



**INACTIVE PRODUCTION ROCK SITES AND QUARRIES  
2010 ANNUAL REPORT**



**Hecla Greens Creek Mining Company**

**April 15, 2011**

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## **1.0 Executive Summary**

This annual report has been prepared by Hecla Greens Creek Mining Company (HGCMC) in accordance with the mine's General Plan of Operations Appendix 11, Attachment C. Monitoring data summaries are presented for five inactive production rock sites (1350, 960, Mill Backslope, Site C and Site E) and five quarries (Pit 405, Pit 6, Pit 174, Pit 5 and Pit 7). Pit 5 was the most recent active quarry and is now part of the Northwest Tailings Expansion area. A discussion of the 2.5 mile roadcut on the B Road is also included in this report.

This report is separated such that all aspects of the inactive production rock sites are discussed first in Section 2 followed by discussion of the quarries in Section 3. Information that is pertinent to both sections is generally not repeated but is discussed in the most relevant section and identified by reference in the other section.

Acid base accounting results from grid samples collected at inactive production rock sites beginning in 2002 support previous investigations. The sites contain a mixture of acid generating and acid neutralizing rock. All inactive sites have drainage dominated by near-neutral waters having sulfate and metals concentrations consistent with exposed production rock. Base flows at inactive site sample locations are low (generally less than 10 gpm).

The exposures in the rock quarries generally contain far less pyrite and carbonate than production rock. Each of the five quarries has zones of pyritic rock exposed in the pit walls; however, the volume of runoff from these zones is relatively small. Lower sulfide contents and smaller surface areas yield a lower flux of oxidation products from quarries compared to production rock sites. However, buildup of acidic oxidation products on overhanging exposures can produce low rinse pH values. Water monitoring indicates that metal loading from pit walls is also lower than loading from production rock sites. Historical metal loading identified in the drainage from Pit 5 does not appear to be solely associated with the pit walls and may reflect influences from the previous water treatment plant as well as recent heavy construction activity in the area. Surface drainage from the Pit 5 area is captured by the tailings area containment system and routed for treatment prior to discharge under the HGCMC NPDES permit AK-004320-6. Authority over the federal permitting, compliance and enforcement NPDES program transferred to the State (ADEC) in November of 2010 for the mining industry.

## 2.0 Inactive Production Rock Sites

### 2.1 Introduction

Hecla Greens Creek Mining Company (HGCMC) has prepared this section of the Annual Report in accordance with the mine's General Plan of Operations (Appendix 11, Attachment C). A summary of all operational and monitoring activities performed at inactive production rock sites in 2010 is provided. Site locations are shown on Figure 2.1. Refer to GPO Appendix 11 for a detailed description of the facilities and associated monitoring requirements. Aspects of the inactive Site D are covered in the Tailings and Production Rock Site 2010 Annual Report (HGCMC 2011), which also covers the adjacent active production rock Site 23 and the Tailings Facility.

Surface sampling entails collecting material from a grid that randomly produces the specified number of samples. Small sites are sampled by taking material from roughly equidistant locations along a transect across the site. The sampling technique is intended to minimize bias toward any one material type. Summary statistics for HGCMC's inactive production rock sites are presented in Table 2.1. Site and sampling locations, removal areas, and acid base accounting (ABA) data are summarized in Figures 2.1 through 2.4. Composite flow and water quality data are summarized in Figures 2.5 to 2.19 for all inactive production rock sites except Site E, which are summarized separately in Figures 2.20 to 2.32. A general summary of trends is discussed in this introductory section, followed by individual site discussions in the subsequent sections.

The results of grid sampling in 2008 and water monitoring in 2010 are consistent with previous investigations (KGCMC 1994, & 2004; Shepherd Miller 2000; ADEC 2003). These investigations concluded that some of the material is potentially acid generating but that the vast majority of the material continues to maintain a pH greater than 6.0, and that sensitive receiving areas continue to be adequately protected. This report serves as an annual follow-up to these previous investigations and generally does not repeat data and information presented in these reports, unless doing so provides continuity and clarity.

Table 2.1 Summary Statistics for Inactive Production Rock Sites  
 (ND=no data)

	Inactive Sites				
	1350	960	Mill Slope	Site C	Site E
Years Active (approx.)	1978-1985	1987-1988	1987-1988	1987-1988	1988-1994
Acreage	5	1	20	2	10
Total Original Volume (yds)	40,000 – 60,000	5,000	ND	50,000	365,000
Remaining Prod Rock Volume (yds)	30,943	Site Fill Removed in 2005	ND	ND	229,700
Reclamation Material (yds)	0		0	0	95,000
Material Removed in 2010 (yds)	9,057		0	0	40,300

Figure 2.3a compares acid potential (AP) with neutralization potential (NP) for surface grid samples for the inactive sites. The inactive sites were constructed prior to development of the classification protocol that HGCMC currently uses. At the time the inactive piles were constructed HGCMC did not classify or segregate its production rock. Symbols in Figure 2.3a represent actual laboratory data points. Lines indicating the currently utilized production rock

classes are shown on Figure 2.3a for reference only. Figure 2.3a shows the distribution of potentially acid generating (upper left half of figure) and potentially acid neutralizing (lower right half of figure) samples. Many samples from Site E have more neutralization potential than those from other sites, reflecting a greater proportion of argillite. Samples from the mill backslope and the 1350 site generally have a higher acid generation potential than those from the other sites. Reclamation activities at the 960, 1350 and Site E have removed significant quantities of potentially acid generating material from these sites.

Figure 2.3b shows the results of rinse pH relative to net neutralization potential (NNP) for the five inactive sites. Most samples produced a rinse pH greater than 6.0; however, each site has produced at least two samples with rinse pH values less than 5.0. This is consistent with the distribution of NNP values and the duration of waste rock exposure. Grid sampling occurs at the surface of the piles where oxidation rates are greatest. Drainage from the inactive sites remains near neutral because the bulk of the material in the piles contains sufficient carbonate to neutralize the acidity formed by pyrite oxidation near the pile surface. There are a few cases where samples produced a low rinse pH and high NNP. This is likely a result of accumulated acidic oxidation products in the fines fraction of the sample and remaining carbonate minerals in the coarse fraction.

Flow data presented in Figures 2.5 and 2.20 demonstrate that flows at most of the sample locations are generally low (less than 10 gpm) with the exception of Site E. Some of the flow data were collected as part of the NPDES stormwater monitoring program. Collected during or following storm events, flow data from these locations (e.g. Site E 356, 960 347) represent short-term maximum flow values in response to relatively large precipitation events. Lack of significant flow from inactive sites is a positive characteristic because it reflects minimization of potential off-site impacts.

Figures 2.6 and 2.21 show pH data from inactive site sampling locations. Lower pH values can represent influences from pyrite oxidation and/or organic acids from muskeg and forest soils. The data show that the vast majority of the site drainage remains above pH 6.0. The sample from the Mill Backslope in 1995 was runoff collected from a bench containing zones of heavily pyritized rock. For a brief period in 1998 and 1999, acidic conditions began developing at the 960 (site 347). HGCMC applied lime and removed 1000 cubic yards of oxidized pyritic rock from the site in 2000. The pH of the drainage quickly rebounded and has remained near-neutral since 2000. Removal of additional Site 960 material in 2003, 2004 and 2005 is discussed below in Section 2.3. The material removal activities may also be responsible for the pH of 8.0 measured at the 960 site in 2005. This is the highest recorded for this site. The reason for the elevated pH is likely due to the removal of pyritic rock that had consumed much of its readily available buffering capacity. Fresh carbonate mineral surfaces exposed during the excavation and the placement of the toe buttress may have contributed to the higher pH values observed. Alkalinity data presented in Figures 2.7 and 2.22 are consistent with the pH results in Figures 2.6 and 2.21. Sample locations continued to maintain measurable alkalinity provided by dissolution of carbonate minerals.

Conductivity data are shown in Figures 2.8 and 2.23. Conductivity indicates the amount of dissolved constituents in the water. HGCMC samples having higher conductivity values usually have higher sulfate, calcium and magnesium (hardness) concentrations, reflecting influences from sulfide oxidation and carbonate mineral dissolution. Water that has contacted production rock is expected to have higher conductivity values than background waters. The 960 (Site 347) shows an overall decreasing trend in conductivity, while the Site 1350 data remains unchanged. The combined drainage from the Mill Backslope area (Site 341) continued to have a lower dissolved load relative to 2003 and 2004 values. The decreasing trends apparent in Figures 2.8 and 2.23 are

the result of decreasing reactive surface area available for oxidation and dissolution. The reactive surface area decreases as reactants are consumed and mineral surfaces become coated with oxidation products. The results for sulfate, magnesium and hardness, shown in Figures 2.9 and 2.24, 2.10 and 2.25, and 2.11 and 2.26, respectively, correlate with conductivity results and are consistent with the concept of generally decreasing or static reactive surface area.

The data for zinc, copper, lead, cadmium, nickel, arsenic, iron and manganese are presented in Figures 2.12 to 2.19 and Figures 2.27 to 2.34. Sample results that were less than the detection limit are plotted at one half the detection limit value. While this allows the results to be plotted on a logarithmic scale, it causes non-detect results with high detection levels to appear more concentrated than they actually are. Detection limits have varied with time and are often evident on the graphs as horizontal groupings of symbols. The results for metals generally correlate with conductivity values. Zinc concentrations reflect the higher solubility of this element relative to the other metals at these near-neutral pH conditions. Manganese concentrations are elevated at most of the inactive sites, indicating the generation of secondary products from localized redox and buffering reactions as well as this metal's higher solubility in the prevailing pH conditions. Metal loads from inactive sites have either remained relatively constant or decreased with time. The decrease in metal loading is attributed to the reduction of reactive surface area discussed above. Site 960 showed some elevated copper, zinc and cadmium concentrations in 2004. This was likely due to the removal of production rock from the area, which exposed additional production rock materials in the base of the road, and rerouted additional water sources into the sampling area, confounding comparative water sampling with pre-removal data. Post removal Site 960 data in 2005-2010 have shown a decrease in most metal concentrations, with close to an order of magnitude decrease in cadmium, nickel, manganese and zinc.

## **2.2 1350 Site**

The 1350 Site is located at 1350 feet above mean sea level (AMSL), up-slope from the main portal and concentrator facility (Figure 2.1). The site contained approximately 40,000 – 60,000 cubic yards of material derived from advancement of the 1350 portal, which began in 1978 and continued intermittently through 1985. Waters collected near the adit opening are redirected back into the mine water collection system. Flow from the site is low, generally less than 10 gpm, and the drainage remains near-neutral. Other characteristics of the drainage (Figures 2.9 to 2.19) include a sulfate load, generally low metal concentrations, and localized iron staining. The results of grid sampling demonstrate that although some of the rock is potentially acid generating, the majority of the material remains near-neutral. Small areas containing rock with the greatest pyrite content have produced acidic oxidation products, but they are limited in extent and do not have a significant effect on the pile drainage. Monitoring in Greens Creek, below the confluence with the 1350 drainage, indicates small but detectable influence from this site.

Steep slopes precluded constructing an oxygen-limiting soil cover on the site in its current configuration. Consequently, removing the rock is the planned reclamation strategy for this site. To date approximately 19,957 cubic yards (cy) have been removed from the 1350. In 2005, 4,120 cy of material was removed, and a portion of that material was returned to the underground as backfill while the remainder was placed into Site 23. The material placed in Site 23 was weakly oxidized and contained low pyrite and abundant carbonate. Inclement weather and lack of backfill capacity underground prevented haulage of additional waste rock from the 1350 in 2006. In September 2007, 2,560 cy of material was removed from the 1350 and hauled underground. In 2008 approximately 4,220 cy were removed and placed in the new Site 23 interim storage facility. In 2010 approximately 9,057 cy were removed and placed in the Site 23 interim storage facility (Figure 2.35).

An area of hydrocarbon contaminated soil was encountered during 2010 removal activities. This contamination was believed to be associated with the 1978 camp fuel tank spill. An estimated 20 to 30 cy of soil was excavated (to bedrock) and disposed of offsite.

The interim storage facility was built in 2008 at Site 23 for rock removed during reclamation activities. Prior to building this facility, the 920 remuck area was used as the temporary storage area for waste rock removed during reclamation activities that needed to be disposed of underground as backfill. The remuck area has a limited capacity of 700 cy and is available only on a seasonal basis. The limited storage capacity and seasonal availability of the remuck area have had an impact on the pace of concurrent reclamation activities. The new interim storage facility at Site 23 increases the storage capacity for waste rock materials to 25,000 cy. Material temporarily stockpiled here will be amended with up to 1% lime. Stockpile runoff and drainage is collected and piped to the treatment plant. Materials placed on the stockpile can be hauled directly to underground void space or to the tailings pile for co-disposal on a continual 12-month schedule.

Two ventilation shafts were drilled above the 1350 portal and a new drainage borehole was drilled from the portal to the main sump in 2006. An additional vertical borehole was drilled near the saddle between the east and west drainages to provide hydrological information. The hole is cased through the overburden.

### **2.3 960 Site**

The 960 Site is located just above the 920 Portal on the road to the 1350' level. Approximately 10,000 cubic yards of production rock were placed at the site in 1987 and 1988 during development of the 920 Portal and access road to the 1350 level. Placement was terminated when signs of slope instability developed below the site. Approximately 1,000 cubic yards (cy) of rock were removed from the site and placed at Site 23 or underground as backfill in 2000. The remaining additional material removed in 2003, 2004 and 2005 is discussed below.

Grid sampling and water monitoring data were consistent with those of earlier reports (KGCMC 1994 and Shepherd Miller 2000) indicating that some of the rock was potentially acid generating. Intermittent periods of acidification have occurred, although the drainage from the site currently continues near-neutral. KGCMC applied lime to the site while material was being removed in 2000. Higher metal concentrations (e.g. zinc, Figure 2.12) are attributed to influences from localized accumulations of acidic oxidation products. The 960 Site is relatively small in extent (1 acre) and drainage flows are low (typically well below 5 gpm). Monitoring in Greens Creek below the 960 Site shows some detectable signs of effects from this site or other upgradient sites.

GCMC removed approximately 10,000 cy of material from the 960 Site and placed it in underground workings in 2003. An additional 5,000 cy of oxidized material and associated underlying soil were removed in 2004. In May and June of 2005, additional removal of road sub-base production rock material was found and removed. Butressing material was brought in as fill to ensure road stability. The site was then recontoured and allowed to naturally reseed with native species. The 960 Site will continue to be monitored for water quality changes.

The 960 Site showed some elevated copper, zinc and cadmium concentrations in 2004. This was likely due to the removal of production rock from the area, which exposed some additional production rock materials in the base of the road. Post removal water quality data for the 960 showed a decrease in most metal concentrations, with close to an order of magnitude decrease in

cadmium, nickel, manganese and zinc. This decrease is attributed to removal of the pyritic rock and to a lesser extent, dilution from surface drainage that now flows into the depression left by the excavation. This latter effect somewhat confounded comparative analysis with pre-removal data; however, late in 2005 much of the surface water was re-routed back into its natural drainage to the southwest.

Localized iron staining persists, however pre- and post-removal monitoring data (Table 2.2) indicate that water quality has improved considerably. Monitoring will continue in 2011. In an effort to monitor the succession of volunteer species, HGCMC did not apply hydroseed to the reclaimed area. Ferns, moss and water tolerant grasses have colonized wet zones. Well drained areas remain free of vegetation, but gentle slopes have prevented erosion problems.

Table 2.2 Effects of Removal of 960 Site Production Rock

Site 347		Before Removal	After Removal	After Removal	After Removal
Parameter	Unit	9/12/95	9/28/06	8/17/09	6/17/10
pH	s.u	6.1	7.6	7.5	7.3
Sulfate	mg/l (tot)	1300	161	230	136
Calcium	mg/l (diss)	412	64	102	64
Magnesium	mg/l (diss)	164	21	28	21
Iron	mg/l (diss)	5.5	0.2	ND	0.61
Manganese	mg/l (diss)	7.1	0.4	0.272	0.196
Zinc	mg/l (diss)	11	0.1	0.054	0.035
Lead	mg/l (diss)	0.004	ND	0.00008	ND
Nickel	mg/l (diss)	0.3	0.005	0.007	0.0015

ND – Non detectable result

## 2.4 Mill Backslope

A bench was cut into the valley floor at the 920 elevation providing level ground to facilitate construction of the Mill/concentrator facility in 1987. Glacial till excavated from the site was hauled to Site D and Site E. Following excavation of the site and construction of the Mill and related facilities, tension cracks developed above the excavated slope. Approximately 100 dewatering drains were drilled into the slope to lower the water table and reduce pore pressures. Two benches of production rock were placed on the lower half of the bank to buttress the slope and protect the drain manifold system. Pyritic rock was also used in the construction of an access road above the cut slope.

Grid sampling of the Mill Backslope rock cover and access road (Figures 2.3a and 2.3b) indicate that this rock is acid generating, and shows the higher sulfide content and low carbonate content in the rock. The low carbonate content is likely a combination of deficient initial composition and depletion of carbonate from the fines fraction through weathering.

Historical sampling of drainage from the Mill Backslope reflected two source waters. Water from the dewatering drains had low conductivity and low metal concentrations. Precipitation that

infiltrates through the pyritic production rock buttress had a higher dissolved load, dominated by sulfate, calcium, magnesium, iron, zinc and other trace metals. Some samples indicated a mixture of these two sources. Drainage from one of the dewatering manifolds (MBS 338 9) had moderate levels of iron, yet appeared to have a minimal production rock component (low sulfate). This illustrates the process of iron mobility in reduced groundwater that is not related to production rock oxidation. When the reduced groundwater reaches the surface it reacts with atmospheric oxygen and produces iron oxyhydroxide (red staining). Average flows from combined Mill Backslope sources are low (less than 10 gpm) and drainage is routed to water treatment facilities via a network of drains and lined ditches.

MBS 341 is a sample site created in 2003. It is located where the drainage from the 920 Mill Backslope enters the lined 920 stormwater ditch which reports to A Pond. The samples taken from this site provide a good current representation of a combination of the historical Mill Backslope sample sites (MBS 333, 336, 337, 338 and 339).

In 2002 GCMC applied lime to localized areas of the Mill Backslope. Such in-situ treatments of lime and polyacrylamide were also utilized in the past. The treatments had positive short term effects on water compositions. In-situ treatment and collection and treatment of slope drainage remain the preferred near-term options for this site, because removal of all of the production rock would destroy the dewatering system that maintains slope stability. Long term closure options for the slope include removing the pyritic material and either replacing it with non-pyritic fill or decreasing the slope angle to ensure long-term slope stability for closure.

Removal of the oxidized material on the Mill Backslope upper road occurred in 2005. Approximately 1500 cubic yards were removed and disposed of underground. The upslope run-on diversion ditch was rebuilt using clean native fill (sourced from the backslope of Site 23) and lined with HDPE. A french drain was installed in the bottom of the ditch prior to installing the liner.

Replacement of the lower reach of this access road and diversion ditch above the 920 site was completed in 2006. Slope stability monitoring continues. Localized, minor movement of some monitoring hubs has been observed, but no systematic, large-scale displacement is apparent. The majority of the site's piezometers continue to show water level variations that are consistent with seasonal variations. Several of the deeper piezometers in the slope behind the Mill show a progressive increase in recent years, which may indicate diminishing capacity of some of the dewatering drains in the slope.

In 2009, Klohn Crippen Berger (KCB) conducted a stability analysis of the Mill backslope. The analyses suggest that the slope currently has an acceptable safety factor against failure (KCB 2009). The most dramatic water table increases have occurred deep in the slope. Looking at data from the key mid-slope piezometer readings, the rate of groundwater rise mid-slope appears to be very slow. Further, piezometer PZ04 is showing an overall decrease in water levels, although it has steadied over the past five years. The possible explanation for this is that performance of the existing horizontal and inclined drains may not be seriously compromised along their full length, or that the rate of rebound of the water table due to deteriorating drain performance is not marked in the mid-slope. Some plugging or reduced performance at the inside end of the drains could result in increased water levels deep in the slope but no change mid-slope, which is the observed pattern. This indicates a possibility that comprehensive remedial measures may not be required for several years, if ever. The recommendation in the report to install an inclinometer down slope from the tension cracks was completed in 2010. This will improve monitoring of that slope and could help confirm the location of past slip planes. While the rate of change in the water levels

has not been fast enough to warrant immediate concern, it is possible that the rate of increase could accelerate in the future, Monitoring will therefore continue in this area.

Evaluation of potential source areas for metal loading to Greens Creek continued in 2010. Previously, HGCMC identified four areas where intermittent drainage from the Mill site rock fill beneath the 920 site enters Greens Creek. The compositions of these drainage sources are summarized in Table 2.3. The data presented in Table 2.3 were collected during a period when flushing of stored oxidation products in the Mill site fill is highest. Despite these conditions, comparison of water compositions in Greens Creek above and below the Mill site toe indicates that the influence of the drainage is minimal (e.g. compare Sites 1 and 7 in Table 2.3). Elements of the action plan to minimize metals loading to Greens Creek from all identified sources have included:

- Installation of a collection pump in Pond C
- Removal of pyritic rock from the access road behind the Mill site
- Improved sediment control at the 920 site
- Reduced spillage of tailings from backfill trucks
- Continued monitoring

Table 2.3 Mill Site Rock Fill Drainage Compositions

Site	pH s.u.	Cond µS/cm	Flow gpm	Alk mg/l	Mg mg/l	SO4 mg/l	As µg/l	Cd µg/l	Cu µg/l	Fe µg/l	Mn µg/l	Ni µg/l	Pb µg/l	Zn µg/l
0	7.9	80.8	13,260	28.5	1.43	6.58	0.341	<DL	0.362	<DL	5.15	0.593	<DL	4.6
1	6.8	1359	0.26	125	47.1	638	0.297	0.799	1.52	55	635	17.6	0.301	164
4	6.7	256	ND	37.4	4.76	52.3	0.58	0.264	2.99	ND	297	3.68	0.681	30.2
5	7.6	ND	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	3	2200	0.2	<DL	67.1	1220	0.505	17.3	93.5	3000	15700	134	49.4	2610
7	7.38	81.6	ND	28.7	1.32	6.82	0.348	<DL	0.379	<DL	4.3	0.632	0.033	4.56

NOTE: Samples were taken in 2007. Site 0 was taken in Greens Creek up gradient of seep sites #1, 4, 5, and 6; Site 7 was taken in Greens Creek down gradient from the seeps. ND = not determined, <DL = less than detection limit. Flow data is from 2006 samples which show relative contributions from the sites.

## 2.5 Site C

Site C is located near the end of the B Road just below the 920 Mill/concentrator facilities. The site received production rock in 1987 and 1988 and currently contains approximately 50,000 cubic yards of material. The 860 safety building and assay lab have been constructed on this site.

Results of ABA analyses (Figures 2.3a and 2.3b) indicate that some of the material is potentially acid generating, however the pH of the site's drainage remains near-neutral. During construction of the assay lab, glacial till from Site 23 was placed over much of the exposed production rock. The Site 23 material is not potentially acid generating and reduces exposure of the covered production rock to precipitation and oxygen. A network of drains and catchments diverts surface water away from the underlying production rock. Flow from the production rock is low (generally less than 1 gpm), remains near-neutral, contains elevated manganese concentrations, as well as moderate sulfate, zinc, cadmium and iron concentrations.

Sporadic fluctuations in lead concentrations in Greens Creek below Site C may be related to sediments contributed from the storm water ditch that sheds water from the B Road between the 920 area and Site C. Corrective actions accomplished in 2004 to improve containment of

sediments and decrease the potential for metal loading to the environment included diversion of upper Pond C flow to lower Pond C, removal of road ditch sediments with enhanced sediment controls installed in this area, and construction of a swale at the 920. In 2005, oxidizing materials were removed from the Mill Backslope upper road (see Section 2.4 above). The caisson for the pump in the pump-back system was installed in 2006 to facilitate collection of stormwater from Pond C. Installation of the pump and commissioning of the system occurred in 2007. Sediments were removed from Pond C in August of 2007. HGCMC continued to make minor improvements to the collection and containment system around Site C in 2008, 2009, and 2010. HGCMC constructed a diversion ditch that diverts clean, noncontact water from entering Pond C during the construction of the 860 parking pad in 2010. This will minimize the volume of clean water routed to treatment, as well as decrease the chance for storm water discharge from this area during large storm events. HGCMC plans to modify the Pond C caisson pump system to make the system more efficient in 2011.

## **2.6 Site E**

Site E is located 4.6 miles up the B Road halfway between the Hawk Inlet port facility and the 920 Mill facility (Figure 2.1). Approximately 365,000 cubic yards of glacial till and production rock were placed at the site from 1988 to 1994. The glacial sediments were excavated from the 920 site during construction of the Mill facility. Once the sediments were naturally dewatered in the placement cells constructed at this site, production rock materials were placed on top of those sediments at Site E. Results from grid sampling and water sampling at the toe of the site demonstrate that the production rock continues to buffer the pH of the drainage near neutral. Sulfate and metal loading in these samples is relatively high (but consistent with exposed carbonate buffered pyritic production rock). Flows from the site are minimal because it sits on a topographic high and only receives water from direct precipitation (e.g., no run-on or groundwater input).

In late 2002 and in 2003, three new monitoring wells were installed and 13 new surface water sampling sites were established at Site E to better understand the potential pile influence on the area. Figure 2.2 shows the locations of these sites. Water quality data for the wells and seven of the 13 surface water sites are shown on Figures 2.21 to 2.34. One of the wells (MW-E-02-03) is completed in till to a depth of approximately 99 feet, and the two other wells are completed in gravels at 76 and 86 feet (MW-E-02-09 and MW-E-02-12). The seven surface water sites depicted in the figures represent water quality at the toe of the pile (recently added sites 708, 709, and 710, along with the old sites 356, South Toe and North Toe), two downgradient drainages (703 and 704) that report to Greens Creek, and two sites in Greens Creek, one upgradient of Site E (711) and one downgradient (712). In general, sulfate and metal concentrations decrease as the distance from Site E increases. However, the downgradient site in Greens Creek (712) detected slightly elevated sulfate and zinc concentrations when compared to the upgradient site (711). Samples from Sites 711 and 712, along with samples from wells MW-E-02-09 and MW-E-02-03 have met Alaska water quality standards for sulfate, cadmium and zinc since their installation.

Surface water and groundwater monitoring at the site continues, with samples collected prior to the removal activities commencing (spring), as well as after the season's removal activities were completed (fall) in 2009. Comparison of the pre-removal to the post-removal water quality sample results showed some increased concentrations of analytes in the post-removal samples (i.e., zinc); however, all results were within the historical ranges of concentrations observed at the sampling sites. Samples collected in 2010 indicate improvement relative to 2009 and pre-removal water compositions (e.g. zinc and sulfate at sites 702, 703 and 704). The low pH (4.65) recorded at Site 707 in 2010 is not indicative of an acid rock drainage source because it coincides with

indications of water quality improvement (e.g. decreases in zinc, sulfate, and conductivity). As the contribution of drainage from the waste rock site decreases, the pH of these drainages is expected to decrease, reflecting a return toward dilute, acidic waters typical of background conditions for the area. Increases in iron concentrations from 2009 to 2010 samples appear to be due to analytical error rather than actual chemistry changes. If the iron increase was a real change in chemistry, manganese and arsenic would have also increased, and this did not occur. Increases in copper concentrations for samples from wells MW-E-02-03, MW-E-02-09 and MW-E-02-12 in 2010 may be anomalous since they are not accompanied by similar increases in other analytes such as zinc or sulfate.

The data for the drainage from the toe of the pile are consistent with the results of a multi-agency review of the site in 1999 (Shepherd Miller 2000). The oxidation and neutralization processes occurring in the pile appear to have reached a steady state. Depletion of buffering capacity is evident in two small areas on the southeast and northeast surfaces of the pile. However, observations from toe seeps and test pits dug in 2005 indicate that the bulk of the material is relatively un-oxidized and contains substantial buffering capacity. These observations indicate that depletion of the neutralization capacity of the pile is not imminent. This area will continue to be closely monitored in the future.

Greens Creek compared the relative costs of recountouring and covering the pile versus consolidating it with one of the other surface facilities, and found that relocating the material to the surface Tailings Facility for co-disposal is the most economical and environmentally protective solution. The geotechnical feasibility of blending production rock with tailings was studied in 2005 (Klohn Crippen 2005). The long term performance of the production rock and tailings blend will also depend on the geochemical performance of the blend. Therefore, geochemical studies have tested the geotechnical-recommended blend ratios for chemical stability, metal leaching, and acid generation potential. For more information on the results of the co-disposal geotechnical and geochemical studies, see the 2008 Tailings and Waste Rock Annual Report.

A total of 7,100 cubic yards of waste rock from Site E was hauled to the Tailings Facility to create a stabilizing berm in the Southeast II area in 2006. No material was removed from the site in 2008. A portion (1 acre) of the Site E pile was covered in the fall of 2006, and this cover was extended in October 2007. Even though the waste rock storage site had an existing layer of vegetation covering most of its surface, there appeared to be additional benefits to placing a synthetic cover on it, including reduction of the moisture content of the waste rock (to improve handling and codisposal properties for the pending removal activities in 2009) and reduction of the amount of seepage from the pile. However, the liner proved extremely difficult to maintain: the presence of small spruce trees, uneven ground, and high winds compromised the effectiveness of the cover, and led to its poor condition noted during an EPA inspection in June 2009. An additional issue with a liner is oxidation processes: while covers can limit the flushing of oxidation products, they do not stop oxidation from occurring. Oxidation processes result in evaporative salts that can build up underneath a liner. When a liner is removed and the material is exposed to runoff, these salts can increase the dissolved load of runoff waters, at least initially. Due to these two difficulties and concerns with the liner, its use as a BMP at Site E was discontinued at the end of 2009.

Approximately 40,000 cubic yards of waste rock and reclamation material were removed from Site E in 2009. In 2010, a 0.9 ac-ft stormwater collection pond was built and approximately 40,300 cy of waste rock was removed from Site E. Figure 2.34 shows Site E on July 2010 during removal activities.

The HGCMC Site E Removal: Waste Rock and Tailings Co-Disposal Plan was approved by the agencies and implemented prior to the commencement of removal activities in 2009. The Plan outlined additional BMP activities that would be instituted during active removal, including capturing and pumping of water to treatment from the work area. Additional removal of waste rock will be undertaken over the next 5 years. The Plan indicated removal activities would occur on a seasonal basis. HGCMC submitted a request to the State and Forest Service in December 2010 for year round co-disposal operations with additional BMPs being utilized.

The 2009 Plan also summarized results from various studies that showed codisposal of tailings and waste rock together was more beneficial geochemically and geotechnically than either tailings or waste rock alone. Therefore, the waste rock from Site E is being hauled to the tailings facility area, and codisposed of with tailings at this location.

HGCMC anticipates recovery of the underlying dewatered glacial till material originally placed at this site from the Mill Backslope excavation. This till material will serve to enhance the barrier layer performance of future reclamation capping efforts. Once the rock materials are removed, the till material will be assessed and consolidated/recontoured as needed. HGCMC expects to utilize the remaining Site E area for the storage of additional reclamation material, minimizing the need for future disturbances in other areas.

## **2.7 2.5 Mile B Road Cut**

Pyritic rock was exposed in the road cut at 2.5 mile during construction of the B Road in 1988. Weathering has decreased the reactive surface area of pyrite grains in the outcrop, and precipitation of hydroxide coatings has further decreased the reactivity of the rock. HGCMC will use monitoring of Zinc Creek to determine if additional efforts are required at the road cut. HGCMC determined that Site 8 (inactive FWMP site) is an appropriate monitoring point in Zinc Creek below the road cut to evaluate its effects on water quality. Monitoring data for Site 8 are shown in Table 2.4. Risks related to bear activity in the area will be evaluated during development of the monitoring schedule. Two areas along the B road corridor were filled with material from the 2.5 mile B Road cut: 1.8 mile pullout and Zinc Creek Bridge Abutment.

### **1.8 Mile Pullout**

Pyritic rock from the road cut at 2.5 mile B Road was used as fill for the 1.8 mile B Road pullout. HGCMC redirected road ditch water around the pad to reduce infiltration through the pyritic rock. Water quality has improved, but the rock lacks the buffering capacity to produce circum-neutral drainage. The effects from the site are moderated by the low flow rate relative to flows from the surrounding area. HGCMC plans to continue monitoring this site, with removal of the pyritic material following removal of other higher priority sites.

### **Zinc Creek Bridge Abutment**

Pyritic rock from the road cut at 2.5 mile B Road was also used as fill in the abutment of the Zinc Creek Bridge during road construction. Iron staining and poor quality runoff has been observed at the site. HGCMC maintains a NPDES stormwater monitoring point at the site and has sampled the water composition of Zinc Creek above (Site 371) and below (Site 368) the bridge.

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Monitoring data (Table 2.4) demonstrate that the contribution of runoff has a detectable effect on the quality of Zinc Creek. The data indicate that concentrations are below water quality standard levels for constituents having practical quantification levels (PQL) low enough to compare to the standard. The PQL for cadmium was higher than the AWQS for hardness values less than 70 mg/l. For future analyses of Zinc Creek samples HGCMC will request a lower PQL for cadmium to allow comparison to the AWQS. HGCMC applied lime to the fill in 1997. Additional treatments will be applied as needed prior to mine closure, when the pyritic rock will be removed with recovery and reclamation of the road.

Table 2.4 Zinc Creek Water Compositions

	Site	Date	pH s.u.	Cond uS/cm	Alk mg/l	Mg mg/l	SO4 mg/l	As ug/l	Cd ug/l	Cu ug/l	Fe ug/l	Mn ug/l	Ni ug/l	Pb ug/l	Zn ug/l
Lower	8	May-07	6.9	62.3	21.0	1.5	2.9	0.3	0.1	7.3	68.4	3.6	2.3	0.2	7.7
	8	Dec-07	8.0	133.3	N/A	3.1	13.4	<2	<4	<2	N/A	12.0	3.3	<2	11.0
Middle	368	Mar-06	7.1	121.3	42.0	3.7	11.9	0.3	<0.2	3.4	0.3	40.0	5.5	<0.1	12.0
	368	May-07	7.2	58.4	21.0	1.4	2.2	0.4	<0.2	0.9	59.7	3.0	2.1	0.1	8.6
	368	Dec-07	7.6	123.9	49.0	2.8	6.9	0.2	<0.3	1.0	120.0	12.0	2.7	<0.1	6.7
	368	Aug-09	6.8	80.4	33.6	2.3	4.8	0.5	0.1	2.0	<27	4.9	2.9	0.2	7.7
	368	Jan-10	7.6	101.0	<2	2.6	6.6	0.4	0.1	5.7	239.0	7.3	3.3	0.1	10.8
Upper	371	Mar-06	7.2	127.4	46.0	3.2	6.0	0.6	<0.2	0.6	0.0	2.7	2.3	0.1	2.4
	371	May-07	7.2	58.2	20.0	1.4	2.0	0.4	<0.2	0.8	51.7	2.4	2.1	0.2	9.0
	371	Dec-07	7.8	120.8	50.0	2.8	5.0	0.4	<0.3	0.7	<50	2.6	1.5	<0.1	4.1
	371	Aug-09	6.7	77.4	33.0	2.4	4.2	0.6	0.1	2.6	<27	2.4	2.9	0.1	6.6
	371	Jan-10	7.5	97.3	<2	2.4	5.2	0.4	<0.1	1.5	64.8	1.8	2.4	0.1	5.5

### 3.0 Quarries

#### 3.1 Introduction

This section of the HGCMC Annual Report is in accordance with the HGCMC General Plan of Operations (Appendix 11, Attachment C). Five quarry sites were developed in 1987 and 1988 to provide rock for constructing roads and other infrastructure at the Greens Creek facilities. All quarries but one (Pit 5) are currently inactive and are being used to stockpile reclamation materials (rock, organic soils and glacial till). A summary of all operational and monitoring activities performed at these five quarry sites (borrow pits) in 2010 is provided. Refer to GPO Appendix 11 for a detailed description of the sites and associated monitoring requirements.

Summary statistics for HGCMC's quarry sites are presented in Table 3.1. Flow and water quality data are summarized in Figures 3.1 to 3.15. The sites are discussed individually in subsequent sections. Refer to Figure 2.1 for site locations.

Table 3.1 Summary Statistics for Quarry Sites

	Quarries				
	Pit 405	Pit 6	Pit 174	Pit 5	Pit 7
Years Active (approx.)	1987-1988	1987-1988	1987-1988	1987-2003	1987-1997
Acreage	3	3	2	Part of NW Tailings Expansion	4
Total Volume (yds)	17,000	22,800	10,000		30,000
Prod Rock/Other Vol (yds)	13,000	0	0		0
Reclamation Material (yds)	4,000	22,800	10,000		30,000

Acid Base Accounting data collected from 2002 to 2008 are summarized in Figures 3.16a and 3.16b. Pit 405 and Pit 174 have significant exposures of potentially acid generating rock and produced several samples with acidic rinse pH. Pit 6 and Pit 7 produced samples showing a broad distribution of NNP and rinse pH, and Pit 5 generally produced acid neutralizing samples with alkaline rinse pH. Buildup of oxidation products (salts) on overhanging quarry walls was noted at each of the five quarry sites and may have contributed to the lower rinse pH readings for several samples.

Flow data for the quarry sites are presented in Figure 3.1. Much of the flow data prior to 2003 were collected during or shortly following storm events and represents maximum flow values. Recent flow estimates vary from 60 gpm to less than 1 gpm with most less than 10 gpm. The bowl-shaped geometry and low permeability of the quarry walls and floors tend to focus flow toward the entrance of the pits.

The amount of reactive surface area available for sulfide oxidation is considerably less for quarries than for production rock piles. Oxidation is limited to the non-coated outer face of the near-vertical quarry wall and near surface fractures. Lower sulfide contents and smaller surface area yield a lower flux of oxidation products from quarries compared to production rock sites.

Figure 3.2 shows pH data from the quarry site sampling locations. Since 1995 all but two samples have had a pH between 6.0 and 8.0. A pH of 5.8 was recorded from Pit 174; however, more recent samples from this site averaged about 6.7. Alkalinity data presented in Figure 3.3 are

consistent with the pH results, with all sites maintaining measurable alkalinity provided by dissolution of carbonate minerals. The lower alkalinity value from Pit 6 represents influences from organic acids derived from forest soils (note associated low conductivities of Pit 6 samples). Sample sites with the highest alkalinity are groundwater monitoring wells in Pit 5. Pit 5 generally shows a higher carbonate content and may also show influences from the water treatment plant which was located near Pit 5 until 2008.

Conductivity data are shown in Figure 3.4. Conductivity indicates the amount of dissolved constituents in the water. Samples having higher conductivity values usually have higher sulfate, calcium and magnesium (hardness) concentrations, reflecting influences from sulfide oxidation and carbonate mineral dissolution. Conductivity data are consistent with waters derived from freshly exposed low to moderately mineralized quarry rock. MW-T-01-07 has considerably higher conductivity and sulfate concentrations, which may reflect an influence from the Pit 5 water treatment plant. Past treatment plant upsets have contributed water to the area around the plant. However, in general since 2001, conductivity and sulfate concentrations in this well have decreased. The increase in sulfate concentrations in MW-T-01-09 in 2005 and 2006 may indicate the movement of the sulfate-rich water from the MW-T-01-07 area to the east. These wells and their relationship to the old treatment plant and the Tailings Facility are discussed in more detail in HGCMC 2003 Annual Report. HGCMC decommissioned the Pit 5 water treatment plant in 2008 to accommodate the Tailings Facility expansion. The results for sulfate, magnesium and hardness, shown in Figures 3.5, 3.6 and 3.7, respectively, correlate with conductivity results.

The data for zinc, copper, lead, cadmium, nickel, arsenic, iron and manganese are presented in Figures 3.8 to 3.15. Sample results that were less than the detection limit are plotted at one half the detection limit value. While this allows the results to be plotted on a logarithmic scale, it causes non-detect results with high detection levels to appear more concentrated than they actually are. Detection limits have varied with time and are often evident on the graphs as horizontal groupings of symbols. The results for metals generally correlate with conductivity values. Zinc and manganese concentrations reflect the higher solubility of these elements relative to the others at the near-neutral pH conditions. Dissolved metal loads from quarry sites have been consistently low and either remained fairly constant or decreased with time. The decrease in dissolved metal loading is attributed to a reduction of reactive surfaces as reactants are consumed and coatings form on mineral surfaces. Elevated total metal concentrations occur periodically in response to increased suspended solids during storm events. The storm water monitoring data are presented to provide a general indication of the effects of sediment loading, typically from road surfaces, and do not reflect dissolved loading from the quarry walls.

Closure options for pyritic pit walls are relatively limited. Since there are no proven long term surface treatments available, it is best to let naturally occurring coatings that have formed over the past 20 years continue to form. As the coatings form and the amount of available pyrite decreases, so too will the relatively small dissolved load generated by these surfaces.

### **3.2 Pit 405**

Pit 405 is located at 7.6 mile on the B Road. The rock from this quarry was used for construction of the B Road and other mine infrastructure. Mine records indicate that approximately 13,000 cubic yards of production rock were backfilled into the quarry in 1988. The quarry received reclamation materials (colluvium and glacial till) in 1994, 1995 and 1998 for use in future reclamation projects. HGCMC drilled a hole through the fill material in June of 2005 to characterize the materials. The profile at the center of the pit from the surface down consists of approximately two feet of glacial till and organics (fill), 15 feet of sericitic phyllite (waste rock)

and 22 feet of grey silty till (fill). The foundation of the pit is fractured, pyritic, chloritic rock. A standpipe was installed to a depth of 37.5 feet below the drill pad surface, but difficulties encountered during installation may have affected its completion. Development and evaluation of the standpipe occurred in 2006; however, the casing was damaged in 2007. The well was repaired in 2008 and water quality results are shown in Table 3.2. The well is completed in pyritic bedrock so there may be some difficulty differentiating between contributions from quarry fill material and the bedrock itself.

Table 3.2 Water Quality Data Pit 405

Site	Date	Alk Tot mg/l	As ug/l	Cd ug/l	Cond Field umho	Cu ug/l	Fe ug/l	Hard mg/l	Mg mg/l	Mn ug/l	Ni ug/l	Pb ug/l	pH Field su	SO4 Tot mg/l	Zn ug/l
1043	11/4/08	124	0.33	<.2	658	0.74	88.6	300	16.5	2320	7.5	1.86	7.31	184	24.8

Monitoring of drainage downgradient of the quarry (Figures 3.1 to 3.15) demonstrates that influences from the site are negligible. Barring a significant change in downstream water quality, the site will be reclaimed when the reclamation materials stored in the quarry have been utilized at other sites. The production rock in the quarry will either be removed or covered in-situ. Removal of the rock could prove detrimental as this would increase exposure of the now covered pyritic quarry wall.

### 3.3 Pit 6

Pit 6 is located at 4.6 mile on the B Road across from Site E. The quarry produced rock for construction of the B Road in 1987. Reclamation materials were hauled to the site from the Site 23 and the 920 facility during various construction seasons. Monitoring of surface drainage from the pit access ramp indicates no significant influence from the pit walls or stored material. Reclamation materials will be used to reclaim other mine facilities. Approximately 3,800 cubic yards of reclamation materials from the backslope of Site 23 were hauled and stored at Pit 6 in September 2007. Reclamation material (6500 cy) from the top of Site E was hauled to Pit 6 in 2009. Water quality at the stormwater sampling site at Pit 6 showed increases in total lead and zinc in 2009, potentially attributable to hauling the reclamation materials from Site E to Pit 6. In 2010, lead and zinc levels returned to within historical levels at this stormwater site. The water quality at this site will continue to be closely monitored.

### 3.4 Pit 174

Pit 174 is located at 3.3 mile on the B road and was used for road construction in 1987. The pit has been partially backfilled with reclamation materials that will be used to reclaim other site facilities. Drainage from the site has an average pH of 6.7 (Figure 3.2). Sulfate and metal concentrations in the pit drainage are moderate, however flows are generally low (typically less than 10 gpm during rain events). Iron staining periodically occurs in the drainage below the site which collects runoff from this quarry and surrounding areas. Once the stored reclamation materials (rock, organic soils and glacial till) are utilized, the site will be reclaimed. Reclamation goals include minimizing runoff from the exposed pit wall and covering as much of the exposed pyritic rock as possible by placing a wedge of glacial till at the base of the wall.

A runaway truck ramp was installed at Pit 174 following a haul truck incident at the site in 2006. The water tank was also moved from the quarry to the other side of the haul road to facilitate the emergency access route to the truck ramp.

### **3.5 Pit 5**

Pit 5 was located in the northern portion of the Tailings Facility at 0.8 mile on the B Road, and until 2008 housed the water treatment plant. The Pit 5 water treatment plant was decommissioned in June of 2008. Rock from the pit was originally used for construction of roads and other surface facility infrastructure. Approximately 13,500 bank cubic yards of rock were quarried from Pit 5 in 2002. Peat and sand from excavation of the West Buttress in 1997 were moved to the east rim of Pit 5 in 2004 and 2005 for temporary storage prior to disposal in the tailings area. The material was hauled to the north end of the tailings pile in 2007. Between 2006 and 2008 approximately 268,110 cubic yards of shot rock were taken from Pit 5 in conjunction with the tailings expansion. The expansion of the Tailings Facility in the Pit 5 area was completed in 2008. Pit 5 is now an active tailings placement location (northwest area) which is underlain with an HDPE liner tied into the natural till underlying the tailings pile to the south.

2008 zinc levels in MW-T-01-07 and MW-T-01-09 showed an increase compared to historic years. This is likely due to the heavy construction and disturbance in the immediate area surrounding the wells. The zinc concentrations decreased in these two wells in 2009 and in 2010. During the construction activities at Pit 5, MW-T-01-08 was compromised and is no longer sampled.

ABA analyses from pit walls indicate that the rock does not have the potential to generate acid, although it does contain small diffuse amounts of pyrite, often occurring as isolated euhedral cubes. Drainage from the site monitored at a surface stormwater site is dominated by sulfate, calcium and magnesium and has moderate to high concentrations of several trace metals (Figures 3.8 to 3.15). This drainage water is captured by the tailings containment system: it is routed to the water treatment facilities via the North Retention pond located near the B Road. These ditch waters receive surface flow from the pit and may also be influenced by near-surface flow from the tailings pile. Final reclamation of the Pit 5 area is contingent upon the ultimate design and construction of the tailings pile.

### **3.6 Pit 7**

Pit 7 is located at 1.8 mile on the A Road between Hawk Inlet and Young Bay. The pit was initially developed in 1987 to support construction of the roads and other mine facilities. Pit 7 has been partially backfilled with peat and gravel material from the Tailings area, and tree stumps and reclamation materials derived during expansion of the tailings pile and development of the sand pit at 1.4 mile on the A Road. In 2008 crews stockpiled, crushed and hauled sorted material from the 1.4 mile sand pit to Pit 7. Despite iron staining on the south pit wall, iron staining observed in the drainage from the pit is mostly due to dissolution of iron-rich oxide coatings in the peat and gravel fill rather than from the pit walls themselves. Temporary hydroseeding of the peat has resulted in a productive grass cover of these materials. Monitoring results of drainage from the pit are shown in Figures 3.2 to 3.15. Relatively low sulfate concentrations (approximately 200 mg/l) and low dissolved metal values support the conclusion that limited sulfide oxidation is occurring at Pit 7. Dissolution of iron and manganese oxides in the fill stored in the pit has produced elevated concentrations of these metals in the drainage. Oxidation of the drainage and re-precipitation of the metals is expected in the constructed wetlands downgradient of the pit. Increases in total lead and zinc concentrations were observed in stormwater samples from Pit 7

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(Site 521) in 2010. The increase in total metals was accompanied by a decrease in conductivity, which suggests that entrainment of sediments from the access road during the storm event could be the source of the elevated metals.

Following removal of stockpiled capping materials for reclamation of other sites, the Pit 7 site will be contoured and hydroseeded. The potential exists in the Pit 7 area to create more wetlands similar to those previously constructed near the entrance to the pit.

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## **APPENDIX 1**



Figure 2.1

### GREENS CREEK SITE LOCATION MAP

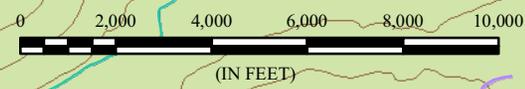
Project No: MH000969.0001

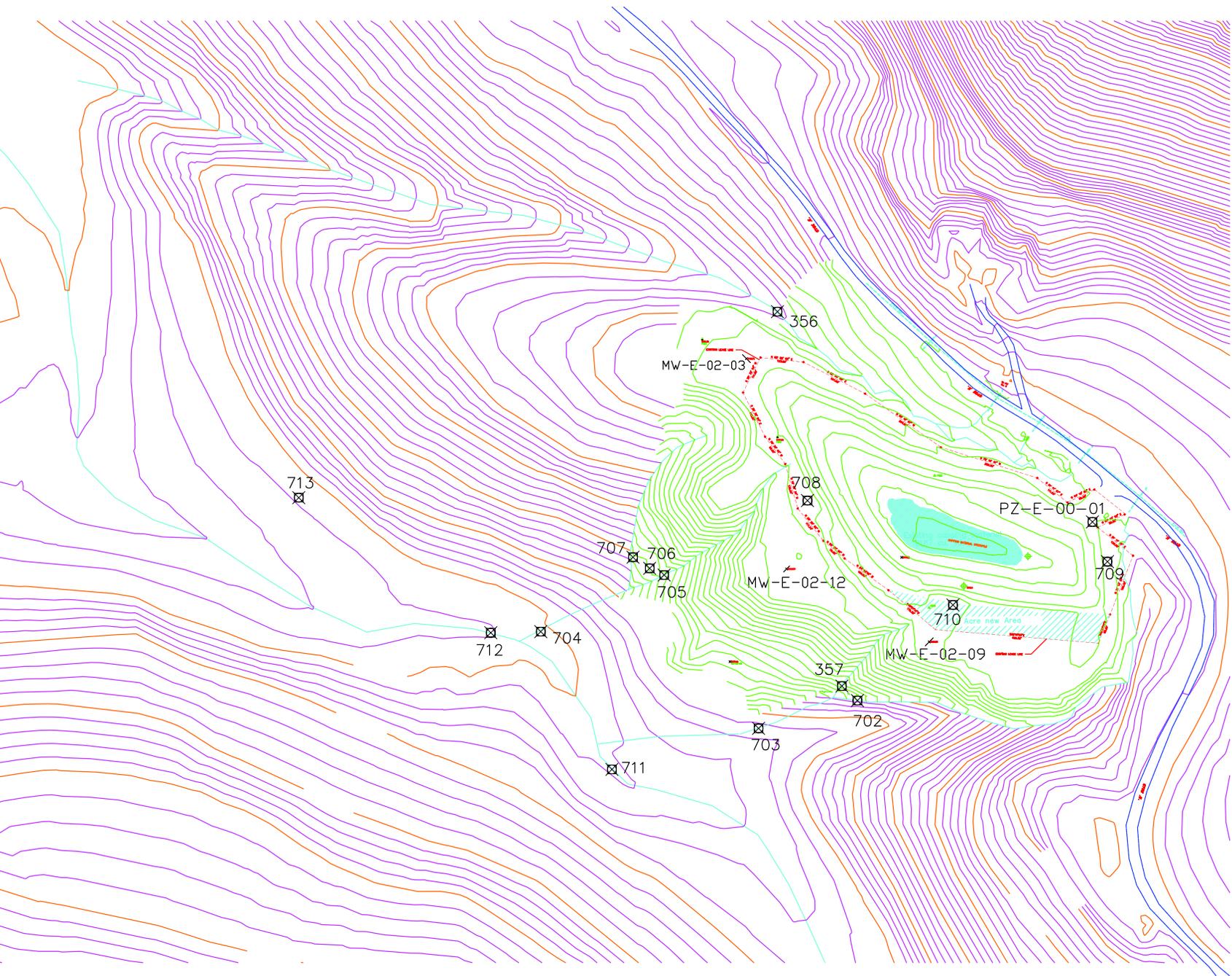
Project Manager: E. Fernandez

Drawn By: J. Chen

Checked By: D. Helmericks

- ⊗ Stormwater Monitoring Site
- ⑦ Road Mile





KENNECOTT GREENS CREEK MINE  
ADMIRALTY ISLAND, ALASKA

FIGURE 2-2  
WASTE SITE E ASBULT

DATE: 1-28-02	PREPARED BY: GREENS CREEK MINING CO.
DRAWING BY: <u>Shelby Edwards</u>	ADIRALTY, ALASKA
DESIGN BY: _____	PHONE: (907)788-8844 FAX: (907)788-8848
REVIEWED BY: _____	DCMC DWG # _____
PROJ. OR. REF. _____	SCALE: _____ SHEET: <u>1</u> OF <u>1</u>

FIGURE 2.3a 2002-2008 INACTIVE SITE ABA DATA

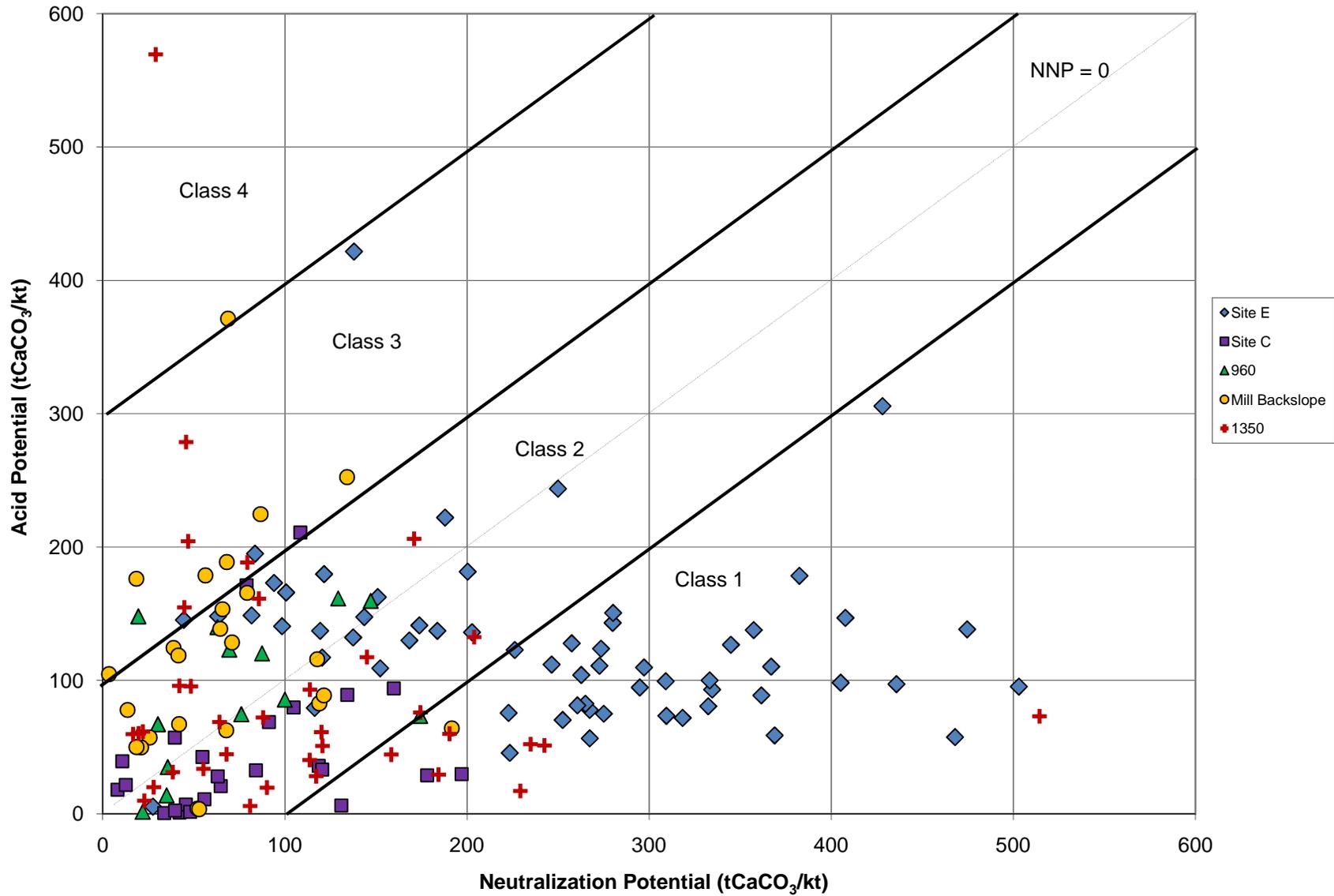






Figure 2.4 Site E Removal July 2010



Figure 2.6 Inactive Production Rock Site pH Data

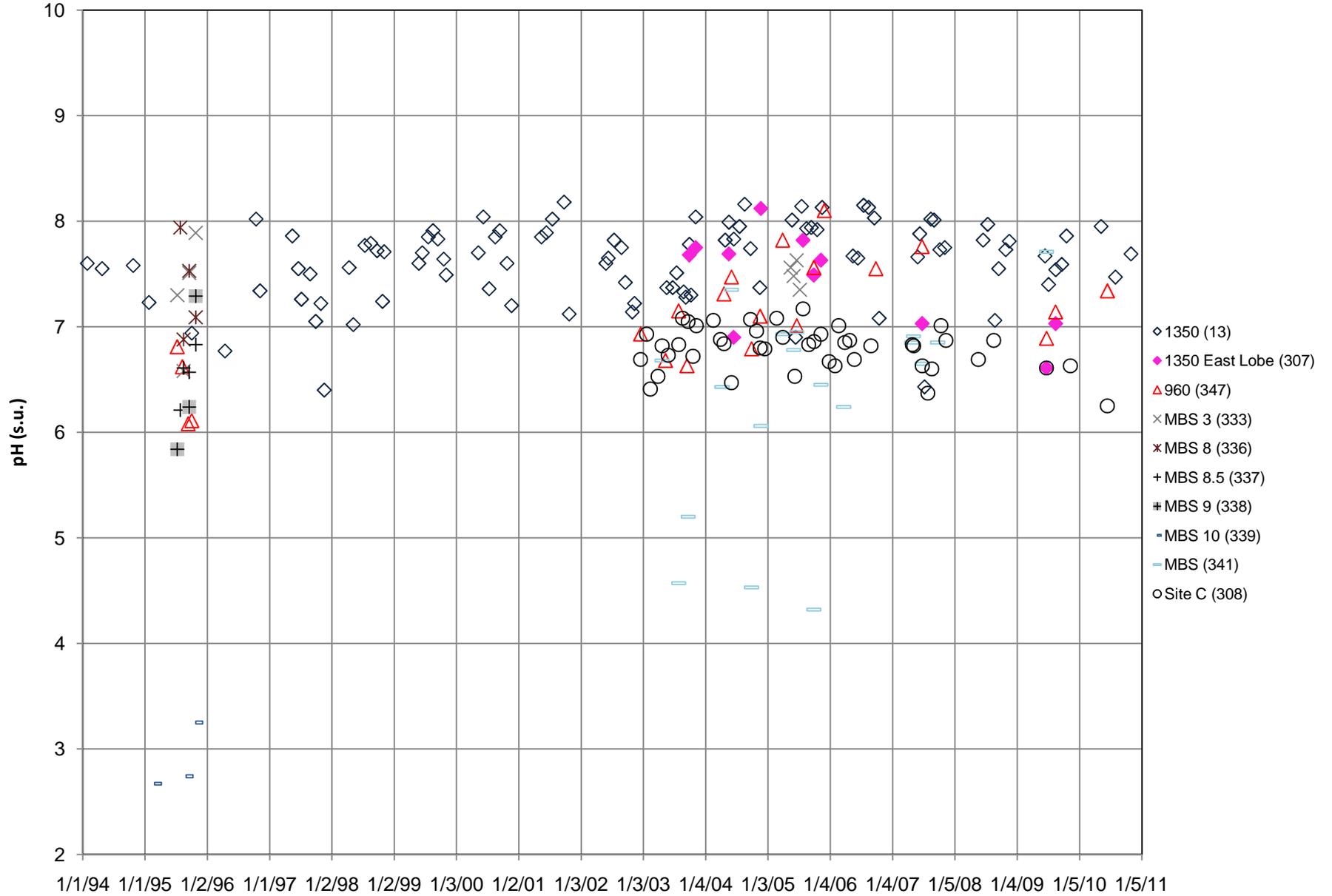


Figure 2.7 Inactive Production Rock Site Alkalinity Data

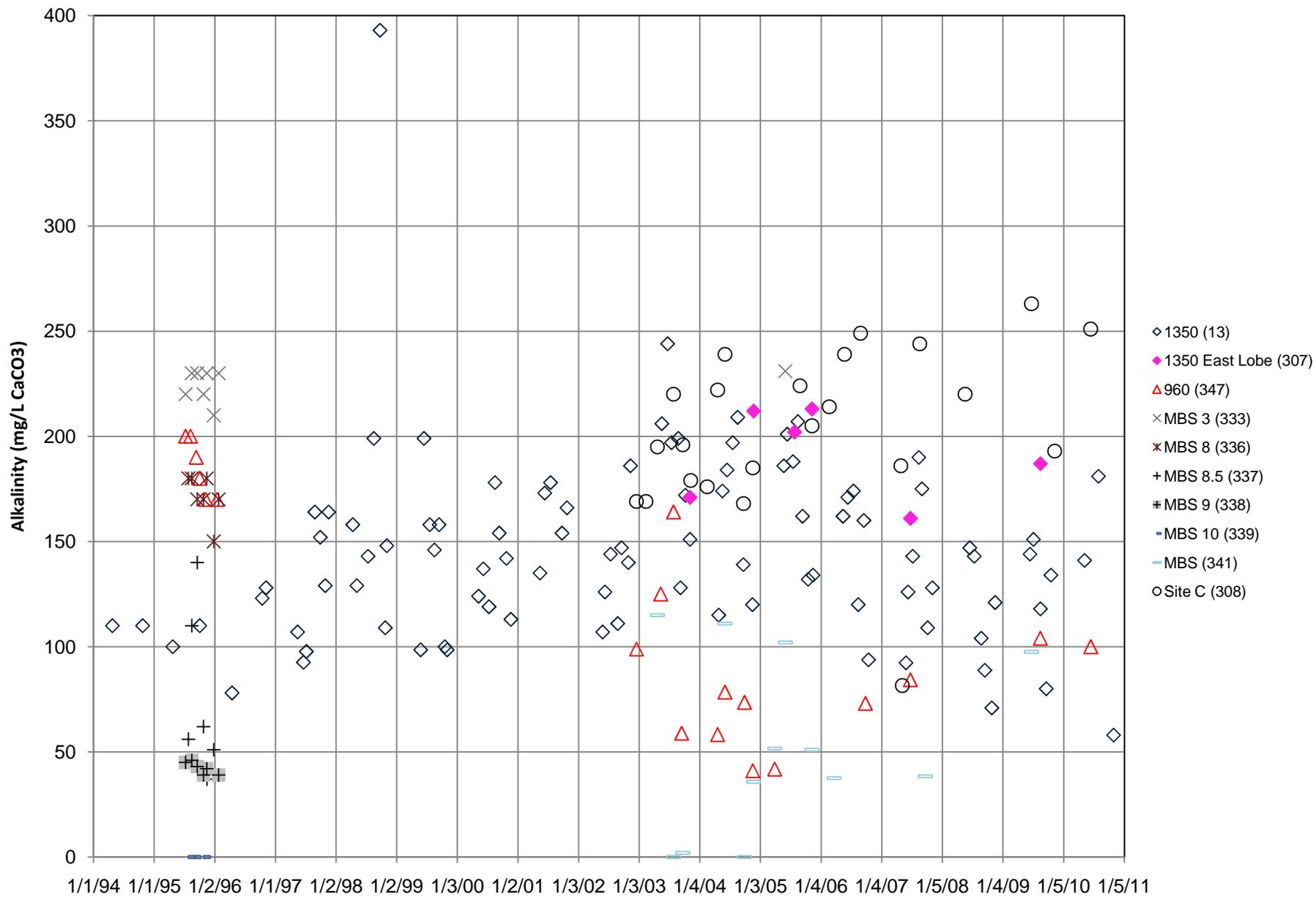


Figure 2.8 Inactive Production Rock Site Conductivity Data

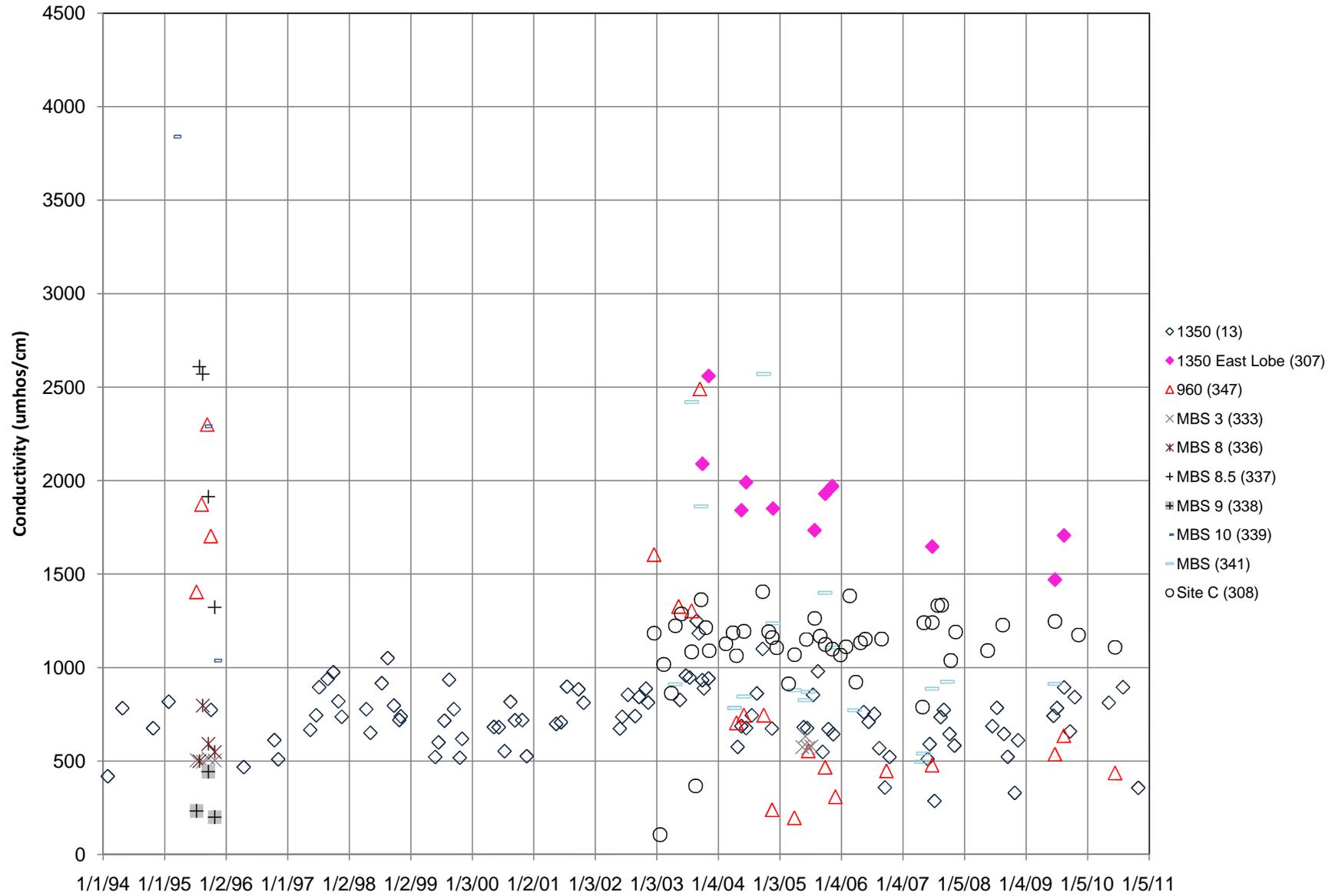
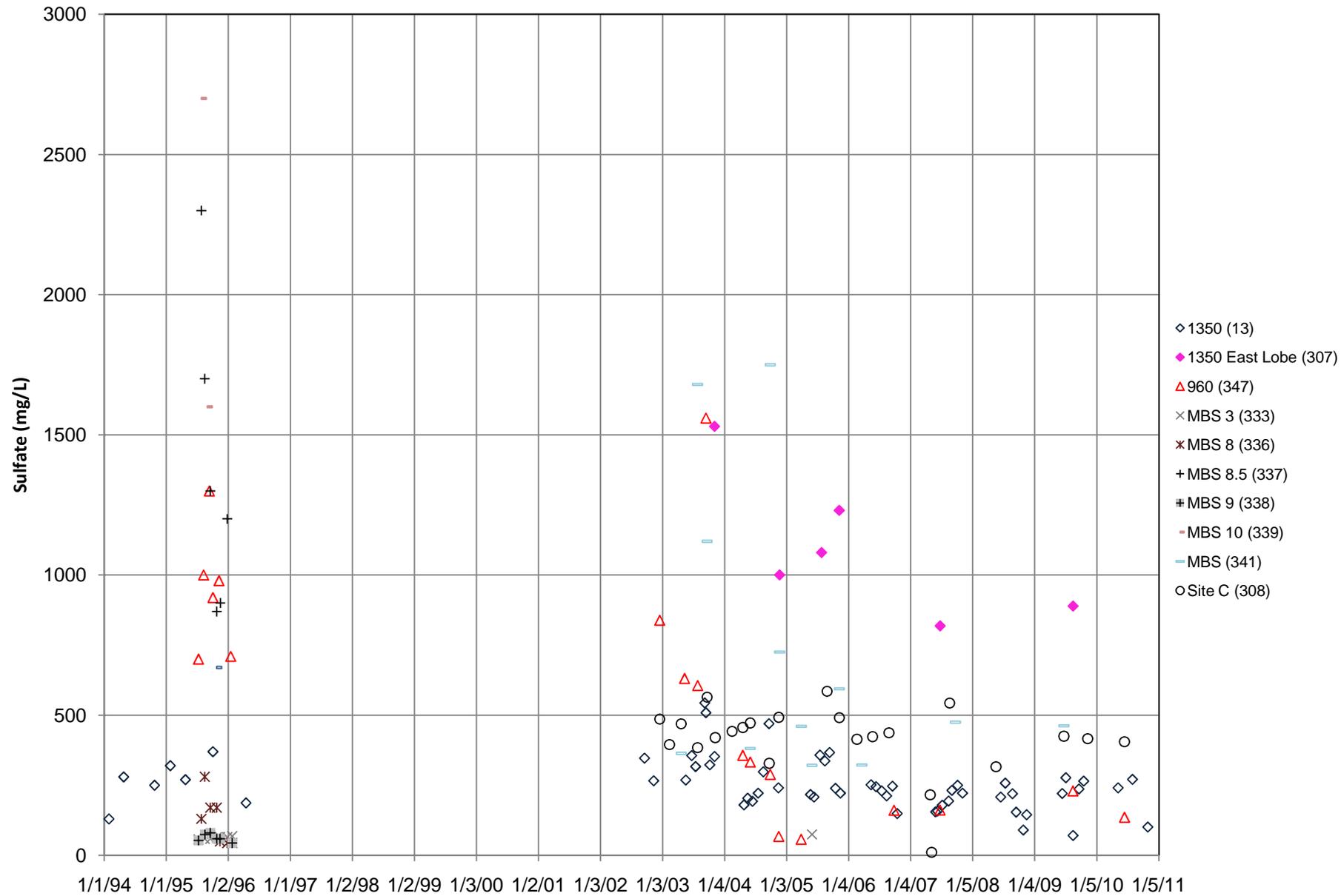
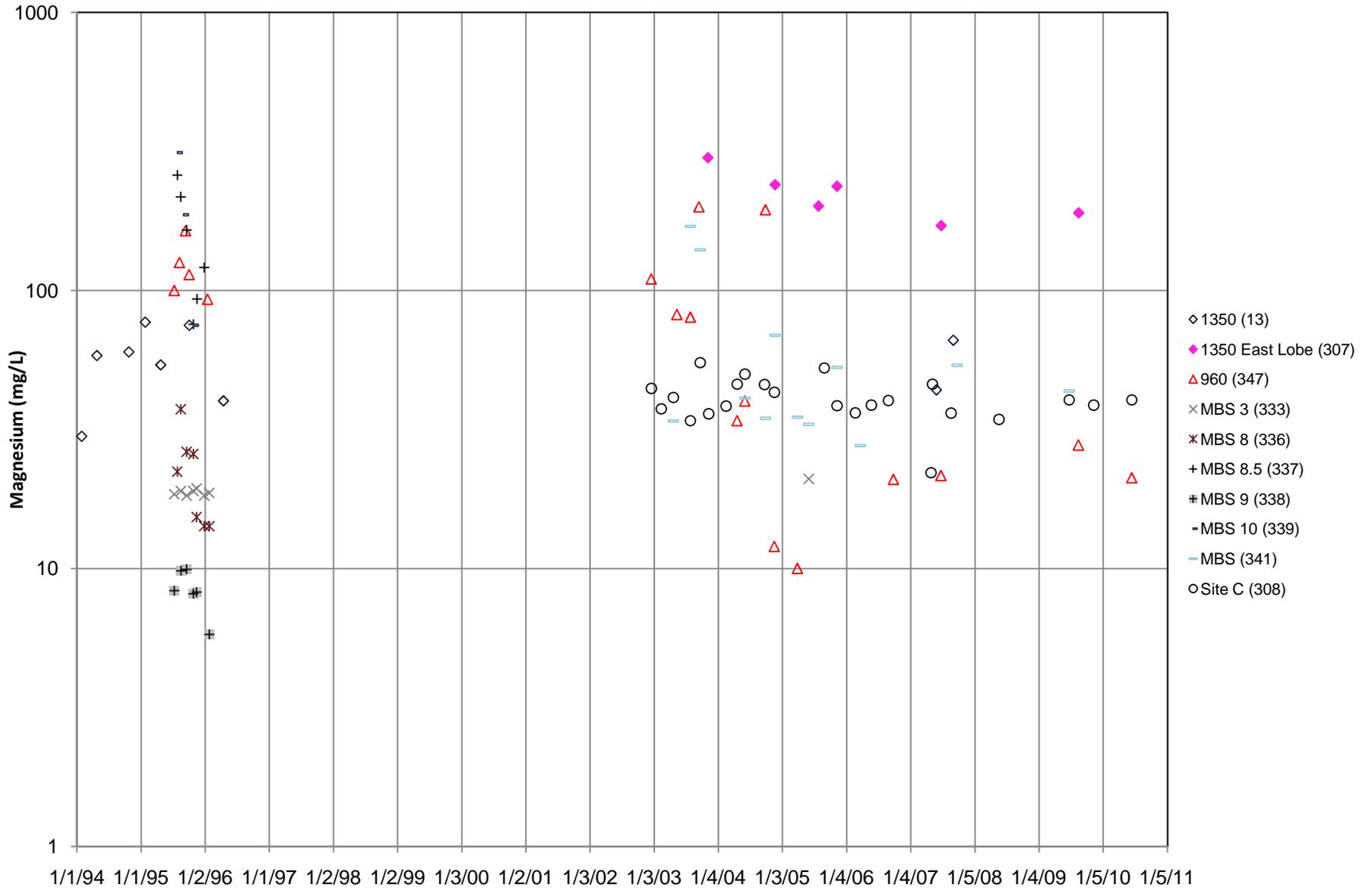


Figure 2.9 Inactive Production Rock Site Sulfate Data



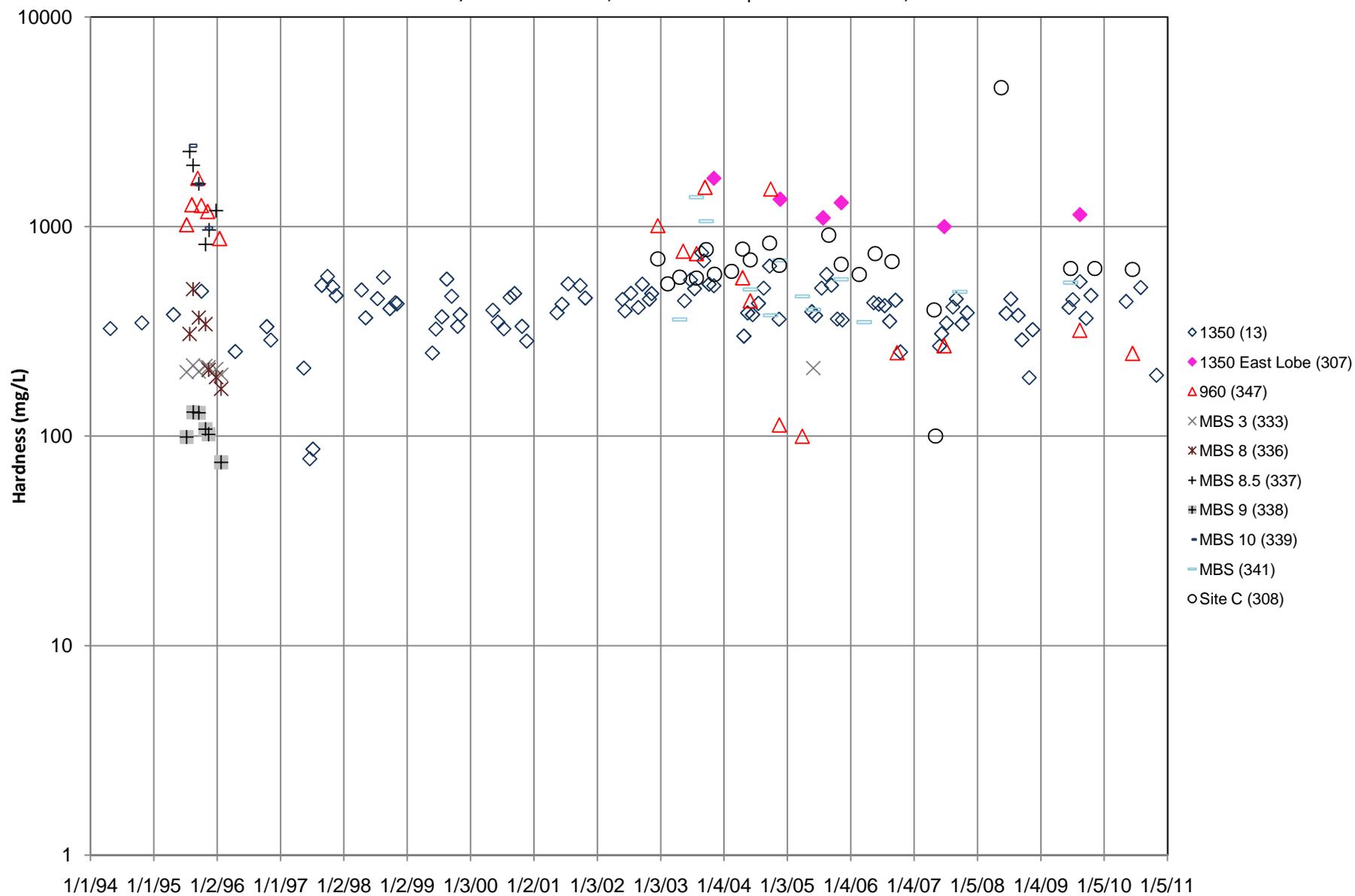
**Figure 2.10 Inactive Production Rock Site Magnesium Data**

Non-detect results shown as 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



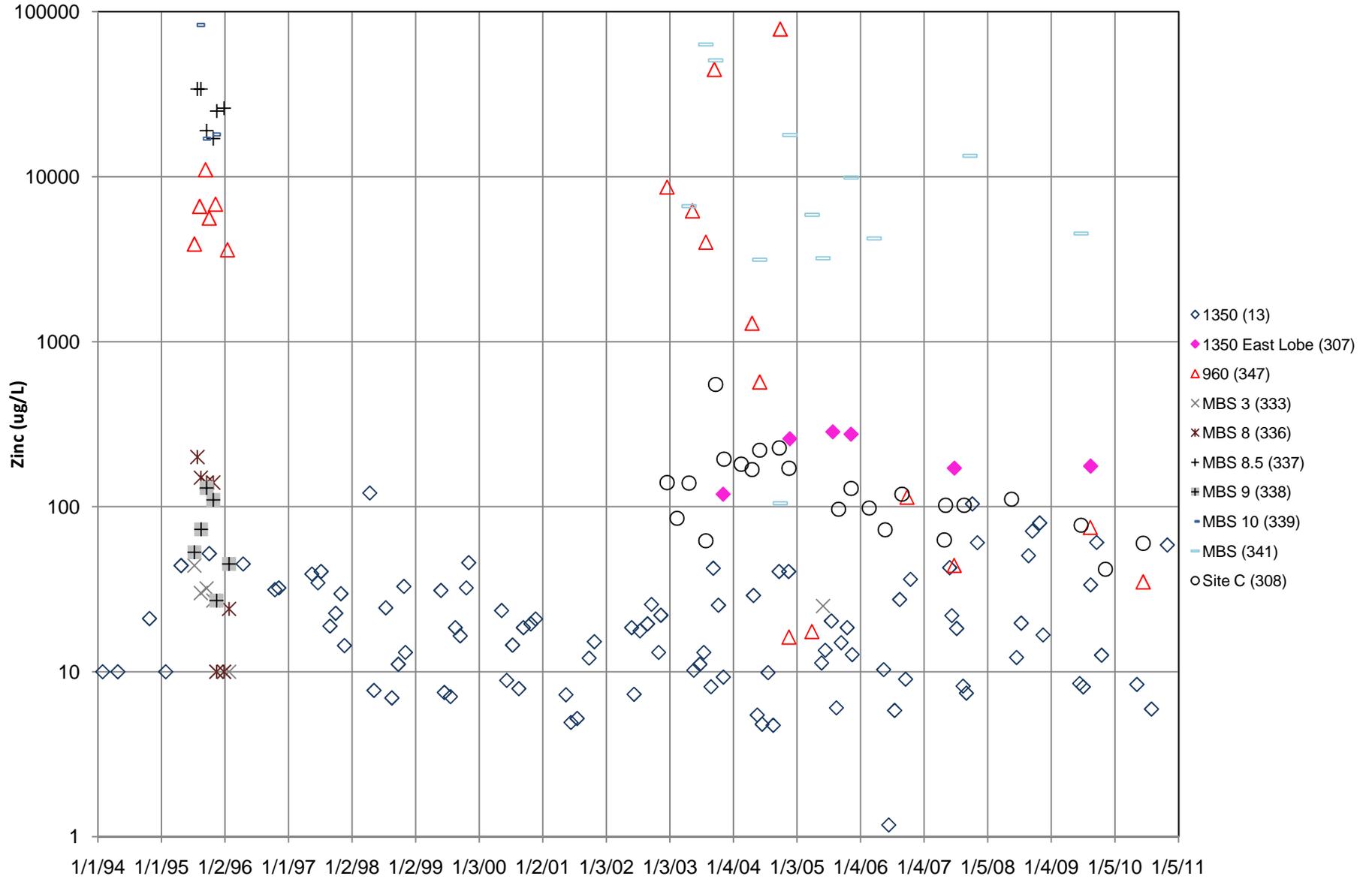
**Figure 2.11 Inactive Production Rock Site Hardness Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



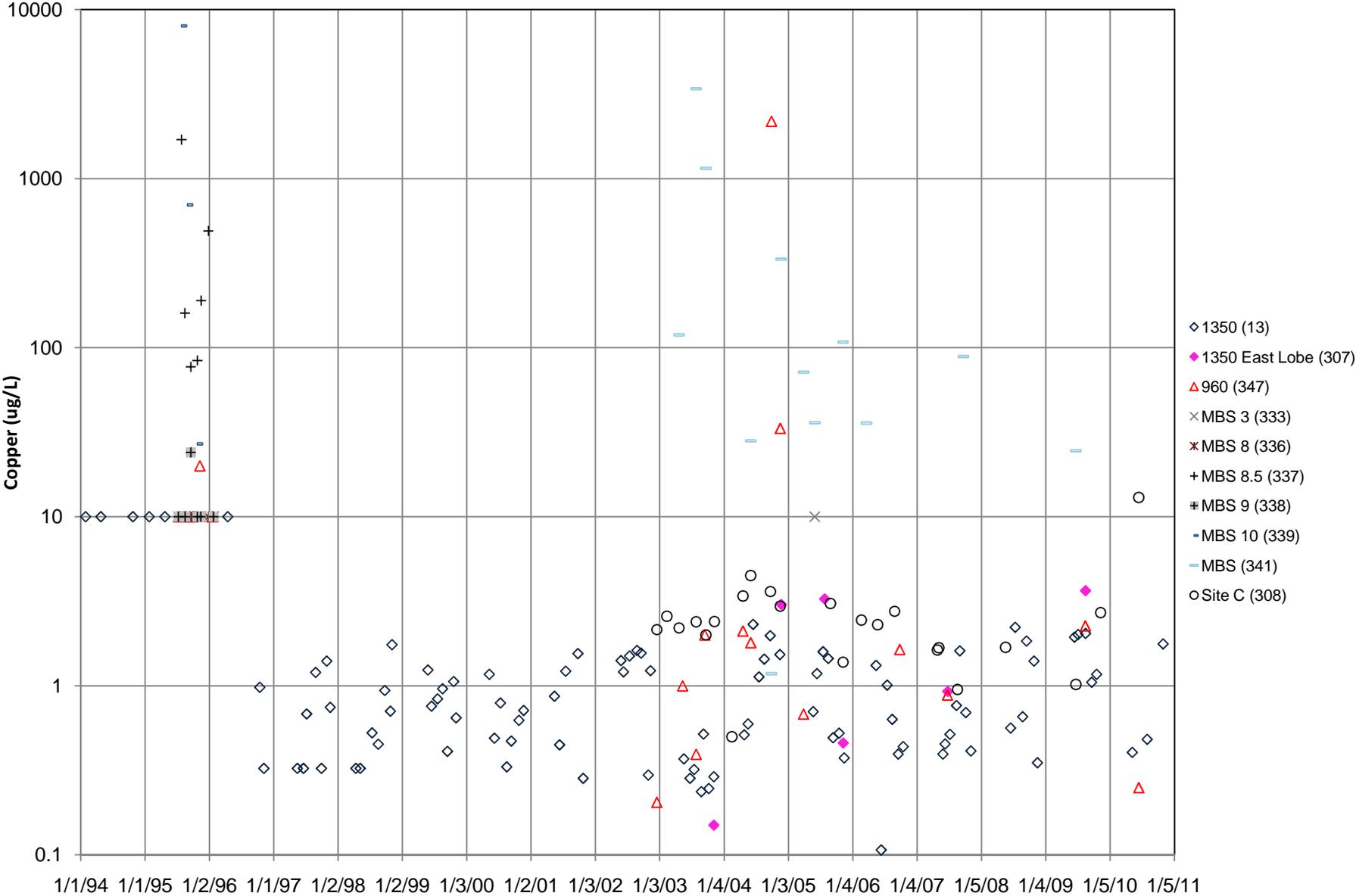
**Figure 2.12 Inactive Production Rock Site Zinc Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



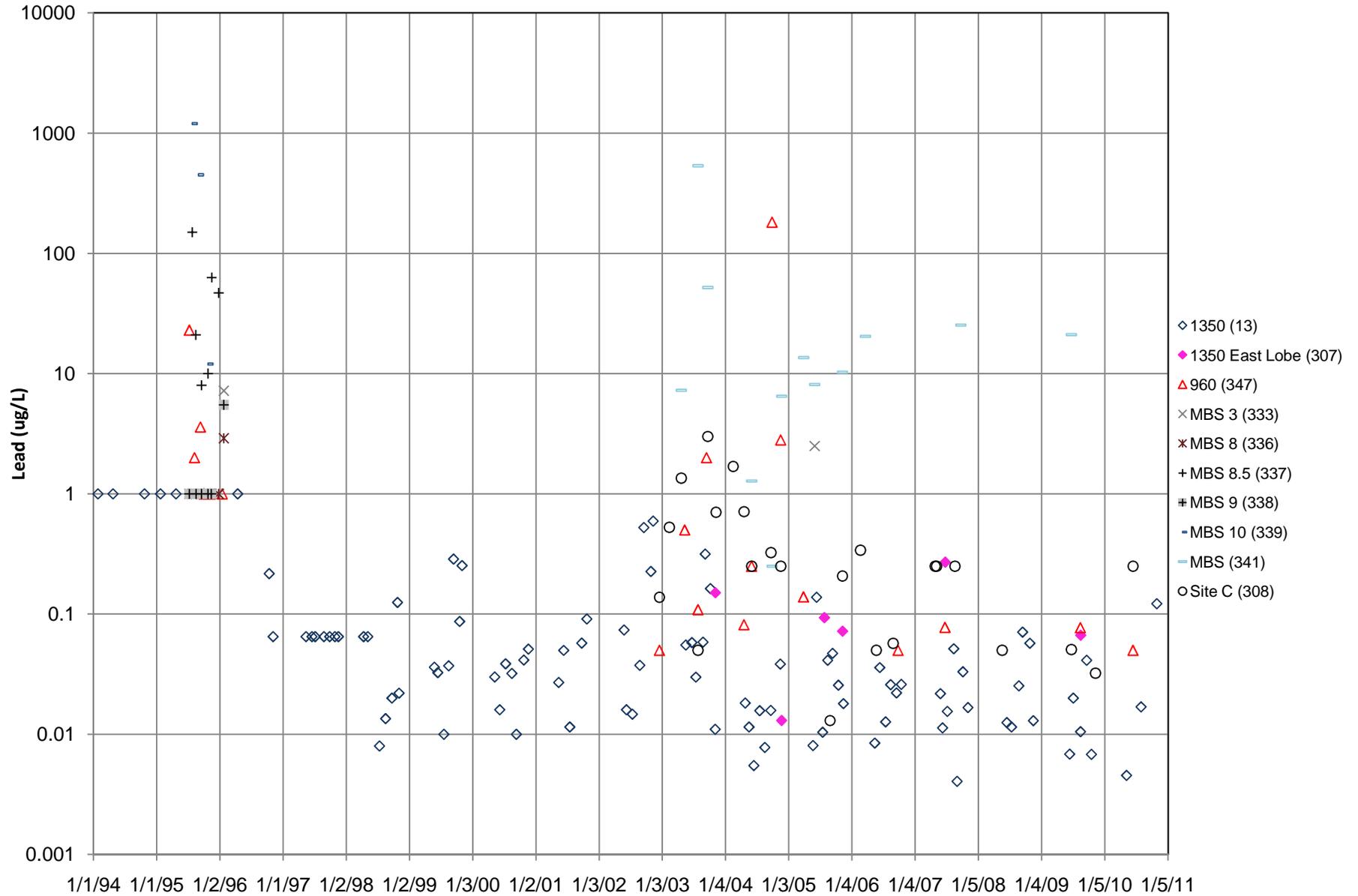
**Figure 2.13 Inactive Production Rock Site Copper Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



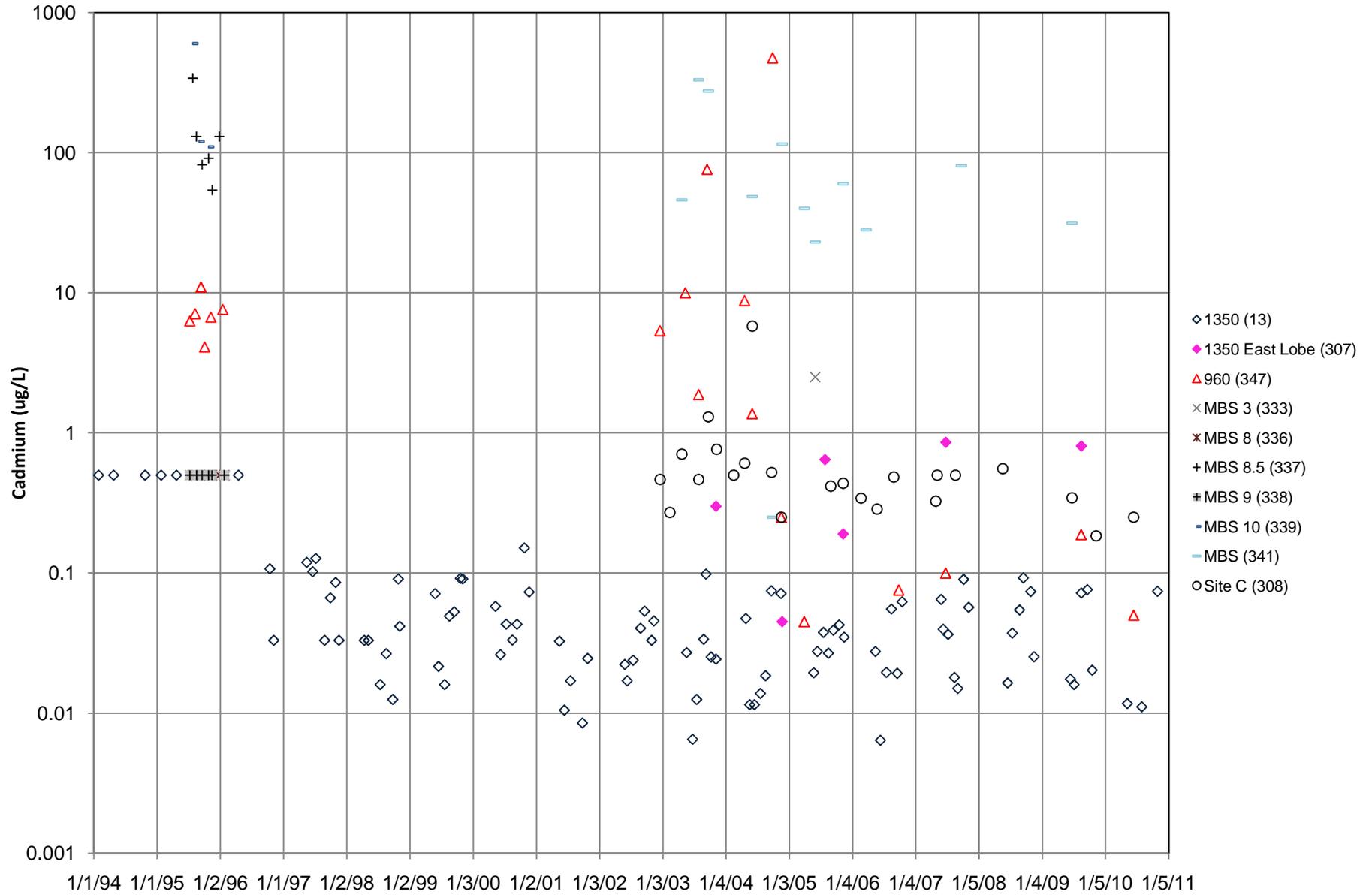
**Figure 2.14 Inactive Production Rock Site Lead Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



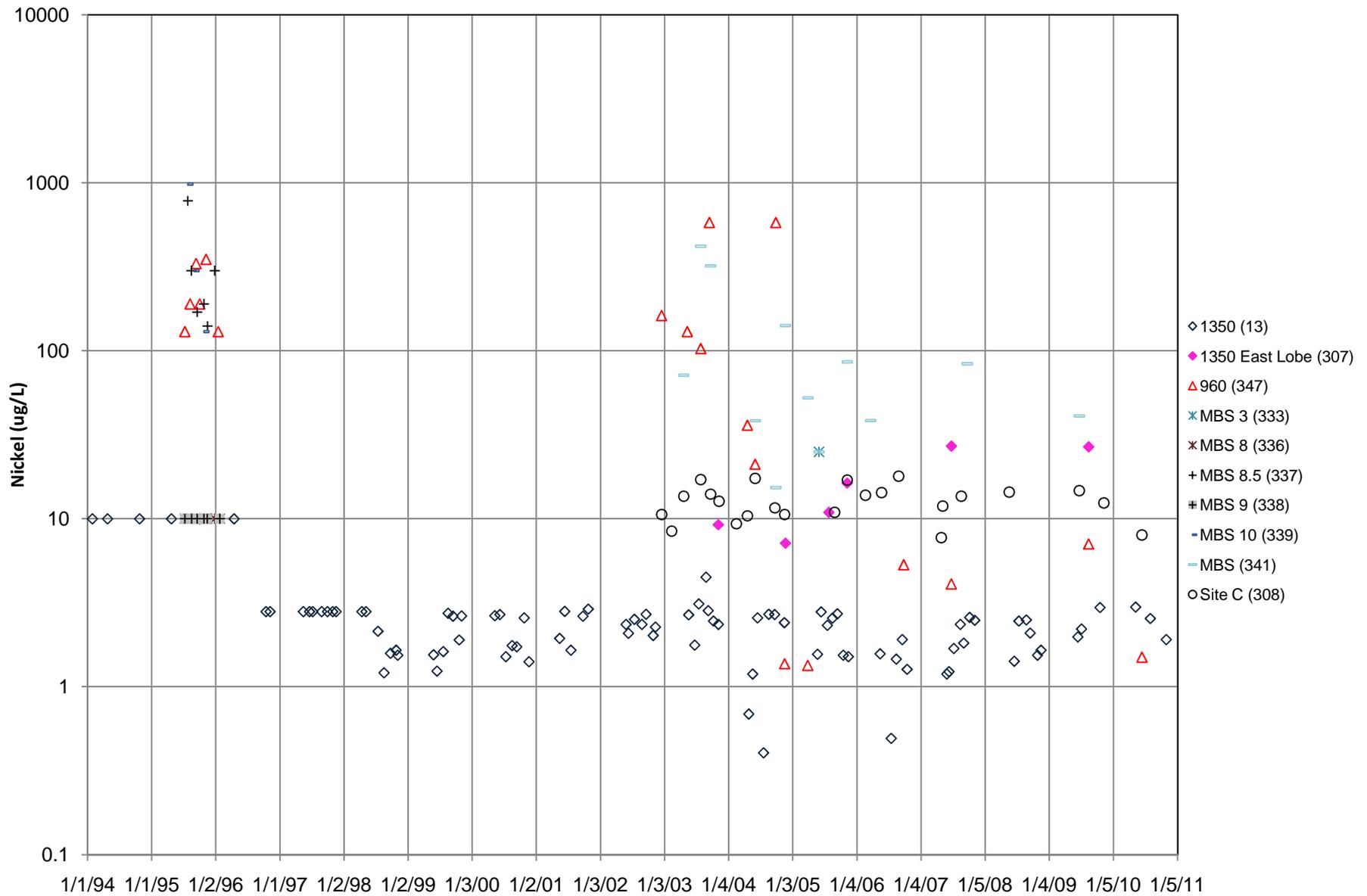
**Figure 2.15 Inactive Production Rock Site Cadmium Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total, and total recoverable results



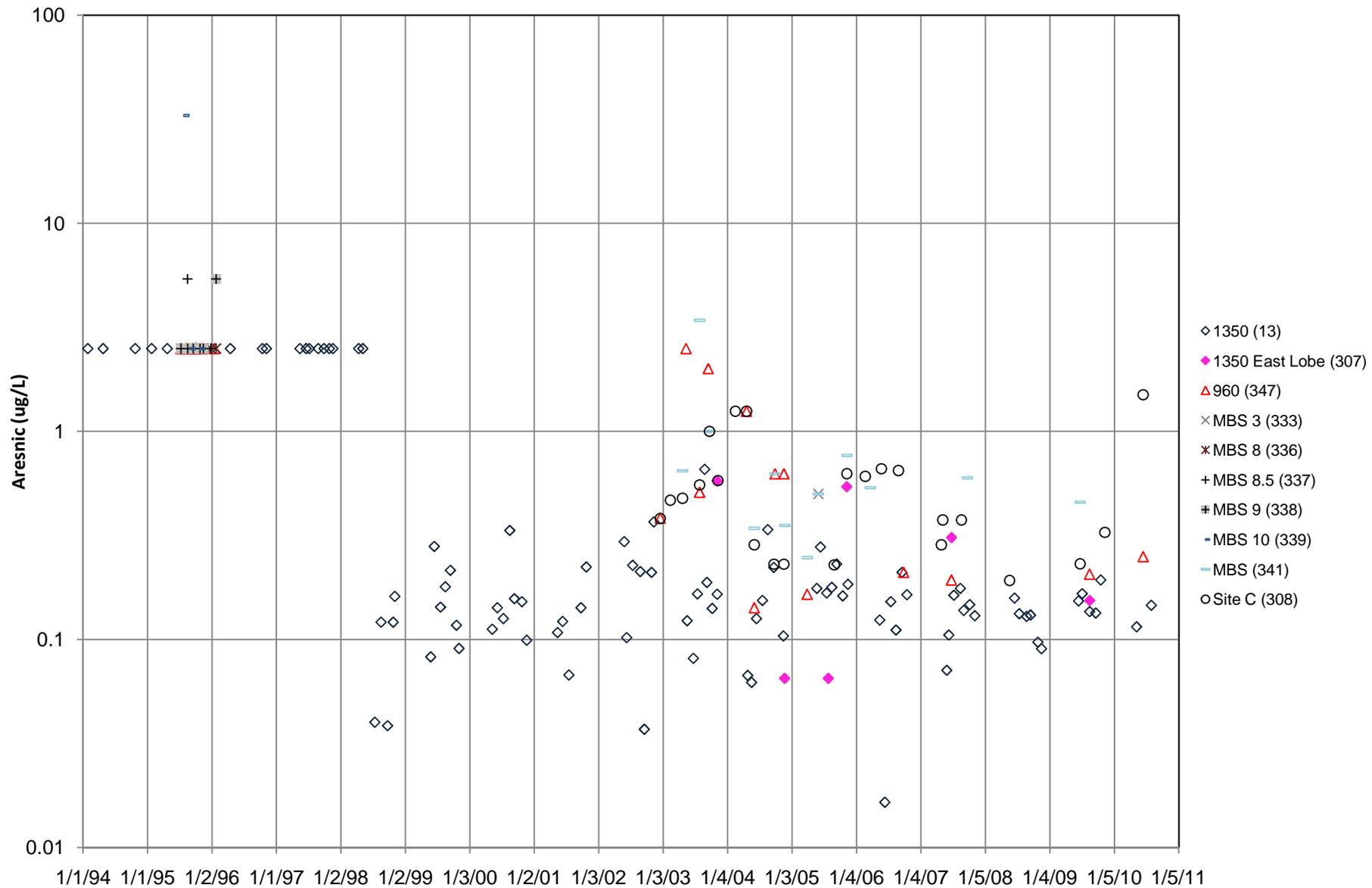
**Figure 2.16 Inactive Production Rock Site Nickel Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



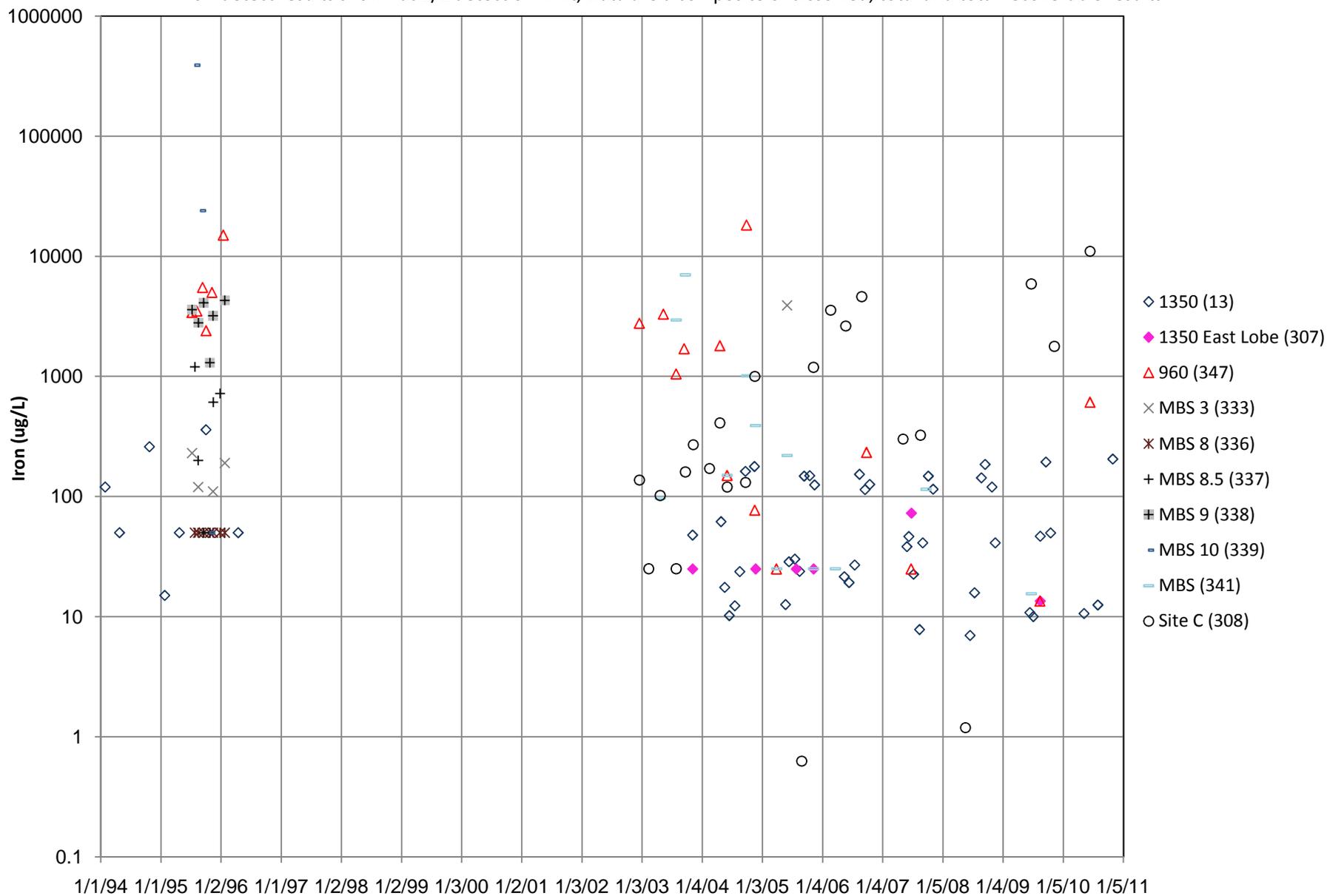
**Figure 2.17 Inactive Production Rock Site Arsenic Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.18 Inactive Production Rock Site Iron Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.19 Inactive Production Rock Site Manganese Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

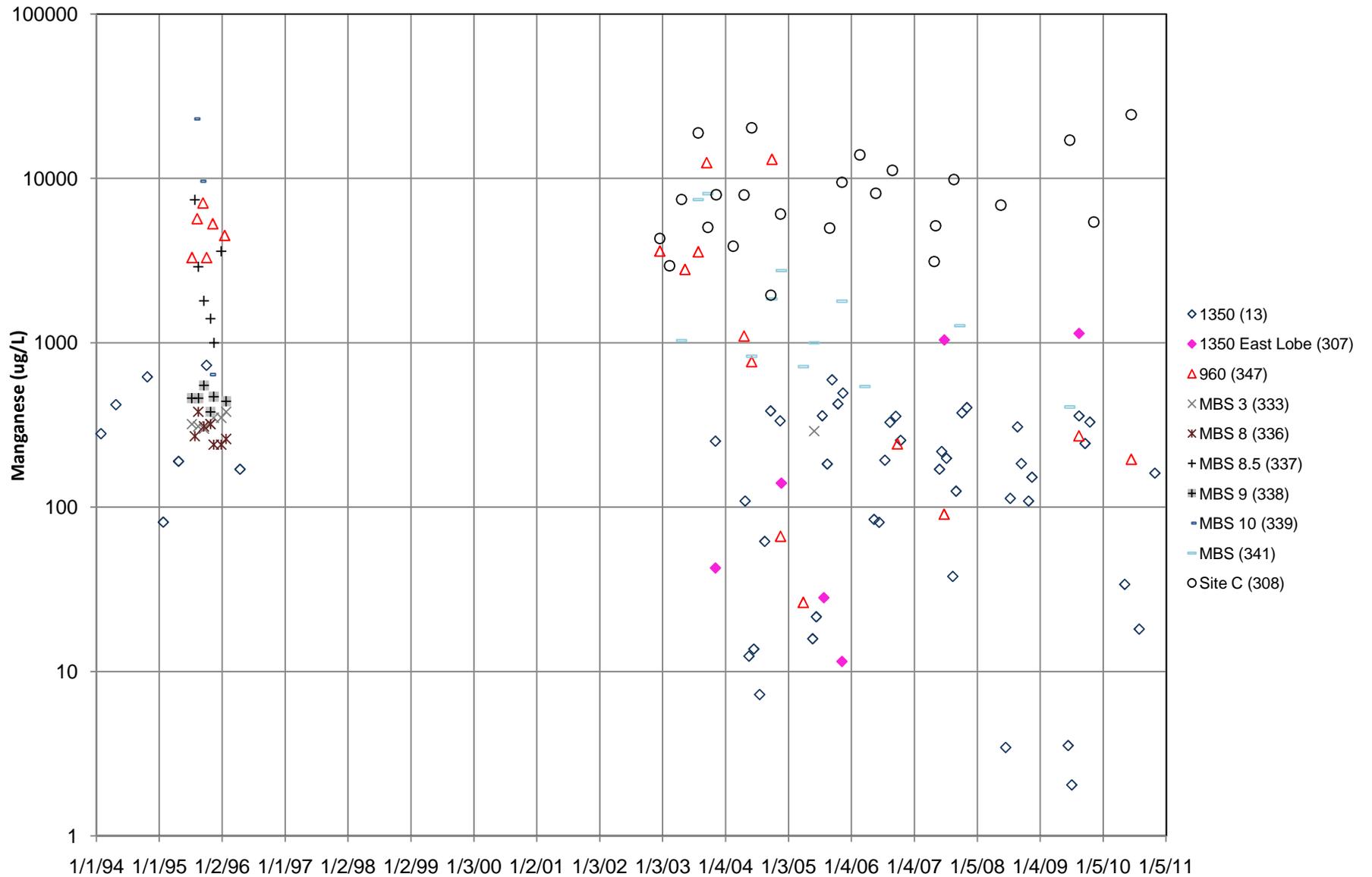


Figure 2.20 Inactive Production Rock Site E Flow Data

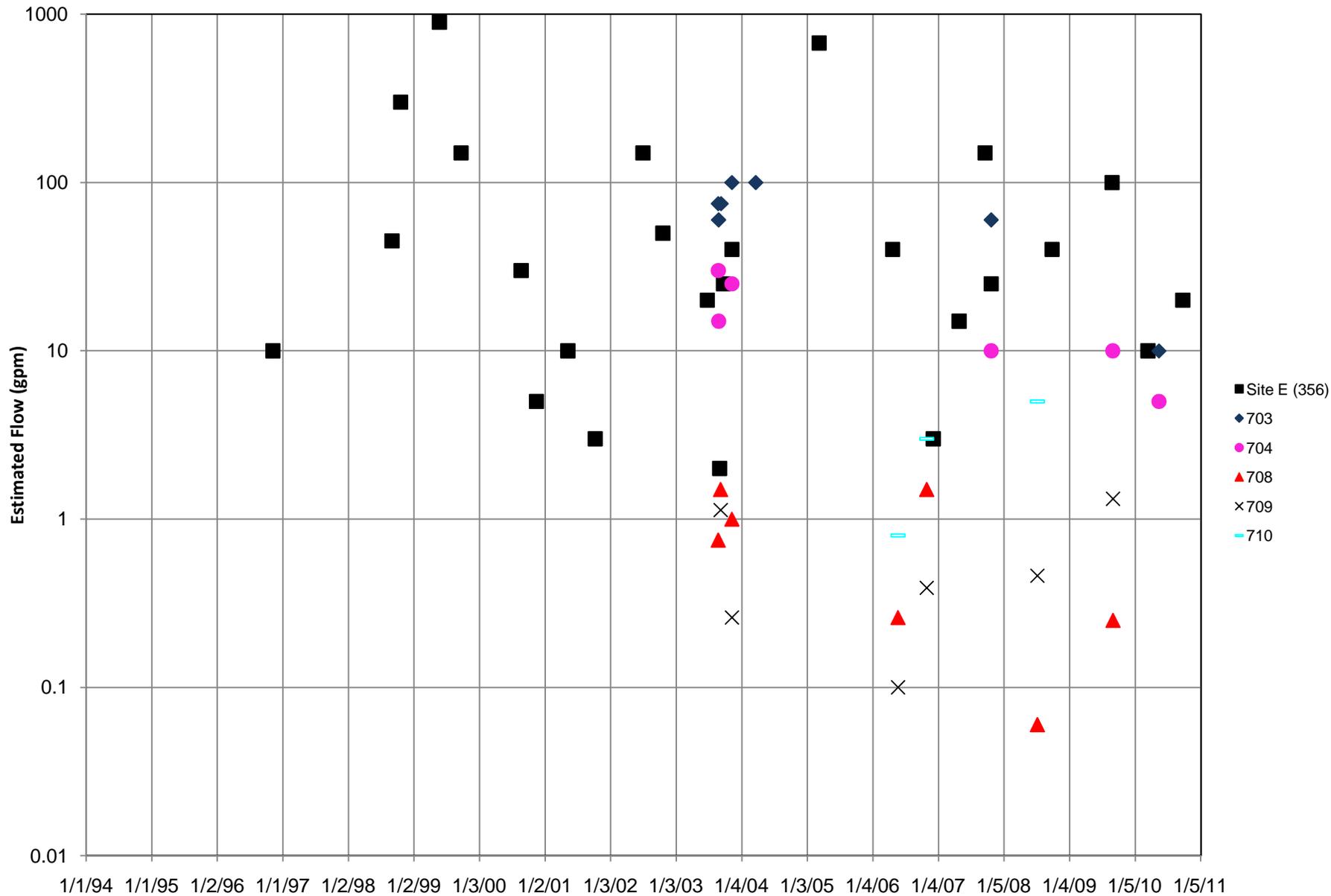


Figure 2.21 Inactive Production Rock Site E pH Data

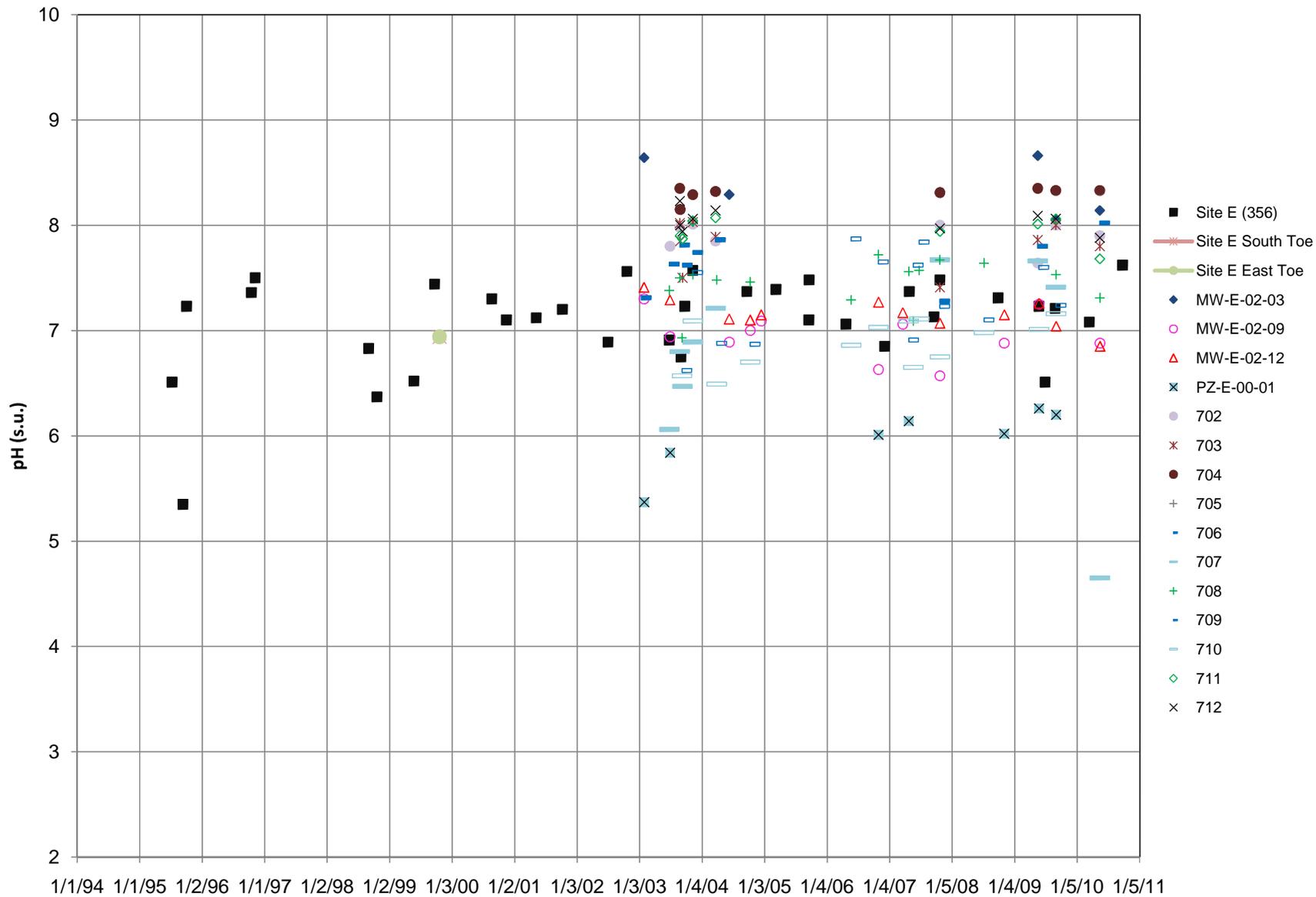


Figure 2.22 Inactive Production Rock Site E Alkalinity Data

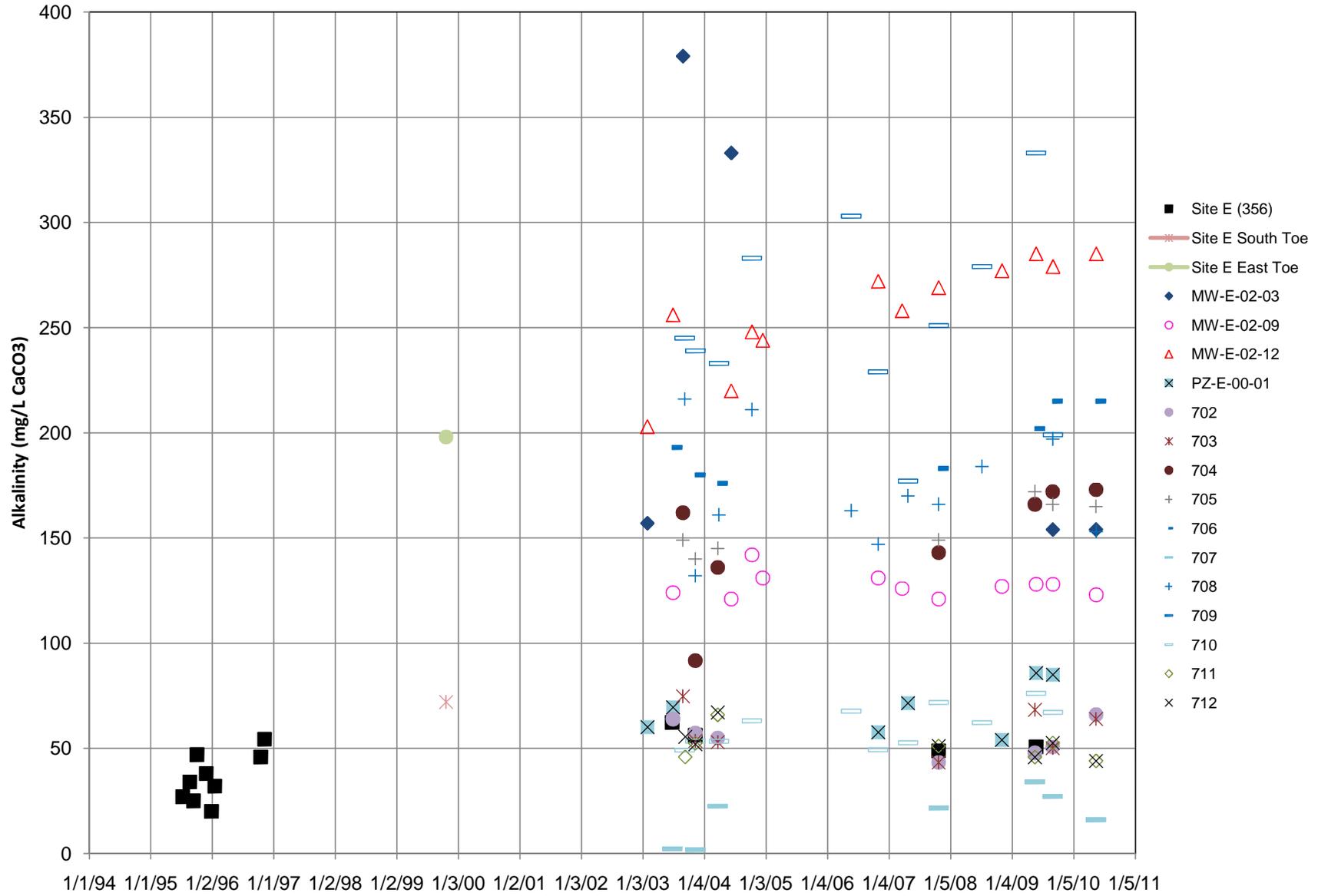


Figure 2.23 Inactive Production Rock Site E Conductivity Data

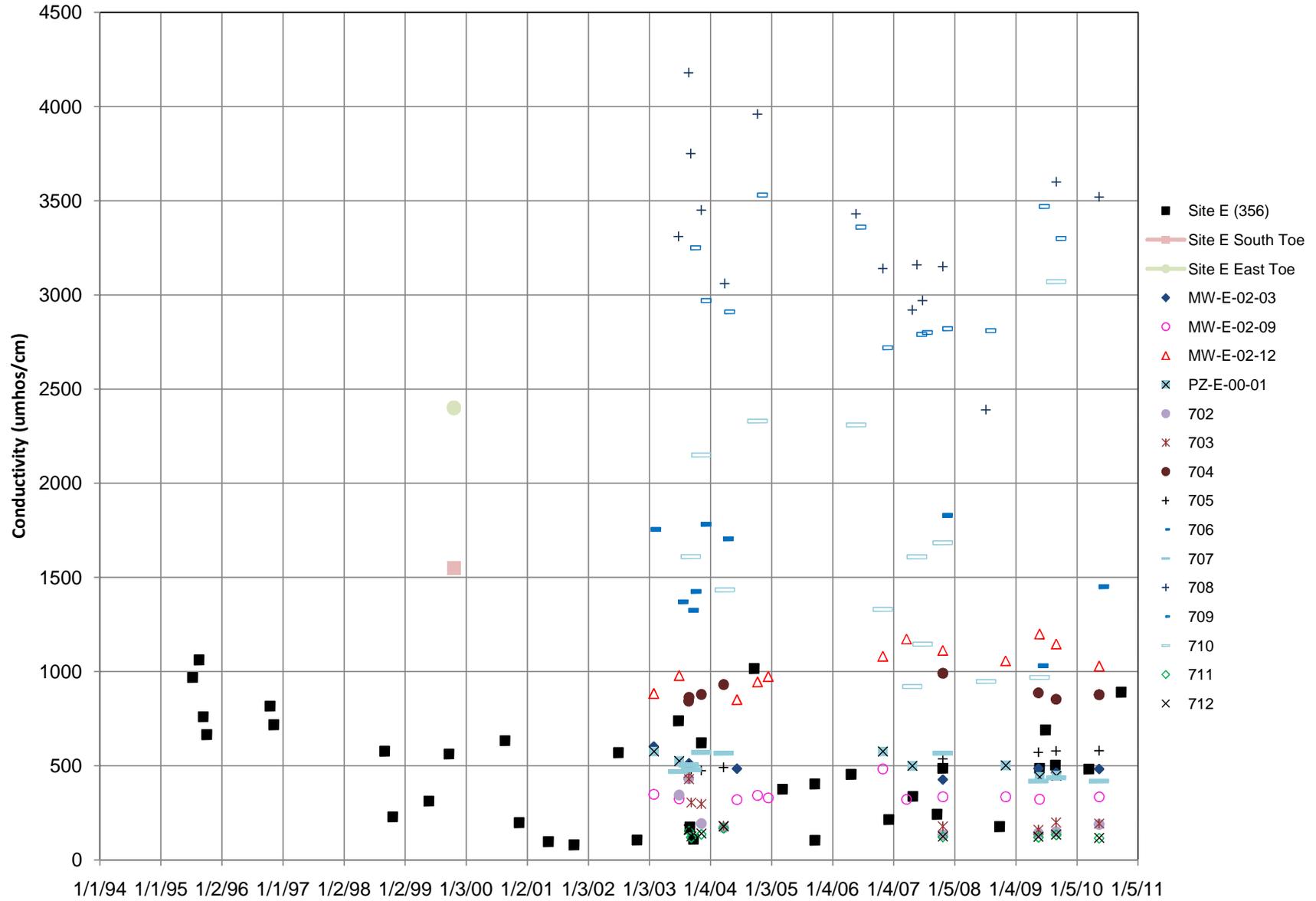
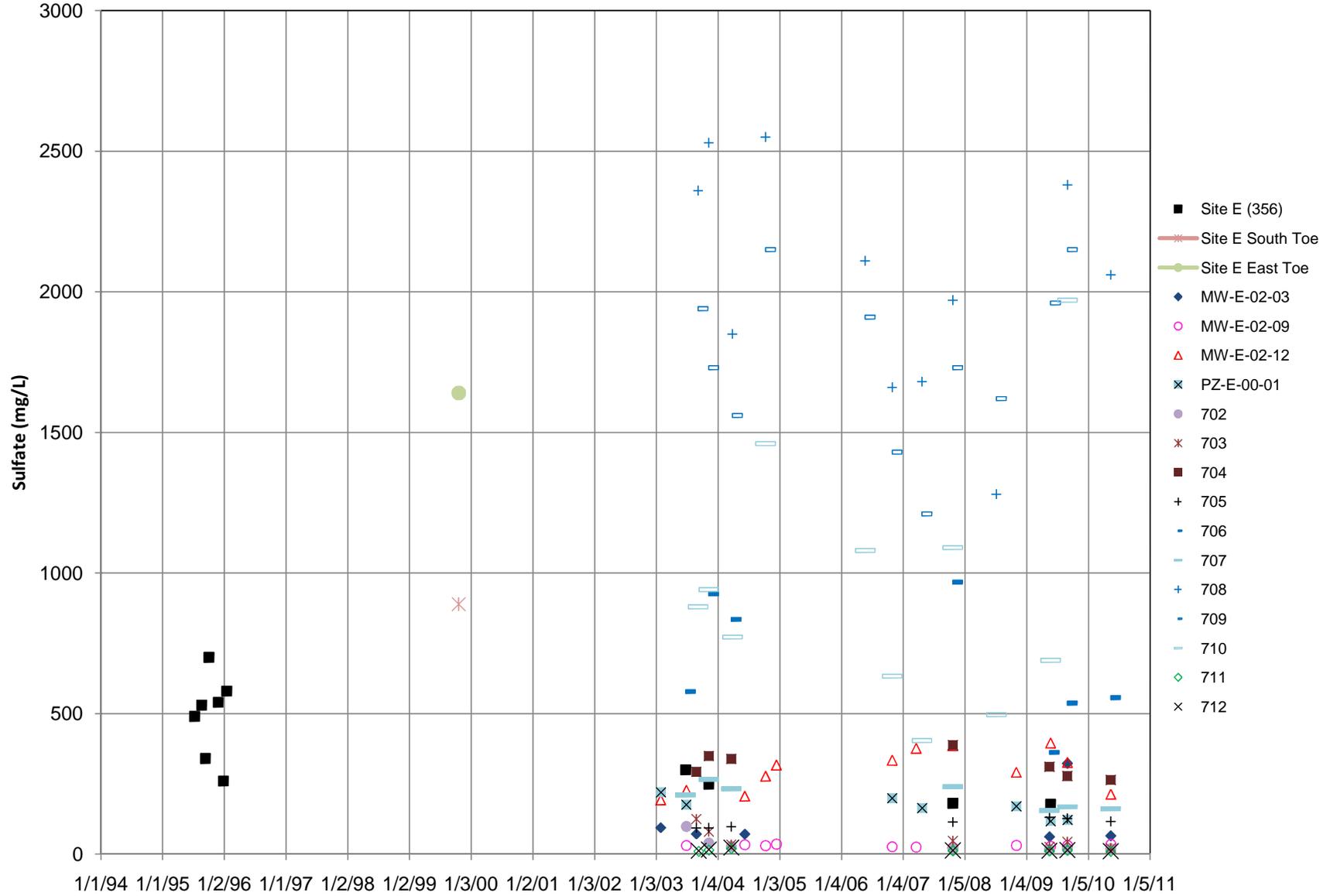
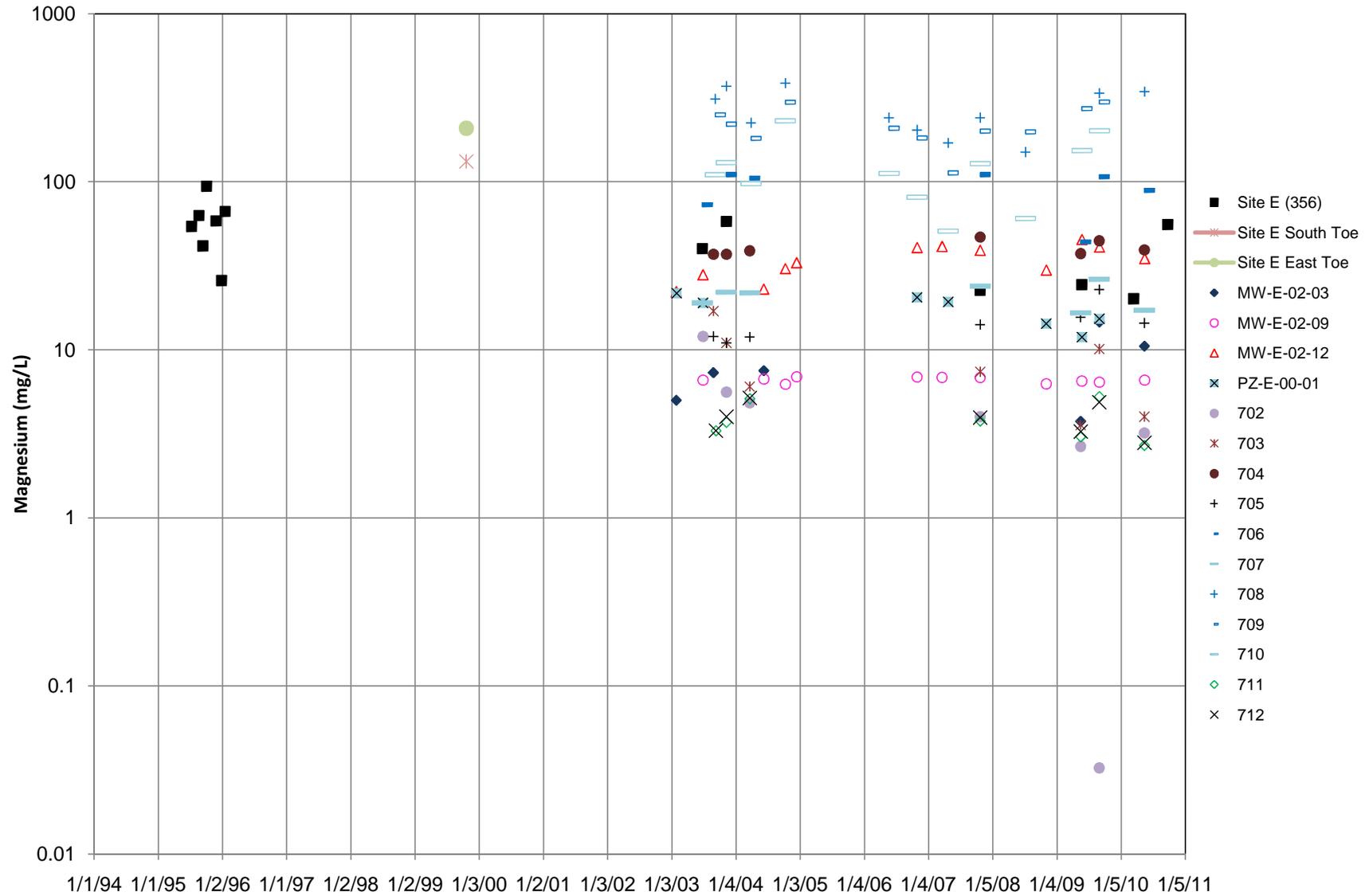


Figure 2.24 Inactive Production Rock Site E Sulfate Data



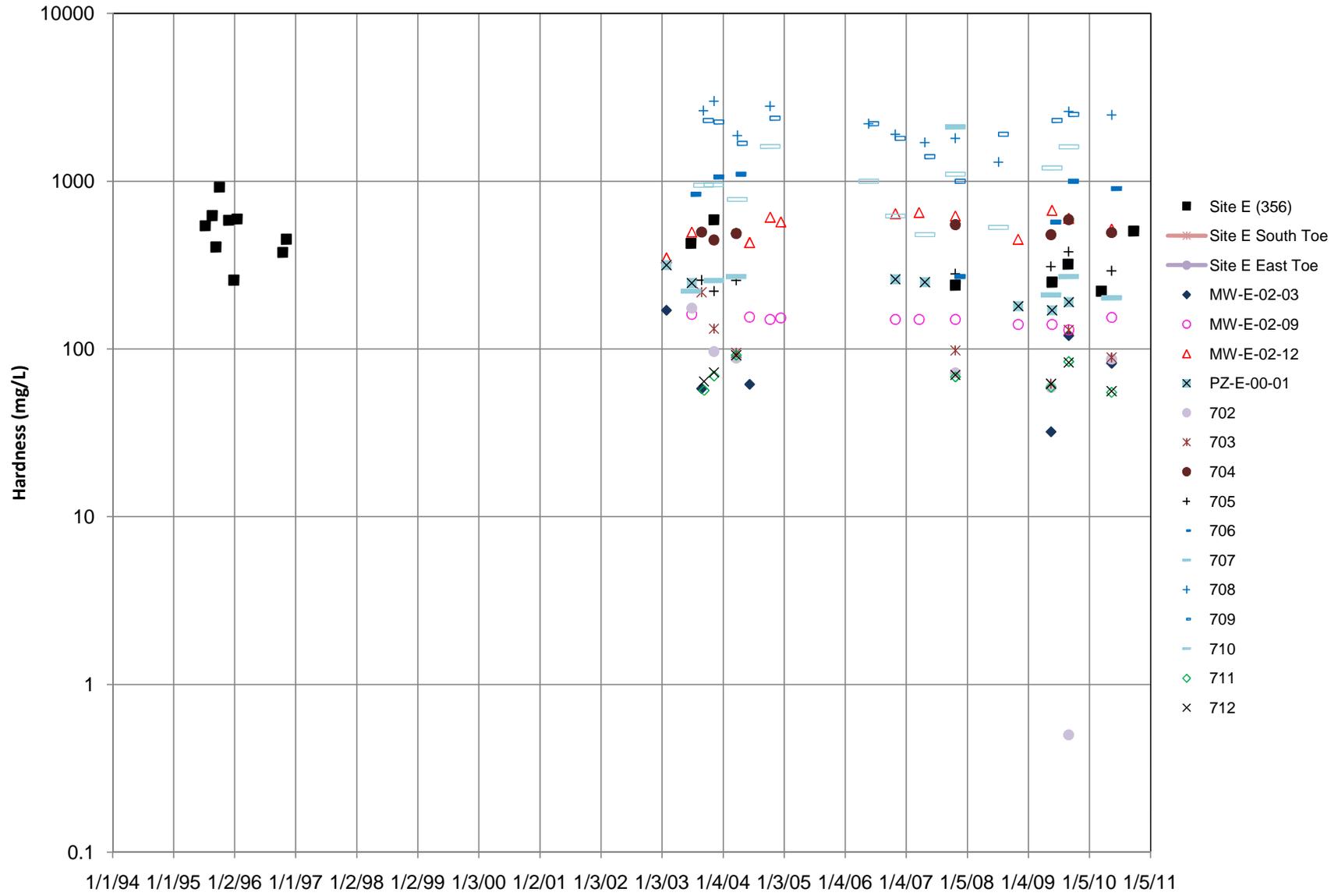
**Figure 2.25 Inactive Production Rock Site E Magnesium Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



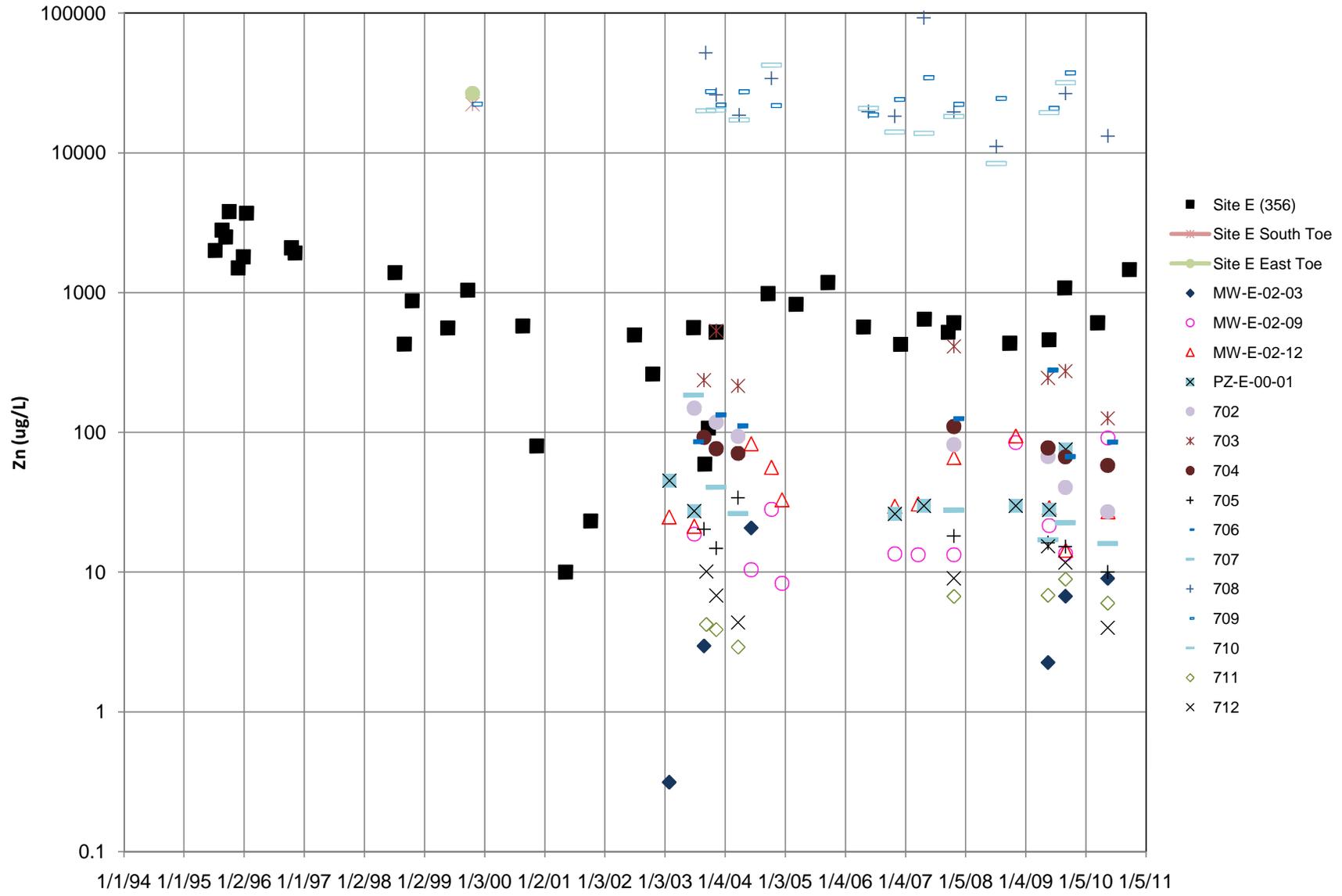
**Figure 2.26 Inactive Production Rock Site E Hardness Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



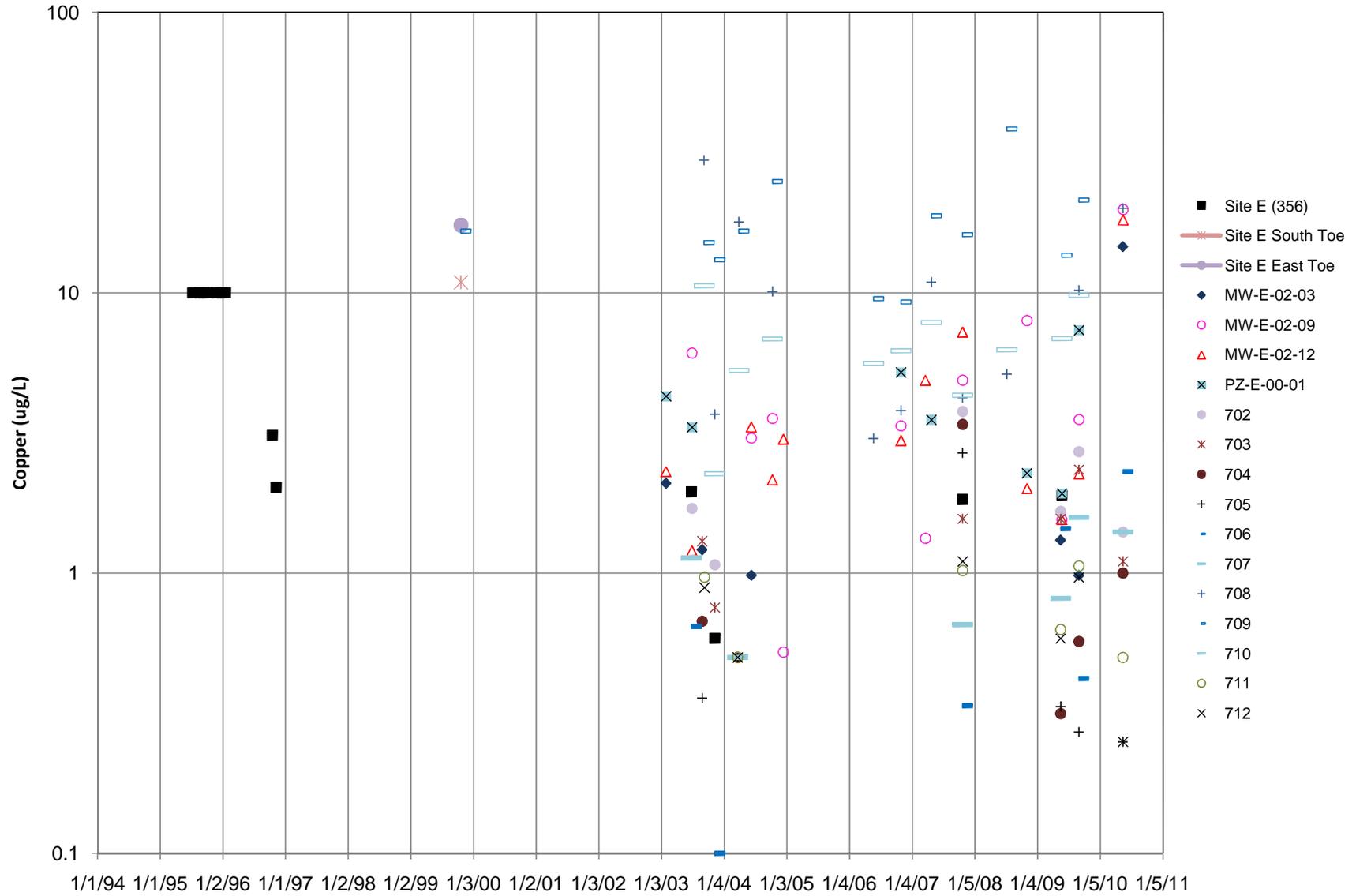
**Figure 2.27 Inactive Production Rock Site E Zinc Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



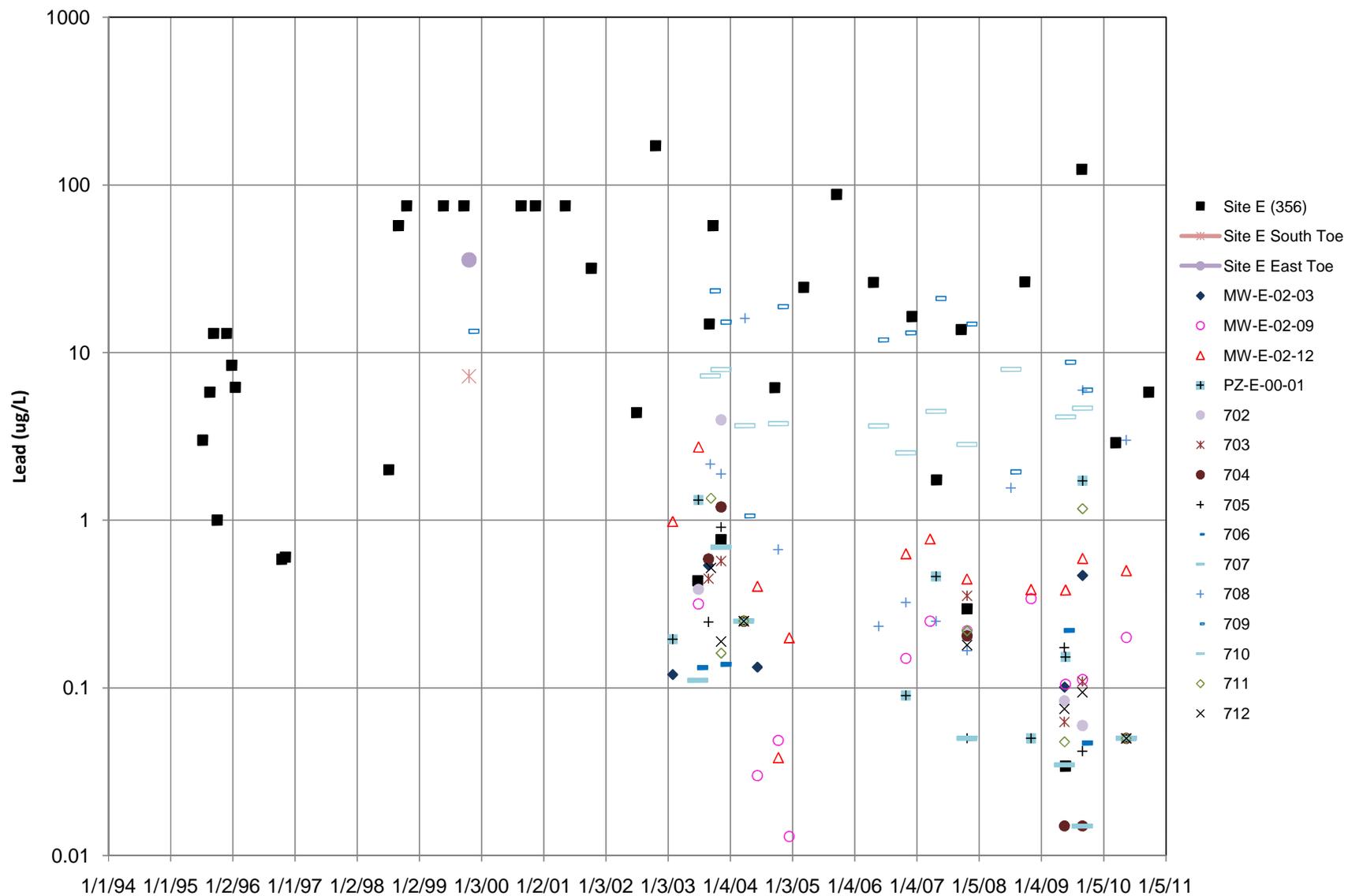
**Figure 2.28 Inactive Production Rock Site E Copper Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



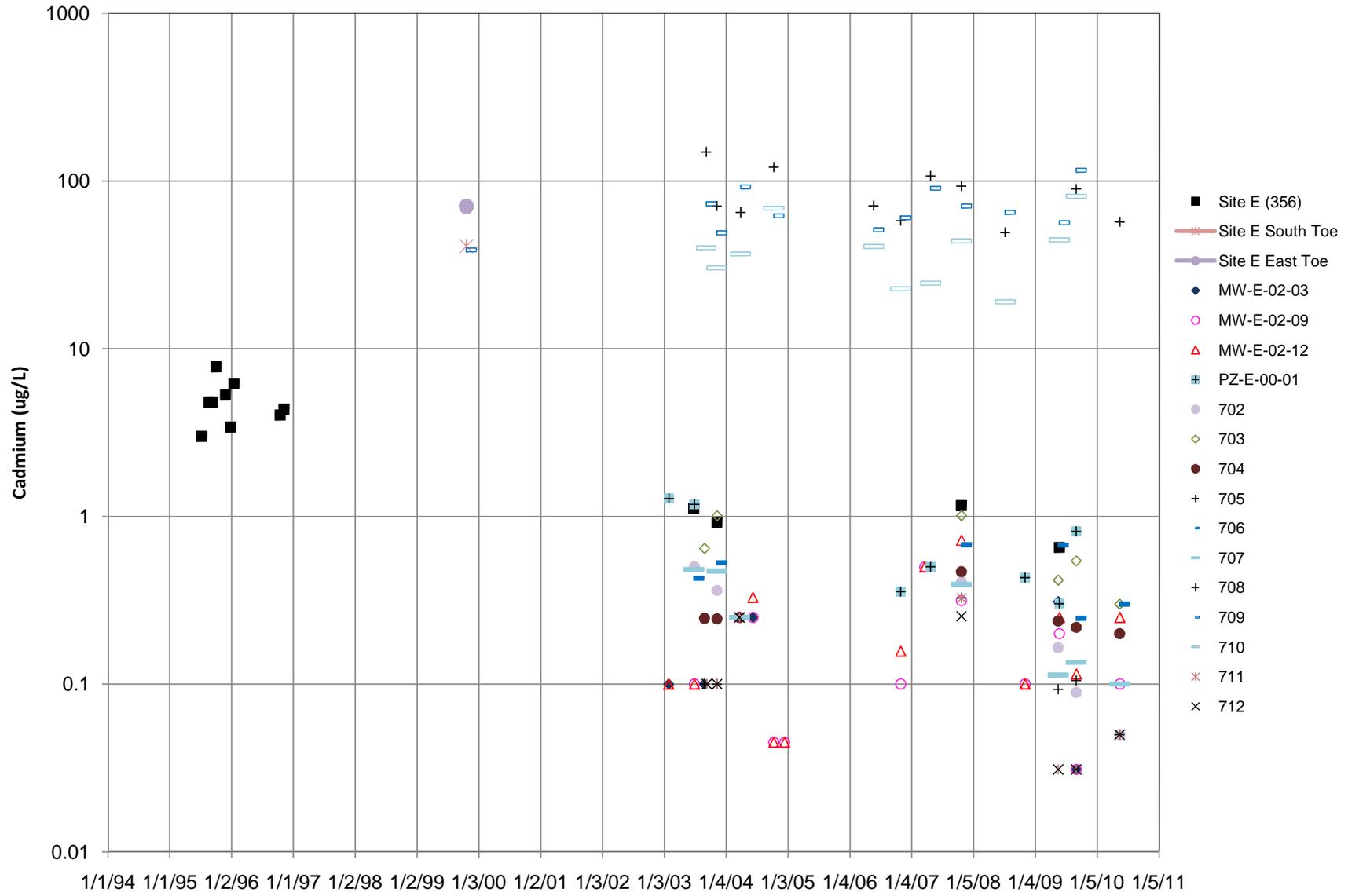
**Figure 2.29 Inactive Production Rock Site E Lead Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



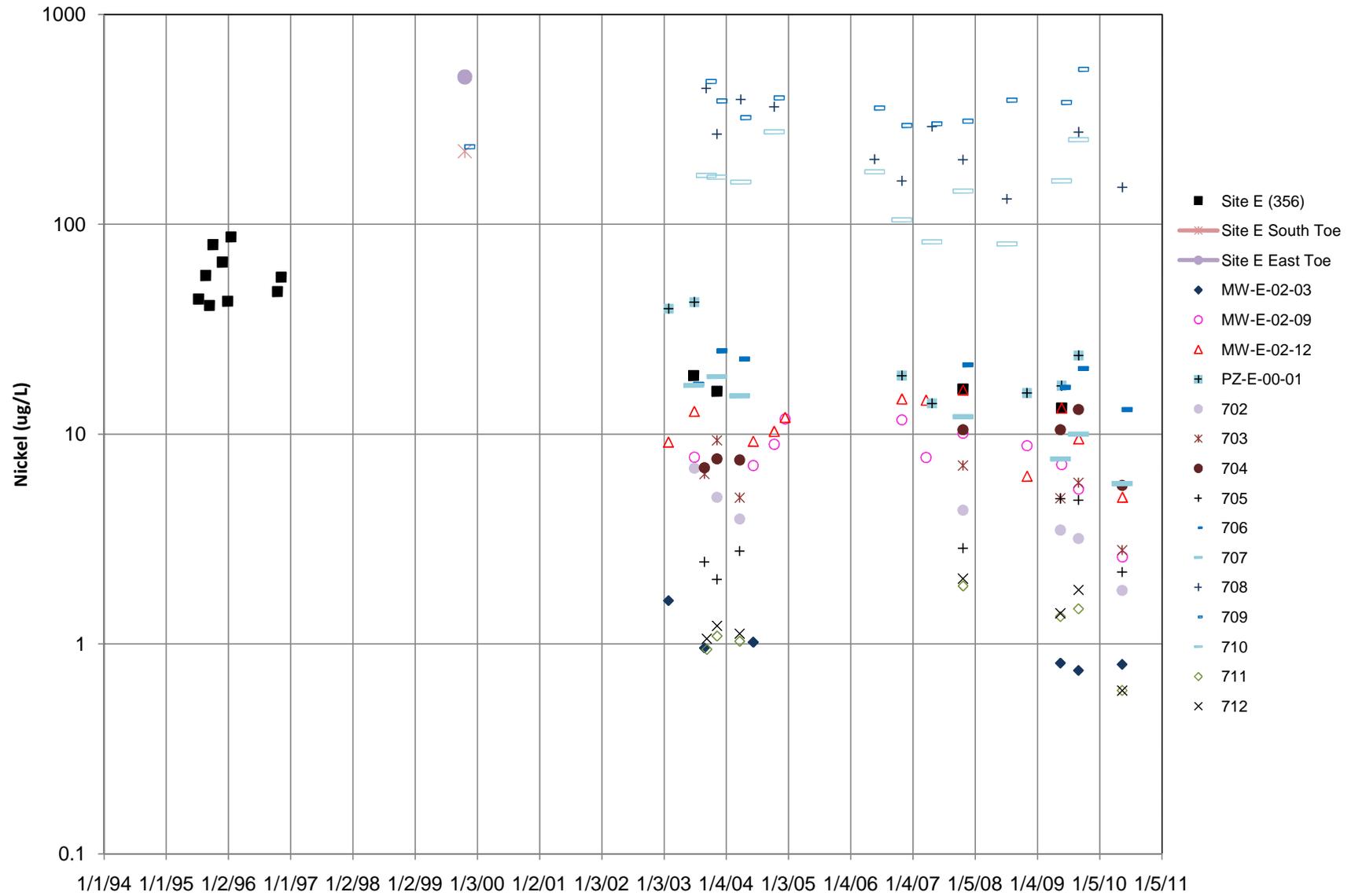
**Figure 2.30 Inactive Production Rock Site E Cadmium Data**

Non-detect results shown at 1/2 detection limit; Data area a composite of dissolved, total and total recoverable results



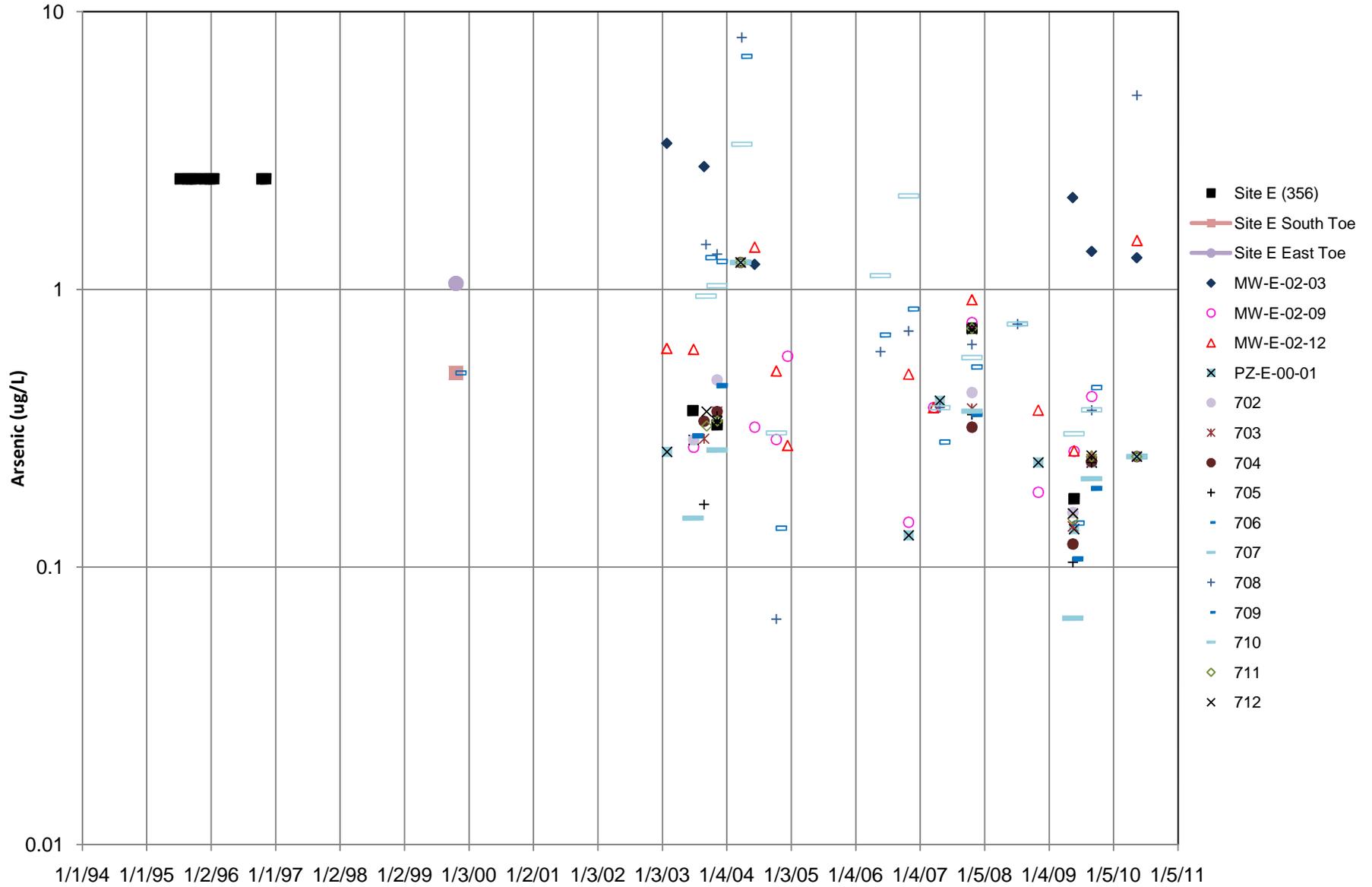
**Figure 2.31 Inactive Production Rock Site E Nickel Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



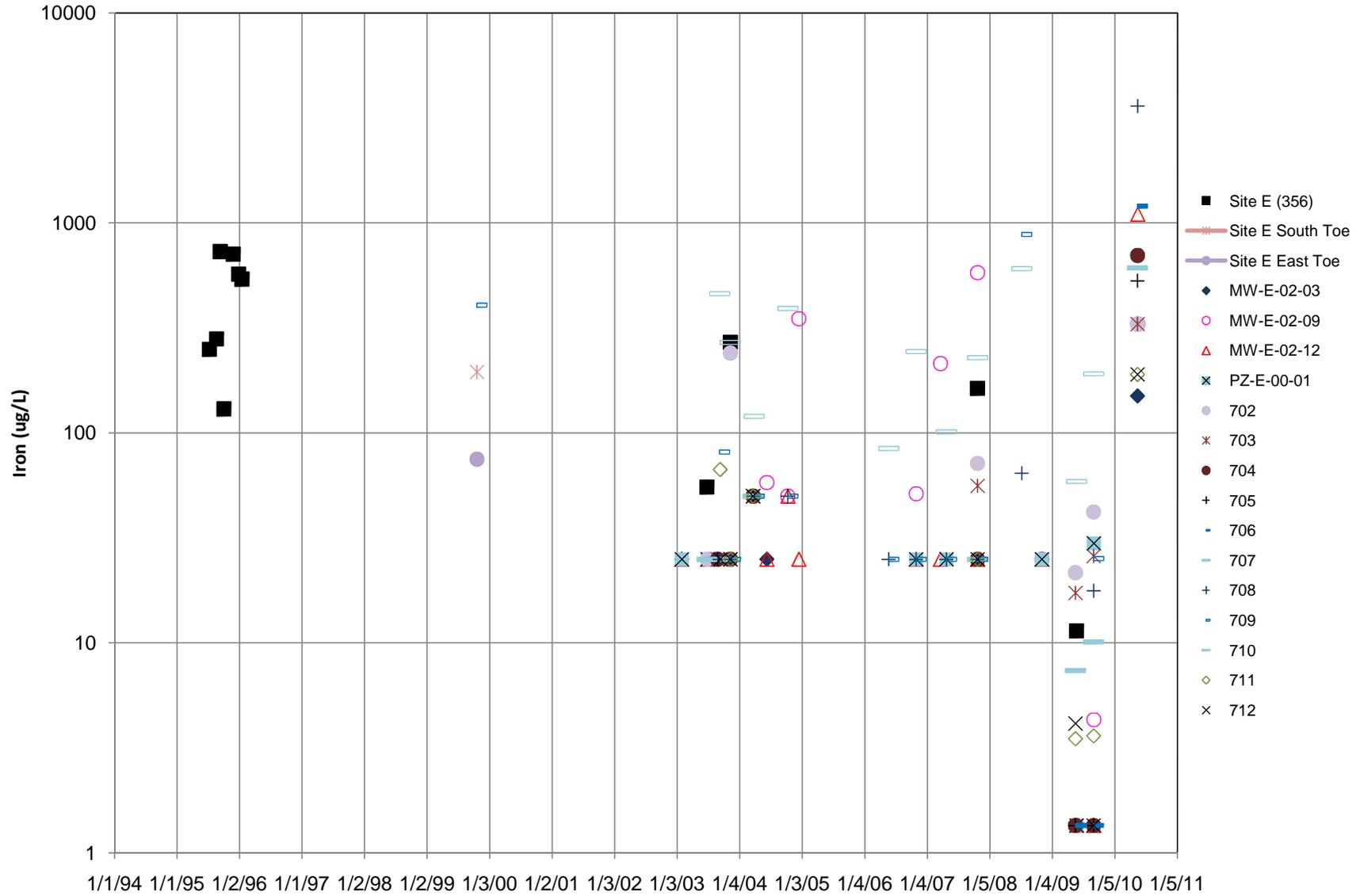
**Figure 2.32 Inactive Production Rock Site E Arsenic Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.33 Inactive Production Rock Site E Iron Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.34 Inactive Production Rock Site E Manganese Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

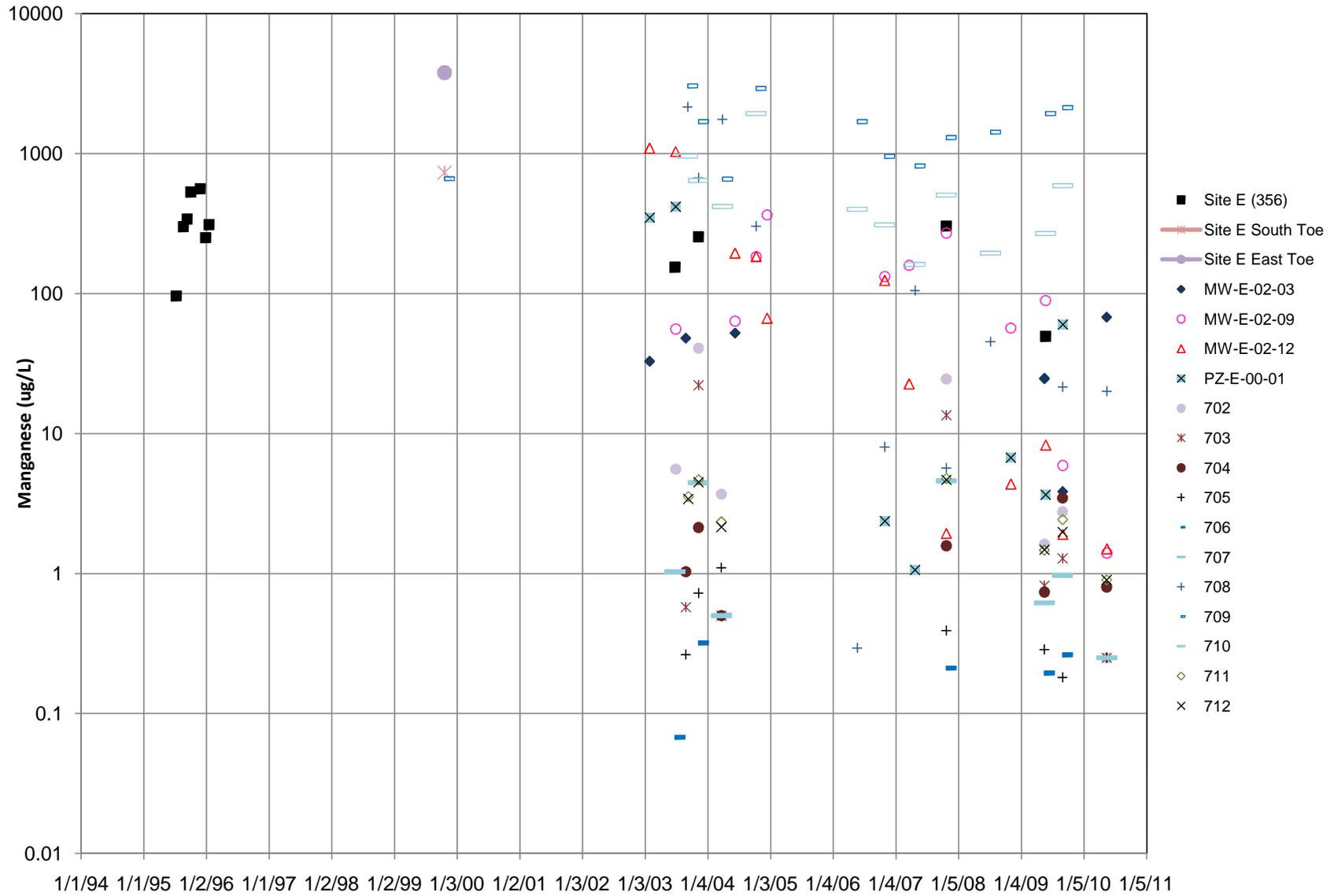




Figure 2.35 1350 Removal August 2010

Figure 3.1 Quarry Site Flow Data

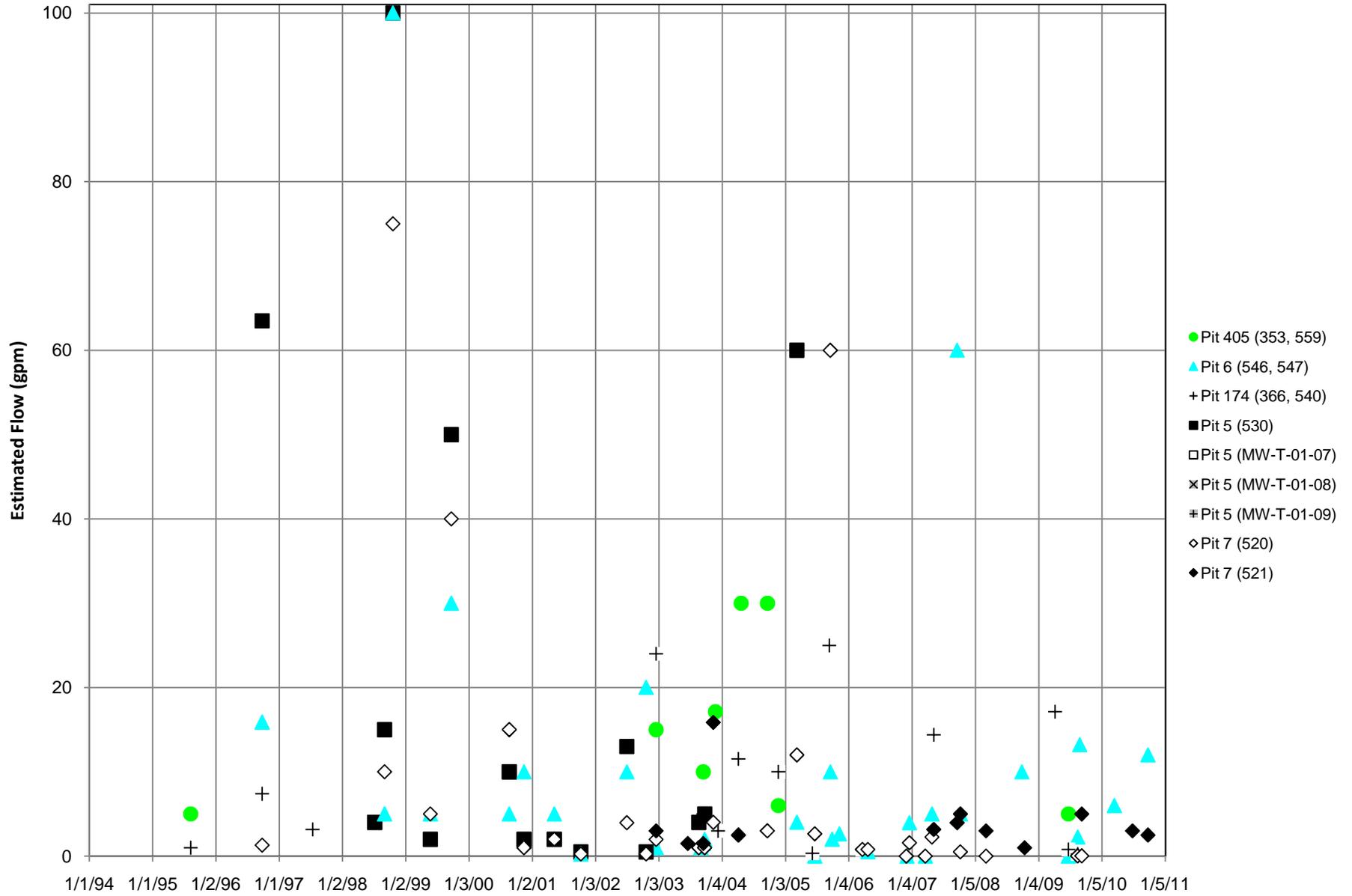
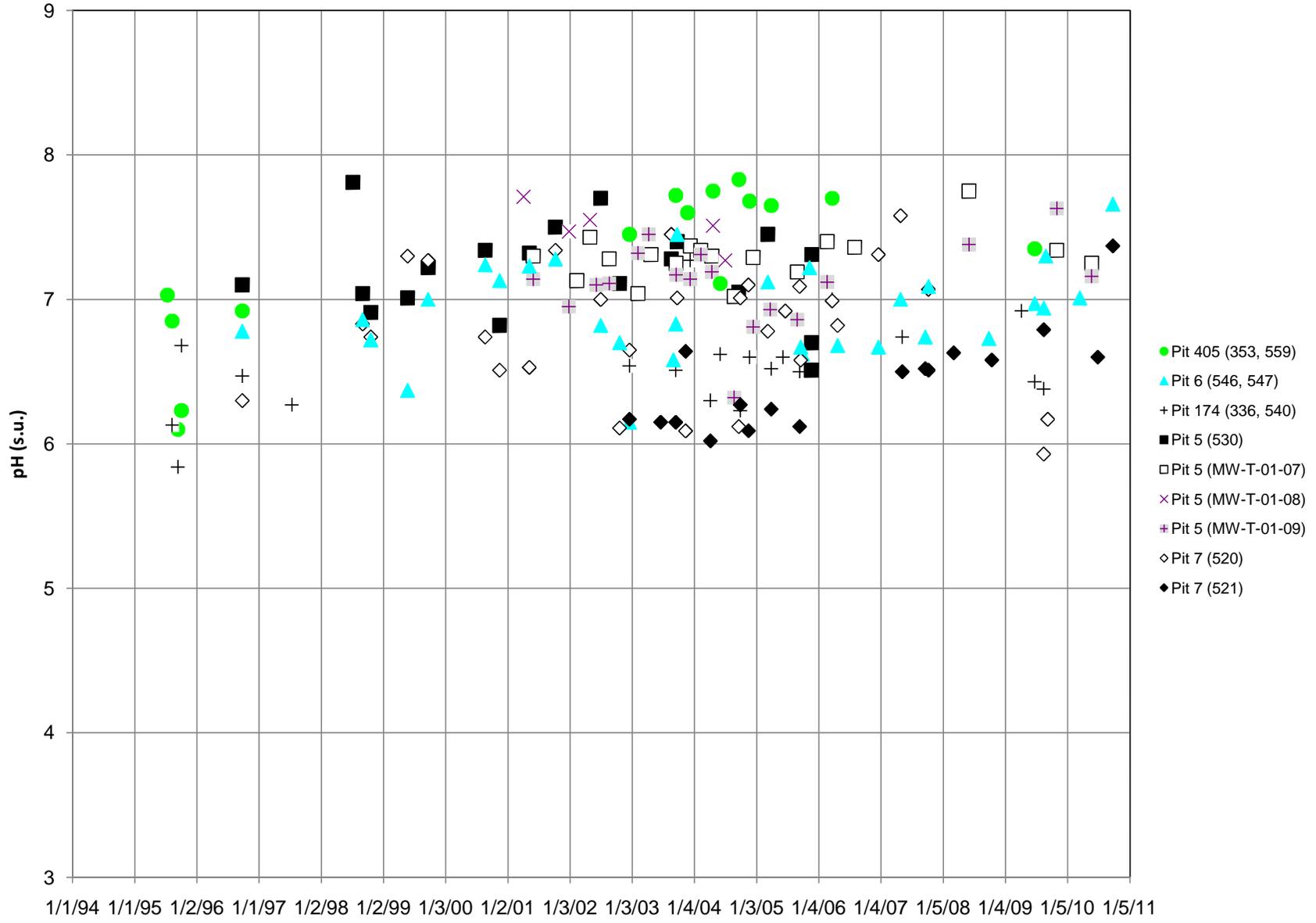


Figure 3.2 Quarry Site pH Data











**Figure 3.7 Quarry Site Hardness Data**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable

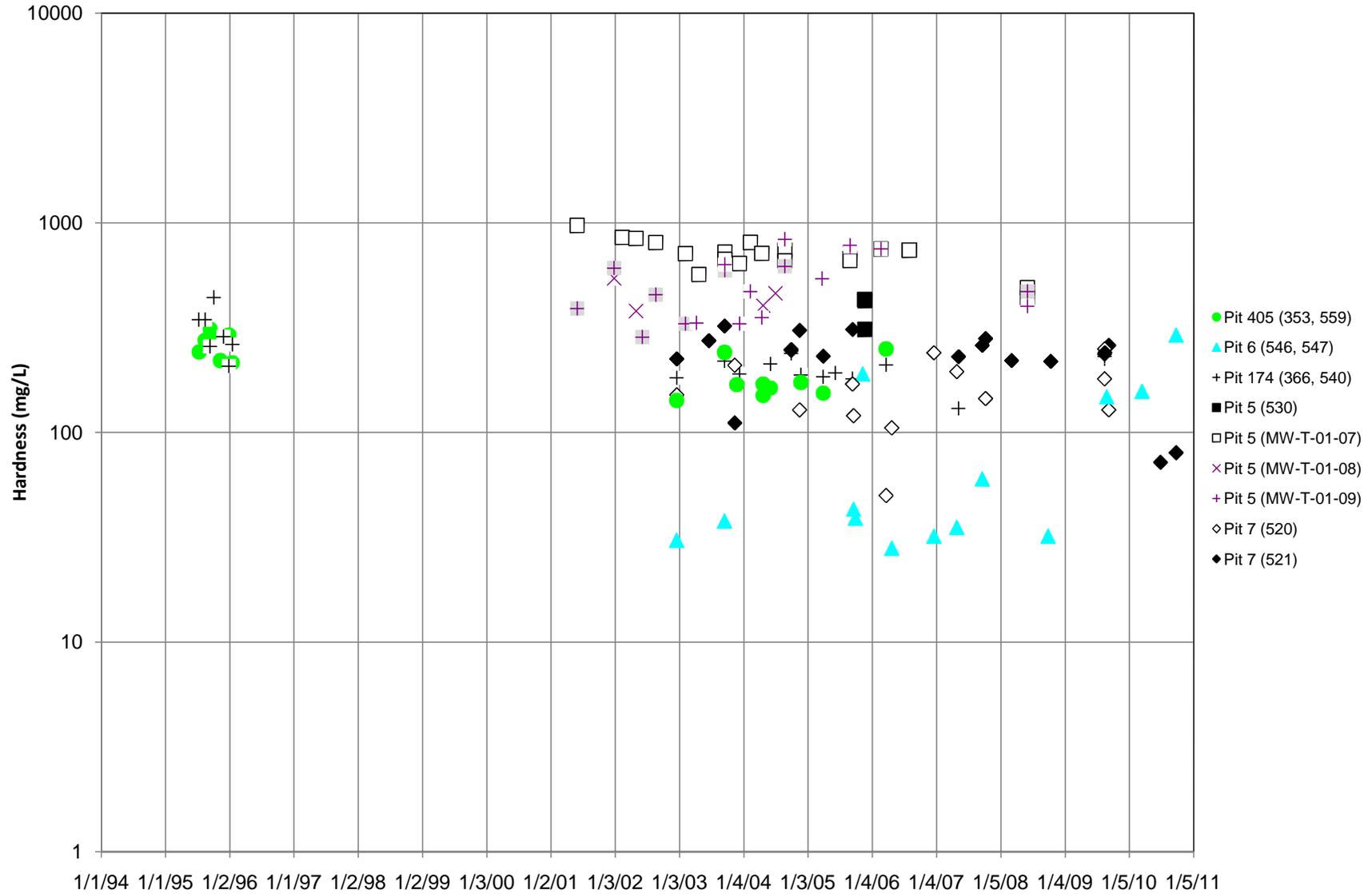


Figure 3.8 Quarry Site Zinc Data

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable

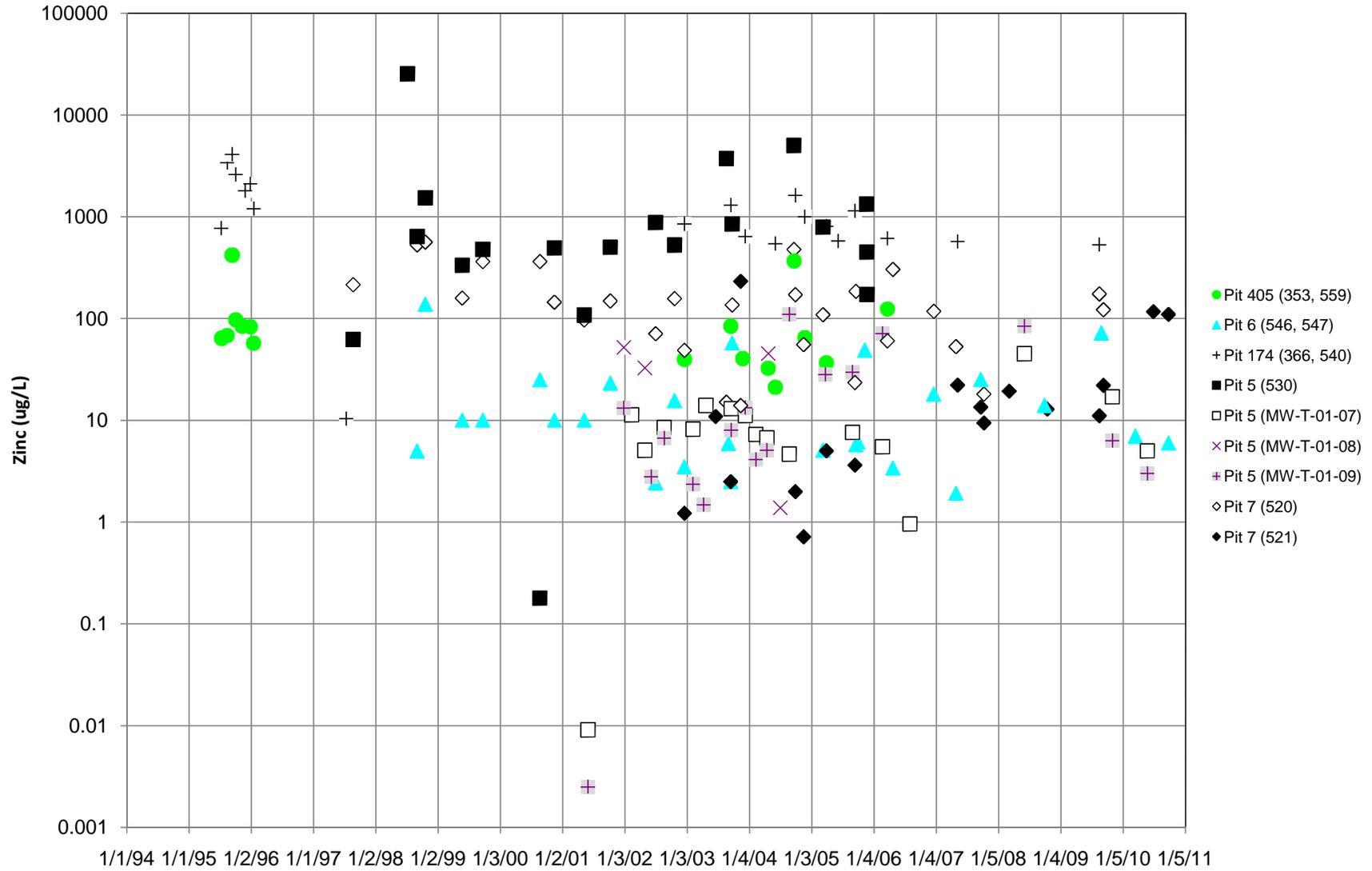
















FIGURE 3.16a 2002-2008 QUARRY SITE ABA DATA

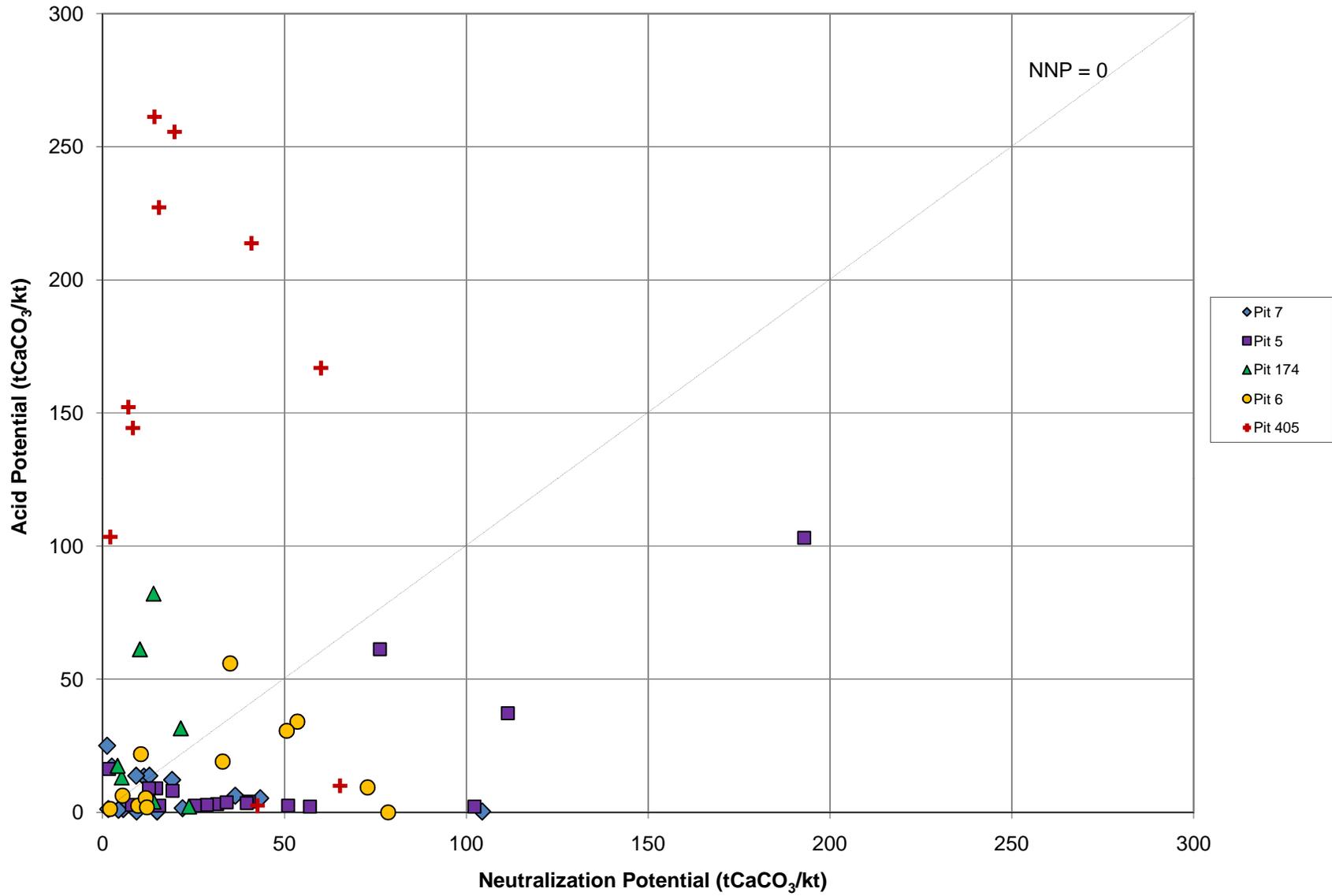


FIGURE 3.16b 2002-2008 QUARRY SITE ABA DATA (NNP vs pH)

