Investigation of Groundwater and Surface-Water Systems in the C.W. Mining Company Federal Coal Leases and Fee Lands, Southern Gentry Mountain, Emery and Carbon Counties, Utah:

Probable Hydrologic Consequences of Coal Mining in the Bear Canyon Mine Permit Area and Recommendations for Surface Water and Groundwater Monitoring

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICIES

1.0 INTRODUCTION

C.W. Mining Company intends to expand their current operations at the Bear Canyon Mine into Federal coal leases in the Wild Horse Ridge area (U-020668 and U-38727) and into Federal coal leases (U-46484, U-61048, U-61049, and U-0243 16) and fee lands in the Mohrland area (Figure 1). These lands include 9,320.54 acres on Gentry Mountain in the Wasatch Plateau Coal Field. The current Bear Canyon Mine lease area, the Wild Horse Ridge area, the Mohrland area, and lands immediately adjacent to these areas comprise the area of study for this investigation.

This report describes the surface-water and groundwater systems of the current mine lease area, the Wild Horse Ridge area, and the Mohrland area, and is written in support of Chapter 7 of the Mining and Reclamation Plan (MRP). This portion of the MRP requires, among other things, a description of groundwater systems, an analysis of the probable hydrologic consequences of coal mining within and adjacent to the permit area, and a surface-water and groundwater monitoring program.

While this report generally focuses on the probable hydrologic consequences of underground coal mining in the study area, specific attention is given to two springs. As culinary water supply sources, these springs, Birch Spring and Big Bear Spring, have been the subject of particular concern to regulatory agencies, local communities, and private citizens. This report provides greater insight into the possible relationship between mining operations and the water quality and quantity of Birch and Big Bear Springs.

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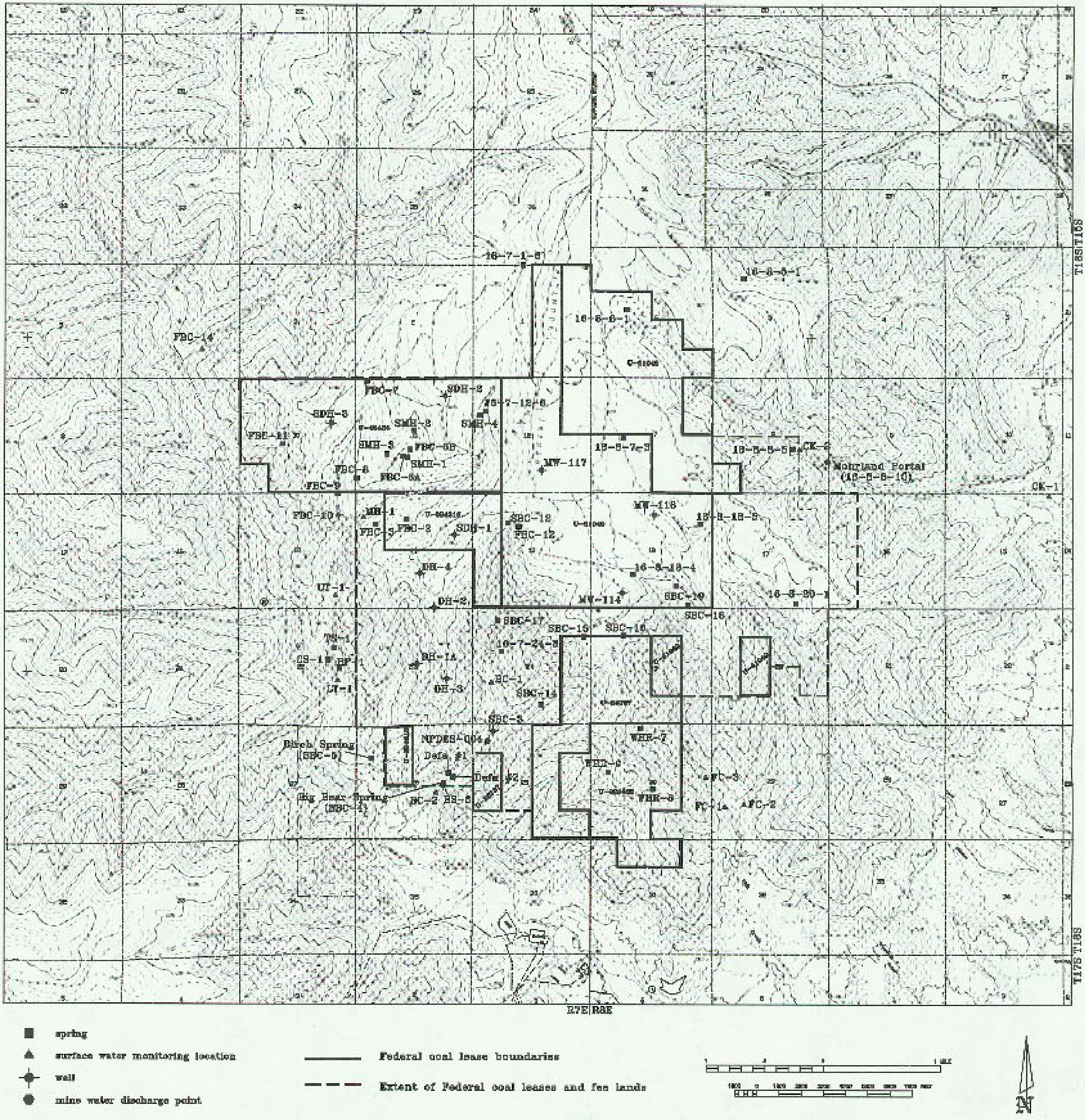

Figure 1 Federal coal leases and fee lands held by C.W. Mining Company. Locations of springs, creeks, wells, and mine water discharge points.

2.0 PROJECT OVERVIEW

2.1 Purpose of investigation

The purpose of this investigation is to characterize surface-water and groundwater resources in the study area in order to assess the probable hydrologic impacts of mining, and to formulate a surface-water and groundwater monitoring program.

2.2 Methods of investigation

Surface-water and groundwater resources in the study area have been evaluated by analyzing: 1) solute and isotopic compositions of surface waters and groundwaters, 2) surface-water and groundwater discharge data, 3) piezometric data, and 4) geologic information. Specific methods of investigation are described below.

2.2.1 Compilation of water quality, discharge, and piezometric data

Water quality, discharge, and piezometric data were obtained in electronic format from C.W. Mining and compiled into an electronic database management system. A printed copy of the data that are included in this database is attached in Appendix A.

2.2.2 Collection and analysis of isotopic data

As part of this investigation, Mayo and Associates have collected water samples from six stream sites, 19 springs, three wells, and two in-mine locations for stable and radiogenic isotope analysis. Additional isotopic data collected previously by Mayo and Associates, C.W. Mining Company, and consultants retained by the Castle Valley Special Services

District and the North Emery Water Users Association have been incorporated into this study. These additional data are from springs, in-mine locations, and one well.

Isotopic samples for δ^2H, $\delta^{18}O$, and tritium analyses were collected, sealed, and preserved in appropriate glass or HDPE plastic bottles. Dissolved inorganic carbon for $\delta^{13}C$ and radiocarbon analysis were precipitated with $BaCl_2 \cdot 2H_2O$.

For this investigation, Mountain Mass Spectrometry, Evergreen, Colorado, performed stable isotopic analysis for δ^2H and $\delta^{18}O$ compositions. Geochron Laboratories, Cambridge, Massachusetts, performed stable isotopic analyses for $\delta^{13}C$ composition and radiogenic radiocarbon content. The University of Miami Tritium Laboratory, Miami, Florida performed tritium analyses using electrolytic enrichment and low-level counting methods. Laboratory reporting sheets for isotopic analyses are included as Appendix B.

2.2.3 Data analysis

Geochemical, isotopic, discharge, and other data were analyzed by graphical, statistical, and computer methods. Solute compositions were graphically analyzed using Stiff (195 1) diagrams. Groundwater ^{14}C residence times were calculated using methods described by Fontes (1980), Mooke (1980), and Pearson and Hanshaw (1970).

3.0 PHYSIOGRAPHIC, CLIMATIC, AND GEOLOGIC SETTING

3.1 Physiography

The study area lies within the central Wasatch Plateau region of the Colorado Plateau physiographic province. The principal physiographic features of the study area are visible on a digital shaded relief image (Figure 2). The northern and central portions of the study area are dominated by Gentry Mountain, a flat-topped mesa at an elevation of approximately 9,400 feet. Most of Gentry Mountain is relatively flat, except for McCadden Hollow in the northwest comer of the study area, which forms a shallow valley as much as a few hundred feet lower than the rest of the mesa. The remainder of the study area consists of steep, narrow canyons cutting into Gentry Mountain from the southwest, south, and east. These canyons include Trail Canyon and Bear Canyon to the southwest, the Left Fork and Right Fork of Fish Creek to the south, and Cedar Canyon to the east.

3.2 Climate

Average precipitation is measured by C. W. Mining Company at the Bear Canyon Mine facilities and in Trail Canyon. For the period 1993-l 997, the average yearly precipitation was 10 inches in Bear Canyon and 14.75 inches in Trail Canyon. Precipitation at the NOAA station (NCDC, 1999a) at the town of Hiawatha on the northern extent of the study area averaged 13.8 inches per year during the period 193 1 - 1992. These three precipitation stations are located in the lower elevations of the study area and represent climatic conditions at the base of the plateau escarpment. The National Resource Conservation Service (NRCS) maintains two higher elevation precipitation stations west of the study area. During the period 196 1- 1990 (NRCS, 1995) the average annual precipitation was 29 inches at the

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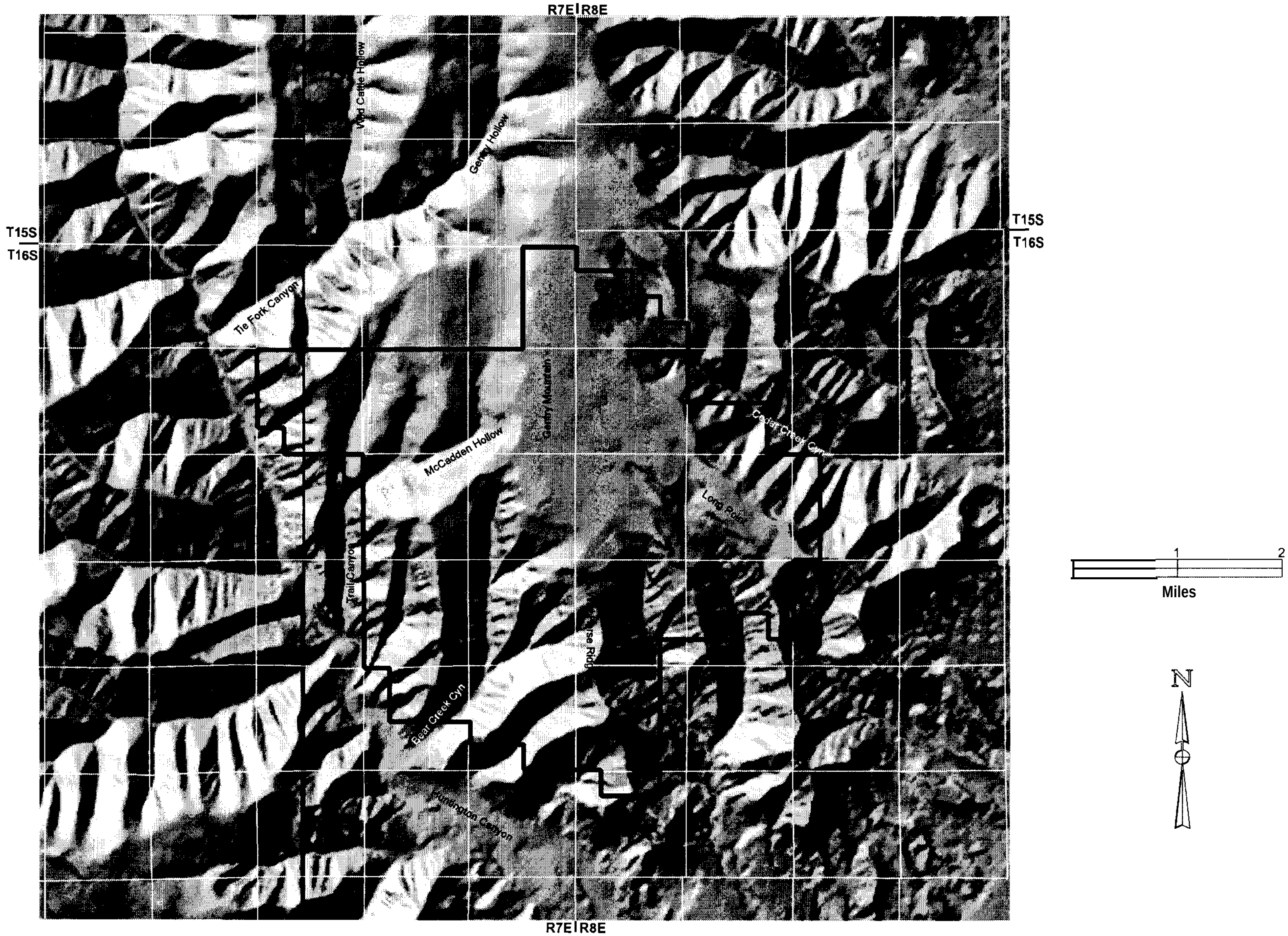

Figure 2 Shaded digital relief map showing the physiography of the study area.

Mammoth-Cottonwood Station (elevation 8,800 feet), and 33 inches at the Red Pine Ridge station (elevation 9,200). These latter stations are more representative of precipitation in the higher elevations of the study area.

The Palmer Hydrologic Drought Index (PHDI; NCDC, 1999b; Karl, 1986; Guttman, 199 1) indicates long-term climatic trends for the region. The PHDI is a monthly value generated by the National Climatic Data Center (NCDC) that indicates the severity of a wet or dry spell. The PHDI is computed from climatic and hydrologic parameters such as temperature, precipitation, evapotranspiration, soil water recharge, soil water loss, and runoff. Because the PHDI takes into account parameters that affect the balance between moisture supply and moisture demand, the index is a useful tool for evaluating the long-term relationship between climate and groundwater recharge and discharge.

Figures 3a and 3b show the PHDI for Utah Division 4 (south central) and Division 5 (northern mountains), respectively. The study area lies near the boundary of these two regions. These graphs indicate several extremely wet years during the early and mid 1980s, followed by several years of drought in the late 1980s and early 1990s. From 1993 through 1998 the regions have had mostly wet conditions with several short dry periods.

3.3 Geology

The geology of the current Bear Canyon Mine permit area is described in Chapter 6 of the Bear Canyon Mine MRP. The geology of the area is also described by Spieker (193 1),

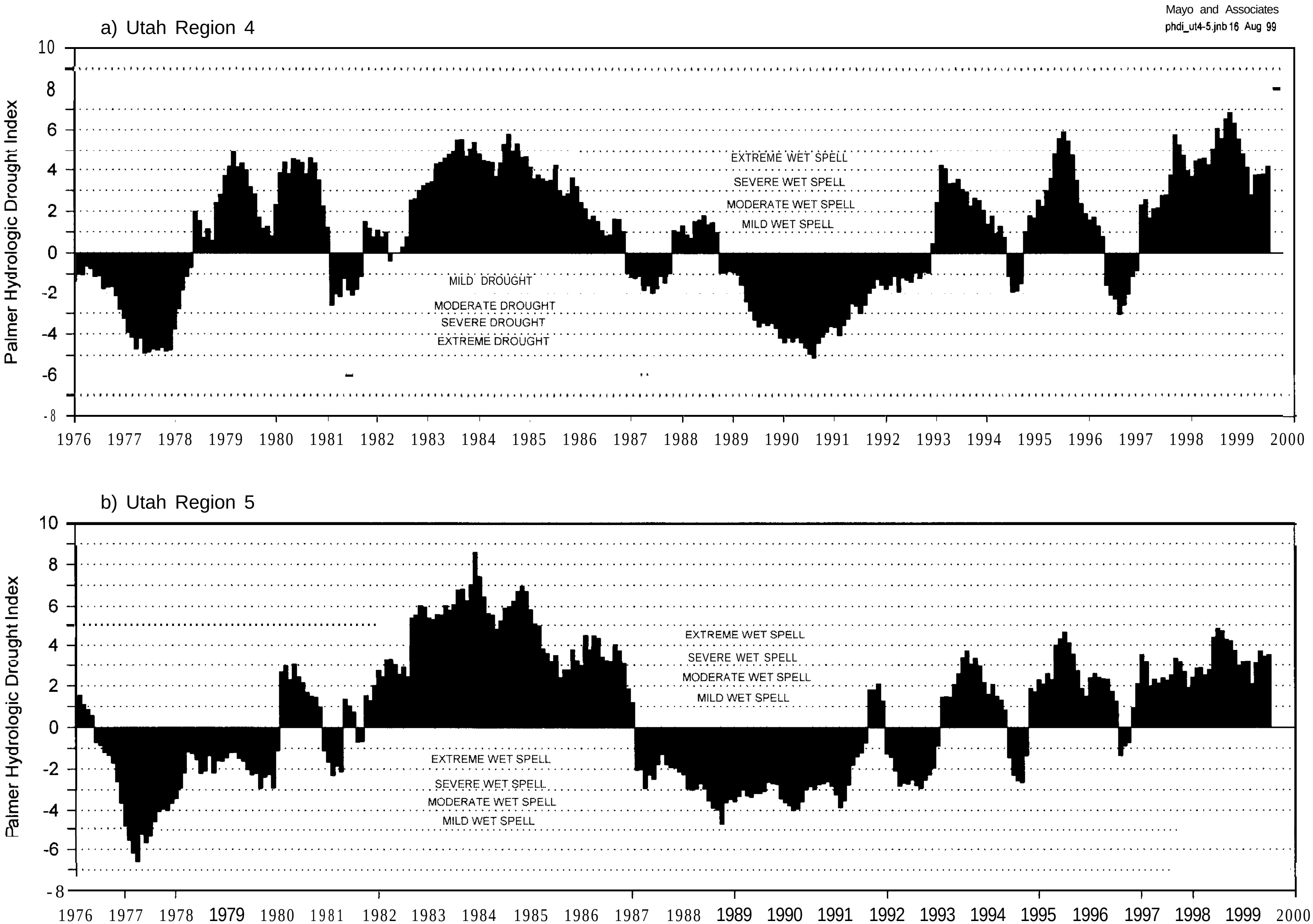

Figure 3 Palmer Hydrologic Drought Index.

Witkind and others (1987), and Brown and others (1987). This geologic information is relied on in the following discussion.

3.3.1 Stratigraphy

Seven bedrock formations, ranging in age from Cretaceous to Eocene, crop out in the study area. These formations are (from oldest to youngest) the Mancos Shale, Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, and Flagstaff Limestone. These formations are shown on a geologic map (Figure 4) and on a generalized stratigraphic column (Figure 5). The outcrop of the Flagstaff Limestone is not shown on Figure 4 because it was not mapped by previous workers (Spieker, 193 1; Witkind and others, 1987) on Gentry Mountain. Field observations indicate that the Flagstaff Limestone is exposed on Gentry Mountain.

Except for the Flagstaff Limestone, these bedrock formations were deposited during transgressions and regressions of the shoreline of the Western Cretaceous Interior Seaway during the Late Cretaceous and Early Tertiary. This ancient shoreline was located along the eastern edge of the tectonically uplifted mountains of the Sevier Orogenic Belt. Sediments eroded from the uplifted mountains were carried toward the seaway by fluvial systems and deposited as terrestrial, shoreline, marine, and interfingered marine and non-marine sedimentary sequences.

On the terrestrial side of the shoreline, sediment deposition occurred in lacustrine (lake carbonates, marls, and sands), alluvial plain (sands and clays), fluvial (stream sands and

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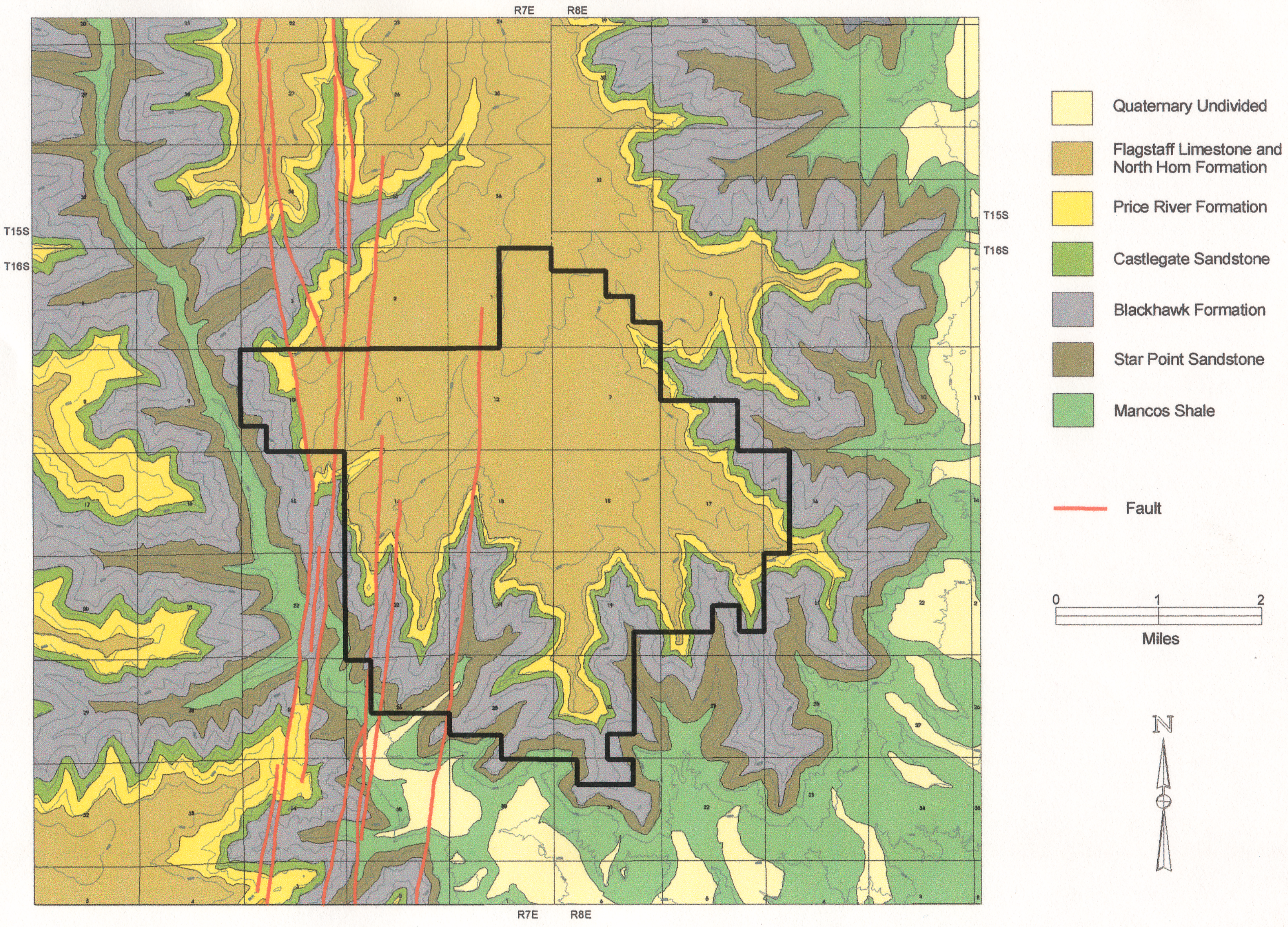

Figure 4 Geologic map of study area (after Witkind and others, 1987).

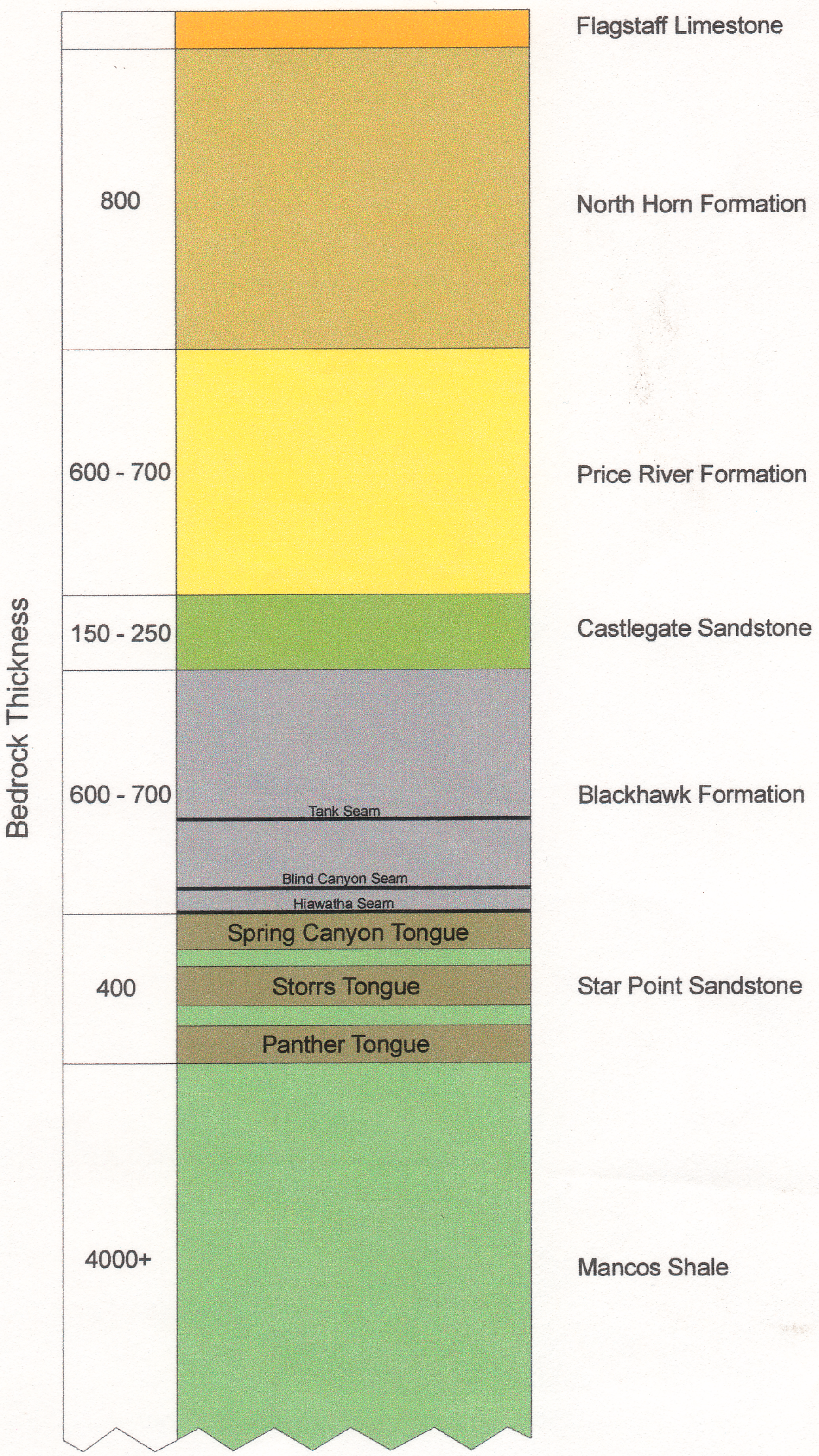

Figure 5 Generalized stratigraphic column of bedrock formations in the study area.

overbank muds), and carbonaceous backshore (coal swamp) environments. Along the shoreline, marine foreshore deposits (beach sands) accumulated. Offshore, sands swept from the beaches were laid down as bars and blankets of sand in the near-shore shallow marine water. These blankets of sand are known as shoreface deposits. The clay fraction of stream-transported sediments which reached the shoreline was deposited as thick marine mud (shale) in the deeper and more quiescent portions of the seaway. Because the transgression and regression of the shoreline was accompanied by the continual deposition of sediments, a variety of horizontally and vertically discontinuous sediment types occur throughout the coal district. This depositional history has resulted in a heterogeneous rock record that has had a profound effect on the water-bearing characteristics of these rocks.

Each of the geologic units that crop out in the study area is discussed briefly below.

3.3.1.1 Mancos Shale

Castle Valley, located east of the study area, is developed on the easily eroded Mancos Shale. This formation is also exposed at the base of the Wasatch Plateau escarpment. The Mancos Shale was deposited in deep, quiescent portions of the Western Cretaceous Interior Seaway from Early to Late Cretaceous time. Consequently, the formation is over 4,000 feet thick and underlies vast portions of the Colorado Plateau. The shale is carbonaceous, gypsiferous, and slightly calcareous. The unit is medium-gray to bluish-gray and is locally fissile with discontinuous stringers of siltstone and mudstone. The contact of the Mancos Shale with the overlying Star Point Sandstone is conformable and intertonguing.

3.3.1.2 Star Point Sandstone

The Star Point Sandstone, which is present throughout the area, forms prominent cliffs where exposed at the surface. The sandstone was deposited as marine shoreface blanket sands which are laterally continuous, but thin basinward (to the east). Landward (to the west), these sandstones terminate abruptly into the mud- and organic-rich backshore facies. Because many of the organic-rich facies have been converted to mineable quality coal, locally the Star Point Sandstone has immediate contact with coal seams. Elsewhere sandstone bodies of the Star Point Sandstone are overlain and underlain by lower shoreface and open marine shales of the Mancos Shale. What this means is that the marine shoreface sandstones are three dimensionally encased by low-permeability marine shales and fine-grained carbonaceous backshore coal-bearing facies.

The Star Point Sandstone thins eastward and merges with the underlying Masuk Member of the Mancos Shale. Three prominent tongues of the Star Point Sandstone inter-finger with the Mancos Shale. These three sandstone members, from bottom to top, are the Panther, Storrs, and Spring Canyon Sandstones. Valuable information about the Star Point Sandstone in the Bear Canyon Mine area was obtained from three in-mine drill holes that penetrated the entire thickness of the Star Point Sandstone (EarthFax, 1993). Data from these holes indicate the following stratigraphic thicknesses in feet:

	DH-1 A	DH-2	DH-3	Average
Spring Canyon SS	88	103	98	96
Mancos Shale	57	37	40	45
Storrs SS	96	105	120	107
Mancos Shale	37	43	84	55
Panther SS	105	88	97	97

The Panther Sandstone is a fine- to coarse-grained sandstone that is poorly cemented. Bedding in the Panther Sandstone is variable from massive to laminated, with muddy partings and local bioturbation. The Panther Sandstone is less dense, coarser-grained, less well cemented, less indurated, and more permeable than the other tongues of the Star Point Sandstone.

The Storrs Sandstone is a very fine- to fine-grained sandstone that is well cemented and well indurated. Bedding ranges from massive to laminated with muddy horizons and parting. The Storrs Sandstone is generally finer-grained, denser, and more highly indurated and less permeable than the other two tongues.

The Spring Canyon Sandstone is fine- to medium-grained sandstone that is well cemented. Like the other tongues, bedding is variable in the unit with muddy horizons and partings.

3.3.1.3 Blackhawk Formation

The Blackhawk Formation consists of an upper non-marine, suspended-load fluvial portion and a lower marine shoreface and non-marine foreshore portion. Massive, cliff-forming units are common in the upper portion, and thinner-bedded, slope-forming units are common in the lower portion. The thickness of the Blackhawk Formation ranges from 600 to 700 feet in the study area. Most of the thicker coal seams occur in the lower portion of the Blackhawk Formation.

The upper portion of the Blackhawk Formation was deposited in an alluvial-plain/suspended-load fluvial channel environment. In these environments layers of mud are more abundant than channel sands, and sandstone channels are generally isolated from each other both laterally and vertically by mud-rich overbank and interfluvial deposits.

The lower portion of the Blackhawk Formation contains the mineable coal deposits and consists of more thinly bedded sandstone and shale layers. The coal-bearing units of the lower Blackhawk Formation overlie and are laterally juxtaposed to marine shoreface sandstones of the Blackhawk Formation and Star Point Sandstone. On a large scale, these sandstone bodies are laterally continuous but terminate abruptly into the mud- and organic-rich backshore faces in a landward direction. However, individual rock layers are lenticular and discontinuous, with abundant shaley interbeds. The fine- to medium-grained sandstones occur as thin- to massively-bedded paleochannel deposits. The paleochannels increase in frequency, thickness, and lateral extent upward in the formation.

The coal seams mined at the Bear Canyon Mine include the Tank Seam, the Blind Canyon Seam, and the Hiawatha Seam. Other seams, which are of lesser economic importance in the permit area, include the Bear Canyon Seam and the upper beds. The uppermost coal seam mined at the Bear Canyon Mine is the Tank Seam, which ranges from 0 to 8 feet thick. The underlying Blind Canyon Seam, which ranges in thickness from 0 to 10 feet, is separated from the Tank Seam by approximately 240 feet of sandstone, mudstone, and shale. The stratigraphically lowest coal seam in the permit area is the Hiawatha Seam, which is separated from the overlying Blind Canyon Seam by between 40 and 110 feet of interbedded sandstone, mudstone, and shale. The Blind Canyon Seam ranges in thickness from 5 to 8 feet. In most locations, the Hiawatha Seam has direct contact with the underlying Spring Canyon Sandstone.

3.3.1.4 Castlegate Sandstone

The resistive Castlegate Sandstone forms a distinct cliff above the Blackhawk Formation. The Castlegate Sandstone was deposited by a bed-load fluvial channel system. The unit lithology is dominated by sandstone with occasional siltstone and claystone interbeds. Sandstone channels are varied in size and interpenetrate. Sands within the channels are coarse-grained and can be conglomeritic. Although the primary porosity is high, the existence of mudstone drapes and pervasive carbonate and silica cement greatly reduces the overall porosity. The Castlegate Sandstone ranges from 150 to 250 feet thick within the study area.

3.3.1.5 Price River Formation

The Price River Formation forms a series of ledges and slopes above the precipitous cliffs of the Castlegate Sandstone. It ranges in thickness from 600 to 700 feet in the study area and consists of poorly cemented argillaceous sandstone that is easily eroded. The depositional environment of the Price River Formation is a mixed-load fluvial channel system, which created interbedded sandstone and shale/claystone layers. This unit was deposited on a coastal plain and as a result contains thin lenses of channel sands and thin, discontinuous coal beds.

3.3.1.6 North Horn Formation

The North Horn Formation overlies the Price River Formation and consists of reddish-brown and grayish-brown mudstone with interbedded siltstone, sandstone, and limestone. Limestone beds are dark gray, dense, thin-bedded, and locally fossiliferous. The deposition of the North Horn Formation was in alluvial plain, lacustrian, and fluvial channel environments. Because sand occurs mostly in fluvial channels, mudstone is more abundant than sandstone. Sandstone channels are isolated spatially by overbank mudstone deposits and lacustrian clays. The North Horn Formation is about 800 feet thick within the study area.

3.3.1.7 Flagstaff Limestone

The Flagstaff Limestone overlies the Price River Formation and consists of freshwater limestones with some marls and thin sandstone stringers. It typically forms a steep cliff at the top of the Wasatch Plateau, and forms the top of Gentry Mountain within the study area. The thickness of the Flagstaff Limestone on Gentry Mountain has not been measured but varies in other locations from 10 to 300 feet. The Flagstaff Limestone contains abundant secondary fractures produced during uplift and subaerial exposure.

3.3.2 Structure

Rock layers within the study area are nearly flat, with an approximate regional dip of 2 to 3 degrees to the south and southeast (Brown and others, 1987). The western portion of the study area includes portions of the Pleasant Valley Graben, a complex north-south trending structure consisting of several parallel or sub-parallel faults. Individual faults within this structure show displacements on the order of 20 to 200 feet. The Pleasant Valley Graben is bounded on the west by the Pleasant Valley Fault, which approximately follows Trail Canyon, and on the east by the Bear Canyon Fault, which approximately follows Bear Canyon. In the area east of this graben, there are no other reported faults.

4.0 PHYSICAL HYDROGEOLOGY

Within the study area, groundwater naturally discharges from the Flagstaff Limestone, North Horn Formation, Price River Formation, lower Blackhawk Formation, and each of the three tongues of the Star Point Sandstone (Table 1). No significant groundwater discharge has been identified from the Castlegate Sandstone, upper Blackhawk Formation, or Mancos Shale. Groundwater is also encountered in mine workings in the Blackhawk Formation. The discharge characteristics and the spatial and stratigraphic occurrence of groundwaters in the study area are discussed below. Monitoring locations and details are listed in Table 1.

4.1 Spring discharge rates

The combined discharges of springs discharging from the geologic formations within the study area are plotted on a bar graph in Figure 6. In Figure 6a, the bar lengths represent the sums of the maximum recorded discharges for all springs in an individual geologic formation. Figure 6b shows the minimum discharges measured for springs in the individual geologic formations. Thus, Figure 6a represents the maximum groundwater discharge rate from each formation during the high-flow season, while Figure 6b represents baseflow groundwater discharge rates during the low-flow season and during periods of drought. There is a large variation between the combined discharge rate for all formations during high-flow conditions, approximately 1,000 gpm, and the baseflow rate of only 135 gpm. The more than seven-fold decline in discharge rates during the low-flow season reflects the importance of seasonal recharge and climatic variability to groundwater systems in the area.

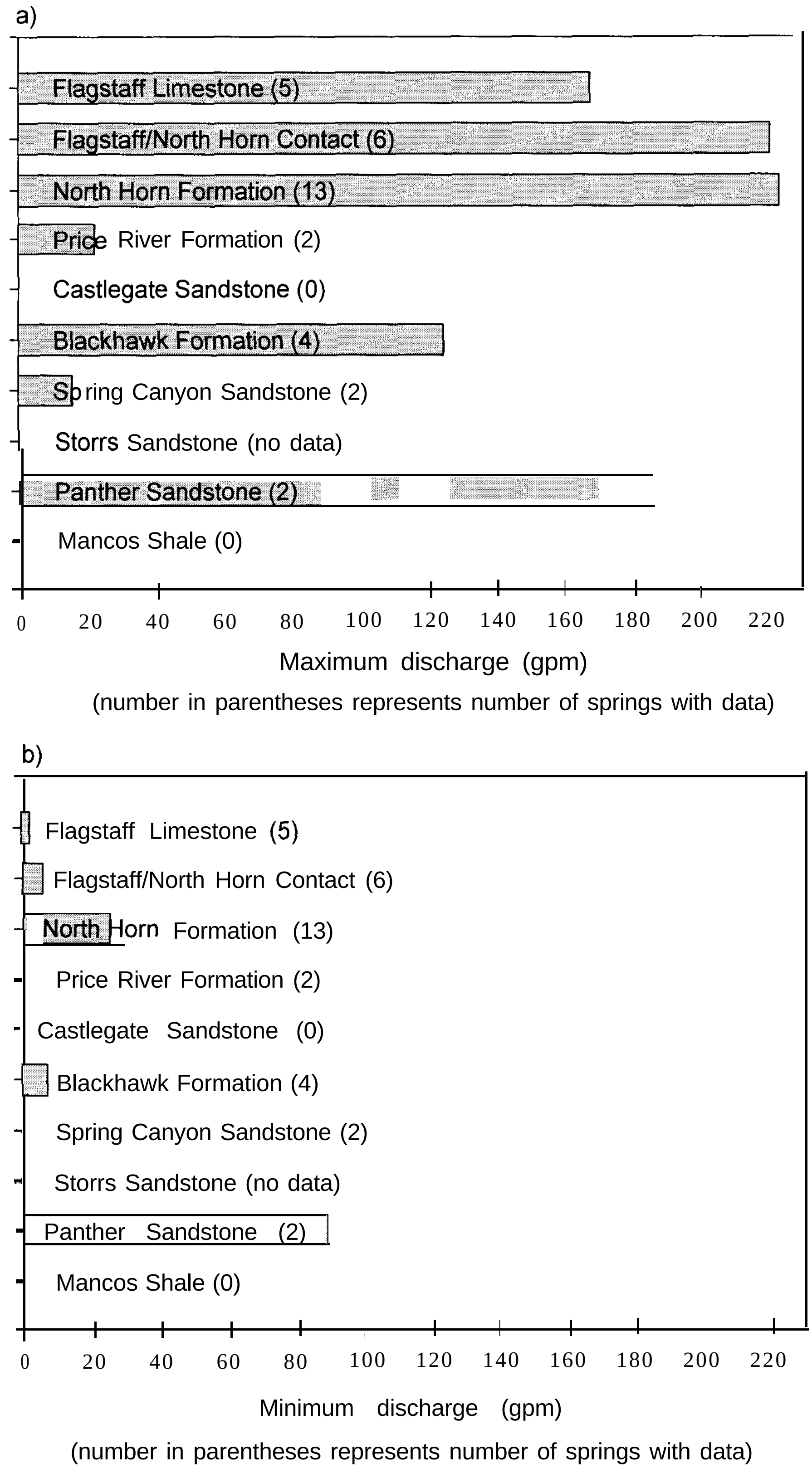

Figure 6 Plot of combined discharge rates from each formation.

Table 1 Monitoring site details

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Site	Description	State Plane		Geology	Period of Record		Flow measurements (gpm)		
		Easting	Nor-thing		First	Last	n	Min	Max
Creeks									
BC-1	Upper Bear Creek	2115162	394356		2128191	10129197	20	15	320
BC-2	Lower Bear Creek	2112715	389315		5128191	8127197	23	28	460
CK-1	Cedar Creek Weir	2140253	402830		619194	10/21/97	8	320	1104
CK-2	Cedar Creek Upper	2129061	404930		619194	10120197	8	4	950
FBC-10	Trail Creek Above Ledges	2108275	401962		7130191	6124197	1	9	9
FBC-14	Tie Fork Creek	2102091	409469		818191	6128195	1	120	120
FC-1	Fish Creek Left Fork	2125681	388684		6/9/94	10128197	8	15	483
FC-2	Fish Creek Right Fork	2126563	388779		7131191	10128197	9	15	316
FC-3	Fish Creek Left Fork	2125217	390140		7131191	10130194	7	2.5	300
LT-1	Lower Trail Creek	2108332	394416		5128191	10129197	15	9	210
MH-1	McCadden Hollow Drainage	2109399	401829		7131191	6116194	5	0.7	120
UT-l	Upper Trail Creek	2108157	398288		5126193	10129197	5	18	200
Springs									
16-7-1-6	Gentry Hollow Spring	2116599	413321	Tf	618194	7119198	8	2	35
16-8-l 8-4	Wild Horse Spring	2121547	399249	Tf	618194	10120197	6	0.5	5
16-8-l 8-5	Chris Otteson Trail Spring	2124585	401545	Tf	618194	10120197	7	8	50
16-8-7-3	Gentry Mountain Spring	2121111	405450	Tf	618194	6125197	4	0	8
SBC-19	Head Fish Creek	2123490	398746	Tf	7130191	10131194	8	0.5	70
16-8-20-l	Long Point Spring	2128889	397992	Tf-TKnh	618194	7119196	3	1	4
FBC-12	Head of Bear Creek	2116397	401431	Tf-TKnh	6129193	10130194	6	21	100
SBC-12	Bear Canyon Fault Spring	2115921	401609	Tf-TKnh	618194	10115197	13	3	15
SBC-15	Bear Canyon, Right Fork, Left Fork	2119318	396425	Tf-TKnh	7/3 1191	10130194	8	0	17
SBC-16	Fish Creek Left Fork Spring-West Side	2121126	396493	Tf-TKnh	7130191	10131194	8	0	65
SBC-18	Fish Creek Left Fork Spring-East Side	2124020	397851	Tf-TKnh	7131191	8/30/94	7	0.2	20
16-7-l 2-6	McCadden Hollow Spring	2114912	406667	TKnh	618194	7119198	8	1	12
16-8-5-l	Bald Ridge Spring	2126524	412731	TKnh	618194	10120197	7	2	12
16-8-6-l	Cedar Creek Left Fork Spring	2121255	411317	TKnh	6/8/94	10120197	7	5	25
FBC-2	McCadden Hollow Spring	2111346	401757	TKnh	811191	811191	1	12	12
FBC-6A	McCadden Hollow Lefl Fork Springs-East Slope	2110258	403439	TKnh	10113192	10126193	2	1.1	2
FBC-6B	McCadden Hollow Left Fork Springs-East Slope	2111509	404916	TKnh	10113192	10131194	6	1.5	25
FBC-7	Trail Canyon Trough	2109565	408045	TKnh	7/30/91	10/31/94	7	0.7	27
FBC-8	Upper Trail Canyon Spring	2109108	403612	TKnh	8/7/91	817191	1	5	5

Site	Description	State Plane Easting	State Plane Northing	Geology	Period of Record First	Period of Record Last	Flow measurements (gpm) n	Min	Max
SMH-1	McCadden Hollow Lefl Fork Springs (7)	2111336	404597	TKnh	812191	10131194	7	8	32
SMH-2	McCadden Hollow Left Fork Trough	2111681	405780	TKnh	812191	10/31/94	8	0.6	12
SMH3	McCadden/Trail Ridge Spring	2110457	404690	TKnh	8129193	6128195	6	21	60
SMH-4	McCadden Hollow Spring	2114668	406478	TKnh	811191	10/31/94	8	0.2	8.7
WHR-9	Wild Horse Ridge Trough	2120439	390277	TKnh	8/8/91	818191	1	4	4
FBC3	McCadden Hollow Spring	2109945	401539	Kpr	811191	811191	1	1.5	1.5
FBC-9	Upper Trail Canyon Spring	2108246	402937	Kpr	8/7/91	6/21/93	2	1	22.4
16-7-24-3	Bear Canyon	2115633	395759	Kbh	3117199	3117199	0		
16-8-8-5	Mohrland Spring Development	2128732	404953	Kbh	618194	10120197	8	0.25	17
cs-1	Trail Canyon Culinary Spring (AML)	2107839	395363	Kbh	5/28/91	10129197	14	5	28
FBC-11	Huntington Canyon Spring	2105751	405161	Kbh	818191	8/8/91	1	15	15
PS-1	Portal Spring (AML)	2108636	397455	Kbh	516193	10130196	4	2.5	11
SBC-17	Bear Canyon	2115472	397171	Kbh	3117199	3117199	0		
TS-1	Trail Creek Spring	2108104	395916	Kbh	5128191	10/29/97	13	2.3	65
WHR-7	Fish Creek Left Fork Spring-West Side	2121913	392269	Kbh	7130191	7/30/91	1	40	40
WHR-8	Wild Horse Ridge Spring	2122461	389485	Kbh	7131191	7131191	1	5	5
Birch #1 Source	Exposed spring box			Ksp	1 0/29/98	10129198	0		
Birch #2 Source	Exposed spring box			Ksp	10129198	10129198	0		
BP-l	Lower Pad Spring	2108332	394932	Ksp	5128191	5123195	9	0	0.75
Defa #1	Behind Defa home, Bear Canyon	2113249	390215	Ksp	116199	1/6/99	1	7	7
Defa #2	Behind Defa home, Bear Canyon	2113467	390045	Ksp	116199	116199	1	10.7	10.7
SBC-4	Big Bear Spring	2113032	389796	Ksp	2128191	10129197	37	73	150
SBC5	Birch Springs	2109765	390882	Ksp	311191	10129197	39	16	36
SBC-5 Overflow	Birch sources #3, #4, and #5			Ksp	10129198	10129198	0		
SBC-14	Bear Canyon, Right Fork, Right Fork	2117428	393332	Ksp	10126193	6124197	8	0.5	15

Bear Canyon Mine Inflows

Site	Description	State Plane Easting	State Plane Northing	Geology	Period of Record First	Period of Record Last	Flow measurements (gpm) n	Min	Max
SBC-9 Source		2113200	400000	Kbh	5115196	1/6/99	0		
3rd West South		2111100	397600	Kbh	5115196	11113196	0		
3rd West Bleeder		2111700	398400	Kbh	5115196	11113196	0		
T.S. North Bleeder		2114000	399000	Kbh	5126198	5126198	0		
SBC-13	1 st East Gob	2111861	395195	Kbh	2/7/95	8126197	6	0.8	35
SBC-9	1 st North Mine Sump	2113328	399768	Kbh	2128191	10/29/97	28	81	178
SBC-1 0	2nd East Sump	2113840	399104	Kbh	1131192	518195	16	21	250

Site	Description	State Plane Easting	State Plane Nor-thing	Geology	Period of Record First	Period of Record Last	Flow measurements (gpm) n	Min	Max
Mine Discharge Points									
16-8-8-l 0	Mohrland Mine Discharge	2130331	404390		6/8/94	10120197	8	176	755
NPDES-004	Bear Canyon Mine Discharge	2115026	391679		5115196	5115196	0		
Wells									
SBC3	Right Fork Creek Well	2115283	392114	Qa	2/28/91	10129197	0		
SDH2	Bear Canyon Ridge Monitor Well	2113096	407363	Ksp	6130198	6130198	0		
SDH3	Bear Canyon Ridge Monitor Well	2107951	406117	Ksp	6130198	6130198	0		
SDH-1	Bear Canyon Ridge Monitor Well	2113517	401056	Ksp	8/29/94	8129194	0		
BS-6	Near Big Bear Spring	2113012	389647	Ksp	2125185	115187	0		
DH-3	1st East Monitoring Well (Abandoned)	2113243	394515	Ksp	2119193	10/21/93	0		
DH-IA	2nd West Monitor Well	2112761	395059	Ksp	2118193	10130197	0		
DH-4	3rd West Bleeder Monitor Well	2111968	399297	Ksp	2115194	10130197	0		
DH-2	3rd West Monitor Well	2112519	397776	Ksp	2122193	10129197	0		
MW-114	North Wild Horse Ridge Monitor Well	2121081	398445	Ksp	8122196	10/23/97	0		
MW-116	North Wild Horse Ridge Monitor Well	2122512	401971	Ksp	10118195	10123197	0		
MW-117	North Wild Horse Ridge Monitor Well	2117424	403991	Ksp	10118195	10123197	0		

KEY TO GEOLOGIC ABBREVIATIONS:

Qa = Alluvium
Tf = Flagstaff Limestone
TKnh = North Horn Formation
Kpr = Price River Formation
Kbh = Blackhawk Formation
Ksp = Star Point Sandstone

Individual geologic formations respond differently to seasonal precipitation and climatic variability. Spring response values ("R-values") are presented for each geologic formation in Table 2. The "Max Q" column represents the sum of the maximum recorded discharges (in gpm) for all of the identified springs in the formation. The "Min Q" column represents the sum of the lowest recorded flows (in gpm) for all of the identified springs in the formation. The R-value represents the ratio, expressed as a percentage, of measured minimum discharge to maximum peak discharge for each formation. The larger the R-value, the more constant the discharge from the formation. Very low R-values are indicative of groundwater systems in which discharge declines greatly during the late summer and fall months or during droughts.

Table 2 Maximum and minimum discharge rates for each formation

	N	Max Q	Min Q	R-Value
Flagstaff Limestone	5	168	2.5	1.5%
Flagstaff Limestone/North Horn Formation	6	221	6.0	2.7%
North Horn Formation	13	224	29	12.9%
Price River Formation	2	22	0	0.0%
Castlegate Sandstone	0	0	0	---
Blackhawk Formation	4	125	7.55	6.0%
Spring Canyon Sandstone	2	15.75	0.5	3.2%
Storrs Sandstone	1	---	---	---
Panther Sandstone	2	186	89	47.8%
Mancos Shale	0	0	0	---

A discussion of groundwater discharge characteristics from each of the water-bearing geologic formations in the study area is presented below. Spring discharge hydrographs for representative springs in each geologic formation are presented in Figure 7.

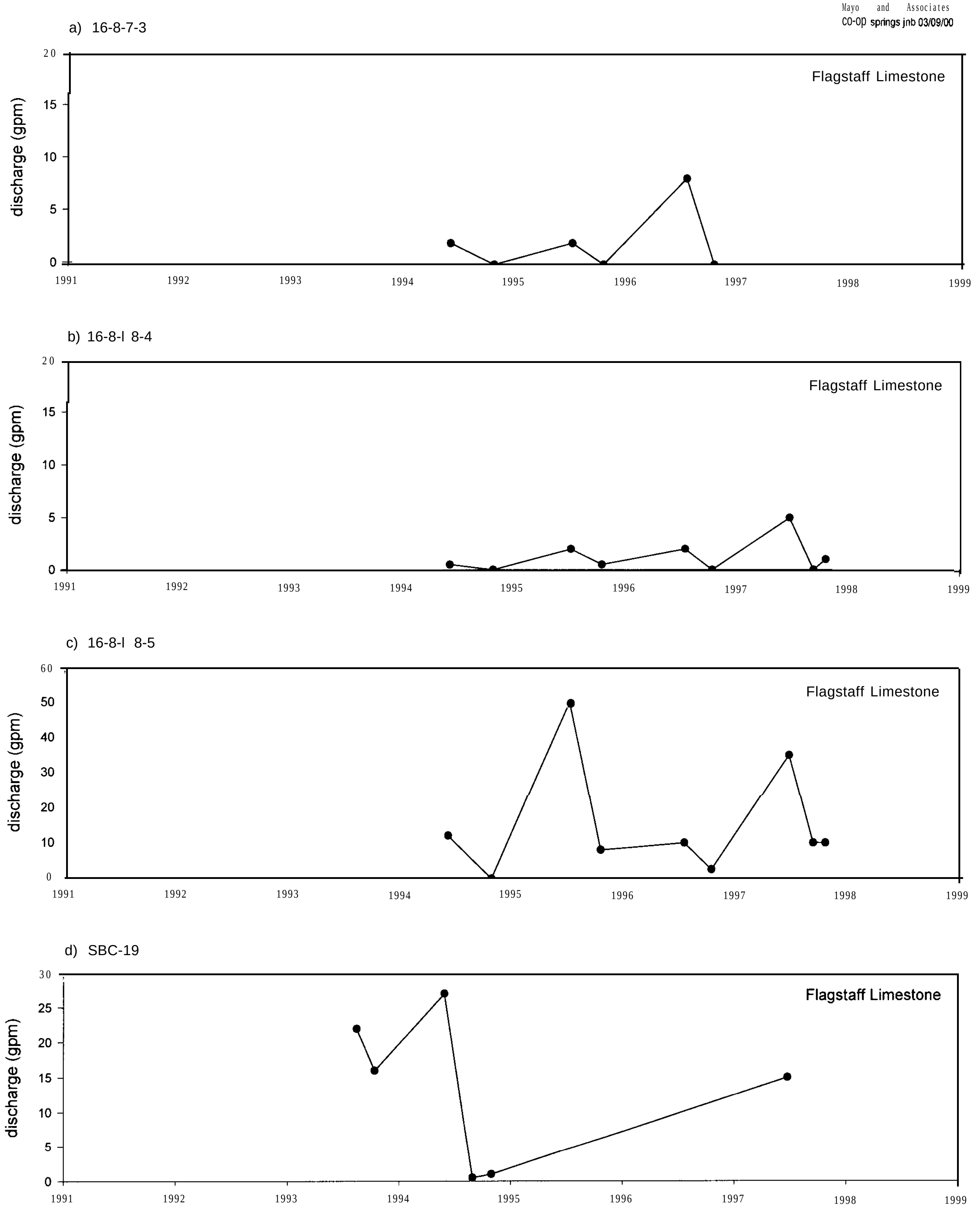

Figure 7 Spring hydrographs.

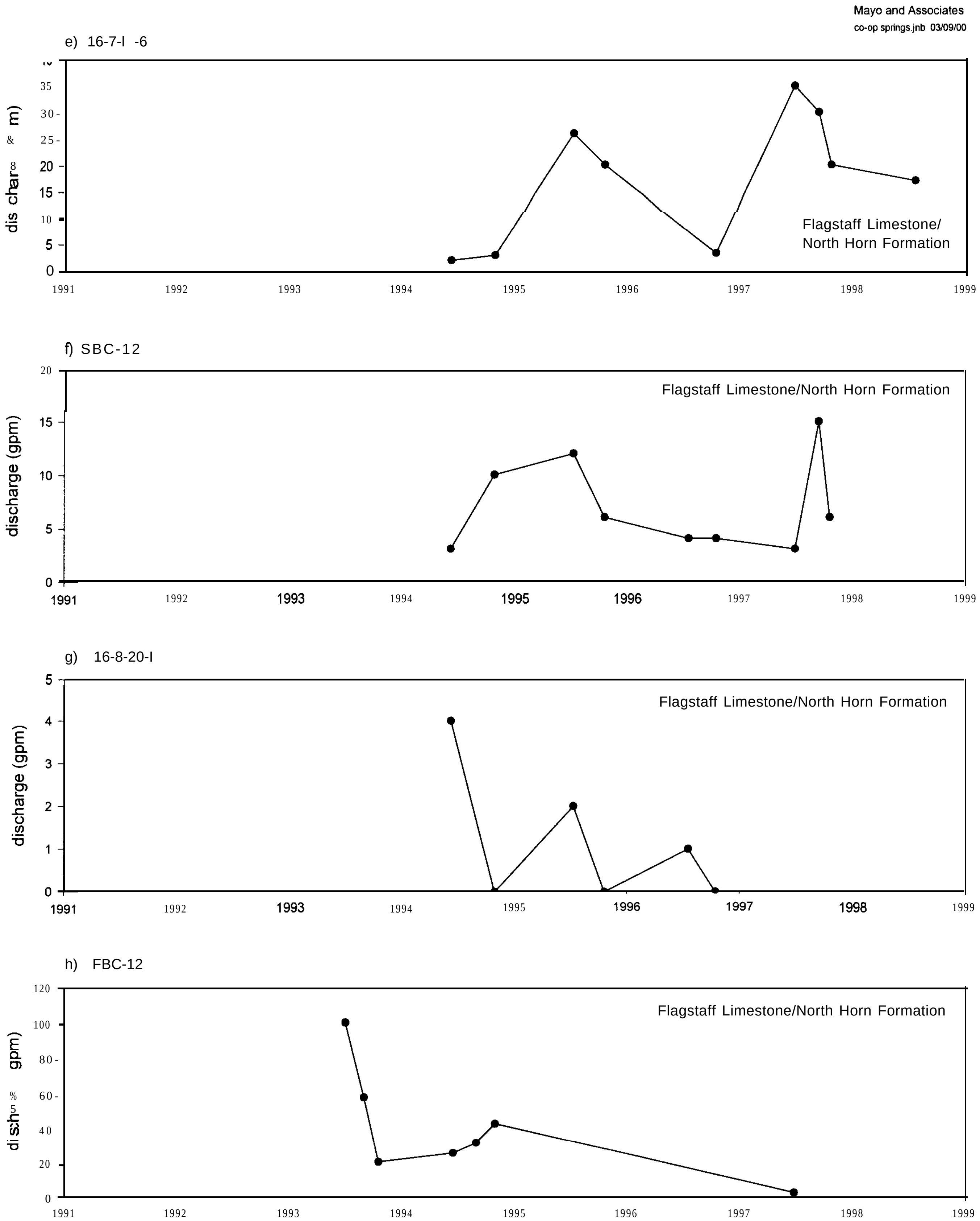

Figure 7 Spring hydrographs (continued).

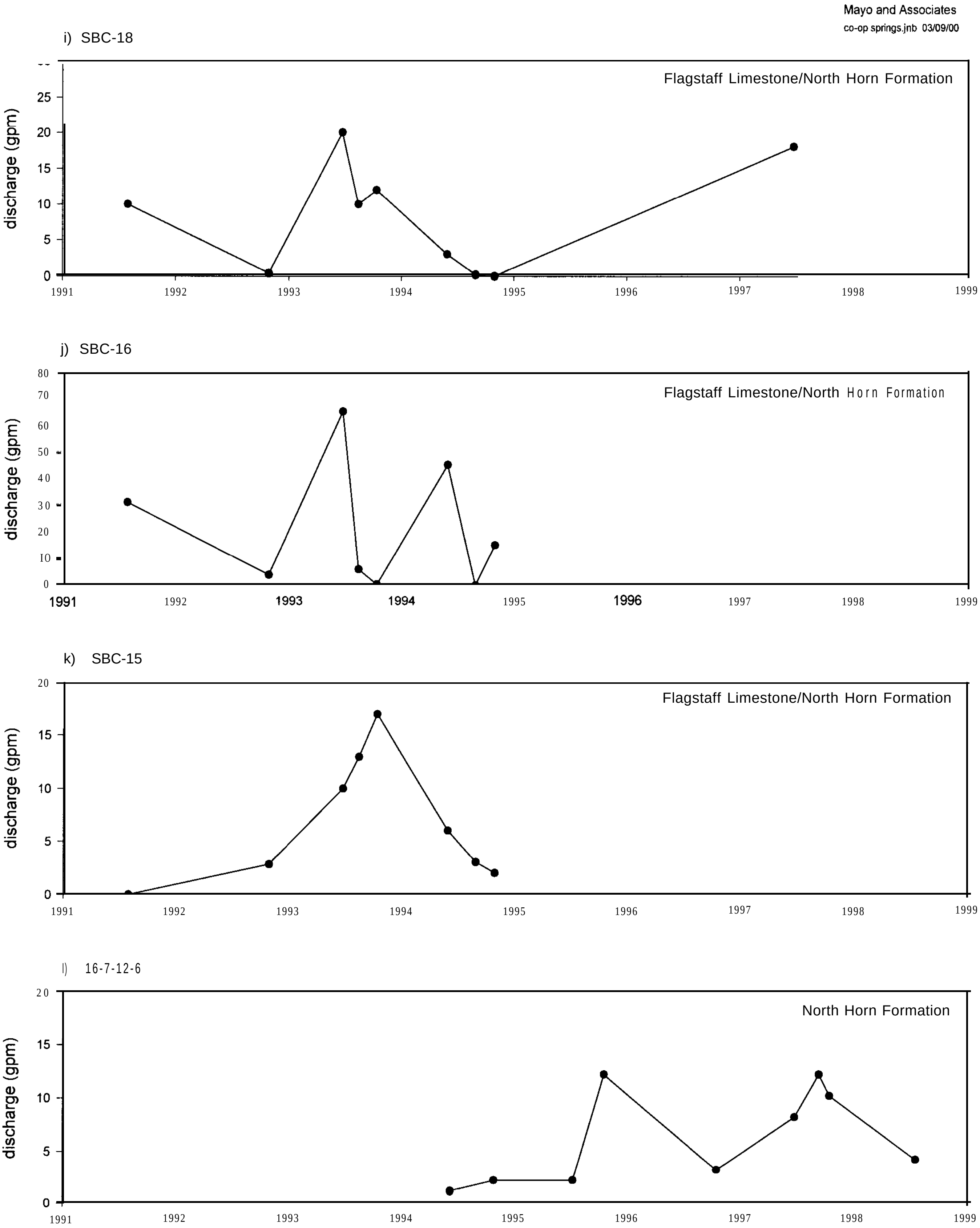

Figure 7 Spring hydrographs (continued).

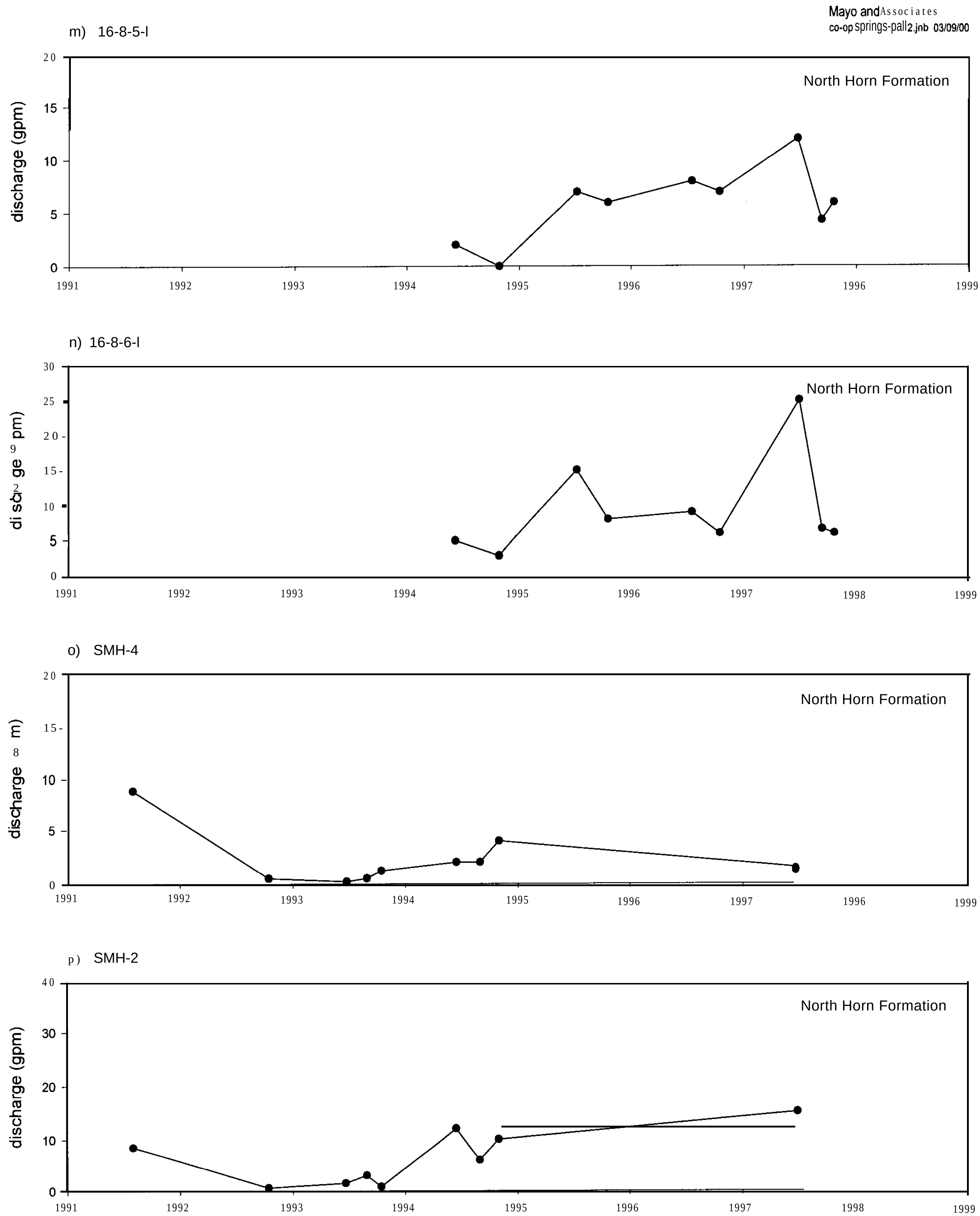

Figure 7 Spring hydrographs (continued).

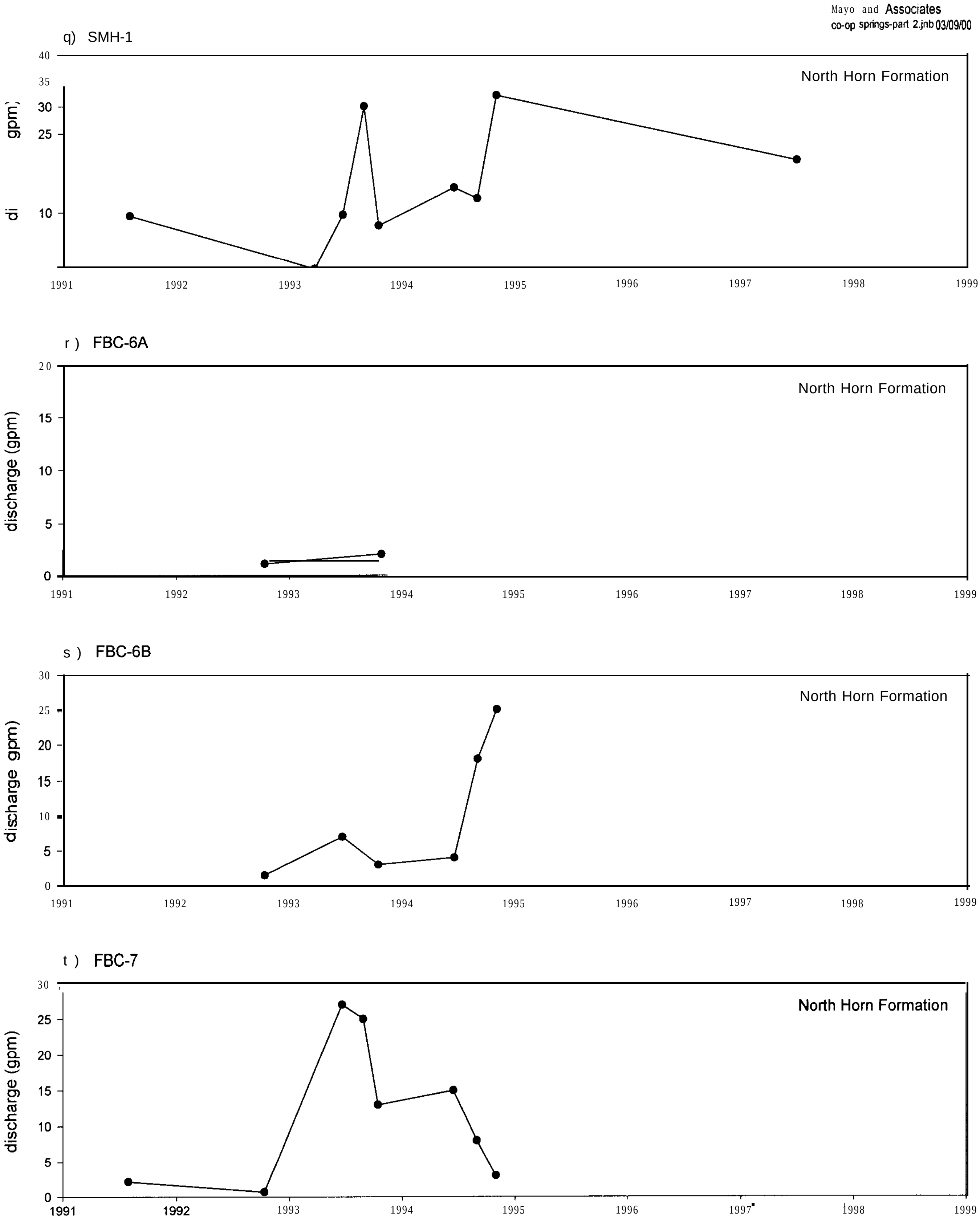

Figure 7 Spring hydrographs (continued).

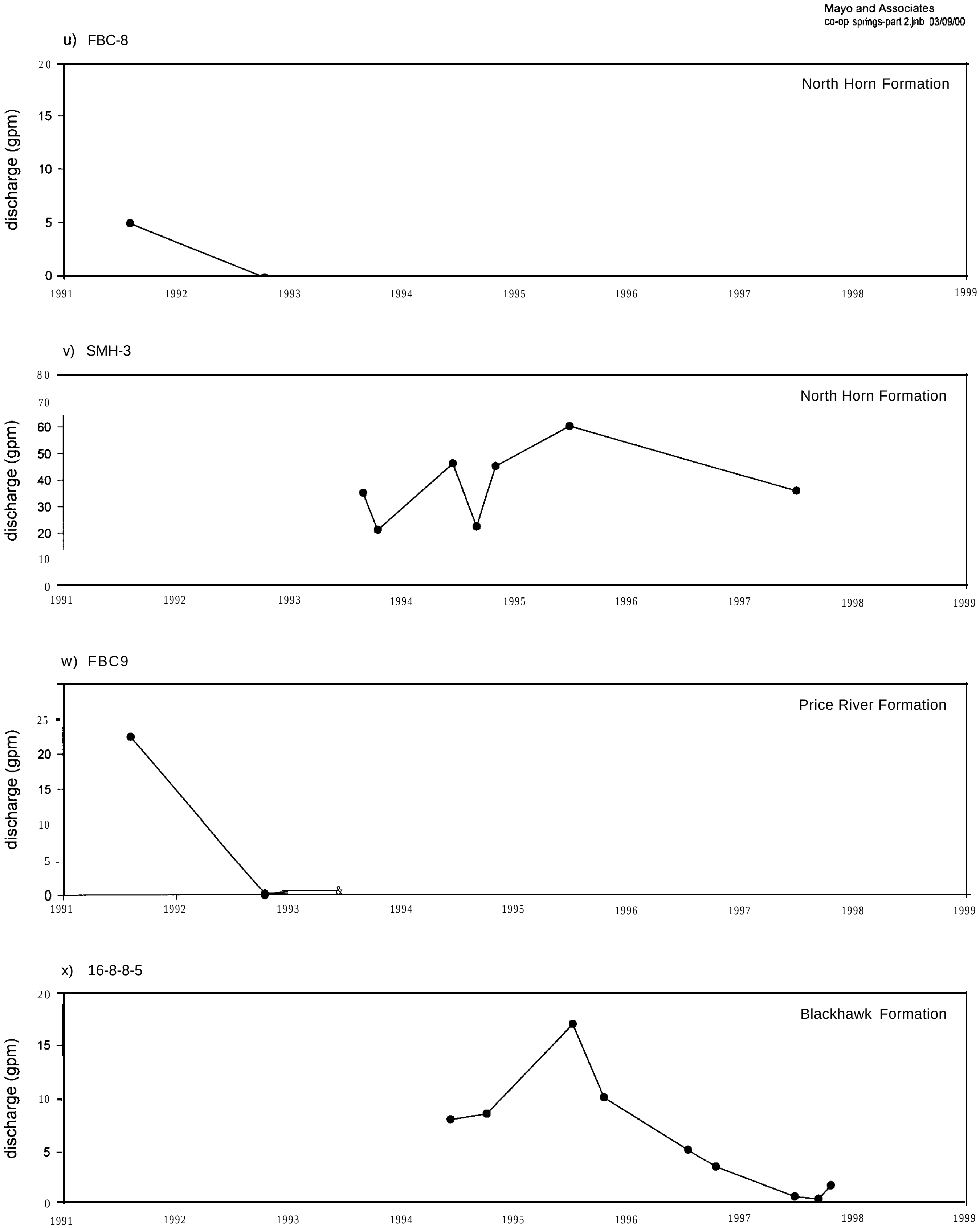

Figure 7 Spring hydrographs (continued).

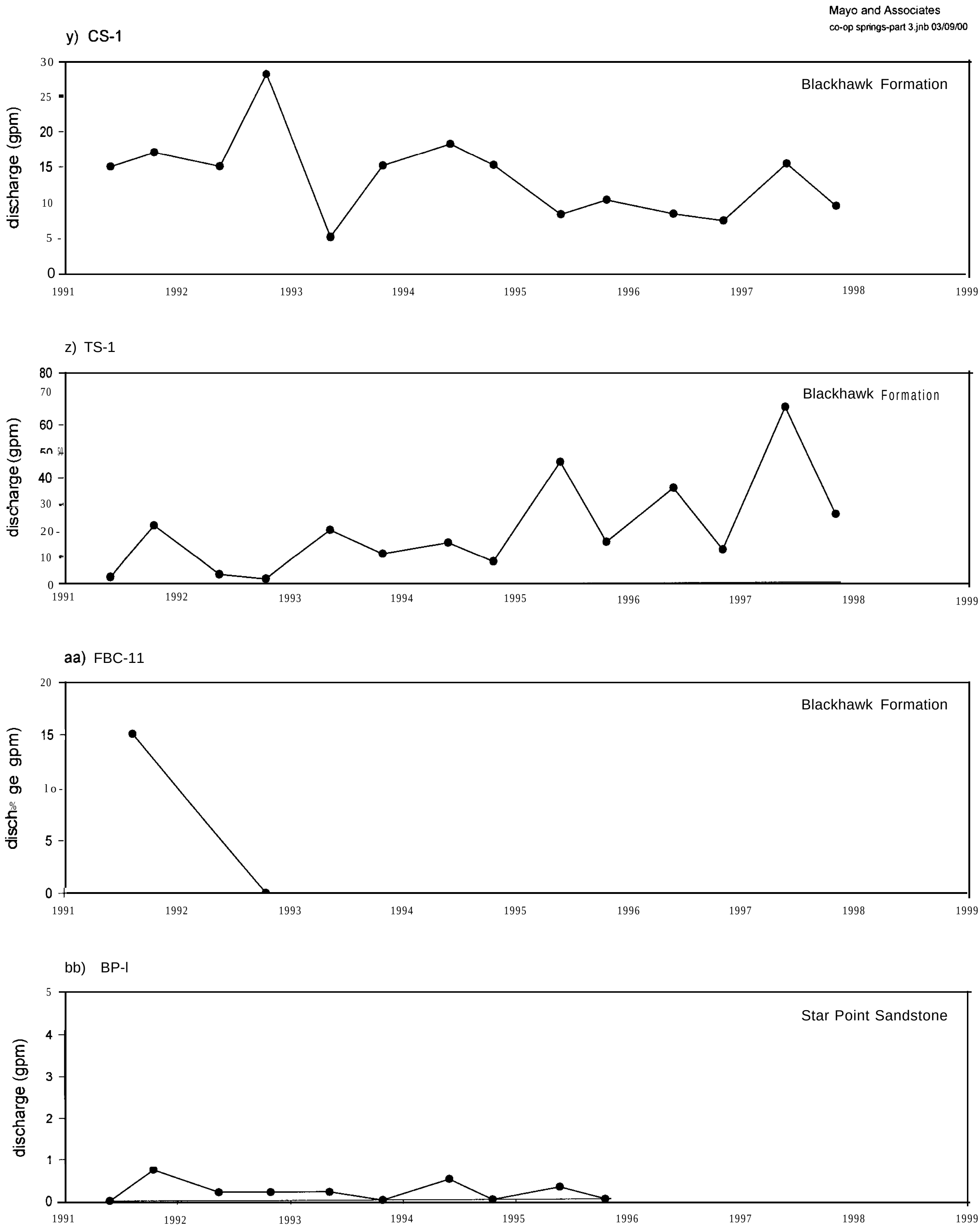

Figure 7 Spring hydrographs (continued).

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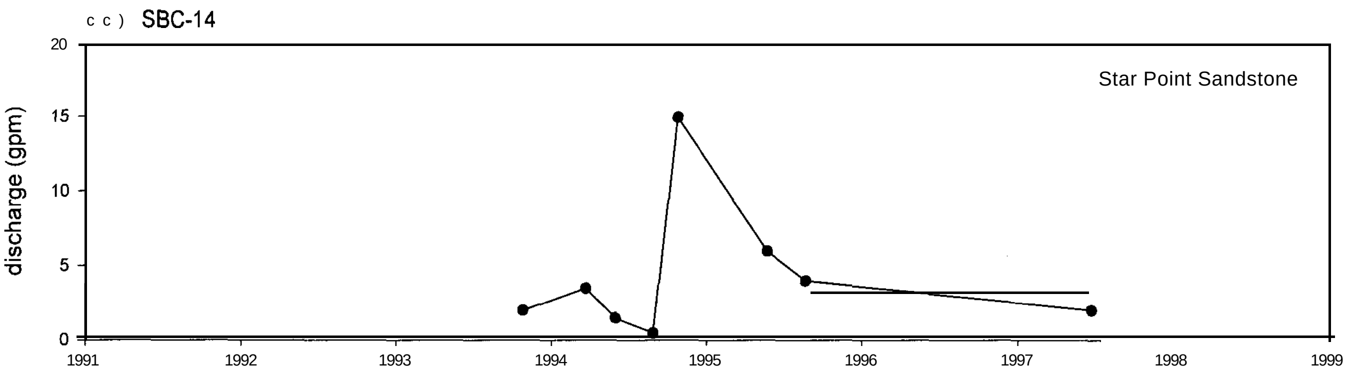

Figure 7 Spring hydrographs (continued).

4.1.1 Flagstaff Limestone Springs

The distribution of Flagstaff Limestone springs is limited to the highest elevation areas on Gentry Mountain. Hydrographs are available for four springs that discharge from the Flagstaff Limestone in the study area (Figures 7a through 7d). These springs include 16-8-7-3, 16-8-18-4, 16-8-18-5, and SBC-19. Each of these springs displays large variations in discharge rates from the high-flow season during the annual snowmelt event to the low-flow season in the late summer and fall months. The R-value for Flagstaff Limestone springs (1.5%) is among the smallest calculated for any of the geologic formations (Table 2), indicating that these springs have the greatest dependence on seasonal recharge. Each of the Flagstaff springs has been observed to be dry on occasions. Commonly, maximum spring discharge rates are measured during the first sampling event of the year when the spring sites are first accessible after the melting of winter snows. When the Flagstaff Limestone springs are revisited during subsequent monitoring events during the year, the springs are commonly dry (e.g. springs 16-8-7-3 and 16-8-18-4). Exceptions to this condition occasionally occur during extended wet spells. This type of spring response indicates that the storage capacity of the limestone rock is low and/or the groundwater flow velocities are high. Groundwater travel times (from recharge location to discharge location) are less than one year. This condition occurs because groundwater flow in limestone rock occurs primarily within fractures, where groundwater can flow rapidly under conduit flow conditions. Groundwater storage does not occur in the bulk (pore spaces) of the rock as commonly occurs in clastic rocks. Rather, storage is limited to the volume of interconnected fractures within the rock. Because groundwater flow velocities are high and the storage volumes are small, the formation drains rapidly after the recharge (seasonal snowmelt) ends. In the future, it will likely be common for these springs to be completely dry during periods of prolonged drought.

4.1.2 Flagstaff Limestone/North Horn Formation Transition Springs

Seven springs discharging near the contact with the Flagstaff Limestone and the North Horn Formation have been routinely monitored for flow in the study area. These springs include 16-7-1-6, SBC-12, 16-8-20-1, FBC-12, SBC-18, SBC-16, and SBC-15. All of the discharge hydrographs (Figures 7e through 7k) for these springs display large seasonal fluctuations in discharge, with an R-value of 2.7% (Table 2). Five of the seven Flagstaff/North Horn springs display large variability in seasonal discharge rates but have more gradual yearly discharge declines. The delayed release of the annual recharge is attributable to the presence of clastic rocks (primarily sandstone channels) near the surface and colluvium at the surface. These materials allow storage of water in the springtime (during the snowmelt event) and a more gradual release of the water as these sediments are slowly drained. Each of these springs has occasionally been dry, or discharged at less than about 10% of their peak discharge rates, during low-flow conditions and in dry years. This suggests that the groundwater systems that support these springs are generally small in size (i.e., the amount of groundwater in storage is generally less than one year's discharge).

Two of the Flagstaff/North Horn springs (16-8-20- 1 and SBC- 16) exhibit discharge characteristics similar to those of the Flagstaff Limestone springs discussed above. It is likely that these springs do not have much communication with the more porous rocks and colluvium of the upper North Horn Formation.

4.1.3 North Horn Formation Springs

Discharge hydrographs (Figures 71 through 7v) are available for 11 springs that discharge from the North Horn Formation in the study area. These springs include 16-7-12-6, 16-8-5-1, 16-8-6-1, SMH-4, SMH-2, SMH-1, FBC-6A, FBC-6B, FBC-7, FBC-8, and SMH-3. All of these springs show large seasonal variations in discharge rate, with all but two of the North Horn Formation springs having a maximum flow at least 10 times the minimum measured flow. Maximum discharge rates are typically measured during June or July shortly after the peak of the annual snowmelt event. However, only three of the North Horn Formation springs have ever been observed to be completely dry. Most of the North Horn Formation springs monitored in the area appear to have a baseflow component that is less than l-2 gpm. This information suggests that 1) North Horn Formation springs are principally recharged by the annual snowmelt event, 2) groundwater storage volumes are small relative to the ability of the formation to transmit water, 3) widely scattered sandstone channels and colluvium of the North Horn Formation facilitate some storage and delayed release of recharge water throughout much of the year, and 4) North Horn Formation groundwater systems are not part of a regional groundwater system.

Because of the small storage capacities of North Horn Formation groundwater systems, springs discharging from the North Horn Formation are very sensitive to changes in climate. There is generally good correlation between spring discharge hydrographs and the plot of the PHDI (Figure 3) for the region. During periods of extended drought, the discharge rates of most springs discharging from the North Horn are expected to decline dramatically. Many springs may cease flowing entirely after the colluvial material and sandstone rocks that support the springs have completely drained.

4.1.4 Price River Formation Springs

A discharge hydrograph (Figure 7w) is available for only one spring (FBC-9) in the Price River Formation in the study area. This spring, and one other spring for which discharge data are not available (FBC-3), are located in the Trail Canyon drainage. On a single occasion in August 1991, a large discharge (greater than 20 gpm) was measured at FBC-9. However, on all six subsequent monitoring events the spring was dry or discharged only about 1 gpm. The great variability in the discharge rate at this spring suggests that the groundwater system which supports this spring is small, and that the storage capacity of this system is small relative to the rate at which groundwater can discharge from the system. Thus, this groundwater system is not part of a large regional system.

Generally, the lack of springs in the Price River Formation suggests a lack of hydraulic communication between higher elevation groundwater recharge areas on the Flagstaff Limestone and North Horn Formation and the rocks of the Price River Formation.

4.1.5 Blackhawk Formation springs

Groundwater discharge from the Blackhawk Formation (excluding water encountered in the mine) is limited to outcrop areas in the southern half of the study area. Spring discharge hydrographs (Figures 7x through 7aa) are available for four springs that discharge from the lower Blackhawk Formation in the study area. These include springs 16-s-8-5, CS- 1, TS- 1, and FBC-11. Each of these springs shows large seasonal fluctuations in discharge rates, with the maximum discharge commonly exceeding the minimum discharge by several times.

The R-value (6.0%) of groundwater discharge from the Blackhawk Formation indicates that the baseflow component of springs in the Blackhawk Formation is small relative to high-flow discharge rates. The fact that there is a 94% decrease between the maximum and minimum discharges suggests that the Blackhawk Formation groundwater systems from which the springs discharge are generally small, local groundwater systems that are highly dependent on seasonal recharge. This suggests that the Blackhawk Formation groundwater discharging along the southeastern margins of the study area has not migrated deep beneath the highlands of Gentry Mountain. Rather, these groundwater systems are likely shallowly-circulating systems with both recharge areas and discharge areas occurring in the southeast portion of the study area.

4.1.6 Star Point Sandstone Springs

Relatively few springs issue from the Star Point Sandstone in the study area. Four Star Point Sandstone springs have been monitored by C.W. Mining. These include BP-l and SBC-14, which issue from the Spring Canyon Sandstone, and Big Bear Spring (SBC-4) and Birch Spring (SBC-5) which issue from the Panther Sandstone. Two other Star Point Sandstone springs, Defa #1 and Defa #2, have also been identified in lower Bear Canyon. These springs discharge from the Storrs and Panther sandstones, respectively. The discharge hydrographs for BP-l and SBC-14 are shown in Figures 7bb and 7cc. The discharge hydrograph of Big Bear Spring is shown in Figure 8 and the hydrograph of Birch Spring is shown in Figure 9.

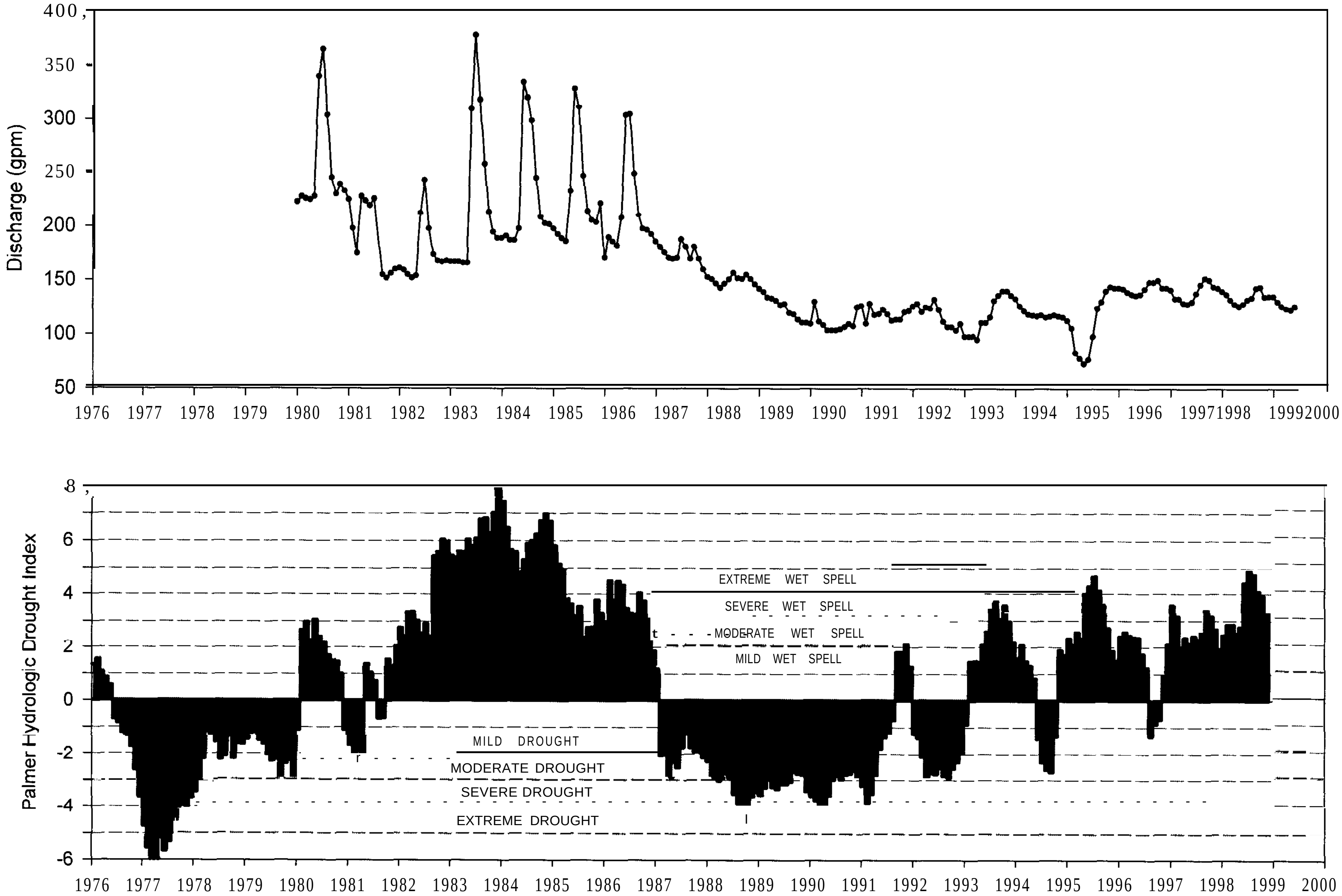

Figure 8 Discharge hydrograph for Big Bear Spring and Palmer Hydrologic Drought Index for Utah Region 5.

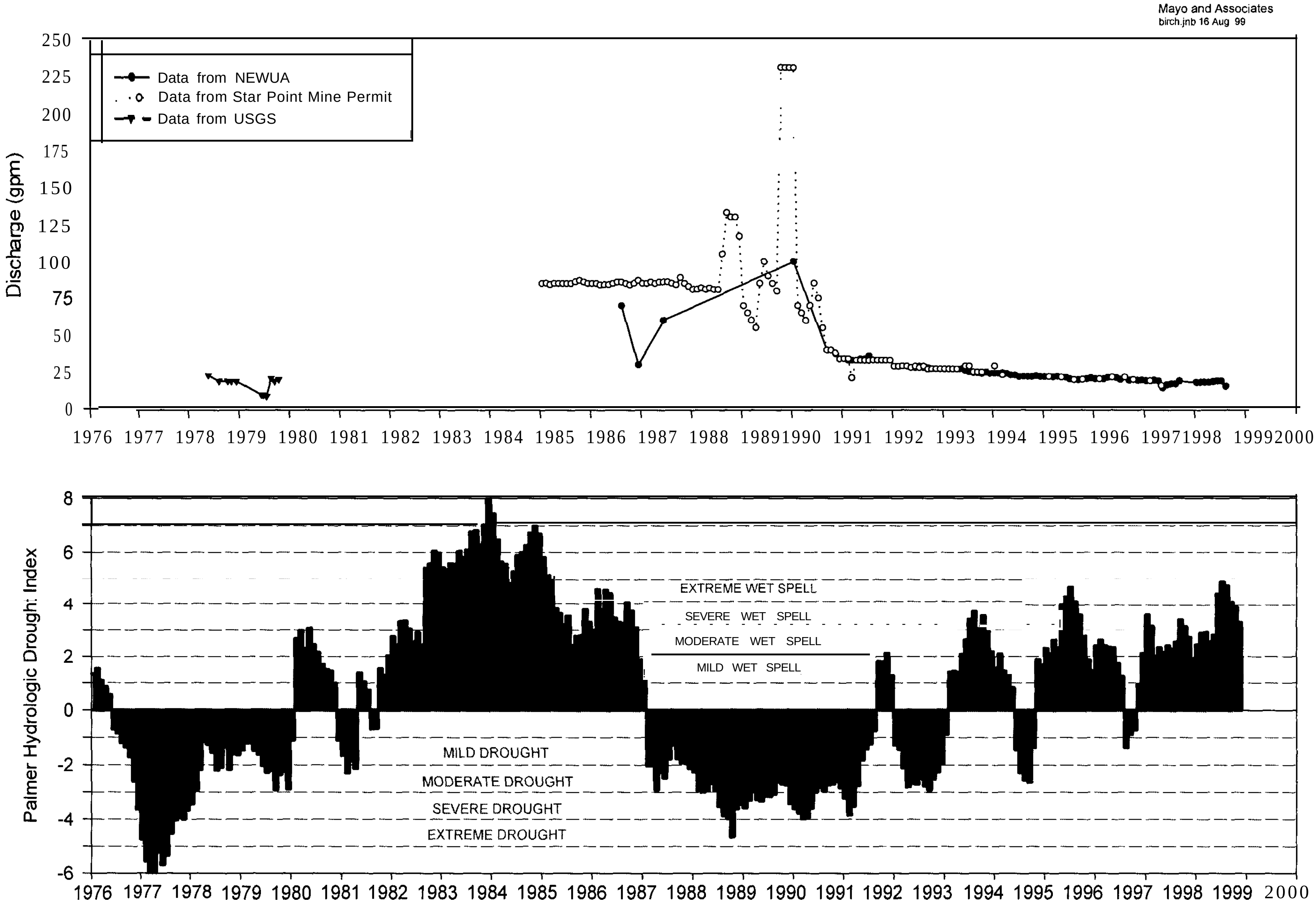

Figure 9 Discharge hydrograph for Birch Spring and Palmer Hydrologic Drought Index for Utah Region 5.

In the vicinity of the Bear Canyon Mine, and throughout the Wasatch Plateau, groundwater discharge from the Star Point Sandstone generally occurs from faults and fractures. Significant groundwater discharge from diffuse flow from the Star Point Sandstone is rare. This is because the relatively low primary porosity of the sandstone rock is generally many orders of magnitude less than the secondary porosity associated with the fracture systems. Where diffuse discharge from the sandstone does occur, these discharges are commonly limited to small seeps.

Spring BP- 1 from the Spring Canyon Sandstone discharges small quantities of groundwater (less than 1 gpm) and has seasonal variations in discharge, suggesting that it is related to a local groundwater system. Spring SBC-14 also discharges from the Spring Canyon Sandstone. The discharge from this spring varies from 0.5 to 15 gpm, suggesting that it is highly influenced by seasonal precipitation and is not derived from deeper, bedrock-derived groundwater sources.

Groundwater discharge from the Panther Sandstone is anomalous in that it is not as influenced by seasonal groundwater recharge events or by climatic variations to the extent that discharge from each of the other geologic units is. The R-value for the Panther Sandstone (47.8%) indicates that nearly half of the high-flow maximum discharge may persist throughout the year.

Big Bear Spring and Birch Spring are of particular significance in this investigation because they are important culinary water supplies to adjacent municipalities. The discharge characteristics of these two springs are discussed below.

Big Bear Spring (SBC-4)

Big Bear Spring discharges from a set of fractures near the base of the Panther Sandstone. Maximum historic flows at Big Bear Spring have exceeded 350 gpm while a baseflow of approximately 100 gpm has persisted even during periods of prolonged drought.

Discharge data are collected by the Castle Valley Special Service District. The district's data (Personal Communication, Darrel Leamaster, 1998, 1999) are plotted on Figure 8 and are tabulated in Appendix A. The hydrograph of Big Bear Spring (Figure 8) shows prominent seasonal discharge peaks from 1980 through 1986. Figure 8 also shows a graph of the PHDI for Utah Region 5. The first large peak indicated by the data occurred in 1980, the first wet year, following a severe regional drought during the late 1970s. Large discharge peaks were measured in each year from 1983 through 1986. These peaks correspond to an intense wet period that the region experienced during that time. That large seasonal discharge peaks are seen in the data intimate that these peak discharges are likely supported by a local groundwater system (i.e. a system with a short flow path from recharge area to discharge area and a small storage volume).

Peak discharges ended and a gradual diminution in flow began about 1987. These events correlate with the onset of a major regional drought in the late 1980s (Figure 8). The gradual flow recession continued until about 1990 when the spring discharge rate somewhat stabilized between 100 and 120 gpm. This approximate baseflow rate persisted throughout the remainder of the drought period (1990-l 993) and beyond. That such a large and fairly stable baseflow component was sustained through the drought periods suggests that a more extensive (longer flow path) and/or more buffered (larger storage) groundwater system supports the baseflow component than supports the seasonal peaks.

The region began to experience a moderate wet cycle starting in 1993 and continuing to the present. Despite the wetter climatic cycle, the large seasonal peak discharges that previously occurred have not been observed at Big Bear Spring. However, starting in about 1993, much smaller seasonal peaks in discharge began to occur. These peaks are somewhat muted (i.e., the peaks on the discharge hydrograph are not as sharp or as high) relative to those occurring before 1986. Additionally, whereas the seasonal peaks in discharge rate at Big Bear Spring before 1986 commonly occurred in June or early July, the yearly peaks after 1993 have occurred in the fall months (September to November). The relationship between the small seasonal peaks now observed and the large seasonal peaks observed previously is uncertain.

It seems unlikely that the recent lack of seasonal discharge peaks from Big Bear Spring is a delayed response to drought conditions. As indicated on Figure 8, a large discharge peak occurred during the first wet year (1980) following the drought of the late 1970s, indicating that peak discharges should have returned during the first wet year following the drought of the late 1980s. The likely explanation for the lack of large seasonal peaks is that the water that once supported the sharp yearly peaks has been diverted to another location because of some physical change at some point in the groundwater system. This change could have been caused by a number of factors including natural changes, catastrophic events (such as the earthquake that occurred on 14 August 1988), or mining-related activities. A more detailed examination of the cause of the loss of large seasonal peak discharges is presented in Section 8.1, following the presentation of solute and isotopic data in subsequent sections.

Birch Spring (SBC-5)

Birch Spring discharges from a fracture zone near the base of the Panther Sandstone in lower Huntington Canyon. Discrete discharge occurs from several individual fractures and diffuse discharge occurs along a sapping front at the base of the Panther Sandstone. Spring boxes have been constructed around the water-bearing fractures and a french-drain-like system collects diffuse flow. Since the spring was first developed in the 1970s, it has been necessary on several occasions to excavate and rework the collection system due to decreasing flows resulting from plugging in the system (Informal Conference, 1997).

There are three sets of discharge data for Birch Spring. During 1978-79, the USGS (Danielson and others, 198 1) made measurements of spring discharge (labeled by the USGS as (D-16-6) 26BCA-S1). The Star Point Mine MRP (1996) reports spring discharge data for the period 1985 to 1997. It is reported (UDOGM, 1998) that these data were obtained by Star Point Mine personnel from an individual who worked for NEWUA but that these data are not available through NEWUA. The third set of data is that on file at NEWUA and was obtained by C.W. Mining. The USGS data may be incongruous with the latter data because of redevelopment of the spring in 1980 and 1984. The Star Point Mine and the NEWUA data do not agree between about 1986 and 1991. Because discharge data are irreconcilable and possibly incongruous, it is prudent to use caution when interpreting the discharge data from Birch Spring. Nevertheless, all three sets of data are plotted on Figure 9 and are tabulated in Appendix A. Also shown on Figure 9 is the PHDI for Utah Region 5.

The first available discharge measurements were made in 1978 and 1979, at the end of a major regional drought. The measurements made during 1978 showed little seasonal variation and ranged from 19-23 gpm. The discharge reported for June and July 1979 are about half (9-10 gpm) of the discharge observed in 1978. During August through October 1979, discharge (19-2 1 gpm) was comparable to that observed in 1978. Because there is consistency in all of the 1978 discharge measurements and the latter 1979 measurements, we suspect that the early 1979 data is questionable. This is important because if the early 1979 measurements are excluded, the data indicate a constant baseflow of about 20 gpm. Because this occurred during a drought cycle, this baseflow is likely being derived from an extensive groundwater system.

Discharge measurements are not reported in any data set between 1980 and 1985. The Star Point Mine MRP data begin in January 1985. Monthly measurements in the Star Point data are constant (81-89 gpm) between January 1985 and July 1988. This time period corresponds to the end of the wet cycle of the early to middle 1980s and the onset of the drought of the late 1980s. That these data show no fluctuations either due to season or an abrupt shift in climatic patterns is suggestive of baseflow discharge and lack of communication with nearby recharge areas. Three data points in the NEWUA data during this time show fluctuations between 30 and 70 gpm, suggesting a possible seasonal influence.

The Star Point Mine MRP data show an abrupt increase in the discharge rate of Birch Spring in August 1988. The timing of the abrupt increase in discharge correlates with the occurrence of a magnitude 5.3 earthquake that occurred in the San Rafael area on August 14, 1988 (Star Point MRP, 1996). Shortly following the earthquake, discharge measured in Birch Spring rose from 81 gpm to 133 gpm. By the beginning of 1989, discharge rates at Birch Spring had returned to near pre-earthquake levels. A similar discharge increase at this time is reported (Star Point MRP, 1996) for the free-flowing Tie Fork Wells located on Gentry Mountain immediately north of the study area. These wells are completed in a fracture zone in the Spring Canyon Sandstone. Thus, it seems likely that the fracture system from which Birch Spring discharges was impacted in some way by the 1988 earthquake.

The Star Point Mine MRP data indicate that following the abrupt peak associated with the 1988 earthquake, discharge rates at Birch Spring fluctuated significantly until late 1990 and included a four month period (October 1989-January 1990) when the reported discharge was 230 gpm. During this time the NEWUA data show a discharge of 100 gpm. Although there are no apparent explanations for the previous disagreements between the Star Point MRP and NEWUA data, this discrepancy may be a function of how the measurements were taken. Mr. Jack Stoyanoff of NEWUA explained at the Informal Conference (1997) that when this peak discharge occurred there was also groundwater discharge from the cliff areas above the spring and water flowing in the ephemeral stream near the spring. Stoyanoff noted that the flow in the stream was 120 gpm and the flow in the spring box had increased from 40 gpm to about 110 gpm. The sum of these flows is 230 gpm, the value reported in the Star Point Mine MRP data. This suggests that the discharge in the NEWUA data set (100 gpm) is likely the flow from the spring boxes only and that the Star Point MRP data may include both the discharge from the spring collection system and the cliff faces.

The cause of the large increase in discharge is not known and has been the subject of protracted scrutiny. That the increased discharge observed in 1989 and 1990 occur during the middle of the drought of the late 1980s and early 1990s, suggests that the increase is not climate related.

A flow meter was installed in the Birch Spring collection system in 1991 and after this time, the Star Point Mine MRP and the NEWUA data are in good agreement. These data indicate a slow steady decline from about 34 gpm in January 1991 to 15.5 gpm in August 1998. During this time, spring discharge data do not show indications of either seasonal or climatic influence. As shown on Figure 9, the drought period ended in 1993 and the region has generally had wet conditions since that time. In September 1998, part of the spring collection system was unearthed and the spring boxes were exposed. The combined discharge from the exposed spring boxes and the unearthed portion of the system was 25 gpm (Personal Communication, C. Reynolds, 1999), indicating that plugging of the pipes in the spring collection system is partially responsible for decreased spring flow. It is suspected that part of the decreased discharge from Birch Spring is attributable to diversion of water to nearby areas. Groundwater seeps below Birch Spring (between Highway 33 and Huntington Creek) are reported (Personal Communication, C. Reynolds, 1998) to be flowing only recently. At least one of these seeps has a stable isotopic affinity for water discharging from Birch Spring (Section 5.4). This suggests the possibility that the present water collection system at Birch Spring is not capturing all of the discharge from the area.

The fact that recent discharge from Birch Spring does not show significant seasonal variation suggests that the groundwater system from which the spring originates is a large, buffered groundwater system. The radiocarbon age of the groundwater discharging from Birch Spring (Section 5.3) is 1,700 to 3,600 years old, indicating that either groundwater travel times are slow or the distances from recharge area to discharge area are large. The tritium contents of water discharging from Birch Spring are low (0.35-l .12 TU) suggesting that the groundwater system that supplies Birch Spring is for the most part hydraulically isolated from the surface.

Given these two conditions, groundwater that contains little tritium and has antiquity, we expect that discharge from this groundwater system would, over time, have a constant baseflow component. Although the data are ambiguous, two baseflow rates are suggested by the data. First, the USGS data from 1978-1979 suggest a baseflow of about 20 gpm. Following redevelopment in 1984, discharge, according to the NEWUA data, was 30 gpm in September 1986. Following the installation of the in-line flow meter in 1991, the initial discharge was 33 gpm. After part of the spring collection system was unearthed in 1998, a flow of 25 gpm was measured. These data suggest that the baseflow discharge is about 20-30 gpm. Fluctuations from this likely arise from collection difficulties. Second, the Star Point

Mine MRP data suggest a baseflow component of about 80 gpm. The relationship between these two apparent baseflow discharge rates is uncertain.

Possible relationships between mining at the Bear Canyon Mine and the fluctuations in flow seen at Birch Spring are examined in Section 8.2, following the presentation of solute and isotopic data in subsequent sections.

4.2 In-mine groundwater occurrence

The mode of occurrence of groundwater in the Bear Canyon Mine and in the mines on Gentry Mountain immediately north of the study area (the Star Point Mine and the Hiawatha Complex) provides insight into the nature of groundwater systems of the Blackhawk Formation deep within Gentry Mountain. A brief history of the encountering of groundwater during mining operations is presented below.

4.2.1 Bear Canyon Mine

Mining at the Bear Canyon Mine began in 1982. Three seams are mined at the Bear Canyon Mine. Inflows to each of these seams are described below. Discharge hydrographs for significant groundwater inflows in the Bear Canyon Mine are presented in Figure 10. The monitoring locations of mine inflows in the Bear Canyon Mine are shown on Figures 11 a through 11 c.

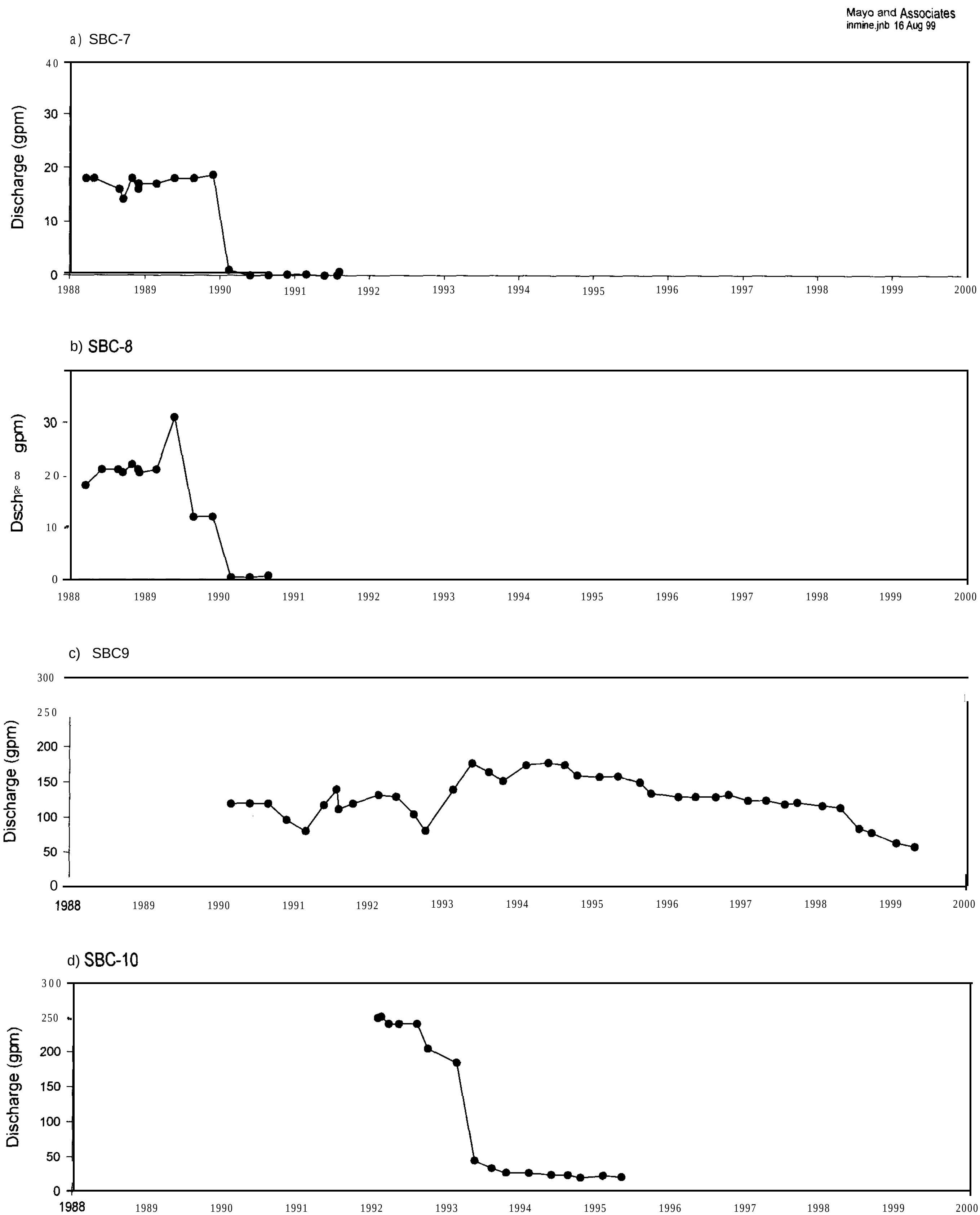

Figure 10 Discharge hydrographs of inflows to the Bear Canyon Mine.

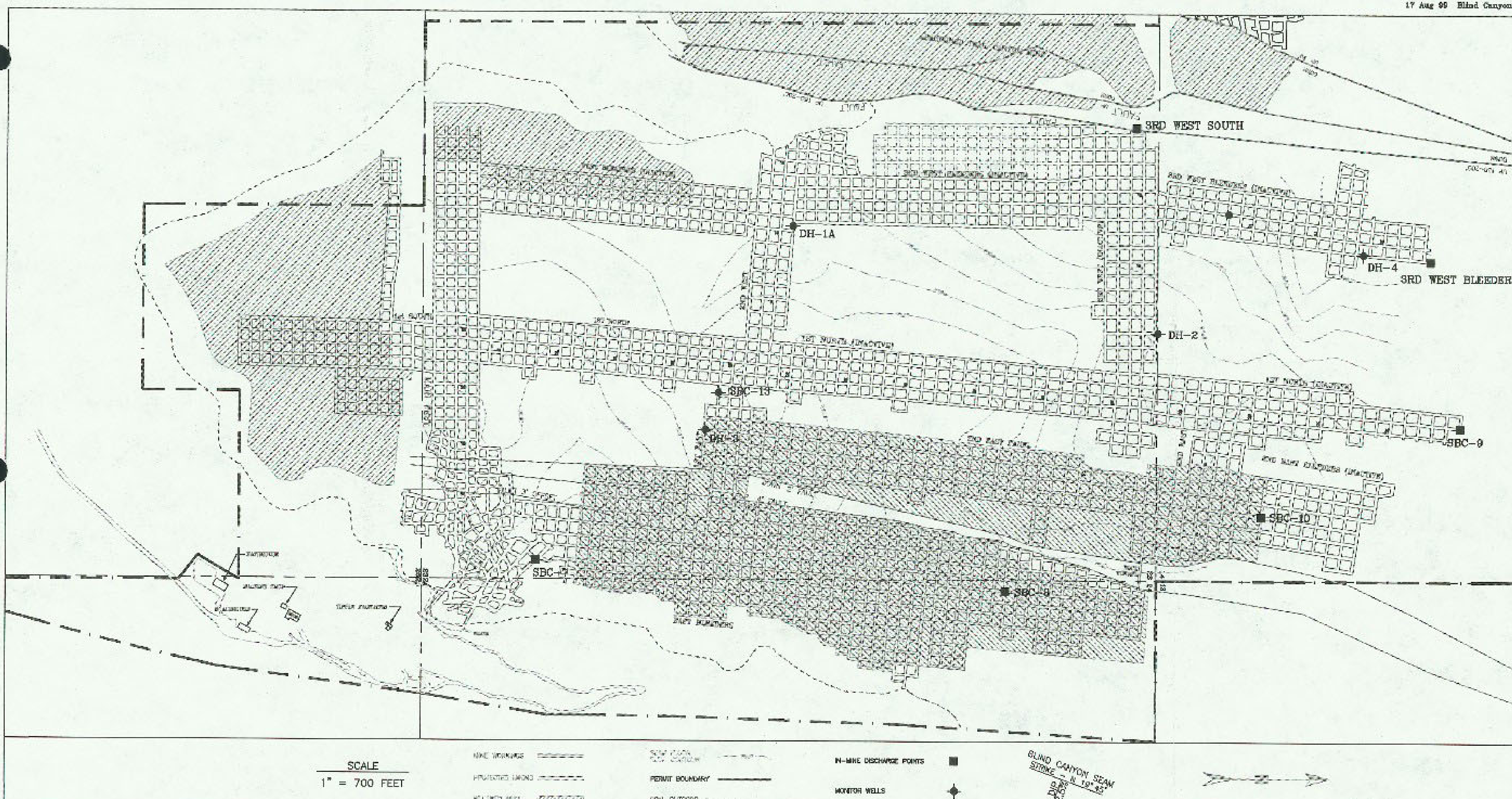

Figure 11a Blind Canyon Seam mine workings and in-mine groundwater sampling locations.

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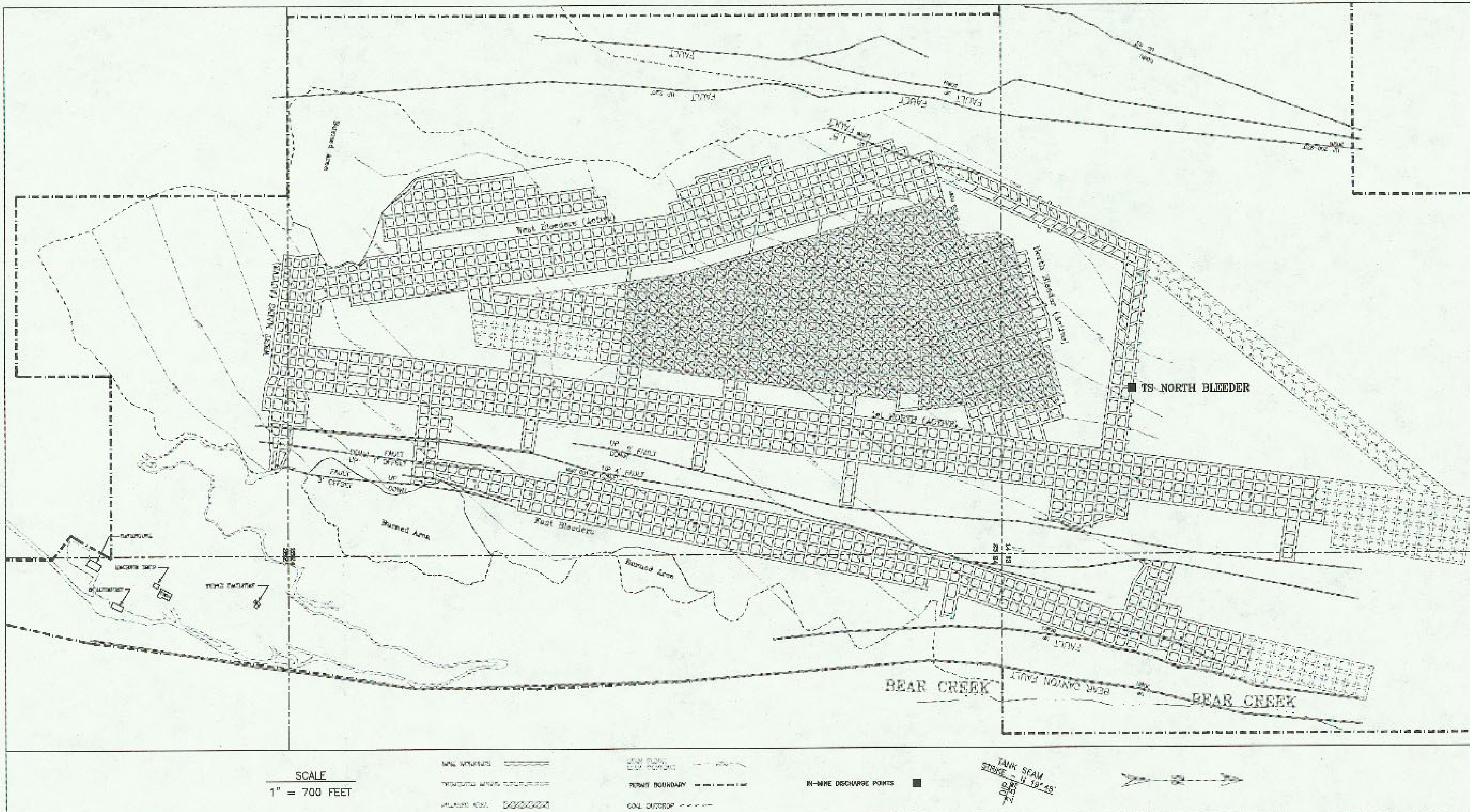

Figure 11b Tank Seam mine workings and in-mine groundwater sampling points.

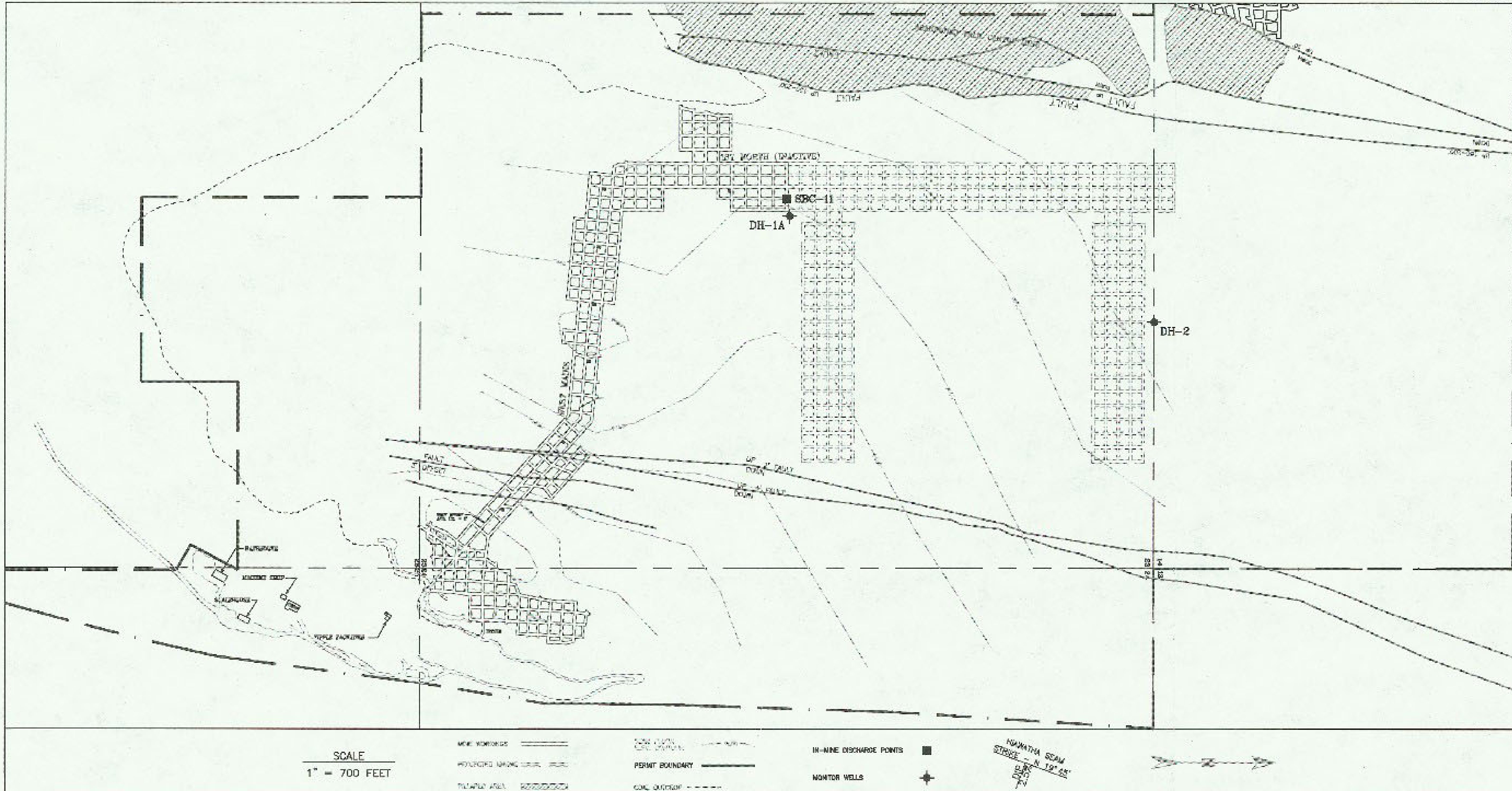

Figure 11c Hiawatha Seam mine workings and in-mine groundwater sampling locations.

Blind Canyon Seam workings

Prior to mining in the Blind Canyon Seam, natural groundwater discharge from the Blackhawk Formation occurred at a spring (SBC-7) near the mine entrance. The discharge hydrograph for SBC-7 is presented in Figure 1 Oa. The first recorded flow measurement at SBC-7 was taken in March of 1988 at 18 gpm. The discharge at SBC-7 did not display significant seasonal variation, varying by only about 1 gpm. By September 1988, the flow had dropped to 14 gpm. Discharge at SBC-7 continued to decline until the spring ceased flowing entirely by February of 1990.

The first significant groundwater encountered in the Blind Canyon workings was at SBC-8 in the East Bleeder section (Figure 1 la). SBC-8 originated from the mine roof and discharged at approximately 18 to 21 gpm (Figure 10b). During 1988 and 1989, the total groundwater discharge from the mine workings consisted of SBC-7 (18 gpm) and SBC-8 (18-21 gpm) for a combined discharge of approximately 40 gpm.

In August 1989, as mining progressed northward in the Blind Canyon Seam, mining operations approached the margins of a large sandstone channel in the mine roof. By November 1989, large roof drips began to be encountered in the mine roof. In August 1989 the discharge at SBC-8 dropped to 12 gpm, and by February 1990, both SBC-7 and SBC-8 had gone dry. The fact that both SBC-7 and SBC-8 went dry shortly after the sandstone channel was drained or depressurized suggests that some of the groundwater at SBC-7 and SBC-8 was likely related to the groundwater in the sandstone channel.

Because of poor coal quality in the vicinity of the sandstone channel, mining was not continuous in the area. Rather, as coal market conditions fluctuated, it was periodically economically feasible for coal mining operations to return to the sandstone channel area. Thus, lateral coal mining advances toward the sandstone channel occurred on several occasions. Groundwater from saturated river-bank deposits on the margins of the sandstone channel was first encountered in the mine roof 1,400 feet laterally from the main channel. When mining operations advanced laterally toward the sandstone channel, water would drip from the mine roof. However, these roof drips commonly dried up rapidly after they were first encountered. Typically, after mining had advanced about two cross cuts from a water inflow, flow from the roof drips would completely cease behind mining operations.

The fact that the discharge from the roof drips near the sandstone channel at SBC-9 declined rapidly, and eventually ceased entirely, suggests that the groundwater systems from which the discharge occurred are not in good hydraulic connection with recharge areas at the surface. This also suggests that the groundwater is not part of a large, continuous aquifer.

The discharge hydrograph for SBC-9 is presented in Figure 10c. The first flow measurement taken at SBC-9 (the sandstone channel) was in February 1990. A flow of 120 gpm was measured at that time. Subsequent measurements taken between 1991 and 1994 indicate that the discharge from the channel fluctuated substantially during that time. The rapid increases in the discharge rate from SBC-9 correlate with the timing of mining advances into the sandstone channel. When mine workings first intersected the sandstone channel, water was rapidly drained from the channel. Most of the water emanated from roof bolt holes and from fractures in the mine roof. When mining in an area ceased, the flow from the area gradually declined. Thus the fluctuations in the discharge from SBC-9 between 1991 and 1994 are more the result of variability in mining operations than a result of conditions in the channel itself

Since about 1994, the flow from the sandstone channel at SBC-9 has steadily declined. The steady decline suggests that the sandstone channel is gradually being drained. From the initial encounter of the sandstone channel in August 1989 until late April 1993, groundwater inflows to mine workings occurred primarily from river-bank deposits associated with the sandstone channel in the mine roof. On 27 April 1993, mine workings intersected the main body of the sandstone channel. The presence of the sandstone channel precluded further mining development to the north.

During 1991, as mining in the Blind Canyon Seam progressed in the 2nd East North section east of SBC-9 (Figure 1 la), water was encountered in a segment of the same sandstone channel from which SBC-9 discharges. Initial inflows at this site (known as SBC-10) were approximately 250 gpm. The discharge hydrograph for SBC- 10 is shown on Figure 10d. It is likely that the portion of the sandstone channel from which SBC-10 originates is isolated from the main channel at SBC-9. When the discharge from SBC-10 occurred, the discharge at SBC-9 was not impacted. By 1993, the discharge from SBC- 10 had declined to about 40 gpm. By October 1994, the discharge had diminished to approximately 20 gpm. The site became inaccessible after May 1995. In 1997, water began to discharge from the gob area at the head of the 1st East section. This source is identified as SBC-13 (Figure 1 la). It is believed that the water at SBC-13 is water from SBC-10 that has filled the gob area and is now spilling out the top of the system (Personal Communication, C. Reynolds, 1999). The discharge from SBC-13 (which averages approximately 20 gpm) is similar to that which was discharging from SBC-10 before it became inaccessible.

An analysis of historic mine water discharge rates at the Bear Canyon Mine suggests that the mine has not intercepted a large continuous aquifer system, or a system which receives constant recharge from overlying horizons. Historic mine water discharge rates are plotted against the cumulative tons of coal mined at the Bear Canyon Mine in Figure 12. The cumulative tons of coal mined is used as a surrogate for the total open volume of the mine. If the mine workings intercepted a large aquifer system or a zone of constant recharge, it would be anticipated that the mine water discharge would increase in proportion to the size of the mine workings. For example, a large diameter well with a long well screen will produce more water than a small diameter well with a short well screen. That this is not the case suggests that the mine has intercepted a series of perched groundwater systems that are isolated from recharge areas. Because there is little recharge to the perched systems, they are rapidly drained and the discharge ceases.

Tank Seam workings

The mine workings in the Tank Seam are dry and dusty in almost all locations where it has been mined, and it is necessary to import water for dust suppression. However, groundwater has been encountered in a few locations in the Tank Seam workings. In one isolated location, a small groundwater inflow of approximately 0.5 gpm occurred from a sandstone channel in

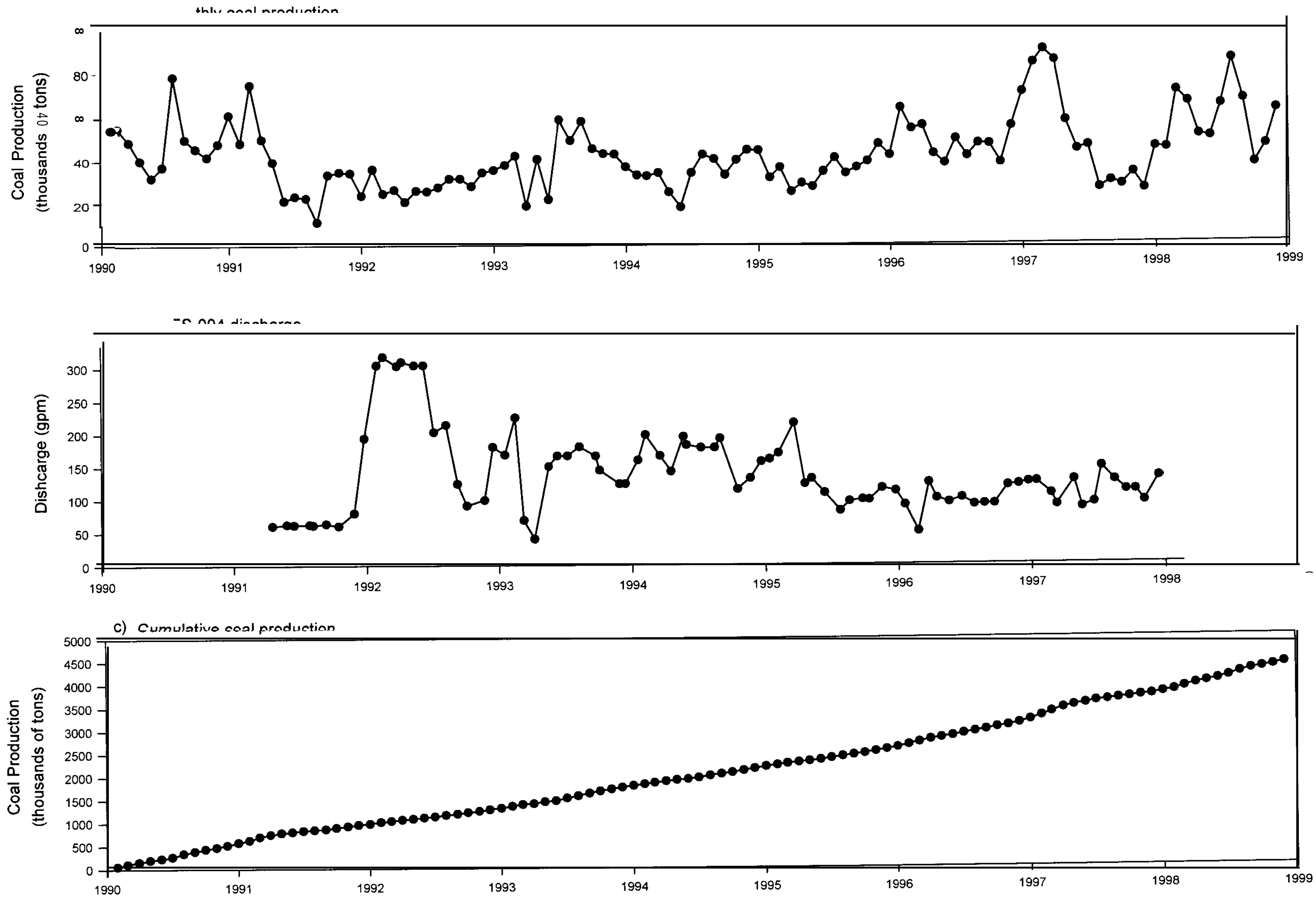

Figure 12 Plots of coal production and mine water discharge from the Bear Canyon Mine.

the Tank Seam workings. However, after a few months this inflow dried up. During the springtime months, a small groundwater inflow into the North Mains section of the Tank Seam mine occurred. The inflow, which was estimated at less than 10 to 15 gpm, occurred adjacent to a fault in an area that had recently been subsided as a result of mining in the underlying Blind Canyon Seam. The water leaked into the mine in a location that was not accessible. A small sump tilled in the springtime months, then drained out in the summer and fall months. This seasonal inflow pattern is likely related to the fact that the Tank Seam was being mined after the underlying Blind Canyon Seam had been mined and subsided (i.e. mining was occurring in the zone impacted by subsidence-related, upwardly-propagating fractures). During 1999, the inflow into the North Mains section did not occur. This suggests that the subsidence-induced fractures have been filled with sediment or with swelling clays and are no longer conduits to groundwater flow. The fact that more than 99% of the total mined area in the Tank Seam was completely dry when it was mined indicates that there is no widespread downward migration of groundwater through the Tank Seam that could be recharging underlying groundwater formations.

A small roof drip in the North Bleeder of the Tank Seam was sampled as part of this investigation (T.S. North Bleeder; Figure 1 lb). This roof drip discharged about 0.5 gpm from small sandstone channel in the roof. This inflow dried up several months after it was encountered.

Hiawatha Seam workings

During mining operations in the Hiawatha Seam (the lowest coal seam), individual groundwater inflows never exceeded about five gallons per minute. Individual sources dried-up shortly after being encountered in the mine. A single sample was collected from SBC-11, a groundwater inflow in the Hiawatha Seam, which had a flow rate of approximately 5 gpm. This location is adjacent to well DH-1 A, which is completed in the Spring Canyon Sandstone, which directly underlies the Hiawatha Seam in the region. The water level in DH-1A was approximately five feet below the elevation of the coal seam. This suggests that, as mining progresses northward, the mine workings may pass below the local pressure surface on the Spring Canyon Sandstone, and upwelling of groundwater through the mine floor may occur.

4.2.2 Hiawatha Complex

The Hiawatha Complex, located immediately north of the Mohrland area, includes the workings of the Blackhawk, Mohrland, Hiawatha, and King mines. Many of these workings are interconnected and groundwater discharges from this complex to the surface via the Mohrland (King No. 2) Portal, the downdip end of the complex. Limited information regarding the groundwater occurrence in these workings is contained in the Hiawatha Coal Company MRP (1992). In this permit it is noted that large groundwater inflows to mine workings in the past have occurred where mine working have encountered the Bear Canyon Fault and that discharge from the fault probably accounts for most of the water presently being discharged from the Mohrland Portal.

In the King No. 4 Mine, a western development encountered the Bear Canyon Fault and an inflow of approximately 100 gpm occurred from the floor of the mine. In the King No. 4 Mine, water has also been observed draining from the roof near the portal during years of high spring runoff. No information is found in the Hiawatha MRP (1992) to indicate whether the discharge rate of inflows to the King No. 4 Mine declined over time.

At one time, water which accumulated in the Blackhawk Mine was pumped to the portal and discharged. Discharge of water from the portal ended when bulkheads were broken in the mine and water was diverted to the Mohrland Portal. Recently, Hiawatha evaluated the possibility of diverting the discharge from the Blackhawk Mine from the Mohrland Portal to the Blackhawk Portal (Personal Communication, C. Reynolds, 1999). However, it was found in the old workings that groundwater discharge from the Blackhawk Mine workings is now just a trickle.

4.2.3 Star Point Mine

The Star Point Mine workings are north and east of the study area. Information about groundwater inflows to these workings are reported in the Star Point Mine MRP (1996). It is reported that east of Gentry Ridge, much of the mine inflow water discharges from sandstone paleochannels. These inflows may initially be large (greater than 5 gpm) but drop off rapidly. Larger mine inflows (20-100 gpm) were generally associated with the western boundary fault of the Gentry Ridge Horst.

4.3 Potentiometric data

Cross sections have been previously constructed (EarthFax, 1997) showing potentiometric surfaces for each of the three members of the Star Point Sandstone in the vicinity of the Bear Canyon Mine (Figures 13a and 13b). These maps are based on water level information from wells (Appendix A) in and adjacent to the mine permit area and on the locations of springs. Generally, it has been our experience in the Wasatch Plateau coal field that these maps are of limited value because of the lateral discontinuity of groundwater systems. However, in the relatively small region of the Bear Canyon Mine, the potentiometric surface maps may be representative of actual conditions in the members of the Star Point Sandstone.

As discussed in Section 4.1.6, groundwater flow in the Star Point Sandstone occurs primarily in fractures. A lesser amount of flow occurs in the intergranular spaces of the sandstone. Therefore, in interpreting the potentiometric surface maps, it is necessary to understand whether the Star Point Sandstone wells used as control points are representative of conditions in the fracture system or the diffuse, intergranular system. It is unknown whether the wells used as control points encountered significant, water-bearing fractures or whether they encountered only unfractured sandstone. Because this is unknown, there is some ambiguity in the interpretation of the potentiometric surface maps. However, some important conclusions can be made based on these maps.

First, the fact that distinct pressure surfaces exist in each of the members of the Star Point Sandstone suggests that there is not significant hydraulic communication between the sandstone members. If groundwater were leaking downward in significant quantities across

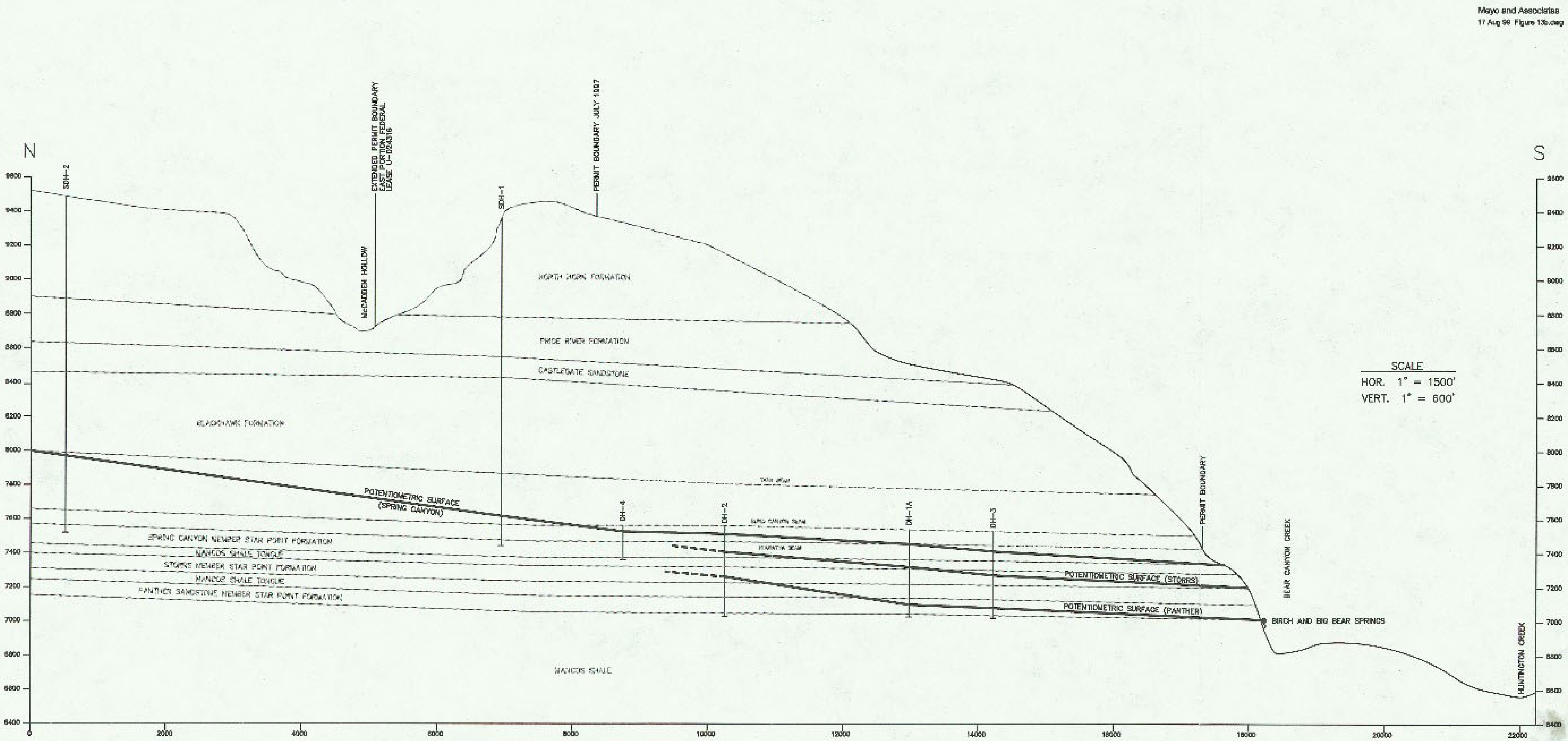

Figure 13a North-south cross-section showing individual potentiometric surfaces in members of the Star Point Sandstone.

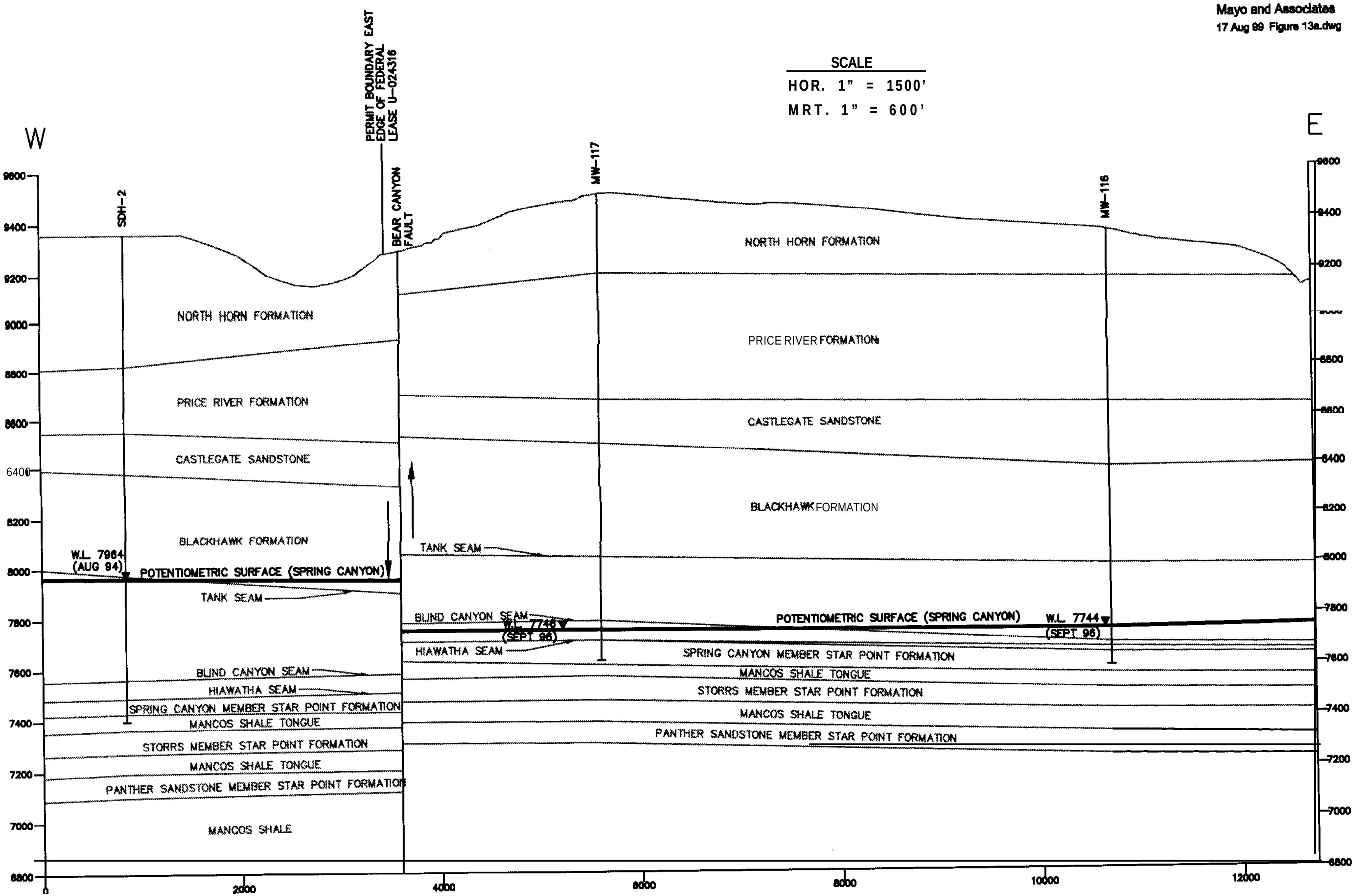

Figure 13b East-west cross-section showing potentiometric surface in Spring Canyon Sandstone.

the members of the Star Point Sandstone and the formation as a whole was acting as a single aquifer in good communication with the surface (i.e. an unconfined system), it would be anticipated that there would be pressure equalization between all three members.

Second, the hydraulic gradients of the three members of the Star Point Sandstone in the vicinity of the mine suggest that groundwater flow is primarily horizontal beneath the mine area. In each member, the slope of the potentiometric surface is such that the hydraulic head is greatest in the north and declines toward the south, where the members are exposed at the surface. This suggests that flow is predominantly horizontal, from the north toward the south. This is consistent with anticipated groundwater flow characteristics in interbedded higher permeability and lower permeability rocks. In the rock sequence of the Wasatch Plateau, horizontal hydraulic conductivity commonly exceeds the vertical hydraulic conductivity by one or more orders of magnitude.

The ages of groundwaters (Section 5.3) in the Blackhawk Formation and Star Point Sandstone in the vicinity of the mine also support the idea that groundwater flow in these two formations is predominantly horizontal. Groundwater discharging from the sandstone channel in Blind Canyon Seam, which makes up approximately 95% of the total discharge from the mine, is approximately 1,500 years old. Groundwater in the underlying Spring Canyon Sandstone sampled from DH-2, approximately 2,200 feet south (down-gradient) of the sandstone channel is only about 1,000 years old. This suggests that there is not vertical communication between these two systems. If this were the case, groundwater at DH-2 would be expected to be older than that at the sandstone channel.

Analysis of the water level hydrographs for the four wells completed in the Spring Canyon Sandstone directly beneath the Bear Canyon Mine indicates that groundwater systems there are not influenced by seasonal recharge. Water level hydrographs for the four in-mine piezometers in the Star Point Sandstone are shown in Figure 14. Three of the wells (DH-1 A, DH-3, and DH-4) show relatively stable or slightly increasing water levels through time, while DH-2 shows a slightly declining trend. Because no significant quantities of groundwater have been removed from the Star Point Sandstone, it is highly unlikely that the responses in the Star Point Sandstone wells are the result of the extraction of water from the formation. Rather, we suspect that these responses are more likely the result of the redistribution of stresses and confining pressures on the Star Point Sandstone resulting from mining activities in the overlying Blackhawk Formation.

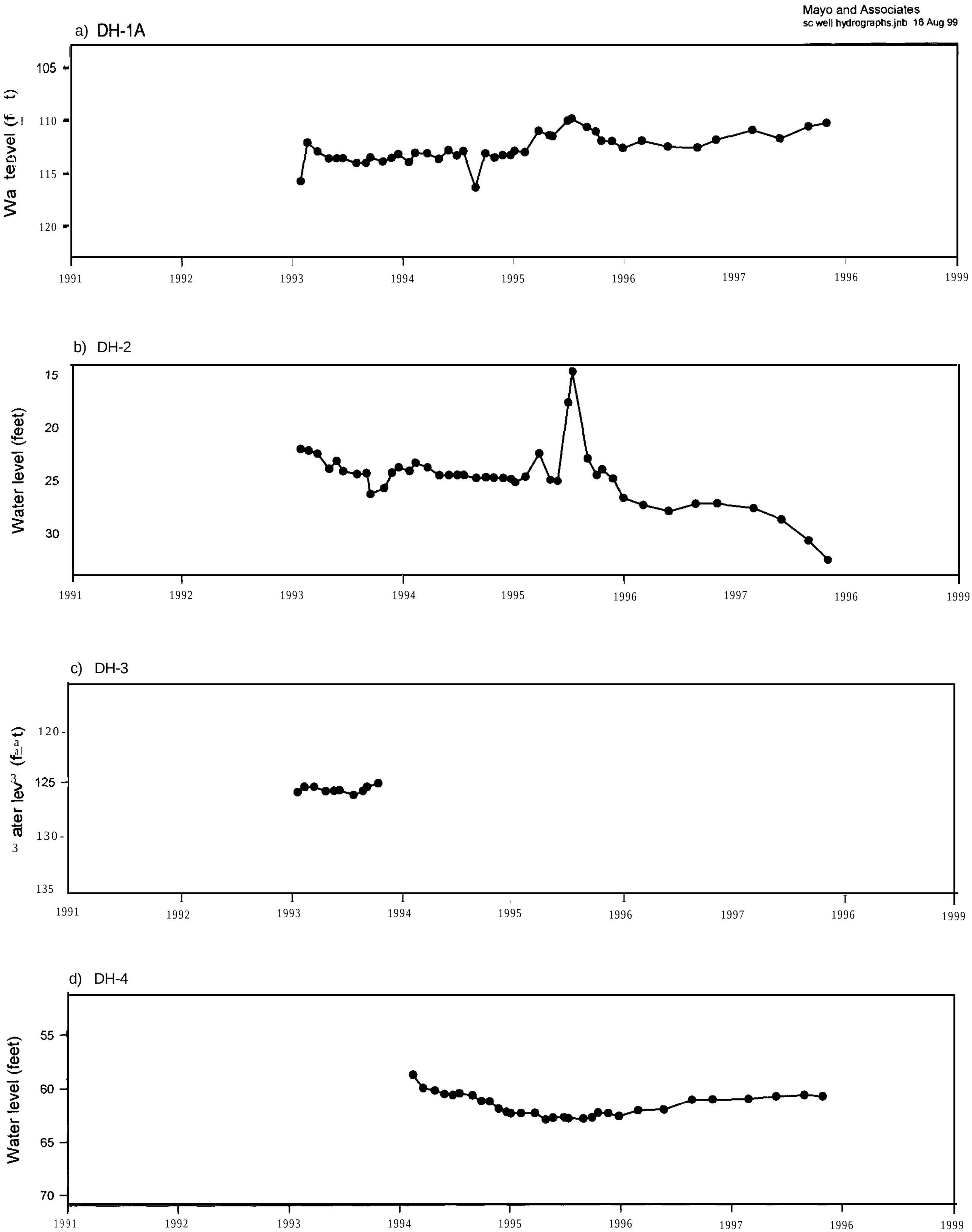

Figure 14 Water level hydrographs for Spring Canyon Sandstone wells.

5.0 SOLUTE AND ISOTOPE CHEMISTRY

Analysis of the solute and isotopic compositions and concentrations of waters in the study area is helpful in understanding the interrelationships between groundwater systems.

5.1 Explanation of chemical reporting units and terms

Reporting units are milligrams per liter (mg/l) and milliequivalents per liter (meq/l) for ionic solutes and per mil (‰) for stable isotopes. Stable isotopic reference standards are Standard Mean Oceanic Water (SMOW) for δ^2H and $\delta^{18}O$, and Pee Dee Formation Belemnite (PDB) for $\delta^{13}C$. The radiogenic isotope ^{14}C is reported relative to percent modern (1950) carbon (pmc), and the radiogenic isotope ^3H is reported in tritium units (TU). One TU is equivalent to 3.2 pCi/l (pica-Curies per liter).

In addition to the familiar mg/l concentration unit, laboratory solute data have been converted to meq/l for analysis and reporting purposes. The meq/l unit allows direct comparison of reacting concentrations of cations and anions. Conversion factors between meq/l and mg/l for major ions follow:

	meq/l	mg/l
Ca^{2+}	1	20.0
Mg^{2+}	1	12.2
Na^+	1	23.0
K^+	1	39.1
HCO_3^-	1	61.0
SO_4^{2-}	1	48.0
Cl^-	1	35.5

From the conversion factors it is apparent that heavy anion molecules such as SO_4^{2-} and HCO_3^- contribute disproportionately to TDS relative to their reacting cation counterparts, such as Ca^{2+}.

The stable isotopic composition of a sample is reported as the per mil (‰) difference of the sample relative to the isotopic composition of a standard using the delta (6) notation defined as:

$$\delta = \frac{(R_{sample} - R_{standard})}{(R_{standard})} x1000 \text{ (‰)}$$

where R = $^{18}O/^{16}O$, $^{2}H/^{1}H$, $^{13}C/^{12}C$, and $^{34}S/^{32}S$. The δ notation is reported in terms of the heavy isotope in the ratio R (i.e., $\delta^{13}C$ for $^{13}C/^{12}C$).

A summary of the application of isotopic methods to hydrogeologic investigations is included as Appendix C. Readers who are not familiar with the use of isotopes in hydrogeologic investigations are encouraged to read Appendix C prior to proceeding with the remainder of this report.

5.2 Solute chemistry

5.2.1 Chemical reactions

Solute compositions of groundwaters are the result of interactions between groundwaters and bedrock lithologies and between groundwaters and atmospheric and soil gases. The general reactions responsible for the chemical evolution of groundwaters in the study and adjacent areas are described below.

Groundwater acquires most of its CO,,,, in the soil zone where the partial pressure of CO, greatly exceeds atmospheric levels. This CO, combines with water to form carbonic acid according to

$$\text{CO,,,,} + H_2O = H_2CO_3. \quad (1)$$

Carbonic acid dissociates into H^+ and HCO_3^- as

$$H_2CO_3 = \text{HCO,} + H^+. \quad (2)$$

The H^+ ions temporarily decrease the pH of the water but are quickly consumed by the dissolution of carbonate minerals that are abundant in the soil zone and in most aquifers. Carbonate mineral dissolution is represented as

$$2H^+ + \underset{\text{(dolomite)}}{CaMg(CO_3)_2} = Ca^{2+} + Mg^{2+} + 2HCO_3^-, \text{ and} \quad (3)$$

$$H^+ + \underset{\text{(calcite)}}{CaCO_3} = Ca^{2+} + \text{HCO;}. \quad (4)$$

The net effect of reactions 2 through 4 is to increase the pH and the Ca^{2+}, Mg^{2+}, and HCO_3^- contents of waters. Dissolution of gypsum, which is present in many formations in the region, can elevate the Ca^{2+} and SO_4^{2-} contents in the absence of additional CO,,,, and H^+ according to

$$\underset{\text{(gypsum)}}{CaSO_4 \cdot 2H_2O} = Ca^{2+} + SO_4^{2-} + 2H_2O. \quad (5)$$

Elevated Na' concentrations may result from either the dissolution of halite or from ion exchange on clay particles or on sodium zeolites. Halite dissolution will increase the overall solute concentration (i.e. TDS) and will yield equal Na^+ and Cl' contents when the solute compositions are reported in meq/l units. Ion exchange will not directly elevate the overall solute content, but will result in increased Na^+ concentrations at the expense of reduced Ca^{2+} and/or Mg^{2+} concentrations. Halite dissolution may be represented as

$$NaCl = Na^+ + Cl^-, \qquad (6)$$

and ion exchange may be represented by reactions involving the sodium zeolite analcime,

$$2NaAlSi_2O_6 \bullet H_2O + Ca^{2+} = Ca(AlSi_2O_6)_2 \bullet H_2O + 2Na^+, \text{ and} \qquad (7)$$

$$2NaAlSi_2O_6 \bullet H_2O + Mg^{2+} = Mg(AlSi_2O_6)_2 \bullet H_2O + 2Na^+, \qquad (8)$$

or clay mineral exchange which may be represented as

$$Ca^{2+} + Na\text{-clay} = 2Na^+ + Ca\text{-clay, and} \qquad (9)$$

$$Mg^{2+} + Na\text{-clay} = 2Na^+ + Mg\text{-clay.} \qquad (10)$$

5.2.2 Solute compositions

The mean solute concentrations of creeks, springs, wells, and in-mine sources are reported in Table 3 and illustrated as Stiff diagrams in Figure 1.5. Locations of these sampling sites are shown on Figure 1. In the calculation of mean solute composition, all analyses that had cation-anion error balances greater than 15% (Appendix A) were excluded.

The solute concentrations of waters in the Flagstaff Limestone, North Horn Formation, and Price River Formation are very similar. The mean TDS concentrations of each of these groups are not distinguishable using a two-tailed t-test analysis. Groundwaters from these formations are generally calcium-bicarbonate or calcium-magnesium-bicarbonate type waters. The mean TDS concentration of these waters is about 300 mg/l (Table 3). The solute concentration of these waters is a result of the dissolution of carbonate minerals in the soil zone and aquifer matrix.

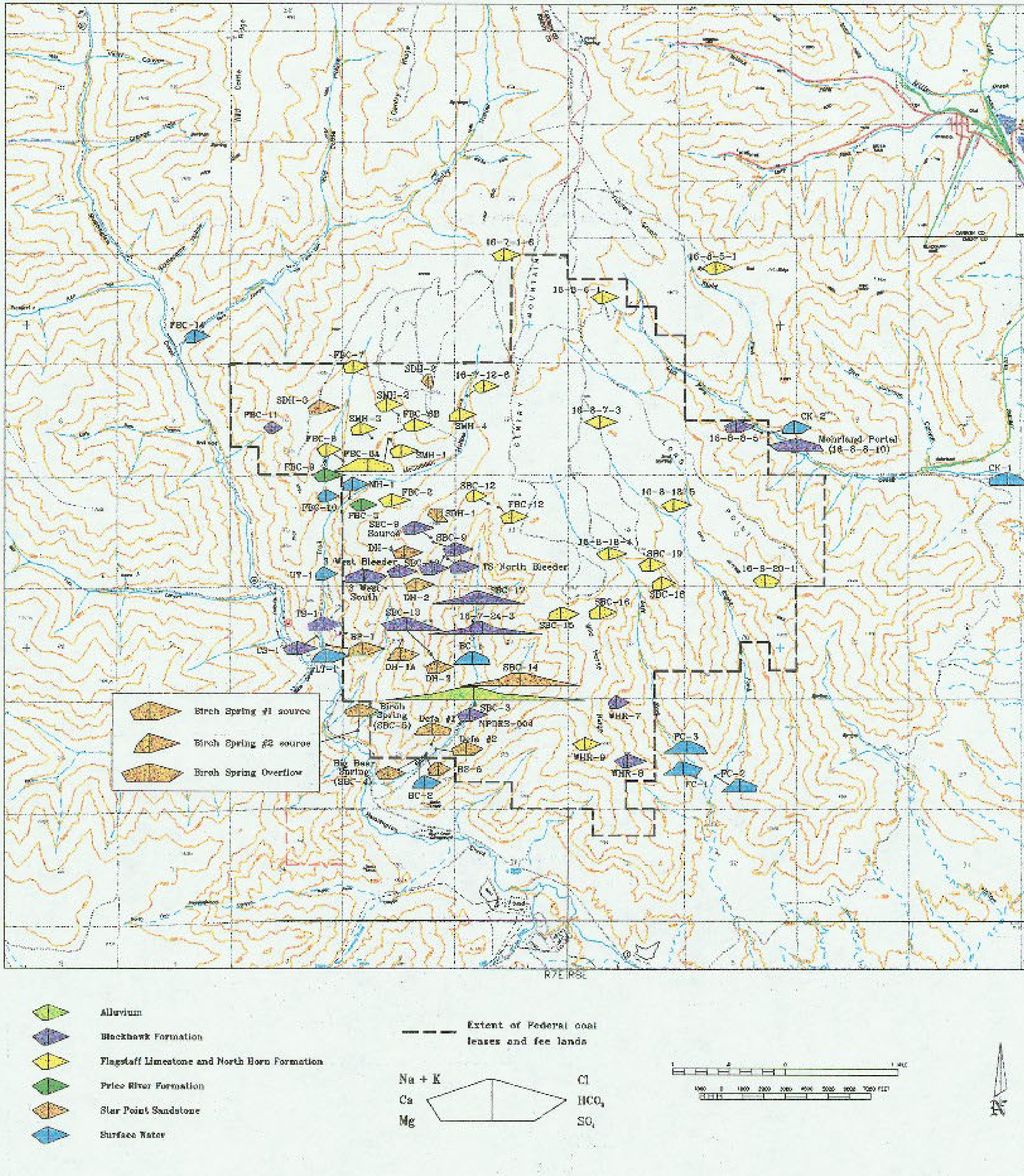

Figure 15 Stiff diagrams of creek, spring, well, in-mine, and mine discharge waters. Location of sampling point is directly under center of Stiff diagram unless otherwise noted.

Table 3 Mean solute chemistry of creeks, springs, wells, and mine inflows

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Site	n	pH	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HC03 mg/l	CO3 mg/l	so4 mg/l	Cl mg/l	Ca meq/l	Mg meqll	Na meqll	K meq/l	HC03 meqll	CO3 meqll	so4 meqll	Cl meqll
Creeks																			
BC-1	20	a.4	544	76.1	72.3	10.8	5.0	291	4.0	262.9	10.4	3.80	5.95	0.47	0.13	4.77	0.13	5.47	0.30
BC-2	23	a.2	365	60.5	46.5	6.9	2.6	306	1.3	115.5	8.1	3.02	3.83	0.30	0.07	5.02	0.04	2.41	0.23
CK-1	a	a.2	732	114.5	66.5	a.4	4.1	273	4.5	346.5	6.2	5.71	5.48	0.36	0.11	4.47	0.15	7.22	0.18
CK-2	a	a.3	423	68.3	44.1	6.5	1.7	321	2.4	115.4	5.1	3.40	3.63	0.28	0.04	5.27	0.08	2.40	0.15
FBC-10	2	a.7	237	51.0	23.5	5.2	0.2	261	0.0	10.5	7.0	2.55	1.93	0.23	0.01	4.28	0.00	0.22	0.20
FBC-14	2	8.0	285	57.9	30.0	5.3	0.8	300	2.5	24.2	7.0	2.89	2.47	0.23	0.02	4.91	0.09	0.50	0.20
FC-1	a	a.3	606	57.2	75.4	31.1	2.7	370	3.0	216.7	10.2	2.85	6.20	1.36	0.07	6.07	0.10	4.51	0.29
FC-2	9	a.2	563	66.9	63.9	20.3	1.9	309	7.2	214.8	10.1	3.34	5.26	0.88	0.05	5.07	0.24	4.47	0.28
FC-3	7	a.4	718	79.5	86.3	41.5	1.5	329	0.0	309.9	21.3	3.96	7.10	1.81	0.04	5.39	0.00	6.45	0.60
LT-1	15	a.2	466	75.5	56.6	17.4	3.6	417	3.3	90.1	25.1	3.76	4.66	0.76	0.09	6.84	0.11	1.87	0.71
MH-1	5	7.9	307	60.2	32.4	5.6	1.0	307	0.0	27.8	7.4	3.00	2.67	0.24	0.03	5.03	0.00	0.58	0.21
UT-l	5	a.5	273	47.9	25.8	5.0	0.4	250	8.0	28.4	6.8	2.39	2.12	0.22	0.01	4.10	0.27	0.59	0.19
Bear Canyon Alluvium Well																			
SBC3	20	7.4	2842	246.3	330.3	74.8	16.1	511	0.5	1682.1	46.1	12.29	27.18	3.26	0.41	8.38	0.02	35.02	1.30
Flagstaff ***Limestone-North Horn Formation-Price River Formation Springs***																			
16-f-12-6	a	7.8	250	66.0	21.5	3.3	0.4	299	0.5	a.2	3.8	3.29	1.77	0.14	0.01	4.91	0.02	0.17	0.11
16-7-1-6	a	7.6	296	74.6	22.4	3.2	0.3	338	0.5	15.0	3.4	3.72	1.84	0.14	0.01	5.54	0.02	0.31	0.09
16-a-184	6	7.6	286	74.3	20.8	2.3	0.1	347	1.0	7.8	3.4	3.70	1.71	0.10	0.00	5.69	0.03	0.17	0.10
16-a-18-5	7	7.4	302	74.7	22.1	2.5	0.1	346	0.3	14.3	3.0	3.72	1.82	0.11	0.00	5.66	0.01	0.30	0.08
16-8-20-I	3	7.8	406	76.6	25.7	23.8	1.2	272	2.3	134.3	6.0	3.82	2.11	1.04	0.03	4.46	0.08	2.80	0.17
168-5-I	7	7.5	339	77.1	21.0	4.7	0.3	340	1.0	25.4	4.3	3.84	1.73	0.20	0.01	5.58	0.03	0.53	0.12
16-a-6-1	7	7.6	264	73.2	15.0	1.9	0.1	308	1.9	a.4	2.9	3.65	1.23	0.09	0.00	5.04	0.06	0.18	0.08
16-a-7-3	4	7.5	307	97.8	10.8	1.8	0.1	347	0.5	7.0	2.0	4.88	0.89	0.08	0.00	5.69	0.02	0.15	0.06
FBC-12	6	7.8	246	71.0	33.0	2.8	1.0	318	0.0	24.7	3.9	3.54	2.71	0.12	0.03	5.21	0.00	0.51	0.11
FBC-2	1	8.1	352	77.8	26.9	4.9	0.9	379	0.0	5.8	2.3	3.88	2.21	0.21	0.02	6.21	0.00	0.12	0.07
FBC3	1	8.0	274	72.4	18.8	3.5	0.8	307	0.0	12.3	2.4	3.61	1.55	0.15	0.02	5.03	0.00	0.26	0.07
FBC-6B	6	7.8	332	72.6	29.9	5.0	1.0	337	0.0	22.3	a.1	3.62	2.46	0.22	0.03	5.53	0.00	0.47	0.23
FBC-7	7	7.5	305	64.1	28.9	5.8	1.0	301	0.0	26.0	12.4	3.19	2.37	0.25	0.03	4.93	0.00	0.54	0.35
FBC-8	1	7.6	250	61.7	18.8	5.6	4.4	289	0.0	11.9	6.2	3.08	1.55	0.24	0.11	4.74	0.00	0.25	0.17

Site	n	pH	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HC03 mg/l	C03 mg/l	so4 mg/l	Cl mg/l	Ca meqll	Mg meqll	Na meqll	K meqll	HC03 meqll	C03 meqll	so4 meqll	Cl meqll
FBC-9	2	7.5	347	76.1	26.6	10.3	1.8	342	***0.0***	24.0	6.2	3.80	2.19	0.45	0.05	5.60	***0.00***	**0.50**	0.18
SBC-12	13	7.9	217	52.9	19.9	2.3	0.2	261	1.2	7.8	2.4	2.64	1.64	0.10	0.01	4.27	**0.04**	0.17	0.06
SBC-15	a	7.9	404	75.8	47.8	a.2	0.8	350	0.0	101.1	6.6	3.78	3.93	0.36	0.02	5.73	**0.00**	2.11	0.19
SBC-16	a	7.7	317	65.1	36.4	6.8	0.3	335	0.0	30.4	6.6	3.25	2.99	0.30	0.01	5.48	**0.00**	0.63	0.19
SBC-18	7	7.6	257	56.5	30.5	4.0	0.2	284	0.0	20.9	4.5	2.82	2.51	0.17	0.00	4.66	**0.00**	0.43	0.13
SBC-19	a	7.5	358	69.5	32.3	5.3	0.8	303	0.0	58.1	9.3	3.47	2.66	0.23	0.02	4.97	**0.00**	1.21	0.26
SMH-1	7	7.6	331	69.4	30.9	6.6	0.7	336	0.5	21.3	7.0	3.46	2.54	0.29	0.02	5.50	**0.02**	0.44	0.20
SMH2	8	7.6	271	71.8	21.6	4.1	0.7	307	0.0	9.0	a.5	3.58	1.78	0.18	0.02	5.04	**0.00**	0.19	0.24
SMH3	6	7.5	317	63.2	30.0	4.0	0.2	309	0.8	22.3	6.9	3.15	2.47	0.17	0.01	5.07	**0.03**	0.47	0.19
SMH-4	a	7.5	338	60.6	40.4	10.4	0.6	320	0.0	41.8	10.1	3.03	3.33	0.45	0.02	5.25	**0.00**	0.87	0.29
WHR-9	1	8.1	270	76.1	16.6	2.4	0.2	320	0.0	6.6	3.0	3.80	1.37	0.10	0.01	5.24	**0.00**	0.14	0.09
Average		**7.7**	306	71.2	26.1	5.4	0.7	321	0.4	26.1	5.4	3.55	2.15	0.23	0.02	5.25	**0.01**	0.55	**0.15**
Flagstaff-North Horn-Price *River Springs--OUTLIER*																			
FBC-6A	2	7.6	1361	127.1	132.5	36.0	55.9	453	0.0	392.5	33.5	6.34	10.91	1.57	1.43	7.43	**0.00**	8.18	**0.95**
Blackhawk Formation Springs																			
16-8-8-5	a	7.7	359	70.7	35.5	4.8	0.7	363	1.1	48.8	4.0	3.52	2.92	0.21	0.02	5.95	**0.04**	1.02	0.11
cs-1	14	7.5	406	86.2	36.8	3.9	1.8	394	0.7	63.0	9.7	4.30	3.03	0.17	0.05	6.46	**0.02**	1.31	**0.27**
FBC-11	1	8.4	182	52.3	9.4	3.2	0.8	194	5.1	9.9	3.4	2.61	0.77	0.14	0.02	3.18	0.17	0.21	**0.09**
TS-1	13	7.1	460	82.7	49.1	11.3	2.0	419	0.0	71.7	18.6	4.13	4.04	0.49	0.05	6.86	0.00	1.49	**0.53**
WHR-7	1	a.2	214	51.6	23.2	4.6	0.9	250	0.0	28.0	2.5	2.57	1.91	0.20	0.02	4.10	0.00	0.58	**0.07**
WHR-8	1	8.1	294	83.3	21.7	3.9	0.5	360	0.0	10.3	2.9	4.16	1.79	0.17	0.01	5.90	0.00	0.21	**0.08**
Average		**7.8**	**319**	***71.1***	***29.3***	5.3	1.1	330	1.2	38.6	6.9	3.55	2.41	0.23	0.03	**5.41**	0.04	0.80	**0.19**
Blackhawk Formation Springs--OUTLIERS																			
16-7-24-3	1		1468	86.4	202.2	23.6	21.6	234	0.0	895.0	5.5	4.31	16.64	1.03	0.55	**3.84**	0.00	18.63	0.16
SBC-17	1		1433	116.1	176.2	23.0	19.3	400	0.0	690.0	a.4	5.79	14.50	1.00	0.49	**6.56**	0.00	14.37	0.24
Composite Blackhawk Formation-Alluvial Spring																			
TS-1	13	7.1	460	82.7	49.1	11.3	2.0	419	0.0	71.7	18.6	4.13	4.04	0.49	0.05	6.86	0.00	1.49	0.53
East-of-fault deep Blackhawk Formation groundwaters																			
SBC-9	28	7.7	345	73.6	32.3	3.4	0.9	353	0.0	40.3	6.0	3.67	2.66	0.15	0.03	5.79	0.00	0.84	0.17
SBC-9 Source	3	7.3	355	77.0	32.0	3.0	0.9	375	***0.0***	33.8	4.0	3.84	2.63	0.13	0.03	6.15	0.00	0.70	0.11

Site	n	pH	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HC03 mg/l	CO3 mg/l	so4 mg/l	C1 mg/l	Ca meqll	Mg meqll	Na meqll	K meqll	HC03 meqll	CO3 meqll	so4 meqll	Cl meqll
SBC-10	16	7.6	354	73.9	30.7	**2.9**	0.5	321	**0.9**	51.6	**7.9**	**3.69**	2.53	0.13	0.01	5.26	0.03	1.07	0.22
3rd West Bleeder	2	7.6	312	70.0	30.0	4.0	0.9	356	0.0	26.5	6.0	**3.49**	2.47	0.17	0.03	5.84	0.00	0.55	0.17
T.S. North Bleeder	1		356	68.0	34.0	4.0	2.0	368	0.0	44.0	24.0	**3.39**	2.80	0.17	0.05	6.03	0.00	0.92	0.68
Average		7.5	345	12.5	***31.8***	3.4	1.1	355	0.2	39.2	9.6	3.62	2.62	0.15	0.03	5.81	0.01	0.82	0.27
East-of-fault deep Blackhawk Formation Groundwaters--OUTLIER																			
SBC-13	6	7.6	1185	185.0	83.5	24.0	4.7	331	0.0	618.0	10.2	9.23	6.87	1.04	0.12	5.43	0.00	12.87	0.29
West-of-fault deep Blackhawk Formation Groundwaters																			
3rd West South	2	7.9	**739**	111.0	71.0	13.5	3.0	442	0.0	234.0	35.5	5.54	5.85	0.59	0.08	7.24	0.00	4.88	1.00
Bear Canyon Mine Discharge																			
NPDES-004	1	7.6	364	77.0	34.0	5.0	1.9	351	0.0	51.4	6.0	3.84	2.80	0.22	0.05	5.75	0.00	1.07	0.17
Mohrland Portal Discharge																			
16-8-a-10	8	7.1	947	169.6	69.1	7.1	4.7	440	0.6	417.8	5.9	a.47	5.69	0.31	0.12	7.20	0.02	8.70	0.17
Spring Canyon Sandstone Springs																			
BP-1	9	7.9	468	79.3	53.1	11.4	1.7	430	2.2	81.2	15.3	3.95	4.37	0.50	0.04	7.04	0.07	1.69	0.43
SBC-14	9	7.6	1784	144.0	221.1	54.3	16.4	547	1.9	894.9	40.1	7.19	18.20	2.36	0.42	a.97	0.06	18.63	1.13
Spring Canyon Sandstone Wells																			
SDH-1	1	10.2	260	59.0	8.0	44.0	9.0	32	24.0	160.0	61.0	2.94	0.66	1.91	0.23	0.52	0.80	3.33	1.72
SDH-2	1	10.0	280	49.0	2.0	13.0	3.0	87	0.0	63.0	31.0	2.45	0.16	0.57	0.08	1.43	0.00	1.31	0.87
SDH3	1	8.4	358	64.0	36.0	12.0	3.0	396	0.0	1.0	28.0	3.19	2.96	0.52	0.08	6.49	0.00	0.02	0.79
DH-IA	20	7.5	479	59.7	49.8	23.1	11.1	350	0.5	123.9	9.3	2.98	4.10	1.00	0.28	5.74	0.02	2.58	0.26
DH-2	16	7.2	342	67.3	31.0	5.1	1.2	353	0.0	27.8	4.8	3.36	2.55	0.22	0.03	5.79	0.00	0.58	0.14
DH-3	4	7.2	331	67.1	31.4	2.7	0.6	320	0.0	30.3	4.8	3.35	2.59	0.12	0.02	5.25	0.00	0.63	0.14
DH-4	12	7.3	358	72.9	32.2	3.6	0.8	353	0.0	43.2	5.1	3.64	2.65	0.15	0.02	5.79	0.00	0.90	0.14
Average		8.2	344	62.7	27.2	14.8	4.1	270	3.5	64.2	20.6	3.13	2.24	0.64	**0.11**	4.43	0.12	1.33	0.58
Storrs Sandstone Spring																			
Defa #1	1	a.3	656	84.0	63.0	9.0	4.0	371	0.0	261.0	6.0	4.19	5.18	0.39	0.10	6.08	0.00	5.43	0.17
Panther Sandstone Springs																			

Site	n	pH	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HC03 mg/l	CO3 mg/l	so4 mg/l	C1 mg/l	Ca meqll	Mg meqll	Na meqll	K meqll	HC03 meqll	CO3 meqll	so4 meqll	C1 meqll
Big Bear (SBC-4)	37	7.2	355	80.0	32.5	4.3	1.0	339	0.3	56.5	8.5	3.99	2.67	0.19	0.03	5.56	0.01	1.18	0.24
Birch Spring (SBC-5)	39	7.2	470	94.8	42.9	5.7	1.6	368	0.2	117.1	10.8	4.73	3.53	0.25	0.04	6.04	0.01	2.44	0.30
Birch Spring Overflow	1	6.3	701	125.0	60.0	8.0	3.0	439	0.0	200.0	7.0	6.24	4.94	0.35	0.08	7.20	0.00	4.16	0.20
Birch Spring #1 Source	1	6.5	476	89.0	42.0	6.0	2.0	409	0.0	91.0	6.0	4.44	3.46	0.26	0.05	6.70	0.00	1.89	0.17
Birch Spring #2 Source	1	6.6	476	51.0	41.0	6.0	2.0	402	0.0	21.0	7.0	2.54	3.37	0.26	0.05	6.59	0.00	0.44	0.20
Defa #2 Spring	1	7.6	474	84.0	47.0	6.0	2.0	327	0.0	132.0	5.0	4.19	3.87	0.26	0.05	5.36	0.00	2.75	0.14
Average		6.9	492	87.3	44.2	6.0	1.9	381	0.1	102.9	7.4	4.36	3.64	0.26	0.05	6.24	0.00	2.14	0.21
Panther* Sandstone *Well																			
BS-6	8	8.1	345	59.4	31.0	17.5	1.5	243	0.8	43.0	20.0	2.96	2.55	0.76	0.04	3.98	0.03	0.89	0.56

The solute composition and concentration of North Horn Formation spring FBC-6A is substantially different than the remainder of the springs in the upper formations. Water from FBC-6A is a magnesium-calcium-bicarbonate-sulfate type water with a mean TDS concentration of 1,361 mg/l. The chemical composition of this water indicates the dissolution of carbonate minerals and gypsum. That this water discharges near the discharge location of SMH-1, a low-TDS calcium-bicarbonate water, suggests that groundwater discharging from the North Horn Formation is not supported by a large aquifer system, but instead by a number of small, localized systems that are not in good hydraulic communication with each other.

With the exception of two springs, groundwaters that discharge from springs in the Blackhawk Formation are similar to waters in the overlying formations. These waters are calcium-bicarbonate type waters with a mean TDS concentration of 3 19 mg/l (Table 3).

Two waters with distinctive solute composition discharge near the base of the Blackhawk Formation in Bear Canyon just east of the trace of the Bear Canyon Fault. These waters, 16-7-24-3 and SBC-17, are magnesium-sulfate waters with elevated TDS (mean about 1,450 mg/l). Similar solute compositions are found in water of the Star Point Sandstone (SBC-14) and in the Bear Canyon alluvial sediments (well SBC-3), which are derived from the Mancos Shale. SBC-14 and SBC-3 are also located in Bear Canyon immediately to the east of the Bear Canyon Fault. The evolution of this distinctive solute composition is problematic, and the mineralogy of the rocks that contributed to this solute composition is unknown.

Magnesium sulfate (epsomite) is not a common evaporite mineral but may be associated with these marine rocks.

Groundwater inflows to the Bear Canyon Mine, to both the Blind Canyon Seam and the Tank Seam, are calcium-magnesium-bicarbonate type waters with mean TDS of 345 mg/l (Table 3; Figure 15). Waters of the Spring Canyon Sandstone below the workings of the Bear Canyon mine (DH-2, DH-3, and DH-4) and water discharging from Big Bear Spring have nearly identical chemical compositions to those waters encountered in the Blind Canyon Seam and Tank Seam workings. We attribute the similar solute compositions and concentrations in mine inflow waters, the Spring Canyon Sandstone, and Big Bear Spring to similar geochemical evolutionary pathways. However, taken alone, these data might suggest that these waters are in hydraulic communication with each other. One indication that these waters are not in hydraulic communication is the solute composition of well DH-1A. This well is completed in the Spring Canyon Sandstone and is located only 1,500 feet from DH-3. Water from this well has a much greater sulfate concentration (124 mg/l) than water from DH-2, DH-3, and DH-4 (mean = 34 mg/l) and somewhat higher magnesium, sodium, and potassium concentrations. This water appears to be influenced by contact with the Mancos Shale rocks that occur immediately below the Spring Canyon Sandstone. The fact that water encountering the Mancos Shale becomes elevated in solute content suggests that water does not migrate downward from the Blackhawk Formation or the Spring Canyon Sandstone through the interbeds of Mancos Shale to provide water to the Panther Sandstone.

Groundwater inflows to the Blind Canyon Seam and Tank Seam workings have lower solute and TDS concentrations than water encountered in semi-horizontal drill holes drilled across the Blind Canyon Fault. Water on the west side of the Blind Canyon Fault (3rd West South; Table 3) has a TDS concentration of 739 mg/l compared to 345 mg/l in the waters east of the fault, and a higher sulfate concentration of 234 mg/l compared to 39 mg/l east of the fault. This suggests that waters that are west of the Blind Canyon Fault do not flow eastward into the area of the Bear Canyon Mine workings. This is also confirmed by observations of dry fault gouge material where mine workings encounter the fault.

Similarly, waters that are east of the Bear Canyon Fault likely do not flow into the workings of the Bear Canyon Mine. As noted above, waters discharging from two springs, 16-7-24-3 and SBC-17, on the east side of the Bear Canyon Fault in Bear Canyon have large magnesium and sulfate concentrations. Waters with similar concentrations have not been encountered west of the Bear Canyon Fault.

Groundwater at in-mine sampling point SBC-13 is collected from a mine sump. That this water has higher concentrations of calcium, magnesium, sulfate, and TDS is attributed to exposure to the mine environment and is likely a result of the dissolution of rock dust and the oxidation of pyrite.

Groundwater discharge from the Bear Canyon Mine at NPDES-004 closely reflects the composition and concentration of water at SBC-9, which is water from the large sandstone paleochannel encountered in the northern extent of the Blind Canyon workings. Mine water discharge at the Mohrland Portal has higher concentrations of TDS, calcium, magnesium, bicarbonate, and sulfate than most groundwaters that discharge from the Blackhawk Formation. The cause of this increased mineralization is likely due to the interactions of groundwater with the mine environment.

Most groundwaters in the Star Point Sandstone are calcium-magnesium-bicarbonate type waters. Exceptions to this generalization are waters from wells SDH-1, SDH-2, and SBC-14. With the exception of these three waters, the average TDS concentration of water in the Star Point Sandstone is 420 mg/l. Star Point Sandstone groundwaters are discussed in the following paragraphs.

Water discharging from Defa #1 Spring discharges from the Storrs Sandstone in close proximity to Big Bear Spring and Defa #2 Spring. Discharge from all three of these springs is fracture-related, but not necessarily from the same fracture. Water from Defa #1 Spring has substantially higher concentrations of magnesium and sulfate (Table 3) than do waters discharging from either Defa #2 or Big Bear springs. What this means is that water that discharges from Defa #2 or Big Bear Spring is not in good hydraulic communication with water in the rock or fractures of the overlying Storrs Sandstone.

Like water discharging from Defa #1 Spring, water in Bear Canyon Creek at BC-1 has higher magnesium and sulfate concentrations than water discharging from Defa #2 or Big Bear springs. What this indicates is that Bear Canyon Creek is likely not a significant source of recharge to the Panther Sandstone.

As noted previously, water that discharges from SBC-14, east of the Bear Canyon Fault is highly mineralized compared to any water that discharges from the Star Point Sandstone west of the Bear Canyon Fault. The evolutionary pathway of the chemistry of SBC-14 is unknown.

Water in wells SDH-1 and SDH-2 have lower TDS concentrations (260-280 mg/l; Table 3) than other waters in the Star Point Sandstone. When Mayo and Associates collected the water sample from SDH-2, water in the well bore still contained drilling foam (water was soapy with an elevated pH). We did not collect the sample from SDH-1, but it also has an elevated pH. Based on these observations we are reluctant to say that the chemistry of these waters are representative of groundwater conditions in the Star Point Sandstone at these locations. The fact that residual drilling foam was present in these wells may indicate that there is not sufficient active flow in the Spring Canyon Sandstone in the vicinity of these wells to disperse the drilling foam. While residual foam could be attributed to inability of groundwater to mix in the well bore, water extracted from well SDH-3, which was constructed in similar manner to SDH-1 and SDH-2 and was only sampled once with limited purging, does not show indications of residual drilling foam.

In October 1998, while the spring collection system at Birch Spring was undergoing repairs, discrete solute samples were collected from two sources (Birch Spring #1 Source and Birch Spring #2 Source) and a composite sample was collected from the remaining sources (Birch Spring Overflow). The designations of these sources are given by NEWUA on the spring development diagrams (Appendix D). The solute concentrations of Birch Spring #1 Source and Birch Spring #2 Source are similar to other waters in the Star Point Sandstone. The concentrations of TDS, calcium, magnesium, and sulfate in Birch Spring Overflow are somewhat elevated relative to other Star Point waters. The elevated solute concentrations in Birch Spring Overflow are attributed to influence from Mancos Shale rocks.

The impact of groundwater contact with the Mancos Shale is clearly demonstrated by the solute chemistry of SBC-3. This well is constructed in the alluvium of Bear Canyon at a point where much of the alluvium is derived from a sliver of Mancos Shale on the east (upthrown) side of the Bear Canyon Fault (Figure 4). The average TDS concentration of this water is 2,842 mg/l and has especially elevated calcium, magnesium, sodium and sulfate concentrations.

The baseflow solute compositions and concentrations of a given creek reflect the chemistry of the groundwater discharge within that particular drainage. The water quality of creeks is addressed in greater detail in Section 7.0.

5.3 Tritium and Radiocarbon

The concept of groundwater age is difficult to define because water arriving at a well or spring seldom travels via pure piston flow. Instead, it is usually a mixture of water molecules that recharged at different locations and at different times, and thus water has no unique age. It is, therefore, best to think of a groundwater ‘age’ as the mean residence *time* of the water molecules sampled at the well or spring. In this report, the term *radiocarbon age* is synonymous with the concept of *mean residence time.*

In this investigation, two radiogenic isotopes, tritium (^3H) and radiocarbon (^{14}C), have been used to evaluate mean residence times. Tritium is a qualitative tool indicating if groundwater has a component of water that recharged since about 1954. Groundwater that recharged prior to about 1954 will contain essentially no tritium. Radiocarbon provides information regarding the number of years that have elapsed since the groundwater became isolated from soil zone gases and near-surface waters. Like tritium, radiocarbon can indicate if groundwater has a component that recharged since the 1950s. Groundwaters with radiocarbon contents greater than about 50 pmc contain anthropogenic (human-induced) carbon associated with atmospheric nuclear weapons testing. It is not uncommon for groundwater issuing from a spring or occurring in a well to be a mixture of old (i.e. containing no tritium) and younger groundwaters.

The tritium and radiocarbon contents of groundwaters in the study area are listed in Table 4 and are discussed below.

Flagstaff, North Horn, Price River, and Blackhawk springs

The tritium contents of 10 spring waters that discharge from the Flagstaff Limestone, North Horn Formation, Price River Formation, and Blackhawk Formation were measured. Tritium contents in these springs varied from 12 to 32 TU (Table 4) which indicates that modem recharge water supports these springs. This is consistent with the seasonal and climatic discharge fluctuations observed in these springs (Section 4.1). Samples were collected from five of these springs in both the springtime and the fall. Although tritium concentrations varied spatially, concentrations varied only slightly between spring and fall. What this

Table 4 Isotopic compositions of creek, spring, well, and mine waters

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Site	Date	Data Source	δ^2H (‰)	$\delta^{18}O$ (‰)	$\delta^{13}C$ (‰)	$\delta^{34}S$ (‰)	^{14}C (pmc)	^3H (TU)	Calculated Radiocarbon Age
Creeks									
BC-1	5126198	1	-113.19	-14.70	-5.9	+7.5	57.90	13	Modern
BC-1	10129198	1	-115.84	-15.50				23	
BC-1	116199	1	-113.28	-15.405					
BC-2	5126198	1	-116.03	-15.05					
BC-2	116199	1	-120.92	-16.745					
Cedar Creek	10118196	1	-116.94	-15.47					
CK-2	6129198	1	-118.35	-15.63					
CK-2	10112198	1	-111.96	-14.43				17	
MH-1	6110198	1	-121.08	-16.01					
MH-1	10/12/98	1	-120.89	-16.05					
Miller Creek	10118196	1	-124.55	-16.01					
Bear Canyon Alluvium Well									
SBC3	1119198	1	-115.95	-15.54	-11.4	+6.5	69.00	7.79	Modern
Flagstaff Limestone-North Horn Formation-Price River Formation Springs									
16-7-12-6	6110198		-122.13	-16.47				20	
16-7-12-6	10112198		-125.16	-16.51				20	
16-8-5-1	10/18/96		-120.32	-15.61					
16-8-5-l	6/30/98		-119.98	-15.96				13	
16-8-5-1	10112198		-118.66	-15.88					
16-8-6-1	10118196		-119.58	-15.58					
16-8-6-I	6129198		-121.15	-15.99	-11.5	+2.0	97.42	12	Modern
16-8-6-1	10/12/98		-120.99	-16.07	-10.2	+1.8	80.25	12	Modern
168-7-3	6129198		-113.00	-15.66					
FBC-12	6129198		-121.14	-16.18				29	
FBC-12	10/12/98		-123.04	-16.30				32	
SBC-15	6129198		-122.41	-15.84					
SBC-15-UP	6129198		-119.33	-15.95					
SBC-16	6129198		-119.78	-15.70					
SBC-19	6129198		-121.51	-15.86					
SMH-1	6110198		-124.49	-16.15	-11.1	+1.9	77.66	22	Modem
SMH-1	10112198		-125.65	-16.46				25	
SMH-2	6110198		-122.31	-16.01					
SMH2	10112198		-123.64	-16.07				21	
SMH-3	6110198		-117.80	-16.19	-11.0	+5.0	84.12		Modern
SMH-3	10112198		-120.71	-16.10				22	
SMH-4	6/10/98		-122.43	-16.21					
SMH-4	10/12/98		-125.17	-16.50				22	
Blackhawk Formation Springs									
16-8-8-5	6129198		-123.06	-15.62				12	
CanyonRoadSpring	10/18/96		-116.62	-15.33					
CanyonRoad Spring	6130198		-119.31	-16.00				20	
CanyonRoadSpring	10/12/98		-112.10	-14.70				19	

Site	Date	Data Source	δ^2H (‰)	$\delta^{18}O$ (‰)	$\delta^{13}C$ (‰)	$\delta^{34}S$ (‰)	^{14}C (pmc)	^3H (TU)	Calculated Radiocarbon Age
East-of-fault deep Blackhawk Formation groundwaters									
3rd West Bleeder	5196	4	-122	-16.8	-12.3	-0.06		-0.05	
3rd West Bleeder	11/13/96	2			-10.9		52.16		500 years
SBC-9	4/8/92	4						0.87	
SBC-9 Source	5196	4	-125	-17.1	-12.1	+11.4		0.40	
SBC-9 Source	5115196	3	-130	-17.2	-10.0	+11.3		0.36	
SBC-9 Source	11113196	2			-10.5		48.04	0.50	1,400 years
SBC-9 Source	116199	1	-129.82	-17.14	-10.4	+3.5	41.62	3.62	2,200 years
SBC-IO	4/8/92	4						1.46	
T.S. North Bleeder	5126198	1	-133.01	-17.01	-9.8	+3.1	44.33	0.07	1,200 years
West-of-fault deep Blackhawk Formation groundwaters									
3rd West South	5196	4	-123	-17.0	-12.0	+10.8		2.22	
3rd West South	11113196	2			-10.6		27.16		5,400 years
3rd West South	1219196	2						-0.02	
3rd West South	116199	1	-118.99	-16.71					
Mohrland Portal Discharge									
16-8-a-I 0	10/18/96	1	-128.37	-16.62					
16-a-a-10	6110198	1	-123.99	-16.83	-9.4	+11.0	19.85	5.52	Mixed / 9,200 years
16-a-a-10	10/12/98	1	-128.99	-16.93	-9.2	+l 1.0	la.39	5.41	Mixed / 9,400 years
Spring Canyon Tongue Wells									
DH-2	11115196	2	-125	-17.1	-10.8		50.17	-0.03	900 years
SDH2	6130198	1	-119.11	-17.09	-25.6	4.1	65.05	0.13	Problematic
SDH3	6/30/98	1	-121.63	-17.19	-11.6	+16.8	35.14	0.32	3,000 years
Storrs Tongue Spring									
Defa Spring #1	116199	1	-118.58	-16.53	-7.9	+0.7	52.95	7.70	Mixed
Panther Tongue Springs									
Big Bear Spring (SBC-4)	4/a/92							17.2	
Big Bear Spring (SBC-4)	5120196	3	-127	-16.7	-9.7	+5.4		14.2	
Big Bear Spring (SBC-4)	5/26/98	1	-129.77	-16.51	-9.6	+6.0	56.02	14	Mixed
Big Bear Spring (SBC-4)	10/29/98	1	-125.39	-16.65	-10.5	+5.1	54.39	17	Mixed
Big Bear Spring (SBC-4)	1/6/99	1	-119.66	-16.58					
Birch Spring (SBC5)	4127192	4						1.12	
Birch Spring (SBC-5)	5120196	3	-129	-17.0	-10.3	+3.8		0.35	
Birch Spring (SBC5)	5/26/98	1	-126.90	-16.85	-10.6	+3.0	43.05	0.49	1,700 years
Birch Spring (SBC-5)	9/15/98	1	-129.61	-17.01					
Birch Spring Drip	9/15/98	1	-131.31	-17.20					
Birch Spring Lower East Seep	9/15/98	1	-128.51	-17.01					
Birch Spring Lower West Seep	9/15/98	1	-105.07	-13.58					
Birch Spring #1 Source	10/29/98	1	-129.49	-17.05	-12.4	+5.1	40.33	0.33	3,600 years
Birch Spring #2 Source	10/29/98	1	-130.94	-17.18	-9.8	+5.0	36.21	0.37	2,500 years
Birch Spring Overflow	10/29/98	1	-128.15	-17.07	-10.4	-7.8	45.47	0.47	1,100 years
Defa Spring #2	1/1/99	1	-120.63	-16.645	-10.2	+3.5	42.21	7.69	Mixed / 1,600 years

Data sources 1 Collected by Mayo and Associates for this investigation
2 Collected by Mayo and Associates for the 1996 hearing
3 Collected by EarthFax Engineering
4 Collected by Co-Op Mining Company

suggests is that most groundwater recharge to these particular systems likely occurs as a single event during the snowmelt.

Bear Canyon Mine inflows

Three groundwater inflows to workings in the Blind Canyon Seam have been sampled as part of this and previous investigations. Sampling locations in the Bear Canyon Mine are shown on Figure 11. Samples have also been collected for tritium and radiogenic carbon analysis fi-om angled test holes drilled from the Blind Canyon workings across the Blind Canyon Fault. As part of this investigation, a sample from a recent inflow to the Tank Seam was analyzed for tritium and radiogenic carbon.

The largest groundwater inflow to the Bear Canyon Mine occurred in the northern extent of the Blind Canyon workings. This inflow is associated with a large sandstone paleochannel. Two sites (SBC-9 and SBC-10) have been established to monitor the quality and quantity of this water. Samples were collected at both of these sites for tritium in 1992. In May and November 1996 and in January 1999 samples were collected directly from one of numerous roof drips contributing water to SBC-9. These samples are designated SBC-9 Source.

Water from this sandstone channel contained little tritium (0.36 to 0.87 TU) when sampled in 1992 and 1996. A radiocarbon age of 1,400 years was calculated for water collected from SBC-9 Source in November 1996. However, when sampled in January 1999, the tritium concentration increased to 3.62 TU and the radiocarbon age increased to 2,200 years. What this suggests is that the groundwater system supporting the discharge from the sandstone channel was not in active hydraulic communication with the surface prior to being encountered by mining. The increased tritium content measured in January 1999 is possibly the result of induced downward migration of surface water along a small fault in the Bear Canyon Fault Zone, both sides of which have been subsided. The increase in the radiocarbon age of the water is attributed to induced flow from some other part of the sandstone paleochannel that contained older water.

A small inflow from the roof in the 3rd West Bleeder of the Blind Canyon workings was sampled in May and November 1996. The sample contained no tritium and had a radiocarbon age of about 500 years. This suggests that this inflow was not in active hydraulic communication with the surface.

A large sandstone channel that yielded water was encountered in the northern extent of the Tank Seam workings. This water (T.S. North Bleeder) contained no tritium and had a radiocarbon age of 1,200 years, indicating that this groundwater system is not in active hydraulic communication with the surface.

Test holes drilled from the Third West South area of the Blind Canyon workings intercepted groundwater west of the Blind Canyon Fault. This water was sampled in May 1996 for tritium. The tritium content of this water was 2.2 TU. However, in December 1996, water discharging from these holes contained no tritium. Because one of the test holes encountered the soil zone, the tritium content of the water in May 1996 is attributed to snowmelt water entering this test hole. Consequently, the December 1996 sample is more representative of groundwater in the rocks west of the Blind Canyon Fault. The radiogenic carbon content of this water was measured in a sample collected in November 1996. The calculated radiocarbon age of this water is 5,400 years. The disparity between the radiocarbon ages of water encountered west of the Blind Canyon Fault and groundwater inflows to the Bear Canyon Mine suggests that the Blind Canyon Fault is a hydraulic barrier.

Star Point Mine groundwater inflows

One sample of a groundwater inflow to the Star Point Mine was collected by Cyprus Plateau Mining Company (Star Point MRP, 1996). This sample was from a roof drip in the Wattis Seam workings. This sample had a radiocarbon content of 34 pmc. We have calculated the radiocarbon age of this water using a linear mixing model (Pearson and Hanshaw, 1970) to be 2,500 years. (The Star Point MRP (1996) reports the radiocarbon age of this water as 8,670 years; this is an incorrect age because the necessary corrections have not been applied to account for the contribution of dead carbon from the dissolution of carbonate minerals in the groundwater system.)

Mohrland Portal Discharge

Groundwater discharging from the Mohrland Portal in Cedar Canyon was sampled for tritium and radiogenic carbon in June and October 1998. Water discharging from these abandoned mine workings contains 5.5 TU and has a radiocarbon age of 9,000 years. This indicates that the water is a mixture of modem waters with waters in excess of 9,000 years old. We suspect that the modem water component enters the mine working where the overburden is thin and/or may be related to water that was diverted (until 199 1) from Miller Creek into the workings of Hiawatha #2 Mine which were used for water storage, (Hiawatha MRP, 1992). The old component is likely associated with the Bear Canyon Fault, which has been identified as the source of much of the water discharging from the Mohrland Portal (Hiawatha MRP, 1992).

Spring Canyon Sandstone wells

Three wells completed in the Spring Canyon Sandstone have been sampled for tritium and radiogenic carbon. Well DH-2 was drilled from the Blind Canyon workings of the Bear Canyon Mine. Water from this well, sampled in November 1996, contained no tritium and had a radiocarbon age of 900 years. Wells SDH-2 and SDH-3 were drilled from the surface and were sampled in June 1998. Water from these wells contained essentially no tritium and water from SDH-3 had a radiocarbon age of 3,000 years. A radiocarbon age for water from well SDH-2 could not be calculated because of the residual influence of drilling foam in the well. (Water from the well formed soap bubbles when extracted from the well; difficulty in pumping water from 1,600 feet precluded purging of the well.) This is indicated by the unusually negative $\delta^{13}C$ value (-25.6) and elevated pH (10.0).

These data indicate that groundwater in the Spring Canyon Sandstone is not in active hydraulic communication with the surface.

Big Bear Spring (SBC-4), Defa #1 Spring, and Defa #2 Spring

Groundwater discharging from Big Bear Spring was sampled for tritium in April 1992, May 1996, and in May and October 1998. Radiocarbon contents were measured in May and

October 1998. Groundwater sampled from Big Bear Spring had tritium contents ranging from 14 to 17 TU and radiocarbon contents of about 55 pmc. The calculated radiocarbon age of water from Big Bear Spring is modem.

As noted in Section 4.1.6, discharge from Big Bear Spring has two components, a seasonal component that is likely derived from local systems and has a residence time less than one year, and a more constant baseflow component that is part of a larger system with a longer residence time and a large storage volume. Isotopic analysis of water from Big Bear Spring has occurred only recently and data are available for the baseflow component only. The tritium and radiogenic contents of Big Bear Spring suggest that the baseflow component is itself comprised of two components: a recent component, which does not show large seasonal discharge fluctuations and a component with some antiquity.

The tritium content and calculated radiocarbon age of water from Big Bear Spring is consistent with modem recharge waters encountered in springs discharging from the Blackhawk Formation and higher stratigraphic units. However the relatively low radiogenic carbon content of Big Bear Spring (55 pmc) coupled with a large tritium content (14 to 17 TU) suggests that the baseflow component of Big Bear Spring is a mixed water. It can be observed in groundwaters that discharge higher in the section that large tritium contents (12 to 30 TU) are accompanied by radiogenic carbon contents ranging from 77 to 97 pmc. This is expected because tritium contents greater than about 8 to 10 TU and radiogenic carbon contents significantly greater than about 50 pmc are a result of atmospheric nuclear weapons testing (anthropogenic source). That a water contains anthropogenic tritium yet has a small anthropogenic radiogenic carbon content suggests that mixing of waters with different residence times has occurred.

Two springs which discharge near Big Bear Spring were recently sampled in an effort to better understand groundwater dynamics of the Star Point Sandstone. These springs have been designated Defa #1 and Defa #2 springs. Defa #1 Spring discharges from the Storrs Sandstone and Defa #2 Spring discharges from the base of the Panther Sandstone. Like Big Bear Spring, both of these springs contain tritium yet do not contain appreciable anthropogenic radiocarbon. Defa #1 Spring has a radiocarbon content of 53 pmc which yields a modem calculated radiocarbon age. Defa #2 Spring, however, has a radiocarbon content of 42 pmc and a calculated radiocarbon age of 1,600 years. Thus, like Big Bear Spring, both of these springs discharge mixed water.

Because of the proximity of Big Bear Spring and Defa #2 (about 500 feet) and because they discharge from the same stratigraphic horizon, these waters may be related. This being the case, it can be surmised that the older component of water discharging from Big Bear Spring has a residence time greater than 1,600 years. If we make the assumption that water discharging from Big Bear Spring and Defa #2 Spring are mixtures of the same old water and the same modem water, only in different proportions, a regression analysis yields the approximate radiocarbon content of the old portion of the water. This analysis suggests that the old portion of the water has a radiocarbon content of about 32.5 pmc. A linear mixing model (Pearson and Hanshaw, 1970) yields a radiocarbon age of 3,500 to 4,500 years for the old portion. Because of the uncertainty in the assumptions used to derive the residence time of the old portion of water in Big Bear Spring, we view this radiocarbon age only as a suggestion of what the actual age might be.

The differences in the radiocarbon contents and solute compositions and concentrations (Section 5.2.2) of Defa #1 and Defa #2 springs suggest that there is little hydraulic communication between the Storrs Sandstone and the Panther Sandstone due to interbedded shale separating these two sandstones. Both of these springs are fracture-related, and so this hydraulic disconnect appears to be operative even in fracture-controlled systems.

That Defa #1 and Defa #2 springs contain a significant portion of older water suggests that the water discharging from these springs is not likely the same water that previously provided a portion of the seasonal flow component previously seen in Big Bear Spring.

Birch Spring (SBC-5)

A composite sample of groundwater from Birch Spring was sampled for tritium in April 1992 and May 1996 and for tritium and radiogenic carbon in May 1998. In October 1998, while the spring collection was undergoing repairs, discrete samples for tritium and radiogenic carbon were collected from two sources and a composite sample was collected from the remaining three sources. Except for the 1992 sample, water from Birch Spring contains less than 0.5 TU and has calculated radiocarbon ages of 1,100 to 3,600 years. The 1992 sample contained 1.12 TU. The small quantity of tritium in water from Birch Spring is likely the result of mixing of older water with modern recharge water. These data are consistent with observations reported in Section 4.1.6 that the discharge from Birch Spring does not show seasonal discharge variations and is likely supported by a more extensive groundwater system than those that support springs higher in the section.

Radiocarbon data from the discrete sources supplying water to the Birch Spring collection system lend insight into the hydrodynamics of the fracture flow groundwater system that supports the spring. Groundwater from Birch Spring #1 Source has a radiocarbon age of 3,600 years while groundwater from Birch Spring #2 Source has a radiocarbon age of 2,500 years. These spring sources discharge from fracture planes separated at the discharge point by about 10 feet. The sample designated Birch Spring Overflow is a composite sample of the remaining three sources and had a radiocarbon age of 1,100 years. What the differences in these radiocarbon ages suggest is that the fracture system supporting this discharge is not well inter-connected and that individual fractures may convey water independently of each other. There is likely little or no lateral communication between parallel fractures.

Bear Canyon Alluvium

The tritium and radiocarbon contents of SBC-3 (Table 4) indicate a modem origin of water from well SBC-3, which is completed in the alluvium of Bear Canyon near the mine.

Creeks

Tritium concentrations of two creeks in the study area, Bear Creek and Cedar Creek, have been measured (Table 4). Expectedly, waters from these creeks have modem tritium concentrations. Unexpectedly, Bear Creek water had a relatively low radiocarbon content (57.9 pmc) relative to spring waters in the Flagstaff Limestone, North Horn Formation, Price

River Formation, and Blackhawk Formation (77-97 pmc). This combination of large tritium content and relatively low radiocarbon content was interpreted to mean a mixed water in Big Bear and Defa #1 springs. This might suggest, then, that groundwater with antiquity may discharge to Bear Creek, perhaps from the Bear Canyon Fault. However, the discharge in Bear Creek, on 26 May 1998, the day that this sample, was taken was 290 gpm, indicating that a large fraction of the flow was snowmelt derived. Additionally, the stable isotopic ratios (Section 5.4) of this sample of Bear Creek water are not consistent with waters having a mixed origin Thus, the meaning of the tritium and radiocarbon data for Bear Creek is problematic.

5.4 Deuterium and Oxygen-18

The stable isotopic ratios of deuterium (δ^2H) and oxygen- 18 ($\delta^{18}O$) of water falling as precipitation are determined by the temperature at which nucleation of the water droplet occurs. The stable isotopic compositions of waters are usually analyzed relative to the Meteoric Water Line (MWL). The MWL is empirically derived from the worldwide plotting locations of coastal zone precipitation and is defined by the equation $\delta^2H = 8\ \delta^{18}O + 10$ (See Appendix C for further discussion of the MWL). On a plot of δ^2H vs. $\delta^{18}O$, precipitation that forms under cooler conditions will plot more negative than precipitation which forms under warmer conditions.

In addition to the nucleation temperature of the water molecule, several other factors may affect the isotopic composition of recharge water. These factors include rainout and orographic effects and the sublimation of snow prior to the springtime snowmelt.

Except for unusual conditions such as geothermal heating above about 100°C, the δ^2H and $\delta^{18}O$ composition of a groundwater is set at the time of recharge and is not affected by subsurface conditions such as residence time and mineral dissolution and precipitation reactions. In other words, the recharge and flow history of a groundwater can be evaluated independently of the solute content of the water.

The δ^2H and $\delta^{18}O$ ratios of surface waters and groundwaters in the study area are reported in Table 4 and are plotted on Figure 16. All these waters plot near the MWL indicating a meteoric origin (i.e. rain and snow).

The stable isotopic ratios of groundwaters in the study area are divided into three groups as indicated on Figure 16. Group 1, indicated by blue symbols, is comprised of waters with $\delta^{18}O$ ratios greater than about -16.5‰. These waters are from creeks, Flagstaff Limestone, North Horn Formation, Price River Formation, Blackhawk Formation springs, and from the Bear Canyon alluvium well. Group 2, indicated by red symbols, includes waters having $\delta^{18}O$ ratios less than about -16.5‰. These waters are from in-mine sources, wells in the Spring Canyon Sandstone, and Birch Spring (SBC-5). The waters of Group 3 are denoted by green symbols and are waters that have isotopic ratios that are transitional between Group 1 and Group 2. Analysis of these groupings and two exceptions to these groupings, Birch Spring Lower West Seep and BC-2, are discussed below.

Waters of Group 1 are modem waters while all of the waters belonging to Group 2 are waters with antiquity. That Group 2 waters plot more negative than waters of Group 1 is interpreted

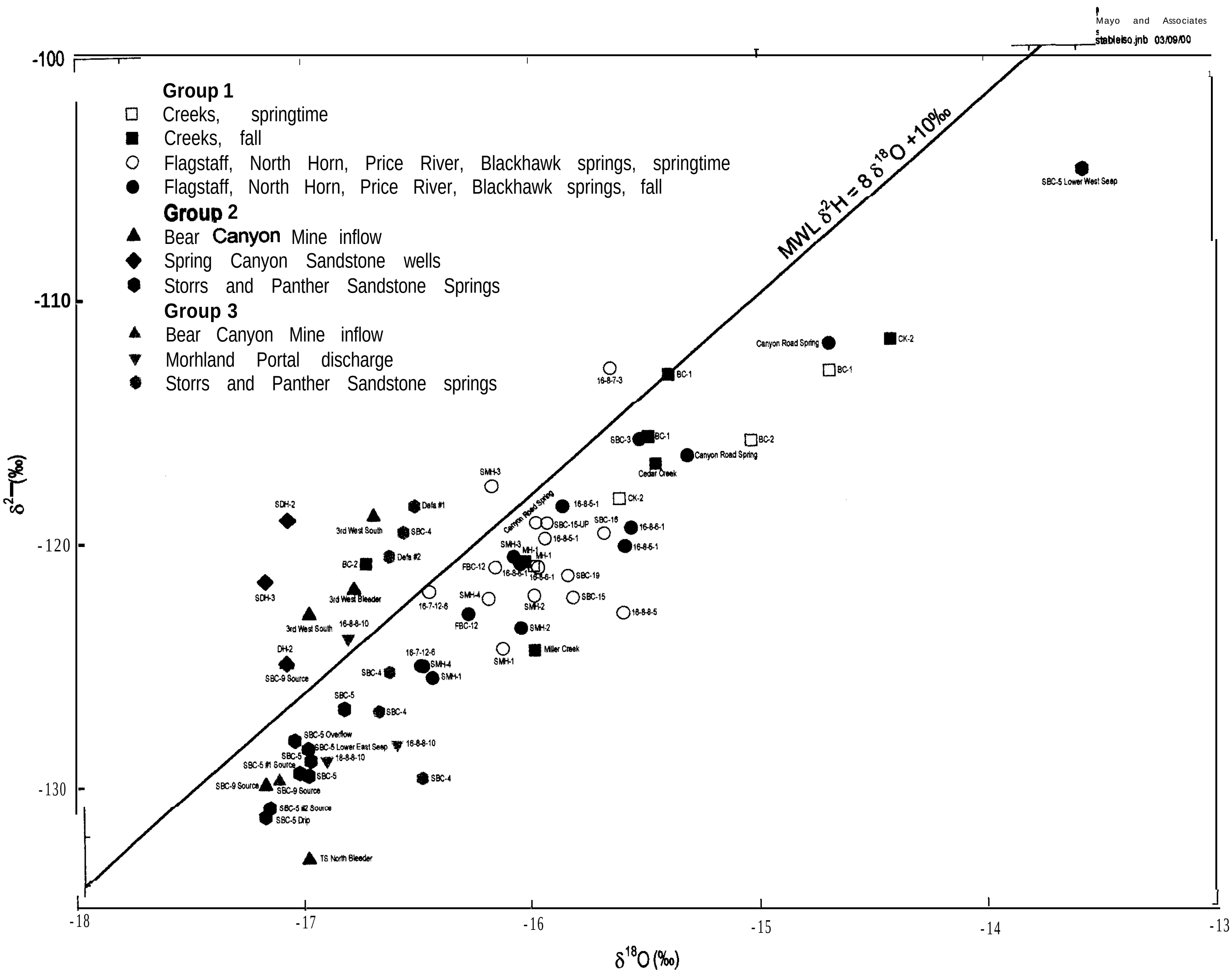

Figure 16 Scatter plot of δ^2H and δ^{18}O compositions of creek, spring, well, and in-mine waters from the study area.

to be a reflection of paleoclimate (i.e., cooler climatic conditions of the past). The relative plotting locations of these groups is not a reflection of differences in the elevation of precipitation formation. If the differences were attributable to groundwater recharge occurring at lower elevations where the Blackhawk Formation and Star Point Sandstone crop out, the stable isotopic ratios of the Blackhawk Formation and Star Point waters would be more positive than waters falling as precipitation higher in elevation. That these waters can be distinguished based on their stable isotopic ratios indicates that Group 2 waters are not in active hydraulic communication with Group 1 waters, meaning that Group 2 waters are essentially isolated from surface waters and near-surface groundwaters.

Among waters of Group 1, the stable isotopic ratios of Flagstaff Limestone and North Horn Formation springs vary spatially. However, the seasonal (spring versus fall) difference between the stable isotopic ratios is small compared to the seasonal difference observed in the stable isotopic ratios of creeks in the study area. A similar phenomenon is noted in tritium contents (Section 5.3) and suggests that recharge to these groundwater systems mostly occurs as a single event during the snowmelt and that little recharge occurs from rainfall.

Waters of Group 3 include the waters identified in Section 5.3 as being a mixture of modem waters with waters having antiquity. Specifically, these waters are Big Bear Spring, Defa #1 spring, Defa #2 spring, and discharge from the Mohrland Portal. That the waters of Group 3 have isotopic ratios intermediate between Group 1 and Group 2 waters further supports the idea that these groundwaters are a mixture of modem and old groundwaters.

Bear Creek has been considered as a possible source of water to Big Bear Spring. However, the large difference in stable isotopic ratios between waters from BC-1 and Big Bear Spring strongly suggests that Bear Creek does not contribute a significant quantity of water to Big Bear Spring. That the stable isotopic ratios of water from BC-2 in January 1999 are consistent with the stable isotopic ratios of Group 2 is a reflection of the contribution of mine water discharge to Bear Creek.

Analysis of stable isotopic ratios in water from Birch Spring (SBC-5) and two seeps below the spring to the south indicate that at least one of these seeps is directly related to Birch Spring. Water discharging from the lower east seep has a strong isotopic affinity for Birch Spring water. However, water in the lower west seep has the most positive stable isotopic composition of any water in the study area. This water may likely be related to Huntington Creek and may also have undergone some evaporation.

6.0 GROUNDWATER SYSTEMS

6.1 Regional picture

The whole of Gentry Mountain is for the most part hydraulically isolated from other areas of the Wasatch Plateau. Figure 17 shows the geology of Gentry Mountain and adjacent areas. Huntington Canyon to the west and south of Gentry Mountain is cut down to the Mancos Shale and Castle Valley to the east is developed on the Mancos Shale. We do not believe that water can be transmitted through the Mancos Shale into Gentry Mountain. Thus, Gentry Mountain is hydraulically isolated on the west, south, and east from adjacent areas, including the highlands of East Mountain to the west. To the north, Gentry Mountain can only be hydraulically connected to other portions of the plateau via a narrow neck of land about two miles wide between Nuck Woodward Canyon on the west and Comer Canyon on the east (Figure 17). What this indicates is that all groundwater in Gentry Mountain either 1) originated as precipitation on Gentry Mountain, or 2) is water that was transmitted into Gentry Mountain through the narrow neck of land on the north.

We have characterized two general types of groundwater systems in Gentry Mountain. These systems are

- Perched groundwater systems, and
- Star Point Sandstone fracture-flow groundwater systems.

We employ the concept of a "groundwater system" in our discussion. A groundwater system includes a recharge area and mechanism, a flow path, and discharge area and mechanism. By characterizing types of groundwater systems, we describe a collection of groundwater

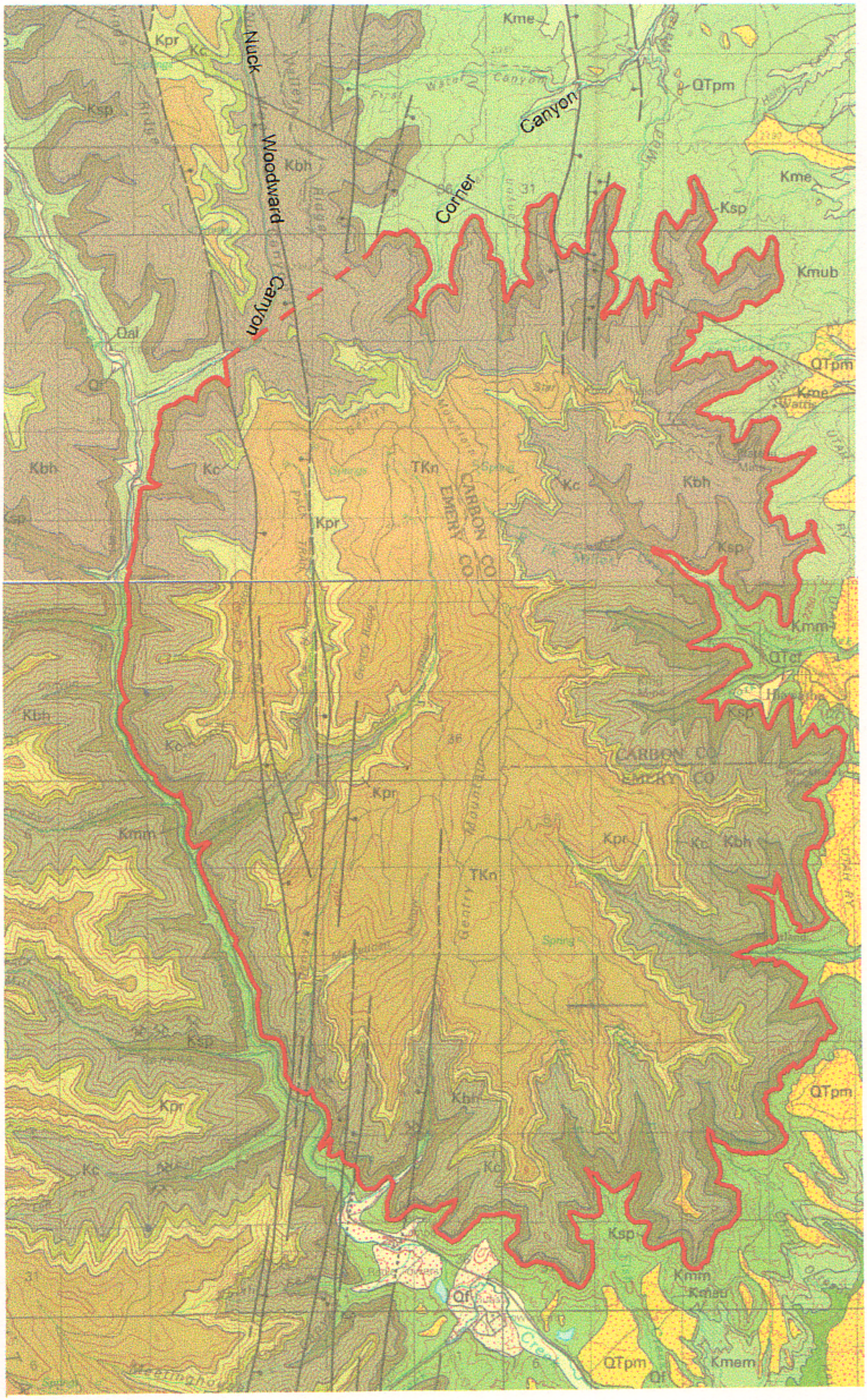

Figure 17 Regional geologic map showing the hydrologic isolation (red outline) of Gentry Mtn. (after Witkind and others, 1987; and Witkind and Weiss, 1991).

systems that operate in a similar fashion but are not necessarily connected to one another hydraulically.

6.2 Perched groundwater systems

A perched groundwater system occurs where rocks of low permeability impede the downward percolation of water and cause groundwater to accumulate above the low permeability horizon. Thus, there is an unsaturated zone beneath the perched groundwater system. This situation is common in the rocks of Wasatch Plateau and Book Cliffs because of the existence of relatively permeable channel sandstones that are interbedded with low-permeability mudstones and shales.

Perched groundwater systems occur in the Flagstaff Limestone, North Horn Formation, Price River Formation, and Blackhawk Formation. In the Flagstaff Limestone groundwater systems are primarily supported by flow in fractures which terminate at the contact with the top of the North Horn Formation. In the North Horn, Price River, and Blackhawk Formations, perched groundwater systems exist in both the intergranular spaces and the joints and fractures of sandstone channels. Based on discharge rate and isotopic information, two types of perched groundwater systems can be discriminated. The terms 'active' and 'inactive' (Mayo and others, 1997) are used to describe these groundwater flow systems, which are discussed below.

Active groundwater flow systems

Active groundwater flow systems have good hydraulic communication with recharge areas and have small storage volumes because of limited lateral and vertical extent. Thus these systems are dependent on annual recharge events and are affected by short-term climatic variability. Groundwater in these systems circulates shallowly and has short flow paths. Active perched groundwater systems support the springs that discharge from all of the bedrock formations except the Star Point Sandstone and the Mancos Shale. It has been suggested (Mayo and others, 1997) that the active groundwater flow systems extend about 500 to 1,000 feet into cliff faces where flow is controlled by fractures and channel sands. Further into the cliff faces the discontinuous character of channel sands prevents active groundwater flow. The vertical movement of groundwater in the active zone is commonly limited to 100 to 200 feet. Active groundwater flow systems contain abundant tritium and anthropogenic radiocarbon.

Inactive groundwater flow systems

Inactive perched groundwater systems are not in good hydraulic communication with recharge and discharge areas. Consequently, the flux of groundwater through these systems is small enough that waters in these systems have measurable antiquity (500-9,000 years in the Gentry Mountain area). Such inactive systems occur in sandstone paleochannels of the Blackhawk Formation and are encountered by mine workings or drill holes. When encountered by mine workings sandstone channels usually drain quickly, indicating poor hydraulic communication with recharge areas. The large inflow to the Blind Canyon Seam in the Bear Canyon Mine (Section 4.2) is from a large sandstone paleochannel. Water from this sandstone paleochannel contained no tritium when first encountered and had a radiocarbon age of 1,400 years (Section 5.3). Short lived groundwater inflows were also encountered in the Star Point Mine (Section 4.2.3).

In addition to antiquity and the lack of tritium, there are other indications that the waters in the perched inactive groundwater systems of the lower Blackhawk Formation are not in good communication with recharge areas on the top of the plateau. First, the lack of springs in the Price River Formation, Castlegate Sandstone, and upper Blackhawk Formation suggests that water is generally not being transmitted downward through North Horn Formation rocks. Second, springs in the lower Blackhawk Formation are scarce, and the discharge from those that do issue from the formation is dependant on seasonal recharge (Section 4.1), suggesting that these systems are recharged locally.

In our experience, most fault-related groundwater inflows to mine workings in the Wasatch Plateau and Book Cliffs appear to be supported by water draining from a sandstone channel which is cut by the fault rather than by water in the fault plane itself. We suspect that the water that was encountered in the Bear Canyon Fault in the mine workings of the Hiawatha Complex is likely associated with a large sandstone channel. Otherwise, it is difficult to envision a reservoir of water large enough to sustain, for such a long period of time, the discharge of water from the Mohrland Portal that has a radiocarbon age greater than 9,000 years.

6.3 Star Point Sandstone fracture-flow groundwater systems

Fracture-flow groundwater systems exist in the Star Point Sandstone. Although fracture flow occurs in sandstone units of overlying formations, these fractures are of limited lateral extent and do not convey large quantities of water over long distances. The Star Point Sandstone is a marine shoreface sand deposit that has greater lateral extent than do channel sands in the overlying formations, and is therefore more capable of transmitting water through fractures for great distances. Because there are no significant shales or mudstones in the tongues of the Star Point Sandstone, fractures in the Star Point can remain open and continuous over large distances. However, the interbedded shales of the Mancos Shale prohibit significant groundwater flow between the tongues of the Star Point Sandstone. Natural discharge from fracture-flow groundwater systems supports two significant Star Point Sandstone springs on Gentry Mountain. These are Big Bear Spring (SBC-4) and Birch Spring (SBC-5), which are located immediately south of the existing permit area.

Analysis of solute, isotopic, and piezometric data suggests that groundwater in the fracture system at Big Bear Spring is not in communication with groundwaters in overlying horizons. What this indicates is that groundwater recharge to the Star Point Sandstone fracture-flow groundwater systems does not occur through the downward percolation of water, either through fractures or the pore spaces of rocks. Instead, groundwater recharge to each member of the Star Point Sandstone occurs where that member is exposed at the surface. Both Big Bear Spring and Birch Spring discharge from the Panther Sandstone; hence, recharge to these systems occurs where the Panther Sandstone is exposed at the surface. More particularly, recharge occurs where the specific fracture set from which a spring discharges is exposed at or near the surface. This is indicated by the large differences in radiocarbon ages of groundwaters discharging from individual fracture planes at Birch Spring. This is also demonstrated by the fact that only a few of the many fractures visible in the tongues of the Star Point Sandstone discharge water. If water were being transmitted horizontally in significant volumes perpendicular to fractures, more fractures would likely support groundwater discharge. Instead, those sets of fractures that do discharge water are either endowed with some different quality that allows them to convey water or, more likely, these fracture sets have good recharge potential due to exposure at or near the surface probably near a perennial surface drainage.

Discharges from both Big Bear Spring and Birch Spring have components of water with different residence times. Big Bear Spring has as least three components, two modern and one which may have some antiquity. The different sources of Birch Spring have substantially different radiocarbon ages and there is a suggestion that in the past during wet periods the spring may have had a component of modern water as well. What this indicates is that there is not a single recharge location for these fracture-flow systems. The modern components of these two springs are likely waters that recharged locally and had a relatively short flow path. Waters with antiquity likely recharged some distance from the spring. We have not been able to determine, nor do we believe that it is possible to readily ascertain, where the recharge locations for these springs are. Possible candidates include some of the more deeply incised canyons to the north such as Tie Fork and Nuck Woodward Canyons (Figure 17).

Sustained groundwater discharge from the fracture-flow systems is supported by the Panther Sandstone and perhaps the Storrs Sandstone. (Although discharge from Defa #1 Spring has only been measured once, we suspect that this is likely a sustained groundwater discharge from the Storrs Sandstone.) That sustained discharge is not supported by the Spring Canyon Sandstone suggests that 1) fractures in the sandstone are not in good communication with recharge sources, 2) the sandstone may contain, in some location, a fraction of shale that impedes fracture flow, or 3) there is vertical communication along fractures between the tongues of the Star Point so that most discharge is from the lowest sandstone. Because only two fracture sets in the Panther Sandstone convey water, and only one of these fracture sets discharges a large quantity of water (200 gpm), it seems most plausible that fractures in the Spring Canyon or Storrs sandstones are not in good hydraulic communication with a significant recharge source just as the remainder of the fractures in the Panther Sandstone are not in hydraulic communication with recharge sources. As discussed in Section 5.3, water from Defa #1 Spring, which discharges from the Storrs Sandstone, is chemically and isotopically distinct from water discharging from Big Bear and Defa #2 springs, which discharge from the Panther Sandstone. All of these waters discharge from fractures within a 500 foot zone. This suggests that water is not being transmitted in significant quantities between sandstones even where fractures exist.

7.0 SURFACE WATER SYSTEMS

The study area is drained by several small drainages (Figure 18). Trail Creek, McCadden Hollow, Blind Canyon, Bear Creek, and the Left and Right Forks of Fish Creek drain south to Huntington Creek, a tributary of the San Rafael River. Surface water in the northeastern portion of the study area drains to Cedar Creek, a tributary of the Huntington Creek.

There are large temporal variations in stream flow within the study area, resulting from seasonal recharge by storm and snowmelt events. During the snowmelt period, ephemeral, intermittent, and perennial streams carry large amounts of runoff water. However, during the spring and summer, as temperatures rise and the snowpack is depleted, stream flows decrease considerably or dry up altogether.

The locations of stream monitoring sites are shown on Figure 18. Available stream flow data are reported in Appendix A and are presented as hydrographs in Figure 19. From these data, several of the drainages appear to have perennial flow, including lower Trail Creek, Bear Creek, and lower Cedar Creek. Upper Trail Creek, McCadden Hollow, Blind Canyon, Left Fork and Right Fork of Fish Creek, and upper Cedar Creek appear to be intermittent or ephemeral. The individual drainages are discussed separately below.

7.1 Trail Creek

Trail Creek is a tributary of Huntington Creek. The creek and surrounding hillsides are steep, with hillsides ranging from 60% to 80% grades, and the stream channel ranging from a 10% grade in the lower reaches to 30% grades higher up. Stream flow has been measured since

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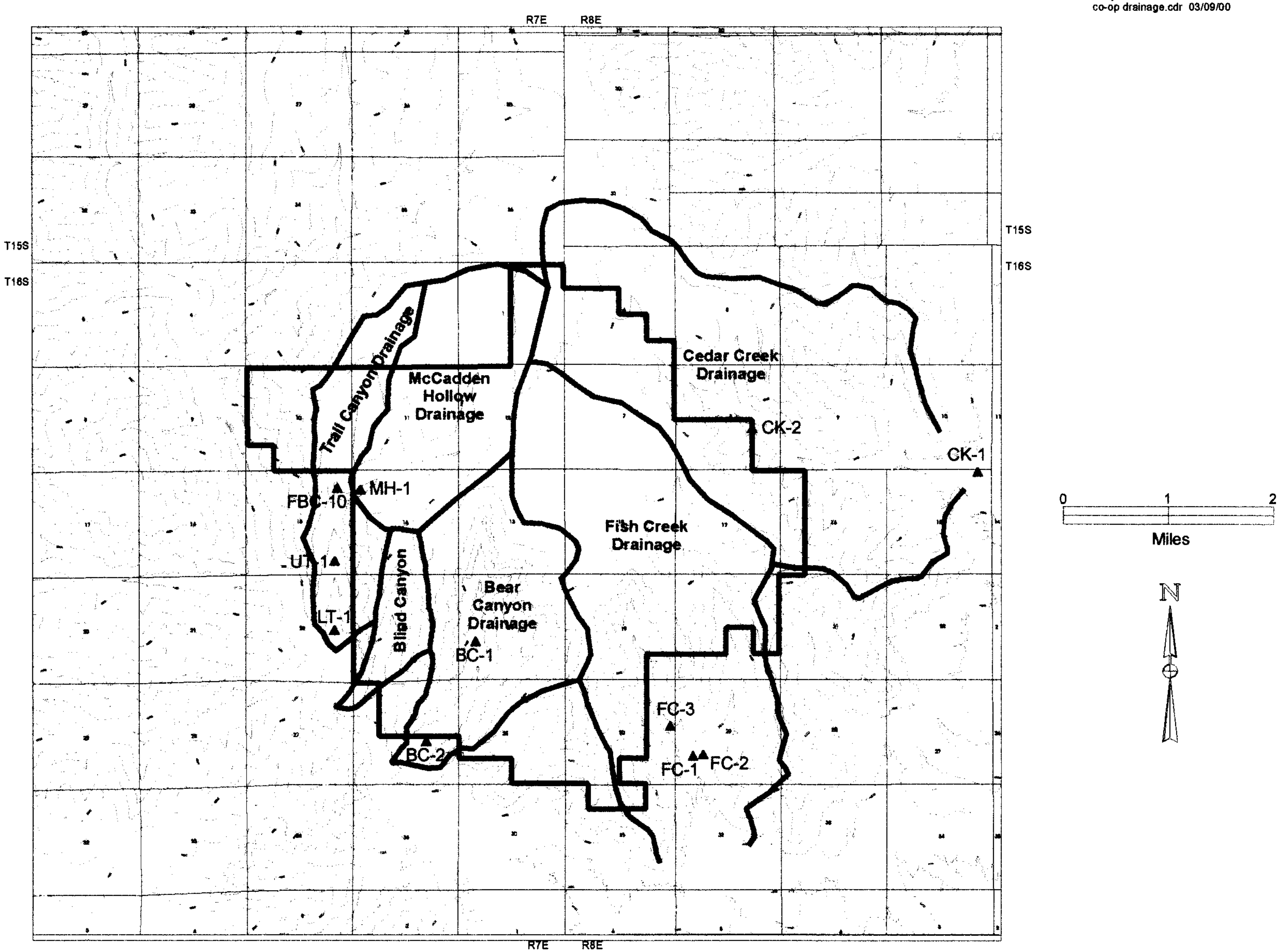


Figure 18 Surface drainages within the study area.

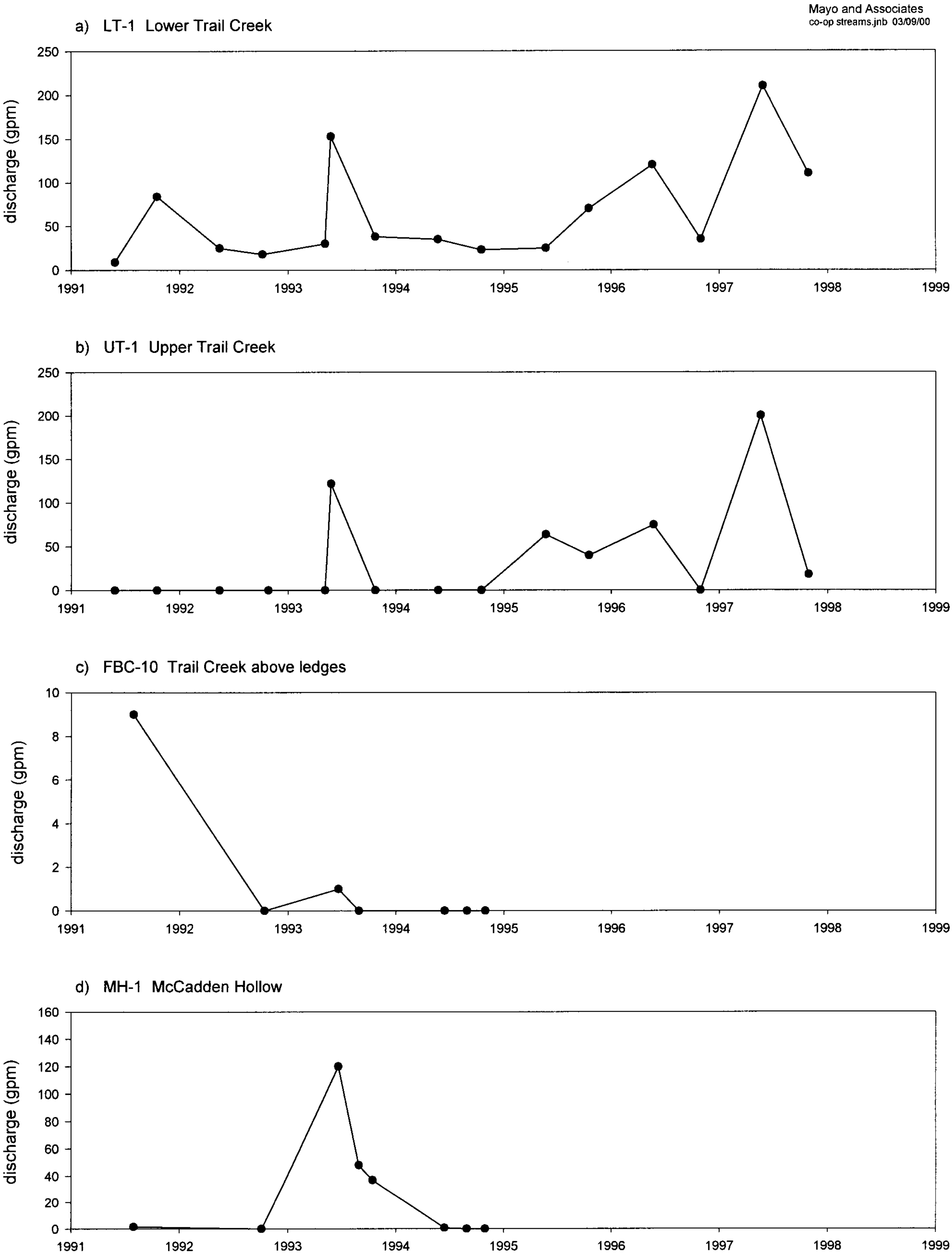


Figure 19 Stream hydrographs.

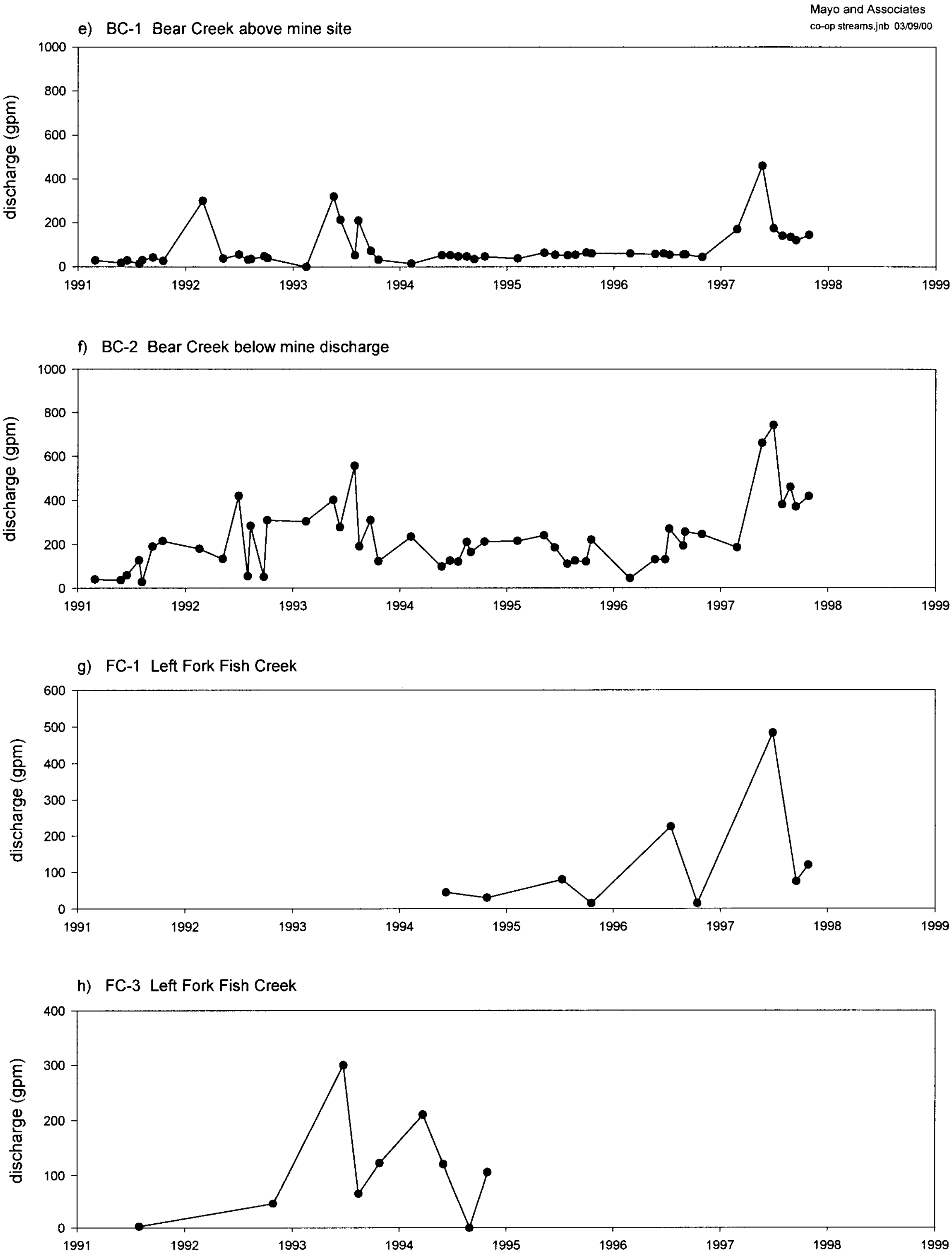


Figure 19 Stream hydrographs (continued).

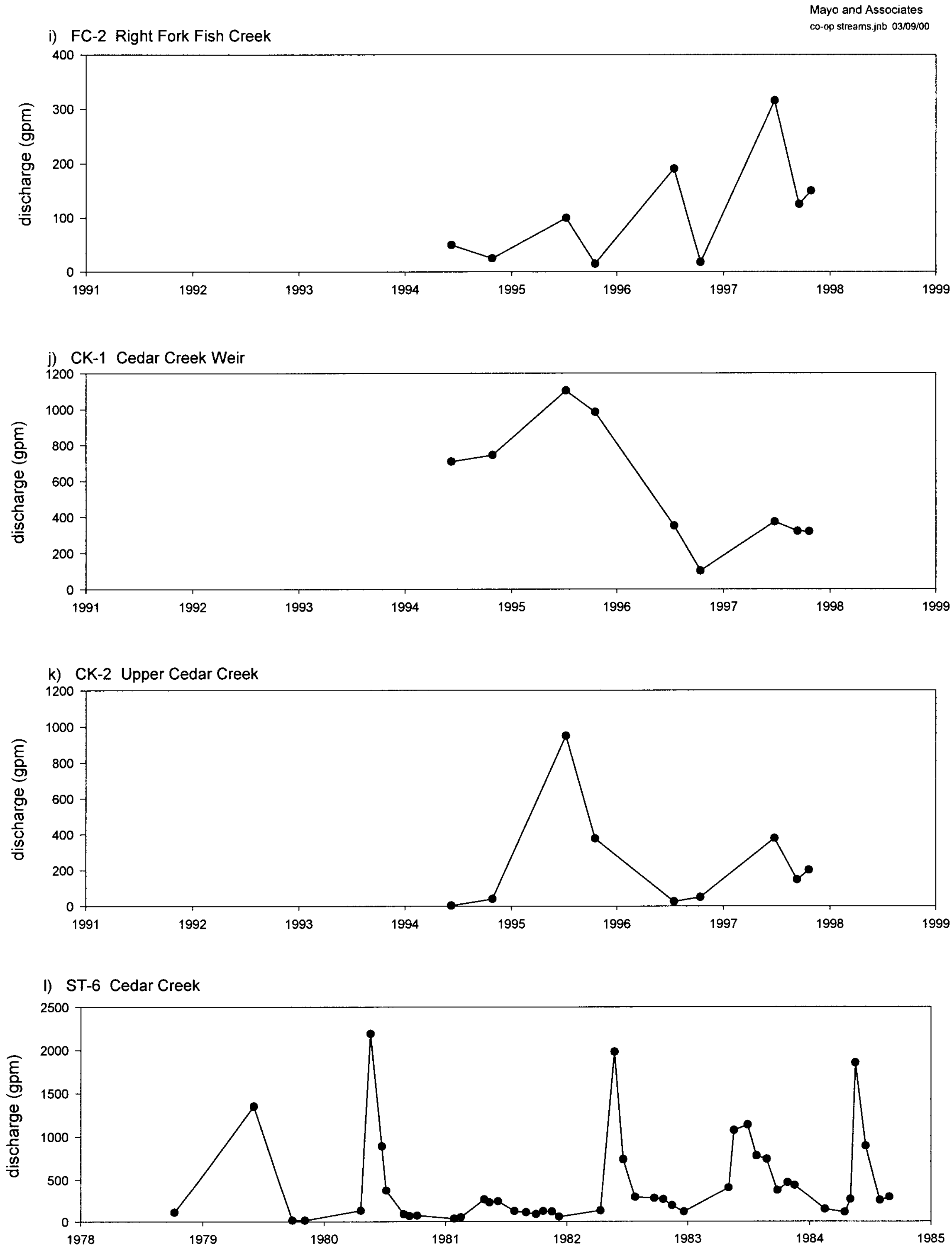


Figure 19 Stream hydrographs (continued).

mid-1991 at monitoring locations LT-1, UT-1, and FBC-10. Stream flow data for station LT-1 (Figure 19a) suggest that the lower portion of Trail Creek is perennial, while the upper portion of Trail Creek at and above UT-1 and FBC-10 (Figures 19b and 19c) is intermittent and dependent on seasonal runoff. The upper intermittent portions of the creek flow across bedrock and alluvium of the North Horn, Price River, Castlegate, Blackhawk, and Star Point formations. The intermittent nature of the creek suggests that these formations do not contribute significant baseflow to the creek. The baseflow in the lower portions of Trail Creek is likely sustained by discharge from springs in that area, especially spring TS-1.

7.2 McCadden Hollow

McCadden Hollow is a tributary of Trail Creek. The creek and surrounding hillsides are less steep than Trail Creek, with hillsides having 20% to 30% grades, and the stream channel having a 9 to 10% grade. Stream flow has been measured at monitoring location MH-1, from mid-1991 through late 1994, and suggests that the stream is intermittent (Figure 19d). The stream in McCadden Hollow flows across alluvium and bedrock of the North Horn and Price River Formations. The intermittent nature of the creek suggests that these formations do not contribute significant baseflow to the creek.

7.3 Blind Canyon

Blind Canyon is a tributary of Huntington Creek. The creek and surrounding hillsides are steep, with hillsides having 60% to 90% grades, and the stream channel having a 12 to 25% grade. There are no streamflow or sampling stations in Blind Canyon, but Blind Canyon Creek is believed to be ephemeral.

7.4 Bear Creek

Bear Creek is a tributary of Huntington Creek. The creek and surrounding hillsides are steep, with hillsides having 60% to 80% grades, and the stream channel having a 6% grade in the lower reaches up to a 25% grade higher up. Stream flow has been measured at monitoring locations BC-1 and BC-2 from early 1991. Stream flow data (Figures 19e and 19f) indicate that the stream is perennial, both above and below the Bear Canyon Mine, with a base flow of 30 to 50 gallons per minute. This base flow is likely sustained by springs, such as FBC-12, emerging from the North Horn Formation at the headwaters of Bear Canyon.

Discharge from the Bear Canyon Mine supplements the flow of the Bear Creek. The contribution of mine water is evident when the upstream (BC-1) and downstream (BC-2) hydrographs are compared.

7.5 Fish Creek

Fish Creek is a tributary of Huntington Creek. Both forks of Fish Creek are steep, with hillsides ranging from 60% to 70% grades, and the stream channels ranging from 8% to 15% grades. Stream flow has been measured at monitoring locations FC-1, FC-2, and FC-3. Stream flow data (Figures 19g, 19h, and 19i) indicate that both the Left Fork and Right Fork of Fish Creek are perennial. Both forks of Fish Creek flow across bedrock and alluvium of the North Horn Formation, Price River Formation, Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone, and Mancos Shale.

7.6 Cedar Creek

Cedar Creek is a tributary of the Huntington Creek. The creek and surrounding hillsides are steep, with hillsides ranging from 45% to 65% grades, and the stream channel ranging from an 8% grade in the lower reaches up to a 15% grade at and above the Mohrland Portal. Stream flow has been measured at monitoring locations CK-1, almost a mile downstream from the study area, and at CK-2, just upstream from the Mohrland Portal (Figure 1). Stream flows in Cedar Creek were also monitored at stations ST-06 and ST-06a, from November 1978 through October 1988, by U.S. Fuel (Hiawatha MRP, 1992). Stream flow data (Figures 19j, 19k, and 19l) suggests that the lower portion of Cedar Creek, outside the study area, is perennial, while the upper portion of the creek is intermittent. The upper intermittent portion of Cedar Creek flows across bedrock and alluvium of the North Horn, Price River, Castlegate, and Blackhawk formations. These formations do not appear to contribute significant baseflow to the upper portion of Cedar Creek, upstream from the monitoring location at CK-2.

7.7 Discussion

Most of the recharge to creeks in the study area occurs from springtime snowmelt and thunderstorms. Discharge rates are variable and many creeks are intermittent, with most creeks drying up completely in the summer or fall. Perennial streams appear to be supported primarily by drainage of water from springs near the mapped faults. Away from these faults creeks tend to be intermittent, suggesting that little water discharges from the bedrock formations exposed in the study area.

7.8 Water Quality

Surface waters within the study area tend to fall into two relatively distinct groups based on chemistry and TDS. These groups include low TDS calcium-magnesium bicarbonate type waters and higher TDS magnesium-calcium-sulfate-bicarbonate type waters. TDS values typically range from 200 to 400 mg/l for the low-TDS type waters and range from 400 to 1000 mg/l for the higher TDS waters. The TDS values of the high-TDS surface waters are not as high as the TDS values of some of the springs and mine discharges. Those waters flowing over rocks of the North Horn, Price River, and Castlegate formations tend to be of the lower TDS calcium-magnesium bicarbonate type, while waters flowing over the Blackhawk and Mancos formations tend to be the higher TDS magnesium-calcium-sulfate-bicarbonate type. Water quality of the various individual creeks is discussed below.

Trail Creek and McCadden Hollow have low-TDS type waters, with the exception of LT-1. Waters at LT-1 show an increase in TDS, magnesium, and sulfate, suggesting a partial change to the higher TDS type waters. This difference is likely caused by discharge of higher TDS waters from spring TS-1, located not far upstream from station LT-1. During periods of low flow, the water chemistry of the stream at LT-1 and spring TS-1 are similar, suggesting that the bulk of the low-flow water in lower Trail Canyon may be derived from this spring.

Surface waters in Bear Canyon include high-TDS waters at BC-1, and intermediate or mixed waters at BC-2. The waters at BC-2 have relatively low TDS values, ranging from 300 to 600, but high magnesium and sulfate concentrations similar to the higher-TDS waters at BC-

1 and elsewhere. Surface waters in the Left Fork and Right Fork of Fish Creek, at stations FC-1, FC-2, and FC-3, are all high-TDS magnesium-bicarbonate-sulfate type waters.

Surface waters in Cedar Creek include low-TDS waters at station CK-2, and higher-TDS sulfate-rich waters farther downstream at station CK-1. The change in chemistry between CK-2 and CK-1 reflects the addition of large volumes of high-TDS water discharging from the Mohrland Mine, as well as streamflow over rocks of the Mancos Shale. As the volume of water discharging from the Mohrland Mine is significantly greater than the volume of lower TDS water into which it flows, this discharge degrades the quality of the existing water in Cedar Creek.

8.0 MINING-RELATED IMPACTS TO BIG BEAR AND BIRCH SPRINGS

8.1 Big Bear Spring

Big Bear Spring discharges from the base of the Panther Sandstone. The discharge is collected from several distinct north-south trending fractures that are visible at the surface at the spring site. Drought-related declines in the discharge rate occurred in the spring in the late 1980s. However, after the end of the drought in the early 1990s, the discharge from the spring failed to return to pre-drought conditions. Specifically, the sharp seasonal discharge peaks that occurred before the drought did not return. Some have suggested that the loss of the seasonal peaks is attributable to mining activities at the Bear Canyon Mine. Several lines of evidence indicate that this is not the case.

Nearly all of the groundwater encountered during mining operations in the Bear Canyon Mine originated from a sandstone channel in the roof of the Blind Canyon coal seam. It has been postulated that the water that was the source of the seasonal peaks in discharge at Big Bear Spring originated from this sandstone channel. The initial water in the sandstone channel contained no tritium and had a radiocarbon age of approximately 1,500 years. Seasonal variations are not associated with the discharge from the sandstone channel in the mine. Significant quantities of tritium in groundwater have not been encountered anywhere in the mine. Although the water that discharges from Big Bear Spring has been characterized as a mixed water (Section 5.3), the water that supplied the seasonal peaks at Big Bear Spring was certainly modern. Thus, the groundwater encountered in the mine could not have supplied the seasonal water to Big Bear Spring.

It has been demonstrated that groundwater chemistry is significantly degraded by passing through the Mancos Shale (Section 5.2.2). The fact that the chemistry of Big Bear Spring water is not degraded relative to groundwaters encountered in active-zone, near surface systems, indicates that the waters discharging from Big Bear Spring have not passed through the tongues of Mancos Shale that divide the Star Point Sandstone. Because all mining in the Bear Canyon Mine occurs above these shale tongues, the source of water to Big Bear Spring cannot pass downward through the mine openings and through the shale tongues. No significant groundwater was encountered during mining operations in the Hiawatha coal seam, which directly overlies the uppermost member of the Star Point Sandstone. Thus, mining in the Hiawatha seam is not a potential mechanism for affecting seasonal flows at Big Bear spring.

Based on the estimated volume of water stored in the sandstone channel and the radiocarbon age of this water, it is calculated that under equilibrium conditions the sandstone naturally discharged at a rate on the order of 1.6 gpm. These calculations are summarized in Figures 20 and 21. For these calculations it is assumed that, before the mine intercepted the sandstone channel, there was equilibrium between the recharge rate and the discharge rate in the groundwater system. Thus, for the sandstone channel to fill completely it required about 1,500 years (the time it takes for a slug of water to travel from the recharge area to discharge area) for the system to go through one filling cycle. Analysis of the discharge hydrograph for the sandstone channel (SBC-9, Figure 20) suggests that, if the discharge decline follows a recession similar to what we have observed in other coal mines of the Wasatch Plateau, then approximately 50% of the total volume of water in storage has already drained from the

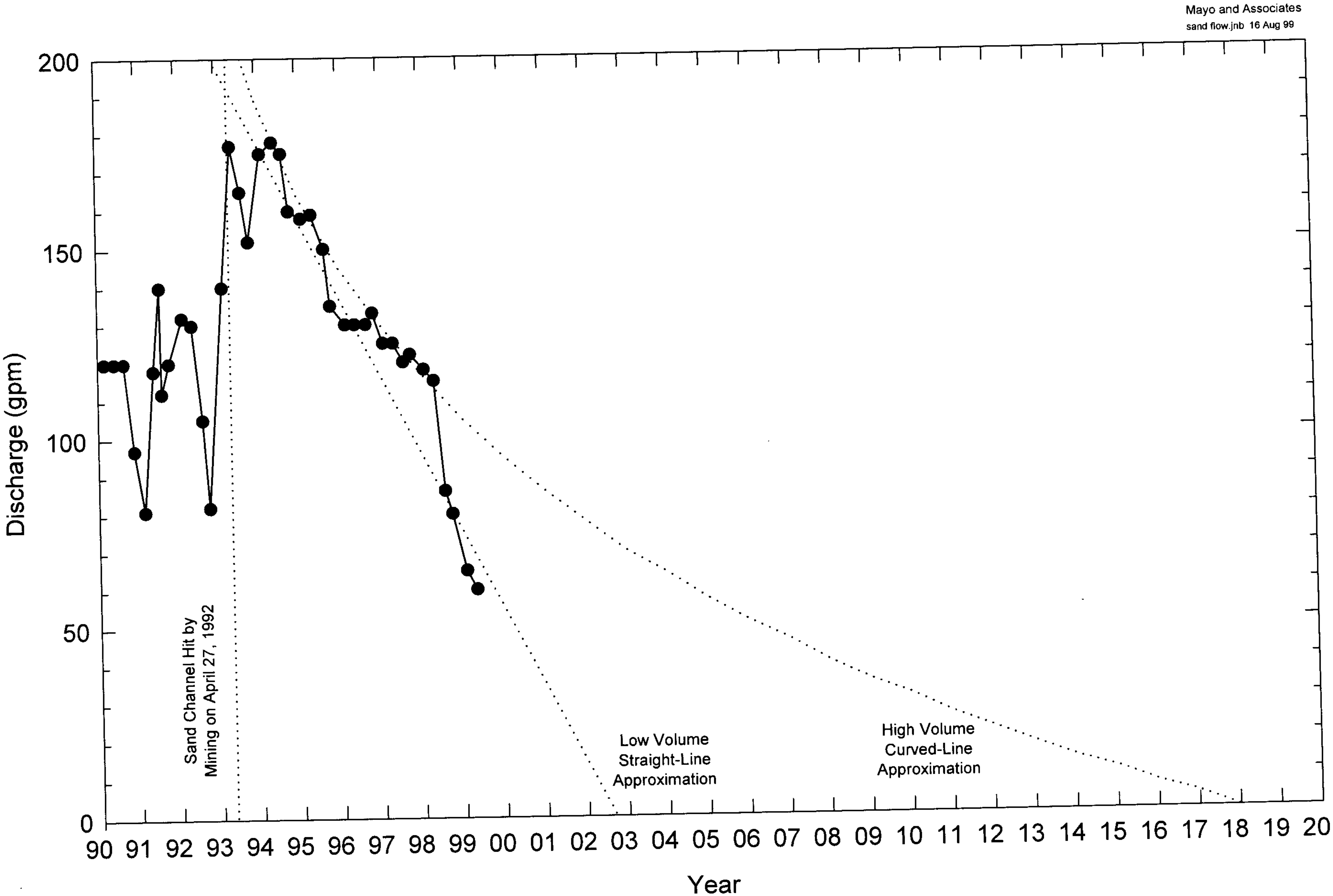
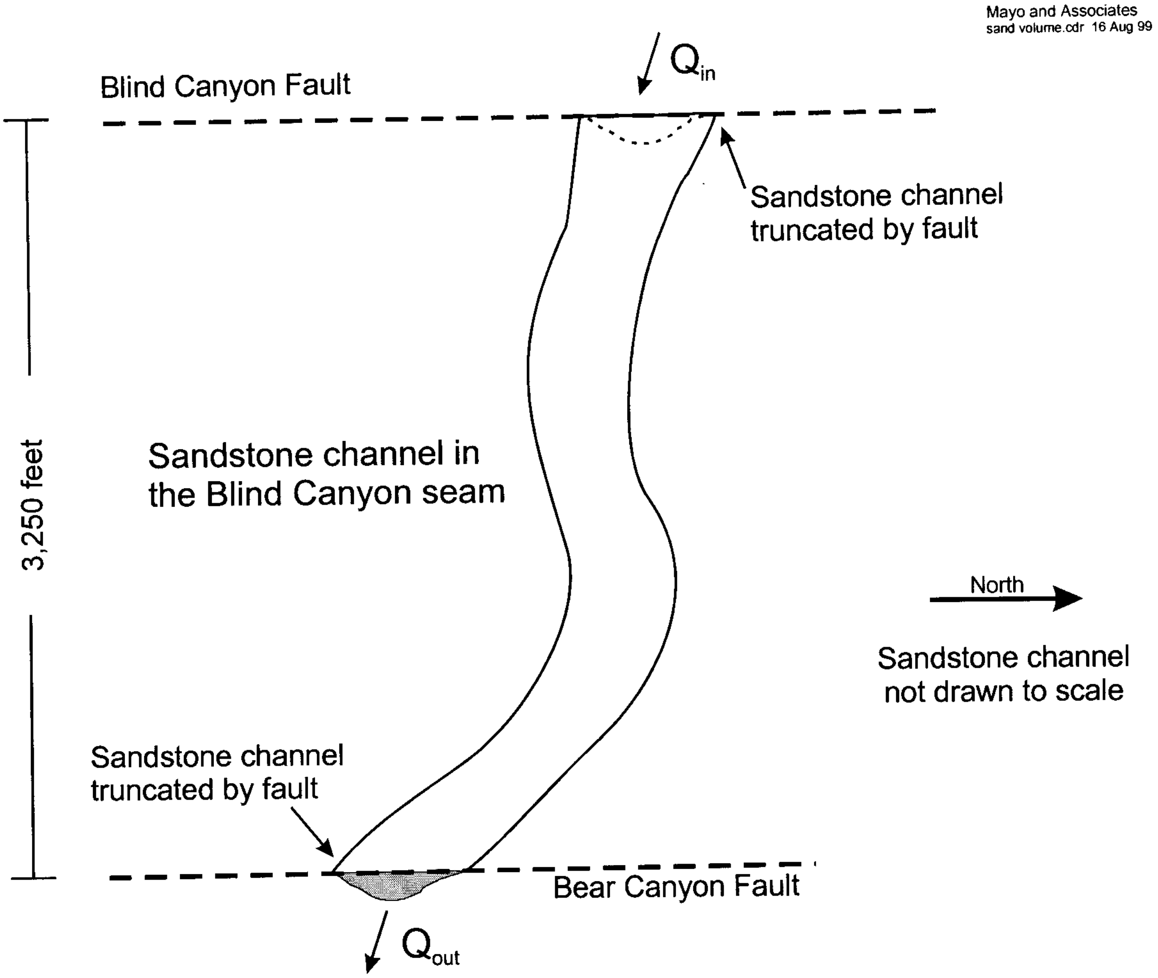


Figure 20 Discharge hydrograph of SBC-9 and estimations of future discharge from sandstone channel.



Under equilibrium, non-mining conditions, $Q_{in} = Q_{out}$

Total volume of water drained from sandstone channel
February 1990 through May 1999 = 616 million gallons

Assuming that channel dewatering is 50% complete
Original volume of water in channel = 1,232 million gallons
Mean residence time of water in channel = 1,500 years

Maximum constant recharge rate prior to mining =

$$\frac{\text{1,232 million gallons}}{\text{1,500 years (789 million minutes)}} = \text{1.6 gpm}$$

Figure 21 Calculation of the estimated natural discharge rate of the sandstone channel encountered in the Blind Canyon Seam Workings of the Bear Canyon channel and 50% remains in storage. Because we know the volume of water that has discharged from the channel since it was first opened (approximately 616 million gallons), and we know that that number represents approximately 50% of the total volume, we can calculate that twice the amount discharged, or 1.23 billion gallons, is the approximate storage volume of the sandstone channel. Because it required approximately 1,500 years to recharge the 1.23 billion gallons, we can calculate a pre-mining equilibrium discharge rate of approximately 1.6 gpm for the sandstone channel. Recently collected data from the sandstone channel indicates that the water now discharging from the channel has a radiocarbon age somewhat greater than that initially encountered (Section 5.3). If the older groundwater age is used in these calculations, a yield of less than 1.6 gpm would be obtained.

The magnitude of the seasonal discharge increases that occurred before 1987 generally exceeded 100 gpm. Obviously, this estimated natural discharge rate from the sandstone channel is wholly insufficient to account for the seasonal peaks in Big Bear Spring discharge. Even if the calculated flow estimations were in error by an order of magnitude, the natural equilibrium discharge rate would only be approximately 16 gpm.

There are insufficient data to definitively determine why the seasonal peaks in discharge have not returned to Big Bear Spring after the drought ended. However, we believe that it is likely that the "plumbing system" that facilitates the transmission of seasonal water to Big Bear Spring may have been impacted by natural causes. The presence of dry tufa mounds in the vicinity of Big Bear Spring indicates that at earlier times groundwater naturally discharged at locations where it does not now discharge. It seems plausible that the magnitude 5.3

earthquake (Section 4.1.6) that occurred in the region in 1988 may have facilitated changes to the fracture network that supplied the seasonal recharge to Big Bear Spring. Significant alterations in discharge occurred at other Star Point Sandstone fracture system springs in response to this seismic event. Discharge at the Tie Fork Wells increased almost instantaneously from 80 gpm to over 130 gpm, a 63% increase. At essentially the same time, NEWUA reports that discharge from Birch Spring increased from 81 to 133 gpm, a 64% increase. At both of these locations, after the sharp increases, groundwater discharge rates gradually declined over the next few years to rates lower than the pre-earthquake levels. It seems likely that the seismic event that significantly altered the fracture controlled groundwater system associated with the Tie Fork Wells and Birch Spring may have also impacted the fracture-controlled system associated with Big Bear Spring.

8.2 Birch Spring

The hydrograph of Birch Spring (Figure 9) shows two large peaks in 1988 and in 1990. The hydrograph also indicates possible diminution of flow. The possible relationship between mining and these events is examined below.

The Bear Canyon Mine permit area is hydraulically isolated from the groundwater flow system that feeds Birch Spring. Several lines of evidence support this conclusion.

The fracture system from which Birch Spring discharges is isolated from the Bear Canyon Mine workings by the Blind Canyon Fault, which has approximately 200 feet of offset. There is no evidence to suggest that quantities of water sufficient to supply the discharge to

Birch Spring can migrate across this fault. In general, the faults encountered in the Bear Canyon Mine (including the Blind Canyon Fault) are filled with clay-rich gouge, which is relatively impermeable to groundwater flow. The Blind Canyon Fault gouge observed in the Bear Canyon Mine is dry and does not show evidence of having conducted water in the past. Rather, the fault is believed to act as a barrier to flow. Additionally, the water-bearing sandstone channel that was encountered in the Bear Canyon Mine is probably completely truncated by the Blind Canyon Fault. The likelihood that there is another permeable sandstone channel on the west side of the Blind Canyon Fault that could juxtapose the one encountered in the mine in three-dimensional space after it had been offset 200 feet seems remote.

The Blind Canyon Fault partitions the Blackhawk Formation groundwater systems in the vicinity of the mine. Groundwater sampled from the vicinity west of the Blind Canyon Fault (3rd West South) had a radiocarbon age of 5,400 years, while groundwater encountered in the sandstone channel east of the Blind Canyon Fault had a radiocarbon age of approximately 1,400 years. Thus, for sandstone channel groundwater to discharge at Birch Spring, it would be necessary to flow across the Blind Canyon Fault gauge, then through the 5,400 year-old water, then emerge at Birch Spring with an age of between 1,100 and 3,600 years. That this could occur seems highly unlikely.

It has been suggested (UDOGM, 1999) that there is very little lateral communication between the north-south trending sub-parallel fractures from which Birch Spring discharges. As discussed in Section 5.3 and 5.4, the isotopic information collected for this investigation supports this conclusion. There is substantial variation in both the stable and unstable isotopic compositions of waters from the different Birch Spring sources (Table 4). This indicates that, even after more than 1,000 years in the groundwater system, the water contained in individual fracture planes has not mixed with water in nearby, subparallel fractures. Thus, from the recharge areas to the spring, the groundwater is likely contained and transported within these fractures. These observations suggest that lateral inflow into the fractures (i.e. from the sandstone channel encountered in the mine more than 1/2 mile to the east) does not occur in significant quantities.

As discussed below, it is our opinion that the baseflow of Birch Spring (approximately 30 gpm) has not been diminished. The measured declines in flow are likely the result of incomplete capture of the entire discharge from the area. Therefore, if the sandstone channel were the source of groundwater for Birch Spring, it would be anticipated that the discharge from the spring would decline rapidly after the sandstone channel was first encountered and began to be depressurized in 1991. That this is not the case suggests that Birch Spring is not sustained by groundwater from the sandstone channel.

Peak flows

Before August 1988, the data reported in the Star Point Mine MRP indicate that the discharge from Birch Spring was relatively constant. During the period from August 1988 to late 1990, the discharge from Birch Spring fluctuated greatly. During this time, the Star Point MRP data indicate that at least four distinct discharge peaks occurred. As discussed in Section 4.1.6, the beginning of this period of discharge variability occurred in August 1988, which correlates closely with the occurrence of an earthquake in the region. A similar effect from the 1988 earthquake was observed in the Tie Fork Wells, suggesting that the initial peak flows and the subsequent instability in discharge from Birch Spring was probably associated by the earthquake. As discussed in Section 4.2.1, only relatively insignificant quantities of water were encountered in the Bear Canyon Mine before August 1988. Therefore, it is highly improbable that mining operations caused the increased discharge from Birch Spring in late 1988. Thus, the conditions in the groundwater system that supports Birch Spring may have changed significantly before any mining-related impacts were possible.

It is uncertain if the larger peak in late 1990 is a residual effect of this earthquake. As noted in Section 4.1.6, the large peak that occurs in late 1990 does not appear to be related to climatic factors because it occurs late in the year during a major regional drought. The peak event of late 1990 was also accompanied by inflow of sediment to the spring boxes and by oil and grease and fecal coliform contamination. These observations indicate that the large inflow to the spring was in good communication with surface water. It has been suggested (UDOGM, 1998) that the late 1990 peak flow could have been related to 1) water impounded in the Trail Canyon Mine, 2) water allegedly discharged from the Bear Canyon Mine through the Blind Canyon Fan Portal, or 3) water pumped into old workings in the southern portion of the Bear Canyon Mine.

Based on exhaustive examination of discharge, solute, and isotopic data, we have determined that the data do not support or refute any of the proposed explanations. Furthermore, we are of the opinion that the data needed to definitively pinpoint the cause of this peak flow may not exist. We do not believe that meaningful new data can now be gathered to resolve this concern. During the past eight years, no similar discharge event has occurred, leading us to believe that the cause of the anomalous discharge in late 1990 was transient and that the conditions leading to this event likely no longer exist.

Diminution of flow

Discharge records suggest two possibly significant decreases in flow. The first possible decrease is observed in the data reported in the Star Point Mine MRP. These data suggest a constant baseflow discharge of about 85 gpm between January 1985 and July 1988. The earthquake that occurred in August 1988 disrupted the baseflow discharge rate and caused discharge to increase for several months. Following this initial earthquake-caused increase, there is a general recession between August 1988 and January 1991 to about 34 gpm, if peak events are omitted. That this represents an actual diminution of baseflow is uncertain because, as stated in Section 4.1.6, the historical discharge data from Birch Spring prior to 1991 are irreconcilable and possibly incongruous. Discharge data from NEWUA during this time suggest that the spring discharge may have fluctuated between 30 and 70 gpm. Because such fluctuations have not been observed since 1991, this suggests that perhaps a seasonal component of discharge may have been lost. Regardless of whether there was a decrease in baseflow or a loss of the seasonal component, we believe that all possible explanations are speculative. Because the decrease followed the earthquake of August 1988, we favor the idea that the earthquake caused some change in the groundwater system supporting Birch Spring that resulted in decreased flows. We do not believe that this decline is mining related. We also do not believe that any new data could be collected that would answer this question.

The second possible decrease in discharge began in January 1991. The data indicate that there is a gradual recession from 34 gpm in January 1991 to 15.5 gpm in August 1998. We suspect that the decline indicated by the discharge data do not reflect an actual decline in discharge from the groundwater system that supports Birch Spring. Instead, these data reflect decreasing effectiveness of the spring collection system. As noted in 4.1.6, part of the spring collection system was unearthed and the spring boxes were exposed in September 1998, and the combined discharge from the exposed spring boxes and the unearthed portion of the system was 25 gpm. Additionally, as noted in 5.4, water discharges from seeps below the spring collection area. Water from one of these springs has a stable isotopic affinity for water discharging from Birch Spring. The seeps discharge in the flood plain of Huntington Creek and it is quite possible that more water is also discharging from the alluvium directly to Huntington Creek. Thus, we propose that there has been no mining-related impact to the discharge from Birch Spring during the period since the flow meter was installed in the collection system and reliable flow data have been collected.

9.0 PROBABLE HYDROLOGIC CONSEQUENCES OF MINING

This section describes the probable hydrologic consequences (PHC) of coal mining in the current Bear Canyon Mine permit area ("current permit area") and the Wild Horse Ridge area ("permit expansion area"). The distinction between these two areas is important because, groundwater systems in these areas are hydraulically isolated from each other by the Bear Canyon Fault. This PHC determination is required by R645-301-728 of the State of Utah Coal Mining Rules and appropriate subsections of the rules are referenced below accordingly. This PHC determination is based on the data and information presented in Sections 1-8 of this document. A proposed monitoring plan is presented in Section 10 of this report.

The hydrologic evaluation presented in Section 1-8 of this report also includes the Mohrland area; however, C.W. Mining is not permitting the Mohrland area at this time.

9.1 Possible adverse impacts to the hydrologic balance (728.310)

9.1.1 Groundwater

In general, there are two mechanisms by which mining in the proposed permit area has the potential to adversely impact natural groundwater discharge rates from horizons overlying or underlying mine workings. The first mechanism is the direct interception and dewatering of groundwater contained either in perched systems in horizons directly overlying the mined or groundwater associated with faults or fractures. The second mechanism is the dewatering of perched groundwater higher in the stratigraphic section caused by interruption and deformation of strata above subsided areas. These mechanisms are discussed below.

Direct interception of perched groundwater

As described in Section 6.3, most water encountered in the workings of the Bear Canyon Mine in the current permit area discharges from inactive-flow perched groundwater systems. Waters in these systems are not in good hydraulic communication with the recharge and discharge areas. This is indicated by the radiocarbon ages of these waters (500-9,000 years), the lack of tritium in these waters, and the rapid decreases in discharge rate after a source of water is encountered (often days to weeks). Although a significant quantity of water has discharged from the large sandstone paleochannel encountered in the northern extent of the Blind Canyon Seam workings in the current permit area for a longer period of time, this inflow is nevertheless supported by an inactive-flow groundwater system. Discharge from this channel (measured at SBC-9 and SBC-10; Figure 10c and 10d) is taking longer to decrease because of the greater length of that particular channel. Calculations of the steady-state flux of groundwater in this channel (Section 8.1) suggest that the natural pre-mining recharge and discharge rates for this channel is less than 2 gpm. The increasing radiocarbon age of water (Section 5.3) in this channel suggests that increased groundwater recharge to this channel due to dewatering of this channel is probably not occurring.

In both the current permit area and the permit expansion area, relatively few springs discharge from the stratigraphic horizons containing the mined coal seams or from horizons below the coal seams (Star Point Sandstone). If there were impacts due to water being encountered in the mined horizon, these are the springs that would be affected.

Springs in and adjacent to the proposed permit area which discharge from the lower Blackhawk Formation include SBC-7 in the current permit area, and 16-7-24-3 and SBC-17 in the permit expansion area. It appears that SBC-7, which previously discharged near the Blind Canyon Seam portals, may have been affected by encountering water in the Blind Canyon Seam workings. As described in Section 4.2.1, this spring discharged about 18 gpm and did not display significant seasonal variation, varying by only about 1 gpm. SBC-7 went dry shortly after the sandstone channel in the northern extent of the Blind Canyon Seam workings was drained or depressurized, suggesting that some of the groundwater at SBC-7 was likely related to the groundwater in the sandstone channel.

Discharge data from springs 16-7-24-3 and SBC-17 are limited, and it is not known if these springs have a relatively constant discharge rate that might indicate that they are supported by an inactive-flow groundwater system. Nevertheless, they discharge from a sandstone horizon directly above the Blind Canyon Seam. These springs discharge near the surface trace of the Bear Canyon Fault and may be related to this structure. If these springs are not associated with the Bear Canyon Fault but instead discharge from perched systems in the Blackhawk Formation, there is the potential that the flow paths of the groundwater system supporting these springs may be intercepted by mining in the permit expansion area. Because the discharge from these springs (about 5 gpm) is small relative to the baseflow in Bear Creek (about 50 gpm), the disruption of flow from these springs would not greatly affect the hydrologic balance of Bear Creek.

Springs that discharge from horizons below the mined coal seam in the current permit area include the Panther Sandstone springs (Big Bear, Birch, Defa #1, and Defa #2). Some or all of the water discharging from the Panther Sandstone springs has antiquity, suggesting a possible relationship with waters encountered by mine workings. However, as discussed extensively in Section 8.0, these springs are hydraulically isolated from the groundwater that has been encountered in the Bear Canyon Mine. Hence, we do not anticipate any impacts from mining activities in the current permit area or in the permit expansion area to Panther Sandstone springs.

Impacts to Big Bear Spring or other groundwater resources in the current permit area due to mining in the permit expansion area are not expected. These areas are separated by the Bear Canyon Fault which likely prevents hydraulic communication from between the west and east side of the fault. That there is a hydraulic disconnect is indicated by the following:

1. The vertical offset of the Bear Canyon Fault is approximately 230 feet. It has been our experience that faults with large displacements in the Blackhawk Formation, Star Point Sandstone, and Mancos Shale are almost always filled with relatively impermeable fault gouge because of abundant shale and mudstone. This suggests that the plane of the Bear Canyon Fault is filled with fault gouge. Where the Bear Canyon Fault is exposed near the headwaters of Bear Canyon, extensive fault gouge is visible. Fault gouge is generally not capable of transmitting water as demonstrated by the lack of water in the gouge of the Blind Canyon Fault where encountered by the Bear Canyon Mine (MRP, Appendix 7-J, p. 78).

If the Bear Canyon Fault is filled with gouge, then the fault is a barrier to flow both vertically down the fault, laterally along the fault, or perpendicularly across the fault. While, the fault plane itself may not support groundwater or groundwater flow, fault-associated fractures on either side of the fault may support groundwater flow. Consequently, any water-bearing fractures east of the Bear Canyon Fault are not in hydraulic communication with fractures west of the fault that may be supporting groundwater flow to Big Bear Spring.

2. Groundwater recharge to the Panther Sandstone likely occurs where the Panther Sandstone is exposed at or near the surface and the little water recharges the Panther Sandstone from overlying horizons (Section 6.3). Along the Bear Canyon Fault, adjacent to the Wild Horse Ridge area, the Panther Sandstone is juxtaposed against the Blackhawk Formation, because of 230 feet of vertical movement along the Bear Canyon Fault. Consequently there can be no direct hydraulic communication between the Panther Sandstone west of the Bear Canyon Fault where Big Bear Spring is located and the Panther Sandstone east of the fault in Wild Horse Ridge.

3. The rocks in the Wild Horse Ridge area dip to the southeast. Thus, groundwater in bedrock formations in the Wild Horse Ridge area would naturally flow to the southeast, away from the Bear Canyon Fault and away from Big Bear Spring.

4. Two springs, 16-7-24-3 and SBC-17, discharge from the Blackhawk Formation immediately east of the Bear Canyon Fault in Bear Canyon. A third spring, SBC-14, discharges from the Spring Canyon Sandstone near the location of the proposed portals for the Wild Horse Ridge expansion. All three of these waters have elevated TDS contents relative to Big Bear Spring or water encountered in the Bear Canyon Mine. These waters also have unusual chemical compositions with magnesium and sulfate being the dominant ions compared to Big Bear Spring water in which calcium and bicarbonate dominate (Section 5.2.2). These chemical data suggest that there is no hydraulic communication between the area east and the area west of the Bear Canyon Fault.

One spring, SBC-14, discharges from a horizon below the mined coal seams in the permit expansion area. This spring discharges from the Spring Canyon Sandstone in the right fork of Bear Canyon. As noted in Section 4.1.6, discharge from SBC-14 fluctuates from 0.5 to 15 gpm, suggesting that this spring is supported by a local, shallow groundwater system in good communication with the surface. The discharge fluctuations measured in this spring suggest nearly all of the discharge from SBC-14 is not supported by groundwater that flows for some great distance through fractures associated with the Bear Canyon Fault. (Discharge from such a groundwater system would tend to have a more constant discharge rate.) Thus, this spring should not be impacted if groundwater associated with the Bear Canyon Fault or groundwater associated with perched horizons in the Blackhawk Formation is encountered in mine workings in the permit expansion area.

We do not expect any additional large groundwater inflows to either the Blind Canyon Seam or Tank Seam workings in the current permit area. If coal mining recommences in the Hiawatha Seam workings, there is a potential for water to upwell from the Spring Canyon Sandstone if mining occurs where the elevation of the coal seam is below the elevation of the potentiometric surface of the Spring Canyon Sandstone. The inflow rate of this water is unpredictable. However, we do not anticipate that dewatering of the Spring Canyon Sandstone will be a significant adverse impact to the hydrologic balance because 1) water in the Spring Canyon Sandstone has antiquity (Section 5.3) indicating that groundwater flow in the sandstone is not active and 2) there are no discernable discharges from the Spring Canyon Sandstone (except the small seep BP-1).

Initially mine workings in the permit expansion area will likely not encounter any large groundwater inflows. As in the current permit area, large inflows will only occur if mining encounters a large water-bearing sandstone paleochannel. The location of such features is not readily predictable. We anticipate that if a large water-bearing sandstone channel is encountered, groundwater discharging from the channel will have antiquity and not be part of an active flow system that supports discernable discharge to the surface.

Direct interception of water associated with faults

Although groundwater is not associated with the Bear Canyon Fault in the current permit area, it is not known if this feature will be the source of groundwater inflows when approached from the east. Although we expect that water associated with the Bear Canyon

Fault may be part of an inactive groundwater flow system, we recommend that if any water is encountered an evaluation be made at that time to confirm this supposition.

Although groundwater that may be associated with the Bear Canyon Fault was encountered in the Hiawatha Complex approximately 5 miles north of the Bear Canyon Mine, it appears that the Bear Canyon Fault does not convey water from the Hiawatha area to the Bear Canyon area. Water encountered in the Hiawatha Complex, which now discharges from the Mohrland Portal, has a radiocarbon age in excess of 9,000 years, which is considerably older than water in either Big Bear Spring or the Bear Canyon Mine (Section 5.3). Thus, water inflows to the Bear Canyon Mine or water discharging from Big Bear Spring is not the same water that is associated with the Bear Canyon Fault in the Hiawatha Complex. What this means is that if water associated with the Bear Canyon Fault is encountered in the permit expansion area, it likely will not impact any significant groundwater resource in either the current permit area or the permit expansion area.

Subsidence-related fracturing and deformation

The second method whereby natural groundwater discharge rates may be adversely affected results from interruption and deformation of strata above subsided areas. Removal of coal during second mining causes the strata immediately above the mined horizon to cave. Above the zone of caving, bedrock fractures in response to subsidence. The height of the fracturing zone can be related to mining height. A relationship applied at some western coal mines is that subsidence fractures propagate upward to approximately 30 times the height of the extracted coal (Kadnuck, 1994). Rock strata above the fracture zone commonly bend rather than fracture. Near-surface fractures, which are the result of tension at the land surface associated with differential subsidence, commonly extend less than 100 feet below the surface.

In the current permit area, mining has occurred in three seams, the Hiawatha, Blind Canyon, and Tank Seams. At the Bear Canyon Mine second mining occurred in the Blind Canyon Seam prior to mining in the overlying Tank Seam. This unconventional mining sequence (i.e. extraction of the lower seam first) provides a unique opportunity to evaluate the integrity of the strata overlying second mined areas at a height of about 250 feet above the Blind Canyon Seam. Mine personnel report (C. Reynolds, Personal Communication, 1999) that the Tank Seam was intact and that vertical fractures did not extend as high as the Tank Seam. Some existing fractures were opened or loosened. Subsided areas at this height above the Blind Canyon Seam did experience bending as demonstrated by increased aperture along horizontal bedding planes. What this means is that fracturing propagates upward considerably less than 250 feet. That fracturing does not propagate upward further is likely a result of the presence of massive sandstones in the Blackhawk Formation.

The effects of second mining in the Tank Seam cannot be as intimately ascertained. Second mining in both the Blind Canyon and the Tank Seams will cause fracturing to propagate upward from the Tank Seam to a greater height than fractures would extend if mining occurred in the Tank Seam alone. However, because of the ameliorating effect of the thick interburden between the Blind Canyon and Tank Seams, it is unlikely that the height of fracturing above areas of multiple seam removal will be significantly greater than the height of fracturing above second mined areas in the Tank Seam alone. Thus, we do not expect fracturing to extend more than about 300 feet above the Tank Seam.

In the permit expansion area second mining will also occur in the Blind Canyon and Tank Seams.

In the current permit area and permit expansion area, no springs have been identified which discharge from the upper Blackhawk Formation or the Castlegate Sandstone, and only two springs discharge from the Price River Formation. Thus, the bulk of the groundwater resources in the area are found in the North Horn Formation and the Flagstaff Limestone. All of the springs with significant discharges identified in the Flagstaff Limestone and North Horn Formation are separated from the Tank Seam by more than 1,000 feet (Plate 6-10 of the Bear Canyon Mine MRP). Thus, the groundwater systems from which these springs discharge are well above the zone of potential impact from subsidence fractures that propagate upward from the mine. Abundant clay and mudstone in the North Horn Formation aids the quick healing of any subsidence-related fractures that do occur. Therefore, the potential for these springs to be impacted as a result of mining-related activities is minimal.

9.1.2 Surface water

The mine plan for the current permit area and the Wild Horse Ridge permit expansion area has been designed to prevent subsidence of Bear Creek, the right fork of Bear Creek, or the Left Fork of Fish Creek. Thus, these perennial and intermittent drainages should not be directly affected by mining. However, the hydrologic balance of these systems would be impacted if groundwater discharge that provided baseflow for these systems were impacted. As noted in the previous section, impacts to the groundwater discharge rates are not expected.

The hydrologic balance of Bear Creek below the mine discharge point will be affected by the addition of mine water to the creek. This impact is discussed in Section 9.5.

9.2 Presence of acid-forming or toxic-forming materials (728.320)

Information on acid- and toxic-forming materials is contained in Appendix 6-C of the MRP. Evaluation of these data using *Guidelines for Management of Topsoil and Overburden* (Table 2; Leatherwood and Duce, 1988) revealed that there have been no poor or unacceptable (acid- or toxic-forming) materials encountered in the permit area. Coal and rock strata in the permit expansion area are expected to be identical to those encountered in the current permit area. However, if any acid- and/or toxic-forming materials are discovered in waste rock in the future, these materials will be disposed of in accordance with the requirements of R645-301-731.300 and as outlined in Chapter 3 of the MRP.

Western coal mines commonly contain sulfide minerals, which, when exposed to air and water, oxidize and release H^+ ions (acid). The sulfide mineral pyrite (FeS_2) has been identified in the Bear Canyon Mine. Although pyrite oxidation does occur, acidic mine drainage does not. Acid derived from pyrite oxidation is readily consumed by dissolution of carbonate minerals, which are pervasive throughout the rocks in the vicinity of the Bear Canyon Mine. Iron liberated during pyrite oxidation is readily precipitated as iron-hydroxide and is not observed in the mine discharge water.

9.3 Impact of coal mining on sediment yield from disturbed areas (728.331)

The sediment load of streams can be impacted by increased sediment yield from disturbed areas and from subsided landscape above mine workings. Sediment control measures for existing and proposed disturbed areas are described in 7.2.7 and 7.2.8 of the MRP. It is expected that the installation and maintenance of these sediment control structures will prevent any adverse impacts to the sediment load of streams. Also of particular concern is spring SBC-14 which discharges immediately below the proposed portal area in the right fork of Bear Canyon. This spring supports a small riparian area in the canyon. The portal facilities, culverts, and sediment control structures have been specifically designed to prevent impacts from sediment yield to this spring and riparian area.

Subsidence can result in either increased or decreased sediment loading of ephemeral and intermittent streams. Differential subsidence can locally increase stream gradients, causing higher flow velocities in the stream channel and greater sediment loading. However, this impact would likely be localized and short-lived. If there is sufficient water in the drainage, the increased erosion of easily eroded sediments will rapidly bring the channel to equilibrium with the stream. If the altered substrate in the channel is not easily eroded, there will be no increase in sediment loading of the stream. The sediment load of ephemeral and intermittent streams would be decreased where subsidence causes water to be impounded. Here, sediment would be deposited in the subsidence-induced depressions in the stream channel. This occurrence would also be short-lived because sediment deposition in the depressions would gradually bring the channel into equilibrium with the stream.

9.4 Impacts to acidity, TDS, and other important water quality parameters (728.332)

There is the potential for surface water and groundwater quality to be affected by mining operations. Potential impacts to the acidity of surface waters and groundwaters resulting from acid mine drainage were discussed in Section 9.2, and the potential impacts of increased suspended solids were discussed in Section 9.3. Other potential impacts from coal mining activity include increasing the concentration of total dissolved solids (TDS) and specific solutes in streams that receive mine discharge water.

As discussed in Section 9.2, pyrite oxidation, which has the potential to cause acid mine drainage, does occur in the mine environment. However, the ubiquitous presence of carbonate minerals in the permit area results in the rapid neutralization of produced acid. Therefore, acid mine drainage does not occur. Toxic forming minerals are generally not found in the permit area. Thus, the potential for detrimental impacts to groundwater or surface-water systems as a result of the discharge or seepage of mine discharge water to the surface is minimal. In fact, the quality of water discharged from the Bear Canyon Mine portals is generally better than that of the receiving water (Bear Creek). Bear Creek above the mine discharge (BC-1) has an average TDS concentration of 544 mg/l, while the mine discharge water (NPDES-004) averages 364 mg/l. The mean sulfate concentration of Bear Creek water is 263 mg/l, while the sulfate concentration of the mine discharge water is less than one fifth as great (51 mg/l).

The practice of using rock dust for the suppression of coal dust in a mine may potentially impact the groundwater flowing through the mine by dissolution of the rock dust constituents into the water. Currently, only limestone or dolomite rock dust is used for dust suppression purposes in the Bear Canyon Mine and this practice is expected to continue during mining in the permit expansion area. Hence, it is doubtful that rock dust usage will adversely impact groundwater quality.

Hydrocarbons (in the form of fuels, greases, and oils) are stored and used in the current permit area and will be used in the permit expansion area. Groundwater contamination could result from spillage of hydrocarbon products during maintenance of equipment during operations, filling of storage tanks and vehicle tanks, or from tank leakage due to the rupture of tanks. The probable future extent of the contamination caused by diesel and oil spillage is expected to be minimal for three reasons:

1. No underground storage tanks will exist in the permit expansion area;
2. Spillage during filling of the storage or vehicle tanks will be minimized to avoid loss of an economically valuable product;
3. The 1997 SPCC Plan provides for (and C.W. Mining has implemented) inspection and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site.

There are no transformers in the current or expanded mine permit areas that contain polychlorinated biphenyls (PCBs). No surface roads capable of handling large volume and or heavy truck traffic will be constructed in the permit expansion area. All roads will be constructed and maintained in such a manner that the approved design standards are met throughout the life of the entire transportation system (see Chapter 3 of the MRP). This fact reduces the potential for hydrocarbon spills. Salting of some roads within the lease area occurs during the winter months. Road salt is applied sparingly to minimize water quality impacts to nearby surface-water and groundwater systems. The impacts resulting from road salting in the permit area are expected to be minimal.

The springs that discharge above the mined horizons on Gentry Mountain are related to shallow, active zone groundwater systems. These springs are not related to the groundwater systems encountered in the mine. We anticipate no detrimental impacts to water quality to these springs as a result of mining activities. Indeed, it is difficult to imagine a mechanism whereby the water quality of springs that discharge above the mined horizon may be significantly impacted by mining operations.

Groundwater systems from which the springs on Gentry Mountain discharge are not related to the groundwater systems encountered in the mine. The water quality characteristics at each of these springs have been well documented. Generally, the concentrations of individual solute parameters have not changed significantly over time (Appendix A).

9.5 Flooding or streamflow alteration (728.333)

Flooding is a potential consequence of mine water discharge. Mine water discharge is a significant addition to the baseflow of Bear Creek (Figures 19e and 19f). During low-flow conditions, the continuous addition of sediment free mine discharge water to Bear Creek may increase the erosion potential in the stream channel. The channel substrate below the mine discharge is located on the Mancos Shale, which is highly erodable. However, the amount of water discharged from the Bear Canyon Mine is relatively small, averaging about 130 gpm with a historic maximum of about 320 gpm. This relatively small quantity can be accommodated in the inner, relatively stable portion of the channel. Significant bank erosion is, therefore, unlikely. The stream gradient in this reach of Bear Creek, approximately 6%, suggests that in general this area has a relatively low erosion potential.

Localized flooding can occur due to increased overland runoff from disturbed areas. This is minimized by runoff control structures and sediment ponds. The proposed surface disturbance in the right fork of Bear Canyon has been specifically designed to prevent flooding of the discharge area of spring SBC-14 or riparian areas supported by this discharge. The mine plan for the current permit area and the permit expansion area has been designed to prevent subsidence of Bear Creek, the right fork of Bear Creek, or the Left Fork of Fish Creek. Thus no stream alteration is anticipated in these perennial and intermittent drainages. In ephemeral drainages, differential subsidence may cause some alterations of stream channels. Possible changes are described above in Section 9.3.

9.6 Groundwater and surface-water availability (728.334)

As described in Section 9.1 there are no expected impacts to the hydrologic balance of either groundwater or surface water systems. Therefore, there are no probable impacts to groundwater or surface water supply. There are no water supply wells in the permit area that could be damaged by subsidence. As described in Sections 8.1 and 8.2, mining has not nor should not affect the groundwater systems that support Big Bear and Birch springs. Thus, we expect that Big Bear and Birch springs will continue to be available for culinary use.

9.7 Contamination, diminution, or interruption of water sources (728.340)

Based on the information presented in this document, we anticipate that there should be no contamination, diminution, or interruption of water sources.

10.0 REVIEW OF PROPOSED MONITORING PLAN

The monitoring plan is designed to provide data to assist in determining whether mining activities impact surface-water or groundwater resources in the current permit area and the Wild Horse Ridge area. Specifically, six stream monitoring locations, eleven springs, four monitoring wells at the surface, two in-mine monitoring wells, and two in-mine groundwater inflow areas are recommended for monitoring. The proposed monitoring locations are shown on Figure 7N-2 of the MRP. The monitoring program is summarized in Tables 5, 6, 7, and 8, and is described below.

10.1 Streams

We recommend the regular monitoring of six stream locations in the current permit area and the Wild Horse Ridge area. Included in the monitoring plan are locations on the Bear Creek, Fish Creek, and Trail Canyon drainages. The recommended stream monitoring plan is described below.

Bear Creek Drainage

Four stream monitoring stations are recommended in the Bear Creek drainage. These include BC-1 (upper left fork of Bear Creek), BC-2 (lower Bear Creek below the mine discharge point), BC-3 (lower right fork of Bear Creek), and BC-4 (upper right fork of Bear Creek).

BC-1 and BC-4 are located topographically above the mine's surface facilities in Bear Canyon. Discharge at BC-1 represents the total surface flow from the main fork of Bear Creek drainage above mine. Discharge at BC-4 represents the total flow from the upper right fork of Bear Creek. Because there are no surface disturbances or mine facilities above these areas, it is highly unlikely that water quality in this stream could be impacted. However, to verify that no impacts to water quality at these locations will occur and to facilitate the determination of downstream mine impacts in Bear Creek, we recommend quarterly laboratory operational water quality measurements at BC-1 and BC-4. We also recommend the quarterly monitoring of BC-1 and BC-4 for flow.

BC-2 is located on lower Bear Creek immediately below the mine discharge point. Because of the potential for detrimental impacts to water quality in Bear Creek as a result of mining operations and mine-water discharge, we recommend quarterly laboratory operational water quality measurements at BC-2. We also recommend quarterly monitoring of BC-2 for flow.

BC-3 is located on the lower right fork of Bear Creek immediately above the confluence with the main fork, below proposed new mine surface facilities. We recommend quarterly laboratory operational water quality and flow measurements at BC-3. This monitoring will assist in determining any mining-related impacts to the stream due to new surface disturbances in the right fork of Bear Canyon.

Trail Canyon Drainage

MH-1 is located in lower McCadden Hollow above the confluence with Trail Canyon Creek. The water quality at MH-1 has been documented through baseline monitoring activities at the site. The solute chemical composition has not varied significantly during baseline monitoring. Because there are no surface disturbances or mine facilities in the McCadden

Hollow area, it is highly unlikely that water quality in this stream could be impacted. However, to verify that no impacts to water quality occur, and to establish that natural seasonal variation in discharge in the creek is the result of climatic factors, we recommend quarterly water quality field measurements and flow measurements at MH-1.

Fish Creek Drainage

FC-1 is located on the Left Fork of Fish Creek in the lower Fish Creek drainage. This stream drains a large area on Gentry Mountain and the eastern flanks of Wild Horse Ridge. The water quality characteristics at FC-1 have been well documented through baseline monitoring activities. There are no surface disturbances planned for the area drained by the creek. Therefore, no detrimental impacts on the water quality in the creek are anticipated. However, to verify that no impacts to water quality occur, and to establish that natural seasonal discharge variation is the result of climatic factors, we recommend quarterly water quality field measurements and flow measurements at FC-1.

10.2 Springs

The proposed monitoring program for springs is designed to provide verification that

1. Groundwater systems from support springs in the permit area operate independently of inactive-flow perched groundwater systems encountered in mine workings,
2. The temporal variability of spring discharges is due to climatic variability (i.e. wet and dry years), and
3. Mining is not affecting groundwater systems from which springs in the permit area discharge.

Ten recommended spring monitoring locations have been chosen in the current permit area and the Wild Horse Ridge area to provide information regarding potential impacts from mining. The springs have been selected from 1) the highland areas of Gentry Mountain in the Flagstaff Limestone and North Horn Formation, and 2) the lower-lying areas on the Blackhawk Formation and Star Point Sandstone. It has been demonstrated in this document that the geologic formations that occur between the base of the North Horn Formation and the lower Blackhawk Formation (the Price River Formation, Castlegate Sandstone, and upper Blackhawk Formation) are generally unsaturated and do not support significant groundwater discharge in the permit area. Therefore, because there are no significant springs to monitor, we do not recommend monitoring sites in these formations.

Gentry Mountain Flagstaff Limestone/North Horn Formation systems

Seven springs from the Flagstaff Limestone and North Horn Formation on the upland areas of Gentry Mountain are proposed for monitoring. These include SMH-1, SMH-2, SMH-3, SMH-4, SBC-12, SBC-16, and SBC-15. It has been demonstrated in this investigation that the groundwater systems from which these springs discharge are not related to the groundwater systems encountered in the mine. The water quality characteristics at each of these springs have been well documented. Generally, the concentrations of individual solute parameters have not changed significantly over time. As described in Section 9.1, all of the Flagstaff Limestone/North Horn Formation springs are separated from the coal seams by at least about 1,000 feet of overburden. Therefore, as discussed in Section 9.1, the groundwater systems from which these springs discharge are well above the zone of potential impact from subsidence fractures that propagate upward from the mine. Thus, the potential for these springs to be impacted as a result mining related activities is minimal. However, to document that the variations in discharge from these springs is the result of climatic factors, and to verify that mining operations will not adversely impact water quality or quantity at these springs, we recommend that these springs be monitored quarterly for field water quality measurements and flow.

Blackhawk Formation and Star Point Sandstone groundwater systems

Significant groundwater discharge does occur from the Blackhawk Formation and Star Point Sandstone in the permit area. We recommend regular monitoring of four springs in these formations. These include SBC-4 (Big Bear Spring), SBC-5 (Birch Spring), SBC-14, and SBC-17. We recommend that monitoring of SBC-6 be discontinued.

It has been demonstrated in this report that it is highly unlikely that mining operations could adversely impact water quality or quantity at either Big Bear or Birch Springs. However, these springs are important water supplies to adjacent municipalities. Because of this fact, and to verify that mining will have no impact on these springs, we recommend quarterly monitoring at Big Bear and Birch Springs for both operational laboratory water quality measurements and flow.

Spring SBC-14 discharges from the Star Point Sandstone in the vicinity of the proposed mine expansion facilities in the right fork of Bear Creek. Because of the proximity of this spring to proposed surface disturbances, we recommend quarterly monitoring at SBC-14 for both operational laboratory water quality measurements and flow.

Spring SBC-17 is located in upper Bear Canyon near the Bear Canyon Fault. The spring discharges from the Blackhawk Formation near horizons that contain the coal to be mined. We recommend the regular monitoring of this spring to provide verification that mining related activities do not impact groundwater resources in this area. Because of the close proximity of this spring to the coal seams, we recommend monitoring for both laboratory operational water quality measurements and flow.

Spring SBC-6 is located a few hundred feet northeast of Big Bear Spring. However, for the past several years this spring has continually been dry. Therefore, we do not recommend continued monitoring of this spring.

In-Mine groundwater inflows

C.W. Mining has historically monitored groundwater inflows in the Bear Canyon Mine at SBC-9 (1st N. Mine Sump, sandstone channel drainage) and SBC-13 (1st E. Pillar Area, drainage from a sealed gob area). We recommend continued flow monitoring at these sites on a quarterly basis. Because this water is either consumed as part of mining operations or is discharged to the surface where water quality is closely monitored, we do not recommend routine water quality measurements at these locations.

Star Point Sandstone Monitoring Wells

C.W. Mining has historically monitored groundwater conditions in the Star Point Sandstone through the use of both in-mine monitoring wells and deep wells drilled from the surface. The purpose of this monitoring is to determine whether mining operations result in a decline in the hydrostatic head on the Star Point Sandstone groundwater systems in the permit area. We recommend that monitoring of the Star Point Sandstone continue. We recommend that wells SDH-2, SDH-3, and MW-114 be monitored quarterly for water level. Additionally, we recommend that in-mine wells DH-1A and DH-2 continue to be monitored quarterly for water level. DH-4 is located in an area of the mine that will soon become inaccessible and will not be able to be monitored. However, we believe that monitoring of the remaining two Star Point Sandstone wells is more than adequate to characterize groundwater conditions in the Star Point Sandstone in the relatively small area beneath the mine. It was demonstrated in this document that there is minimal potential for impacting water quality in the underlying Star Point Sandstone. Therefore we do not recommend routine water quality measurements on the Star Point Sandstone wells.

10.3 Chemical Parameters

The recommended list of water quality analytical parameters for operational monitoring of springs and streams is given in Tables 7 and 8.

Table 5 Recommended monitoring program

Protocol		Comments
Monitoring Wells		
SDH-2	A	Spring Canyon member of Star Point Sandstone
SDH-3	A	Spring Canyon member of Star Point Sandstone
MW-114	A	Spring Canyon member of Star Point Sandstone
DH-1A	A	Spring Canyon member of Star Point Sandstone
DH-2	A	Spring Canyon member of Star Point Sandstone
Streams		
Bear Creek Drainage		
BC-1	B,1	Bear Creek, upper main fork
BC-2	B,1	Bear Creek, main fork below mine discharge point
BC-3	B,1	Bear Creek, lower right fork
BC-4	B,1	Bear Creek, upper right fork
Trail Canyon Drainage		
MH-1	B,3	Lower McCadden Hollow creek
Fish Creek Drainage		
FC-1	B,3	Fish Creek, lower left fork
Springs		
SMH-1	C,4	upland plateau area
SMH-2	C,4	upland plateau area
SMH-3	C,4	upland plateau area
SMH-4	C,4	upland plateau area
SBC-12	C,4	upland plateau area
SBC-16	C,4	upland plateau area
SBC-15	C,4	upland plateau area
SBC-4	C,2	Big Bear Spring, Star Point Sandstone
SBC-5	C,2	Birch Spring, Star Point Sandstone
SBC-14	C,2	Star Point Sandstone
SBC-17	C,2	Blackhawk Formation near Bear Canyon Fault
In-Mine groundwater inflows		
SBC-9	D	1st N. Mine Sump, sandstone channel inflow
SBC-13	D	1st E. Pillar Area, drainage from sealed gob area

Table 6 Field and laboratory measurement protocol

Water level and flow measurements

A Monitoring well: quarterly water level measurements

B Stream: quarterly discharge measurements

C Spring: quarterly discharge measurements

D In-mine groundwater inflow: quarterly discharge measurements

Water Quality

1 Stream: quarterly water quality operational laboratory measurements

2 Spring: quarterly water quality operational laboratory measurements

3 Stream: quarterly water quality field parameter measurements

4 Spring: quarterly water quality field parameter measurements

Table 7 Recommended groundwater operational water quality monitoring

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Temperature	°C

LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/l
Carbonate	mg/l
Bicarbonate	mg/l
Calcium (dissolved)	mg/l
Chloride	mg/l
Iron (dissolved)	mg/l
Iron (total)	mg/l
Magnesium (dissolved)	mg/l
Manganese (dissolved)	mg/l
Manganese (total)	mg/l
Potassium (dissolved)	mg/l
Sodium (dissolved)	mg/l
Sulfate	mg/l
Cations	meq/l
Anions	meq/l

Table 8 Recommended surface water operational water quality monitoring

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Dissolved Oxygen	mg/l
Temperature	°C
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/l
Carbonate	mg/l
Bicarbonate	mg/l
Calcium (dissolved)	mg/l
Chloride	mg/l
Iron (dissolved)	mg/l
Iron (total)	mg/l
Magnesium (dissolved)	mg/l
Manganese (dissolved)	mg/l
Manganese (total)	mg/l
Potassium (dissolved)	mg/l
Sodium (dissolved)	mg/l
Sulfate	mg/l
Oil and grease	mg/l
Cations	meq/l
Anions	meq/l

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Appendix A

Table A-1 Field parameters, water quality paramters, and major-ion solute data

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Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
16-7-12-6	06/08/94	1		7.76	320	5		226					343		102	32.5	3.5	0.72	345	4	2.5	8.1	13.7
16-7-12-6	10/27/94	2		8.17	364	6		237					294		75	21.8	5.5	1.75	290	N/D	4	N/D	8.9
16-7-12-6	07/10/95	2		7.96	630	5		274					241		66	22	3.1	0.56	300	N/D	3.1	10.6	0.1
16-7-12-6	10/18/95	12		7.54	380	6		246					261		50.8	16.6	3.1	0.3	294	N/D	3	10	-11.7
16-7-12-6	10/15/96	3		7.21	439	5																	
16-7-12-6	06/24/97	8		8.18	537	6.1		250					225		57	20	3	N/D	293	N/D	5	9	-5.2
16-7-12-6	09/11/97	12		7.71	433	6.7		290					216		57	18	3	N/D	289	N/D	3	9	-5.9
16-7-12-6	10/15/97	10		7.89	343	11.2		230					226		56	21	2	N/D	291	N/D	4	10	-4.9
16-7-12-6	07/19/98	4		6.95	403	6		246					242		64	20	3	N/D	292	N/D	6	9	-1.8
16-7-1-6	06/08/94	2		7.44	325	4.5		226					273		71.9	20.3	3.14	0.6	320	4	N/D	13.1	-2.0
16-7-1-6	10/28/94	3		7.69	456	6		291					380		98.2	24.8	3.6	0.98	367	N/D	3	14	5.5
16-7-1-6	07/09/95	26		7.81	614	4		298					253		72	22	2.9	0.57	328	N/D	3	15	-2.0
16-7-1-6	10/18/95	20		7.26	450	6		300					269		63	20	2.7	0.4	320	N/D	3	14	-6.6
16-7-1-6	10/15/96	3.4		8.18	468	4																	
16-7-1-6	06/24/97	35		7.85	632	4.7		290					268		71	22	3	N/D	340	N/D	5	14	-4.5
16-7-1-6	09/10/97	30		7.82	479	7.3		360					263		69	22	4	N/D	340	N/D	4	16	-5.2
16-7-1-6	10/20/97	20		7.86	420	8.8		300					284		74	24	3	N/D	352	N/D	4	16	-3.5
16-7-1-6	07/19/98	17		7.2	480	6		302					294		78	24	3	N/D	337	N/D	5	18	-0.3
16-7-24-3	03/17/99														86.38	202.2	23.6	21.58	234	0	5.54	895	-0.2
16-8-18-4	06/08/94	0.5		7.45	350	7		253					281		80.3	21.4	2.3	0.37	357	1	3	6.9	-1.8
16-8-18-4	10/28/94	DRY																					
16-8-18-4	07/09/95	2		7.69	720	8		309					301		82	19	2.8	0.39	341	N/D	3.6	10.1	-1.0
16-8-18-4	10/18/95	0.5		7.06	520	8		239					275		67.2	22.1	1.9	0.1	356	N/D	3	8	-7.3
16-8-18-4	07/18/96	2		6.9	475	13.3	7.9	322					299		82	23	2	N/D	336	5	6	7	0.6
16-8-18-4	10/15/96	DRY																					
16-8-18-4	06/24/97	5		8.01	589	9.9		310					261		73	19	3	N/D	355	N/D	2	8	-6.3
16-8-18-4	09/10/97	Seep only																					
16-8-18-4	10/20/97	1		8.35	430	8.9		280					235		61	20	2	N/D	338	N/D	3	7	-9.4
16-8-18-5	06/08/94	12		7.69	325	5		248					276		75.3	19.4	2.24	0.25	333	2	N/D	8.4	-2.1
16-8-18-5	10/28/94	SEEP																					
16-8-18-5	07/09/95	50		7.77	548	5		295					306		80	19	2.2	0.13	333	N/D	3.8	11.4	-1.4
16-8-18-5	10/18/95	8		7.01	450	6		304					289		70.4	20.1	2.1	N/D	351	N/D	3	10	-7.0
16-8-18-5	07/18/96	10		6.5	474	6		284					284		79	21	2	N/D	339	N/D	4	N/D	0.8
16-8-18-5	10/15/96	2.5		8.02	450	5																	
16-8-18-5	06/24/97	35		7.3	574	5.7		320					276		79	19	2	N/D	335	N/D	3	9	-1.5
16-8-18-5	09/10/97	10		7.64	435	11.4		380					318		68	36	5	N/D	371	N/D	4	54	-5.3
16-8-18-5	10/20/97	10		7.98	400	11.4		280					260		71	20	2	N/D	357	N/D	3	7	-7.0
16-8-20-1	06/08/94	4		7.95	550	8		540					291		59.7	29	60.6	1.36	93	N/D	7	372	-8.2
16-8-20-1	10/28/94	SEEP																					
16-8-20-1	07/10/95	2		7.88	718	7.5		331					303		87	20	2.8	0.35	360	N/D	4	12.8	-1.3
16-8-20-1	10/18/95	DRY																					
16-8-20-1	07/19/96	1		7.65	520	11.7	5.7	348					323		83	28	8	2	364	7	7	18	0.5
16-8-20-1	10/15/96	DRY																					
16-8-5-1	06/08/94	2		7.61	350	5		286					288		73.4	20.6	4.71	0.68	317	7	2.5	N/D	0.7
16-8-5-1	10/28/94	DRY																					
16-8-5-1	07/09/95	7		7.99	552	8		259					236		73	9.7	1.9	0.59	277	N/D	3.6	12	-3.7
16-8-5-1	10/18/95	6		7.82	370	8		316					320		73	21.8	5	0.5	356	N/D	5	29	-7.4
16-8-5-1	07/18/96	8		6.9	534	7		362					320		87	25	5	N/D	354	N/D	6	30	0.2

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
16-8-5-1	10/15/96	7		7.54	521	5																	
16-8-5-1	06/25/97	12		7.8	678	6.4		350					289		78	23	5	N/D	366	N/D	5	32	-6.3
16-8-5-1	09/10/97	4.3		7.37	530	9.2		450					292		79	23	6	N/D	344	N/D	5	38	-3.8
16-8-5-1	10/20/97	6		7.33	508	9.8		350					289		76	24	5	N/D	368	N/D	3	37	-7.0
16-8-6-1	06/08/94	5		7.79	300	6		234					248		77.4	14.7	1.99	0.36	302	5	3.5	9.5	-2.4
16-8-6-1	10/28/94	3		7.9	391	6							271		84.6	16.1	3.8	0.81			5.5	10	87.9
16-8-6-1	07/09/95	15		7.63	635	6		282					253		78	16	1.9	0.28	307	N/D	2.1	9	0.2
16-8-6-1	10/18/95	8		7.46	400	6		264					253		68.8	14.1	1.7	0.2	308	N/D	3	9	-6.5
16-8-6-1	07/17/96	9		7.6	432	8		278					271		82	16	2	N/D	292	8	4	7	1.7
16-8-6-1	10/15/96	6		8.05	450	6																	
16-8-6-1	06/29/97	25		7.74	630	5.9		290					237		70	15	2	N/D	313	N/D	2	8	-5.4
16-8-6-1	09/10/97	6.58		7.51	371	13.4		250					234		69	15	2	N/D	323	N/D	3	8	-7.6
16-8-6-1	10/20/97	6		7.58	396	8.2		250					225		67	14	2	N/D	309	N/D	3	8	-7.4
16-8-7-3	06/08/94	2		7.58	310	3		236					266		88.2	9.36	1.59	0.14	318	2	N/D	8.1	-2.0
16-8-7-3	10/28/94	SEEP																					
16-8-7-3	07/09/95	2		7.81	669	6		331					376		108	12	1.8	0.06	370	N/D	2	7	1.5
16-8-7-3	10/18/95	DRY																					
16-8-7-3	07/18/96	8		6.7	546	9		351					337		115	12	2	N/D	391	N/D	3	5	1.7
16-8-7-3	10/15/96	DRY																					
16-8-7-3	06/25/97	<0.25		8.09	496	10.1		310					241		80	10	2	N/D	309	N/D	3	8	-4.0
16-8-7-3	09/10/97	Dry																					
16-8-8-10	06/08/94	745		7.17	1050	13		1052					812		198	79.7	7.4	5.2	406	5	6.5	490	-0.9
16-8-8-10	10/28/94	708		6.97	1220	12		1110					872		205	81.4	8.1	5.53	427	N/D	5.5	559	-3.8
16-8-8-10	07/09/95	755		7.21	1174	13		1160					865		204	77	6.99	5.48	426	N/D	4.8	539	-3.9
16-8-8-10	10/18/95	672		7.27	1150	11		1030					788		164	64.7	6.3	4.5	478	N/D	5	464	-11.9
16-8-8-10	07/16/96	755		7.21	1174	12		852					728		176	70	8	5	436	N/D	8	352	1.0
16-8-8-10	10/15/96	67		7.16	1028	11																	
16-8-8-10	06/24/97	180		7.15	1081	12.4		800					585		137	59	7	4	451	N/D	5	349	-10.0
16-8-8-10	09/10/97	176		7	934	16.4		790					622		147	62	7	4	444	N/D	6	302	-3.4
16-8-8-10	10/20/97	320		6.93	951	8.9		780					558		126	59	6	4	448	N/D	6	287	-7.9
16-8-8-5	06/08/94	8		7.68	425	7		312					326		69.4	36	5.36	1.05	357	5	4	58.4	-4.8
16-8-8-5	10/02/94	8.5		7.75	538	5		377					347		74.1	40.2	5.3	1.24	373	N/D	3	60	-1.2
16-8-8-5	07/09/95	17		7.78	823	7		376					331		75	40	6.2	1.2	362	N/D	4.2	54.1	1.0
16-8-8-5	10/18/95	10		7.88	540	6		398					371		66.8	36.8	4.7	0.9	381	N/D	4	66	-8.0
16-8-8-5	07/17/96	5		6.9	564	9		372					343		73	39	5	1	350	4	6	47	0.6
16-8-8-5	10/15/96	3.3		8.03	563	4																	
16-8-8-5	06/25/97	0.5		8.12	622	10.1		360					297		63	34	5	N/D	355	N/D	5	45	-5.7
16-8-8-5	09/10/97	0.25		8.02	543	15.6		310					276		76	21	2	N/D	347	N/D	3	9	-3.0
16-8-8-5	10/20/97	1.5		7.63	496	7.2		370					322		68	37	5	N/D	381	N/D	3	51	-5.2
3rd West Bleeder	05/15/96			7.75	730	11		315			<2	285	323		71	30	4	0.8	347	<2	6	26.9	-1.7
3rd West Bleeder	11/13/96			7.37		11.5		309				299	296		69	30	4	1	365	<5	6	26	-4.5
3rd West South	05/15/96			7.85	1200	10		748			<2	359	606		113	69	12	2.9	438	<2	38	227	-4.3
3rd West South	11/13/96			7.85		10.1		730				364	573		109	73	15	3	445	<5	33	241	-4.2
BC-1	02/28/91	29		8	2640	1	9	1730		34	<5	277	1360	0	256	175	23.6	10.4	313	12.3	24.5	1120	-1.9
BC-1	05/28/91	18		8.1	910	8	8	494		1950		310	431	0	77	72.7	8.4	5.07	378	0	4.87	183	0.8
BC-1	06/17/91	29		7.9	700	8	8																
BC-1	07/29/91	13.7		8.1	790	8	9																
BC-1	08/08/91	30		7.9	580	12	9	404		500	<5	270	457	0	62.9	72.9	10.1	5.32	329	0	5.17	218	-1.8
BC-1	09/13/91	42		8.1	540	10	9																
BC-1	10/17/91	27.6		8.1	640	8	8	504		9	<5	189	376	0	55.4	58	9.3	4.8	230	0	3.42	198	0.4
BC-1	02/28/92	300		8.16	584	9	7.2	288	12	2442	12.4		1213	8	359.3	76.8	8.42	14.03	461	0	20	500	14.8
BC-1	05/07/92	38.5		8.36	836	8.6	6.9	507	0	594	1.3		632	1	118.5	81.6	11.74	3.05	389	0	15	230	6.5

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
BC-1	06/30/92	56		8.52	740	19.8	4.8																
BC-1	07/31/92	32		8.54	724	23	4.5																
BC-1	08/10/92	36		8.45	752	19.6	4.8	512	0	221	0.3		444	1	66.7	67.4	9.16	3.75	258	0	10	190	5.1
BC-1	09/24/92	48		8.45	781	11.8	8																
BC-1	10/05/92	39.6		8.45	763	10.2	5.4	491	0	3	0		420	0	70.4	59.4	7.63	8.96	231	0	35	180	2.5
BC-1	02/15/93	Dry																					
BC-1	05/19/93	320		8.09	805	6.5	5.0	496	95.0	37,940	0.9		873	N/D	113	143.4	12.9	18.8	242	N/D	13.8	800	-6.4
BC-1	06/11/93	214		8.3	645	11.9	5.5																
BC-1	07/31/93	53		8.41	648	16.9	5.0																
BC-1	08/11/93	210		7.98	717	8.9	5.4	414	N/D	551	0.2		367	N/D	66	49	8.5	5	256	N/D	7.9	100	9.2
BC-1	09/24/93	72		7.33	770	7.8	5.2																
BC-1	10/20/93	32		7.9	785	8	5.5	419	0.8	197	N/D		588	N/D	120	70	16	N/D	376	N/D	5	210	7.7
BC-1	02/09/94	15		8.3	1340	-0.4	5.5	621	N/D	12	N/D		515		66	85	11	4	342	N/D	7	280	-3.5
BC-1	05/24/94	52		8.1	790	10.9	5.1	920	50.0	6,250	N/D		386		54	61	10	4	239	N/D	4	1000	-50.2
BC-1	06/22/94	52		8.6	669	21.2	5.2																
BC-1	07/19/94	47		8.6	636	16.8	5.4																
BC-1	08/17/94	47		8.4	670	24.7	5.3	430	N/D	237	N/D		306		32	55	6	5	228	N/D	2	190	-8.7
BC-1	09/12/94	35		8.35	615	15.9	5.3																
BC-1	10/18/94	47		8.77	657	6.9	5.5	380	N/D	1298	N/D		320		49	49	8	N/D	270	N/D	8	110	-0.9
BC-1	02/07/95	38		8.7	1181	1.06	4.6	560	2.0	1110	N/D		450		62	71	10	6.0	245	N/D	8	210	5.0
BC-1	05/09/95	64		8.61	929	9.2	5.3	560	60	11800	N/D		450		67	69	13	5.0	298	40	8.0	180	-2.4
BC-1	06/15/95	55		8.56	689	10.9	5.7																
BC-1	07/27/95	52		8.68	547	21.4	5.4																
BC-1	08/22/95	55		8.73	565	22.3	5.6	360	N/D	240	N/D		262		34	43	8	0.1	250	12	5.0	98	-8.9
BC-1	09/29/95	65		8.62	682	6.9	5.6																
BC-1	10/17/95	60		8.3	704	3.7	5.6	390	4.0	1320	N/D		327		50	49	8	0.3	600	15	6	102	-29.4
BC-1	02/26/96	60		8.4	630	0.7	5.4	540	N/D	81	N/D		395		64	57	14	3.0	297	N/D	16	241	-9.4
BC-1	05/22/96	58		8.58	906	14	5.5	664	0.5	152	N/D		447		59	73	13	6.0	370	15	9.0	283	-13.5
BC-1	06/20/96	60		8.7	767	13	5.5																
BC-1	07/10/96	55		8.76	720	12.6	5.6																
BC-1	08/27/96	56		8.73	593	17.6	5.4	351	N/D	658	N/D		589		39	47	7.0	3.0	347	N/D	7.0	131	-16.3
BC-1	09/02/96	56		8.73	601	19.6	5.5																
BC-1	10/30/96	45		8.55	647	4.4	5.5	254	N/D	2305	N/D		250		11.3	39	6	3	590	N/D	7	317	-60.1
BC-1	02/26/97	170		8.25	690	1.8	6.8	360	7	2336	N/D		279		44	41	8	2	408	N/D	5	149	-24.9
BC-1	05/22/97	461		8.66	684	7.4	7.8	400	0.7	1024	N/D		296		51	41	8	2	534	N/D	7	103	-27.5
BC-1	06/30/97	175		9	654	10.2	7.2																
BC-1	07/30/97	140		8.8	576	13.3	7.5																
BC-1	08/27/97	135		8.7	540	18.9	7.2	360	0.6	1066	N/D		278		37	45	8	3	232	N/D	5	98	0.0
BC-1	09/15/97	120		8.56	584	15.3	6.6																
BC-1	10/29/97	145		8.67	621	7.9	7.7	430	0.6	606	N/D		317		46	49	7	3	284	N/D	16	139	-8.7
BC-2	02/28/91	41		8.2	1940	1	9	1810		31	<5	267	1380	0	267	172	23.3	10.2	301	12.2	24.5	11.1	64.2
BC-2	05/28/91	37		8.1	910	9	9	442		622	<5	477	430	0	73	60.3	9.7	5.19	582	0	4.97	3.09	-3.1
BC-2	06/17/91	59.8		8	800	8	8																
BC-2	07/29/91	129		8	490	6	9																
BC-2	08/08/91	28		8	640	14	9	424		400	<5	280	400	0	61.9	59.8	7.2	3.68	342	0	5.17	130	-0.4
BC-2	09/13/91	190		8	610	10	9																
BC-2	10/17/91	216		7.9	469	6	9	494		5	<5	207	242	0	51	27.9	4.1	1.7	253	0	2.59	48.2	-1.6
BC-2	02/18/92	180		7.92	548	7.2	8.3	321	0	6	0.4		298	0	71.9	28.7	1.73	0	294	0	15	33	0.8
BC-2	05/07/92	133.8		8.27	605	13	6.3	391	0	132	1.5		389	2	75	49.1	6.67	0	275	0	15	140	1.4
BC-2	06/30/92	420		8.29	724	15.3	5																
BC-2	07/31/92	55		8.4	542	23.4	4.3																
BC-2	08/10/92	285		7.64	580	15.2	4.5	345	0.9	180	1		389	7	89.9	40	2.06	0	297	0	20	90	3.8

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
BC-2	09/24/92	52		8.31	591	14	5.2																
BC-2	10/05/92	310		8.32	569	10.5	5.8	328	0	21	0.4		409	0	89.3	45.2	4.93	2.09	362	0	15	110	-1.2
BC-2	02/15/93	305		7.35	588	6.28	5.6	284	0.0	7.0	0.5		289	2.0	63	32	4.2	0.0	301	0.0	0.6	40	1.4
BC-2	05/19/93	403		8.04	780	8.2	6.3	430	50	13,110	1.4		869	0.0	79.2	163.1	12.8	13.8	242	0.0	6.5	800	-6.5
BC-2	06/11/93	278		8.03	584	11.8	5.6																
BC-2	07/31/93	557		8.09	587	14.5	5.6																
BC-2	08/16/93	190		8.16	668	8.6	5.9	348	N/D	30	0.1		247	N/D	49.5	30	6.3	3	228	N/D	4.7	130	-10.9
BC-2	09/24/93	310		7.64	618	10.5	5.1																
BC-2	10/21/93	123		7.5	680	9.9	5.6	318	N/D	56	N/D		315	N/D	65	37	10	N/D	342	N/D	6	60	-2.3
BC-2	02/09/94	235		8.35	787	2.8	5.4	352	N/D	17.0	N/D		255		51	31	20	2.0	296	N/D	30	40	-4.1
BC-2	05/24/94	98		7.98	600	11.3	5.3	340	5	1,120	N/D		285		50	39	6	N/D	269	N/D	3	100	-4.8
BC-2	06/22/94	125		8.53	598	19.6	5.5																
BC-2	07/20/94	120		8.42	523	21	5.5																
BC-2	08/18/94	210		8.34	583	15.6	5.5	330	N/D	79	N/D		250		36	39	N/D	N/D	254	N/D	1	80	-7.8
BC-2	09/01/94	164		8.16	628	15.8	5.4																
BC-2	10/18/94	212		8.62	578	9	5.5	350	N/D	624	N/D		300		62	35	6	N/D	330	N/D	7	30	0.0
BC-2	02/07/95	215		8.62	702	4.7	5.4	310	N/D	90.0	N/D		280		53	35	4	2.0	300	N/D	5	46	-2.4
BC-2	05/09/95	240		8.56	851	14.8	5.5	440	10	3983	N/D		360		60	50	8	4.0	1385	25	9.0	140	-55.9
BC-2	06/15/95	185		8.63	627	12.3	5.9																
BC-2	07/27/95	110		8.64	543	20.7	5.4																
BC-2	08/22/95	125		8.42	515	19.8	5.7	290	N/D	165	N/D		236		40	33	6	2.0	263	6	6.0	52	-6.8
BC-2	09/29/95	120		8.3	650	8.2	5.8																
BC-2	10/17/95	220		8.14	610	5.4	5.7	310	N/D	555.0	N/D		274		52	35	5	2	475	N/D	6	52	-22.3
BC-2	02/26/96	45		8.25	655	0.8	5.8	685	N/D	214	N/D		489		69	77	12	5.0	320	N/D	9.0	299	-5.8
BC-2	05/22/96	130		8.42	693	12.4	5.5	415	N/D	5.0	N/D		294		48	42	7.0	2.0	265	25	7.0	35	0.9
BC-2	06/26/96	130		8.5	708	12.8	5.7																
BC-2	07/10/96	270		8.53	694	12.6	5.8																
BC-2	08/27/96	193		8.4	619	15.4	5.6	390	N/D	226	N/D		305		56	40	7.0	2.0	313	N/D	7.0	79	-4.0
BC-2	09/02/96	256		8.39	637	16.7	5.6																
BC-2	10/30/96	245		8.34	624	9	6	35	N/D	136	N/D		305		56	40	6.0	11	330	N/D	6.0	70	-3.1
BC-2	02/27/97	185		8.4	960	1.5	7.5	460	N/D	347	N/D		363		58	53	9	3	302	N/D	6	186	-7.6
BC-2	05/22/97	660		8.78	637	11.8	7.5	360	0.9	1079	N/D		276		51	36	7	2	609	N/D	6	69	-32.9
BC-2	06/30/97	743		8.52	615	12.9	7.4																
BC-2	07/30/97	380		8.68	773	13.2	7.9																
BC-2	08/27/97	460		8.38	825	15	6.9	320	3.1	2644	N/D		243		43	33	5	2	282	N/D	4	56	-6.9
BC-2	09/15/97	370		8.29	566	14.4	7.1																
BC-2	10/29/97	419		8.42	816	9.9	7.8	550	0.8	650	N/D		407		79	51	10	3	296	N/D	9	382	-20.2
BC-3	02/28/91	DRY																					
BC-3	05/28/91	DRY																					
BC-3	06/17/91	DRY																					
BC-3	07/29/91	DRY																					
BC-3	08/08/91	DRY																					
BC-3	09/13/91	DRY																					
BC-3	10/17/91	DRY																					
BC-3	02/18/92	Dry																					
BC-3	05/07/92	Dry																					
BC-3	06/30/92	Dry																					
BC-3	07/31/92	Dry																					
BC-3	08/10/92	Dry																					
BC-3	09/24/92	Dry																					
BC-3	10/05/92	Dry																					
BC-3	02/15/93	Dry																					

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
BC-3	05/19/93	Dry																					
BC-3	06/11/93	Dry																					
BC-3	07/31/93	Dry																					
BC-3	08/16/93	Dry																					
BC-3	09/24/93	Dry																					
BC-3	10/20/93	Dry																					
BC-3	02/09/94	Dry																					
BC-3	05/24/94	Dry																					
BC-3	06/22/94	Dry																					
BC-3	07/19/94	Dry																					
BC-3	08/10/94	Dry																					
BC-3	09/01/94	Dry																					
BC-3	10/18/94	Dry																					
BC-3	02/07/95	Dry																					
BC-3	05/23/95	Dry																					
BC-3	06/15/95	Dry																					
BC-3	07/27/95	Dry																					
BC-3	08/22/95	Dry																					
BC-3	09/29/95	Dry																					
BC-3	10/17/95	Dry																					
BC-3	02/27/96	Dry																					
BC-3	05/22/96	Dry																					
BC-3	06/20/96	Dry																					
BC-3	07/10/96	Dry																					
BC-3	08/30/96	Dry																					
BC-3	09/02/96	Dry																					
BC-3	10/31/96	Dry																					
BC-3	02/27/97	Dry																					
BC-3	05/22/97	Dry																					
BC-3	06/30/97	Dry																					
BC-3	07/30/97	Dry																					
BC-3	08/26/97	Dry																					
BC-3	09/15/97	Dry																					
BC-3	10/29/97	Dry																					
Birch #1 Source	10/29/98			6.45	700	10		476			<2	335	395		89	42	6	2	409	<5	6	91	-3.2
Birch #2 Source	10/29/98			6.55	720	10		476			<2	330	296		51	41	6	2	402	<5	7	21	-7.5
BP-1	05/28/91	<0.1		8	790	10		406			N/A		370		72.8	45.8	10.8	2.76	398	0	10.8	67.5	-1.8
BP-1	10/17/91	0.75		7.9	797	8		496			N/A		428		92.7	47.9	11.2	4.85	475	0	11.2	55.6	-0.5
BP-1	05/14/92	0.2		7.57	802	12.2		443			0.2		459		92.7	55.2	9.47	0	348	0	25	53	12.1
BP-1	10/28/92	0.2		7.92	825	48.1		436			1.3		335		54.7	48.2	15.08	1.74	460	0	15	35	-8.0
BP-1	05/06/93	0.2		7.13	966	9.2		615					507		77.4	76.1	15.3	2.6	403	N/D	22.8	210	-3.4
BP-1	10/26/93	<0.1		8.06	1009	10.7		475					453		89	56	12	N/D	474	N/D	16	80	-1.6
BP-1	05/31/94	0.5		7.9	757	11.1		410	N/D	N/D	N/D		379		76	46	9	N/D	449	N/D	9	60	-5.3
BP-1	10/18/94	<0.1		7.75	730	9.1		420	N/D	N/D	N/D		400		83	46	9	N/D	450	N/D	12	70	-4.9
BP-1	05/23/95	0.3		8.42	821	14		510					420		75	57	11	3	410	20	16	100	-4.9
BP-1	10/17/95	Seep		N/A	N/A	N/A																	
BP-1	05/22/96	Seep																					
BP-1	10/31/96	Seep																					
BP-1	05/21/97	Seep		7.65	794	15.1																	
BP-1	10/29/97	Seep		7.28	811	5.3																	
BS-6	02/25/85			8.2				320		46					68	29	5	1.2	269	0	3	27	8.8
BS-6	03/20/85			8				390		54					67	27	2	0.8	261	0	4	29	6.4

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
BS-6	04/18/85			8.2				310		62					54	28	2	1.5	214	0	4	35	8.1
BS-6	05/06/85			8				270		10					58	28	9	0.8	238	0	4	25	10.6
BS-6	06/17/85			7.9				270		4					62	26	4	1	243	0	3	17	10.4
BS-6	08/20/85			8.2				240		2					46	30	3	1	219	0	3	31	6.6
BS-6	09/24/85			8.5				664		26					62	46	111	5	184	6	135	150	7.7
BS-6	04/23/86		10	8.1	296	4																	
BS-6	01/05/87			8.1	497			294		18		256	285		58	34	4	1	312	0	4	30	0.4
CK-1	06/09/94	708		7.65	755	18		808					702		144	70.6	8.15	4.79	274	1	8	477	-4.3
CK-1	10/28/94	745		7.74	1040	8.5		990					794		175	82.6	8.6	5.34	274	N/D	6	534	0.8
CK-1	07/09/95	1104		8.26	1133	18		809					571		140	67	8.4	4.3	266	N/D	4.8	389	1.5
CK-1	10/18/95	985		8.06	1000	11		894					691		139	77	8.8	5.2	294	4	6	467	-3.7
CK-1	07/16/96	352		7.8	849	19		625					512		98	65	8	4	224	23	8	224	6.8
CK-1	10/15/96	103		8.29	849	3																	
CK-1	06/25/97	375		8.71	693	19.3	7.2	480					346		61	47	8	3	254	8	5	178	-6.0
CK-1	09/11/97	323		8.51	814	18.3	6.7	600					413		73	56	8	3	264	N/D	6	238	-4.3
CK-1	10/21/97	320		8.5	791	11.7	9.4	650					491		86	67	9	3	331	N/D	6	265	-4.0
CK-2	06/09/94	4		7.55	850	10		352					436		70.7	36.6	5.38	1.1	352	5	3.5	61	-3.6
CK-2	10/28/94	40		8.11	716	2		563					500		86.8	64.2	8.3	2.79	343	N/D	7	214	-1.2
CK-2	07/09/95	950		8.65	692	17		334					371		69	35	5.91	1.7	289	N/D	4.5	74.5	1.5
CK-2	10/18/95	376		8.27	650	4		482					428		70.5	46.7	6.6	1.7	358	1	5	142	-7.8
CK-2	07/16/96	25		8.15	548	13		364					330		63	42	6	1	272	13	7	89	-0.4
CK-2	10/15/96	50		8.26	548	0.5																	
CK-2	06/25/97	377		9.04	634	6.9	7.5	370					294		60	35	6	1	295	N/D	4	69	-1.8
CK-2	09/10/97	147		8.34	578	13.9	7	450					336		62	44	7	2	313	N/D	5	138	-7.1
CK-2	10/20/97	200		8.16	535	5.8	8.8	470					362		64	49	7	2	347	N/D	5	136	-6.7
CO-1	05/23/95	DRY																					
CS-1	05/28/91	15		8.1	410	9		342			N/A		309		83.2	24.6	5.1	2.58	316	0	5.47	65.8	-1.8
CS-1	10/17/91	17		7.6	602	6		418			N/A		309		75.5	29.5	4.6	2.4	323	0	3.73	60.5	-1.5
CS-1	05/14/92	15		7.34	725	10		385			0.0		405		89.9	43.9	3.9	0.0	326	0.0	30	100	0.0
CS-1	10/12/92	28		7.45	773	54.1		408			0.0		477		127.7	38.3	1.99	1.91	430	0.0	15	50	6.3
CS-1	05/06/93	5		7.25	824	11.2		413					366		82.8	38.7	4.6	2.8	387	N/D	8.7	100	-6.7
CS-1	10/24/93	15		7.36	766	10.6		440					423		97	44	N/D	N/D	413	N/D	15	60	0.1
CS-1	05/31/94	18		7.16	780	11.1		410	N/D	N/D	N/D		387		89	40	5	3	428	N/D	5	60	-2.3
CS-1	10/18/94	15		7.42	708	12.5		400	N/D	16	N/D		380		91	38	5	N/D	420	N/D	9	60	-3.0
CS-1	05/23/95	8		7.5	720	13.1		400					370		85	38	4	3	400	10	7	50	-3.2
CS-1	10/18/95	10		7.24	719	11.5		400					367		86	37	5	2	410	N/D	9	58	-3.7
CS-1	05/22/96	8		7.47	728	12.4		426					351		81	36	5	2	410	N/D	7	52	-4.8
CS-1	10/31/96	7		8	726	11.5		405					318		68	36	4	2.0	421	N/D	9	55	-11.6
CS-1	05/23/97	15		7.49	715	12.8		420					337		79	34	3	1	410	N/D	7	56	-7.9
CS-1	10/29/97	9		7.59	683	11.8		420					332		72	37	3	2	422	N/D	5	54	-9.1
Defa #1	01/06/99	7		8.3	690	5.8		656		<5		304	469		84	63	9	4	371	<5	6	261	-8.4
Defa #2	01/06/99	10.7		7.6	620	10.4		474		9		268	403		84	47	6	2	327	<5	5	132	0.7
DH-1A	01/27/93		115.83																				
DH-1A	02/18/93		112.17	7.48	620	10.9		352					224		41.9	29	13.4	39.3	207	N/D	0.1	120	1.5
DH-1A	03/23/93		113																				
DH-1A	04/30/93		113.67																				
DH-1A	05/26/93		113.67	7.07	986	10.8		597					391		66.6	54.6	32.5	24.0	352	N/D	24.9	220.0	-5.8
DH-1A	06/15/93		113.67																				
DH-1A	07/31/93		114.15																				
DH-1A	08/31/93		114.12	7.09	681	11		514					381.8		82.0	43	19	1.4	341	N/D	7.4	130.0	-0.1
DH-1A	09/14/93		113.59																				
DH-1A	10/26/93		114	7.21	763	11.2		395					338		66	42	11	20.0	276	N/D	7.0	70.0	11.2

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
DH-1A	11/23/93		113.67																				
DH-1A	12/15/93		113.33																				
DH-1A	01/20/94		114.1																				
DH-1A	02/09/94		113.25	7.4	644	10.7		302					314		63	38	7	13	355	N/D	3	40	1.2
DH-1A	03/21/94		113.25																				
DH-1A	04/29/94		113.8																				
DH-1A	05/31/94		113	7.24	668	10.2		320					305		66.0	34	6	10.0	390	N/D	5.0	40.0	-5.4
DH-1A	06/27/94		113.5																				
DH-1A	07/19/94		113.1																				
DH-1A	08/28/94		116.5	7.6	653	10.7		400					321		74.0	33	7	9.0	361	N/D	3.0	22.0	3.6
DH-1A	09/30/94		113.3																				
DH-1A	10/30/94		113.7	7.33	581	11.2		340					300		66	32	N/D	8.0	350	N/D	7.0	40.0	-5.0
DH-1A	11/26/94		113.5																				
DH-1A	12/22/94		113.5																				
DH-1A	01/04/95		113.1																				
DH-1A	02/07/95		113.2	7.62	1656	10.6		1630					1090		83	215	145.0	30.0	610	N/D	36.0	700	6.1
DH-1A	03/25/95		111.2																				
DH-1A	04/29/95		111.65																				
DH-1A	05/09/95		111.75	7.78	767	11.5		450					340		57.0	48	34	8	260.0	10	10	150	2.9
DH-1A	06/29/95		110.3																				
DH-1A	07/13/95		110.1																				
DH-1A	08/31/95		110.9	7.94	811	12.67		450					316		49	47	28	8	300	N/D	10	157	-4.5
DH-1A	09/29/95		111.33																				
DH-1A	10/17/95		112.2	7.35	657	11.7		450					301		53	41	20	6	355	N/D	9	96	-6.9
DH-1A	11/21/95		112.25																				
DH-1A	12/26/95		112.9																				
DH-1A	02/27/96		112.2	7.4	512	9.3		388					258		45	35	26	5.0	252	N/D	9.0	125	-4.4
DH-1A	05/22/96		112.8	7.4	733	11.7		486					317		53	45	23	6.0	365	N/D	10	105	-6.0
DH-1A	08/28/96		112.9	7.5	680	11.8		383					312		59	40	12	6.0	373	N/D	7.0	52	-3.4
DH-1A	10/29/96		112.2	7.25	675	9.9		354					271		49	36	9.0	4.0	373	N/D	6	44	-9.9
DH-1A	02/27/97		111.3	7.27	771	10.3		520					371		58	55	24	7	409	N/D	10	112	-3.7
DH-1A	05/28/97		112.1	7.82	751	11.6		470					311		47	47	24	6	307	N/D	9	138	-4.8
DH-1A	08/31/97		111	7.86	544	11.9		410					323		60	42	13	6	390	N/D	6	71	-5.7
DH-1A	10/30/97		110.7	7.66	620	10.6		370					298		55	39	8	5	379	N/D	6	45	-6.5
DH-2	01/27/93		22																				
DH-2	02/22/93		22.13	6.9	626	11.3		356					316		70.4	34	8.1	N/D	344	N/D	0.8	30	2.9
DH-2	03/23/93		22.4																				
DH-2	04/30/93		23.83																				
DH-2	05/25/93		23.1	6.83	623	11.2		346					293		68.3	29.8	5.4	2.0	340	N/D	3.9	30.0	-1.3
DH-2	06/15/93		24.06																				
DH-2	07/31/93		24.35																				
DH-2	08/31/93		24.25	7.02	625	11.2		353					311		65.0	36.0	22.9	2.0	330	N/D	4.2	26.0	8.9
DH-2	09/14/93		26.25																				
DH-2	10/29/93		25.7	7.34	749	11.4		290					237		75	34	N/D	N/D	350	N/D	5.0	28.0	0.6
DH-2	11/23/93		24.25																				
DH-2	12/15/93		23.75																				
DH-2	01/20/94		24.1																				
DH-2	02/10/94		23.33	7.27	638	28.8		312					300		69	31	5	N/D	342	N/D	5	29	-1.1
DH-2	03/21/94		23.75																				
DH-2	04/29/94		24.5																				
DH-2	05/31/94		24.5	7.02	603	10.7		300					295		67.0	31	5	N/D	373	N/D	4.0	30	-5.6
DH-2	06/27/94		24.5																				

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
DH-2	07/19/94		24.5																				
DH-2	08/29/94		24.75	7.39	628	11.3		630					307		72.0	31.0	N/D	N/D	355	N/D	4.0	23	-2.2
DH-2	09/30/94		24.7																				
DH-2	10/26/94		24.75	7.24	578	12.6		330					300		66	32	N/D	N/D	350	N/D	6.0	28	-4.6
DH-2	11/26/94		24.8																				
DH-2	12/22/94		24.9																				
DH-2	01/04/95		25.2																				
DH-2	02/07/95		24.65	7.49	605	11.9		330					300		69		5	2	330	N/D	6	20	-23.6
DH-2	03/25/95		22.5																				
DH-2	04/29/95		25																				
DH-2	05/23/95		25.1	7.09	586	11.8		370					270		65.0		4	2	360.0	N/D	6	25	-31.1
DH-2	06/29/95		17.8																				
DH-2	07/13/95		14.9																				
DH-2	08/31/95		23	7.25	630	11.7		330					278		62		2	2	350	N/D	6	30	-33.8
DH-2	09/29/95		24.55																				
DH-2	10/17/95		24.03	7.18	568	11.8		320					283		67		5	2	365	N/D	6	24	-29.6
DH-2	11/21/95		24.9																				
DH-2	12/26/95		26.7																				
DH-2	02/29/96		27.4	7.42	507	12		302					288		67	30	6.0	2.0	354	N/D	6.0	30	-3.7
DH-2	05/22/96		28	7.36	588	10.7		335					286		65	30	5.0	2.0	355	N/D	6.0	29	-4.9
DH-2	08/20/96		27.3	7.2	622	12.4		311					302		70	31	4.0	2.0	357	N/D	6.0	28	-2.6
DH-2	10/30/96		27.3	7.2	590	11.8		320					259		56	29	4.0	1.0	363	N/D	6.0	25	-10.5
DH-2	11/15/96			7.32		10		313				293	291		67	30	4	2	358	<5	7	27	-4.7
DH-2	02/27/97		27.75	7.09	564	11.4		330					293		68	30	4	2	358	N/D	6	28	-4.3
DH-2	05/29/97		28.8	7.22	589	11.4		310					305		71	31	4	2	355	N/D	6	28	-2.0
DH-2	08/27/97		30.8	7.32	569	11.7		310					278		65	28	5	2	359	N/D	5	27	-6.2
DH-2	10/29/97		32.6	7.5	562	11.2		340					270		62	28	3	2	362	N/D	3	26	-8.1
DH-3	01/27/93		125.92																				
DH-3	02/19/93		125.42	7.29	608	10.6		342					301		67.8	32	4.3	N/D	256	N/D	4.4	44	8.4
DH-3	03/23/93		125.4																				
DH-3	04/30/93		125.83																				
DH-3	05/28/93		125.8	7.04	591	11.2		349					283		64.6	29.6	3.3	0.5	340	N/D	4.5	29.0	-4.0
DH-3	06/15/93		125.75																				
DH-3	07/31/93		126.2																				
DH-3	08/31/93		125.8	7.08	611	10.6		317					236.9		52.0	26	3.3	1.9	329	N/D	5.3	24	-10.2
DH-3	09/14/93		125.42																				
DH-3	10/21/93		125.1	7.25	607	12		317					366		84	38	N/D	N/D	355	N/D	5	24	6.2
DH-4	02/15/94		58.75	723	668	10.6		342					314		73	32	4	2	345	N/D	3	30	1.1
DH-4	03/21/94		60																				
DH-4	04/29/94		60.25																				
DH-4	05/31/94		60.6	7.14	630	10.9		350					293		68	30	3	N/D	395	N/D	3	30	-9.0
DH-4	06/27/94		60.7																				
DH-4	07/19/94		60.5																				
DH-4	08/31/94		60.7	7.2	623	10.7		400					314		73	32	N/D	N/D	361	N/D	5	26	-2.6
DH-4	09/30/94		61.25																				
DH-4	10/27/94		61.3	7.12	546	12.3		350					302		70	31.0	6	N/D	354	N/D	7.0	28	-2.2
DH-4	11/26/94		62																				
DH-4	12/22/94		62.3																				
DH-4	01/04/95		62.4																				
DH-4	02/07/95		62.4	7.45	622	11.7		330					320		72		3	1	330.0	N/D	6	30	-24.6
DH-4	03/25/95		62.4																				
DH-4	04/29/95		63																				

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
DH-4	05/23/95		62.85	7.23	701	11.9		380					280		67.0		3	2	360.0	N/D	5	25	-30.2
DH-4	06/29/95		62.8																				
DH-4	07/13/95		62.9																				
DH-4	08/31/95		62.92	7.2	621	12.4		290					286		65		3	1	350	N/D	6	54	-34.8
DH-4	09/29/95		62.84																				
DH-4	10/18/95		62.4	7.17	574	11.6		350					294		70		4	1	360	N/D	10	20	-28.3
DH-4	11/21/95		62.45																				
DH-4	12/26/95		62.7																				
DH-4	02/27/96		62.17	7.04	494	11.8		334					307		72	31	4.0	1.0	345	N/D	5.0	46	-3.1
DH-4	05/22/96		62.1	7.05	618	11.8		356					323		75	33	5.0	1.0	355	N/D	6.0	45	-1.6
DH-4	08/23/96		61.2	7.22	660	12.3		338					328		77	33	3.0	1.0	352	N/D	6.0	46	-1.3
DH-4	10/31/96		61.2	7.68	586	11.5		354					284		61	32	3.0	1.0	372	N/D	6.0	50	-11.3
DH-4	02/27/97		61.15	7.1	619	11.4		370					337		79	34	4	1	356	N/D	6	58	-1.9
DH-4	05/29/97		60.9	7.56	601	11.9		350					336		80	33	4	1	353	N/D	6	59	-2.0
DH-4	08/30/97		60.8	7.47	620	11.7		380					317		74	32	4	1	345	N/D	4	34	0.4
DH-4	10/30/97		60.9	7.37	621	11.9		370					318		73	33	3	1	305	N/D	4	66	0.3
FBC-10	07/30/91	9		7.8	450			244					244		60	22.9	5.40	0.40	294	0.00	8.01	9.05	-1.3
FBC-10	10/12/92	Dry																					
FBC-10	06/21/93	1		7.46	760	9.4	6.2																
FBC-10	08/29/93	Dry																					
FBC-10	06/16/94	Dry																					
FBC-10	08/30/94	Dry																					
FBC-10	10/31/94	Dry																					
FBC-10	06/24/97			9.52	435.00	13.40	6.50	230.00					204.00		42.00	24.00	5.00	N/D	228.00	N/D	6.00	12.00	1.5
FBC-11	08/08/91	15		8.4	300			182					169		52.3	9.39	3.20	0.82	194	5.10	3.35	9.88	-1.5
FBC-11	10/12/92	Dry																					
FBC-12	06/29/93	100		8.14	420	13.6		220					345		75.7	37.9	5.6	3.8	286	N/D	4.3	70	7.2
FBC-12	08/29/93	58		7.82	472	10		245					564		140	52	3	1.9	461	N/D	3.7	40	14.8
FBC-12	10/15/93	21		7.72	546	4.7		261					311		65	36	N/D	N/D	292	N/D	4.5	14	8.7
FBC-12	06/15/94	26		7.65	564	4.4		270					243		51	28	3	N/D	301	N/D	1	15	-2.9
FBC-12	08/29/94	32		7.78	393	11.1		220					178		45	16	N/D	N/D	255	N/D	2	2	-9.0
FBC-12	10/30/94	43		7.87	484	6.3		260					240		49	28	5	N/D	311	N/D	8	7	-4.9
FBC-12	06/25/97	3		8.51	510	10.1																	
FBC-12	*6/29/93 sample taken in Bear Creek where sources converge.																						
FBC-14	08/08/91	120		8	500			250					257		53.7	29.9	4.60	1.58	284	N/D	4.06	31.3	-0.3
FBC-14	06/28/95							320					280		62	30	6	N/D	315	5.00	10	17	-1.2
FBC-2	08/01/91	12		8.05	550			352					305		77.8	26.9	4.90	0.89	379	N/D	2.33	5.76	-0.6
FBC-3	08/01/91	1.5		8.00	450			274					258		72.4	18.8	3.50	0.84	307	N/D	2.43	12.3	-0.3
FBC-6B	10/13/92	1.5		7.8	820	11.6		277					280		60.4	31.3	3.83	2.64	368	N/D	15	28	-9.3
FBC-6B	06/21/93	7		7.98	642	9.8		379					312		75.3	30.1	6.1	3.2	313	N/D	7.6	25	5.9
FBC-6B	10/15/93	3		7.9	660	5.8		323					347		83	34	N/D	N/D	306	N/D	10	28	8.3
FBC-6B	06/16/94	4		7.75	635	6.2		323					291		72	27	6	N/D	359	N/D	2	20	-2.3
FBC-6B	08/30/94	18		7.6	593	6.2		350					309		76	29	6	N/D	327	N/D	7	14	4.8
FBC-6B	10/31/94	25		7.51	589	7.4		340					288		69	28	8	N/D	350	N/D	7	19	-2.0
FBC-7	07/30/91	2.1		8.2	700			440					368		53.4	57.1	10.1	5.04	333	0.00	5.07	96.3	2.1
FBC-7	10/12/92	0.7		7.28	563	7.78		301					286		83.6	18.7	2.21	0.00	295	0.00	45	17	-5.3
FBC-7	06/21/93	27		6.63	630	5.2		340					301		70.6	30.2	6.4	2	311	N/D	7.6	16	5.8
FBC-7	08/29/93	25		7.83	590	9.8		301					264.7		62	43	15	20	298	N/D	5.3	14	18.8
FBC-7	10/15/93	13		7.4	588	5		284					256		63	24	N/D	N/D	297	N/D	9	15	-3.0
FBC-7	06/15/94	15		7.38	580	5		250					256		63	24	5	N/D	305	N/D	5	12	-0.6
FBC-7	08/30/94	8		7.8	542	6.7		260					244		58	24	8	N/D	283	N/D	7	10	1.6
FBC-7	10/31/94	3		7.81	590	7.6		260					290		57	24	9	N/D	280	N/D	8	16	0.5

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
FBC-7	06/24/97			7.89	604	6.7																	
FBC-8	08/07/91	5		7.6	450			250					231		61.7	18.8	5.60	4.40	289	N/D	6.18	11.9	-1.8
FBC-8	10/12/92	Dry																					
FBC-9	08/07/91	22.4		7.6	480			252					257		68.1	21.2	5.00	0.45	307	0.00	5.17	14	-0.9
FBC-9	10/12/92	Dry																					
FBC-9	06/21/93	1		7.46	760	9.4		441					342		84.1	32	15.5	3.1	376	N/D	7.2	34	3.5
FBC-9	08/29/93	Dry																					
FBC-9	06/16/94	Dry																					
FBC-9	08/30/94	Dry																					
FBC-9	10/31/94	Dry																					
FC-1	06/09/94	45		7.46	1250	12		570					454		52.5	70.1	29.9	3.08	325	9	10.5	236	-5.2
FC-1	10/27/94	30		8.06	1180	9.5		1030					736		82.2	124	67.9	4.71	485	N/D	18	484	-3.3
FC-1	07/10/95	80		8.81	629	20		386					398		64	50	13	1.6	333	N/D	6.2	98.8	1.4
FC-1	10/18/95	15		8.34	910	10		778					584		64.5	100	47.3	4.6	419	9	13	318	-1.9
FC-1	07/16/96	226		8.3	550	18.9	7.2	350					327		48	52	15	2	286	6	8	97	1.7
FC-1	10/15/96	15		8.24	550	6																	
FC-1	06/29/97	483		8.52	629	11.5	7.2	360					284		41	44	11	N/D	310	N/D	5	N/D	8.2
FC-1	09/17/97	75		8.54	856	18.4	6.1	620					415		46	73	28	3	356	N/D	10	229	-6.2
FC-1	10/28/97	120		8.55	1212	5.6	6.8	750					518		59	90	37	3	449	N/D	11	271	-5.0
FC-2	07/31/91	80		7.6	500			270					270		69.7	23.4	3.90	0.73	310	0.00	2.23	19.3	0.5
FC-2	06/09/94	50		7.4	1200	12		790					637		85.3	88.9	32.6	2.89	326	7	16	415	-5.7
FC-2	10/27/94	25		8.36	1110	9		1020					751		101	119	45.6	3.18	390	N/D	22	509	-2.1
FC-2	07/10/95	100		8.82	780	19		360					286		47	40	12	1.3	260	N/D	6	92.7	-1.4
FC-2	10/18/95	15		8.52	450	12		620					476		74.8	80.9	23.5	2.7	326	11	10	238	2.4
FC-2	07/16/96	191		8	594	21.1	6.3	403					344		52	52	13	1	219	47	9	118	-2.6
FC-2	10/15/96	18		8.49	594	6																	
FC-2	06/25/97	316		8.5	626	10.5	7	370					274		47	38	11	1	287	N/D	6	93	-6.4
FC-2	09/17/97	125		8.35	773	18.6	6	600					389		55	61	19	2	307	N/D	9	241	-8.8
FC-2	10/28/97	150		8.37	7.2	7.2	6.4	630					471		70	72	22	2	360	N/D	11	207	-0.5
FC-3	07/31/91	2.5		7.9	800			272					283		72.6	24.8	2.80	0.33	333	0.00	2.13	9.05	0.7
FC-3	10/28/92	46		8.6	946	7.61		614	N/D	668	2.10		547		108.1	67.2	18.4	3.21	281	0.00	20	250	6.4
FC-3	06/24/93	300		8.35	663	7.6		433	N/D	7	0.1		354		55.7	52.1	19.6	0.3	274	N/D	7.9	150	0.6
FC-3	08/15/93	65		8.15	890	23.1		648		17	N/D		549.7		75	88	38	3.1	311	N/D	10	29	36.0
FC-3	10/26/93	122		8.04	1415	7.5		648					642		74	111	53	N/D	302	N/D	15	330	10.6
FC-3	03/23/94	210		8.6	1671	8.1		1000	N/D	10	N/D		712		89	119	69	4	349	N/D	65	600	-7.3
FC-3	06/01/94	120		8.6	1268	11		820	N/D	9	N/D		578		70	98	47	3	374	N/D	15	330	0.9
FC-3	08/29/94	Dry																					
FC-3	10/30/94	105		8.5	1637	8.6		1240	N/D	N/D	N/D		760		87	132	81	N/D	390	N/D	24	500	3.4
FC-3	06/29/97			8.49	648	10.9																	
LT-1	05/28/91	9		8.2	910	8	9	478	N/R	<1	<5.0		401	N/R	66	57.4	18.1	4.42	367	0	22	92.2	2.0
LT-1	10/17/91	84		7.8	890	2	9	474	N/R	1	<5.0		395	N/R	73.6	51.5	18.8	4.97	434	0	18.2	77	-2.0
LT-1	05/14/92	25		8.08	890	10.6	4.8	471	0.0	4	0.2		445	2	73.3	63.5	21.26	0.0	416	0.0	35	110	-1.5
LT-1	10/05/92	18		7.94	938	9.1	5.8	505	0.0	3	0.0		514	0	112.2	56.9	10.25	5.35	452	0.0	30	50	7.8
LT-1	05/06/93	30		7.82	1027	9.9	6	552	N/D	5	1.1		464		75.3	66.9	21.4	4.9	420	N/D	31.5	140	-1.7
LT-1	05/26/93	153		8.08	1000	9.4	6.2	605	N/D	99	0.2		535		94.5	72.6	20.8	9.0	407	N/D	28.1	170	3.6
LT-1	10/24/93	38		8.04	975	8.7	5.8	535	N/D	3	N/D		487		88	65	21	N/D	463	N/D	25	90	2.3
LT-1	05/24/94	35		8.07	882	10.9	5.4	480	N/D	4	N/D		415		72	57	21	4	433	N/D	26	90	-2.2
LT-1	10/18/94	23		8.51	919	8.3	5.1	520	N/D	N/D	N/D		470		85	62	20	N/D	470	N/D	26	80	0.5
LT-1	05/23/95	25		8.44	957	9.7	5.5	540	N/D	105	N/D		430		75	59	20	5	450	10	31	90	-4.2
LT-1	10/17/95	70		8.12	804	11.3	5.5	480	N/D	10	N/D		370		69	48	14	3	405	20	21	64	-6.6
LT-1	05/20/96	120		8.43	842	10.9	5.6	502	N/D	15	N/D		410		80	51	15	3	360	20	23	77	0.6
LT-1	10/31/96	35		8.61	952	5.7	5.7	517	N/D	N/D	N/D		365		57	54	18	4.0	469	N/D	25	89	-11.4

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
LT-1	05/29/97	210		8.84	550	10.3	7.4	320	N/D	174	N/D		268		58	30	7	2	338	N/D	11	32	-6.6
LT-1	10/29/97	110		8.39	809	9.2	7.9	15	N/D	N/D	N/D		355		53	54	15	4	377	N/D	24	100	-6.6
MH-1	07/31/91	1.5		7.9	800			468					445		85.9	56.1	13.8	1.53	464	N/D	15.3	72.8	0.0
MH-1	10/04/92	Dry																					
MH-1	06/21/93	120		7.94	364	14.3	6	259					203		46.9	20.9	3	2.3	209	N/D	4.3	10	6.1
MH-1	08/29/93	48		7.75	435	12.4	5.4	246					241		52	27	4	1.2	253	N/D	3.2	10	5.9
MH-1	10/15/93	37		7.45	695	3.6	4.9	286					293		68	30	N/D	N/D	313	N/D	10	15	1.2
MH-1	06/16/94	0.7		8.52	484	14.2	5.5	276					235		48	28	7	N/D	294	N/D	4	31	-5.5
MH-1	08/30/94	Dry																					
MH-1	10/31/94	Dry																					
MH-1	06/29/97			8.53	565	17.8	7.5																
NPDES	04/18/91	60		7.81	842	N/R		464	N/A	46	3.4												
NPDES	05/28/91	62		8	600	9		360	N/A	39	<5.0												
NPDES	06/17/91	61.5		8	540	9		364	N/A	16	<5.0												
NPDES	07/29/91	62		8.1	640	6		300	N/A	3	<5.0												
NPDES	08/08/91	61.2		8	440	11		362	N/A	<1	<5.0												
NPDES	09/13/91	63.2		8	410	9		482	N/A	<1	<5.0												
NPDES	10/17/91	60		7.9	483	7		336	N/A	1	<5.0												
NPDES	11/29/91	79.5		7.9	450	7		LOST	N/A	LOST	LOST												
NPDES	12/27/91	194		7.3	510	6		298	N/A	2	1.1												
NPDES	01/17/92			7.8	742	7																	
NPDES	01/31/92	305		6.4	890	6.5		676	N/A	20	0.4												
NPDES	02/18/92	318		7.92	595	8.2		340	N/A	0.5	0												
NPDES	02/29/92			7.79	647	7.5																	
NPDES	03/12/92			7.8	725	7.5																	
NPDES	03/27/92	304		7.8	1110	7		782	N/A	1	0												
NPDES	04/09/92	310		7.66	N/A	8		278	N/A	0	0												
NPDES	04/30/92			7.72	N/A	8.3																	
NPDES	05/14/92	305		7.82	694	8.1		409	N/A	6	0.3												
NPDES	05/29/92			7.86	N/A	10.4																	
NPDES	06/09/92	305		7.86	586	8.3		337	N/A	1	1.8												
NPDES	06/30/92			7.84	N/A	10.2																	
NPDES	07/07/92	203		7.84	584	10.9		335	N/A	1	0												
NPDES	07/31/92			7.8	597	8.6																	
NPDES	08/10/92	214		7.75	640	16		362	N/A	2	0.8												
NPDES	08/21/92			7.8	643	10.5																	
NPDES	09/10/92	124		7.57	717	10.8		365	N/A	2	2.6												
NPDES	09/24/92			7.79	680	9.8																	
NPDES	10/05/92	90.52		7.63	598	10		276	N/A	3	0.4												
NPDES	10/30/92			7.72	632	9.6																	
NPDES	11/23/92	99.1		7.65	685	10.2		436	N/A	6	4.1												
NPDES	11/30/92			7.42	748	49.5																	
NPDES	12/16/92	180.3		7.11	640	7.72		376	N/A	9	2.2												
NPDES	12/31/92			7.33	610	9.7																	
NPDES	01/18/93	168		7.32	651	15.6		353	N/A	0	0												
NPDES	01/26/93			7.29	667	8.5																	
NPDES	02/15/93	225		7.33	691	18		420	N/A	15	0												
NPDES	02/26/93			7.2	683	14.4																	
NPDES	03/10/93	68		7.28	665	11.9		376	N/A	2	0												
NPDES	03/24/93			7.44	632	14.8																	
NPDES	04/08/93	39.5		7.22	683	11		361	N/A	3	N/D												
NPDES	04/21/93			7.25	656	10.6																	

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
NPDES	05/06/93			7.3	648	10.4																	
NPDES	05/18/93	150		7.39	707	10.2		299	N/A	2	1.8												
NPDES	06/11/93	166.5		7.38	604	10.4		615	N/A	14	N/D												
NPDES	06/24/93			7.4	642	10.4																	
NPDES	07/09/93	166.5		7.43	668	10.8		319	N/A	N/D	N/D												
NPDES	07/28/93			7.48	650	10.7																	
NPDES	08/11/93	180		7.54	709	10.5		399	N/A	5	0.6												
NPDES	08/25/93			7.39	652	11																	
NPDES	09/14/93			7.23	606	11.1																	
NPDES	09/24/93	166		7.5	607	10.2		329	N/A	2	N/D												
NPDES	10/05/93	144		7.6	643	9.6		318	N/A	3	1												
NPDES	10/21/93			7.34	589	12.6																	
NPDES	11/12/93			7.36	645	10.1																	
NPDES	11/29/93	123		7.28	651	9.8		332	N/A	3	N/D												
NPDES	12/15/93	123		7.41	634	8.6		328	N/A	N/D	N/D												
NPDES	12/27/93			7.34	620	9.2																	
NPDES	01/19/94	159.1		7.71	359	7.5		301	N/A	6	N/D												
NPDES	01/26/94			7.57	432	7.6																	
NPDES	02/09/94	198		7.85	670	6.5		317	N/A	N/D	N/D												
NPDES	02/28/94			7.6	590	8.5																	
NPDES	03/21/94	165.67		7.94	583	7.9		340	N/A	N/D	N/D												
NPDES	03/28/94			7.91	740	7.1																	
NPDES	04/20/94	142		7.68	643	7.9		320	N/A	9	N/D												
NPDES	04/27/94			7.92	650	8.2																	
NPDES	05/24/94	195		7.75	630	9.1		330	N/A	N/D	N/D												
NPDES	05/31/94			7.7	664	8.8																	
NPDES	06/01/94	182		8.1	740	9.7		350	N/A	N/D	N/D												
NPDES	06/20/94			7.88	622	10.2																	
NPDES	07/11/94	178		7.58	641	10.6		380	N/A	N/D	N/D												
NPDES	07/20/94			7.79	630	11.3																	
NPDES	08/17/94	178		7.76	636	11.9		330	N/A	N/D	N/D												
NPDES	08/23/94			7.79	637	10.5																	
NPDES	09/01/94	192		7.5	616	14.5		350	N/A	N/D	N/D												
NPDES	09/12/94			7.48	640	11.6																	
NPDES	10/18/94	114.4		7.88	594	10.6		330	N/A	N/D	N/D												
NPDES	10/31/94			7.13	649	9.1																	
NPDES	11/05/94			7.28	665	8.6																	
NPDES	11/22/94	131		7.62	646	9.7		320	N/A	N/D	N/D												
NPDES	12/22/94	156.5		7.9	594	9.2		320	N/A	N/D	N/D												
NPDES	12/30/94			7.8	648	9.1																	
NPDES	01/14/95	160		7.87	602	9.2		330	N/A	4	N/D												
NPDES	01/27/95			7.86	624	9.4																	
NPDES	02/07/95	169		8	656	8.9		330	N/A	N/D	N/D												
NPDES	02/28/95			8.02	659	9.2																	
NPDES	03/22/95	215		7.5	670	8.3		350	N/A	N/D	N/D												
NPDES	03/27/95			7.68	672	9.3																	
NPDES	04/20/95	122		7.45	945	9.8		370	N/A	N/D	N/D												
NPDES	04/29/95			7.31	881	8																	
NPDES	05/09/95	130		7.99	641	9.7		350	N/A	N/D	N/D												
NPDES	06/14/95	108		7.79	609	11.1		350	N/A	14	N/D												
NPDES	06/20/95			7.93	653	10.7																	
NPDES	06/30/95			8.02	648	11.5																	

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
NPDES	07/20/95			7.75	642	11.5																	
NPDES	07/27/95	81		7.6	629	11.7		320	N/A	N/D	N/D												
NPDES	08/22/95	95		7.97	608	12.3		310	N/A	20	N/D												
NPDES	08/31/95			7.85	621	12.4																	
NPDES	09/15/95			7.92	628	11.9																	
NPDES	09/28/95	98		8.1	597	11.5		350	N/A	5	N/D												
NPDES	10/16/95	97		7.61	571	10.9		310	N/A	5	N/D												
NPDES	10/31/95			7.5	574	10.5																	
NPDES	11/07/95			7.46	599	10.7																	
NPDES	11/21/95	115		7.6	591	9.9		290	N/A	N/D	N/D												
NPDES	12/28/95	110.7		7.63	601	7.3		340	N/A	N/D	N/D												
NPDES	12/29/95			7.71	612	8.6																	
NPDES	01/22/96	89		7.75	589	7.3		399	N/A	N/D	N/D												
NPDES	01/31/96			7.61	599	9.4																	
NPDES	02/12/96			7.7	580	5.1																	
NPDES	02/28/96	49		7.4	594	3.6		399	N/A	N/D	N/D												
NPDES	03/15/96			7.49	582	9.2																	
NPDES	03/28/96	123		7.46	441	11.3		304	N/A	N/D	N/D												
NPDES	04/18/96	99		7.6	605	9.9		308	N/A	N/D	N/D												
NPDES	04/30/96			7.54	580	10.2																	
NPDES	05/06/96			7.52	635	10.8																	
NPDES	05/22/96	93		7.72	943	10		364	N/A	N/D	N/D												
NPDES	06/20/96			7.78	1085	10.4																	
NPDES	06/26/96	99.7		8.05	608	10.6		324	N/A	N/D	N/D												
NPDES	07/10/96			7.95	1038	10.8																	
NPDES	07/30/96	89		8.35	774	11.4		457	N/A	N/D	2												
NPDES	08/27/96	90		7.87	730	11.4		437	N/A	N/D	N/D												
NPDES	08/30/96			7.64	710	12.2																	
NPDES	09/02/96			7.86	730	12.7																	
NPDES	09/23/96	90		7.81	616	11.2		348	N/A	N/D	N/D												
NPDES	10/17/96			7.88	680	10.2																	
NPDES	10/30/96	118		8.09	665	9.8		392	N/A	13	N/D												
NPDES	11/20/96			7.95	693	8.4																	
NPDES	11/29/96	120		7.8	693	7.2		368	N/A	N/D	N/D												
NPDES	12/26/96	123		8.41	636	8.9		310	N/A	N/D	N/D												
NPDES	12/29/96			7.95	650	9.2																	
NPDES	01/17/97	124		8.05	610	9.1		350	N/A	N/D	N/D												
NPDES	01/31/97			8.1	647	9.5																	
NPDES	02/26/97	105		7.94	591	9		340	N/A	N/D	N/D												
NPDES	02/28/97			8.02	607	9.8																	
NPDES	03/13/97	88		7.9	588	8.9		340	N/A	N/D	N/D												
NPDES	03/31/97			7.86	489	9.3																	
NPDES	04/17/97			7.95	532	9.8																	
NPDES	04/30/97	126		7.82	570	9.7		330	N/A	N/D	N/D												
NPDES	05/21/97	84		8.03	593	10.3		310	N/A	N/D	N/D												
NPDES	05/29/97			7.95	580	10.6																	
NPDES	06/23/97	91		7.95	591	10.4		340	N/A	N/D	N/D												
NPDES	06/30/97			7.98	594	10.7																	
NPDES	07/14/97	146		8.32	580	11.4		310	N/A	N/D	N/D												
NPDES	07/30/97			8.05	610	10.4																	
NPDES	08/18/97	125		8.2	583	11.2		340	N/A	N/D	N/D												
NPDES	08/31/97			8.16	544	11.2																	

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
NPDES	09/18/97	110		7.85	663	11.6		440	N/A	N/D	N/D												
NPDES	09/29/97			7.92	624	11																	
NPDES	10/14/97	110		7.92	595	10.6		350	N/A	N/D	N/D												
NPDES	11/07/97	93		7.58	546	10.1		310	N/A	N/D	N/D												
NPDES	11/29/97			8.26	609	4.2																	
NPDES	12/17/97	130		7.8	615	8.9		360	N/A	N/D	N/D												
NPDES	12/31/97			7.75	691	9.7																	
NPDES-004	05/15/96			7.55	775	10		364			<2	287	342		77	34	5	1.9	351	<2	6	51.4	-0.6
PS-1	05/28/91	Dry																					
PS-1	10/17/91	Dry																					
PS-1	05/13/92	Dry																					
PS-1	10/26/92	Dry																					
PS-1	05/06/93	4		7.14	940	9.3		529			1.9		444		81.8	58.2	25.6	2.4	409	N/D	19.5	100	3.7
PS-1	10/24/93	Dry		N/A	N/A	N/A																	
PS-1	05/25/94	11		7.29	835	9.7		470	N/D	N/D	N/D		403		84	47	10	2	425	N/D	11	90	-3.4
PS-1	10/18/94	DRY		N/A	N/A	N/A																	
PS-1	05/23/95	DRY		N/A	N/A	N/A																	
PS-1	10/17/95	10		7.43	677	11.3		380	N/D	10	N/D		321		66	38	8	2	390	N/D	14	55	-7.5
PS-1	05/23/96	Seep		N/A	N/A	N/A																	
PS-1	10/30/96	2.5		7.44	751	11		427					324		67	38	5	2.0	412	N/D	5	55	-8.8
PS-1	05/21/97	Dry		N/A	N/A	N/A																	
PS-1	10/29/97	3		7.67	709	10.3		370					298		50	42	9	2	403	N/D	15	84	-15.7
SBC-10	01/31/92	248		6.8	510	N/R		313			0.0		320		76.6	31.2	3.88	0.0	312	0.0	10.0	58	-0.3
SBC-10	02/18/92	250		7.8	720	8.6		345			0.0		321		83.7	27.3	1.3	0.0	339	0.0	5.0	36	0.3
SBC-10	03/26/92	240		7.75	628	7.9		332			0.0		355		91.7	30.6	5.01	0.0	373	0.0	15.0	70	-4.4
SBC-10	05/14/92	240		7.83	638	8		322					321		77.9	30.8	2.57	0.0	353	0.0	20.0	33	-3.8
SBC-10	08/10/92	240		7.53	670	11.4		389			1.3		351		85.1	33.6	1.21	0.0	331	0.0	20.0	100	-6.7
SBC-10	10/01/92	185		7.49	660	8.2		451			0.0		350		97.6	25.83	1.19	0.0	322	0.0	5	60	2.8
SBC-10	02/18/93	185		7.09	689	9.8		356					319		73.2	33.0	4.1	0.00	319	N/D	1.3	40.0	3.6
SBC-10	05/19/93	46		7.3	635	10		360					323		77.5	31.4	3.8	1.2	320	N/D	3.6	60.0	0.5
SBC-10	08/11/93	35		7.18	637	9.9		335					230		52.7	24.0	5.1	2.0	308	N/D	11.5	5.0	-5.8
SBC-10	10/20/93	28		7.7	670	11.2		387					248		48	31.0	2	N/D	152	N/D	8.0	70.0	9.3
SBC-10	02/09/94	28		8.05	611	7.6		338					316		72	33.0	4	N/D	412	N/D	N/D	70.0	-11.8
SBC-10	05/30/94	25		7.7	620	8.8		330					304		69	32.0	4	N/D	346	N/D	4.0	6.0	2.8
SBC-10	08/18/94	25		7.85	625	9.7		340					282		65	29	N/D	N/D	316	N/D	1.0	50.0	-5.2
SBC-10	10/19/94	21		7.56	551	10.4		360					290		68	30.0	N/D	N/D	303	N/D	8	70.0	-6.4
SBC-10	02/07/95	24		8.03	645	8.9		340					310		66	34	4.0	2.0	300	5	8.0	43	0.7
SBC-10	05/08/95	22		7.81	682	10.2		370					340		78	35	4.0	3.0	330	10	6.0	54	-0.1
SBC-12	06/08/94	3		8.08	250	7		190					213		51.7	17.7	1.91	0.42	255	2	N/D	7.5	-3.3
SBC-12	10/28/94	10		8	385	5		195					240		62.5	20.6	2.5	0.55	268	N/D	N/D	6.4	4.4
SBC-12	07/10/95	12		8.03	605	6		255					241		57	24	2.7	0.42	284	N/D	3	9.1	0.2
SBC-12	10/18/95	6		7.99	360	6		228					217		49.6	18	1.8	0.2	271	N/D	3	8	-7.3
SBC-12	07/18/96	4		7.7	353	14.4	5.6	220					215		53	20	2	N/D	230	6	5	7	1.4
SBC-12	10/15/96	4		8.21	406	5																	
SBC-12	06/25/97	3		6.08	410	9.1		230					200		47	20	3	N/D	262	N/D	3	8	-4.7
SBC-12	09/10/97	15		8.29	457	12.2		230					198		48	19	3	N/D	251	N/D	3	7	-3.0
SBC-12	10/15/97	6		8.27	329	7.2		190					191		45	19	2	N/D	259	N/D	3	11	-7.8
SBC-13	02/07/95	0.8		7.3	1441	11.3		1010					740		179	71	14	4	280	N/D	12	500	0.5
SBC-13	05/08/95	Dry																					
SBC-13	08/28/96	10		7.51	1840	11.8		1533			N/D		1057		245	108	34	6	330	N/D	12	907	-4.0
SBC-13	10/30/96	35		7.59	1718	9.3		1355			N/D		906		203	97	29	5	360	N/D	11	730	-4.7
SBC-13	02/27/97	18		7.56	1503	8.9		1170			N/D		796		185	81	26	5	346	N/D	9	699	-8.8

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SBC-13	05/22/97	16		7.62	1416	10.8		1080			N/D		703		158	75	24	5	345	N/D	10	482	-2.4
SBC-13	08/26/97	28		7.98	1190	11.3		960			N/D		634		140	69	17	3	327	N/D	7	390	-0.7
SBC-13	10/29/97	23		7.84	1319	8.1		1020			N/D		690		151	76	17	4	426	N/D	8	701	-19.7
SBC-14	10/26/93	2		7.46	2690	7.5		1908					1367		160	235	68	22	496	N/D	42	750	10.6
SBC-14	03/23/94	3.5		7.34	2370	4.7		1500					1061		120	185	44	13	506	N/D	66	850	-8.6
SBC-14	06/01/94	1.5		7.58	2480	6.3		1530					1210		135	212	50	14	561	N/D	31	800	0.0
SBC-14	08/28/94	0.5		7.89	2670	10.8		2050					1397		172	235	61	21	533	N/D	37	990	1.2
SBC-14	10/26/94	15		7.22	2320	9.8		1840					1280		146	223	56	18	630	N/D	37	1000	-6.0
SBC-14	05/24/95	6		7.71	2280	7.8		1720					1280		132	230	47	14	520	10	40	850	0.4
SBC-14	08/22/95	4		7.58	2570	11		1840					1321		138	237	56	14	573	5	40	1046	-5.3
SBC-14	06/24/97	2		8.07	2110	16.1		1880					1245		149	212	52	15	558	N/D	27.5	873	-1.0
SBC-15	07/31/91	<0.2		8	1450			1140					891		114	148	37.8	5.86	503	N/D	18.8	541	-0.9
SBC-15	10/27/92	2.8		7.72	563	5.61		328					295		67.2	31	4.86	0.01	303	N/D	5.00	50	-0.3
SBC-15	06/24/93	10		7.6	589	8.1		295					310		71	32.2	4.6	N/D	330	N/D	5.3	12	4.8
SBC-15	08/15/93	13		7.29	600	9.4		332					452		120.00	37	4.70	0.50	337	N/D	4.70	140	3.8
SBC-15	10/13/93	17		7.73	602	5.5		267					316		64	38	N/D	N/D	308	N/D	9	12	6.5
SBC-15	05/30/94	6		7.96	620	8.1		300					289		63	32	5	N/D	380	N/D	3	15	-5.0
SBC-15	08/29/94	3		8.42	534	12.4		300					289		63	32	N/D	N/D	346	N/D	2	20	-3.2
SBC-15	10/30/94	2		8.45	525	2.6		270					240		44	32	9	N/D	290	N/D	5	19	-0.7
SBC-15	06/24/97			7.67	601	7.3																	
SBC-16	07/30/91	31		8.2	600			342					326		43.3	53.1	10.8	1.93	312	N/D	4.97	98.8	-1.8
SBC-16	10/28/92	4		8.41	626	5.39		280					337		81.9	32.1	6.05	N/D	284	N/D	15	36	9.1
SBC-16	06/24/93	65		7.24	663	9.5		335					358		79.9	38.6	9.9	N/D	367	N/D	5.9	26	6.1
SBC-16	08/15/93	6		7.31	579	10.6		314					313.3		76	30	3.8	0.3	346	N/D	4.7	10	3.5
SBC-16	10/13/93	0.4		7.6	628	7.9		332					345		59	48	N/D	N/D	348	N/D	9	17	4.5
SBC-16	05/30/94	45		7.45	575	7.7		280					268		66	25	3	N/D	352	N/D	2	10	-4.9
SBC-16	08/29/94	<0.1		7.39	545	13.4		320					267		51	34	10	N/D	338	N/D	4	20	-2.4
SBC-16	10/31/94	15		8	613	2.8		330					280		64	30	11	N/D	330	N/D	7	25	0.1
SBC-16	06/24/97			7.8	538	11.2																	
SBC-16	06/24/93							311					325		81.5	29.6	3.8	0.1	342	N/D	5.9	13	4.9
SBC-17	03/17/99														116.1	176.2	23.04	19.31	400	0	8.41	690	1.4
SBC-18	07/31/91	10		8	500			262					272		76.3	19.8	3.20	0.40	328	N/D	2.23	8.23	-0.2
SBC-18	10/28/92	0.4		7.98	510	7.78		221					251		51.4	29.9	4.79	0.56	245	N/D	15	25	2.7
SBC-18	06/24/93	20		7.34	480	32.2		257					271		58.1	30.7	3.6	N/D	279	N/D	N/D	15	6.8
SBC-18	08/15/93	10		6.56	472	14.7		253					349.6		79	37	4.4	0.4	353	N/D	N/D	31	5.4
SBC-18	10/13/93	12		7.44	515	7.8		267					269		50	35	N/D	N/D	275	N/D	7	21	2.2
SBC-18	05/30/94	3		8.14	480	8.5		240					271		42	30	5	N/D	271	N/D	2	28	-2.9
SBC-18	08/30/94	0.2		7.56	421	15.4		300					225		39	31	7	N/D	237	N/D	5	18	4.5
SBC-18	10/31/94	Dry																					
SBC-18	06/25/97	18		8.18	489	7.2																	
SBC-19	07/30/91	20		8.3	1050			822					585		68	101	24.8	6.52	260	N/D	13.5	413	-1.1
SBC-19	10/27/92	4		7.64	434	5.39		258					236		55.9	23.3	2.49	N/D	262	N/D	10	9.00	0.6
SBC-19	06/24/93	70		6.44	626	22.7		292					343		101.90	21.4	2.90	N/D	344.00	N/D	3.5	9.00	8.1
SBC-19	08/15/93	22		6.88	658	5.7		319					291.1		77	24	2.5	N/D	347	N/D	4.7	8	-0.6
SBC-19	10/13/93	16		7.27	522	7.7		254					257		60	26	N/D	N/D	278	N/D	32	7	-4.5
SBC-19	05/30/94	27		7.36	572	6.3		280					277		78	20	2	N/D	378	N/D	2	6	-6.2
SBC-19	08/30/94	0.5		7.89	390	13.4		360					204		47	21	N/D	N/D	234	N/D	4	6	0.1
SBC-19	10/31/94	1		8.14	538	5.6		280					260		68	22	8	N/D	320	N/D	5	7	0.2
SBC-19	06/25/97	15		7.85	539	43.2																	
SBC-3	02/28/91		18.4	7.9	27000	3		2120		704	5.0	410	1590	0	221	252	65.7	15.4	501	0	49	1270	-1.4
SBC-3	05/28/91		23	8.3	3300	8		2360		290	LOST	466	1800	0	237	295	71.2	16.1	569	0	53.2	1400	-0.5
SBC-3	08/26/91		22.6	8.6	3000	5		2580		338	N/R	472	1950	0	260	315	83.5	16	575	0	51.9	1570	-0.7

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SBC-3	10/17/91		23.5	7.7	3100	7		2700		140	N/R	461	1970	0	61.2	443	79	17.6	563	0	52.4	1600	-0.7
SBC-3	02/28/92		29.33	6.9	3760	8		2778					2391		542.9	251.5	106.5	25.71	509	0	55	2000	1.5
SBC-3	05/29/92		Dry																				
SBC-3	08/10/92		Dry																				
SBC-3	10/22/92		Dry																				
SBC-3	02/05/93		Dry																				
SBC-3	05/27/93		18.75	6.88	2980	12.5		2691					839		273	38.1	83.8	20.1	458	0.0	52.9	1700	-35.9
SBC-3	08/16/93		28	7.18	4000	7.9		2750					1538.9		204	250	60	1	488	N/D	53	1500	-9.9
SBC-3	10/25/93		35	7.23	3967	9.3		3267					2623		300	455	74	16	527	N/D	57	2200	0.0
SBC-3	02/09/94		Dry																				
SBC-3	05/30/94		26.1	7.2	4720	9.2		4140					2868		347	486	98	23	541	N/D	67	2500	-0.5
SBC-3	08/29/94		29.33	7.29	4810	9.2		4180					2938		362	494	108	24	533	N/D	64	2000	10.2
SBC-3	10/19/94		32.7	7.3	4290	8.8		4090					2920		364	489	105	21	537	N/D	67	3000	-7.1
SBC-3	02/28/95		Dry																				
SBC-3	05/23/95		22.5	7.2	4710	8.2		480					410		83	48	9.0	3.0	330	10.0	8.0	140	-1.8
SBC-3	08/22/95		23.67	7.52	2640	11.6		1880					1224		134	216	55.0	13.0	492	N/D	33.0	976	-3.8
SBC-3	10/18/95		26.5	7.16	4610	8.4		4330					2889		357	485	102	21	565	N/D	60	2808	-5.1
SBC-3	02/27/96		22.5	7.16	2,880	8.5		3,288					2,288		255	401	83	20	495	N/D	52	2,113	-3.6
SBC-3	05/22/96		25.55	7.09	2370	8.3		1730					1162		137	199	47	13	500	N/D	30.0	810	-0.6
SBC-3	08/27/96		28.75	7.51	1840	12.4		2552					1672		203	283	62	17	494	N/D	41	1356	-1.3
SBC-3	10/30/96		31.4	6.71	3980	8.8		3594					2334		265	406	90	19	630	N/D	54	2278	-7.5
SBC-3	02/27/97		23.15	6.98	3960	7.4		3150					2040		238	351	75	23	391	N/D	47	1819	-1.1
SBC-3	05/22/97		20.8	7.47	2350	9.7		1860					1179		144	199	42	9	503	N/D	32	990	-7.4
SBC-3	08/26/97		28.25	7.07	3560	10.1		2440					1458		180	245	75	13	518	N/D	38	932	6.1
SBC-3	10/29/97		30.8	7.08	384	9.6		3720					2294		269	394	81	18	349	N/D	5	2199	-1.8
SBC-4	10/01/86			8	527			262				258	287		53	38	4	1	315	0	4	27	0.9
SBC-4	10/28/86			8.2	529			300				264	293		58	36	5	1	323	0	5	25	1.3
SBC-4	01/05/87			8.1	500	4	NT	294		18		256	285		58	34	4	1	312	0	4	30	0.5
SBC-4	04/07/87	4		8.1	540	2	NT	272		19		262	286		35	48	5	1	319	0	4	33	0.8
SBC-4	08/26/87			8.1	520	12	NT	264		11		276	303		72	30	4	1	337	0	4	26	0.6
SBC-4	10/05/87			8	500	9	NT	296					304		67	33	4	1	338	0	4	30	0.2
SBC-4	02/28/91	130		8.3	800	2		512		11		291	442	N/S	94.5	50.1	6.3	2.63	338	8.1	12.3	160	-1.7
SBC-4	05/28/91	119		7.9	360	8		396		<1.0		304	364	N/S	86.3	36.2	4.9	1.46	371	0	4.46	75.3	-1.6
SBC-4	07/29/91	119		7.9	460	9		382		24	5.7	300	347	N/S	82.7	34.2	5	1.55	365	0	3.85	58	-0.7
SBC-4	08/08/91	113		8	300	10		366		<1	<5.0	300	346	N/S	87.3	31.2	5.3	1.43	360	2.7	4.06	57	-0.6
SBC-4	09/13/91	114		7.9	340	8		376		<1	<5.0	288	340	N/S	85.8	30.5	5.06	0.78	351	0	3	50.4	1.1
SBC-4	10/25/91	114		7.7	N/S	10		326		<1	3.6	265	291	N/S	74.3	25.6	3.88	N/D	323	0	10	39	-3.2
SBC-4	11/26/91	121		7	510	8		349		N/S	1.8	307	347	N/S	90.1	29.6	3.75	3.45	378	0	15	44	-2.4
SBC-4	12/27/91	122		6.7	610	9.5		343		1	1.7	269	301	N/S	67.1	32.4	4.68	4.52	328	0	10	38	-0.9
SBC-4	01/31/92	126		6.1	500	9		314			0		348		85.1	32.8	4.55	0	348	0	10	50	0.9
SBC-4	02/28/92	128		7.7	470	9		312			0.4		374		102.6	28.7	4.55	2.35	398	0	5	49	0.4
SBC-4	03/26/92	121		7.8	1500	11		357			0		477		123.5	40.9	2.19	0	337	0	10	50	16.9
SBC-4	04/24/92	125		7.12	450	9		320			0.2		338		97.4	23	3.58	0	283	0	20	70	1.8
SBC-4	05/29/92	124		7.63	500	9.8		368			0.6		326		78.0	31.9	2.13	0.0	345	0.0	15.0	70.0	-6.5
SBC-4	07/23/92	123		6.6	480	12		289			0.1		363		78.4	40.68	5.02	0.0	352	0.0	15.0	38.0	3.5
SBC-4	08/28/92	112		7.15	360	11.5		344			1.5		348		80.9	35.4	3.97	0.0	344	0.0	25.0	30.0	1.1
SBC-4	09/24/92	107		6.7	700	10		350			0.2		391		106.3	30.5	1.15	0.0	330	0.0	20.0	32.0	8.4
SBC-4	10/30/92	107		7.3	625	9.5		314			0.0		360		95.8	29.4	4.67	0.0	336	0.0	10.0	37.0	6.0
SBC-4	11/18/92	104		6.9	500	11		330			0.0		318		78.9	29.4	3.98	0.0	319	0.0	10.0	50.0	-0.2
SBC-4	12/16/92	100		7.00	568	12.3		346			1.9		393		95.9	37.2	3.9	0.8	322	0.0	10.0	50.0	9.8
SBC-4	01/01/93	98																					
SBC-4	02/08/93	97.6		7.7	570	18.7		355			N/D		322		97.7	19	5.84	1.5	328	N/D	12.5	37	1.7

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SBC-4	03/01/93	98.4																					
SBC-4	04/01/93	95.5																					
SBC-4	05/20/93	111		7.3	520	14		328			1.0		318		78.4	29.8	3.9	N/D	318	N/D	5.2	50.0	1.0
SBC-4	06/01/93	121																					
SBC-4	07/01/93	116																					
SBC-4	08/16/93	131		7.4	560	11		328			N/D		300		69.0	31	4.1	0.9	328	N/D	4.2	40.0	-1.1
SBC-4	09/01/93	136																					
SBC-4	10/01/93	140		7.01	565	10		329			N/D		322		76	32	N/D	N/D	334	N/D	5.0	31.0	1.3
SBC-4	11/01/93	140																					
SBC-4	12/01/93	136																					
SBC-4	02/01/94	126		7.6	544	9		298					288		69	28	4	N/D	309	N/D	4	34	0.3
SBC-4	05/16/94	118		7.5	400	20		310					284		66	29	4	N/D	341	N/D	5	60	-8.8
SBC-4	08/10/94	116		6.7	400	16		310					286		70	27.0	N/D	N/D	321	N/D	6	60	-7.8
SBC-4	10/19/94	118		7.7	270	12		330					310		74	30.0	5	N/D	320.0	N/D	7.0	40	0.9
SBC-4	02/15/95	106		6.65	580	8		350			N/D		310		71	32	4.0	1.0	310	N/D	6.0	40	2.3
SBC-4	05/31/95	73		6.7	290	12		430			N/D		310		72	32	5.0	1.0	340	N/D	6.0	49	-2.2
SBC-4	08/23/95	124		7.45	610	14		360			N/D		315		70	34.0	6.0	2.0	336	N/D	7.0	59	-2.5
SBC-4	10/18/95	140		7.2	190	14		430			N/D		332		77	34	5.0	2.0	340	N/D	6.0	98	-5.9
SBC-4	02/27/96	142		6.95	648	7		369			N/D		338		76	36	7.0	2.0	338	N/D	6.0	88	-3.0
SBC-4	05/10/96	136		7.63	795	11		381			N/D		338		79	34.0	5.0	1.4	333	N/D	7.0	68	-0.6
SBC-4	08/13/96	148		7.38	763	12		466			N/D		406		90	44.0	6.0	2.0	387.0	N/D	9.0	95	-0.9
SBC-4	10/24/96	150		7.35	425	N/D		346			N/D		304		69	32	5.0	1.0	338	N/D	6.0	56	-4.2
SBC-4	02/26/97	133		7.35	560	11		370			N/D		318		73	33	5	1	340	N/D	7	55	-2.3
SBC-4	05/20/97	128		6.15	415	12		330			N/D		300		69	31	4	1	342	N/D	7	61	-6.7
SBC-4	08/14/97	146		7.15	490	14		360			N/D		317		74	32	5	1	341	N/D	5	54	-2.1
SBC-4	10/29/97	150		6.95	440	11		360			N/D		313		71	33	4	1	350	N/D	4	56	-4.2
SBC-4	05/26/98			6.7	480	11		337			<2	285	298		70	30	4	1	348	<5	6	45	-5.0
SBC-4	10/29/98			6.5	580	10		373			<2	288	311		70	33	5	1	352	<5	4	51	-3.6
SBC-5	03/01/91	33		7.9	680	2		484		1	<5.0	308	426		101	42.5	6.1	2.09	376	0	8.17	129	-1.2
SBC-5	06/17/91	33		7.9	640	6		500		3		328	442		101	46.5	7	2.64	400	0	6.64	123	-0.4
SBC-5	07/29/91	36		7.9	690	6		508		<1	<5.0	325	436		99	46	7.1	2.28	397	0	6.59	124	-1.0
SBC-5	08/08/91	33		7.8	390	10		480		1	<5.0	325	441		101	45.8	7	2.2	397	0	5.78	121	-0.1
SBC-5	09/27/91	29		7.7	700			473		<1	1.5	<1	462	<1	106.3	47.8	6.34	0.3	366		15	140	1.0
SBC-5	10/28/91	29		6.9		11		465		<1		330	499		117.8	49.8	6.96	0.95	402		10	140	2.6
SBC-5	11/26/91	29		6.9	610	11		487			0.6	290	447		108.5	42.7	5.59	4.37	353		20	140	0.1
SBC-5	12/27/91	29		6.8	700	10		482		1	0.8	302	366		82	39.26	5.68	4.19	368	N/D	25	90	-5.7
SBC-5	01/31/92	29		7.7	730	10.5		436			0.6		435		95	48	6.12	0.0	353	0.0	10	150	-1.3
SBC-5	02/28/92	29		7.3	600	8.8		437			0.4		424		99.2	42.9	8.13	4.8	356	0.0	5	110	4.0
SBC-5	03/26/92	29		7.7	1100	10.0		448			0.0		331		90.8	25.2	0.94	0.0	320	0.0	10	150	-13.1
SBC-5	04/27/92	29.9		7.15	550	10.9		541			0.4		476		130.5	36.4	5.88	0.0	337	0.0	20	180	-0.3
SBC-5	05/29/92	28		7.71	800	11.5		490			0.1		420		92.2	46.1	5.87	0.0	340	0.0	10	140	-0.6
SBC-5	07/23/92	28		7.8	610	12.0		455			0.6		342		82.3	33.2	2.1	0.0	267	0.0	15	130	-4.0
SBC-5	08/28/92	28		6.9	550	13.3		495			0.3		471		105.8	50.2	6.93	1.36	384	0.0	25	150	-1.9
SBC-5	09/24/92	28		7.4	500	14.8		467			0.3		466		99.1	53	3.07	0.0	370	0.0	20	140	-0.5
SBC-5	10/30/92	28.2		6.9	600	11		463			0.0		453		110.2	43.3	6.2	0.97	377	0.0	10	120	2.1
SBC-5	11/18/92	27.4		6.7	600	12		468			0.1		388		91.3	38.8	6.95	1.00	405	0.0	10	140	-9.8
SBC-5	12/16/92	27.5		7.25	748	12.6		467			0.0		533		135.0	47.6	10.30	4.10	372	0.0	25	140	7.1
SBC-5	02/08/93	27		7.7	740	18		468			N/D		306		83.1	24	3.92	0.49	242	N/D	25	115	-5.8
SBC-5	03/01/93	27																					
SBC-5	04/01/93	27																					
SBC-5	05/20/93	26		7.0	640	15		444			1.0		376		80.6	42.5	6.1	3.5	322	N/D	6.5	120	-0.5
SBC-5	06/01/93	26																					

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SBC-5	07/01/93	25																					
SBC-5	08/16/93	24.5		6.8	732	12.5		473			N/D		468		100	53	7.2	1.0	366	N/D	6.8	120	5.4
SBC-5	09/01/93	25																					
SBC-5	10/21/93	24.5		6.73	762	10.5		475			N/D		485		105	54	N/D	N/D	392	N/D	10	100	4.9
SBC-5	11/01/93	25																					
SBC-5	12/01/93	24																					
SBC-5	02/01/94	24		6.95	718	8		422					385		85	42	7	N/D	364	N/D	7	110	-2.8
SBC-5	02/01/94	22		6.55	720	10		460			N/D		400		86	45	6.0	2.0	355	N/D	7.0	90	2.5
SBC-5	05/16/94	23		7.2	640	21		450					378		82	42	6	N/D	374	N/D	7	90	-2.4
SBC-5	08/10/94	22		7.05	390	15		450					388		86	42	N/D	N/D	378	N/D	7	80	-2.0
SBC-5	10/06/94	22		6.4	382	12.5		430					390		90	40	N/D	N/D	366.00	N/D	7.0	130	-6.8
SBC-5	05/31/95	21.5		7.1	300	9.6		519			N/D		400		88	43	7.0	2.0	390	N/D	8.0	100	-2.5
SBC-5	08/23/95	20		7.25	320	13		440			N/D		373		80	42.0	8.0	2.0	380	N/D	8.0	96	-3.7
SBC-5	10/18/95	20		7.35	200	16		510			N/D		394		87	43	7.0	3.0	395	N/D	8.0	97	-2.7
SBC-5	02/27/96	20.5		6.9	750	7		451			N/D		377		84	41	7.0	2.0	385	N/D	3.0	105	-4.1
SBC-5	05/10/96	21.5		7.45	1100	11		462			N/D		401		90	43	7.0	1.9	384	N/D	8.0	104	-1.8
SBC-5	08/13/96	21.5		7.6	624	13		377			N/D		319		75	32	5.0	2.0	337	N/D	6.0	57	-1.8
SBC-5	10/24/96	20		7.4	540	11		466			N/D		387		84	43	6.0	2.0	395	N/D	11	95	-4.3
SBC-5	02/26/97	19		6.35	670	12		460			N/D		388		86	42	7	2	395	N/D	7	38	4.1
SBC-5	05/20/97	16		5.9	538	11		460			N/D		379		84	41	5	1	394	N/D	7	121	-8.1
SBC-5	08/14/97	17		7.1	660	14		520			N/D		418		93	45	7	3	401	N/D	7	113	-2.2
SBC-5	10/29/97	21		6.8	740	13		540			N/D		443		100	47	6	3	415	6	6	127	-3.2
SBC-5	05/26/98			6.75	620	12		459			<2	321	385		85	42	6	2	392	<5	6	85	-2.1
SBC-5 Overflow	10/29/98			6.25	920	11		701			<2	360	559		125	60	8	3	439	<5	7	200	0.2
SBC-6	02/28/91	Dry																					
SBC-6	05/28/91	Dry																					
SBC-6	08/26/91	Dry																					
SBC-6	10/28/91	Dry																					
SBC-6	02/18/92	Dry																					
SBC-6	05/07/92	Dry																					
SBC-6	08/10/92	Dry																					
SBC-6	10/23/92	Dry																					
SBC-6	02/15/93	Dry																					
SBC-6	05/28/93	Dry																					
SBC-6	08/16/93	Dry																					
SBC-6	10/21/93	Dry																					
SBC-6	02/09/94	Dry																					
SBC-6	05/18/94	Dry																					
SBC-6	08/10/94	Dry																					
SBC-6	10/18/94	Dry																					
SBC-6	02/07/95	Dry																					
SBC-6	05/31/95	Dry																					
SBC-6	08/22/95	Dry																					
SBC-6	10/17/95	Dry																					
SBC-6	02/27/96	Dry																					
SBC-6	05/22/96	Dry																					
SBC-6	08/27/96	Dry																					
SBC-6	10/31/96	Dry																					
SBC-6	02/21/97	Dry																					
SBC-6	05/22/97	Dry																					
SBC-6	08/14/97	Dry																					
SBC-6	10/29/97	Dry																					

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SBC-9	02/28/91	81		8	800	3		478		N/S	N/S	282	426	N/S	94.5	46.3	6.1	2.36	344	0	10.2	151	-1.2
SBC-9	05/28/91	118		7.9	400	6		334		2	N/S	289	321	N/S	76.2	31.8	3.9	1.45	353	0	3.35	38.3	-0.4
SBC-9	07/29/91	140		7.9	410	6		312		N/D	N/S	290	315	N/S	74.1	31.5	4	1.64	354	0	1.62	31.5	-0.1
SBC-9	08/08/91	112		7.8	300	7		340		N/D	LOST	292	311	N/S	78	28.3	3.7	1.61	356	0	4.16	30.5	-1.3
SBC-9	10/17/91	120		7.9	511	7		338		N/D	N/S	221	251	N/S	64.1	22.2	3.4	1.4	270	0	2.59	33.4	0.2
SBC-9	02/18/92	132		7.77	613	10.8		321					308		78.8	27	1.3	0	325	0	5	33	0.4
SBC-9	05/14/92	130		8.7	588	8.7		293					338		74.7	36.8	2.38	0	360	0	10	28	0.7
SBC-9	08/10/92	105		7.4	659	11.4		330					318		75.2	31.7	0.73	0	346	0	15	20	-0.9
SBC-9	10/05/92	82		7.22	619	8.7		349					346		78.2	36.7	4.03	3.11	358	0	25	27	0.3
SBC-9	02/18/93	140		6.62	530	9.8		321					294		68.2	30	3.4	0.00	341	N/D	0.5	20	0.0
SBC-9	05/19/93	177		7.35	616	10.1		328					330		77.8	33	3.4	N/D	348	N/D	4.0	28	2.7
SBC-9	08/11/93	165		6.77	725	9.9		384					278		61.7	30	3.6	1	369	N/D	6.4	40	-10.3
SBC-9	10/20/93	152		7.81	640	11.2		341					326		71	36	2	N/D	356	N/D	5	31	-0.2
SBC-9	02/09/94	175		7.96	608	8.9		349					307		70	32	3	N/D	336	N/D	N/D	70	-5.4
SBC-9	05/30/94	178		7.64	605	8.2		300					302		70	31	4	N/D	356	N/D	4	31	-3.0
SBC-9	08/18/94	175		7.03	770	9.9		420					327		78	32	N/D	N/D	395	N/D	N/D	30	-4.2
SBC-9	10/19/94	160		8.08	551	10		330					320		76	31	N/D	N/D	350	N/D	6	36	-2.5
SBC-9	02/07/95	158		7.93	626	9.5		340					310		67	34	4.0	2.0	295	N/D	5.0	28	6.7
SBC-9	05/08/95	159		7.83	685	11.1		350					360		86	35	4.0	2.0	360	N/D	6.0	33	4.5
SBC-9	08/24/95	150		7.82	590	11.55		290					307		72	31.0	5.0	1.0	357	N/D	4.0	31	-1.7
SBC-9	10/17/95	135		7.54	581	11.1		340					292		69	29	4.0	1.0	355	N/D	6.0	39	-6.0
SBC-9	02/27/96	130		7.35	485	10.7		336					287		67	29	4.0	1.0	351	N/D	11	34	-6.6
SBC-9	05/21/96	130		7.9	598	10.7		484					420		102	40	6.0	2.0	440	N/D	8.0	64	-0.5
SBC-9	08/28/96	130		7.54	650	10.4		365					312		69	34	4.0	1.0	357	N/D	6.0	48	-4.3
SBC-9	10/30/96	133		7.85	577	9.8		350					335		49	29	4.0	1.0	362	N/D	6.0	43	-16.3
SBC-9	02/27/97	125		7.85	602	9.8		340					318		73	33	4	2	357	N/D	6	43	-2.5
SBC-9	05/23/97	125		8.09	658	9.9		350					273		63	28	3	N/D	356	N/D	5	39	-9.8
SBC-9	08/26/97	120		7.89	601	11.1		320					287		64	31	4	1	356	N/D	4	54	-8.6
SBC-9	10/29/97	122		7.7	568	11.6		290					289		63	32	3	1	392	N/D	4	36	-10.2
SBC-9 Source	05/15/96			7.05	730	10		341			<2	298	339		75	33	3	0.8	364	<2	6	29.3	-1.0
SBC-9 Source	11/13/96			7.26		11.1		361				306	319		75	32	3	1	373	<5	3	28	-1.8
SBC-9 Source	01/06/99			7.5	490	9.6		363		<5		319	330		81	31	3	1	389	<5	3	44	-4.5
SDH-1	08/29/94		1796	10.2	720	11.1		260					180		59	8	44	9	32	24	61	160	-5.2
SDH-2	08/22/95		1522.3																				
SDH-2	06/30/98			9.97	325	13.8	0	280				72	131		49	2	13	3	87	<5	31	63	-5.1
SDH-3	08/26/95		1510.9																				
SDH-3	06/30/98			8.39	540	16.9	0	358				325	308		64	36	12	3	396	<5	28	1	-3.9
SMH-1	08/02/91	9.8		8.4	500			272					261		69.2	21.5	5.10	0.61	303	3.30	5.27	15	-0.7
SMH-1	03/22/93	Dry																					
SMH-1	06/21/93	10		6.39	713	7.11		378					355		81.3	37	7.9	2.5	366	N/D	13.1	27	4.0
SMH-1	08/29/93	30		7.3	648	8.4		324					263.6		71	38	7.4	1.6	301	N/D	6.3	22	11.6
SMH-1	10/15/93	8		7.4	673	6.3		324					357		50	32	N/D	N/D	328	N/D	9	25	-9.0
SMH-1	06/16/94	15		7.69	632	8.1		306					290		70	28	7	N/D	348	N/D	6	19	-1.5
SMH-1	08/30/94	13		7.9	627	7.8		370					311		75	30	7	N/D	334	N/D	1	21	4.6
SMH-1	10/31/94	32		8.02	594	9.3		340					300		69	30	12	N/D	370	N/D	8	20	-2.1
SMH-1	06/29/97	20		7.45	676	7.8																	
SMH-2	08/02/91	8.5		8	550			328					302		81.7	23.9	5.80	2.91	367	0.00	7.20	13	-0.9
SMH-2	10/13/92	0.6		7.68	549	9.72		149					319		103.8	14.6	1.81	0.00	328	0.00	25	9.00	1.4
SMH-2	06/21/93	1.5		7.39	495	10.9		321					295		75.9	25.6	4.5	2.1	306	N/D	4.2	10	7.0
SMH-2	08/29/93	3		6.9	550	7.9		294					221.3		54	21	3.9	0.4	294	N/D	4.6	7	-5.2
SMH-2	10/15/93	0.8		7.34	572	5.9		278					260		66	23	N/D	N/D	231	N/D	13	8	8.9
SMH-2	06/15/94	12		7.7	527	7.4		260					249		65	21	4	N/D	329	N/D	3	10	-5.0

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
SMH-2	08/30/94	6		7.85	505	11.8		270					255		64	23	6	N/D	293	N/D	6	7	2.1
SMH-2	10/31/94	10		8.14	499	8.8		270					246		64	21	7	N/D	311	N/D	5	8	-1.8
SMH-2	06/29/97	15		8.05	546	9.4																	
SMH-3	08/29/93	35		6.99	607	7.2		332					313.2		71	33	6	1.1	313	N/D	4.2	23	6.7
SMH-3	10/15/93	21		7.85	597	6.4		287					308		69	33	N/D	N/D	311	N/D	9	20	3.3
SMH-3	06/15/94	46		7.4	617	5.6		290					275		64	28	5	N/D	325	N/D	4	21	-1.5
SMH-3	08/30/94	22		7.72	462	13		370					240		50	28	N/D	N/D	267	N/D	7	27	-3.4
SMH-3	10/31/94	45		7.6	502	8.6		300					273		63	28	7	N/D	325	N/D	7	26	-2.8
SMH-3	06/28/95	60		7.55	542	7.8		320					280		62	30	6	N/D	315	5	10	17	-1.2
SMH-3	06/29/97	35		7.32	590	7																	
SMH-4	08/01/91	8.7		7.5	500			396					326		86.3	27	4.60	3.40	391	N/D	5.27	8.64	0.6
SMH-4	10/13/92	0.5		7.26	642	8.44		318					342		66.1	42.9	6.83	0.27	314	N/D	10	90	-1.1
SMH-4	06/24/93	0.2		7.24	667	5.7		325					337		71.6	38.4	8.4	N/D	317	N/D	8.3	35	7.1
SMH-4	08/29/93	0.5		6.95	780	6.6		354					327.2		70	37	16	1.1	297	N/D	12.6	50	7.3
SMH-4	10/15/93	1.2		7.42	682	4.6		333					338		53	50	11	N/D	302	N/D	16	41	7.3
SMH-4	06/15/94	2		7.8	618	5.3		320					290		47	42	10	N/D	321	N/D	8	40	-0.6
SMH-4	08/30/94	2		7.8	558	10.9		330					297		48	43	11	N/D	311	N/D	10	32	3.0
SMH-4	10/31/94	4		7.8	643	8.2		330					280		43	43	15	N/D	310	N/D	11	38	1.3
SMH-4	06/25/97	1-2		7.76	646	6.7																	
SP-1	05/28/91	Dry																					
SP-1	10/27/91	Dry																					
SP-1	05/14/92	Dry																					
SP-1	10/28/92	Dry																					
SP-1	05/06/93	Dry																					
SP-1	10/26/93	Dry																					
SP-1	05/31/94	Dry																					
SP-1	10/18/94	Dry																					
SP-1	05/23/95	DRY																					
SP-1	10/18/95	DRY																					
T.S. North Bleeder	05/26/98							356				301	309		68	34	4	2	368	<5	24	44	-8.7
TS-1	05/28/91	3.2		7.9	749	8		414			N/A		362		68.3	46.6	15.3	3.26	360	0	15	88.5	-1.1
TS-1	10/17/91	22		8.1	800	7		490			N/A		416		96.9	42.5	11	2.71	438	0	11.6	78.7	-1.4
TS-1	05/13/92	4		7.21	843	7.8		463			0.3		440		85.7	54.9	12.16	0.0	425	0.0	25	60	2.2
TS-1	10/10/92	2.3		2.3	904	50.2		480			0.0		545		135.5	50.3	5.76	2.56	424	0.0	25	90	8.1
TS-1	05/06/93	20		7.22	980	9.4		534					426		75.1	58	13.1	2.0	430	N/D	21.7	100	-3.2
TS-1	10/24/93	11		7.48	863	9.7		378					435		85	54	12	N/D	422	N/D	16	80	0.9
TS-1	05/25/94	15		7.1	900	9.8		470	N/D	N/D	N/D		417		83	51	12	2	447	N/D	15	70	-1.7
TS-1	10/18/94	8		7.47	829	10.1		490	N/D	N/D	N/D		430		88	52	13	N/D	440	N/D	18	120	-5.0
TS-1	05/23/95	45		7.43	871	10		510					420		84	52	12	3	430	N/D	23	7	7.2
TS-1	10/18/95	15		7.34	702	10.6		380					328		67	39	9	2	380	N/D	14	57	-5.5
TS-1	05/23/96	35		7.4	856	9.9		489					5		78	51	12	3	430	N/D	20	68	-1.9
TS-1	10/30/96	12		7.36	845	10.6		490					354		66	2	11	2.0	467	N/D	18	68	-41.3
TS-1	05/21/97	65		7.53	756	9.7		400					343		68	42	9	3	381	N/D	15	58	-3.6
TS-1	10/29/97	25		7.23	756	10.8		480					338		61	45	10	3	434	N/D	23	55	-10.2
UT-1	05/28/91	Dry																					
UT-1	10/17/91	Dry																					
UT-1	05/14/92	Dry																					
UT-1	10/26/92	Dry																					
UT-1	05/06/93	Dry		N/A	N/A	N/A	N/A																
UT-1	05/26/93	122		8.17	492	6.7	6.1	262	N/D	63	0.3		239	N/D	61.4	20.9	3.0	N/D	258	N/D	3.8	20	1.6
UT-1	10/24/93	<0.05		N/A	N/A	N/A	N/A																
UT-1	05/25/94	Dry																					

Site	Date	Flow gpm	DTW ft bgs	pH	Cond µS/cm	T °C	D.O. mg/l	TDS (mg/l)	T Set Sol (mg/l)	TSS (mg/l)	O &G (mg/l)	T. Alk (mg/l)	T. Hard (mg/l)	T. Acid (mg/l)	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	CO3 mg/l	Cl mg/l	SO4 mg/l	Bal %
UT-1	10/18/94	Dry																					
UT-1	05/23/95	64		8.8	497	7.8	5.4	270	0.6	565	N/D		240		65	19	3	2	350	30	7	2	-16.7
UT-1	10/17/95	40		8.37	464	11.8	5.5	250	N/D	15	N/D		232		45	29	7	1	245	25	9	24	-6.0
UT-1	05/23/96	75		8.65	451	6.4	5.4	265	N/D	148	N/D		214		46	24	5	N/D	255	15	7	45	-12.9
UT-1	10/30/96	Dry		N/A	N/A	N/A	N/A																
UT-1	05/21/97	200		8.79	442	10.9	8.2	240	0.7	N/D	N/D		198		48	19	3	N/D	274	N/D	5	28	-12.0
UT-1	10/29/97	18		8.63	545	6.6	7.5	350	N/D	8	N/D		246		39	36	7	1	218	N/D	9	25	9.4
WHR-7	07/30/91	40		8.2	450			214					224		51.6	23.2	4.60	0.88	250	0.00	2.53	28	-0.5
WHR-8	07/31/91	5		8.1	500			294					297		83.3	21.7	3.90	0.45	360	0.00	2.94	10.3	-0.5
WHR-8	10/28/92																						
WHR-9	08/08/91	4		8.1	450			270					258		76.1	16.6	2.40	0.22	320	0.00	3.04	6.58	-1.8

Table A-2 Trace constituent water quality data

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Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
16-7-12-6	06/08/94		1.19			0.05		1.3	N/D		0.03	N/D		N/D		N/D		N/D		N/D	N/D	0.45		0.23	N/D		N.D	
16-7-12-6	10/27/94		0.84			0.03		0.57	N/D		0.07	N/D		N/D		0.01		N/D		N/D	N/D	0.44		0.13	N/D		0.02	
16-7-12-6	07/10/95		N/D			N/D		0.04	N/D		N/D	N/D		N/D		0.02		N/D		N/D	N/D	0.4		0.02	N/D		N/D	
16-7-12-6	10/18/95		0.64			N/D		0.41	0.03		N/D	N/D		N/D		N/D		N/D		N/D	0.01	0.44		0.12	N/D		N/D	
16-7-12-6	06/24/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.4		0.02	N/D		0.01	
16-7-12-6	09/11/97		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.6		0.01	N/D		N/D	
16-7-12-6	10/15/97		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.4		N/D	N/D		N/D	
16-7-12-6	07/19/98		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.5		N/D	N/D		N/D	
16-7-1-6	06/08/94		0.18			N/D		0.18	N/D		0.02	N/D		N/D		N/D		N/D		N/D	N/D	0.23		0.04	N/D		N/D	
16-7-1-6	10/28/94		1.11			0.02		1.08	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.15		0.2	N/D		0.02	
16-7-1-6	07/09/95		N/D			N/D		0.02	N/D		N/D	N/D		0.02		N/D		N/D		N/D	N/D	0.23		N/D	N/D		N/D	
16-7-1-6	10/18/95		N/D			N/D		N/D	N/D		N/D	N/D		N/D		0.02		0.01		N/D	0.01	0.2		0.01	N/D		N/D	
16-7-1-6	06/24/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		0.02	
16-7-1-6	09/10/97		N/D	ND		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.4		0.02	N/D		0.02	
16-7-1-6	10/20/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.2		N/D	N/D		N/D	
16-7-1-6	07/19/98		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
16-8-18-4	06/08/94		0.363			0.02		0.484	N/D		0.021	N/D		0.011		N/D		N/D		N/D	N/D	0.246		0.045	N/D		N/D	
16-8-18-4	07/09/95		N/D			N/D		0.039	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.114		N/D	N/D		N/D	
16-8-18-4	10/18/95		N/D			N/D		0.03	N/D		N/D	N/D		N/D		0.02		0.01		N/D	0.01	0.2		0.05	N/D		N/D	
16-8-18-4	07/18/96			N/D		N/D		N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		0.1	
16-8-18-4	06/24/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		0.02	
16-8-18-4	10/20/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.5		N/D	N/D		0.01	
16-8-18-5	06/08/94		0.01			N/D		N/D	N/D		0.02	N/D		N/D		N/D		N/D		N/D	N/D	0.21		N/D	N/D		N/D	
16-8-18-5	07/09/95		N/D			N/D		0.02	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.17		N/D	N/D		N/D	
16-8-18-5	10/18/95		N/D			N/D		N/D	N/D		N/D	N/D		N/D		0.01		N/D		N/D	0.01	0.13		N/D	N/D		N/D	
16-8-18-5	07/18/96		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
16-8-18-5	06/24/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.03	N/D		N/D	
16-8-18-5	09/10/97		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		0.02	
16-8-18-5	10/20/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.2		N/D	N/D		0.01	
16-8-20-1	06/08/94		0.028			N/D		0.016	N/D		0.043	N/D		N/D		N/D		N/D		N/D	N/D	0.048		N/D	N/D		N/D	
16-8-20-1	07/10/95		0.053			0.04		0.12	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.078		0.022	N/D		0.011	
16-8-20-1	07/19/96			N/D		N/D		N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.06	N/D		N/D	
16-8-5-1	06/08/94		0.02			N/D		N/D	N/D		0.02	N/D		N/D		N/D		N/D		N/D	N/D	0.09		N/D	N/D		N/D	
16-8-5-1	07/09/95		N/D			N/D		0.02	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.16		0.02	N/D		N/D	
16-8-5-1	10/18/95		N/D	N/D		N/D	N/D	N/D	0.02		N/D	N/D		N/D		N/D		0.01		N/D	0.01	0.04		0.01	N/D		N/D	
16-8-5-1	07/18/96		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.2		N/D	N/D		0.02	
16-8-5-1	06/25/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		0.01	
16-8-5-1	09/10/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		N/D	
16-8-5-1	10/20/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
16-8-6-1	06/08/94		0.09			N/D		0.07	N/D		0.02	N/D		N/D		N/D		N/D		N/D	N/D	0.22		0.04	N/D		N/D	
16-8-6-1	10/28/94		0.88			0.04		0.95	N/D		N/D	N/D		N/D		0.01		N/D		N/D		0.2		0.09	N/D		0.02	
16-8-6-1	07/09/95		N/D			N/D		0.03	N/D		N/D	N/D		N/D		0.03		N/D		N/D	N/D	0.24		N/D	N/D		N/D	
16-8-6-1	10/18/95		N/D			N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	0.01	0.16		0.02	N/D		N/D	
16-8-6-1	07/17/96		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.6		N/D	N/D		N/D	
16-8-6-1	06/29/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		0.01	
16-8-6-1	09/10/97		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.03	N/D		N/D	
16-8-6-1	10/20/97		0.2	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
16-8-7-3	06/08/94		0.08			N/D		0.03	0.01		0.02	N/D		N/D		N/D		N/D		N/D	N/D	0.04		N/D	N/D		N/D	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
CK-2	10/28/94		0.82			0.02		0.58	N/D		0.05	N/D		N/D		N/D		N/D		N/D	0.01	N/D		0.07	N/D		0.02	
CK-2	07/09/95		1.4			0.04		0.8	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.16		0.11	N/D		0.01	
CK-2	10/18/95		0.04			N/D		0.03	N/D		N/D	N/D		N/D		0.03		0.01		N/D	0.01	N/D		0.02	N/D		N/D	
CK-2	07/16/96		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
CK-2	06/25/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		0.03	
CK-2	09/10/97		0.6	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.05	N/D		N/D	
CK-2	10/20/97		0.2	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.09	N/D		0.01	
CS-1	05/28/91	0.72			N/D																							
CS-1	10/17/91	N/D			N/D																							
CS-1	05/14/92	0.0			0.39																							
CS-1	10/12/92	0.0			0.0																							
CS-1	05/06/93	0.13			N/D			N/D	N/D	N/D	0.15	0.0002	N/D	N/D	0.12	0.003	N/D	N/D	N/D	N/D	N/D	0.07		N/D	0.01		N/D	0.4
CS-1	10/24/93	0.21			0.03			N/D	N/D	N/A	0.1	N/D	N/A	N/D	N/A	N/D	N/A	0.4	N/A	N/D	N/D	N/D		0.002	N/D		1.5	N/A
CS-1	05/31/94		N/D	N/D		N/D	N/D																					
CS-1	10/18/94		N/D	N/D		N/D	N/D																					
CS-1	05/23/95		N/D	N/D		N/D	N/D																					
CS-1	10/18/95		N/D	N/D		N/D	N/D																					
CS-1	05/22/96		N/D	N/D		N/D	N/D																					
CS-1	10/31/96		N/D	N/D		N/D	N/D																					
CS-1	05/23/97		N/D	N/D		N/D	N/D																					
CS-1	10/29/97		N/D	N/D		N/D	N/D																					
Defa #1	01/06/99		<0.1	<0.1			<0.1																					
Defa #2	01/06/99		<0.1	<0.1			<0.1																					
DH-1A	02/18/93		2.24			0.07		0.99	0.001	0.03	0.08	N/D	N/D	N/D	0.16	N/D	N/D	N/D	0.02	0.05	N/D	0.03		0.01	0.02		0.07	1.6
DH-1A	05/26/93		0.4			0.05		N/D	N/D	N/D	0.11	N/D	N/D	N/D	0.11	N/D	0.0017	N/D	N/D	N/D	N/D	0.09		0.014	0.004		0.07	1.4
DH-1A	08/31/93		0.55			0.2		2.0	N/D	0.2	0.08	N/D	N/D	0.01	0.2	N/D	N/D	N/D	N/D	0.3	0.02	0.07		N/D	N/D		0.16	N/D
DH-1A	10/26/93		0.58	N/D		0.08	N/D	N/D	N/D		0.10	N/D		N/D		N/D		0.2		N/D	N/D	N/D		N/D	N/D		0.05	
DH-1A	02/09/94		2	N/D		N/D	N/D																					
DH-1A	05/31/94		0.4	N/D		N/D	N/D																					
DH-1A	08/28/94		0.3	N/D		N/D	N/D																					
DH-1A	10/30/94		N/D	N/D		N/D	N/D																					
DH-1A	02/07/95		2.9	N/D		N/D	N/D	N/D	N/D		0.4	N/D		0.1		N/D		N/D		N/D	0.06	1.4		0.01	N/D		0.3	
DH-1A	05/09/95		0.1	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	.2		.02	N/D		.07	
DH-1A	08/31/95		.2	N/D		N/D	N/D	N/D	N/D		.1	N/D		N/D		N/D		N/D		N/D	N/D	.2		.01	N/D		.19	
DH-1A	10/17/95		N/D	N/D		N/D	N/D	N/D	N/D		.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		.04	
DH-1A	02/27/96		N/D	N/D		N/D	N/D																					
DH-1A	05/22/96		N/D	N/D		N/D	N/D																					
DH-1A	08/28/96		0.4	N/D		N/D	N/D																					
DH-1A	10/29/96		0.6	N/D		N/D	N/D																					
DH-1A	02/27/97		1.1	N/D		N/D	N/D																					
DH-1A	05/28/97		N/D	N/D		N/D	N/D																					
DH-1A	08/31/97		N/D	N/D		N/D	N/D																					
DH-1A	10/30/97		N/D	N/D		N/D	N/D																					
DH-2	02/22/93	0.51			0.09			N/D	0.003	N/D	0.11	0.001	N/D	N/D	0.15	N/D	0.9	N/D	0.06	0.03	N/D	0.03		N/D	0.022		0.07	3.4
DH-2	04/30/93																											
DH-2	05/25/93	0.55			0.1			N/D	N/D	0.2	0.17	N/D	N/D	N/D	0.15	N/D	N/D	N/D	N/D	0.08	N/D	0.07		0.005	N/D		N/D	1.0
DH-2	08/31/93	2.17			0.06			N/D	0.01	N/D	0.08	N/D	N/D	N/D	0.21	N/D	0.0003	N/D	N/D	0.21	0.01	0.02		N/D	0.009		N/D	N/D
DH-2	10/29/93	0.7			0.09			N/D	N/D		N/D	N/D		N/D		N/D		0.3		N/D	N/D	N/D		0.006			N/D	
DH-2	02/10/94		0.6	N/D		N/D	N/D																					
DH-2	05/31/94		0.6	N/D		N/D	N/D																					
DH-2	08/29/94		0.70	N/D		N/D	N/D																					
DH-2	10/26/94		0.6	N/D		N/D	N/D																					

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
DH-2	02/07/95		0.6	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D	32	N/D		N/D	N/D	N/D		0.01	N/D		N/D	
DH-2	05/23/95		0.9	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D	27	N/D		N/D	0.01	N/D		N/D	N/D		N/D	
DH-2	08/31/95		0.8	N/D		N/D	N/D	N/D	N/D		0.1			N/D		N/D	30	N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-2	10/17/95		0.7	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D	28	N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-2	02/29/96		N/D	N/D		N/D	N/D																					
DH-2	05/22/96		0.6	N/D		N/D	N/D																					
DH-2	08/20/96		0.6	N/D		N/D	N/D																					
DH-2	10/30/96		0.6	N/D		N/D	N/D																					
DH-2	02/27/97		0.5	N/D		N/D	N/D																					
DH-2	05/29/97		0.6	N/D		N/D	N/D																					
DH-2	08/27/97		0.5	N/D		N/D	N/D																					
DH-2	10/29/97		0.4	N/D		N/D	N/D																					
DH-3	02/19/93	1.59			0.37			N/D	N/D	N/D	0.08	0.00	N/D	N/D	0.16	N/D	0.06	N/D	0.02	0.05	N/D	0.03		0.01	0.019		0.07	1.6
DH-3	05/28/93	1.64			0.03			N/D	0.013	N/D	0.11	N/D	N/D	N/D	0.12	N/D	N/D	N/D	N/D	0.08	N/D	0.01		0.01	0.004		0.06	23.0
DH-3	08/31/93	0.23			N/D			N/D	N/D	0.10	N/D	N/D	N/D	0.01	0.17	N/D	N/D	N/D	0.02	N/D	N/D	0.03		N/D	N/D		N/D	N/D
DH-3	10/21/93	1.62			0.07			N/D	0.02		0.1	N/D		N/D		N/D		N/D		N/D	0.01	N/D		0.001	N/D		N/D	
DH-4	02/15/94		0.40	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
DH-4	05/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		0.03	
DH-4	08/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-4	10/27/94		0.2	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.01	N/D		N/D	
DH-4	02/07/95		0.3	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D	33	N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-4	05/23/95		0.3	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D	27	N/D		N/D	N/D	N/D		N/D	N/D		0.01	
DH-4	08/31/95		0.3	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D	30	N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-4	10/18/95		0.3	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D	29	N/D		N/D	N/D	N/D		N/D	N/D		N/D	
DH-4	02/27/96		0.2	N/D		N/D	N/D																					
DH-4	05/22/96		0.2	N/D		N/D	N/D																					
DH-4	08/23/96		0.2	N/D		N/D	N/D																					
DH-4	10/31/96		N/D	N/D		N/D	N/D																					
DH-4	02/27/97		0.2	N/D		N/D	N/D																					
DH-4	05/29/97		0.3	N/D		N/D	N/D																					
DH-4	08/30/97		0.3	N/D		N/D	N/D																					
DH-4	10/30/97		0.2	N/D		N/D	N/D																					
FBC-10	07/30/91		1.27		0.00			1.70	0.00		0.02	0.00		0.01		0.00		0.00		0.07	0.00	0.39		0.00	0.00		0.01	
FBC-10	06/24/97		4.70	N/D	0.20			N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		0.01	
FBC-11	08/08/91	1.30			0.05			0.60	0.00	0.13	0.00	0.00	0.00	0.01	0.12	0.00	0.00	0.00	0.16	0.14	0.00	0.03		0.00	0.00		0.02	0.00
FBC-12	06/29/93		3.28	N/D		0.08	N/D	8	0.005		0.17	N/D		0.07		N/D		0.3		N/D	0.03	0.18		0.29	N/D		0.03	
FBC-12	08/29/93		3.4	N/D		0.2	N/D	3	N/D		N/D	N/D		N/D		N/D		N/D		0.09	0.01	0.21		0.073	0.002		0.01	
FBC-12	10/15/93		0.21	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	0.38		0.003	N/D		N/D	
FBC-12	06/15/94		N/D	N/D		N/D	N/D	N/D	N/D		0.10	N/D		N/D		N/D		N/D		N/D	N/D	0.30		0.06	N/D		N/D	
FBC-12	08/29/94		2.7	N/D		N/D	N/D	N/D	N/D		0.10	N/D		N/D		N/D		N/D		N/D	N/D	0.30		0.02	N/D		N/D	
FBC-12	10/30/94		1.1	N/D		N/D	N/D	N/D	N/D		0.10	N/D		N/D		N/D		N/D		N/D	0.01	0.30		0.12	N/D		N/D	
FBC-14	08/08/91	0.28			N/D			N/D	N/D	0.13	0.02	N/D	N/D	0.01	0.16	N/D	N/D	N/D	0.09	0.15	N/D	N/D		N/D	N/D		N/D	N/D
FBC-14	06/28/95	0.30			N/D			N/D	N/D		0.10	0.01		N/D		N/D		N/D		N/D	N/D	0.30		N/D	N/D		0.04	
FBC-2	08/01/91		7.60	N/D		0.26	N/D	10.4	N/D	0.69	N/D	N/D	N/D	0.02	0.33	N/D	N/D	N/D	0.01	0.07	N/D	N/D		N/D	N/D		0.03	N/D
FBC-3	08/01/91		0.22	N/D		N/D	N/D	0.20	N/D	0.20	N/D	N/D	N/D	0.03	0.20	N/D	N/D	N/D	0.01	0.05	N/D	0.38		N/D	N/D		0.01	N/D
FBC-6B	10/13/92		0.67	N/D		0.07	N/D	N/D	N/D		0.08	0.05		0.011		N/D		N/D		0.02	0.03	0.04		0.08	N/D		0.02	
FBC-6B	06/21/93		0.49	0.08		N/D	N/D	N/D	0.004		0.04	N/D		0.07		N/D		N/D		N/D	0.04	0.33		N/D	N/D		N/D	
FBC-6B	10/15/93		0.28	N/D		N/D	N/D	1.00	N/D		0.1	N/D		N/D		N/D		0.20		N/D	0.27	N/D		0.00	N/D		N/D	
FBC-6B	06/16/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		N/D	
FBC-6B	08/30/94		0.3	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
FBC-6B	10/31/94		0.2	0.2		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		0.05	
FBC-7	07/30/91		7.10			0.16		7.00	0.00		0.00	0.00		0.03		0.00		0.00		0.05	0.00	0.21		0.50	0.00		0.03	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
FBC-7	10/12/92		0.00			0.00		0.03	0.00		0.00	0.03		0.011		0.00		0.00		0.02	0.00	0.00		0.00	0.00		0.00	
FBC-7	06/21/93		0.32			N/D		N/D	N/D		0.05	N/D		0.06		0.003		N/D		N/D	0.03	0.29		N/D	0.005		N/D	
FBC-7	08/29/93		0.16			0.05		N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.27		N/D	N/D		0.1	
FBC-7	10/15/93		0.16	N/D		N/D	0.1	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.4		N/D	N/D		N/D	
FBC-7	06/15/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.02	N/D		N/D	
FBC-7	08/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.4		N/D	N/D		N/D	
FBC-7	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.4		0.02	N/D		N/D	
FBC-8	08/07/91		4.15	N/D		0.11	N/D	3.60	0.005		0.04	N/D		0.02		N/D		N/D		0.27	N/D	N/D		N/D	N/D		0.05	
FBC-9	08/07/91	0.76			0.00			0.40	0.00	0.21	0.00	0.00	0.00	0.05	0.26	0.00	0.00	0.00	0.11	0.08	0.00	0.23		0.00	0.00		0.03	0.00
FBC-9	06/21/93	0.35			N/D			N/D	N/D	N/D	0.08	N/D	0.005	0.07	0.23	0.003	N/D	N/D	N/D	N/D	0.04	0.04		0.02	N/D		N/D	N/D
FC-1	06/09/94		0.053			N/D		0.033	N/D		0.095	N/D		0.013		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
FC-1	10/27/94		0.064			N/D		0.289	N/D		0.174	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.022	N/D		N/D	
FC-1	07/10/95		0.93			0.038		0.86	N/D		N/D	N/D		N/D		N/D		N/D		N/D	0.007	0.138		0.117	N/D		N/D	
FC-1	10/18/95		N/D			N/D		N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	0.009	N/D		0.02	N/D		N/D	
FC-1	07/16/96			N/D		N/D		N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		N/D	
FC-1	06/29/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	0.01	N/D		0.05	N/D		0.02	
FC-1	09/17/97		0.1	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		0.01	
FC-1	10/28/97		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.01	N/D		0.01	
FC-2	07/31/91	0.10			0.00			0.10	0.00	0.21	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.05	0.00	0.00		0.00	0.00		0.01	0.00
FC-2	06/09/94		0.056			N/D		0.017	N/D		0.059	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
FC-2	10/27/94		0.063			N/D		0.063	N/D		0.073	N/D		N/D		0.0057		N/D		N/D	N/D	N/D		0.05	N/D		0.015	
FC-2	07/10/95		N/D			N/D		0.023	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.103		N/D	N/D		N/D	
FC-2	10/18/95		N/D			N/D		N/D	0.02		N/D	N/D		N/D		N/D		N/D		N/D	0.013	N/D		N/D	N/D		N/D	
FC-2	07/16/96			N/D		N/D		N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
FC-2	06/25/97		1	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		N/D	
FC-2	09/17/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		0.01	
FC-2	10/28/97		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.01	N/D		N/D	
FC-3	07/31/91		0.05			0.00		0.10	0.00		0.00	0.00		0.00		0.00		0.00		0.07	0.00	0.17		0.00	0.00		0.00	
FC-3	10/28/92		5.67			0.17		3.85	0.00		0.33	0.00		0.00		0.00		0.00		0.00	0.00	0.54		0.22	0.00		0.10	
FC-3	06/24/93		0.07	N/D		0.03		N/D	0.007		0.2	0.0002		0.05		N/D		N/D		N/D	0.01	0.07		0.02	N/D		0.04	
FC-3	08/15/93		0.31			0.03		1	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.04		0.04	N/D		0.47	
FC-3	10/26/93		0.29	N/D		0.04	N/D	N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	0.1		N/D	N/D		N/D	
FC-3	03/23/94		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		0.1	N/D	0.1		N/D	0.01		N/D	
FC-3	06/01/94		N/D	N/D		N/D	N/D	N/D	N/D		0.5	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		N/D	
FC-3	10/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		N/D	
LT-1	05/28/91	0.12			N/D																							
LT-1	10/17/91	0.13			N/D																							
LT-1	05/14/92	0.0			0.0																							
LT-1	10/05/92	0.0			0.02																							
LT-1	05/06/93	0.21			N/D			N/D	N/D	N/D	0.26	0.0002	N/D	0.03	0.28	N/D	N/D	N/D	N/D	N/D	N/D	0.04		N/D	0.005		N/D	2.8
LT-1	05/26/93	1.99			0.06			2.0	N/D	N/D	0.2	N/D	0.0036	N/D	0.29	0.003	N/D	N/D	N/D	N/D	0.02	1.57		0.16	N/D		N/D	20.4
LT-1	10/24/93	0.25			0.04			N/D	N/D	N/A	0.2	N/D	N/A	N/D	N/A	N/D	N/A	N/D	N/A	N/D	N/D	0.5		0.007	N/D		N/D	N/A
LT-1	05/24/94		N/D	N/D		N/D	N/D																					
LT-1	10/18/94		N/D	N/D		N/D	N/D																					
LT-1	05/23/95		1.6	N/D		0.1	N/D																					
LT-1	10/17/95		0.1	N/D		N/D	N/D																					
LT-1	05/20/96		0.25	N/D		N/D	N/D																					
LT-1	10/31/96		N/D	N/D		N/D	N/D																					
LT-1	05/29/97		3.2	N/D		N/R	0.1																					
LT-1	10/29/97		N/D	N/D		N/D	N/D																					
MH-1	07/31/91		0.44	N/D		0.15	N/D	0.2	N/D		N/D	N/D		N/D		N/D		N/D		0.07	N/D	N/D		N/D	N/D		N/D	
MH-1	06/21/93		0.57	N/D		N/D	N/D	N/D	N/D		0.05	N/D		0.06		N/D		N/D		N/D	0.04	0.01		0.04	0.004		N/D	

Table A-2

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
MH-1	08/29/93		0.79	N/D		0.03	N/D	1	N/D		N/D	N/D		N/D		N/D		N/D		N/D	0.01	0.1		0.051	N/D		0.01	
MH-1	10/15/93		0.27	N/D		N/D	N/D	N/D	N/D		0.10	N/D		N/D		N/D		0.2		N/D	N/D	0.27		0.007	N/D		N/D	
MH-1	06/16/94		1.6	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	0.01	0.1		0.02	N/D		N/D	
NPDES	04/18/91	0.19																										
NPDES	05/28/91	0.2																										
NPDES	06/17/91	0.09																										
NPDES	07/29/91	0.09																										
NPDES	08/08/91	0.23																										
NPDES	09/13/91	0.07																										
NPDES	10/17/91	0																										
NPDES	12/27/91	0.03																										
NPDES	01/31/92	0.2																										
NPDES	02/18/92	0.06																										
NPDES	03/27/92	0																										
NPDES	04/09/92	0.06																										
NPDES	05/14/92	0																										
NPDES	06/09/92	0.1																										
NPDES	07/07/92	0.1																										
NPDES	08/10/92	0.57																										
NPDES	09/10/92	0.05																										
NPDES	10/05/92	0.09																										
NPDES	11/23/92	0.09																										
NPDES	12/16/92	0																										
NPDES	01/18/93	0																										
NPDES	02/15/93	0.11																										
NPDES	03/10/93	0																										
NPDES	04/08/93	N/D																										
NPDES	05/18/93	N/D																										
NPDES	06/11/93	0.8																										
NPDES	07/09/93	0.1																										
NPDES	08/11/93	N/D																										
NPDES	09/24/93	0.05																										
NPDES	10/05/93	0.09																										
NPDES	11/29/93	N/R																										
NPDES	12/15/93	N/D																										
NPDES	01/19/94	N/D																										
NPDES	02/09/94	N/D																										
NPDES	03/21/94	N/D																										
NPDES	04/20/94	N/D																										
NPDES	05/24/94	N/D																										
NPDES	06/01/94	N/D																										
NPDES	07/11/94	N/D																										
NPDES	08/17/94	N/D																										
NPDES	09/01/94	N/D																										
NPDES	10/18/94	N/D																										
NPDES	11/22/94	N/D																										
NPDES	12/22/94	N/D																										
NPDES	01/14/95	N/D																										
NPDES	02/07/95	N/D																										
NPDES	03/22/95	N/D																										
NPDES	04/20/95	N/D																										
NPDES	05/09/95	N/D																										

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
NPDES	06/14/95	0.2																										
NPDES	07/27/95	0.7																										
NPDES	08/22/95	N/D																										
NPDES	09/28/95	N/D																										
NPDES	10/16/95	N/D																										
NPDES	11/21/95	N/D																										
NPDES	12/28/95	N/D																										
NPDES	01/22/96	0.6																										
NPDES	02/28/96	0.6																										
NPDES	03/28/96	N/D																										
NPDES	04/18/96	N/D																										
NPDES	05/22/96	N/D																										
NPDES	06/26/96	N/D																										
NPDES	07/30/96	N/D																										
NPDES	08/27/96	N/D																										
NPDES	09/23/96	N/D																										
NPDES	10/30/96	N/D																										
NPDES	11/29/96	N/D																										
NPDES	12/26/96	N/D																										
NPDES	01/17/97	N/D																										
NPDES	02/26/97	N/D																										
NPDES	03/13/97	N/D																										
NPDES	04/30/97	N/D																										
NPDES	05/21/97	0.2																										
NPDES	06/23/97	N/D																										
NPDES	07/14/97	N/D																										
NPDES	08/18/97	N/D																										
NPDES	09/18/97	N/D																										
NPDES	10/14/97	N/D																										
NPDES	11/07/97	N/D																										
NPDES	12/17/97	N/D																										
NPDES-004	05/15/96		0.03	<0.03		<0.04	<0.04	<1	<0.004		0.23	<0.004		<0.03		<0.08		<0.07		<0.2	0.003	0.07		0.005	<0.003		0.01	
PS-1	05/06/93	0.34			N/D			N/D	N/D	N/D	0.17	0.0002	N/D	N/D	0.18	N/D	N/D	N/D	N/D	N/D	0.02	0.52		N/D	N/D		N/D	4
PS-1	05/25/94		N/D	N/D		N/D	N/D																					
PS-1	10/17/95		N/D	N/D		N/D	N/D																					
PS-1	10/30/96		N/D	N/D		N/D	N/D																					
PS-1	10/29/97		0.4	N/D		N/D	N/D																					
SBC-10	01/31/92	0.56			0.0			0.0	0.0	0.0	0.04	0.0	0.0	0.02	0.09	0.0	0.0	0.0	0.0	0.18	0.0	0.0		0.0	0.0		0.0	4
SBC-10	02/18/92	0.08			0.07			0.0	0.007	0.0	0.1	0.0	0.0	0.0	0.45	0.0	0.0	0.0	0.0	0.2	0.0	0.16		0.02	0.0		0.0	0.0
SBC-10	03/26/92	0.09			0.0			0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.13	0.0	0.0	0.0	0.02	0.45	0.0	0.0		0.01	0.0		0.0	0.01
SBC-10	05/14/92	0.0			0.0			0.0	0.0	0.0	0.07	0.0	0.0	0.0	0.04	0.0	0.0	0.0	0.0	0.43	0.0	0.27		0.01	0.0		0.04	3.4
SBC-10	08/10/92	0.02			0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.23	0.0	0.0	0.0	0.0	0.01	0.01	0.1		0.0	0.0		0.0	6.0
SBC-10	10/01/92	0.0			0.04			0.32	0.0	0.0	0.08	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.1	0.0	0.21		0.0	0.0		0.0	2
SBC-10	02/18/93	0.05			0.00																							
SBC-10	05/19/93	0.1			N/D																							
SBC-10	08/11/93	0.09			N/D																							
SBC-10	10/20/93	N/D			0.1																							
SBC-10	02/09/94		N/D	N/D		N/D	N/D																					
SBC-10	05/30/94		N/D	N/D		N/D	N/D																					
SBC-10	08/18/94		N/D	N/D		N/D	N/D																					
SBC-10	10/19/94		N/D	N/D		N/D	N/D																					
SBC-10	02/07/95		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.01	N/D		N/D	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
SBC-10	05/08/95		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.02	N/D		0.02	
SBC-12	06/08/94		0.026			N/D		0.021	N/D		0.016	N/D		N/D		N/D		N/D		N/D	N/D	0.332		N/D	N/D		N/D	
SBC-12	10/28/94		0.459			0.018		0.328	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.256		0.072	N/D		0.011	
SBC-12	07/10/95		N/D			N/D		0.023	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.36		N/D	N/D		N/D	
SBC-12	10/18/95		N/D			N/D		N/D	0.03		N/D	N/D		N/D		N/D		N/D		N/D	0.012	0.28		0.01	N/D		N/D	
SBC-12	07/18/96			N/D		N/D		N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
SBC-12	06/25/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.02	N/D		0.01	
SBC-12	09/10/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.4		0.02	N/D		0.01	
SBC-12	10/15/97		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		0.05	
SBC-13	02/07/95		0.10	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.01	N/D		N/D	
SBC-13	08/28/96		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D				N/D		N/D		N/D	N/D	0.1		N/D	N/D		0.03	
SBC-13	10/30/96		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D				N/D		N/D		N/D	N/D	N/D		0.02	N/D		0.02	
SBC-13	02/27/97		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D				N/D		N/D		N/D	N/D	N/D		0.02	0.02		0.02	
SBC-13	05/22/97		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D				N/D		N/D		N/D	N/D	N/D		0.01	N/D		0.02	
SBC-13	08/26/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D				N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
SBC-13	10/29/97		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D				N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
SBC-14	10/26/93		0.23	N/D		0.04	N/D	N/D	N/D		0.4	N/D		N/D		N/D		0.2		N/D	N/D	0.9		0.004	N/D		N/D	
SBC-14	03/23/94		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		0.2		N/D		N/D	N/D	0.7		N/D	N/D		N/D	
SBC-14	06/01/94		N/D	N/D		N/D	N/D	N/D	N/D		0.9	N/D		N/D		N/D		N/D		N/D	N/D	0.7		N/D	0.01		N/D	
SBC-14	08/28/94		N/D	N/D		N/D	N/D	N/D	N/D		0.5	N/D		N/D		N/D		N/D		N/D	N/D	1.9		0.02	N/D		N/D	
SBC-14	10/26/94		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	0.9		N/D	N/D		N/D	
SBC-14	05/24/95		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		N/D	
SBC-14	08/22/95		N/D	N/D		N/D	N/D	N/D	N/D		0.5	N/D		N/D		N/D		N/D		N/D	N/D	0.8		0.01	N/D		N/D	
SBC-14	06/24/97		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D		N/D		N/D		N/D		N/D	N/D	1.1		0.03	N/D		0.03	
SBC-15	07/31/91		0.10	N/D		N/D	N/D	0.10	N/D		N/D	N/D		N/D		N/D		N/D		0.07	N/D	N/D		N/D	N/D		N/D	
SBC-15	10/27/92		0.05	N/D		N/D	N/D	N/D	N/D		0.15	0.13		N/D		N/D		N/D		N/D	N/D	0.02		N/D	N/D		0.12	
SBC-15	06/24/93		0.06	N/D		N/D	N/D	N/D	0.08		0.15	N/D		0.05		N/D		0.20		N/D	N/D	0.06		N/D	0.01		N/D	
SBC-15	08/15/93		0.36	N/D		0.02	N/D	1.00	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.05		N/D	0.002		0.01	
SBC-15	10/13/93		0.12	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	0.18		0.003	N/D		N/D	
SBC-15	05/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.4	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		N/D	
SBC-15	08/29/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.03	N/D		N/D	
SBC-15	10/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		N/D	
SBC-16	07/30/91		0.66	N/D		0.02	N/D	0.70	N/D		N/D	N/D		N/D		N/D		N/D		0.29	N/D	N/D		N/D	N/D		N/D	
SBC-16	10/28/92		N/D	N/D		N/D	N/D	N/D	N/D		0.18	N/D		N/D		N/D		N/D		N/D	N/D	0.01		N/D	N/D		0.12	
SBC-16	06/24/93		0.15	N/D		0.03	N/D	1	0.004		0.06	N/D		0.06		N/D		N/D		N/D	N/D	0.02		0.02	0.004		N/D	
SBC-16	08/15/93		0.05	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		N/D	
SBC-16	10/13/93		0.2	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		0.03	
SBC-16	05/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	N/D		N/D	N/D		N/D	
SBC-16	08/29/94		1.4	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	0.02	0.01		0.06	N/D		N/D	
SBC-16	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.02	N/D		N/D	
SBC-16	06/24/93	N/D			N/D			N/D	0.005	N/D	0.12	N/D	0.0018	0.06	0.18	N/D	N/D	N/D	0.12	0.08	0.01	N/D		N/D	0.004		N/D	N/D
SBC-18	07/31/91		0.90	N/D		0.02	N/D	1.30	N/D		N/D	N/D		N/D		N/D		N/D		0.08	N/D	0.28		N/D	N/D		0.01	
SBC-18	10/28/92		0.05	N/D		0.03	N/D	N/D	N/D		0.15	N/D		N/D		0.44		N/D		N/D	N/D	0.34		N/D	N/D		0.08	
SBC-18	06/24/93		N/D	N/D		N/D	N/D	N/D	0.005		0.09	N/D		0.06		N/D		N/D		N/D	N/D	0.16		N/D	N/D		N/D	
SBC-18	08/15/93		1.06	N/D		0.07	N/D	1	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.07		0.31	N/D		0.01	
SBC-18	10/13/93		0.2	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		0.2		N/D	N/D	0.2		N/D	N/D		0.08	
SBC-18	05/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		N/D	
SBC-18	08/30/94		0.5	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		N/D	N/D		N/D	
SBC-19	07/30/91		0.55	N/D		N/D	N/D	0.40	N/D		N/D	N/D		N/D		N/D		N/D		0.04	N/D	N/D		N/D	N/D		0.01	
SBC-19	10/27/92		N/D	N/D		N/D	N/D	N/D	N/D		0.12	0.01		N/D		0.17		N/D		N/D	N/D	0.03		N/D	N/D		0.02	
SBC-19	06/24/93		N/D	N/D		N/D	N/D	N/D	N/D		0.29	N/D		0.06		N/D		N/D		N/D	N/D	0.18		0.02	N/D		N/D	
SBC-19	08/15/93		0.03	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.06		N/D	N/D		0.01	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
SBC-19	10/13/93		0.1	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.08		N/D	N/D		N/D	
SBC-19	05/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.3	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	
SBC-19	08/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		N/D	N/D		N/D	
SBC-19	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.02	N/D		N/D	
SBC-3	02/28/91	8.25			0.41																							
SBC-3	05/28/91	4.45			0.27																							
SBC-3	08/26/91	4.73			0.31																							
SBC-3	10/17/91	7.49			0.35																							
SBC-3	02/28/92	4.32			0.29																							
SBC-3	05/27/93	0.33			N/D																							
SBC-3	08/16/93	0.57			0.06																							
SBC-3	10/25/93	2.1			0.3																							
SBC-3	05/30/94		0.4	N/D		N/D	N/D																					
SBC-3	08/29/94		N/D	N/D		N/D	N/D																					
SBC-3	10/19/94		1.1	N/D		N/D	N/D																					
SBC-3	05/23/95		0.5	N/D		N/D	N/D	N/D	0.01	0.2		N/D		N/D		N/D		N/D		N/D	0.0	0.2		0.0	N/D		0.06	
SBC-3	08/22/95		0.5	N/D		N/D	N/D	N/D	N/D	0.5		N/D		N/D		N/D		N/D		N/D	N/D	0.8		0.0	N/D		N/D	
SBC-3	10/18/95		7.6	N/D		0.4	0.2	N/D	N/D	1.1		N/D		N/D		N/D		N/D		N/D	0.0	N/D		0.16	N/D		0.01	
SBC-3	02/27/96		0.2	N/D		N/D	N/D																					
SBC-3	05/22/96		0.4	N/D		N/D	N/D																					
SBC-3	08/27/96		0.7	N/D		N/D	N/D																					
SBC-3	10/30/96		1.2	N/D		N/D	N/D																					
SBC-3	02/27/97		0.2	N/D		N/D	N/D																					
SBC-3	05/22/97		0.2	N/D		N/D	N/D																					
SBC-3	08/26/97		1	N/D		N/D	N/D																					
SBC-3	10/29/97		0.4	N/D		N/D	N/D																					
SBC-4	10/01/86			<0.05			<0.02	<0.1	<0.005	<0.5	0.04	<0.002	0.02	<0.01	0.12	<0.02	<0.001	<0.02	<0.01	0.05				<0.01	<0.005	<0.04	<0.01	
SBC-4	10/28/86			0.06			<0.02	<0.1	<0.005	<0.5	0.03	<0.002	0.02	<0.01	0.14	<0.02	<0.001	<0.02	<0.01	0.07				<0.01	<0.005	<0.04	<0.01	
SBC-4	01/05/87		0.25			<0.02																						
SBC-4	04/07/87		0.15			<0.02																						
SBC-4	08/26/87		0.18			<0.02																						
SBC-4	10/05/87		0.1			<0.02																						
SBC-4	02/28/91	0.3			N/D			0.22	N/D	0.18	0.08	N/D	N/D	0.01	1.19	N/D	N/D	N/D	N/D	0.27	0.25	<0.04	N/D		N/D	0.08	0.04	
SBC-4	05/28/91	0.21			N/D			N/D	N/D	N/D	0.01	N/D	N/D	0.02	0.18	N/D	N/D	N/D	N/D	0.05	0.6	<0.04	0.14		N/D	0.38	0.06	
SBC-4	07/29/91	0.27			N/D			N/D	N/D	0.19	0.04	N/D	N/D	0.01	N/S	N/D	N/D	0.02	N/D	0.33	0.19	<0.02	N/D		N/D	N/D	0.02	
SBC-4	08/08/91	N/D			N/D			N/D	N/D	0.16	N/D	N/D	N/D	N/D	0.19	N/D	N/D	N/D	N/D	0.04	0.27	<0.02	N/D		N/D	N/D	N/D	
SBC-4	09/13/91	0.08			N/D			N/D	N/D	N/D	0.02	N/D	N/D	0.01	0.16	N/D	N/D	N/D	N/D	0.08	<0.02	<0.02	0.1		N/D	N/D	0.11	
SBC-4	10/25/91	0.36			0.04			0.5	N/D	0.14	0.02	0.005	N/D	N/D	0.06	N/D	N/D	0.16	N/D	N/D	<0.01	<0.01	0.02		0.007	N/D	0.07	
SBC-4	11/26/91	N/D			N/D			N/D	N/D	N/D	0.09	N/D	N/D	N/D	0.06	N/D	N/D	N/D	N/D	0.63	N/D	N/D	0.03		N/D	12.5	N/D	
SBC-4	12/27/91	N/D			N/D			N/D	N/D	N/D	0.01	N/D	N/D	N/D	0.2	N/D	N/D	N/D	0.02	0.13	N/D	N/D	0.01		N/D	3	0.05	
SBC-4	01/31/92	0			0			0	0	0	0	0	0	0	0.08	0	0	0	0	0.12	0	0		0.01	0		0.53	1.8
SBC-4	02/28/92	0			0			0	0	0	0	0	0	0.015	0.05	0	0.001	0	0.02	0.07	0	0		0	0		0.21	0
SBC-4	03/26/92	0			0			0	0	0	0.19	0	0	0	0.13	0	0	0	0.02	0.55	0.01	0.05		0.01	0		0	0.01
SBC-4	04/24/92	0			0			0	0.002	0	0	0	0	0	0.3	0	0	0	0	0	0	0		0.01	0		0.03	3.4
SBC-4	05/29/92	0.08			0.0			0.0	0.0	0.0	0.08	0.0	0.0	0.018	0.23	0.0	0.0	0.0	0.02	0.0	0.0	0.32		0.0	0.0		0.0	4.6
SBC-4	07/23/92	0.02			0.0			0.0	0.0	0.03	0.12	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.04	0.02	0.01	0.27		0.01	0.0		0.07	5.0
SBC-4	08/28/92	0.03			0.0			0.0	0.0	0.0	0.1	0.0	0.0	0.016	0.18	0.0	0.0	0.0	0.0	0.0	0.02	0.34		0.0	0.0		0.02	4.40
SBC-4	09/24/92	0.0			0.0			0.0	0.0	0.0	0.08	0.0	0.0	0.008	0.22	0.0	0.0	0.0	0.0	0.0	0.36	0.23		0.0	0.0		0.28	0.0
SBC-4	10/30/92	0.0			0.0			0.0	0.0	0.0	0.13	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.01	0.0	0.05	0.26		0.0	0.0		0.09	0.6
SBC-4	11/18/92	0.1			0.03			0.0	0.06	0.0	0.06	0.05	0.0	0.0	0.2	0.018	0.0	0.0	0.16	0.0	0.03	0.23		0.0	0.005		0.08	2.0
SBC-4	12/16/92	0.07			0.0			0.5	0.00	0.3	0.03	0.004	0.0	0.05	0.11	0.0	0.0	0.0	0.1	0.0	0.02	0.34		0.0	0.0		0.1	4.8
SBC-4	02/08/93	0.08			0.01			N/D	N/D	N/D	0.09	N/D	N/D	N/D	0.22	N/D	N/D	N/D	N/D	0.2	0.15	0.28		0.00	0.00		0.01	1.4

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
SBC-4	05/20/93	0.08			N/D			N/D	0.027	N/D	0.23	N/D	N/D	10.03	0.14	N/D	N/D	N/D	N/D	N/D	0.01	0.19		0.01	0.009		N/D	N/D
SBC-4	08/16/93	0.0			N/D			N/D	N/D	0.1	N/D	N/D	N/D	N/D	0.21	N/D	N/D	N/D	0.01	N/D	N/D	0.2		0.010	0.002		0.01	N/D
SBC-4	10/01/93	0.2			0.03			N/D	N/D		0.10	N/D		N/D		N/D		0.2		N/D	0.04	0.3		0.020	N/D		N/D	
SBC-4	02/01/94		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.4		N/D	N/D		0.04	
SBC-4	05/16/94		N/D	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.05	N/D		0.03	
SBC-4	08/10/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.05	N/D		N/D	
SBC-4	10/19/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.18	N/D		N/D	
SBC-4	02/15/95		N/D	N/D		N/D	N/D	N/D	N/D	0.1		N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.0	N/D		N/D	
SBC-4	05/31/95		N/D	N/D		N/D	N/D	N/D	N/D	0.1		N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.1	N/D		N/D	
SBC-4	08/23/95		N/D	N/D		N/D	N/D	N/D	N/D	0.2		N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.2	N/D		N/D	
SBC-4	10/18/95		N/D	N/D		N/D	N/D	N/D	N/D	0.2		0.01		N/D		N/D		N/D		N/D	N/D	0.1		0.1	N/D		N/D	
SBC-4	02/27/96		N/D	N/D		N/D	N/D																					
SBC-4	05/10/96		N/D	N/D		N/D	N/D																					
SBC-4	08/13/96		N/D	N/D		N/D	N/D																					
SBC-4	10/24/96		N/D	N/D		N/D	N/D																					
SBC-4	02/26/97		N/D	N/D		N/D	N/D																					
SBC-4	05/20/97		N/D	N/D		N/D	N/D																					
SBC-4	08/14/97		N/D	N/D		N/D	N/D																					
SBC-4	10/29/97		N/D	N/D		N/D	N/D																					
SBC-4	05/26/98		<0.1	<0.1		<0.1	<0.1																					
SBC-4	10/29/98		<0.1	<0.1		<0.1	<0.1																					
SBC-5	03/01/91	0.1			N/D			N/D	N/D	0.13	0.1	N/D	N/D	N/D	0.65	N/D	N/D	N/D	N/D	0.13		<0.04	N/D		N/D	<0.01	N/D	
SBC-5	06/17/91	0.12			0.02			N/D	N/D	0.13	0.02	N/D	N/D	N/D	0.17	N/D	N/D	N/D	N/D	0.12		<0.01	N/D		N/D	N/S	N/D	
SBC-5	07/29/91	0.25			0.02			0.2	N/D	0.13	0.07	N/D	N/D	0.01	N/S	N/D	N/D	0.02	N/D	0.3		0.02	N/D		N/D	0.1	0.01	
SBC-5	08/08/91	N/D			N/D			N/D	N/D	0.11	N/D	N/D	N/D	N/D	0.16	N/D	N/D	N/D	N/D	0.03		<0.02	N/D		N/D	<0.1	0.01	
SBC-5	09/27/91	N/D			N/D			0.21	N/D	N/D	0.06	N/D	0.06	0.047	0.06	N/D	N/D	N/D	0.29	0.19		N/D	0.06		N/D	3	N/D	
SBC-5	10/28/91	N/D			N/D			0.5	N/D	0.07	0.12	N/D	N/D	N/D	0.05	N/D	N/D	N/D	N/D	N/S		N/D	0.02		0.003	5.5	0.05	
SBC-5	11/26/91	N/D			N/D			N/D	N/D	N/D	0.16	N/D	N/D	N/D	0.05	N/D	N/D	N/D	N/D	0.4		N/D	0.03		N/D	N/D	0.02	
SBC-5	12/27/91	N/D			N/D			N/D	N/D	N/D	0.11	N/D	N/D	N/D	0.17	N/D	N/D	N/D	0.02	0.09		N/D	N/D		N/D	5.5	N/D	
SBC-5	01/31/92	0.03			0.0			0.0	0.0	0.0	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14	0.0	0.0		0.31	0.0		0.0	18.0
SBC-5	02/28/92	0.0			0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.001	0.0	0.02	0.09	0.0	0.0		0.0	0.0		0.02	0.0
SBC-5	03/26/92	0.0			0.0			0.0	0.003	0.0	0.09	0.0	0.0	0.0	0.14	0.0	0.0	0.0	0.02	0.55	0.01	0.13		0.01	0.0		0.0	0.01
SBC-5	04/27/92	0.0			0.0			0.0	0.0	0.0	0.13	0.0	0.0	0.0	0.27	0.0	0.0	0.0	0.0	0.0	0.0	0.05		0.02	0.0		0.04	1.8
SBC-5	05/29/92	0.06			0.0			0.0	0.0	0.0	0.04	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.02	0.0	0.0	0.09		0.0	0.0		0.0	4.2
SBC-5	07/23/92	0.06			0.0			0.0	0.0	0.03	0.12	0.0	0.0	0.0	0.17	0.0	0.0	0.0	0.1	0.01	0.0	0.12		0.01	0.0		0.06	4.2
SBC-5	08/28/92	0.14			0.05			0.0	0.0	0.0	0.16	0.0	0.0	0.014	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.2		0.0	0.0		0.08	6.2
SBC-5	09/24/92	0.0			0.0			0.0	0.0	0.0	0.11	0.0	0.0	0.0	0.21	0.0	0.0	0.0	0.0	0.0	0.0	0.34		0.0	0.0		0.0	1.0
SBC-5	10/30/92	0.0			0.0			0.0	0.0	0.0	0.16	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.08	0.21		0.0	0.0		0.05	1.0
SBC-5	11/18/92	0.04			0.03			0.05	0.006	0.0	0.42	0.005	0.01	0.0	0.38	0.019	0.0	0.0	0.15	0.0	0.03	0.05		0.0	0.0		0.08	1.4
SBC-5	12/16/92	0.09			0.0			0.50	0.0	0.30	0.22	0.003	0.0	0.050	0.13	0.003	0.0	0.0	0.10	0.0	0.02	0.20		0.0	0.0		0.1	4.8
SBC-5	02/08/93	0.07			0.01			N/D	N/D	N/D	0.11	N/D	N/D	N/D	0.11	N/D	N/D	N/D	0.07	0.01	N/D	151.0		N/D	N/D		N/D	N/D
SBC-5	05/20/93	0.12			N/D			1.0	N/D	N/D	0.27	N/D	N/D	N/D	0.14	N/D	N/D	N/D	N/D	0.08	0.01	0.06		0.008	N/D		N/D	2.4
SBC-5	08/16/93	0.07			N/D			N/D	N/D	0.1	N/D	N/D	N/D	N/D	0.21	N/D	N/D	N/D	0.01	N/D	N/D	0.13		0.02	0.002		0.01	N/D
SBC-5	10/21/93	0.20			0.03			N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	N/D		0.05	N/D		0.03	
SBC-5	02/01/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.03	N/D		N/D	
SBC-5	02/01/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.01	N/D		N/D	
SBC-5	05/16/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.02	N/D		0.04	
SBC-5	08/10/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	0.01	0.3		0.04	N/D		N/D	
SBC-5	10/06/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.14	N/D		N/D	
SBC-5	05/31/95		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.3	N/D		0.01	
SBC-5	08/23/95		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.1	N/D		N/D	
SBC-5	10/18/95		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		N/D	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
SBC-5	02/27/96		N/D	N/D		N/D	N/D																					
SBC-5	05/10/96		N/D	N/D		N/D	N/D																					
SBC-5	08/13/96		N/D	N/D		N/D	N/D																					
SBC-5	10/24/96		N/D	N/D		N/D	N/D																					
SBC-5	02/26/97		N/D	N/D		N/D	N/D																					
SBC-5	05/20/97		N/D	N/D		N/D	N/D																					
SBC-5	08/14/97		N/D	N/D		N/D	N/D																					
SBC-5	10/29/97		N/D	N/D		N/D	N/D																					
SBC-5	05/26/98		<0.1	<0.1		<0.1	<0.1																					
SBC-5 Overflow	10/29/98		<0.1	<0.1		<0.1	<0.1																					
SBC-9	02/28/91	0.02			N/D			N/D	N/D	0.18	0.11	N/D	N/D	0.01	0.55	N/D	N/D	N/D	N/D	0.07	0.22	N/D	N/D		N/D	N/D	0.05	
SBC-9	05/28/91	0.21			N/D			N/D	N/D	N/D	0.02	N/D	N/D	0.02	0.17	N/D	N/D	N/D	N/D	0.05	0.15	N/D	0.11		N/D	N/S	0.06	
SBC-9	07/29/91	0.08			N/D			N/D	N/D	0.16	0.15	N/D	N/D	0.07	0.17	N/D	N/D	N/D	0.02	0.22	N/D	N/D	0.8		N/D	N/D	0.42	
SBC-9	08/08/91	0.55			N/D			N/D	N/D	0.15	N/D	N/D	N/D	0.01	0.18	N/D	N/D	N/D	0.25	0.04	N/D	N/D	N/D		N/D	N/D	0.22	
SBC-9	10/17/91	N/D			N/D			0.1	N/D	0.13	0.05	N/D	N/D	0.06	0.12	N/D	N/D	N/D	0.01	0.15	N/D	N/D	N/D		N/D	0.04	0.22	
SBC-9	02/18/92	0.06			0.06																							
SBC-9	05/14/92	1.14			0																							
SBC-9	08/10/92	0			0																							
SBC-9	10/05/92	0.09			0																							
SBC-9	02/18/93	0.12			0.00																							
SBC-9	05/19/93	N/D			N/D																							
SBC-9	08/11/93	N/D			N/D																							
SBC-9	10/20/93	N/D			N/D																							
SBC-9	02/09/94		N/D	N/D		N/D	N/D																					
SBC-9	05/30/94		N/D	N/D		N/D	N/D																					
SBC-9	08/18/94		N/D	N/D		N/D	N/D																					
SBC-9	10/19/94		N/D	N/D		N/D	N/D																					
SBC-9	02/07/95		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.0	N/D		N/D	
SBC-9	05/08/95		0.1	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.0	N/D		N/D	
SBC-9	08/24/95		0.1	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	N/D		0.0	N/D		N/D	
SBC-9	10/17/95		N/D	N/D		N/D	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		N/D		N/D		N/D	N/D		N/D	
SBC-9	02/27/96		N/D	N/D		N/D	N/D																					
SBC-9	05/21/96		N/D	N/D		N/D	N/D																					
SBC-9	08/28/96		0.1	N/D		N/D	N/D																					
SBC-9	10/30/96		N/D	N/D		N/D	N/D																					
SBC-9	02/27/97		N/D	N/D		N/D	N/D																					
SBC-9	05/23/97		N/D	N/D		N/D	N/D																					
SBC-9	08/26/97		N/D	N/D		N/D	N/D																					
SBC-9	10/29/97		N/D	N/D		N/D	N/D																					
SBC-9 Source	05/15/96		0.16	<0.03		<0.04	<0.04	<1	<0.004		0.22	<0.004		<0.03		<0.08		<0.07		<0.2	<0.002	<0.06		0.006	<0.003		<0.01	
SBC-9 Source	01/06/99		0.1	<0.1			<0.1																					
SDH-1	08/29/94		12.4	N/D		0.2	N/D	N/D	N/D		0.2	N/D		N/D		N/D		N/D		3.3	0.04	1.1		0.10	N/D		N/D	
SDH-2	06/30/98		3.3	<0.1			<0.01																					
SDH-3	06/30/98		2.4	<0.1			0.3																					
SMH-1	08/02/91		0.10	N/D		N/D	N/D	N/D	N/D		N/D	N/D		0.01		N/D		N/D		0.09	N/D	0.29		N/D	N/D		0.01	
SMH-1	06/21/93		0.59	N/D		N/D	N/D	N/D	0.003		0.06	N/D		0.07		0.003		N/D		N/D	0.04	0.24		0.03	0.006		0.06	
SMH-1	08/29/93		0.04	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.27		N/D	N/D		0.01	
SMH-1	10/15/93		0.15	N/D		N/D	N/D	1.00	N/D		0.1	N/D		N/D		N/D		0.20		N/D	0.01	0.32		0.003	N/D		N/D	
SMH-1	06/16/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.02	N/D		N/D	
SMH-1	08/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	1.2		N/D	N/D		N/D	
SMH-1	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.1		0.02	N/D		N/D	
SMH-2	08/02/91		1.24			0.06		1.30	0.00		0.00	0.00		0.00		0.00		0.00		0.12	0.00	0.00		0.00	0.00		0.01	

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l
SMH-2	10/13/92		0.10			0.00		0.00	0.00		0.08	0.04		0.012		0.22		0.00		0.02	0.00	0.10		0.00	0.00		0.03	
SMH-2	06/21/93		0.68			N/D		N/D	N/D		0.05	N/D		0.06		0.003		N/D		N/D	0.04	0.28		N/D	N/D		N/D	
SMH-2	08/29/93		N/D			N/D		N/D	N/D		N/D	N/D		0.01		N/D		N/D		N/D	N/D	0.18		0.004	N/D		N/D	
SMH-2	10/15/93		0.15			N/D		N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	0.33		N/D	N/D		N/D	
SMH-2	06/15/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		N/D	
SMH-2	08/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		N/D	N/D		N/D	
SMH-2	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.2		0.02	N/D		0.04	
SMH-3	08/29/93		0.06	N/D		N/D	N/D	N/D	N/D		N/D	N/D		N/D		N/D		N/D		N/D	N/D	0.23		0.008	N/D		N/D	
SMH-3	10/15/93		0.16	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		0.2		N/D	N/D	0.35		0.003	N/D		N/D	
SMH-3	06/15/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.02	N/D		N/D	
SMH-3	08/30/94		0.3	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.02	N/D		N/D	
SMH-3	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.3		0.02	N/D		N/D	
SMH-3	06/28/95		0.3	N/D		N/D	N/D	N/D	N/D		0.1	0.01		N/D		N/D		N/D		N/D	N/D	0.3		N/D	N/D		0.04	
SMH-4	08/01/91		9.51	N/D		0.51	N/D	6.70	0.008		0.07	N/D		0.02		N/D		N/D		0.28	N/D	N/D		1.20	N/D		0.05	
SMH-4	10/13/92		N/D	N/D		N/D	N/D	N/D	N/D		0.02	0.23		0.011		0.12		N/D		0.02	N/D	0.43		N/D	N/D		N/D	
SMH-4	06/24/93		N/D	N/D		N/D	N/D	N/D	6.04		0.14	N/D		0.05		N/D		0.2		N/D	N/D	0.48		0.3	N/D		N/D	
SMH-4	08/29/93		0.43	N/D		0.14	N/D	2	N/D		0.07	N/D		N/D		N/D		N/D		N/D	N/D	0.29		N/D	0.002		0.14	
SMH-4	10/15/93		0.16	N/D		N/D	N/D	1	N/D		0.1	0.02		N/D		N/D		N/D		N/D	N/D	0.5		N/D	N/D		N/D	
SMH-4	06/15/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.5		N/D	N/D		N/D	
SMH-4	08/30/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.4		N/D	N/D		N/D	
SMH-4	10/31/94		N/D	N/D		N/D	N/D	N/D	N/D		0.1	N/D		N/D		N/D		N/D		N/D	N/D	0.5		0.02	N/D		N/D	
T.S. North Bleeder	05/26/98		<0.1	<0.1		<0.1	<0.1	<1	<0.01		0.1	<0.01		<0.1		<0.1		<0.1		0.6	0.01	<0.1		<0.01	<0.01		0.02	
TS-1	05/28/91	0.29			N/D																							
TS-1	10/17/91	0.05			N/D																							
TS-1	05/13/92	0.0			0.0																							
TS-1	10/10/92	0.0			0.0																							
TS-1	05/06/93	0.15			N/D			N/D	N/D	N/D	0.23	0.0002	N/D	0.03	0.18	N/D	N/D	N/D	0.1	N/D	N/D	0.43		N/D	N/D		N/D	1.6
TS-1	10/24/93	0.21			0.04			N/D	N/D	N/A	0.1	N/D	N/A	N/D	N/A	N/D	N/A	0.2	N/A	N/D	N/D	0.6		0.01	N/D		N/D	N/A
TS-1	05/25/94		N/D	N/D		N/D	N/D																					
TS-1	10/18/94		N/D	N/D		N/D	N/D																					
TS-1	05/23/95		N/D	N/D		N/D	N/D																					
TS-1	10/18/95		N/D	N/D		N/D	N/D																					
TS-1	05/23/96		N/D	N/D		N/D	N/D																					
TS-1	10/30/96		N/D	N/D		N/D	N/D																					
TS-1	05/21/97		N/D	N/D		N/D	N/D																					
TS-1	10/29/97		N/D	N/D		N/D	N/D																					
UT-1	05/26/93	1.27			0.03			2.0	N/D	0.3	N/D	N/D	0.0014	0.03	0.16	N/D	N/D	N/D	N/D	0.08	N/D	0.29		0.055	0.004		N/D	3.8
UT-1	05/23/95		12.9	N/D		0.3	N/D																					
UT-1	10/17/95		N/D	N/D		N/D	N/D																					
UT-1	05/23/96		3.50	N/D		N/D	N/D																					
UT-1	10/30/96																											
UT-1	05/21/97		7.7	0.1		0.3	N/D																					
UT-1	10/29/97		0.1	N/D		N/D	N/D																					
WHR-7	07/30/91	0.08			0.00			0.10	0.00	0.18	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.01	0.15	0.00	0.00		0.00	0.00		0.02	0.00
WHR-8	07/31/91	1.60			0.02			1.20	0.00	0.33	0.00	0.00	0.00	0.03	0.20	0.00	0.00	0.00	0.00	0.09	0.00	0.00		0.00	0.00		0.07	0.52
WHR-9	08/08/91	0.71			0.02			0.70	0.00	0.36	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.02	0.22	0.00	0.20		0.00	0.00		0.01	0.00

Site	Date	Fe mg/l	Fe(T) mg/l	Fe(D) mg/l	Mn mg/l	Mn(T) mg/l	Mn(D) mg/l	Al mg/l	As mg/l	Ba mg/l	B mg/l	Cd mg/l	Cr mg/l	Cu mg/l	F mg/l	Pb mg/l	Hg mg/l	Mo mg/l	Ni mg/l	NH3 mg/l	NO2 mg/l	NO3 mg/l	P mg/l	PO4 mg/l	Se mg/l	H2S mg/l	Zn mg/l	S mg/l

Table A-3 Big Bear Spring discharge data

big bear discharge.xls 17 Aug 99

Date	GPM
Jan-80	223
Feb-80	228
Mar-80	226
Apr-80	225
May-80	228
Jun-80	340
Jul-80	365
Aug-80	304
Sep-80	245
Oct-80	230
Nov-80	239
Dec-80	233
Jan-81	225
Feb-81	198
Mar-81	175
Apr-81	228
May-81	224
Jun-81	220
Jul-81	226
Sep-81	155
Oct-81	152
Nov-81	156
Dec-81	160
Jan-82	161
Feb-82	159
Mar-82	155
Apr-82	152
May-82	154
Jun-82	213
Jul-82	243
Aug-82	198
Sep-82	174
Oct-82	168
Nov-82	167
Dec-82	168
Jan-83	167
Feb-83	167
Mar-83	167
Apr-83	166
May-83	166
Jun-83	310
Jul-83	378
Aug-83	319
Sep-83	258
Oct-83	214
Nov-83	195
Dec-83	189
Jan-84	189
Feb-84	191
Mar-84	187
Apr-84	187
May-84	198
Jun-84	335
Jul-84	321
Aug-84	299
Sep-84	245
Oct-84	209
Nov-84	203
Dec-84	202
Jan-85	198
Feb-85	193
Mar-85	189
Apr-85	186
May-85	233
Jun-85	329
Jul-85	312
Aug-85	247
Sep-85	215
Oct-85	206
Nov-85	204
Dec-85	222
Jan-86	171
Feb-86	190
Mar-86	186
Apr-86	182
May-86	208
Jun-86	304
Jul-86	305
Aug-86	249
Sep-86	211
Oct-86	198
Nov-86	197
Dec-86	193
Jan-87	186
Feb-87	181
Mar-87	176
Apr-87	171
May-87	170
Jun-87	171
Jul-87	188
Aug-87	181
Sep-87	170
Oct-87	181
Nov-87	170
Dec-87	160
Jan-88	153
Feb-88	151
Mar-88	147
Apr-88	143
May-88	147
Jun-88	151
Jul-88	157
Aug-88	152
Sep-88	151
Oct-88	155
Nov-88	151
Dec-88	146
Jan-89	142
Feb-89	139
Mar-89	134
Apr-89	133
May-89	131
Jun-89	127
Jul-89	128
Aug-89	120
Sep-89	119
Oct-89	114
Nov-89	111
Dec-89	111
Jan-90	110
Feb-90	130
Mar-90	112
Apr-90	109
May-90	104
Jun-90	104
Jul-90	104
Aug-90	105
Sep-90	107
Oct-90	110
Nov-90	108
Dec-90	125
Jan-91	126
Feb-91	110
Mar-91	128
Apr-91	118
May-91	119
Jun-91	123
Jul-91	119
Aug-91	113
Sep-91	114
Oct-91	114
Nov-91	121
Dec-91	122
Jan-92	126
Feb-92	128
Mar-92	121
Apr-92	125
May-92	124
Jun-92	132
Jul-92	123
Aug-92	112
Sep-92	107
Oct-92	107
Nov-92	104
Dec-92	110
Jan-93	98
Feb-93	98
Mar-93	98
Apr-93	95
May-93	111
Jun-93	111
Jul-93	116
Aug-93	131
Sep-93	136
Oct-93	140
Nov-93	140
Dec-93	136
Jan-94	133
Feb-94	126
Mar-94	122
Apr-94	119
May-94	118
Jun-94	117
Jul-94	118
Aug-94	116
Sep-94	117
Oct-94	118
Nov-94	117
Dec-94	116
Jan-95	113
Feb-95	106
Mar-95	83
Apr-95	78
May-95	73
Jun-95	77
Jul-95	98
Aug-95	124
Sep-95	130
Oct-95	140
Nov-95	144
Dec-95	143
Jan-96	143
Feb-96	142
Mar-96	139
Apr-96	137
May-96	136
Jun-96	137
Jul-96	142
Aug-96	148
Sep-96	148
Oct-96	150
Nov-96	143
Dec-96	143
Jan-97	141
Feb-97	133
Mar-97	133
Apr-97	129
May-97	128
Jun-97	130
Jul-97	138
Aug-97	146
Sep-97	152
Oct-97	150
Nov-97	144
Dec-97	143
Jan-98	140
Feb-98	137
Mar-98	132
Apr-98	128
May-98	126
Jun-98	128
Jul-98	132
Aug-98	134
Sep-98	143
Oct-98	144
Nov-98	135
Dec-98	135
Jan-99	135
Feb-99	130
Mar-99	126
Apr-99	124
May-99	123
Jun-99	126

Table A-4 Birch Spring discharge data

all birch discharge.xls 17 Aug 99

USGS

Date	GPM
25-May-78	23
10-Aug-78	19
11-Oct-78	19
7-Nov-78	19
13-Dec-78	19
14-Jun-79	10
28-Jun-79	10
20-Jul-79	9.3
22-Aug-79	21
17-Sep-79	19
16-Oct-79	20

NEWUA

Date	GPM
Jan-85	
Feb-85	
Mar-85	
Apr-85	
May-85	
Jun-85	
Jul-85	
Aug-85	
Sep-85	
Oct-85	
Nov-85	
Dec-85	
Jan-86	
Feb-86	
Mar-86	
Apr-86	
May-86	
Jun-86	
Jul-86	
Aug-86	70
Sep-86	
Oct-86	
Nov-86	
Dec-86	30
Jan-87	
Feb-87	
Mar-87	
Apr-87	
May-87	
Jun-87	60
Jul-87	
Aug-87	
Sep-87	
Oct-87	
Nov-87	
Dec-87	
Jan-88	
Feb-88	
Mar-88	
Apr-88	
May-88	
Jun-88	
Jul-88	
Aug-88	
Sep-88	
Oct-88	
Nov-88	
Dec-88	
Jan-89	
Feb-89	
Mar-89	
Apr-89	
May-89	
Jun-89	
Jul-89	

Star Point Mine MRP

Date	GPM
Jan-85	85
Feb-85	85
Mar-85	84
Apr-85	85
May-85	85
Jun-85	85
Jul-85	85
Aug-85	85
Sep-85	86
Oct-85	87
Nov-85	86
Dec-85	85
Jan-86	85
Feb-86	85
Mar-86	84
Apr-86	84
May-86	84
Jun-86	85
Jul-86	86
Aug-86	86
Sep-86	85
Oct-86	84
Nov-86	85
Dec-86	87
Jan-87	85
Feb-87	85
Mar-87	86
Apr-87	85
May-87	86
Jun-87	86
Jul-87	86
Aug-87	85
Sep-87	84
Oct-87	89
Nov-87	85
Dec-87	83
Jan-88	81
Feb-88	81
Mar-88	82
Apr-88	81
May-88	82
Jun-88	81
Jul-88	81
Aug-88	105
Sep-88	133
Oct-88	130
Nov-88	130
Dec-88	117
Jan-89	70
Feb-89	65
Mar-89	60
Apr-89	55
May-89	85
Jun-89	100
Jul-89	90

USGS Date	USGS GPM	NEWUA Date	NEWUA GPM	Star Point Mine MRP Date	Star Point Mine MRP GPM
		Aug-89		Aug-89	85
		Sep-89		Sep-89	80
		Oct-89		Oct-89	230
		Nov-89		Nov-89	230
		Dec-89		Dec-89	230
		Jan-90	100	Jan-90	230
		Feb-90		Feb-90	70
		Mar-90		Mar-90	65
		Apr-90		Apr-90	60
		May-90		May-90	70
		Jun-90		Jun-90	85
		Jul-90		Jul-90	75
		Aug-90		Aug-90	55
		Sep-90	40	Sep-90	40
		Oct-90		Oct-90	40
		Nov-90	37.5	Nov-90	38
		Dec-90		Dec-90	34
		Jan-91	34	Jan-91	34
		Feb-91	33	Feb-91	34
		Mar-91	33	Mar-91	21
		Apr-91	33	Apr-91	33
		May-91	34	May-91	33
		Jun-91	34	Jun-91	33
		Jul-91	36	Jul-91	33
		Aug-91	33	Aug-91	33
		Sep-91	33	Sep-91	33
		Oct-91	33	Oct-91	33
		Nov-91	33	Nov-91	33
		Dec-91	33	Dec-91	33
		Jan-92	29	Jan-92	29
		Feb-92	29	Feb-92	29
		Mar-92	29	Mar-92	29
		Apr-92	29	Apr-92	29
		May-92	28	May-92	28
		Jun-92	28	Jun-92	29
		Jul-92	29	Jul-92	28
		Aug-92	28	Aug-92	29
		Sep-92	28	Sep-92	27
		Oct-92	27	Oct-92	27
		Nov-92	27	Nov-92	27
		Dec-92	27	Dec-92	27
		Jan-93	27	Jan-93	27
		Feb-93	27	Feb-93	27
		Mar-93	27	Mar-93	27
		Apr-93	27	Apr-93	27
		May-93	27	May-93	
		Jun-93	26	Jun-93	29
		Jul-93	25	Jul-93	29
		Aug-93	24.5	Aug-93	25
		Sep-93	24.5	Sep-93	25
		Oct-93	24	Oct-93	25
		Nov-93	25	Nov-93	
		Dec-93	24	Dec-93	
		Jan-94	24	Jan-94	29
		Feb-94	24	Feb-94	
		Mar-94	24.5	Mar-94	23
		Apr-94	24	Apr-94	
		May-94	23	May-94	

USGS		NEWUA		Star Point Mine MRP	
Date	GPM	Date	GPM	Date	GPM
		Jun-94	23	Jun-94	
		Jul-94	22	Jul-94	
		Aug-94	22	Aug-94	
		Sep-94	22	Sep-94	
		Oct-94	22	Oct-94	
		Nov-94	22.5	Nov-94	
		Dec-94	22	Dec-94	
		Jan-95	22	Jan-95	
		Feb-95	22	Feb-95	22
		Mar-95	21.5	Mar-95	
		Apr-95	22	Apr-95	
		May-95	21.5	May-95	21.5
		Jun-95	21.5	Jun-95	
		Jul-95	20.5	Jul-95	
		Aug-95	20	Aug-95	20
		Sep-95	20	Sep-95	
		Oct-95	20	Oct-95	20
		Nov-95	20.5	Nov-95	
		Dec-95	21	Dec-95	
		Jan-96	20.5	Jan-96	
		Feb-96	20.5	Feb-96	20.5
		Mar-96	20.5	Mar-96	
		Apr-96	21.5	Apr-96	
		May-96	21.5	May-96	21.5
		Jun-96	21	Jun-96	
		Jul-96	20	Jul-96	
		Aug-96	21.5	Aug-96	21.5
		Sep-96	19.5	Sep-96	
		Oct-96	20	Oct-96	20
		Nov-96	19.5	Nov-96	
		Dec-96	19.5	Dec-96	
		Jan-97	19	Jan-97	
		Feb-97	19	Feb-97	19
		Mar-97	19.5	Mar-97	
		Apr-97	19	Apr-97	
		May-97	16	May-97	16
		May-97	14.5	May-97	
		Jun-97	16.5	Jun-97	
		Jul-97	17	Jul-97	
		Aug-97	17	Aug-97	
		Sep-97	19	Sep-97	
		Oct-97		Oct-97	
		Nov-97		Nov-97	
		Dec-97		Dec-97	
		Jan-98	18	Jan-98	
		Feb-98	18	Feb-98	
		Mar-98	18	Mar-98	
		Apr-98	18	Apr-98	
		May-98	18.5	May-98	
		Jun-98	19	Jun-98	
		Jul-98	19	Jul-98	
		Aug-98	15.5	Aug-98	

Table A-5 Mine inflow rates

inmine.xls 17 Aug 99

SBC-7

Date	GPM
03/22/88	18
04/30/88	18
08/29/88	16
09/17/88	14.2
10/31/88	18
11/29/88	16
12/02/88	17
02/27/89	17
05/25/89	18
08/28/89	18
11/29/89	18.7
02/14/90	1
05/30/90	0
08/28/90	0
11/27/90	0.2
02/28/91	0.2
05/28/91	0
07/29/91	0
08/08/91	0.7

SBC-8

Date	GPM
03/22/88	18
06/07/88	21
08/26/88	21
09/17/88	20.5
10/31/88	22
11/29/88	21
12/07/88	20.4
02/27/89	21
05/25/89	31
08/28/89	12
11/29/89	12
02/27/90	0.5
05/30/90	0.5
08/28/90	0.8

SBC-9

Date	GPM
02/27/90	120
05/30/90	120
08/28/90	120
11/27/90	97
02/28/91	81
05/28/91	118
07/29/91	140
08/08/91	112
10/17/91	120
02/18/92	132
05/14/92	130
08/10/92	105
10/05/92	82
02/18/93	140
05/19/93	177
08/11/93	165
10/20/93	152
02/09/94	175
05/30/94	178
08/18/94	175
10/19/94	160
02/07/95	158
05/08/95	159
08/24/95	150
10/17/95	135
02/27/96	130
05/21/96	130
08/28/96	130
10/30/96	133
02/01/97	125
05/01/97	125
08/01/97	120
10/01/97	122
02/01/98	118
05/01/98	115
08/01/98	86
10/01/98	80
02/01/99	65
05/01/99	60

SBC-10

Date	GPM
01/31/92	248
02/18/92	250
03/26/92	240
05/14/92	240
08/10/92	240
10/01/92	205
02/18/93	185
05/19/93	46
08/11/93	35
10/20/93	28
02/09/94	28
05/30/94	25
08/18/94	25
10/19/94	21
02/07/95	24
05/08/95	22

Table A-6 Monitoring well water elevations

monwell.xls 03/09/00

Well	Date	Elevation	Well	Date	Elevation	Well	Date	Elevation
DH-1A	01/27/93	7419	DH-2	04/30/93	7533	DH-4	08/31/94	7549
DH-1A	02/18/93	7423	DH-2	05/25/93	7534	DH-4	09/30/94	7549
DH-1A	03/23/93	7422	DH-2	06/15/93	7533	DH-4	10/27/94	7549
DH-1A	04/30/93	7421	DH-2	07/31/93	7533	DH-4	11/26/94	7548
DH-1A	05/26/93	7421	DH-2	08/31/93	7533	DH-4	12/22/94	7548
DH-1A	06/15/93	7421	DH-2	09/14/93	7531	DH-4	01/04/95	7548
DH-1A	07/31/93	7421	DH-2	10/29/93	7531	DH-4	02/07/95	7548
DH-1A	08/31/93	7421	DH-2	11/23/93	7533	DH-4	03/25/95	7548
DH-1A	09/14/93	7421	DH-2	12/15/93	7533	DH-4	04/29/95	7547
DH-1A	10/26/93	7421	DH-2	01/20/94	7533	DH-4	05/23/95	7547
DH-1A	11/23/93	7421	DH-2	02/10/94	7534	DH-4	06/29/95	7547
DH-1A	12/15/93	7422	DH-2	03/21/94	7533	DH-4	07/13/95	7547
DH-1A	01/20/94	7421	DH-2	04/29/94	7533	DH-4	08/31/95	7547
DH-1A	02/09/94	7422	DH-2	05/31/94	7533	DH-4	09/29/95	7547
DH-1A	03/21/94	7422	DH-2	06/27/94	7533	DH-4	10/18/95	7548
DH-1A	04/29/94	7421	DH-2	07/19/94	7533	DH-4	11/21/95	7548
DH-1A	05/31/94	7422	DH-2	08/29/94	7532	DH-4	12/26/95	7547
DH-1A	06/27/94	7422	DH-2	09/30/94	7532	DH-4	02/27/96	7548
DH-1A	07/19/94	7422	DH-2	10/26/94	7532	DH-4	05/22/96	7548
DH-1A	08/28/94	7419	DH-2	11/26/94	7532	DH-4	08/23/96	7549
DH-1A	09/30/94	7422	DH-2	12/22/94	7532	DH-4	10/31/96	7549
DH-1A	10/30/94	7421	DH-2	01/04/95	7532	DH-4	02/27/97	7549
DH-1A	11/26/94	7422	DH-2	02/07/95	7532	DH-4	05/29/97	7549
DH-1A	12/22/94	7422	DH-2	03/25/95	7535	DH-4	08/30/97	7549
DH-1A	01/04/95	7422	DH-2	04/29/95	7532	DH-4	10/30/97	7549
DH-1A	02/07/95	7422	DH-2	05/23/95	7532			
DH-1A	03/25/95	7424	DH-2	06/29/95	7539	SDH-1	08/29/94	7591
DH-1A	04/29/95	7423	DH-2	07/13/95	7542			
DH-1A	05/09/95	7423	DH-2	08/31/95	7534	SDH-2	08/22/95	7964
DH-1A	06/29/95	7425	DH-2	09/29/95	7532	SDH-2	8/97	7976
DH-1A	07/13/95	7425	DH-2	10/17/95	7533			
DH-1A	08/31/95	7424	DH-2	11/21/95	7532	SDH-3	08/26/95	7600
DH-1A	09/29/95	7424	DH-2	12/26/95	7530	SDH-3	8/97	7605
DH-1A	10/17/95	7423	DH-2	02/29/96	7530			
DH-1A	11/21/95	7423	DH-2	05/22/96	7529	MW-114	08/22/96	7650
DH-1A	12/26/95	7422	DH-2	08/20/96	7530	MW-114	09/24/96	7650
DH-1A	02/27/96	7423	DH-2	10/30/96	7530	MW-114	10/23/97	7651
DH-1A	05/22/96	7422	DH-2	02/27/97	7529			
DH-1A	08/28/96	7422	DH-2	05/29/97	7528	MW-116	10/18/95	7745
DH-1A	10/29/96	7423	DH-2	08/27/97	7526	MW-116	07/19/96	7744
DH-1A	02/27/97	7424	DH-2	10/29/97	7524	MW-116	09/24/96	7744
DH-1A	05/28/97	7423				MW-116	10/23/97	7744
DH-1A	08/31/97	7424	DH-4	02/15/94	7551			
DH-1A	10/30/97	7424	DH-4	03/21/94	7550	MW-117	10/18/95	7746
			DH-4	04/29/94	7550	MW-117	07/19/96	7746
DH-2	01/27/93	7535	DH-4	05/31/94	7549	MW-117	09/24/96	7747
DH-2	02/22/93	7535	DH-4	06/27/94	7549	MW-117	10/23/97	7746
DH-2	03/23/93	7535	DH-4	07/19/94	7550			

Appendix B

Laboratory reporting sheets for isotopic analyses

Cross-reference Information

iso xref.xls 03/08/00

Sample designation on laboratory reporting sheet	Designation used in this report
FBC-1	MH-1
FBC-4	SMH-4
FBC-5	SMH-2
FBC-6	SMH-1
FBC-13	SMH-3
WHR-3	SBC-19
WHR-4	SBC-16
WHR-5	SBC-15
WHR-5-UP	SBC-15-UP

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.

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RADIOCARBON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. GX-22599-PRIORITY

Date Received: 11/15/96

Your Reference: letter of 11/14/96

Date Reported: 11/22/96

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 3rd West South (Co-op Mine)
groundwater precipitate

AGE = 10,470 +/- 435 C-14 years BP (C-13 corrected).
(27.16 +/- 1.48) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB} = -10.6$ ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid. The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION | REPORT OF ANALYTICAL WORK

Our Sample No. GX-22598-PRIORITY

Date Received: 11/15/96

Your Reference: letter of 11/14/96

Date Reported: 11/22/96

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 3rd West Bleeders (Co-op Mine)
groundwater precipitate

AGE = 5,230 +/- 265 C-14 years BP (C-13 corrected).
(52.16 +/- 1.73) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB} = -10.9$ ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22600-PRIORITY

Date Received: 11/15/96

Your Reference: letter of 11/14/96

Date Reported: 11/22/96

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: SBC-9 Source (Co-op Mine)
groundwater precipitate

AGE = 5,890 +/- 210 C-14 years BP (C-13 corrected).
(48.04 +/- 1.26) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB} = -10.5$ ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22601-PRIORITY

Date Received: 11/19/96

Your Reference: letter of 11/18/96

Date Reported: 11/27/96

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: DH-2 (Co-op Mine) 15 November 1996
groundwater precipitate

AGE = 5,540 +/- 280 C-14 years BP (C-13 corrected).
(50.17 +/- 1.76) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = -10.8 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24398-AMS**	Date Received:	08/06/98
Your Reference:	C.W. Mining	Date Reported:	10/02/98

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **C.W. Mining: SDH-2 06/30/98**

AGE = **3,450 ± 40 ^{14}C years BP (^{13}C corrected).**
(65.05 ± 0.31) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The sample was rapidly transferred, by aspiration, to the evacuated flask, and acidified to recover carbon dioxide from the dissolved carbonates for the analysis. 13C analysis was performed on a small portion of the same evolved gas.

The sample yielded very little carbon and analysis by accelerator mass spectrometry was required.

Comments:

$\delta^{13}C_{PDB}$ = **-25.6 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24399-AMS**

Date Received: 08/06/98

Your Reference: C.W. Mining

Date Reported: 10/02/98

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **C.W. Mining: SDH-3 06/30/98**

$\bar{t}$ = **8,400 ± 50 ^{14}C years BP (^{13}C corrected).**
(35.14 ± 0.18) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The sample was rapidly transferred, by aspiration, to the evacuated flask, and acidified to recover carbon dioxide from the dissolved carbonates for the analysis. 13C analysis was performed on a small portion of the same evolved gas.

The sample yielded very little carbon and analysis by accelerator mass spectrometry was required.

Comments:

$\delta^{13}C_{PDB}$ = **-11.6 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24400**

Date Received: 08/06/98

Your Reference: C.W. Mining Company

Date Reported: 08/19/98

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **C.W. Mining: T.S. North Bleeder 05/26/98**

AGE = **6,540 ± 250 ^{14}C years BP (^{13}C corrected).**
(44.33 ± 1.39) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = - 9.8 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24401**	Date Received:	08/06/98
Your Reference:	C.W. Mining Company	Date Reported:	08/19/98
Submitted by:	Mr. Kelly Payne Mayo & Associates 710 East 100 North Lindon, Utah 84042		

Sample Name: **C.W. Mining: Morhland Portal 06/10/98**

AGE = **12,990 ± 400 ^{14}C years BP (^{13}C corrected).**
(19.85 ± 0.98) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 9.4 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24402**	Date Received:	08/06/98
Your Reference:	C.W. Mining Company	Date Reported:	08/19/98
Submitted by:	Mr. Kelly Payne Mayo & Associates 710 East 100 North Lindon, Utah 84042		

Sample Name: **C.W. Mining: SBC-4 05/26/98**

AGE = **4,655 ± 185 ^{14}C years BP (^{13}C corrected).**
(56.02 ± 1.29) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 9.6 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	GX-24403	Date Received:	08/06/98
Your Reference:	C.W. Mining Company	Date Reported:	08/19/98

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **C.W. Mining: BC-1 05/26/98**

AGE = **4,390 ± 145 ^{14}C years BP (^{13}C corrected).**
(57.90 ± 1.04) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 5.9 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION | REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24404**	Date Received:	08/06/98
Your Reference:	C.W. Mining Company	Date Reported:	08/19/98

Submitted by:
Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **C.W. Mining: SBC-5 05/26/98**

AGE = **6,770 ± 220 ^{14}C years BP (^{13}C corrected).**
(43.05 ± 1.17) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **-10.6 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-25313**

Date Received: 01/15/99

Your Reference: C.W. Mining

Date Reported: 03/24/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **SBC-9 Source 01/06/99**

AGE = **7,040 ± 320 ^{14}C years BP (^{13}C corrected).**
(41.62 ± 1.64) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 10.4 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-25314**	Date Received:	01/15/99
Your Reference:	C.W. Mining	Date Reported:	03/24/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **Defa Spring #1 01/06/99**

AGE = **5,110 ± 230 ^{14}C years BP (^{13}C corrected).**
(52.95 ± 1.50) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 7.9 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-25315**

Date Received: 01/15/99

Your Reference: C.W. Mining

Date Reported: 03/24/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **Defa Spring #2 01/06/99**

AGE = **6,930 ± 290 ^{14}C years BP (^{13}C corrected).**
(42.21 ± 1.52) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 10.2 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24900**	Date Received:	11/12/98
Your Reference:	C.W. Mining	Date Reported:	01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **FBC-6 6/10/98**

AGE = **2,030 ± 180 ^{14}C years BP (^{13}C corrected).**
(77.66 ± 1.74) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 11.1 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24901**

Date Received: 11/12/98

Your Reference: C.W. Mining

Date Reported: 01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **FBC-13 6/10/98**

AGE = **1,390 ± 135 ^{14}C years BP (^{13}C corrected).**
(84.12 ± 1.42) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 11.0 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	GX-24902	Date Received:	11/12/98
Your Reference:	C.W. Mining	Date Reported:	01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **16-8-6-1 6/29/98**

AGE = **210 ± 135 ^{14}C years BP (^{13}C corrected).**
(97.42 ± 1.67) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 11.5 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24903-LS**

Date Received: 11/12/98

Your Reference: C.W. Mining

Date Reported: 01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **16-8-6-1 10/12/98**

AGE = **1,770 ± 200 ^{14}C years BP (^{13}C corrected).**
(80.25 ± 1.95) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates. The carbon dioxide was converted to benzene and counted by liquid scintillation. ^{13}C analysis was made on a small portion of the same evolved carbon dioxide gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 10.2 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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ADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

ır Sample No.	**GX-24904**	Date Received:	11/12/98
›ur Reference:	C.W. Mining	Date Reported:	01/26/99
ıbmitted by:	Mr. Kelly Payne Mayo & Associates 710 East 100 North Lindon, Utah 84042		

ımple Name: **Morhland Portal 10/12/98**

ƎE = **13,610 ± 640 ^{14}C years BP (^{13}C corrected).**
(18.39 ± 1.46) % of the modern (1950) ^{14}C activity.

ɘscription: Sample of groundwater precipitate.

etreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

›mments:

$^{3}C_{PDB}$ = **- 9.2 ‰**

›tes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24905**	Date Received:	11/12/98
Your Reference:	C.W. Mining	Date Reported:	01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **SBC-4 10/29/98**

AGE = **4,890 ± 400 ^{14}C years BP (^{13}C corrected).**
(54.39 ± 2.72) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 10.5 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

GEOCHRON LABORATORIES

a division of Krueger Enterprises, Inc.

711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138-1002 ✦ U.S.A
TELEPHONE: (617)876-3691 TELEFAX: (617)661-0148 E-MAIL: staff@geochronlabs.com

RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No.	**GX-24906**	Date Received:	11/12/98
Your Reference:	C.W. Mining	Date Reported:	01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **SBC-5 Overflow 10/29/98**

AGE = **6,330 ± 240 ^{14}C years BP (^{13}C corrected).**
(45.47 ± 1.37) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 10.4 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

GEOCHRON LABORATORIES

a division of Krueger Enterprises, Inc.

711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138-1002 ✦ U.S.A
TELEPHONE: (617)876-3691 TELEFAX: (617)661-0148 E-MAIL: staff@geochronlabs.com

RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24907**

Date Received: 11/12/98

Your Reference: C.W. Mining

Date Reported: 01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **Birch #1 Source 10/29/98**

AGE = **7,290 ± 350 ^{14}C years BP (^{13}C corrected).**
(40.33 ± 1.75) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 12.4 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is ± 1σ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138-1002 ✦ U.S.A
TELEPHONE: (617)876-3691 TELEFAX: (617)661-0148 E-MAIL: staff@geochronlabs.com

RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24908** — Date Received: 11/12/98

Your Reference: C.W. Mining — Date Reported: 01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **Birch #2 Source 10/29/98**

AGE = **8,160 ± 380 ^{14}C years BP (^{13}C corrected).**
(36.21 ± 1.73) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 9.8 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

GEOCHRON LABORATORIES

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TELEPHONE: (617)876-3691 TELEFAX: (617)661-0148 E-MAIL: staff@geochronlabs.com

RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. **GX-24918**

Date Received: 11/18/98

Your Reference: C.W. Mining

Date Reported: 01/26/99

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: **SBC-3 11/9/98**

AGE = **2,980 ± 350 ^{14}C years BP (^{13}C corrected).**
(69.00 ± 3.01) % of the modern (1950) ^{14}C activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. ^{13}C analysis was made on a small portion of the same evolved gas.

Comments:

$\delta^{13}C_{PDB}$ = **- 11.4 ‰**

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

GEOCHRON LABORATORIES a division of
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TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 11/12/98
Date Reported: 03/29/99
Your Reference: Phone Call

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-99179	SBC-5 Overflow 10/29/98	$BaSO_4$	-8.4 -7.9 **

** Duplicate analyses on separate aliquots of the original sample.

This is a re-analysis of a sample originally reported on 02/02/99.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1\right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.
711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 08/06/98
Date Reported: 10/19/98
Your Reference: C.W. Mining
Charles Reynolds

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-98005	T.S. North Bleeder 5/26/98	$BaSO_4$	+ 3.1
SR-98006	Morhland Portal 6/10/98	$BaSO_4$	+11.2 +10.8 **
SR-98007	SBC-4 5/26/98	$BaSO_4$	+ 6.0 + 5.9 **
SR-98008	BC-1 5/26/98	$BaSO_4$	+ 7.5
SR-98009	SBC-5 5/26/98	$BaSO_4$	+ 3.0
SR-98010	SDH-2 6/30/98	$BaSO_4$	+ 9.1
SR-98011	SDH-3 6/30/98	$BaSO_4$	+16.8

** Duplicate analyses on separate aliquots of the original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1\right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.
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TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 01/15/99
Date Reported: 03/11/99
Your Reference: C.W. Mining

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-99640	SBC-9 Source 1/6/99	$BaSO_4$	+10.9 +11.1 **
SR-99641	Defa Spring #1 1/6/99	$BaSO_4$	+ 0.7
SR-99642	Defa Spring #2 1/6/99	$BaSO_4$	+ 3.5

** Duplicate analyses on separate aliquots of original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.
711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 11/16/98
Date Reported: 02/-2/99
Your Reference: C.W. Mining
Charles Reynolds

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-99173	FBC-6 6/10/98	$BaSO_4$	+1.9
SR-99174	FBC-13 6/10/98	$BaSO_4$	+5.0
SR-99175	16-8-6-1 6/10/98	$BaSO_4$	+2.0
SR-99176	16-8-6-1 10/12/98	$BaSO_4$	+1.8
SR-99177	Morhland Portal 10/12/98	$BaSO_4$	+11.1 +10.9 **
SR-99178	SBC-4 10/29/98	$BaSO_4$	+5.1
SR-99179	SBC-5 Overflow 10/29/98	$BaSO_4$	-7.8
SR-99180	Birch #1 Source 10/29/98	$BaSO_4$	+5.1
SR-99181	Birch #2 Source 10/29/98	$BaSO_4$	+5.0
SR-99182	SBC-3 11/09/98	$BaSO_4$	+6.5

** Duplicate analyses on separate aliquots of the original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

UNIVERSITY OF MIAMI

May 28, 1992

TRITIUM LABORATORY

Data Release #92-32 - Amendment
Job # 391

CO-OP MINING COMPANY
TRITIUM SAMPLES

Zafer Top
Research Professor

Distribution:
Co-Op Mining Company
Box 1245
Huntington, Utah 84528

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: CO-OP MINING COMPANY
Recvd : 92/04/10
Job# : 391
Final : 92/05/26 LAB REMEASUREMENT

Purchase Order: CHECK
Contact: Charles Reynolds, 801/381-2450
Box 1245 (fax) /381-5238
Huntington, Utah 84528

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
CO-OP--SBC-9	391.02	920408	1000	275	0.87*	0.10

* Average of duplicate runs

UNIVERSITY OF Miami

May 29, 1992

TRITIUM LABORATORY

Data Release #92-38
Job # 398

CO-OP MINING COMPANY
TRITIUM SAMPLES

Dr. Zafer Top
Research Professor

Distribution:
Co-Op Mining Company
Box 1245
Huntington, Utah 84528

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: CO-OP MINING COMPANY
Recvd : 92/04/30
Job# : 398
Final : 92/05/26

Purchase Order: CHECK

Contact: Charles Reynolds, 801/381-2450
Box 1245 (fax) /381-5238
Huntington, Utah 84528

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
CO-OP--SBC-5	398.01	920427	1000	275	1.12*	0.10

* Average of duplicate runs

UNIVERSITY OF
Miami

April 30, 1992

TRITIUM LABORATORY

Data Release #92-32
Job # 391

CO-OP MINING COMPANY
TRITIUM SAMPLES

H. Gote Ostlund
Head, Tritium Laboratory

Distribution:

Co-Op Mining Company
Box 1245
Huntington, Utah 84528

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: CO-OP MINING COMPANY
Recvd : 92/04/10
Job# : 391
Final : 92/04/29

Purchase Order: CHECK
Contact: Charles Reynolds, 801/381-2450
Box 1245 (fax) /381-5238
Huntington, Utah 84528

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
CO-OP--SBC-4	391.01	920408	1000	263	17.2	0.6
CO-OP--SBC-9	391.02	920408	1000	275	0.90r	0.09
CO-OP--SBC-10	391.03	920408	1000	267	1.46	0.09

r: RERUN in progress. Please call for result.

detection limit

Surface water in terms

Mixing can take place

Client: CO-OP MINING COMPANY
Recvd : 96/05/24
Job# : 847
Final : 96/06/11

Purchase Order: 12264
Contact: Co-Op Mining Co. 801/687-2450
P.O. Box 1245 Fax -5238
Huntington, UT 84528

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
CO-OP	BIRCH SPRING	847.01	960520	1000	275 r	0.35	0.10
CO-OP	BIG BEAR SPRING	847.02	960520	950	229	14.2	0.5
CO-OP	SBC-9 SOURCE	847.03	950515	1000	247 r	0.36	0.09

r: RERUN in progress

UNIVERSITY OF MIAMI

(0-00

January 3, 1997

TRITIUM LABORATORY

Data Release #97-10
Job # 905

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
Head, Tritium Laboratory

Distribution:
Erick C. Petersen
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: MAYO and ASSOCIATES - CO-OP
Recvd : 96/11/18
Job# : 905
Final : 97/01/02

Purchase Order: 96-0106
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	SBC-9 Source (CO-OP)	905.01	961113	1000	250 *	0.50	0.09

* Average of duplicate runs

UNIVERSITY OF
Miami

January 3, 1997

TRITIUM LABORATORY

Data Release #97-11
Job # 906

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
Head, Tritium Laboratory

Distribution:
Erick C. Petersen
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: MAYO and ASSOCIATES - CO-OP
Recvd : 96/11/19
Job# : 906
Final : 97/01/02

Purchase Order: 96-0107
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	DH-2 (CO-OP)	906.01	961115	1000	275	-0.03	0.09

UNIVERSITY OF MIAMI

February 20, 1997

TRITIUM LABORATORY

Data Release #97-23
Job # 919

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
Head, Tritium Laboratory

Distribution:
Erick C. Petersen
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100

Client: MAYO and ASSOCIATES - ENERGY WEST
Recvd : 97/01/02
Job# : 919
Final : 97/02/18

Purchase Order: 96-0111
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	CO-OP MINE 3RD W.FAULT	919.01	961209	1000	273	-0.02	0.09

Same as
3rd west South
KLP/ECP.

UNIVERSITY OF MIAMI
THE ROSENSTIEL SCHOOL

October 8, 1998

TRITIUM LABORATORY

Data Release #98-88
Job # 1105

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
Professor Emeritus

Distribution:
Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
Phone: (305) 361-4100
Fax: (305) 361-4112

Client: MAYO and ASSOCIATES - C.W. MINING
Recvd : 98/08/06
Job# : 1105
Final : 98/10/07

Purchase Order: 98-0013
Contact: K. Payne 801/796-0211
710 E. 100 North, (F) 785-2387
Lindon, UT 84042

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-T.S.NORTH BLEEDER	1105.01	980526	1000	271	0.07	0.09
MAYO-MORHLAND PORTAL	1105.02	980610	1000	254	5.52	0.18
MAYO-SDH-2	1105.03	980630	1000	250	0.13*	0.09
MAYO-SDH-3	1105.04	980630	1000	222	0.32*	0.09
MAYO-SBC-4	1105.05	980526	1000	DIR	13 r	3
MAYO-BC-1	1105.06	980526	1000	DIR	15 r	3
MAYO-SBC-5 PRE-TEST	1105.07	980526	1000	250	0	5
MAYO-SBC-5	1105.07	980526	1000	250	0.49*	0.10
MAYO-FBC-6	1105.08	980610	1000	DIR	22	3
MAYO-16-7-12-6	1105.09	980610	1000	DIR	20	3
MAYO-16-8-8-5	1105.10	980629	1000	DIR	14 r	3
MAYO-16-8-6-1	1105.11	980629	1000	DIR	11 r	3
MAYO-SBC-12	1105.12	980629	1000	DIR	29	3
MAYO-CANYON RD. SPRING	1105.13	980629	1000	DIR	20	3
MAYO-16-8-5-1	1105.14	980630	1000	DIR	13 *	1

* Average of duplicate runs

r LABORATORY RERUN in progress. Will report by phone if different from ORIGINAL value.

UNIVERSITY OF MIAMI
THE ROSENSTIEL SCHOOL

November 18, 1998

TRITIUM LABORATORY

Data Release #98-88 - Amendment
Job # 1105

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. James D. Happell
Associate Research Professor

Distribution:
Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
Phone: (305) 361-4100
Fax: (305) 361-4112

Client: MAYO and ASSOCIATES - C.W. Mining
Recvd : 98/08/06
Job# : 1105
Final : 98/11/17 LABORATORY RERUNS

Purchase Order: 98-0013
Contact: K. Payne 801/796-0211
710 E. 100 North, (F) 785-2387
Lindon, UT 84042

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU		eTU
MAYO-SBC-4 DIRECT	1105.05	980526	1000	DIR	14	*	3
MAYO-BC-1 DIRECT	1105.06	980526	1000	DIR	13	*	3
MAYO-16-8-8-5 DIRECT	1105.10	980629	1000	DIR	12	*	3
MAYO-16-8-6-1 DIRECT	1105.11	980629	1000	DIR	12	*	3

* All reruns agree with original runs; above values are average of duplicate runs

UNIVERSITY OF
Miami
THE ROSENSTIEL SCHOOL

January 5, 1999

TRITIUM LABORATORY

Data Release #99-05
Job # 1145

MAYO & ASSOCIATES
TRITIUM SAMPLES

James D. Happell

Dr. James D. Happell
Assistant Research Professor

Distribution:
Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
Phone: (305) 361-4100
Fax: (305) 361-4112
email: tritium@rsmas.miami.edu

Client: MAYO and ASSOCIATES - C.W.MINING
Recvd : 98/11/12
Job# : 1145
Final : 98/12/31

Purchase Order: 98-0016
Contact: K. Payne 801/796-0211
710 E. 100 North, (F) 785-2387
Lindon, UT 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-C.W.M.	MORHLAND PORTAL	1145.01	981012	1000	245	5.41	0.18
MAYO-C.W.M.	SBC-5 OVERFLOW	1145.02	981029	1000	275	0.47*	0.09
MAYO-C.W.M.	BIRCH 1 SOURCE	1145.03	981029	1000	266	0.33*	0.09
MAYO-C.W.M.	BIRCH 2 SOURCE	1145.04	981029	1000	275	0.37*	0.09
MAYO-C.W.M.	SBC-3	1145.05	981109	1000	275	7.79	0.26
MAYO-C.W.M.	16-8-6-1 DIR	1145.06	981012	1000	DIR	12	3
MAYO-C.W.M.	~~17~~ 16-7-12-6 DIR	1145.07	981012	1000	DIR	20	3
MAYO-C.W.M.	KP FBC-4 DIR	1145.08	981012	1000	DIR	22	3
MAYO-C.W.M.	FBC-5 DIR	1145.09	981012	1000	DIR	21	3
MAYO-C.W.M.	FBC-6 DIR	1145.10	981012	1000	DIR	25	3
MAYO-C.W.M.	FBC-12 DIR	1145.11	981012	1000	DIR	32	3
MAYO-C.W.M.	FBC-13 DIR	1145.12	981012	1000	DIR	22	3
MAYO-C.W.M.	CANYON RD. DIR	1145.13	981012	1000	DIR	19	3
MAYO-C.W.M.	CK-2 DIR	1145.14	981012	1000	DIR	17	3
MAYO-C.W.M.	BC-1 DIR	1145.15	981029	1000	DIR	23	3
MAYO-C.W.M.	SBC-4 DIR	1145.16	981029	1000	DIR	17	3

* Average of duplicate runs

UNIVERSITY OF MIAMI
THE ROSENSTIEL SCHOOL

February 19, 1999

TRITIUM LABORATORY

Data Release #99-30
Job # 1169

MAYO & ASSOCIATES
TRITIUM SAMPLES

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Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	SBC-9 Source	1169.01	990106	1000	228	3.62	0.12
MAYO-	Defa Spring 1	1169.02	990106	1000	275	7.70	0.25
MAYO-	Defa Spring 2	1169.03	990106	1000	275	7.69	0.25

Appendix C

Application of Selected Isotopes to Hydrogeologic Problems

Mayo and Associates, LC
Consultants in Hydrogeology

Application of Selected Isotopes to Hydrogeologic Problems

Oxygen-18 ($\delta^{18}O$) and Hydrogen-2 ($\delta^{2}H$)

Worldwide, the $\delta^{2}H$ and $\delta^{18}O$ of precipitation (rain and snow) generally follow the empirical relationship:

$$\delta^{2}H = 8(\delta^{18}O) + d \text{ (‰)}$$

Where *s* is the slope and *d* is the deuterium (hydrogen-2) excess (Merlivant and Jouzel, 1983). Craig (1961) and Dansgaard (1964) have shown that, on the global scale, *s* approximates 8 and *d* approximates 10 for coastal meteoric water. The Meteoric Water Line (MWL) is therefore defined as:

$$\delta^{2}H = 8(\delta^{18}O) + 10 \text{ (‰)}$$

The $\delta^{18}O$ and $\delta^{2}H$ composition of groundwaters can be used to help evaluate the origin, flow and mixing patterns of groundwaters. Groundwater recharged during cooler climates or at higher elevations will have more negative isotopic compositions than groundwater that recharged during warmer climates or at lower elevations. Groundwaters which have been heated above about 100°C during deep circulation will exhibit a positive $\delta^{18}O$ shift relative to the $\delta^{2}H$ composition. Groundwater of non-meteoric origin (i.e. connate and magmatic) will not plot along the MWL.

Carbon-13 ($\delta^{13}C$)

Most groundwater acquires 50 percent of its carbon from soil zone water and 50 percent of its carbon from the dissolution of carbonate minerals in the soil zone or aquifer skeleton. Because the $\delta^{13}C$ of marine carbonate minerals is about 0‰ (Muller and Mayo, 1986) and soil zone CO_2 gas has a $\delta^{13}C$ of -18 to -27‰, most groundwaters have a $\delta^{13}C$ of approximately -9 to -13‰.

Sulfur-34 ($\delta^{34}S$)

The anticipated range of $\delta^{34}S$ values in Mesozoic early Tertiary gypsum and anhydrite is +10 to +20‰ (Holser and Kaplan, 1966). At non-thermal aquifer temperatures, isotopic fractionation accompanying gypsum dissolution may be represented as:

$$\underset{(\delta^{34}S = +15 \text{ ‰})}{CaSO_{4(s)}} \quad \xrightarrow{^{34}S \text{ enrichment}} \quad \underset{(\delta^{34}S = +9 \text{ ‰})}{Ca^{2+} + SO_4^{2-}}$$

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where the value $\delta^{34}S \approx +15‰$ has been arbitrarily selected.

The typical $\delta^{34}S$ value of magmatic pyrite is about 0 ‰ (Faure, 1986). A $\delta^{34}S$ of -2.2‰ has been reported for pyrite in the Park City, Utah District (Thode and others, 1961). Mayo and Klauk (1991) found a mean $\delta^{34}S$ of +1.3 ‰ in groundwater from non-carbonate (crystalline rock) aquifers in north central Utah. Mayo, Petersen, and Kravits (unpublished data) found a $\delta^{34}S$ value of pyrite in the SUFCO coal mine, Utah of +3.4‰. Sulfur isotopic fractionation does not accompany the dissolution of pyrite.

Tritium (^3H)

Tritium (^3H), the radioactive isotope of hydrogen, has been used in groundwater investigations to differentiate between groundwaters which recharged prior to or after the advent of atmospheric thermonuclear weapons testing. Tritium, whose half-life is 12.43 years, forms naturally in the upper stratosphere by the interaction of ^{14}N with cosmic ray neutrons according to the reaction:

$$^{14}N + n \Rightarrow {}^{3}H + {}^{12}C$$

Tritium is rapidly incorporated into water molecules and is removed from the atmosphere by precipitation.

Prior to the advent of atmospheric thermonuclear weapons testing in 1952, tritium activity in precipitation ranged from 4 to 25 tritium units (TU). One TU equals one ^3H atom per 10^8 hydrogen atoms. In mountainous areas, larger natural concentrations have been observed (Fontes, 1983). During the peak of atmospheric weapons testing, tritium levels in precipitation rose to more than 2,200 TU in some northern hemisphere locations (Fontes, 1983). As of 1987, the ^3H concentrations in rain water varied from 25 to 50 TU. Unpublished data of 1991, 1992, and 1997 snow and rain samples collected in the central Wasatch Range, Utah have ^3H concentrations ranging from about 5 to 20 TU or more.

Carbon-14 (^{14}C)

Carbon-14, the radioactive isotope of carbon, has a half-life of 5730 ± 30 years (Godwin, 1962). Carbon-14 is produced in the upper atmosphere by a variety of reactions that involve the collision of cosmic radiation (neutrons) with stable isotopes of nitrogen, oxygen, and carbon. The most important of these reactions is between neutrons and ^{14}N according to the reaction:

$$n + {}^{14}N \Rightarrow {}^{14}C + p$$

where n is a neutron and p is a proton (Libby, 1955). Carbon-14 is incorporated into $CO_{2(g)}$ and rapidly mixes throughout the atmosphere and hydrosphere where steady state equilibrium between ^{14}C production and ^{14}C decay is attained (Faure, 1986).

The pre-industrial revolution atmospheric ^{14}C content has been assigned the steady state value of 100 percent modern carbon (pmc). The burning of fossil fuels and the advent of atmospheric thermonuclear weapons testing greatly altered the ^{14}C activity in post-industrial revolution atmosphere. Burning of fossil fuels, whose ^{14}C had previously completely decayed away, decreased the ^{14}C content in the troposphere in the northern hemisphere by about 3% (Houtermans and others, 1967). Atmospheric weapons testing greatly increased the atmospheric ^{14}C activity by the mid-1960's (Ferronsky and Polyakov, 1982).

The post-industrial revolution atmospheric ^{14}C perturbations and laboratory measurement error in measuring the ^{14}C content of groundwater make the reliable lower limit for ^{14}C dating about 450 years. The upper limit of ^{14}C dating, using conventional laboratory analytical methods, is about 35,000 years.

Estimating the age of dead wood or other organic carbon is relatively simple. The ^{14}C activity of pre-industrial revolution organic material is assumed to be 100 pmc. The radiocarbon date is then corrected for systematic variations in atmospheric ^{14}C that have been established by comparing tree ring dates of the wood of Sequoia and Bristlecone Pines with their corresponding radiocarbon ages (LaMarche and Harlan, 1973; Michael and Ralf, 1970).

Estimating the radiocarbon age of groundwaters is not as straightforward as estimating the age of dead organic matter. Groundwater acquires carbon from numerous sources, many of which had initial ^{14}C activities of less than 100 pmc. The ^{14}C content of groundwater is affected by four factors:

1) the addition of "live" carbon (i.e., $^{14}C \approx 100$ pmc) from the biogenic production of $CO_{2(g)}$ in the soil zone,
2) the addition of "dead" carbon from the weathering of minerals in the soil zone and the dissolution of carbonate minerals in the soil zone or aquifer (i.e., $^{14}C \approx 0$ pmc),
3) the addition of "dead" carbon from the soil or aquifer during isotopic exchange reactions, and
4) the addition of both "live" and "dead" carbon by other processes.

The crux of dating groundwater is estimating the initial ^{14}C activity (A_o) of the water at the time of recharge. This may be accomplished by using the solute and isotopic chemistries of the groundwater and applying correction procedures. Correction procedures for estimating A_o are in the form of mathematical equations that attempt to account for the contribution of "dead" carbon and ^{14}C from various sources, and for the effects of the isotopic exchange and fractionation processes.

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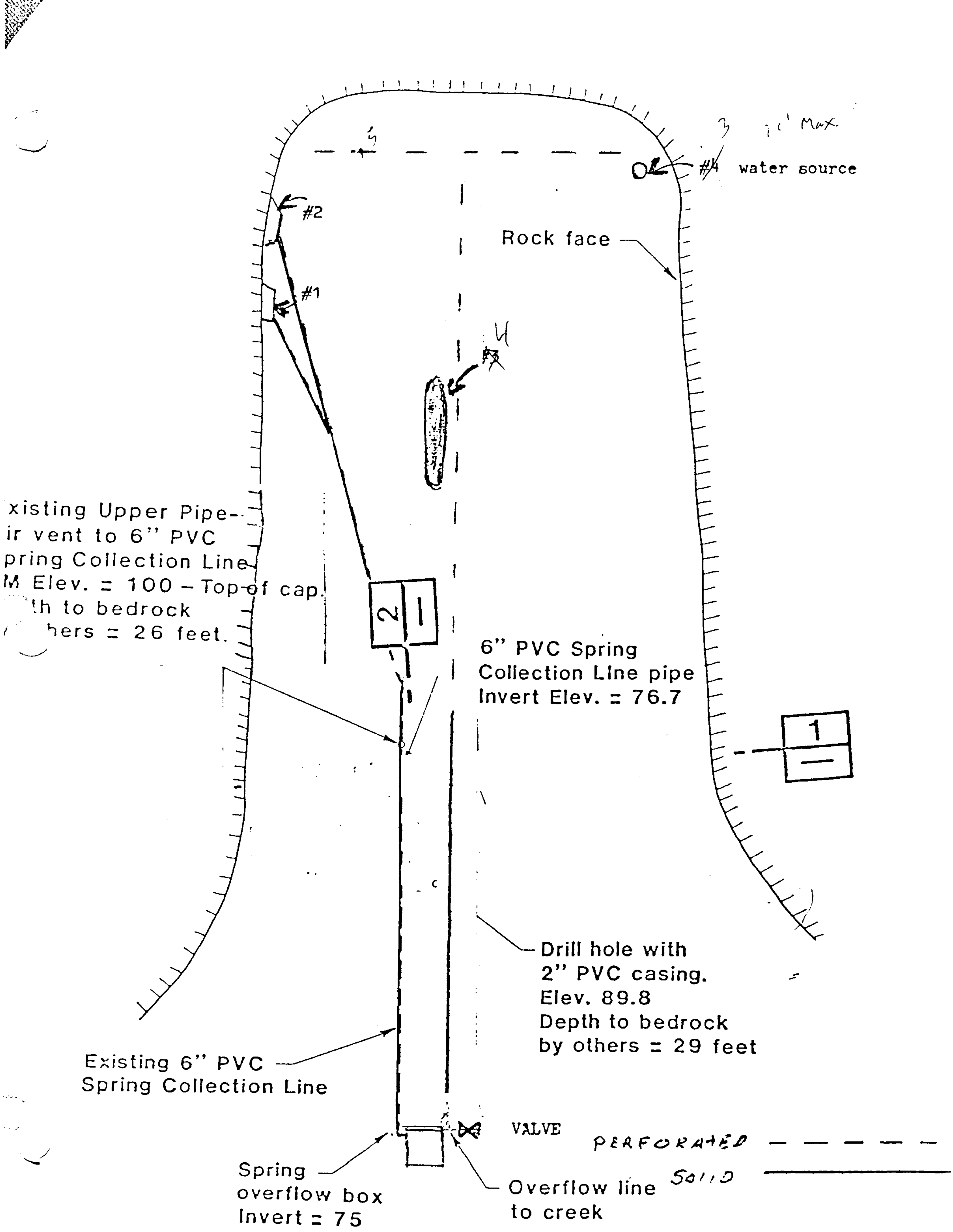
Appendix D

Diagram of Birch Spring sources



#4 water source
#2
Rock face
#1
xisting Upper Pipe-
ir vent to 6" PVC
pring Collection Line
M Elev. = 100 - Top of cap.
th to bedrock
hers = 26 feet.
2
1
6" PVC Spring
Collection LIne pipe
Invert Elev. = 76.7
1
Drill hole with
2" PVC casing.
Elev. 89.8
Depth to bedrock
by others = 29 feet
Existing 6" PVC
Spring Collection Line
VALVE
PERFORATED
SOLID
Spring
overflow box
Invert = 75
Overflow line
to creek