2005 Consent Decree Update
Water-Level Monitoring and Water-Quality Sampling
Butte Underground Mines and Berkeley Pit
Butte, Montana
1982 – 2005

Photo, by Dave Carter, Montana Tech

prepared for

The Montana Department of Environmental Quality
Remediation Division
and
U.S. Environmental Protection Agency
Region VIII

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Executive Summary

The Record of Decision and Consent Decree for the Butte Mine Flooding Operable Unit stipulates that a yearly update of data collected from the Post Remedial Investigation/Feasibility Study and Consent Decree monitoring program be prepared. The report is to incorporate the most recent year's data with the existing data. This report presents data collected during the year 2005, combined with data collected since 1982, when ARCO suspended underground mine dewatering and mining in the Berkeley Pit.

Major new observations and developments discussed in this report are:

1. July 25, 2005 earthquake affects East Camp bedrock water levels.

2. Influence of Montana Resources dewatering test in central zone on East Camp bedrock water levels. The test was conducted to determine the feasibility of future mining in this area.

3. West Camp pumping activities continue to maintain the ground-water level below the 5,435-foot elevation, stipulated in the 1994 Record of Decision. The volume of water pumped in 2005 was up about 1 percent from 2004 (257.8 vs. 254.7 acre-feet). Although more water was pumped during 2005, the water levels increased between 0.20 ft and 0.40 ft throughout the system.

4. The annual Berkeley Pit model was updated this year, taking into account the continued diversion of Horseshoe Bend drainage water away from the pit, discharge of sludge from the treatment plant into the pit, and the addition of storm water flow from the Butte Hill. The date projected in the 2004 report of December 2020 was modified to June 2021, <u>a change of 0.5 years</u>, when the 5,410-foot water-level elevation would be reached at the Anselmo Mine.

5. Water-quality changes seen in East Camp alluvial wells LP-9 and LP-17 continued. Well LP-9 was sampled once during 2005 and metal concentrations remain very elevated. Well LP-17 continues to show an increase in cadmium, copper and zinc. However, water-quality samples collected from bedrock well E, adjacent to well LP-9, failed to show any increase in metals.

6. Four new East Camp alluvial wells were installed the end of 2005, in accordance with the 2002 Consent Decree. These wells replaced the domestic wells that were part of the monitoring program from 1997 through 2002.

Water-level and water-quality data are presented in the same order and manner as the previous reports:

MBMG 376	Duaime, Metesh, Kerschen, Dunstan	1998
MBMG 410	Duaime, Metesh	2000
MBMG 435	Duaime, Metesh	2001
MBMG 456	Duaime, Metesh	2002
MBMG 473	Duaime, Metesh	2003
MBMG 489	Duaime, Metesh	2004
MBMG 518	Duaime, Metesh	2005
MBMG 527	Duaime, Metesh	2005

Hydrographs for <u>selected</u> sites and total and yearly water-level changes for all sites are presented. Water-quality data follow the presentation of water-level data in each section where water-quality data are available, as not all sites were sampled.

Monitoring and sampling activities performed during 2005 reflect the long-term program outlined in the 2002 Consent Decree. Therefore, some monitoring sites that were part of the early monitoring program have been deleted, while others have been added.

List of Acronyms used in text

AMC	Anaconda Mining Company
ARCO	Atlantic Richfield Company
BP/ARCO	British Petroleum/Atlantic Richfield Company
BMFOU	Butte Mine Flooding Operable Unit
CD	Consent Decree
CWL	Critical Water Level
DEQ	Montana Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
HSB	Horseshoe Bend
HSB Falls	Horseshoe Bend Falls
MBMG	Montana Bureau of Mines and Geology
MCL	Maximum Contaminant Level
MR	Montana Resources
MSD	Metro Storm Drain
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SMCL	Secondary Maximum Contaminant Level

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SECTION 1.0 SITE BACKGROUND

Underground mining in Butte began in the 1870's with the development of silver mines, i.e. the Alice and Lexington mines. However, by the late 1800's copper became the primary mineral of interest. Over the years other mines were developed for the production of manganese and zinc; these mines included the Anselmo and Emma. As mining expanded and mines deepened, the handling of groundwater became a major concern. The Anaconda Copper Mining Company, which would eventually control almost all of the underground mining in Butte, began interconnecting selected mine levels in an effort to establish a common mine level for draining water to a central pump station as early as 1901. Water was drained to these common levels through a combination of stopes, drifts, or diamond-drill drainage holes. The collected water was then routed to a central pump station where it was pumped to the surface. One of the earliest pump stations was located on the 2800 level of the High Ore Mine (fig. 1-1a); the station was lowered to the 3900 level (fig. 1-1b) and then eventually moved to the Kelley Mine. The water, which was acidic and contained substantial concentrations of copper and other trace metals, was used in the leach pad and precipitation plant operations where copper was removed from the water.

The Anaconda Company, looking for ways to reduce operating costs as ore grades lessened as the mines deepened, began open-pit mining in the Berkeley Pit in July 1955. As open-pit mining expanded, it consumed some of the primary underground mines, i.e. the Leonard, St. Lawrence, Anaconda, and High Ore mines and the emphasis on underground mining was reduced. Mines in the zinc, silver, and manganese zones were eventually closed and sealed off from the remainder of the Butte Hill. Active underground mining continued until 1976 in the Kelley and Steward Mines; however, the Anaconda Company continued to operate the underground pumping system, which not only kept the mines dewatered, but also did the same for the Berkeley Pit.

When the Anaconda Company announced on April 23, 1982, that they were no longer going to operate their underground mine pump system, the Kelley pump station was removing up to 5,000 gallons per minute (gpm) of water. This cessation of pumping allowed the Butte underground mines and, ultimately the Berkeley Pit, to begin filling with water. Allowing water in the underground mines to rise resulted in a corresponding rise in water levels in the bedrock adjacent to the mines. Other contaminated surface waters from mine operations, i.e. precipitation plant operations, were diverted into the Berkeley Pit during 1982-1983. Water levels rose over 1300 ft the remainder of 1982 and over 800 ft in 1983 in the underground mines.

The full nature of the influence that historic mine dewatering had on the local ground-water system was not well documented, thus a comprehensive water-level and water-quality monitoring network was established. Concerns about the site's long-term environmental impact on ground water and surface water led to the site being listed on the Federal EPA Superfund list. Current monitoring is the result of this listing and settlement agreements.

The Butte Mine Flooding Operable Unit (BMFOU) Remedial Investigation/Feasibility Study (RI/FS) began in 1990 and resulted in the 1994 Record of Decision (ROD) (EPA, 1994). The ROD included provisions for: 1) continued monitoring and sampling of both ground water and surface water, 2) diversion of the Horseshoe Bend Drainage (HSB) water away from the Berkeley Pit (to slow the pit filling rate), 3) incorporation of the HSB water in the Montana Resources (MR) mining operations for treatment, 4) construction of a water treatment plant if changes in mining operations prevent treatment of HSB water (e.g. mine shutdown), and 5) establishment of a maximum level to which water in the underground mines and Berkeley Pit can rise, before a water treatment plant must be built and in operation.

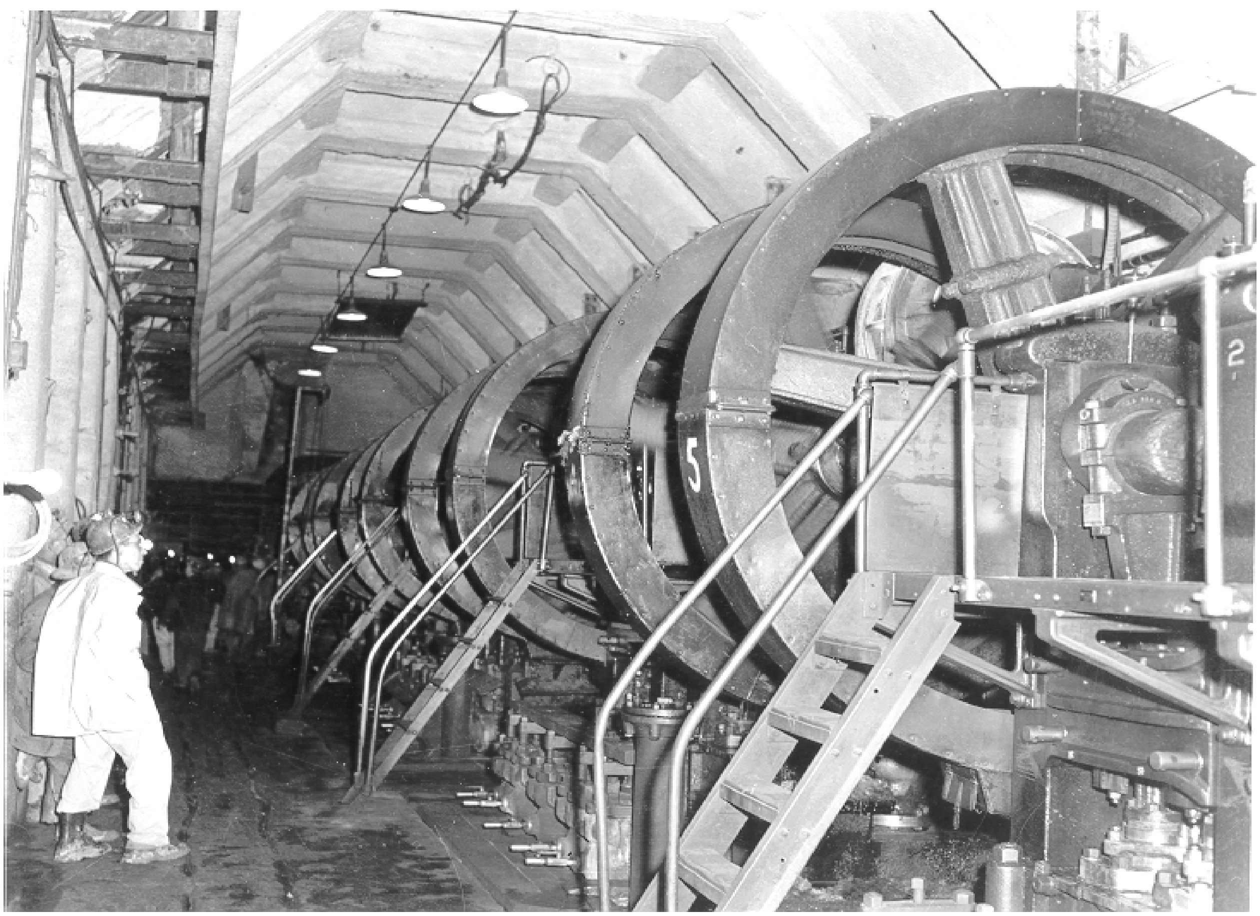

Figure 1-1a. High Ore Mine pump station located on the 2800 level. (Photo courtesy of the World Museum of Mining.)

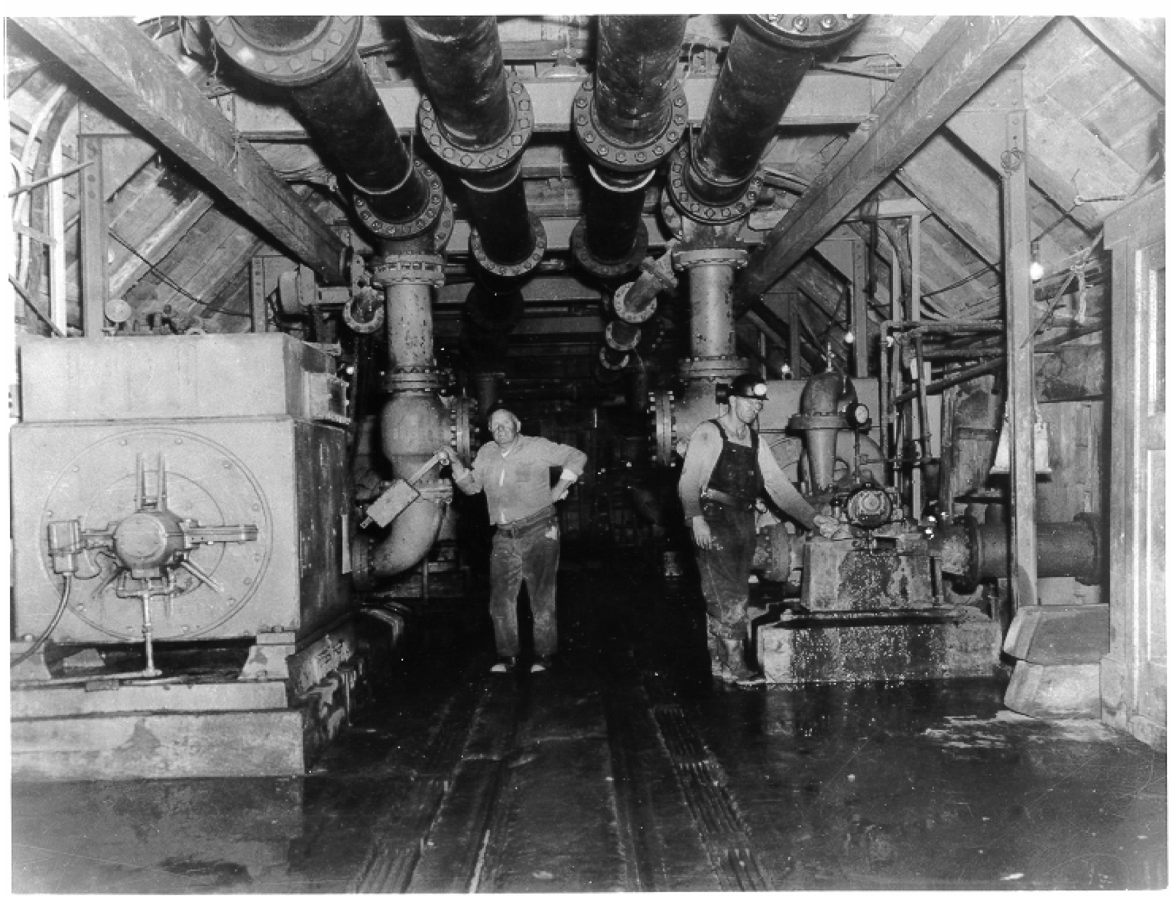

Figure 1-1b. High Ore Mine pump station located on the 3900 level. (Photo courtesy of the World Museum of Mining.)

The U.S. Environmental Protection Agency (EPA) and Montana Department of Environmental Quality (DEQ) began Consent Decree (CD) negotiations with British Petroleum/Atlantic Richfield Company (BP/ARCO) and the Montana Resources Group in the fall of 2001 with an agreement approved by the U.S. District Court in August 2002. The CD addressed all current and future activities relating to the BMFOU and reimbursed EPA and DEQ for past costs associated with the site. Funding for the continuation of the long-term ground-water, surface-water, and Berkeley Pit/Continental Pit monitoring were included in the CD. The monitoring performed by the Montana Bureau of Mines and Geology (MBMG) is under the direction of DEQ and EPA. BP/ARCO and the Montana Resources Group agreed in the CD to be responsible for all costs associated with the design, construction, operation, and maintenance of a water-treatment plant for treating HSB, Berkeley Pit, and other contaminated waters associated with the site. (Refer to the CD and the Explanation of Significant Differences to see the entire scope of activities addressed in the CD and an explanation of differences from items contained in the 1994 ROD.)

Section 1.1 Introduction

The BMFOU 1994 ROD and subsequent 2002 CD specify that an annual review of water levels and water quality shall be performed. The first water-level review was completed in 1998 as a 15-year evaluation, from the beginning of flooding of the Butte underground mines and Berkeley Pit in 1982 through 1997 (Duaime et al, 1998); the present study is the ninth such report. Notable changes and a comparison of trends for water levels and water quality are discussed.

This report does not present a detailed overview of the history of mining on the Butte Hill, nor the Superfund processes that have followed since the EPA designated the flooding underground Butte Mines and Berkeley Pit a Superfund site in 1987. The reader is referred to the Butte Mine Flooding RI/FS, Butte Mine Flooding ROD, Butte Mine Flooding CD, and MBMG Open-File Report No. 376 for greater detail and information about the site.

Monitoring activities continued in 2005 in the East Camp, West Camp and Outer Camp systems (fig. 1-2). The East Camp System includes mines and mine workings draining to the Kelley Mine pump station when mining and dewatering were suspended in 1982. The West Camp System includes mines and underground workings that historically drained to the East Camp from the southwest portion of the Butte mining district, but were hydraulically isolated by the placement of bulkheads within the interconnected mine workings to separate the West Camp from the East Camp. The Outer Camp System consists of the western and northern extent of mine workings that were connected to the East Camp at some time, but were isolated many decades ago, with water levels returning to, or near, pre-mining conditions. By the time water levels in the underground mines reached the elevation of the bottom of the Berkeley Pit in late November 1983, more than 66 percent of the underground workings had already been flooded. More than 80 percent of the underground mine workings have been inundated with water through 2005.

Section 1.2 Notable 2005 Activities and Water-Level and Water-Quality Observations

The main activities and observations for 2005 are listed below:

(1) Montana Resources' (MR) continued mining and milling operations throughout 2005 following their November 2003 resumption of mining.

(2) A magnitude 5.6 earthquake occurred on July 25, 2005, affecting water-levels in several East Camp bedrock wells.

(3) MR conducted a limited pumping test in the vicinity of the old Pittsmont Mine workings to evaluate dewatering options for future mining plans.

(4) East Camp alluvial wells LP-9 and LP-17 continue to show increases in metal concentrations from previous levels.

(5) Four new East Camp alluvial wells were installed to supplement the existing network.

(6) West Camp pumping rates were slightly higher than previous years, however, water-level increases were observed in West Camp mines.

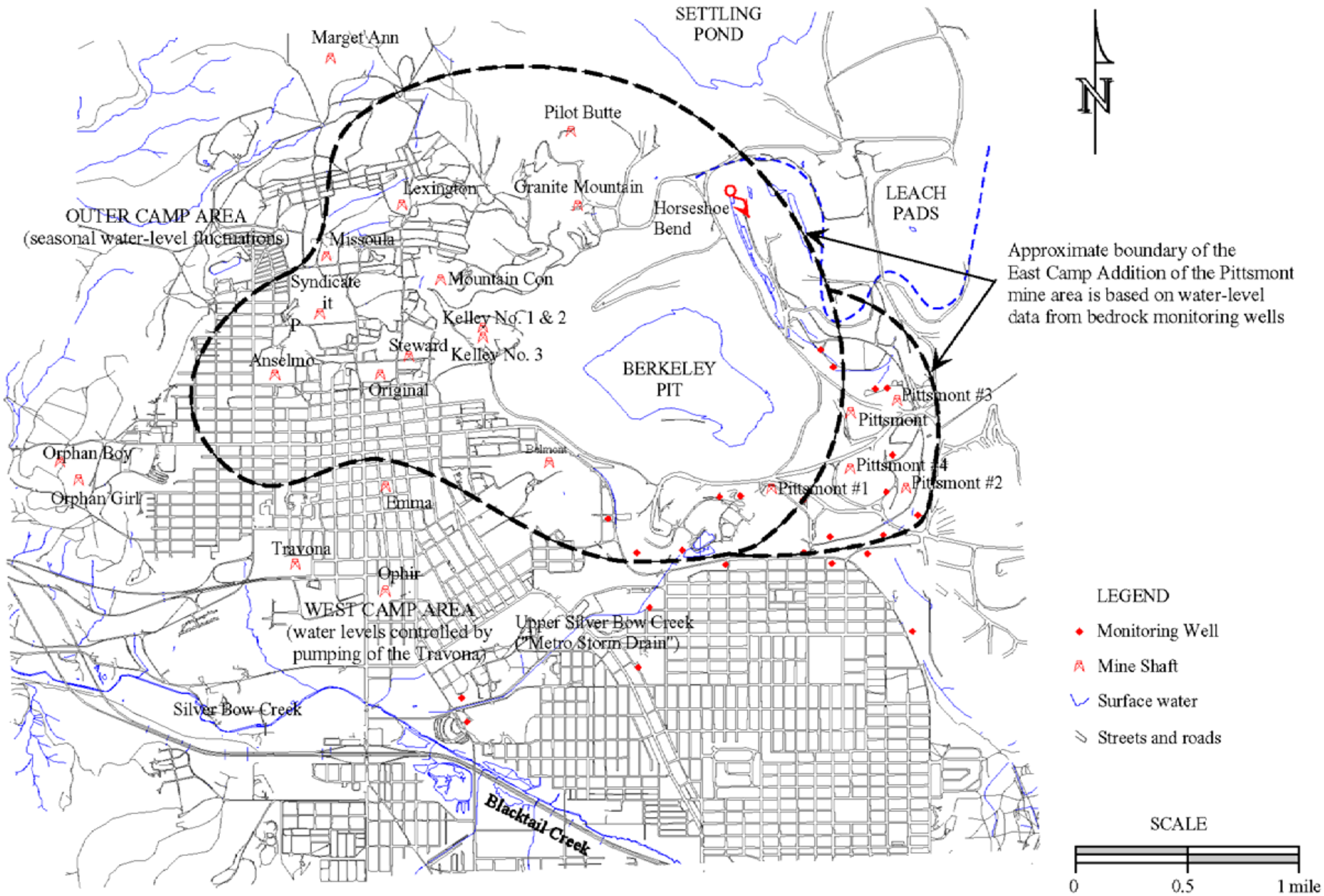

Figure 1-2. The mines of the Butte hill are presently considered in three groups: the East Camp, which includes the Berkeley Pit and the area east; the West Camp in the southwest part of the hill; and the Outer Camp which includes the outlying mines.

Section 1.3 Precipitation Trends

Precipitation during 2005 exceeded the long-term average for the first time in seven years. Total precipitation was 13.24 inches compared to the 2004 total of 10.87 inches. The 2005 precipitation total was an increase of almost four percent above the long-term average of 12.74 inches. Table 1.3.1 contains monthly precipitation statistics from 1982 through 2005, while figure 1-3 shows this information graphically in comparison to the long-term yearly average. Overall precipitation totals, since flooding of the mines began, are very similar to the long-term average (12.62 inches vs. 12.74 inches). Figure 1-4 shows departure from normal precipitation from 1895 through 2005.

Table 1.3.1 Butte NOAA Precipitation Statistics, 1982-2005.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Mean	0.51	0.47	0.80	1.06	1.95	2.16	1.49	1.37	0.98	0.70	0.62	0.54	12.65
Std. Dev.	0.36	0.29	0.40	0.63	0.76	1.26	1.16	0.87	0.67	0.52	0.40	0.40	3.17
Maximum	1.40	1.26	1.84	2.57	3.88	4.62	4.18	3.10	2.50	1.73	1.50	1.99	19.96
Minimum	0.10	0.11	0.18	0.00	0.89	0.50	0.00	0.15	0.07	0.00	0.07	0.11	8.32
Number of years precipitation greater than mean													7.00
Number of years precipitation less than mean													17.00

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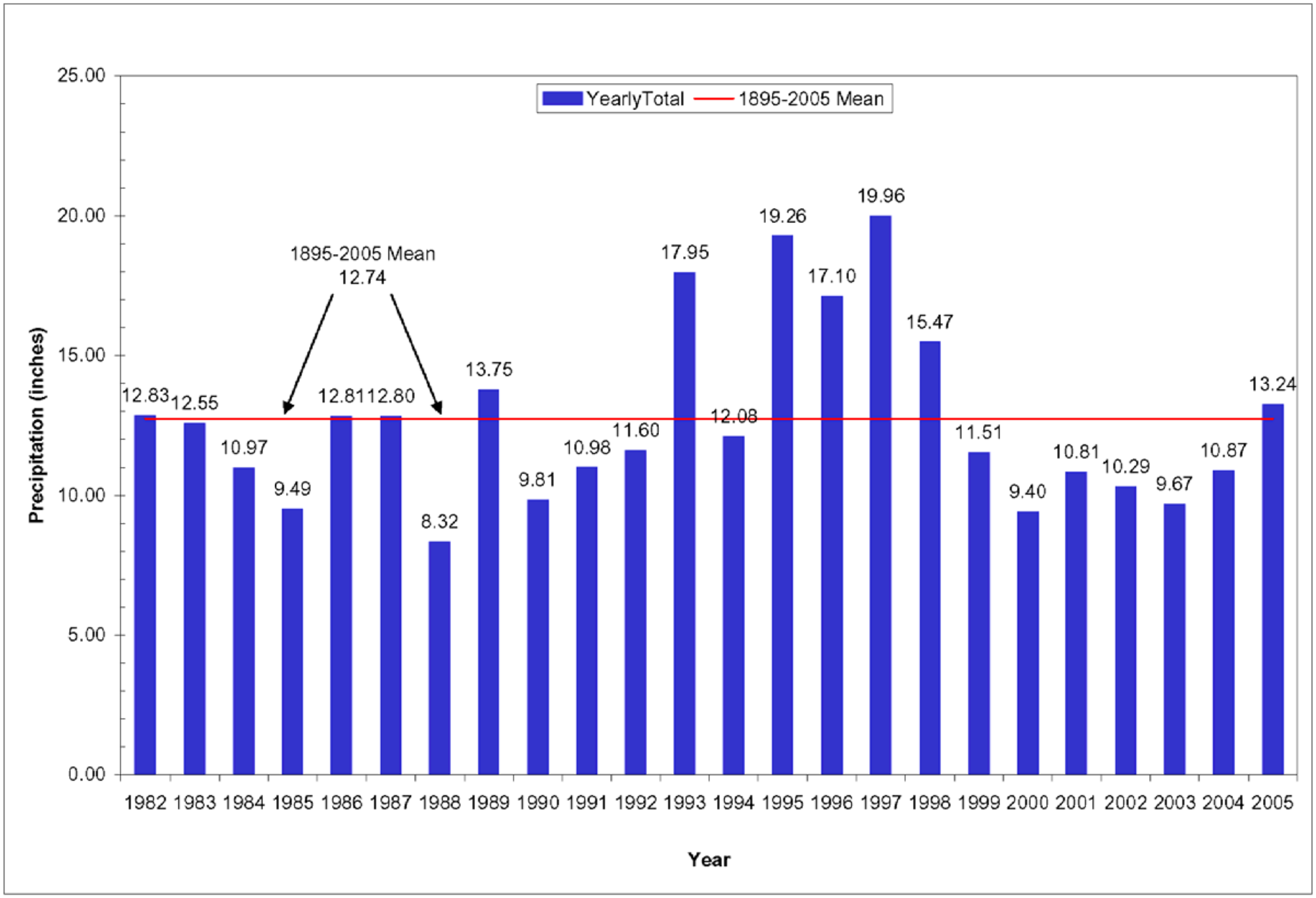

Figure 1-3. Yearly precipitation totals, 1982-2005, showing 1895-2005 mean.

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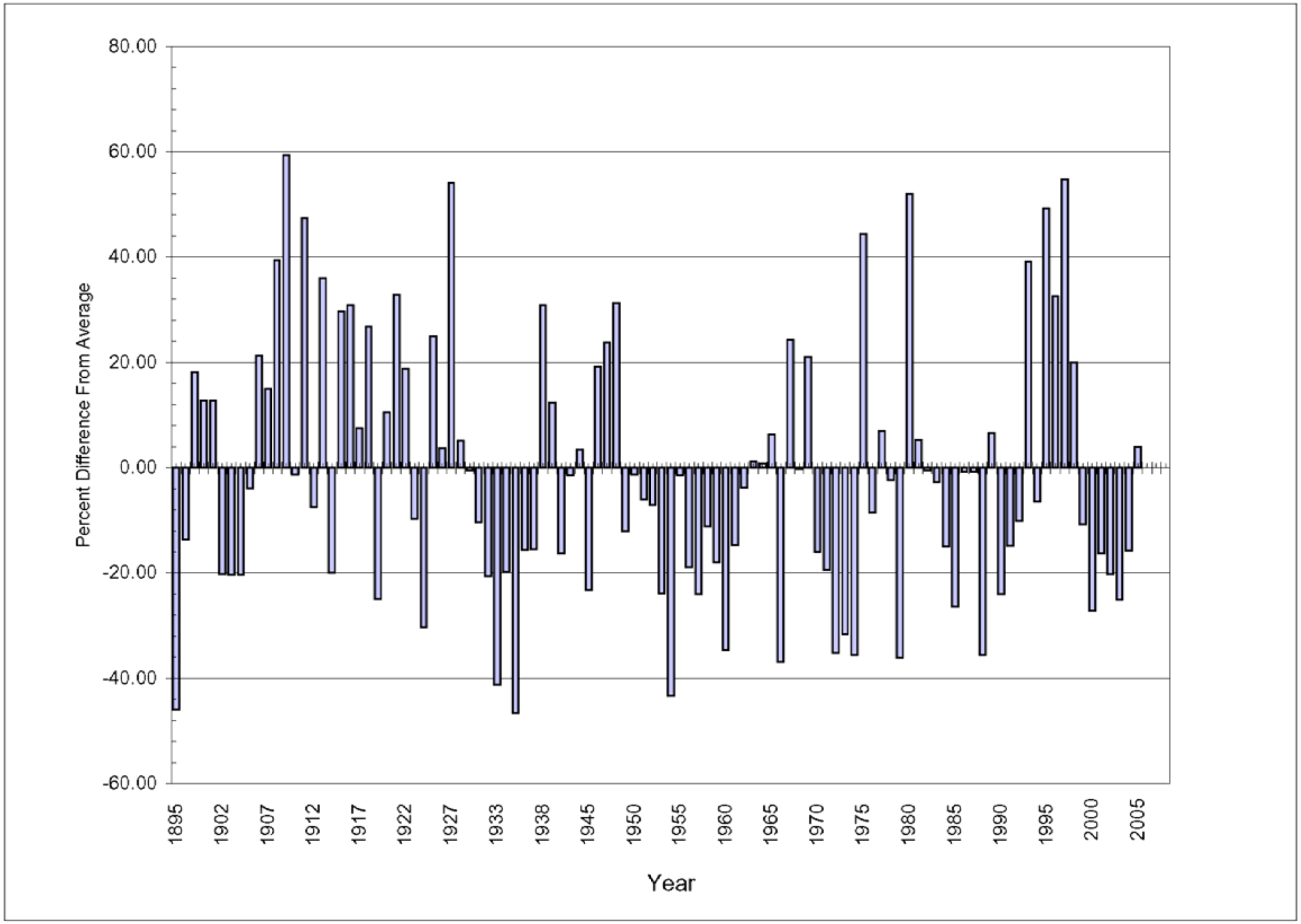

Figure 1-4. Percent precipitation variation from normal, 1895-2005

SECTION 2.0 EAST CAMP SYSTEM

The East Camp is comprised of that portion of the bedrock aquifer affected by underground mine dewatering in 1982 and the overlying shallow alluvial aquifer (fig. 2-1). The East Camp Bedrock Monitoring System consists of the Anselmo, Belmont, Granite Mountain, Kelley, Steward, Lexington and Pilot Butte Mines, and the Berkeley Pit. It also includes the bedrock system adjacent to the East Camp mines and the shallow East Camp alluvial system. The East Camp alluvial system is discussed first, followed by the East Camp bedrock system.

Section 2.1 East Camp Alluvial System

The East Camp alluvial monitoring system consists of a series of different groups of wells. Each group of wells represents sites installed or monitored during different studies that have been incorporated in the BMFOU-CD monitoring program. Water-level changes and monthly precipitation amounts are shown on hydrographs for selected wells. Water-quality results are shown and discussed for the wells sampled. Unlike the water-level monitoring program, water-quality sampling does not occur at every East Camp monitoring well and takes place only once or twice per year.

Four new alluvial monitoring wells were installed within the East Camp system during the later part of 2005. These wells were stipulated in the 2002 Consent Decree as a replacement for the domestic wells that were monitored from 1997 through 2002. The installation of dedicated monitoring wells enables the collection of more reliable water level data. The wells were situated in areas where data gaps existed and were equipped with transducers for increased water level data collection. The new wells are identified as BMF05 series and will be discussed with the GS series wells.

Water-level conditions and water-quality characteristics vary throughout the alluvial system. Wells within or adjacent to historic mining activities show trends relating to the influence of those activities. Sites outside historic mining areas reflect conditions more typical of the regional hydrogeology.

Section 2.1.1 AMC-Series Wells

The locations of the Anaconda Mining Company (AMC) wells are shown on figure 2-2; table 2.1.1.1 lists the annual water-level changes for these sites.

Water levels declined in all the AMC series wells for 2005, which is in contrast to the water-level increases observed in a number of these wells during 2003 and 2004. In the last two reports it was speculated that the water level changes noted specifically in wells AMC-6 and AMC-8 were related to the resumption of mining by MR; however, the exact relationship between water-level increases and start-up activities was not well defined. Whatever the activities were that led to the water level increases, water levels appear to have reached a state of equilibrium where climatic and regional water level changes had a greater influence on changes.

Table 2.1.1.1 AMC-series wells, annual water-level changes, in feet

Year	AMC-5	AMC-6	AMC-8	AMC-10	AMC-12	AMC-13	AMC-15
1983	-23.75	-2.30	-4.90	DRY	0.20	0.60	-5.80
1984	-4.50	-2.55	-3.75	DRY	-1.80	-1.10	-3.40
1985	-3.40	-3.90	-3.00	DRY	-2.45	-1.85	-2.80
1986	8.70	3.90	-0.90	DRY	1.90	1.00	-2.10
1987	0.10	0.40	1.50	DRY	0.60	0.10	0.00
1988	0.20	-0.40	0.30	DRY	-0.10	-1.00	0.80
1989	-2.30	-0.80	-0.90	DRY	-0.20	-0.10	0.10
1990	0.20	0.10	0.30	DRY	1.10	0.00	-0.10
1991	0.00	0.30	0.80	DRY	-0.60	0.30	-0.30
1992	0.40	-0.40	0.50	DRY	-0.30	0.00	-0.10
1993	0.40	0.70	0.80	DRY	1.10	1.00	-0.40
1994	0.64	0.53	0.91	DRY	-0.19	-0.50	0.96
1995	0.64	1.01	0.51	DRY	1.23	1.13	0.97
1996	-0.05	0.62	2.14	DRY	0.74	0.69	2.60
1997	1.80	1.47	2.24	DRY	1.20	0.70	2.80
1998	-1.52	0.42	1.15	DRY	0.18	0.09	0.58
1999	-1.56	-2.03	-2.45	DRY	-1.56	-1.09	-1.50
2000	-2.46	-2.56	-3.88	DRY	-1.77	-1.17	-3.73
2001	-1.89	-1.92	-3.03	DRY	-0.55	-0.36	-2.34
2002	-0.89	-1.25	-1.77	DRY	-0.98	-0.73	-1.65
2003	6.97	3.50	0.97	DRY	0.53	0.03	0.37
2004	-1.13	0.13	1.42	DRY	-0.37	-0.42	0.43
2005	-1.68	-1.06	-0.45	DRY	-0.51	-0.22	-0.76
Net Change	***-25.08***	***-6.09***	***-11.49***	***0.00***	***-2.60***	***-2.90***	***-15.37***

Well AMC-5 exhibited the greatest water-level increase following MR's resumption of mining in 2003 and has had the largest amount of decline since then. This well is located just north of the Emergency Pond in the west corner of the concentrator yard. This pond received considerable inputs of fresh water prior to MR's start-up in the fall of 2003. The water-level trend for 2003-2005 shown on figure 2-3 for this well is very similar to the trend seen in 1986-1987, which coincides with the start-up of mining following ARCO's 1983 suspension of mining. It is apparent that filling the Emergency Pond with make-up water for milling operations has a considerable influence on alluvial water levels in the immediate area. The water level in well AMC-5 did not show any influence from precipitation events in 2005.

Whereas well AMC-5 is located within the active mine area, wells AMC-6, and AMC-8 are located south of the active mine area and the Butte Concentrator facility (fig. 2-2). Well AMC-12 is located southwest of these wells. Hydrographs for wells AMC-12 (fig. 2-3) and AMC-6 and AMC-8 (fig. 2-4) show the long-term trends in the shallow alluvial ground-water system south of the pit. Monthly precipitation amounts are shown as bars and are plotted on the right-hand y-axis.

Well AMC-6 is directly south of the concentrator facility and the Emergency Pond. Water-level trends during 2003-2004 were similar to those seen in 1986-1987 following the resumption of mining. However, water levels in 2005 appear to be less influenced by water levels in the Emergency Pond.

Water levels in this well continued their strong downward trend that began the fall of 2004 through the summer of 2005. Beginning late-summer minor water-level increases occurred which might be in response to precipitation events (fig 2-4).

The water-level trend in well AMC-8 (fig2-4) was very similar to the 1986-1988 time periods, with water-levels declining following a period of increase associated with the resumption of mining. While water levels had a net decline for 2005 there was a slight increase during the late fall-early winter that might have been in response to precipitation events.

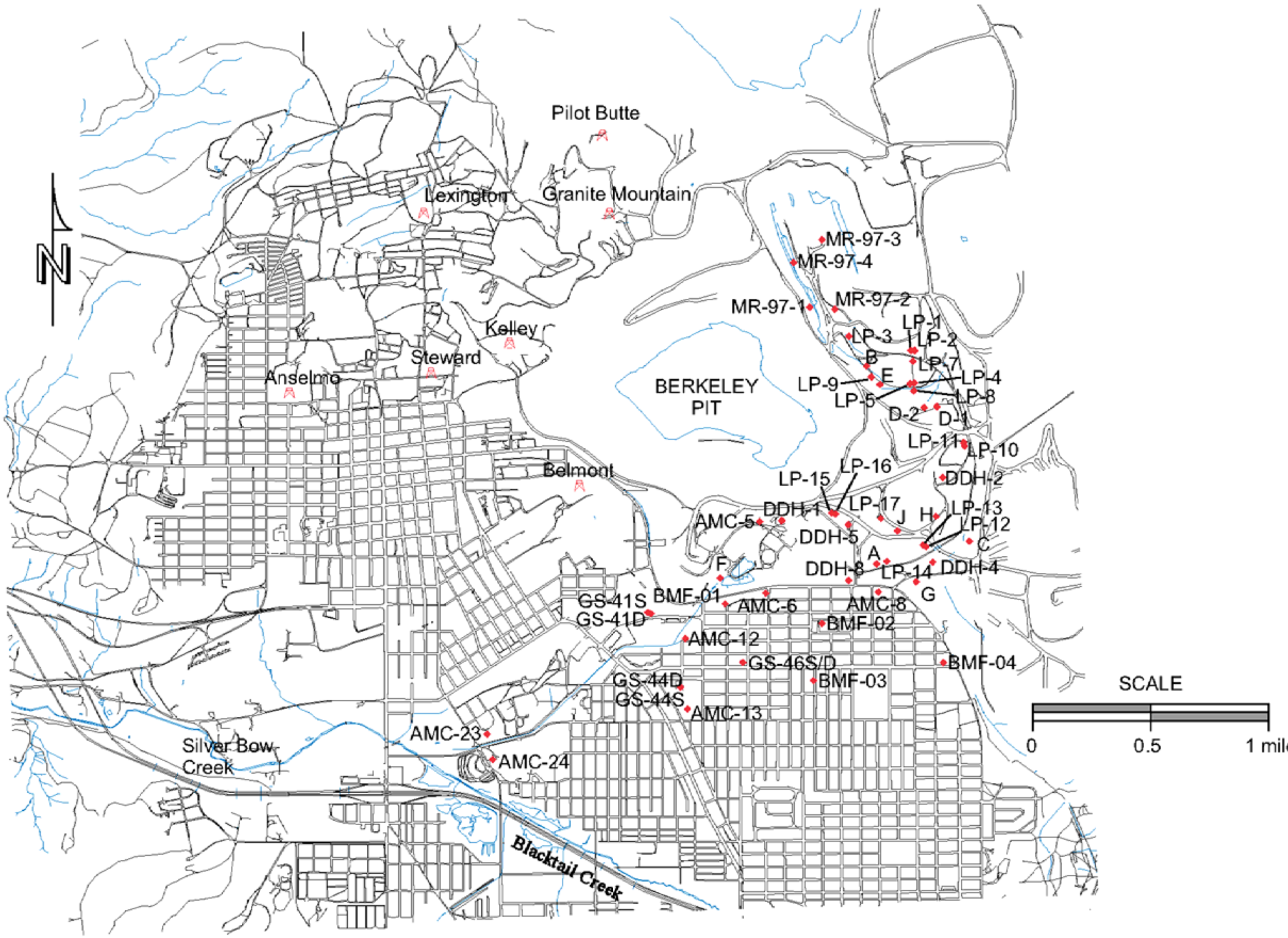

Figure 2-1. East Camp Monitoring Sites.

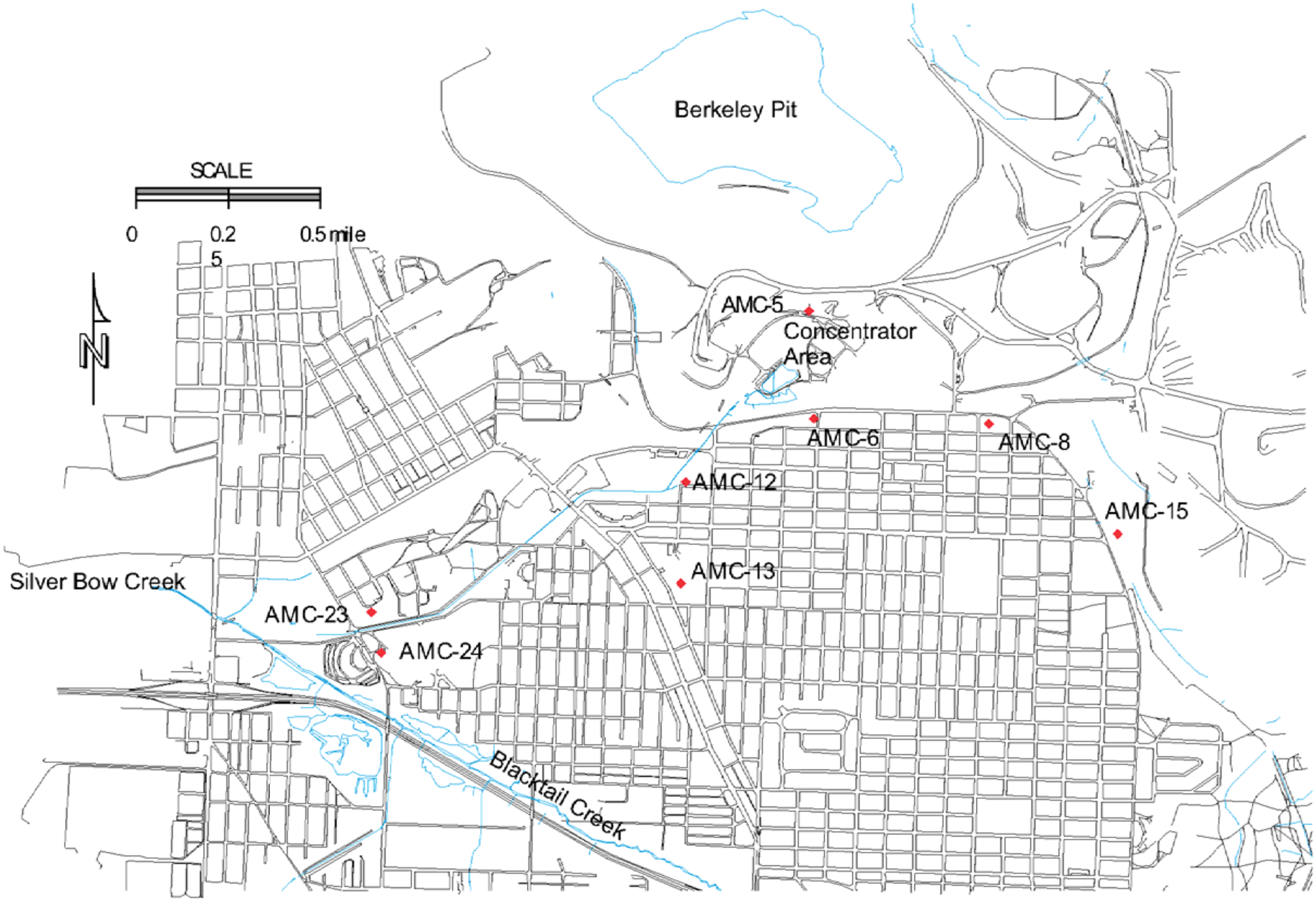

Figure 2-2. AMC well location map.

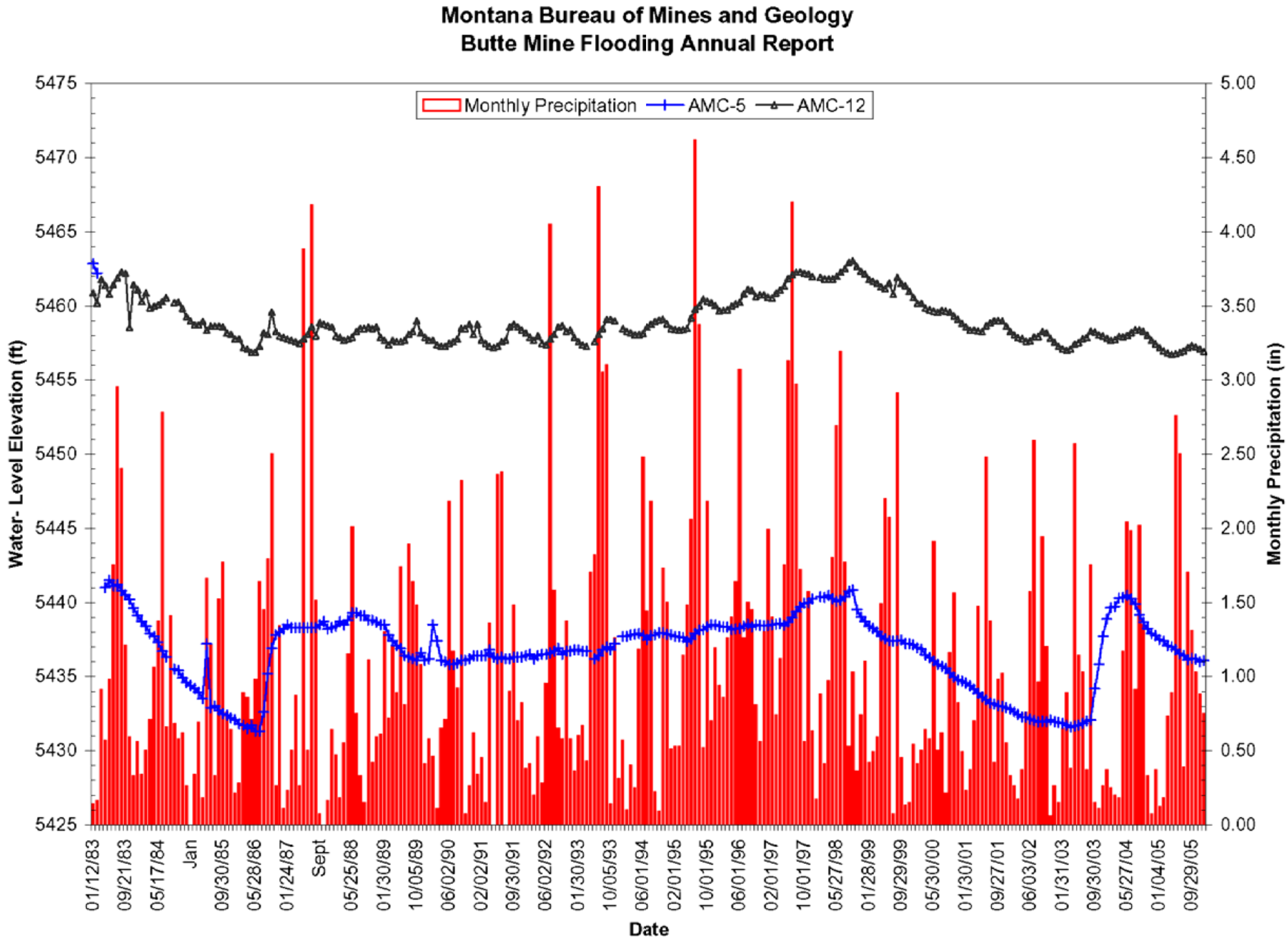

Figure 2-3. Water-level hydrographs for AMC-5 and AMC-12 wells.

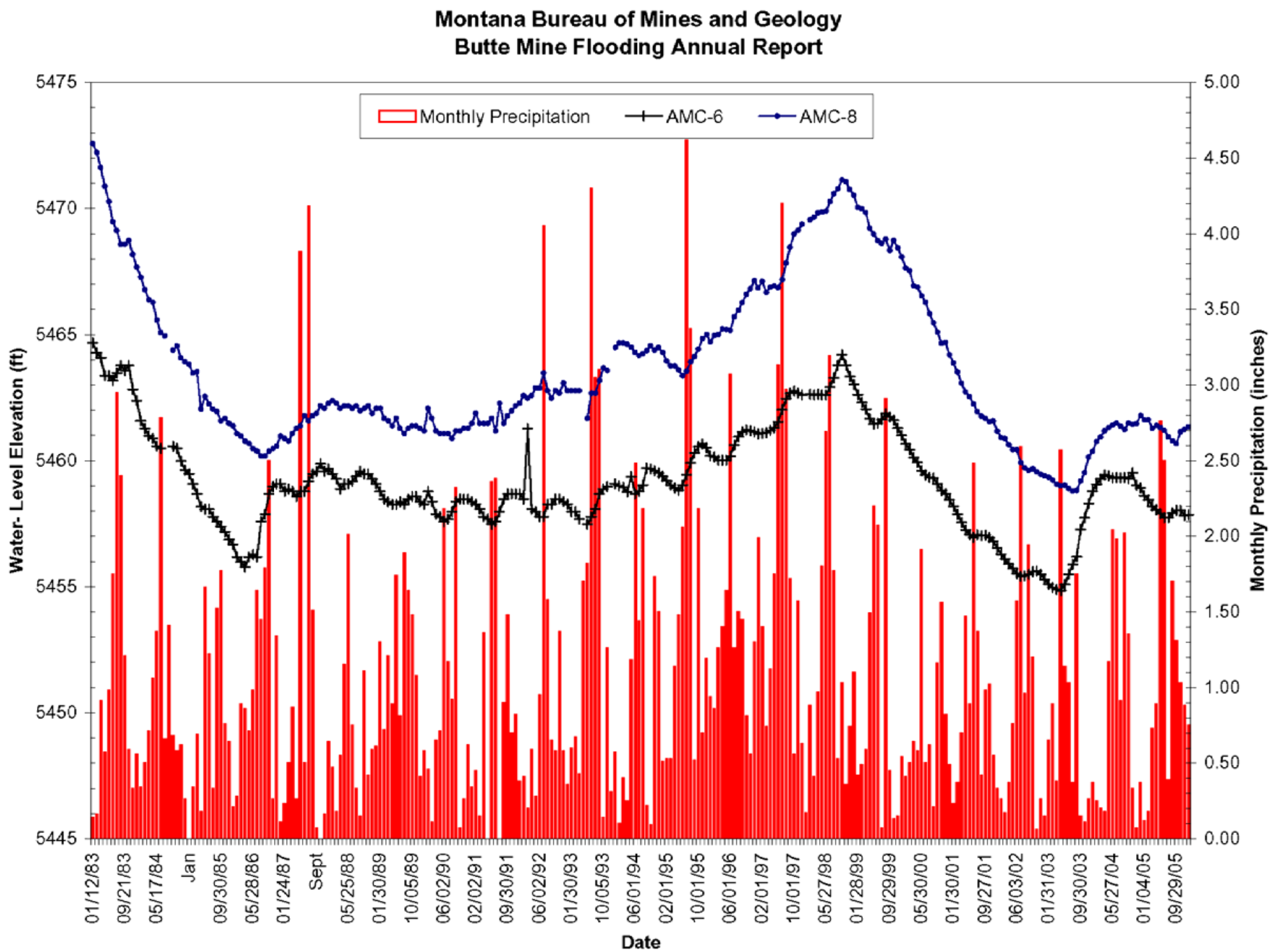

Figure 2-4. Water-level hydrographs for AMC-6 and AMC-8 wells.

Well AMC-12 water-level variations were similar to those of 2001 through 2004, with the overall trend remaining downward. The 2005 changes may be related to equilibrium of water levels following MR's resumption of mining or related to the end of construction activities in the nearby Metro Storm Drain (MSD) channel. Water levels increased in the spring with increased precipitation and then declined through the fall (fig. 2-3), a trend similar to the previous years.

Well AMC-13 is located on the west side of Clark's Park, south of wells GS-44S and GS-44D. This well's hydrograph shows both a response to precipitation events and possibly lawn watering (fig. 2-5a). Water levels began to rise in the spring and continued throughout the summer, before starting to decline in the fall. This trend is similar to that of prior years.

Well AMC-15 is located on the west side of the Hillcrest waste dump (fig. 2-2) in an area where reclamation has taken place. Water in this well is much deeper (90 feet) compared to the other AMC wells, and the hydrograph reflects this. There were minor seasonal changes in water levels for a number of years. However, the influence of the recent below-normal precipitation is shown by the steep decline in water levels beginning in late 1999 (fig. 2-5b), when this well did not show any significant response to precipitation. The water-level decline began leveling off in mid-2003, then the water level rose almost one-half foot from September through December 2003. The water level continued to rise (0.43 ft) throughout 2004, before declining in 2005. This recent trend does not show any response to precipitation patterns. However, access problems at this site interfered with monitoring periodically throughout 2005. Therefore, the actual response, or lack of, is uncertain.

2.5(a)

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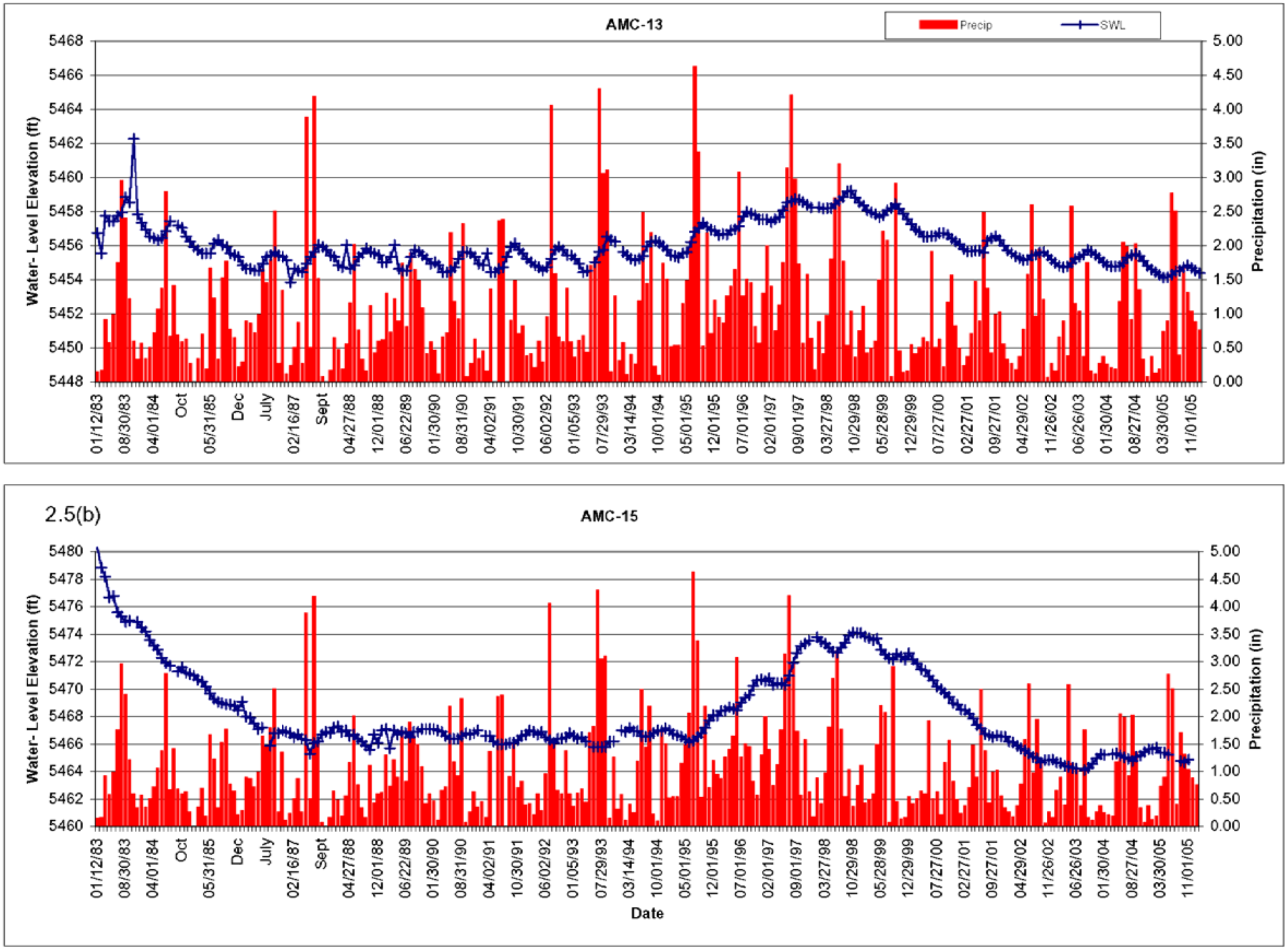


Figure 2-5. Water-level hydrographs for AMC-13 (a), and AMC-15 (b) wells.

Section 2.1.1.1 AMC Series Wells Water Quality

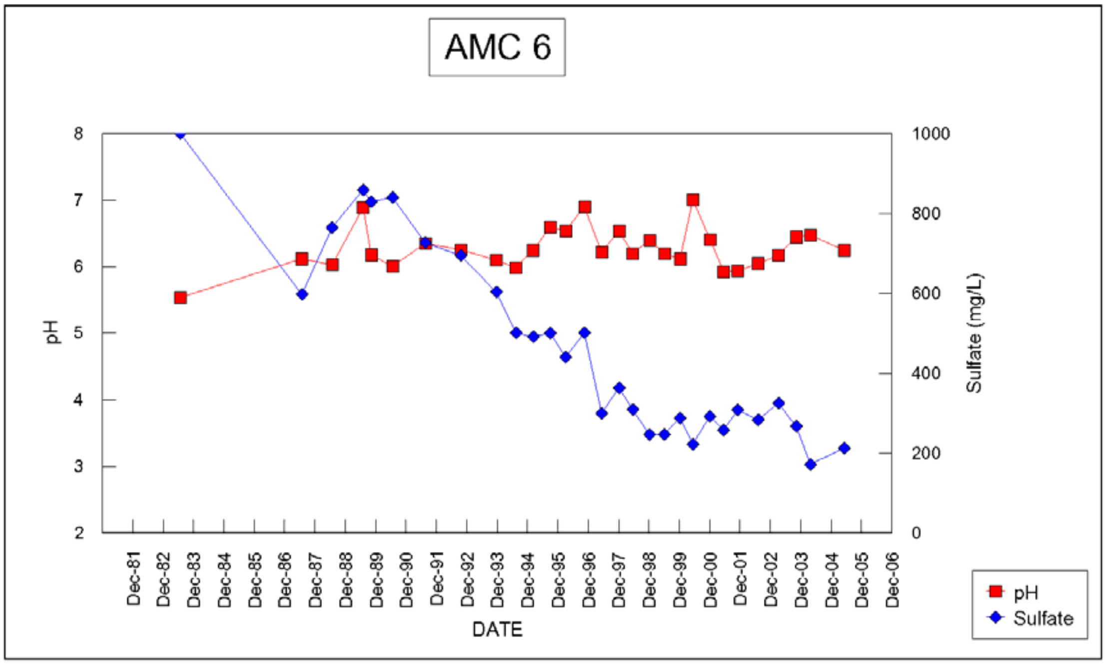
Concentration trends of the 2005 data collected from the AMC-series wells are summarized in Table 2.1.1.1.1. Well AMC-5, just south of the Berkeley Pit, has exceeded MCLs and SMCLs throughout the period of record. The concentrations of most of the dissolved metals have shown a slight downward trend.

AMC-6 shows a continued, consistent trend of decreasing concentrations of nearly all dissolved constituents. At 18 ug/L (6/05 sample), cadmium is the only constituent whose concentration exceeds a drinking water standard. The concentration of sulfate increased slightly from the175 mg/L in 2004 to 200 mg/L (fig. 2-6). Data for AMC-8 was questionable with respect to the concentration of cadmium in 2004. The analysis of a sample collected on 11/7/03 indicates a concentration of 3.9 ug/L, similar to concentrations in recent years. The analysis of a sample collected on 4/18/04 indicates a concentration of 21.3 ug/L, roughly an order of magnitude greater than the previous years. Both 2005 samples had concentrations similar to prior years (2003 and before) (2 ug/L, 12/05). The concentrations of other dissolved constituents in the 2005 samples are consistent with previous samples. As in the past, the concentration of other constituents have increased, but not at such a high rate. Sulfate, for example, ranged from 413 to 386mg/L, a similar rate as previous years (fig. 2-6).

Table 2.1.1.1.1 Exceedances and trends for AMC series wells, 2005.

Well Name	Exceedances	Concentration Trend	Remarks
AMC-5	Y	Variable	Sulfate exhibits upward trend
AMC-6	Y	Downward	Downward trend continues
AMC-8	Y	Variable	Increasing sulfate
AMC-12	Y	Variable	Not sampled
AMC-15	Y	Variable	Not sampled

Wells AMC-12 and AMC 15 were not sampled in 2005 due to access problems. As in the recent past, no strong trends are apparent in any wells; most show a slight downward trend over the period of record. Overall, metal concentrations in 2005 showed very little change from previous years. Wells closest to historic and current mining operations have the highest levels of contamination; well AMC-5 has very high levels of iron, manganese, cadmium, copper, and zinc.



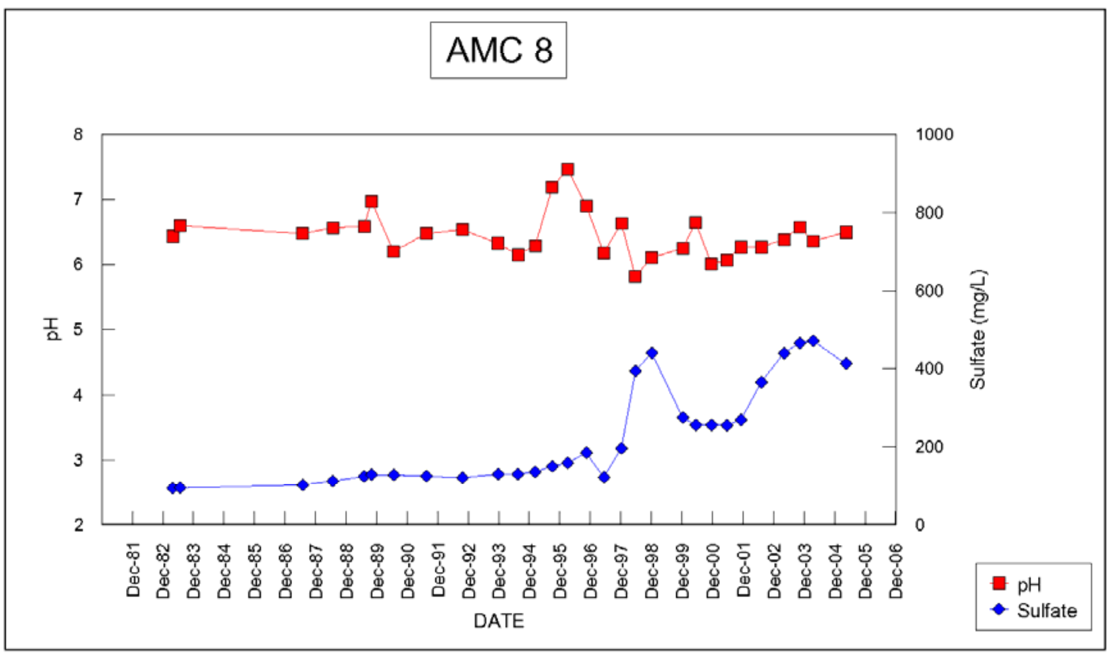


Figure 2-6. Sulfate concentrations for AMC-6 and AMC-8 just south of the Berkeley Pit.

Section 2.1.2 LP-Series Wells

The locations of the LP-series monitoring wells are shown on figure 2-7. As discussed in Duaime and others (1998), these wells were installed in 1991 and 1992 as part of the BMFOU RI/FS study. Water-level monitoring and sampling of the LP-series wells continued throughout 2005. Table 2.1.2.1 presents a summary of annual water-level changes for these 17 sites. Well LP-11 was plugged and abandoned in 2001; well LP-03 was plugged and abandoned in 2002 to make room for the HSB water-treatment plant. Well LP-06, had been dry for over three years, before having a water-level rise of more than 3 ft during 2004; however, it had a corresponding decline in 2005. Therefore, wells LP-06 and LP-07 are dry. Water levels declined in five wells during 2005, compared to three wells during 2004. Water levels rose in the remaining 10 wells during 2005. Wells north of the Pittsmont Waste Dump saw the greatest rise, with rises exceeding 4 ft in wells LP-04 and LP-09, respectively. However, since monitoring began, water levels have experienced a net decline in all 17 wells, ranging from 2.12 feet to 31.45 feet in wells LP-14 and LP-03, respectively.

The rise in water levels to the north of the Pittsmont Waste Dump is a <u>substantial</u> change from trends seen in years prior to 2004. Water levels had declined in a <u>majority</u> of the north wells since 1992. This had been especially true since the deactivation of the leach pads in 1999. However, as part of its resumption of mining, MR began leaching operations on a limited scale in 2004, continuing periodically throughout 2005. The wells with the greatest water-level rise (LP-04 and LP-10) are located south and down gradient of the leach pads where the leaching took place. Figures 2-8 and 2-9 show water levels over time for five of the LP series wells, which are located south of the re-activated leach pad.

Wells LP-01 and LP-02 are located near the base of several leach pads and are screened in two different intervals. Well LP-01is completed at a deeper depth and as shown on figure 2-8, water levels increased gradually throughout 2005. The water-level changes in this well are less erratic than those seen in the shallow well, LP-02, possibly the result of the increased lag-time associated with recharge events. The lag-time, or delay in water-level changes seen in the deeper well is the additional time necessary for the water applied as part of the leaching operation to move through the leach pads and underlying alluvial material to reach the screened interval for this well, which is at a depth of 177-197 ft below ground surface. This is 25 ft deeper than the screen interval of well LP-02. Water levels in wells LP-01 and LP-02 show a greater response to operational practices associated with the leach pads than from precipitation events. This is consistent with interpretations of water-level responses made following MR's 1999 deactivation of the leach pads.

Figure 2-9 shows water levels over time for wells LP-04, LP-07, and LP-08, which are located south of wells LP-01 and LP-02 and north of the Pittsmont Waste Dump (fig. 2-7). These wells are completed at different depths also. Well LP-04 is screened from 125-145 ft below ground surface, while well LP-07 is screened from 90-95 ft below ground surface, and well LP-08 is screened 81-96 ft below ground surface. Based upon these well-completion depths, wells LP-07 and LP-08 would be considered to be completed in the upper portion of the alluvial aquifer, while well LP-04 would be considered to be completed in the deeper portion of the alluvial aquifer.

Table 2.1.2.1 Annual water-level change in LP-series wells

Year	LP-01	LP-02	LP-03	LP-04	LP-05	LP-06	LP-07	LP-08	LP-09
1991	1.23	-0.91	-2.02	1.38	4.35	-1.46	-	-	-0.70
1992	-1.14	-1.56	-0.66	-1.75	-1.08	0.80	-3.79	-3.78	-7.16
1993	-0.91	-1.69	1.84	-1.69	-2.42	-0.53	-3.06	-4.83	-2.24
1994	-0.53	-0.80	-1.61	-0.57	-1.42	-2.28	-1.03	-2.11	-2.90
1995	-0.08	-0.19	-1.74	2.94	0.34	0.47	4.91	4.30	3.35
1996	-2.05	-2.00	-0.73	-1.28	-3.40	2.01	-4.30	-1.14	-1.49
1997	-1.58	-1.86	-0.09	-1.73	-3.32	-1.37	-2.24	-2.63	-0.29
1998	0.12	0.23	-2.03	1.01	-0.03	-0.58	2.44	0.99	1.60
1999	-2.24	-1.76	-7.44	-2.64	-3.15	-1.65	-6.47	-3.52	-3.77
2000	-7.55	-7.16	-5.45	-10.83	-7.87	-0.20	-3.10	-14.03	-13.28
2001	-5.13	-4.73	-9.51	-8.88	-5.47	Dry	Dry	-12.10	-3.04
2002	-5.21	-3.91	-2.01*	-6.03	-4.86	Dry	Dry	-4.11	-3.46
2003	-2.29	1.60	P&A*	-1.75	-2.00	Dry	Dry	-0.04	-1.15
2004	-0.65	0.46	P&A*	13.06	3.85	3.24	Dry	18.13	2.96
2005	0.81	-0.43	P&A*	4.12	3.40	-3.62	-0.79	2.85	2.08
Net Change	**-27.20**	**-24.71**	**-31.45**	**-14.64**	**-23.08**	**-4.17**	**-17.43**	**-22.02**	**-29.49**

Year	LP-10	LP-11	LP-12	LP-13	LP-14	LP-15	LP-16	LP-17
1991	-	-	-	-	-	-	-	-
1992	-0.50	-1.83	0.31	-0.07	0.70	0.54	0.89	-
1993	-0.83	-2.78	1.42	1.11	1.18	1.62	1.83	-
1994	-2.14	1.65	-1.41	-1.47	-0.09	0.26	-1.16	-
1995	-0.57	-0.23	-0.16	0.43	0.18	1.89	3.57	3.10
1996	1.20	0.23	1.87	1.74	2.07	1.79	1.77	1.66
1997	0.23	-0.09	2.42	2.24	2.64	1.99	1.77	2.32
1998	0.92	0.07	1.00	-0.62	0.39	-7.90	-9.69	-2.41
1999	-2.05	-2.12	-2.94	-2.36	-2.73	-4.39	-4.60	-3.95
2000	-1.37	-0.28	-3.60	-2.93	-3.64	-1.73	-2.18	-2.86
2001	0.51	P&A*	-1.16	-1.30	-2.31	-0.72	-1.18	-1.50
2002	-0.15	P&A*	-1.83	-1.21	-1.65	-0.68	-0.86	-0.67
2003	-2.75	P&A*	-1.74	-0.26	0.46	1.08	0.89	0.09
2004	-1.41	P&A*	0.20	0.26	0.95	-0.06	0.52	0.71
2005	4.19	P&A*	1.53	0.78	-0.27	0.27	-0.27	0.26
Net Change	**-4.72**	**-5.38**	**-4.09**	**-2.66**	**-2.12**	**-6.04**	**-8.70**	**-3.25**

(*) Plugged and abandoned

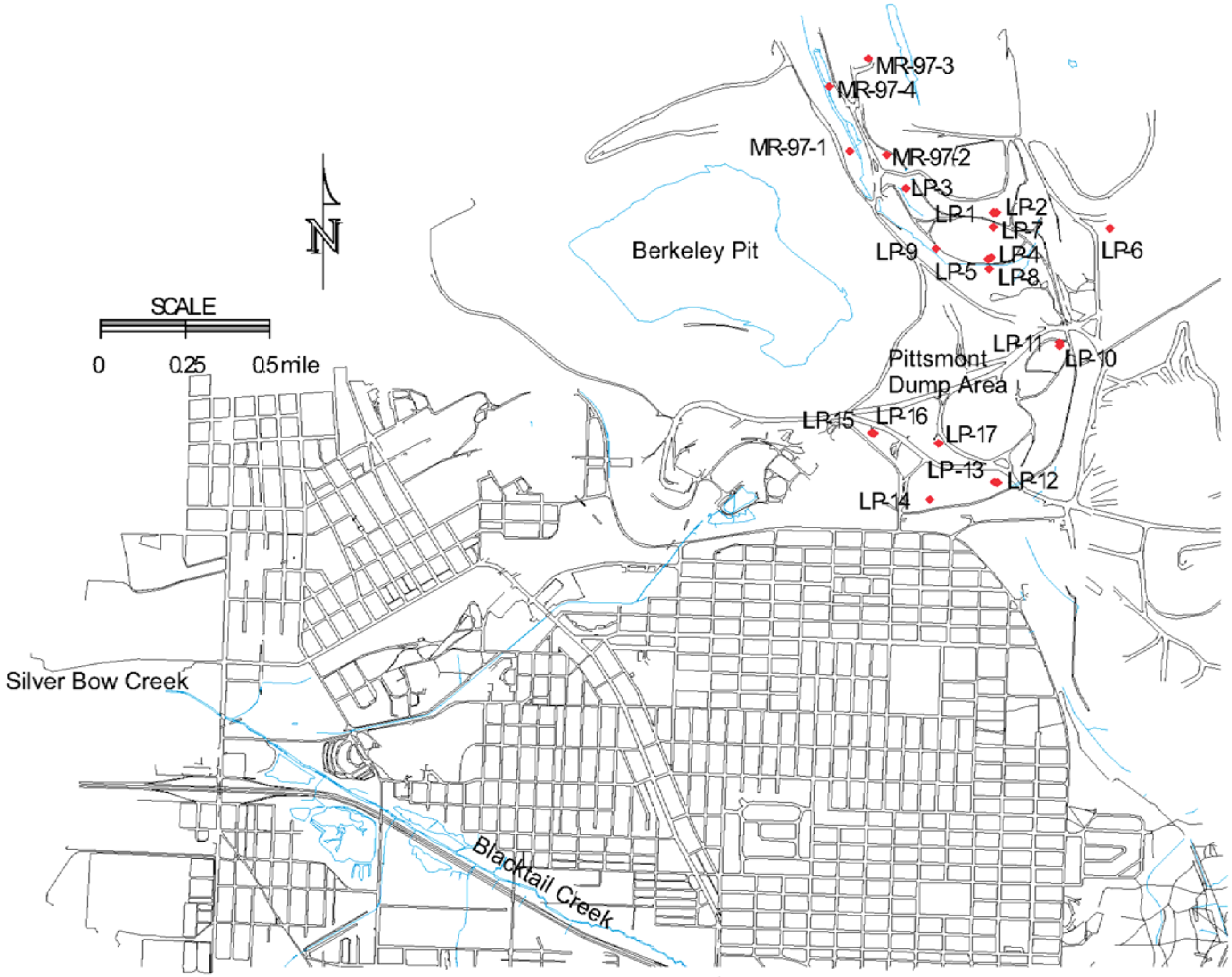


Figure 2-7. LP series and MR97 Wells location Map.

The water-level trends are similar for wells LP-04, LP-07, and LP-08. It is interesting to note that while well LP-08 was dry for a period from mid-2003 through mid-2004, the water-level trend did not vary from that shown for well LP-04 once the water level rose back above the screen interval. It is apparent that the control on water levels is the same on both of these wells and the operation, or lack of operation of the leach pads whichever the case maybe, has a much greater influence on water levels than precipitation. Well LP-07 which had remained dry since the later part of 2000 had a slight water-level increase in early 2005, before declining the remainder of the year, until the well went dry.

Wells LP-14, LP-15, and LP-16 are located southwest of the Pittsmont Dump (fig. 2-7). A consistent increase in water levels occurred in these wells following their installation in 1992, until the Berkeley Pit landslide of 1998 (fig. 2-10). After that landslide, water levels had declined in a similar manner in all three wells until beginning to rise in September 2003 and continuing through May of 2004. Since then water-level changes have been minor. Wells LP-15 and LP-16 are located near one another and were completed as a nested pair, with well LP-15 screened from a depth of 215-235 ft below ground surface and well LP-16 screened from 100-120 ft below ground surface. Water-level trends are similar in these wells regardless of completion depth. However, water levels had a net increase in the deep well, LP-15, for 2005, while well LP-16 had a slight water-level decline for the year. Neither of these wells shows any response to precipitation events.

Well LP-14 is located south of wells LP-15 and LP-16, but its overall water-level trend is similar to that seen in wells LP-15 and LP-16. There were a few more fluctuations in this well during 2005 which do not appear to be related to precipitation events.

The general observation made in the last several yearly reports, that wells between the leach pads and Pittsmont Waste Dump were affected by leach-pad operations, including the 1999 leach-pad dewatering and historic-mine dewatering, remains true. Water levels in these LP-series wells were either controlled by the operation and subsequent dewatering of the leach pads, operation of the Yankee Doodle Tailings Dam, by the depressed water levels in the Berkeley Pit, or a combination of all three. The water-level response seen in wells adjacent and down gradient of limited leaching operations during 2005 clearly demonstrates the relationship of water-level changes and the leach pads operations. While water levels increased in a majority of these LP series wells in 2005, all these wells have a net decline in water level since their installation. The influence of precipitation is minimal, at most, on any of these wells.

An alluvial aquifer potentiometric map (fig. 2-11) constructed using December 2005 water levels, shows how alluvial waters are flowing towards the Berkeley Pit from the north, east and south. Water contaminated by historic mining activities (Metesh, 2000) is flowing towards and into the Berkeley Pit, ensuring that there is no outward migration of contaminated water into the alluvial aquifer.

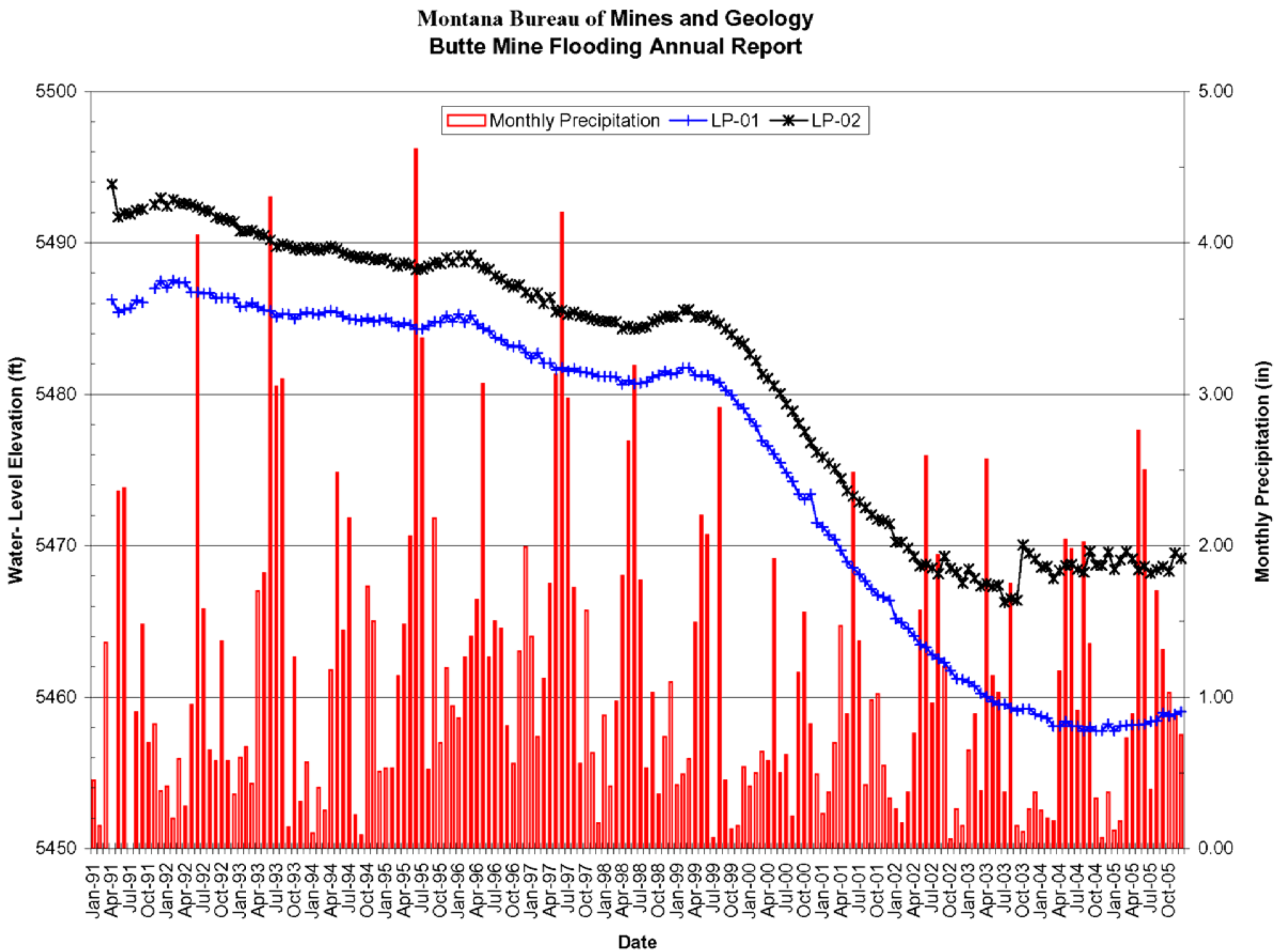


Figure 2-8. Water-level hydrographs for LP-01 and LP-02 wells.

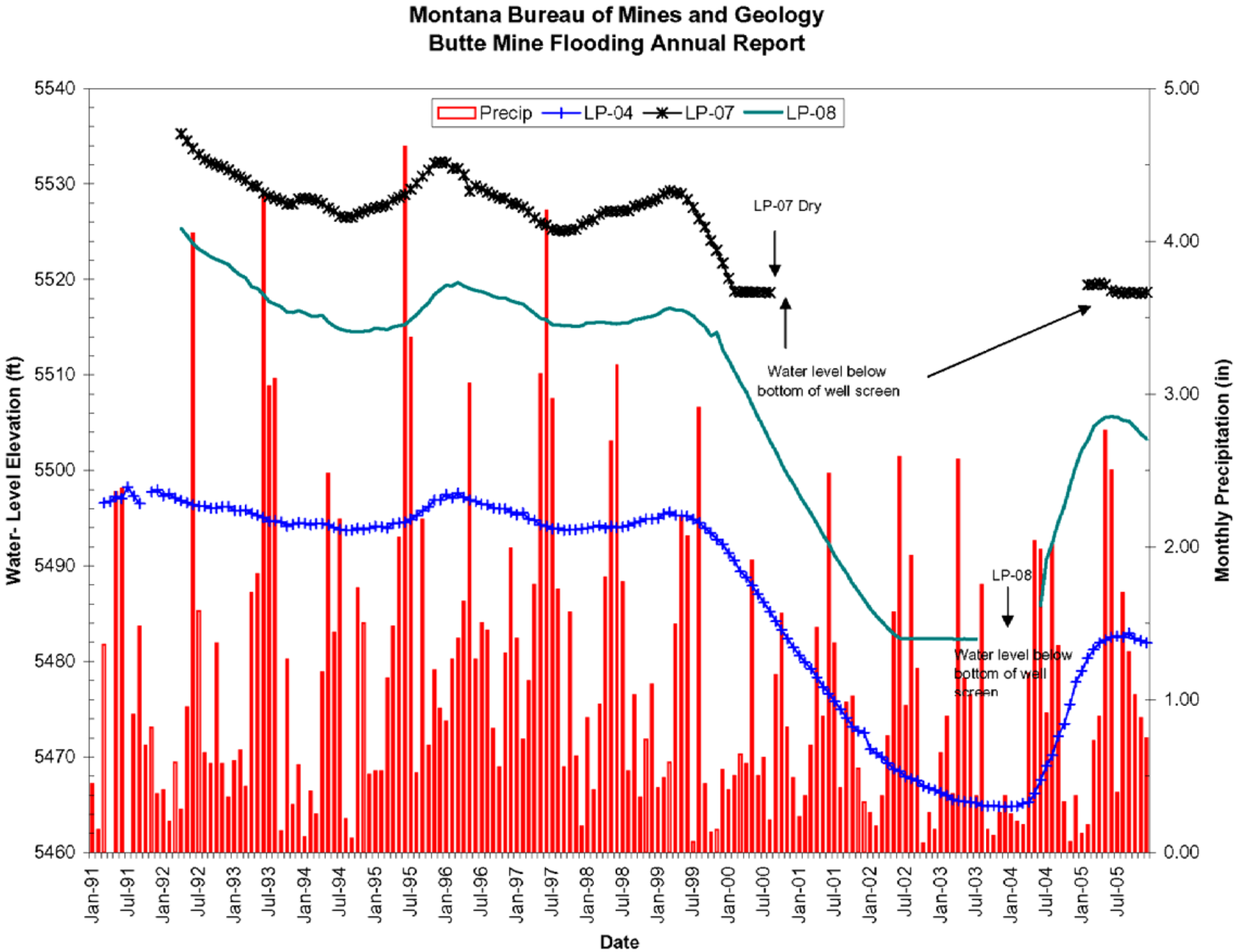


Figure 2-9. Water-level hydrograph for LP-04, LP-07 and LP-08 wells.

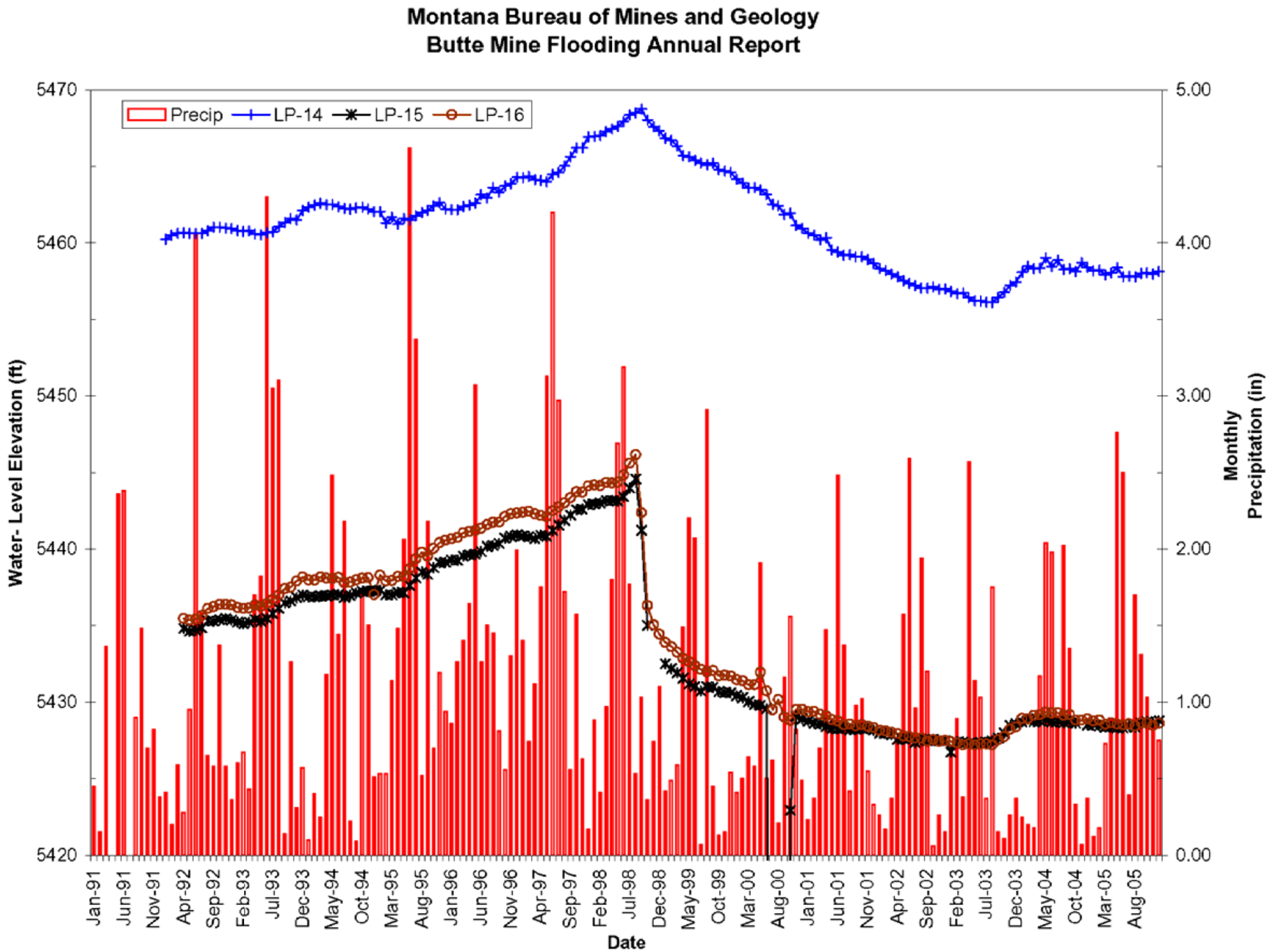


Figure 2-10. Water-level hydrograph for LP-14, LP-15, and LP-16 wells.

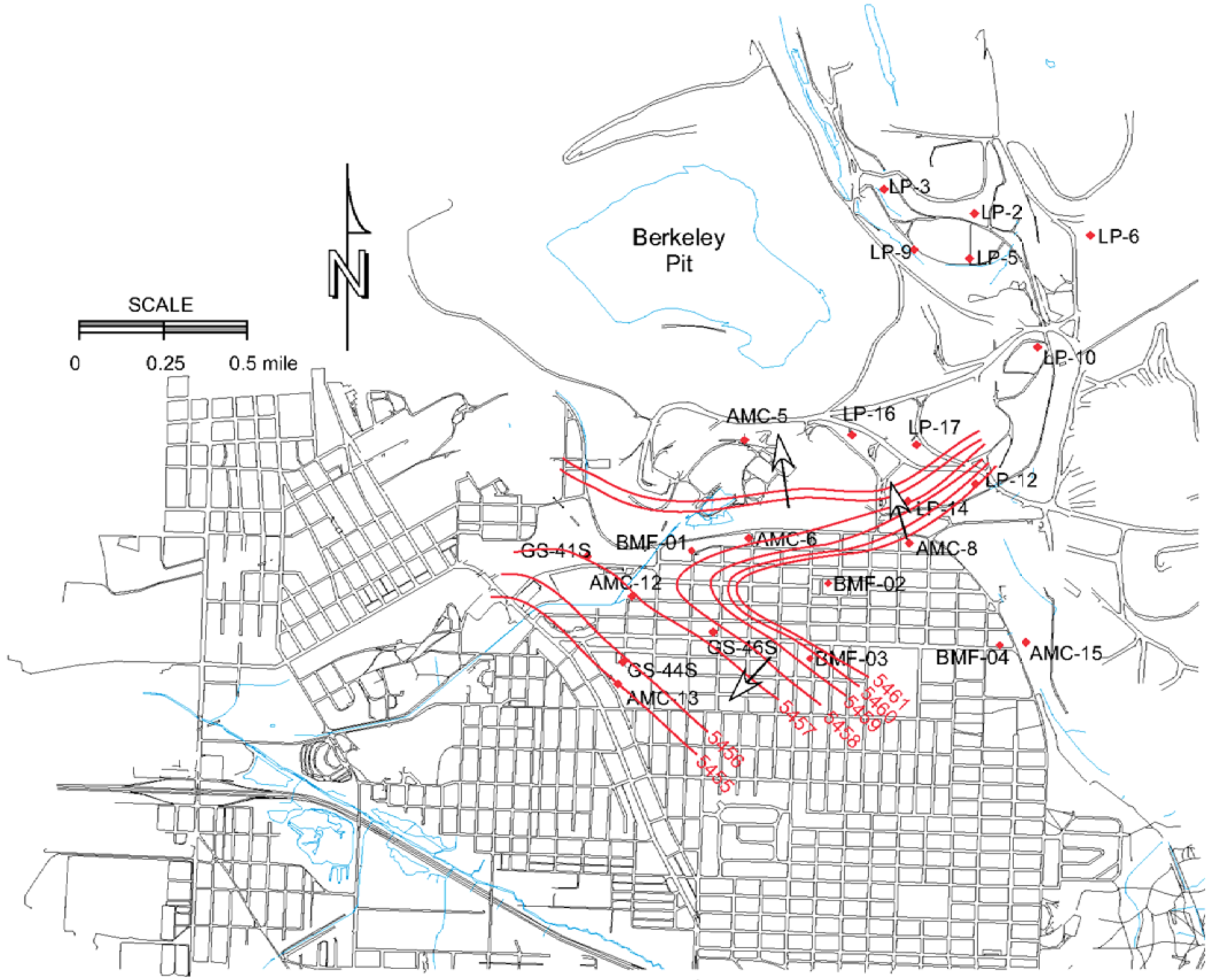
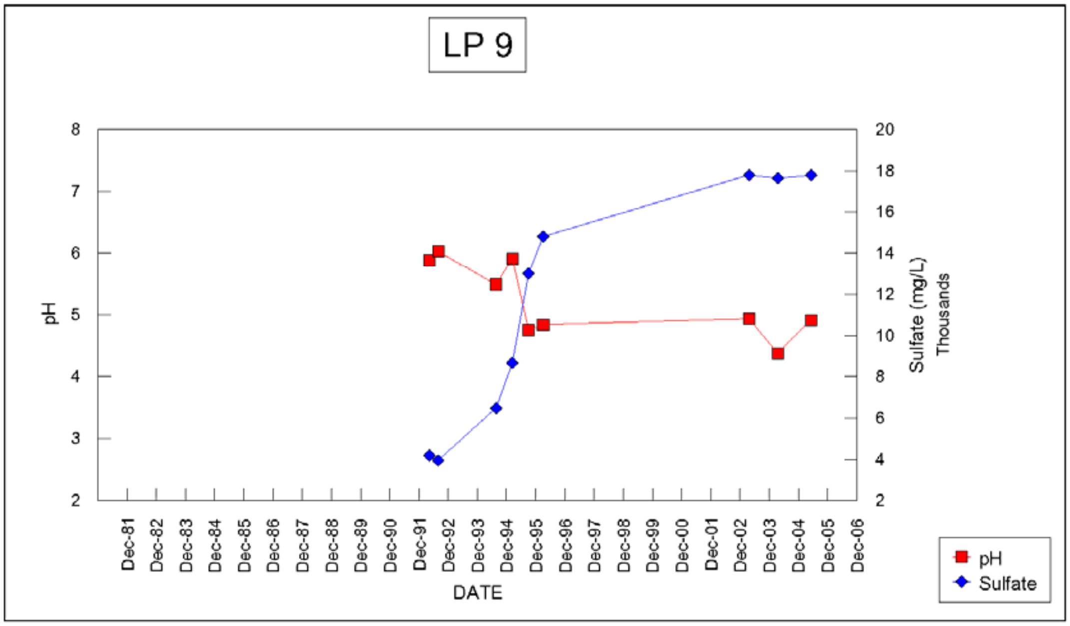


Figure 2-11. Alluvial aquifer potentiometric map for December, 2005; arrows indicate direction of ground-water flow implied by contours (contour interval is 1 foot).



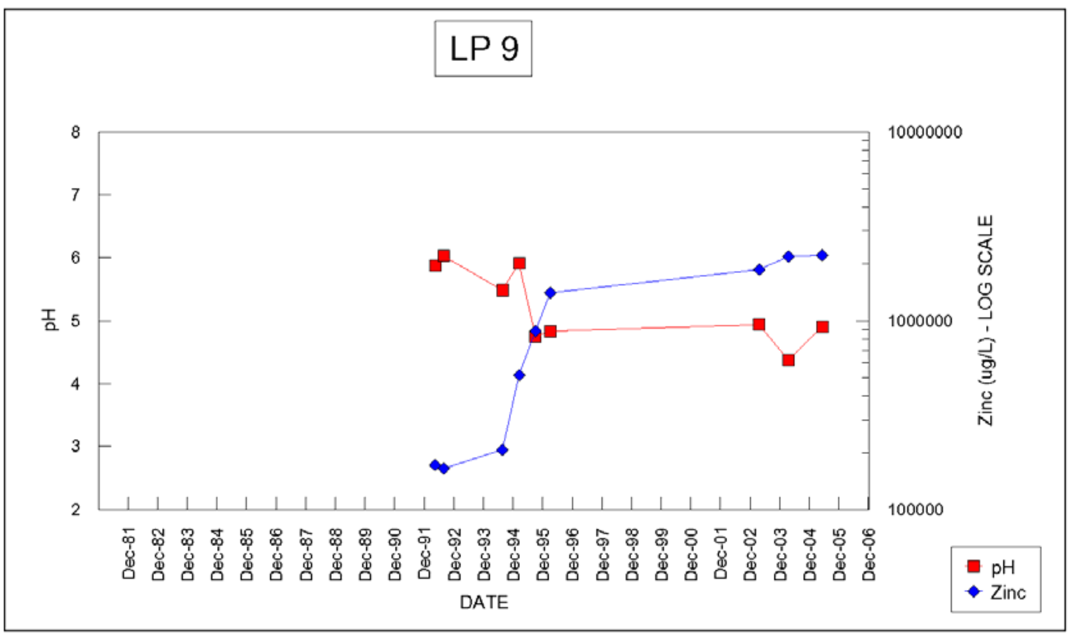


Figure 2-12. Sulfate and zinc concentrations for LP-9.

Section 2.1.2.1 LP-Series Wells Water Quality

Current water-quality monitoring of the LP-series wells is restricted primarily to those wells west and south of the Pittsmont Dump (fig. 2-7) with the exception of three wells (LP-08, LP-09, and LP-10), which are south of the leach pad area and north of the Pittsmont dump. Water-quality trends in 2005 showed limited changes in several wells; the changes are summarized in Table 2.1.2.1.1

Well LP-08 was sampled in May 2005 to determine if water quality changes seen previously in well LP-09 were occurring further south. While the water in this well was highly contaminated, concentrations were less than historic levels in most cases (i.e. Al – 1,710,000 μg/L in 1992 and 739,000 μg/L in 2005), the exception being an increase in arsenic. Well LP-9 was sampled in August of 1992 and then not sampled until April of 2003; it has been sampled three times since. A comparison of the data indicates large increases in the concentration of most dissolved constituents starting in 2003. Data collected in 2005 show that the increase is sustained, if not greater (fig. 2-12). The concentration of aluminum increased from <100 in 2002 to 50,000 μg/L in 2003 to 102,000 in 2004, and then to 147,000 μg/L in 2005; arsenic increased from 4.4 to 43 and then increased to 74 μg/L; cadmium increased from 510 in 2002 to 14,600 in 2003 to 19,367μg/L in 2004 and then to 20,058 μg/L in 2005; and zinc increased from 165,000 in 2002 to 1,870,000 in 2003 to 2,194,000 in 2004 and then to 2,223,259 μg/L in 2005. In general, the concentrations of dissolved metals increased by nearly an order of magnitude and approach those values seen in the pregnant solution of the up-gradient leach pads. The trend that first appeared in the 2003 data certainly continued in 2005.

The trend of water quality in other LP-series wells generally remained the same in 2005 as in recent years. A summary of exceedances and trends is presented in table 2.1.2.1.1.

Table 2.1.2.1.1 Exceedances and trends for LP series wells, 2005

Well Name	Exceedances (1 or more)	Concentration Trend	Remarks
LP-08	Y	Downward	Downward trend with exception of arsenic
LP-09	Y	Upward	Large increases since 1992
LP-10	N	None	No significant changes in 2005
LP-12	Y	None	No significant changes in 2005
LP-13	Y	None	No significant changes in 2005
LP-14	Y	Variable	Slight increase in sulfate continues
LP-15	Y	None	Net change is small for most analytes
LP-16	Y	Variable	Downward sulfate trend continues
LP-17	Y	Upward	Slight upward trend continues

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Section 2.1.3 Precipitation Plant Area Wells

Wells MR97-1, MR97-2, MR97-3, and MR97-4 (fig. 2-7) are adjacent to various structures (drainage ditches, holding ponds) associated with the leach pads and precipitation plant. Table 2.1.3.1

lists annual and net water-level changes for these wells. Water-level changes appear to correspond to flow in these ditches and water levels in ponds.

Table 2.1.3.1 Annual water-level changes in MR97-series wells.

Year	MR97-1	MR97-2	MR97-3	MR97-4
1997	-0.25	-0.84	-0.40	0.34
1998	1.07	-1.04	-0.67	2.20
1999	-0.27	-4.40	-3.91	0.02
2000	-0.20	-0.89	-2.88	-0.03
2001	6.17	-1.32	-0.29	0.78
2002	-5.88	-1.02	-0.47	1.60
2003	7.43	-0.70	-1.29	-2.45
2004	-10.01	-0.08	-4.28	1.86
2005	-0.67	-0.06	0.60	-1.84
Net Change	**-2.61**	**-10.35**	**-13.59**	**2.49**

Water levels in well MR97-1 have shown the greatest degree of variation (fig. 2-13) due to the various changes in mining operations. Water levels increased when MR began to discharge water from their Berkeley Pit copper recovery project into the pit (Spring 1999). These variations are characterized by an initial <u>increase</u> in water levels followed by a gradual decrease before leveling off. The channel that carried water back to the pit after the removal of copper is adjacent to well MR97-1. This channel had been unused since April 1996, when HSB drainage water was captured and prevented from flowing into the pit. Water-level increases were seen again following MR's summer 2000 suspension of mining. Water from the HSB drainage that had been pumped to the Yankee Doodle Tailings Dam since April 1996 was allowed to flow into the pit following the June 2000 mine shut-down. What is somewhat surprising is the HSB discharge water used the same drainage channel as the discharge water from the copper recovery project and the flow of water was only about one-third. If anything, with the decrease of flow in the channel, less water would be available for ground water recharge and water levels would either stabilize or drop. Instead, they rose before gradually declining over the next year.

Similar variations were observed in well MR97-1 during July 2001 and again in 2002, when a weir was installed (2001) and then relocated (2002) in the channel. The weir that was installed in 2001 was relocated upstream to the outlet of what was historically referred to in MR's precipitation plant operations as Pond 4. The weir was relocated as part of infrastructure changes relating to the HSB water treatment plant construction. The area occupied by Pond 4 was excavated and enlarged, then lined with lime rock during construction activities. The weir's relocation resulted in a drop in water levels in well MR97-1, because the weir and the accompanying impounded water were moved upgradient of this well. Water levels showed some minor fluctuations during early 2003, before rising several feet and then leveling off, until a substantial rise during December 2003. The December rise coincides with the resumption of MR's copper recovery project and the corresponding flow of discharge water in the drainage ditch near well MR97-1. Water levels subsequently declined the first part of 2004 before leveling off for most of the remainder of 2004 and early 2005. Water-levels increased during the summer of 2005 before declining.

Wells MR97-2 and MR97-3 are adjacent to historic collection ditches associated with the leach pads. Water-level changes were apparent in these two wells during 1999-2000 when MR made operational changes in leaching operations. As a result, the amount and level of water in collection ditches became less and were reflected in a drop of water levels in wells MR97-2 and MR97-3 (fig. 2-14 and 2-15).

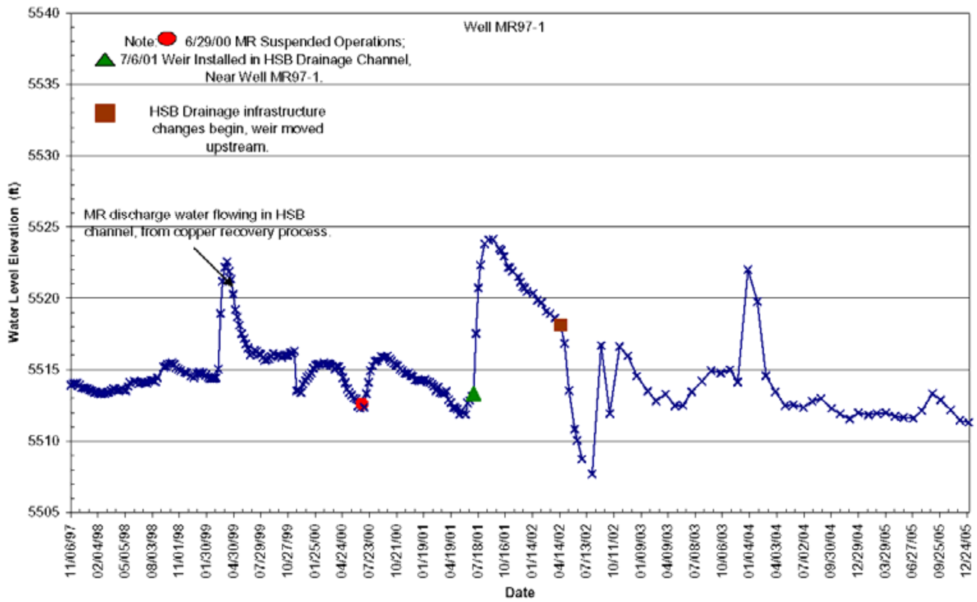
Water-level increases were also seen in wells MR97-2, MR97-3, and MR97-4 following MR's suspension of mining (fig. 2-14, 2-15, and 2-16). The response in water levels in well MR97-2, figure 2-14, was very similar to that seen in well MR97-1. A similar increase was seen in well MR97-2 following the 2001 weir installation. Water levels were stable at this site during 2003-2005 and did not show the same fluctuations as noted in well MR97-1.

The water level in well MR97-3 showed only a minor response to the 2001 and 2002 construction activities. However, water levels rose the first part of 2003, before leveling off for the next 5 to 6 months and falling the last several months of the year (fig. 2-15). With the exception of a brief period early in 2004, water levels continued to drop in this well until spring 2005 when they rose for several months before leveling off. This well had a net water-level increase for 2005. This MR-series well is the farthest away from the HSB drainage channel and appears to be the least responsive to operational changes and flows in the discharge channel.

Water-level changes during 2003 in well MR97-4, figure 2-16, were similar to those seen in well MR97-3, except the decline in water levels began earlier in 2003 and were greater. Since this well is closer to the precipitation plant facilities and HSB ponds and drainage ditches, it is possible that changes in operational flows in this area are responsible for the water-level declines observed the later part of 2003. Changes would be more pronounced in this well than in well MR97-3. The water-level increase seen during early 2004 possibly relates to water flowing into holding ponds associated with the precipitation plant as these operations were brought back on-line with MR's fall 2003 start up of mining. Water levels were fairly consistent until mid-year when they began to decline. Overall, water-levels fell almost 2 ft in 2005 at this site.

Water levels have declined more than 10 ft in the two wells (MR97-2 and MR97-3) nearest the leach pads and ancillary facilities since their installation in 1997 (table 2.1.3.1), while having a decline just less than 2 ft in well MR97-1. Only well MR97-4 has a net water-level increase; this well is nearest the precipitation plant and its ancillary facilities. It appears there is a direct influence on the shallow alluvial aquifer in this area by mining operations. Changes in mine operations (i.e. precipitation plant and leach pad) affect groundwater recharge in this area. Other changes, such as the weir installation and relocation, have affected groundwater levels in the area in the past.

No water-quality samples were collected from this group of wells in 2001, 2002, 2003, 2004 or 2005. Previous sampling documented the presence of elevated metals in the area. This contamination is most likely the result of the leach pad and precipitation plant operations.



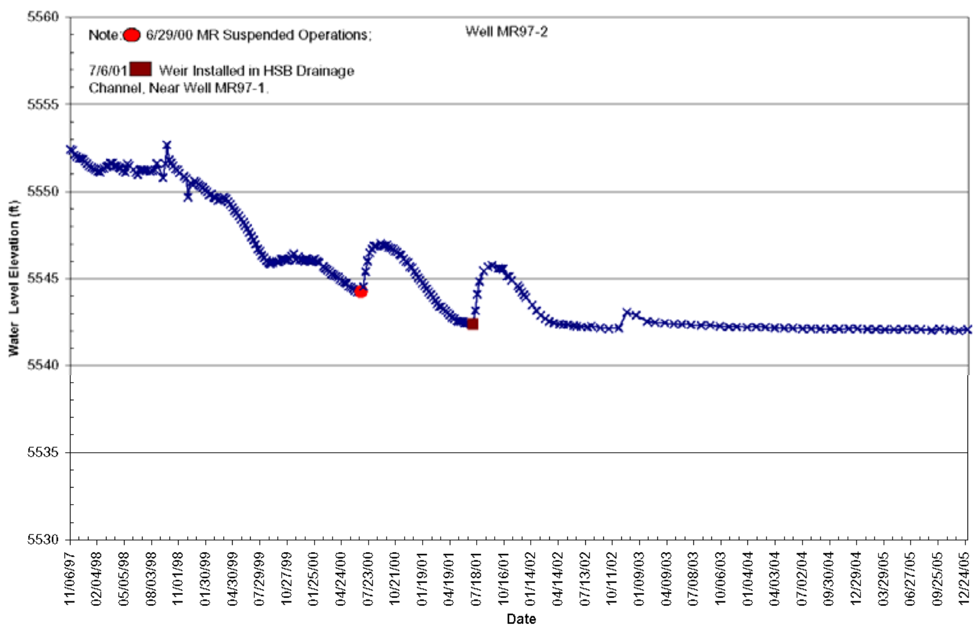
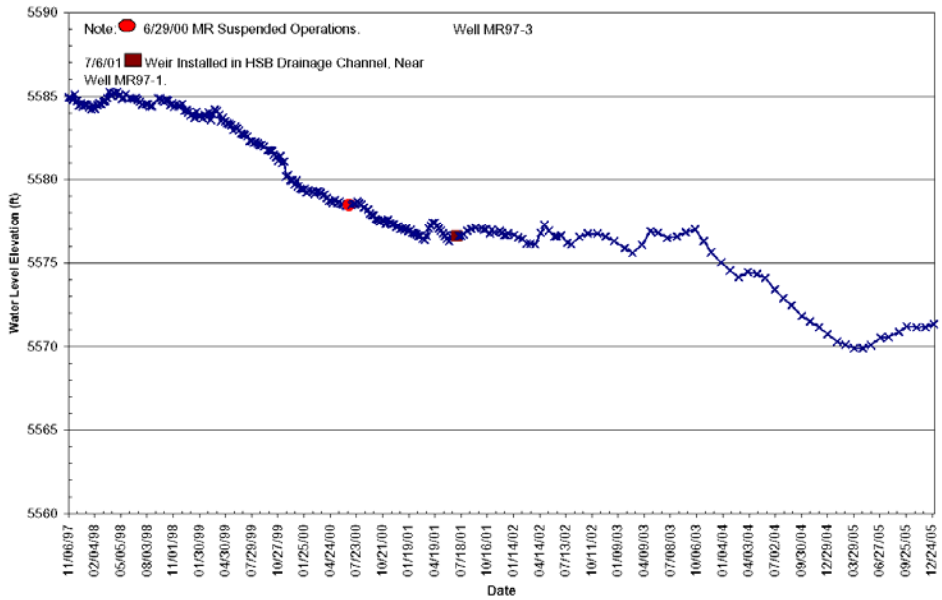


Figure 2-13 (Top) and 2-14 (Bottom). Water-level hydrographs for wells MR97-1 and MR97-2.



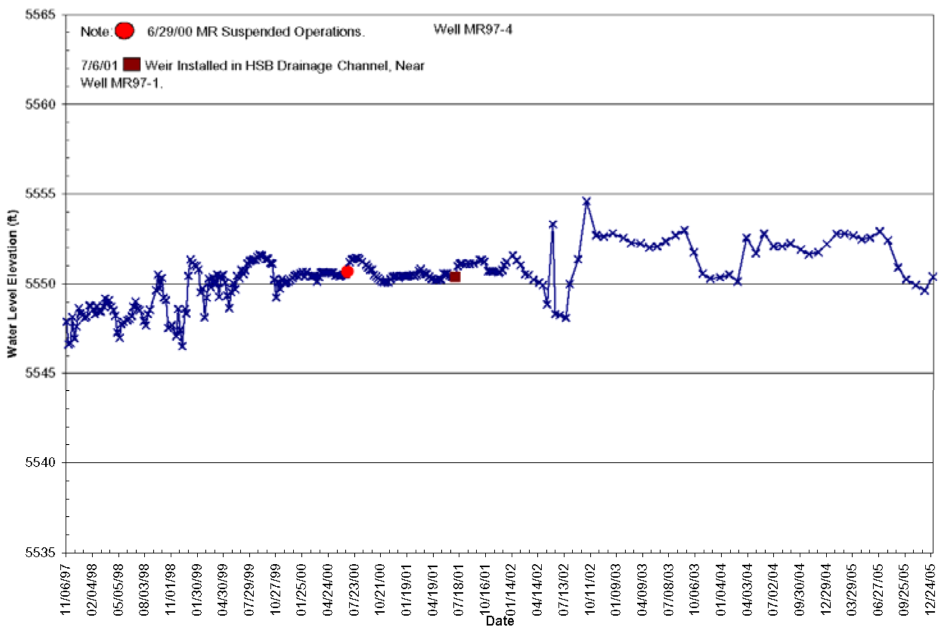


Figure 2-15 (Top) and Figure 2-16 (Bottom). Water-level hydrographs for wells MR97-3 and MR97-4.

Section 2.1.4 GS and BMF05-Series Wells

Continuous and monthly water-level monitoring of the six GS wells continued throughout 2005; however, only a single water-level reading was obtained from the four new wells due to the time of the year these wells were installed. The locations of these wells are shown on figure 2-17. Table 2.1.4.1 contains annual water-level changes for these wells (no water-level changes are shown for the BMF05 wells). Wells GS-41, GS-44, and GS-46 are nested pairs. That is, the wells are drilled adjacent to each other, but they are drilled and completed at different depths. The S and D identify the shallow and deep wells in each nested pair. Water levels had a net decline in all six wells during 2005, following 2003's net increase. Water levels have declined during seven of the past eight years.

Table 2.1.4.1 Annual water-level changes in GS-series wells.

Year	GS-41S	GS-41D	GS-44S	GS-44D	GS-46S	GS-46D
1993	0.76	0.78	0.62	0.66	0.80	0.78
1994	0.20	0.23	0.00	0.00	0.18	0.24
1995	1.35	1.29	1.32	1.26	1.38	1.30
1996	0.59	1.65	1.12	0.89	0.98	1.20
1997	1.32	0.20	0.58	0.79	1.09	1.18
1998	-0.18	-0.06	0.09	0.07	0.17	0.24
1999	-1.41	-1.49	-1.28	-1.25	-2.41	-1.65
2000	-1.91	-1.78	-1.51	-1.39	-1.21	-20.7
2001	-0.28	-0.41	-0.22	-0.38	-1.78	-0.92
2002	-0.82	-0.81	-0.94	-0.82	-1.18	-1.18
2003	0.19	0.26	0.27	0.17	-081	0.77
2004	-0.31	-0.28	-0.76	-0.52	-0.08	-0.02
2005	-0.60	-0.53	-0.40	-0.33	-0.59	-0.52
Net Change	**-1.10**	**-1.08**	**-1.11**	**-0.85**	**-0.70**	**-0.65**

Figures 2-18 through 2-20 are water-level hydrographs with monthly precipitation totals shown for well pairs GS-41, GS-44, and GS-46. The seasonal variations in water levels closely follow monthly precipitation trends. Water levels begin a gradual increase in the spring as precipitation increases and then declines throughout the fall. In the past there has been a two to three-month lag (delay) between peak rainfall and peak water levels; however, in 2004 water levels declined as rainfall decreased.

Water-level changes in wells GS-41S and GS-41D were similar once again during 2005 (fig. 2-18) and the influence of precipitation was very noticeable. Water levels decreased about 0.5 foot in these two wells during 2005.

Wells GS-44S and GS-44D had similar water-level changes throughout 2005 (fig. 2-19). The rise and fall of seasonal water levels are similar to those described for wells GS-41S and 41D. The water levels had a decline somewhat less than the GS-41 wells, varying between 0.3 foot and 0.4 foot for 2005.

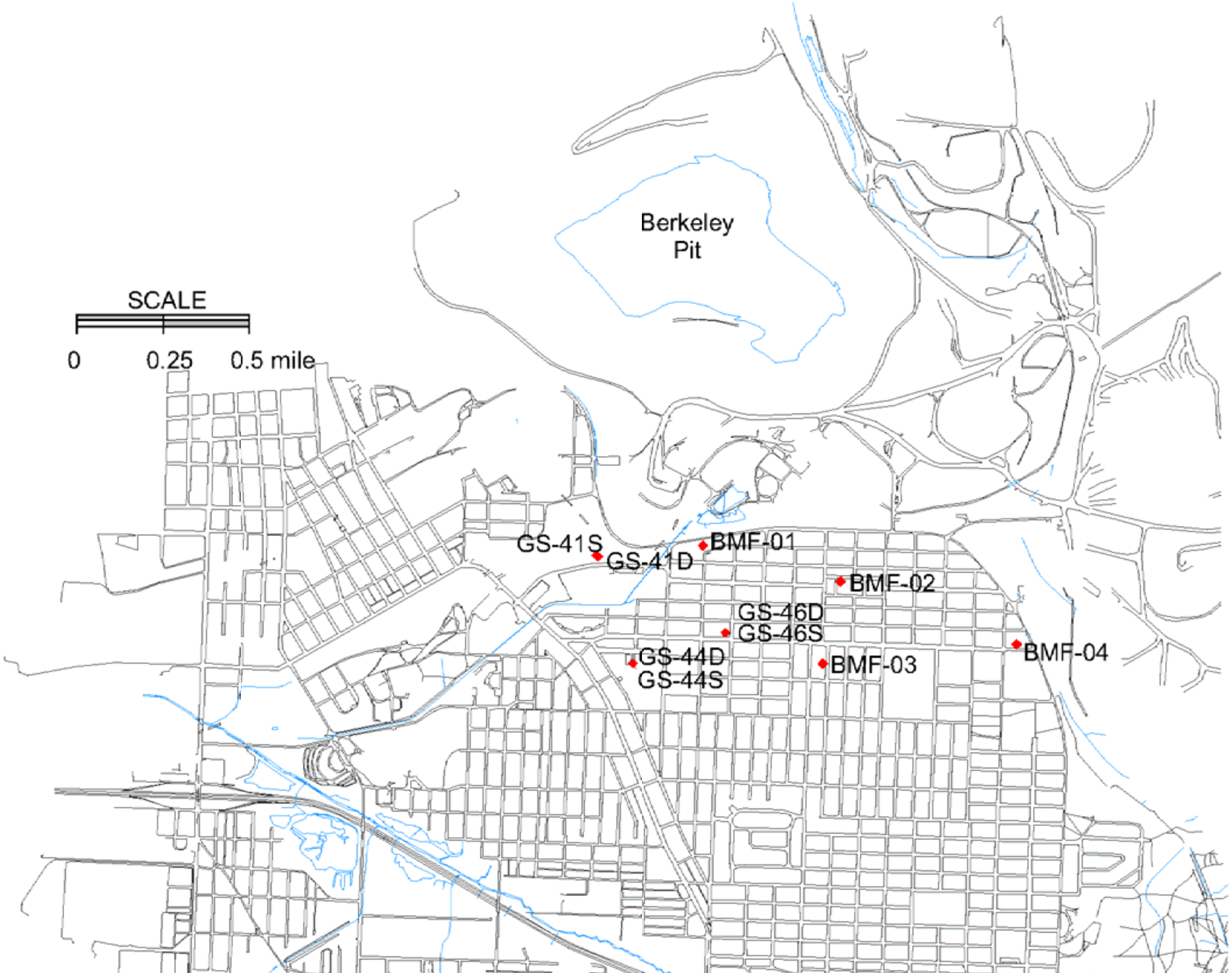


Figure 2-17. GS and BMF wells.

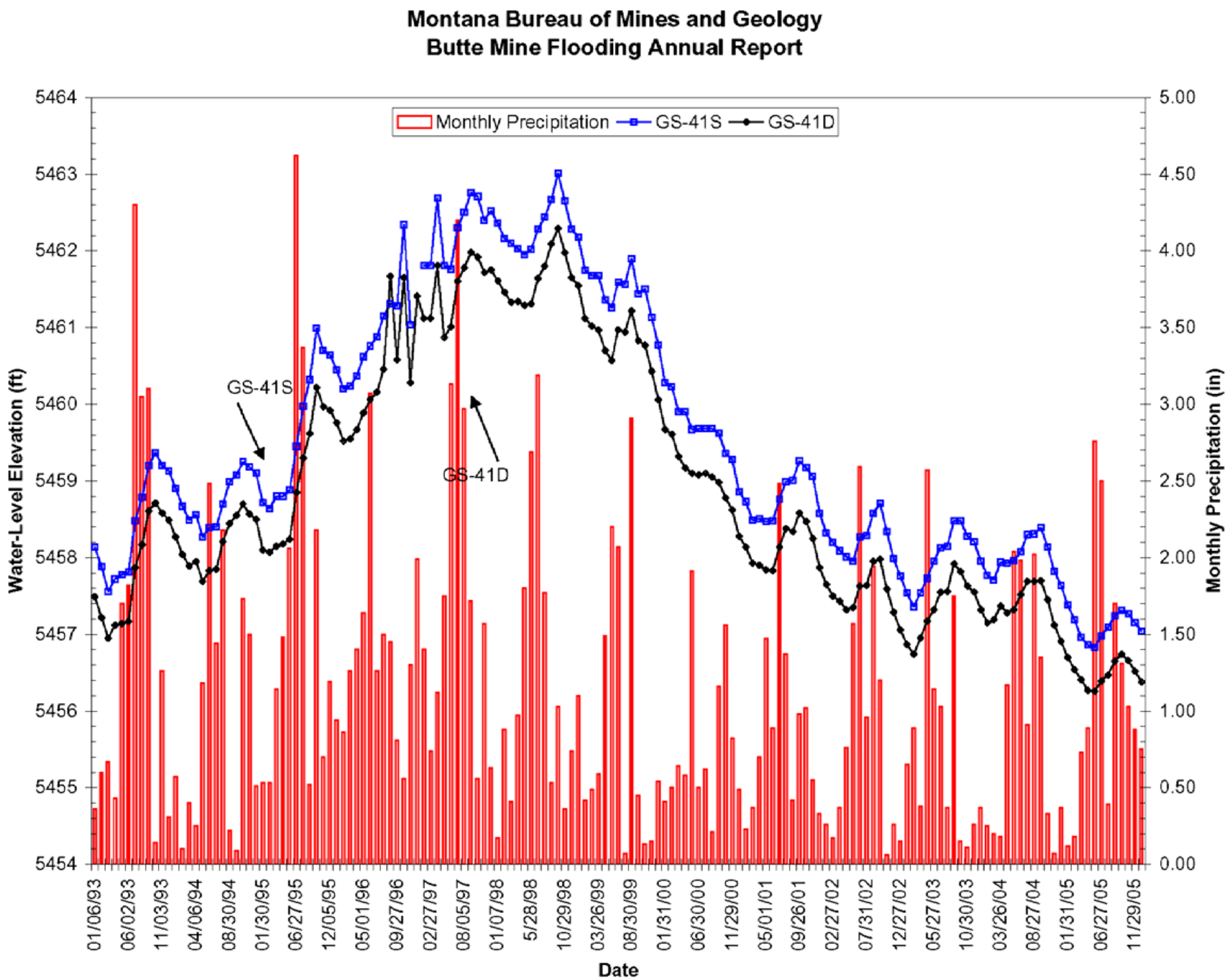


Figure 2-18. Water-level hydrographs for GS-41S and GS-41D wells.

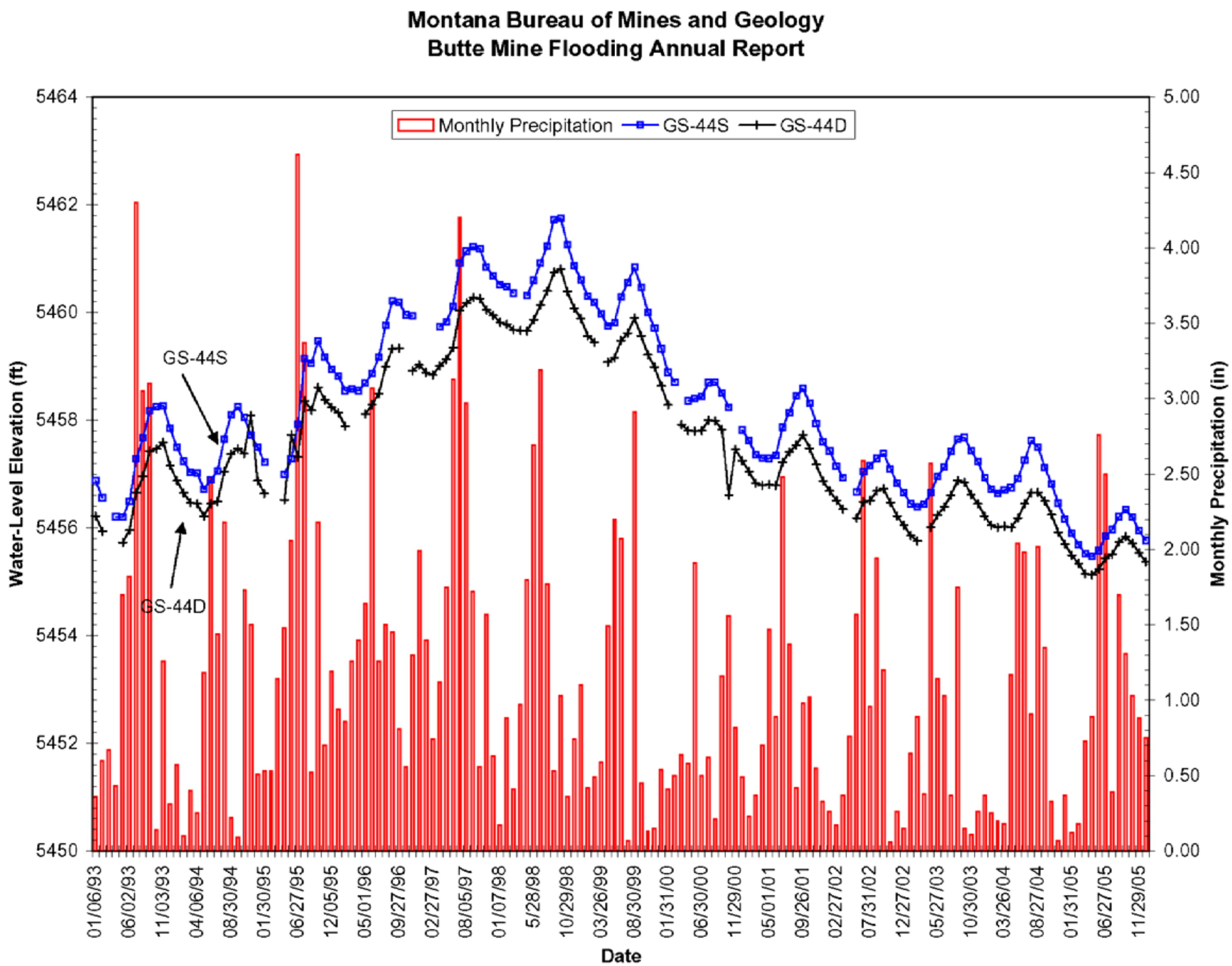


Figure 2-19. Water-level hydrographs for GS-44S and GS-44D wells.

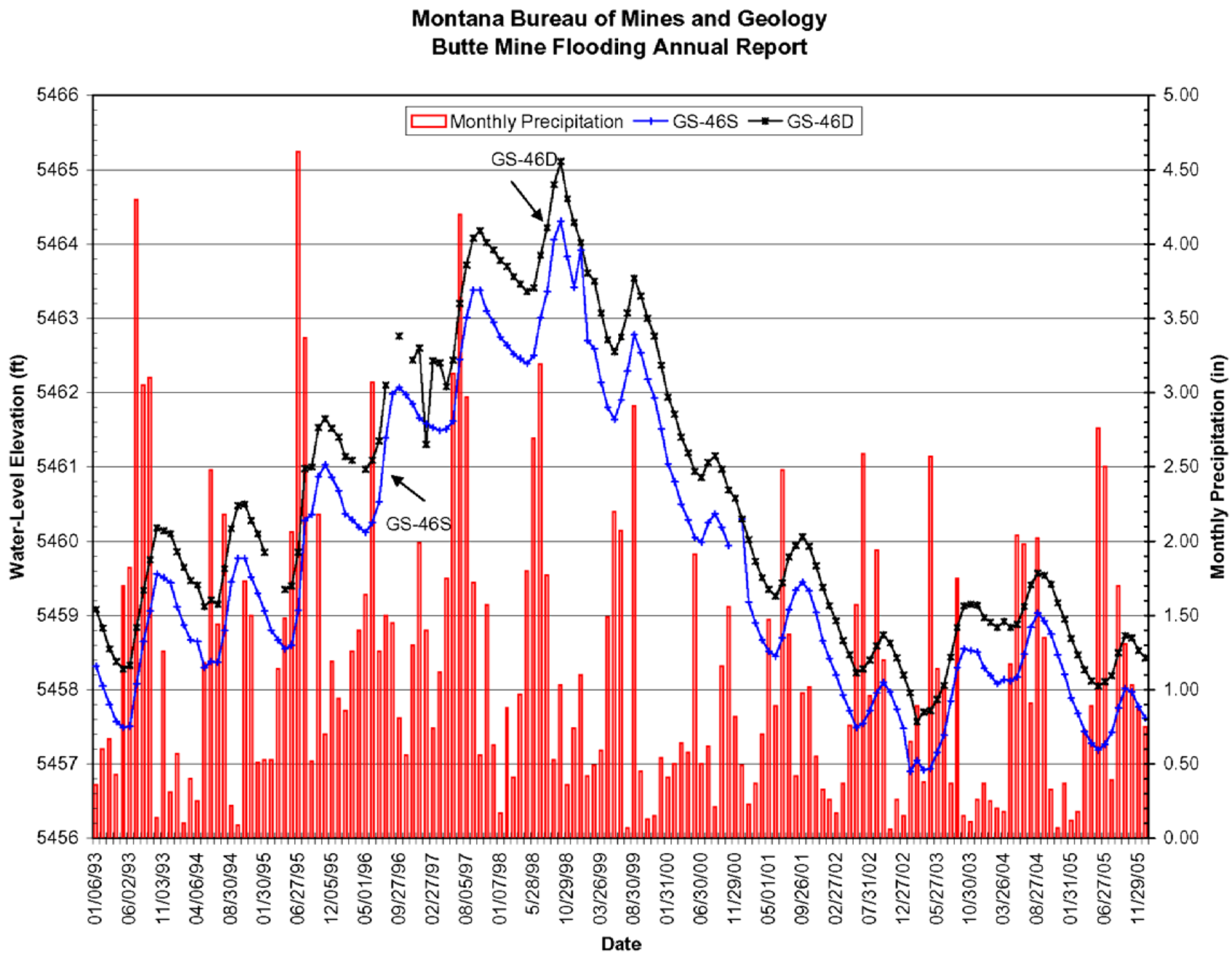


Figure 2-20. Water-level hydrographs for GS-46S and GS-46D wells.

Overall, water-level trends were similar during 2005 in wells GS-46S and GS-46D (fig. 2-20), and followed the trends discussed previously for wells GS-41 and GS-44. Water levels declined more than 0.50 ft in both wells during 2005.

In both the GS-41 and GS-44 wells, the water levels in the shallow wells are higher than those of the deeper wells, implying that there is a downward vertical gradient. That is, water in the upper part of the alluvial aquifer is moving down, providing recharge to the lower portions of the aquifer. Water levels in wells GS-46S and GS-46D show the opposite. The water level in well GS-46D is higher than the water level in GS-46S. This implies that water has the potential to move upwards in the aquifer and possibly discharge into a surface-water body, such as Silver Bow Creek. However, as noted below below, the water quality in well GS-46D is of good quality.

The BMF05-series wells were installed in late 2005 and early 2006. These wells were installed to replace the domestic wells that were part of the post RI/FS monitoring program. The domestic wells were monitored from 1997 through 2002; however, it was felt that dedicated monitoring wells would be more reliable for the long-term monitoring program and would not be influenced by household usage. The location of these wells is shown on figure 2-17. The wells were located to provide coverage throughout the same area covered by the domestic wells and to provide information to the south of the Berkeley Pit-active mine area. This area is important to better define the groundwater divide between the Butte Mine Flooding alluvial aquifer and Butte Priority Soils. Copies of wells logs are contained in Appendix1. Not enough water level data was available to determine water level changes or trends for 2005. In the future these wells will be part of the monthly water-level monitoring program; in addition pressure transducers will be installed in each well for continuous water-level monitoring.

2.1.4.1 GS and BMF05-Series Wells Water Quality

Water-quality samples were collected during the spring (May) sample event from these wells as part of the 2005 BMFOU monitoring. The poor water quality in GS-41S reflects its proximity to the Parrot tailings area; concentrations of dissolved constituents are extremely high. Data collected in 2005 confirms upward trends in nearly all dissolved constituents in GS-41S. The concentrations of several dissolved metals exceed maximum historic values. Well GS-41D, which has slightly better (but still extremely poor) water quality, exhibits a similar increase in the concentration of most dissolved constituents.

The concentration of several dissolved constituents continues to exceed MCLs in Well GS-44S at the north end of Clark's Park. Cadmium concentrations increased to a level just above the MCL in 2005, after being below it for the past two years. Well GS-44D continues to exhibit concentrations greater than MCLs, but overall concentrations have decreased by as much as 50 percent over the period of record and several were approaching the MCL. Data collected in 2005, continue to suggest a reversal of the downward trend. Wells GS-46S and D, northeast of Clark's Park continued to exhibit good water quality in 2005 and show little or no change in trend.

No water quality samples were collected from the BMF05 wells during 2005; however, quarterly samples will be collected during 2006 and 2007 to establish baseline conditions for these sites.

Section 2.2 East Camp Underground Mines

Monitoring of water levels in the seven East Camp underground mines continued. Their locations are shown on figure 2-21. During the year 2005, water levels rose between 7 and 7.5 feet in the mines, which is about 1 foot less than last year (a 5% to 10% decrease). The Berkeley Pit water level rose 7.03 feet, which is 0.65 feet less than last year (Table 2.2.1). The lower rate of water-level rise is most likely directly related to the increase in void area in the pit. Figure 2-22 shows the annual water level changes graphically for these sites. The net 2005 water-level change between the mine shafts and Berkeley Pit were very comparable.

Table 2.2.1 Annual water-level changes in East Camp mines, in feet.

Year	Berkeley Pit	Anselmo	Kelley	Belmont (1)	Steward	Granite Mountain	Lexington(2)	Pilot Butte
1982			1,304.00	117.00	85.00			
1983			877.00	1,054.00	1,070.00			
1984			262.00	269.00	274.00			
1985			122.00	121.00	123.00			
1986		56.00	96.00	102.00	101.00			
1987		77.00	84.00	77.00	79.00	67.00		
1988		53.00	56.00	53.00	52.00	57.00	8.10	
1989		29.00	31.00	31.00	29.00	31.00		
1990		32.00	33.00	34.00	33.00	34.00		
1991	12.00	29.00	33.00	30.00	29.00	31.00		
10- Year Change	***12.00***	***276.00***	***2,898.00***	***1,888.00***	***1,875.00***	***220.00***	***8.10***	
1992	25.00	22.00	24.00	24.00	23.00	25.00		
1993	26.00	24.00	25.00	26.00	25.00	26.00		
1994	27.00	25.00	26.00	25.00	25.00	27.00		
1995	29.00	28.00	27.00	18.00	28.00	30.00		
1996	18.00	16.00	19.00	4.15	18.00	18.00	1.19	3.07
1997	12.00	13.58	16.09	15.62	14.80	15.68	12.79	18.12
1998	17.08	13.23	14.73	13.89	14.33	14.24	13.71	11.26
1999	12.53	11.07	11.52	12.15	11.82	11.89	10.65	11.61
2000	16.97	14.48	14.55	15.66	14.60	15.09	14.01	14.11
2001	17.97	16.43	11.77	16.96	16.48	16.35	15.95	16.59
2002	15.56	11.60	13.15	13.02	12.60	12.82	12.08	11.33
2003	13.08	13.05	13.94	13.74	13.44	14.23	2.75	14.05
2004	7.68	7.31	7.86	7.54	7.48	7.67		7.53
2005	7.03	7.10	7.37	7.17	7.00	6.98		6.97
Grand Total Change*	***257.09***	***498.11***	***3,128.43***	***2,099.61***	***2,106.69***	***460.92***	***91.23***	***114.64***

(1) Mine shaft collapsed in 1995; a replacement well was drilled adjacent to the mine, into mine workings, in 1997. Since the well was drilled into the Belmont Mine workings, it is assumed that this water level is reflective of the Belmont Mine.
(2) No water-level measurements since February 2003, due to obstruction in shaft at 366 ft below surface.
(*)Total change is the measured change in water level. Access or obstructions have prevented continuous water-level measurements at some sites.

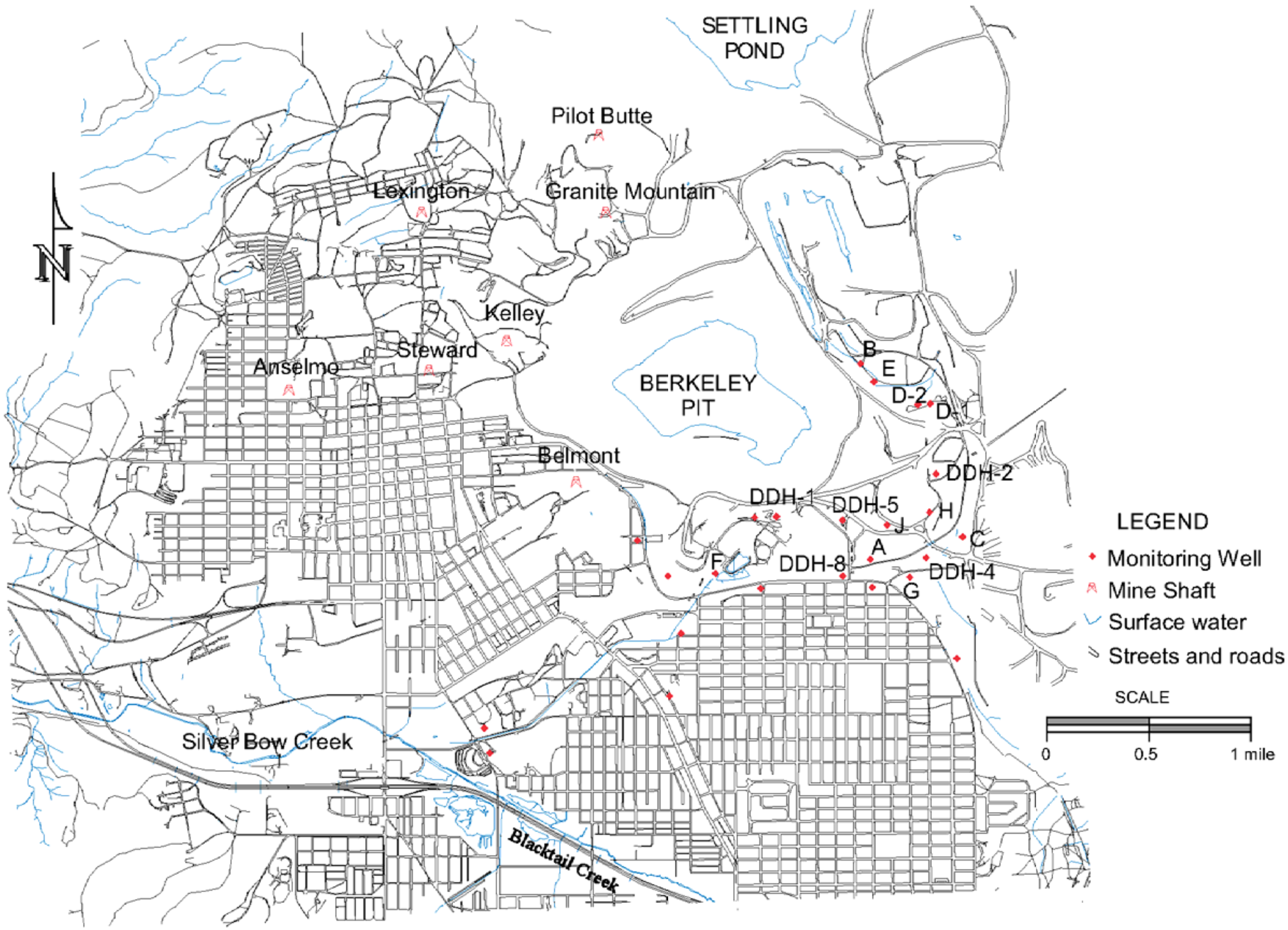


Figure 2-21. East Camp mines and Bedrock Wells Location Map.

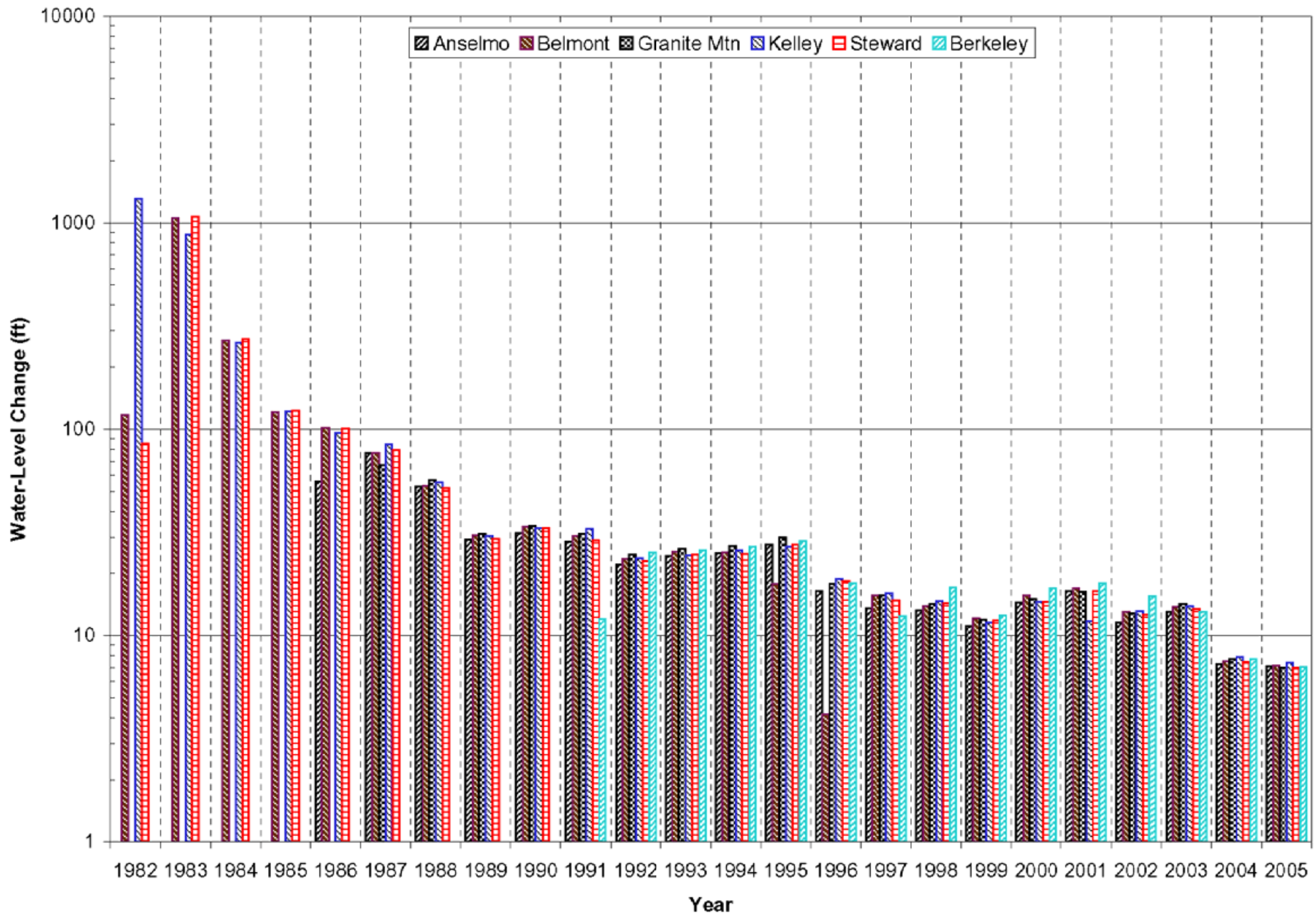


Figure 2-22. East Camp mines annual water-level changes.

Figure 2-23 is a hydrograph based upon water levels for the Anselmo Mine and Kelley Mine. There are no obvious variations in water levels on this figure; however, when water levels are plotted from 1995 through 2005, several changes are noticeable (fig. 2-24). The removal of HSB drainage water from discharging into the pit in April 1996 resulted in a flattening of the line, while the July 2000 addition of the HSB drainage water, following MR's suspension of mining, resulted in an increased slope of the line. The slope of the line, or rate of rise, shown on fig. 2-24 flattened out throughout 2005, corresponding to the removal of the HSB drainage water and its subsequent treatment. The HSB treatment plant came on-line during late November 2003.

Figure 2-25 shows monthly water-level changes in the Berkeley Pit through 2005. The addition of HSB drainage water continued through late November 2003, after which this water was diverted to the HSB water-treatment plant. Water-level changes seen over the last 6 months of 2000, following the addition of HSB drainage water, continued through 2003. However, water-level increases were much less throughout 2004 and 2005 as a result of the decreased inflow of water into the pit. A similar trend was seen in all the East Camp underground mines. Water levels remain the highest in the sites farthest from the Berkeley Pit. This continues to confirm that water is flowing towards the pit, thus keeping the pit the low point in this system.

Figure 2-26 is a plot of selected mine-shaft water-levels versus precipitation. There is no apparent influence on water levels in the underground mines from monthly precipitation. It is obvious that the rise in water levels is a function of historic mine-dewatering activities and the void areas in the underground mine workings and Berkeley Pit and is not a function of precipitation. Based upon volume estimates of the underground mines and December 2005 water-level elevations, almost 85 percent of the underground workings are flooded. However, since almost 12 percent of the underground workings are above the CWL elevation of 5410-ft, only 3 to 4 percent of the underground workings remain to be flooded.

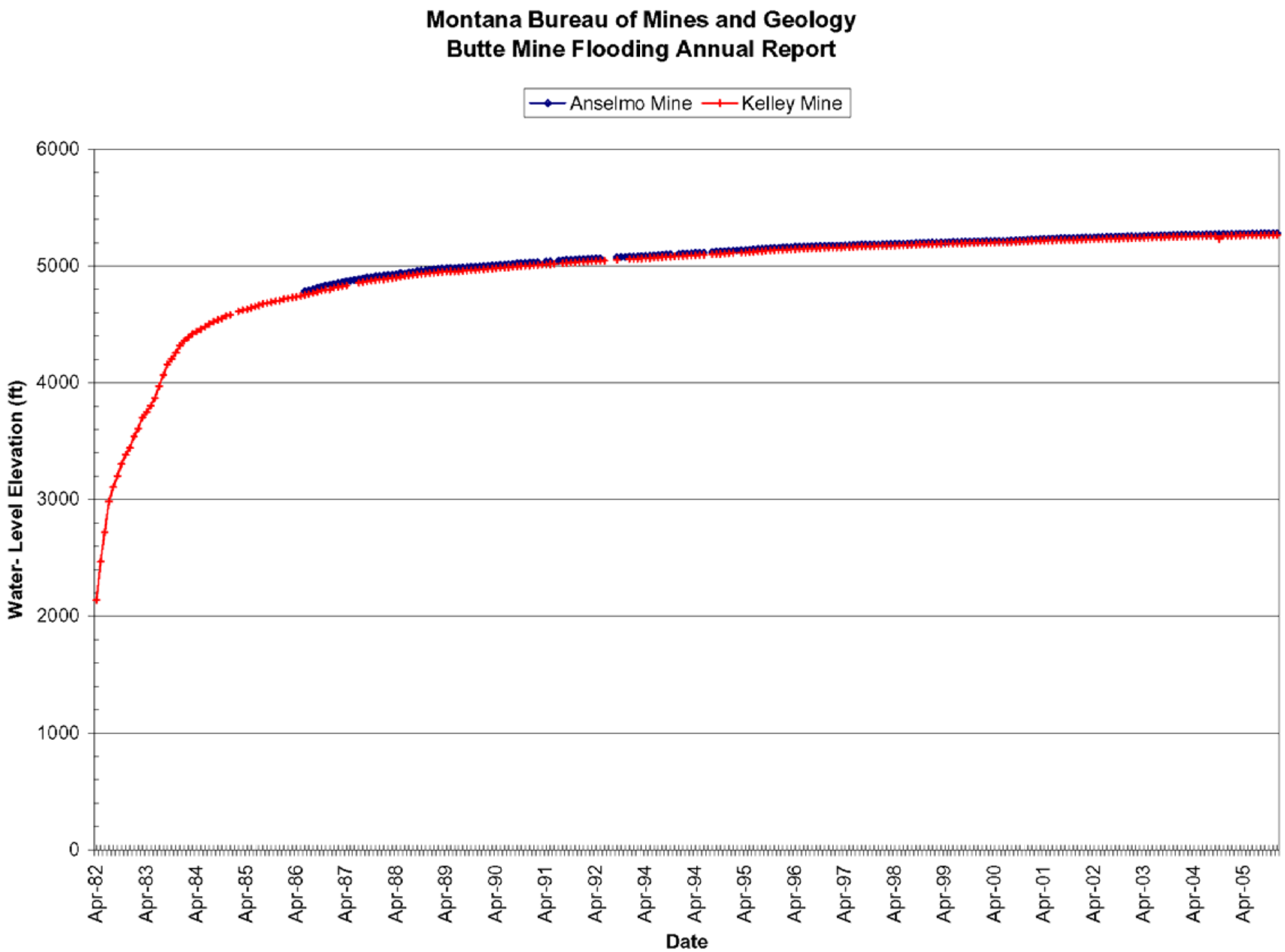


Figure 2-23. Water-level hydrographs for the Anselmo Mine and Kelley Mine.

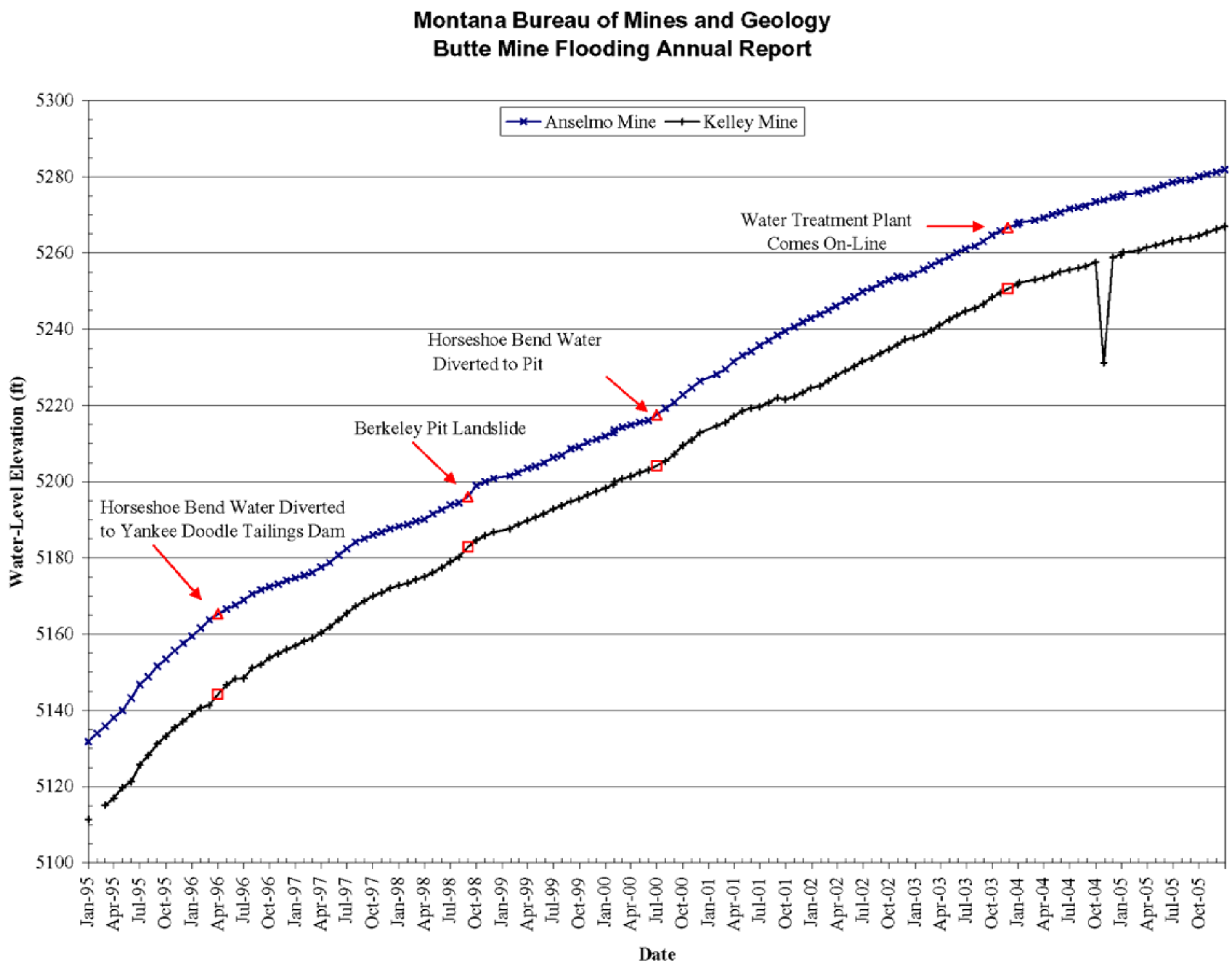


Figure 2-24. Water-level hydrograph, 1995-2005, Anselmo Mine and Kelley Mine.

Montana Bureau of Mines and Geology
Butte Mine Flooding Annual Report

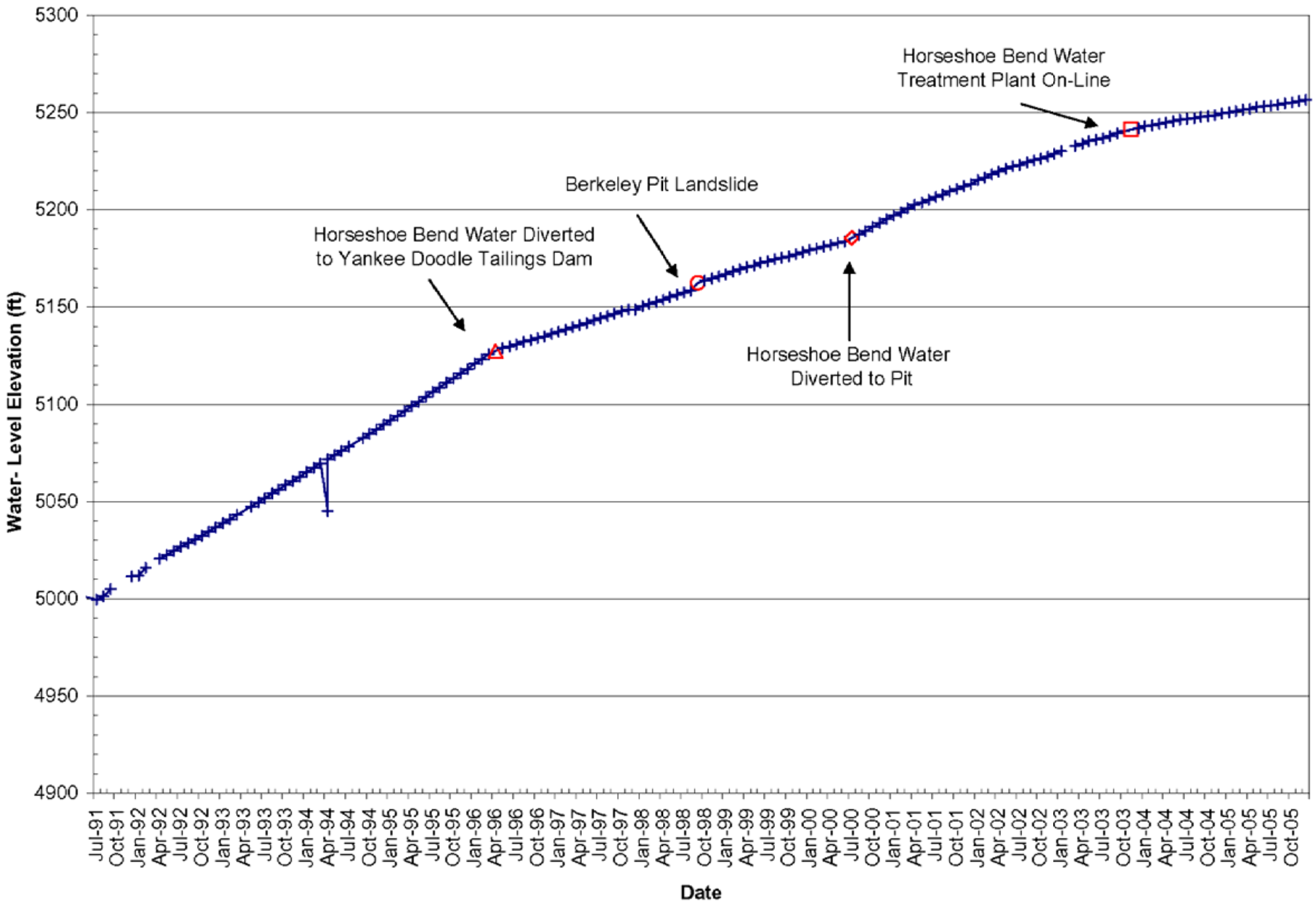


Figure 2-25. Water-level hydrograph for the Berkeley Pit.

Montana Bureau of Mines and Geology
Butte Mine Flooding Annual Report

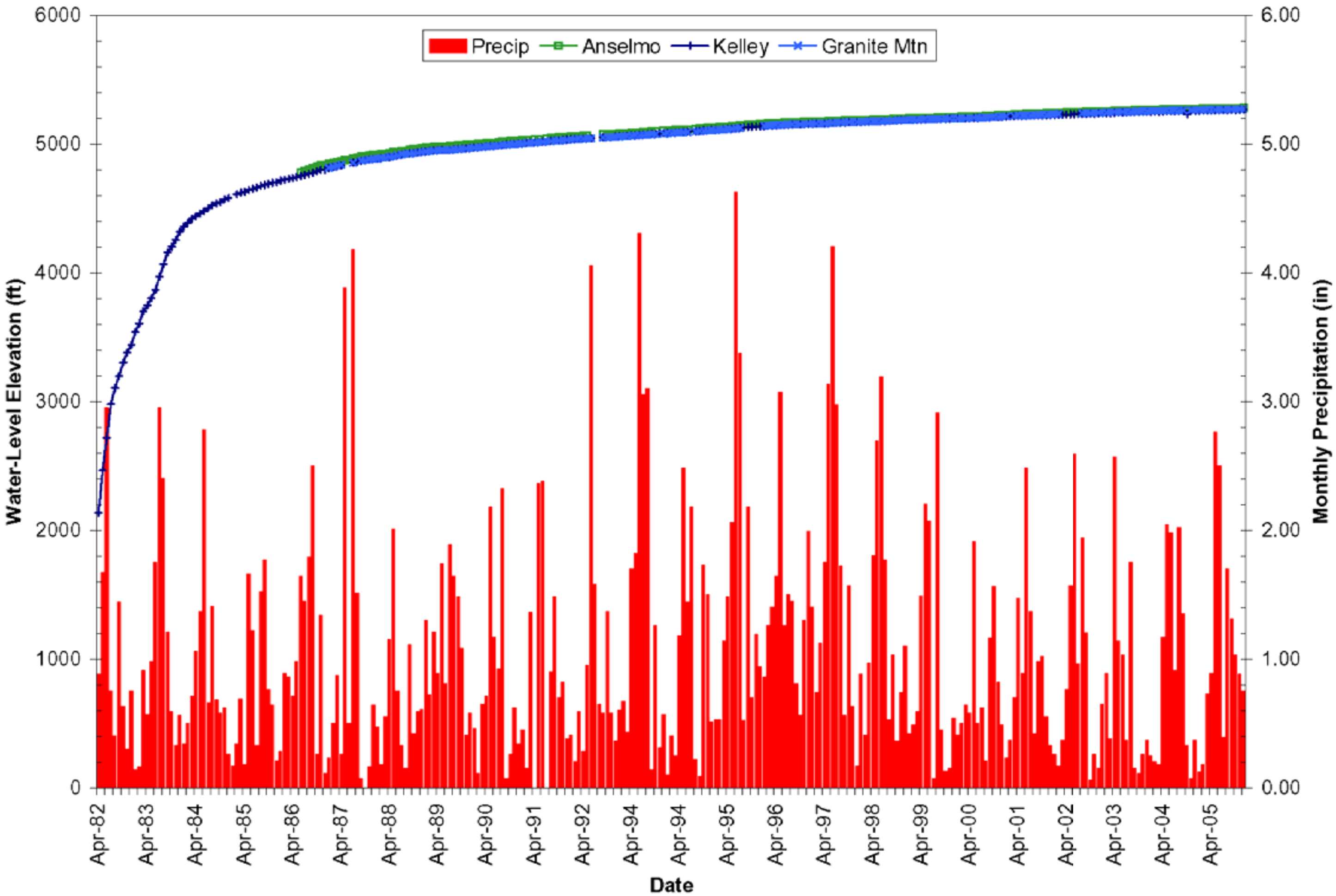


Figure 2-26. Water-level hydrographs for selected East Camp Mines, with monthly precipitation.

Section 2.2.1 Water Quality

Earlier reports discussed the lack of appreciable change in water quality of the East Camp mines until 2002 when several of the shafts exhibited significant departure from previous trends. Data from the 2005 sampling indicate that the changes in concentration are sustained for yet another year. Again, most notable is the increase in the concentration of metals, arsenic, and sulfate in the Kelley shaft; the exception being that of dissolved copper that continues to decrease in concentration. The relationship between the concentration of zinc (increasing) and copper (decreasing) should be explored, but requires a great deal more sampling than the current effort. Samples were collected twice during 2005 and from two different depths (100-ft and ~500-ft below the water surface) to better document water quality conditions at the Anselmo, Steward, and Kelley Mines.

The Anselmo shaft exhibits a continued increase in arsenic and iron concentrations (fig. 2-28). The concentration trends in the Steward shaft also continue as they have in the recent past. As with the Kelley, the current data collection at these sites only allows the observation of change, not an explanation.

Kelley: iron, sulfate, arsenic, and aluminum have increased to near historic concentrations; copper concentration remains very low (fig. 2-27).

Anselmo: the concentration trend for iron and arsenic concentrations continue upward to near or above historic concentrations; zinc and cadmium show large (order of magnitude) fluctuations (fig. 2-28), with the 2005 concentrations being the lowest recorded to date. Copper concentrations remain very low (<20 μg/L).

Steward: the trend of concentrations of most constituents (i.e. arsenic) in the Steward shaft has been slightly upward in the recent period of record. The trend has been downward for zinc and copper (fig. 2-29).

Water quality samples were collected during the spring sampling event at the Pilot Butte Mine. The concentrations trends for iron, aluminum, arsenic, and zinc continue their downward trend from historic concentrations.

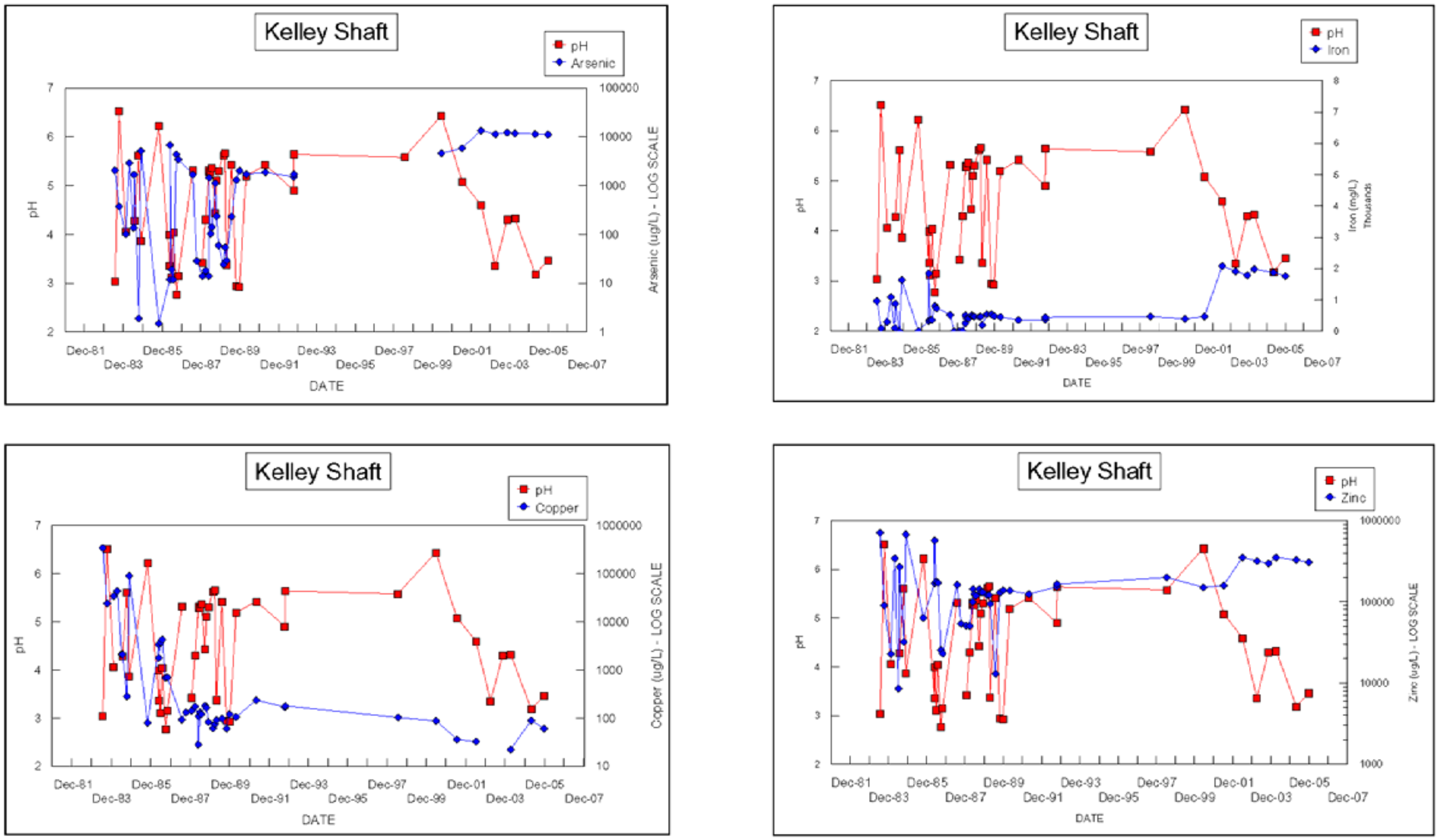


Figure 2-27. The concentrations of most dissolved constituents in the Kelley shaft continued the trend of recent years.

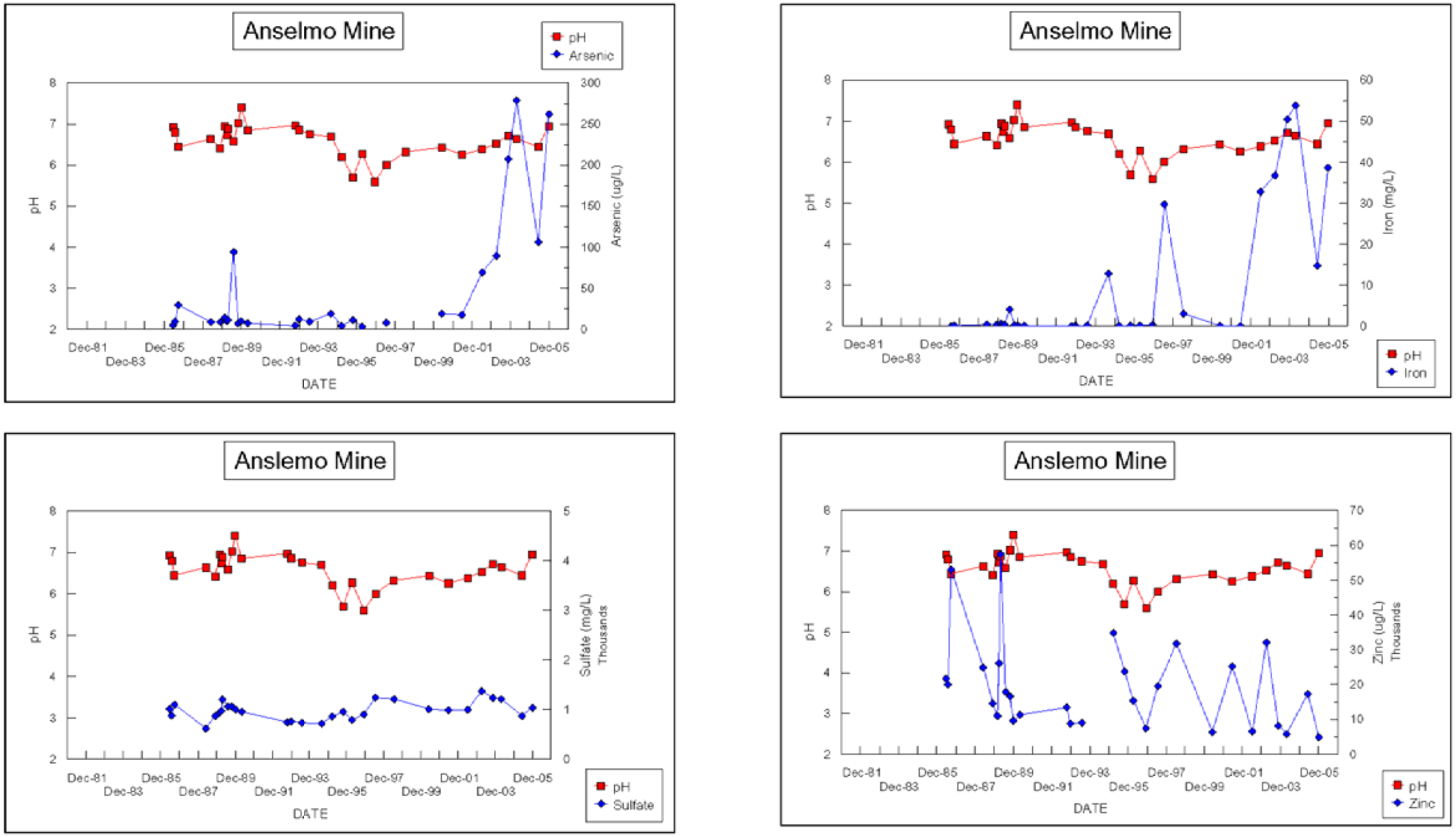


Figure 2-28. The concentration of arsenic and iron have recently increased dramatically in the Anselmo shaft. The trend of sulfate and zinc concnetrations continue those of recent years.

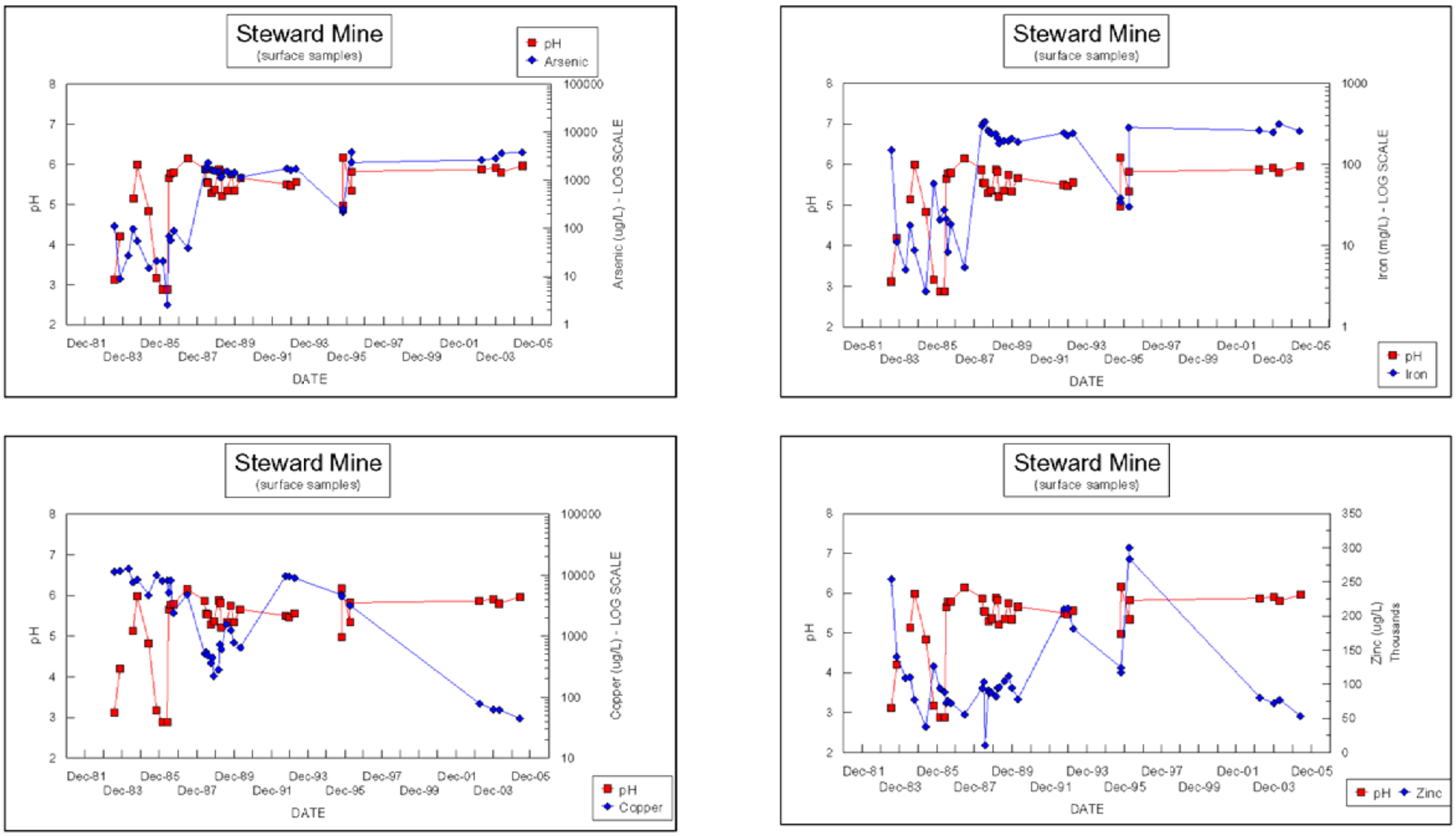


Figure 2-29. The concentrations of most dissolved constituents have increased in the Steward shaft over the period of record. Copper and zinc, however, have decreased to near historic levels.

Section 2.2.2 RI/FS Bedrock Monitoring Wells

Monitoring of the 9 RI/FS and ROD-installed bedrock wells continued. Monitoring well locations are shown on figure 2-21. Water levels continue to rise in wells A, C, D-1, D-2, G, and J at rates similar to those in the East Camp Mine system. Water levels in well E continue to follow patterns identified in earlier reports, while water levels in well F decreased slightly. Table 2.2.2.1 contains yearly water-level changes and figure 2-30 shows these changes graphically.

The monitoring program contained in the 2002 CD specified that water levels be monitored on a continuous basis in bedrock wells A, B, C, and G. Water-level transducers were installed in each of these wells and set to collect water-level data every hour. This detailed level of monitoring allows recording of changes in water levels not seen when only one water-level measurement is taken monthly.

There were two events that occurred during 2005 that affected water levels in the East Camp bedrock system, one natural and one manmade. The evening of July 25, 2005 shortly after 10:00 PM a magnitude 5.6 earthquake struck southwest Montana and was felt in Butte. Water-level changes in the bedrock system were noticeable in wells equipped with pressure transducers, with some wells exhibiting a greater response than others, especially wells A and B. Water levels had an almost immediate response to the earthquake, with water-levels falling for a period of time before beginning to rise again. Figures 2-31a, 2-31b, and 2-31c show water levels for July and August for wells A, B, and C. Water levels returned to pre-earthquake levels and trends in all the bedrock wells with the exception of well B. Water levels in this well continued to decline for a number of months before leveling off and rising again (figure 2-31b). Water-level response to earthquakes is not a new or unusual phenomenon. Responses usually occur in confined aquifers and the East Camp bedrock system would fall into such a system. Similar water-level responses were seen in these same wells following the 2002 November Alaskan earthquake (figure 2-31d). One explanation for the water level response is that the ground motion associated with the earthquake opens up fractures or faults in the bedrock system thus increasing permeability for a short time. The water in the system then drains (fills) these voids resulting in a water-level decline. Once these new voids are filled, the water levels begin to rise again. Another possibility is that the clay material contained in the bedrock swells again sealing the voids and water levels begin to rise.

The second event that affected bedrock water levels was the December pumping test conducted by MR in support of future mine expansion. MR opened up the Pittsmont #3 shaft and installed a pump to test the feasibility of dewatering the Central Ore Zone for future mining. They ran a moderate length pumping test from December 9, 2005 through December 15, 2005, pumping at a rate of approximately 1000 gallons per minute. Figures 2-32a and 2-32b show the water level drawdown in the bedrock system associated with this testing. Bedrock wells D-1 and J are in close proximity to the Pittsmont shaft while wells A, C and G (figure 2-32b) are farther away. The wells closest to the pumping site respond almost instantaneously to the start and stop of pumping; while the wells farther away show a more gradual drawdown and recovery. There were no long-term influences on water levels in the bedrock system from these pumping activities.

Water levels in the bedrock aquifer, which had been affected by historic underground mine dewatering, are responding to the cessation of pumping and show no apparent relationship to precipitation through 2005. Instead, physical changes that affect the flow of water into the Berkeley Pit and underground mines, e.g. the 1996 HSB water diversion and the 2000 addition of the HSB drainage flow, are the major influences on water-level increases. Figure 2-33 is a hydrograph showing monthly water-levels and monthly precipitation totals with 1996, 2000 and 2003 HSB operational changes identified. The void areas in the mines and Berkeley Pit control the annual rate of rise in this system.

Table 2.2.2.1 RI/FS bedrock well annual water-level change, in feet.

Year	Well A	Well B	Well C	Well D-1	Well D-2	Well E	Well F	Well G	Well H	Well J
1989										
1990										
1991	33.18		22.38	24.20	22.68	1.73				
1992	39.22	8.78	26.53	27.89	25.04	0.47	-1.92			
1993	27.95	8.68	21.72	24.41	24.51	-0.37	1.09			
1994	25.65	7.90	23.88	25.12	25.21	0.27	0.11			
1995	28.69	13.41	29.55	26.99	27.50	0.44	1.65	28.74	30.37	
1996	19.31	14.56	26.22	18.77	18.92	0.48	-0.11	22.40	18.72	
1997	14.44	12.35	19.25	13.62	13.68	-0.64	1.41	15.67	3.76	
1998	15.96	11.30	16.68	16.41	16.39	0.44	1.03	15.56	154	
Total 10-Year Change	**204.4**	**76.98**	**186.21**	**177.41**	**173.93**	**2.82**	**3.26**	**82.37**	**68.29**	
1999	11.21	5.11	12.44	12.18	12.03	-0.78	-1.80	12.00	P&A	1.99
2000	15.12	8.20	13.39	14.66	15.79	-2.68	-2.49	12.84	P&A	16.19
2001	18.33	9.08	16.86	19.81	18.61	-3.58	-0.61	16.56	P&A	18.81
2002	15.16	1.73	14.41	14.69	14.76	-3.37	-0.73	14.84	P&A	15.29
2003	12.75	8.70	13.20	13.69	13.72	-2.66	1.16	12.71	P&A	13.48
2004	7.60	4.46	8.71	7.90	7.83	-1.12	0.32	8.31	P&A	7.58
2005	5.82	-7.00	6.76	5.56	6.08	-2.51	-0.73	5.95	P&A	7.03
Total Change*	**290.39**	**107.26**	**271.98**	**265.90**	**262.75**	**-13.88**	**-1.62**	**165.67**	**68.29**	**80.37**

Year	DDH-1	DDH-2	DDH-4	DDH-5	DDH-8
1989	29.53			34.83	30.48
1990	36.24	30.99	5.44	27.61	35.96
1991	27.03	28.20	39.81	27.01	28.96
1992	28.25	26.09	37.66	21.07	26.16
1993	24.33	24.16	26.88	24.40	24.46
1994	25.00	25.65	28.34	19.78	15.97
1995	27.66	28.74	28.80	26.10	--
1996	18.53	18.97	20.24	12.41	55.68
1997	13.33	14.09	14.32	15.89	13.38
1998	15.03	16.20	16.25	16.50	16.50
***Total 10- Year Change**	**244.93**	**213.09**	**217.74**	**235.60**	**247.55**
1999	11.66	12.00	11.88	4.82	15.50
2000	14.64	16.11	14.77	P&A	10.42
2001	18.14	18.78	18.52	P&A	18.93
2002	14.63	14.80	13.14	P&A	13.64
2003	13.05	13.90	NA	P&A	14.49
2004	7.08	7.89	NA	P&A	7.90
2005	4.87	5.89	NA	P&A	57.52
Total Change*	**329.00**	**302.46**	**276.05**	**240.42**	**385.95**

(*)Total change is the measured change. Access or obstructions prevented continuous water-level measurements at some sites. P&A – well plugged and abandoned due to integrity problems. Well J was drilled as a replacement for well H.

Water levels measured in well J since its completion in 1999 have been in the same range as those in other surrounding bedrock wells, and are shown on figure 2-34. Historic water levels for well H are shown on this figure with a linear projection of water levels included. Water levels for well J plot very closely to those projected for well H, verifying that well J was completed in the same bedrock zone as well H. However, beginning in April 2004, the water level for well J plots below the projected water level for well H. This is a result of the filling rate slowing from the diversion and treatment of water from the HSB drainage. The projected water level for well H does not take into account the removal of HSB water from the pit.

The water-level change in well B was about one-half the rate of that of the above bedrock wells and Berkeley Pit over a number of years, until November 2002. Due to a water-level decline during November and December, the 2002 rate of water-level rise was only 11 percent of that of the Berkeley Pit. The 2003 and 2004 water-level increases were closer to 60% that of the other bedrock wells; however, as a result of the influence of the July earthquake and water quality sampling on this well, the water level had a net 7-ft decline for 2005. Hydrographs for wells A and B, showing monthly water-level elevations are shown on figure 2-35.

Water levels in wells E and F do not follow the trends seen in the other bedrock wells (fig. 2-36). Water levels in these two wells are considerably higher than those in the other bedrock wells, indicating a lack of dewatering and interconnection to historic mining activities.

Water-level monitoring continues to confirm that the flow of water in the affected bedrock aquifer is towards the Berkeley Pit. The potentiometric-surface map (fig. 2-37) for the East Camp bedrock aquifer shows the flow of water from all directions is towards the pit. While there were short-term influences on water levels in a number of these wells, the overall direction of groundwater flow did not change.

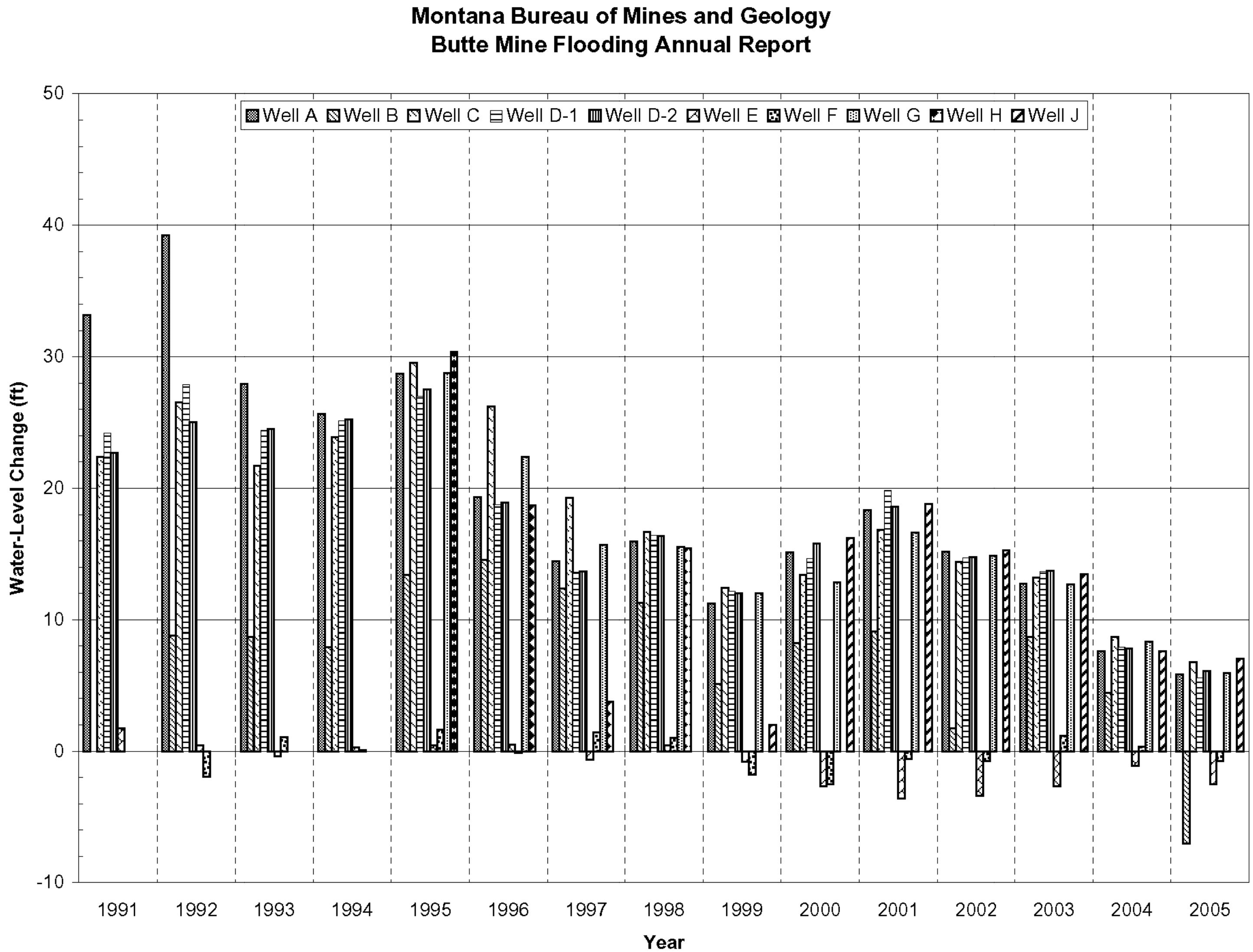


Figure 2-30. RI/FS bedrock wells annual water-level change.

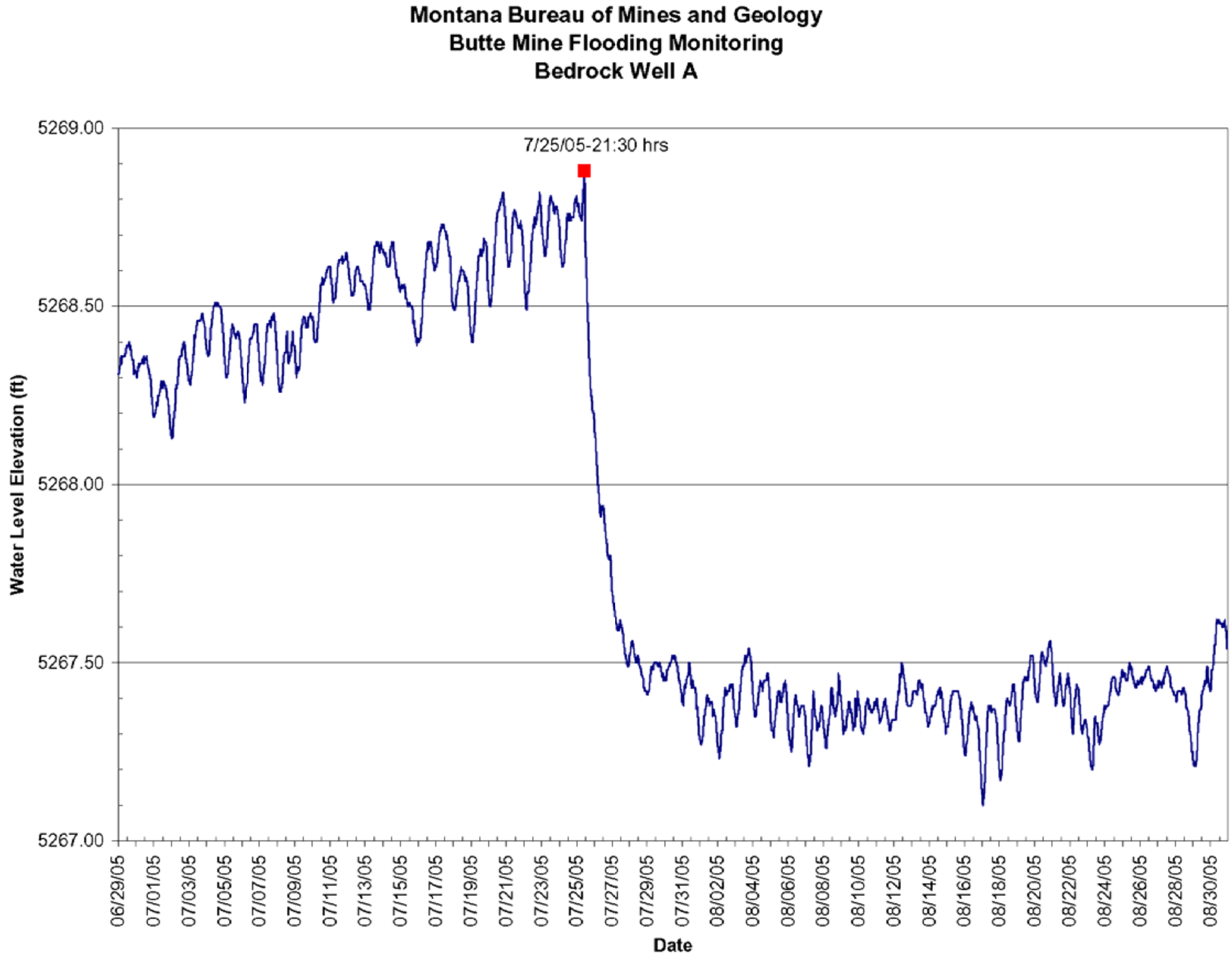


Figure 2-31a. July-August hydrograph for well A showing influence of July 25, 2005 earthquake.

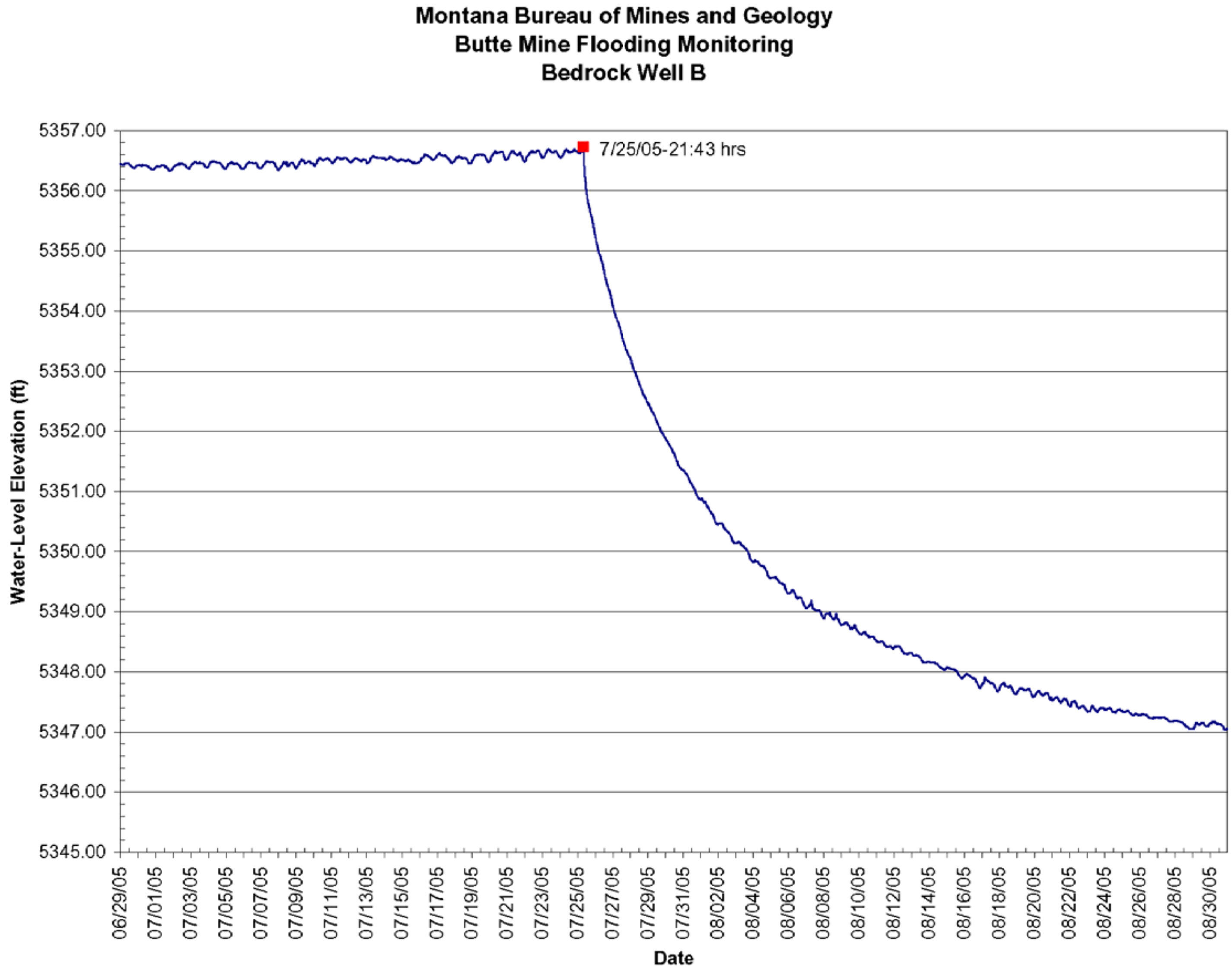


Figure 2-31b. July-August hydrograph for well B showing influence of July 25, 2005 earthquake.

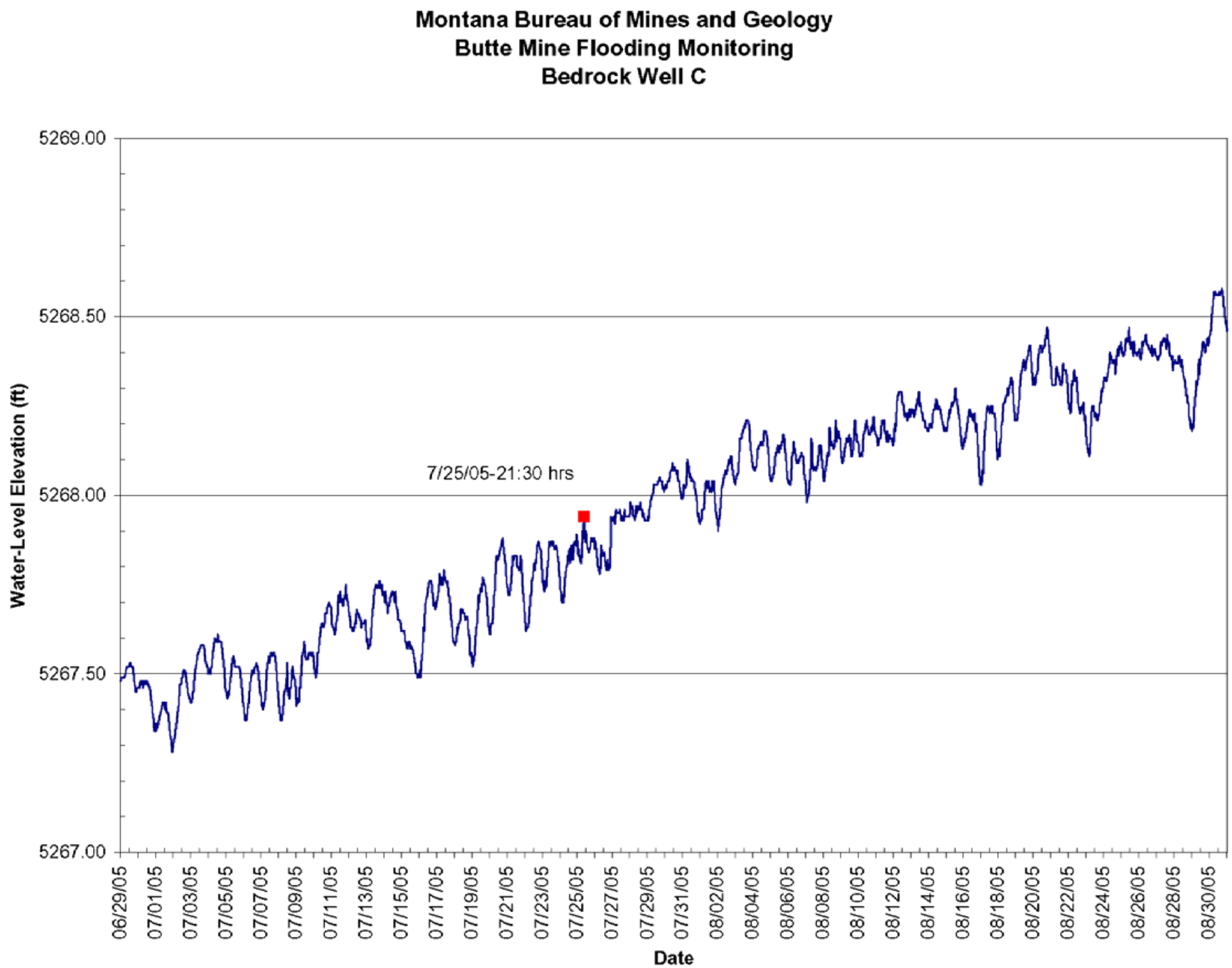


Figure 2-31c. July-August hydrograph for well C showing influence of July 25, 2005 earthquake.

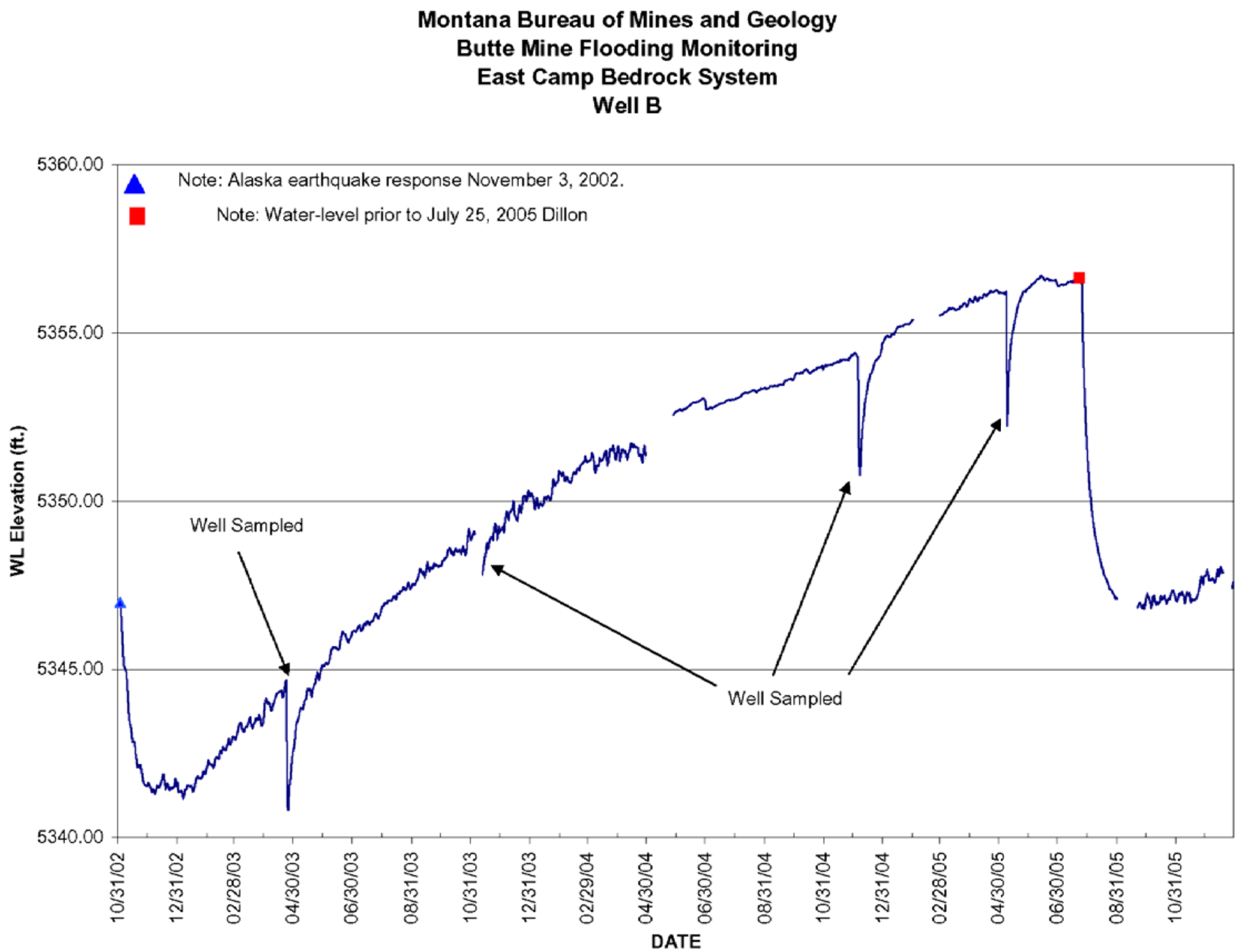


Figure 2-31d . Hydrograph of bedrock well B showing influence of July 2005 earthquake.

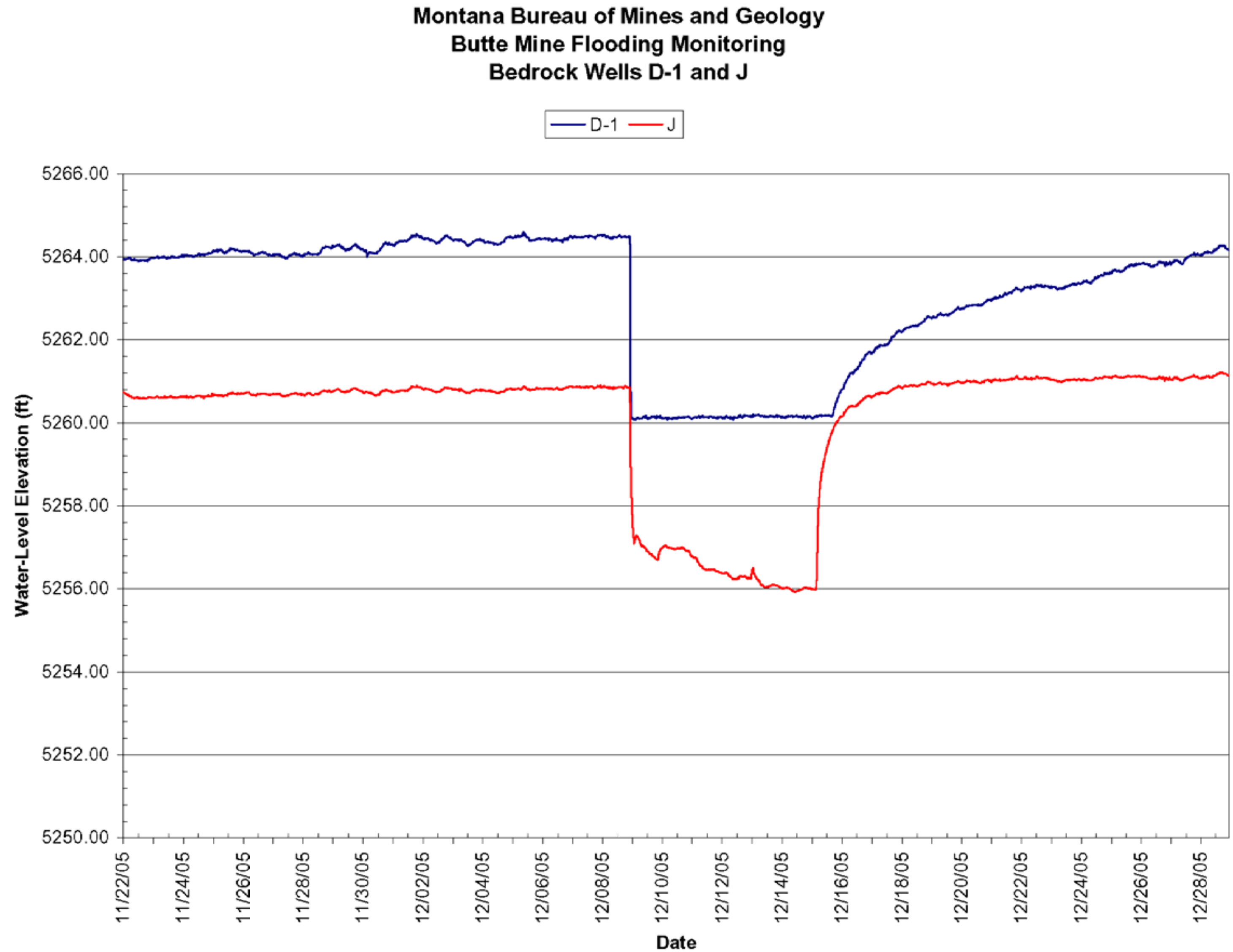


Figure 2- 32a. Hydrograph showing influence of MR pumping test on East Camp bedrock water-levels.

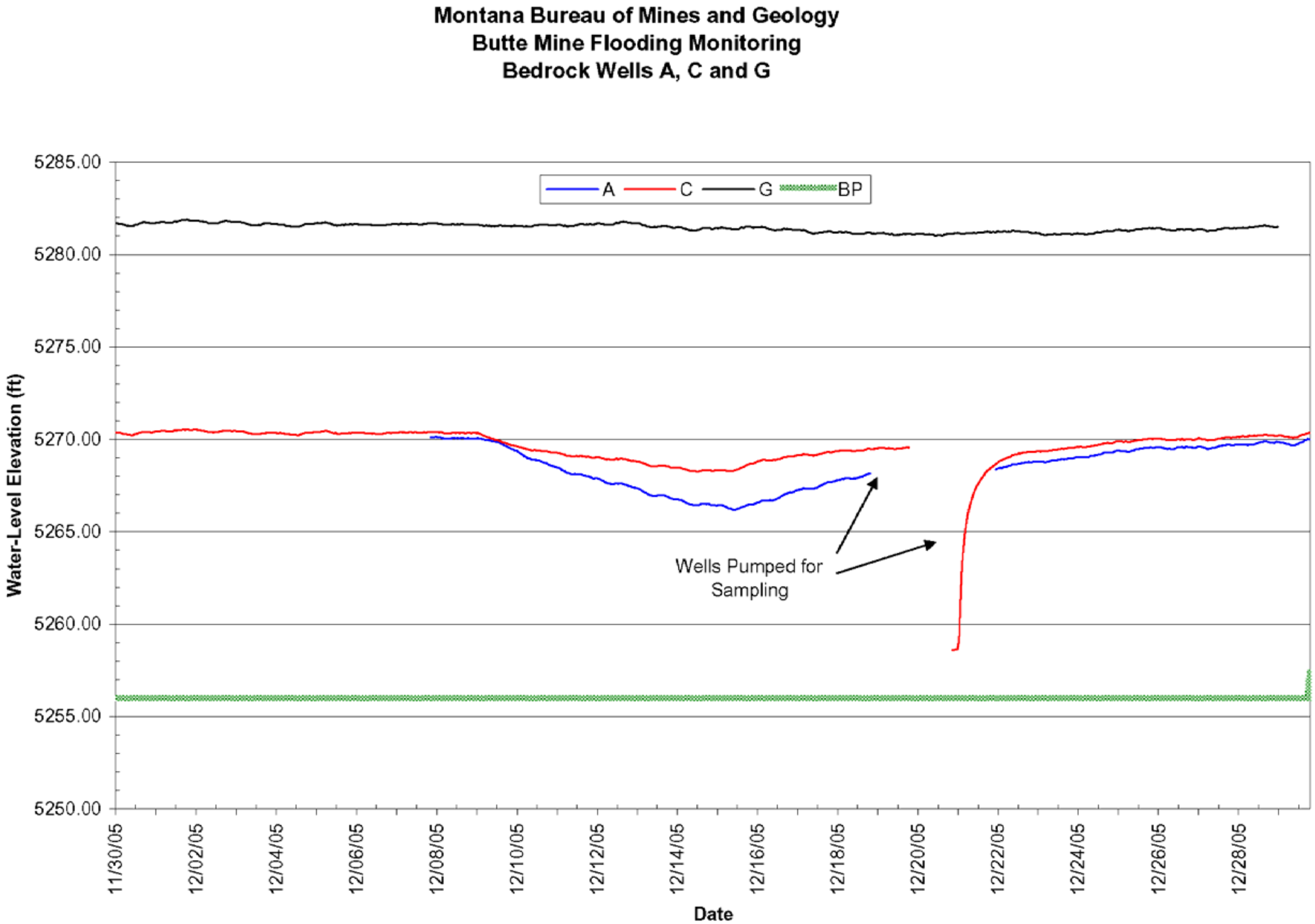


Figure 2- 32b. Hydrographs showing the influence of MR pumping test on East Camp bedrock water levels, wells A, C, and G.

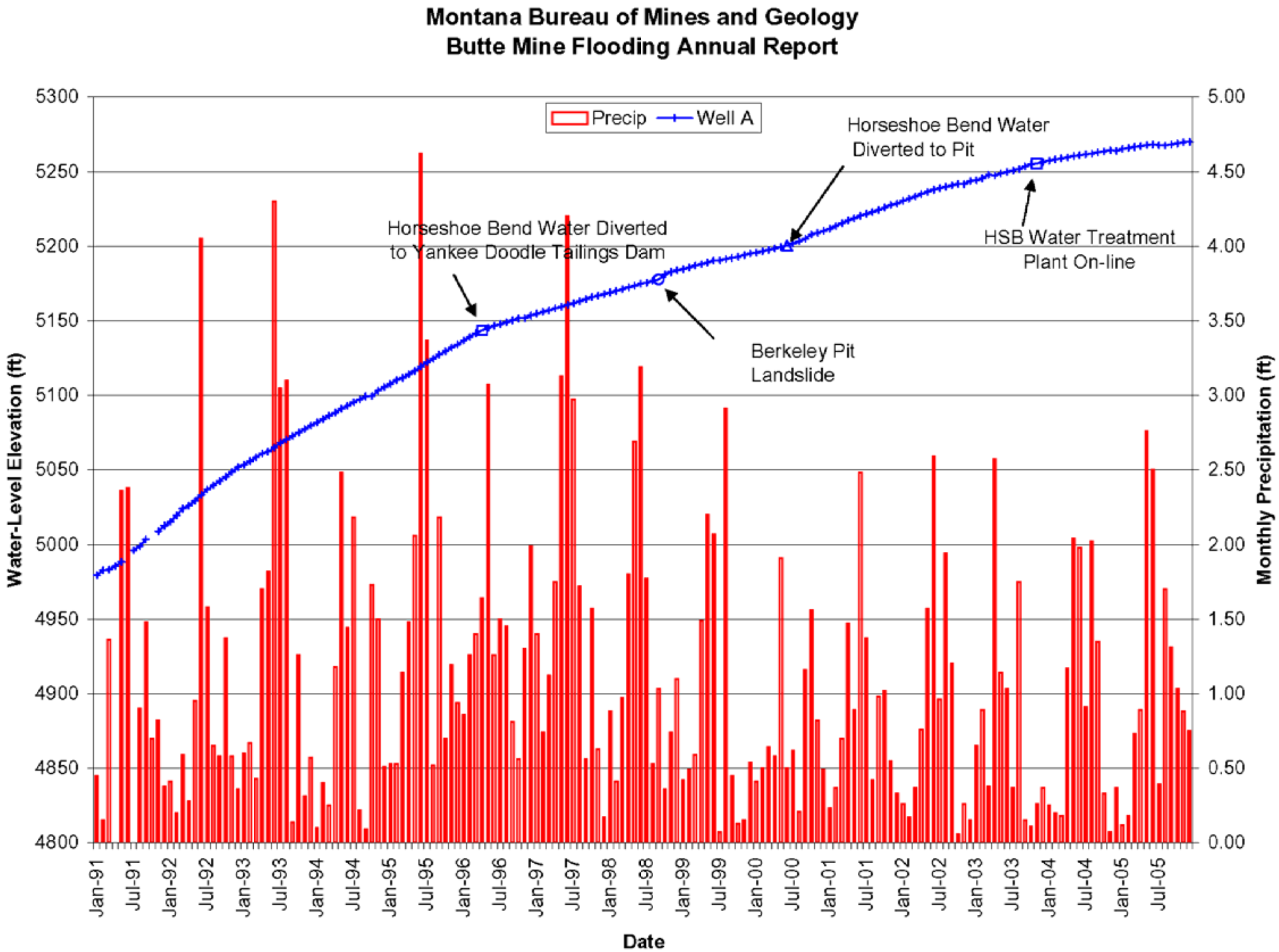


Figure 2-33. Water-level hydrograph for bedrock well A.

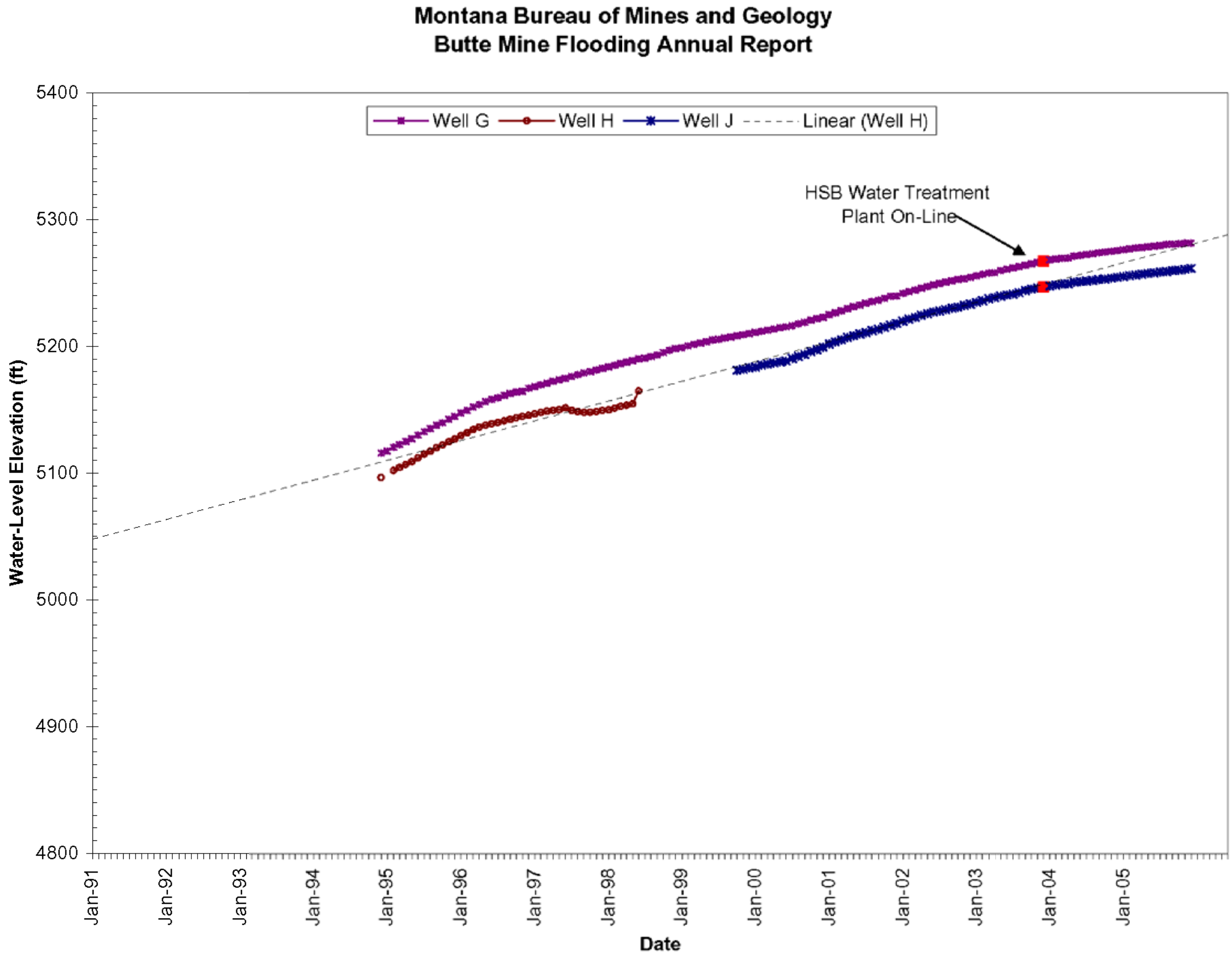


Figure 2-34. Water-level hydrographs for bedrock wells G, H, and J.

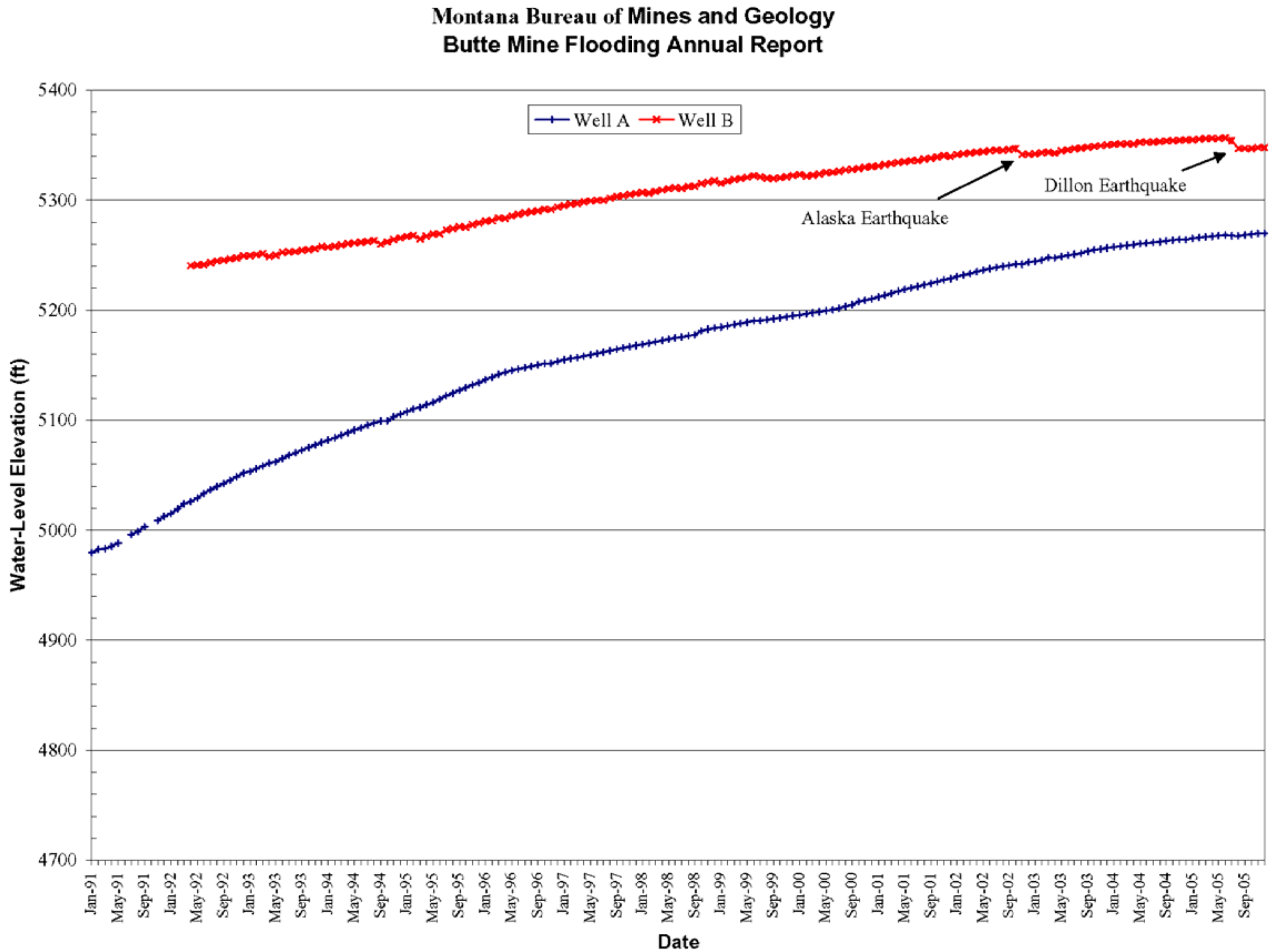


Figure 2-35. Water-level hydrograph for bedrock wells A and B.

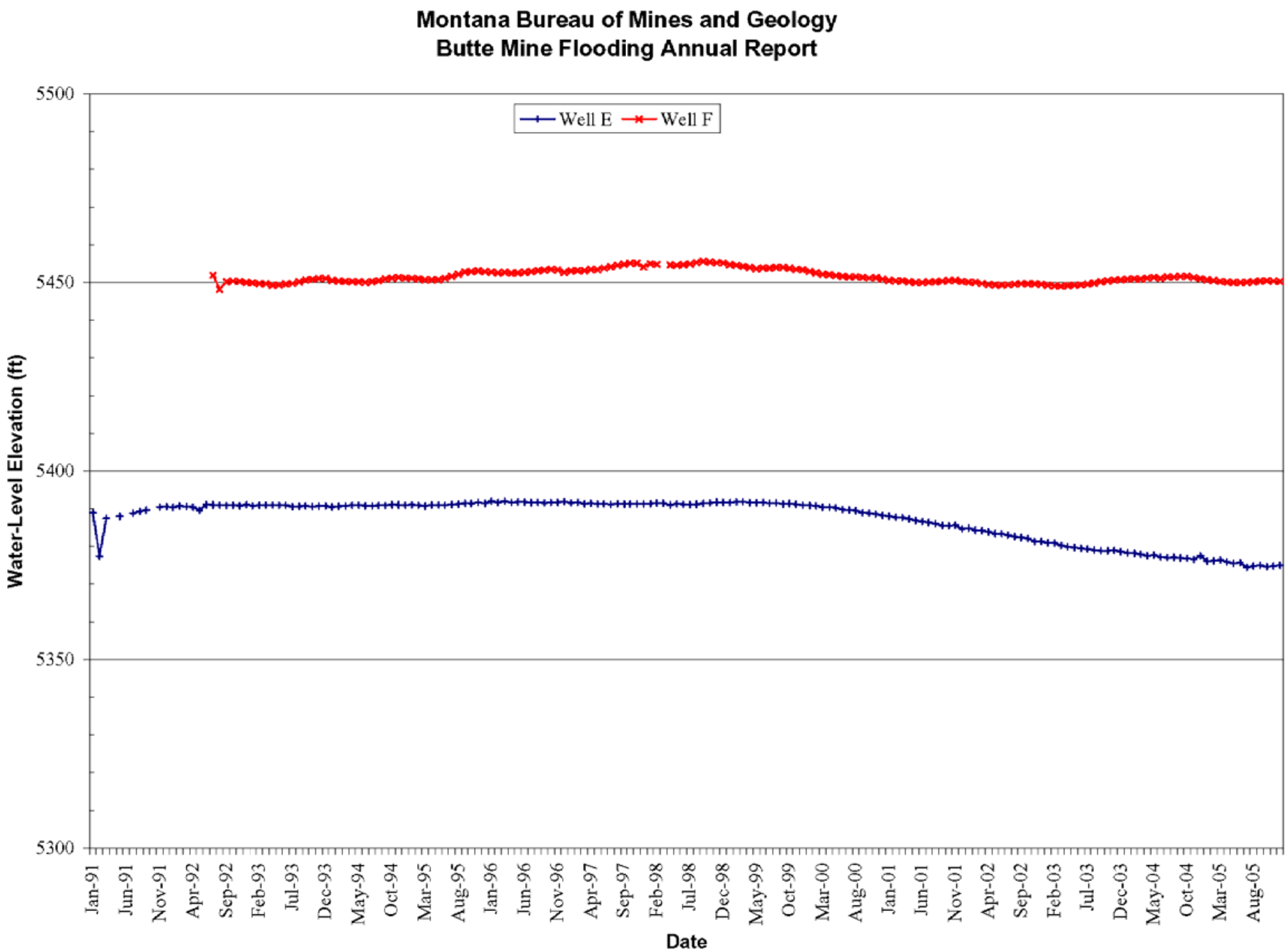


Figure 2-36. Water-level hydrograph for bedrock wells E and F.

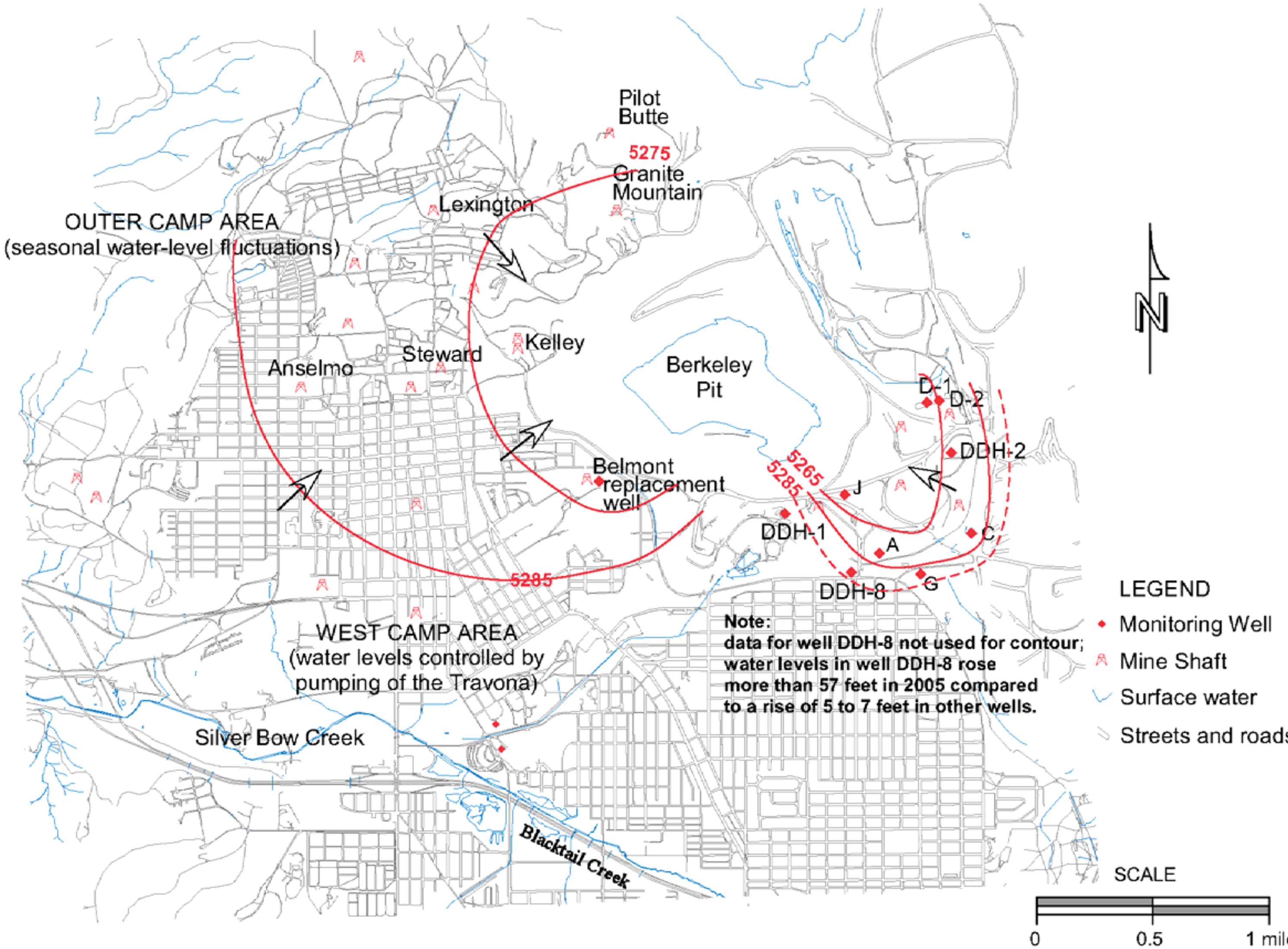


Figure 2-37. Potentiometric map for the East Camp bedrock aquifer, December of 2005; arrows indicate direction of ground-water flow (contour interval is 10 feet).

Section 2.2.2.1 RI/FS Bedrock Well Water Quality

Water quality in the East Camp bedrock wells has shown little change in recent years. Data collected in 2005 indicate only slight change for most wells. Table 2.2.2.1.1 summarizes the water-quality trends over the past few years; as noted in previous reports, the status of wells B and D-1 changed with respect to MCLs due to the change in the water-quality standard of arsenic from 18 to 10 μg/L. In most wells, there was little change in the concentration of dissolved constituents. Well J has been showing increased concentrations of zinc, cadmium, and several other metals. For example, arsenic has increased from 1,280 to 1,332 ug/L and zinc has increased from 44,400 to 69,378 ug/L since 2003 (fig 2-38).

Table 2.2.2.1.1 Exceedances and recent trends for East Camp bedrock wells, 1989 through 2005.

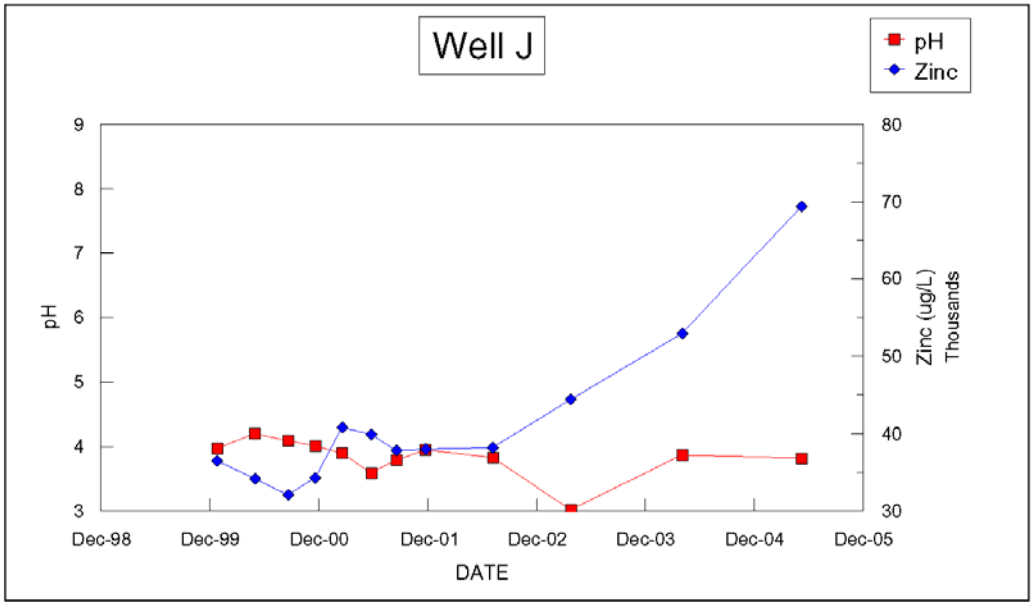
Well Name	Exceedances* (1 or more)	Concentration Trend	Remarks
A	Y	None	arsenic (MCL), sulfate (SMCL)
B	Y	None	arsenic (MCL), sulfate (SMCL)
C	N	None	sulfate (SMCL)
D-1	Y	Variable	arsenic (MCL), sulfate (SMCL)
D-2	N	None	sulfate (SMCL)
E	Y	Variable	sulfate (SMCL), arsenic (MCL)
F	Y	None	arsenic (MCL), sulfate (SMCL)
G	N	None	sulfate (SMCL)
J	Y	Upward	very poor quality water

(*) exclude sulfate

Section 2.2.3 DDH Series Wells

Water-level monitoring of the DDH series wells continued. Water levels have continued to rise in these wells, following previous trends with the exception of well DDH-8. The water-level rise in wells DDH-1 and DDH-2 ranged from 4.5 to 6 feet in 2005. The rates of rise are consistent with those of the other bedrock wells and East Camp mine shafts. Figure 2-39 shows a hydrograph for well DDH-2 showing water-level increases. Once again, precipitation does not show any affect on water-level rise. Well DDH-8 had an unexplained water-level increase during August 2005. Its water-level rose over 52-ft during the month. During this time the 2-inch PVC casing was removed and a submersible pump was installed to test the water for possible irrigation use. The water-level rise began prior to the well pumping and continued after its completion. Nothing out of the ordinary was noted during the pumping to account for the abnormal water-level change. During the remainder of the year water-level changes were similar to those of the other DDH series wells. It is important to note that these groups of wells were not installed for monitoring purposes, they are old exploration holes that extend several thousand of feet below ground surface and have various size casings installed. Due to completion uncertainties and the drilling techniques it is not unexpected to have problems occur with these wells. In the past, another well (DDH-6) had to be plugged and abandoned due to casing integrity problems.

No water-quality samples were collected from these wells, as they are used for water-level monitoring only.



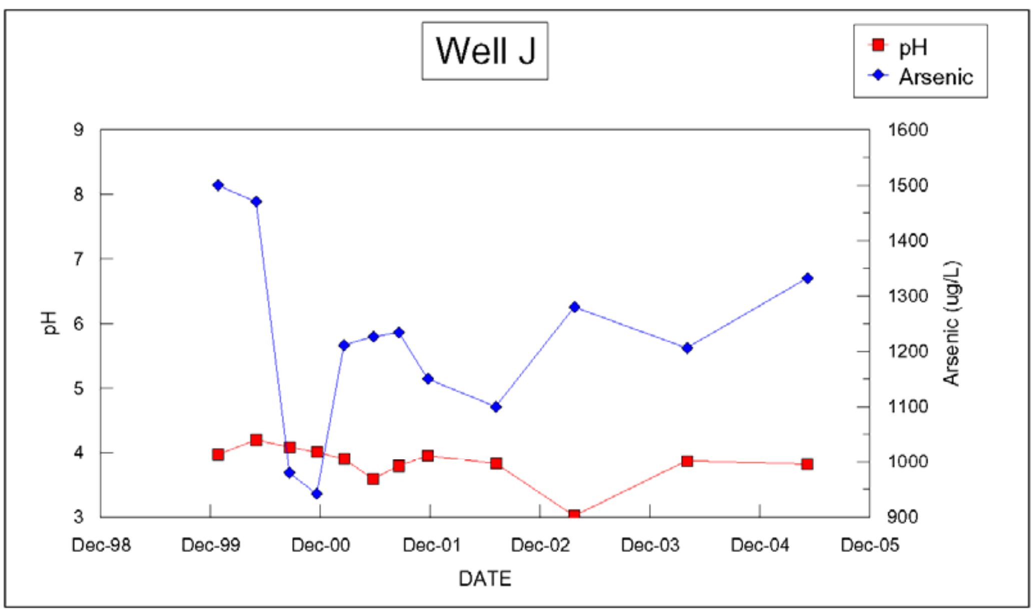


Figure 2-38. Zinc and arsenic concentrations for Bedrock well J.

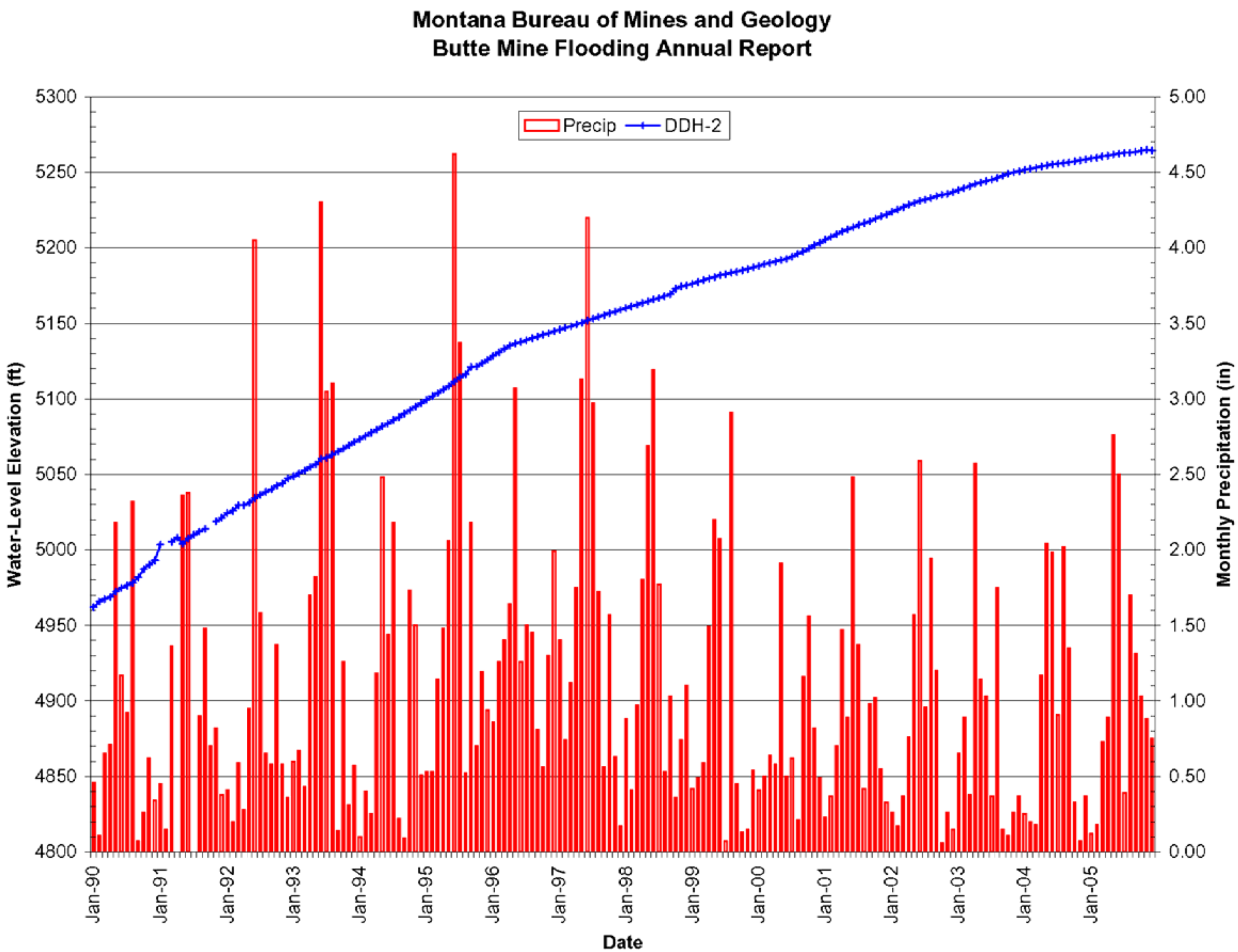


Figure 2-39. Water-level hydrographs for bedrock well DDH-2.

Section 2.3 Berkeley Pit and Horseshoe Bend Drainage

The Berkeley Pit water-level elevation was surveyed each month to coincide with monthly water-level monitoring in wells. Figure 2-40a is a hydrograph showing the pit's water-level rise over time; while figure 2-40b is a hydrograph showing water-levels changes since 1995. The overall trend is similar to that of previous years. There are four noticeable changes on figure 2-40b which show the influence of physical changes on water-level rise. The first change represents a decrease in the filling rate (seen as a change in slope on the graph) when the HSB drainage diversion occurred in April of 1996; the second is an almost instantaneous water-level rise from the September 1998 landslide; the third depicts an increased filling rate (seen as a change in slope on the graph) following MR's June 2000 suspension of mining and the subsequent inflow of water from the HSB drainage to the pit; and the fourth shows the decrease in filling rate as a result of the HSB water-treatment plant coming on-line in November 2003 and the diversion of HSB drainage water away from the pit. From April 1996 through June 2000, water from the HSB drainage was diverted and incorporated into the mining and milling process. Following the June 2000 suspension of mining, water from the HSB drainage was again allowed to flow into the Berkeley Pit. The volume of water allowed to enter the pit exceeded 3.2 billion gallons from July 2000 through November 2003 when the water-treatment plant became operable. This represents an average flow of 1,820 (gpm) during the period of mine suspension. The overall Berkeley Pit water-level rise for 2005 was 7.03 feet compared to 7.68 feet in 2004 and 13.08 feet in 2003.

Flow monitoring of the Horseshoe Bend drainage continued throughout 2005. As discussed in previous reports, the 90° V-notch weir was relocated upstream in the HSB drainage to accommodate infrastructure changes associated with the water-treatment plant construction. Construction activities affected flow monitoring at times from April through October 2002, however, there have been no major disruptions of monitoring activities since then. Ice build-up on the holding pond and bio-fouling of the transducer used to measure flow are on-going problems associated with monitoring at this site. The average daily flow rate was 2,036 gpm for 2005, an increase of almost 800 gpm from last year. A total of 1.08 billion gallons of water flowed through this site for treatment in the HSB water treatment plant. Figure 2-41 shows the daily average flow rate from July 2000 through December 2005.

Flows measured at the HSB Falls flume averaged 511 gpm for the year, an increase of almost 400 gpm from 2004. This flow is well below the historic flows of 1,000 gpm or more reported by MR; however, flows recorded during the last half of 2005 were beginning to approach historic levels. The increased flow from this site accounts for about one-half the total flow increase seen for the entire HSB drainage; the remaining increase most likely coming from the combination of other seeps.

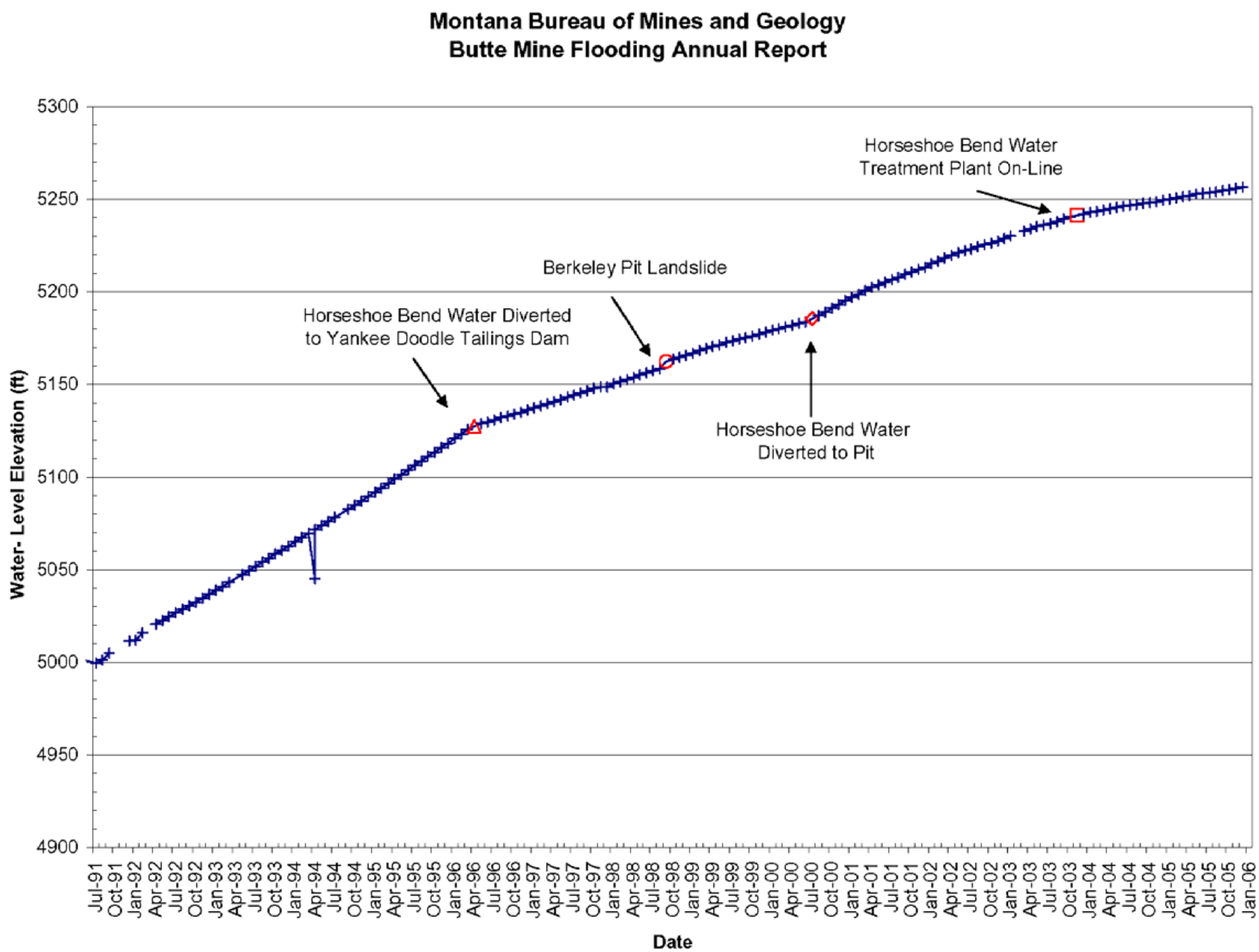


Figure 2-40a. Water-level hydrograph for the Berkeley Pit.

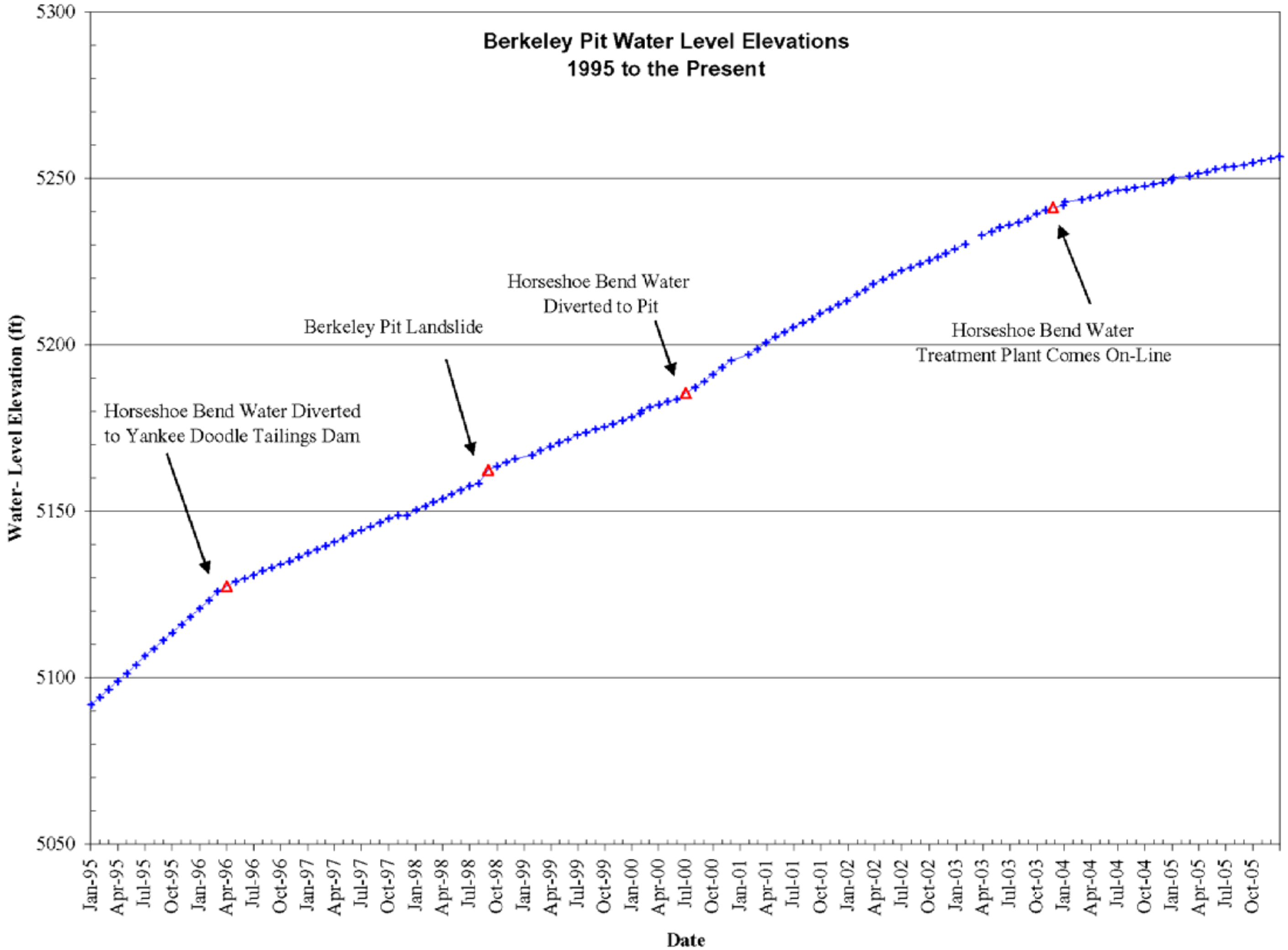


Figure 2-40b. Water-level hydrograph of Berkeley Pit, 1995-2005.

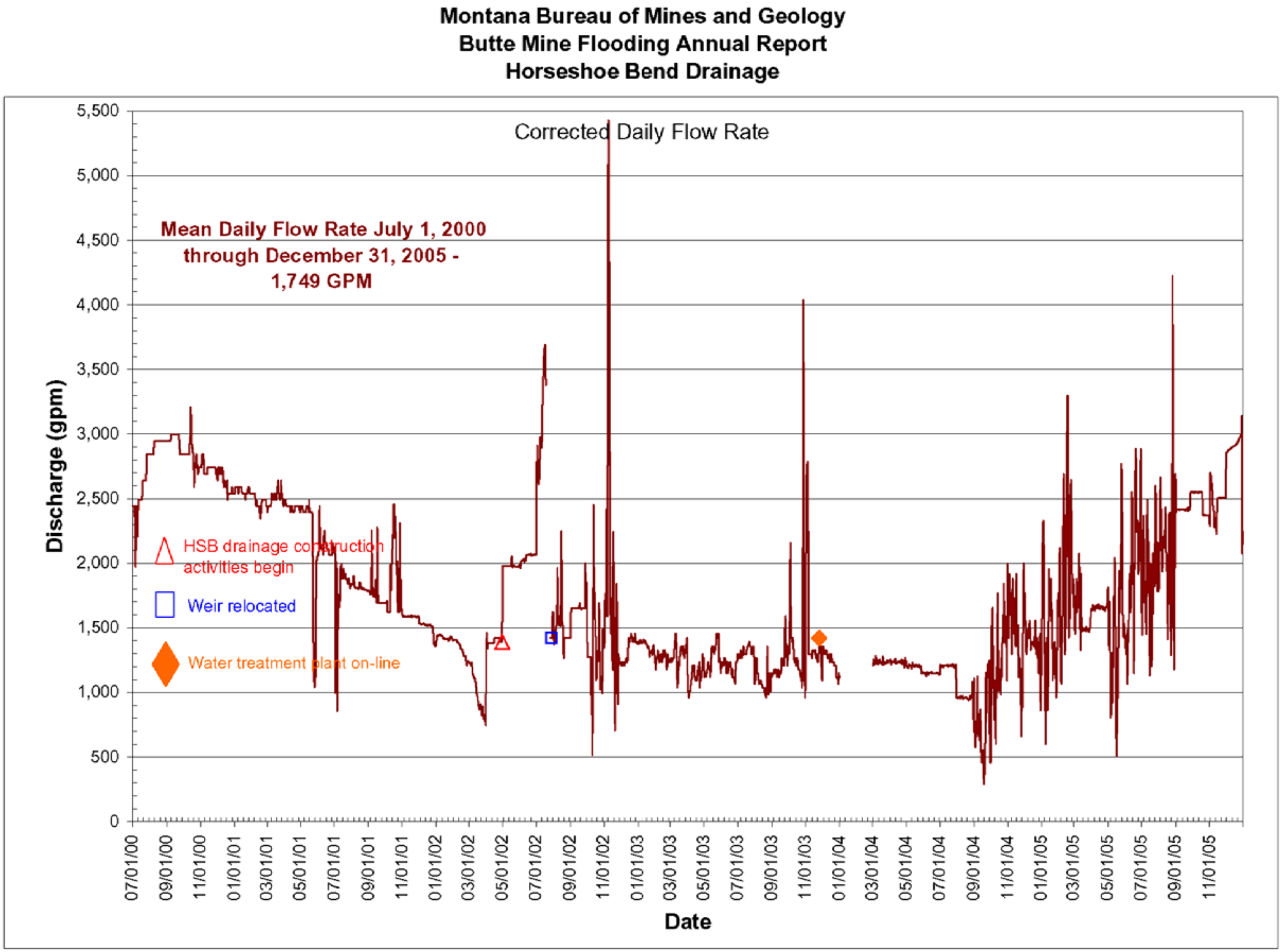


Figure 2-41. Horseshoe Bend Drainage flow rate, July 1, 2000 through December 31, 2005

Section 2.3.1 Berkeley Pit and Horseshoe Bend Drainage Water Quality

The overall trend in the concentrations of most dissolved constituents in the Berkeley Pit have changed little in recent years; data for 2005 show similar concentrations as those observed in the last 3 years (fig. 2-42a, b, and c). As noted in the 2003 report, there is a remarkable difference in the concentration of iron between the Berkeley Pit and the Kelley shaft. The same difference continued in 2005; the concentration of iron was about 1,000 mg/L in the deep pit compared to about 2,000 mg/L in the Kelley shaft and about 300 mg/L in the Horseshoe Bend discharge.

The chemistry of the discharge from the Horseshoe Bend drainage has shown little change in recent years; however, increases in the concentrations of dissolved constituents occurred in 2005 (fig. 2-43). The water quality of the HSB drainage continues to be slightly better than that of the Berkeley Pit (table 2.3.1).

Table 2.3.1 Selected chemistry from the Berkeley Pit and Horseshoe Bend.

Area	Sample Date	pH (S.U.)	Al (μg/L)	Cu (μg/L)	Pb (μg/L)	SO_4 (mg/L)	Zn (μg/L)
Berkeley Surface	10/5/05	2.93	252,575	67,827	31.9	6,559	569,312
HSB	12/19/05	3.31	238,870	50,144	<20	5,634	314,232

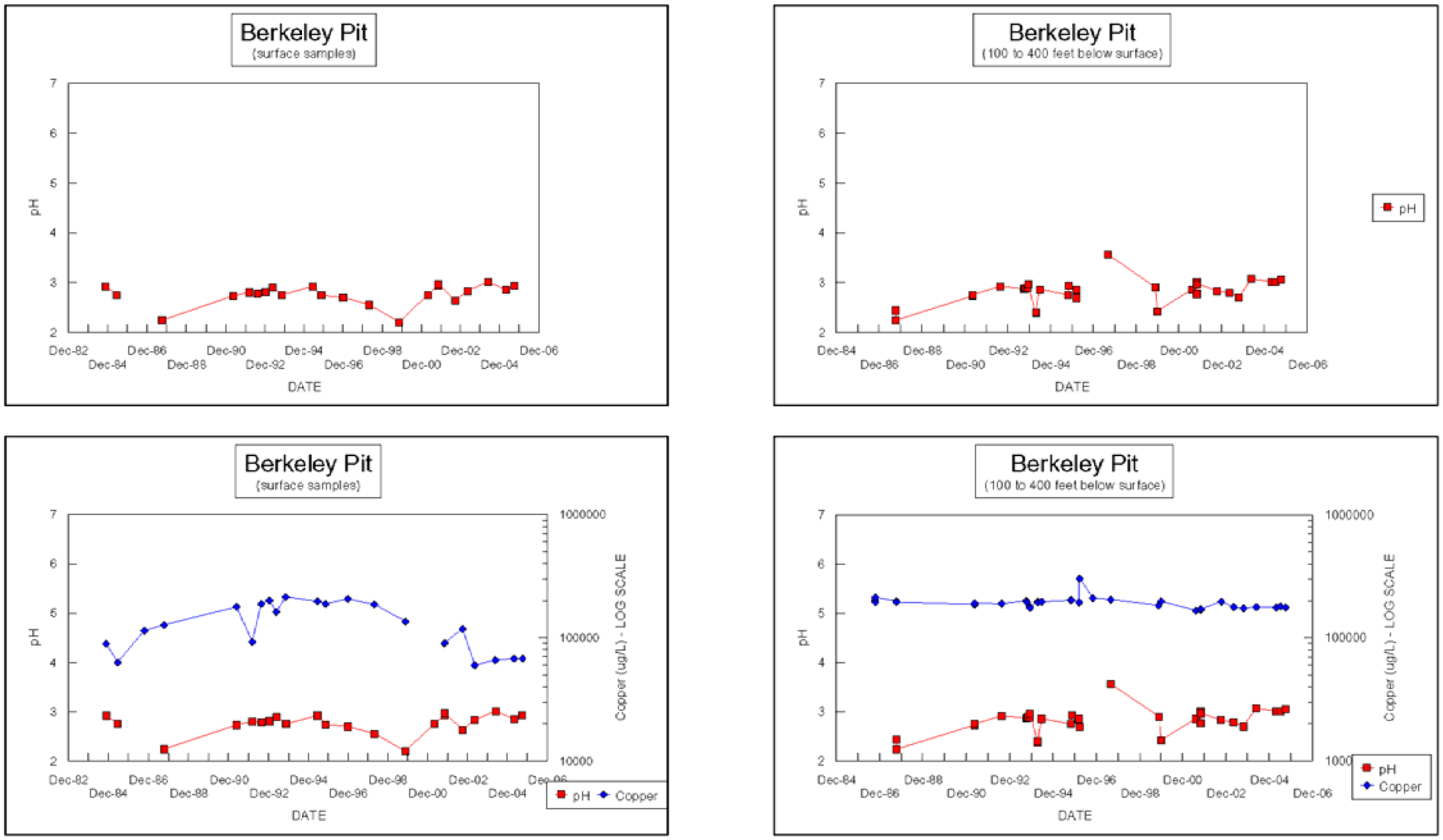


Figure 2-42a. Selected chemistry for the Berkeley Pit

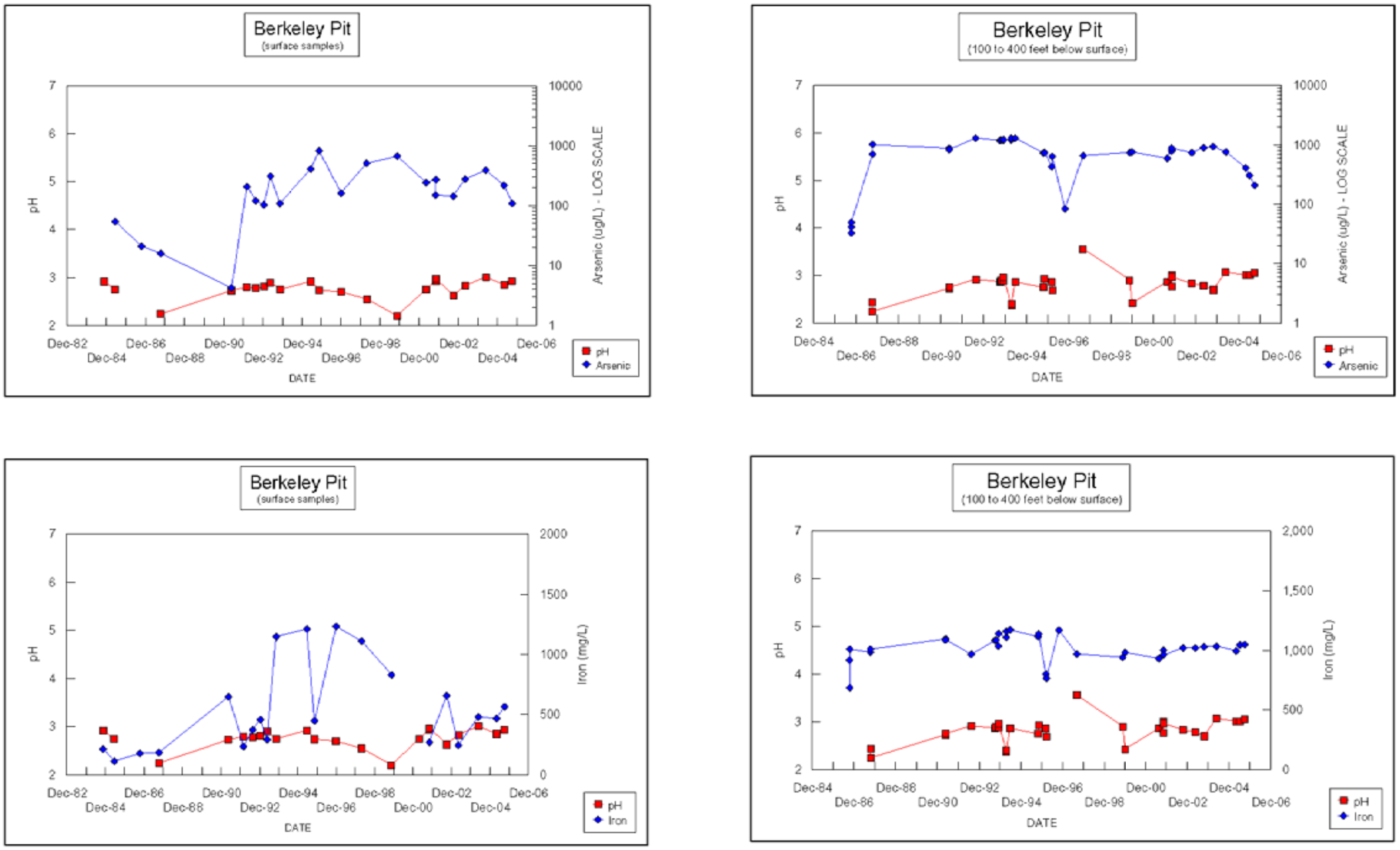


Figure 2-42b. Selected chemistry for the Berkeley Pit

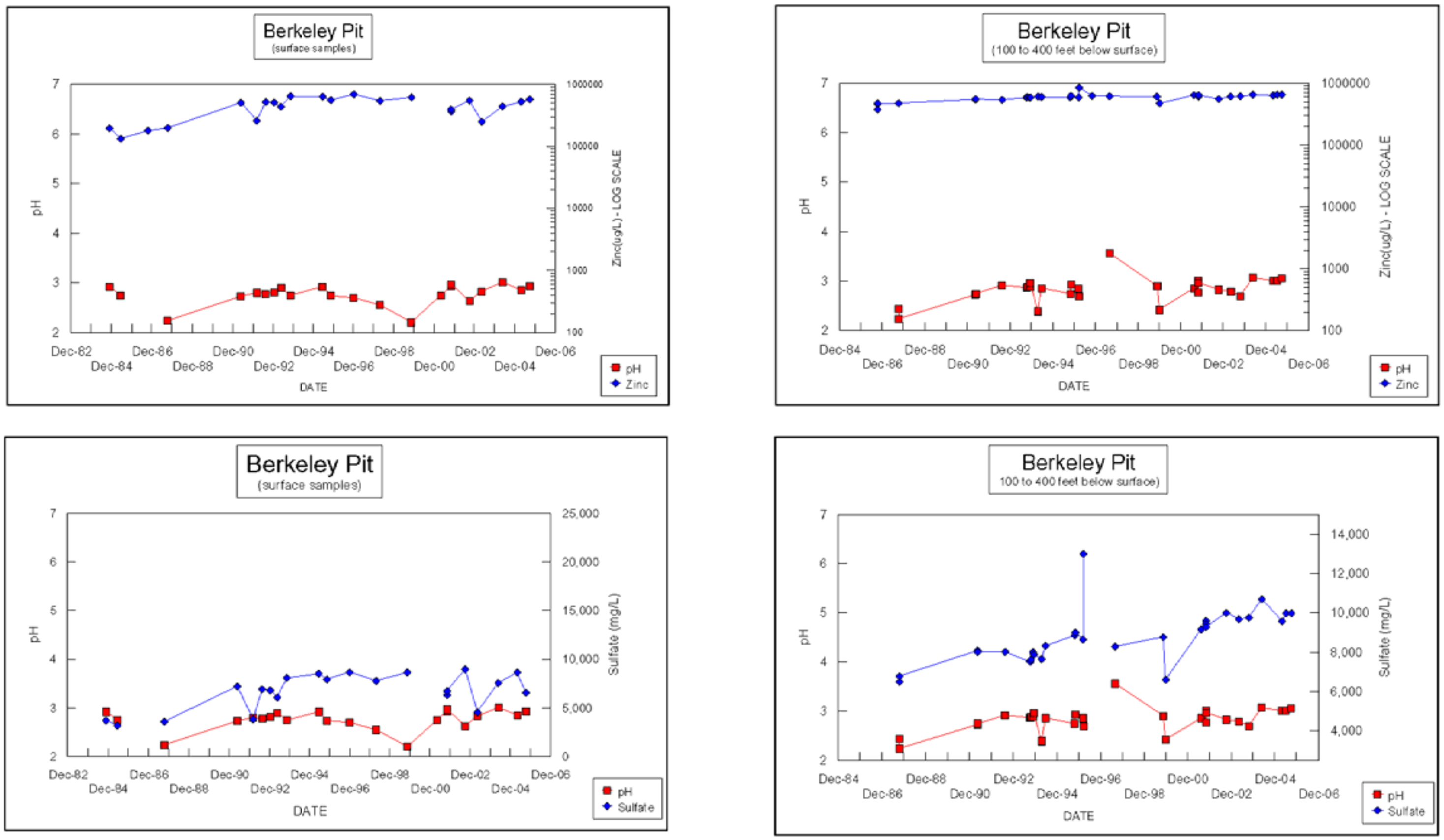


Figure 2-42c. Selected chemistry for the Berkeley Pit

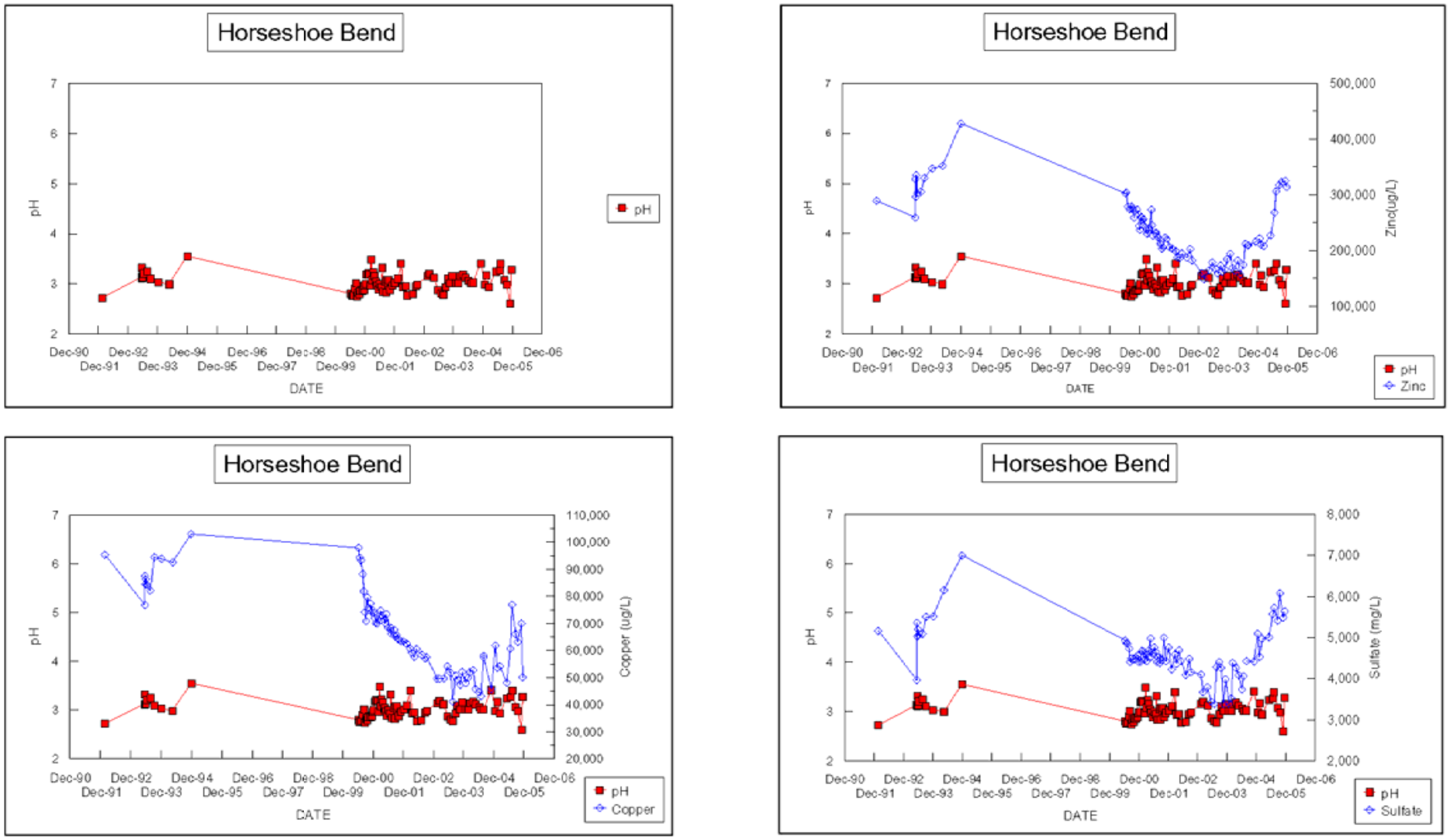


Figure 2-43. Selected chemistry for the Horseshoe Bend discharge.

SECTION 3.0 WEST CAMP SYSTEM

Water-level monitoring continued during 2005 in the three mine shafts and six monitoring wells (fig. 3-1) that comprise the West Camp system. ARCO diverted the water pumped from the West Camp to the Lower Area One wetlands demonstration site during March 2002. Pumping occurred almost continuously, with pumping rates about one percent higher than 2004. There were small water-level increases throughout the system, despite the slight increase in pumping rates.

Section 3.1 West Camp Underground Mines

Water levels in the West Camp Mine system continue to be controlled by pumping facilities located at the BMF-96-1D and BMF-96-1S sites. ARCO had a special well drilled for dewatering (pumping) purposes in the fall of 1997. This well is referred to as the West Camp Pumping Well (WCPW). Pumping activities were transferred from the Travona Mine to this site on October 23, 1998. The pump and pipeline at the Travona Mine were left intact, however, allowing it to serve as a backup pumping system.

The West Camp pumping system operated almost continuously during 2005, with the exception of several short periods caused by power outages and for maintenance. The pumping rates were greater than those of 2003 and 2004. A total of 257 acre-ft of water was pumped compared to 254 acre-feet pumped in 2004 and 231 acre-feet in 2003. Table 3.1.1 shows the annual amount of water pumped in acre-feet on a yearly basis, change in acre-feet from the previous year, and the percent change from 1996 (the first full year of continuous pumping). Figure 3-2 shows the amount of water pumped annually and the percent of average annual precipitation since 1982.

Table 3.1.1 Annual quantity of water pumped from the West Camp, in acre-feet.

Year	Total Amount Pumped (Acre ft)	Change From Prior Year (Acre ft)	Percent Change From 1996
1989	8.50		
1990	212.54	+204.04	
1991	130.16	-82.38	
1992	92.82	-37.34	
1993	140.18	+47.36	
1994	109.31	-30.87	
1995	182.54	+73.23	
1996	244.56	+62.02	
1997	287.70	+43.14	118
1998	370.72	+83.02	152
1999	326.56	-44.16	134
2000	270.20	-56.36	110
2001	260.37	-9.83	106
2002	247.66	-12.71	101
2003	231.43	-16.23	95
2004	254.70	+23.26	104
2005	257.82	+3.12	105

Two of the three mines had net water-level increases less than 0.5-ft, while one mine had a water-level decrease. This decrease is somewhat misleading since water-level readings were not obtained from this site (Ophir) during the last part of 2004 due to vandalism problems. Based upon the history of similar water-level changes at all three mines it is probable that water-levels increased throughout the entire West Camp system. Water-level changes in the West Camp mines reflect changes in pumping rates in the WCPW and precipitation amounts. Figure 3-3 shows annual water-level changes for the West Camp sites. Water levels are more than 10 feet below the West Camp action level of 5,435 feet stipulated in the 1994 ROD.

Water-level elevations for the three West Camp mines are shown on figure 3-4. Water levels in these mines are almost identical and continue to follow the trends of previous years. Pumping rates and the amount of water pumped are the most important controls on water levels.

Table 3.1.2 Annual water-level changes for the West Camp sites, in feet.

Year	Travona	Emma	Ophir	Chester Steele	BMF 96-1D	BMF 96-1S	BMF 96-2	BMF 96-3	BMF 96-4
1982	4.30								
1983	2.00								
1984	55.90								
1985	61.90								
1986	36.10								
1987	49.70								
1988	15.69	14.20		16.42					
1989	5.67	6.60		1.79					
1990	-18.42	-18.66		-5.77					
1991	13.88	13.52		-8.28					
Total 10-Year Change*	**226.72**	**15.66**		**4.16**					
1992	7.21	6.79		-11.20					
1993	1.01	0.93		-1.11					
1994	4.24	4.26	4.00	5.36					
1995	-0.98	-1.00	-0.96	12.72					
1996	-3.72	-3.76	-3.56	6.14	-1.50	-5.41	0.00	-2.85	
1997	7.29	7.28	7.22	14.82	7.20	7.36	2.13	-0.19	-0.80
1998	-7.31	-7.88	-7.20	-2.51	-7.35	-5.63	-2.00	-0.26	-5.88
1999	-0.97	-0.47	-1.03	-5.37	-0.82	-0.61	-1.15	-0.38	-1.76
2000	5.56	5.61	5.53	-4.64	5.70	1.45	-1.13	-0.07	1.86
2001	-1.65	-1.70	-1.52	15.61	-1.78	1.70	3.23	0.10	1.40
2002	1.33	1.74	1.51	6.35	2.03	-0.62	-2.06	-0.21	-0.93
2003	1.45	0.95	0.87	12.94	0.56	0.96	-0.01	0.00	0.54
2004	-1.06	-0.72	0.73*	-4.22	-0.72	1.03	1.41	0.33	-0.31
2005	0.39	0.22	-1.30	-11.35	3.35	-1.19	0.19	-3.35	-6.35
Total Change*	**239.51**	**27.91**	**4.29**	**25.00**	**6.67**	**-0.96**	**0.61**	**-6.88**	**-12.23**

Total water-level change is that measured. Access or obstructions occasionally prevent water-level measurements.

*Vandalism to Ophir Mine monitoring point resulted in no water levels being obtained for the last quarter of 2004

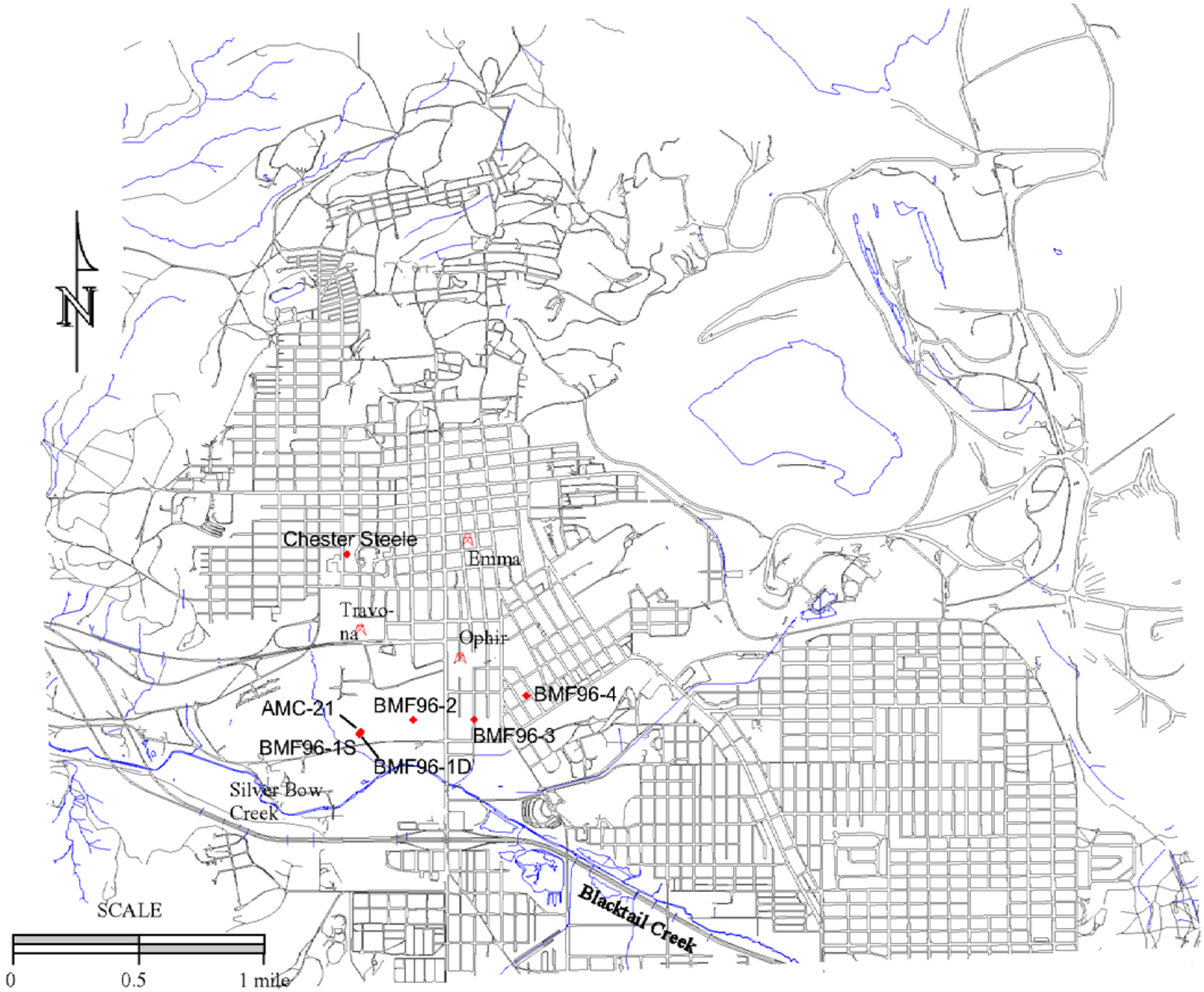


Figure 3-1. West Camp Monitoring Sites Location Map.

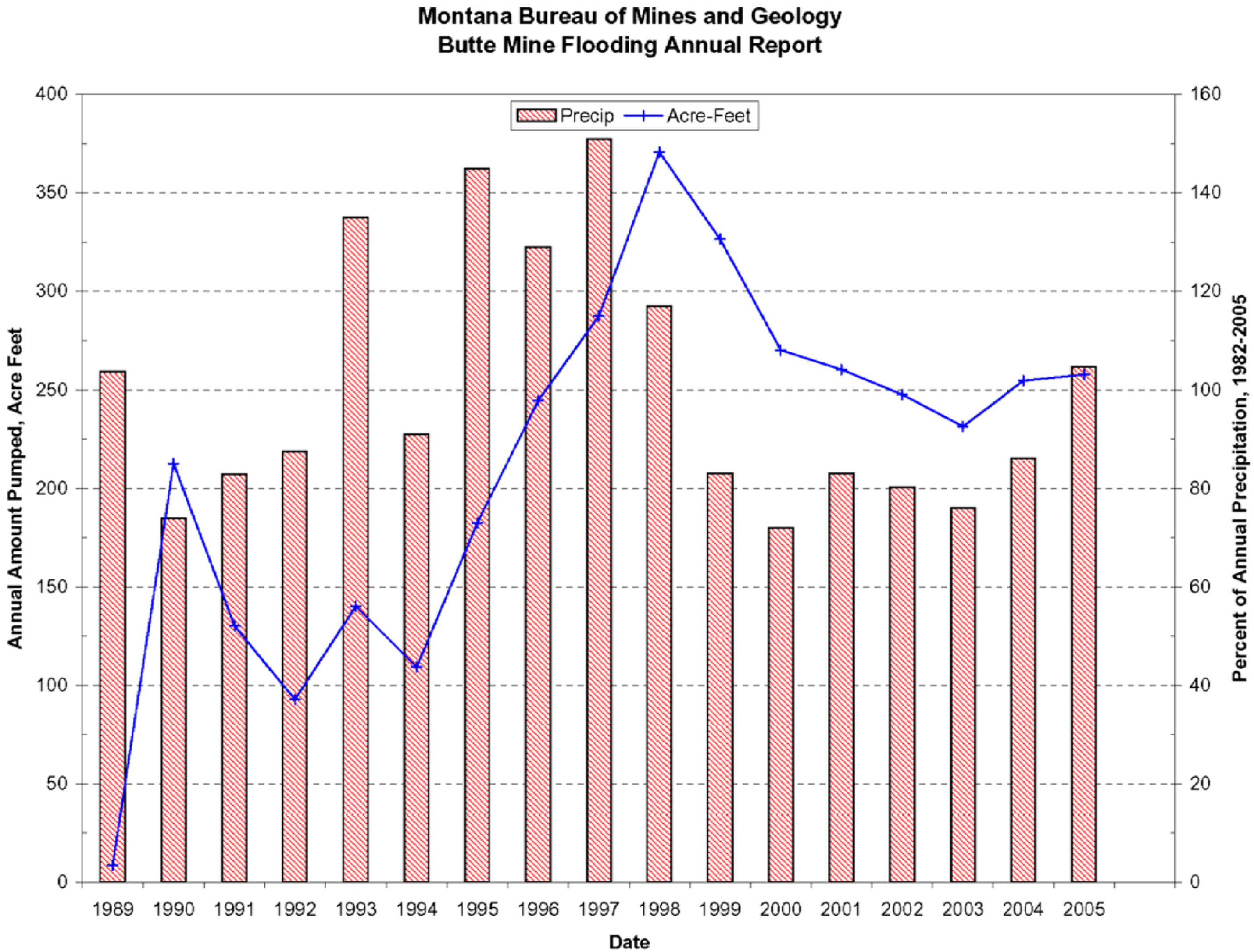


Figure 3-2. Annual amount of water pumped from the West Camp system.

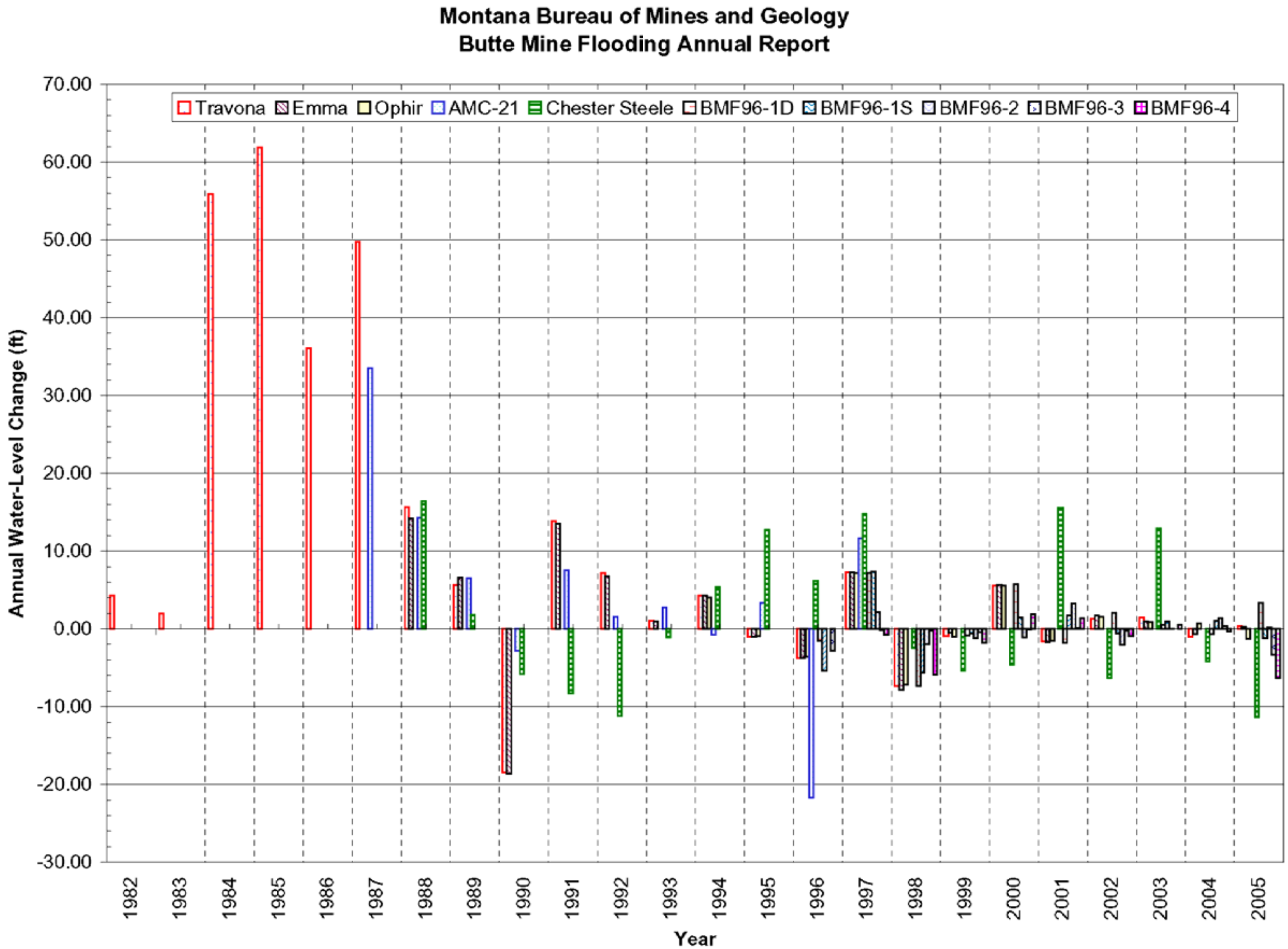


Figure 3-3. Annual water-level change for West Camp sites.

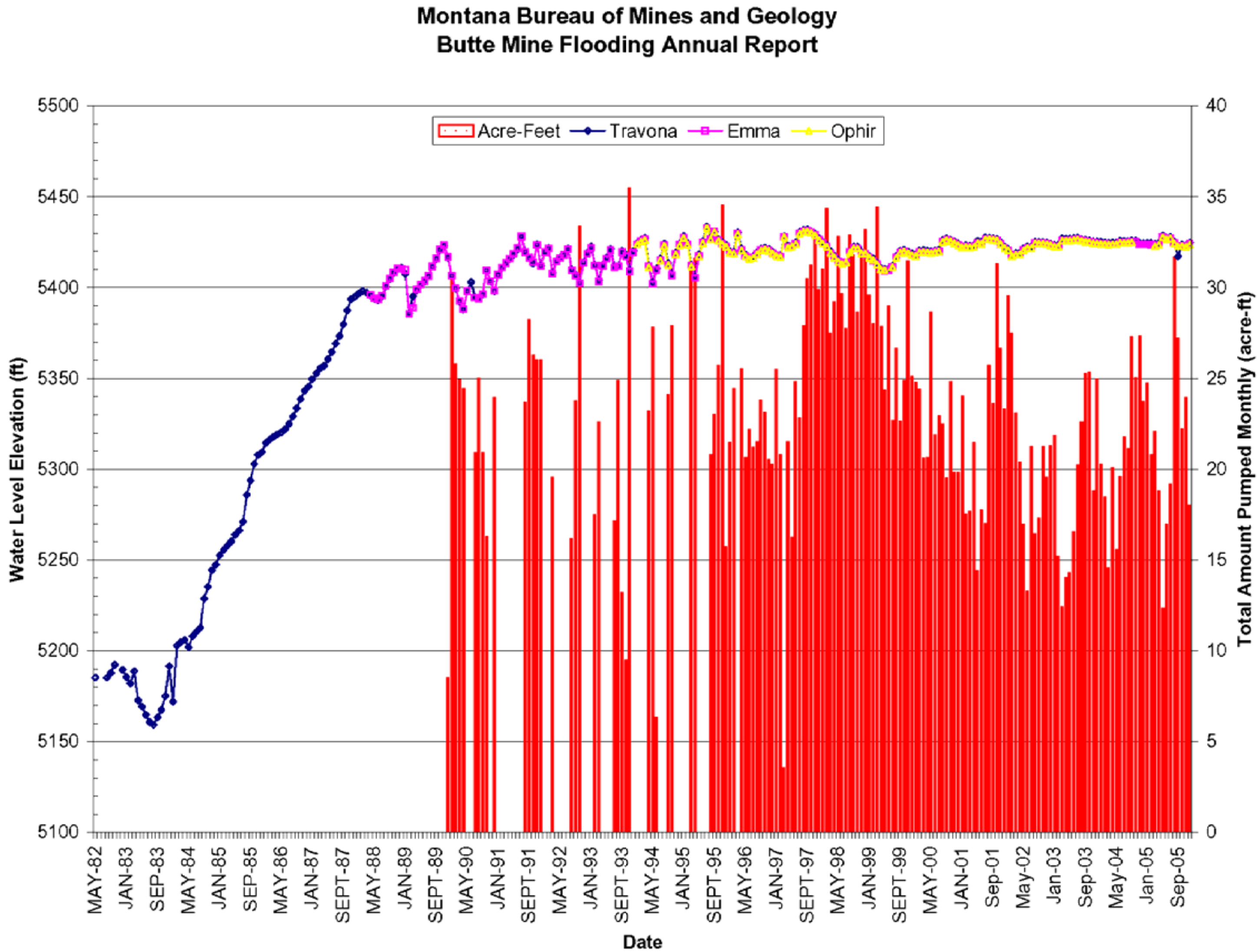


Figure 3-4. West Camp water-level hydrographs and total amount of water pumped monthly.

Section 3.2 West Camp Monitoring Wells

Water levels declined in three of the five BMF96 West Camp wells, while rising in the other two wells during 2005. Well BMF96-1D, which was completed into the Travona Mine workings, had water-level changes (increases) similar to the West Camp mines. These changes are shown in table 3.1.2 and on figure 3-3.

Figure 3-5 contains water-level hydrographs for wells BMF96-1D, BMF96-1S and BMF96-4. Water levels in wells BMF96-1D and BMF96-4 respond similarly to one another, reflecting the influence pumping has on the system. This is an important trend since well BMF96-4 was not completed into mine workings. It is, however, in the area of the historic 1960's flooding problems that led the Anaconda Company to install well AMC-21 for control of water levels in the West Camp. (See Duaime, et al, 1998 for a greater discussion of historic flooding problems in the West Camp System). There is a lag time between the responses seen in these two wells, which is most likely because well BMF96-4 was not completed into mine workings. During periods of continued water-level change in wells BMF96-1D and BMF96-4, there appears to be a similarity in water-level change in well BMF96-1S. Well BMF96-1S is located adjacent to well BMF96-1D, but was completed at a much shallower depth in the weathered bedrock of the Missoula Gulch drainage. This well also shows a response to pumping in the WCPW. There was no change in longer-term trends in any of these wells from those described in the previous reports.

Water levels in wells BMF96-2 and BMF96-3 are 20 to 50 feet higher than those in wells BMF96-1D and BMF96-4, and when plotted with the other BMF96 wells, initially appeared to show very little change (fig. 3-6). Since 2002, water levels in these two wells appear to follow trends similar to the other wells. When these wells are plotted separately (fig. 3-7a), there is considerable variation in monthly water levels, and water levels in both wells respond similarly. Monthly precipitation is shown on this figure and water levels are seen to respond very quickly to precipitation events. Although these wells were completed at depths of 175 feet below ground surface, their water levels are less than 20 feet below ground surface. Water-level trends during 2005 in these wells for the most part were similar to those seen the previous several years. Figure 3-7b is a hydrograph for these two wells for the period 2002-2005 to better show recent water-level changes. Water levels rise not only with precipitation, but with infiltration from snow melt, which is shown by the early season (March) water-level increases. During the last half of 2001, an unexplained water-level increase of several feet occurred in well BMF96-2; this was not seen in other wells. This trend did not continue in 2002; the water level in well BMF96-2 has followed that of well BMF96-3 ever since.

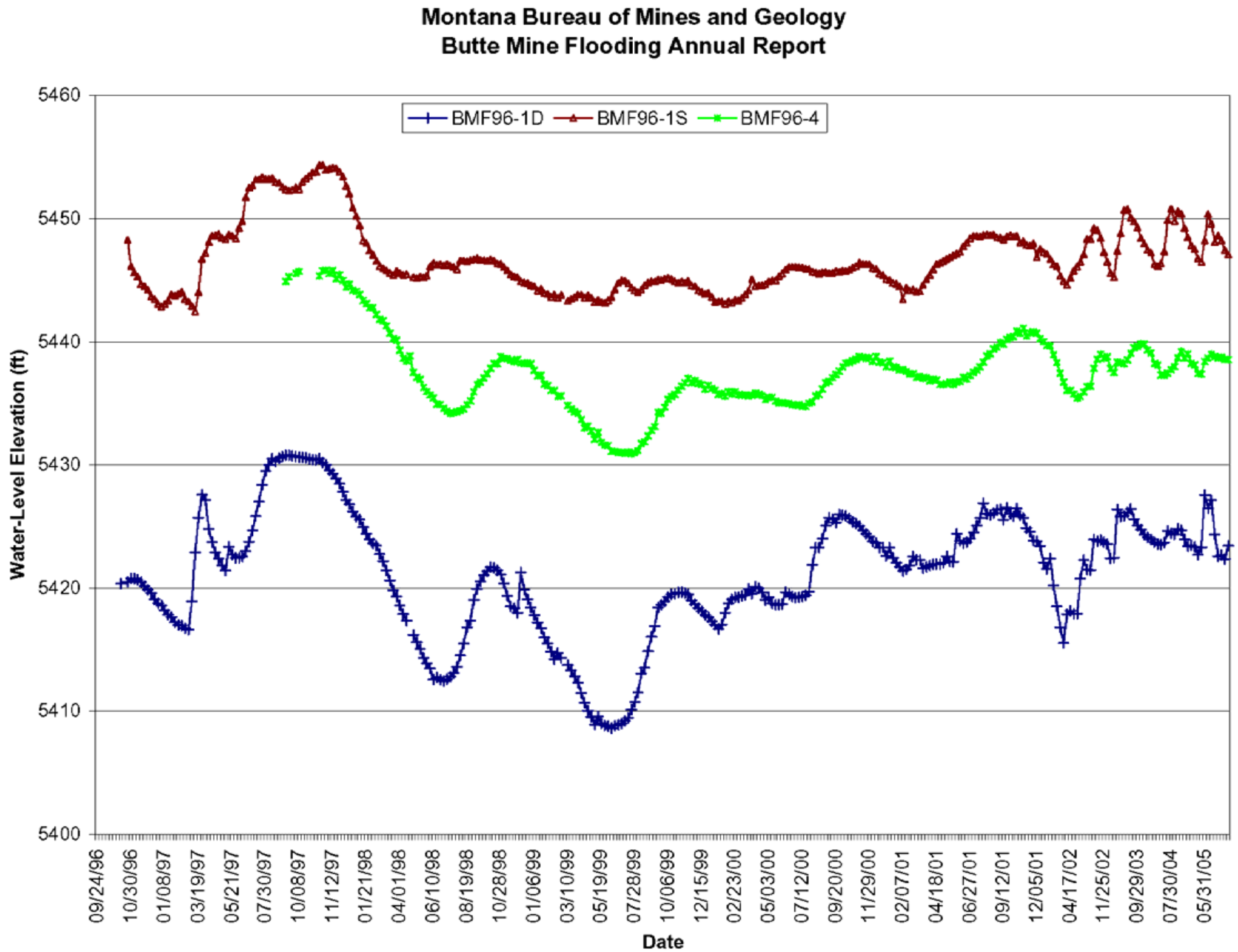


Figure 3-5. Water-level hydrographs for West Camp BMF96-1D, BMF96-1S, and BMF96-4 wells.

Montana Bureau of Mines and Geology
Butte Mine Flooding Annual Report

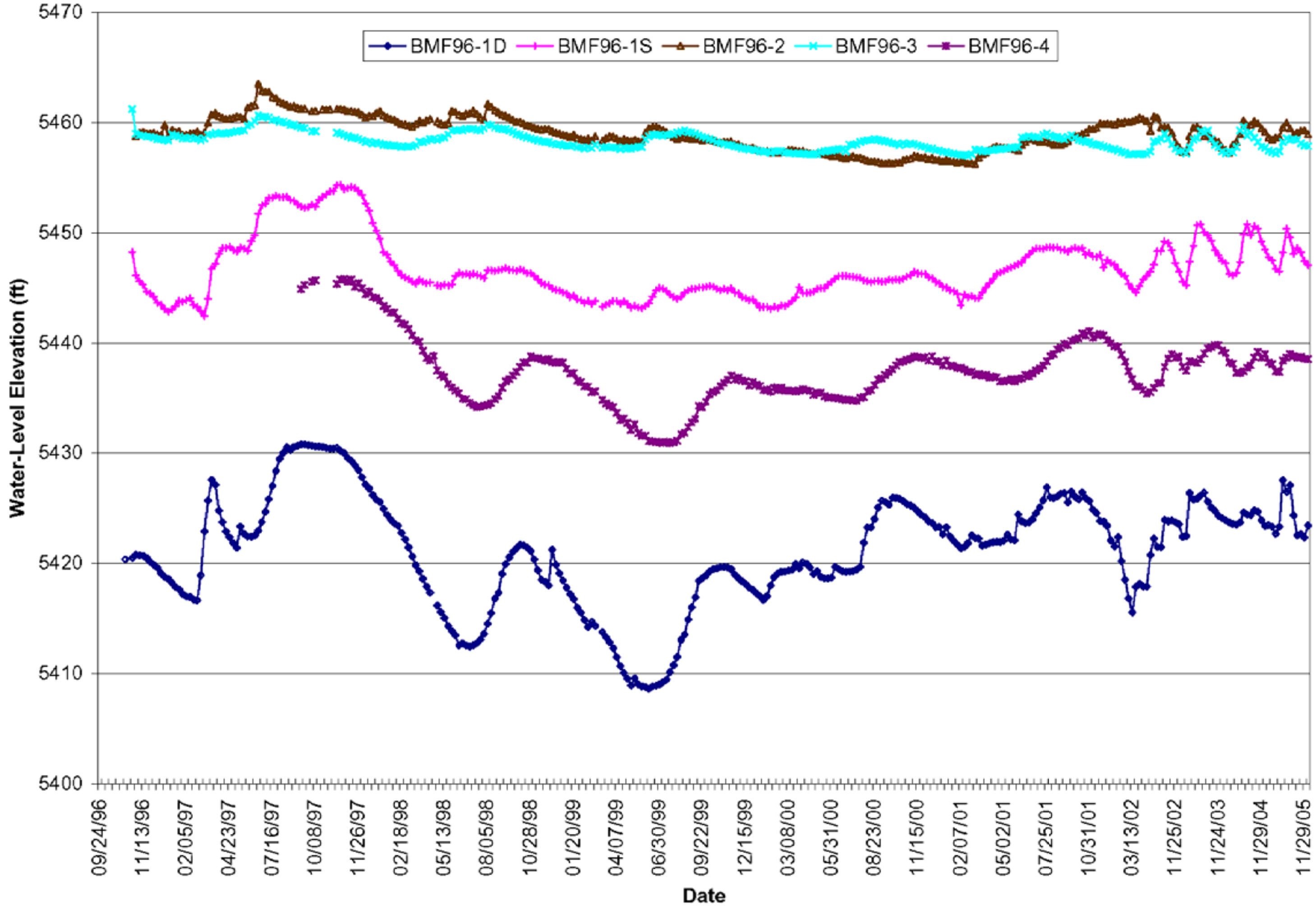


Figure 3-6. Water-level hydrographs for BMF96 series wells.

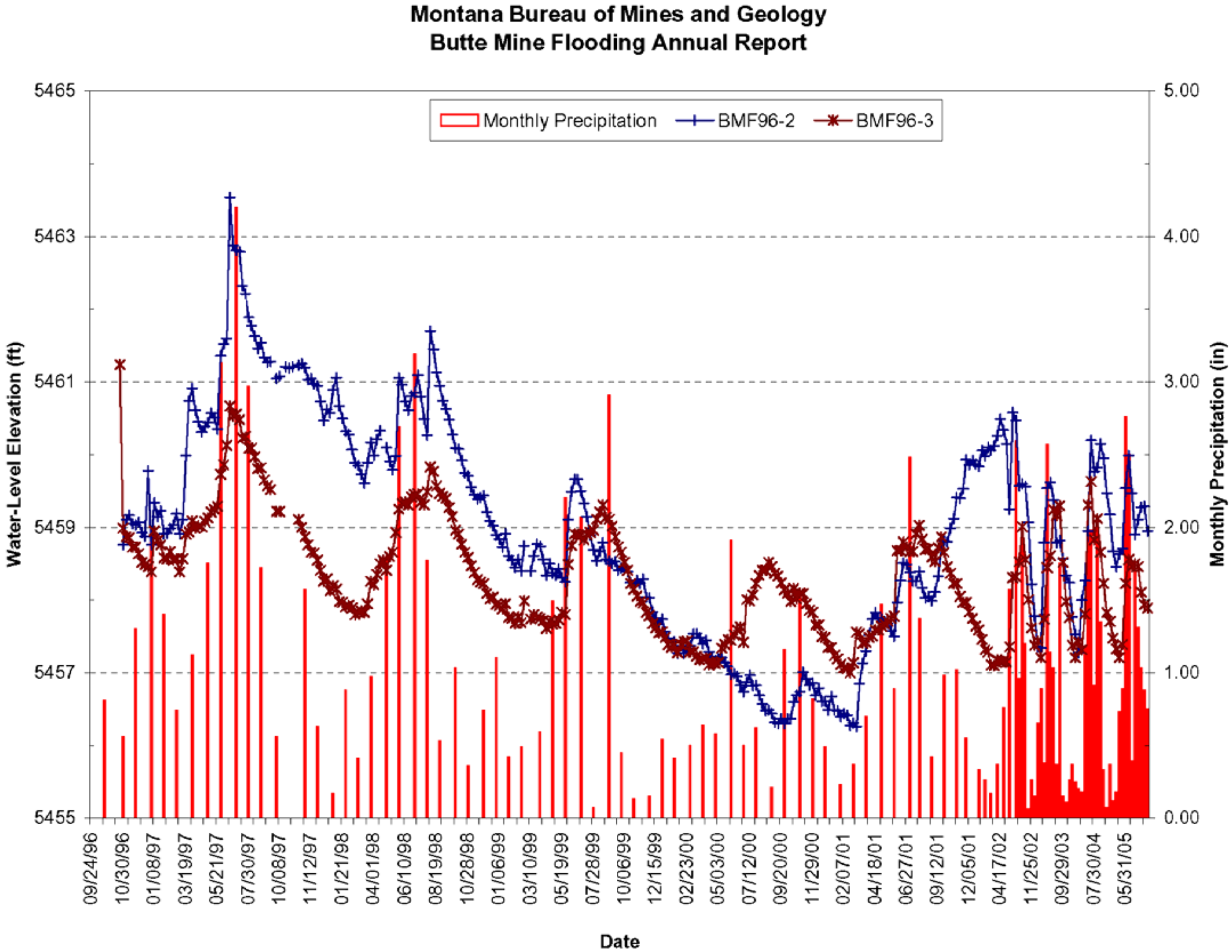


Figure 3-7a. Water-level hydrographs for BMF96-2 and BMF96-3 wells.

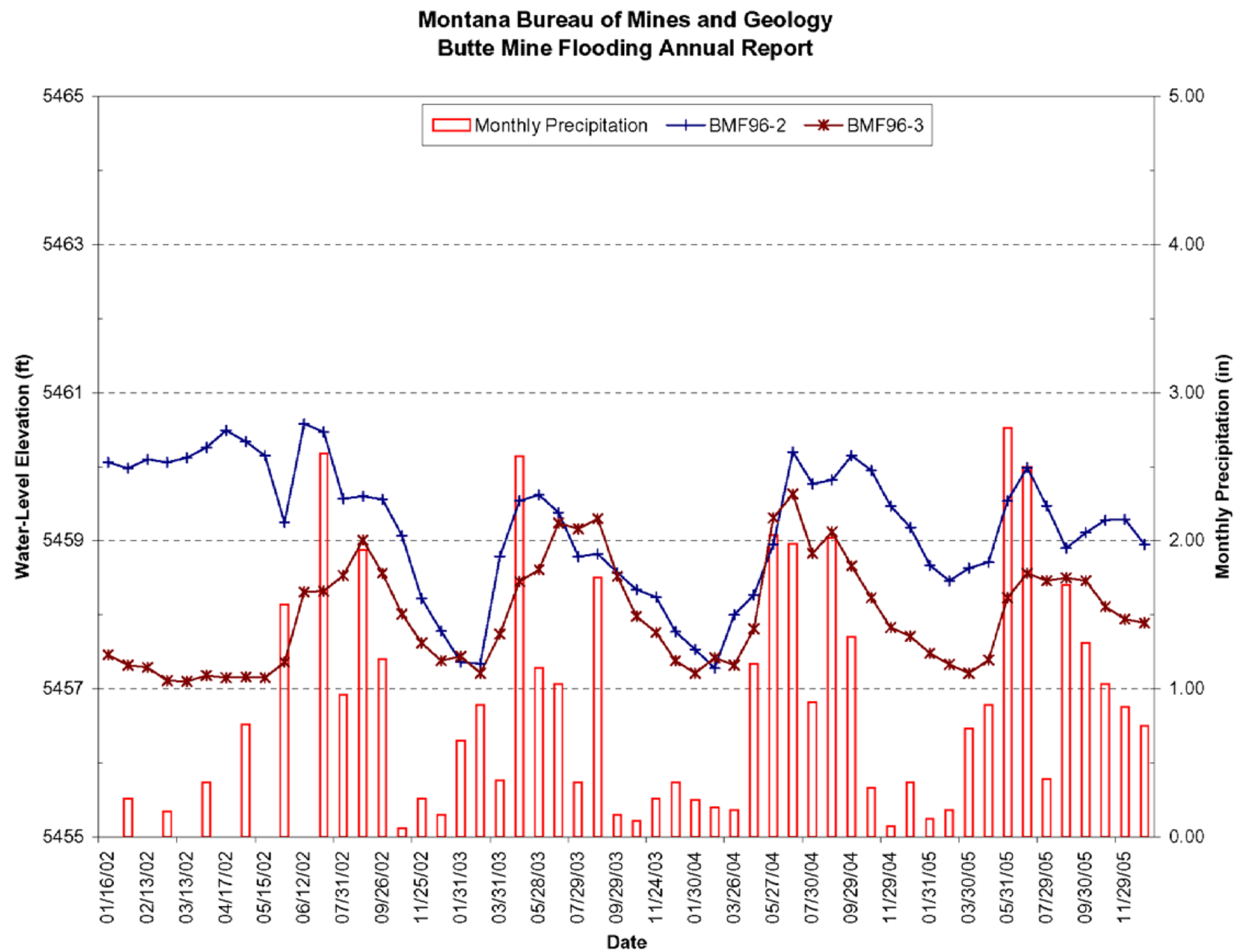


Figure 3-7b. Water-level hydrographs for BMF96-2 and BMF96-3 wells from 2002 through 2005.

Section 3.2.1 West Camp Mines and Monitoring Wells Water Quality

With the exception of arsenic, the concentration of which is about 100 ug/L in the Travona pumping well and about 25 ug/L in the Emma, the concentrations of most dissolved constituents are similar in the West Camp (fig. 3-8a and 3-8b); a slight trend toward decreasing concentrations continues in 2005. The concentration of most dissolved metals in the Ophir Mine are low and continued to exhibit a slight downward trend through 2005 (fig. 3-9).

Water-quality data for the West Camp monitoring wells in 2005 are again limited to BMF96-04; data for the period of record for all the non-pumping West Camp wells are presented in figure 3-10a and 3-10b. The 2005 data appear to confirm a change in trend for several constituents. The reported field temperature has increased again in 2005 and the concentration of arsenic increased slightly.

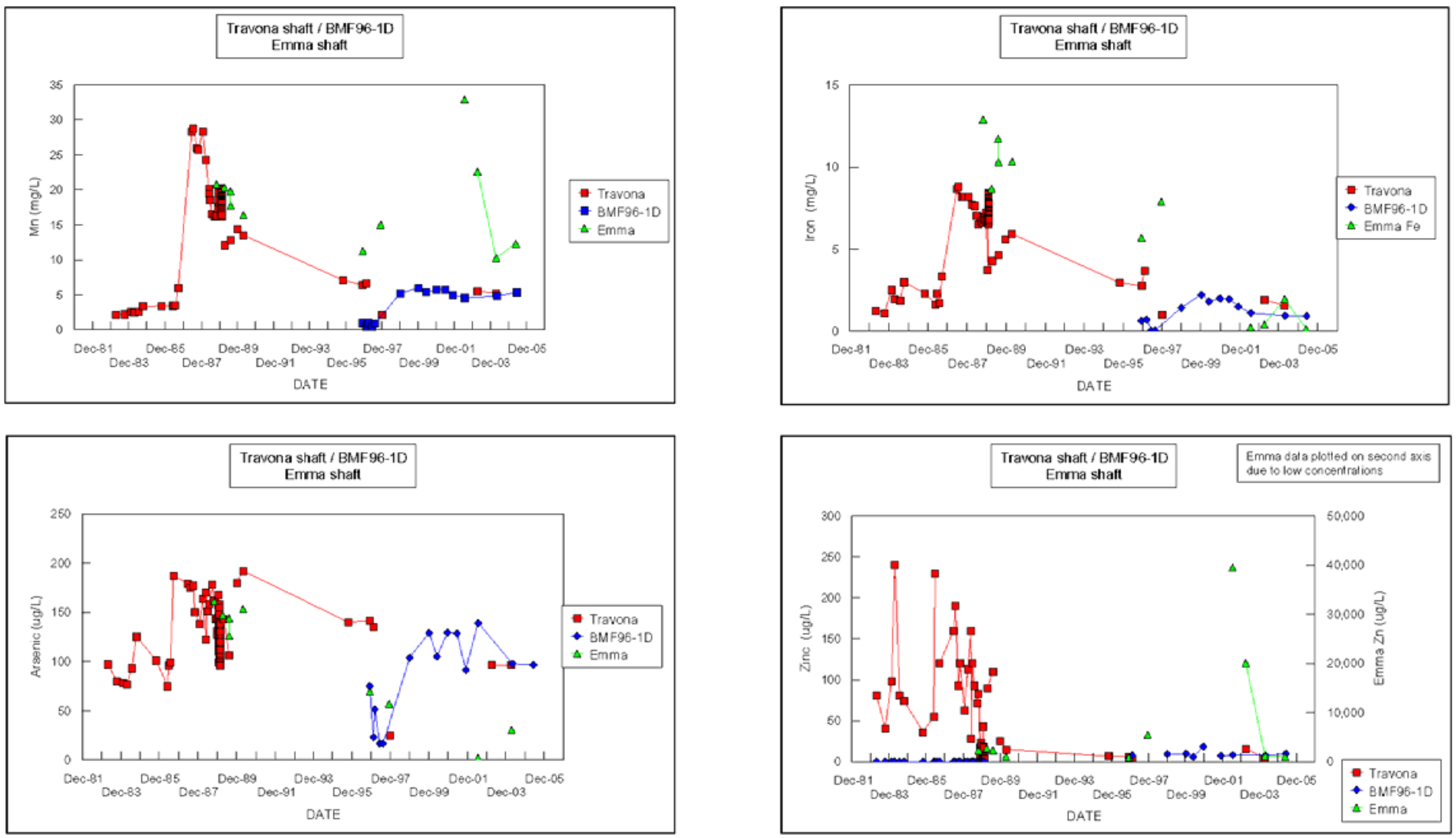


Figure 3-8a. Selected chemistry for the Travona shaft (and replacement well) and the Emma shaft

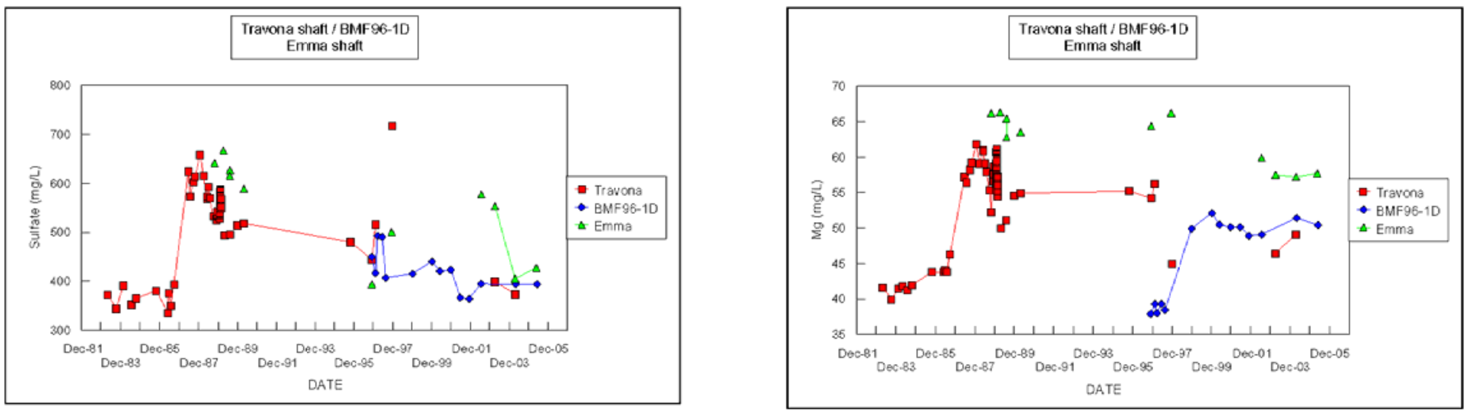


Figure 3-8b. Selected chemistry for the Travona shaft (and replacement well) and the Emma shaft.

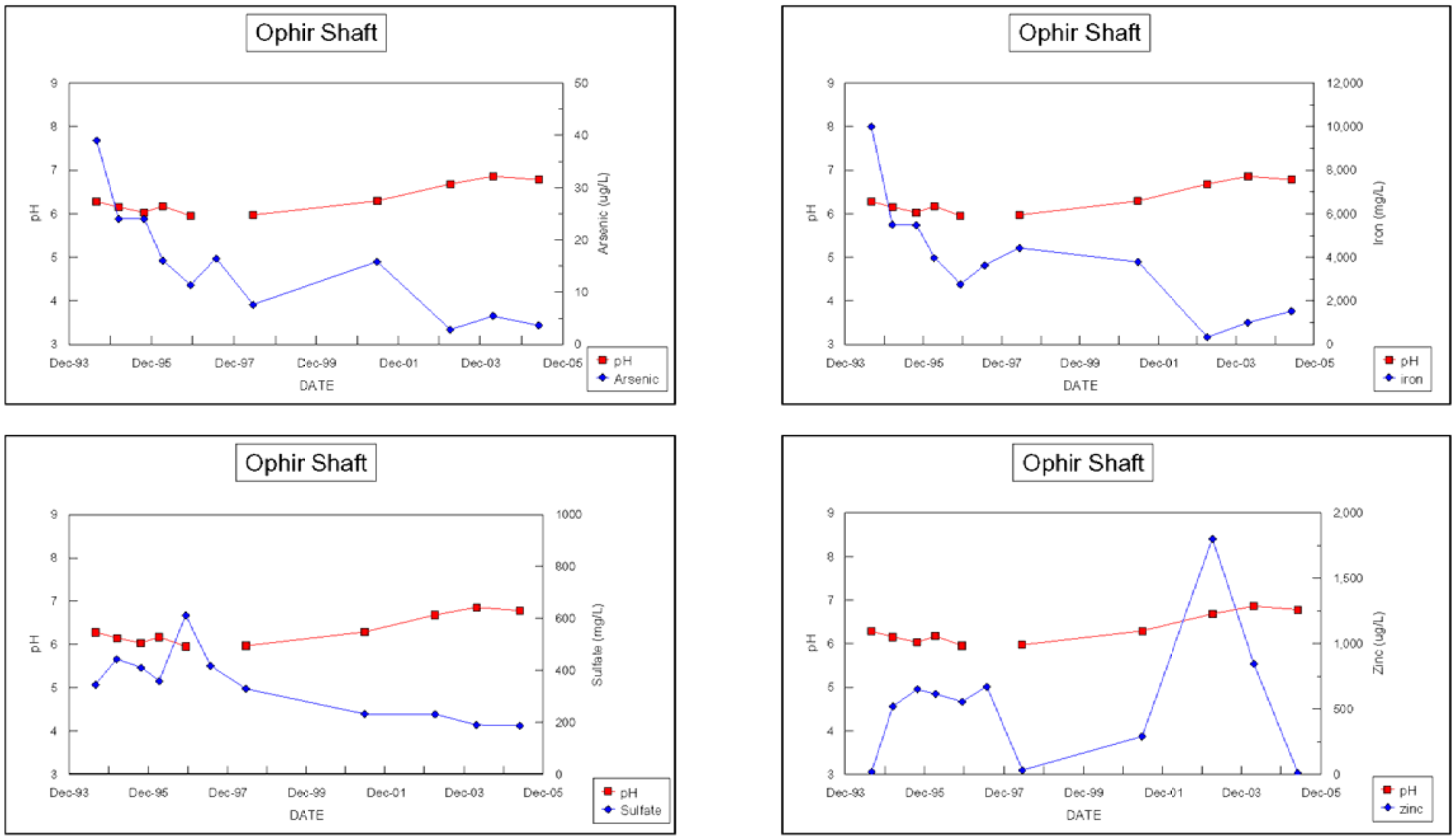


Figure 3-9. Selected chemistry for the Ophir shaft.

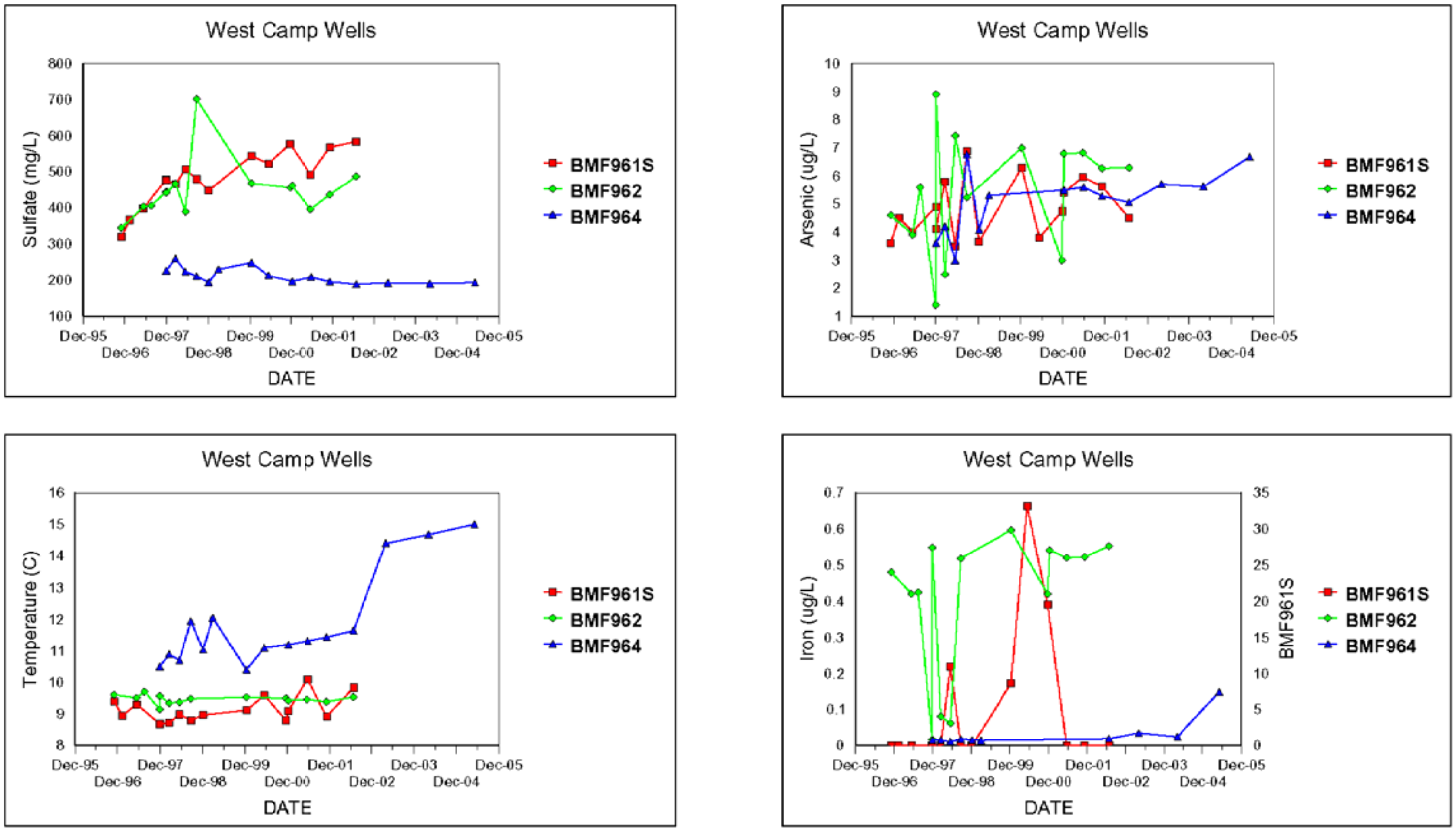


Figure 3-10a. Selected chemistry for the West Camp monitoring wells.

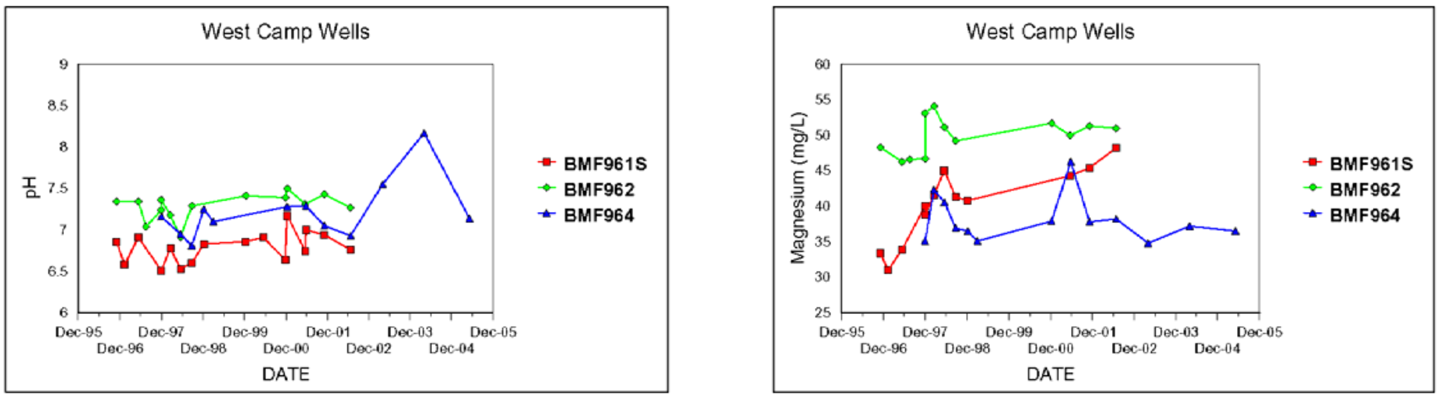


Figure 3-10b. Selected chemistry for the West Camp monitoring wells.

SECTION 4.0 OUTER CAMP SYSTEM

The Outer Camp System consists of the Orphan Boy Mine, Marget Ann Mine, well S-4 and the Montana Tech well (fig. 4-1). It is believed that water levels in the Outer Camp System are at or near pre-mining condition, as these mines had not operated for many years prior to ARCO's suspension of underground mining. It is also believed the few interconnections that existed between these mines and other Butte Hill mines had been sealed off decades earlier by the placement of bulkheads.

Section 4.1 Outer Camp System Water Levels

Outer Camp water levels rose in 2003 for the first time in 5 years; however, water levels declined in all but one site during 2004 and at all sites in 2005. Table 4.1.1 contains yearly water-level change data, while figure 4-2 shows these changes graphically.

Table 4.1.1 Annual water-level changes for the Outer Camp sites, in feet.

Year	Orphan Boy	Marget Ann	Well S-4	MT Tech Well
1987	2.40			
1988	-1.10			
1989		-3.56	-3.56	
1990		-1.34	-4.23	
1991				
1992	1.41			
1993	5.49			0.36
1994	-0.72	4.66		2.51
1995	5.44	12.41		6.48
1996	-0.96	10.44	18.41	-1.47
Total 10-Year Change	**11.96**	**22.61**	**10.62**	**7.88**
1997	7.56	14.50	16.42	7.76
1998	-2.79	0.59	2.17	-2.72
1999	-1.94	-2.87	-2.32	-1.57
2000	NA	-4.71	-4.08	-4.24
2001	NA	-1.49	-1.59	-1.79
2002	NA	-2.99	-3.13	-3.64
2003	NA	1.09	2.23	2.76
2004	-7.67	-2.18	-3.07	0.23
2005	-0.56	-3.01	-2.85	-1.97
Total Change*	**14.76**	**21.54**	**14.40**	**2.70**

Total water-level change is that measured. Access or obstructions occasionally prevent water-level measurements.

Figure 4-3 shows water levels for the Orphan Boy Mine and the Montana Tech well, along with monthly precipitation amounts. Water levels in the Montana Tech well showed a similar response to precipitation events as was seen in 2004 and prior years, rising in the spring and declining throughout the winter. However, during 2005 the water-level rise was less than the previous two years although precipitation amounts were higher.

Water levels in the Marget Ann Mine and well S-4 declined between 2.8 feet and 3 feet during 2005. Figure 4-4 shows water-level hydrographs for these two sites with monthly precipitation totals shown. Water levels from 1994 through 1998 showed a consistent increase regardless of precipitation amounts. From 1999 through 2002, water levels declined, with little apparent influence from precipitation. Water levels in the Marget Ann Mine and well S-4 increased throughout 2003. The initial 2003 water-level rise occurred shortly after a substantial amount of precipitation in the spring (April) of 2003 and continued to rise regardless of precipitation trends the remainder of the year. During 2004 and 2005, water levels declined steadily throughout the year regardless of precipitation events. No water-quality samples were collected during 2005 in the Outer Camp System.

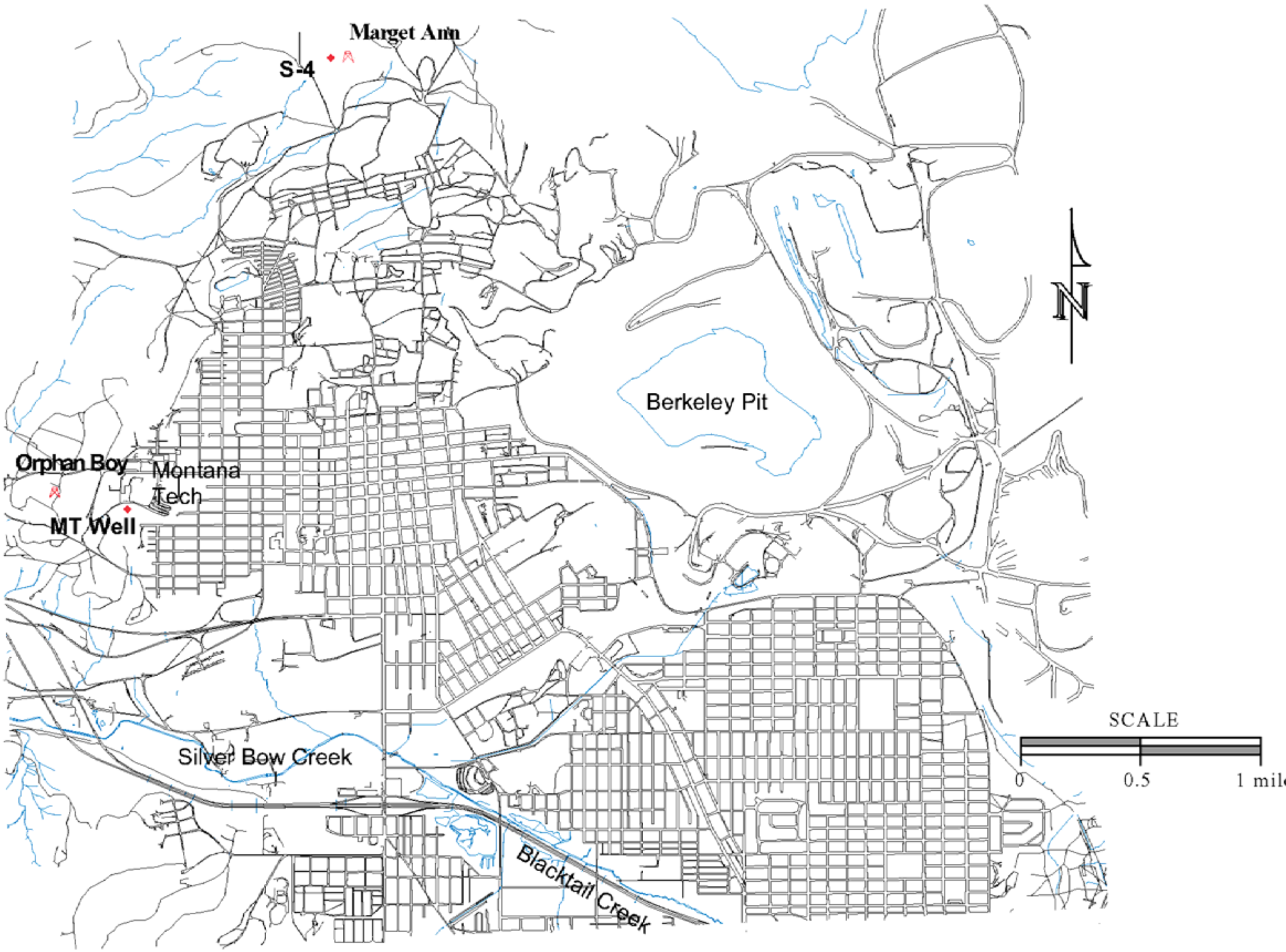


Figure 4-1. Outer Camp Monitoring Sites Location Map.

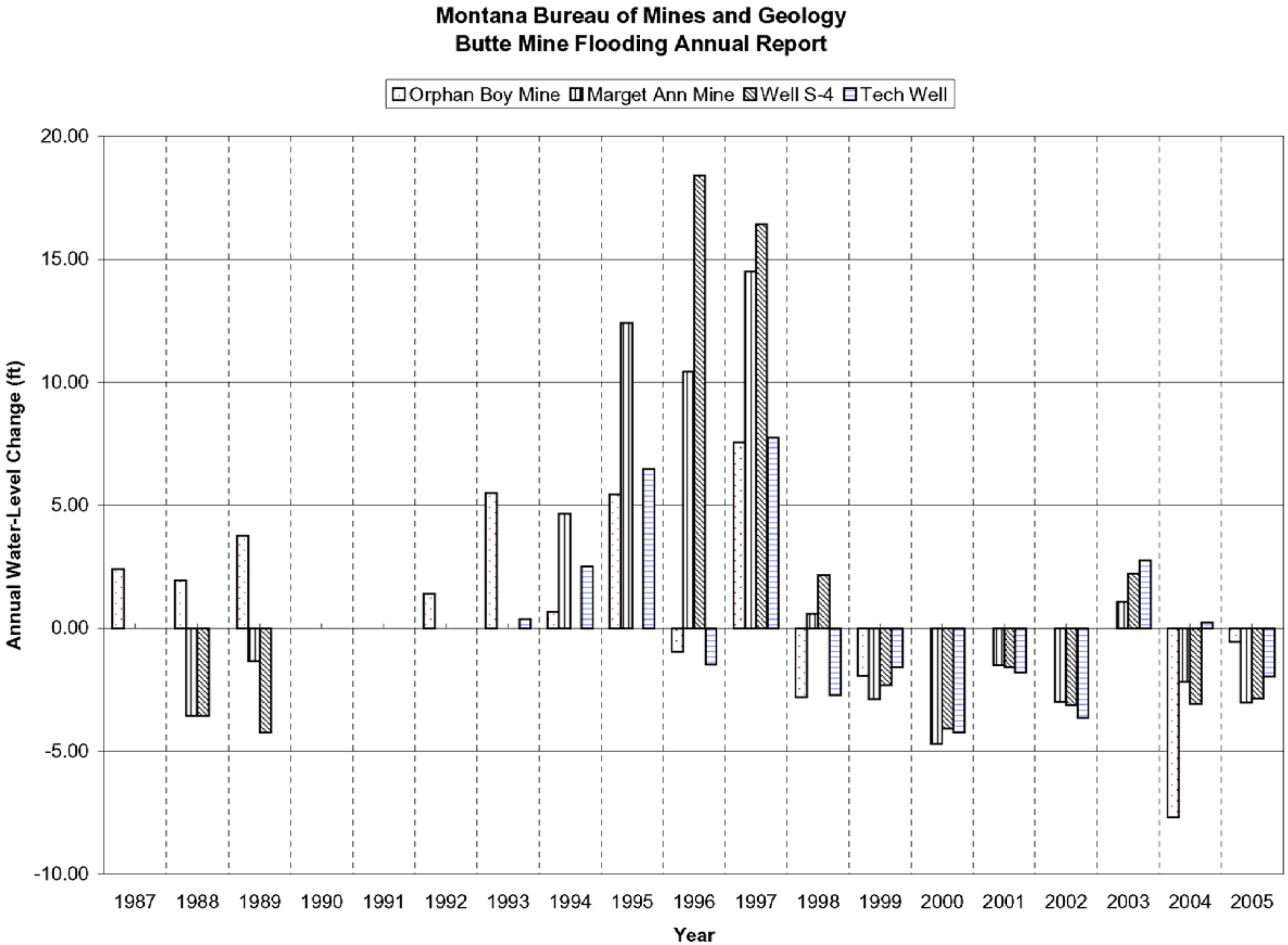


Figure 4-2. Outer Camp sites annual water-level change.

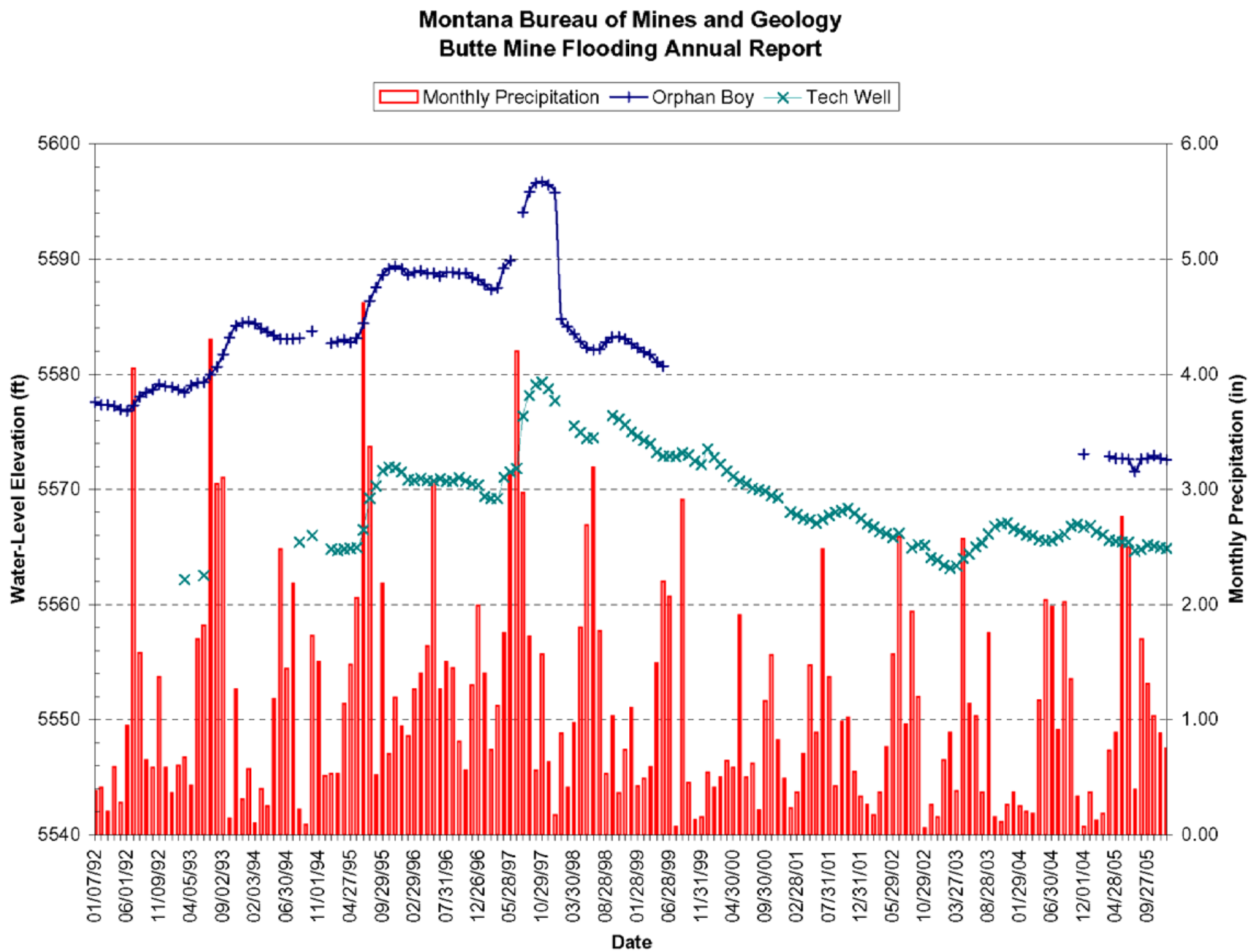


Figure 4-3. Water-level hydrograph of the Orphan Boy Mine and Montana Tech wells.

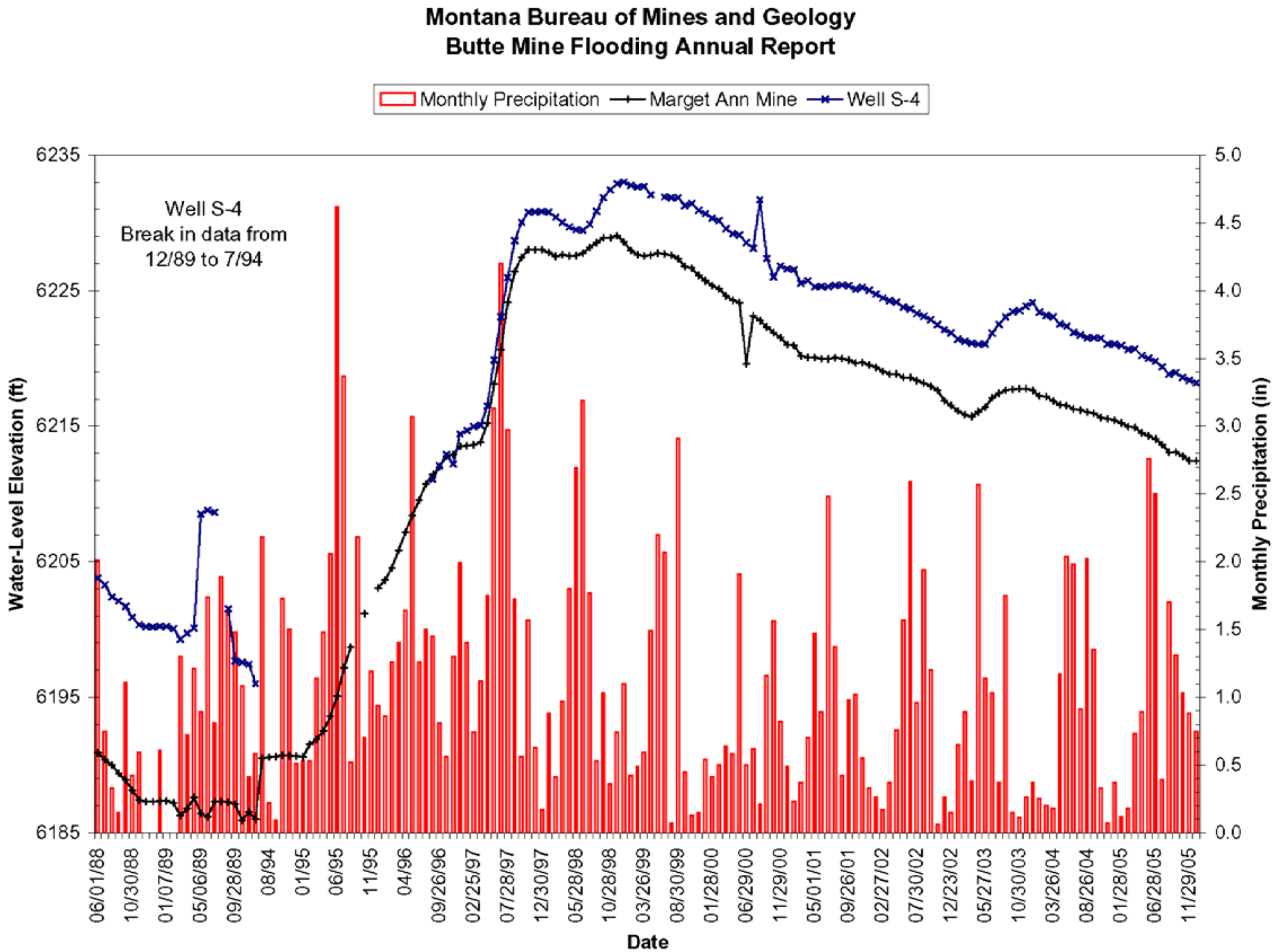


Figure 4-4. Water-level hydrograph for Marget Ann Mine and well S-4.

SECTION 5.0 MISCELLANEOUS WELLS

The locations of the miscellaneous monitoring wells are shown on figure 5-1. In the past, these sites consisted of 11 shallow alluvial monitoring wells (MF) and two bedrock monitoring wells. The eleven alluvial wells are no longer part of the BMFOU monitoring program and will not be discussed in this report. However, the Hebgen Park and Parrott Park wells are both part of the monitoring program specified in the 2002 CD.

Section 5.1 Miscellaneous Wells' Water Levels

Annual water-level changes are listed in Table 5.1.1. Water-level responses in the Hebgen Park well (fig. 5-2) were similar to those seen in prior years. Water levels begin to rise during the late spring and continue through the fall, which coincides with both summer precipitation and lawn watering of the park. Precipitation, or the lack of, does not appear to influence water levels once they begin to rise in the spring. Since the water-level rise extends into the fall and early winter, it is probable that a portion of the increase in water level is due to lawn watering in addition to precipitation. The water level in this well decreased over 2 ft during 2005. Since monitoring began at this site, water levels have increased over 1.4 ft.

Table 5.1.1 Annual water-level change for miscellaneous wells, in feet.

Year	Hebgen[1]	Parrott	Year	Hebgen[1]	Parrott
1983			1993	6.27	1.39
1984			1994	-0.25	5.96
1985			1995	Na	2.67
1986			1996	2.75	-1.50
1987			1997	4.22	4.75
1988			1998	-0.62	-0.33
1989	1.54	1.43	1999	-2.93	-5.34
1990	-2.18	0.42	2000	-6.07	1.50
1991	-1.90	5.23	2001	0.37	5.47
1992	3.09	-6.10	2002	-0.41	-3.27
	-1.40	0.63	2003	1.25	3.52
			2004	-0.12	-1.12
			2005	-2.19	6.76
Total 10-Year Change*	**-0.85**	**1.61**	**Total Change***	**1.42**	**22.07**

(1) Hebgen Park Well – No data from 06-1992 to 01-1993, 01-1995 to 09-1996, and 01-1998 to 01-1999.
(*)Total water-level change is that measured. Access or obstructions occasionally prevent water-level measurements.
NA- no access.
P&A- well plugged and abandoned.

The water-level hydrograph for the Parrott Park well is shown on figure 5-3, along with monthly precipitation totals. Water levels declined during most of 2002 before leveling off and rising during December of 2002. The 2003 water levels and trends were similar to those of 2000 and 2001; however 2004 water levels did not show the same level of response to precipitation. Water levels declined for most of 2004 before rising almost 3.5 ft the last two months of the year. The rise that occurred the last

2 months of 2004 is not related to either precipitation events or lawn irrigation. Water levels at this site continued to rise throughout 2005 regardless of precipitation trends. The greater than 6-ft water-level rise for 2005 is unlike any other site outside the East Camp bedrock system.

Figure 5-4 is a water-level hydrograph for both the Parrott and Hebgen Park wells which shows the recent water-level trends. The water-level increases seen in the Parrott well coincides with a water-level decline and stabilization in the Hebgen well. No water-quality samples are collected from either of these monitoring sites.

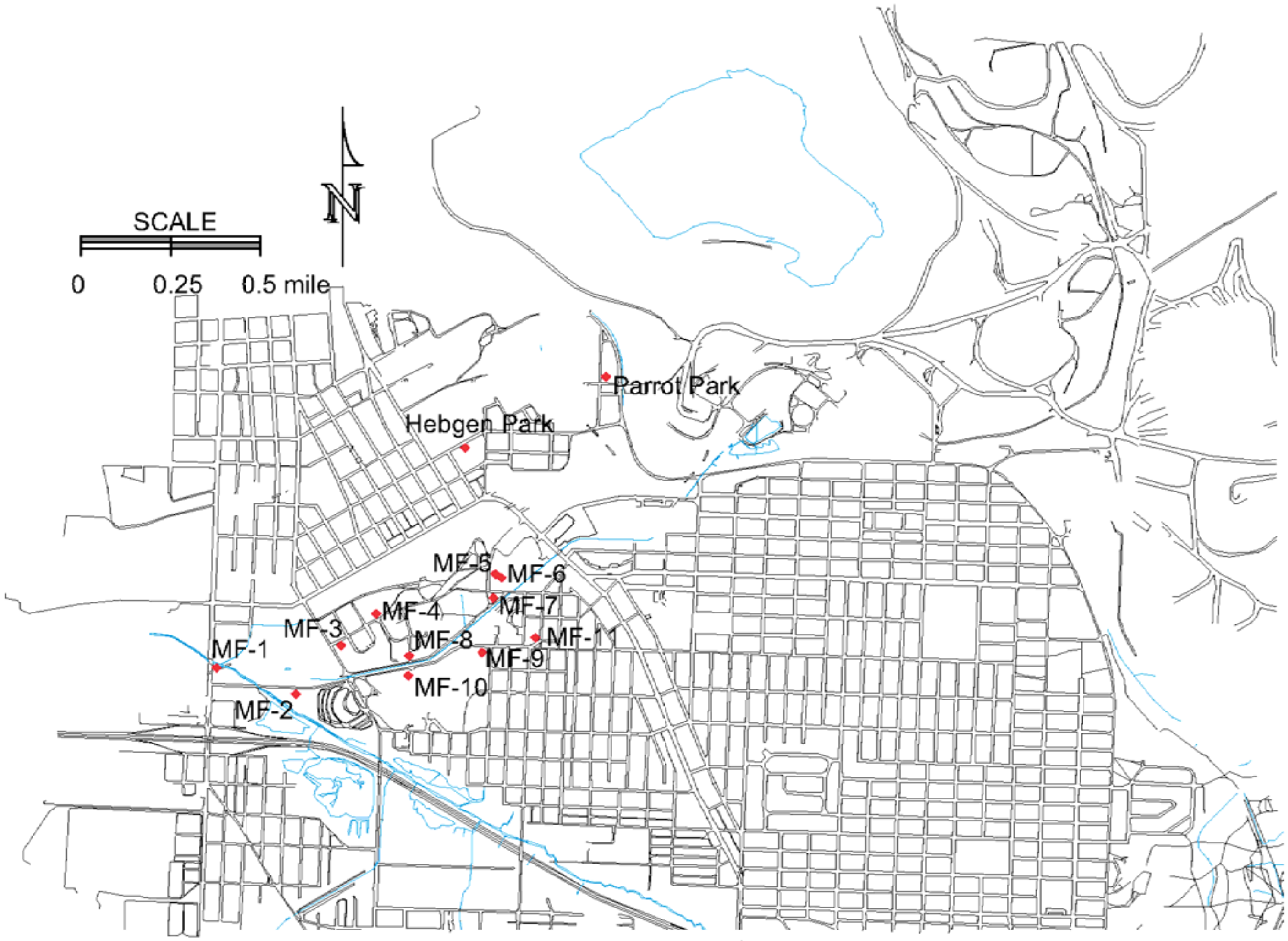


Figure 5-1. Miscellaneous Monitoring Wells Location Map.

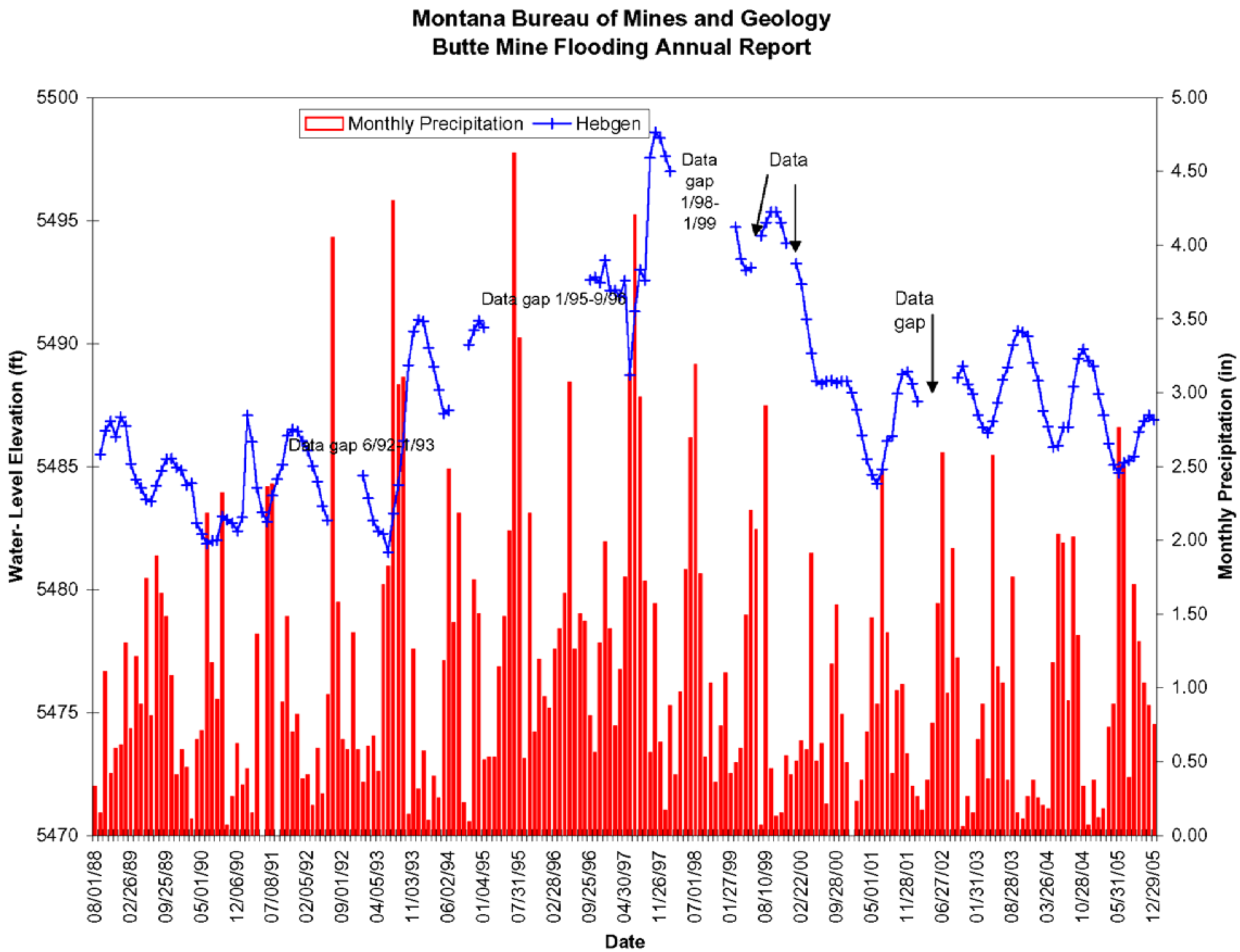


Figure 5-2. Water-level hydrograph for the Hebgen Park Well.

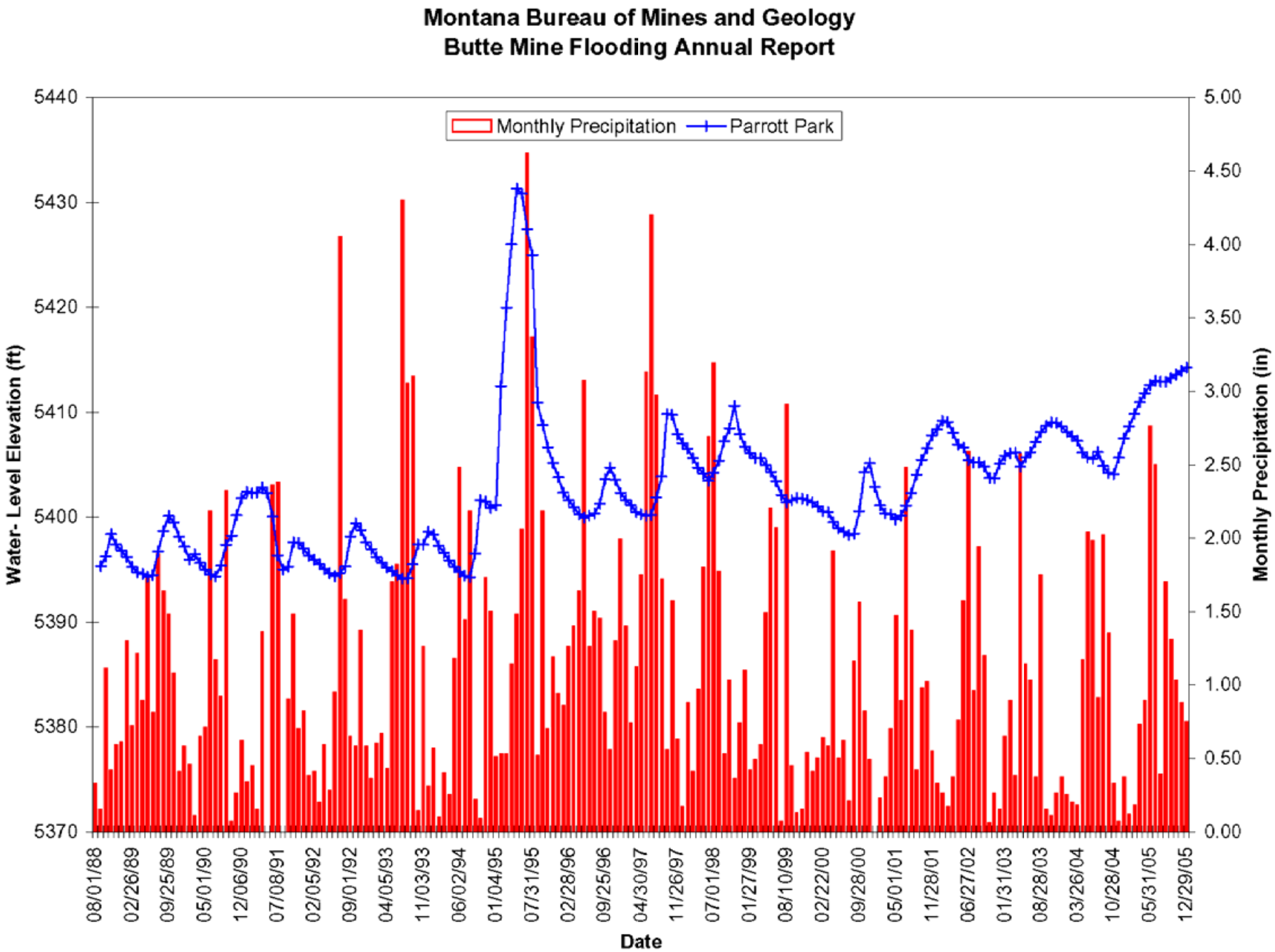


Figure 5-3. Water-level hydrograph for Parrott Park well.

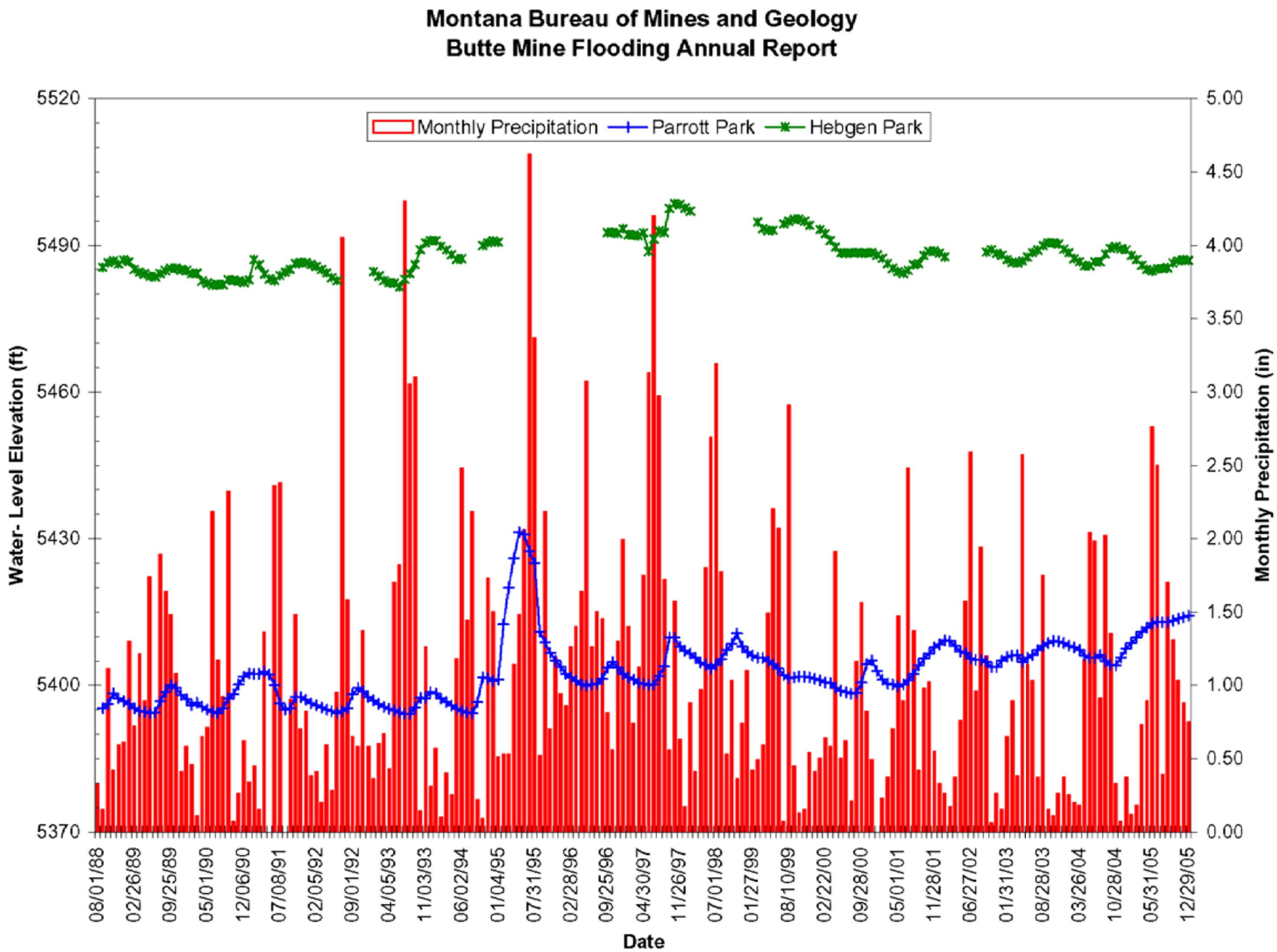


Figure 5-4. Water-level hydrograph for Parrott and Hebgen Park wells.

SECTION 6.0 REVIEW OF THE BERKELEY PIT MODEL

The Berkeley Pit water-level model was updated based upon actual 2005 water-level measurements and HSB flows as measured in the water-treatment plant. The model incorporates monthly water-level rise information from July 1996 through December 2005.

Based upon the 2005 model update, it is projected that the critical water level (CWL) of 5,410 feet will be reached at the Anselmo Mine in June 2021, 6 months later than predicted in the 2004 model (December 2020). The model update includes the surface water inputs from storm water diversions in the Kelley Mine area, the addition of sludge from the HSB water-treatment plant, and previous models infilling rates adjusted for the diversion of HSB water away from the pit. The HSB drainage water that was flowing into the pit from June 2000 through November 17, 2003 is now being diverted to the HSB water-treatment plant for treatment and is being used in MR's mining operations. No major additions into or withdrawals of water were made from the Berkeley Pit during 2005; the consistent filling rate and operational activities led to the slight adjustment in filing rate projections.

The treatment technology and plant-construction time frame for Berkeley Pit water are based upon the schedule listed in the EPA 1994 ROD, and included in the 2002 CD for the Butte Mine Flooding Operable Unit (EPA, 1994). Based upon the current water-level projections, a review of the HSB treatment plant design and operation would begin in June 2017. Any necessary upgrades would have to be completed by June 2019.

SECTION 7.0 CONCLUSIONS AND SUMMARY

Water-level trends in the alluvial monitoring system, while varying some from those noted in last year's report, still continued to rise at a number of sites north of the Pittsmont waste dump. This is a change from historic trends when water-levels declined in the majority of those wells prior to 2004. Water levels also rose in a majority of the wells south of the Pittsmont dump, following trends that began in 2003.

Precipitation events still have little or no influence on water levels in the LP-series alluvial wells near the Berkeley Pit and leach pads. Water-level variations in these wells have a greater response to mining activities than precipitation events.

Water levels in a majority of the alluvial monitoring wells located outside the mine area show a response to seasonal precipitation events. The response time varies from immediate to a two- to three-month lag time. The decrease in annual precipitation in the Butte Basin since 1999 was considered a good explanation for the overall water-level decrease seen in a number of monitoring wells, however, water levels increased in all of these wells (AMC and GS series) in 2003, before decreasing again in 2004. The 2003 water-level increase occurred although precipitation levels were less than previous years. The increases were greater in wells nearest the mine site and water levels rose the most from late summer through the remainder of the year. While this period of time coincides with MR's mine start-up activities, no direct link was found between start-up activities and water-level changes. However, a relationship between filling of the MR concentrator Ecology/Emergency Pond and water-level increases in several AMC wells was apparent. Water-level declines in 2005 were consistent in the alluvial monitoring network.

The increased water-level changes in the East Camp bedrock system are independent of precipitation, and are a result of the 1982 cessation of long-term mine dewatering activities. No notable precipitation influence was seen in any of the bedrock wells or underground mines water levels. However, the continued diversion of HSB drainage water away from the Berkeley Pit did have an influence on East Camp bedrock water levels. The water-level rise for 2005 was about 75% that of 2004. Water levels in the bedrock system were affected in varying degrees by the July earthquake and December pumping test. Well B showed the greatest level of water-level change from previous years as a result of these two events.

The date the East Camp system water level is predicted to reach the CWL elevation of 5,410 feet was changed from December 2020 to June 2021, or 6 months later than that predicted in 2004. The CWL date is assumed to be the date the 5,410-foot elevation would be reached at the Anselmo Mine. The Anselmo Mine is the anticipated compliance point in order to keep the Berkeley Pit the lowest point in the East Camp bedrock-mine system. This will ensure that all water in the historic underground mine system will continue to flow towards the Berkeley Pit.

The pumping of ground water in the West Camp System continues to control water levels in this system. The volume of water pumped during 2005 was 1% more than 2004; however, water levels still increased slightly throughout this system and are now over10 feet below the maximum-allowable level.

Monitoring wells in the alluvial aquifers associated with the Mine Flooding Operable Unit continue to show a wide range of water-quality concentrations, both spatially and temporally. As is the case for the last few years, the AMC-series wells show a wide variation and few trends with respect to the concentration of dissolved constituents. The LP-series wells show a continuation of recent trends in most wells for most constituents.

In several cases, chemistry data from the East Camp mines show a strong departure from historic trends, particularly with respect to iron concentrations. What was possibly a sampling or analytical problem is likely a real change in the chemistry of water in the underground workings.

Recent data from the West Camp monitoring sites generally indicate a continuation of recent trends in water quality. Although the concentrations of several dissolved constituents trend upward, they are generally well below values observed during initial flooding. Data from the Emma shaft continue to show departure from recent trends and a notable difference in water quality compared to the Travona Mine.

Results of the 2005 monitoring program continue to show that the current monitoring (water-level and water-quality) is adequate for ensuring that contaminated bedrock ground water is flowing into the Berkeley Pit, and that West Camp water levels are being sufficiently controlled by West Camp pumping operations. These are two of the main environmental concerns associated with the flooding of Butte's historic underground mines and the Berkeley Pit.

Acknowledgments

The information contained in this report represents the work of many companies and agencies over the past 24 years. Numerous individuals have been responsible for actual data collection. Their dedication and creativity in monitoring and sampling of mine waters provided the information that all future work and evaluations rely upon.

The State of Montana, Department of Environmental Quality and the U.S. Environmental Protection Agency have provided funding for the MBMG to conduct monitoring and sampling activities and preserve continuity between various studies. This support has been invaluable; while their realization that flexibility is needed in the monitoring program has allowed modifications in monitoring as conditions change.

The continued cooperation of Montana Resources and British Petroleum/Atlantic Richfield Company is greatly appreciated, while representatives of New Butte Mining and Montana Mining Properties continue to allow access to their properties for monitoring purposes. Special appreciation is extended to the property owners who allowed access to their property for the installation of the new alluvial monitoring wells: Gilman Construction, Continental Public Land Trust, Butte School District #1, and Race Track Volunteer Fire Department.

Special recognition is given to Mike Kerschen and Nick Tucci, MBMG, for their dedication to monitoring and sampling tasks, and to Peggy Delaney, MBMG, for assisting with the preparation of this report.

Errors and omissions remain the authors' responsibility.

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