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March 3, 1986 C-30

Mr. Dave Hooper
Utah Division of Oil, Gas & Mining
355 Wset North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203

Dear Dave:

Enclosed for your review are three copies of our initial draft report entitled "Results of Overburden and Hydrologic Investigations of the Boyer Mine, Summit County, Utah." As requested in our contract, this initial draft contains information concerning the investigations conducted to date. Sections concerning the overburden investigations are largely complete. However, since data are still being gathered, only the methodologies of the hydrologic investigations are presented herein.

At your request, we have delayed submittal of this initial draft until now. Please contact us if you have any questions or concerns.

Sincerely,

Randy

Randolph B. Gainer
Project Manager

Enclosure

RESULTS OF OVERBURDEN AND HYDROLOGIC INVESTIGATIONS OF THE BOYER MINE, SUMMIT COUNTY, UTAH

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RESULTS OF OVERBURDEN AND HYDROLOGIC INVESTIGATIONS OF THE BOYER MINE, SUMMIT COUNTY, UTAH

Initial Draft Report
Submitted to

Utah Division of Oil, Gas & Mining
Salt Lake City, Utah

Prepared by

EarthFax Engineering, Inc.
Salt Lake City, Utah

March 3, 1985

***** **INITIAL DRAFT** - Subject to Revision *****

RESULTS OF OVERBURDEN AND HYDROLOGIC INVESTIGATIONS OF THE BOYER MINE, SUMMIT COUNTY, UTAH

1.0 INTRODUCTION

This report presents the results of overburden and hydrologic investigations conducted at the proposed Boyer Mine permit area located in Summit County, Utah near the small community of Upton (Figure 1-1). These investigations were performed under the Small Operator Assistance Program of the Utah Division of Oil, Gas & Mining (DOGM) for Summit Coal Company.

The material presented herein is divided into seven sections, including this introduction. Section 2.0 provides a literatur review of general site conditions. Section 3.0 presents the methods and results of overburden investigations conducted at the site, followed by a similar treatment of hydrologic investigations contained in Section 4.0. Probable hydrologic consequences of mining at the Boyer Mine are discussed in Section 5.0 of this report. Conclusions are presented in Section 6.0, followed by a list of references in Section 7.0. Attachments to this report follow the references.

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In preparation

Figure 1-1. General vicinity of the Boyer Mine.

2.0 GENERAL SITE CONDITIONS

2.1 Climate

The climate of the mine area is semiarid and continental. As is typical of this type of climate, most of the precipitation in the region of the mine occurs due to frontal activitiy in the winter months. According to Jeppson et al. (1968), the normal annual precipitation at the site is approximately 19 inches, two-thirds of which occurs during the period of October through April. Although the area is subject to summer thunderstorms, these storms tend to be of secondary importance to the annual precipitation total. Although total precipitation yielded by summer thunderstorms is generally low compared with winter storms, intensities tend to be higher in the summer than the winter (Frederick et al., 1981).

Variations in normal monthly ~~temperature~~ precipitation at Coalville (located approximately 12 miles west of the site) are shown in Figure 2-1. Although the average annual precipitation at Coalville is about 4 inches less than at the site (Jeppson et al., 1968), monthly trends are expected to be similar.

Depth-duration-frequency data for precipitation at the site were determined using methodologies and maps presented by Miller et al. (1973). These data are provided in Table 2-1.

Jeppson et al. (1968) indicated that mean minimum temperatures at the site vary from 6 ^{o}F in January to 46 ^{o}F in July. Mean maximum temperatures vary from 32 ^{o}F in January to 79 ^{o}F in July. Due to the predominantly cool climate of the area, the average length of the freeze-free period at the site is only about 80 days each year (Jeppson et al., 1968).

2.2 Vegetation

Three main vegetative types are present at the site. The sagebrush vegetative community is present in lower elevations at the site (below about 6400 feet). This vegetative community is dominated by big sagebrush, Utah juniper, various species of wheatgrass, Indian ricegrass, and other range grasses.

The Pinyon-Juniper Woodland occupies intermerdiate elevations at the site (between about 6400 feet and 6800 feet). Many of the species that make up the Sagebrush community appear as

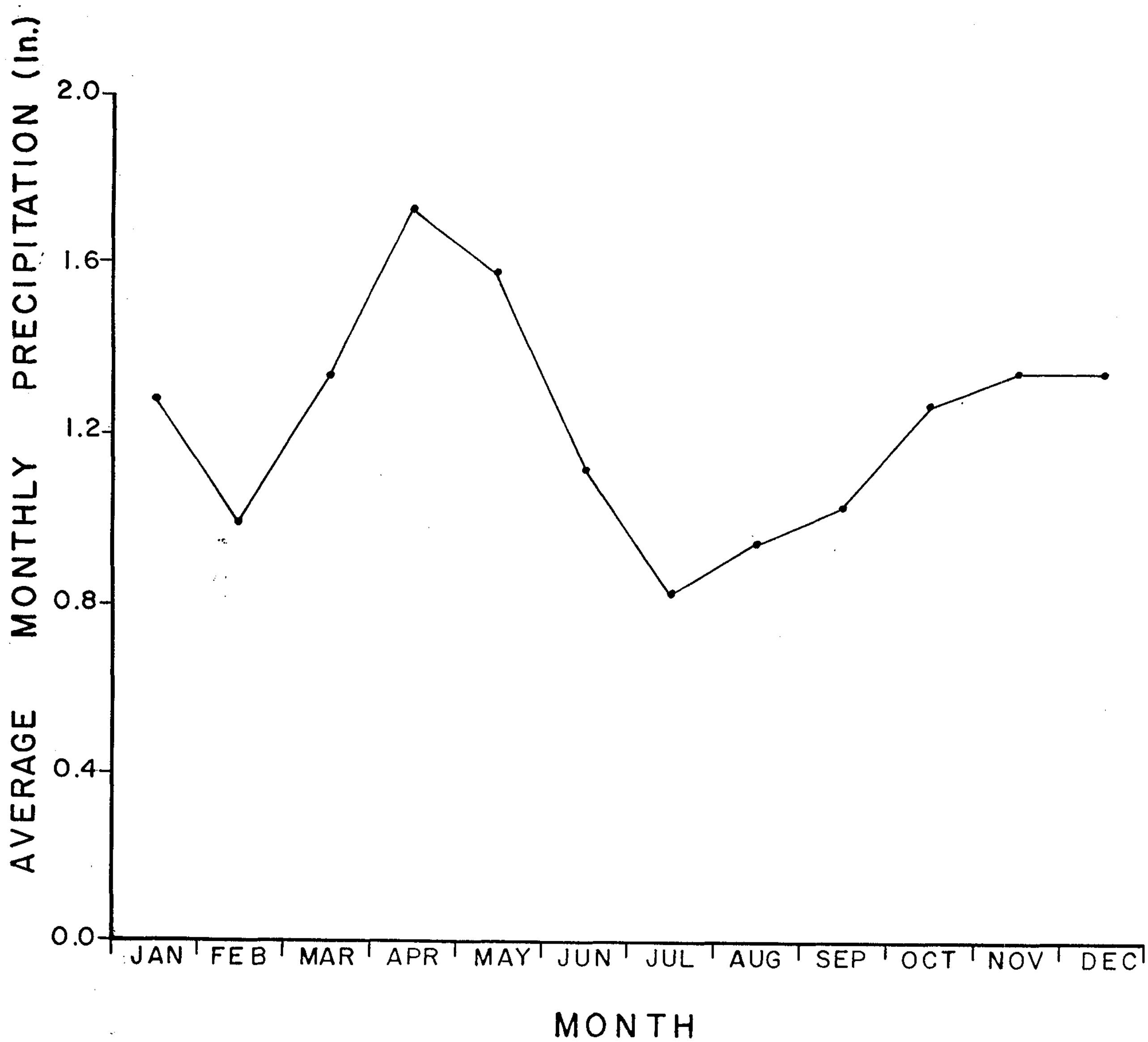

Figure 2-1. Normal monthly precipitation at Coalville, Utah.

understory in the Pinyon-Juniper community. Additionally, some mountain mahogany and oak brush are present in this community.

The Mountain Shrub community occupies elevations higher than about 6800 feet along the ridge north of the permit area. This community is typified by mountain mahogany, oak brush, and many of the grasses that are typical of the Sagebrush community.

2.3 Soils

Four main soil series and one phase of a series exist at the site according to the preliminary soil survey of the area recently conducted by the U.S. Department of Agriculture, Soil Conservation Service. As shown on Figure 2-2, these soils are the Kovich Loam (EKA), Pringle-Sowan Complex (UfA), Richsum-Bequinn Family Gridge Complex (UHG), and the Watkins Ridge Loam (WdB and WdC).

The Kovich loam is developed on 0 to 2 percent slopes on flood plains and valley floors. Slopes are mainly concave. The native vegetation is mainly sedges and grasses. Elevation is 6,300 to 6,700 feet. The average annual precipitation is about 18 to 25 inches and the mean annual air temperature is 42 to 45 degrees F.

The Kovich loam soils are very deep and poorly drained. Permeability of the soil is moderately slow. Available water capacity is about 7 to 9 inches. Runoff is slow and the hazard of water erosion is slight. This unit is used for irrigated grass hay pastures and home sites.

The Pringle-Sowan family complex is on 0 to 3 percent slopes and has developed on flood plains and low stream terraces. Slopes are linear and concave. The present vegetation is wet meadow grasses, sedge and wiregrass. Elevation is 5,400 to 7,000 feet. The average annual precipitation is about 16 to 20 inches and the mean annual air temperature is 42 to 45 degrees F.

The Pringle soil is very deep and somewhat poorly drained. It is formed in alluvium derived dominantly from sandstone, quartzite, and limestone. Permeability is moderately rapid. Available water capacity is about 3 to 6 inches. Runoff is slow and the hazard of water erosion is slight. A seasonal high water table is at a depth of 20 to 40 inches in April and May.

The Sowan soil is wet, very deep and somewhat poorly drained. Permeability is moderate. Available water capacity is about 5 to 7 inches. Runoff is slow and the hazard of water erosion is slight.

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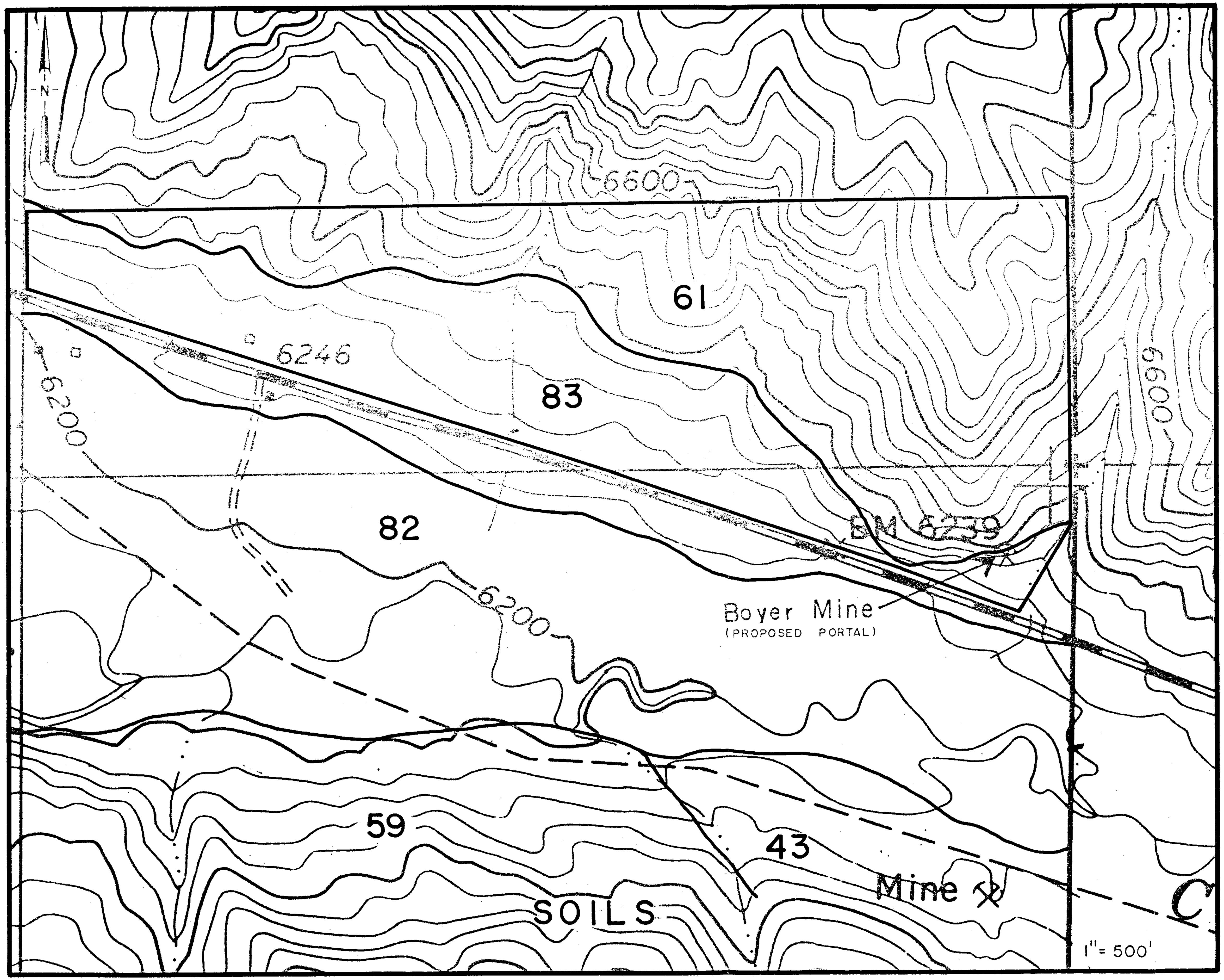


LEGEND

- # 43 - KOVICH LOAM, 0 to 2 PERCENT SLOPES.
- # 59 - PRINGLE - SOWCAN WET- IRIM FAMILY COMPLEX, 0 to 3 PERCENT SLOPES.
- # 61 - RICHSUM - BEQUINN FAMILY-GRIDGE COMPLEX, 25 to 70 PERCENT SLOPES.
- # 82 - WATKINS RIDGE LOAM, 2 to 5 PERCENT SLOPES.
- # 83 - WATKINS RIDGE LOAM, 5 to 8 PERCENT SLOPES.

Figure 2-2. Soils in the area of the Boyer Mine (from preliminary U.S. Soil Conservation Service data).

The Watkins Ridge loam B Phase developed on 2 to 5 percent slopes on gently rolling foothills and alluvial fans. Slopes are concave and complex. The present vegetation is alfalfa, small grain and pasture grasses. Elevation is 5,600 to 7,000 feet. The average annual precipitation is about 14 to 18 inches, with a mean annual air temperature of 42 to 45 degrees F. Permeability of the Watkins Ridge soil is moderate. Available water capacity is about 8 to 9 inches. Water supplying capacity is 10 to 14 inches. Surface runoff is slow and the hazard of water erosion is slight.

The Watkins Ridge loam C phase developed on 5 to 8 percent slopes. The soil is similiar to the B phase except that it ranges in elevation from 5,600 to 6,000 feet, the runoff is medium and the water erosion hazard is moderate.

The Richsum-Bequinn Family-Gridge complex developed on 25 to 70 percent slopes on south, east and west facing valley sides and hillsides. Slopes are convex and concave. The native vegetation is mainly grasses and sagebrush with areas of juniper. Elevation is 6,000 to 7,000 feet. The average annual precipitation is about 14 to 18 inches, the mean annual air temperature is 42 to 45 degrees F. Permeability is moderate. Available water capacity is about 7 to 9 inches. Runoff is very rapid and the hazard of water erosion is severe.

The Bequinn family soil is very deep and well drained. Permeability is moderate. Available water capacity is about 5 to 6 inches. Water supplying capacity is 8 to 11 inches. Runoff is very rapid and the hazard of water erosion is severe.

The Gridge family soil is shallow and well drained. Permeability is moderate. Available water capacity is about 1 to 2 inches. Water supplying capacity is 3 to 8 inches. Runoff is very rapid and the hazard of water erosion is very severe.

2.4 Geology

The Boyer Mine is situated in a structural transition zone between the Uinta Mountains to the east and the Wasatch Mountains to the west. The area has been structurally affected by the major orogenic activities which created both mountain ranges, and by subsequent erosion of those features. Numerous folds, faults, anticlines, and synclines are evident and have been mapped in the immediate area. The Dry Canyon Anticline and the Clark Canyon Syncline are of particular importance to the project area since the Boyer mine is located on the adjoining limb of these two structures.

The Boyer mine is being developed in the Wasatch Coal Bed in an area where sporadic mining activities have occurred over the past 90 years. The Wasatch Coal bed has never been extensively developed and has been used only to meet local demands.

2.4.1 Physiography

The Coalville-Upton area is physiographically located near the western edge of the Central Rocky Mountains. It is bounded on the west by the Wasatch Mountains, on the east-southeast by the Uinta Mountains, and on the northeast by the Bridger Basin (Stark, 1953). The transition zone position is reflected in the topography and is best characterized by high hills and low mountains, with well developed drainages.

Local relief in the vicinity of the proposed Boyer Mine ranges from a low of 6200 feet at Chalk Creek to a high of 8271 feet on the crest of Porcupine Ridge. The area is drained by Chalk Creek (a west trending drainage in the area contiguous to the mine) which is a tributary of the Weber River. Numerous surficial structural expressions of the bedrock, in combination with faulting, erosion, and landslides, have created irregular drainage patterns and topographic features.

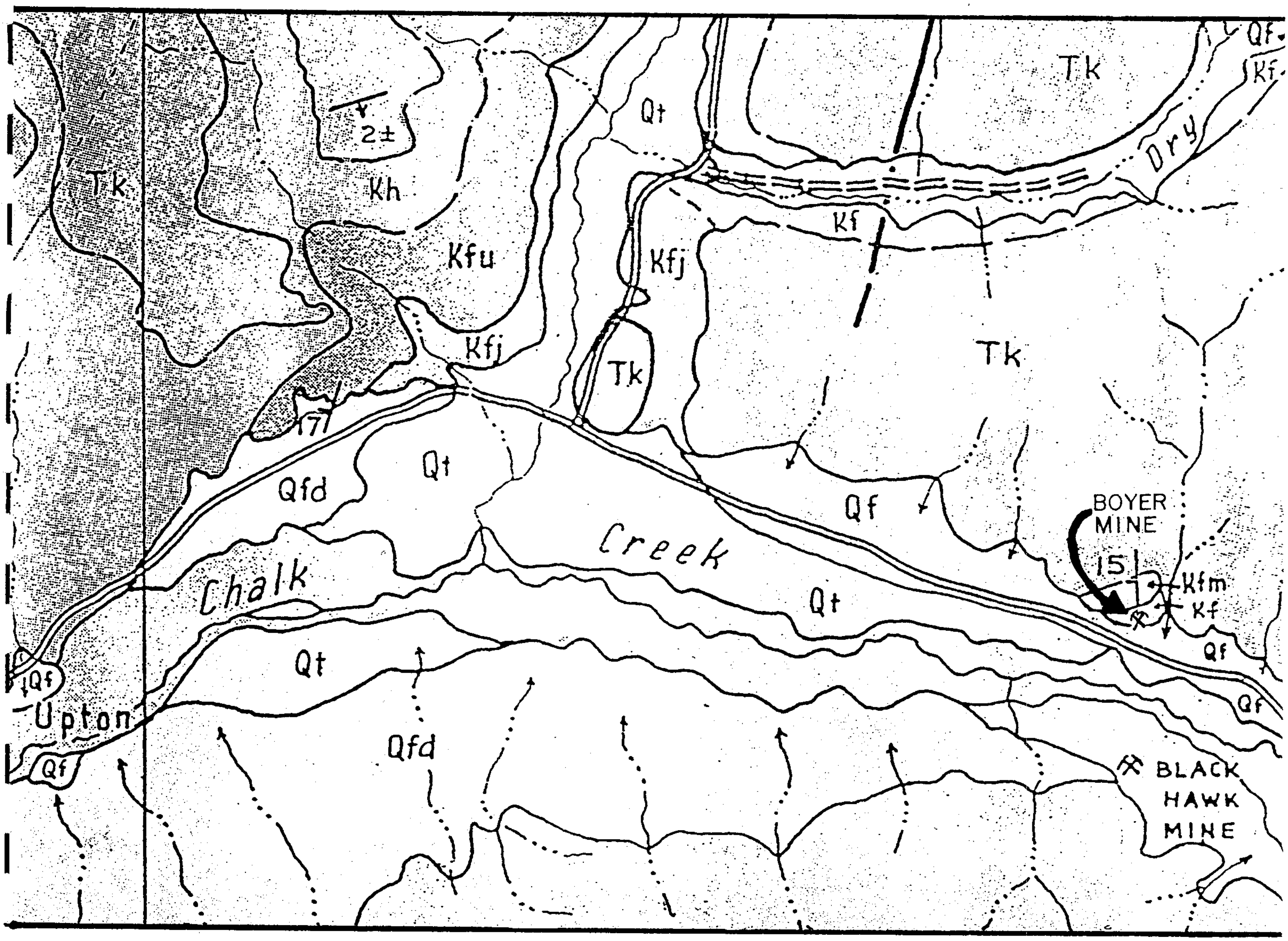
2.4.2 Unconsolidated Deposits

The existing soils and alluvial sediments derived from the Chalk Creek drainage account for the unconsolidated materials which are present in the vicinity of the mine. The sediments in the Chalk Creek drainage range from a few feet to approximately 40 feet or more in thickness. These sediments underly the stream itself and its associated floodplain and terraces.

Numerous landslides have been noted in the area. However, none have been mapped within the permit boundary. The majority of the landslides have occurred on the north-facing slopes across the canyon from the mine site and have developed on the dip-slope of the existing geologic formations.

2.4.3 Consolidated Deposits

In the vicinity of the site, Chalk Creek and its tributaries have cut through the nearly horizontal Tertiary formations to expose folded and truncated Cretaceous strata (Stark, 1953). The exposed Cretaceous formations were deposited during the Coloradoan and Montannan periods and consist of resistant sandstones, conglomerates, shales, and some interbedded coal seams. Locally these units are a part of the Frontier Formation of Upper Cretceous age (Figure 2-3). This formation contains alternating



scale!

Figure 2-3. Surficial geology in the Boyer Mine area (modified from Trexler, 1966).

beds of yellow and gray sandstone with yellow, gray, and black carbonaceous clays and coal beds. The Frontier Formation forms pronounced parallel ridges and hogbacks (Veatch, 1907).

In the Upton area, the Frontier Formation consists of four marine divisions seperated by three non-marine divisions (Trexler, 1966). The lower marine division of massive sandstone (Skunk Point Sandstone member) and other thin shallow-water marine deposits measure 70 feet in thickness. Overlying this is approximately 350 feet of non-marine sandstones, claystones, and shales. The capping unit of these non-marine sediments is a marine sandstone with interbedded coals (the Chalk Creek member). The Chalk Creek member is overlain by 600 feet of shales which belong to the Grass Valley Shale member.

The Chalk Creek member of the Frontier Formation is composed of the Wasatch coal bed and the underlying and overlying lenticular sandstones. The average thickness for this member is about 85 feet. However, because of the lenticular nature of the formation, its thickness varies from place to place.

The basal unit of the Chalk Creek member (the mine underburden) is a light yellow-gray lenticular fine-grained calcareous sandstone. The Wasatch coal unit is subbituminous in rank and varies in thickness from 8-12 feet (Wegemann, 1915). This unit was probably developed in a coastal-swamp environment.

The overburden unit of the Wasatch Coal is a dark gray lenticular hard pebbly fossiliferous sandstone (Trexler, 1966). This thin bed in combination with lower units of the overlying shale is represented by a massive 35-foot bed of fine-grained sandstone. The lenticular nature of the sandstone would suggest a beach environment.

2.4.4 Structure

The Upton area lies about 12 miles east of the Wasatch uplift and about 17 miles north of the western end of the Uinta uplift. The Uinta uplift is a broad, open anticline whose axis plunges to the east and west. East-west trending normal and reverse faults border the uplift on the north and south (Trexler, 1966).

The Wasatch mountains to the west of the site are a complex of thrust sheets and related folds and normal faults. The folds are of the foreland type and are related to the eastward thrusting of the Wasatch mountains (Eardley, 1944). A cross-section of the structure of the Coalville-Upton area (Figure 2-4) depicts broad, assymetrical anticlines and tight assymetrical synclines.

Folds tend to be the most obvious structural features in

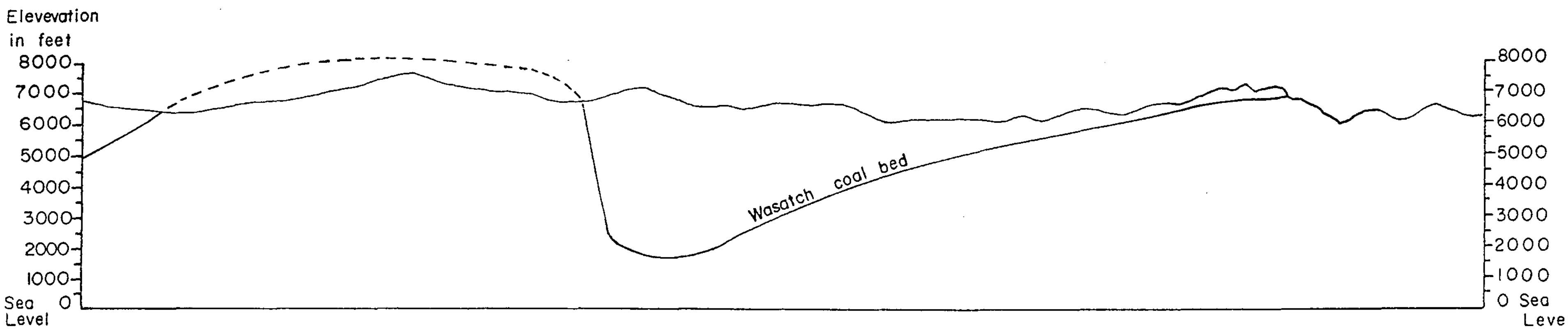


Figure 2-4. General geologic cross section of the Coalville-Upton region.

the area. They trend north-south to northeast-southwest. The most significant folds in the permit area are the Clark Canyon syncline and the Dry Canyon anticline.

The Clark Canyon syncline lies between the Clark Canyon anticline to the west and the Dry Canyon anticline to the east. The western limb of the Clark Canyon syncline is steep and overturned, varying from 70° east to 70° west (Wegemann, 1915). The eastern limb dips at 15-25 degrees to the west. The axis trends north-northeast. The axial plane dips at 50° west.

The Dry Canyon anticline trends north-south. The fold is nearly symmetrical with westerly dips of 15-25 degrees and dips of 20-25 degrees to the east. The permit area lies close to the axis of this anticline on its western limb.

Regionally, the faults in the Coalville-Upton area are of two distinct ages: faults of pre-Knight age which are related to the folds in the Cretaceous formations and faults of post-Knight age which displaced all rocks except those of Quarternary age. Wegemann (1915) mapped all the faults in the area contiguous to the site as belonging to the pre-Knight age (Eocene). These faults are the ones which principally effect the coal-bearing strata (Trexler, 1966).

Immediately west of the western-most boundary of the permit area a small normal fault has been mapped (Figure 2-3). This fault has approximately 50 feet of displacement. Another high angle fault appears to exist on the eastern boundary of the permit area. The eastern fault appears in a small window in the unconsolidated overburden above and east of the mine entry area. This fault has approximately 20-50 feet of offset (as noted in the field). No other faults were observed in the permit area.

2.5 Water Resources

2.5.1 Surface Water

The permit area is located adjacent to Chalk Creek, a major west-flowing tributary of the Weber River. During the 56-year period of record prior to October 1983, Chalk Creek had an average discharge of 47,740 acre-feet per year at Coalville. Extremes during the period of record at Coalville have varied from a maximum of 1570 cubic feet per second to a minimum of less than one cubic foot per second (U.S. Geological Survey, 1984).

Dissolved solids concentrations in Chalk Creek tend to be significantly higher than in the Weber River (Thompson, 1983).

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Near their junction, Thompson (1983) reported that the total dissolved solids concentrations of the Weber River varied from 163 to 256 milligrams per liter during his investigations (September 1979 through August 1980), while Chalk Creek water from 237 to 446 milligrams per liter. Variations in the quality of the two rivers is attributable to differences in the surficial geology of the watersheds.

In general, the quality of water in Chalk Creek near the permit area is better than that at the mouth of the stream. Thompson (1983) reports that total dissolved solids concentrations approximately three miles upstream from the mine varied from 202 to 234 millgrams per liter during his investigation, compared with the higher concentrations reported previously at the mouth of Chalk Creek. Calcium and bicarbonate are the predominant ions in Chalk Creek both above and below the mine during high- and low-flow periods (Thompson, 1983).

2.5.2 Groundwater

Groundwater in the region surrounding the permit area occurs in the alluvium of Chalk Creek and in various consolidated rock units (Gates et al., 1984). However, due to limited development, little is known about groundwater supplies in the Coalville-Upton area.

Near Coalville, the flow of groundwater in the alluvium of Chalk Creek is downstream toward the junction with the Weber River, as would be expected. Locally, Chalk Creek has been shown to be both a gaining and a loosing stream due to groundwater-surface water interactions (Gates et al., 1984); however, conditions near the permit area were not included in previous investigations.

Gates et al. (1984) report that the average specific capacity of wells completed in the Frontier Formation near Coalville is 2.3 gallons per minute per foot of drawdown. This specific capacity is considered moderately low. No information was reported concerning the hydraulics of wells completed in alluvium near Coalville.

According to Gates et al. (1984), groundwater in the Coalville area tends to be fresh (less than 1000 milligrams per liter total dissolved solids). However, as expected, groundwater derived from bedrock is more saline than that obtained from alluvial wells. This is due to the longer residence time of water flowing through bedrock and subsequent dissolution of minerals contained in the rock. Water contained in the Frontier Formation is particularly noted in the Coalville area for its elevated iron concentrations, making it somewhat unsuitable for domestic use (Gates et al., 1984).

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3.0 METHODS AND RESULTS OF OVERBURDEN INVESTIGATIONS

3.1 Methods of Data Collection

3.1.1 Geologic Profiles

Data were collected for the preparation of the geologic cross-section for the permit area using surface outcrops, cutslope exposures, and drill hole logs. Strike and dip data were collected using a Brunton pocket transet and from published data. The location of this cross-section is found in Figure 3-1.

During July and August 1982, four exploratory holes were drilled at the property to determine local coal reserves. Locations of these drill holes are shown in Figure 3-1. Each hole was rotary drilled to a pre-determined depth and then core drilled through the coal and immediately adjacent strata. Data obtained from these holes were used in development of the geologic cross section of the permit area.

3.1.2 Lithologic Sample Collection

A total of eight lithologic samples were collected from the permit area to determine the physical and chemical characteristics of the overburden, coal, and underburden. Sampled units are listed in Table 3-1.

Lithologic samples were collected from both the recovered core obtained in the drill holes and from channel samples in exposed faces in order to obtain a complete suite of three representative samples for each stratigraphic location (overburden, coal, and underburden). Coring of all three lithologic units (overburden, coal, and underburden) was completed on only one of the four drill holes. Thus, an additional suite of channel samples was collected from an exposed face near the portal to arrive at the total number of lithologic samples desired.

The channel samples were collected from a newly exposed cutslope where the mine entry was being driven. The overburden channel sample (PBO) represents a twenty-foot high face of silty sandstone. The channel was excavated three inches wide and two inches deep. All materials excavated from the channel were collected and submitted for laboratory analyses.

The coal channel sample (PBC) was collected from the Wasatch coal at a freshly exposed face in the portal entry. A six-foot

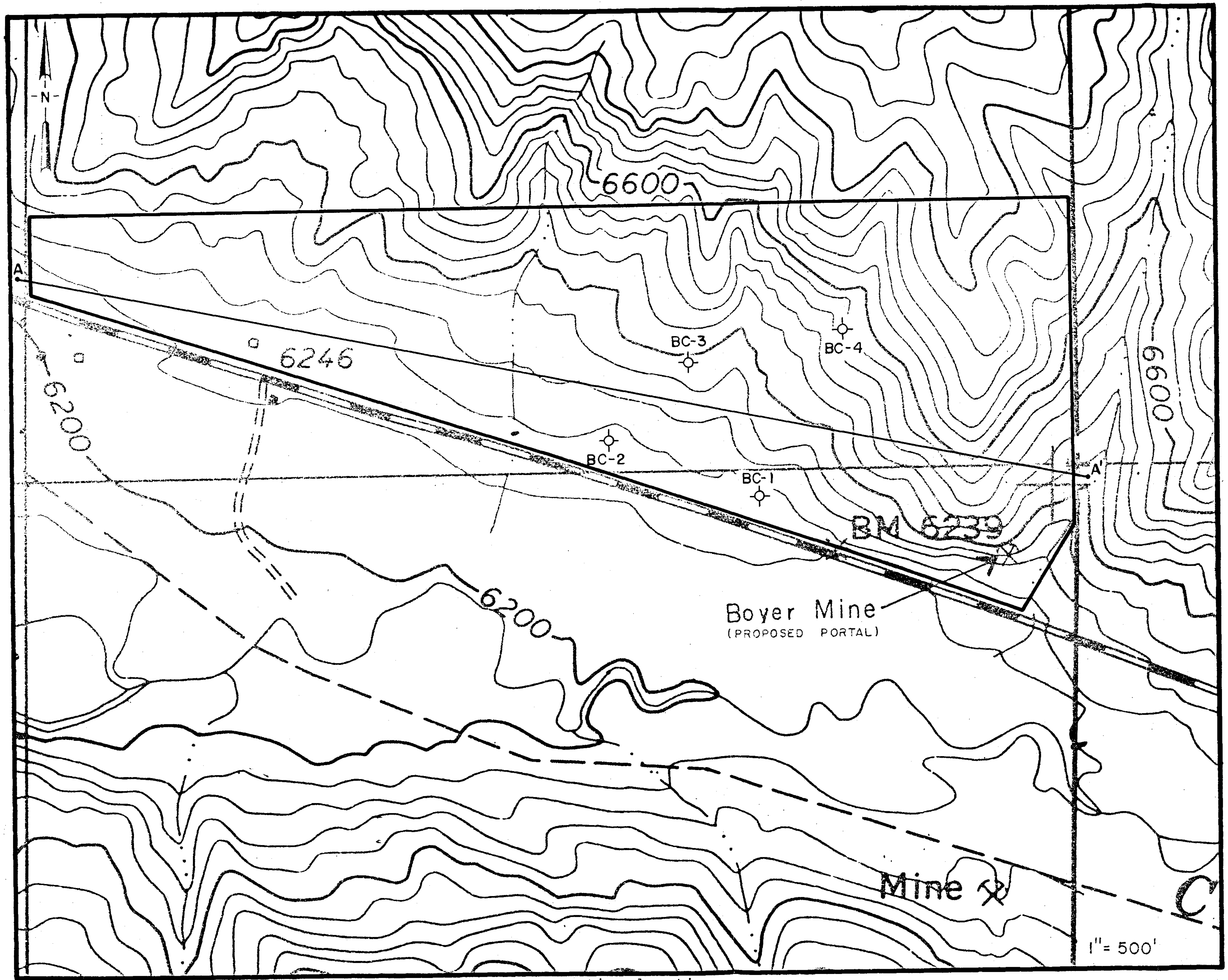

Figure 3-1. Geologic sample and cross section locations.

Table 3-1. Lithologic samples collected from the permit area.

Sample Number	Sample Description	Sample Location[a]	Sample Type
PBO	Overburden Shale	Portal	Channel
PBC	Wasatch Coal	Portal	Channel
PBU	Underburden Sandstone	Portal	Channel
BC2O	Overburden Shale	BC-2	Core Split
BC2C	Wasatch Coal	BC-2	Core Split
BC2U	Underburden Sandstone	BC-2	Core Split
BC3U	Underburden Shale	BC-3	Core Split
BC3C	Wasatch Coal	BC-3	Core Split

[a] See Figure 3-1

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high, three-inch wide and two-inch deep sample was taken. The coal was moderately fresh in appearance but slightly weathered.

The underburden channel sample (PBU) was collected from the sandstone underlying the coal at the portal entry. A sample four feet high by three inches wide and two inches thick was taken. The sandstone was fresh in appearance and unweathered.

Five lithologic samples were collected from the core returns obtained from the drill holes BC-2 and BC-3. The core from these drill holes is approximately three and a half years old. However, the core was in very good shape. Core samples were obtained by spliting the core vertically, returning one half of the core to its original container and the other half to a sample bag for subsequent laboratory analyses.

Originally, it was desired that three samples of each lithologic unit would be obtained for chemical analyses to determine areal variations at the site. However, as noted previously, only one core hole contained core for the overburden (all other holes were rotary drilled to the coal before coring began). Because of the small area over which the coal and associated overburden outcrop at the site (see Figure 2-3), multiple samples of the exposed overburden would of necessity be taken from the same approximate location. Thus, areal variations would not be determined. Thus it was decided to collect only one surface sample and utilize only two total samples of the overburden for this investigation.

Lithologic sample BC2O is the overburden gray, sandy, fossiliferous shale. The immediately overlying 20 feet of core of the shale which caps the coal was split, described, and submitted to the laboratory for analyses.

Lithologic sample BC2C is the Wasatch Coal. The drill hole encountered a total of 5.5 feet of coal. Coring of this softer sub-bituminous coal shattered the bedding features and yielded gravel sized fragments of coal. The coal samples were collected in plastic bags during drilling operations and stored in these bags until samples were extracted. The owner extracted samples to determine the potential economic value of the coal, and EarthFax Engineering extracted samples to deterine the physical and chemical characteristics of the coal. Splits were obtained from the sample in both cases.

Lithologic sample BC2U (underburden) consists of dark gray carbonaceous sandstone with intercalated beds of clay, shales, and quartz pebbles. Only eight feet of underburden was cored in BC-2. Therefore, only an eight foot sample of the of the core split was submitted to the laboratory for analyses.

Lithologic sample BC3O (overburden) is a a dark brownish-gray carbonaceous, fossiliferous shale. Twelve feet of core was available for splitting, sampling, and laboratory analyses.

Lithologic sample BC3C is a sample of the Wasatch Coal. The drill hole encountered a 6.0 foot thickness of coal. Coring of the coal destroyed the bedding features and the coal which was collected during the drilling operations was in gravel sized pieces. The coal fragments were placed in plastic bags. Splits from the coal have been obtained by the owner to determine the economic value of the coal and by EarthFax Engineering to determine the physical and chemical characteristics of the coal by laboratory analyses.

Rock samples were submitted to Chemical and Mineraligical Services, Inc. (CMS) of Salt Lake City, Utah and ACZ, Inc. of Steamboat Springs, Colorado for analyses. Analyses and methods used for the samples are outlined in Table 3-2.

3.2 Local Geologic Conditions

The Boyer Mine is located on a south facing slope on the western limb of the Dry Fork anticline. The mine entry is located in a small window within the Frontier Formation near the crest of the Dry Fork anticline where the coal outcrops.

The mine will be developed along the dipslope. The average dip is from 20-25 degrees west. The coal and contiguous formations are fractured and jointed.

Field observations indicate that the Chalk Creek member in the vicinity of the mine site is capped by an angular unconformity. Hence, only about 160 feet of Cretaceous age lithology is exposed in a 500 foot long stretch along the southeastern edge of the permit boundary. The remainder of the permit area is covered by the Tertiary-age Wasatch Formation and Pleistocene alluvial fans and terrace deposits.

The Chalk Creek member of the Frontier Formation strikes north 5 to 15 degrees west and dips 15 to 20 degrees southwest. Whereas, the overlying Wasatch Formation strikes north to 10 degrees northeast and dips 5 to 10 degrees to the east-southeast. This unconformity is very apparent within the permit boundary. The coal has been truncated on the western egde of the permit boundary by either large scale faulting or erosion, thereby eliminating the western limb of the Dry Fork anticline in the area immediately east and contiguous to the permit area.

Small scale normal faults were observed in the Wasatch

Formation within the permit area, but could not be traced to the buried Cretaceous age formations. These faults appear to be continuous on the surface and entend through the permit boundary. They are a part of the regional system and can be traced for several miles both to the north and south of the permit boundary. All of the observed faults within the permit area were further than 1500 feet west of the mine entry.

As noted previously, four exploratory holes were drilled at the site by Summit Coal Company in 1982. The logs of these holes are summarized in Figures 3-2 through 3-5, with written descriptions contained in Attachment A. The holes were logged in the field during drilling operations. The core was relogged by EarthFax during the course of this investigation.

A cross-section (Figure 3-6), developed utilizing the drilling logs, shows the coal to be continuous laterally without any substantial offset. The logs do indicate that the thickness of the coal varies from as thin as 5.5 feet to over 8 feet. As shown in the cross-section, by the time the mine has developed 2000 feet laterally the workings will be over 400 feet below the ground surface. A projection of the same dip angle indicates that when the mine reaches the western permit boundary it will be over 1600 feet below the ground surface.

3.4 Physical Properties of the Overburden, Coal, and Underburden

Results of phsical analyses of the rock samples are contained in Table 3-3. Raw data obtained from the laboratory are provided in Attachment B.

Lithologically, the overburden is a carbonaceous sandstone to shale. Results of the hydrometer analyses indicate that the sand-sized particles range from 8 to 25 percent, with 38 to 45 percent silt-sized and 37 to 47 percent clay-sized.

The hydrometer analyses of the coal indicated that the sand-sized particles range from 60 to 75 percent, 0 to 20 percent silt-sized, and 0 to 40 percent clay-sized. The sample with the high clay content was slightly weathered as collected at the mine entry.

The hydrometer analyses of the underburden indicates that 36 to 43 percent of the material is sand-sized, 33 to 42 percent silt-sized, and 15 to 23 percent clay-sized.

It should be noted that the rock samples which were analyzed for particle size with the hydrometer required crushing before

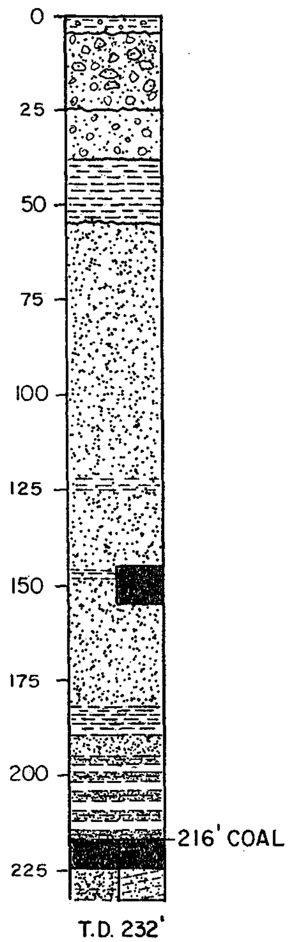

Figure 3-2. Drill hole log of BC-1.

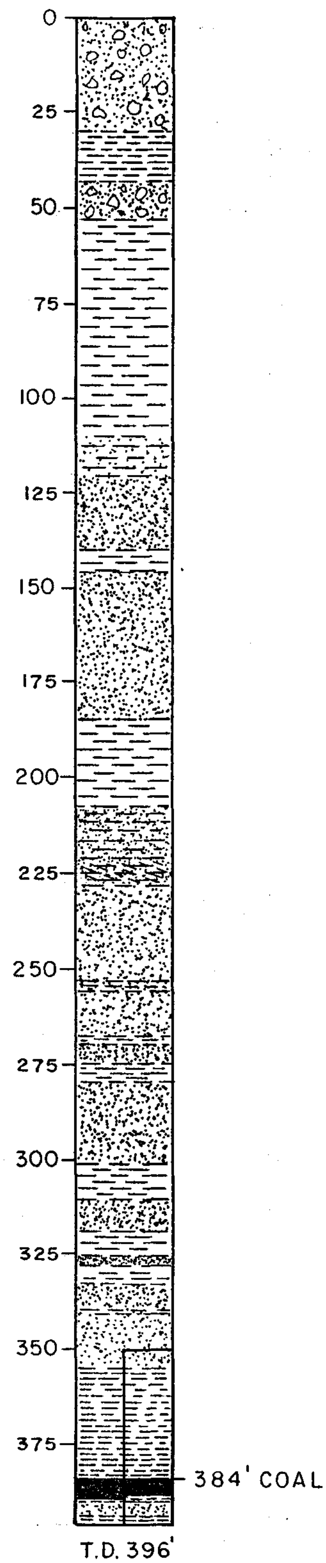

Figure 3-3. Drill hole log of BC-2.

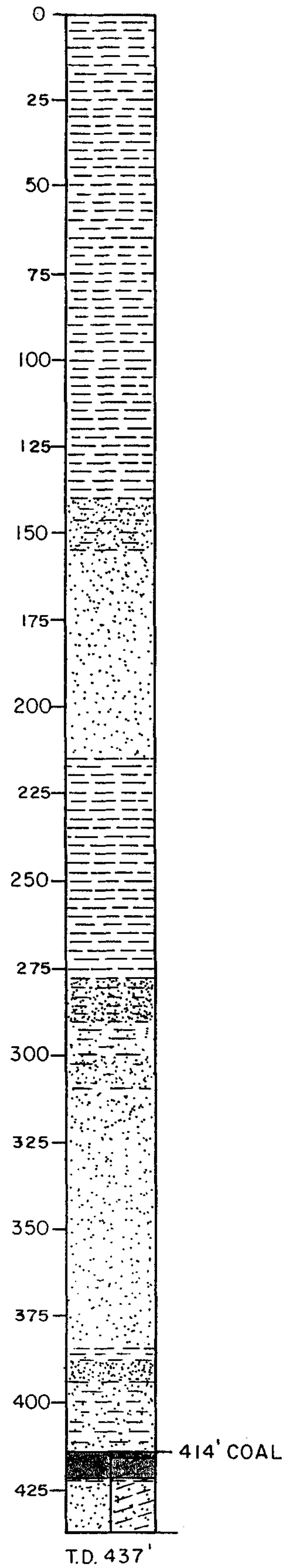

Figure 3-4. Drill hole log of BC-3.

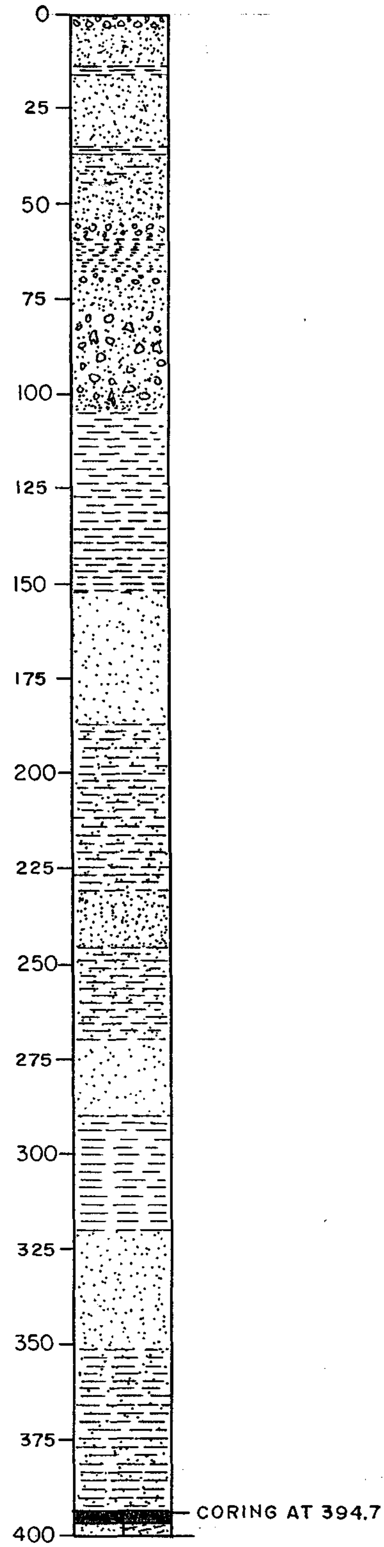

Figure 3-5. Drill hole log of BC-4.

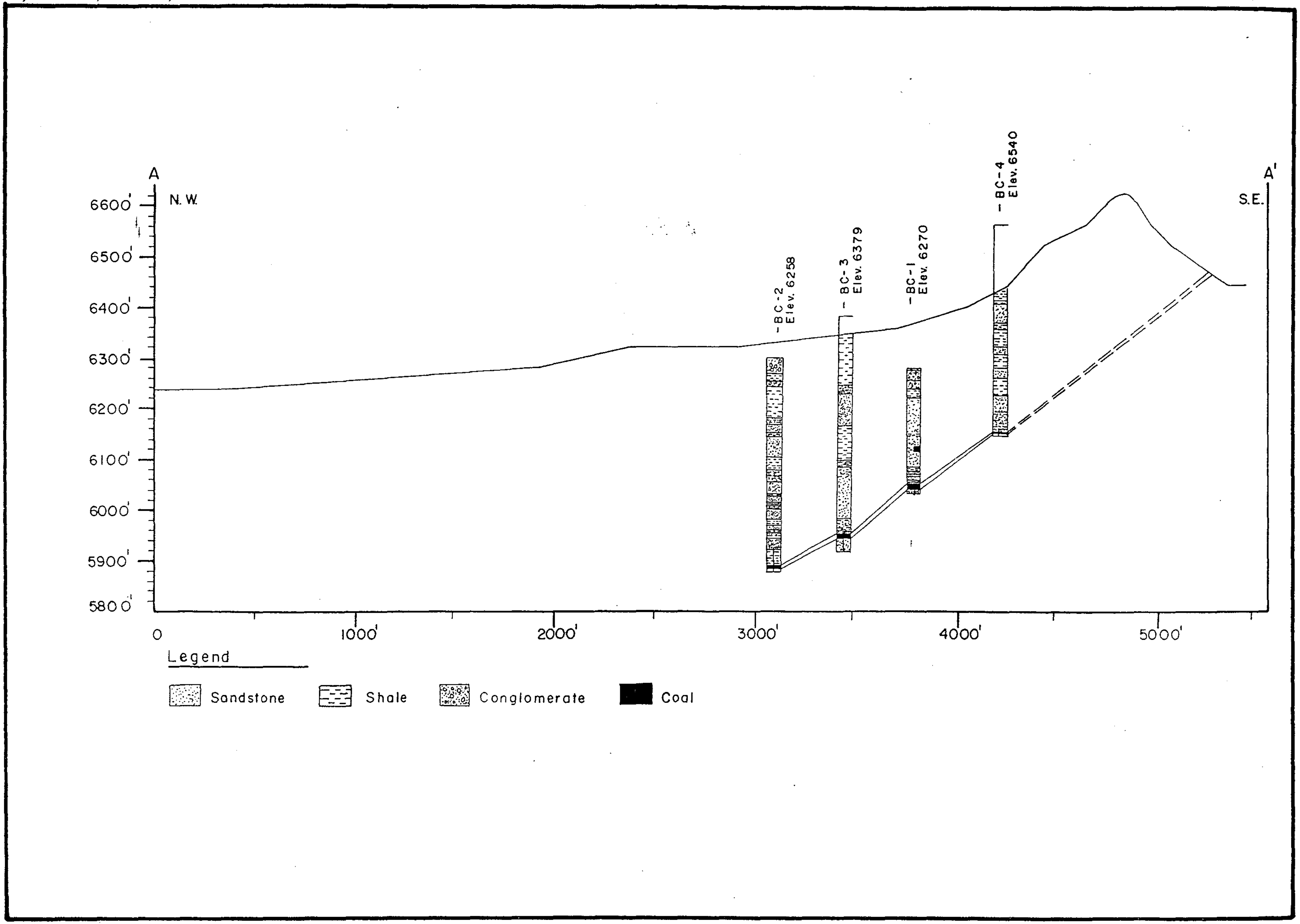

Figure 3-6. Geologic cross section A-A'.

Table 3-3. Physical properties of overburden, coal, and underburden.

Sample No.	Satuartion Percent	Percent Finer Sand	Silt	Clay
PBO	60	8	45	47
PBC	(a)	60	0	40
PBU	25	44	33	23
BC2O	22	25	38	37
BC2C	(a)	75	20	5
BC2U	22	36	44	20
BC3C	(a)	85	15	0
BC3U	22	43	42	15

[a] Not determined

the analysis could be run. Hence, the results may be of questionable validity.

The Chalk Creek member of the Frontier Formation which hosts the coal was deposited in a beach front and coastal lagoon type environment. The sediments deposited in these areas tend to be fine grained and reflect a static environment which is seasonally interrupted by regionally large scale storm events. Hence, some variation in grain size is expected between samples.

3.5 Chemical Properties of the Overburden, Coal, and Underburden

Results of chemical analyses of the overburden and underburden samples are summarized in Table 3-4, while those of the coal samples are contained in Table 3-5. Raw data obtained from the laboratories are provided in Attachment B.

The samples collected from the Boyer Mine entry were somewhat more weathered than the samples collected from the drill holes. Therefore, some moderate chemical variations can be expected. As noted in Table 3-4, the overburden is slightly alkaline, with an average pH of 7.74.

According to personnel with ACZ, the neutralization and acid-producing relationships of a given material can be compared by multiplying the percent total sulfur by 31.25 and the neutralization potential by 10.0. If the resulting neutralization factor exceeds the acid-producing factor, the material will not be acid producing. If the opposite is true, the material will be acid producing.

In the case of the mine-site overburden, the average neutralization factor exceeds the average acid-producing factor by a multiplier of approximately 8.4. Thus, the overburden at the site will not be an acid producer, but rather an acid neutralizer.

According to Table 3-5, the coal has an a average pH of 4.63 which is acidic. The acid-producing potential of the coal is also apparent when examining the neutralization/acid-producing factors and the acid-base potential. Even though the pyritic sulfur content is considered to be fairly low, the coal has a very low calcium carbonate content and is, therefore, unable to overcome the acidic effects of the sulfur.

It should be noted that the coal will be largely removed during mining, thus minimizing its impact on the overall acid-base equilibrium of the area. Although mining will increase the

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Table 3.3. Chemical properties of overburden and underburden from the Boyer Mine area.

Sample No.	Unit	pH	EC umhos	Ca ppm	Mg ppm	Na ppm	As ppm	Hg ppm	CO_3 ppm	NO_3-N ppm	B ppm	Se ppm	Mo ppm	Tot. S	Neu Pot.	Ac.-Base Pot.
PBO	Shale	7.70	1449	16	80	55	<.10	.0004	119.6	.74	1.8	<.1	<.1	.04	21.8	217
PBU	Sandstone	6.50	4566	45	320	210	<.10	<.0001	95.2	2.66	2.0	<.1	<.1	.50	-.4	-20
BC2O	Shale	7.78	1838	25	100	90	<.10	<.0001	157.6	.75	.8	.18	<.1	.93	18.5	156
BC2U	Sandstone	7.68	4016	35	220	430	<.10	.0006	309.6	1.10	.8	.16	<.1	.41	21.8	161
BC3U	Sandstone	7.68	2786	30	230	200	<.10	<.0001	171.6	.70	.4	<.10	<.1	.48	18.3	168

Table 3.4. Chemical characteristics of coal from the Boyer Mine area.

Sample No.	pH	EC (mmhos/cm @ 25 °C)	Pyritic Sulfur (%)	Neutralization Potential (% $CaCO_3$)	Acid-Base Potential (tons $CaCO_3$/ 1000 tons)
PBC	2.7	10.50	0.01	-10.1	-101
BC2C	5.9	3.66	0.35	2.3	12
BC3C	5.3	2.60	0.34	0.5	-6

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surface area of the coal that is open to the atmoshpere, it will also decrease the residence time of water flowing through the mined-out section. This, in addition to the neutralizing effect of the underburden (see subsequent discussions), minimizes potential impacts of mining on local acidity.

The underburden has an average pH of 7.29 and can be considered relatively neutral with respect to pH. In general, the underburden has a very strong neutralization potential and could be beneficial in neutralizing any acid which may develop from the overlying coal bed.

Both the overburden and underburden from drill hole BC-2 contained elevated selenium concentrations (0.180 and 0.160 ppm, respectively). Although not directly comparable, these rock concentrations exceed the drinking water standard of 0.01 mg/l by at least an order of magnitude. Groundwater and surface water samples collected from the area indicate that selenium concentrations in the area of the mine are generally low. However, occasional samples have been collected showing background concentrations that exceed the drinking water standard (see Sections 4.2.3 and 4.2.4).

Mercury was detected in only two samples (PBO and BC2U). The concentrations found in the samples (0.0004 and 0.0006 ppm, respectively) are comparable to concentrations of mercury found in the surface-water samples collected near the site (see Section 4.2.3). These concentrations are below the drinking water standards.

3.6 Potentially Acidic, Toxic, or Alkaline Horizons

As mentioned in section 3.5, the pH of rock samples collected from the site range from a low of 2.7 (sample PBC) to a high of 7.78 (sample BC2O). The coal was the only acidic lithlogic unit sampled. Because the coal is bounded by two lithologic units which are relatively alkaline, any water which enters the mine form these units is also expected to be slightly alkaline.

During the mining process rock dust (calcium carbonate) will be used to reduce the potential for explosions. The alkaline rock dust will also assist in raising the pH of water flowing through the mine to within the neutral zone.

After mining operations have ceased and the mine has shut down, mine drainage will not be a problem because of the dip of the bedrock and the depth to the static water table. Mine water will not discharge from the mine entry or portals.

In general, with the exception of the potential for acid production within the coal, it does not appear that sufficient concentrations of any metals or nonmetals are present to create a problem. Concentrations which were found within the lithologic units are very comparable with those concentrations found in both the surface waters and groundwaters for the area.

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4.0 METHODS AND RESULTS OF HYDROLOGIC INVESTIGATIONS

4.1 Methods of Data Collection

4.1.1 General

Seven stream monitoring stations and one rain gage were established at the site (Figure 4-1) for the collection of hydrologic data. The location of each station was selected in consultation with representatives of DOGM and Summit Coal Company during an initial site visit in June 1985.

In addition to the collection of data within the permit area, water-quality data were also collected from three private wells near the site. These wells are located as noted in Figure 4-2. Lithologic and completion logs for two of the wells (as obtained from the Utah Division of Water Rights) are contained in Attachment F. A log was not available from the Utah Division of Water Rights for the Morby well. None of the water obtained from the private wells is treated.

4.1.2 Precipitation Data

The rain gage that was installed at the site is a Belfort Universal Recording (weighing type) gage equipped with a 31-day chart. The gage was installed in an area indicated by the mine operator to be remote from future earth-moving activities. Guidelines outlined by Brakensiek et al. (1979) were followed in choosing a location to minimize interference from surrounding trees and spoil piles.

4.1.3 Stream Stations

Since the streams at stations SS-1, SS-2, and SS-3 are ephemeral, each of these stations was established with a crest-stage gage and three single-stage sediment samplers. This equipment allows the automatic collection of streamflow data from the ephemeral channels when the site is unattended.

Each crest-stage gage was constructed basically as outlined by Buchanan and Sommers (1968) and shown in Figure 4-3. These gages prvide information regarding the peak depth of flow at the station since the last field visit. This depth can be converted to a peak flow rate through the use of open-channel hydraulic methods.

The single-stage sediment samplers automatically collect

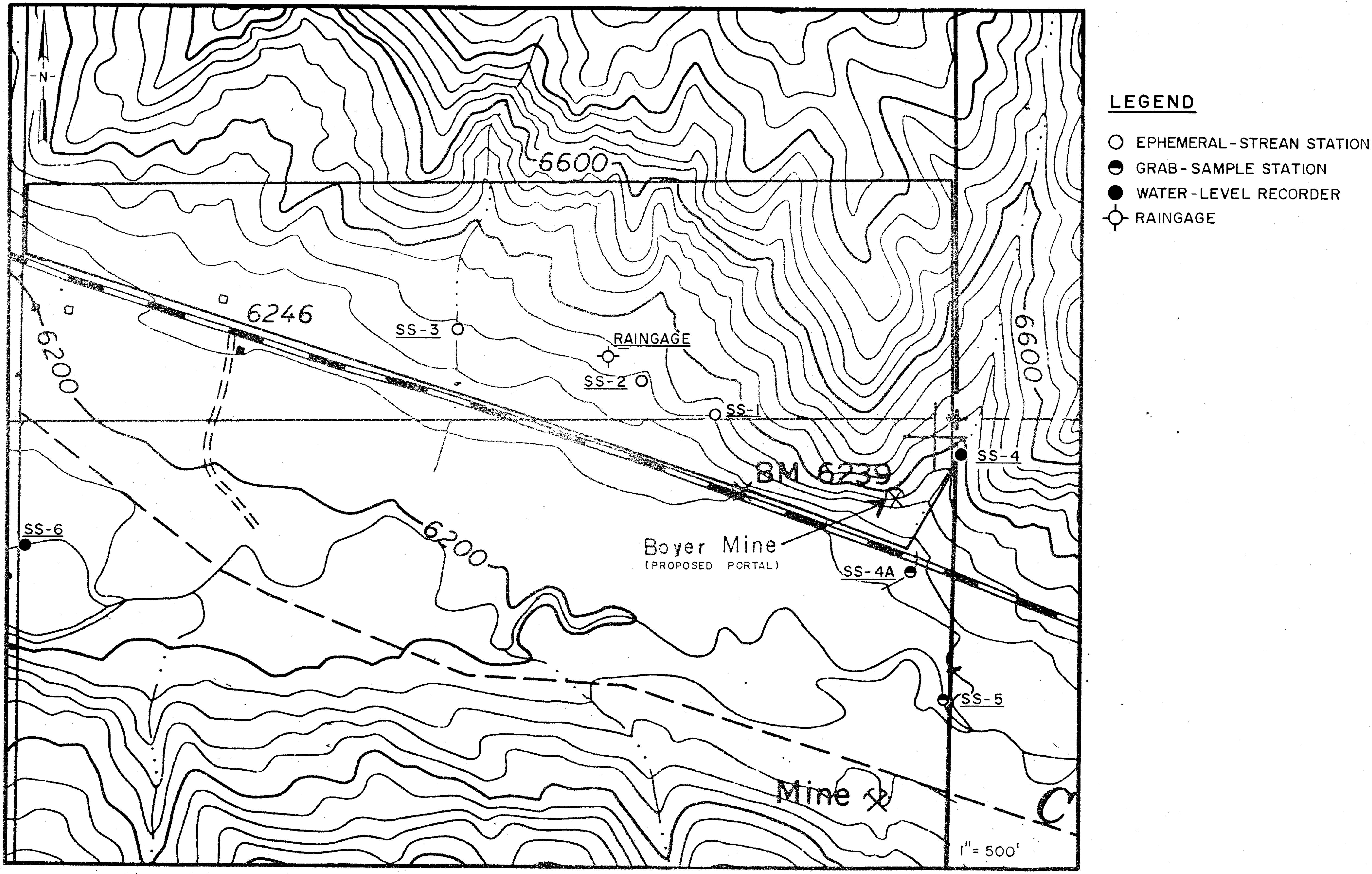

Figure 4-1. Locations of hydrologic monitoring stations.

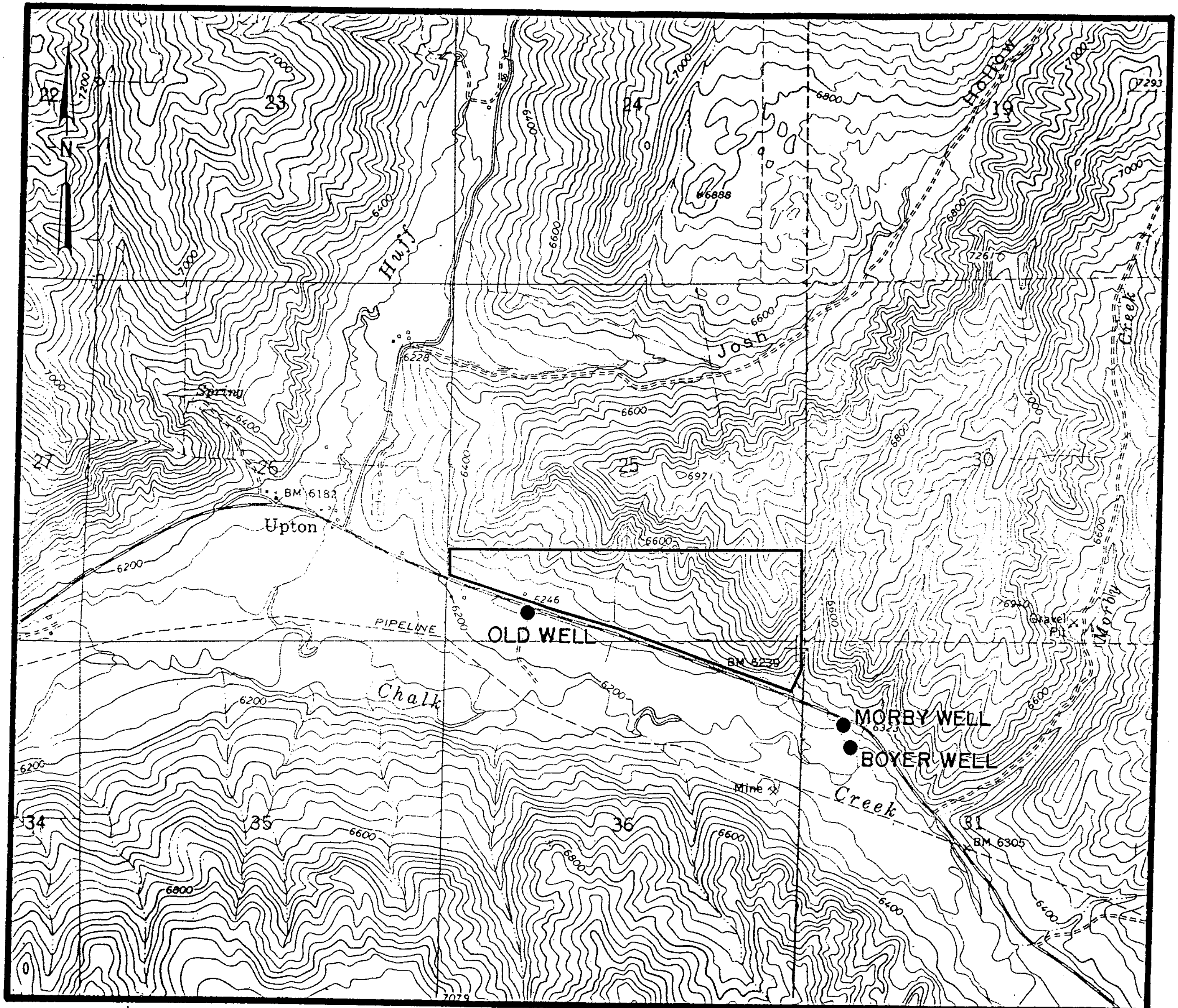

Figure 4-2. Locations of private wells included in the monitoring program.

SCALE: 1" = 2000'

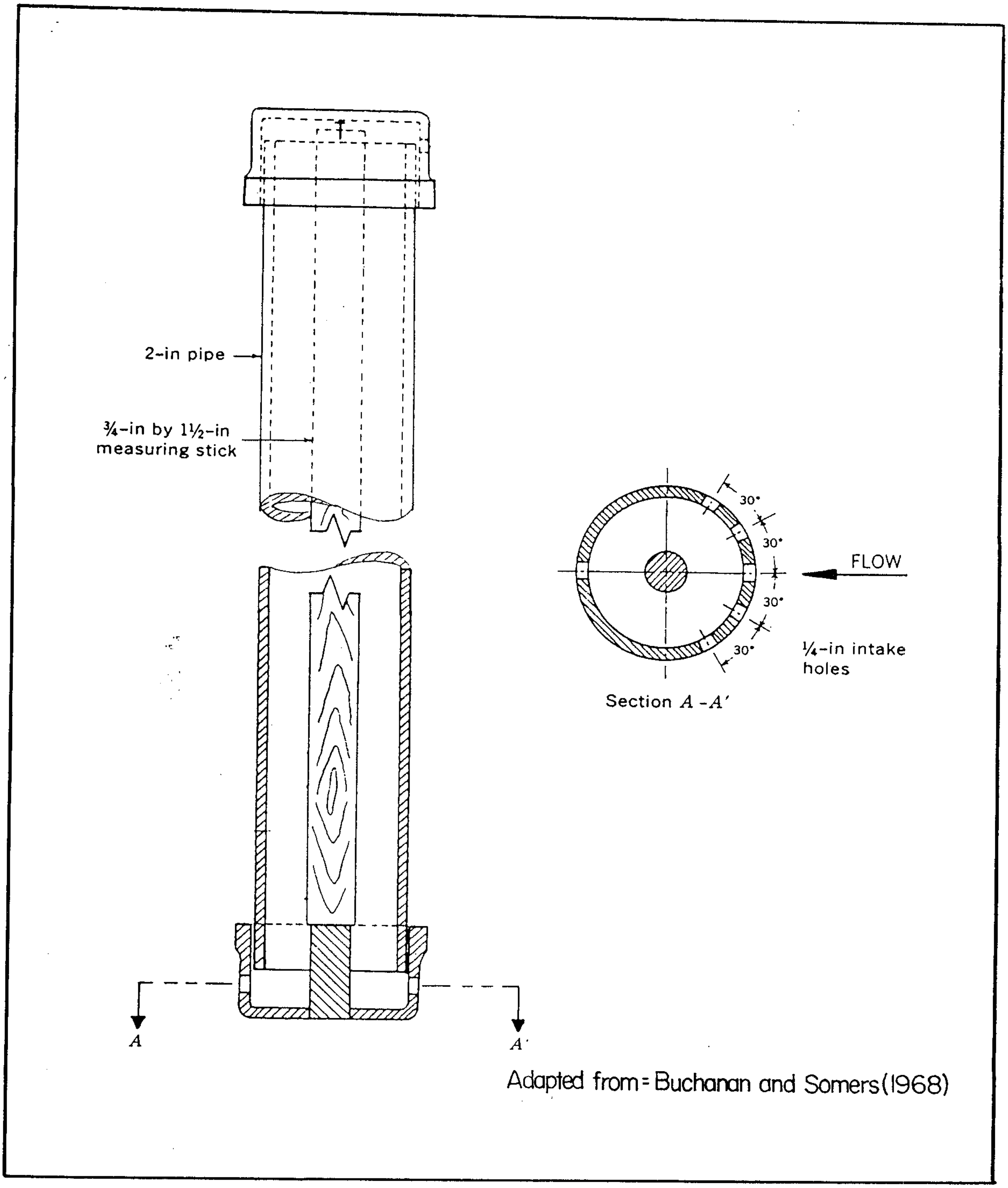

Figure 4-3. Crest-stage gage design.

water during the rising limb of a runoff event by syphoning water from the stream into a collection bottle, thus allowing the collection of water-quality samples during runoff events between field visits. Each single-stage sediment sampler was constructed using guidelines established by Guy and Norman (1970), as noted in Figure 4-4. Polyethylene tubing and bottles were used in place of the copper tubing and glass bottles suggested by Guy and Norman (1970) to prevent contamination of the samples with trace metals and to ensure resiliancy of the samplers. The samplers were stacked vertically to allow the collection of samples at various flow depths during a runoff event.

4.1.4 Seep and Spring Inventory

A seep and spring inventory was conducted in the vicinity of the proposed mine in June 1985 and then repeated in October 1985 to determine seasonal variations. This survey consisted of traversing the permit and adjacent areas on foot and noting the locations of all seeps and springs in the area. The area within one mile of the permit area was included in the survey. Data were collected during the survey to identify the flow (normally a visual estimate), temperature, pH, and specific conductance of each seep or spring. Geologic conditions at the point of issuance were also noted.

4.1.5 Field Data Collection

Monthly field visits were made in the latter part of each month from May 1985 through April 1986 for the collection of hydrologic data. During these visits, charts on the rain gage and the water-level recorders were changed. Crest-stage gages were inspected for streamflow activity during the previous month and recharged with sawdust if flow had occurred.

Periodic water-quality samples were collected from the wells of concern and the streams (if flowing). Each time a water-quality sample was collected, the field water temperature, pH, and specific conductance were determined. Dissolved oxygen concentrations were also determined in the field at the surface-water stations. At stations other than SS-5 and SS-6, flow rates were measured volumetrically where conditions permitted and estimated visually otherwise. At the latter two stations, flow rates were measured General site conditions were also noted if appropriate.

At stations SS-5 and SS-6, flow measurements were made monthly using a Price Type AA current meter. The six-tenths depth method (U.S. Geological Survey, 1977) was used to collect flow data, whereby the velocity at a given point is measured 0.6 of the total depth below the water surface. Normally, velocities

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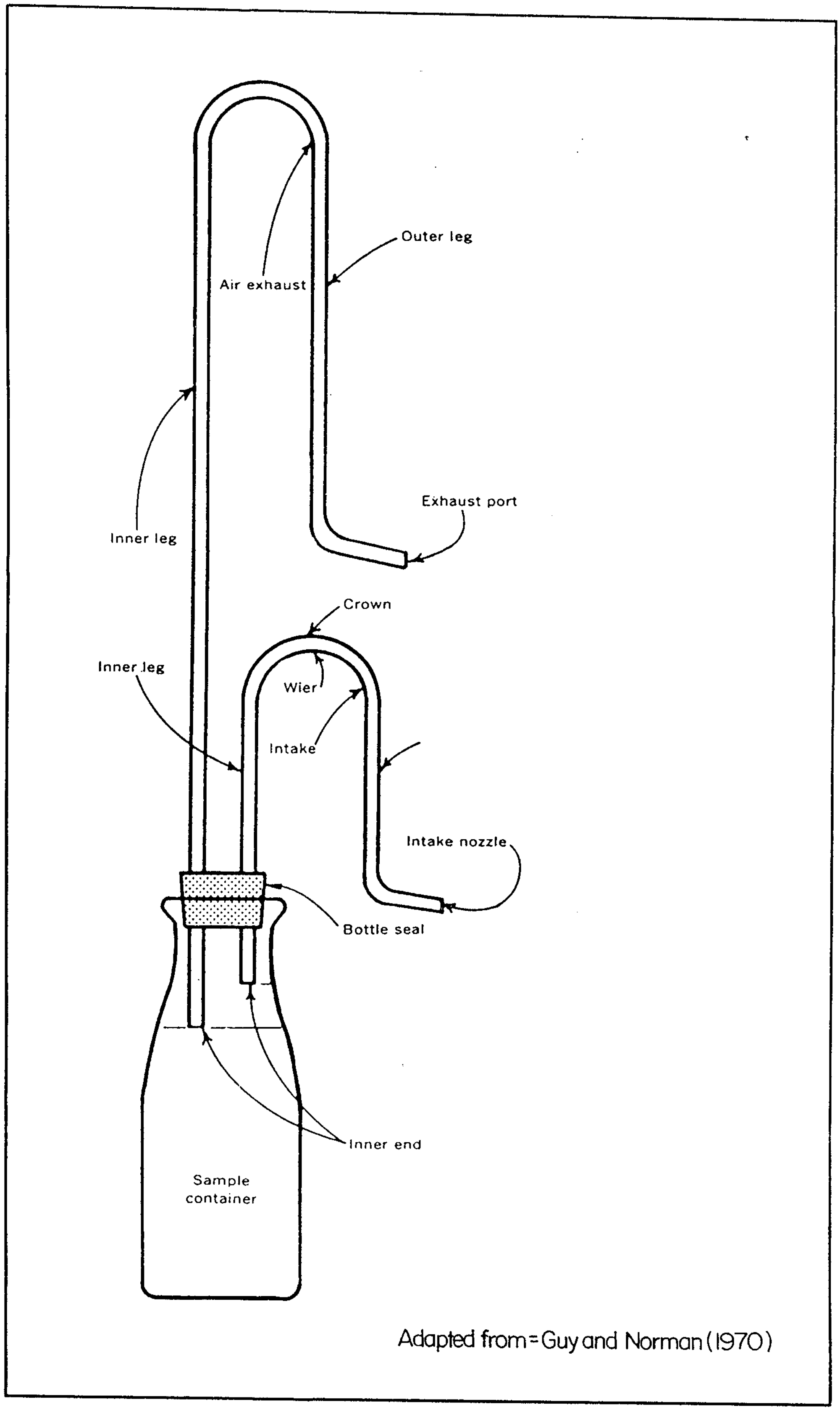

Figure 4-4. Single-stage sediment sampler design.

were measured at at least 10 points across the stream at each station. Cup rotation data for the current meter were converted to velocities using the rating table provided by the manufacturer (Scientific Instruments, Inc. of Milwaukee, Wisconsin).

Water-quality samples were collected quarterly form the stream stations and periodically from the water wells. Samples collected from Chalk Creek were depth integrated, with multiple samples being collected across the stream at locations chosen in the field. At SS-4 and SS-4A, flows were sufficiently low during collection that samples were depth integrated at single points. Samples were filtered in the field for subsequent dissolved-metal analyses using a 0.45 micrometer membrane filter and a peristaltic pump. All samples were preserved in the field (using acid or ice) as recommended by the U.S. Geological Survey (1977).

Samples collected from Boyer and Morby domestic wells were taken from taps at the houses after running the tap for a sufficient period of time to ensure that fresh water was being delivered (usually 5 to 10 minutes). Field analyses and sample collection methods then proceded as outlined previously.

Samples collected from the abandoned Boyer well (the "Old Well" of Figure 4-2) were taken after pumping the well for a sufficient period of time to ensure that at least one borehole volume of water had been removed from the well prior to sample collection. A stainless-steel submerssible pump was used for pumping and sample collection, with PVC discharge pipe on the pump. Field analyses and sample collection methods proceded as outlined previously.

4.1.6 Laboratory Analyses

All water-quality samples collected for the project were submitted for analyses to Chemical and Mineralogical Services, Inc. of Salt Lake City, Utah. Chemical and Mineralogical Services is certified as an Environmental Laboratory by the Utah Department of Health, a certification that is recognized by the U.S. Environmental Protection Agency. Parameters for which the samples were analyzed are listed in Table 4-1.

4.2 Analysis and Discussion of Results

Section to be prepared subsequently. To include the following subheadings:

Table 4-1. Laboratory methods used for water-quality analyses.

Parameter	Method	Method No.[a]
Aluminum (Al)	ICP	200.7
Ammonia (NH_3-N)	Colorimetric	350.1
Arsenic (As)	AA, furnace technique	206.2
Barium (Ba)	ICP	200.7
Boron (B)	ICP	200.7
Carbonate (CO_3)	Titrimetric	403[b]
Bicarbonate (HCO_3)	Titrimetric	403[b]
Cadmium (Cd)	AA, direct aspiration	213.1
Calcium (Ca)	ICP	200.7
Chloride (Cl)	Colorimetric, automated ferricyanide AAII	325.2
Chromium (Cr)	AA, direct aspiration	218.1
Copper (Cu)	AA, direct aspiration	220.1
Fluoride (F)	Ion selective electrode	340.2
Hardness, total ($CaCO_3$)	Colorimetric, EDTA	130.1
Iron (Fe)	AA, direct aspiration	236.1
Lead (Pb)	AA, furnace technique	239.2
Magnesium (Mg)	ICP	200.7
Manganese (Mn)	AA, direct aspiration	243.1
Mercury (Hg)	Manual cold vapor technique	245.1
Molybdenum (Mo)	AA, furnace technique	246.2
Nickel (Ni)	AA, direct aspiration	249.1
Nitrate (NO_3-N)	Colorimetric	352.1
Nitrite (NO_2-N)	Colorimetric	354.1
Oil and Grease	Gravimetric	413.1
Potassium (K)	AA, direct aspiration	258.1
Phosphate (PO_4)	Colorimetric, automated ascorbic acid	365.1
Selenium (Se)	AA, furnace technique	270.2
Sodium (Na)	AA, direct aspiration	273.1
Solids, dissolved (TDS)	Gravimetric at 180 °C	160.1
Solids, settleable	Volumetric, Imhoff cone	160.5[c]
Solids, suspended (TSS)	Gravimetric at 103-105 °C	160.2[c]
Sulfate (SO_4)	Colorimetric, automated, methylthynol blue, AAII	375.2
Sulfide (S)	Titrimetric, iodine	376.1
Zinc (Zn)	AA, direct aspiration	289.1

[a] From U.S. Environmental Protection Agency (1979)
[b] Standard Methods of Water and Wastewater Analysis, 16th ed.
[c] Surface water only

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4.2.1 Local Precipitation
4.2.2 Water Balance
4.2.3 Existing Surface-Water Conditions
- 4.2.3.1 Watershed Characteristics
- 4.2.3.2 Stream-Channel Characteristics
- 4.2.3.3 Local Stream Flow
- 4.2.3.4 Surface-Water Quality
- 4.2.3.5 Erosion and Sediment Yield

4.2.4 Existing Groundwater Resources
- 4.2.4.1 Seeps and Springs
- 4.2.4.2 Groundwater Hydraulics
- 4.2.4.3 Groundwater Quality

4.2.5 Water Rights

5.0 PROBABLE HYDROLOGIC CONSEQUENCES OF MINING

5.1 Surface-Water Impacts

To be prepared

5.2 Groundwater Impacts

To be prepared

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6.0 CONCLUSIONS

To be prepared

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