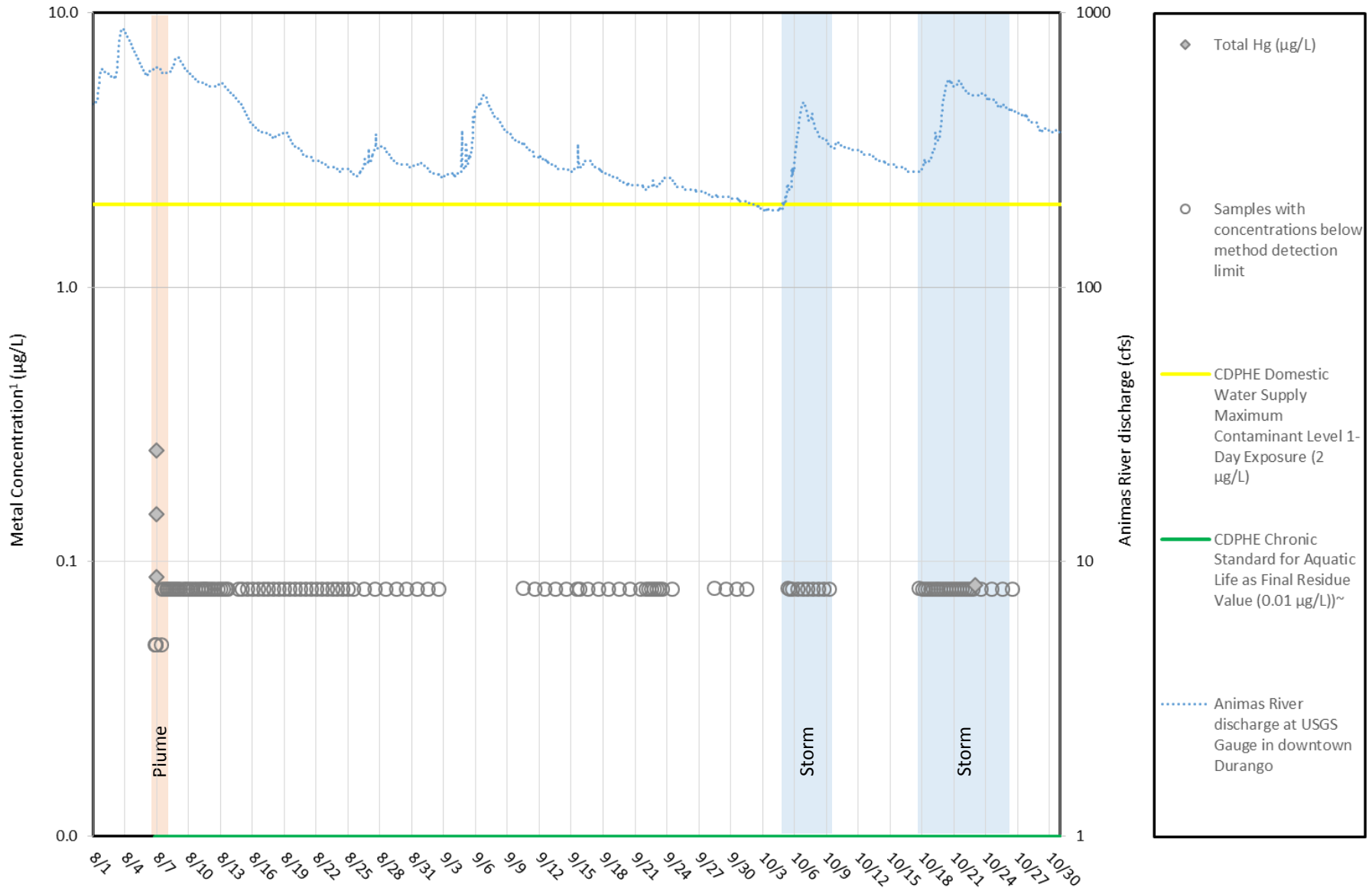
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2 µg/L (8/6 - 8/7 10AM) and 1.2 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Aquatic life standards vary with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 31

Water Quality Time Series - Rotary Park, Durango, CO Mercury (Hg), Total

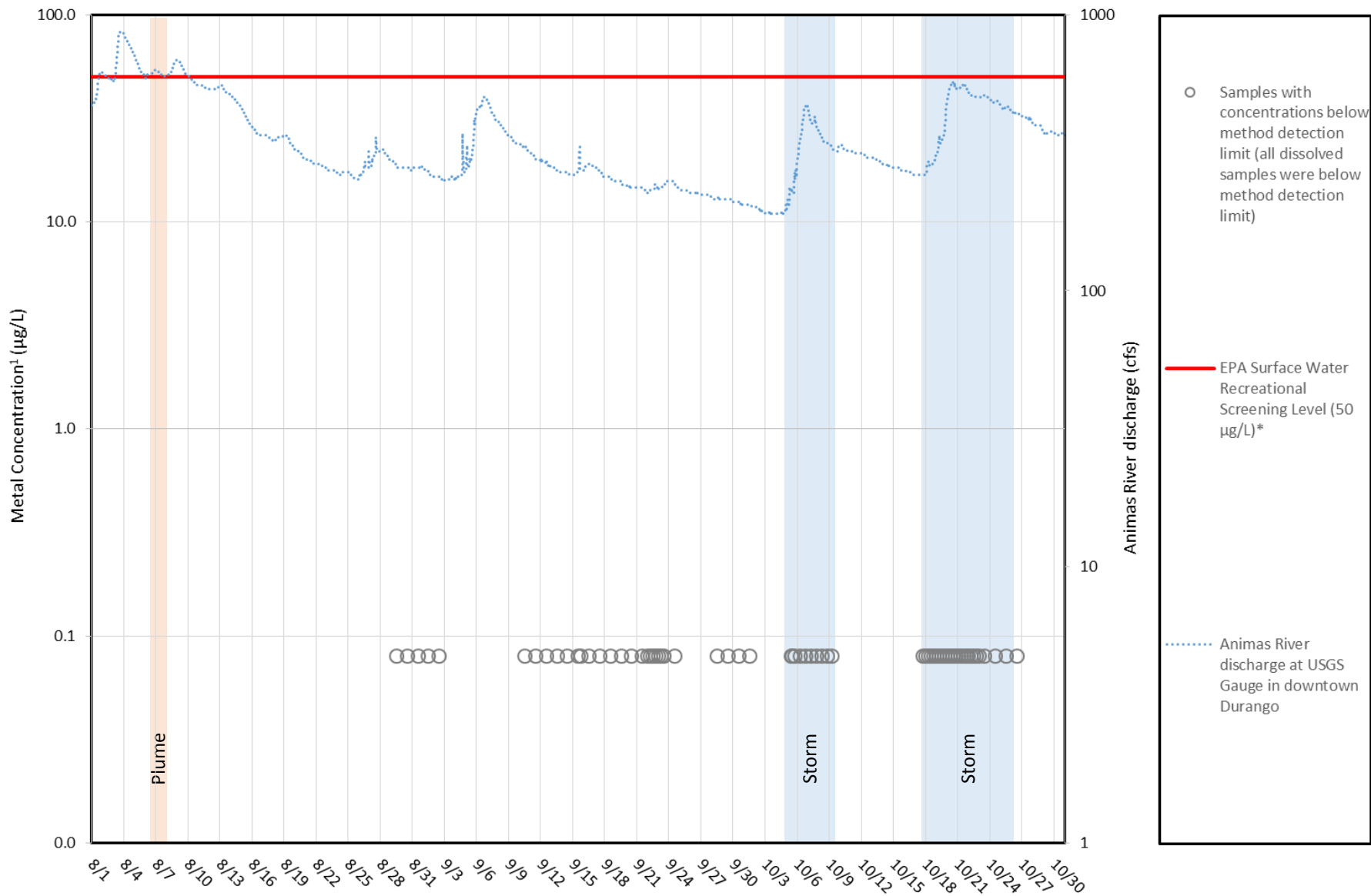


¹ EPA analytical method 245.1. Method detection limit was 0.05 µg/L (8/6 - 8/7 10AM) and 0.08 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. The mercury chronic standard for aquatic life is based on the final residue value (FRV) of 0.01 µg/L, which is the maximum allowed concentration of total mercury in the water that will present bioaccumulation of methylmercury in edible fish tissue. Since our method detection limit was higher than the mercury chronic standard for aquatic life (0.01 µg/L), comparing observed total mercury concentrations to this standard is problematic.

Figure 32

Water Quality Time Series - Rotary Park, Durango, CO Mercury (Hg), Dissolved

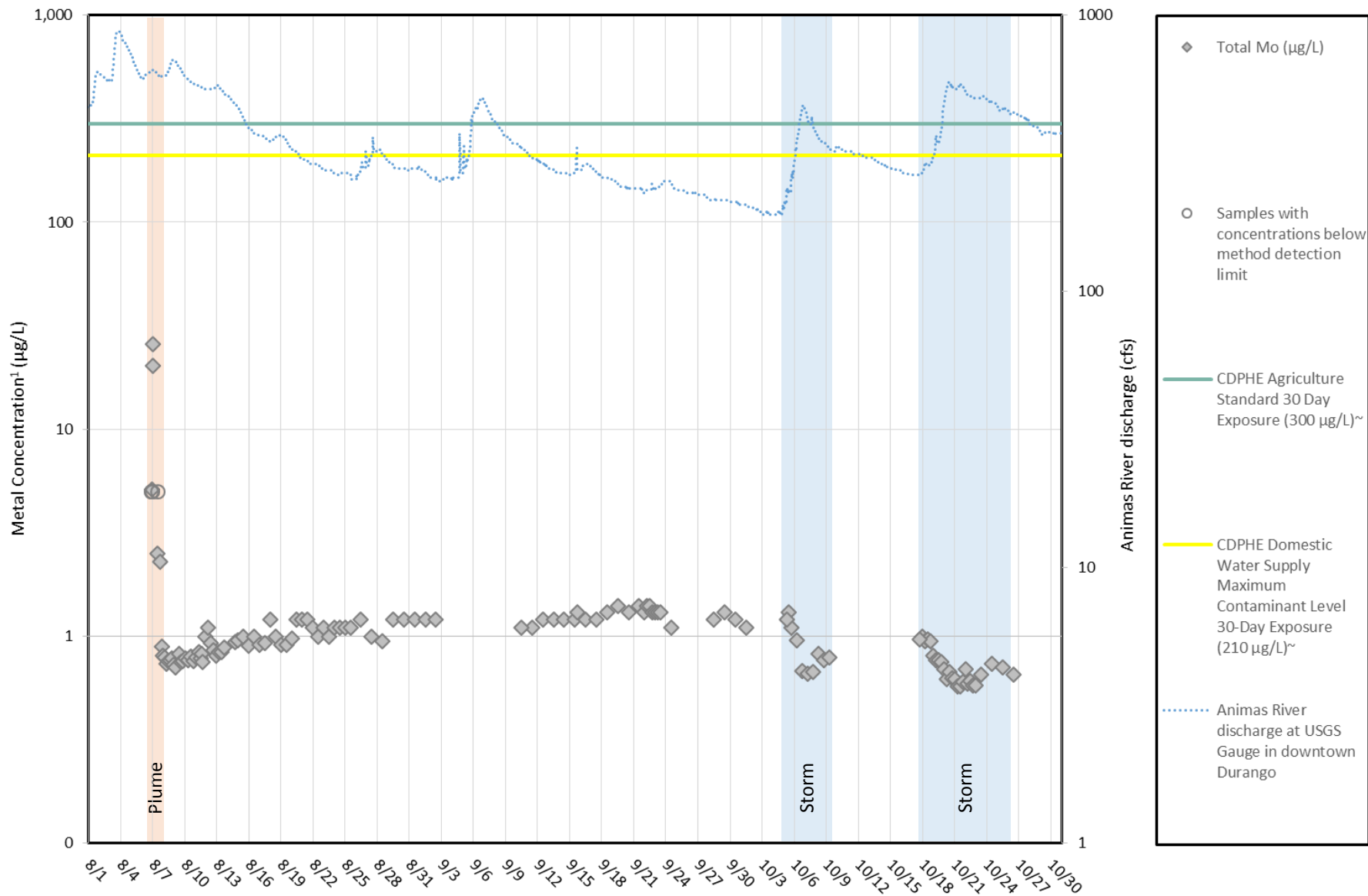


¹ EPA analytical method 245.1. Method detection limit was 0.08 µg/L.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 33

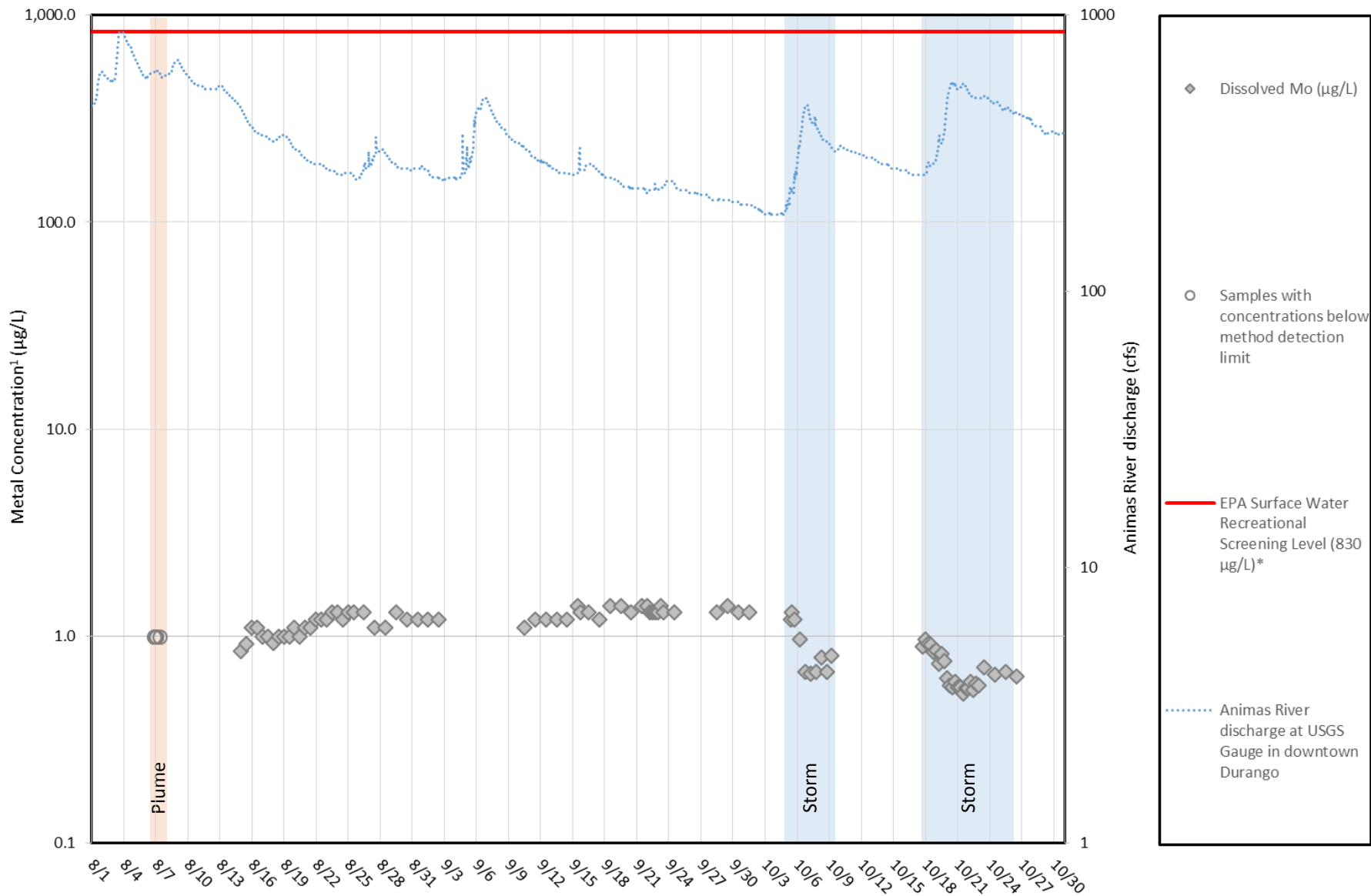
Water Quality Time Series - Rotary Park, Durango, CO Molybdenum (Mo), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 5 µg/L (8/6 - 8/7 10AM) and 0.45 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 34

Water Quality Time Series - Rotary Park, Durango, CO Molybdenum (Mo), Dissolved

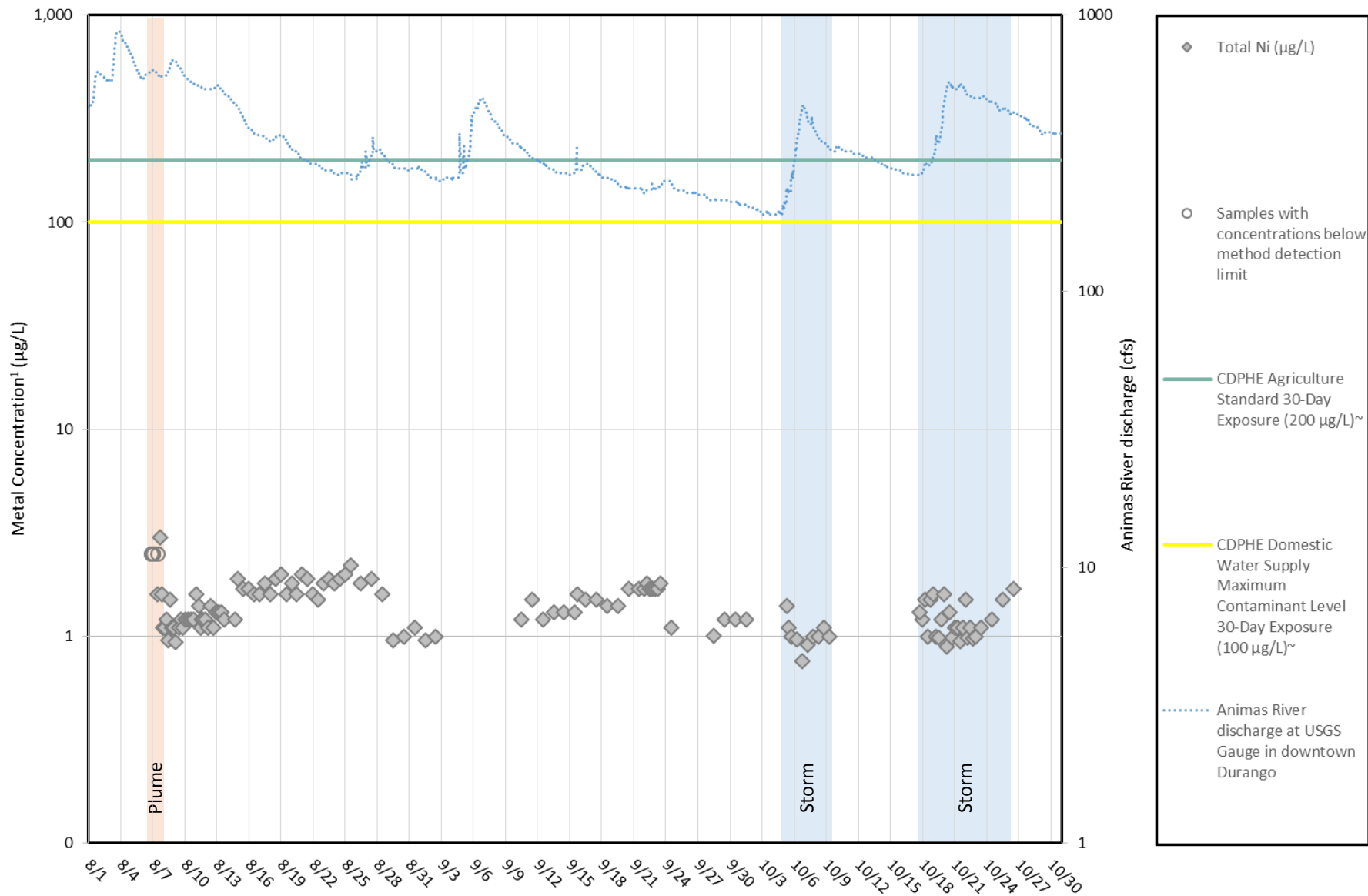


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 1 µg/L (8/6 - 8/7 10AM) and 0.45 µg/L (8/7 12PM - 10/26).

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 35

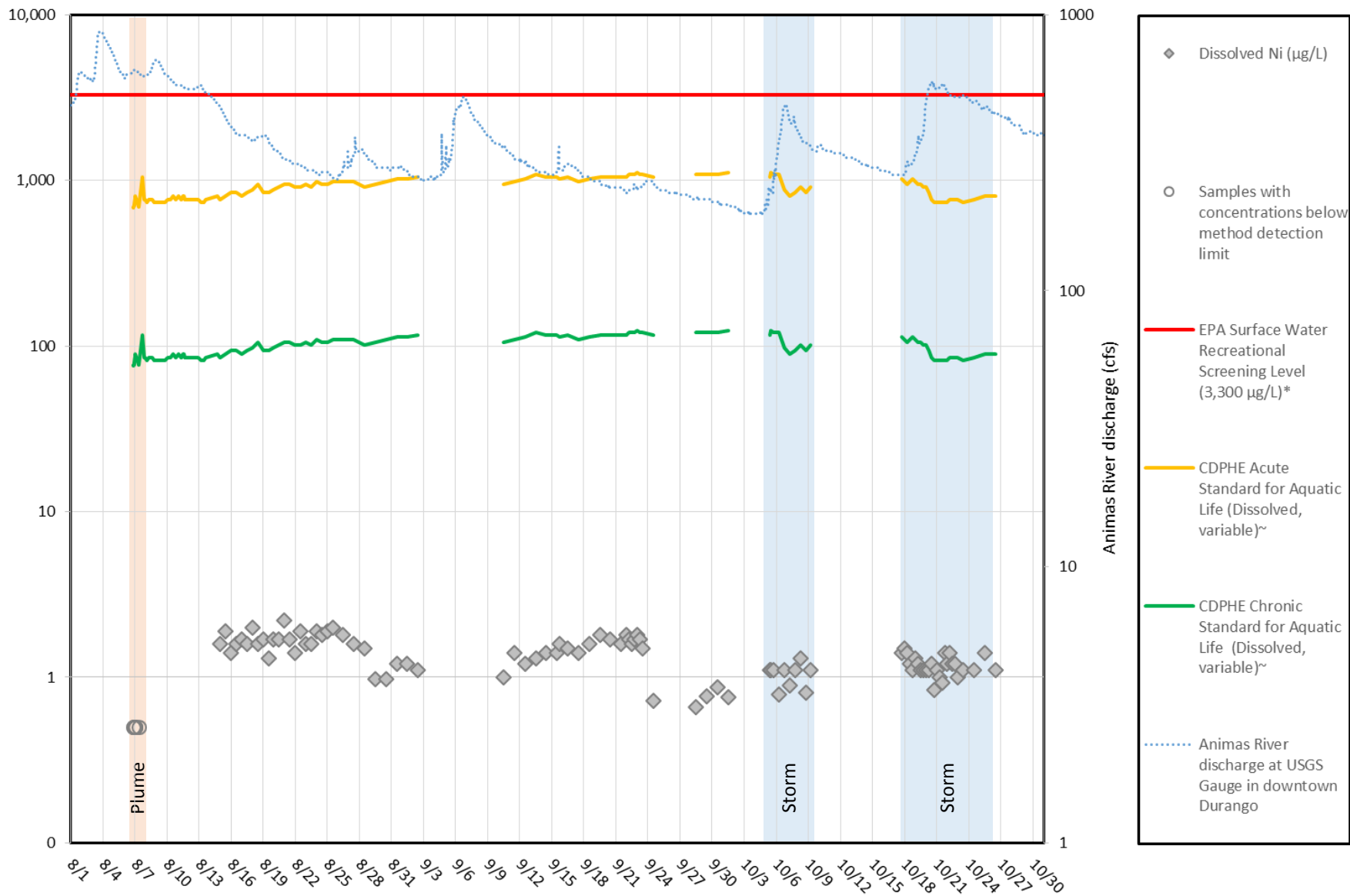
Water Quality Time Series - Rotary Park, Durango, CO Nickel (Ni), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6 - 8/7 10AM) and 0.4 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 36

Water Quality Time Series - Rotary Park, Durango, CO Nickel (Ni), Dissolved



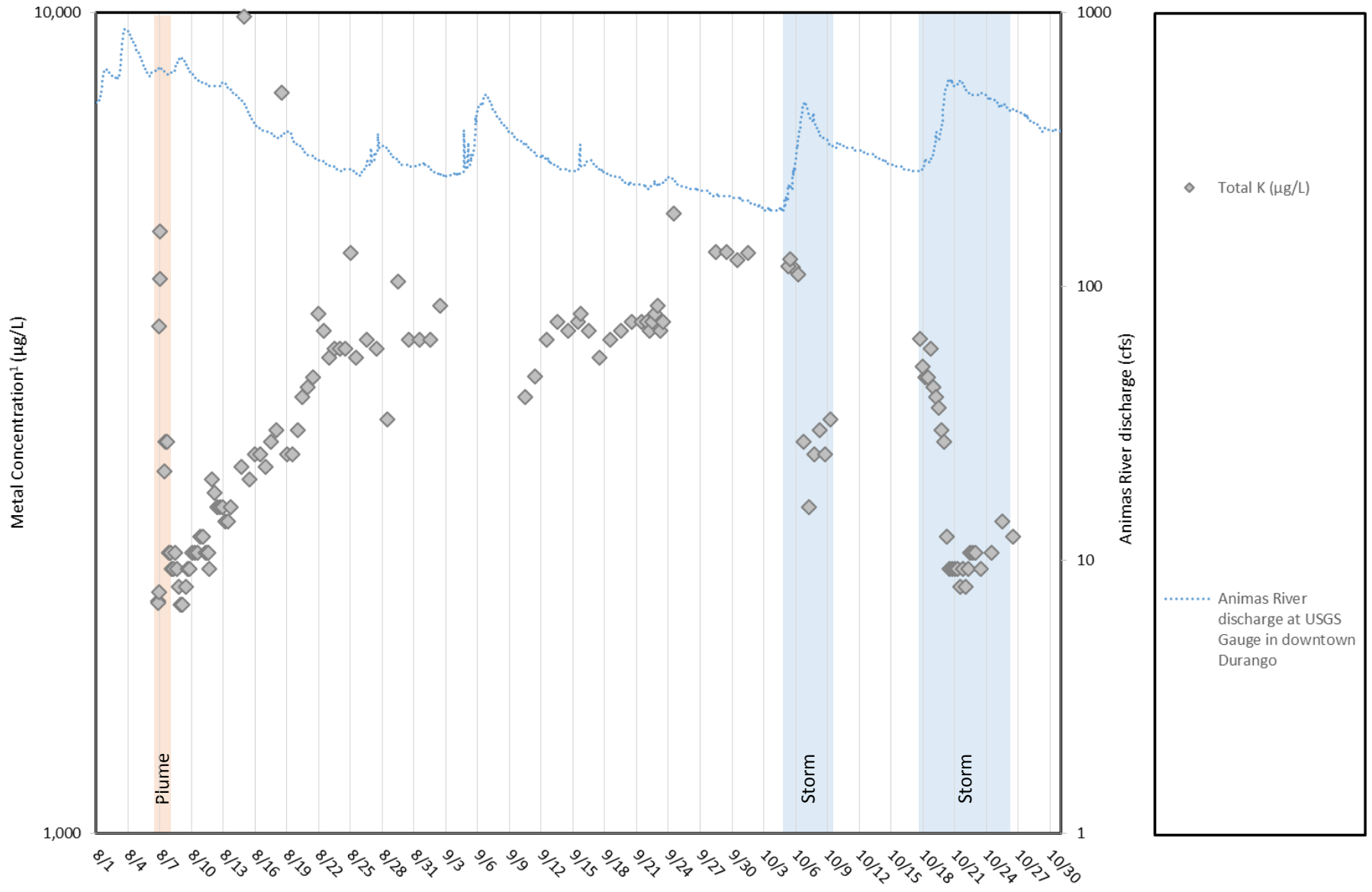
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L (8/6 - 8/7 10AM) and 0.4 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 37

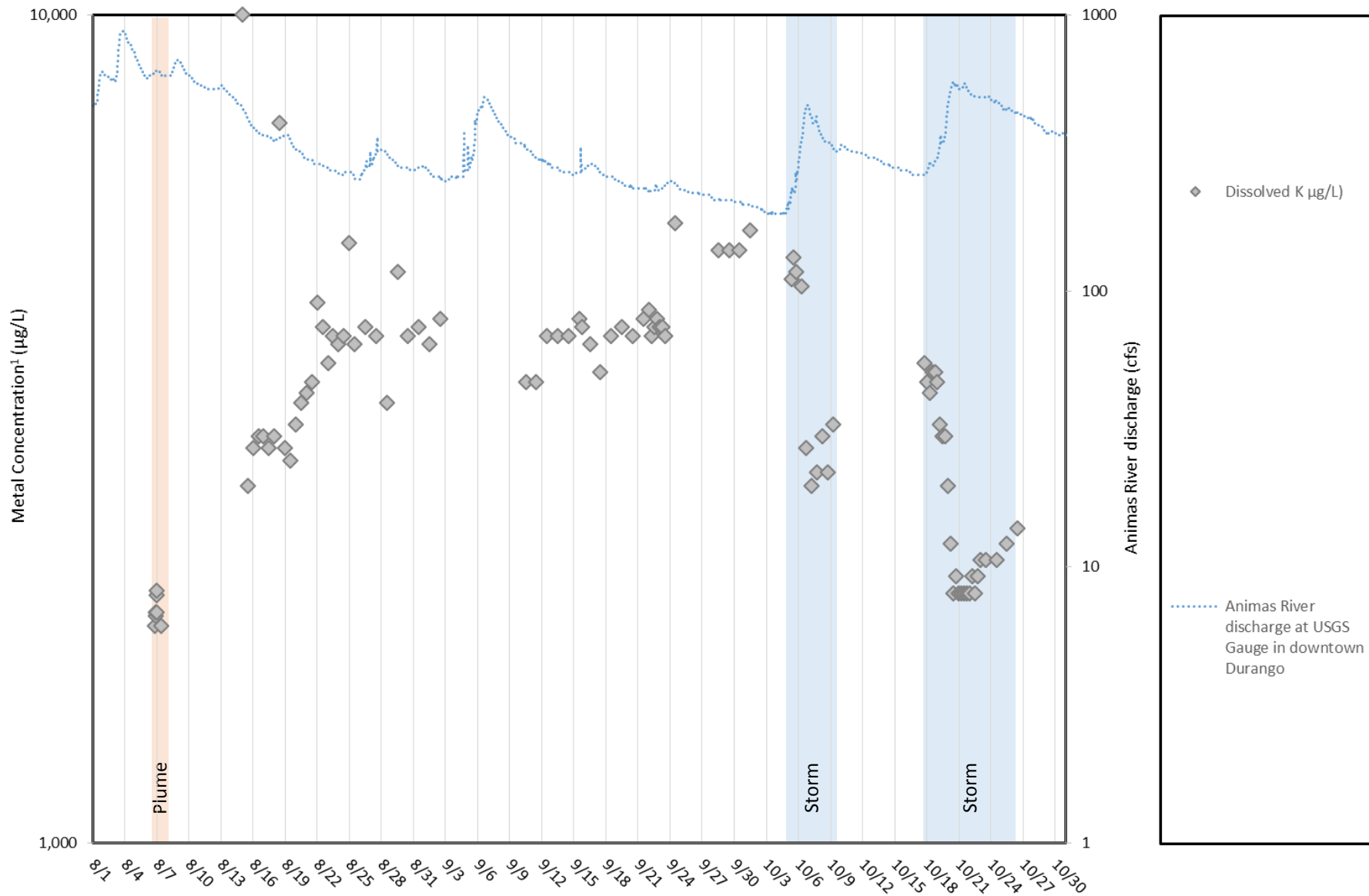
Water Quality Time Series - Rotary Park, Durango, CO Potassium (K), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 250 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 17 $\mu\text{g/L}$ (8/7 12PM - 10/26).

Figure 38

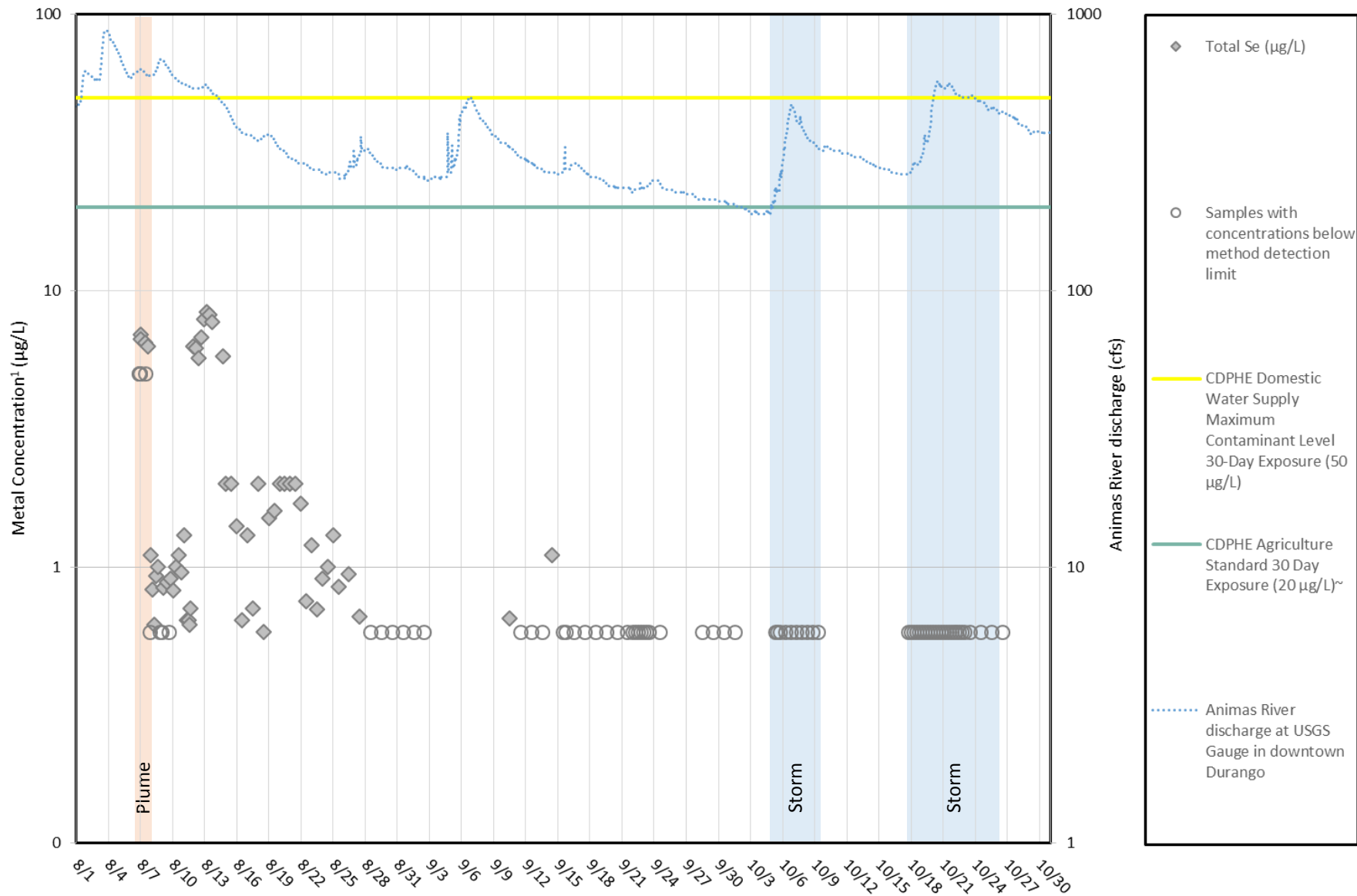
Water Quality Time Series - Rotary Park, Durango, CO Potassium (K), Dissolved



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 250 µg/L (8/6 - 8/7 10AM) and 17 µg/L (8/7 12PM - 10/26).

Figure 39

Water Quality Time Series - Rotary Park, Durango, CO Selenium (Se), Total

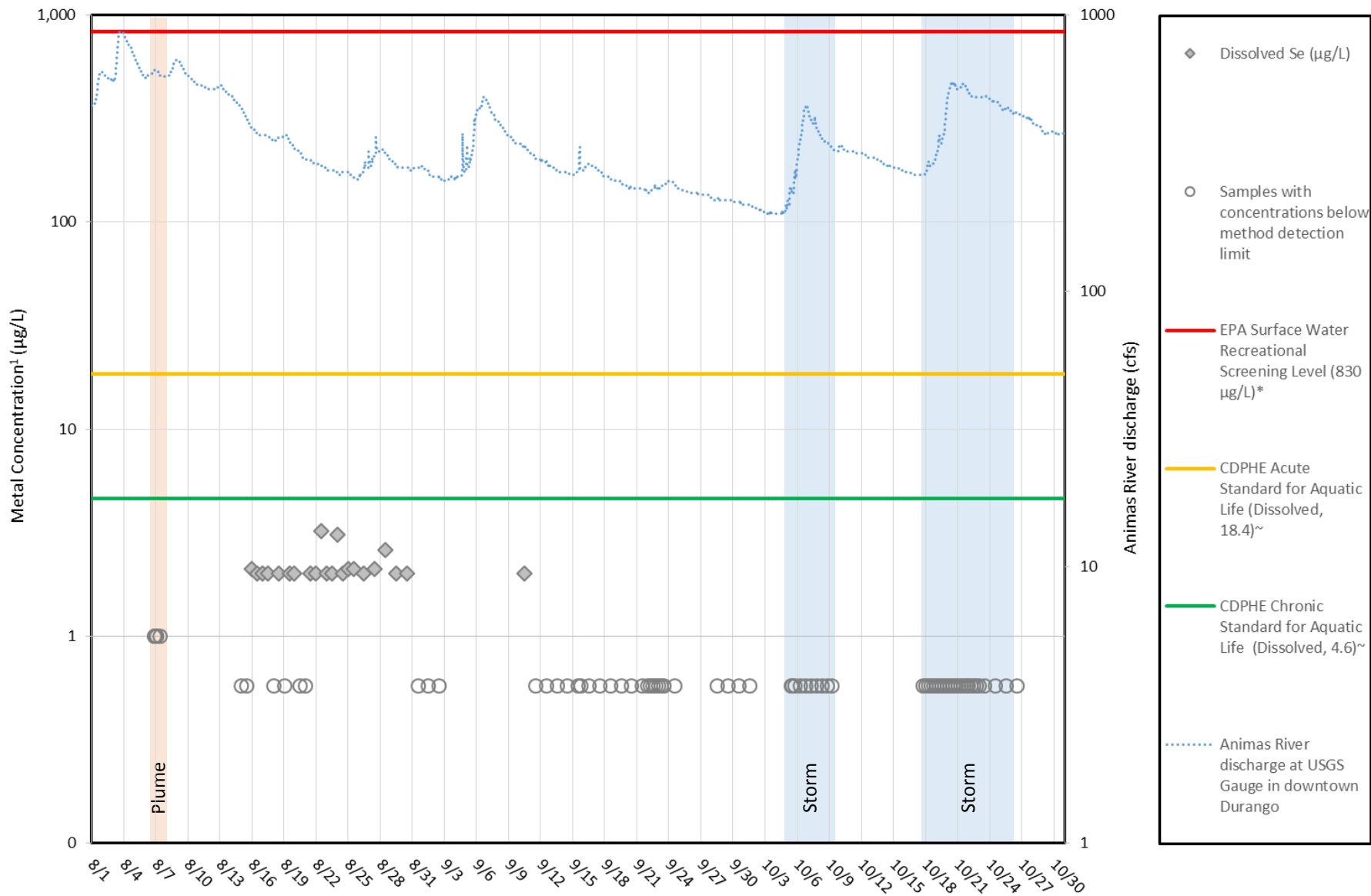


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 5 µg/L (8/6 - 8/7 10AM) and 0.58 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 40

Water Quality Time Series - Rotary Park, Durango, CO Selenium (Se), Dissolved



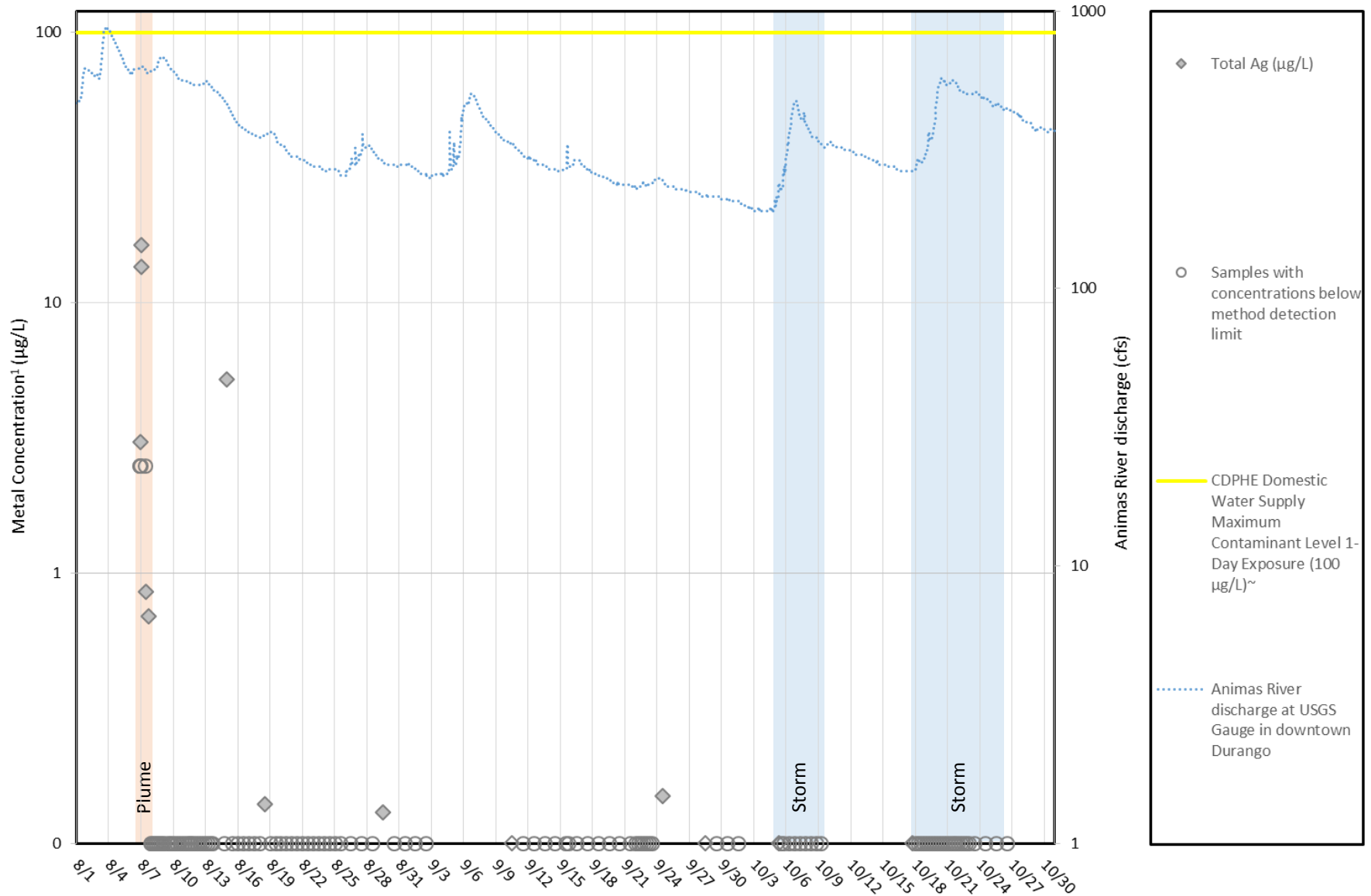
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 1 µg/L (8/6 - 8/7 10AM) and 0.58 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 41

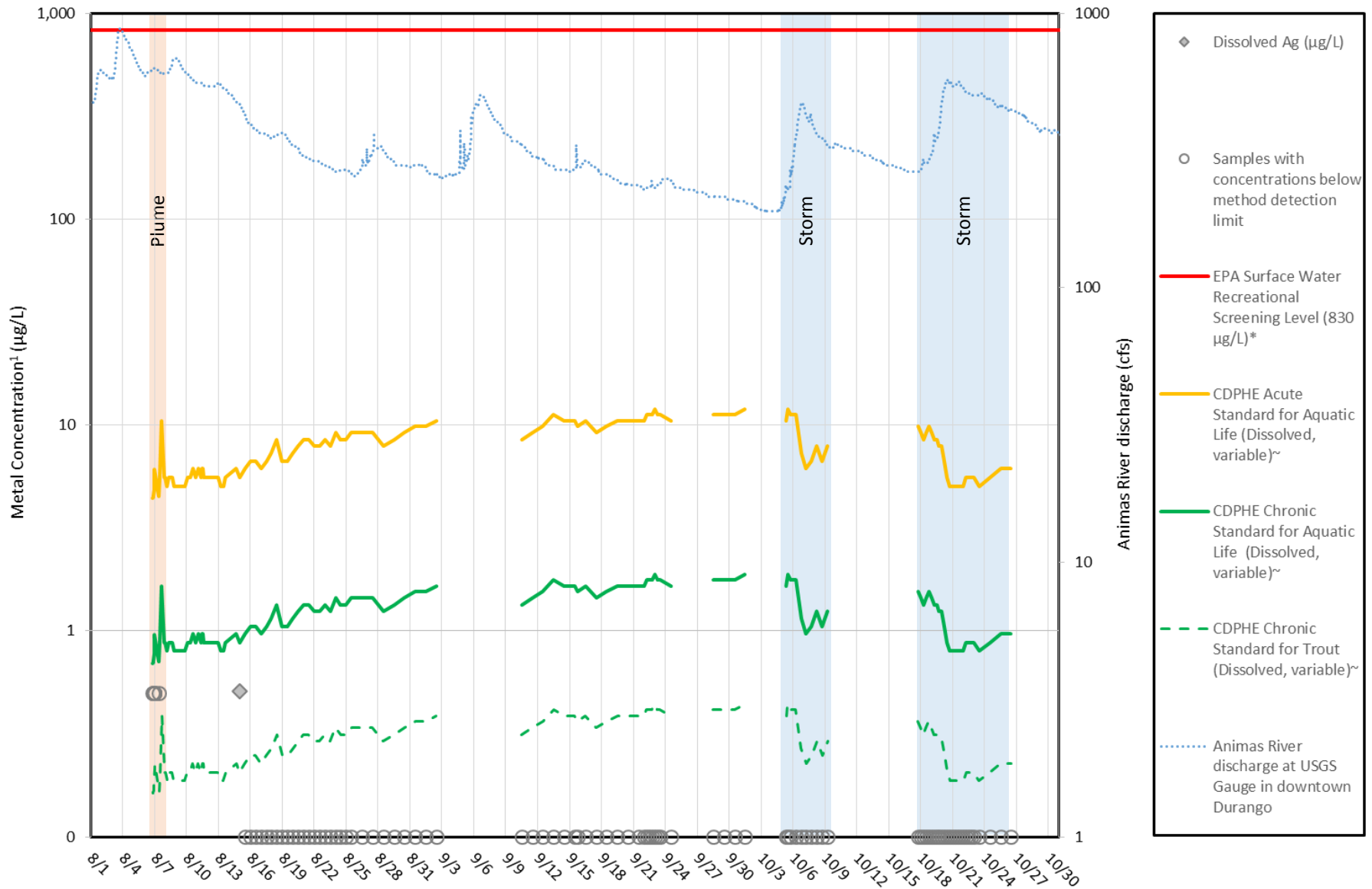
Water Quality Time Series - Rotary Park, Durango, CO Silver (Ag), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6- 8/7 10AM) and 0.1 µg/L (8/7 12PM - 10/26).
~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 42

Water Quality Time Series - Rotary Park, Durango, CO Silver (Ag), Dissolved



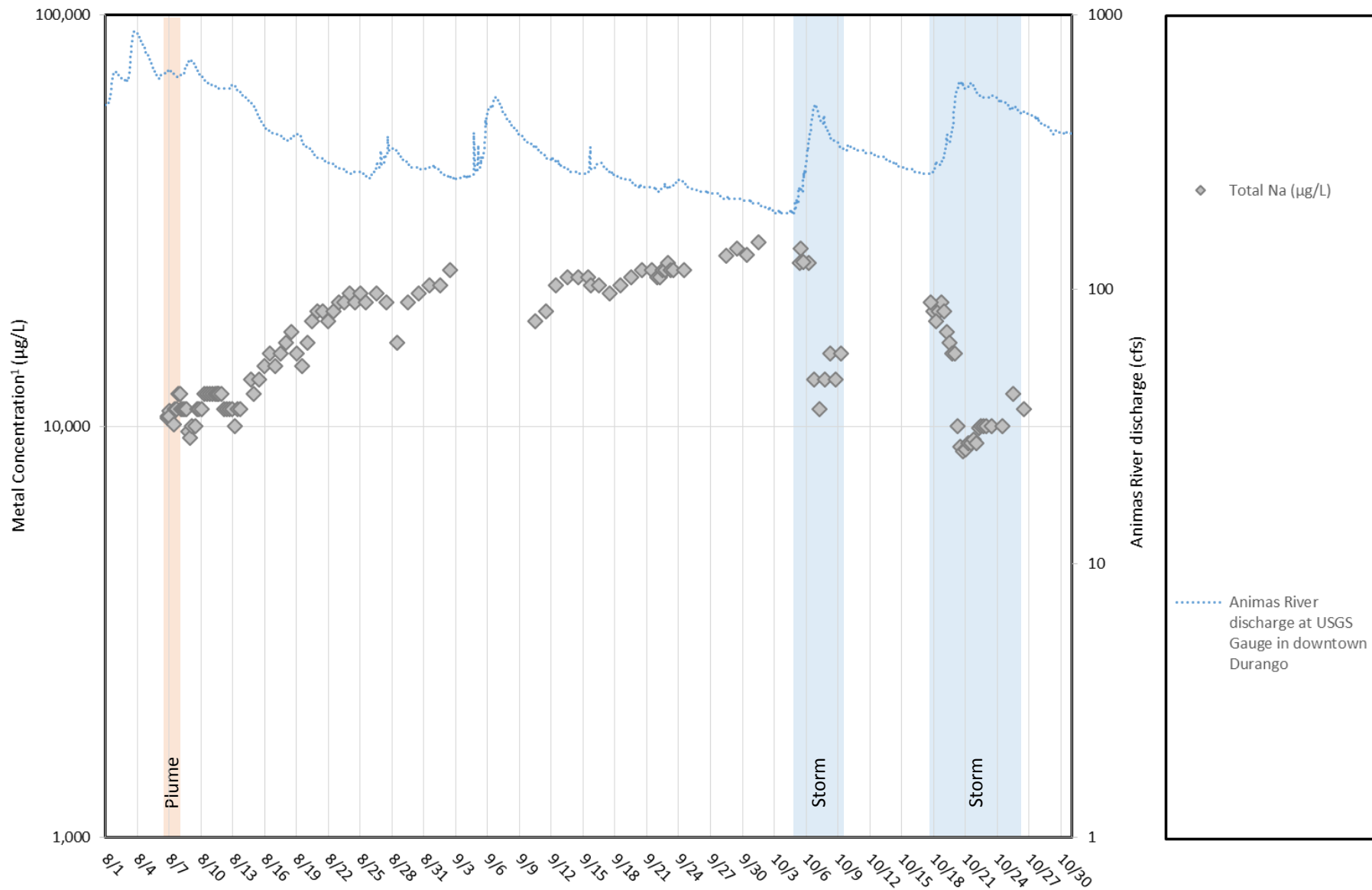
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 0.1 $\mu\text{g/L}$ (8/7 12PM - 10/26).

[~]CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 43

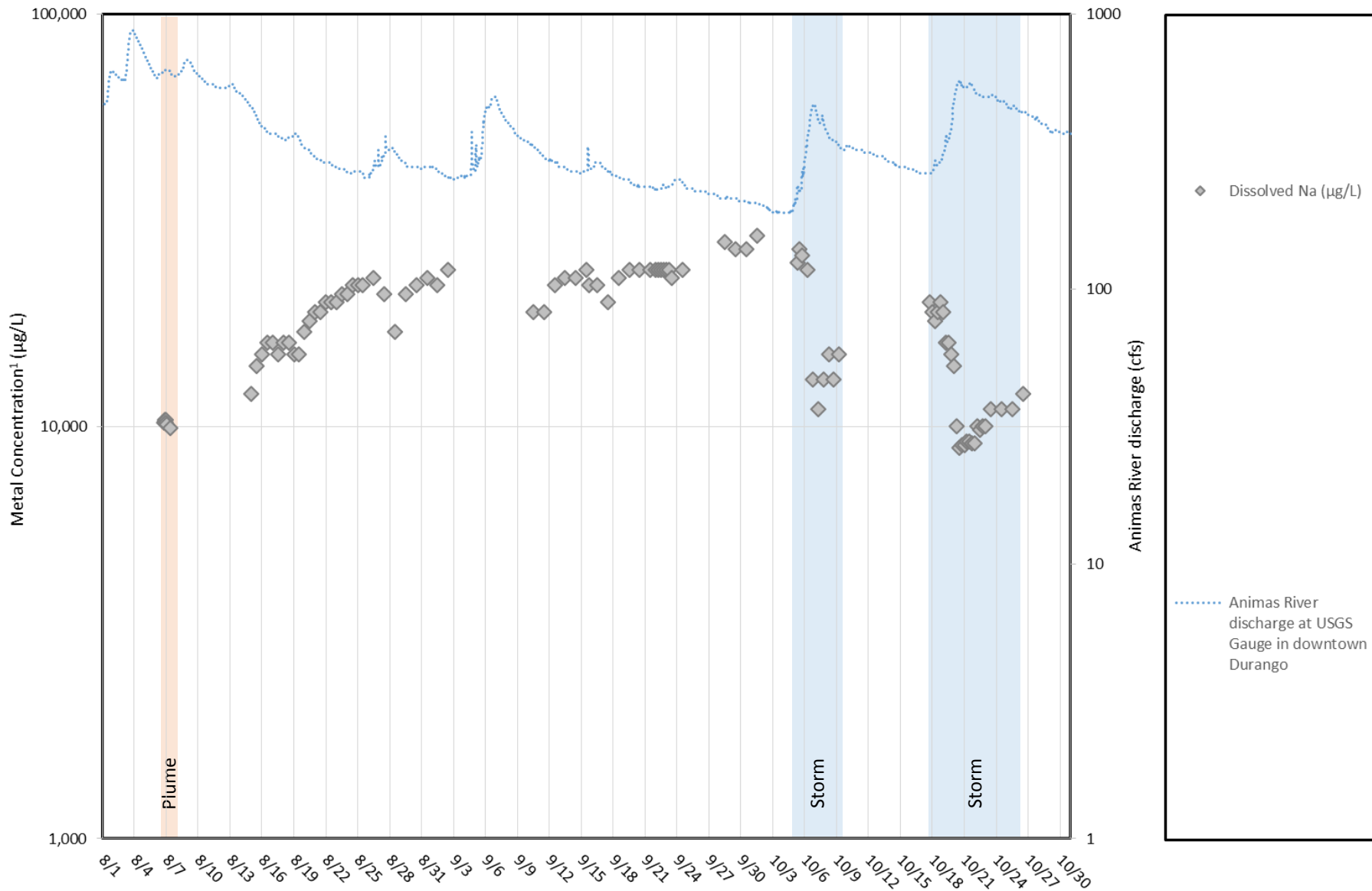
Water Quality Time Series - Rotary Park, Durango, CO Sodium (Na), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 250 µg/L (8/6 - 8/7 10AM) and 480 µg/L (8/7 12PM - 10/26).

Figure 44

Water Quality Time Series - Rotary Park, Durango, CO Sodium (Na), Dissolved

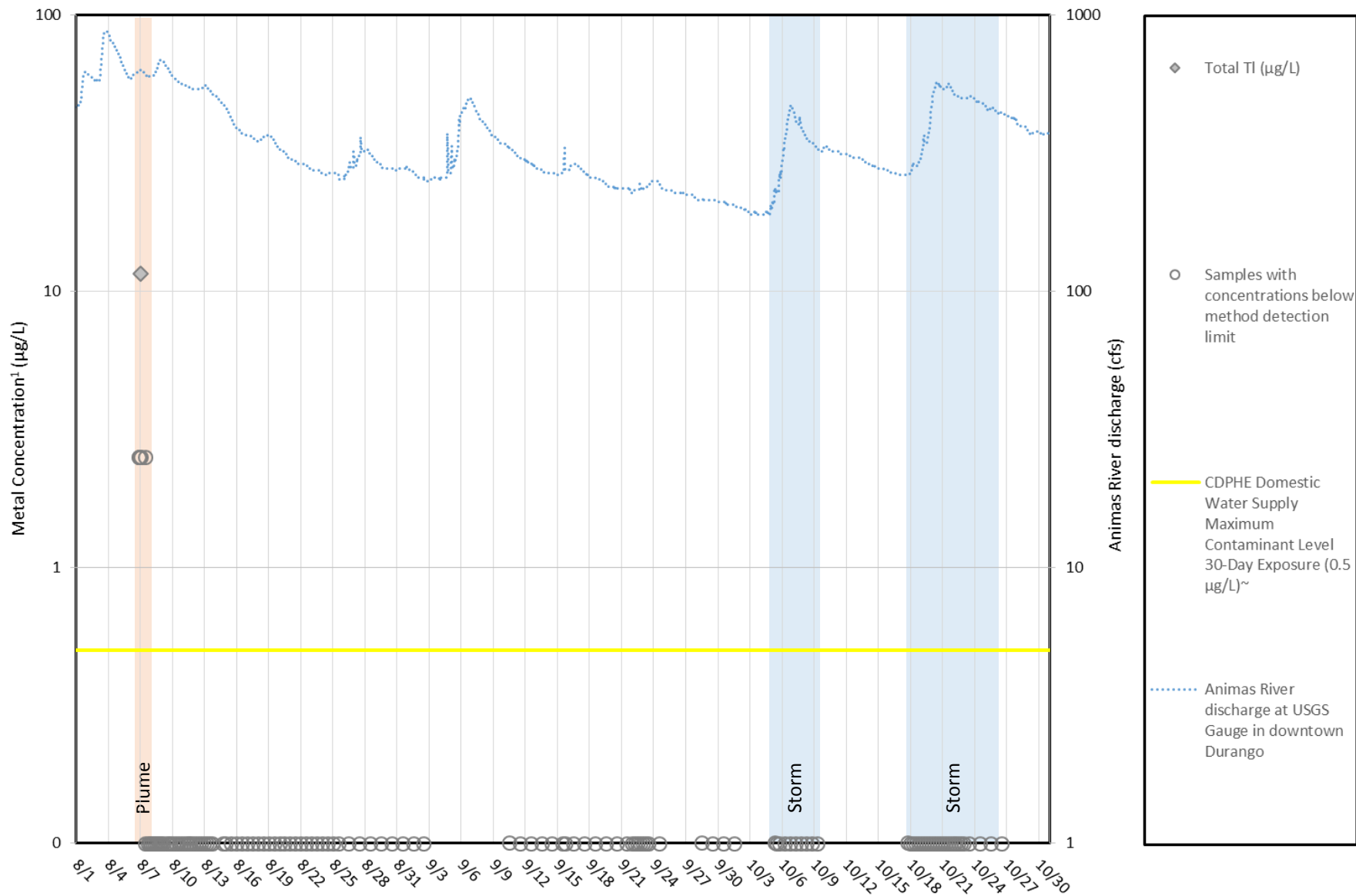


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 250 µg/L (8/6 - 8/7 10AM) and 480 µg/L (8/7 12PM - 10/26).

Figure 45

Water Quality Time Series - Rotary Park, Durango, CO

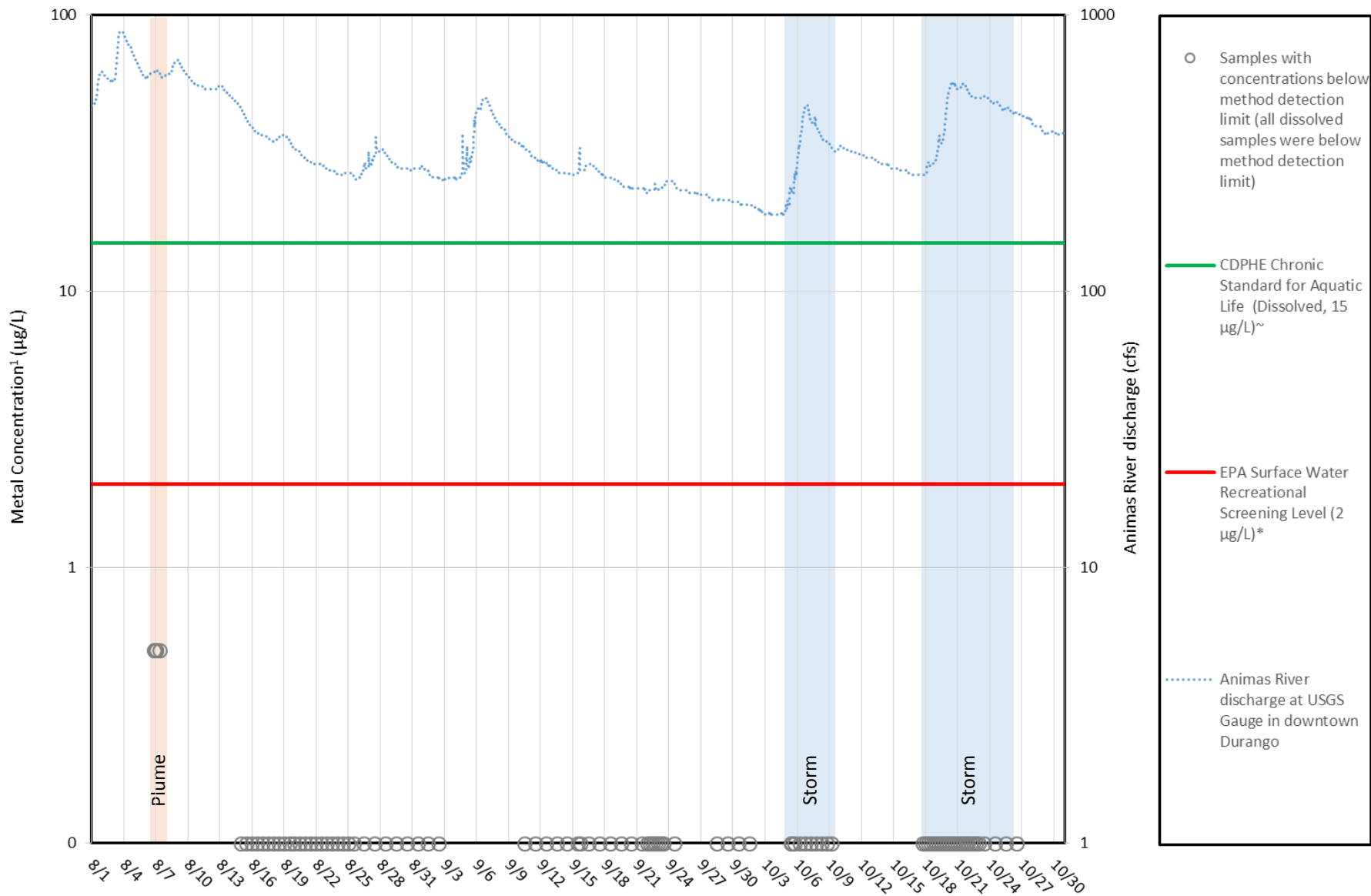
Thallium (Tl), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6 - 8/7 10AM) and 0.1 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 46

Water Quality Time Series - Rotary Park, Durango, CO Thallium (Tl), Dissolved



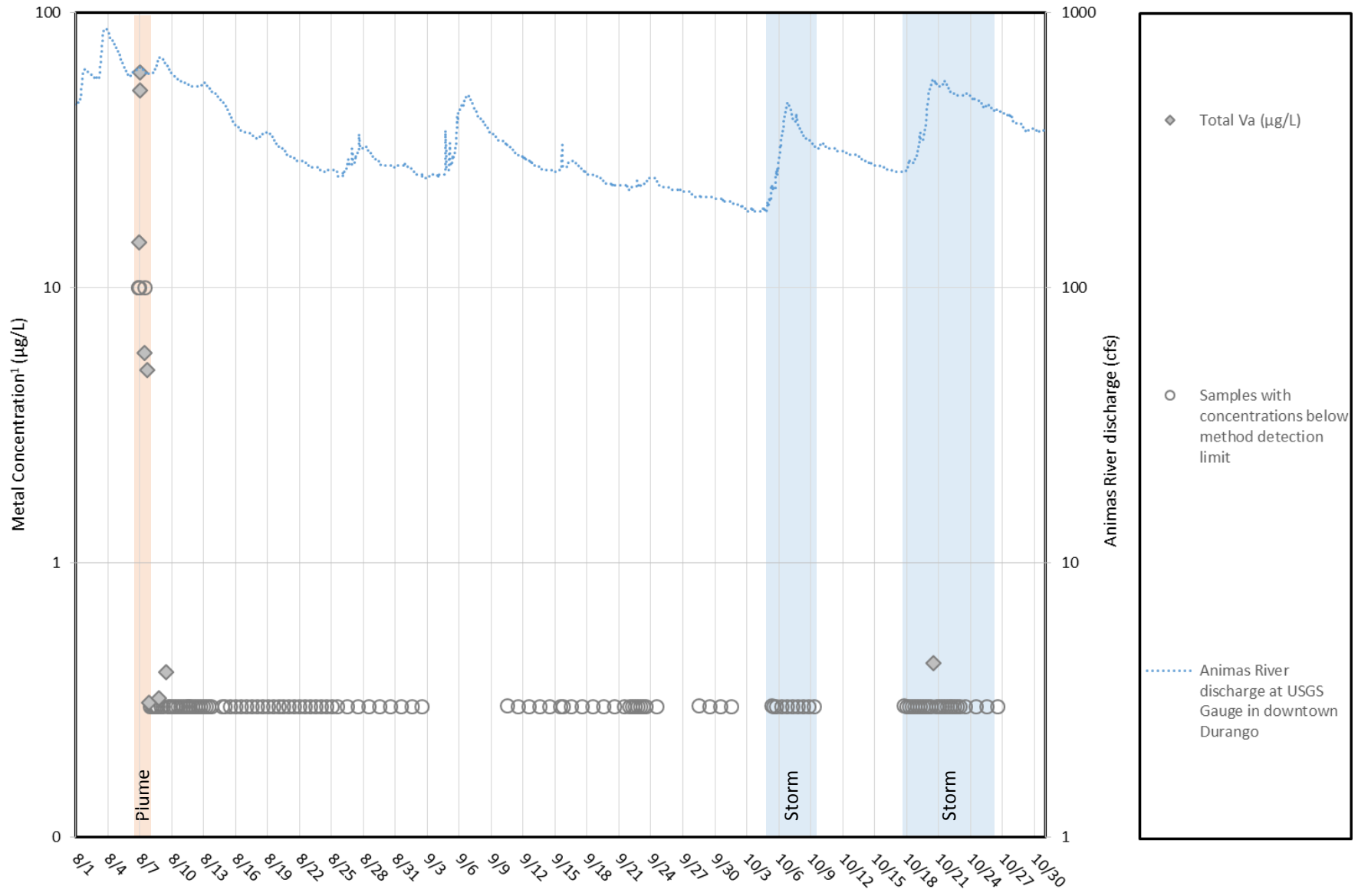
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 0.5 µg/L (8/6 - 8/7 10AM) and 0.1 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 47

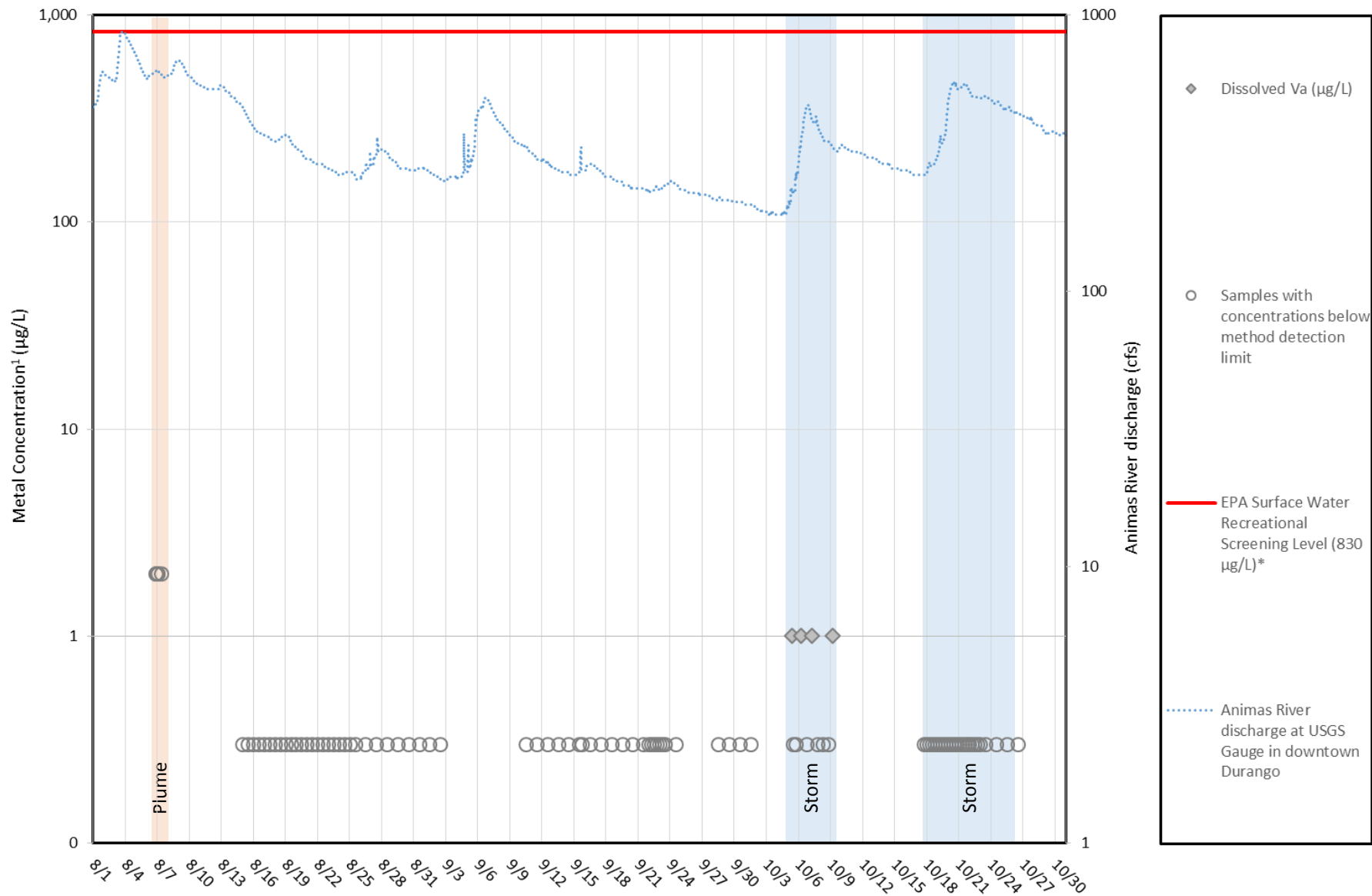
Water Quality Time Series - Rotary Park, Durango, CO Vanadium (Va), Total



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 10 µg/L (8/6 - 8/7 10AM) and 0.3 µg/L (8/7 12PM - 10/26).

Figure 48

Water Quality Time Series - Rotary Park, Durango, CO Vanadium (Va), Dissolved

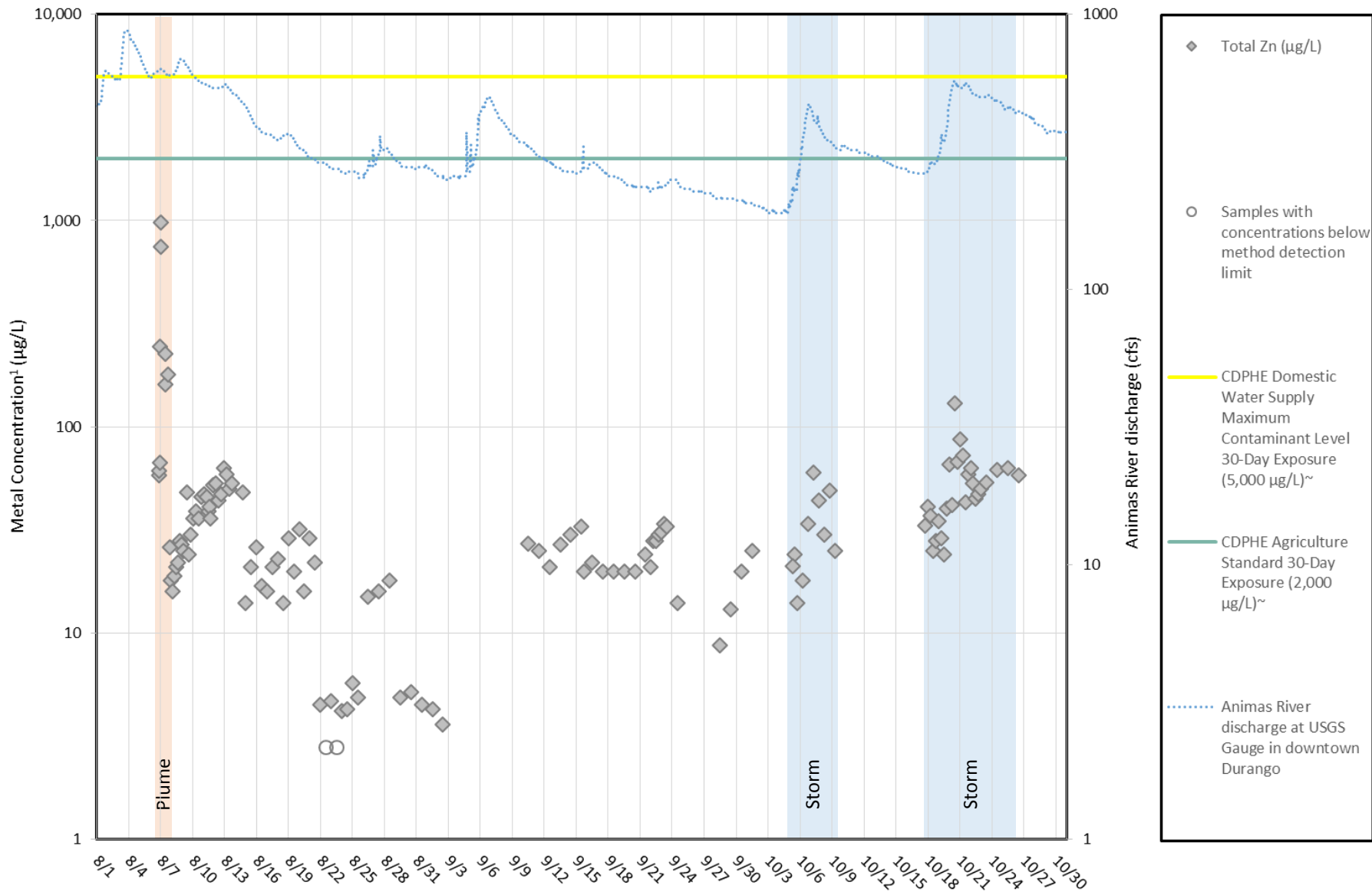


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2 µg/L (8/6 - 8/7 10AM) and 0.3 µg/L (8/7 12PM - 10/26).

* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Figure 49

Water Quality Time Series - Rotary Park, Durango, CO Zinc (Zn), Total

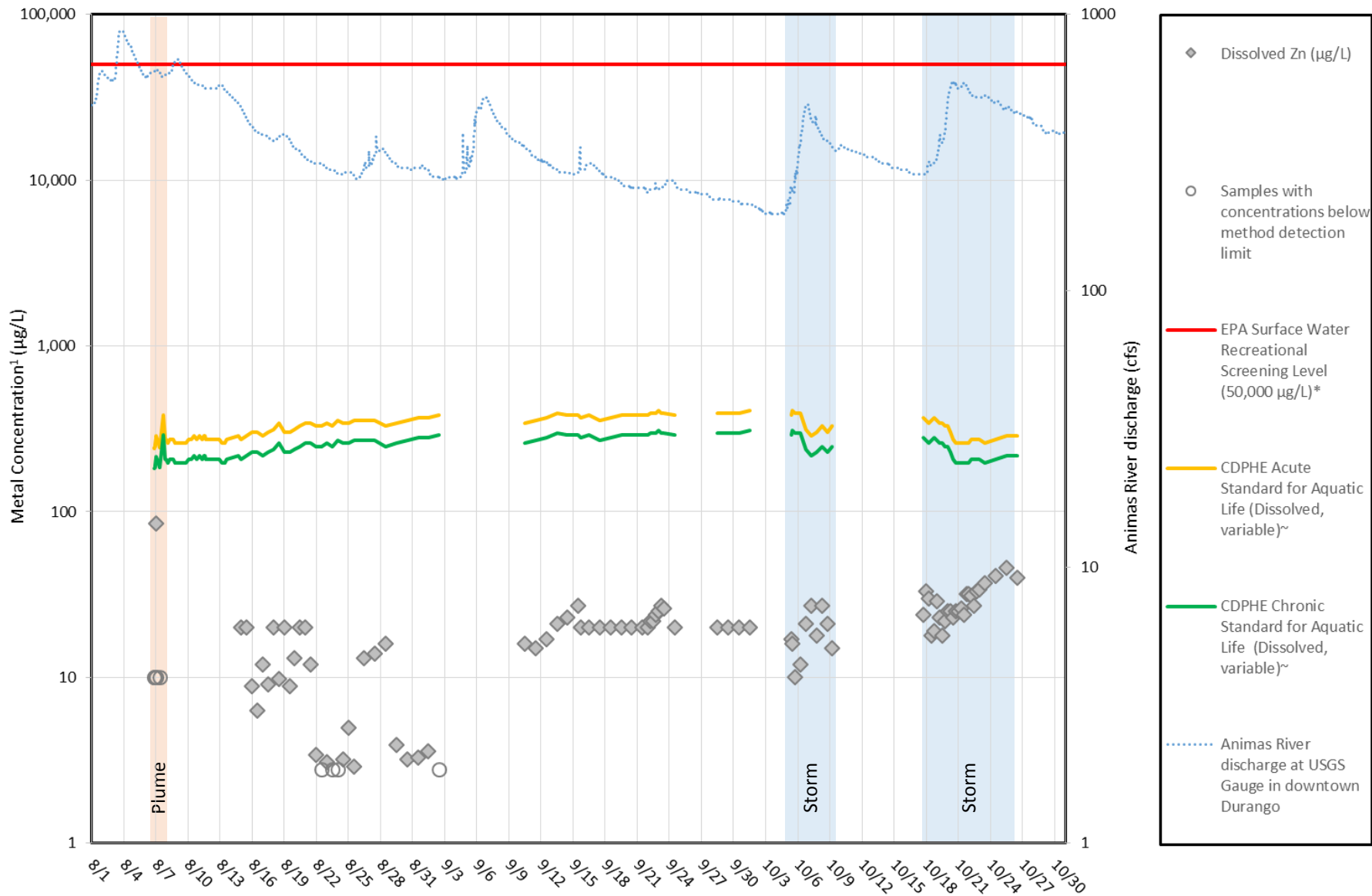


¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 10 µg/L (8/6 - 8/7 10AM) and 2.8 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34.

Figure 50

Water Quality Time Series - Rotary Park, Durango, CO Zinc (Zn), Dissolved



¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 10 $\mu\text{g/L}$ (8/6 - 8/7 10AM) and 2.8 $\mu\text{g/L}$ (8/7 12PM - 10/26).

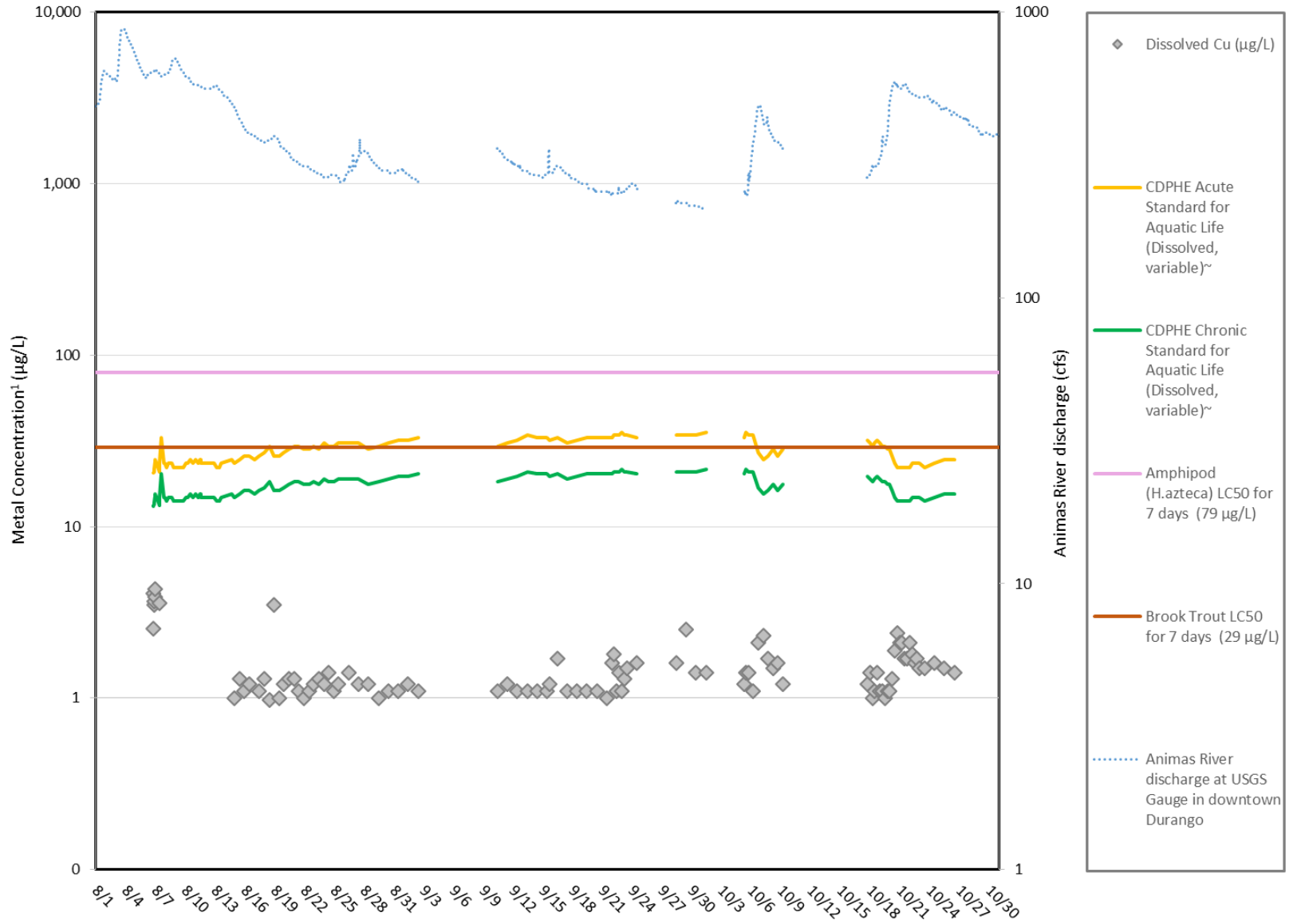
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

**Appendix C - Dissolved Copper and Zinc from Rotary Park,
Durango, CO in context of toxicity thresholds for aquatic life.**

Figure 1

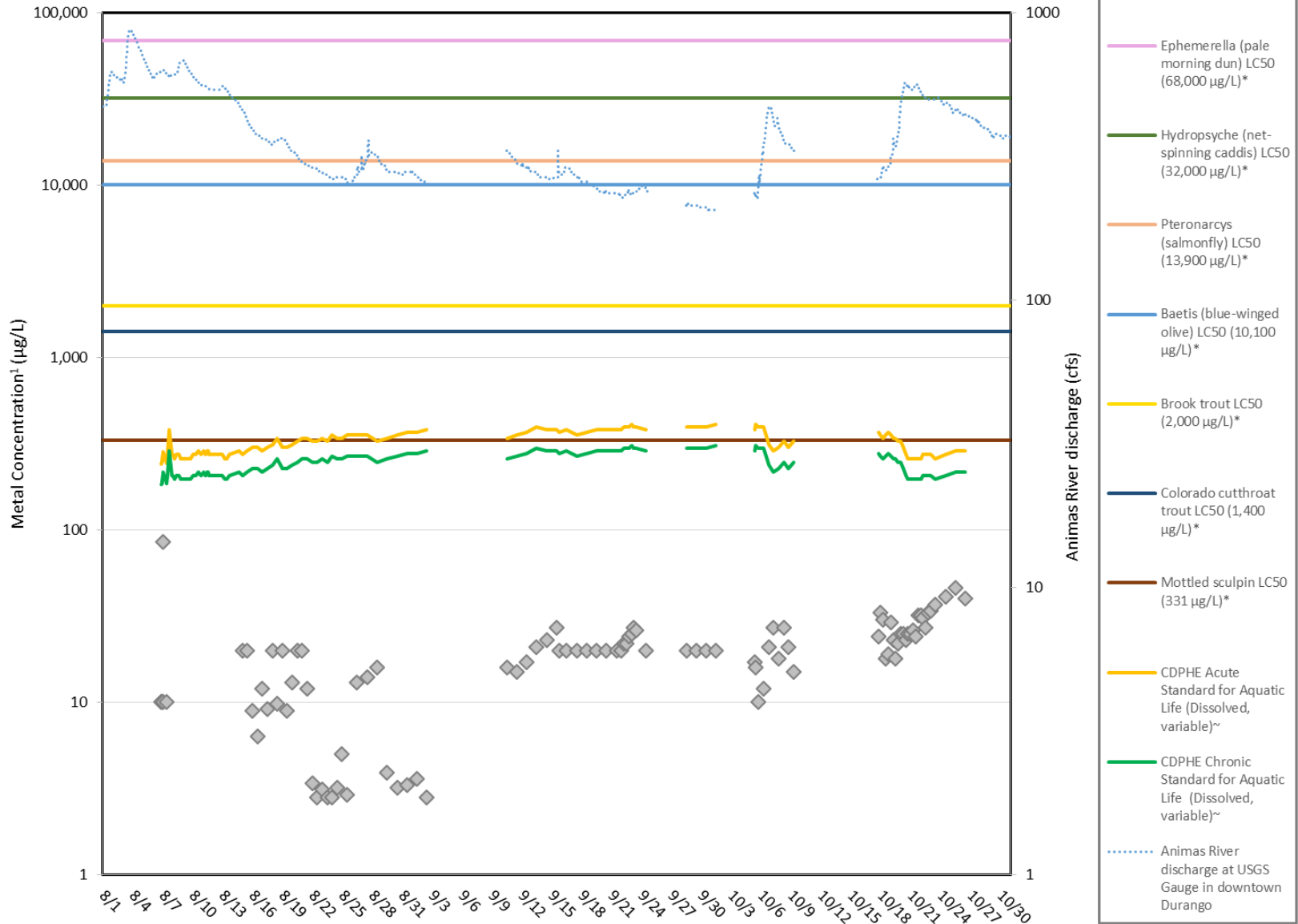
Water Quality Time Series - Rotary Park, Durango, CO Copper (Cu), Dissolved



*LC50 is the lethal concentration that causes 50% mortality of test organisms in laboratory bioassays. The LC50s depicted here are not directly comparable because tests were conducted at varying water hardnesses and for different durations. Sources include: Besser and Leib 2007; Brinkman and Johnston 2012; Nehring 1976; Warnick and Bell 1969.
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 2.5 µg/L (8/6 - 8/7 10AM) and 0.5 µg/L (8/7 12PM - 10/26).
 ~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

Figure 2

Water Quality Time Series - Rotary Park, Durango, CO Zinc (Zn), Dissolved



*LC50 is the lethal concentration that causes 50% mortality of test organisms in laboratory bioassays. The LC50s depicted here are not directly comparable because tests were conducted at varying water hardnesses and for different durations. Sources include: Besser and Leib 2007; Brinkman and Johnston 2012; Nehring 1976; Warnick and Bell 1969.

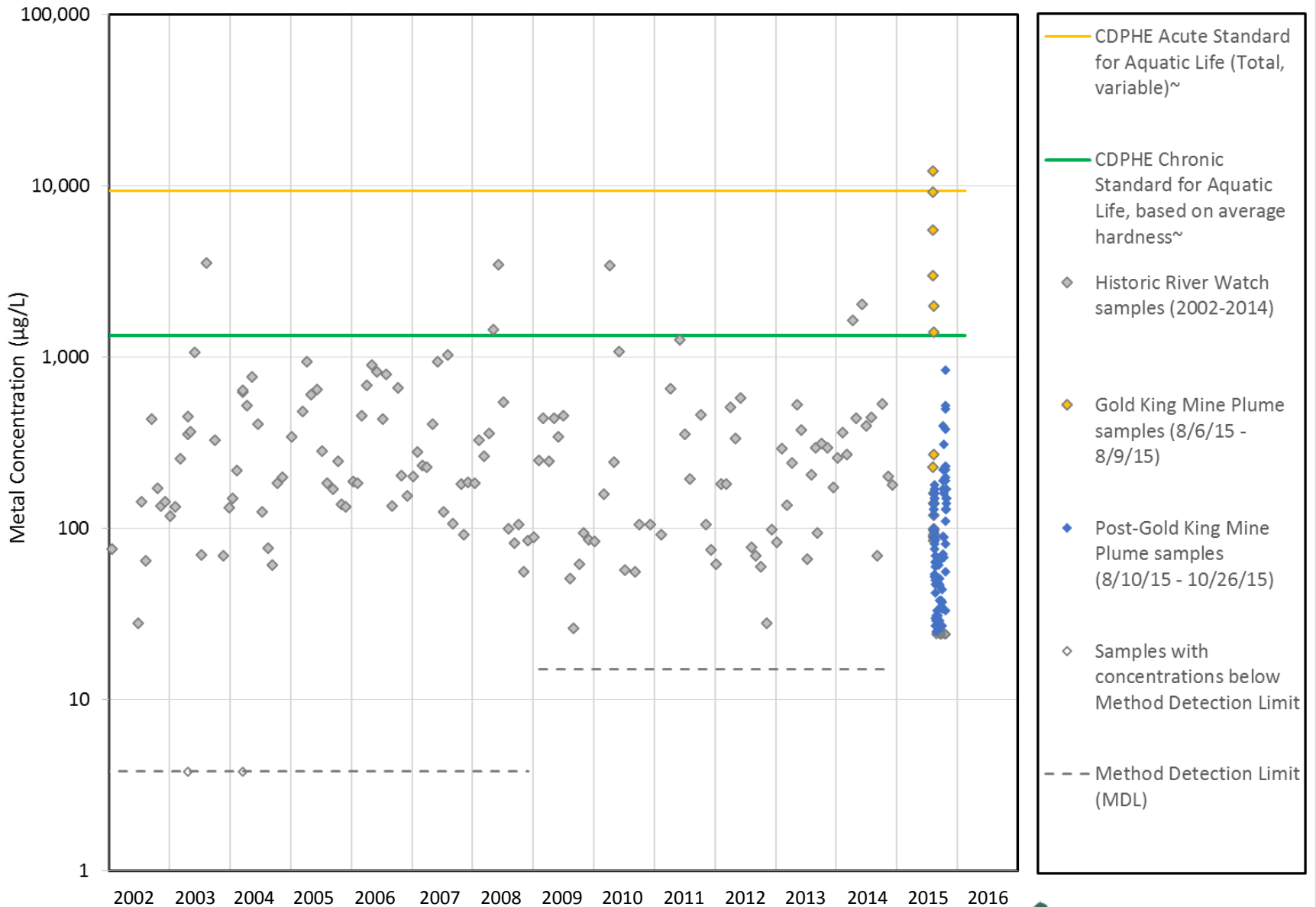
¹ EPA analytical methods 200.7 and 200.8. Method detection limit was 10 µg/L (8/6 - 8/7 10AM) and 2.8 µg/L (8/7 12PM - 10/26).

~CDPHE standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standard varies with water hardness.

**Appendix D – Water quality results from Rotary Park, Durango, CO
in context of historic water quality data from the Animas River.**

Figure 1

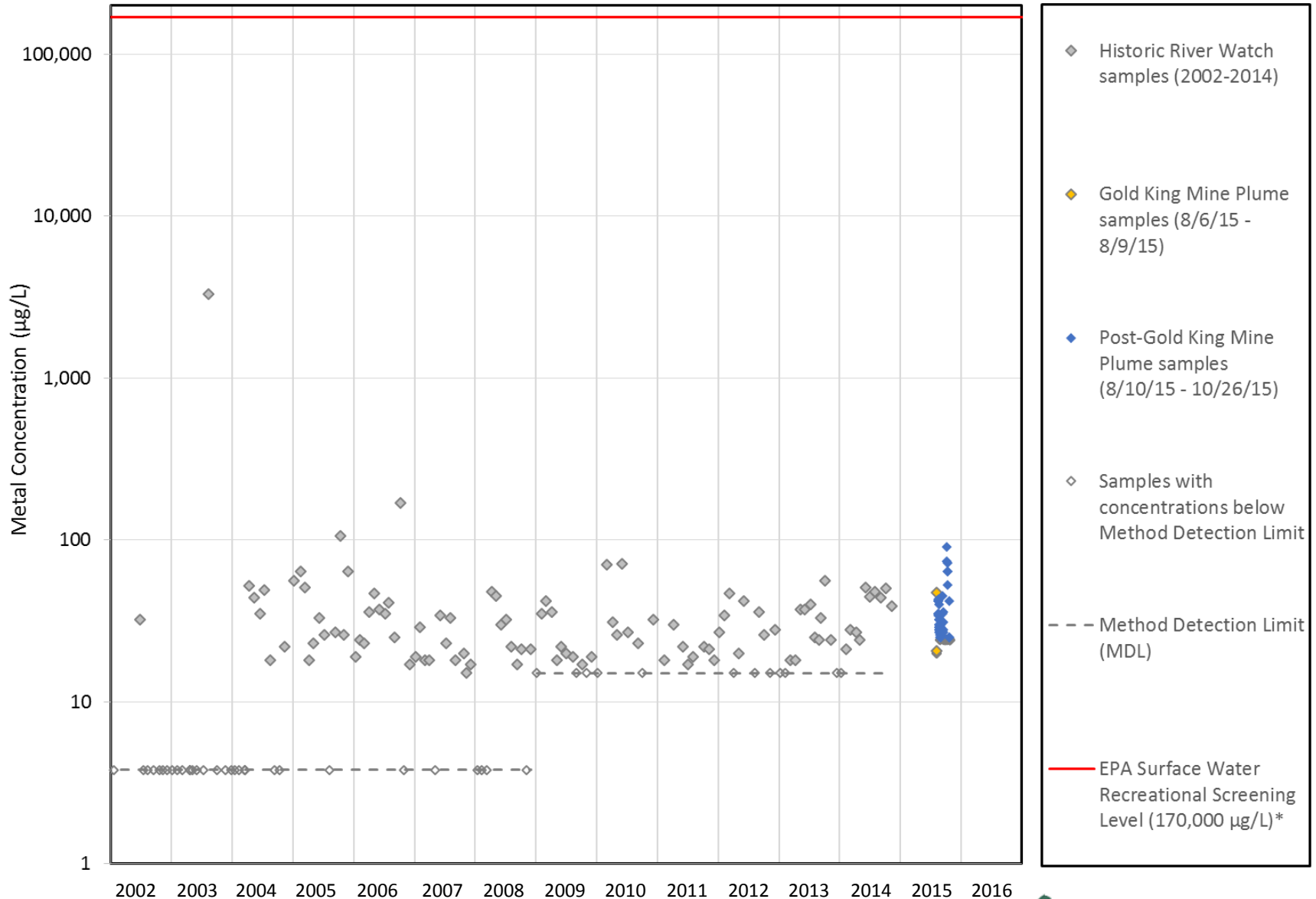
Total Aluminum, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.
Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 2

Dissolved Aluminum, Animas River at Durango, CO: 2002-2016

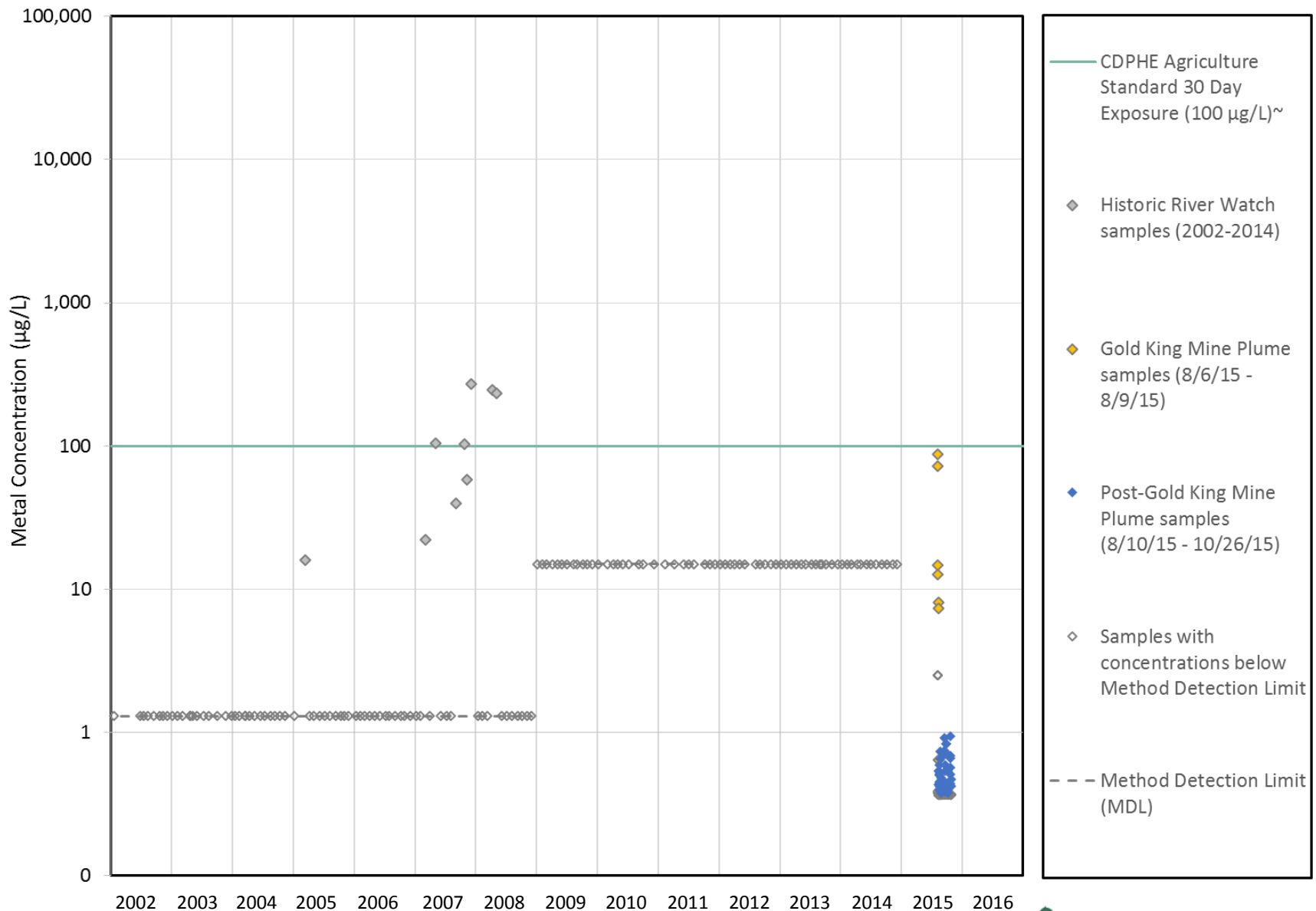


* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO.

Figure 3

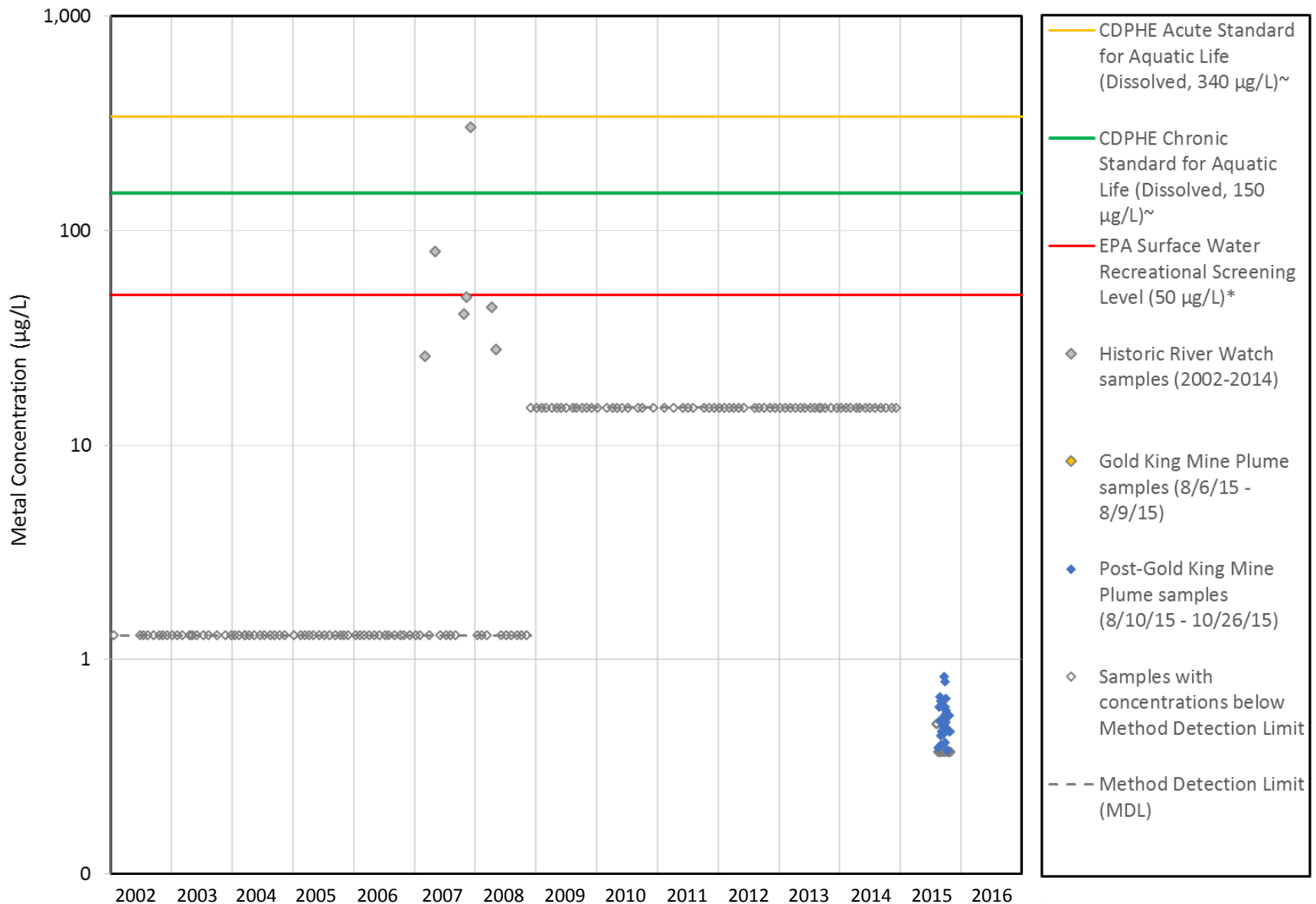
Total Arsenic, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 4

Dissolved Arsenic, Animas River at Durango, CO: 2002-2016



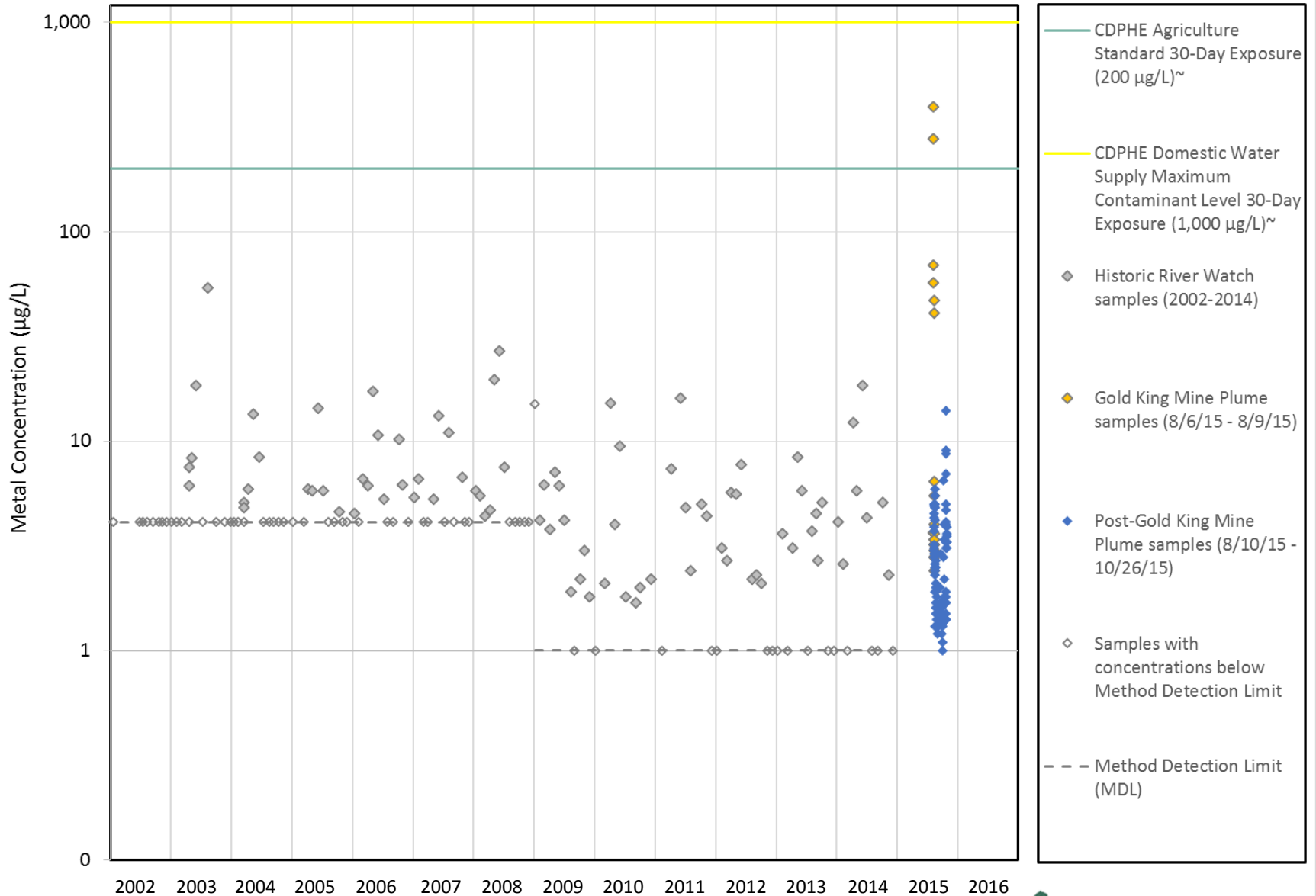
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.

2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.

Figure 5

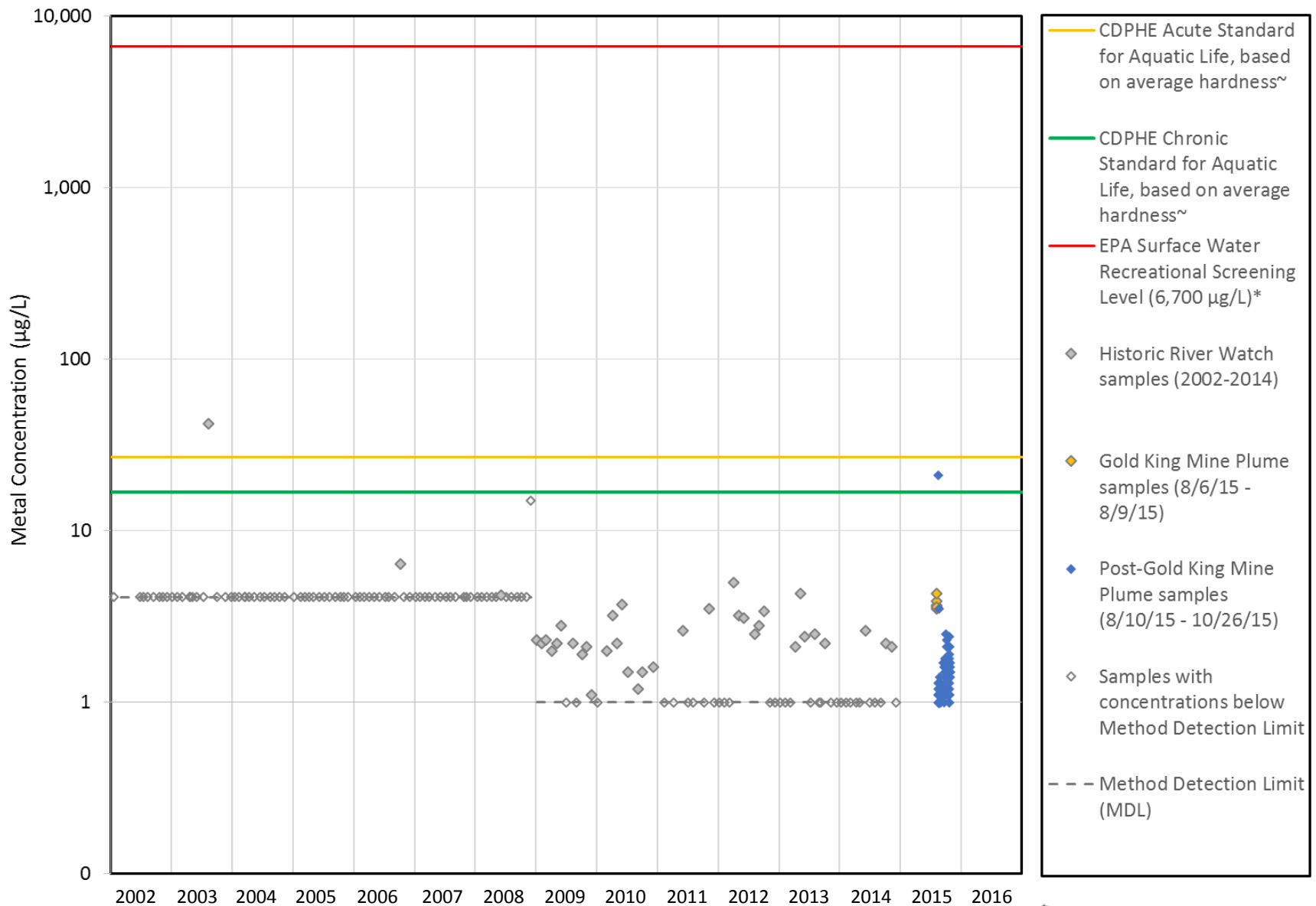
Total Copper, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 6

Dissolved Copper, Animas River at Durango, CO: 2002-2016



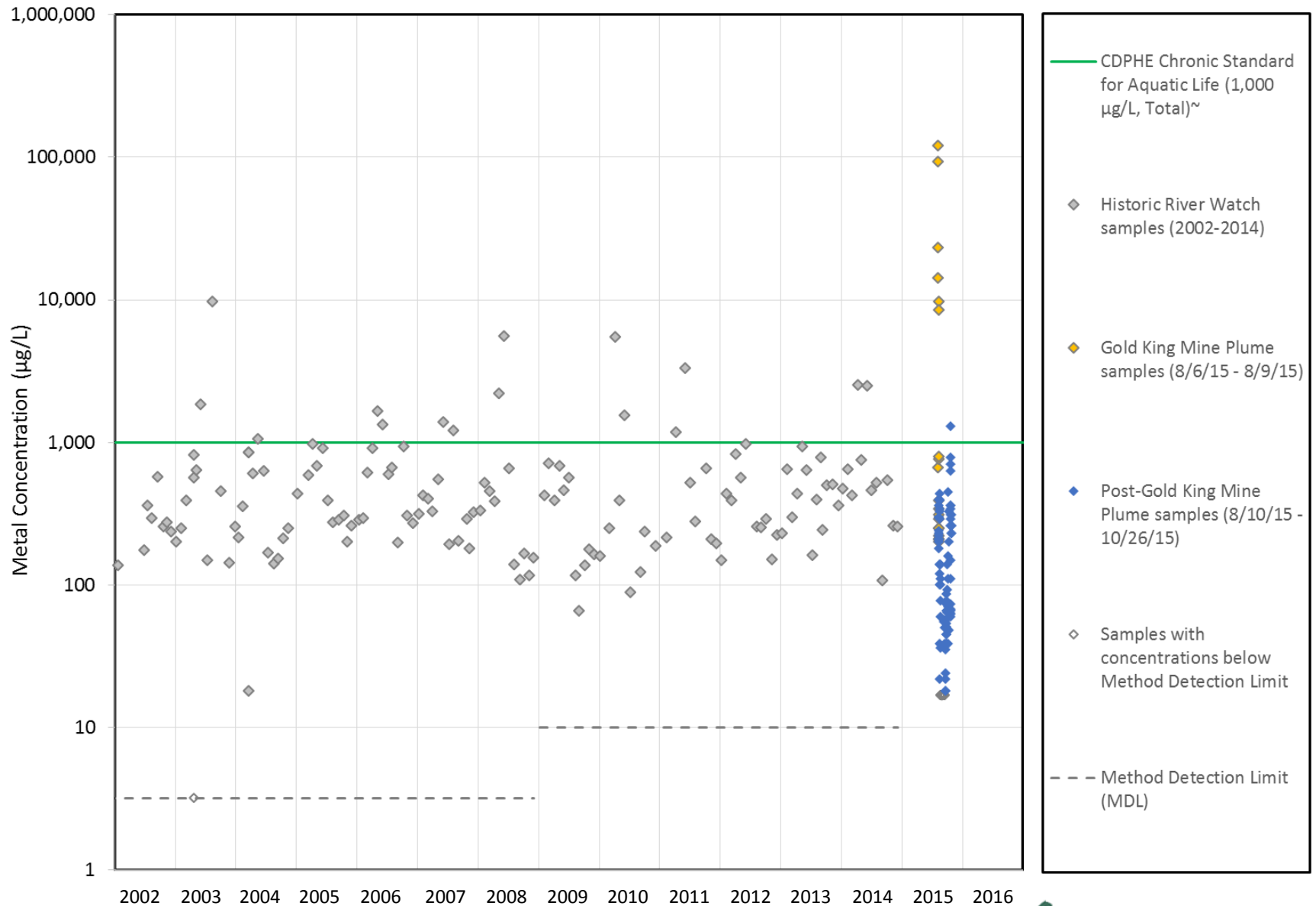
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.

2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.

Figure 7

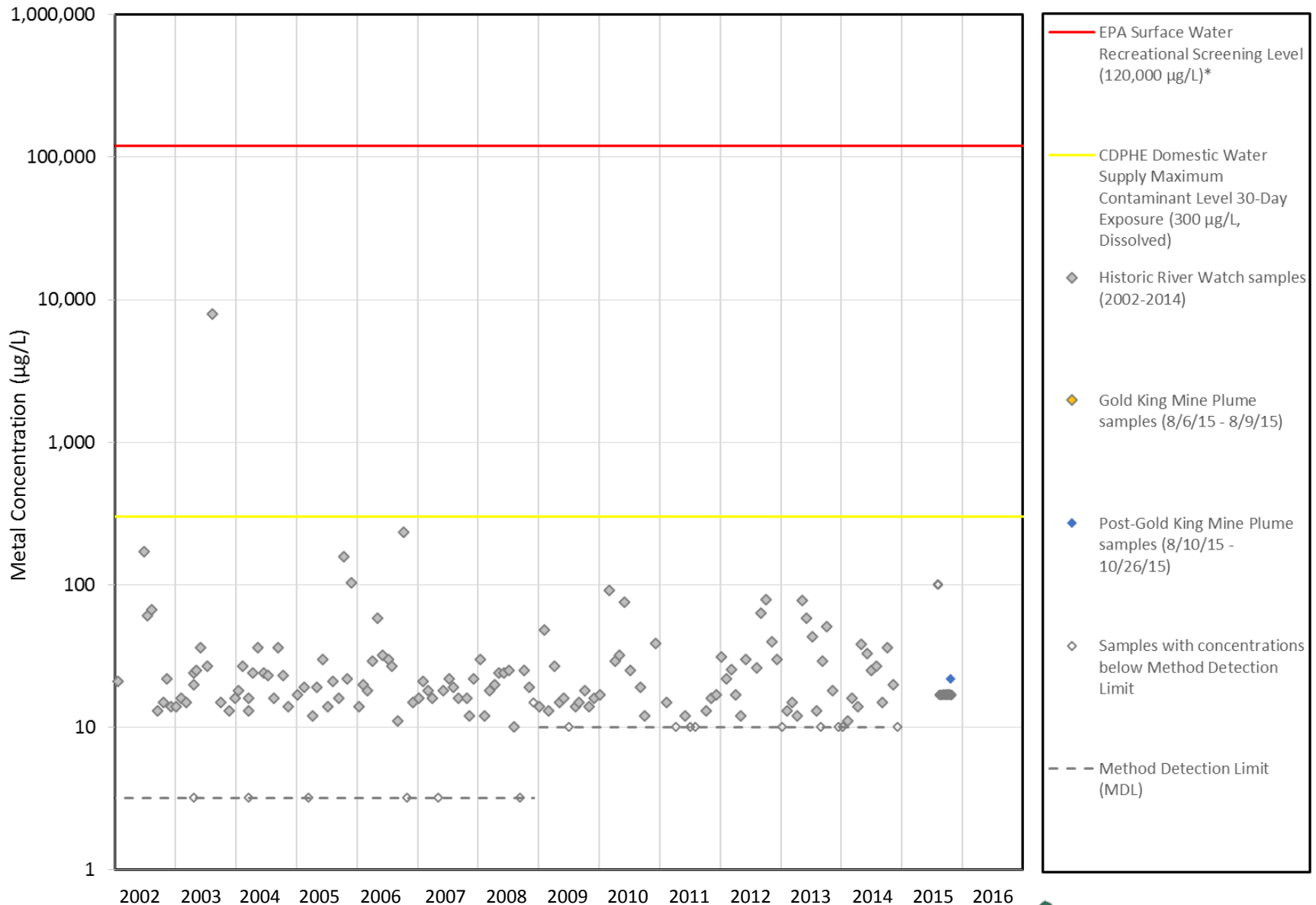
Total Iron, Animas River at Durango, CO: 2002-2016



[~]Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 8

Dissolved Iron, Animas River at Durango, CO: 2002-2016

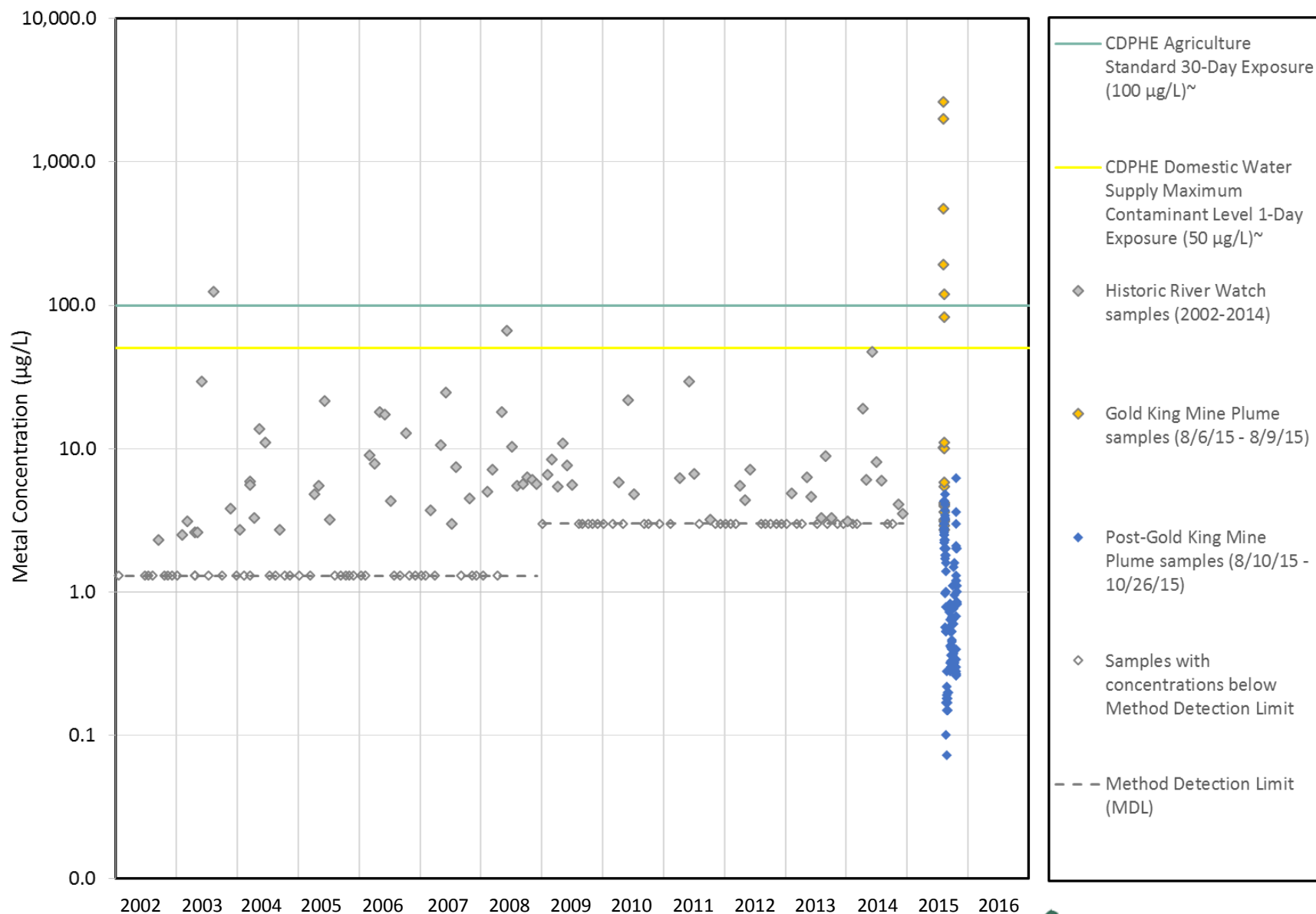


* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO.

Figure 9

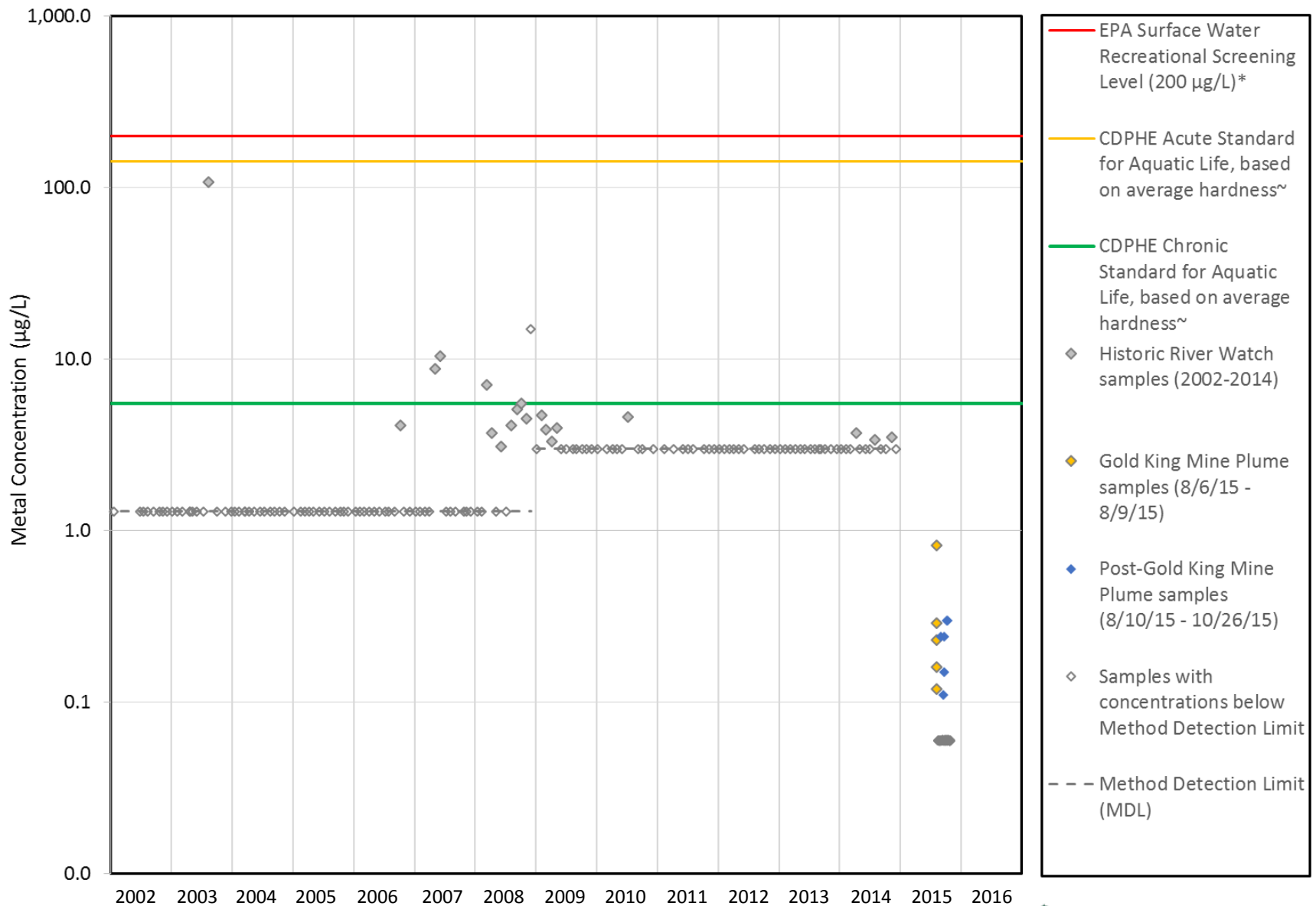
Total Lead, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 10

Dissolved Lead, Animas River at Durango, CO: 2002-2016

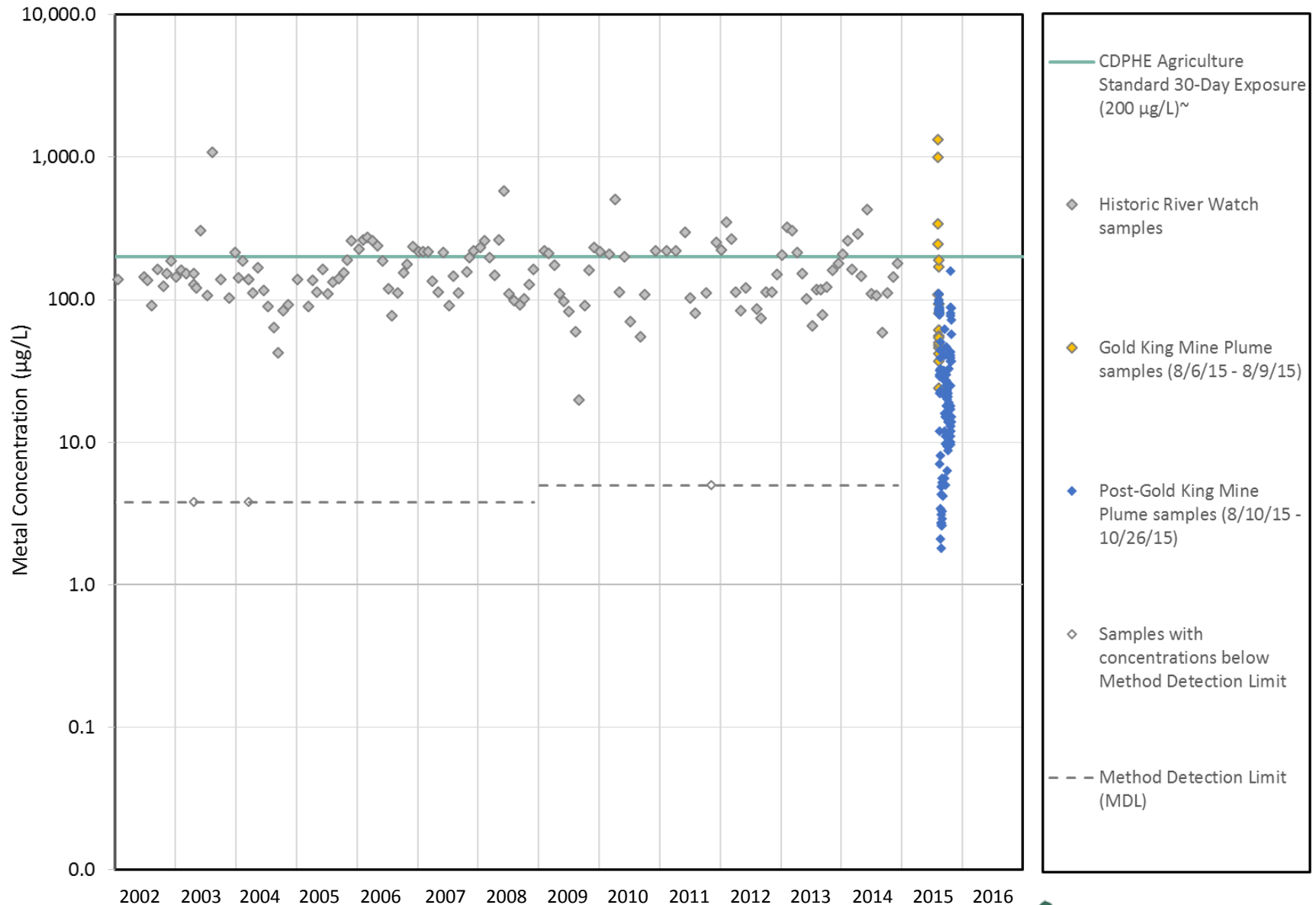


* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L. 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.

Figure 11

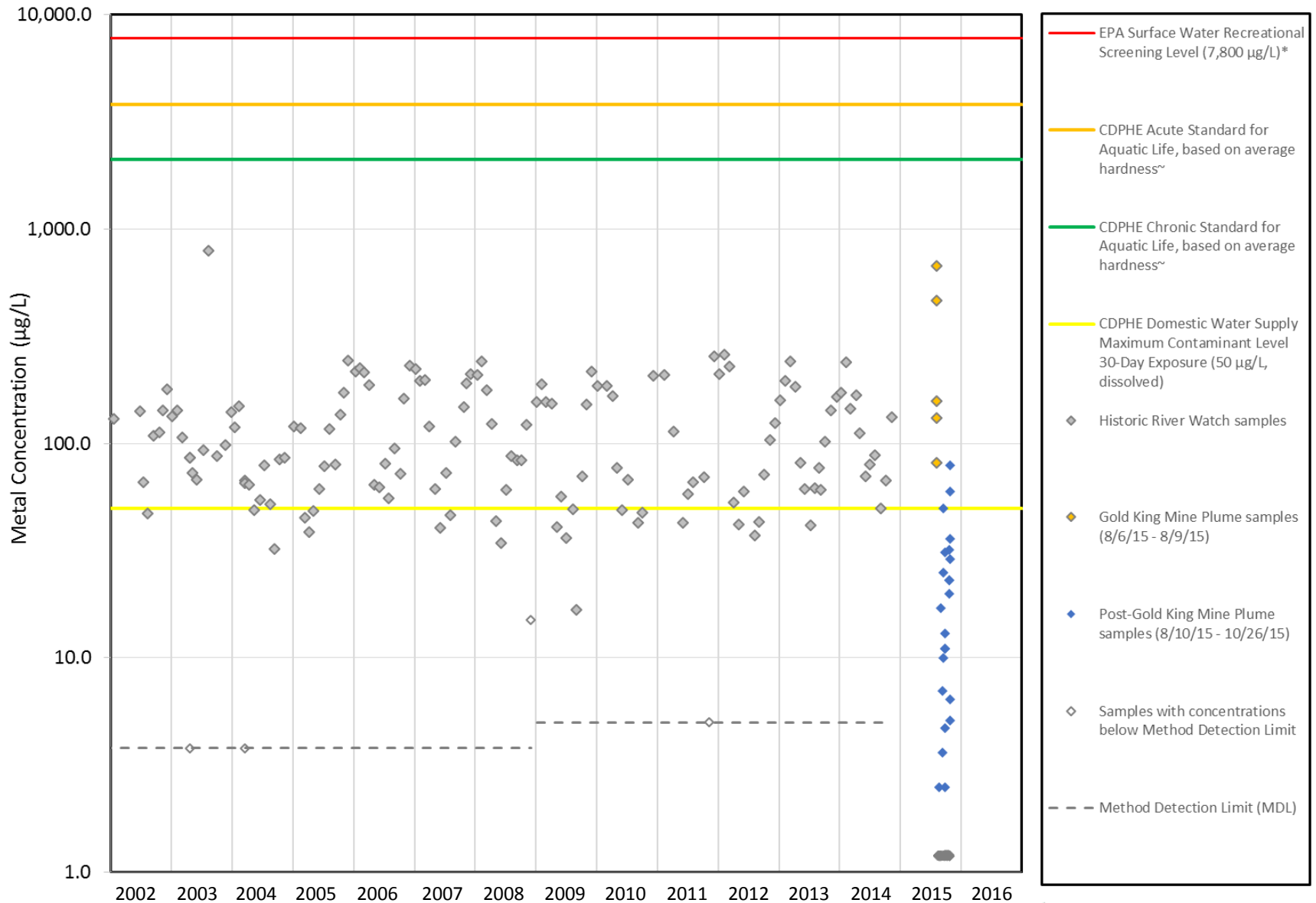
Total Manganese, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 12

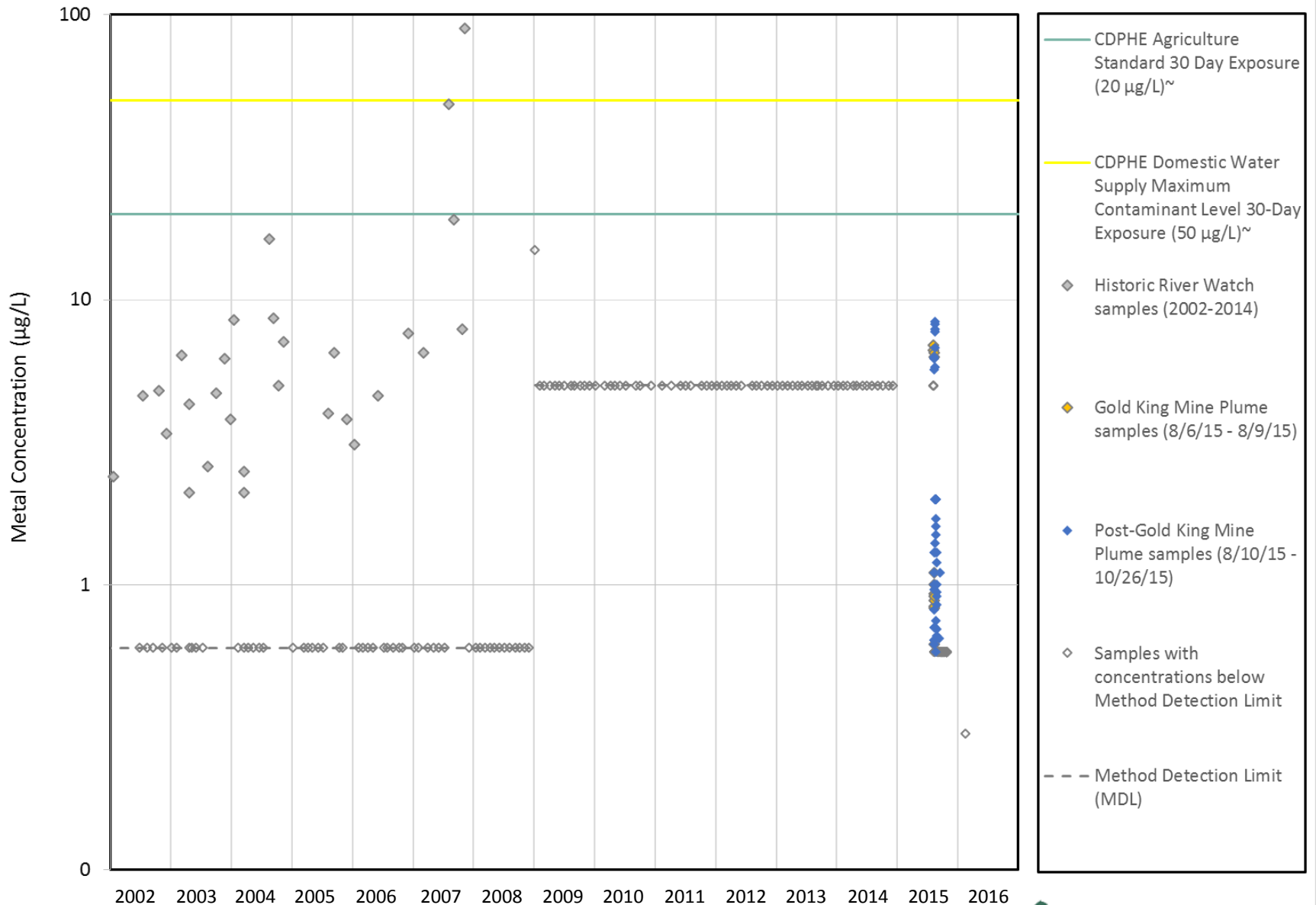
Dissolved Manganese, Animas River at Durango, CO: 2002-2016



* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.
 ~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.
 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.

Figure 13

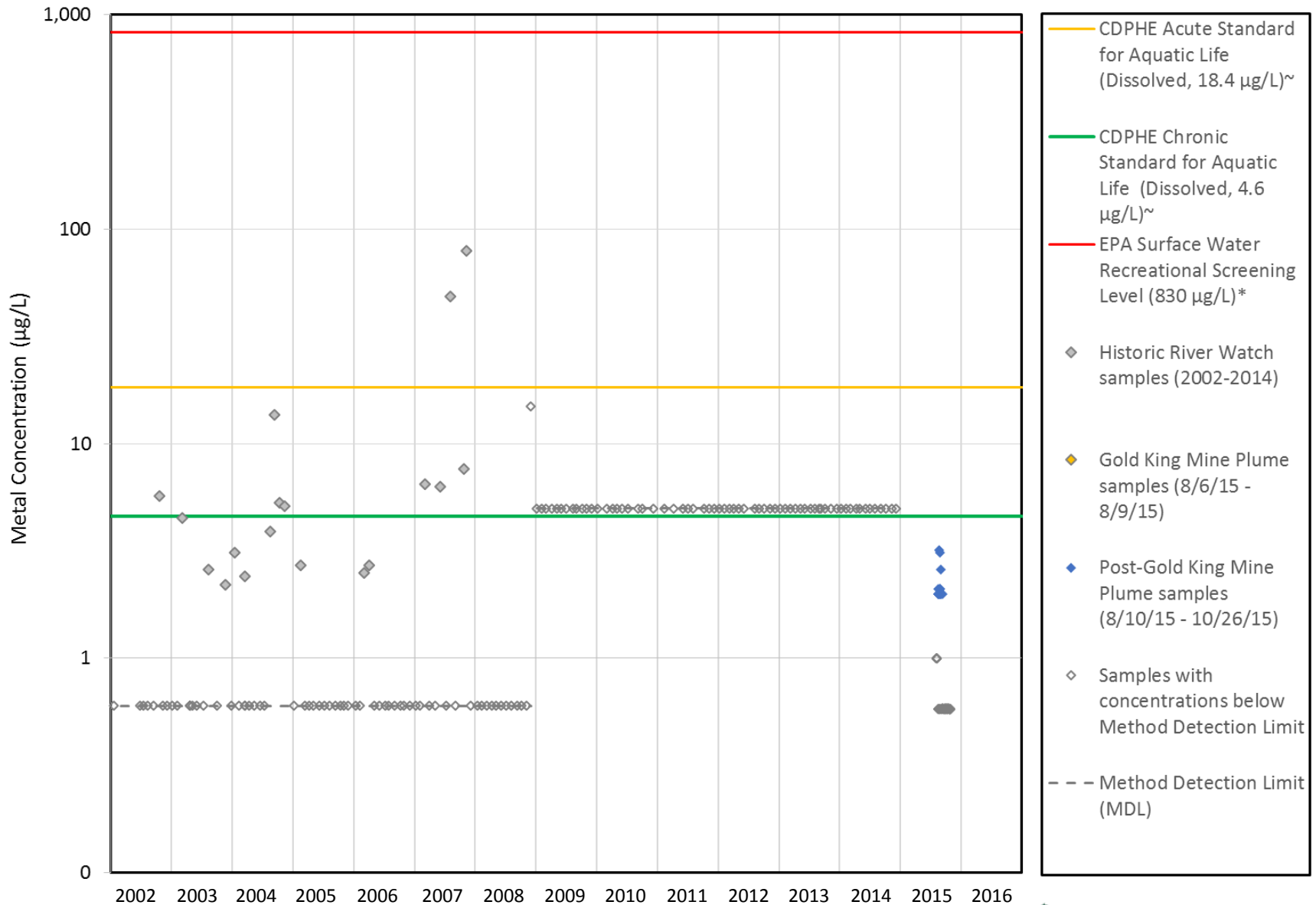
Total Selenium, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 14

Dissolved Selenium, Animas River at Durango, CO: 2002-2016



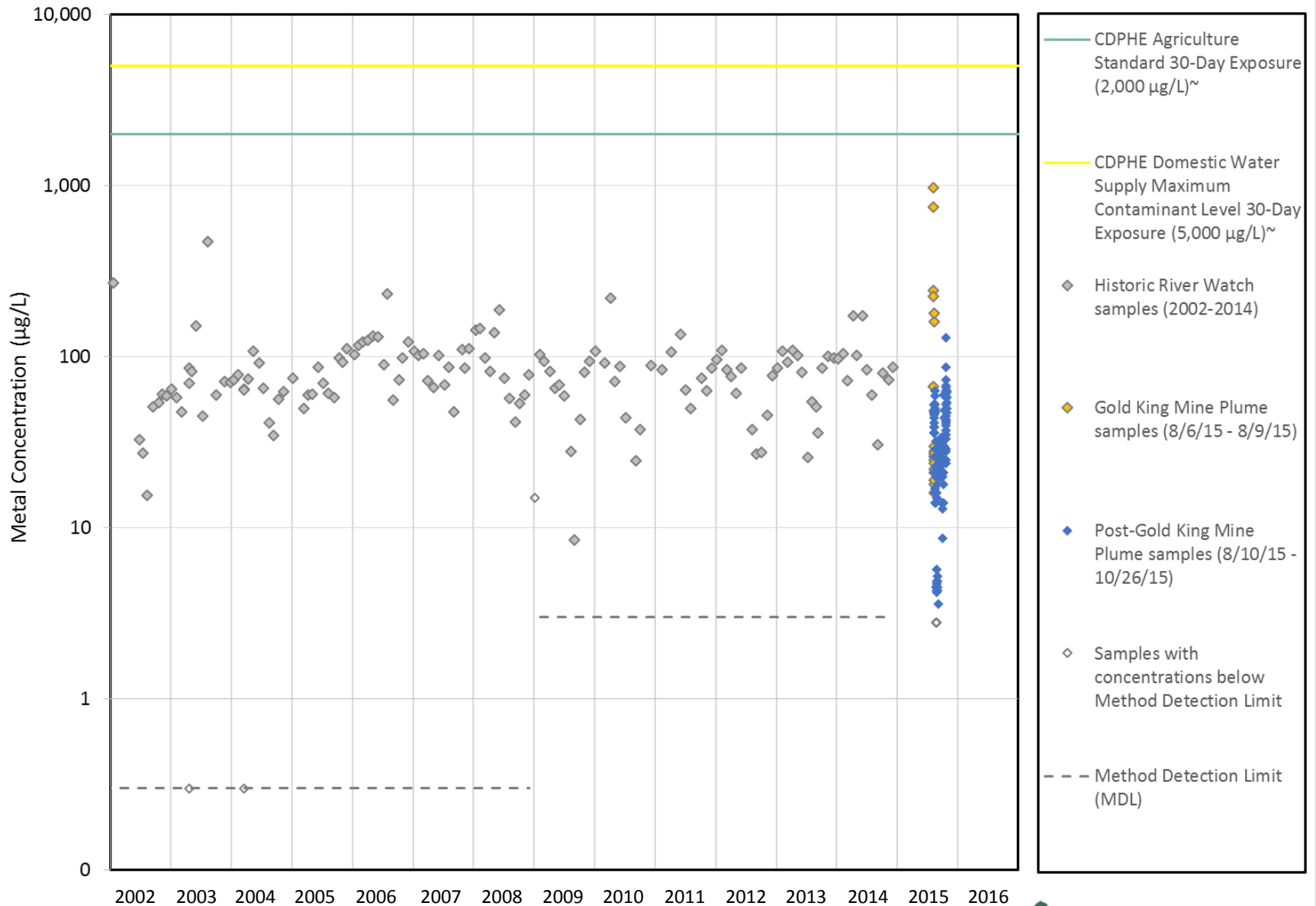
* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.

2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.

Figure 15

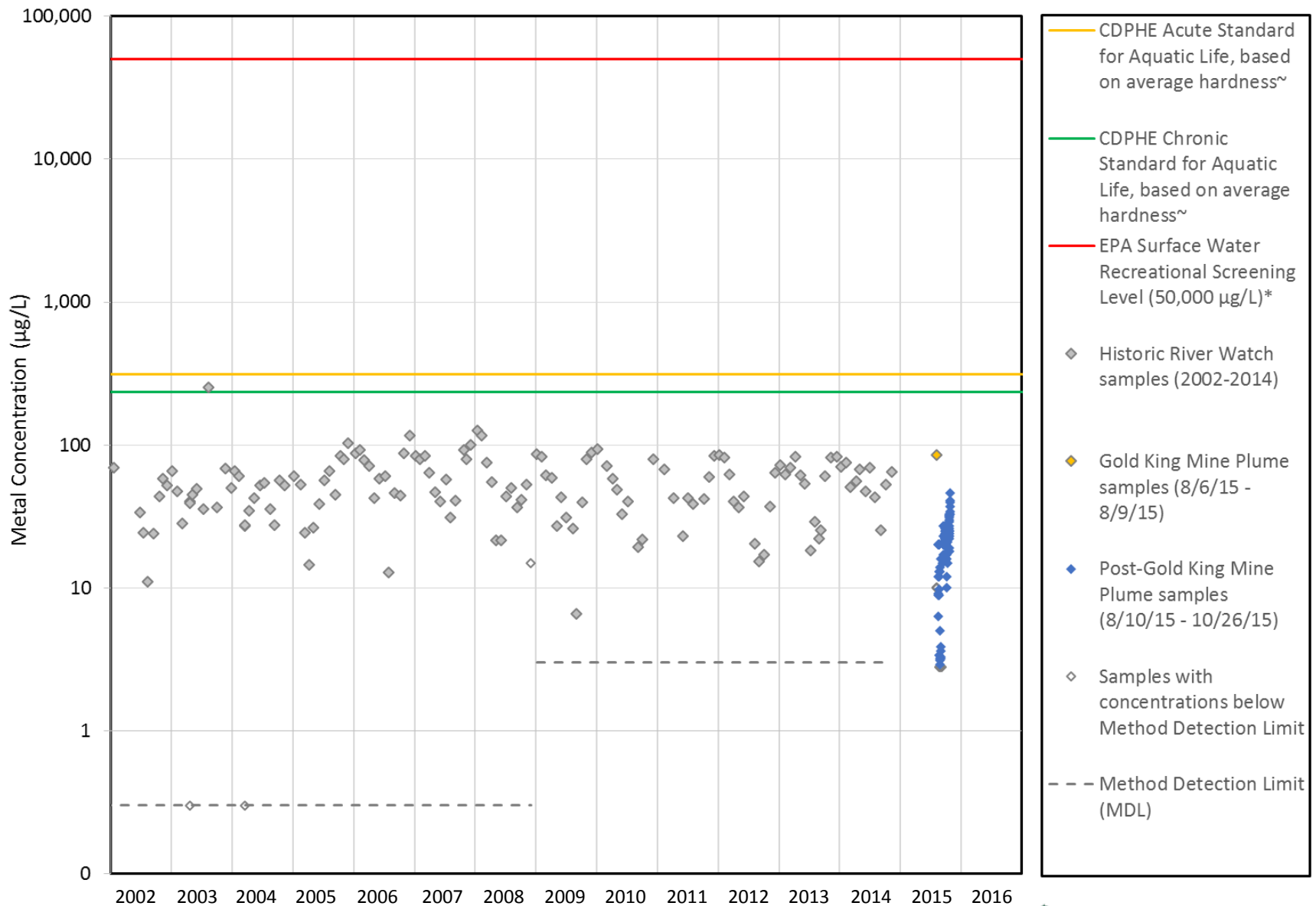
Total Zinc, Animas River at Durango, CO: 2002-2016



~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Note: 2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from the Animas River at Rotary Park in Durango, CO

Figure 16

Dissolved Zinc, Animas River at Durango, CO: 2002-2016



* The recreational screening level represents the level at which no adverse health effects are expected to occur in humans consuming 2L of filtered water per day, from the Animas, orally, for 64 days each year for a total of 30 years.

~Colorado Department of Public Health and the Environment (CDPHE) standards based on Colorado surface water quality classifications and Reg. 31 and 34. Standards vary with water hardness and are plotted here using an average water hardness of the Animas River at this location, 208 mg/L.

2002 - 2014 data is River Watch data from the Animas River at the fish hatchery in Durango, CO. 2015 data is Mountain Studies Institute data from Rotary Park in Durango, CO.



**Appendix E - Water quality results from Rotary Park, Durango, CO
in context of other sites along the Animas River.**

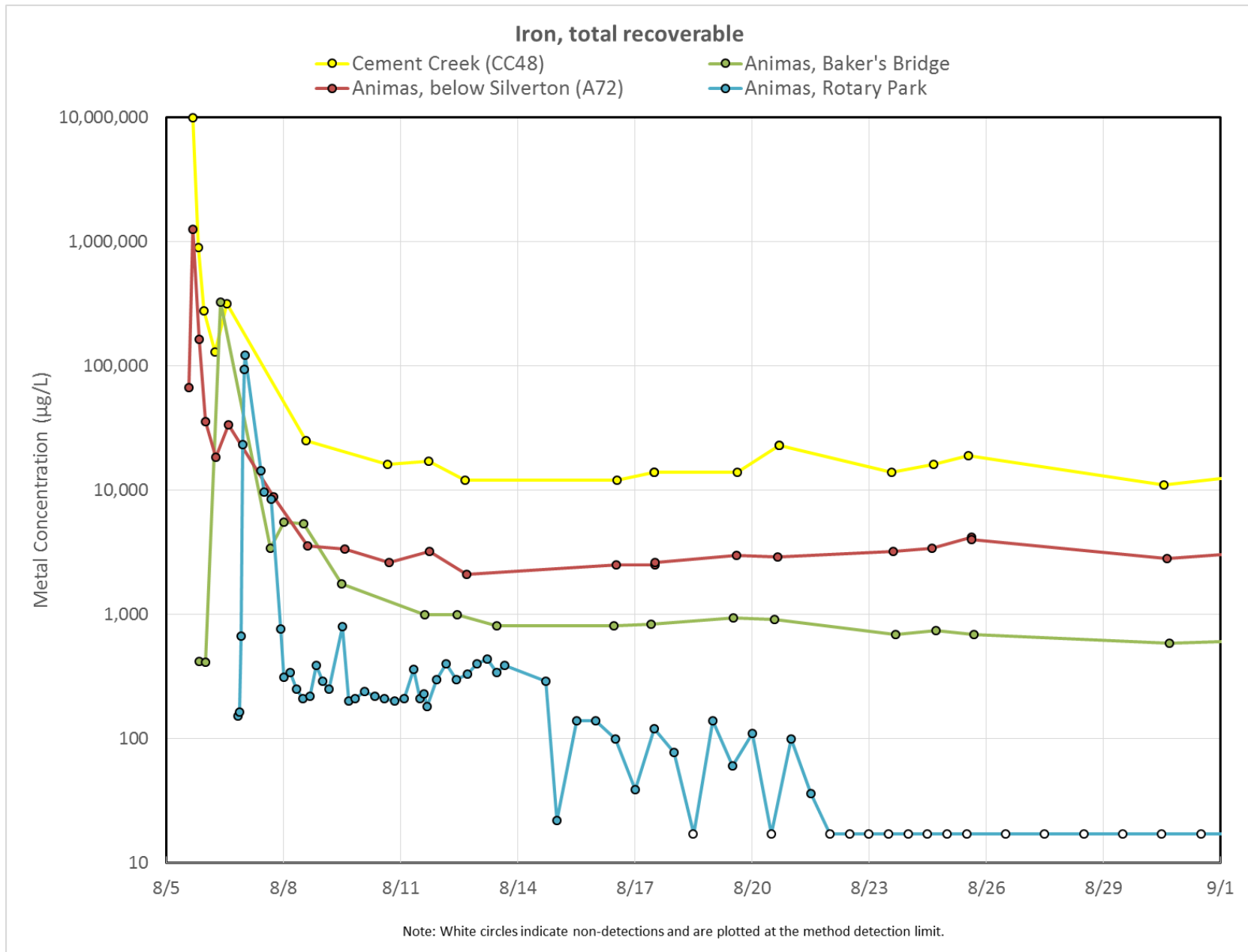


Figure 1: Total recoverable Iron at Cement Creek (CC48); Animas, below Silverton (A72); Animas, Baker's Bridge; Animas, Rotary Park. White circles indicate non-detection and are plotted at the method detection limit.

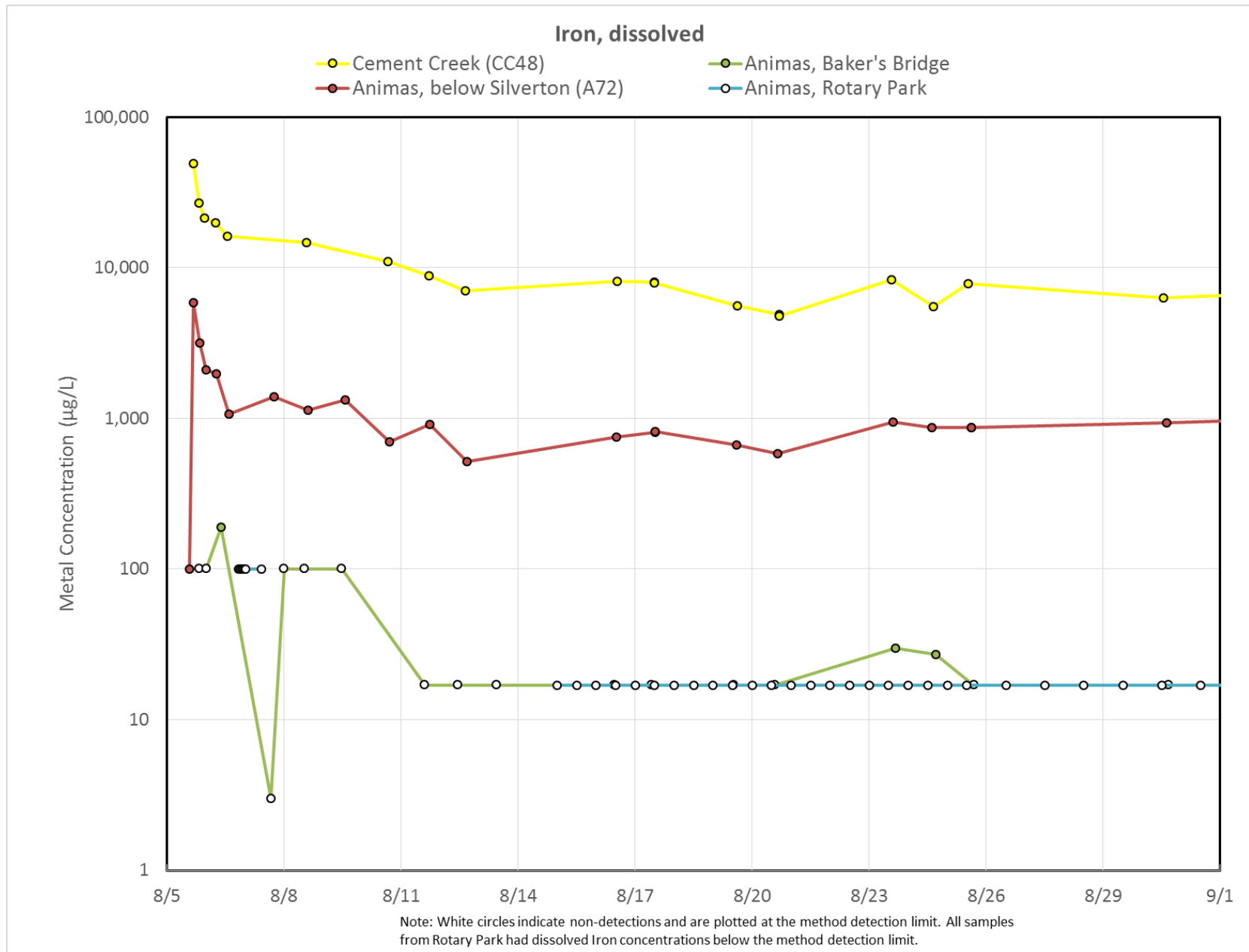


Figure 2: Dissolved Iron at Cement Creek (CC48); Animas, below Silverton (A72); Animas, Baker's Bridge; Animas, Rotary Park. White circles indicate non-detection and are plotted at the method detection limit.

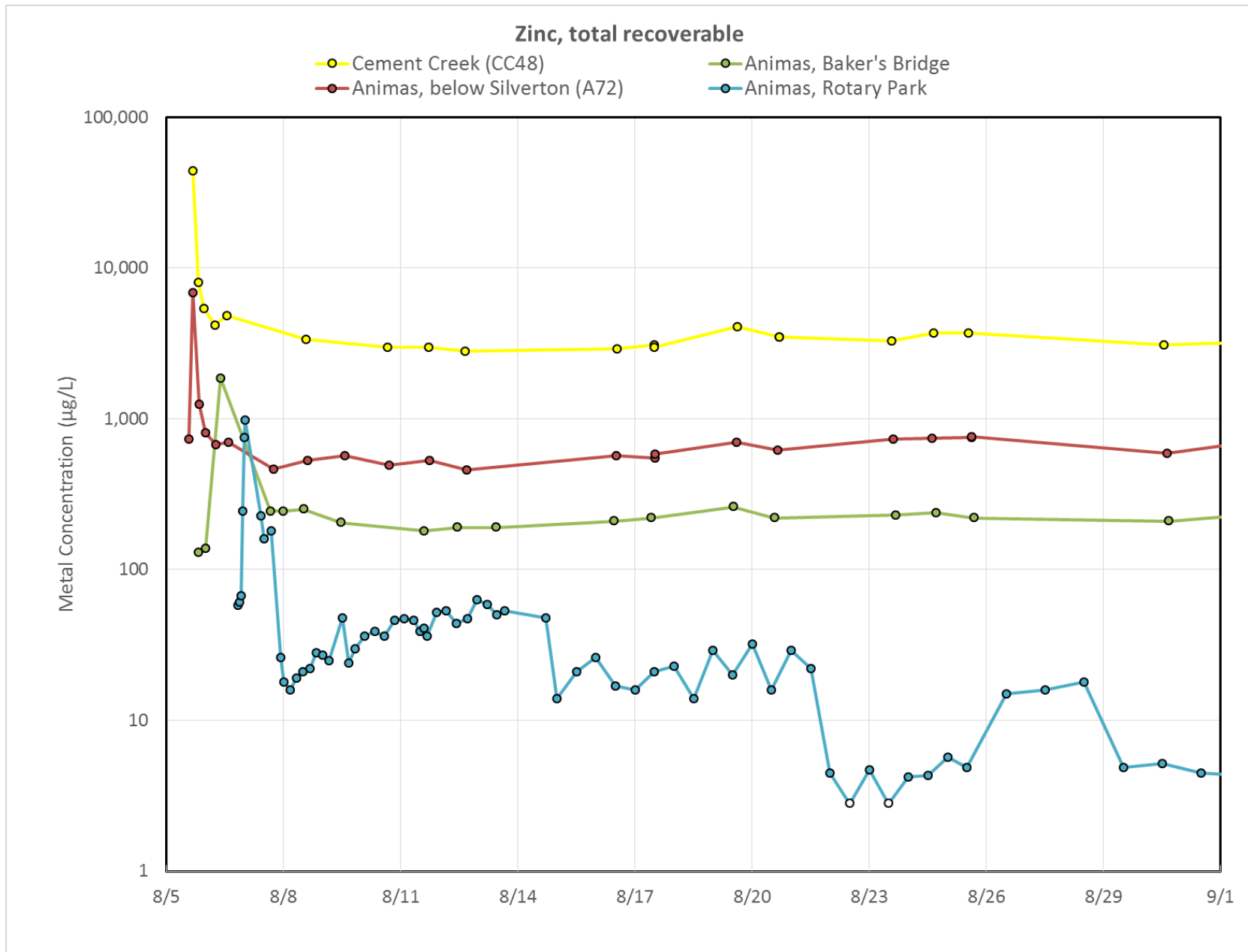


Figure 3: Total recoverable Zinc at Cement Creek (CC48); Animas, below Silverton (A72); Animas, Baker's Bridge; Animas, Rotary Park. White circles indicate non-detection and are plotted at the method detection limit.

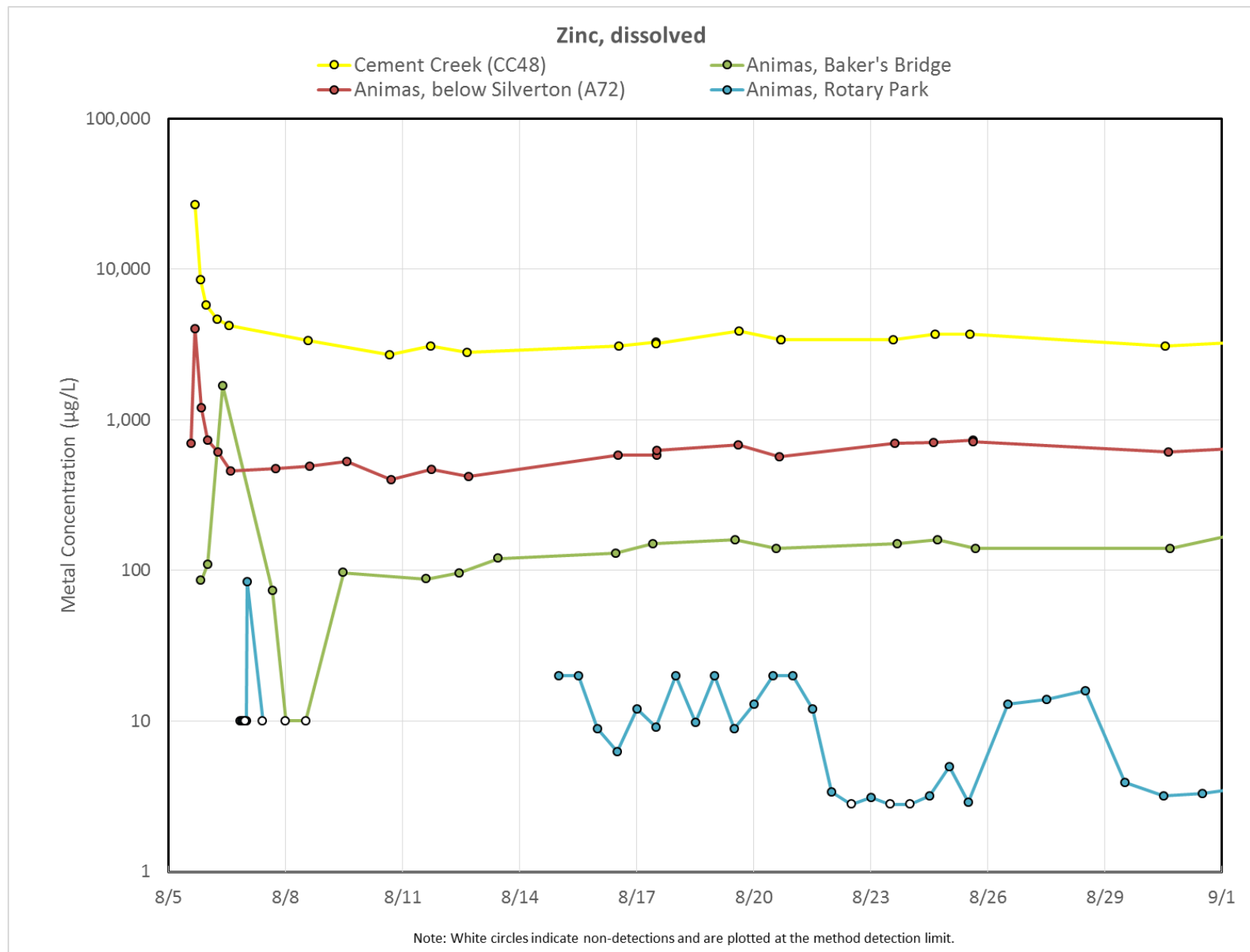


Figure 4: Dissolved Zinc at Cement Creek (CC48); Animas, below Silverton (A72); Animas, Baker's Bridge; Animas, Rotary Park. White circles indicate non-detection and are plotted at the method detection limit.