M/035/009

MINING AND RECLAMATION PLAN

KENNECOTT BARNEYS CANYON

MINING COMPANY

SUBMITTED TO UTAH DIVISION OF OIL, GAS AND MINING

CONSOLIDATED PLAN RECEIVED 4-15-97

VOLUME I

TEXT AND APPENDICES

MARCH 07, 1997

KENNECOTT BARNEYS CANYON

MINING COMPANY

P.O. BOX 311

BINGHAM CANYON, UTAH 84006-0311

File in:
- ❑ Confidential
- ❑ Shelf
- ❑ Expandable

Refer to Record No 0020 Date 4-15-97
In M/035/002, 2007, Incoming
For additional information

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

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March 17, 1997

Steve Lackey
Kennecott Barney's Canyon Mining Company
P.O. Box 311
Bingham Canyon, Utah 84006

Re: Final Approval of Plan Amendment, Kennecott Barney's Canyon Mining Company, Barney's Canyon Mine, M/035/009, Salt Lake County, Utah

Dear Mr. Lackey:

The Division has completed its review of the additional information received March 7, 1997, regarding the proposed amendment. This latest information was provided in response to the Division's March 4, 1997 review letter. This additional information satisfies our remaining technical concerns. There are a few minor corrections which will need to be made in this latest redlined submission prior to submitting a clean copy. These corrections are listed separately. Please make the corrections and provide us with a clean version of this volume without redline text within the next 30 days. By this letter, the Division hereby issues final approval of the Amended Mining and Reclamation Plan for the Barneys Canyon Mine. This permit amendment will not result in an increase in the existing reclamation surety amount. Therefore, our approval to begin the proposed operations is effective immediately upon your receipt of this notice.

The Division hereby grants variances to the following rules as requested in this amendment:

R647-4-111.9 Dams and Impoundments. The East Barneys Pit will be allowed to remain as an impounding structure after final reclamation.

R647-111.7 Highwalls. The highwalls in the East Barneys Pit will be allowed to remain at angles steeper than 45 degrees after final reclamation.

If you have any questions in this regard please call me at 538-5286 or Tony Gallegos at 538-5267. Thank you for your patience and cooperation in completing this permitting action.

Sincerely,

D. Wayne Hedberg
Permit Supervisor
Minerals Regulatory Program

jb
Attachment: Review
cc: Kiran Bhayani, DWQ
Minerals Staff (route)
m035009.apv

MINING AND RECLAMATION PLAN

KENNECOTT CORPORATION

BARNEYS CANYON MINE

East Barneys Canyon Project

SUBMITTED TO UTAH DIVISION OF OIL, GAS AND MINING

March 7, 1997

KENNECOTT BARNEYS CANYON MINING COMPANY
P. O. BOX 311
Bingham Canyon, Utah 84006-0311

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1.0 INTRODUCTION

Kennecott Barneys Canyon Mining Company, operates an open pit gold mine and heap leach process facility known as the Barneys Canyon mine. The project mines and processes approximately 2,600,000 tons of ore per year at an average rate of 7,000 tons per day (TPD). The principal project components are the Barneys, Melco, East Barneys and BC North *and* South open pit mines and related mine waste dumps and a processing plant. The processing plant consists of screening, conveying, ore crushing and agglomerating facilities, a number of heap leach pads, a leachate processing plant and refinery, and offices and shops.

Kennecott submitted a Notice of Intent to Commence mining operations to the Division of Oil, Gas and Mining (DOGM) in February, 1988. The NOI was revised in September 1989, again in March 1994. The area being proposed for this amendment is directly adjacent to the study area of the original environmental evaluations.

Kennecott commenced construction of the Barney Canyon Mine in the third quarter of 1988 leading to gold production in the third quarter of 1989.

Kennecott obtained approval from DOGM in December 1992 to modify its Barneys Canyon mining operations beginning in the first quarter of 1993. The modification involved development and operation of two new open pit mines and expansion of the Melco open pit mine. Process plant facilities, ancillary facilities, and mine service facilities were not affected by the changes. The principal project components were the South BC South, the North BC South, and Melco open pit mines and related mine waste dumps and haulage roads. Pre-stripping of topsoil in the BC South area began in the fourth quarter of 1992 and mining commenced in February of 1993. The finalized version of a combined Notice Of Intent was submitted to DOGM in December 1993.

Kennecott intends to modify its Barneys Canyon mining operations by expanding the size and depth of the North BC South and Melco pits, by creating a series of waste dumps north of the current Melco pit, by redesigning the permitted 7200 dump to improve drainage and by constructing a haul road from the north side of the expanded Melco Pit to the North BC South pit (Plate II-C).

This latest revision includes the East Barneys project consisting of a small pit and the associated haul roads. The East Barneys waste will be taken to the Barneys Canyon Pit as backfill. Prestripping for this project is to begin in the first quarter of 1997.

Kennecott requests that its existing permit (reference file number M/035/009) be amended in accordance with the additional operating and reclamation plans presented herein.

1.1 Location

The project area is located on the east flank of the Oquirrh Mountains in Salt Lake County, Utah, approximately 3 miles northwest of Copperton, Utah. The project location is shown on the location map, Figure 1.1-1. Project facilities will be located as follows:

Main Access Road	Township 2 South, Range 2 West, Sections 31 and 32 Township 3 South, Range 2 West, Sections 3, 4, 5, and 6
Plant Site and Barneys Mine Pit and Dump	Township 2 South, Range 2 West, Section 31 Township 2 South, Range 3 West, Section 36 Township 3 South, Range 3 West, Section 1
Melco Mine Pit and Dump	Township 3 South, Range 3 West, Sections and Access Road 1, 2, 3, and 11.
South BC South, North BC South	Township 3 South, Range 3 West, Section 1 and 2 Township 3 South, Range 3 West, Section 1 and 2
BC South Dump	Township 3 South, Range 3 West, Section 1
Melco Mine Pit and Dump and Access Road	Township 3 South, Range 3 West, Sections 1, 2, 3, 10, and 11.
Melco North Dumps	Township 3 South, Range 3 West, Sections 2 and 3 (northern 1/2). Township 2 South, Range 3 West, Sections 34 and 35 (southern 1/8).
Melco 7200 Dump	Township 3 South, Range 3 West, Sections 2 (southern 1/8) and 11 (northwest 1/4).
North Haul Road	Township 3 South, Range 3 West, Section 2 (northern 1/2).
East Barneys Pit	Township 3 South, Range 3 West, Section 1

Project facilities are shown on the Project Facilities Map, Plates I-A & I-B (in pocket).

1.2 Land Ownership

1.2.1 Surface Ownership.

All land surface within the project disturbed area is owned in fee by Kennecott Barneys Canyon Mining Company. A third party, Calvin J. Spratling and William Max Spratling originally owned the roadway and right of way that provided access to a television broadcast tower owned by Station KCPX, located in the northeast quarter of the northeast quarter of Section 34, Township 2 South, Range 3 West. Kennecott, through a land exchange arrangement, has provided an alternate access road to the TV tower site.

Kennecott owns all land that will be disturbed and all land adjacent to the proposed disturbed area. The Surface and Mineral Ownership map (Figure 1.2-1) shows all surface land ownership within an approximate 21-square-mile area around the project site. The names and addresses of adjacent surface land owners whose properties are shown on the land map are listed in Table 1.2.1.

Table 1.2-1 Surface Land Ownership

Name	Address	Comments
Federal Government	BLM - Salt Lake District Office 2370 South 2300 West Salt Lake City, UT 84119	Surface ownership on western boundary of area. Kennecott controls mineral rights via unpatented mining claims.

1.2.2 Subsurface Ownership.

Subsurface land or mineral rights ownership within and immediately adjacent to the ore bodies is also shown on the Surface and Mineral Ownership map (Figure 1.2-1). The names and addresses of the subsurface owners, other than Kennecott, are listed in Table 1.2.2. Kennecott leases mineral rights to the Barneys Canyon deposit from the State of Utah.

Table 1.2-2 Subsurface Ownership

Name	Address	Comments
Leroy E. Everett	411 East 100 South Salt Lake City, UT 84111	Owns 4.17 % mineral interest in large tracts NE, N and NW of the Barneys Canyon mine. Kennecott owns remaining 95.83% mineral interest and 100% surface.
Calvin J. Spratling	Star Route, Box 400 Pendleton, OR 87801	50% mineral interest east of the Barneys Canyon mine , shares ownership with Carla P. Spratling. Kennecott owns remaining 50% mineral interest and 100% surface.
Carla P. Spratling	Star Route Pendleton, OR 87801	50% mineral interest east of the Barneys Canyon mine , shares ownership with C. J. Spratling. Kennecott owns remaining 50% mineral interest and 100% surface.
State of Utah Division of State Lands and Forestry	3 Triad Center, #350 Salt Lake City, UT 84180	State Lease for Metalliferous Minerals: Lease No. 27390, Sec. 36. T. 2S., R. 3W. Kennecott owns 100% surface.

Barton Syndicate	c/o A. Park Smoot Barton Syndicate Trust 765 East Three Fountains Circle No. 33 Murray, UT 84107	Unpatented mining claims and State Lease for Metalliferous Minerals SW of Melco. Under lease to Kennecott. Kennecott and Federal Government own surface.
William Max Spratling	Starr Valley Deeth, NV 89823	50% mineral interest in tract east of the Barneys Canyon mine . Remaining 50% mineral interest owned by Kennecott. Kennecott owns 100% surface.
Richard & Mary L. Kehl	1022 Shields Lane South Jordan, UT 84065	19/60 mineral interest in patented claim NW of Melco, shares ownership with F. & J. Serassio, A. Parsons, D. & J.L. Rudd, and Quality for Animal Life. Kennecott owns 100% surface.
Frank & Julin Serassio	1694 E. Juhlo St. Sandy, UT 84092	39/100 mineral interest in patented claim NW of Melco, shares ownership with above. Kennecott owns 100% surface.
Alan Parsons	724 S. 300 E. Salt Lake City, UT 84111	1/100 mineral interest in patented claim NW of Melco, shares ownership with above. Kennecott owns 100% surface.
Drew & Josephine Rudd	12014 S. Mill Ridge Circle Sandy, UT 84070	1/5 mineral interest in patented claim NW of Melco, shares ownership with above. Kennecott owns 100% surface.

Quality for Animal Life	150 East 1300 South Salt Lake City, UT 84115	5/60 mineral interest in patented claim NW of Melco, shares ownership with above. Kennecott owns 100% surface.

1.2.3 Surface and Mineral Ownership

Parcels for which combined surface and mineral rights are owned by the same individuals are also shown on the Surface and Mineral Ownership map (Figure 1.2-1). The names and addresses of these owners, other than Kennecott, are listed in Table 1.2-3.

Table 1.2-3. Surface and Mineral Ownership

Name	Address	Comments
Evelyn Harmon Est.	C/O Howard H. Haynes, Jr. 2830 E. St.Marys Way Salt Lake City, UT 84108	100 % ownership of small parcel north of the Barneys Canyon mine, shares ownership with E. Daniels Est.
Edith Daniels Est.	C/O Howard H. Haynes, Jr. 2830 E. St.Marys Way Salt Lake City, UT 84108	100 % ownership of small parcel north of the Barneys Canyon mine, shares ownership with E. Harmon Est.
Calvin J.Spratling	Star Route, Box 400 Pendleton, Oregon 87801	100 % ownership of road corridor through project area, shares ownership with W. M. Spratling. Kennecott presently negotiating land swap.

William Max Spratling	Starr Valley Deeth, NV 89823	100 % ownership of road corridor through project area, shares ownership with C. J. Spratling. Kennecott presently negotiating land swap.
Copperton Improvement District	208 South 400 East Copperton, UT 84006	100 % ownership of water well sites east of the Barneys Canyon mine .

1.3 Land Use

The lands in the project site are patent lands under the control of Kennecott. The principal land use at the project site-proper has been for wildlife habitat. The areas that will be developed are currently undeveloped and wildlife usage is relatively high, although recent exploration and mining activity has undoubtedly caused at least local changes in the level of wildlife usage. The wildlife in the area is discussed in Section 2.6. The lands are presently closed to pubic access and, consequently, little hunting occurs here. These lands also are leased for livestock grazing. An access road through the property allows access to the KCPX TV tower on the ridge adjacent to Harkers Canyon (Plate I-A). Land adjacent to the current project access road is under cultivation for wheat.

1.4 Existing Facilities

The locations of existing mine and processing facilities are shown on Plate 96-1. These facilities have been in place since completion of construction in 1989. Development of open pit mines, related mine waste dumps, and leach pads have been in accordance with the development plans approved by the Division. There are no buildings, lakes or reservoirs within the project area or within 500 feet of it. The locations of streams, springs, and wells are discussed in Sections 2.2 and 2.3. Powerline locations are shown on Plate II-A, the Pre-Disturbance Map. There are no other transmission lines in the project area.

1.5 Mineral Exploration

Kennecott commenced mineral exploration on the project in 1981, with drilling beginning in 1985. A total of 215 exploration drill holes ranging in depth from 35 to 976 feet were drilled using rotary reverse circulation and diamond core drilling machines. The Pre-Disturbance site Map, Plate II-A, shows the locations of exploration drill holes outside the mine development area. This map is Confidential. The locations of exploration drill holes have also been provided the Division in previous submittals of exploration Notices of Intent. Areas of more intensive drilling at the sites of the proposed open pits are outlined on the map.

Exploration and delineation of the North BC South and South BC South deposits have been ongoing since 1988. Approximately 214 exploration drill holes defined the two deposits. Exploration drill hole locations were provided to the Division in previous submittals of exploration Notices of Intent and Mineral Exploration Progress Reports.

All drill holes have been or will be plugged according to regulations, unless they have been completed as piezometers. In addition to drilling, a number of trenches were dug with a backhoe, and access roads for drilling equipment were built with bulldozers.

Other exploration work consisted of geologic mapping and sampling.

Ongoing exploration has identified a minable reserve in the East Barneys area. This is approximately 1200 feet south and east of the current entrance to the Barneys Pit. This reserve contains approximately 1.5m tons, consisting of nearly equal amounts of ore, alluvium overburden and rock overburden.

1.6 Utilities and Access

The entire plant site, warehouse, and truck shop are supplied with electricity from Kennecott's Utah Copper Division. The Facilities Layout and Operational Surface Water Management Plan map, Plate III-A, shows the location of the powerline. Propane for heating is supplied to the site via truck. Telephone service is supplied by Mountain Bell. Telephone service is brought to the site via the powerline or access road corridor.

Access to the project area is via an improved access road from Highway 48. The principal access to the Melco mine pit is via a graveled road from Barneys Canyon along the route shown on Plate III-A.

Two short segments of the Melco access road will be realigned to allow for the construction of the North BC South and the South BC South pit.

A new haul road *was* constructed from the north side of the expanded Melco pit to the North BC South pit. This road will provide shorter ore and waste hauls for the duration of the Melco pit life thereby, reducing fuel consumption and PM10 emissions (Plate II-C).

Access to the East Barneys area will be from a haul road currently used to access a permitted clay pit and topsoil stockpile. The road will be widened to accommodate the mining equipment and reclaimed at the end of the project.

2.0 Site Description

2.1 Geology

2.1.1 Geologic Setting

The Barneys Canyon project area is located at the east edge of the Paleozoic core of the Oquirrh Mountains. The surficial geology of the project area is shown on Figure 2.1-1. The Oquirrh Mountains are composed principally of Pennsylvanian and Permian miogeoclinal sedimentary rocks with an aggregate thickness of more than 35,000 feet. The principal rock types are limestones and sandstones that were deposited cyclically.

The Barneys Canyon mine site is underlain by the Permian Kirkman-Diamond Creek and Park City Formations. The Melco pit lies near the contact of the Kirkman-Diamond Creek sandstone and orthoquartzite of the Freeman Peak Formation. These units are moderately to steeply dipping in directions ranging from northwest at Melco to north and northeast at Barneys Canyon. Structurally, the Kirkman-Diamond Creek and the Freeman Peak Formations are part of the footwall plate of the Oquirrh thrust fault (Figure 2.1-1). The Park City Formation occurs at the east side of the Barneys Canyon deposit and has been preserved in a down-faulted block, as shown on the geologic map (Figure 2.1-1). The rock units in the project area are exposed on the "nose" of the north-trending, north-plunging Copperton Anticline and vary in strike across the map (Figure 2.1-1). The stratigraphic units dip moderately to the northeast, north, and northwest. In addition to thrusting, the Paleozoic rocks have been broken by a number of northeast and north-trending, high-angle normal faults (Figure 2.1-1).

The project process facilities are cited on Quaternary alluvial sediments to the east of the bedrock outcrop line. The Pleistocene Harkers Formation alluvium is the dominant type; however, recent alluvium occupies stream channels. These alluvial types are not differentiated on the geologic map, Figure 2.1-1. Tertiary volcanic rocks, comprised chiefly of latitic flows, breccias, and agglomerates crop out to the north and south of the process facilities. The Quaternary alluvium in the process area unconformably overlies the buried volcanic rocks.

2.1.2 Geology of Mineral Deposits

The Barneys and Melco ore bodies will be developed as separate open pits. The Barneys ore body is hosted by the lower Permian Park City and Kirkman-Diamond Creek formations. The host rocks consist of silty dolomite with chert interbeds and calcareous sandstone, respectively, in the two stratigraphic units. The gold-mineralized zone in the Barneys deposit has been extensively oxidized and only minor sulfide minerals are present. Decalcification of dolomite and minor clay alteration of sandstones are the typical alteration products at the deposit. Overburden at the Barneys pit consists of dolomite with chert interbeds and sandstone. Strata dip gently to the north and the maximum ore depth is approximately 600 feet in the northern part of the ore body. Structurally, the deposit has

been faulted by both a low-angle thrust fault and a number of high-angle normal faults. The geology of the Barneys deposit is depicted in cross section on Figure A-I-1 which can be found in Appendix A-I. The contents of Appendix A-I is confidential and is therefore bound separately from the main body of this document.

The Melco ore body, located approximately 1.5 miles southwest of the Barneys deposit, is hosted at a structurally prepared boundary between footwall orthoquartzites of the Freeman Peak Formation and hanging wall calcareous sandstone of the Kirkman-Diamond Creek Formation. Like the Barneys Canyon deposit, the Melco ore body has been extensively oxidized. However, sulfide ore, characterized by the presence of pyrite and marcasite, occurs in the deeper parts of the ore body. Overburden at Melco consists of sandstone and quartzite. The strata hosting the ore body are vertically or near vertically dipping. The geology of the Melco deposit is shown in cross section on Figure A I-2, which can be found in Appendix A-I.

A geologic cross section (A-A') showing the pit geology and the pit outline of the proposed Melco expansion is shown on Figure 2.1-9.

The BC South deposits are hosted in Kirkman-Diamond Creek Sandstone at a structural contact with orthoquartzites of the underlying Freeman Peak Formation (Figure 2.1-10 and 2.1-11). The two deposits are approximately 1,000 feet apart. The relative locations of the deposits are shown on the Geologic Map (Figure 2.1-1). Gold mineralization is hosted in moderately dipping, clay-rich zones of slip and brachiation within interlayed sandstone and orthoquartzite. The rock sequence is very similar to that encountered at the Melco deposit; however, unlike Melco, both ore bodies are almost totally oxidized with only minor (less than 1%) sulfide remaining. Overburden at both deposits consists of sandstone and orthoquartzite which has been locally clay-altered. The overburden in the South BC South deposit is generally much more clay-rich than that in the North BC South deposit, owing to the more extensive brachiation and clay alteration in South BC South. Geologic cross sections of the North BC South and the South BC South deposits, showing the ultimate pit outlines, are found on geologic cross sections C-C' (Figure 2.1-10) and B-B' (Figure 2.1-11), respectively. Figure 2.1-12 is a revised geologic cross section showing the pit geology and outline of the Melco mining phases. The line of cross section is shown on the geologic map (Figure 2.1-13).

The East Barneys Canyon deposit is hosted in the Kirkman-Diamond Creek sandstone. Gold mineralization is hosted in moderately dipping, clay-rich zones of slip and brachiation within interlayed sandstone and orthoquartzite. The rock sequence is very similar to that of the BC South deposit, however, the orebody is totally oxidized. The deposit is overlain by about sixty feet of Quarternary Alluvium composed of sandstone, quartzite and limestones. A Geologic cross section of the East Barneys deposit showing the final pit outline, is denoted a section A-A' on Plate 96-6 and included as Figure 3.2-12.

2.1.3 Subsurface Geology of the Process Facilities Site

The process facilities site is outlined on the geologic map (Figure 2.1-1). Drilling has been done in the process site area both for the purpose of condemnation (determination that economic mineral deposits are not present) and foundation testing. The locations of these drill holes and borings are shown on Plate II-A and geologic logs are presented in Appendix A-II. Condemnation drilling by Kennecott in the process plant area has consisted of three rotary-reverse circulation drill holes. Geologic logs of two holes, BC-148 and BC-150 are available. Foundation investigation studies by Sergent, Hauskins, and Beckwith (SHB) led to the drilling of a number of test borings and test pits. The locations of the deeper auger borings are also shown on Plate II-A. Additional geologic data comes from logs of water supply wells in the area. The locations of water supply wells used in evaluating the site geology are shown on Plate II-A, the Pre-Disturbance Site Map. Sources of groundwater information for the area are discussed in Section 2.3.

No faults or other geologic structures have been identified by the limited amount of drilling that has been done in the process site area. Mapped geologic structures in the Permian-aged bedrock to the west of the site (Figure 2.1-1) are not known to have been active since the mid-Tertiary or before.

A number of geologic cross sections through the proposed process facility area have been prepared using available geologic logs. The lines of section are shown on Plates I-A and II-A. The sections are shown on Figures 2.1-2 through 2.1-7. The scales, both vertical and horizontal, of the sections are variable depending on the length of the section and topographic relief along the line of section. Hence in making direct comparisons between sections, the effects of scale changes must be taken into account. The explanation for the symbols used in the cross sections is shown on Figure 2.1-8.

Cross sections A-A' (Figure 2.1-2) and A-A" (Figure 2.1-3) are northwest trending sections drawn through the process site condemnation holes and then more than a mile southeast of the site through wells K-405 and W-32, respectively. The lines of section for each of these cross sections are shown on Plate I-A. Well K-405 is a Kennecott water production well drilled adjacent to the new Copperton Concentrator. Well W-32 is one of the two Copperton community water supply wells. These sections show that the alluvial deposits near the project site were deposited on a pediment of underlying volcanic rocks and that the dominant bedrock in the area is Tertiary volcanic flows. These sections also depict the aquifer types in the project area. In drill holes BC-148 and BC-150, the occurrence of clays identified in the rotary drill cuttings are interpreted to represent air-fall tuff beds. In each drill hole, the groundwater surface is closely associated with a tuff-derived clay layer. As discussed in Section 2.3, hydrogeologic data suggest that tuff beds in the volcanic flow sequence serve, at least locally, as confining beds or aquitards.

The geologic log of well W-32 describes volcanic rocks, presumably Tertiary in age, overlying clay-dominant sediments described as lake bed sediments and presumably of Pleistocene age. The most reasonable explanation of this incongruity seems to be that the volcanics were deposited on top of the apparent Lake bed sediments by a debris flow or other mass movement. The description in the log of "rocks in mud" within occurrence

interval of the volcanic rocks supports this contention.

Cross section A-A''' (Figure 2.1-4) is a northwest-trending section that extends across the entire process area. Again, the relationship of the ground water surface to the volcanic tuff layers in the volcanic flows is apparent. Because the condemnation holes were drilled by a rotary drill, detailed logs of the unconsolidated alluvium were not prepared. The logs of the auger holes are, as a result of the drilling method, more detailed. Attempts to correlate alluvial lithologies between foundation borings were made, as the section shows; however, the drill hole density and variability in lithologies makes such interpretation difficult. It is significant that of the seven borings depicted on Section A-A''' (Figure 2.1-4), five have clay as their uppermost lithology. Each of these five borings are located on hilltops or hillsides. This relationship is displayed in most borings similarly located in the process site area.

Cross section B-B' (Figure 2.1-5) is a northeast-trending section through the western-most proposed leach pad site.

Cross sections C-C' (Figure 2.1-6) and C'-C'' (Figure 2.1-7) are, respectively, northwest and northeast-trending sections in the area of the eastern-most leach pad sites. Again, as was the case in section A-A''' (Figure 2.1-4), lithologic correlation between drill holes is difficult. The geologic occurrence of very minor perched groundwater is depicted in these cross sections. This perched groundwater is discussed further in Section 2.3.

2.1.4 Seismicity

The site is located near the eastern boundary of the seismically active Basin and Range Province. Regional seismicity maps have been compiled for Utah based on historic data from 1850 to 1980 (SHB, 1988). Small to moderate sized earthquakes are numerous in the State and are largely associated with the Wasatch fault zone and Basin and Range faults such as those on the west side of the Oquirrh Range. The closest recorded earthquake was a 1962 magnitude 5.2 event in Magna approximately 9 miles north of the site.

Two mapped fault systems with Holocene activity are near the site. They are the Wasatch Fault about 16 miles to the east, and the frontal fault of the Oquirrh Range about 5 miles west of the site. The seismicity in the Magna area suggests the possibility of active faulting; however, interpretation of low-sun angle aerial photographs and aerial infrared photography indicate that there is no surface rupture in the Magna area (SHB, 1988). This has been interpreted as evidence that there have been no events larger than magnitude 6.0 near the site area during the late Quaternary.

The site does lie within the UBC-3 seismic zone and maximum credible earthquakes for various faults in the area have been calculated. The estimated horizontal bedrock acceleration resulting from a maximum credible earthquake of Magnitude 7.6 for the Wasatch Fault was used for the project site. An effective peak horizontal ground acceleration of 0.18g (corresponding to a 500 year recurrence interval) was used for the earthquake design evaluation. The earthquake design evaluation indicated that permanent

deformations under this design acceleration value would be less than six inches, which is considered well within safe limits. It was also determined that major earthquakes generating accelerations of 0.2g to 0.3g would probably create slides of sufficient mass to damage the pad liner. The recurrence interval of these events is estimated at 600 to 1200 years; thus, a small risk of earthquake-induced liner damage is inherent with the use of heap placement by dumping (SHB, 1988)

2.2 Surface Water Hydrology

The mean annual precipitation in the Barneys Canyon project area is 16 inches (Dames and Moore, 1988). Approximately one third of the precipitation falls as snow from December through March and the remainder falls as rain, predominately in the Spring. Summer precipitation is largely characterized by thunderstorms influenced by the orographic effects of the Oquirrh Mountains (SCS, 1974). Annual snowfall along the Oquirrh Mountain foothills is approximately 81 inches (Dames and Moore, 1988).

Surface water drainage around the Barneys Canyon project site is governed by the north-south trending Oquirrh Mountains. These mountains rise to an elevation of 9,000+ feet AMSL (above mean sea level) or approximately 5,000 feet above the 4,300 feet AMSL Salt Lake Valley.

The Barneys Canyon Project site lies along the southeastern flank of the Oquirrh Mountains. Barneys Creek, which flows from Barneys Canyon, is intermittent at its headwaters and perennial over a two mile reach adjacent to the project area. Direction of flow is from west to east where runoff contributes to the Jordan River located roughly five miles away. Continuous stream gauging has never been performed on Barneys Creek. Other small, intermittent and ephemeral drainages in the project area are localized by the topography of the Barneys Canyon project site which consists of low hills sloping easterly at a gradient of about 10%. Elevations rage from 5700 feet to 7000 feet along these foothills. Many small valleys with watershed areas less than one square mile run through the site. Because of their small drainage areas, runoff from these ephemeral channels is small.

The Melco pit site is located on the drainage divide (el. 7600 top) south of Barneys Canyon and at the head of a small tributary to Dry Fork. Dry Fork is ephemeral and the runoff from the watershed formerly drained into Bingham Creek approximately two miles south (Figure 1.1-1). A waste rock dump of Kennecott's Bingham Canyon mine now fully impounds Dry Fork below the Melco pit and dumps. The Melco waste dump will lie on the southeastern edge of this ridge approximately 2500 feet southeast of the pit area. Water from this area drains into the Dry Fork basin.

Surface water quality has been analyzed from several of the springs in the area. Barneys Spring (S-318) (Figure 2.3-1)) is located approximately 1.2 miles southeast of the project area. Water quality analyses indicate high levels of total dissolved solids (TDS) (1,890 - 2,200 mg/l), chlorides (304 - 502 mg/l), and sulfates (187 - 263 mg/l). Water pH ranged from 7.3 to 8.3. Barneys Spring is believed to originate from the Tertiary Volcanics. Crystal Spring (S-316) and Maple Spring (S-319), located 2 and 4.5 miles respectively,

northwest of the project site, were also analyzed for water quality. The data indicate both springs emit good quality water within the standards set by the Utah Department of Environmental Quality. These springs appear to emanate from the Pennsylvanian-age, White Pine Formation. Bancroft Spring emanates in the small valley south of the proposed leach pad area (Plate II-A) and provides a source of flow in that drainage for part of the year. Bancroft Spring appears to result from infiltrating subsurface flow in alluvial fill being intercepted by a buried occurrence of quartz latite which occurs at the location of the spring. Flow rates from this spring have been estimated at 30 gallons per minute, though the consistency of this flow rate is unknown. Aquifer recharge from this spring is probably low due to the low permeability of the volcanic aquifer. This spring has been sampled for water quality parameters and falls within Utah Department of Environmental Quality standards. The Barneys Canyon tunnel water source, located approximately two miles southeast of the project area (Plate II-A), is of drinking water quality and has been used as culinary water at the Geology Building, Precipitation Plant, Lead Mine townsite and the uranium extraction plant. Currently this water is directed to Kennecott's Copperton concentrating facility and is being used as process water. A summary of this water quality analysis may be found in Appendix B (Dames and Moore, 1988).

Several surface water sites have in the past been analyzed for water quality downgradient of the Melco mine site. Historic concentration levels from surface water sample sites S-29, S-59, S-59a, K-61, K-78, K-79, and K-102 indicate a wide range: TDS (1,300 - 46,500 mg/l), sulfate (8,600 - 17,800 mg/l), copper (6 - 11.2 mg/l), chloride (1,300 - 2,030 mg/l) and very low pH values near 3.0. A complete listing of these values may be found in Appendix B (Dames and Moore, 1988). Water quality data for Dry Fork Creek East (S-59) indicate low to moderate levels of TDS, sulfate and chloride but there are unexplained fluctuations in the values listed (Appendix B). At the Dry Fork shops site (S-29), located further downgradient, good water quality generally exists with TDS from 281 - 1,110 mg/l. Sulfate and chloride levels were also low (Appendix B) (Dames and Moore, 1988).

Modifications to natural surface water flow patterns, which have resulted from mining activities to date have been largely as predicted. A description of these modifications has been incorporated into the discussion of operational runoff controls presented in Section 3.10 of this amendment.

The Melco north dumps are located in Barneys Canyon and will affect approximately 7000 feet of the intermittent and perennial Barneys Creek. the waste dumps will be constructed in accordance with the Utah Division of Water Quality ground water discharge permit.

2.3 Groundwater Hydrology

2.3.1 Regional Aquifer Characteristics

The Barneys Canyon Pit and heap leaching facilities are located north of the mouth of Barneys Canyon along the eastern flank of the Oquirrh Mountains, Salt Lake County, Utah. Groundwater generally flows in an easterly direction from the Oquirrh Mountains toward the Jordan River. Depth to the water table in this part of the Salt Lake Valley generally increases with the rise in topographic elevation. Therefore, groundwater depths will be greatest near the mountains and shallower as distance from the mountains increases. This occurrence is characteristic of a groundwater recharge area (Waddell, Seiler and Solomon, 1987).

The aquifer materials along the margins of the Salt Lake Valley are characterized by thick unconsolidated alluvial sand and gravel deposits containing lenses and beds of finer grained sands, silts and clays. The aquifers along the valley margins are generally unconfined and are recharged from precipitation, seepage from ephemeral streams, irrigation ditches, ponds and reservoirs, and seepage from bedrock. Recharge from the bedrock is believed to contribute the greatest volume of water (approximately 45% of total recharge) to the valley-fill aquifer. The bedrock is predominantly recharged in the upper elevations of the Oquirrh Mountains (Waddell et al, 1987).

Pump tests have been performed on the coarse grained unconsolidated aquifer beneath the valley bench near Bingham Canyon. The hydraulic conductivity of the aquifer material has been estimated to range from 1.0×10^{-4} to 3.5×10^{-4} feet per second. Hydraulic gradients are estimated at 0.063 and substratum porosity is approximately 30 percent. Using these figures as a basis for the Barneys Canyon area, average linear groundwater velocities could range from 660 to 2300 feet per year (Waddell, Seiler and Solomon, 1987).

Groundwater quality has also been characterized at several locations downgradient and north of Barneys Canyon. Water analyses show a total dissolved solids concentration ranging from 430 to 910 milligrams per liter. These dissolved constituents are dominated by calcium, magnesium, bicarbonate, and chloride.

The Melco Pit and waste dump is located near the topographic divide between Barneys Canyon on the north and Dry Fork on the south. Direction of groundwater flow from this ridge is expected to be generally subparallel to the ground surface. As an upland recharge area, groundwater depths are great (approximately 600 feet) and hydraulic gradients would be expected to be higher than gradients on the bench. The bedrock aquifer is comprised of fractured sandstone and limestone.

2.3.2 Local Recharge Characteristics

The rate of groundwater recharge is dependent on the hydraulic characteristics of the surficial soil, underlying unconsolidated sediments and bedrock. Descriptions of the surficial soils by the Soil Conservation Service (SCS) indicate clay and silt loams are present in the Barneys Canyon project area. Infiltration rate is moderate (0.5 - 2.0 inches

per hour) and permeability is slow to moderately slow (SCS, 1974). Runoff from precipitation events is rapid as these fine-grained soil layers limit the infiltration and percolation of water downward into the soil horizon. Laboratory permeability tests were also conducted on samples of compacted surficial soils obtained from the leach pad areas; Table 2.3-1 lists the results of these tests. The soils from the surface to a depth of 3 feet were classified as silty to gravelly clay with compacted permeabilities ranging from 1.1 x 10^{-5} to less than 1 x 10^{-7} cm/sec.

Table 2.3-1 Permeability of Leach Pad Area Surficial Soils

Sample Site	Sample Depth	Material	Permeability(cm/sec)
TP-1	0.5-1.5	Silty Clay	< 1 x 10^{-7}
TP-5	0.5-2.0	Clay with fine sand	1.1 x 10^{-6}
TP-6	0.5-2.0	Sandy clay with gravel	< 1 x 10^{-7}
TP-11	0.5-2.0	Sandy clay with gravel	< 1 x 10^{-7}
TP-12	1.0-3.0	Gravelly clay with sand	1.1 x 10^{-5}

Beneath the surficial soils, the unconsolidated alluvium consists of highly variable, layers of clay, silt, sand, gravel, cobbles, and boulders. Most of the material encountered is poorly sorted including clay, silt, sand and gravel. As discussed in Section 2.1, clay or clay-rich sediments appear to be the dominant material types in the alluvium on site. The stratification of the layers is highly variable and wide changes in strata thickness occur laterally, as indicated by the geologic cross sections illustrated in Figures 2.1-2 through 2.1-8. The permeability of these materials was tested in-situ through the use of packer tests in intervals up to depths of 65 feet. Table 2.3-2 shows the results of this testwork. The measured permeabilities range from 3.9 x 10^{-4} to 6.9 x 10^{-6} cm/sec.

The lower permeability strata in the alluvium would tend to impede vertical flow of recharge water and form perched water tables. The auger drilling conducted in the alluvium did encounter isolated saturated conditions in four borings where the water was perched above the deeper bedrock aquifer within gravelly clay or sandy gravel between clay layers. The locations and depth of the water table are as follows: B-2 water depth 26.5 feet, B-2B water depth 22.7 feet, B-3 water depth 26.9 feet, and B-24 water depth 46.7 feet. Geologic cross sections in Figures 2.1-6 and 2.1-7 show the relationship of the perched water to the alluvial lithologies. The occurrence of these perched saturated conditions is not considered to be significant as the lateral extent of these conditions is limited.

Table 2.3-2 Permeability of Leach Pad Area Alluvium

Boring	Interval (feet)	Material	Permeability(cm/sec)
B-1-MW	36.3-40.6	Gravelly clayey sand	1.5×10^{-5}
B-2B-MW	36.0-40.0	Sandy clayey gravel	3.9×10^{-4}
B-5-MW	61.5-65.3	Sandy gravel with clay	1.3×10^{-4}
B-8-MW	26.1-30.2	Sandy clay and gravel	3.2×10^{-5}
B-10-MW	21.0-25.0	Sandy gravel with clay	8.5×10^{-5}
B-13-MW	40.8-45.2	Clayey sandy gravel	6.9×10^{-6}
B-14-MW	41.4-45.5	Gravel with sand and clay	3.4×10^{-4}
B-16-MW	26.1-30.3	Clayey gravel with sand	1.3×10^{-4}
B-20-MW	26.0-30.0	Clayey sand with gravel	1.9×10^{-4}
B-22-MW	26.0-29.9	Clayey sand with gravel	2.2×10^{-4}

Aquifer recharge takes place from precipitation, seepage from ephemeral streams, seepage from ponds, reservoirs, irrigation ditches and from springs. Since no ponds, reservoirs, or irrigation ditches are located within the project area, precipitation events alone define the quantity of water available for recharge. Barneys Creek running from Barneys Canyon is an ephemeral stream and likely contributes measurable quantities of recharge water to the aquifer during spring snowmelt and runoff events although these events are short lived and the total amount of recharge contributed by surface seepage into the alluvium appears to be limited.

Most of the groundwater recharge takes place in the higher elevations of the Oquirrh Mountains (Waddell, Seiler and Solomon, 1987). In these areas, shallow soils and fractured bedrock allow for rapid percolation of snowmelt and rain into the aquifer below. This recharge water flows down from the mountains and enters the valley fill underground. Therefore, groundwater flowing beneath the Barneys Canyon project area is mainly recharged from higher elevations while little recharge actually takes place in the project area.

2.3.3 Local Aquifer Characteristics

A total of 11 deep monitoring wells have been installed at the Melco and Barneys Canyon pit areas, the leach facility area, and nearby at the Utah Copper Concentrator. Table 2.3-3 lists these holes and the depths to the water table. Contouring the water elevation data from these holes shows that the main water table surface subparallels the land surface at the Barneys Canyon project site (Figure 2.3-1). From the proposed mine area, flow is generally eastward toward the Jordan River. The hydraulic gradient at the leach pad site is steep, at around 0.1 ft/ft, but decreases to about 0.03ft/ft under the 5,300 topographic contour about one mile east of the leach pads. Water table depths vary from 600 feet at the Melco Pit site to between 140 to 350 feet below the ground surface in the Barneys Canyon Pit area. Water table depths in the leach pad area range from 145 to 160 feet below the ground surface (Dames and Moore, 1988).

The main aquifer is composed of volcanic rocks consisting of andesite, latite

porphyry, latite tuff, and dacite. Aquifer tests from wells near the Utah Copper Concentrator located about 1.5 miles from the project site reveal aquifer permeabilities in the volcanic rocks range from 0.098 - 3.0 feet/day. However, aquifer tests of drill holes BC-148 and BC-150, located at the Barneys leach facility, indicate hydraulic conductivities of 6×10^{-3} ft/day and 1×10^{-4} ft/day respectively which are considerably less than the down-gradient well. Therefore, given a hydraulic gradient of 10% and a porosity of 0.3, calculated rates of bedrock groundwater flow velocity under the leach pad area would range from 0.01 to 0.12 feet per year.

Certain site specific data suggest that the bedrock aquifer in the vicinity of the leach facilities is confined. The Kennecott drill hole BC-148 encountered water during drilling at a depth of 165 feet, immediately beneath a clay-rich volcanic ash bed. Subsequent measurements of the water level in this hole have revealed depths to the water from 122 to 123 feet which would indicate that the bedrock aquifer in this hole is confined. To better quantify the hydraulic characteristics of the aquifer below the Barneys Canyon facilities, all future monitoring and water wells drilled in the area will be field tested using pump tests, packer tests or slug tests.

The other leach facility drill hole, BC-150, located about 1 mile downgradient from BC-148, also encountered a clay-rich ash zone above the water table, although the water table in this location is beneath the bottom of the clay zone. This clay zone may be equivalent to that which forms the aquitard in BC-148 and may also act as an aquitard in this location.

Table 2.3-3 Water Table Depths in Project Area

Drill Hole	Surface El.(ft.)	Water Depth(ft.)	Water El.(ft.)
BC-65	6623.1	356.7	6266.4
BC-68	6564.4	292.	6272.4
BC-69	6280.	136.6	6143.4
BC-71	6374.8	157.6	6217.2
MC-31	7422.	595.9	6826.1
BC-148	6170.1	123.2	6046.9
BC-150		125.	
BC-153		160.	
W-31	5368.	140.	5228.
W-32	5313.	87.	5226.
K-404	5620.	124.4	5495.6
K-405	5560.	296.	5264.0

Maple and Crystal Springs, draining groundwater from the Pennsylvanian-age, White Pine Formation, are upgradient of the Barneys Canyon project site. Bancroft Spring is located approximately 900 feet south of the leach pad area. Investigations on the water quality and yield of this spring are in progress and information will be provided when available.

The Melco Pit site is located along a topographic divide along the southern border of Barneys Canyon. The upper portion of the mine pit area rests about 1,000 feet higher than the Barneys Canyon Pit site. The potentiometric surface beneath the ridge lies at a depth of approximately 600 feet below the topographic surface. The aquifer is made up of Kirkman, Clinker and Curry Formations which typically have quite low permeabilities. Since no aquifer tests have been done at this site, permeabilities are estimated to be the same as the aquifer beneath Barneys project site. Assuming a hydraulic gradient of 10% and a porosity of 30%, groundwater flow velocities would not significantly differ from those calculated at the Barneys Canyon project area.(Dames and Moore, 1988)

Extensive additional exploration drilling in and around the Melco pit area indicates that the water level measured in hold MC-31 was a localized anomaly and that the water table is below the 6400 feet AMSL.

2.3.4 Baseline Groundwater Quality

Recent characterization of the groundwater quality from wells and springs near the Barneys Canyon Project area has been performed. Since few activities have occurred north of Bingham Canyon along the base of the Oquirrh Mountains, groundwater quality has likely remained unaffected by man's activities.

Water quality analyses performed on the wells at the new Utah Copper Concentrator (W-31 and W-32-A), three monitoring wells located 1 to 3 miles downgradient of the project site (P-275, P-276, and P-278B) and Barneys Spring (S-318), indicate that groundwater quality downgradient is generally good with the exception of high concentrations of chlorides (200 - 500 mg/l) and high total dissolved solids (TDS)(1039 - 1650 mg/l) (Appendix B). Values greater than 500 mg/l exceed secondary drinking water standards. Water quality analyses from samples taken from monitoring wells BC - 148 and BC - 150 west and south of the leach pad area indicate groundwater quality is good. TDS values range from 825 to 904 mg/l. Field electrical conductivity measurements in these wells were 1100 and 1610 umhos (see Appendix B). Water quality analyses were conducted on samples for Bancroft Spring, located south of the proposed leach pads. Water quality in this spring reflects many of the same general chemical concentrations as was found in the other springs and wells. The results of this analysis may be found in Appendix B.

Baseline groundwater quality parameters have not been examined at the Melco Pit site. The nearest locations from which water quality data has been investigated is 2.3 miles downgradient of the pit in the Dry Fork Creek drainage basin (Figure 2.3-1), southeast of the Mel-Co Pit site. In 1976, concentration levels of TDS (1,300 - 46,500 mg/l), sulfate (8,600 - 17,800 mg/l), copper (6 -11.2 mg/l), chloride (1,300 - 2,030 mg/l) and very low pH values near 3.0 were encountered (Dames and Moore, 1988). A complete listing of these values may be found in Appendix B.

None of the wells or springs sampled during the baseline investigations occur in the vicinity of either the Melco pit or the site of the planned BC South pits. Kennecott monitors wells located near the existing heap leach facilities. These results are regularly reported to the Division of Water Quality. No significant changes in water quality have been documented; however, because a much greater number of samples have been taken, a more statistically significant background data base has been established. These data are available either from the files of Kennecott or the Division of Water Quality.

2.3.5 Melco and BC South Deposit Area Aquifer Characteristics

The enlarged Melco pit and the BC South pits are not predicted to encounter the local water table, based upon comparison of the planned pit-bottom elevations with the ground water elevation contour map and data gathered from exploration drill holes.

The bottom of the expanded Melco pit will be at approximately 6460 feet AMSL. Extensive additional exploration drilling in the area indicates that the water level measured in hole MC-31 was a localized anomaly and that the water table is below 6400 feet AMSL. To date, no significant quantities of water have been intercepted in the planned pit area.

The water table in the vicinity of the BC South deposits is estimated to occur within an elevation range of 6200 to 6400 feet AMSL, according to information provided in the 1989 NOI. The final pit depths for the North BC South and South BC South pits are estimated to be 6475 feet AMSL and 6575 feet AMSL, respectively. No water was

encountered in exploratory drill holes within the proposed limits of the North BC South pit. Minor amounts of water were encountered during drilling within the proposed South BC South pit area. These occurrences were found at relatively shallow depths in five closely spaced drill holes near the south edge of the deposit (Figure 2.3-2). As Figure 2.3-2 shows, the three northeastern drill holes found water at depths ranging from 15 to 55 feet while the two holes located further to the west encountered water at depths of 145 to 225 feet. The water flow rates shown on Figure 2.3-2 represent flows at the wellhead estimated by Kennecott geologists during drilling by air rotary methods. None of the holes flowed due to artesian conditions. The deepest of these occurrences was encountered at an elevation of 6800 feet AMSL, approximately 500 feet above the predicted water table elevation. These water occurrences probably represent two perched horizons of limited extent as depicted in the cross section shown on Figure 2.3-3. These water occurrences are found in the clay-altered quartzite which comprises the ore and waste in the southwest corner of the deposit where the perched zones are clustered. The strata in the BC South pit area dip moderately to the northeast (Figure 2.1-2), suggesting that the perched horizons are probably not controlled by bedding planes. No other information on the geologic setting of these occurrences is known. The proposed open pit does not reach the identified perched water occurrences in the immediate vicinity of the five exploration drill holes (Figure 2.3-3). The open pit will reach the elevation of these perched occurrences several hundred feet to the north of the boreholes, but no exploration holes in this part of the proposed pit encountered water (Figure 2.3-2). It is unlikely that the pit will encounter the perched ground water zones found by the five exploration holes drilled near the south margin of the site of the BC South pit. The water encountered is very localized, perhaps trapped by clay zones in the altered bedrock.

2.3.6 East Barneys Aquifer Characteristics

Drilling at the East Barneys deposit has encountered water at two levels: along the alluvium-bedrock contact and at a sub surface water table about 60 feet below the designed pit bottom. No subsurface aquifers are expected to be encountered below the bedrock contact in the pit area.

2.4 Soils

2.4.1 Technical Approach

A soil survey was conducted by JBR Consultants Group in October-November, 1987 at the Barneys Canyon project site. This survey was supplemented and expanded in October, 1991. The SCS Soil Survey of Salt Lake Area, Utah was used as the basis for the ground survey. Pits or fresh road cuts were used to obtain profile descriptions and define the actual soil boundaries on the project site. Soil samples were obtained and sent to a commercial laboratory for fertility analyses. The average surface layer and subsurface layer thicknesses were used to define potential maximum topsoil depths.

In September 1993, an additional supplemental field soil investigation was conducted by JBR Consultants Group to include soils in the proposed mining expansion area in Barneys Canyon. This investigation consisted of verification and/or refinement, as necessary, of the 1987/91 soils maps and collection of topsoil samples for lab analysis in the area of proposed new developments in Barneys Canyon.

As a result of this supplemental investigation, some minor modifications have been made to the original soils map, resulting in the new Melco Area Soils Map (Plate III-C). The types and quantities of topsoil in the 1993 survey (the Melco expansion area) are detailed in table 2.4-1.

Nutrient and sodium absorption ratio (SAR) analyses were conducted on topsoil samples to determine if any amendments to the topsoil would be needed during reclamation. Topsoil depths were also measured and were determined to be approximately the same as those listed in the previous 1987 - 91 studies.

2.4.2 Soil Types

The soils on the east slope of the Oquirrh Range are derived from mixed sedimentary rocks or the alluvium and colluvium from mixed sedimentary rocks. The soils of the 1993 extended project area all lie above 6,300 feet AMSL and, thus, were not influenced by the prehistoric Lake Bonneville. The soils are calcareous throughout with additional, but variable, lime accumulation in the C horizons. The B horizons are well developed in the deeper soils.

Plate IV-A presents the soil map for the initial project area. Five soil associations occur within the project area. The Agassiz-Bradshaw Association is found on steep slopes in the Melco pit area. The Fitzgerald soils are found on the north-facing slopes with fir forests. The Gappmayer-Wallsburg Association is found on ridges along the Melco haul road. The Harker soils are found in the Barneys Canyon pit and dump areas. The Dry Creek-Copperton Association is found on the lower slopes where the leach pads will be sited.

Plate III-B presents the baseline soil map for the BC South and the expanded Melco project areas. Two soil associations (Bradshaw-Agassiz Association and Gappmayer-Wallsburg Association) occur within these project areas.

Plate III-C is the modified soil map for the study area. Two main soil association were surveyed in the Barneys Canyon extended study area. Both the Bradshaw-Agassiz and the Gappmayer-Wallsburg associations are found on the steep south-facing slopes of Barneys canyon. In addition, five main soil series have been identified in the Barneys Canyon study area. In general, within this study area, soil types are closely associated with vegetation types. Agassiz soils are found on the convex portions of the long, steep, south-facing slopes in the study area. Bradshaw soils occur in association with Agassiz

soils occupying the concave portions of steep, south-facing slopes. Daybell soils are located on east and north-facin gslopes and are usually defined by the aspen groves they support. Fitzgerald soils are found on the steep north-facing slopes in association with conifer and aspen forests. Gappmayer soils are found on less steep north-facing slopes at lower elevations.

In addition to the five main soil types identified in Barneys Canyon, there are three soil types of minor occurrence. The Wallsburg soils occur with the Gappmayer soils usually occupying ridge tops and the upper parts of steep slopes. Rock outcrops are found throughout the study area on mountain crests and ridges. Deep alluvial soils occur in the drainage bottoms.

The full profile descriptions for the soil associations can be found in Appendix C-II. Detailed descriptions of each soil association are presented below.

The soil chemistry descriptions can be found in Appendix C-III. Detailed descriptions of each soil association are presented below.

Laboratory reports for soil fertility and chemistry are presented in Appendix C-III. In general, the results of the laboratory analyses indicate that the soils available for salvage are of good quality having good nutrient values. Organic matter content is generally high. The soils are generally neutral and have high cation exchange ratios. Phosphorus contents are normal, ranging from 804 to 872 mg/kg. Despite the high chemical quality of the topsoil, much of the topsoil is not suitable for salvaging because of the high quantity of rock fragments, steep slopes, or shallow solum profiles.

Bradshaw-Agassiz Association

Bradshaw

Bradshaw soils occur in association with Agassiz soils occupying the concave portions of steep, south-facing slopes. Taller oak and maple/chokecherry stands indicate the presence of Bradshaw soils. The surface layer is very cobbly silt loam as is the lighter colored subsurface layer. The horizons are weakly developed. The substratum is colluvium developed from limestone and quartzite. According to the SCS the potential for erosion is high. While these soils have relatively poor quality topsoils, the greater depths of the solum, and thus greater volume of soil available, makes stripping desirable. Topsoil depth averages 20 inches but approaches 50 inches in the small drainages and near the bottom of slopes. Stripping would be difficult on the steep slopes but perhaps 70% of the potential topsoil could be recovered, especially if the stripping operation concentrated on the areas of deepest soils. Topsoil quality is rated poor due to excessive amounts of gravels and cobbles in the profile but the soil materials are very fertile as evidenced by increased plant growth in comparison to Agassiz soils.

Agassiz

Agassiz soils are found on the convex portions of the long, steep, south-facing slopes in the study area. The scrubby low-growth of gambel oak indicates that these soils are shallow and low in fertility. The topsoil depth is generally equal to the solum depth, averaging 10 - 12 inches. The quality is poor due to excessive gravel and cobbles in the profile. The SCS describes the potential for erosion as high. Generally it would be unprofitable to strip these soils due to the steepness of the sites and the difficulty of removing the low oak cover. If these soils are to be stripped, the crests of the convex slopes where the soil is shallowest should be avoided.

Daybell

These soils are located on east- and north-facing slopes and are usually defined by the aspen groves they support. However, some Daybell soils also support a mixed stand of conifers and aspen. The Daybell series consists of somewhat excessively drained soils. These soils developed in residuum and colluvium from mixed sedimentary rocks. Slopes range from 40 to 70 percent. The surface layer is dark grayish-brown silt loam and varies greatly from 2 - 29 inches but averages 12 inches. Subsurface layers range from brown to light yellowish-brown very cobbly light sandy loam to a depth of 60 inches or more. The topsoil quality is fair as fertility is good but the soil is excessively gravelly. The topsoil texture is good enough, however, for stripping and should be recovered where feasible. Stripping will only be feasible on the deeper profiles found on the lower portions of the slopes. The removal of aspen and conifer trees will account for about 6 - 9 inches of soil loss, reducing the available topsoil by 30 - 50 percent, depending on the depth of the profile.

Fitzgerald

These soils are found on north-facing slopes where conifer stands are prevalent. The surface layers are dark grayish-brown gravelly loam and the subsurface layers are yellowish-brown gravelly silt loam. The substratum is colluvium and residuum from mixed sedimentary rocks. The SCS lists the potential for erosion as high for this soil type. The average topsoil depth is 18 inches but varies from 10 - 30 inches; the marker of the bottom of the topsoil is the presence of rocks and a yellow-brown sub-soil. The topsoil quality is fair; the presence of excessive gravels lowers the overall quality rating. While soils will be lost when the trees are removed, efforts should be made to recover the remaining soil, especially in the areas of deeper soils.

Gappmayer-Wallsburg Association

Gappmayer

Gappmayer soils are found on the less steep slopes at the lower elevations of the study area. The parent material is colluvium and residuum from mixed sedimentary rocks. The surface layer is very cobbly loam and gravelly silt loam and the subsurface layers are very gravelly silt loam. The SCS states that the potential for erosion is moderate. The mean thickness of this soil unit is 20 inches. It usually supports shrubs and grass but it does extend into the lower elevation conifer stands in some areas. It also forms an ecotone with the Fitzgerald soils. The topsoil quality rating is poor due to the presence of excessive gravels or cobbles. However, the silt loam texture provides a good base for soil fertility. Because this occurs on less rigorous sites it will be easier to strip and recover most of the available topsoil from this unit.

Wallsburg

Wallsburg soils are of minor occurrence in Barneys Canyon. They occur with the Gappmayer soils usually occupying the ridge tops and upper parts of steep slopes. The parent material is colluvium and residuum from mixed sedimentary rocks. The surface layers are very cobbly loam while the subsurface layers are very cobbly silty loam. Bedrock is present at 17 inches. The depth of topsoil is about 15 inches. The potential for erosion is described as high by the SCS. Wallsburg soils are rated unsuitable for topsoil due to the presence of excessive cobblestones throughout the profile. Topsoil from this series should not be considered for stripping.

Rock Outcrops

Rock Outcrops are on ridge-tops and on steep slopes. The crests of the ridges are generally marked by the growth of mountain mahogany shrubs that manage to grow in the rock fractures. These sites have no appreciable soil and should not be considered suitable for stripping.

Alluvial Soil

These soils occur in the drainage bottoms in Barneys Canyon. They are generally deep and very fertile throughout their profile. The range of depths observed during the survey was from 12 to 72 inches. An average depth could not be determined given the small number of observation points and the wide, erratic range of depths observed. Topsoil quality is excellent and these soils should be recovered completely and stockpiled for future reclamation efforts. These soils can be mixed with lesser quality topsoil materials to increase the fertility and volume of the topsoil materials suitable for reclamation.

Table 2.4-1 Summary of Topsoil Materials in the Melco Study Area

Soil	Terrain	Quality	Texture	Mean Depth (inches)	Area (Acres)	Marker*	Salvageable Volume** (CY)
Outcrops	Ridge crests	Unsuitable	Rocky	0	61	None	0
Alluvial	Drainages	Excellent	Silt and clay loams	42	63	Gravel beds	249,018
Agassiz	Steep convex slopes, south aspect	Poor	Gravelly loam	10	120	Bedrock	112,929
Bradshaw	Steep concave slopes, south aspect	Poor	Gravelly/ cobbly silt loam	20	153	Excess gravel	287,986
Daybell	Steep slopes, north aspect	Fair	Gravelly silt loam	12	75	Sandy loam	84,700
Fitzgerald	Steep slopes, north aspect	Fair	Gravelly loam	18	131	Excess stones	221,914
Gappmayer	Moderate slopes, north aspect	Poor	Very gravelly silt loam	20	71	Yellow-brown layer	133,640
Mixed Fitzgerald/ Gappmayer	Moderate to steep slopes, north aspect	Fair to poor	Gravelly loam to very gravelly silt loam	19	40	Excess stones or yellow-brown layer	71,523
Wallsburg	Mountain slopes	Unsuitable	Cobbly silt loam	0	15	None	0
Totals					729		1,161,710

* Marker is the diagnostic field feature for lower limits of topsoil materials
** Volume is based on efficiency of stripping operation which may loose 30% or more on steep slopes or under large plant cover.

2.4.3 Topsoil Fertility

All the soil materials are very gravelly and/or cobbly so they have large amounts of coarse materials. The soil textures range from loams to silt or clay loams. The organic matter is usually above seven percent which is higher than that normally found in Basin and Range soils. Sufficient plant macronutrients of nitrates, calcium, potassium and magnesium are present for plant growth.

The lab analyses indicate very high iron levels in a few locations. The blending of topsoil materials should ameliorate hot spots.

See Appendix C-III for detailed lab results.

Bradshaw-Agassiz Soils

These cobbly sandy loams are relatively neutral with a high percentage of organic matter in the surface and subsoil horizons. The cation exchange capacity is good. The phosphate levels are good and the other major nutrients are adequate.

Fitzgerald Soil

These cobbly sandy loams are relatively neutral with a high percentage of organic matter in the surface and subsoil horizons. The cation exchange capacity is high. Phosphate levels are good and the other major nutrients are adequate.

Daybell Soils

These sandy loam soils are relatively neutral and moderately fertile with high organic matter (above ten percent) in the surface and subsoil horizons. The cation exchange capacity is very high. Phosphate levels are good and the other major nutrients are adequate.

The other soil groups have been described in previous reports.

Gappmayer-Wallsburg Soils

These soils are neutral and moderately fertile. The organic matter is about 1.5%. The phosphates are low. Some higher-than-normal copper and sulfate levels are found in the surface horizons.

Copperton Soils

The relatively shallow Copperton soils are slightly acidic with moderate fertility. There is a moderate amount of organic matter in the topsoil materials. The copper content is relatively high in the surface layer.

Harker-Dry Creek Soils

These soils are generally deeper than other soils of the area and will provide the bulk of the topsoil material. This is especially true for the Harker soils which are the deepest soils and occupy much of the disturbed areas of the Barney Pit and dumps. The soil texture varies from loam to clay loam with clays in the lower B horizons.

The soils are neutral to slightly alkaline with moderate fertility. The percent of organic matter varies but is generally lower than the other soils in the area. Phosphates are low as expected. One incident of high copper levels in the surface horizons was found.

All the soil materials are very gravelly and/or cobbly so they have large amounts of coarse materials. The soil textures range from loams to silt or clay loams. The organic matter is usually above seven percent which is higher than that normally found in Basin and Range soils. Sufficient plant macronutrients of nitrates, calcium, potassium and magnesium are present for plant growth.

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Daybell Soils

These sandy loam soils are relatively neutral and moderately fertile with high organic matter (above ten percent) in the surface and subsoil horizons. The cation exchange capacity is very high. Phosphate levels are good and the other major nutrients are adequate.

The other soil groups have been described in previous reports.

2.4.4 Soil Descriptions

The data for the soil descriptions was taken the field surveys, the lab fertility analyses available in Appendix C-III and from the U.S.D.A., S.C.S. Soil Survey of Salt Lake Area, Utah, April 1974.

Series: Agassiz

The Agassiz soil is found in association with Bradshaw soils on the steep south-facing convex portions of slopes.

Family: loamy-skeletal, mixed, frigid Lithic Haploxerolls

Parent Material: residuum and colluvium from mixed sedimentary rock, mainly calcarious quartzite and limestone

Landforms: steep, south-facing slopes, 40 - 70 percent, convex sites

Solum Depth: 12"; range from 6" - 16"

Erosion Hazard: water = high

Range Site: Mountain Shallow Loam

Topsoil Rating: poor
depth: 10"
texture: gravelly or cobbly loam
pH: 6.9, neutral
salinity: none
water holding capacity: 0.10 - 0.12 in/in, low

Typical Pedon:

O1 2 - 0 inches; leaf and twig litter (O1 not always present at every site).

A1 0 - 10 inches; dark grayish brown (10YR 4/2) cobbly or gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate granular structure; soft, very friable, slightly sticky and slightly plastic; common fine roots; clear wavy boundary.

C1 10 - 16 inches; brown (10YR 5/3) very cobbly silt loam, dark brown (10YR 3/3) moist; very weak, small subangular blocky structure to weak granular structure; slightly hard to loose, very friable, sticky, slightly plastic; common fine roots; abrupt irregular boundary.

R Calcareous quartzite.

Series: Bradshaw

Bradshaw soils occur in association with Agassiz soils on the steep south-facing concave portions of slopes. They are deeper than Agassiz soils and support taller oak and maple/chokecherry woodlands.

Family: loamy-skeletal, mixed, frigid Typic Haploxerolls

Parent Material: colluvium of weathered mixed sedimentary rocks, mainly calcarious quartzite and limestone

Landforms: steep, south-facing slopes, 40 - 70 percent, concave sites

Solum Depth: 50+"

Erosion Hazard: water = high

Range Site: Mountain Stony Loam

Topsoil Rating: poor
depth: 20 inches
texture: very gravelly or cobbly silt loam
pH: 6.9, neutral
salinity: none
water holding capacity: 0.07 - 0.10 in/in, low

Typical Pedon:

O1 2 - 0 inches; leaf and twig litter.

A11 0 - 9 inches; dark brown (7.5YR 4/3) gravelly or cobbly loam, dark brown (7.5YR 3/2) moist; moderate fine granular to small subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common fine and very fine roots and few medium roots; clear, smooth boundary.

A12 9 - 19 inches; dark brown (7.5YR 4/3) gravelly or cobbly clay or silt loam, very dark brown (7.5YR 3/3) moist; moderate, fine granular or small subangular blocky structure; soft, friable, sticky, plastic; common fine and medium roots; gradual, wavy boundary.

B2 19 - 39 inches; dark brown (7.5YR 4/4) very gravelly silt loam, dark brown (7.5YR 3/4) moist; weak, medium and fine subangular blocky to granular structure; soft, friable, slightly sticky and slightly plastic; common fine and few medium roots; gradual, wavy boundary.

C1 39 - 50+ inches; dark brown (7.5YR 5/3) very gravelly silt loam, dark brown (7.5YR 4/3) moist; massive; hard, very firm, slightly sticky, slightly plastic; 80 percent coarse fragments; lime coating on large fragments.

R Weathered limestone.

Series: Daybell

Family: coarse-loamy over fragmental, mixed Pachic Cryoborolls

Parent Material: residuum and colluvium from mixed sedimentary rocks

Landforms: east and north-facing slopes, 40 - 70 percent

Solum Depth: 30"

Erosion Hazard: water = high

Range Site: High Mountain Stony Loam

Topsoil Rating: fair
depth: 12"
texture: very gravelly silt loam
pH: 6.4, neutral
salinity: none
water holding capacity: 0.09 - 0.10 in/in, low

Typical Pedon:

A11 0 - 9 inches; dark grayish brown (10YR 4/2) gravelly silt loam, very dark brown (10YR 2/2 moist; moderate, fine, granular structure; soft, very friable, slightly sticky, non-plastic; common fine roots and few medium roots; 30 percent gravel; slightly acid (pH 6.4); clear, smooth boundary.

A12 9 - 16 inches; brown (10YR 4/3) gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; common fine and few medium roots; 30 percent gravel; slightly acid (pH 6.4); clear wavy boundary.

C1 16 - 21 inches; brown (10YR 5/3) gravelly fine sandy loam, dark brown (10YR 4/3) moist; weak, very fine, granular structure; soft, very friable, nonsticky, non-plastic; common fine roots and few medium roots; 35 percent gravel and cobblestones; slightly acid (pH 6.4); clear wavy boundary.

C2 21 - 52 inches; pale brown (10YR 6/3) very cobbly light sandy loam, yellowish brown (10YR 5/4) moist; weak, very fine, granular structure; slightly hard, very friable, nonsticky, non-plastic; few fine and medium roots; 50 percent cobblestones and gravel; slightly acid (pH 6.4); gradual, irregular boundary.

C3 52 - 60 inches; light yellowish brown (10YR 6/4) very cobbly fine sandy loam, dark yellowish brown (10YR 4/6) moist; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky, non-plastic; 60 percent cobblestones and gravel; slightly acid (pH 6.4).

R Sandstone.

Series: Fitzgerald

Family: loamy-skeletal, mixed, frigid Mollic Paleboralfs

Parent Material: residuum and colluvium from mixed sedimentary rocks

Landforms: north-facing slopes

Solum Depth: 60+"

Erosion Hazard: water = high

Range Site: none

Topsoil Rating: fair
depth: 18"
texture: gravelly loam
pH: 7.2, neutral
salinity: none
water holding capacity: 0.06 - 0.08 in/in, low

Typical Pedon:

O2 0 - 2 inches; very dark grayish brown (10YR 3/2) litter of partially decomposed leaves, grass, and other plant residue, very dark brown (10YR 2/2) moist.

A11 0 - 4 inches; very dark grayish brown (10YR 3/2) gravelly loam, very dark brown (10YR 2/2) moist; moderate, very fine, granular structure; soft, very friable, nonsticky, non-plastic; common fine, medium and large roots; neutral (pH 6.8); clear, smooth boundary.

A12 4 - 8 inches; dark grayish brown (10YR 4/2) gravelly loam, very dark brown (10YR 2/2) moist; moderate, very fine, granular structure; soft, very friable, slightly sticky, non-plastic; common fine, medium, and large roots; neutral (pH 6.8); abrupt, wavy boundary.

A2 8 - 18 inches; light yellowish brown (10YR 6/4) very gravelly silt loam, yellowish brown (10YR 5/4) moist; moderate, fine granular structure; soft, very friable, slightly sticky, non-plastic; common fine, medium, and large roots; neutral (pH 6.6); gradual, irregular boundary.

B&A 18 - 34 inches; mixed B2t and A2 horizons; B2t part is brown (7.5YR 5/4) very gravelly loam, brown (10YR 4/3) moist; massive; soft, very friable, slightly sticky, non-plastic; few thin clay films; A2 material is like that in the A2 horizon; few fine and large roots; neutral (pH 6.6); clear, wavy boundary.

B2t 34 - 70 inches; reddish yellow (7.5YR 6/6) very gravelly sandy clay loam, yellowish brown (10YR 5/5) moist; moderate, medium, subangular blocky structure; very hard, friable, sticky, plastic; few moderately thick clay films on peds and thin, continuous clay films on coarse fragments; few fine and large roots; neutral (pH 6.6).

Series: Gappmayer

This soil is common at elevations just below Barneys Canyon and occurs only at a few sites in the Barneys Canyon area.

Family: loamy-skeletal, mixed, frigid Boralfic Argixerolls

Parent Material: residuum and colluvium of mixed sedimentary rocks

Landforms: northerly slopes, 30 - 60 percent

Solum Depth: 60+"

Erosion Hazard: water = moderate

Range Site: Mountain Gravelly Loam

Topsoil Rating: poor
depth: 20"
texture: very gravelly silt loam
pH: 6.6 - 7.3, neutral
salinity: none
water holding capacity: 0.08 - 0.10 in/in, low

Typical Pedon:

O1 2 - 0 inches; undecomposed to slightly decomposed litter of oak and conifer leaves and grass.

A1 0 - 10 inches; very dark grayish-brown (10YR 3/2) very cobbly loam, very dark brown (10YR 2/2) moist; moderate, very fine, granular structure; soft, very friable, nonsticky, non-plastic; many fine and medium roots and few large roots; common fine pores; neutral (pH 6.6); clear, wavy boundary.

A12 10 - 16 inches; grayish brown (10YR 5/2) very gravelly silt loam, dark grayish brown (10YR 3/2) when crushed, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine and medium roots and few large roots; common fine pores; neutral (pH 6.6); abrupt, wavy boundary.

A2 16 - 20 inches; pale brown (10YR 6/3) very gravelly silt loam, dark brown (10YR 4/3) moist; moderate, fine and medium, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; common fine pores, neutral (pH 6.6); abrupt wavy boundary.

B21t 20 - 26 inches; pale brown (10YR 6/3) gravelly silty clay loam, grayish brown (10YR 5/2) when crushed, brown (7.5YR 4/4) moist, brown (7.5YR 4/3) moist and crushed; moderate, medium and fine subangular blocky structure; hard, friable, sticky, plastic; common fine roots and few medium and large roots; moderately thick, continuous clay films on most peds and coarse fragments; some peds coated with bleached sand; neutral (pH 6.8); clear, wavy boundary.

B22t 26 - 44 inches; light yellowish brown (10YR 6/4) very gravelly clay loam, dark yellowish brown (10YR 4/4) moist; moderate, medium and fine, subangular blocky structure; very hard, friable, sticky, plastic; common fine roots and few medium and large roots; thin, continuous clay films on coarse fragments; neutral (6.8); clear, wavy boundary.

C1 44 - 72 inches; pale brown (10YR 6/3) very gravelly silt loam, brown (10YR 4/3) moist; massive; slightly hard, very friable, slightly sticky, slightly plastic; common fine roots and few medium roots; below depth of 60 inches this horizon has thin lime coatings on undersides of coarse fragments; matrix noncalcareous; neutral (pH 7.2).

Series: Wallsburg

Family: clayey-skeletal, montmorillonitic, frigid Lithic Argixerolls

Parent Material: residuum and colluvium from sedimentary rocks

Landforms: mountain slopes

Solum Depth: 17"

Erosion Hazard: water = high

Range Site: Mountain Shallow Loam

Topsoil Rating: not suitable
depth: 17"
texture: cobbly silt loam
pH: 6.5 - 7.3, neutral
salinity: none
water holding capacity: 0.05 - 0.10 in/in, low

Typical Pedon:

O1 1 - 0 inches; leaves and twigs.

A1 0 - 5 inches; grayish brown (10YR 5/2) very cobbly silt loam, very dark grayish brown (10YR 3/2) moist; weak, thin platy structure parting to moderate, fine, granular; soft, very friable, slightly sticky and slightly plastic; common fine roots; 50 percent cobblestones and gravel; neutral (pH 6.6); clear, wavy boundary.

B1t 5 - 9 inches; dark brown (10YR 4/3) very cobbly silty clay loam, very dark grayish brown (10YR 3/2) moist, dark brown (7.5YR 3/2) moist and crushed; very hard, friable, sticky, plastic; common fine roots; 60 percent cobblestones; thin continuous clay films; neutral (pH 6.6); clear, wavy boundary.

B2t 9 - 17 inches; brown (7.5YR 5/4) very cobbly light silty clay, dark brown (7.5YR 3/3) moist, brown (7.5YR 4/3) when moist and crushed; strong, medium and fine, angular blocky structure; extremely hard, firm, sticky, plastic; common fine roots; 70 percent cobblestones; thin, continuous clay films; neutral (pH 6.6); clear, irregular boundary.

R 17+ inches; fractured rock.

2.5 Vegetation

The Barneys Canyon area of the Oquirrh Mountains ranges from an elevation of 8,242 feet at Barneys Peak to 6,250 feet at the Melco Haul Road that defines the study boundary. Several plant communities inhabit the steep canyon walls and bottom.

The steep terrain emphasizes the difference in north and south aspects. Douglas fir (Pseudotsuga menziesii), quaking aspen (Populus tremuloides), with intermingled heavy stands of gambel oak (Quercus gambelii) and curl-leaf mountain mahogany (Cercocarpus ledifolius) shrubs characterize north aspects. South aspects mostly support pure gambel oak stands, and on the rocky soils and rock outcrops, curleaf mountain mahogany stands. Steep drainages on the south-facing slopes and the canyon bottom are mostly dominated by the bigtooth maple (Acer grandidentatum)/chokecherry (Prunus virginiana) - riparian community. Sagebrush (Artemisia tridentata) also exists at all south-facing slope elevations associated mostly with the gambel oak community, but only becomes dominant on the higher slopes and ridge tops above the study area.

A vegetation community map was developed for all the area affected by the overall mining project. This map is presented on Figure 2.5-1. The area was surveyed on the ground and community boundaries drawn onto topographic maps. One hundred-foot, line-point transects were run in each major plant community on the sites of proposed mining activity.

The vegetative mapping arbitrarily established boundaries for the various oak shrub communities as described above. In reality these communities do not have definite boundaries but grade from one community to the next. Thus, many community boundaries or extremities are characterized by ecotones. Also many subcommunities or extensions of adjacent communities can exist within the major communities usually due to terrain aberrations.

2.5.1 Methodology

In September 1993 the vegetation of the Barneys Canyon expansion area was mapped and this map is presented as Plate V-C. The area was surveyed on the ground and community boundaries drawn onto topographic maps.

The mapping of communities required the use of aerial photos, U.S.G.S. 7.5 minute maps, and ground-truthing. Ground transects provided a data base of species frequency and dominance for the community descriptions.

The communities were identified by the dominant plant species, which were determined by canopy dominance. For each representative vegetation community, transects were conducted to measure percent cover of dominant species and percent composition of all species encountered.

One hundred-foot, point-intercept transects were conducted in each of the main vegetative communities on the sites of proposed mining activity. Understory as well as canopy species were noted at each foot mark of the transect. The number of transects needed for sample adequacy was determined by using the following formula:

$$n = \frac{t^2 s^2}{(0.2\ x)^2}$$

where n = the desired sample size,

t = the table "t" value at the given confidence level,

s = the standard deviation,

0.2 = the confidence interval around the mean, and

x = the mean

Sample adequacy was achieved at the 80% confidence level.

The vegetative mapping established approximate boundaries for the various communities as described above. In reality these communities do not have definite boundaries but grade from one community to the next. Thus, many community boundaries or extremities are characterized by ecotones. Also many subcommunities or extensions of adjacent communities can exist within the major communities usually due to terrain aberrations.

2.5.2 Survey Results

2.5.2.1 Gambel Oak Community

The Gambel Oak (Quercus gambelii) Community mostly occurs as small shrubs on the higher exposed south-facing ridges, as tall shrubs or small trees on the protected upper slopes, or as medium shrubs at mid-slopes and on the lower alluvial slopes. Occasionally, oak stands occur on north-facing slopes mixed in with the douglas fir (Pseudotsuga menziesii) and aspen (Populus tremuloides) communities.

Within the study area, this plant community ranges in elevation from 6,300 feet near the Melco haul road to 7,600 feet at the extreme northwest corner of the study area. It is characterized by oak woodlands composed of small trees on favorable sites but can be oak shrub stands on less favorable sites. The open areas between shrub and tree stands are vegetated with various grasses and forbs.

The vegetative cover for the Gambel Oak Community is summarized as follows:

Ground Cover, Percent:

Bare soil & Rock	1 - 6, mean 4.8
Litter	15 - 48, mean 25.8
Total Non-vegetative	22 - 49, mean 30.6
Vegetative	51 - 78, mean 69.4
Overstory	6 - 71, mean 41.7

Understory Vegetative Cover:		Percent
Bromus marginatus	(mountain brome)	0.7
Bromus tectorum	(cheatgrass)	0.7
Elymus glaucus	(blue wildrye)	0.8
Elymus spicatus	(blue-bunch wheatgrass)	11.7
Elymus triticoides	(creeping wildrye)	1.3
Festuca ovina	(sheep fescue)	0.3
Poa secunda	(Sandberg's bluegrass)	3.2
Balsamorhiza sagittata	(balsamroot)	10.3
Lathyrus lanszwertii	(thickleaf sweetpea)	6.0
Mentha arvensis	(field mint)	0.8
Mertensia sp.	(bluebells)	1.3
Penstemon sp.	(Penstemon)	0.5
Senecio sp.	(Senecio)	0.8
Solidago canadensis	(goldenrod)	1.2
Wyethia amplexicaulis	(mulesears)	1.0
unknown forbs		2.5
Acer grandidentatum	(bigtooth maple)	1.0
Chrysothamnus viscidiflorus	(green rabbitbrush)	1.3
Prunus virginiana	(chokecherry)	1.0
Quercus gambelii	(Gambel oak)	16.5
Rosa woodsii	(woods rose)	0.8
Symphoricarpos oreophilus	(mountain snowberry)	4.5

Overstory Vegetative Cover:		
Quercus gambelii	(Gambel oak)	12.3
Prunus virginiana	(chokecherry)	0.8

Range Condition: Good

Productivity: 2,400 lbs/acre.

2.5.2.2 Mahogany/Rock Outcrop Community

The Mahogany/Rock Outcrop Community occupies the shallow soils of rocky slopes and mountain crests from about 6,600 feet to 7,960 feet in elevation. Closely associated with this community is the Gambel oak (Quercus gambelii) community. The understory has generally been disturbed by past grazing practices and often consists of mulesears, pepperweed and cheatgrass and scattered sagebrush (Artemisia tridentata). Those mahogany communities in better condition support an understory of bluebunch wheatgrass and a mix of various other perennial grasses and forbs.

The vegetative cover for the Mahogany/Rock Outcrop Community is summarized as follows:

Ground Cover Percent:

Bare Soil & Rock	18 - 25, mean 21.5
Litter	13 - 29, mean 21.0
Total Non-vegetative	31 - 54, mean 37.5
Vegetative	46 - 69, mean 57.5
Overstory	21 - 24, mean 22.5

Understory Vegetative Cover:		Percent
Bromus marginatus	(mountain brome)	1.5
Bromus tectorum	(cheatgrass)	3.5
Elymus spicatus	(blue-bunch wheatgrass)	1.0
Festuca ovina	(sheep fescue)	4.0
Poa secunda	(Sandberg's bluegrass)	0.5
Allium sp.	(wild onion)	2.0
Lathyrus lanszwertii	(thickleaf sweetpea)	0.5
Lepidium virginicum	(Virginia pepperweed)	1.0
Petradoria pumila	(rock goldenrod)	6.0
Wyethia amplexicaulis	(mulesears)	14.5
Artemisia tridentata	(big sagebrush)	2.0
Cercocarpus ledifolius	(curleaf mountain mahogany)	12.5
Gutierrezia sarothrae	(broom snakeweed)	0.5
Quercus gambelii	(gambel oak)	7.0
Symphoricarpos oreophilus	(mountain snowberry)	1.5

Overstory Vegetative Cover:		
Cercocarpus ledifolius	(curleaf mountain mahogany)	22.5

Range condition: good

Productivity: 2,000 lbs/acre

2.5.2.3 Maple/Chokecherry - Riparian Community

The Maple/Chokecherry - Riparian Community varies greatly depending upon the size of the drainage in which it occurs and elevation. Generally, moist side slopes, drainages, and canyon bottom riparian areas have trees and shrubs that grow in dense stands and are taller than the surrounding vegetative community. Where drainages have wide flat channels and floodplains, the deciduous trees can form extensive woodlands. This community varies greatly with respect to composition. Bigtooth maple (Acer grandidentatum) usually dominates on the more mesic northeast-facing hillside sites and in drainage bottoms, and chokecherry (Prunus virginiana) occasionally dominates on slightly dryer northeast-facing hillside sites.

The maple/chokecherry - riparian community in Barneys Canyon is dominated by large stands of maple and/or chokecherry, with scattered gambel oak (Quercus gambelii), douglas fir (Pseudotsuga menziesii) and quaking aspen (Populus tremuloides) intermingling. The understory is comprised of a variety of perennial grasses and forbs.

The vegetative cover for they Maple/Chokecherry - Riparian Community is summarized as follows:

Ground Cover Percent:

Bare Soil & Rock	0 - 3, mean 3.0
Litter	25 - 47, mean 32.7
Total Non-vegetative	25 - 53, mean 35.7
Vegetative	47 - 75, mean 67.3
Overstory	62 - 100, mean 89.3

Understory Vegetative Cover		Percent
Bromus diandrus	(ripgut brome)	0.3
Bromus marginatus	(mountain brome)	1.3
Carex geyeri	(elk sedge)	2.7
Dactylis glomerata	(orchard grass)	0.3
Elymus spicatus	(blue-bunch wheatgrass)	0.7
Elymus triticoides	(creeping wildrye)	5.3
Achillea millefolium	(yarrow)	0.7
Aster chilensis	(everywhere aster)	1.3
Aster perelegans	(Nuttal aster)	2.3
Lathyrus lanszwertii	(thickleaf sweetpea)	3.0
Mentha arvensis	(field mint)	8.0
Thalictrum fendleri	(Fendler meadowrue)	1.0
Urtica dioica	(stinging nettle)	1.0
Viguiera multiflora	(showy goldeneye)	2.0
Acer grandidentatum	(bigtooth maple)	25.7
Amelanchier alnifolia	(saskatoon serviceberry)	0.3
Prunus virginiana	(chokecherry)	5.0
Pseudotsuga menziesii	(douglas fir)	1.3
Symphoricarpos oreophilus	(mountain snowberry)	2.0

Overstory Vegetative Cover:

Acer grandidentatum	(bigtooth maple)	50.3
Prunus virginiana	(chokecherry)	20.7
Pseudotsuga menziesii	(douglas fir)	1.3
Quercus gambelii	(Gambel oak)	4.0

Range condition: good

Productivity: 2,300 lbs/acre

2.5.2.4 North Slope Douglas Fir Community

The North Slope Douglas Fir Community is mostly confined to the steep north-facing slopes, usually above 6,400 feet in elevation. This community usually consists of large stands of conifer trees with a sparse understory. Snow cover may persist here until early summer keeping the soil moist into the summer season.

In September 1993, field work was conducted to prepare a more detailed map of vegetative communities for the area of proposed expansion. Modifications were made to the map especially with regard to the North Slope Community (Plate V-C).

The vegetative cover for the North Slope Douglas Fir Community is summarized as follows:

Ground Cover Percent:

Bare Soil & Rock	1 - 4, mean 2.3
Litter	38 - 71, mean 58.3
Total Non-vegetative	42 - 74, mean 60.6
Vegetative	26 - 58, mean 56.0
Overstory	72 - 85, mean 81.0

Understory Vegetative Cover		Percent
Bromus marginatus	(mountain brome)	0.3
Thalictrum fendleri	(fendler meadowrue)	0.3
Viola canadensis	(Canada violet)	0.8
Lathyrus lanszwertii	(thickleaf sweetpea)	0.3
Pachystima myrsinites	(mountain lover)	6.0
Physocarpus malvaceus	(mallow ninebark)	3.0
Acer grandidentatum	(bigtooth maple)	4.6
Pseudotsuga menziesii	(douglas fir)	3.0
Symphoricarpos sp.	(snowberry)	3.3
Mahonia repens	(Oregon grape)	14.8
Cercocarpus montanus	(birchleaf mountain mahogany)	1.0
Quercus gambelii	(gambel oak)	3.5

Overstory Vegetative Cover:

Pseudotsuga menziesii	(douglas fir)	70.8
Populus tremuloides	(quaking aspen)	4.5
Prunus virginiana	(chokecherry)	1.8
Physocarpus malvaceus	(mallow ninebark)	2.0
Quercus gambelii	(gambel oak)	1.0
Cercocarpus ledifolius	(curleaf mountain mahogany)	1.0

Range condition: Good

Productivity: 2,000 lbs/acre

2.5.2.5 Quaking Aspen Community

Similar to the Douglas Fir Community, this community is confined to the steep north- and south- facing slopes and drainages of the higher terrain usually above 6,800 feet in elevation, with small colonies existing at lower elevations. The sites occupied by this community are some of the more mesic areas on the Oquirrh Mountains and usually support large trees with a thick brush, grass, and forb understory. As with the douglas fir community, snow cover may persist here until early summer keeping the soil moist.

The quaking aspen community in Barneys Canyon is dominated by large stands of quaking aspen (Populus tremuloides) with a thick understory of bigtooth maple (Acer grandidentatum) and a variety of perennial grasses and forbs.

In September 1993, field work was conducted to prepare a more detailed map of vegetative communities for the area of proposed expansion. Modifications were made to the map especially with regard to the Quaking Aspen Community (Plate V-C).

The vegetative cover for the Quaking Aspen Community is summarized as follows:

Ground Cover Percent:

Bare Soil & Rock	1 - 0, mean 0.7
Litter	23 - 48, mean 32.0
Total Non-vegetative	23 - 49, mean 32.7
Vegetative	51 - 77, mean 67.3
Overstory	79 - 99, mean 89.3

Understory Vegetative Cover		Percent
Bromus inermis	(smooth brome)	1.3
Bromus marginatus	(mountain brome)	1.3
Elymus triticoides	(creeping wildrye)	11.0
Poa reflexa	(nodding bluegrass)	2.7
Asclepias sp.	(milkweed)	0.3
Lathyrus lanszwertii	(thickleaf sweetpea)	3.0
Osmorhiza depauperata	(bluntseed sweetroot)	1.0
Thalictrum fendleri	(fendler meadowrue)	1.0
Verbascum thapsus	(flannel mullein)	0.3
Acer grandidentatum	(bigtooth maple)	25.0
Mahonia repens	(Oregon grape)	0.7
Pachystima myrsinites	(mountain lover)	6.0
Picea pungens	(blue spruce)	0.7
Pseudotsuga menziesii	(douglas fir)	6.3
Sambucus caerulea	(blue elderberry)	0.3
Symphoricarpos sp.	(snowberry)	6.3

Overstory Vegetative Cover:

Acer grandidentatum	(bigtooth maple)	25.3
Populus tremuloides	(quaking aspen)	58.7
Prunus virginiana	(chokecherry)	1.3
Pseudotsuga menziesii	(douglas fir)	2.7
Symphoricarpos sp.	(snowberry)	1.3

Range condition: Good

Productivity: 2,600 lbs/acre

2.6 Wildlife

The project area is located in the mountain brush zone of the Oquirrh Mountains. Included within this broad plant zone are the widespread gambel oak community, the mountain mahogany community on rock outcrop sites, the conifer stands on the steep north slopes, the aspen community at the higher elevations, and the riparian tree community in the major drainages. All of these communities are considered high value wildlife habitats.

The wildlife data was gathered over several survey periods (1987, 1991, 1993) during soil and vegetation surveys. Also, a raptor nest survey was conducted in the fall of 1993. From these sources, a large quantity of qualitative data has been accumulated on the wildlife populations and wildlife habitats of the project areas.

The restricted access and the removal of livestock grazing has allowed wildlife to fully utilize the area with a minimum disturbance and sufficient forage and cover.

2.6.1 Elk

Elk use the area year-round, wintering on the exposed ridges and lower elevations in the gambel oak and mountain mahogany communities. They summer at the highest elevations of the mountain brush zone. Elk numbers are unknown but they are common on the respective use areas. The most critical areas for elk are the calving habitats.

The calving habitats are defined as dense shrub and tree cover with herbaceous and graminoid ground cover sufficient to conceal calves. These habitats are generally confined to northerly aspects in drainages or concave portions of the slopes where mesic conditions provide for optimal plant growth. The plant communities are aspen and conifer or more specifically the ecotone between these communities where several layers of plant growth provide the necessary cover and seclusion.

2.6.2 Mule Deer

Deer also use the project area year-round in a manner similar to Elk. Deer may winter at lower elevations than elk, in the oak and sagebrush communities, because of their inability to negotiate deep snows. Deer are very common in all habitats as the mountain brush zone is the most productive habitat for mule deer in Utah. Deer fawn in areas of heavy ground cover, and in addition to the elk calving habitats described above, would also utilize the heavier oak/maple stands in the concave sites on the slopes and in the riparian zones.

The lack of surface water in much of the project area limits the use of some potential fawning habitats especially during years of below-normal snowfall. Most of the deer summer near the main ridge of the mountains at the higher elevations of the project area due to springs located close to the main ridge.

2.6.3 Predatory Mammals

Coyotes and lions are probably the most common predators in the mountainous habitats. Lions, while very secretive, have been observed in the area. They are attracted to the plentiful large mammal prey supply in a secluded area.

Coyotes are also very common and utilize a wide variety of prey.

The mammalian prey base consists of cottontail rabbits, ground squirrels and tree squirrels, wood rats, mice, voles, and shrews.

2.6.4 Raptors

Large raptors, such as eagles and buteos (large soaring hawks), utilize the large open, mature conifers as roost sites. From observations over the years in the Oquirrh Mountains and recently at Barneys Canyon, large raptors hunt in the valleys and foothills but return in the evening to the high elevations of the mountains to roost. The large open trees and cliffs provide a safe roost site away from disturbance.

The lack of large nests in Barneys Canyon is probably due to the lack of cliff habitats and large open mature conifers. Most of the conifers in the area are second growth or stands on poor sites. These younger or smaller trees lack the open growth type that would be used by large nesting raptors. All of the open mature conifers identified in the survey were searched carefully for nests.

The smaller raptors, more specifically the kestrel falcon and the coopers hawk, are the more common raptors in the mountain brush zone. They prefer this habitat due to the large variety of small bird populations and protective cover of large shrubs and small trees. The multiple layers of plant cover common to the mountain brush zone provide niches for a large variety of birds (which serve as prey for raptors), increasing the density of birds per acre over most other habitats.

The raptor nest survey did not reveal any nests of large raptors. The nests located were of the smaller raptors, especially coopers hawks, that nest in trees in drainages and hunt in the tree and shrub plant communities for small prey. These small nests are not easy to locate and additional small nests may be present in the area due to the abundance of sites in this area. Kestrel falcons nest in tree or rock cavities. None of these raptors are considered endangered species.

Owls, common in the mountain brush zone, include the small screech owl and the flammulated owl, and the larger great-horned owl. Most owls prey on small mammals and medium-sized mammals that inhabit this habitat type; however, the flammulated owl is insectivorous. Owl populations in the project area are unknown due to the lack of surveys specific to detecting owls. Owl nests are rarely observed during raptor nest surveys due to the secretive nesting habitats and nocturnal hunting habitats of owls.

3.0 OPERATION PLAN

The locations of the various project facilities are shown on Figure 1.1-1 and a detailed layout is presented on Plate I-B. The project consists of five open pit mines and their associated dumps, a crushing plant, heap leach facilities, a carbon adsorption, desorption and regeneration (ADR) plant, a gold refinery and necessary support facilities.

Peak employment for the project is estimated at 210. Approximately 85% of the work force will work during any 24-hour period. The remainder of the personnel will be off. Slightly less than 50% of the work force works the day shift and the remaining employees man the afternoon and night shifts.

Employees reach the project site via the access road from State Highway 48, and the employee parking lot is located at the administration building. Employees working at the truck shop, the mine pits, the crushing plant, leaching facilities and process plant are transported to these locations in crew-transport mini-buses.

Commencing in 1993 Kennecott will mine two recently discovered ore bodies, the North BC South and South BC South deposits, which are located between the Barneys Canyon and Melco Deposits (Figure 2.1-1). In addition, Kennecott will increase the size of the Melco Pit to extract additional ore reserves discovered as a result of on-going exploration. The locations of these planned operations are shown on Figure 1.1-1.

Access to these project areas is the same as described above. However, two short segments of the Melco access road will be realigned to allow for the construction of the North BC South and the South BC South pits. The segment passing through the North BC South pit will be relocated prior to commencement of overburden removal at South BC South to maintain access to the Melco area and will result in no additional disturbed area (Plate II-B). The access road will be routed to the south of the North BC South deposit where it will be constructed on fill generated during mining of the South BC South deposit (Plate II-B).

Commencing in the 1st quarter of 1994 Kennecott will begin construction of a sulfide flotation plant located next to the existing crushing and conveying infrastructure (Plate II-C). Approximately two million tons of "ore grade" sulfidic material will be liberated as a by product of oxide mining and treated through this flotation plant. Previously these tons would have been treated as waste and blended with oxide waste in the dumps.

The sulfide plant will utilize the existing oxide coarse crushing plant to reduce approximately 8,000 tons per week of sulfide ore to minus 1.5 inch size. Fine crushing and grinding units will produce feed to a flotation plant where approximately 45% of the gold and over 90% of the sulfur (which was originally in the range of 2%-5%) will report to the concentrate. After dewatering, the concentrate (29,000 tons/year) will be shipped offsite for further processing.

The tailings from the flotation plant, containing the remaining 55 percent of the gold, will be partially dewatered and blended with dry oxide ore on the existing agglomerating conveyors for heap leaching.

Commencing in 1997 the East Barneys pit will be mined. Haulage access will be built from the East Barneys pit exit to a road currently used to access the topsoil stockpile, then continued along that existing road to the Barneys Canyon haul road. The second part of the road will be widened to accommodate mine haulage equipment.

3.1 Description of Mineral Deposits

The gold in the Barneys Canyon deposit is hosted in sandy dolomite and sandstone. The ore in the Melco deposit is contained in calcareous sandstone. The geology of the Barneys Canyon and Melco mineral deposits is described in detail in Section 2.1.2. The Barneys deposit is a sub-horizontal occurrence of gold ore that is highly variable in thickness and overlain by zero (0) to perhaps 400 feet of overburden. Maximum pit depth is planned to be approximately 750 feet. The general geometry of the ore deposit is shown in plan and in cross section in Figure A-I-1 which is found in Appendix A (CONFIDENTIAL). The Melco deposit is a near-vertically dipping ore deposit that is somewhat elongate in plan, as Figure A-I-2 in Appendix A (CONFIDENTIAL) shows. The

Melco ore body is exposed at the surface; however, removal of overburden above and adjacent to the ore body will result in a pit with a maximum depth of approximately 1000 feet.

The North BC South and the South BC South ore bodies are hosted in sandstone of the Kirkman-Diamond Creek Formation near the basal contact with the orthoquartzite of the Freeman Peak Formation (orthoquartzite). Gold mineralization is hosted in moderately northeast-dipping clay-rich zones of slip and brecciation within interlayered sandstone and orthoquartzite.

The rock sequence is similar to that at the Melco deposit, but, unlike Melco, the BC South ore bodies are almost totally oxidized with minor sulfides (less than 1 %) remaining. Overburden at both deposits consists of sandstone and orthoquartzite which are locally altered to clays. Exploration drilling encountered no water within the limits of the proposed North BC South pit, and only minor amounts of perched water at the South BC South pit (see Section 2.3.1).

Geologic cross sections A-A' (Figure 2.1-9), B-B' (Figure 2.1-10), and C-C' (Figure 2.1-11) depict the geology of the Melco, South BC South, and North BC South ore bodies, respectively. The ultimate pit outlines are also shown on the cross sections. Lines of section are shown on the geologic map (Figure 2.1-1).

The East Barneys deposit is hosted in the Kirkman-Diamond Creek sandstone. Gold mineralization is hosted in moderately dipping, clay-rich zones of slip and brecciation within interlayed sandstone and orthoquartzite. The rock sequence is very similar to that of the BC South deposit, however, the orebody is totally oxidized. The deposit is overlain by about sixty feet of the Quarternary alluvium composed of sandstone, quartzite and limestones. A Geologic cross section of the East Barneys deposit showing the final pit outline, is denoted as section D-D' on Figure 2.1-12 and included as Figure 2.1-14.

3.2 Mining

The Barneys Canyon project, prior to 1993, consisted of two separate open pit mines, the Barneys pit and the Melco pit. The locations of these pits are shown on Plates I-A and III-A. The Barneys Canyon pit is located at an average elevation of 6,600 feet AMSL on predominantly south-facing slopes which form part of the north wall of Barneys Canyon. The Melco pit, located 1.5 miles southwest of the Barneys Canyon pit, occurs near the headwaters of the right fork of the Dry Fork Creek drainage, a tributary to Bingham Canyon. The Melco pit site is on a south-facing slope at an average elevation of 7,400 feet.

In 1993, the project involves expansion of will expand the existing Melco pit and develop two new deposits, known as the North BC South and the South BC South pits. The locations of the pits are shown on Plate II-B. The North BC South and the South BC South pits are located along the Melco haul road at an average elevation of approximately 6600 feet.

The Melco pit will be expanded and the bottom of the pit lowered to approximately 6460 feet AMSL to allow extraction of additional ore reserves at depth. A series of new waste dumps will be constructed north of the pit in Barneys Canyon. Annual ore production will be maintained at the 2.6 million tons per year rate while the average annual waste production will increase to approximately 18.5 million tons during 1994 through 1998. The Melco expansion extends the life of the project approximately 3-1/2 years.

The North BC South pit will be expanded and the bottom of the pit lowered to approximately 6460 feet AMSL. The additional waste rock generated by mining the larger pit will be used to cap the existing BCS waste dump and continue backfilling the SBCS pit.

The East Barneys Pit is located near the Barneys pit haul road at an average elevation of 6100 feet. Waste rock will be dumped into the existing Barneys Canyon Pit. (Figure 3.2-12 and Plates 96-5 and 96-6)

3.2.1 Mining Operations

The Barneys Canyon mines operates 52 weeks per year and 7 days per week on two 12-hour shifts per day. The maximum average ore production rate is approximately 7,000 tons per day.

Work to date at the mine sites has consisted of exploration drilling, construction, and mining of overburden and ore at the Barneys Canyon and Melco Phase A pits. Initial overburden removal began in February, 1989 Mining of the Melco Phase A pit commenced in October, 1989 and was completed October, 1990. Prior to commencement of mining activities, the topsoil at each pit was removed and placed in topsoil stockpiles. Topsoil management plans are presented in detail in section 3.7. Vegetation was also removed.

Ore and waste is mined by drilling and blasting, loading, and truck transport to the crusher and mine waste dumps, respectively. The blast hole drilling program serves the additional purpose of providing samples for analysis for grade control. The gold analyses are performed at the on- site analytical laboratory. Drilling is conducted with either tracked or rubber-tired, 360-horsepower diesel air drills. Blast holes are drilled approximately 20 feet deep on 16-foot centers with blasting taking place only during the day shift. An average of about 30,000 tons of ore and waste are blasted per day. Blasting is conducted so as to minimize noise and vibrations. Up to a total of 136 blast holes may be drilled, loaded, and shot per day. Ammonium nitrate/fuel oil (AN/FO) is the primary explosive agent and is supplied to the blast areas in bagged or bulk form by truck.

Blasted ore and waste are loaded with a Cat 992 C front end loader. The excavators generally do not require dozer assistance. The excavators load ore and waste into 55 and 85-ton-class, off-road-type haul trucks. Run-of-mine (ROM) ore is hauled to an ore stockpiles which is located at the crusher. The crusher is located northeast of the Barneys Canyon pit and consists of primary and secondary crushers, screens, and agglomeration facilities. The average haul distance to the crusher from the Barneys Canyon pit is approximately 1.5 miles. Run of mine ore from the Melco pit was transported approximately 4.5 miles to the crusher stockpile by 85 ton rear dumphaul trucks.

Waste rock, or overburden, from the Barneys Canyon pit is hauled in haul trucks to one of three mine dumps located north and east of the open pit, as shown on Plate III-A. Waste rock from the Melco pit is hauled to the mine dump located southeast of the pit (Plate III-A). Average waste hauling distances for the Barneys Canyon and Melco waste rock are approximately 1.0 mile.

Fugitive dust emissions on haul roads are suppressed by application of water by two 350-horsepower, 8,000 gallon water trucks equipped with six sprays. The water trucks operate as required for dust control.

Dumps are created by end-dumping waste from the haul trucks. The dumps are constructed in lifts of up to 500 feet in height at Melco and 300 feet at Barneys, each with slope angles of 37 degrees. Track-type dozers are used to assist in pushing waste rock over the dumps.

Other operations that take place as part of mining include grading of road surfaces by 150 horsepower motor graders and general housekeeping and materials handling functions. In addition to initial construction of haul roads, on-going construction of drill pads and haul roads will take place throughout the life of the mine. Road construction is carried out by two 370-horsepower, tracked dozers, with drilling and blasting used where necessary.

As of December 31, 1992 approximately 8.24 million tons of ore and 27.65 million tons of waste have been excavated from Barneys Canyon and Melco mines.

In 1993, the mining operations resumed at Melco, and commenced at North BC South, and South BC South pits.

Waste rock from the Melco pit will be hauled to one of three waste dumps located east, southeast and south of the pit, as shown on Plate II-B. The maximum one-way waste haul distance from the Melco pit is approximately 2 miles. Waste rock from the North BC South pit will be hauled and used to backfill the South BC South pit. Waste rock from the South BC South pit will be hauled to a waste dump located east of the mine in an ephemeral tributary to Barneys Canyon (Plate II-B). Approximate one-way waste haul distances from the North BC South and the South BC South pits are 0.5 and 0.6 miles, respectively.

Waste rock from the Melco pit will be dumped to the north and south of the pit as show in Plate II-C. Construction of a haul road from the north side of the Melco pit to the North BC South pit will shorten the ore and waste hauls. The Melco southern dumps (formerly the 7200 Dump) will be constructed in lifts of up to 1000 feet and will be modified from that already permitted to improve drainage. The Melco north dumps will be constructed in lifts up to 500 feet in height. Other mining operations will remain essentially the same.

Annual ore production will be 2,600,000 tons. Average annual waste production during the years 1992 through 1995 is expected to be 10,500,000 tons.

East Barneys Waste rock consists of about 500,000 tons of alluvium and 500,000 tons of sandstone, quartzite and limestone. Waste will be dumped into the existing BC Pit as backfill.

The Pit will disrupt the surface drainage pattern in the bottom of Barneys canyon. The diversion ditch will be designed and built to contain a 10 year, 24 hours storm event. Water collected in the ditch will be diverted through an engineered ditch located along an upper bench of the pit and discharged back into the existing drainage downstream of the pit. The design and flow calculations of the diversion ditch (attachment DII(a)) was prepared by the Barneys Canyon Mine to carry the flow from the 10-year, 24-hour precipitation event for the Barneys Canyon watershed uphill from the diversion. The design flow of 4 cfs was calculated by JBR Environmental Consultants for the November 11, 1993 NOI submitted to DOGM by the Barneys Canyon Mine. Appendix D-II of that document will provide the background information for the calculation of the design flow.

The riprap designs for the outlet of the diversion ditch and the culvert under the East Barneys pit access road have been prepared by JBR. The design flow velocity for the outlet of the ditch was provided by the Barneys Canyon Mine as 5.68 fps. We recommend that the flow of 4 cfs at 5.68 fps be discharged from the end of the ditch onto a bed of riprap having a D_{50} of 4 inches. The riprap bed should be built between the outlet of the ditch and the inlet of the culvert under the East Barneys pit access road. The riprap bed should be approximately 1.5-feet thick and should inlaid into the receiving soil so that the top surface of the riprap bed is at the same elevation of the bottom of the ditch.

We calculate that the velocity of the water (4cfs) exiting the 24-inch diameter culvert under the access road would be approximately 8 fps. The riprap bed at the end of this culvert should be 6-feet wide by 17-feet long, having a D_{50} of 4 inches and a thickness of 1.5 feet. If the slope or channel downstream from this riprap bed is subject to erosion, the same riprap could be extended down slope as necessary.

At completion of mining, the diversion basin will be breached, resulting in surface water flow into the pit. Water that does not evaporate or soak into the soil will collect in the pit, which will be about 60 feet below the canyon bottom. If the pit fills, water will flow downstream into the existing drainage.

3.2.2 Pit Slope Stability Analysis

The locations and maximum extent of the Barneys Canyon and Melco Phase A pits are shown on Plate III-A. The locations and the maximum extent of the North BC South, South BC South and the expanded Melco pits are shown on Plate II-B. Each of the pits will be developed with 20 foot benches. Safety catch benches with a minimum 27-foot width will be left every 60 feet. Median bench face angles are expected to be 75 and 76 degrees for the Barneys and Melco Phase A pits, respectively. A maximum interramp or overall pit slope angle of 47 degrees results from this configuration, shown on Figures 3.2-1 and 3.2-2. The interramp slope design at the Barneys Canyon pit is designed at a uniform 47 degree interramp angle. Present surface topography and ultimate pit cross sections for the Barneys and Melco Phase A pits are shown in Figures 3.2-3 & 4, and 3.2-5 & 6, respectively.

Median bench face angles are expected to be approximately 64 and 58 degrees at North BC South and South BC South respectively, and approximately 64 degrees at the Melco expansion. An overall pit slope angle of 47 degrees is expected at Melco, angles ranging from 39 to 47 degrees are expected at North BC South (Figure 3.2-7), and South BC South is expected to have an overall slope angle from 39 to 41 degrees (Figure 3.2-8). The design pit configurations for the Melco, South BC South, and North BC South pits are shown on figures 3.2-9, 3.2-10, and 3.2-11, respectively. Ultimate pit cross sections for the North BC South, South BC South, and Melco expansion pits are shown in Figures 2.1-9, 2.1-10, and 2.1-11, respectively. The slope angles described above are approximations and will vary somewhat based upon rock types and other field conditions.

Pit wall slopes in the East Barneys pit will average 47 degrees on the north wall and 37-39 degrees on the south wall. Lithology is orientated similar to the North Barneys Canyon pit, dipping at about 30 degrees to the north east. Pit walls on the east and west walls will be dictated by haulage access and will be well below the angle of repose. Figure 3.2-12 shows the East Barneys pit design. Bench face angles are expected to be 64 degrees in the bedrock and 45 degrees in the alluvium.

Pit slope stability has been analyzed by geotechnical consultants, Call and Nicholas. Rock fall and large-scale slope failures were considered. As a result of this analysis, 27 foot wide safety catch benches are constructed every 60 feet down the pit highwall.

The stability analysis indicated that large-scale slope failures are unlikely. The mine will be operated in accordance with all Federal Mine Safety and Health Administration (MSHA) guidelines and standards from mine safety, which include requirements for pit slope stability.

3.2.3 Carbonaceous Ore Stockpile

The Melco ore body contains identified zones of carbonaceous mineralization. The revised mining plan for the Melco pit has resulted in a larger pit than was previously contemplated or permitted. Approximately 1,100,000 tons of carbonaceous ore from a zone near the base of the ore body will be mined. These carbonaceous rocks contain gold mineralization, but cannot be readily processed by heap leaching methods. Kennecott has evaluated several alternatives for processing these ores, which will be stockpiled at a site on the Melco mine dump until they can be processed. The location of these planned ore stockpiles are shown on Plate II-B. If the carbonaceous ore cannot be economically processed, the stockpiled material will be placed in the Melco waste rock dumps and covered with waste rock.

The carbonaceous ore stockpile will be rehandled and processed through the sulfide flotation plant.

Kennecott has secured approval of its plan for handling the sulfide ore stockpiles from the Division of Water Quality (DWQ). A copy of the correspondence describing this plan is provided in Appendix J.

3.3 Crushing, Screening, Conveying and Stockpiling

The crushing plant receives run-of-mine ore and delivers crushed, agglomerated ore for constructing heaps. The crushing operation is depicted on the flow diagram in Figure 3.3-1. The limits of the crushing plant extend from the stockpile to the heaps constructed by the radial stacker. Fifty-five or 85-ton ore haulage trucks transport ore to a stockpile located adjacent to the primary crushing plant. A rock breaker is used to break oversized rocks. Ore is reclaimed from the stockpile by a Caterpillar 988B front-end loader and placed in a 35-ton crusher feed hopper which discharges to a vibrating grizzly feeder.

Grizzly oversize (bar separation is five inches) falls through an enclosed chute directly into a 42-inch x 48-inch primary jaw crusher. In the primary crusher cavity, ore up to three feet in size is crushed to minus nine inches. Grizzly undersize is discharged through an enclosed chute onto a 48-inch x 232-foot belt conveyor leading to the secondary crushing plant. Size reduction in the primary jaw crusher occurs at a four-inch closed-side setting. Jaw crusher and grizzly undersize products are combined and transported via a 48-inch conveyor to an eight-foot x 20-foot double-deck vibrating screen. Capacity of the crushing facility is 650 dry short tons per hour. Oversize from both screen decks is conveyed by a series of 36-inch conveyors to a five-and-one-half-foot standard cone crusher which is operated in closed circuit with the screen to produce minus one-and one-half-inch product.

Cement from a 150-ton capacity silo is dumped at a controlled nominal rate of around 7.5 pounds per ton to the minus-one-and-one-half-inch screen undersize product. The combined ore-cement mixture is transported via a conveyor to the five 36-inch x 20-foot agglomeration conveyors. Water is added by sprays on the five conveyors to produce an agglomeration product suitable for heap construction. Agglomeration is a technique that combines the water and fine cement with the ore to facilitate improved leaching and gold extraction. The moisture content of the agglomerated ore is controlled to approximately 10 to 12 percent. The agglomerated ore is transferred from the crushing plant to the upper edge of the leach pad area via interconnecting 36-inch overland conveyor belts. The last overland conveyor discharges onto the first of a series of 28 portable 100-foot-long conveyors for subsequent feed to a 100-foot radial arm stacker via the transfer conveyor and a shuttle type stacker feed conveyor. The stacker progressively retreats up the leach pad to spread agglomerated ore evenly on top of the overliner blanket or previous lift. Cyanide solution is sprayed on the ore to initiate the leaching of gold.

Initial plans called for the crushed and agglomerated ore to be stacked in three lifts of 17 feet each to a total height of 51 feet. The specified lift height may be increased or decreased in the future depending on metallurgical results. The maximum ore heap height is limited to 125 feet.

To ensure heap stability, as progressive lifts are stacked, the toe of each new lift is set back a pre-determined distance from the crest of the prior lift around the full periphery of the pad.

Water sprays at conveyor transfer points are part of the dust suppression system that controls both moisture content and air quality.

Sulfide ore will be batched through the existing crushing plant on a weekly basis and conveyed to a 5,000 ton live capacity enclosed stockpile. The planned annual combined ore tonnage will consist of approximately 417,000 tons of sulfide ore and 2,183,000 tons of oxide ore for a total of 2.6 million tons per year.

Sulfide ore will be reclaimed from the stockpile at a nominal 1,200 tons/day with belt feeders in a reclaim conveyor tunnel. This conveyor will feed a 3 foot Nordberg water flush cone crusher which will discharge into the ball mill sump. Grinding will be accomplished with a ball mill.

The concentrate will be produced in standard mechanical flotation cells, cleaned in a column cell, and reground if necessary. The concentrate will be dewatered in a thickener with a vacuum filter to ensure a proper solids density. The tailings will be metered back to the agglomerating conveyors for blending with the oxide ore stream enroute to the heap leach pads. A generalized site map, flowsheet and building layout are included as Figures 3.3-2, 3.3-3 and 3.3-4.

3.4 Leaching

Ore is transferred from the crushing area to the leach pads in a series of fixed overland conveyors. The radial stacker heaps the ore into 17-foot-high lifts on the previously prepared leach pads. The ore is then sprinkled with a weak (0.3 pound NaCN per ton of leach solution) sodium cyanide and sodium hydroxide (NaOH) solution. Wobbler-type spray heads are used. The solutions leach the gold from the ore as they percolate through the heaps. The resulting "pregnant solution" is collected on the pad and piped to a lined pregnant solution pond located adjacent to the process plant at the east end of the property. Pregnant solutions from the pond are pumped to carbon columns located within the process building, where carbon adsorption takes place. The loaded carbon columns are then processed further through desorption, electrowinning, and refining. The leach pads, solution ponds, and process building locations are shown on Plate 96-1.

3.4.1 Leach Pads

A total of approximately 270 acres of pad area is required over the life of the project. The pads have been designed and approved by DWQ for a maximum ore height of 125 feet. To reduce capital outlay, the pads are constructed sequentially as needed with the first (BC-1) leach pad constructed in 1989. As of February 1997, pad BC1, BC2, BC3, BC4, and BC5 were all operational. Other pads will be constructed in later years. The general arrangement of the leaching facility is shown on Plate 96-1. A generalized drawing depicting the major components of leach pads is shown on Figure 3.4-2. Leach pads will be sized and arranged on the site to reduce the amount of grading required for pad foundations.

<u>Leach Pad Foundations</u>

Each pad is first graded to produce a firm foundation. Grading is preceded by vegetation and topsoil removal. The topsoil is placed in stockpiles for future use in

reclamation of the facilities. The pad foundations are built with cut and fill techniques where the alluvial soils are excavated from the ridges and placed in the low spots as engineered fills. The backfills are raised in horizontal lifts not exceeding 8-inches in thickness, conditioned with moisture and compacted to 90-95% of maximum dry density (see Appendix E for full specification). The general grade of the pad foundations slope along their long dimensions at 6% maximum and less than 1% along their short dimensions so that each pads lowest point is in a corner for efficient solution collection (Figure 3.4-3). (Stability analyses performed by Sergent, Hauskins and Beckwith (1988) indicate that the heaps will be stable.) The detailed grade of the pad surfaces will typically accommodate the topography through the use of long terraces which themselves have slopes along their long and short dimensions for drainage of solutions (Figure 3.4-3). The final foundation grade forms a sub-base with a permeability of less than or equal to 1×10^{-6} cm/sec upon which a leak detecting system is placed.

At the downhill margins of the pads, the pad surface terminates in a solution collection trench that is 11-feet wide at the crest and 2 feet deep. Outside of the trench, there is a perimeter berm that is 2-feet high with an 8-foot wide toe (Section A, Figure 3.4-3). The bottom corner of each leach pad cell is equipped with a leachate collection pipe extending through the perimeter berm (Detail 6, Figure 3.4-4). This pipe is made of welded HDPE and transports the collected solutions to the leach pads.

Liner Leak Detection System

A Six-inch-thick, high permeability pad drainage system is installed above the compacted low-permeability subgrade. The purpose of the leak detection system is to alert operations personnel to solution losses through the HDPE and clay liners. Typical cross sections of the pad lining and leak detection system are shown on Figure 3.4.3.

Leak detection under all areas of the pad is accomplished by monitoring the presence of any solution flow in a closed HDPE collector pipe which connects to a series of two- or three-inch-diameter corrugated polyethylene pipes resting on the subgrade (Figure 3.4-5). Each pipe exits at the side of the pad. The leak detection pipes are factory-milled with 0.66-inch-wide slots placed on 40-foot centers. A minimum slope of one percent is maintained on the leak detection pipes. Each six-inch HDPE collection pipe at the margin of the leach pads is joined to the non-perforated end of the leak detection pipe by a polyethylene snap adapter. The other end of the non-perforated leak detection pipe is joined by a pipe sleeve to its perforated equivalent that rests on the leak detection layer.

Leach Pad Liners

The secondary earth liner is placed on top of the leak detection system. This is a fine-grained clay soil borrowed from the property near the leach pads. It is spread in layers that when compacted will be approximately 6 inches thick, conditioned with water and compacted to 95% of the maximum dry density as determined under ASTM-D698 (see Appendix E). Two layers are placed for a total compacted thickness of 1 foot. The permeability of this compacted soil liner is 1.0×10^{-7} cm/sec which, combined with the design thickness, ensures that any seepage through the primary plastic liner is essentially

stopped by the secondary liner. This liner is extended to the perimeter berms as shown on Figures 3.4-3. The clay for the secondary liner is recovered from borrow pits on the Barneys Canyon property. Three borrow sources have been identified thus far and their locations are shown on Plate III. Further pit development will depend on the resources available at each of the existing sites. Clay pits 1 and 2 have been finished and reclaimed. Clay pit 3 has been partially developed. The extent of current development and estimated ultimate pit size is shown on Plate III-A. Pits will be expanded or developed as demand for liner materials arise.

The primary liner is immediately placed on top of the earth secondary liner. The primary liner is 60 mil HDPE installed according to the manufacturer's recommendations (see Appendix F for full specification). This material covers all interior areas of the pads, as shown of Figures 3.4-2 and 3.4-3.

Solution Collection

The final step in pad construction is the installation of the crushed ore blanket, or overliner, on top of the primary liner. Solution collection piping is installed on each cell prior to covering the liner with overliner. The piping consists of a three-inch-diameter corrugated, perforated polyethylene pipe spaced at 40-foot centers (Figure 3.4-2). These pipes connect to an eight-inch-diameter polyethylene collection main which runs downslope to the discharge end of each cell. The blanket is minus 11/2-inch crushed ore, produced at the plant crushing facility, which will be trucked or conveyed to the pad and spread to a thickness of approximately 4 feet. The overliner functions as a protective cushion separating the primary plastic liner from the overlying ore. The crushed and agglomerated ore is then be stacked on top of the cushion.

3.4.2 Solution Conveyances

Leach solutions draining from the bottoms of the heaps flow in pipes in the solution collection trenches along the margins of the pads to the low points of each cell where the solutions are routed into HDPE pregnant solution pipes. The pregnant and barren solution pipes have secondary containment, a lined ditch which flows toward the process solution ponds. Pregnant solutions entering the ponds are routed through measuring flumes that record the flow rates.

The collection trenches are HDPE lined ditches from the pads to the solution ponds to collect any leaks of solutions from the pipes, as shown on Figure 3.4-4. These collection trenches are separated from the general site drainage by their lateral berms and carried under all road crossings with culverts. The layout of the trenches provide suitable grade (1% minimum) so that any leakage is conveyed in the trenches back to the process solution ponds (Figure 3.4-4).

The barren solution piping system on the heaps consists of a 12-inch HDPE pressure main on each cell, a network of six-inch PVC branch lines, and a network of three-inch spray PVC lines spaced at 40-foot intervals. The sprinklers are "Senninger-Wobblers" spray heads. The Senninger-Wobbler sprinkler is highly resistant to corrosion which reduces the risk of plugging or stalling. Since it has a single moving part, the Wobbler also resists wear.

The spray heads operate between 15 and 25 pounds per square inch and provide a solution application rate of .0025 to .004 gallons per minute per square foot of pad area. Yelomine SDR-21 PVC is employed using spline connections. The piping system is inspected daily by the leaching crew. The Wobblers require occasional un-blocking of orifices. The leaching crew surveys the spray pattern and note non-performing sprinklers. After shutting down the feedlines, the sprinkler is unplugged or replaced. The sprinkler system is restarted after maintenance is completed.

Solution pumping is accomplished with submersible-type pumps in the solution ponds. Outside of the solution process building, pumped solution pipes are equipped with pressure sensors which immediately and automatically shut down the pump should there be a significant break in the pipeline.

3.4.3 Solution Ponds

The process solution ponds are HDPE-lined basins located at the lowest point in the process area (Figure 3.4-1). The ponds will have a total capacity sufficient to contain the following volumes:

1) The working inventory of leach solution. This is the combined volume of solutions in the pregnant barren and intermediate ponds. Normal volume is 4,000,000 gallons in each pond (12,000,000 gallons total).

2) The drainage of leach solution from the connected heaps during a 24 hour shutdown of the leach pumping system. The calculation assumes a 24-hour draindown volume enters the ponds at the prevailing barren solution pumping rate to the heaps. For example, at a pumping rate of 2000 gpm, the calculated volume would be 2,880,000 gallons.

3) The volume of runoff from the exposed, lined pad and trench areas that occurs during the 100-yr 24-hour precipitation event. This is based upon 3.5 inches of rain. This runoff will be a variable and will equal 218,200 gallons for each 100,000 square feet of bare plastic.

4) The runoff from the leach pads. Due to the water storage capacity of the heaps, it is assumed that runoff occurs only from areas under active leach. Runoff from the 100-year storm (3 1/2 inches of rain) would provide 218,200 gallons for each 100,000 square feet under active leach.

5) The direct precipitation on the ponds during the 100-yr 24-hour precipitation event. This will equal 403,670 gallons based on 3.5 inches of rain falling on the 185,000 square foot pond area.

6) A freeboard value of at least 2 feet above the level for volumes 1) through 5) above.

The combined capacity of the barren pregnant and intermediate solution ponds is available for the draindown and storm inflows. The total capacity of the process solution ponds is 15,200,000 gallons.

The ponds have 3h:1v sideslopes and bottoms that are sloped to one low corner (Figure 3.4-6 and 3.4-7). The bottoms of the ponds have a rectangular configuration and are inclined at 2.0%, then graded to one corner where the pond leak detection collection sump is placed (Figure 3.4-7)

The ponds were first excavated to approximate final grade. Twelve inches of secondary liner material was then applied in two 6-inch compacted lifts (Figure 3.4-6). The permeability, material type, and placement techniques for this liner material were identical to those described for the leach pads in Section 3.4.1. A geotextile followed by a drainage grid material was then placed on the secondary liner (Figure 3.4-6). The primary liner of 60 mil HDPE was then placed on top of the drainage grid and anchored in trenches along the margin of the ponds (Figure 3.4-6).

The function of the drainage grid is to capture any leaks that might occur through the primary liner and allow leakage to be drained to the low point of the pond bottom for removal. The low point of the leak detection system is equipped with a small sump to collect the seepage. Eight-inch diameter standpipes are used to monitor the leak detection sumps for leakage (Figure 3.4-6). A probe inserted in the standpipe detects any solution accumulated in the leak detection sump. If confirmed that the solution is leakage from the ponds, the DWQ will be notified as required in their construction permit.

3.5 Leach Solution Processing

Leach solutions are processed in the process building. The building's location is shown on Plate IIIA. Leach solution processing is depicted on the flow sheets shown on Figures 3.5-1 and 3.5-2.

3.5.1 Carbon Adsorption

The carbon adsorption process is depicted on Figure 3.5-1. The leach solution from the pregnant solution ponds is pumped to carbon columns, each filled with granulated, activated carbon, and located in the process building. The gold-cyanide complex is adsorbed on the carbon as the pregnant solution passes through the columns. The solution coming from the carbon columns is the barren solution and is refortified with solutions of NaOH and NaCN and recycled to the barren solution pond. The barren solution is then pumped back to the heaps to complete the leach cycle. Fresh water as needed is added to the barren ponds to make up for evaporative losses from the leach heap and the leach solution ponds.

When the gold content of the carbon is sufficient for stripping, the loaded carbon is moved to the carbon processing plant. The carbon is pumped to an acid wash tank where the loaded carbon is treated with a 5% solution of hydrochloric acid (HCl) to remove any mineral scale build-up (Figure 3.5-2). Acid soluble metals are also washed from the carbon in this step. The acid wash solution is neutralized in the acid wash tank by reaction with the natural carbonate minerals on the carbon The metals that were dissolved from the carbon are precipitated as hydroxide sludges within the tank. This dilute sludge is rinsed from the carbon, passed over a fine carbon screen, and pumped to the chemical waste sump. From the chemical waste sump, the sludge is pumped to the active barren pond where the sludge is mixed and pumped to the heap. If the acid is not adequately

neutralized in the acid wash tank, washed carbon in the tank is treated with a NaOH solution to elevate the pH prior to pumping the washed carbon to the carbon strip tanks.

3.5.2 Carbon Stripping

The washed carbon is stripped of its gold with a solution of 1% NaOH at atmospheric pressure and a temperature of 190°F. The stripping is conducted in 2 banks of 2 closed, strip tanks, each bank connected in closed circuit with a strip solution tank, strip solution heater and electrowinning cell Figure 3.5-2. Approximately 20 GPM of strip solution is circulated for 72 hours to strip each batch of carbon.

3.5.3 Electrowinning

Gold is precipitated from the heated strip solutions onto steel wool cathodes in a process called electrowinning (Figure 3.5-2).

3.5.4 Carbon Regeneration

Stripped carbon is pumped from the carbon strip tanks back to the carbon columns (Figure 3.5-2). Continued reuse of the carbon results in a degradation of its adsorption quality so the carbon is occasionally reactivated (Figure 3.5-3). The carbon is first washed with water to remove any cyanide and then reactivated in a 1,500,000-BTU/HR, propane-fired kiln by heating to a temperature of 1200°F in an oxygen deficient atmosphere. The reactivated carbon is then quenched in a tank of water and pumped back to the carbon adsorption columns.

3.5.5 Gold Refining

The gold refining process is depicted on Figure 3.5-3. Cathodes, consisting of steel wool with plated gold, are removed from the electrowinning cells about every third day. After being air dried, the cathodes are placed in an electrically heated mercury retort to drive off any contained mercury. The mercury fumes are drawn off by a vacuum pump into a condenser where the mercury is collected for sale. The vacuum pump exhausts to the outside and does not have mercury carry-over. The cathodes are then mixed with soda ash, silica and borax flux and melted in an electric induction furnace to form a gold dore'.

3.6 Ancillary Facilities

Ancillary or support facilities for the Barneys Canyon Project consist of an analytical laboratory, a truck shop and warehouse, explosives storage, fuel storage facilities, parking areas, and an administration building. The locations of most of these facilities are shown on Plate III-A. The total laboratory facility includes a sample preparation room with drying and crushing equipment, wet chemistry laboratory, fire-assay laboratory, a metallurgical testing laboratory, and an atomic adsorption analytical room. The truck shop is used to service and maintain all mining equipment. The warehouse is used for storage of parts and equipment for the shop. The fuel storage facilities are sited as appropriate for efficient operations. Fuel spill control measures including safety berms are installed at the fuel storage site. A Spill Prevention Control and Countermeasures (SPCC) Plan has been prepared and implemented as required by Federal law. The administration building houses

offices for management personnel. Parking lots for employees are located at the administration building. Parking for company-owned equipment and man-carrying vehicles are provided adjacent to the truck shop, process building and administration building.

Ancillary facilities required for the expansion will be the infrastructure associated with the sulfide flotation plant (Figure 3.3-2).

3.7 Waste Disposal

Waste materials generated by the activities at the Barneys Canyon project consist of mine waste rock, spent ore on the leach pads, and trash. Mine waste rock is disposed in the waste rock dumps, as described in Section 3.2. Spent ore will be reclaimed in place. Trash is hauled to a nearby, permitted municipal landfill. Waste solutions from the labs and process buildings are handled in the process system in accordance with DWQ permits.

Waste rock dumps are created by end-dumping material from haul trucks. Track type dozers push waste rock over the crest of the dump. The dumps are constructed with top surfaces sloping gently back toward the natural hillsides for the purpose of drainage control. During mining, the dump outslopes will have a slope angle of approximately 37 degrees.

Waste material from the North BC South and South BC South deposits will consist of calcareous sandstone, clay altered sandstone, and orthoquartzite. Similar material was mined from the Melco deposit and has formed very stable waste rock dumps in terrain steeper than the site of the proposed BC South waste rock dump.

East Barneys deposit contains approximately 500,000 tons of Quarternary alluvium and 500,000 tons of sandstone, quartzite and limestone waste rocks These rocks are similar to materials currently being mined in the North Barneys and South Barneys Pits.

Dump slope stability analyses have been performed by Sergent, Hauskins & Beckwith for the large Melco dump and the Barneys Canyon 6300 and 6500 mine dumps. Analyses were performed in those parts of the planned dumps where the most critical natural slope conditions were encountered. The planned dump configurations for this project, including placement of the dump material at the angle of repose(37 degrees) were used in the calculations. Stability analyses performed for the proposed dumps resulted in the following ranges of factors of safety (F.S.) under static conditions:

Barneys Canyon Dumps	F.S. = 1.05 to 1.33
Melco Dump	F.S. = 1.1 to 1.4

A safety factor of 1.0 or more indicates that a slope is stable; therefore, the Barneys Canyon and Melco dumps are predicted to be stable.

Sergent, Hauskins & Beckwith also conducted dynamic stability analyses for the dumps. These calculations indicate that "...permanent deformations under horizontal accelerations of 0.2 to 0.3 for the critical failure zones would be less than 2 feet." (Sergent, Hauskins & Beckwith, 1988) Further details can be found in the dump stability analysis report which has been separately submitted.

In order to respond to the Division's rule regarding identification and handling of toxic materials, analyses of waste rock, ore, and leached ore were performed using one or more analytical techniques that are accepted means of determining toxicity of waste materials that are either naturally occurring or have been disposed in the natural environment. Waste rock was analyzed for total content of selected metals, weak-acid-soluble metals (EP toxicity test), and acid-base potential. Raw ore was analyzed for total metals. Spent leach material (leached ore) was subjected to total metals analyses and EP toxicity tests.

The EP toxicity test involves a 24-hour leach of solid material in a solution of acetic acid with a pH of 5.5. The ratio of leachate to sample is 20:1. The EP toxicity test was designed to simulate weakly acid conditions that can exist in landfill environments, and under which many metals may be dissolved and mobilized. The EP toxicity test was selected because it is an accepted U.S. EPA analytical protocol and is a worst case test for mine-related material. Mining of the Melco deposit will result in the disposal at the mine dump of a small amount of pyritic waste rock in comparison to the total waste volume. It is important to point out that mining wastes are currently exempted by Federal and State law from regulation under the laws and regulations that established the EP toxicity tests and for which EP toxicity analyses have regulatory impact.

The acid-base potential test was developed for evaluation of coal mine wastes. Each sample is analyzed for acid-generating potential and neutralization potential. Acid-generating potential is based on the total sulfur content of the sample. Neutralization potential is based principally upon the carbonate content of the sample; however, the effect of the ion-exchange capacity of clays is also taken into account. The results of acid-generating and neutralizations tests are calculated in tons of $CaCO_3$ per 1000 tons of material. In the case of acid potential, the result is expressed as a negative number equivalent to the tons of $CaCO_3$ required to neutralize the amount of acid generated. Neutralization potential is expressed as the tons of $CaCO_3$-equivalent material per 1000 tons of waste. The results of each separate test are then added together. A positive result indicates that the sample is neutralizing, a negative number indicates that it is potentially acid generating. This result is used to determine the amount of neutralizing material (soil or overburden with neutralizing potential, or additives like agricultural lime) necessary to neutralize acid-generating waste.

Acid-base potential analyses for Barneys Canyon representative waste rock composite sample and two Melco representative composite waste rock sample. Acid-base potential analyses for East Barneys consisted of 18 waste rock samples from four waste rock types. The results from each rock type were averaged. The overall acid-base potential was calculated using a weighted average based on the volume percentage of each rock type within the East Barneys Pit. The acid-base potential is as follows:

Sample	pH	Acid-Base Potential
Barneys Canyon (BC-85, composite)	8.9	+556 T/1000T

Melco (MC-25,5' to 255' composite)	8.6	-4 T/1000T
Melco (MC-25,375' to 570' composite)	6.3	-4 T/1000T
East Barneys	9.3	+12.5T/1000T

The full laboratory report is available in Appendix C-III. The analytical laboratory has determined that the Melco samples are only slightly acid-forming, and therefore non-toxic. This is due to the relatively low pyrite content of the ore and waste samples. The samples selected for analysis were from drill holes containing both oxide and sulfide materials and were selected as representative of zones of mixed ore and waste that will be encountered during mining of the ore body. Most of the ore body contains only oxide ore and waste. The estimated total quantity of sulfide-bearing ore and waste in the original Melco pit was 625,000 tons; the sulfide fraction was estimated at approximately 300,000 tons. Total waste for Melco was 14,000,000 tons; therefore, the total sulfide-bearing material comprises only 4.5 percent of the total mine waste to be removed from the Melco pit. The mine dumps contain a like proportion of sulfidic waste. Therefore, the dumps will not generate acid solutions as a result of percolating rain water. Therefore, the dumps and this will greatly reduce the potential for dissolution and mobilization of metals, since these metals are insoluble at moderate to high pH's.

The only significant sulfide mineral present in the ore and waste at Barneys Canyon is pyrite. Pyrite in quantities sufficient to generate significant acid will be readily identifiable by visible means. In addition, as part of gold assaying for mine ore grade control, the mine analytical laboratory determines not only gold content but also whether the ore and adjacent rocks are sulfide bearing or oxidized. The laboratory analysis is performed on closely spaced blast holes. The mine geologist or other person responsible for ore grade control in the pit is responsible for delineating and marking the pyritic waste rock in the pit throughout the life of the mine. During overburden removal, pyrite-bearing waste is identified both from the blast hole analytical results and by visual means, marked with flags and loaded in separate trucks for haulage to the waste rock dump where it is dumped such that non-sulfidic waste can be blended with it.

The Melco ore body contains identified zones of sulfide mineralization as shown on Cross-Sections A-I-3-5 which are included in Appendix A-I, the Confidential Appendix. Some of the sulfide-bearing material occurs in isolated and irregular pods within the middle and upper parts of the ore body. The revised mining plan for the Melco deposit has resulted in a larger pit than had originally been contemplated. As a result, a discrete sulfide zone at the base of the ore body and near the pit bottom will be removed. The sulfide-bearing waste in the upper portions of the pit will, by virtue of its irregularity, be mixed with non-sulfidic waste during overburden removal and dumping; therefore, no concentrations of sulfide waste will be deposited in the dump from these zones. The sulfide-bearing rock at the base of the ore body, though containing gold mineralization, does not lend itself to heap leaching and will not be mined with oxide ore. It was originally Kennecott's intention to mine the ore fraction of this material and haul it to its Magna smelter where, because of its high silica content, it could be used as flux and the contained gold recovered. It was determined that this sulfide could not be used as a flux but the ore grade material was stockpiled for treatment to recover the gold

and remove the contained sulfide from the waste rock dumps. A sulfide flotation plant has been designed to remove most of the sulfur from the sulfide ore that has been stockpiled on site and the additional sulfide ore which will be liberated during mining. Engineering work and permitting are actively being pursued to treat this material which otherwise would have been placed in the waste dumps.

The results of the total metals analyses and EP toxicity tests for the ore and waste are presented in Tables 3.7-1 and 3.7-2, respectively.

Total metal contents of various ore and waste samples are elevated above normal background as the results of natural hydrothermal processes that formed the gold ore bodies.

The results of the EP toxicity analyses on unleached and leached ore are compared to appropriate U.S. EPA limits in Table 3.7-1. As this table demonstrates, none of the samples exceed or even approach the limits for EP toxicity set by the EPA. Hence, ore stockpiles and spent leach materials in the heaps are not anticipated to provide a source of soluble metals to the environment.

The results of EP toxicity analyses on Barneys Canyon and Melco waste rock, along with EPA EP toxicity limits are presented in Table 3.7-2. As in the case of the ore samples, the results of these analyses indicate no quantities of soluble metals in excess of the EPA standards for the EP toxicity procedure. In addition, since, as the acid-base potential analyses indicate, the waste rock dumps will not substantially lower the pH of the water percolating through them, the pH 5.5 conditions simulated in the EP toxicity test should not be approached at the site. Therefore, even the levels of metals reported out of the EP toxicity tests should not be reached in waters percolating through the mine dumps.

The current mining plan for Melco estimates that a total of 29,000,000 tons of waste rock, including that excavated in the first phase of mining, will be generated. Of this quantity, approximately 1,100,000 tons of the waste will be sulfide-bearing or sulfidic waste rock. This represents approximately 4.0 percent of the total waste rock quantity. Sulfide waste generated by the expanded Melco operations will be blended with oxide waste rock during ordinary waste disposal operations to ensure adequate dispersal of sulfide material within the oxide waste and avoid encapsulation of significant concentrations of sulfide waste rock in the dumps. If necessary, non-sulfidic waste rock will be stockpiled for use as cover material for the sulfidic material. A minimum three-foot depth of non-sulfidic waste will be used to cover the sulfidic material.

The North BC South deposit contains no visible sulfide-bearing material. The results for analyses for acid-generation and neutralization potential for samples of waste rock and pit wall rock material from the North BC South deposit are summarized in Table 3.7-3. Copies of laboratory analytical reports from which this table was derived may be found in Appendix C. The non-weighted average acid-base potentials are 58.1 tons $CaCO_3$/1000 tons and 287.1 tons CaCO3/1000 tons, respectively, for the waste rock and wall rock. These data indicate that the North BC South waste rock and wall rock are not acid-generating.

The South BC South deposit contains small amounts of visible sulfide and carbon in discontinuous pods. The only sulfide species identified was pyrite. This material represents one tenth of one percent (0.1 %) of all South BC South waste material. This is an order of magnitude less sulfide than is present at the Melco deposit. Based on the nature of the

visible sulfide occurrence in the deposit and the pit design, the sulfide-bearing waste rock will be blended with and covered by oxide waste rock during ordinary waste disposal.

Table 3.7-1 Results of Total Metals and EP Toxicity Analyses For Barneys Canyon Project Ore

Concentrations (in ppm)

Sample Type and Designation	As	Sb	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Te	Tl	Zn
Untreated Ore (Total) Barneys															
(BC-131)	4300	<10	869	<0.5	4	33	45	36	1.0	23	16	17	9	90	103
Melco															
(MC-36)	3800	<10	3120	0.5	1	12	37	10	1.7	8	8	4	57	180	29
Melco															
(MC-38)	700	<10	2550	<0.5	1	11	36	15	1.0	41	7	17	39	50	43
Mean	2390	<10	2180	<0.5	2	19	39	20	1.2	29	10	13	38	107	58

Designation	As	Sb	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Te	Tl	Zn
Leached Ore (Total)Barneys															
(BC-131)	1300	2	1020	<0.2	2	35	52	56	NA	29	0.9	1.4	1.1	80	165
Melco															
(MC-36)	3900	10	3500	<0.2	<0.5	16	24	27	NA	14	2.3	0.3	5.6	190	29
Barneys/Melco															
Composite	50	2	475	0.2	1	54	47	56	NA	28	0.6	1.4	0.8	76	156
Mean	1750	5	1670			35	41	46		24	1.3	1.0	2.5	115	117

Leached Ore (EP Toxicity) Designation	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
Barneys								
(BC-131)	0.1	0.13	NA	<0.01	<0.01	0.0001	<0.01	<0.01
Melco								
(MC-36)	0.013	1.5	<0.01	<0.005	<0.005	0.0023	<0.004	<0.01
Barneys/Melco								
Composite	0.004	2.4	0.03	0.03	<0.005	0.0040	<0.0040	<0.01
Mean	0.04	1.3				0.0021		
EP Toxicit								
Limits (EPA)	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0

The results of analyses for acid-generation and neutralization potential for samples of waste rock and pit wall rock material from the South BC South deposit are summarized in Table 3.7-4. Copies of laboratory analytical reports from which this table was derived may be found in Appendix C. The results of analysis of the four wall rock samples indicate that pit wall rocks have a mean net neutralizing potential of 19.9 tons of $CaCO_3$/1000 tons and will not be acid-generating. Waste rock classified as non sulfide, due to the absence of visible sulfide minerals, comprises approximately 99.9 percent of the waste material, approximately 1,864,000 tons. This waste rock has a mean net neutralizing potential of 1.35 tons of $CaCO_3$/1000 tons. The sulfide waste rock comprises an estimated 1,800 tons of material and is represented by one sample, SS-1, which has a mean net acid-generating potential of 278 tons of $CaCO_3$/1000 tons. An acid base accounting of all the waste samples indicates that there is a net acid consuming capacity with the ratio of neutralizing potential: acid generating potential for all samples being 2.3:1

The small amount of sulfide-bearing waste rock can be readily identified visually and will be placed in the BC South waste rock dump such that it will be covered by the non-acid-generating, clayey waste rock. As a part of the mine waste dump management plan submitted to the Utah Division of Water Quality, it has been determined that all dumps will be shaped to promote runoff of precipitation and minimize deep infiltration of water to the dumps. No dumps will be allowed to impound water or to collect water in surface ponds which may enhance infiltration.

The expanded mining plan for Melco estimates that a total of 121.4 million tons of waste rock, including all waste mined to date, will be excavated and placed in waste dumps. Of this quantity, approximately 8.2 million tons or 6.8 percent of the waste will be sulfide-bearing or sulfidic waste rock. The sulfide bearing waste generated by the Melco mining operations will be handled in accordance with the existing Utah Division of Water Quality ground water discharge permit.

Table 3.7-2 Results of Total Metals and EP Toxicity Analyses For Barneys Canyon Project Waste Rock Samples (in ppm)

Sample Type and Designation	As	Sb	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Te	Tl	Zn
Total Metals															
Barneys															
(BC-85)	200	<10	338	<0.5	5	80	31	185	0.5	42	<4	18	<5	60	129
Melco															
(MC-25,5'-95')	300	<10	650	<0.5	1	7	21	131	0.4	10	<4	4	<5	10	47
(MC-25,375')	2900	<10	730	<0.5	1	7	21	68	0.4	33	<4	3	8	120	105
Mean	1130	<10	573	<0.5	2	31	24	128	0.4	28	<4	8		60	94

EP Toxicity Designation	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
Barneys								
(BC-85)	0.11	0.4	<0.05	<0.05	<0.05	0.0001	0.08	<0.05
Melco								
(MC-25,5'-95')	0.07	1.3	<0.05	<0.05	<0.05	0.0001	<0.05	<0.05
(MC-25 375')	1.86	0.1	<0.05	<0.05	<0.05	0.0023	<0.05	<0.05
Mean	0.68	0.6	<0.5	<0.5	<0.5	0.0008	<0.5	<0.5
EP Toxicity								
Limits (EPA)	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0

Table 3.7-3 Summary of North BC South Waste and Wall Rock Acid Generation Potential Analysis

Sample No. (BCM)	% Sulphur	AGP as $CaCO_3$	ANP as $CaCO_3$	Net ABP as $CaCO_3$
Waste Rock				
NW - 1	0.03	-0.9	2.1	1.2
NW - 2	0.02	-0.8	2.3	1.7
NW - 3	<0.01	<0.3	441	440
NW - 4	<0.01	<0.3	78.5	78
NW - 5	<0.01	<0.3	8.1	7.8
NW - 6	0.01	-0.3	9.9	9.6
NW - 7	0.02	-0.6	6.6	6.0
NW - 8	0.01	-0.3	24.6	24.3
NW - 9	<0.01	<0.3	8.0	7.7
NW - 10	<0.01	<0.3	5.3	5.0
Mean	0.01	58.1		
Wall Rock				
NP - 1	0.02	-0.6	35.8	35.8
NP - 2	0.11	-3.4	4.7	1.3
NP - 3	0.03	-0.9	63.3	62
NP - 4	<0.01	<0.3	28.4	28
NP - 5	<0.01	<0.3	552	551
NP - 6	<0.01	<0.3	981	980
NP - 7	<0.01	<0.3	<0.1	*
NP - 8	<0.01	<0.3	14.5	14
NP - 9	<0.01	<0.3	913	912
Mean	0.02	287.1		

* All values less than detection limit

** AGP, ANP, ABP units expressed in tons of $CaC0_3$ per 1,000 tons of material

Table 3.7-4 Summary of South BC South Waste and Wall Rock Acid Generation Potential Analysis

Sample No.	% Sulphur	AGP as $CaCO_3$	ANP as $CaCO_3$	Net ABP as $CaCO_3$
Waste Rock				
SW - 2	0.79	-24.7	3.9	-20.8
SW - 3	0.08	- 2.5	18.8	16.3
SW - 4	0.13	- 4.1	0.8	- 3.8
SW - 5	0.06	- 1.9	6.4	4.5
SW - 6	0.08	- 2.5	2.5	0
SW - 7	0.09	- 2.8	3.0	- 0.2
SW - 8	0.28	- 8.8	1.3	- 7.5
SW - 9	<0.01	< 0.3	15.7	15.4
SW - 10	0.32	-10.0	<0.1	-10.0
SW - 11	<0.01	< 0.3	8.0	7.7
SW - 12	0.09	- 2.8	<0.1	- 2.8
SW - 13	0.41	-12.8	5.2	- 7.6
SW - 14	0.38	-11.9	<0.1	-11.9
SW - 15	<0.01	< 0.3	40.4	40.1
SW - 16	0.23	- 7.2	0.1	- 7.1
SW - 17	0.03	- 0.9	5.6	4.7
SW - 18	<0.01	< 0.3	26.3	26.0
SW - 19	0.09	- 2.8	8.1	5.4
SW - 20	0.10	- 3.1	<0.1	- 3.0
SW - 21	0.45	-14.1	4.1	-10.0
SW - 22	<0.01	< 0.3	<0.1	-
SW - 23	0.06	- 1.9	2.3	0.4
SW - 24	0.05	- 1.6	<0.1	- 1.6
SW - 25	0.07	- 2.2	0.5	- 1.7
Mean	0.16 1.35			
Sulfide Waste Rock				
SS - 1	8.75	-273	<0.1	-273
Wall Rock				
SP - 1	<0.01	< 0.3	<0.1	*
SP - 5	1.01	-31.6	36.0	4.4
SP - 6	0.04	- 1.3	38.9	37
SP - 7	0.01	- 0.3	38.9	38
Mean	0.27 19.9			

*AGP, ANP, ABP units expressed in tons of $CaCO_3$ per 1,000 tons of material3.8 Production Schedule

3.8 Production Schedule

Waste rock removal began in the Barneys Canyon pit in the first quarter of 1989 and in the Melco pit in late 1989. Barneys Canyon and Melco pits were mined concurrently in 1989 and 1990, by which time the first phase of Melco was mined out. Mining will continue in the Barneys Canyon pit through 1995.

In order to mine the North BC South, the South BC south and the Melco ore bodies in a timely manner, Kennecott will begin pre-stripping the South BC South deposit during the fourth quarter of 1992. This schedule will allow the ore body to be placed in production during the first quarter, 1993. Pre-stripping of the North BC South pit could begin during the second quarter of 1993 with ore production beginning during the first quarter, 1994. The second phase of pre-stripping at Melco will begin during the first quarter, 1993, with ore production commencing during the first quarter, 1994. Barneys Canyon and Melco pits will be mined concurrently in 1994 and 1995 until the Barneys Canyon ore deposit is exhausted. Mining will continue at Melco alone from 1995.

The Barneys Canyon mine will operate two 12-hour shifts per day, 7 days per week, 52 weeks per year. Because of limitations imposed by severe weather conditions, Melco operations may be curtailed during the worst winter months; however, if conditions permit, mining will proceed 24 hours per day and 52 weeks per year. The crushing plant and process plant are scheduled to operate 24 hours per day and up to 365 days per year. The laboratory and truck shop are operated year-round in support of both and mining and process operations.

Construction of the Melco north dumps is scheduled to begin in the third quarter of 1994 with prestripping of the Melco D phase planned to begin in early 1995. Mining of the North BC South pit is scheduled to begin in the 4th quarter of 1994.

The East Barneys Deposit is scheduled to be mined in 1997. Topsoil stripping and removal of alluvium will commence as weather allows early in the year. Mining is expected to continue through the third quarter 1997.

3.9 Topsoil Management

Available topsoil materials at the Barneys Canyon mining site were stripped with dozers and scrapers then placed in storage piles on sites protected from excessive surface runoff. Planned topsoil stockpile sites are shown on Plate III-A. The topsoil portion of the soil profile, consisting, on average, of the upper 12 inches, was salvaged. In areas underlain by Copperton soils no more than the upper 12 inches of topsoil was salvaged. The Soil Conservation Service (SCS) has determined that these soils are less than ideal for use as topsoil. Facility sites having Copperton soils include all the leach pads, the solution ponds, process building, substation, administration building, crushing and screening area, the eastern 3.8 acres of the shop building area, and the eastern 2.6 acres of the ore stockpile area. All other facilities are covered with Harkers-Dry Creek association, Dry Creek-Copperton association or Bradshaw-Agassiz association soils which the SCS recognizes as suitable for use as topsoil. For these soil types, borrow depths exceeded 12 inches where possible to meet topsoil volume needs.

Recoverable soil volumes for each component of the project are summarized in Table 3.9-1. In the event that areas currently identified for topsoil salvage are found during recovery operations to lack the 12 inches of topsoil necessary, the balance of the soil necessary to carry out the topsoil redistribution plan described in Section 5.4 will be maintained by borrowing additional soils from other areas having greater than 12 inches of soil.

In the Melco Phase A area, total available topsoil exceeded the anticipated topsoil demand for reclamation by approximately 28,000 cubic yards, as described in Table 3.9-1 and section 5.4. Because of the steep terrain and resultant difficulties in removing and transporting the material, only a sufficient volume of topsoil to accomplish the planned reclamation work, was recovered and stockpiled from the pit and dump sites.

Recoverable soil volumes for each component of the two new proposed pits and the Melco expansion are summarized in Table 3.9-2. Kennecott proposes to salvage topsoil from all areas where salvaging operations can be safely conducted. Areas with very steep slopes, principally the sites of the Melco 7200 and 7300 waste dumps, are not generally suitable for the safe removal of topsoil.

The potential for loss of topsoil during salvage operations due to equipment inefficiencies on relatively steep slopes and the reduction of salvageable topsoil in some wooded areas caused by large tree roots has been considered. It is assumed that this loss will be balanced by ordinary swelling following salvaging and the added volume that will be created by mixing vegetation with the soil during salvaging and stockpiling operations. In addition, although it has been assumed for the purposes of estimation that only one foot of soil would be available for salvage, it is probable that soil will be stripped to a greater depth in many areas.

The topsoil recovery plan will include mixing the existing vegetation into the soils which will provide additional organic matter to the salvaged soils. The topsoil storage piles will be protected from wind erosion and slope drainage by seeding with 6 lbs per acre of annual rye to protect the surface with a quick growing vegetative cover. In addition, Kennecott will apply the permanent reclamation seed mix to those topsoil stockpiles or parts of topsoil stockpiles which will not receive future contributions of topsoil. Stockpile surfaces that will receive additional topsoil as part of ongoing mine expansion will be vegetated with the interim seed mix.

Kennecott will salvage topsoil from areas where salvaging operations can be safely conducted and up to the quantity of topsoil required to achieve the reclamation plan. This topsoil will predominately be salvaged from the main drainage of Barneys Canyon where access is easy and the soil depth the greatest.

Table 3.9-1 Topsoil Yields

Salvage Site	Salvageable Soil Types	Average Depth	Acreage	Volume (Cu. Yds.)
Barneys Canyon Pit	Harker-Dry Creek	12"	52.3	84,377
" "	Rocky Variant	0"	4.1	0
Barneys Canyon Dumps	Harker-Dry Creek	12"	125.6	202,635
Melco Pit	Bradshaw-Agassis	12"	35.2	56,789(1)
Melco Dumps	Bradshaw-Agassis	12"	42.4	68,405(1)
Admin. Bldg., Process/Lab & Solution Ponds, Gravel/Clay Pits 1 & 2	Dry Creek-Copperton	12"	24.7	39,849
Clay Pits 2 & Alternate	Harker-Dry Creek	12"	2.0	3,227
Potable Water Storage, Ore Stockpile	Harker-Dry Creek	12"	6.9	11,132
East Portion Crushing/Screening and Shop	Harker-Dry Creek	12"	10.7	17,263
West Portion Crushing/Screening and Shop	Dry Creek-Copperton	12"	8.8	14,197
Leach Pads BC-1,2,3; M-1,2; Future Leach Pad and North & South Portions of BC-4	Dry Creek-Copperton	12"	215.6	347,835
Remaining Portion of Leach Pad BC-4	Copperton	12"	12.5	20,167
Substation	Dry Creek-Copperton	12"	0.4	645
Total			541.2	866,521(1)

(1) Actual topsoil borrowed in the Melco area is estimated to be 97,363 cubic yards; therefore, a total of 100,000 cubic yards of material, sufficient to cover the surfaces to be topsoiled, as described in Section 5.4, will be recovered and stockpiled.

Table 3.9-2 Topsoil Yields

Salvage Site	Salvageable Soil Types	Average Depth	Acreage	Volume (Cu. Yds.)
NBCS Pit	Fitzgerald	18"	0.1	360
	Gappmayer	24"	6.3	20,190
SBCS Pit	Fitzgerald	18"	4.7	11,360
	Gappmayer	24"	5.2	16,720
	Rock Outcrop	0"	1.2	0
	Wallburg	15"	9.0	18,090
BCS Waste Dump	Gappmayer	24"	4.4	14,170
	Wallsburg	15"	5.6	11,330
Relocated Melco Haul Road	Wallsburg	15"	4.6	9,230
Melco Pit (Expansion)	Bradshaw-Agassiz	12"	5.5	8,910
	Fitzgerald	18"	17.8	43,170
	Rock Outcrop	0"	5.2	0
Subtotal			69.5	153,530
Topsoil Stockpile H	N/A	N/A	N/A	*20,000
Topsoil Stockpile I	N/A	N/A	N/A	*117,110
Total			69.6	290,640

* Topsoil currently in stockpiles at Melco

3.10 Runoff and Sediment Control

The BC South and Melco pits and waste dumps occur in drainage basins that will be extensively disturbed by current and proposed operations. The extent of the proposed disturbances, drainage basin boundaries, the surface runoff flow directions, and operational erosion and sediment control devices are shown on Plate II-B. Both the Melco and BC South areas occur in small watersheds near watershed divides. The Melco pit, roads, and waste dumps will occupy essentially the entire watershed area of the upper right fork of Dry Fork, as Plate II-B shows. The BC South watershed area will contain a small amount of undisturbed watershed above the South BC South pit and the BC South waste rock dump (Plate II-B). The runoff from this area will flow to the BC South pits and around the BC South waste rock dump. Most runoff from this small area of undisturbed watershed cannot be diverted from the down-gradient disturbed areas; therefore, it is not possible to separate the runoff from this disturbed area from the runoff that will be generated in the down gradient disturbed area. Since most runoff from the BC South area will be collected and prevented from being released outside the small disturbed watershed, the inability to separate runoff from disturbed and undisturbed areas will have no adverse impact on the local surface water hydrology.

The Melco north dumps are located in Barneys Canyon and will affect approximately 7000 feet of the intermittent and perennial Barneys Creek. Many of the slopes in the watershed area are cross-cut by the KTVX access and exploration roads. These existing roads are intersecting the up slope runoff and channeling the water laterally away from much of the planned dumping area. Where necessary, the existing exploration roads will be upgraded to double as diversionary ditches to keep any runoff water from entering the disturbance areas. The waste dumps will be constructed in stages over the next several years starting in the southern fork of the drainage and progressing downstream to the east. Any runoff water will be handled in accordance with the existing DWQ ground water discharge permit. The operational runoff and sediment control plan can be seen on Plate II-C.

The East Barneys pit lies in the bottom of the Barneys Canyon drainage. Existing sediment controls (settling basin and diversion ditch) are located about 500 feet upstream from the pit. A diversion berm that will provide some containment capacity and sediment control will be constructed at the upstream boundary of the pit to divert surface water flow from the existing drainage to the pit area. At completion of mining, this containment will be breached, allowing surface runoff water to flow into the pit. Erosion of the west pit walls will be minimized by rip-rapping the west border of the pit where the drainage will run.

The operational diversion ditch will begin in the bottom of the Barneys Canyon channel uphill (west) from the East Barneys pit and lead around the north end of the pit. Where this diversion ditch begins, an earth berm will be constructed by excavating a hole approximately 4 feet deep in the bottom of the natural channel uphill from the desired berm location and pushing the excavated alluvial materials into a berm at least 4 feet high, with a 3-foot wide top, 2h:lv side slopes and a crest length sufficient to completely dam the Barneys Canyon channel just below the entrance to the diversion ditch. This berm will be compacted with the bulldozer during construction. If the alluvial materials used to construct the berm are devoid of cobbles or larger rocks to provide erosion protection, the uphill face of the berm should be covered with at least 6 inches of riprap have a D_{50} of at least 3 inches. Alternatively, the entire berm could be constructed of oxide mine overburden

that was rocky enough to withstand erosion. The Appendix, DII (b), conceptually shows the design of this berm which will need to be field fit during construction.

The East Barneys pit will remain in its as-built condition within the bottom of the Barneys Canyon drainage. The operational drainage diversion used to divert Barneys Canyon around the pit during operations will be backfilled and reclaimed. The diversion berm constructed to block the natural Barneys Canyon Channel and divert it into the temporary ditch will also be removed from the natural channel to open the natural channel to a free-flowing condition. A permanent reclamation channel will be constructed to drop the Barneys Canyon channel into the East Barneys pit in a stable fashion.

The permanent reclamation channel will begin at the contact between alluvium and rock within the pit and be graded at an overall 33% grade uphill to the natural Barneys Canyon channel elevation (see Appendix DII (c)). The bottom of this channel excavation will be approximately 8 feet wide and the sides slopes will be approximately 4h:1v or flatter. The design flow for this permanent channel is 195 cfs which is the 100-year, 24-hour peak flow calculated by JBR for the Barneys Canyon watershed. This calculation used the same watershed configuration and computer model last used in the November, 1993 NOI except that the average weighted Curve Number for the watershed was increased from 48 to 57 to take into account the approximately 300 acres of reclaimed overburden dumps that will exist in Barneys Canyon when the Melco wasterock dumps are completed.

The flow conditions in the permanent channel were calculated using the SECAD 3 computer program (Appendix DII(c)). The calculated flow velocity of 13 fps will require the use of a 4-foot thick blanket of riprap, having a D_{50} of 15 inches over the bottom of the channel and extending at least 2 feet up the channel sides. This same riprap will extend up the natural Barneys Canyon channel for approximately 50 feet uphill of the start of the constructed channel to protect this transition section. There will be no need for a similar riprap blanket at the outlet of the channel where it discharges onto the rock surface of the East Barneys pit.

The East Barneys pit will contain the water draining down the Barneys Canyon channel. The pit will not be self draining and will hold water within the pit bottom up to the 6080 foot elevation before any additional water will drain over the east end of the pit and down the natural Barneys Canyon channel. All the rock in the East Barneys pit is expected to by oxide material with no sulfidic mineralization. Therefore, the water in the pit should not contact any acid generating material and should have no deleterious water quality impacts on local surface water or ground water quality. The water contained in the pit is expected to be ephemeral to intermittent in nature and will be available for seasonal use by wildlife as a water source. The local water table is below the bottom elevation of the pit so a perennial water impoundment is not expected to occur. Any overflow from the pit will flow down the natural Barneys Canyon channel.

3.10.1 Runoff Volumes Estimates

Runoff volumes and peak flows in and around the project area were calculated using the Soil Conservation Service (SCS) Curve Number technique, utilizing a computer program developed by Hawkins and Marshall (1980). Precipitation depths for the 10-year, 25-year and 100-year, 24-hour rainfall events were used in the calculations to determine the runoff peaks and volumes for each event. The precipitation depths were obtained from the National Oceanic and Atmospheric Administration Precipitation Frequency Atlas for Utah (1973). The precipitation depths for these events were found to be 2.7 inches, 3.0 inches, and 3.7 inches, respectively. Runoff peaks were generated using the SCS Type II rainfall distribution which is typical for the western United States.

The curve numbers used in these calculations were based on local soil hydrologic characteristics and vegetation types. Soils were grouped according to infiltration characteristics, hydrologic soil group A having the highest infiltration rates and group D having the lowest infiltration rates. There are three main hydrologic soil groups in the project area. Soils of group C are found largely in the valley alluvium and colluvium beneath the Barneys Canyon project area. Soils of hydrologic group B are predominantly found in the higher elevations. Soil Group D represents the dumped waste material. The vegetation types are largely sage/grass community in the lower elevations and gambel oaks on the low elevation north facing slopes and in the higher elevations. Based on this and other information obtained over one year of work at the site, the base curve numbers have been revised to better reflect actual runoff conditions at the project site.

Vegetation type	Soil Group B	Soil Group C	Soil Group D
Oak/Aspen/Woods	CN= 35	CN= 64	CN= 79
Sagebrush	CN= 48	CN= 65	
North Slope	CN= 58		CN= 78

Source: U.S. Department Interior, Bureau of Reclamation (1977)

Curve numbers were weighted according to the area covered by each vegetation and soil type. A curve number of 89 was used for calculating runoff volumes and peaks from the compacted waste dump surfaces and surrounding disturbed areas at Melco. A high curve number was intentionally selected to provide a conservative estimate of runoff from waste dumps; the actual runoff would be expected to be less than that predicted. The assumptions used in these calculations may be found in Table 3.10-1 below.

The drainage basins and watershed areas used in the runoff peak and volume calculations are outlined on Plate V-A and II-B. Calculations were made using the undisturbed watershed areas so that all designs would be conservative once the facilities are built. All operational culvert and ditches have been designed to transfer runoff from the 10-year, 24-hour runoff event. The largest watershed to be disturbed by the operation is Barneys Canyon with an area of 1430 acres. The Barneys Canyon drainage will remain largely unaffected by the operations with the exception of the Melco pit access/haul road crossing. Six drainages will be significantly disturbed by the mining operations. The Barneys Canyon pit, adjacent waste dumps, leach pads, and process facilities will occupy large sections of drainages P, Q, S, and T. Drainage area R will remain largely undisturbed by the operations except for a small area to be occupied by the two northeastern-most leach pads.

The BC South drainage area will be affected by the proposed pits and waste dump. The Melco pit and waste dumps will occupy a large portion of the right fork of Dry Creek.

After taking into account the planned locations of new proposed dumps, these drainage areas have been given the designations listed in Table 3.10-1.

The Melco north dumps will eventually occupy a large portion of the upper Barneys Canyon main drainage. Approximately 300 acres of the 1430 acre watershed will be disturbed during the mine life. This disturbance will occur at the rate of about 80 acres per year and is not expected to significantly affect the runoff volume estimate due to sediment and runoff control measures.

Table 3.10-1 Curve Numbers for Barneys Canyon Drainage Basins

Drainage	WS	Curve	Soil	Vegetation		Runoff Depth (in)		
Basin ID	Area	Number	type	% oak	% sage	10Yr	25Yr	100Yr
M (impdmt)	56.5	65	C	45	55	0.38	0.51	0.86
N	118.0	48	B	40	60	0.03	0.06	0.18
O	45.2	48	B	100	00	0.03	0.06	0.18
P	332.0	65	C	30	70	0.38	0.51	0.86
Q	96.0	65	C	40	60	0.38	0.51	0.86
R	462.0	65	C	25	75	0.38	0.51	0.86
S	580.0	65	C	45	55	0.38	0.51	0.86
T	37.8	65	C	00	100	0.38	0.51	0.86
BCS*	126	56				0.14		0.45
M-a	231	89				1.63		2.54
M-b	16	89				1.63		2.54
M-c	7	89				1.63		2.54
Barneys Canyon	1430	48	B	75	25	0.03	0.06	0.18
Waste Dumps	N/A	89.0	D	00	00	1.63	1.90	2.45

*Curve number calculated assuming pits would have been pre-stripped, but not excavated.

3.10.2 Operational Runoff Control

The operational runoff control plan, depicted on Plate III-A, has been designed to take advantage of the existing impoundment capacity created by the B&G railroad grade fill structures. The B&G railroad grade runs along the eastern perimeter of the project site. The fill structures through drainage crossings will impound all runoff from the upland drainage basins including Barneys Creek (Plate III-A). Approximately 60 years ago when the railroad was constructed, culverts were placed in the stream channel at the bottom of the railroad fill to allow runoff water to flow through this embankment. Since that time, these culverts have become partially or completely filled with sediments rendering them ineffective and causing the embankment to act as an impounding structure. In 1985, each impoundment was fitted with a spillway culvert approximately 15 feet below the grade elevation in each drainage to permit impounded water to drain through the impoundment without the likelihood of overflow. The spillway culverts were designed to pass the 50-year flood event or larger and were placed high enough in the embankments to provide significant storage capacities below the spillways. All spillway culverts are 24 inches or greater in diameter to meet minimum design criteria by the Utah State Engineer. These spillway culverts are in place and the calculated capacity of each impoundment is based on the invert elevation of the these spillway culverts. Water is not routinely impounded behind these structures. A diagram illustrating the placement of these culverts may be found in Appendix D-I. The stage/capacity curves for all impoundments located in the project area may be found in Appendix D-I. The runoff volumes from the watersheds upgradient of these impoundments were calculated using undisturbed acreages. Using this technique, the runoff volumes calculated should be in excess of the actual runoff volumes after all facilities are constructed, because precipitation falling on active leach pads will be directed to the solution ponds and inactive, ore-covered pads will have substantial moisture retention capacity.

Most haul roads have been designed to allow water runoff from both road surfaces and the upgradient watersheds to move along or beneath them with minimal impacts from erosion (Plate III-A). The fill material from the landbridge haul roads southeast of waste dumps 6400 and 6500 created three temporary impoundments which were later filled with dump materials. Culverts were be installed in the road fill materials that create these temporary impoundments. The roads are sloped away from the road fill slope so all precipitation water falling on the road surface will drain toward roadside ditches. Roadside ditches run the length of the haul roads through the project area and are placed along the roadside cut slope to collect all runoff from the watersheds upgradient before the water flows onto the road surface. The roadside ditches are triangular in shape and a minimum of 1.75 feet deep. The ditches have a 2h:1v sideslope from the road surface and 1h:1v from the cut slope. These ditches are placed at the same gradient as the road. Many of the haul roads are excavated into the bedrock adding stability to these ditches during high runoff events. All roadside ditches drain to corrugated metal pipe culverts to transfer the water below the road and into impoundments or natural stream channels below (Plate III-A).

Corrugated metal pipe culverts divert runoff water beneath the road at selected crossings. These culverts have been designed to pass runoff from the 10-year, 24-hour runoff event. The culverts are placed along the natural channel gradient to minimize erosion. Design specifications for these culverts may be found in Appendix D-II.

During operations, all waste dumps are constructed so that the dump surface slopes from the dump crest toward the natural hillside from which it projects to control runoff down the outslope of

the dump. Safety berms are placed around the top perimeter of the waste dumps as needed to prevent runoff flow from the dump crest down the dump face. The dumps are then sloped so that runoff drains toward one corner of the dump for removal to either a drainage channel or to an impoundment.

Runoff from the small drainage area upgradient of the Barneys Canyon pit waste rock dumps and from the adjacent waste rock dump surfaces has been diverted into Impoundment M located upgradient of the lower elevation haul road leading from the Barneys Canyon pit to the waste dump (Plate III-A). Runoff from the undisturbed watershed area upgradient of the haul roads drains onto the uppermost haul road and is diverted along a roadside ditch and through a culvert for containment in Impoundment M. Runoff from dump 6500 will also drain through a culvert for collection in Impoundment M. In addition, runoff from the waste dump 6400, adjacent to the Barneys Canyon pit, will drain into Impoundment M. The 100-year, 24-hour runoff volume from the three waste dumps and the upper watershed will be 10.3 acre-feet and will be easily contained within Impoundment M (Table 3.10-2). Current Utah DOGM regulations require that the impoundments must contain the 10-year, 24-hour runoff volume.

Before the waste dumps were built, the haul road to the truck shop created three impoundments in the area to later be occupied by the waste dumps. The impoundment occupied by dump 6400 had a capacity in excess of 80 acre-feet and received runoff from the 15 acre basin in which it occupied. This impoundment did not receive runoff from beyond its perimeter. The other two impoundments, designated Dump 6500 A for the next impoundment to the north and Dump 6500 B for the north impoundment, were used to contain runoff from the watershed above until the waste dumps were completed. These impoundments are not shown on Plate III-A. The capacity of Dump 6500 Impoundments A and B contained the full runoff volume from the 100-year, 24-hour runoff event from the upland drainage basins.

The leach pads will occupy portions of drainage areas P, Q, R, and T (Plate III-A). Due to the closed leaching system, any precipitation falling on the active leach pad surfaces will run through the pad solution drainage systems before containment in the downgradient pregnant solution ponds. The leach solution systems will have the capacity to contain the 100-year, 24-hour runoff event from active pads in addition to the volume of water used in the leaching process. The ponds have been designed to overflow into one another before discharging thereby creating additional impoundment capacity above the 100-year, 24-hour runoff capacity design. Any solution pond overflow from the ponds is contained behind the B&G grade railroad impoundment.

The retention capacity of each of the railroad grade impoundments was calculated from topographic maps and known spillway culvert invert elevations. Based upon the elevation of spillway culvert inverts, the capacity of each of these impoundments and the calculated runoff volumes for the 10-year, 25-year, and 100-year, 24-hour runoff events draining into these impoundments from upland drainage basins are given in Table 3.12-2. As can be seen in Table 3.12-2, all impoundments on the property will contain runoff from the 100-year, 24-hour events with the exception of Impoundments R and P. However, Impoundment R will contain runoff from the calculated 25-year, 24-hour runoff event and the capacity of Impoundment P falls 0.3 acre-feet short of containing the calculated 100-year, 24-hour runoff volume from the undisturbed drainage basin. None of the railroad grade impoundments show signs of significant water impoundment.

Table 3.10-2 Barneys Canyon Project Impoundment Containment Volumes

Impoundment/ Basin I. D.	Watershed Area (ac)	Impoundment Capacity (AF)	Runoff Volumes (Acre-feet) 10yr 24hr	25yr 24hr	100yr 24hr
M	56.5	47.0	5.8	7.1	10.3*
P	332.0	23.5	10.5	14.1	23.8
Q	96.0	12.4	3.0	4.1	6.9
R	462.0	21.0	14.6	19.6	33.1
S	580.0	85.4	18.4	24.7	41.6
T	37.8	9.0	1.2	1.6	2.7
Barneys Canyon at B&G Grade	143.0	182.0	16.1	28.6	62.0
Melco Soil Dam	13.1	6.6	1.1	2.0	
Dump 6500 A	28.1	51.9	0.9	1.2	2.0
Dump 6500 B	30.2	13.2	1.0	1.3	2.2

Runoff volumes are based on the weighted curve numbers for each watershed.
* Runoff volumes cited for M include runoff from the adjacent waste dumps.

The placement of the Melco mine dumps will affect the natural surface water drainage characteristics of a tributary watershed of Dry Fork Canyon (Plates II-B and 96-1). Precipitation in the pit and upgradient runoff will be contained within the pit (Plate II-B). Water will not drain from the pit into the Dry Fork drainage. A soil dam was placed in the upland drainage area of the Dry Fork basin creating the temporary Melco sediment impoundment (Plate II-B). This dam currently has the capacity to hold 6.6 acre-feet of runoff volume. This is adequate to hold the 2.0 acre-feet of runoff for the 100-year, 24 hour precipitation event, which would not be collected in the Melco pit (Table 3.10-1). A capacity curve showing the storage capacity of this dam in relation to elevation is shown in Appendix B-II. Any water released from the Melco sediment impoundment will be contained downstream in a much larger impoundment that has been created by mine dumps placed across Dry Fork as part of Kennecott's Utah Copper operations.

The Melco pit haul roads will carry runoff water along a series of roadside triangular ditches to be routed around the mine dumps before release into either the existing Melco sediment impoundment, the Melco pit, or the impoundments created by the waste rock dumps, as discussed above (Plate II-B). Corrugated metal pipe (CMP) culverts will be placed in areas where drainage will cross the roads (Plate II-B). Culverts will be installed using the same procedures as for the existing culverts. (Culvert diameters are given on Plate II-B.) All ditches have been designed to carry the peak flow from the 10-year, 24-hour rainfall event.

The operational runoff control plan, depicted on Plate II-B, has been designed to take advantage of the existing structures, described previously. Except for the Melco pit area, the culverts have been installed as described.

Ditches were designed using a computer program developed by Hawkins and Marshall (1980). Culverts were designed using procedures outlined by the American Iron and Steel Institute (AISI, 1983). A Mannings constant of 0.03 was used in ditch calculations. This value was obtained from AISI (1983).

Most haul roads have been designed to allow water runoff from both the surfaces and the upgradient watersheds to move along or beneath them with minimal impact from erosion (Plate II-B).

Haul road ditches and culverts will provide the means of runoff control during the period that mining is in progress. In most areas the roads will be sloped away from the road fill slope so that all precipitation water falling on the road surface will drain toward roadside ditches. Runoff from the section of re-aligned Melco haul road located south of the North BC South pit will flow to the North BC South pit impoundment, as shown on Plate II-B. Roadside ditches will extend the length of most haul roads through the project area and will be placed along the inboard margins to collect runoff from the watersheds upgradient before the water flows onto the road surface. The roadside ditches will be triangular in cross section and a minimum of 2.0 feet deep. In most cases the ditches will drain to corrugated metal pipe culverts which will direct the water beneath the road and into impoundments or natural stream channels below (Plate II-B). In the vicinity of the Melco 7200 and 7300 waste rock dumps, runoff will flow directly from the road surface to impoundments created by these dumps or directly to the Melco open pit, as shown on Plate II-B. The surface of the 7300 dump will be sloped back from the outslope sufficiently to create sediment and runoff retention capacity on its surface. The 7200 dump surface will also be sloped away from the south outslope. Runoff will flow down the north slope of the dump to the haul road below and then into the Melco pit.

Erosion of the roadfill material from culvert outfall will be prevented by installation of erosion control mats which will extend from the outfall point, downslope to the undisturbed drainage below. The locations of these mats is shown on Plate II-B. These mats will be made of either commercially available erosion control matting or of used conveyor belt material. The former would be installed according to manufacturer's specifications and the latter would be installed using appropriate anchoring devices, as determined by Kennecott mine staff. These mats would extend from just above the culvert outfall points, across the road fill slope, and to the undisturbed natural hillside or channel below.

During operation, all waste dumps will be constructed so that dump surfaces slope away from the crest toward the adjacent natural hillside or upstream impoundments to control runoff down the outslope of the dump. Berms will be placed around the top perimeter of the waste dumps as needed to prevent runoff flow from the dump crest down the dump face. The dumps will also be sloped so that runoff drains toward one corner of the dump for removal to either a drainage channel or to an impoundment.

The existing impoundment created by the B&G grade crossing Barneys Canyon (Plate II-B) is located downstream from the BC South disturbances and will contain any runoff and sediment that may be released from the site (Table 3.10-1). A stage-capacity curve for the Barneys Canyon B&G grade impoundment is included in Appendix B. Emergency discharge culverts in these impoundments have resulted in retention capacities well in excess of the 10-year, 24-hour precipitation event, as described in Section 3.10-3. The Dry Fork impoundment that has been created by the waste rock dumps of Kennecott's Utah Copper Division will serve a similar function for the Melco area.

The existing runoff control plan has been modified so that runoff water is no longer diverted into the Melco or NBCS pits. Direct precipitation will, of course, continue to fall unimpeded into the pits. The Melco 7200 waste dump has been redesigned to drain away from instead of into the Melco pit. Control measures for the Melco north dumps will use a combination of existing measures (haul road ditches, dump surface sloping, B&G grade and explorations roads).

3.10.3 Operational Sediment Control

The nature and placement of the mine pits, waste dumps and leach pads will potentially increase the erosion and sedimentation rates in the project area. Much of the rock and alluvium exposed during mining will increase the potential for sediment movement both on the site and to locations off site. To control this process, a number of sediment control features are placed on site to inhibit the movement of sediment. These structures include detention basins to contain sediment, diversion channels to divert the flow of water around areas having a high potential for sediment movement, and silt fences placed below potentially erosive areas to control sediment movement into nearby channels. Hay bales are placed in areas recognized as having excessive sediment movement during operation for additional control of erosion.

The desilting pond, located immediately west of the solutions ponds, is designed to contain storm runoff from the 100-year, 24-hour event in the upland watershed. This design is based on DWQ approved criteria. The discharge from the pipe spillway serving the sediment control impoundment is collected in a bifurcated pipe that is connected to a 36-inch diameter CMP storm drain. This pipe bypasses the solution pond area and discharges into an existing 48-inch diameter culvert which passes under the B&G grade east of the solution ponds. This storm drain will pass the flow from a 100-year, 6-hour precipitation event. The majority of the runoff from the small drainage area surrounding the solution ponds themselves is collected in a concrete sump just west of the ponds and is pumped into the desilting basin.

The abandoned B&G grade railroad embankment, located along the eastern edge of project site, creates a number of impoundments which will be used to eliminate sediment release from the site. These impoundments will also be used as emergency containment for solution pond overflow (Plate III-A). The designed 50-year event capacity emergency culverts, described above, provide the only discharge points from the impoundments. These sediment storage basins will be maintained as needed by periodic removal of the collected sediments to maintain the existing capacities of the impoundments. Stage capacity curves (Appendix D-I) for each of these impoundments have been produced to verify that the impoundments have adequate capacities to contain the 10-year, 24-hour runoff volumes from the upstream drainage areas. Since this railroad grade cuts across all of the drainages downgradient of the project site, any sediment not contained by upstream sediment control structures such as silt fences or hay bales would ultimately be contained within these impoundments.

Two forms of sediment control will be implemented to control sediment runoff from the waste dumps, the largest potential sources of sediment on the property (Plate III-A). Waste dump surfaces will be sloped away from the dump margins. Sediment barriers will be placed downgradient of the toe of the dumps where needed to provide protection against sediment movement from these dumps. Any sediment not contained by these forms of sediment control will be deposited either in the ephemeral channels or behind the impoundments. Natural vegetation in areas undisturbed by operations will also retard sediment movement downward.

The Melco Pit and waste dumps are situated near the ridge of the Dry Fork drainage basin (Plate III-A). The mining disturbances that could potentially increase sedimentation rates include haul roads and waste dumps. Sediment will be controlled by using sediment barriers and the Melco impoundment to minimize sediment movement from the site. All uncontrolled sediment will be contained by the downgradient waste dump impoundment operated by Kennecott's Utah Copper Division.

The haul roads connecting the waste dumps to the Melco Pit will be sloped such that runoff from the road surface and the uphill watershed area will run along a series of connecting roadside ditches before being spilled into Dry Fork below. The ditches will be excavated into bedrock therefore, the erosive forces of gully erosion during ditch runoff will be small. The roadside fill slopes offer the greatest potential for erosion as these slopes will be much steeper than the hillside on which they lie. Sediment from these slopes will be carried along the roadside ditches to be deposited behind silt fences or the Melco impoundment. These structures will be placed in the lower elevation of the Dry Fork channel (Plate III-A). The natural vegetation in the area will also retain some sediment as it moves from the disturbed areas.

Other operational sources of sediment would be from the fill slopes created by the haul roads, leach pads, and process areas. This sediment will move down into the drainage channels and will eventually be carried to the railroad impoundments where sediment build-up will be monitored and cleaned out when necessary.

The potential impacts to Barneys Creek from the proposed mining facility will be caused mainly from haul roads and the Barneys Canyon pit (Plate III-A). The largest potential impacts to Barneys Creek will be from the erosion of haul road fill material during construction increasing sedimentation rates into the stream channel. This impact should be of short time frame. Other impacts to Barneys Creek could occur from haul road placement across the stream channel potentially causing degradation or aggradation of the stream channel upgradient and downgradient of the crossing. Any additional sediment loads entering the stream channel will be impounded behind the railroad impoundment downstream and will not leave Kennecott property. Due to the location of this impoundment, water quality stream flow monitoring is not planned. There will be no impact on Barneys Creek from Barneys Canyon open pit because the pit itself will prevent any discharge from occurring.

Topsoil stockpiles will also be potential sources of sediment release (Plate III-A). The topsoil stockpiles will be located on the ridge-tops away from the stream channels to minimize topsoil discharge into the channel. To prevent the topsoil from washing away during heavy rainfall events, silt fences will be placed in areas around the stockpiles where the potential for erosion is high. These structures will be periodically checked and maintained when needed.

The Melco mine dumps will be located just downgradient of the ridge and extend nearly to the base of the slope (Plate III-A). The angle of repose of these dumps will be steep so the potential for erosion is significant. Any sediment originating from these dump faces will be carried directly downgradient to be deposited behind the sediment barriers located in the drainage area below. Any sediment originating in the mine pit will also be deposited behind these sediment barriers.

Sediment generated by North BC South as well as a segment of the Melco access road will be captured by the temporary impoundment created by the South BC South Pit. The dump surface will be sloped away from the dump and toward the upstream face of the dump to minimize erosion

on the dump face. Because this temporary impoundment will be backfilled with waste, no sediment removal for maintenance purposes will be required. Sediment from the section of re-alaigned Melco haul road located south of the North BC South pit will flow to the North BC South pit impoundment, as shown on Plate II-B. Any sediment released from the downstream face of the dump will be collected by silt fences which will be maintained as necessary. The B&G grade impoundment of Barneys Canyon prevents sediment and surface water from leaving Kennecott property.

Topsoil stockpiles will also be potential sources of sediment release (Plate II-B). The topsoil stockpiles will be near the ridge-tops and away from the stream channels to minimize topsoil discharge into the channel. To prevent the topsoil from washing away during heavy rainfall events, silt fences will be placed in areas around the stockpiles where the potential for sediment release is high. These structures will be checked periodically and maintained as needed. In addition, the stockpiles will be revegetated with a hydroseeder using the approved interim seed mixture described in Table 5.6.1.

The existing operational sediment control plan remains essentially the same with the exception that the Melco and NBCS pits will not be used for long term sediment control. The same sediment control measures will be used for the Melco north dumps as for the south dumps.

The East Barneys pit will be about 500 feet down stream of the intersection of the Barneys Canyon drainage with the Melco Haul road. Sedimentation will be controlled by diversion ditches during mining operation. Ditches will be constructed at the alluvium - bedrock contact to channel water around the pit area.

At completion of mining, the East Barneys pit will remain a permanent excavation in the bottom of the Barneys Canyon drainage and will collect and impound any surface water flow entering the pit. The pit will have a significant capacity for holding water up to the 6080 elevation at which point water would discharge from the pit down the Barneys Canyon drainage channel. It is possible that surface water may be temporarily impounded in the bottom of the pit but this water is likely to drain by infiltration into the oxide rock of the pit an/or evaporate.

Pit slope stability studies completed by others have indicated that large-scale slope failures in the East Barneys pit are unlikely.

3.11 Disturbed Acreage

The total disturbed acreage for the project area is summarized in Table 3.11-1.
The additional disturbance acreage for the project expansion is summarized in table 3.11-2

Table 3.11-1 Disturbed Area Summary

Site	Existing	New	Acreage (Ac)
PITS			
Barneys			56.4
North BC South			8.0
South BC South			20.1
Melco			135.4
East Barneys (Expansion)	0.0	15.3	15.3
ROADS			
BC/SBC Haul Road			31.0
Process Roads	10.7	13.0	23.7
Main Access Road			4.6
BC Pit Area			11.0
Runaway Ramp			1.2
West Melco Haul Road			11.0
Melco East Haul Roads			18.0
SBC/NBC Haul Road			8.0
Melco Haul Road (Melco-SBC)			27.0
Melco-NBCS HR	11.0	21.0	32.0
East Barneys	15.3	3.7	19.0
Upper Barneys	0.0	14.0	14.0
ADMIN/PROCESS/SHOP			
Administration Building			3.0
Process Building			13.0
Crushing/Screening			8.0
Shop			9.0
Potable Water Storage			2.0
Ore Stockpile			18.0
Gravel/Clay Pit #1			1.5
Clay Pit #2			2.5
Clay Pit #3			2.5
TV Adit	0.0	14.0	14.0

Table 3.11-1 Disturbed Area Summary (continued)

TOPSOIL STORAGE PILES	Existing	New	Acreage (Ac)
A			2.7
C			8.5
D			4.3
E			2.7
G			5.5
H			1.5
I			3.6
South BC South			3.3
North BC South			2.3
BC South			3.9
J			0.5
K_1			0.7
K_2			2.3
K_3			2.1
LP-5			5.5
WASTE DUMPS			
Barneys 6300			66.7
6400/6500 West			46.0
UBW 6600			18.0
South Barneys			7.0
Melco 7480			12.1
Melco 7460			16.0
Melco 7300			83.0
Melco 7200			38.0
Melco 7100			47.0
Melco 6920	71.0	33.0	104.0
Melco Sulfide Repository			12.0
NBCS Sulfide Repository	(See North BC South Pit)		0.0
Melco South Dumps			135.0
LEACH PADS			
BC-1			38.0
BC-2			35.0
BC-3	62.0	12.0	74.0
BC-4			32.0
BC-5	45.0	8.0	53.0
Solution Ponds			7.0
MISCELANEOUS			
Substation			.4
TOTAL			1,382.8

Table 3.11-2 Expansion Disturbance Area

Location/Site	Disturbance (acres)
Upper Barneys	14
TV ADIT	14
Melco 6920 Dump	33
Melco-NBCS HR	21
Leach Pads	33
East Barneys Pit	19
Total Additional Disturbance	134

Explanation of Expanded Disturbance Areas

Upper Barneys (14 acres) - This disturbance is needed for access to remove topsoil for the north Melco dumps. In addition, it will provide access to the Melco 6920 dump for reclamation.

TV Adit (14 acres) - This area contains a mineralized resource that will be examined for future mining.

Melco 6920 Dump (33 acres) -
Melco - NBCS HR (21 acres) - The need for these additional 54 acres is the result of minor changes in dump configuration which will make operations more efficient.

Leach Pads (33 acres) - The increase at the leach pad area will accommodate a slightly larger disturbance of the BC-3 and BC-5 leach pad when they are pushed out to a 2:1 slope for reclamation. Also included are access roads to the clay pits.

East Barneys Pit (19 acres) - This disturbance is needed to accommodate the area encompassed by the pit and access road.

4.0 Impact Assessment

The predicted impacts of the Barneys Canyon, BC South, and Melco pits and waste dumps are summarized below.

4.1 Surface Water

Barneys Creek which flows from Barneys Canyon is intermittent at its headwaters and perennial over a mile reach adjacent to the south side of the Barneys Canyon open pit and mine dump. The location of Barneys Creek is shown on Plate I-A. It is anticipated that the project will have no impact on Barneys Creek. Other natural drainages in the area contain intermittent streams. The mining operations will interrupt several of the intermittent drainages in the area. The major interruptions will be located at the mine waste dumps which will fill areas where natural drainages currently exist. Additional project facilities influencing surface water runoff from the site include haul roads, open pits, the crusher site, and the leach facilities.

The operational runoff control plan has been designed so that the site will have zero discharge during storm events with a 10-year, 24-hour recurrence interval. Hence, no impact to offsite surface water is anticipated.

Despite the modifications that the project will make to the local ephemeral and intermittent drainage pattern, these modifications will have no effect on existing non-wildlife water use. The creation of impoundments on the site may have a beneficial affect on wildlife and livestock that will use the area following reclamation by providing seasonal water supplies.

The BC South operation will have a slight incremental effect upon ephemeral and intermittent drainages above that which has or will be created by the initially permitted Barneys Canyon operations. The North BC South open pit will trap all sediment eroded from the BC South disturbed area, preventing offsite sediment impact to undisturbed drainages from these sources. Sediment eroded from the outslope of the BC South waste dump prior to reclamation will be contained in the sediment control structures located in the ephemeral drainage below the waste dump. Earthen sediment control dams will provide sediment control in the ephemeral channel below the Melco dumps and the deepened Melco pit will act as a permanent sediment control impoundment. These structures will result in a minimal sediment impact to the channel of Dry Fork below. All sediment control structures will be maintained through the reclamation bond period and will be removed after bond release.

The Melco north dumps are located in Barneys Canyon and will affect approximately 7000 feet of the intermittent and perennial Barneys Creek. The waste dumps will be constructed in accordance with DWQ approved water management plans.

The East Barneys project is located in the Barneys Creek drainage, however, diversion conduits that will accommodate a 10 year, 24 hour event have been engineered and may be constructed around the pit perimeter (800') and back into natural drainage to minimize impact on production. The project duration is anticipated to be about 9 months. At closure, the pit will be left in place and will serve as a stormwater containment and settling pond. Division of Water Quality has reviewed the project and agrees impact to surface or ground water will be de minimis (see Appendix L).

4.2 Ground Water

The Barneys Canyon mining project is anticipated to have no impact on groundwater quality because all leach solutions will be contained on site in lined surface impoundments or within the lined heap leach pads.

The groundwater quantity may be altered by dewatering the Barneys Canyon pit during mining operations. Because of the planned depth of the Barneys Canyon pit, mining below the water table expected to occur has occurred. To control water in the pit, dewatering is required using deep penetration production wells placed within the circumference of the pit. This pumping will remove water from the bedrock aquifer creating a cone of depression below the pit area. This cone of depression is not anticipated to influence nearby water wells, given the low permeability of the aquifer. All intercepted pit water will be utilized as necessary for dust control on the roads, and for process makeup water. Water rights have been filed with the Division of Water Rights for the volume of water to be used during operations. It is not anticipated that inflow to the pit will yield more water than can be used during operations, however, if this takes place, excess water will be discharged into one or more nearby drainages where the water will impound behind the railroad impoundments on the eastern edge of the property. No discharge into the live stream channel of Barneys Creek will take place. The water will infiltrate into the ground behind the grade. No discharge permit will be needed because this water will not leave the property.

The Melco mine pit and adjacent waste dump will also have minimal impacts on the groundwater. Dames and Moore (1988) determined, based upon piezometers completed in exploration drill holes, the approximate elevation of the water table beneath Melco to be 6800 feet (AMSL). Subsequent exploration drilling to elevations below 6500 feet has not intersected water, indicating that the water table probably lies below the 6500' elevation. Current mine plans reflect the maximum possible pit depth and indicate that the elevation of the pit bottom will not lower than a depth of 6900 feet. Therefore, no impact upon groundwater quantity or quality from the Melco pit is anticipated.

Since the proposed BC South pits will not intercept the water table, significant accumulations of water will not occur in the pits. Therefore, no significant impact on ground water quality is expected to occur. Similarly, the lack of significant water accumulations in the pits will result in negligible impact to wildlife.

The bottom of the expanded Melco pit will be at approximately 6460 feet AMSL. Extensive additional exploration drilling in the area indicates that the water level measured in hole MC-31 was a localized anomaly and that the water table is below 6400 feet AMSL. To date, no significant quantities of water have been intercepted in the planned pit area.

4.3 Soil Resources

Operations and post-operational runoff control plans prevent the erosion of in-place and stockpiled topsoils. Due to steep slopes and related worker safety requirements, variances for topsoil salvaging and replacement are being sought, as discussed in Section 6.0. With the exception of areas proposed for variances, topsoil will be salvaged from all other disturbed areas. Sufficient topsoil will be salvaged to ensure that all surfaces receiving topsoil during

reclamation will be covered by at least one foot of topsoil. Replaced topsoil will be revegetated with an appropriate seed mix both for the purpose of erosion prevention and for wildlife and cattle forage. Soil stockpiles will be protected from erosion with an interim cover of grass. Soil resources will, therefore, be protected to the maximum extent that prudent and safe mining practices allow.

All areas safely accessible to excavating equipment will be stripped of available topsoil and the topsoil will be stored in stockpiles as described in Section 3.9.

4.4 Critical Wildlife Habitats

The open pit highwalls will be the only parts of the disturbed areas that will not be reclaimed and, therefore, will not be available as high-quality wildlife habitat as they are now. The project area is important habitat to both deer and elk; however, the loss of forage and cover will be minimal in the context of the project as a whole. Possible changes in migration routes will only be temporary given the short life of the mine. This minimal impact to the wildlife habitat will be mitigated somewhat by the creation of wildlife watering sites in impoundments in the Barneys Canyon pit and behind mine dumps. In addition, Kennecott's practice of allowing no hunting on its property will eliminate the impacts of combined hunting pressure and habitat loss of the herds.

The Division of Wildlife Resources (DWR) has been informed of the Barneys Canyon project asking for their recommendations concerning elk calving habitat and elk and deer winter range. Kennecott and the Division of Oil, Gas and Mining have been informed by the DWR that the project operations will not adversely affect elk calving habitat and that the only mitigation necessary will be to reduce travel in the main branch of Dry Fork and that portion of Barneys Canyon above the 7000 foot elevation as much as possible during calving season. Neither the Melco or Barneys Canyon operations will require access to these areas. Kennecott cannot of course restrict access to private landowners or lease holders who may require access to properties in these canyons or to its own personnel who may have to enter the main branch of Dry Fork for the purposes of property maintenance or water monitoring.

4.5 Air Quality

Air emissions resulting from the mining operations will be fugitive dust and diesel emissions. A number of point source air emission sources will occur within the process plant area. The principal point source emissions will be dust from the crushing and screening operations. Detailed air emissions calculations are incorporated in Kennecott's "Notice of Intent to Commence Mining and Gold Processing Operations, Barneys Canyon Project, Salt Lake County, Utah, Submitted to Utah Division of Air Quality" (AQNOI).

Kennecott's emission control plans for the project will incorporate, as Utah Division of Air Quality regulations require, best available control technology for suppression of emissions. The controlled emissions calculations in the above-referenced AQNOI indicate that the Barneys Canyon project will not be a major emission source under Federal Prevention of Significant Deterioration (PSD) regulations. Therefore, it is concluded that the project will not cause a significant deterioration of air quality in the area.

Detailed estimates of air emissions are included in the Technical Report submitted to the Division of Air Quality (DAQ) in March, 1992. A revised Approval Order for Barneys Canyon Mine was issued by DAQ in September, 1992.

A revised Approval Order was obtained from the Utah Division of Air Quality on December 20th, 1993 to allow increased dump heights. This new approval order allows the height of the waste dump lifts on the south side of the Melco Mine to increase from 500 feet to 1000 feet and for all other project waste dump heights to increase from 300 feet to 500 feet. On February 9th, 1994 a revised Approval Order was obtained which covers the sulfide flotation plant and associated infrastructure.

4.6 Public Health and Safety

All mining and process operations will be operated in full accordance with safety regulations administered by the Federal Mine Safety and Health Administration (MSHA). The occupational safety and health program will not only protect worker safety and health, but also that of members of the general public that will visit the property. Maintenance of a safe on-site work environment and adherence to the air emission control program will insure that no harmful airborne particulate or chemical emissions will leave the property.

Kennecott, by virtue of its extensive land ownership in the area, controls all access to the property. Hence, an effective safety buffer zone is adjacent to the project site. In addition to overall controlled access and the site safety program, other specific safety measures will be taken to further ensure public safety. These measures will include locked gates at all access points when operations are dormant, fences around all process areas, and security guards to control public access at all times during the life of the project. Warning signs and safety berms will be installed adjacent to pit highwalls following completion of mining as part of reclamation. In addition, all process facilities will be reclaimed after any cyanide-bearing or other toxic-materials-bearing wastes are neutralized or safely removed from the property.

The East Barneys Project will not leave any shafts or tunnels at the end of the project. Therefore all safety considerations are covered under the existing permit requirements.

5.0 Reclamation plan

5.1 Post-mining Land Use

The post-mining land use for the reclaimed mine dumps and leach pads will be for wildlife habitat and livestock grazing. The post-mining land use for the open pits will be sediment control. The pits will contain sediment eroded from the open pit walls. The Barneys Canyon pit will serve a secondary purpose of providing a source of water for wildlife. Reclamation treatments are summarized in the following text, on the Reclamation Treatments Maps. (Plate 96-1 and Plate 96-2)

5.2 Demolition and Disposal

5.2.1 Facilities Removal

All non-earthen facilities will either be transported from the site for use elsewhere, salvaged, or demolished, if necessary. Any paved surfaces will be removed and handled as demolition debris as described below. The various facilities will be removed or disposed as follows:

crushers, conveyors, and mobile equipment will be salvaged or transported from the site for use elsewhere;

buildings will be salvaged or demolished and removed from the site, unless they are required for other non-mining use;

powerlines and substations will be removed and salvaged upon completion of the operations, unless they are preserved for a continued, non-mining use;

fuel and explosives storage facilities will be salvaged or transported off-site for disposal; and

fences will be removed and salvaged or junked following completion of reclamation.

Necessary security measures will be maintained until satisfactory reclamation has been achieved.

5.2.2 Demolition Debris Disposal

Demolition debris that cannot be salvaged will be deposited in a permitted solid waste landfill.

5.2.3 Hazardous Substances

Leach testing of waste materials has demonstrated that materials left on site following reclamation will not be hazardous. As discussed below, each heap leach installation will be rinsed and have its cyanide neutralized prior to regrading and reclamation. Mine dumps will not be toxic. Any other process waste materials that accumulate on site, either in containers or impoundments will be disposed of properly, taking into account potential hazardous characteristics.

5.3 Regrading and Process Facilities Closure

Proposed procedures for mine dump and process facilities regrading, open pit and haul road reclamation, and/or closure are presented below and depicted on the Reclamation Treatments Maps, Plate 96-1 and Plate 96-2.

5.3.1 Open Pits

The East Barneys Canyon, Melco, and North BC South pits will not be used for waste rock disposal and, will not be backfilled. The pits will serve as catchment basins and prevent release of sediment eroded from the pit walls.

The South BC South open pit will be partially backfilled with waste from the North BC South open pit, as shown on Plate IV-B. The pit will be backfilled as shown on Plate IV-B and Figures 5.3-1 and 5.3-2. The South BC South pit will be non-water-impounding; however, the terraces will be sloped toward the remaining highwalls for the purpose of runoff control and sediment retention. The non-backfilled portions of the pits will not be revegetated or topsoiled. Safety berms or fences will be installed along the margins of all pit highwalls. The Barneys Canyon Pit will be partially backfilled with waste from the East Barneys Project.

The pit bottoms at Melco will be covered with six inches of topsoil and revegetated (Plates 96-1 and 96-2). Pit benches that are safely accessible to equipment following completion of mining at each pit will be topsoiled to the extent that topsoil is available.

The East Barneys pit will remain in its as-built condition within the bottom of the Barneys Canyon drainage. The operational drainage diversion used to divert Barneys Canyon around the pit during operations will be backfilled and reclaimed. The diversion berm constructed to block the natural Barneys Canyon Channel and divert it into the temporary ditch will also be removed from the natural channel to open the natural channel to a free-flowing condition. A permanent reclamation channel will be constructed to drop the Barneys Canyon channel into the East Barneys pit in a stable fashion.

The permanent reclamation channel will begin at the contact between alluvium and rock within the pit and be graded at an overall 33% grade uphill to the natural Barneys Canyon channel elevation (see Appendix DII(c)). The bottom of this channel excavation will be approximately 8 feet wide and the sides slopes will be approximately 4h:1v or flatter. The design flow for this permanent channel is 195 cfs which is the 100-year, 24-hour peak flow calculated by JBR for the Barneys Canyon watershed. This calculation used the same watershed configuration and computer model last used in the November, 1993 NOI except that the average weighted Curve Number for the watershed was increased from 48 to 57 to take into account the approximately 300 acres of reclaimed overburden dumps that will exist in Barneys Canyon when the Melco wasterock dumps are completed.

The flow conditions in the permanent channel were calculated using the SECAD 3 computer program (Appendix DII(c)). The calculated flow velocity of 13 fps will require the use of a 4-foot thick blanket of riprap, having a D_{50} of 15 inches over the bottom of the channel and extending at least 2 feet up the channel sides. This same riprap will extend up the natural Barneys Canyon channel for approximately 50 feet uphill of the start of the constructed channel to protect this transition section. There will be no need for a similar riprap blanket at the outlet of the channel where it discharges onto the rock surface of the East Barneys pit.

The East Barneys pit will contain the water draining down the Barneys Canyon channel. The pit will not be self draining and will hold water within the pit bottom up to the 6080 foot elevation before any additional water will drain over the east end of the pit and down the natural Barneys Canyon channel. All the rock in the East Barneys pit is expected to by oxide material with no sulfidic mineralization. Therefore, the water in the pit should not contact any acid generating material and should have no deleterious water quality impacts on local surface water or ground water quality. The water contained in the pit is expected to be ephemeral to intermittent in nature and will be available for seasonal use by wildlife as a water source. The local water table is below the bottom elevation of the pit so a perennial water impoundment is not expected to occur. Any overflow from the pit will flow down the natural Barneys Canyon channel.

5.3.2 Mine Waste Dumps

Waste dump outslopes will be developed during mining at a slope of approximately 37 degrees. All Barneys Canyon pit mine dumps will be regraded to a slope of 2.5h:1v (22 degrees). The regraded bench outslopes will be pitted for the purpose of runoff and erosion control. The regraded Barneys Canyon dump outslopes will be covered with approximately six inches of topsoil and revegetated according to the revegetation plan presented in Section 5.5 through 5.8. The top of the dump will be ripped to 24 inches and will receive six inches of topsoil and revegetated as outlined in Section 5.5 -5.8.

The BC South waste rock dump will be regraded to a slope of 2.5h:1v (22 degrees). The regraded bench outslopes will be roughened using a pitter to create a series of depressions on the dump outslope surface. These depressions will function as sites for concentrated revegetation and for the purpose of runoff and erosion control. The regraded BC South dump outslopes will be covered with approximately six inches of topsoil prior to excavation of the depressions described above and revegetated according to the revegetation plan presented in Section 5.5 through 5.8. The top of the dump will be ripped to 24 inches and will receive six inches of topsoil and revegetated as outlined in Section 5.5 -5.8.

The configurations of the Melco mine dumps have been revised as a result of the decision to increase the size of the Melco open pit. Selected outslopes of the 7240 and 7460 dumps outlined on the Reclamation Plan (Plate 96-1) will be regraded to a slope of 2.5h:1V and revegetated as outlined in Section 5.5 - 5.8. The south outslope of the Melco South dumps will not be regraded because such activities would result in additional disturbance of the watershed including adjacent hillsides and the ephemeral channel in the canyon below. The outslope of these dumps will be hydroseeded using mulch and tackifier for stabilization and erosion control.

The configuration of the Melco dumps have been designed to eliminate upgradient watershed runoff water from draining into the pit at mine closure.

All of the outslopes of the Melco north dumps will be regraded to a slope of 2.5h:1v and the dump surfaces and slopes covered with approximately six inches of topsoil and revegetated.

5.3.3 Heap Leach Pads and Solution Ponds

When a leach pad is completed, it will be rinsed to remove the cyanide solutions, drained, and left for reclamation at the close of all operations. The neutralization criteria will be

determined by the Water Pollution Control Committee or the Division of Water Quality (DWQ) at the time of decommissioning. The neutralization criteria will ensure that no degradation of the surface or groundwater quality or beneficial uses thereof takes place following regrading and revegetation of the heaps.

The closure process will begin by terminating the addition of NaOH and NaCN to the barren pond water and allowing the pH of the circulating leach solution to gradually adjust to a natural pH of about 7. The neutral solution pH will cause the CN in the wet ore to gradually be converted to volatile HCN which will be liberated to the air-filled voids within the heap. This HCN will gradually and harmlessly diffuse to the surface of the heap where it will be released into the atmosphere. The final neutralization procedures will be described in a closure plan to be reviewed and approved by DWQ six months prior to beginning neutralization of any pad.

When the heap has been neutralized, the makeup water flow to the barren pond will be turned off and the water in the pregnant intermediate and barren ponds will either be pumped to another active leach pad or evaporated. The ponds will then be allowed to dry and remaining sludges will be sampled for EP toxicity characteristics. All solid wastes will be properly disposed of taking into account their chemical characteristics. The pond liners will then be removed from the anchor trenches and folded into the ponds. The pond areas will then be backfilled with earth, and topsoil from nearby stockpiles will be spread evenly over the regraded surface.

The leach heaps will be re-contoured to gradually rounded slopes of 2.5h:1v or less. The recontouring process will include pushing neutralized heap material over the pad marginal dikes to cover the exposed liner. Topsoil from the stockpiles will then be spread evenly over the recontoured surface and the specified vegetation mixture will be established.

The rinsed leach solution pipelines will be taken up and removed from the site. The liners in the pipeline trenches outside of the leach pads will be removed from the trenches, rolled up, and disposed in the solution pond excavations prior to their being backfilled. The trenches will then be regraded, topsoiled, and revegetated.

5.3.4 Haul Roads

All haul road surfaces will be covered with six inches of topsoil and revegated as described below in Sections 5.3 and 5.4 (Plates 96-1 and 96-2). Haul road outslopes and cut slopes will be hydroseeded, using methods described in Section 5.4.3.

5.4 Soil Materials

5.4.1 Topsoil Application

All disturbed areas, with the exception of the open pits, the clay borrow pits, and the Melco South dump outslopes, will be covered with topsoil having a nominal thickness of six inches; areas to receive topsoil are described in Section 5.4.3.

Kennecott commits to placement of at least six inches of topsoil on all disturbed slopes having an outslope of 2.5h/1v or less. A revegetation test plot program, will be developed to determine if the Melco dump material can be directly revegetated. However, the design

of this program will not be included in the mining and reclamation plan at this time.

5.4.2 Topsoil Handling

The topsoil redistribution will be carried out during the summer in anticipation of fall seeding. Thus, the soil will be relatively dry and compaction minimized. Minimizing topsoil compaction is very important considering the clays and clay loams present in many of the soil types, especially the Harker and Dry Creek soils. Topsoil materials will be moved with a scraper or loader-dump truck operation and will require some spreading with a blade. The contractor will be cautioned to keep the soil surface rough and to avoid balding to obtain a smooth surface. Evenness of depth will be sacrificed for roughness of surface.

To relieve compaction, all topsoiled areas will be ripped to a depth of at least 24 inches with the rippers set at 12 inch spacing.

5.4.3 Topsoil Balance

Topsoil sources by soil type are summarized in Table 5.4-1. Table 5.4-2 presents the topsoil volumes to be applied to the various sites. A swell factor of 21 percent, one-half that estimated by the Caterpillar Performance Handbook (Caterpillar, 1988), was applied to the in-place topsoil volume. The topsoil excess will be applied as site-specific conditions require or used at other Kennecott properties or put to beneficial use by other outside sources.

Soil types for Melco expansion study area are detailed in Table 2.4-1 and on Plate III-C. Much of this soil resides on steep, tree covered slopes and will not be recovered because of safety concerns. The quantity of soil in the area (prior to salvage losses and unsalvaged slopes) is approximately double the amount required for the reclamation plan. Kennecott will salvage topsoil from areas where salvaging operations can be safely conducted. This topsoil will predominately be salvaged from the main drainage of Barneys Canyon where access is easy and the soil depth the greatest.

Table 5.4-1 Topsoil Sources by Soil Types

Soil Type	Volume, Cu.Yds.
Bradshaw-Agassiz	125,194 +8910 = 134,104
Fitzgerald	54,890
Harker-Dry Creek	318,634
Gappmeyer	51,080
Dry-Creek Copperton	402,526
Wallsburg	38,650
Copperton	20,167
Total Topsoil Available	1,020,051
Swell Factor of 21%	214,211
Total After Swell	1,234,262

Table 5.4-2 Topsoil Applications by Sites

Site	Acreage (Ac)	Volume (CY)
ROADS		
BC/SBC Haul Road	31.0	28,758
Process Roads	10.7	9,926
Main Access Road	4.6	4,267
BC Pit Area	11.0	10,204
Runaway Ramp	1.2	1,113
West Melco Haul Road	11.0	10,204
Melco East Haul Road	18.0	16,698
SBC/NBC Haul Road	8.0	7,421
Melco Haul Road (SBC-Melco)	27.0	25,047
East Barneys A**	19.0	17,626
ADMIN/PROCESS/SHOP		
Administration Building	3.0	2,783
Process Lab	13.0	12,060
Crushing/Screening	8.0	7,421
Shop	9.0	8,349
Potable Water Storage	2.0	1,855
Ore Stockpile	18.0	16,698
Gravel/Clay Pit #1	0.0	0
Clay Pit #2	2.5	2,319
Clay Pit #3	2.5	2,319
SBC High Wall	9.0	16,698
SBC Pit Fall	9.0	8,349
Upper B.C. Disturbance**	14.0	12,987
WASTE DUMPS		
Barneys 6300	37.0	37,663
6400/6500 West	46.0	42,673
UBW 6600	4.0	3,711
UBW 6600 A **	14.0	12,987
South Barneys	7.0	7,050
Melco 7480	12.1	12,356
Melco 7460	16.0	16,698
Melco 7300	83.0	82,562
Melco 7200	38.0	37,107
Melco 7100	47.0	47,125
Melco 6920	57.0	59,185
Melco 6920 A **	47.0	43,600
Melco-NBCS HR	11.0	10,946
Melco-NBCS HR A **	21.0	19,481
Melco Sulfide Repository	12.0	11,132
NBCS Sulfide Repository	8.0	7,421
Melco South Dumps	72.0	71,430

LEACH PADS

BC-1	38.0	35,251
BC-2	35.0	32,468
BC-3	44.0	40,817
BC-3A **	18.0	16,698
BC-4	32.0	29,685
BC-5	30.0	27,830
BC-5 A **	15.0	13,915
Solution Ponds	7.0	6,494
Melco and Satellite Expansion (Table 5.0-1)	147.1	237,320
Total Demand	982.6	949,391
Total Available		1,279,700
Topsoil Balance (Excess)		(330,309)

Table 5.4-3 Expansion Topsoil Application Requirements

Location/Site	Disturbance (acres)	Topsoil (cubic yards)
Upper B.C. Disturbance	14	12,987
UBW 6600	14	12,987
6920 Dump	33	30,613
NBCS HR	21	19,481
Leach Pads	33	30,613
East Barneys Pit	19	17,626
Reclamation Requirements	134	124,307

In determining the topsoil balance for reclamation of the waste dumps and roads, it has been assumed that inefficiencies in topsoil salvaging may result from excavating equipment working on the steeper slopes and the reduction of salvageable topsoil in some wooded areas caused by topsoil clinging to large tree roots. It was assumed that this possible loss would be balanced by ordinary swelling following salvaging and the added volume that will be created by mixing vegetation with the soil during salvaging and stockpiling operations.

5.5 Seedbed Preparation

Topsoiled areas will require seedbed preparation only if seeding does not closely follow placement of topsoil. If seeding occurs more than 60 days following topsoil placement, the soils will be scarified or disked prior to seeding. Seeding on topsoiled dump surfaces will be accomplished with a pitter, range drill or hydroseeder.

5.6 Seed Mixture

Three different seed mixtures are proposed for the Barneys Canyon project. Species were derived from the plant community descriptions and experience with other revegetation projects in the Oquirrh Range, along with input from DOGM.

Areas which are proposed to receive topsoil will be revegetated with the seed mix shown in Table 5.6-1. Outslopes of the Melco, 7200 and 7300 dumps have been granted a variance from the topsoil redistribution requirement by the Division. The seed mixture recommended for non-topsoiled surfaces is shown in Table 5.6-2. The two sulfide repositories located at Melco and North BC Pit will be revegetated using the seed mix presented in Table 5.6-3.

Revegetation will be carried out in the manner described in Section 5.7, including hand-seeding of tubestock.

Areas that have been hydroseeded and are safety accessible will receive an even mixture of Gambel oak, rabbitbrush and snowberry tube stock planted in clumps of 3 to 5 each will be planted at a rate of 135 plants per acre, three times the application rate proposed for the topsoiled surfaces. The planting procedure for each clump will begin with excavation of an over-sized hole which will be lined with mulch. A slow-release fertilizer pellet will be placed at the bottom of each hole. The tube stock will then be planted and the hole filled and tamped. A mixture of legume seed will be hand-applied to the surface of each planting site for enhancement of nitrogen development in the planting medium. The Division will establish a survival rate, as a percentage of total seedlings planted, for the un-topsoiled dumps surface. This survival rate is currently estimated to be 50 percent. This survival rate will be achieved at the end of the three year period following completion of reclamation.

As a result of discussions with Department of Wildlife Resources (DWR) personnel, it has been agreed that additional legumes and forbs will be added to the revegetation seed mix to improve the spring forage for deer and elk in the reclaimed areas of the project. DWR personnel feel that the addition of these species to this large reclaimed area will significantly improve the early spring forage above what is currently present. This improved forage over this large reclaimed area will provide enhanced habitat to both deer and elk. Therefore, the current reclamation plan with the modified seed mix is, according to DWR, the best means of enhancing the post-mining use of the reclaimed area.

Table 5.6-1 Seed Mixture for Topsoiled Areas

Common Name	Scientific Name	*PLS(1) lbs. acre
Grasses		
bluebunch wheatgrass	Agropyron spicatum	3
intermediate wheatgrass	Agropyron intermedium	3
great basin wildrye	Elymus cinereus	3
canby bluegrass	Poa canby	1
cereal rye	Secale cereale	4
Legumes		
yellow sweetclover	Melilotus officinalis	1
cicer milkvetch	Astragalus cicer	2
ladak alfalfa	Medicago sativa	2
Forbs		
yarrow	Achillea millefolium	0.2
small brunette	Sanguisorba minor	1.5
Shrubs		
basin big sagebrush	Artemisia tridentata	0.5
rubber rabitbrush	Chrysothamnus nauseosus	0.5
Total		21.7

(1) PLS = Pure Live Seed
* Rates reduced by 30% if drill seeded.

Table 5.6-2 Seed Mixture for Non-Topsoiled Areas

Common Name	Scientific Name	PLS(1) lbs/acre
Grasses:		
regreen wheatgrass	Triticum x Agropyron	2.5
intermediate wheatgrass	Agropyron intermedium	2.5
bluebunch wheatgrass	Triticumx agropyron	2.5
indian rice grass (2)*	Orxyopis hymenoides	2.5
streambank wheatgrass	Agropyron riparium	2.5
Lequmes:		
cicer milkvetch	Astralagus cicer	1
yellow sweetclover	Melilotus officinalis	0.5
palmer penstemon	Penstemon palmeri	0.5
alfalfa	Medicago satira	1
mountain lupine	Lupinus alpestris	1
Forbs:		
yarrow	Achillea lanulasa	0.2
small brunette	Sanguisorba minor	1
Plantings:		
gambel oak	Quercus gambelli	135 #1/A(2)
snowberry	Symphoricarpus albus	135 #1/A(2)
rabbitbrush	Crysothamnus nauseosus	135 #1/A(2)

(1) PLS = Pure Live Seed (these rates apply to broadcast or hydroseeding; for areas where seed is to be drilled, the application rates will be reduced by 30%)
(2) Tube stock will be planted in clumps at a rate of 45 plants per acre. Protective measures, such as netting or tubing will be applied to each clump of tublings.

Table 5.6-3 Sulfide Repository Cap Seed Mixture

Common Name	Scientific Name	PLS(1) lbs/acre
Grasses:		
regreen wheatgrass	Triticum x Agropyron	6.5
intermediate wheatgrass	Agropyron intermedium	3.5
bluebunch wheatgrass		3.5
Legumes:		
yellow sweetclover	Meliotus officinalis	1.5
small brunette	Sanguisorba minor	1.5

(1) PLS = Pure Live Seed

5.7 Seeding Methods

Topsoiled dump top surfaces will be seeded with a range drill and topsoiled dumps slopes will be seeded with a pitter or hydroseeder. Seeding will take place in the fall prior to snowfall. The seeding depth for drill-placed seed will be 0.5-0.75 inches at the rate of application specified in the seed mixtures presented in Section 6.5. Since the seed drilling will be the last step in revegetation, the fertilizer and mulch will be turned into the soil by the disks on the drill.

The outslope of the Melco 7300 dump and the south outslope of the Melco 7200 dump will be seeded with a hydroseeder. In addition, tube stock will be hand-planted the outslopes that are safely accessible. The outslopes and cut slopes of all haul roads (Plate IV-B) will also be hydroseeded, using the seed mixture shown in Table 5.6-2.

The planting stock will be tube stock and will be hand planted in early spring at snowmelt. Planting will be in clumps of three at the planting rates as shown in Table 5.6-4. The clumps will be planted in sites with aspect and slope to maximize moisture entrapment. A small catch basin will be constructed around the three plants.

Kennecott proposes to establish the minimum revegetation standard for the 7300 and 7200 angle of repose dump slopes at Melco by performing vegetation transects of south facing angle of repose fill slopes along the Melco haul road or by other appropriate means as determined in conjunction with DOGM. These slopes were hydroseeded in 1990 using seed mixtures very similar to those prescribed in the Mine Reclamation Plan (MRP).

Kennecott commits to applying to the 7300 and 7200 dump south outslopes the currently approved reclamation treatment for the Melco 7200 dump outslopes unless, prior to reclamation, Kennecott and DOGM jointly adopt a modified program of revegetation. Kennecott will cooperate fully with DOGM in the evaluation of alternate reclamation techniques for these dump outslopes . If the success of the regevetation efforts on the 7300 dump establishes a higher revegetation standard, it will be applied to the 7200 dump angle-of-repose slopes.

5.8 Fertilization and Mulching

5.8.1 Fertilization of Topsoiled Areas

The goal of fertilization is to raise the available phosphorus and nitrogen concentrations to 25 ppm, and 0.02 ppm, respectively and to maintain the organic matter at 1.5 percent. This will be accomplished by utilizing green alfalfa hay in combination with diammonium-phosphate fertilizer in the fall seeding schedule. This fertilizer will provide the nitrogen required for seedling growth in the first growing season. The soils that will be used for topsoiling have adequate nutrient contents; therefore, no additional fertilizer is necessary.

During the planting of the shrub species, a fertilizer tablet of 20-10-5 will be inserted in the hole at root depth and irrigated. These slow release tablets are designed to provide fertilization to the seedings for two years.

The diammonium-phosphate fertilizer 18-46-0 at 310 pounds per acre will proved 49 pounds per acre of nitrogen and 64 pounds per acre of P_2O_5.

5.8.2 Fertilization of Non-Topsoiled Areas

Fertilization of non-topsoiled areas (Melco South dump outslopes) will be identical in chemical fertilizer type and quantity as described for the topsoiled area in Section 5.8.1. Fertilizer, mulch, and tackifier will be applied in a slurry by hydroseeding methods.

5.8.3 Mulching

Green alfalfa hay will be applied to all topsoiled surfaces. As a mulch, it will increase the organic content of the soils, increase the soil moisture holding capacity, and provide nutrients for microorganism colonization. The buildup of microorganisms and the resultant increase in nutrient cycling capability in the soils will facilitate plant establishment and growth.

The hay mulch will be applied at the rate of 4,000 lbs/acre following ripping and prior to seeding. The use of a mulcher or mulch chopper to blow in the hay will allow for even distribution and dismemberment of stems to allow the disks on the seed drill to turn in the hay particles.

The hay at 4,000 pounds per acre will provide nitrogen, phosphorus, and potassium at the rates of 100 pounds per acre, 20 pounds per acre, and 84 pounds per acre, respectively.

On sites where the seed drill is unable to function and broadcast seeding is used, the hay will need to be covered with soil by backdragging or raking.

Runoff from upgradient watersheds will no longer be routed into the NBCS and Melco pits at mine closure.

5.9 Surface Water Hydrology and Sediment Control

Post-reclamation runoff and sediment control measures are described below and are depicted on Plate IV-B, the Reclamation Treatments Map.

5.9.1 Drainage Plan

The post-reclamation surface water drainage plan will differ slightly from the operational water management plan. Main variances will include restoring water drainage to the natural channels by removing all road culverts, placing waterbars on the roads to

prevent road runoff, and allowing precipitation water that falls onto the reclaimed leach pads to drain into nearby drainage channels. In addition, Impoundment M, which was created by waste dumps, will continue to be used as permanent impoundment following reclamation.

Upon project completion, all haul roads will be ripped to permit the infiltration of water through the road surface. At this time, all culverts will be removed and channels restored to their natural course. Newly created slopes adjacent to areas of culvert removal will be regraded to slopes of less than angle of repose to the extent possible. Slopes in the vicinity of culvert removal that are 2h:1v or less will be ripped, topsoiled, and revegetated using the appropriate seed mix. Water bars will then be installed, at the spacing listed below, to divert runoff water from the road surface to the roadside fill slopes to reduce erosion (Plate VI-A and IV-B).

Road Grade (percent)	Spacing (feet)
10 to 14	200 to 100
6 to 10	300 to 200
4 to 6	400 to 300
less than 4	as needed

In addition, the road outslopes that have not been previously hydroseeded with some degree of success will be roughened to the extent possible using equipment which can safely access the outslopes from existing roadways. The effectiveness of various tackifiers will be evaluated for use in seed stabilization on both cut and fill slopes of haul roads. The results of this evaluation will be used to determine the tackifier(s) to be used in conjunction with further hydroseeding. In addition, the appropriate seed mix will be re-applied to those road and fill outslopes that have not been successfully revegetated by past hydroseeding efforts.

The ditches that border the leach pads will be covered during regrading to allow the free flow of water from the leach pads to drain to an existing natural channel.

The mine dumps will be ripped and revegetated to control runoff velocities across the dump surfaces. All precipitation water falling on the dump surface will seep into the dump surfaces or drain back toward the natural hillside. Precipitation water falling on the dump fill slopes will drain toward the dump toe over the ripped and revegetated dump surfaces.

Runoff from upgradient watersheds will no longer be routed into the NBCS and Melco pits at mine closure. Due to waste dump 6400 near the Barneys Canyon pit, Impoundment M will be 50.7 acre-feet. Therefore, this impoundment has the capacity to contain runoff from events three times that of the 100-year runoff event. Water impounded behind this structure will be released via infiltration and evaporation. Infiltration will provide recharge to the underlying aquifer.

Runoff from the watershed upgradient of the BC South dump will drain into the North BC South Pit. The Melco, North BC South, and South BC South pits will also remain following reclamation. Water impounded in the pits will be released via infiltration and evaporation. Infiltration will provide recharge to the underlying aquifer.

Kennecott will examine techniques that may be implemented for the revegetation of the cut and fill-slopes of the Melco haul roads. In general, the following are proposed: 1) all road surfaces will be deeply ripped with a dozer/ripper and topsoil will be placed on the road surface in a roughened condition prior to hydroseeding; 2) all road outslopes that have not previously been hydroseeded with some relative degree of success will be roughened to the extent possible using equipment which can safely access the outslopes from existing roadways; 3) the effectiveness of tackifiers will be evaluated for use in seed stabilization on both cut and fill slopes and, if found to be effective, the appropriate tackifier will be used in conjunction with further hydroseeding; 4) a reapplication of the appropriate seed mix will be applied by hydroseeder to all previously hydroseeded cut and fill slopes that have not been successfully revegetated by past revegetative efforts; 5) culverts and roadfill at drainage crossings will be removed in accordance with the original NOI; 6) newly created slopes adjacent to areas of culvert removal will be regraded to slopes of less than angle of repose to the extent possible; 7) slopes in the vicinity of culvert removal that are 2h:1v or less will be ripped, topsoiled, and revegetated using the appropriate seed mix.

5.9.2 Sediment Control Structures

Reclamation sediment control procedures will be implemented so that soil conservation measures will require little maintenance and will lead to natural long term sediment control. One of the most effective forms of sheet wash sediment control will be the reestablishment of vegetation over the disturbed areas. The establishment of vegetation and reduction of effective runoff length using water bars on the reclaimed haul roads will be the most significant forms of sediment control over the site. Sediment control structures described in Section 3.12.3 and shown on Plate II-B will be retained and maintained following reclamation to the extent that reclamation regrading will allow. Sediment control structures to remain in place are shown on Plate IV-B. These sediment structures will be removed at the time of reclamation bond release and the sites of the structures will be revegetated using the seed mix shown in Table 5.6-1. Any sediment loads originating from the watershed upgradient of impoundments created by the Melco and BC South pits will be deposited in these impoundments. Sediment loads from pit walls will be retained in pit impoundments. The capacity of these impoundments will be in excess of the potential volume of sediment to be released from the upgradient areas.

The existing impoundments created by the B&G railroad grade will remain after reclamation and continue to function as sediment control structures.

6.0 VARIANCE REQUESTS

As the result of natural terrain conditions, the planned location of mine dumps, the proposed final outslope angle of certain dumps, and the planned post-mining use of the open pits, a number of variances from the Division's rule R613-004-112, Reclamation

Practices, have been approved. These variances are presented below in order of the listing of sub-parts of the rule in the regulations.

Kennecott requested variances from Rule R613-004-111.6, Slopes, R613-004-111.7, Highwalls, Rule R613-004-111.12, Topsoil Redistribution, and Rule R613-004-111.13, Revegetation. Likewise, Kennecott has an approved variance from regrading of the lower Melco dump outslopes.

6.1 Variance from Rule R613-004-111.9 Dams and Impoundments

Kennecott will leave in place upon reclamation, Impoundment M created by the 6400 mine dump at the Barneys Canyon site. This facility is part of the overall plan for site sediment control and its exceeds the runoff volume predicted for the 100-year, 24-hour precipitation event. In fact, as discussed in Section 3.12, Impoundment M and the Melco impoundment will have the capacity to store four times the volume of runoff predicted to result from the 100-year event. In addition, the fill will be constructed of porous waste rock and will not be designed to permanently impound water, hence the actual amount of water retained in the impoundments is anticipated to be much less than the predicted volume from any given storm. Approval for installation of these two impounding structures will be sought from the Utah State Engineer in the Division of Water Rights.

6.2 Variance from Rule R612-004-111.6 Slopes

Kennecott requested that a variance from this rule be granted for regrading of the outslopes of the Melco 7200 and 7300 waste rock dumps. A variance from this rule has been approved because regrading would result in substantial additional disturbed area and in an adverse impact to the ephemeral channel in Dry Fork. This affected area is valuable wildlife habitat which further justifies the variance. In addition, the steep slope on which the 7300 dump is sited has a natural slope of approximately 1.75:1 beneath the footprint of the proposed dump and the slope below the proposed dump's toe is even steeper, locally approaching the angle of repose for the waste rock material. Therefore, regrading of this waste rock dump is not possible given the steep terrain upon which it is sited.

The Melco 7200 dump is designed such that the shorter north slope can be regraded and Kennecott has committed to doing so, as described in Section 5.3.2. Kennecott has been granted a variance for the south slope of the 7200 dump. Regrading of this outslope to 2h:1v would result in the regraded waste material reaching the main fork of Dry Fork below. In addition, regrading this dump to a slope of 2h:1v will require double handling of the waste because it is not possible to accomplish regrading in a single slot dozing operation. Five million tons of waste rock would have to be moved in at least two stages requiring the handling of at least 10 million tons of waste rock at a cost that would be at least twice that of a standard slot dozing operation. In consideration of both the financial impact and the impact to the disturbance of the downslope area, Kennecott has been granted a variance from this rule to cover the Melco 7200 and 7300 dumps.

6.3 Variance from Rule R613-004-111.7 Highwalls

In addition to a variance for slope angles, Kennecott has also been granted variances for topsoil application and revegetation.

The lower portions of the Barneys Canyon, Melco and North BC South pits will be below local grade which will allow them to serve as sediment retention basins thereby preventing the release of sediment eroded from the pit walls.

These pits may serve as a benefit to wildlife by providing a watering site through collection of runoff from the pit walls.

A variance from this rule which requires that highwalls be ".. . stabilized...to a slope of 45 degrees or less" has been granted for the Barneys Canyon, North BC South and Melco highwalls and for the slopes of the South BC South pit that will remain following backfilling. Maximum overall pit angles at Melco and North BC South are expected to be 47 degrees, while at South BC South, the maximum overall pit angle is planned to be 39 degrees.

Reduction of inter-bench slope angles by modification of mine plans to as low as 45 degrees would require either a major reduction in the quantity of ore mined, a substantial increase in the amount of waste mined, or a reduction in the overall grade of ore mined. Any of these alternatives would have an unacceptable impact on the economic viability of the project and may significantly increase the disturbed area.

All of the open pits at Barneys Canyon would be excavated in bedrock; hence, conventional concepts of angles of repose and stability of unconsolidated materials would not apply. These pits must meet the stability requirements of the Mine Safety and Health Administration (MSHA). Because pits must be excavated in a manner that assures pit wall stability during mining, the pits as currently designed are inherently more stable than a pit that has been reclaimed to 45 degrees by placement of unconsolidated materials against bench slopes.

Reduction of inter-bench angles to 45 degrees through regrading is generally not possible for the following reasons:

1) The angle of repose of waste rock materials is substantially less than 45 degrees; hence it is not practicable to regrade to such a standard.

2) Regrading of individual benches to 45 degrees or less at Melco would not be possible because the overall pit slope is greater than 45 degrees.

3) Individual benches will be inaccessible following completion of the mining operations; therefore, placement of fill material along benches would not be possible.

4) Regrading of slopes from the pit margins would be an unsafe work practice since equipment would be required to work on slopes that would be no less steep than the angle of repose.

Kennecott has committed to partially backfilling the South BC South pit with waste from the North BC South pit. The approximate backfilled configuration is shown on Plate IV-B. Kennecott has been granted a variance from this rule for further regrading of the highwalls that will remain following regrading, as shown on Plate IV-B. Backfilling of the Melco pit and the North BC South pit would require double-handling of waste rock or excessive haul distances from other open pits, resulting in an unacceptable increase in overall mining costs. In addition, currently uneconomic mineralization will remain in the North BC South deposit following completion of the planned mining operation. Backfilling this pit would render the mining of this reserve impossible in the event of improved economic conditions. For both reasons stated above, a variance from this rule has been granted for both the Melco and North BC South open pits.

6.4 Variance from Rule R613-004-111.2 Drainages

For the reasons discussed above in Section 6.1, Kennecott has been granted a variance from this rule to enable Impoundment M to remain following reclamation.

6.5 Variance from Rule R613-004-111.12 and 111.13 Topsoil Distribution and Revegetation

Kennecott has an approved variance from topsoil placement and revegetation at the Melco pit. Kennecott has committed to topsoiling open pit floors and benches that are safely accessible following completion of mining, including the Melco pit. It is not anticipated that any of the benches at Melco will be accessible, however. Kennecott has also been granted a partial variance from topsoil placement and revegetation in the BC South pits. Topsoil placement on most pit benches is not possible because benches will not generally be accessible either during mining, for reasons of safety, or following completion of mining due to isolation of individual benches as pits are advanced. However, those benches more than 40 feet wide that are safely accessible will be topsoiled and revegetated. Revegetation of the un-topsoiled parts of the disturbed pit areas, which are excavated in bedrock, is not possible.

Kennecott has also been granted a variance from Rule 111.13.11, which requires that revegetative cover achieve 70 percent of the pre-mining vegetative cover. This variance has been granted for all surfaces that are not covered with topsoil as part of reclamation, including open pit walls, road fill outslopes, roadcuts, and the outslopes of the Melco 7200 and 7300 waste rock dumps. A similar variance from this revegetation standard had been granted in the original NOI. Kennecott agrees to work with the Division to develop an alternate numerical revegetation success standard for the angle of repose waste dump and haul road outslopes and haul road cut slopes. This standard would be developed by evaluating the relative success of past hydroseeding efforts, evaluating natural vegetative cover in undisturbed areas that have similar elevation and slope aspect, and by using whatever information the current literature may provide. In addition, the 7300

dump outslopes revegetation program will be initiated as soon as practicable following completion of dump construction. The experience gained from this effort will be applied to reclamation of the 7200 dump and may be used to revise the numerical revegetation standard for the angle of repose slopes.

6.6 REQUEST FOR VARIANCE

Kennecott Barneys Canyon Mining Company requests a variance for R647-4-111.9 Dams and Impoundments, based on the following information;

1) The pit will be a permanent, stable feature on the landscape because it will be excavated below grade in rock.

2) Water impounding in the pit will only be a temporary feature after periods of high precipitation and/or surface water runoff in Barneys Canyon. This impounded water is expected to drain naturally by infiltration into the oxide rock of the pit bottom and by evaporation.

3) Temporary water storage in the pit bottom should not produce a hazard to human health and will be a drinking water source of local wildlife.

4) There are no feasible, alternate methods to be utilized because there are no plans to backfill or otherwise grade the East Barneys pit to eliminate its impounding nature. Such grading would cause additional land disturbance in addition to the pit itself.

6.7 REQUEST FOR VARIANCE

Kennecott Barneys Canyon Mining Company requests a variance for rule R647-4-111.7 limiting high wall slope angles for the East Barneys Pit.

1) Reduction of inter-bench slope angles by modification of mine plans to as low as 65° would require either major reduction in quantity of ore mined, a substantial increase in the amount of waste mined, or a reduction in the overall grade of ore mined. Any of these alternatives would have an unacceptable impact on the economic viability of the project and may significantly increase the disturbed area.

2) Because pits must be excavated in a manner that assures pit wall stability during mining. The pit is inherently more stable than a pit that has been reclaimed to 45° by placement of unconsolidated materials against bench slopes.

7.0 RECLAMATION COST ESTIMATE

Revegetation test plot results have indicated that the previous topsoil requirement of 12" can be successfully reduced and still achieve the specified vegetation standard required for final reclamation. This change in topsoil requirement significantly reduces final reclamation costs from previous estimates. This recent cost estimation is based on placement of six inches of topsoil in all areas except those identified for hydroseeding or special treatment (see Plate 96-1 for details). Please see Appendices H-1 and H-2 for a detailed cost accounting.

Currently permitted area requiring reclamation	= 961 acres
Expansion area requiring reclamation	= 134 acres
Total project area requiring reclamation	= 1,095 acres

The total revised reclamation cost is:

(1,095 acres) * ($3,325 per acre) = $3,640,615 (in 2001 dollars)

The existing reclamation bond is $4,604,000.

Although the current bond is almost 1 million dollars above the projected cost, no decrease in the surety is being requested as part of this amendment.

8.0 REFERENCES

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APPENDIX A-I

(CONFIDENTIAL - BOUND SEPARATELY)

APPENDIX A-II

GEOLOGIC LOGS OF DRILL HOLES AND WELLS

PROJECT Heap Leach Bad Site 1 Investigation

JOB NO. ES7-2038A DATE 12-18-87

LOG OF TEST BORING NO. B-1

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 5601.7

DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist hard	GRAVELLY SILT AND CLAY with some fine to medium sand, low plasticity, brown
5				S	84/11"			ML		
10				S	50/2.5"			GC	slightly moist hard	SILTY CLAYEY GRAVEL AND COBBLES with some sand, sub-rounded, low plasticity, light brown note: very difficult augering form 10' to 12', refusal at 12' (coved into weak sandstone boulder), moved hole 5' south and resumed
15				S	42 (no recovery)					
20				S	33		17	SC/GC	slightly moist very firm to firm	GRAVELLY CLAYEY SAND/SANDY CLAYEY GRAVEL, low plasticity to medium plasticity, brownish red, and mottled brown, light gray and yellow (possibly volcanic mud flow) note: added water below 15' to reduce friction
25				S	50/1.5"					
30				S	55		16			
35				S	50/2"					note: very difficult augering from 35' to 40'
40				S	60/5"		12			
				A	50/3"					
45										Auger refusal at 41.5' (1400 psi, lifting drill rig). Installed monitoring well: pipe to: 40.6' slots to: 37.6' pea gravel to: 36.3'. crushed bentonite to: 33.8'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample

SERGENT, HAUSKINS & BECKWITH

PROJECT Heat Leach Fm. Site 1 Investigation

JOB NO E87-2038A DATE 12-3 to 12-4-87

LOG OF TEST BORING NO. B-2

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 5646.7

DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC	wet soft	CLAYEY SAND AND GRAVEL, low plasticity, dark brown
5				S	50/5.5"			GM	slightly moist dense to very dense	SILTY GRAVEL AND SAND, non-plastic, subrounded, light grayish tan
10				S	50/4"				moist very dense to dense	SANDY GRAVEL with trace of clay, well graded, subrounded, low plasticity, tan, orange, and light gray
15				S	50/5.5"			GW-GC		
20				S	47					
25				S	18			GC	moist very stiff to stiff	CLAYEY SANDY GRAVEL, predominantly fine sand, low plasticity to medium plasticity, tan
				U	25					
				S	100/5"			GP	saturated below 29.5'	
30				S	12		17	CL-ML	saturated stiff	SANDY CLAY-SILT, predominantly fine sand with scattered gravel, low plasticity to medium plasticity, tan
35				S	50/5"					
40				S	50/4.5"			GP	saturated very dense	SANDY GRAVEL, predominantly fin to medium sand, subangular, light gray and tan
45				S	50/3"					Stopped auger at 45.0' Stopped sampler at 45.3' difficulty removing rods, had to turn augers several times mixing clays, moved east 15' to resample and install monitoring well

GROUND WATER

DEPTH	HOUR	DATE
26.5	09:00	12-4-87

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

A-10A

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 12-04-87

LOG OF TEST BORING NO. B-2B
(25' E. of B-2)

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. Approximately 5647±1
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC		CLAYEY SAND
5								GM		SILTY GRAVEL
10								GW-GC		GRAVEL with some sand and trace of clay
15										
20			U	40/3"					moist to saturated medium stiff to very stiff	SANDY CLAY, predominantly fine sand with gravelly zones and gravel/cobbles layers, note: felt soft at 24'
25			U	52				CL/GC	H_2O Surface	
			U	15		110	19			
30			U	22						
35								GP/GC		GRAVEL/CLAYEY GRAVEL
40										Stopped auger at 40.0' Installed monitoring well: Bottom of pipe at 40.0' Slotted to 37.0' Coarse sand to 36.0' Bentonite pellets to 34.0'
45										

GROUND WATER

DEPTH	HOUR	DATE
22.7	08:45	12-5-87

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

A-10B

PROJECT [illegible] Investigation

JOB NO. E87-2038A DATE 11-23-87

LOG OF TEST BORING NO. B-3

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5813.2
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	33				moist very firm	CLAY with some fine sand, medium plasticity, dark brown
				S	59					
5				S	50		16	CL		note: some fine gravel below 5'
				U	44	99	18			
10				S	37				moist very firm to hard	SANDY CLAY with some gravel, low plasticity to medium plasticity, brownish gray with orange and white streaks
15				S	50/4"			CL		
20				S	83/11"					
25				U	100/10"		27	CL	slightly moist to moist very firm to hard — H2O Surface	GRAVELLY CLAY with some sand, low plasticity, tan with some light brown-gray and black pockets
30				S	50/3.5"			GC	slightly moist hard	CLAYEY GRAVEL AND SAND, sub-angular, low plasticity, brown-gray with orange pockets note: drilling pressure 400-1500 psi at 26' to 27'
35				S	50/4"					
40				S	50/3"				saturated below 39.5' to 40'	
45										Stopped auger at 40' Stopped sampler at 40.8'

GROUND WATER

DEPTH	HOUR	DATE
26.9	16:00	11-24-87

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

PROJECT

JOB NO. ES7-2038A DATE 11-23-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5785.9
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	23			CL	slightly moist very firm to hard	GRAVELLY SILTY CLAY with some sand, some organics, low plasticity, dark brown
				S	63					
5				S	81					
				S	50/5.5"				slightly moist hard	SANDY GRAVEL with trace to some clay binder, gap graded, low plasticity, light brownish gray
10				S	75/10.5"			GP-GC		
15				S	50/3"					
									slightly moist to moist hard	CLAYEY GRAVEL with some sand, low plasticity, light brownish gray
20				S	50/4"					
25				S	75/10.5"			GC		note: difficult augering below 26' to 28' added water from 26' to 40'
30				S	50/3.5"					
35				S	50/2.5"					
40				S	50/2"					
										Stopped auger at 40' Stopped sampler at 40.2'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

PROJECT:
JOB NO. E87-2038A DATE 11-24-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5898.0
DATUM Mine

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								ML	wet moderately stiff	SANDY SILT with some gravel, low plasticity, dark brown
				S	71/11.5"					
				S	78		2	GM	slightly moist dense to very dense	SILTY GRAVEL AND SAND, sub-angular to subrounded, non-plastic, well graded, light brownish gray
5				S	70					
				S	31					
10				S	43				moist dense to very dense	SANDY GRAVEL with trace of silt, predominantly fine to medium gravel, subrounded, nonplastic, light tanish gray
15				S	50/6"		5			
20				S	98/8.5"		4			
								GW-GM		
25				S	50/5"					
30				S	52		12			note: binder varies from clay to silt below 30'
35				S	50/5"					note: difficult drilling; added water from 37' to 47'
40				S	50/3"					
								GW-GC	moist very dense	SANDY GRAVEL with trace of clay binder, subrounded, well graded, low plasticity to nonplastic, tan, orange and light gray
45				S	59		9			

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

A-13A

SERGENT, HAUSKINS & BECKWITH
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PHOENIX - TUCSON - ALBUQUERQUE - SANTA FE - SALT LAKE CITY - EL PASO

PROJECT [illegible]

LOG OF TEST BORING NO. B-5

JOB NO. ES7-2033A DATE 11-24-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5898.0
DATUM Mine

Depth (feet)	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50				S	50/4"				moist very dense	SANDY GRAVEL with trace of clay binder, low plasticity to nonplastic, tan, orange and light gray
55				S	50/5.5"		9	GW-GC		
60				S	50/5"					note: difficult drilling through cobbles from 61.5'
65				S	50/1"					

Sampler refusal at 65.1'
Auger refusal at 65.5'

Installed monitoring well:
Bottom of pipe at 65.3'
Slotted to 62.3'
Coarse sand to 61.5'
Bentonite tablets to 57.4'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT Heap Leach Pad Site Investigation

LOG OF TEST BORING NO. B-6

JOB NO. E87-2038A DATE 11-30-87

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 5870.5

DATUM Mine

Depth Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/5.5"				moist to slightly moist	SANDY GRAVEL, subangular with some to trace of silt, well graded, nonplastic, light grayish brown
5				S A	50/3"		3			note: auger refusal on rock at 6.5', moved ahead 6' and resumed drilling
				S	50/4"					
10				S	43		5	GM		note: subrounded and tan below 10'
15				S	50/4"					
20				S	50/5"					
25				U	18			CL	moist moderately firm	GRAVELLY CLAY with some sand, medium plasticity, tan
								GW-GM		GRAVEL
30				S	77		13	CL	moist moderately firm	SANDY CLAY with some gravel, low plasticity, tan
								GW-GM	slightly moist very dense	GRAVEL, subangular with some sand and trace of silt, well graded, nonplastic, light gray
35				S	47		6			
40				S	54		14	GW-GC	moist dense	SANDY GRAVEL with trace of clay, well graded, low plasticity, tan note: augering resistance alternating from moderate to high from 35' to 44'; very high at 44'
45				S	50/5.5"					
										Stopped auger at 45.0' Stopped sampler at 45.5'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

A-14

SERGENT, HAUSKINS & BECKWITH

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PHOENIX · TUCSON · ALBUQUERQUE · SANTA FE · SALT LAKE CITY · EL PASO

PROJECT: [illegible] Site I Investigation

JOB NO. E87-2038A DATE 11-30-87

LOG OF TEST BORING NO. B-7

RIG TYPE: CME-55
BORING TYPE: 6¼" Hollow Stem Auger
SURFACE ELEV.: 5976.0
DATUM: Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/4"			GW-GM	slightly moist medium dense to very dense	SANDY GRAVEL with trace of silt, well graded, subangular, nonplastic, light gray to tan
5				S	56		5			
				S	50/5.5"				slightly moist to moist firm to hard	GRAVELLY CLAYEY SAND, subrounded gravel, low plasticity, tan and light tan-gray with orange pockets
10				S	63		7			
15				S	20		7			
20				S	35		10			note: very moist seam at 21'
								GC		
25				S	70		8			
30				S	50/5"					
35				S	50/4"					
40				S	50/3"					
								SW	slightly moist very dense	GRAVELLY SAND, predominantly fine to medium, slight trace of silt, nonplastic, light gray
45				S	50/4"					
										Stopped auger at 45' Stopped sampler at 45.3'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample

SERGENT, HAUSKINS & BECKWITH

PROJECT: [illegible] LOG OF TEST BORING NO. B-8

JOB NO. E87-2038A DATE 12-16-87 (22' NE of staked location)

RIG TYPE: CME-55
BORING TYPE: 6½" Hollow Stem Auger
SURFACE ELEV.: 5957.4
DATUM: Mine

Depth (feet)	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist hard to firm	CLAYEY GRAVELLY SAND, medium plasticity, dark brown, tan and brown with some clayey gravel zones note: large rock(s) from 6.5' to 7.5'
				S	67					
5				S	27		9			
10				S	18		11			
								SC		
15				S	81/11"		10			
20				S	73		16			
25				S	50/5"					
				A			12	CL	slightly moist to moist very firm to hard	SANDY CLAY AND GRAVEL, predominantly fine to medium sand, low plasticity, brownish red note: probably volcanic mud flow
30				S U	20/0" /4"					
35										Stopped auger at 30' Stopped sampler at 30' Installed mointoring well: Bottom of pipe at: 30.2' Slotted to: 27.2' Pea gravel to: 26.1' Crushed bentonite to: 23.9'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT Heap Leach Pad Site Investigation LOG OF TEST BORING NO.

JOB NO. E87-2038A DATE 12-21-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6061.5
DATUM Mine

D	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL	moist firm	SANDY GRAVELLY CLAY FILL, (material dozer placed for drill pad)
								CL		
5			S		40		15	SM	moist very firm	GRAVELLY CLAY, low plasticity, brown
								CL	moist dense	SILTY SAND, predominantly fine with some gravel, non-plastic, tan
10			S		59		16	SC	slightly moist very firm	GRAVELLY CLAY with some sand, low plasticity to medium plasticity, dark brown
15			S		93/9"		14	CL	moist hard	CLAYEY SAND with some fine gravel, predominantly fine sand, low plasticity, brown and gray
			S		50/1"					
20									slightly moist hard	SANDY CLAY with some fine gravel, predominantly fine sand, low plasticity to medium plasticity, dark brown to brownish red
25										COBBLES/BOULDER
30										Auger and Sampler refusal on boulder at 20'
35										
40										
45										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT Heap Leach Pad Site I Investigation

JOB NO. E87-2038A DATE 12-15-87

LOG OF TEST BORING NO. B-10

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6051.0

DATUM Mine

Depth (ft)	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									moist firm to hard	CLAYEY GRAVELLY SAND, low plasticity to medium plasticity, dark brown
				S	29		14			
5				S	47		12			
10				S	60		9	SC		
15				S	50/1"					
				A			7			
20				S	50/1"			GP-GC	slightly moist very dense	SANDY GRAVEL AND COBBLES, some to trace of clay, light gray
25				S	50/½"					Stopped auger and sampler at 25', extremely difficult augering Installed monitoring well: Bottom of pipe at: 25.0' Slotted to. 22.0' Pea gravel to: 21.0' Crushed bentonite to: 19.1'
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

H – 3" O.D. 2.42" I.D. tube sample

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PROJECT Heap Leach [illegible] Site 1 Investigation

JOB NO. E87-2038A DATE 12-15-87

LOG OF TEST BORING NO. B-11

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6055.7

DATUM Mine

Depth Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	29		18	CL	slightly moist firm	GRAVELLY CLAY with some fine to medium sand, low plasticity to medium plasticity, dark brown to brown
5			X	S	42				slightly moist very firm	CLAYEY GRAVEL with some sand, low plasticity, brown, light gray and tan
10			X	S	48			GC		
15			X	S	20		14		moist moderately firm to firm	SANDY CLAY, predominantly fine sand with some fine to medium gravel, low plasticity, tan
20			X	S	11		20	CL		
25			X	S	71				slightly moist to moist very dense	GRAVEL with some sand and trace to some clay, low plasticity, light gray-brown
30			X	S	34			GP-GC		
35			X	S	14		24		moist moderately firm to very firm	SANDY CLAY, low plasticity, tan note: gravelly below approximately 37'
40			X		40			CL		
45										Stopped auger at 40.0' Stopped sampler at 41.5' note: drilled supplemental boring 12' south of original boring for ring samples: 15.0' to 16.0': blows 15 and 14, no recovery, too gravelly at 20' so sample not attempted

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT Heap Leach Pad Site 1 Investigation

JOB NO. E87-2038A DATE 12-16-87

LOG OF TEST BORING NO. B-12

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5936.2
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist very firm to hard	SANDY CLAY with some gravel predominantly fine sand, low plasticity, brown and tan
				S	39		17	CL		
5				S	52					
10				S	45		15	GC	slightly moist very firm	CLAYEY GRAVEL with some sand low plasticity, brown, light gray, and yellow
15				S	7		25	CL	moist soft to firm	SANDY CLAY with trace of fine gravel, predominantly fine sand, low plasticity to medium plasticity, tan
				U	53	100	22			
20				S	55				moist very firm to hard	CLAYEY GRAVEL with some sand low plasticity, brown, light gray and tan
								GC		
25				S	50/1"					
30				S	50/4"			CL	moist firm to hard	GRAVELLY CLAY with some fine sand, low plasticity, tan
35										Auger refusal at 31.5' (felt like hard clayey gravel-possibly mud flow)

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

PROJECT Heap Leach Pad Site 1 Investigation

JOB NO. E37-2038A DATE 12-17-87

LOG OF TEST BORING NO. B-13

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5827.5
DATUM Mine

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist very firm	SANDY CLAY AND SILT with some gravel, predominantly fine sand, low plasticity, brown and tan
				S	32		15	CL		
5				S	41					
10				S	32		7		slightly moist firm to hard	CLAYEY SANDY GRAVEL/GRAVELLY CLAYEY SAND, low plasticity, brown light gray, and tan
15				S	82/11"					
20				S	50/5.5"					note: very difficult aguering from 17' to 20', added water to reduce side friction
								GC/SC		
25				S	44		10			
30				S	68/11.5"					
35				S	50/5.5"		24			
40				S	50/5"					Stopped auger at 45.0' Stopped sampler at 45.3' Installed monitoring well: Bottom of pipe at: 45.2' Slotted to: 42.2' Pea gravel to 40.8' Crushed bentonite to: 38.6'
45				S	50/3"					
50										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT Heap Leach Pad Site 1 Investigation

JOB NO. E87-2038A DATE 12-02-87

LOG OF TEST BORING NO. B-14

RIG TYPE CME-55
BORING TYPE 6¼" Hollow Stem Auger
SURFACE ELEV. 6180.9
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			S		26		17		moist firm to very firm	GRAVELLY CLAY with some sand, low plasticity to medium plasticity, dark brown with tan and gray pockets
5			U		32			CL		note: color change to light grayish tan and less gravel from 7' to 13'
			S		48		10			
10			S		31		11			
15			U		19		20		moist firm	GRAVELLY CLAY with some sand, low plasticity to medium plasticity, tan
								CL		
20			S		30		12			
25			S		47				moist very firm	CLAYEY GRAVEL with some sand, low plasticity, tan with some orange zones
								GC		
30			S		39		13			note: high augering resistance below 35', added water for lubrication
35			S		60				moist very dense	GRAVEL with some sand and trace of clay, well graded, low plasticity, tan, orange and light gray
40			S		73					Stopped auger at 45.0' Stopped sampler at 46.5' Installed monitoring well: Bottom of pipe at 45.5' Slotted to: 42.5' Coarse sand to: 41.4' Bentonite pellets at: 39.8'
								GW-GC		
45			S		56		8			

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

PROJECT Heap Leach Pad Site I Investigation

JOB NO. E87-2038 DATE 12-10-87

LOG OF TEST BORING NO. B-15

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6138.3

DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50			GP-GM	slightly moist very dense	SANDY GRAVEL with trace of silt, predominantly medium gravel, nonplastic, light grayish tan
5				S	32		17	ML	moist very firm	SANDY SILT AND CLAY, predominantly fine sand, low plasticity, brown
10				S	45				slightly moist dense	SANDY GRAVEL with slight trace of fines, predominantly fine to medium sand and medium gravel, nonplastic, tan, orange and light gray note: heavy auger chatter from 17'
15				S	42			GP		
20				S	30					
25				S	30		13	GC	slightly moist very firm to hard	SANDY GRAVEL with some clay, predominantly fine to medium sand, low plasticity, brown and tan
30				S	63/11.5"		16			
35										Stopped auger at 29.5' Stopped sampler at 31.0'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

PROJECT Heap Leach Pad Site 1 Investigation

JOB NO. E87-2038 A DATE 12-14-87

LOG OF TEST BORING NO. B-16

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6006.1
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content, Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			S		62		11	ML	slightly moist hard	SANDY CLAYEY SILT with some fine gravel, low plasticity, light brown
5			S		58			GM	slightly moist very dense	SANDY GRAVEL with some silt, nonplastic, brown
10			U		37	99	23	CL	moist firm	CLAY with some fine sand and gravel, medium plasticity, brown
15			S		22		25			
20								GP		GRAVEL AND COBBLES
			S		50/4"		17		moist hard	GRAVELLY CLAY/CLAYEY GRAVEL with some sand, low plasticity
25			S		50/5.5"			CL/GC		
30			S		50/2.5"					
35										Stopped auger at 30.0' Stopped sampler at 30.2' Installed monitoring well: Bottom of pipe at: 30.3' Slotted to: 27.3' Pea gravel to: 26.1' Crushed bentonite to: 23.9'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

PROJECT [illegible]

JOB NO. E87-2038A DATE 12-10-87

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6002.1

DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CH	wet soft	CLAY with some sand and gravel, medium plasticity to high plasticity, dark grayish brown
			X	S	47		8	GP-GM		
5			X	S	36		22		slightly moist dense	SANDY GRAVEL with trace of silt, predominantly fine sand, light grayish tan
								SC		
10			X	S	35		19		slightly moist very firm to firm	CLAYEY SILTY SAND with trace to some gravel, low plasticity to nonplastic, light tan
15			X	S	21		14		moist firm to moderately firm	CLAYEY GRAVEL AND SAND, well graded, subrounded, low plasticity to medium plasticity brown
								GC		
20			X	S	39		19			
25			X	S	41		9		slightly moist to moist very firm	GRAVEL AND SAND with some clay, subrounded, low plasticity, brown
								GC		
30			X	S	46		7			
35										Stopped auger at 30.0' Stopped sampler at 31.5' note: attempted to install monitoring well, bentonite pellets bridged within auger and caused pipe to pull up, well was aborted and pipe withdrawn

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

PHOENIX · TUCSON · ALBUQUERQUE · SANTA FE · SALT LAKE CITY · EL PASO

PROJECT

JOB NO. ES7-2038A DATE

LOG OF TEST BORING NO.

RIG TYPE

BORING TYPE

SURFACE ELEV.

DATUM

Elevation	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION

BORING B-19 WAS NOT DRILLED

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

NO. E87-2038A DATE 12-14-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5768.9
DATUM Mine

Depth	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								slightly moist to moist very firm to hard	GRAVELLY CLAY with some sand, low plasticity to medium plasticity, brown
5			S	48		13			
			S	64		25	CL		note: color change to light grayish brown and white at 8' to 9'
10			S	49		23			
15			S	42		21		slightly moist to moist very firm to hard	CLAYEY SAND with trace to some gravel, low plasticity to medium plasticity, brown with some light grayish brown pockets
20			S	75			SC		
25			S	50/5.5"		23			
30			S	50/3.5"		23			
35									Stopped auger at 30.0' Stopped sampler at 30.8' Installed monitoring well: Bottom of pipe at: 30.0' Slotted to: 27.0' Pea gravel to: 26.0' Crushed bentonite to: 24.0'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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JOB NO. E87-2038A DATE 12-8-87

LOG OF TEST BORING NO. B-23

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. Approximately 5920±5
DATUM Mine

Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									moist to slightly moist firm to hard	CLAY with trace of fine sand and occasional gravel, medium plasticity to high plasticity, brown and tan
5				S	16		20			
				U	50	99	12			
10				S	50			CH		
15				S	38		19			
20				S	44				slightly moist very firm to hard	GRAVELLY CLAY with some sand, low plasticity to medium plasticity, tan with brown, orange and light gray
25				S	42		15	CL		
30				S	33		29			
35				S	15		45		very moist to moist moderatley firm to firm	CLAY with some fine sand and occasional gravel, medium plasticity, brown
40				S	66		18	CL		
45				S	50/4.5"		41			
50				S	50/5.5"					

GROUND WATER

DEPTH	HOUR	DATE
see remarks on log		

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

PROJECT Heap Leach Pad Site 1 Investigation

JOB NO. E87-2038A DATE 12-8-87

LOG OF TEST BORING NO. B-23

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. Approximately 5920±5

DATUM Mine

Depth in Feet	Cone Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50								CL		
55			S		50/5.5"				moist with saturated zones stiff to hard	SANDY SILT AND CLAY, low plasticity, brown note: sample at 54.5' was saturated (but no water on drill rods)
60			S		50/2.5"		43	ML		
65			S		34		40			note: drilling resistance alternates from very high to moderate from 59' to 67'
70			S		50/5			GC	moist to saturated hard	CLAYEY GRAVEL AND SAND, sub-angular, well graded, low plasticity, tan, orange and pink
75			S		50/5.5"					Stopped auger at 74.2' Stopped sampler at 74.7' note: attempted to install monitoring well; unsuccessfull because bentonite pellets bridged within augers

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

H – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH

LOG OF TEST BORING NO. B-24

JOB NO. E87-2038A DATE 12-05-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5889.6
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC	very moist medium stiff	CLAYEY SAND with some gravel predominantly fine to medium sand, low plasticity, dark brown
								GW-GM		
5				S	30				moist medium dense	SANDY GRAVEL with trace of silt, subrounded, well graded, nonplastic, tan
				U	24			CH		
10				T		86	30		moist moderately firm to firm	SANDY CLAY with trace of gravelly zones, predominantly fine sand, medium plasticity, tan
								GC-GP		
15				S	28				moist firm	CLAYEY GRAVEL with some sand low plasticity, tan with gravel zones
20				U	17				moist firm	SANDY CLAY with scattered gravel, medium plasticity, brown note: approximately 5" gravel layer at 27'
25				U	18	95	23			
								CL		
30				S	18		24			note: alternating clay and gravel zones from 33' to 42'
35				S	15		16			
40				S	19					
				S	50/5"			GC	moist very firm to hard	CLAYEY GRAVEL with some sand, low plasticity, greenish brown
									H2O Surface	
				S	50/5"					Stopped auger at 50.0' Stopped sampler at 50.4'

GROUND WATER

DEPTH	HOUR	DATE
46.7	14:00	12-5-87

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

PROJECT [illegible] Canyon Project - Site No. 1

JOB NO. E87-2038A DATE 09-29-87

LOG OF TEST PIT NO. TP-1

Backhoe Type Caterpillar 235

Location Pad No. 1, See Site Plan

Elevation 5830 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not	encountered	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D	13	CL		SILTY CLAY, low plasticity to medium plasticity, trace of gravel, dark brown
		X	D	12	SC		CLAYEY SAND, predominantly fine, some gravel, occasional cobbles, low plasticity
5		X	D.		SC		CLAYEY SAND AND GRAVEL, occasional cobbles, low plasticity
10		X	D				SILTY SAND AND GRAVEL, gravel to 2", occasional cobbles, nonplastic, brown
15					GM		
20							
							End of test pit at 22.3'
25							

SAMPLE TYPE

D - Disturbed Bulk Sample

S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

PROJECT

JOB NO. E87-2038A DATE 09-29-87

LOG OF TEST PIT NO. TP-2

Backhoe Type Caterpillar 235

Location Pad No. 1, See Site Plan

Elevation 5860 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Ft	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			D	10	CL		SILTY CLAY with some sand and trace of gravel, low plasticity, dark brown
			S		SM		SILTY SAND, fine, nonplastic, brown
5			S				SILTY SAND, fine, nonplastic, light brown
			T		SM		
10			S		GM		SILTY SAND, some gravel, occasional cobbles, nonplastic, light brown
			S				SILTY SAND, fine, nonplastic, brown
15					GM		
20							
							End of test pit at 22.2'
25							

SAMPLE TYPE

D - Disturbed Bulk Sample

S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 09-24-87

LOG OF TEST PIT NO. TP-3

Backhoe Type Caterpillar 235

Location Pad No. 1, See Site Plan

Elevation 5925 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0	X	S	5	ML		CLAYEY SILT with some sand and trace of gravel, low plasticity, dark brown
5	X	D	14	CL		SANDY CLAY, medium plasticity, light brown
10	X	D		GM		SILTY SAND AND GRAVEL, gravel to 3", occasional cobbles, nonplastic, brown
15	X	S		GM		SILTY SAND AND GRAVEL, gravel to 1", occasional cobbles, nonplastic, brown
20	X	S		GM		SILTY SAND AND GRAVEL, some cobbles, nonplastic, brown
25						End of test pit at 24'

SAMPLE TYPE

D - Disturbed Bulk Sample

S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 09-29-87

TEST PIT NO.

Backhoe Type Caterpillar 235

Location Pad No. 1, See Site Plan

Elevation 5990

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	S	11	SC		CLAYEY SAND, some gravel, medium plasticity, dark brown
5		X	S		GM		SILTY SAND AND GRAVEL, gravel to 4", occasional cobbles, nonplastic, light brown
10		X	S		GM		SITLY SAND AND GRAVEL, gravel to 6" with cobbles, nonplastic, brown
15							
20		X	S		GM		SILTY SAND AND GRAVEL, gravel to 2", occasional cobbles, nonplastic, brown
							End of test pit at 22'

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. ES7-2038A DATE 09-29-87

GROUND WATER		
DEPTH	HOUR	DATE
not encountered		

Backhoe Type Caterpillar 235

Location Pad No. 3, See Site Plan

Elevation 6010 (±)

Datum Site Topo

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		D	9	CL		CLAY with some sand and gravel, medium plasticity, dark brown
		S	12	SM		SILTY SAND, fine, some gravel, trace of clay, low plasticity, light brown
5		S		GM		SILTY SAND AND GRAVEL, gravel to 5", occasional cobbles, nonplastic, brown
10		D				CLAYEY SILT, trace to some fine sand, low plasticity, light brown
15				ML		
20						
25						End of test pit at 23'

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

JOB NO. F87-2038A DATE 09-24-87

LOG OF TEST PIT NO. TP-6

Backhoe Type Caterpillar 235

Location Pad No. 3, See Site Plan

Elevation 5890

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			D	21	CH		SANDY CLAY with occasional gravel and cobbles, high plasticity, dark brown
			S	20			
5			S		GM		SILTY SAND AND GRAVEL, gravel to 5", occasional cobbles, nonplastic, brown
10			S		GM		SILTY SAND AND GRAVEL, gravel to 3", occasional cobbles, nonplastic, brown
15							
20							
25							End of test pit at 22'

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 09-29-87

LOG OF TEST PIT NO.

Backhoe Type Caterpillar 235

Location Pad No. 3, See Site Plan

Elevation 5890 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not	encountered	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	S	15	CH		SANDY CLAY with scattered gravel and cobbles, high plasticity, dark brown
		X	S	3			SILTY SANDY GRAVEL, occasional cobbles, nonplastic, light brown
5					GM		
10							
		X	D				SILTY SAND, predominantly fine, nonplastic, brown
15					SM		
20							
							End of test pit at 20.2'

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 09-9-87

LOG OF TEST PIT NO. TP-8

Backhoe Type Caterpillar 235

Location Pad No. 2, See Site Plan

Elevation 6150

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not	encountered	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	S		CL		SILTY CLAY, low plasticity to medium plasticity, dark brown
		X	S	12	CH		GRAVELLY SANDY CLAY, high plasticity, brown
5		X	S		GM		SILTY SAND AND GRAVEL, gravel to 3", occasional cobbles, nonplastic, brown
10		X	S		GM		SILTY SAND AND GRAVEL, occasional cobbles and boulders to 3', nonplastic, brown
15		X	S		GM		SILTY SAND AND GRAVEL, trace of clay, nonplastic to low plasticity, brown
20							End of test pit at 20.5'

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. F87-2038A DATE 09-29-87

LOG OF TEST PIT NO. [illegible]

Backhoe Type Caterpillar 235

Location Pad No. 2, See Site Plan

Elevation 6170 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0	X	S	4	GC		CLAYEY SANDY GRAVEL with cobbles, low plasticity to medium plasticity, dark brown
	X	S		GM		SILTY SAND AND GRAVEL, gravel to 3", non-plastic, light brown
5	X	S		GM		SILTY SAND AND GRAVEL, gravel to 2", non-plastic, brown
10	X	S		SM		SILTY SAND, medium fine, trace of gravel, nonplastic, brown
15						
20						End of test pit at 20.3

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

JOB NO. E87-2035A DATE 09-29-87

LOG OF TEST PIT NO. TP-10

Backhoe Type Caterpillar 235

Location Pad No. 2, See Site Plan

Elevation 6090 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not	encountered	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					CL		SILTY CLAY, trace of gravel, medium plasticity, dark brown
			D	17			SILTY CLAY with some fine sand, trace of gravel, high plasticity, brown
					CH		
5			D	16			
			S		CL		SILTY CLAY, trace of gravel, low plasticity, brown
10							SILTY SAND AND GRAVEL, nonplastic, brown
15					GM		
20							End of test pit at 19'
25							

SAMPLE TYPE

D – Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. ES7-2038A DATE 09-30-87

Backhoe Type Caterpillar 235

Location Pad No. 2, See Site Plan

Elevation 6030 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not	encountered	

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
	X	D	17	CH		SANDY CLAY, some gravel and cobbles, high plasticity, dark brown
	X	D	10	GC		SANDY CLAYEY GRAVEL, gray cobbles, nonplastic, light brown
	X	D	13	SC		CLAYEY GRAVELLY SAND, occasional cobbles, low plasticity, dark brown
						End of test pit at 13.6'

15

20

25

SAMPLE TYPE
D - Disturbed Bulk Sample
S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

JOB NO. E87-2038.A DATE 09-30-87

LOG OF TEST PIT NO. TP-12

Backhoe Type Caterpillar 235

Location Pad No. 2, See Site Plan

Elevation 6050 (±)

Datum Site Topo

GROUND WATER

DEPTH	HOUR	DATE
not encountered		

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
		D	8	CL		GRAVELLY CLAY with some sand, occasional cobbles, low plasticity, brown
		D	8	GC		CLAYEY SANDY GRAVEL, occasional cobbles, low plasticity, brown
10		D		SM		SILTY SAND, trace to some gravel, occasional cobbles, nonplastic, brown
15						
20		D		CL		SANDY CLAY, considerable silt, some cobbles, low plasticity, brown with mottled white
25						End of test pit at 24'

SAMPLE TYPE

D - Disturbed Bulk Sample

S - Disturbed Small Bag Sample

SERGENT, HAUSKINS & BECKWITH

LOG OF TEST PIT NO. _____

JOB NO. E87-2038A DATE 11-20-87

Backhoe Type CASE 580 C

Location See Site Plan

Elevation _____

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphic Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D	27	CL	very moist soft to medium stiff	CLAY with some sand, medium plasticity, dark brown note: several roots to 8" depth
5		X	D	16	CL	moist very stiff	SANDY CLAY, with some gravel, medium plasticity, light brownish gray note: grading to clayey gravel and sand at 5.5'
					GC		
					CL		note: grading to sandy clay, medium plasticity
0							End of test pit at 9.0'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-203SA DATE 11-20-87

LOG OF TEST PIT NO. CS-2

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER		
DEPTH	HOUR	DATE
	none	

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					very moist to 6", then slightly moist firm	SANDY CLAY with trace of gravel, low plasticity, brown note: small roots t0 8" depth
				CL		
5	X	D	10			
				SM		SILTY SAND with some fine gravel, well graded, nonplastic, brown note: more gravel below 7.5'
10						End of test pit at 9.5'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

B NO. E87-2038 A DATE 11-20-67

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Visual Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0						moist soft to medium stiff	SILTY CLAY with some fine sand, low plasticity to medium plasticity, alternating dark brown and brown
					CL		note: small roots to 3" depth
		X	D	28			
5							
					MH	very moist soft	CLAYEY SILT with some fine sand, medium plasticity, dark brown
10					GW	moist medium dense	SANDY GRAVEL with slight trace of clay, subrounded, well graded, orange-brown
15							End of test pit at 11.5'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 11-20-87

LOG OF TEST PIT NO. C-4

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				CL	moist soft to moderately firm	SILTY CLAY with some sand and occasional gravel, low plasticity to medium plasticity, alternating brown to dark brown. note: small roots to 5" depth
5	X	D	12	SC	slightly moist moderately firm	GRAVELLY CLAYEY SAND, low plasticity, dark brown note: less gravel below 7'
10				SM	moist medium dense	SILTY GRAVELLY SAND, predominantly medium to coarse, nonplastic to low plasticity
15						End of test pit at 12.3'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

JOB NO. E87-2038A DATE 11-20-87

LOG OF TEST PIT NO. CB-5

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					CL	wet medium stiff	GRAVELLY CLAY AND SAND FILL, low plasticity to medium plasticity, orange-brown
		X	D	17		moist moderately firm	SILTY CLAY with some fine to medium sand and gravel, low plasticity to medium plasticity, brown to dark brown note: roots from 1.5' to 2.0' depth
5					CL		
0					ML	moist moderately firm	SANDY SILT, low plasticity, orange-brown
					CL	moist moderately firm	SILTY CLAY with some fine sand, medium plasticity, brown
5							End of test pit at 12.3'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

NO. E87-2038A DATE 11-20-87

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				CL	moist to slightly moist firm	SILTY CLAY with some fine sand, low plasticity to medium plasticity, ligth grayish brown note: small roots to 5" depth
5	X	D	11			
	X	S	13	CL	slightly moist very firm	CLAY with some sand, gravel, and occasional cobbles, medium plasticity, light grayish brown with white streaks
0				GC	moist very firm	CLAYEY GRAVEL AND SAND, low plasticity, light brown
						End of test pit at 10'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH
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JOB NO. ES7-2033A DATE 11-20-87

LOG OF TEST PIT NO. [illegible]

Backhoe Type CASE 580 C

Location See Site Plan

Elevation

Datum Mine

GROUND WATER

DEPTH	HOUR	DATE
	none	

Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					moist moderately firm	SILTY CLAY with some fine to medium sand, low plasticity, dark brown
	X	D	15			note: small roots and organics to 4" depth
				CL		
5						note: color change to brown to orange-brown at 3.5'
				ML	moist moderately firm	SANDY SILT with some gravel, low plasticity to nonplastic, orange-brown
	X	S	13	CL	moist moderately firm	SANDY CLAY with some gravel, low plasticity, orange-brown
10						
						End of test pit at 10.2'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

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JOB NO. E87-2038A DATE 12-15-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5577.4
DATUM Mine

Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL	wet soft	SANDY CLAY, predominantly fine to medium sand, low plasticity, dark brown with roots and organics
				S	63		19			
5				S	76			CH	slightly moist hard	CLAY with some sand and scattered fine gravel, low plasticity to medium plasticity, brown and tan
				S	68		18			
10				S	84					
15										Stopped auger at 10' Stopped sampler at 11.5' note: drilled two 3.5-foot deep percolation test holes approximately 20' East and 20' West of PB-1

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. 237-2038A DATE 12-21-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5617.9
DATUM Mine

Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								ML		SANDY SILT AND CLAY with several roots and organics, low plasticity, dark brown
				S	56		5	SM		
5				S	28		10	SC		GRAVELLY SILTY SAND, well graded, nonplastic, tan, light gray and orange
				S	50/5.5"					
10										CLAYEY GRAVELLY SAND, sub-rounded, low plasticity, orange brown
										Stopped auger at 8.5' Stopped sampler at 9.5' note: drilled two 3.5-foot deep percolation test holes approximately 15' north and 15' south of PB-2

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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NO. ES7-2038A DATE 12-29-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6263.5
DATUM Mine

Depth	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			S	55				moist dense to very dense	GRAVELLY CLAYEY SAND; sub-angular to subrounded, low plasticity, tan to orange note: drilling began at a depth of 3'. See note below
5			S	48		2	SC		
			S	53					
10									Soil types in both 4' percolation borings are consistent with that of the upper 4' of the classification boring note: drilling platform was placed in a 3 foot cut. Surface soils above platform consist of: 1.5' clay; with minor amounts of gravel, medium plasticity, dark brown 1.5' gravelly clay; some sand, low plasticity, tan to orange note: drilled two 4-foot deep percolation test holes approximately 15' north and 15' south of PB-3

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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JOB NO. E87-2[illegible]8A DATE 12-29-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6145.0
DATUM Mine

Depth	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									very moist moderately firm to firm	SANDY CLAY with some gravel, low plasticity to medium plasticity, dark brown to orange note: sharp color change in clays from dark brown to orange at 5.5'
				S	16			CL		
5				S	14		21			
								CL	moist firm to hard	GRAVELLY CLAY; minor amounts of sand, medium plasticity, tan and orange
10				S	85/11.5"		7			

Stopped auger at 8.5'
Stopped sampler at 9'11"

note: soil types in both 4' percolation borings are consistent with upper 4' in classification boring

note: drilled two 4-foot deep percolation test holes approximately 15' east and 15' west of PB-4

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube

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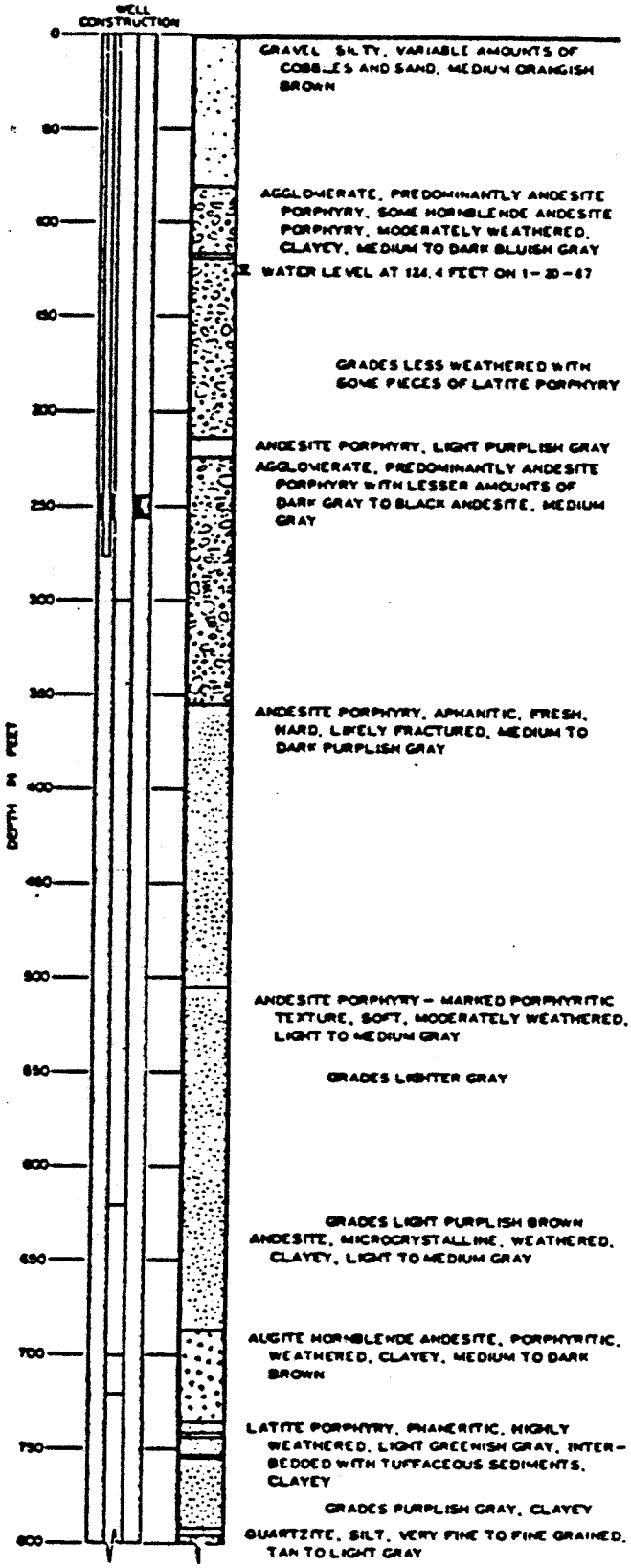
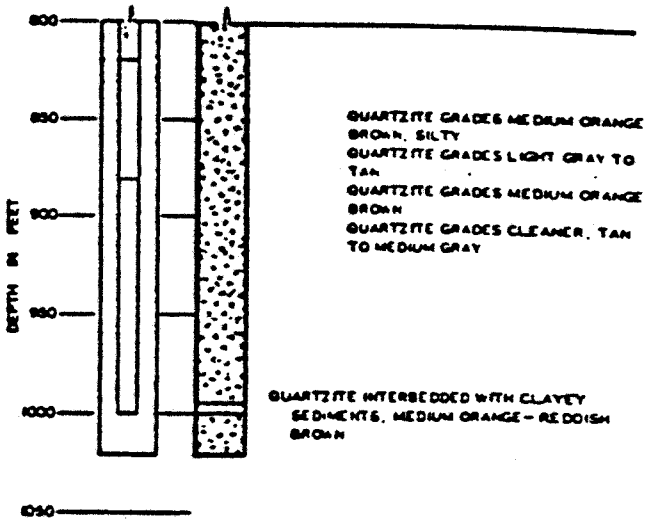
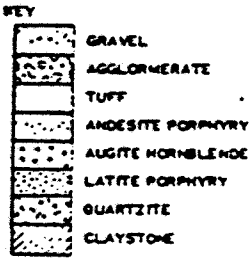
TEST WELL No. 1

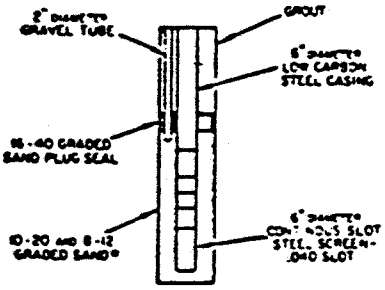


TEST WELL No. 1 (CONTINUED)





KEY TO WELL CONSTRUCTION

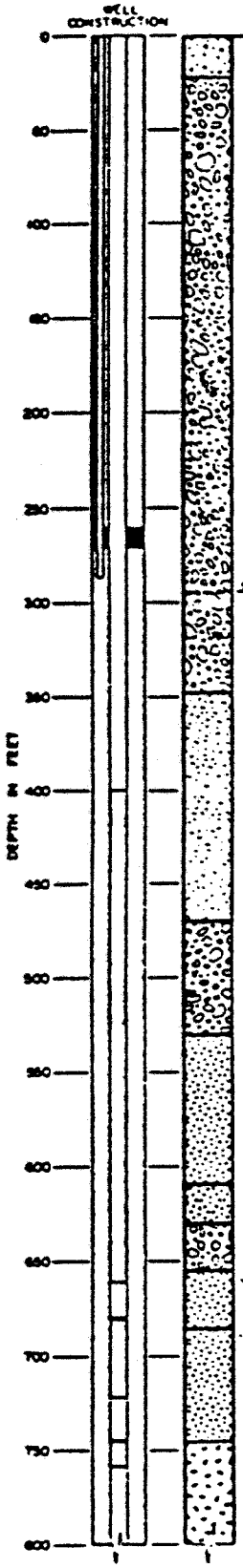


*SEE WELL CONSTRUCTION SPECIFICATIONS FOR SAND PACK INTERVALS.

LOG OF BORING

Dames & Moore

TEST WELL No. 2



GRAVEL, SILTY, MEDIUM TO DARK BROWN

AGGLOMERATE, PREDOMINANTLY ANDESITE PORPHYRY, SOME LATITE PORPHYRY, MEDIUM BROWNISH GRAY

AGGLOMERATE, GRADES PREDOMINANTLY ANDESITE, PHANERITIC, REDDISH BROWN TO GRAYISH BROWN

GRADES WITH SOME ANDESITE PORPHYRY DARK REDDISH BROWN

GRADES PREDOMINANTLY LATITE PORPHYRY

GRADES PREDOMINANTLY ANDESITE PORPHYRY

GRADES WITH MORE LATITE PORPHYRY, MEDIUM TO DARK GRAY

WATER LEVEL AT 285.5 FEET ON 3-2-67

ANDESITE, APHANITIC, VERY FINE GRAINED, WEATHERING OF HORNBLENDE AND BIOTITE, MEDIUM BROWNISH GRAY

AGGLOMERATE, PREDOMINANTLY ANDESITE, APHANITIC, TRACE AMOUNT OF LATITE PORPHYRY, MEDIUM REDDISH BROWN TO BROWNISH GRAY

GRADES WITH SOME HORNBLENDE ANDESITE PORPHYRY

LATITE PORPHYRY, PHANERITIC, MEDIUM TO COARSE GRAINED, LIGHT TO MEDIUM GRAY

LATITE TUFF, WELDED, PORPHYRITIC, CRYPTO-CRYSTALLINE GROUNDMASS, LIGHT PURPLISH GRAY

AGGLOMERATE, PREDOMINANTLY LATITE PORPHYRY, PHANERITIC, LESSER AMOUNT ANDESITE PORPHYRY, MEDIUM TO DARK REDDISH BROWN

LATITE PORPHYRY, MINOR SECONDARY ALTERATION OF FELDSPARS, WEATHERS YELLOWISH TO GREENISH GRAY

LATITE PORPHYRY, PHANERITIC, LIGHT TO MEDIUM PURPLISH GRAY

GRADES CLAYEY

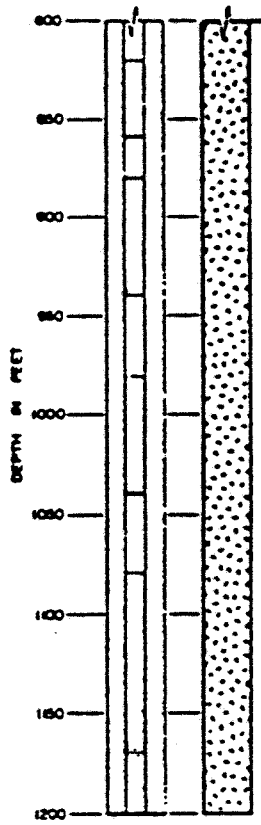
GRADES WITHOUT CLAY

GRADES CLAYEY

DACITE, APHANITIC, VERY FINE GRAINED, MEDIUM TO DARK GRAY

GRADES CLAYEY

TEST WELL No. 2 (CONTINUED)



GRADES WITHOUT CLAY

GRADES TO CLAY

GRADES WITHOUT CLAY

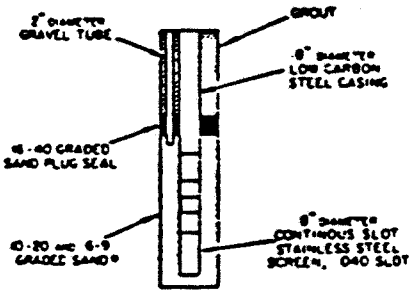
GRADES TO CLAY

GRADES WITHOUT CLAY

GRADES WITH SOME CLAY

GRADES WITHOUT CLAY

KEY TO WELL CONSTRUCTION



*SEE WELL CONSTRUCTION SPECIFICATIONS FOR SAND PACK INTERVALS.

LOG OF BORINGS

Dames & Moore

DETAILED EXPLORATION [illegible]
BOREHOLE LOG B.P.MINERALS
EXPLORATION

BC-148

Completed: 11-25-87 9:00AM
Conventional: —

Project: Barneys Canyon
Location: Bingham, UT
Hole No.: BC-148
Bearing: —
Inclination: -90°
Contractor: Harris/Gerry Stearns
Bit size: 5 1/2
T.D.: 400'

Casing Depth: 4'
Casing Diameter: 8"
Overburden depth: 52'
Sample damp: —
Inject H_2O: 0' (at surface)
Producing H_2O: 165, 235
GPM: ~5-10 gal/min (165')
GPM at T.D.: —

REMARKS: End of hole in Volcanics (Upper 52' Gravels)
Clays: 160-165 / mixed with Volcanics
215-220 / " " "
205-215

WL = 123.15' 12/10/87

No.	Geology	FINES color	%	COARSE MIN
0-5	Boulders Gravels	Tan	Wet	2-20+
5-10		Paleozoic Sediments		
10-15		Gravels + Sand		
15-20		90% Sandstone Quartzites		
20-25		4% Dolomite		
25-30		1% Volcanics		
		H brn		
30-35				
35-40				
40-45				
45-50				
50-55	Wk Brn Volc	Med Brn at 52'		2-15
55-60				
60-65				
65-70		Red-Green Med Gray to Dark Gray		
70-75				
75-80		Quartz, Hornblende		
80-85		Phanaritic Volcanic		
85-90		Rock		
90-95				
95-100				

Sa. No.	Geology	FINES color	%	COARSE MIN
100-105	Brn Volc	Med Brn	Wet	2-15
105-110				
110-115				
115-120				
120-125				
125-130				
gray-green color 130-135	gray Volc	Med grn		
135-140				
140-145				
145-150				
150-155		(155'-165' Yellow Clay or Volcanic Ash; 30% clay, 70% Volcanic Rocks)		
155-160				
Water 160-165	Wk/Clay	▽ 165'		
165-170	Volc/cht.			
170-175				
175-180		(185'-207' Same, But 10-15% Clay 85-90% Volcanic Rock)		
180-185				
185-190				
190-195	cht/Volc Volc/cht.			
195-200				

Piezometer - No Lower Bentinite Seal because hole was bridged at 200' (desired depth of Piezometer). PVC Pipe was installed, at which time, bridge broke, so Backfilled hole with gravels. Was then

BC-150

Completed: 12-4-87 1100
Conventional: 0-387'

Project: Barney's Canyon
Location: Bingham, UT
Hole No.: BC-150
Bearing: —
Inclination: -90°
Contractor: Harris / Gerry Stearns
Bit size: 5 1/2
T.D.: 387'

Casing Depth: 4'
Casing Diameter: 8"
Overburden depth: 115'
Sample damp: —
Inject H_2O: 0' (at surface)
Producing H_2O: 120'
GPM:
GPM at T.D.: - Very Minor amount: ≈ 1 gal/m

REMARKS: Drilled 0-387' w/ Rock bit.
Clays: 110'-120'

Sa. No.	Geology	FINES color	FINES %	COARSE MIN
0-5	Overburden Gravels	lt Brn	wet	2-15
5-10				
10-15				
15-20				
20-25				
25-30				
30-35				
35-40				
40-45				
45-50				
50-55				
55-60				
60-65				
65-70				
70-75				
75-80				
80-85				
85-90				
90-95				
95-100				

0-112' Overburden Gravels, Unconsolidated Sandstones, Quartzites, Limestones and Dolomites, Sand → Boulders.

Sa. No.	Geology	FINES color	FINES %	COARSE MIN
100-105	Gravels	lt brn	Wet	2-15
105-110				
110-115	Gravels/clay			
115-120	Volc/clay	Yellow-Brn		
120-125				
125-130				
130-135				
135-140	Green Volc	med grn.		
140-145	Volc/clay	Med Grn-blue		
145-150				
150-155				
155-160				
160-165				
165-170				
170-175				
175-180				
180-185				
185-190				
190-195				
195-200				

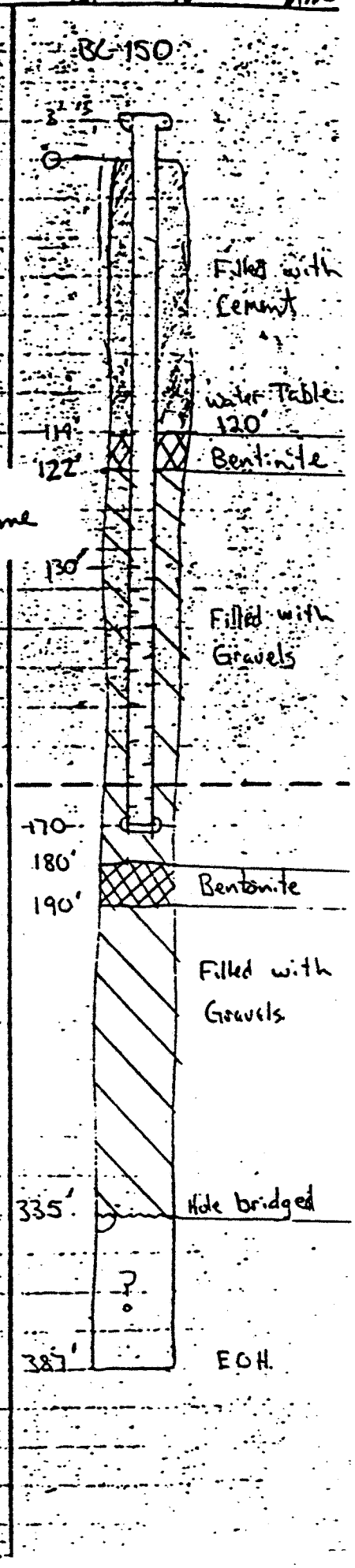
Brn Clay
Water
yellow grn.
Green Clay
Blue-green Volc
Pyrite

112-113.5' Brown Volcanic Clay

113.5'-387' Dark Gray, Quartz, Feldspar, Biotite, Hornblende, Phaneritic Volcanic Rock

140-385' Green-Gray Volcanic Clay intermixed with the Dark Gray Volcanic Rocks

Sa. No.	Geology	Color	Sa. No.	Geology	Color
Pyrite 200-205	Volc/clay	Med grn wet 2-15	400-405		BC-150
205-210			405-410		
210-215			410-415		
215-220			415-420		
220-225			420-425		
225-230			425-430		
230-235			430-435		Filled with Cement
235-240			435-440		
240-245			440-445		
245-250			445-450		water Table 120'
250-255			450-455		119'
255-260	Clay/Volc		455-460		122' Bentonite
260-265	Volc/clay	Same	460-465	Same	
Pyrite-? 265-270			465-470		
270-275			470-475		130'
275-280			475-480		Filled with Gravels
280-285			480-485		
285-290			485-490		
290-295			490-495		
295-300			495-500		
300-305			500-505		170
305-310	Volc	Dk gray	505-510		180'
310-315		Lt gray	510-515		190' Bentonite
315-320		Slate gray	515-520		
320-325			520-525		Filled with Gravels
Pyrite 325-330			525-530		
330-335			530-535		
Pyrite 335-340			535-540		
340-345			540-545		
345-350			545-550		
350-355			550-555		335' Hole bridged
Pyrite-? 355-360			555-560		
Pyrite 360-365			560-565		?
365-370	Volc/clay	Med grn	565-570		
370-375		Slate grn	570-575		387' EOH.
375-380			575-580		
380-385			580-585		
E.O.H. 385-390			585-590		
387' 390-395			590-595		
395-400			595-600		



LOG OF TEST BORING NO. B-21

JOB NO. E87-2038A DATE

RIG TYPE

BORING TYPE

SURFACE ELEV.

DATUM

Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
								BORING B-21 WAS NOT DRILLED	

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

LOG OF TEST BORING NO. B-22

JOB NO. E87-2038A DATE 12-09-87

RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 5977.5'
DATUM Mine

Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									moist to slightly moist firm to hard	SILT AND CLAY with some fine to medium sand and trace of gravel, low plasticity, dark brown
				S	28		15	ML-CL		
5				S	32		14			
10				S	51		22	GC	slightly moist hard	CLAYEY GRAVEL with some sand, low plasticity, brown
15				U	24	99	22	CH	moist firm to very firm	CLAY, some fine sand, trace of gravel, medium plasticity, light brown
20				S	50/2"				slightly moist to moist very firm to hard	CLAYEY SAND with some to trace of gravel, subangular, predominantly fine to medium sand, light gray and white
25				S	30/0"			SC		
				A			19			
30				S	50/3"					
35										Stopped auger at 30.0' Stopped sampler at 30.3' Installed monitoring well: Bottom of pipe at: 29.9' Slotted to: 27.0' Pea gravel to: 26.0' Bentonite pellets to: 24.0'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

APPENDIX B

BASELINE WATER QUALITY DATA

From (Dames and Moore, 1988)

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZI (mg/
S59	07/10/69	00 0	0.00	0.00	7.3	0	0	90	50	0	0	0.00	0	0	0.0	0	0.420	0.000	0.0
S59	07/17/69	00 0	318.00	0.00	7.0	0	0	63	120	0	0	0.00	0	0	0.0	0	0.280	0.000	0.0
S59	07/31/69	00 0	0.00	0.00	0.0	0	0	590	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.0
S59	08/06/69	00 0	230.00	0.00	7.4	571	0	110	330	0	0	0.00	0	0	0.0	0	1.800	0.000	0.0
S59	09/05/69	00 0	330.00	0.00	7.1	495	0	124	120	0	0	0.00	0	0	0.0	0	1.530	0.000	0.0
S59	09/25/69	00 0	320.00	0.00	7.0	460	0	99	0	0	0	0.00	0	0	0.0	0	0.070	0.000	0.0
S59	10/09/69	00 0	0.00	0.00	0.0	0	0	99	92	0	0	0.00	0	0	0.0	0	0.000	0.000	0.0
S59	11/24/69	00 0	325.00	0.00	6.7	2310	0	125	103	0	0	0.00	0	0	0.0	0	0.010	0.000	0.0
S316	10/25/84	00 0	0.00	0.00	7.6	0	0	0	7	0	0	0.00	88	0	1.1	6	0.020	0.004	0.0
S316	10/25/84	00 0	0.00	0.00	0.0	264	340	14	0	5	0	1.30	0	0	0.0	0	0.000	0.000	0.0
S316	06/21/85	00 0	0.00	0.00	7.5	240	440	19	6	225	0	0.05	85	0	1.0	6	0.010	0.004	0.0
S316	02/04/87	00 0	0.00	0.00	7.9	0	0	0	211	0	0	0.00	155	0	0.0	106	0.010	0.004	0.1
S316	02/04/87	00 0	0.00	0.00	0.0	974	1540	225	0	120	0	0.00	0	0	0.0	0	0.000	0.000	0.0
S318	10/11/83	32 6cac	0.00	0.00	7.3	1650	0	263	502	0	1	0.00	204	0	9.0	245	0.030	0.004	0.0
S318	10/11/83	32 6cac	0.00	0.00	0.0	0	1980	0	0	390	0	0.33	0	0	0.0	0	0.000	0.000	0.0
S318	10/25/84	32 6cac	0.00	0.00	8.1	0	0	0	444	0	0	0.00	155	0	6.5	215	0.020	0.004	0.0
S318	10/25/84	32 6cac	0.00	0.00	0.0	1450	1600	231	0	7	0	0.20	0	0	0.0	0	0.000	0.000	0.0
S318	06/21/85	32 6cac	0.00	0.00	8.3	0	0	0	410	0	0	0.00	160	0	6.0	196	0.020	0.004	0.1
S318	06/21/85	32 6cac	0.00	0.00	0.0	1400	2200	189	0	7	0	0.02	0	0	0.0	0	0.000	0.000	0.0
S318	02/04/87	32 6cac	0.00	0.00	7.6	0	0	0	304	0	0	0.00	115	0	0.0	200	0.010	0.004	0.0
S318	02/04/87	32 6cac	0.00	0.00	0.0	1140	1890	187	0	175	0	0.00	0	0	0.0	0	0.000	0.000	0.0
S319	10/25/84	00 0	0.00	0.00	8.2	0	0	0	84	0	0	0.00	85	0	3.2	52	0.010	0.000	0.0
S319	10/25/84	00 0	0.00	0.00	0.0	527	690	68	0	5	0	0.50	0	0	0.0	0	0.000	0.000	0.0
S319	06/21/85	00 0	0.00	0.00	8.7	0	0	0	43	0	0	0.00	85	0	1.5	38	0.010	0.004	0.1
S319	06/21/85	00 0	0.00	0.00	0.0	485	800	77	0	345	0	0.04	0	0	0.0	0	0.000	0.000	0.0
S319	02/04/87	00 0	0.00	0.00	7.2	0	0	0	123	0	0	0.00	87	0	0.0	138	0.010	0.004	0.1
S319	02/04/87	00 0	0.00	0.00	0.0	716	1140	110	0	155	0	0.00	0	0	0.0	0	0.000	0.000	0.0

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l)
S29	10/31/67	00 0	0.00	0.00	7.7	338	0	32	28	285	1	3.00	15	18	1.0	25	0.016	0.000	0.000
S29	01/07/69	00 0	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.000
S29	04/08/69	00 0	0.00	0.00	7.2	0	0	0	0	0	0	0.00	0	0	0.0	0	0.110	0.000	0.000
S29	10/31/69	00 0	0.00	0.00	7.4	1110	0	260	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.000
S29	01/21/71	00 0	0.00	0.00	7.3	556	0	80	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.000
S29	03/09/71	00 0	0.00	0.00	7.6	599	0	20	0	0	0	0.00	0	0	0.0	0	0.480	0.000	0.000
S29	11/08/71	00 0	0.00	0.00	7.8	358	0	40	0	0	0	0.00	0	0	0.0	0	0.350	0.000	0.000
S29	06/12/72	00 0	0.00	0.00	7.4	281	0	42	0	0	0	0.00	0	0	0.0	0	0.130	0.000	0.000
S29	09/11/73	00 0	0.00	0.00	7.7	862	0	170	0	0	0	0.00	0	0	0.0	0	0.570	0.000	0.000
S29	11/11/75	00 0	0.00	0.00	6.3	378	392	49	0	0	0	0.00	0	0	0.0	0	0.220	0.000	0.000
S29	04/15/76	00 0	0.00	0.00	6.6	350	415	43	35	0	0	0.00	0	0	0.0	0	0.160	0.000	0.000
S29	08/29/77	00 0	0.00	0.00	7.9	410	790	62	45	0	0	0.00	0	0	0.0	0	0.010	0.000	0.000
S29	08/03/78	00 0	0.00	0.00	7.4	378	410	40	28	0	0	0.00	0	27	0.0	0	0.030	0.000	0.000
S29	01/18/79	00 0	0.00	0.00	7.7	380	660	42	30	0	0	0.00	0	28	0.0	0	0.030	0.000	0.000
S59	09/16/68	00 0	0.00	0.00	7.1	511	0	65	111	0	0	0.00	0	0	0.0	0	0.030	0.000	0.000
S59	01/07/69	00 0	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.071	0.000	0.000
S59	02/10/69	00 0	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.000
S59	03/10/69	00 0	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.112	0.000	0.000
S59	03/20/69	00 0	340.00	0.00	7.5	0	0	0	1010	0	0	0.00	0	0	0.0	0	5.200	0.000	0.000
S59	04/03/69	00 0	0.00	0.00	8.3	0	0	0	0	0	0	0.00	0	0	0.0	0	3.550	0.000	0.000
S59	04/08/69	00 0	0.00	0.00	8.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.000
S59	04/24/69	00 0	319.00	0.00	7.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.600	0.000	0.000
S59	05/08/69	00 0	318.00	0.00	6.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.000
S59	05/20/69	00 0	0.00	0.00	7.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.090	0.000	0.000
S59	05/22/69	00 0	321.00	0.00	6.8	5950	0	110	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.000
S59	06/06/69	00 0	0.00	0.00	6.5	0	0	120	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.000
S59	06/13/69	00 0	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.000
S59	06/13/69	00 0	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.500	0.000	0.000
S59	06/13/69	00 0	320.00	0.00	7.6	0	0	530	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.000
S59	06/19/69	00 0	321.00	0.00	7.3	1190	0	135	225	0	0	0.00	0	0	0.0	0	0.580	0.000	0.000
S59	06/26/69	00 0	332.00	0.00	7.2	0	0	60	50	0	0	0.00	0	0	0.0	0	1.050	0.000	0.000
S59	07/03/69	00 0	341.00	0.00	7.3	0	0	0	0	0	0	0.00	0	0	0.0	0	1.850	0.000	0.000

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)
P275	09/16/86	32 9bbc	0.00	0.00	8.2	1460	2250	210	0	0	0	0.00	0	0	0.0	0	0.000	0.000
P275	09/23/86	32 9bbc	123.00	5225.17	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000
P275	04/14/87	32 9bbc	0.00	0.00	7.2	0	0	0	513	0	0	0.00	236	0	4.9	42	0.010	0.006
P275	04/14/87	32 9bbc	0.00	0.00	0.0	1260	2100	135	0	65	0	0.00	0	0	0.0	0	0.000	0.000
-	04/28/87	32 9bbc	115.33	5232.84	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000
P276	05/19/87	00 0	286.00	4698.15	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000
P276	06/02/87	00 0	0.00	0.00	7.3	1039	1475	50	334	0	0	0.00	0	0	0.0	0	0.000	0.000
P278B	08/17/87		245.00	5242.10	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000
P278	09/09/87		0.00	0.00	7.2	1252	0	0	485	0	0	0.00	0	0	0.0	0	0.000	0.000
W31	07/24/45	32 5aac-1	140.00	5228.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000
W31	01/15/61	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.336	0.000
W31	01/27/61	32 5aac-1	0.00	0.00	7.9	0	0	11	0	0	0	0.00	0	0	0.0	0	0.010	0.000
W31	01/29/62	32 5aac-1	0.00	0.00	7.8	0	0	6	0	0	0	0.00	0	0	0.0	0	0.020	0.000
W31	02/15/62	32 5aac-1	0.00	0.00	7.9	0	0	10	0	0	0	0.00	0	0	0.0	0	0.030	0.000
W31	04/15/62	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.096	0.000
W31	08/15/62	32 5aac-1	0.00	0.00	7.5	0	0	27	0	0	0	0.00	0	0	0.0	0	0.003	0.000
W31	10/15/62	32 5aac-1	0.00	0.00	7.3	0	0	10	0	0	0	0.00	0	0	0.0	0	0.010	0.000
W31	11/15/62	32 5aac-1	0.00	0.00	7.6	0	0	9	0	0	0	0.00	0	0	0.0	0	0.042	0.000
W31	12/15/62	32 5aac-1	0.00	0.00	7.8	0	0	12	0	0	0	0.00	0	0	0.0	0	0.068	0.000
W31	01/15/63	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.042	0.000

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l)
W31	04/15/63	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.072	0.000	0.000
W31	07/22/63	32 5aac-1	0.00	0.00	8.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.076	0.000	0.000
W31	10/21/63	32 5aac-1	0.00	0.00	6.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.055	0.000	0.000
W31	11/21/63	32 5aac-1	0.00	0.00	6.2	0	0	0	0	0	0	0.00	0	0	0.0	0	0.280	0.000	0.000
W31	01/23/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.105	0.000	0.000
W31	01/29/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.059	0.000	0.000
W31	02/05/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.053	0.000	0.000
W31	02/13/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.039	0.000	0.000
W31	02/17/64	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.035	0.000	0.000
W31	02/25/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.035	0.000	0.000
W31	03/05/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.062	0.000	0.000
W31	03/09/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.053	0.000	0.000
W31	03/18/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.052	0.000	0.000
W31	03/23/64	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.043	0.000	0.000
W31	04/03/64	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.055	0.000	0.000
W31	04/16/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.000
W31	04/21/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.155	0.000	0.000
W31	04/29/64	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.110	0.000	0.000
W31	05/05/64	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.127	0.000	0.000
W31	05/21/64	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.134	0.000	0.000
W31	05/26/64	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.132	0.000	0.000
W31	06/03/64	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.101	0.000	0.000
W31	06/18/64	32 5aac-1	0.00	0.00	8.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.000
W31	06/24/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.134	0.000	0.000
W31	07/07/64	32 5aac-1	0.00	0.00	7.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.098	0.000	0.000
W31	08/04/64	32 5aac-1	0.00	0.00	7.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.019	0.000	0.000
W31	08/14/64	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.025	0.000	0.000
W31	08/15/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.035	0.000	0.000
W31	08/20/64	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.000
W31	09/04/64	32 5aac-1	0.00	0.00	7.2	0	0	0	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.000
W31	09/11/64	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.102	0.000	0.000

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZIN (mg/
W31	09/18/64	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.095	0.000	0.0
W31	09/25/64	32 5aac-1	0.00	0.00	6.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.902	0.000	0.0
W31	10/01/64	32 5aac-1	0.00	0.00	7.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.0
W31	11/01/64	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.158	0.000	0.0
W31	12/01/64	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.053	0.000	0.0
W31	01/15/65	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.0
W31	02/15/65	32 5aac-1	0.00	0.00	6.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.0
W31	03/15/65	32 5aac-1	0.00	0.00	7.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.0
W31	04/15/65	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.182	0.000	0.0
W31	05/15/65	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.0
W31	06/15/65	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.065	0.000	0.0
W31	07/15/65	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.0
W31	08/15/65	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.001	0.000	0.0
W31	09/15/65	32 5aac-1	0.00	0.00	6.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.132	0.000	0.0
W31	10/15/65	32 5aac-1	0.00	0.00	7.2	0	0	0	0	0	0	0.00	0	0	0.0	0	0.073	0.000	0.0
W31	11/15/65	32 5aac-1	0.00	0.00	6.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.074	0.000	0.0
W31	12/15/65	32 5aac-1	0.00	0.00	7.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.001	0.000	0.0
W31	01/15/66	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.035	0.000	0.0
W31	02/15/66	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.001	0.000	0.0
W31	03/15/66	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.250	0.000	0.0
W31	04/15/66	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.0
W31	05/15/66	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.210	0.000	0.0
W31	07/05/66	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.110	0.000	0.0
W31	09/07/66	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.033	0.000	0.0
W31	10/27/66	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.110	0.000	0.0
W31	11/30/66	32 5aac-1	0.00	0.00	6.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.126	0.000	0.0
W31	12/20/66	32 5aac-1	0.00	0.00	8.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.076	0.000	0.0
W31	02/02/67	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.070	0.000	0.0
W31	02/23/67	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.0
W31	03/17/67	32 5aac-1	0.00	0.00	8.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.0
W31	04/26/67	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.320	0.000	0.0

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l
W31	05/10/67	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.268	0.000	0.00
W31	06/06/67	32 5aac-1	0.00	0.00	8.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.019	0.000	0.00
W31	07/13/67	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.034	0.000	0.00
W31	08/23/67	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.060	0.000	0.00
W31	09/15/67	32 5aac-1	0.00	0.00	8.3	1120	0	24	0	232	1	0.00	90	32	6.0	35	0.000	0.000	0.00
W31	10/31/67	32 5aac-1	345.00	5023.00	7.5	606	0	15	134	238	1	5.00	30	23	8.0	22	0.067	0.000	0.00
W31	11/22/67	32 5aac-1	0.00	0.00	8.2	0	0	33	0	0	0	0.00	0	0	0.0	0	0.141	0.000	0.00
W31	12/20/67	32 5aac-1	0.00	0.00	8.2	0	0	15	0	0	0	0.00	0	0	0.0	0	0.097	0.000	0.00
W31	01/31/68	32 5aac-1	0.00	0.00	8.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.055	0.000	0.00
W31	03/05/68	32 5aac-1	0.00	0.00	6.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.117	0.000	0.00
W31	04/05/68	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.023	0.000	0.00
W31	04/25/68	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.112	0.000	0.00
W31	05/23/68	32 5aac-1	0.00	0.00	8.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.090	0.000	0.00
W31	06/26/68	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.170	0.000	0.00
W31	07/28/68	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.035	0.000	0.00
W31	08/22/68	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.00
W31	10/01/68	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.062	0.000	0.00
W31	10/16/68	32 5aac-1	0.00	0.00	8.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.00
W31	11/21/68	32 5aac-1	0.00	0.00	8.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.00
W31	12/09/68	32 5aac-1	0.00	0.00	8.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.00
W31	01/07/69	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.092	0.000	0.00
W31	02/10/69	32 5aac-1	0.00	0.00	8.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.00
W31	03/10/69	32 5aac-1	0.00	0.00	7.9	0	0	0	0	0	0	0.00	0	0	0.0	0	0.180	0.000	0.00
W31	04/08/69	32 5aac-1	0.00	0.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.125	0.000	0.00
W31	05/20/69	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.150	0.000	0.00
W31	06/13/69	32 5aac-1	0.00	0.00	8.2	0	0	26	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.00
W31	08/21/69	32 5aac-1	0.00	0.00	7.8	0	0	0	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.00
W31	09/30/69	32 5aac-1	0.00	0.00	7.1	0	0	0	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.00
W31	10/31/69	32 5aac-1	0.00	0.00	7.7	0	0	29	0	0	0	0.00	0	0	0.0	0	0.130	0.000	0.00
W31	12/12/69	32 5aac-1	0.00	0.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.060	0.000	0.00
W31	01/15/71	32 5aac-1	0.00	0.00	7.5	0	0	0	0	0	0	0.00	0	0	0.0	0	0.085	0.000	0.00

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZI (mg
W31	01/21/71	32 5aac-1	0.00	0.00	6.3	694	0	19	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.
W31	02/02/71	32 5aac-1	0.00	0.00	7.6	659	0	14	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.
W31	03/09/71	32 5aac-1	0.00	0.00	7.8	639	0	20	0	0	0	0.00	0	0	0.0	0	0.260	0.000	0.
W31	04/12/71	32 5aac-1	0.00	0.00	6.7	766	0	20	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	05/11/71	32 5aac-1	0.00	0.00	7.5	690	0	22	0	0	0	0.00	0	0	0.0	0	0.150	0.000	0.
W31	06/08/71	32 5aac-1	0.00	0.00	7.9	695	0	21	0	0	0	0.00	0	0	0.0	0	0.300	0.000	0.
W31	07/14/71	32 5aac-1	0.00	0.00	7.7	364	0	28	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	08/10/71	32 5aac-1	0.00	0.00	7.5	644	0	20	0	0	0	0.00	0	0	0.0	0	0.210	0.000	0.
W31	09/13/71	32 5aac-1	0.00	0.00	6.8	563	0	23	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	10/11/71	32 5aac-1	0.00	0.00	7.8	515	0	22	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.
W31	11/08/71	32 5aac-1	0.00	0.00	7.9	539	0	10	0	0	0	0.00	0	0	0.0	0	0.440	0.000	0.
W31	01/10/72	32 5aac-1	0.00	0.00	7.4	588	0	20	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.
W31	02/14/72	32 5aac-1	0.00	0.00	6.4	662	0	22	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	03/14/72	32 5aac-1	0.00	0.00	7.6	591	0	11	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.
W31	04/10/72	32 5aac-1	0.00	0.00	7.4	597	0	18	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.
W31	05/08/72	32 5aac-1	0.00	0.00	7.7	585	0	11	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.
W31	06/12/72	32 5aac-1	0.00	0.00	7.3	600	0	12	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.
W31	07/10/72	32 5aac-1	0.00	0.00	7.0	837	0	14	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.
W31	08/14/72	32 5aac-1	0.00	0.00	7.4	862	0	17	0	0	0	0.00	0	0	0.0	0	0.310	0.000	0.
W31	09/11/72	32 5aac-1	0.00	0.00	7.3	730	0	15	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.
W31	02/13/73	32 5aac-1	0.00	0.00	7.9	621	0	0	0	0	0	0.00	0	0	0.0	0	0.130	0.000	0.
W31	03/13/73	32 5aac-1	0.00	0.00	7.9	698	0	13	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.
W31	04/10/73	32 5aac-1	0.00	0.00	7.4	680	0	16	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.
W31	06/14/73	32 5aac-1	0.00	0.00	7.5	741	0	24	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.
W31	07/11/73	32 5aac-1	0.00	0.00	7.9	779	0	19	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	08/14/73	32 5aac-1	0.00	0.00	8.1	786	0	18	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	09/11/73	32 5aac-1	0.00	0.00	7.7	654	0	21	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.
W31	10/15/73	32 5aac-1	0.00	0.00	7.9	665	0	23	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.
W31	11/12/73	32 5aac-1	0.00	0.00	7.3	699	0	19	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.
W31	12/11/73	32 5aac-1	0.00	0.00	7.6	657	0	4	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
W31	01/15/74	32 5aac-1	0.00	0.00	7.9	658	0	17	0	0	0	0.00	0	0	0.0	0	0.030	0.000	0.

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l)
W31	02/20/74	32 5aac-1	0.00	0.00	7.8	681	0	15	0	0	0	0.00	0	0	0.0	0	0.210	0.000	0.000
W31	03/12/74	32 5aac-1	0.00	0.00	8.6	810	0	20	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.000
W31	04/11/74	32 5aac-1	0.00	0.00	8.0	662	0	23	0	0	0	0.00	0	0	0.0	0	0.070	0.000	0.000
W31	05/16/74	32 5aac-1	0.00	0.00	7.8	814	0	26	0	0	0	0.00	0	0	0.0	0	0.090	0.000	0.000
W31	07/18/74	32 5aac-1	0.00	0.00	7.5	784	0	40	0	0	0	0.00	0	0	0.0	0	0.100	0.000	0.000
W31	08/12/74	32 5aac-1	0.00	0.00	8.2	550	0	21	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.000
W31	09/11/74	32 5aac-1	0.00	0.00	7.2	608	0	20	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.000
W31	10/15/74	32 5aac-1	0.00	0.00	7.4	668	0	23	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.000
W31	11/20/74	32 5aac-1	0.00	0.00	7.4	660	0	14	0	0	0	0.00	0	0	0.0	0	0.110	0.000	0.000
W31	12/17/74	32 5aac-1	0.00	0.00	7.3	674	0	75	0	0	0	0.00	0	0	0.0	0	0.160	0.000	0.000
W31	01/16/75	32 5aac-1	0.00	0.00	7.0	662	0	23	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.000
W31	02/19/75	32 5aac-1	0.00	0.00	6.5	666	0	21	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.000
W31	03/12/75	32 5aac-1	0.00	0.00	6.8	692	0	25	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.000
W31	04/15/75	32 5aac-1	0.00	0.00	7.1	1090	755	19	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.000
W31	05/13/75	32 5aac-1	0.00	0.00	6.1	712	816	20	0	0	0	0.00	0	0	0.0	0	0.190	0.000	0.000
W31	07/22/75	32 5aac-1	0.00	0.00	6.4	762	860	19	0	0	0	0.00	0	0	0.0	0	0.090	0.000	0.000
W31	08/12/75	32 5aac-1	0.00	0.00	6.4	810	820	17	0	0	0	0.00	0	0	0.0	0	0.050	0.000	0.000
W31	09/23/75	32 5aac-1	0.00	0.00	6.2	602	786	27	0	0	0	0.00	0	0	0.0	0	0.060	0.000	0.000
W31	10/16/75	32 5aac-1	0.00	0.00	6.2	650	711	18	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.000
W31	11/11/75	32 5aac-1	0.00	0.00	6.3	652	628	25	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.000
W31	12/09/75	32 5aac-1	0.00	0.00	7.1	638	619	18	0	0	0	0.00	0	0	0.0	0	0.140	0.000	0.000
W31	01/19/76	32 5aac-1	0.00	0.00	7.0	646	625	19	0	0	0	0.00	0	0	0.0	0	0.080	0.000	0.000
W31	04/15/76	32 5aac-1	0.00	0.00	6.7	624	597	19	153	0	0	0.00	0	0	0.0	0	0.010	0.000	0.000
W31	06/29/76	32 5aac-1	0.00	0.00	7.6	664	760	16	143	0	0	0.00	0	0	0.0	0	0.080	0.000	0.000
W31	10/14/76	32 5aac-1	0.00	0.00	0.0	638	714	19	133	0	0	0.00	0	0	0.0	0	0.120	0.000	0.000
W31	04/18/77	32 5aac-1	0.00	0.00	7.7	786	690	20	160	0	0	0.00	0	0	0.0	0	0.750	0.000	0.000
W31	07/20/77	32 5aac-1	0.00	0.00	6.9	700	840	18	175	0	0	0.00	0	0	0.0	0	0.060	0.000	0.000
W31	10/26/77	32 5aac-1	0.00	0.00	7.0	598	750	19	150	0	0	0.00	0	31	0.0	0	0.040	0.000	0.000
W31	01/12/78	32 5aac-1	0.00	0.00	7.8	646	680	22	140	0	0	0.00	0	38	0.0	0	0.140	0.000	0.000
	01/13/78	32 5aac-1	0.00	0.00	8.0	415	640	20	144	215	0	1.14	82	33	5.0	22	0.000	0.000	0.000
W31	04/05/78	32 5aac-1	0.00	0.00	7.7	646	630	21	150	0	0	0.00	0	30	0.0	0	0.190	0.000	0.000

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l
W31	08/03/78	32 5aac-1	0.00	0.00	7.4	664	600	19	120	0	0	0.00	0	27	0.0	0	0.050	0.000	0.00
W31	07/11/79	32 5aac-1	0.00	0.00	8.1	662	550	16	0	0	0	0.00	0	36	0.0	0	0.000	0.000	0.00
W31	07/11/79	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	36	0.0	0	0.030	0.000	0.00
W31	07/11/79	32 5aac-1	0.00	0.00	0.0	0	0	0	125	0	0	0.00	0	0	0.0	0	0.030	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	700	500	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	31	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	700	0	18	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	147	0	0	0.00	100	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	18	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.08
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.11
W31	02/24/82	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.08
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	99	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	7.4	0	0	0	0	0	0	0.00	0	0	0.0	29	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.040	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	500	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	147	0	0	0.00	0	0	0.0	0	0.040	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	26	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	26	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	100	0	0.0	0	0.000	0.000	0.00
W31	02/24/82	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.00	0	31	0.0	0	0.000	0.000	0.00
	08/24/82	32 5aac-1	0.00	0.00	7.9	534	799	27	125	224	0	0.95	38	26	8.0	29	0.000	0.000	0.00
W31	01/11/84	32 5aac-1	0.00	0.00	0.0	606	0	21	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.01
W31	01/11/84	32 5aac-1	0.00	0.00	0.0	0	0	0	0	0	0	0.73	0	0	0.0	0	0.000	0.000	0.00
W31	01/11/84	32 5aac-1	0.00	0.00	6.5	0	0	0	147	0	0	0.00	92	0	5.0	33	0.020	0.004	0.09
	03/07/85	32 5aac-1	0.00	0.00	0.0	525	0	26	165	0	0	1.00	0	0	0.0	0	0.000	0.000	0.00
W31	03/07/85	32 5aac-1	0.00	0.00	7.1	525	1600	26	165	0	0	1.80	0	32	0.0	27	0.010	0.004	0.04
W31	10/23/85	32 5aac-1	0.00	0.00	0.0	577	925	23	0	190	0	0.00	0	0	0.0	0	0.000	0.000	0.04
W31	10/23/85	32 5aac-1	0.00	0.00	7.1	0	0	0	157	0	0	0.00	82	0	6.0	34	0.020	0.004	0.05
W31	09/05/86	32 5aac-1	0.00	0.00	7.1	491	0	0	121	0	0	0.00	85	0	0.0	30	0.010	0.004	0.01
W31	03/10/87	32 5aac-1	0.00	0.00	7.3	0	0	0	141	0	0	0.00	153	0	20.0	69	0.010	0.004	0.32
W31	03/10/87	32 5aac-1	0.00	0.00	0.0	548	860	28	0	100	0	0.00	0	0	0.0	0	0.000	0.000	0.27

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l
27	10/18/85	32 8cdd-2	0.00	0.00	0.0	855	1450	254	0	260	0	0.00	0	0	0.0	0	0.000	0.000	1.04
27	11/12/85	32 8cdd-2	0.00	0.00	0.0	841	1550	109	0	3	0	0.00	0	0	0.0	0	0.000	0.000	1.33
27	11/12/85	32 8cdd-2	0.00	0.00	6.8	0	0	0	245	0	0	0.00	137	0	7.0	127	0.040	0.004	1.48
27	06/03/86	32 8cdd-2	0.00	0.00	0.0	879	1450	1260	0	145	5	0.84	0	0	0.0	0	0.000	0.000	1.33
27	06/03/86	32 8cdd-2	0.00	0.00	7.3	0	0	0	265	0	0	0.00	0	0	0.0	118	0.040	0.004	1.48
27	09/24/86	32 8cdd-2	0.00	0.00	0.0	975	1630	128	0	0	0	3.82	0	0	0.0	0	0.000	0.000	0.99
27	09/24/86	32 8cdd-2	0.00	0.00	7.0	0	0	0	272	0	0	0.00	135	36	5.2	130	0.030	0.004	1.15
27	03/10/87	32 8cdd-2	0.00	0.00	7.1	0	0	0	265	0	0	0.00	140	0	5.0	138	0.020	0.005	1.37
27	03/10/87	32 8cdd-2	0.00	0.00	0.0	965	1600	141	0	125	0	0.00	0	0	0.0	0	0.000	0.000	1.23
32C	07/01/45	32 5acb	332.00	5036.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.00
61	08/08/63	3217	113.00	5601.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.00
61	01/31/66	3217	121.00	5593.00	6.4	0	0	0	0	0	0	0.00	0	0	0.0	0	2.220	0.000	0.00
61	02/28/66	3217	123.00	5591.00	5.9	0	0	0	0	0	0	0.00	0	0	0.0	0	1.600	0.000	0.00
61	03/30/66	3217	124.00	5590.00	5.9	0	0	0	0	0	0	0.00	0	0	0.0	0	1.580	0.000	0.00
61	04/30/66	3217	123.00	5591.00	5.9	0	0	0	0	0	0	0.00	0	0	0.0	0	1.880	0.000	0.00
61	05/30/66	3217	122.00	5592.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	1.520	0.000	0.00
61	06/30/66	3217	123.00	5591.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	1.670	0.000	0.00
61	07/31/66	3217	121.00	5593.00	6.5	0	0	0	0	0	0	0.00	0	0	0.0	0	1.550	0.000	0.00
61	08/31/66	3217	124.00	5590.00	5.9	0	0	0	0	0	0	0.00	0	0	0.0	0	1.820	0.000	0.00
61	09/30/66	3217	124.00	5590.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	2.650	0.000	0.00
61	10/31/66	3217	125.00	5589.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	1.710	0.000	0.00
61	11/30/66	3217	124.00	5590.00	6.2	0	0	0	0	0	0	0.00	0	0	0.0	0	1.400	0.000	0.00
61	12/31/66	3217	124.00	5590.00	6.1	0	0	0	0	0	0	0.00	0	0	0.0	0	2.900	0.000	0.00
61	01/31/68	3217	125.00	5589.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	2.270	0.000	0.00
61	02/28/68	3217	125.00	5589.00	6.0	0	0	0	0	0	0	0.00	0	0	0.0	0	2.900	0.000	0.00
61	03/30/68	3217	123.00	5591.00	6.2	0	0	0	0	0	0	0.00	0	0	0.0	0	1.900	0.000	0.00
61	04/30/68	3217	126.00	5588.00	6.3	0	0	0	0	0	0	0.00	0	0	0.0	0	1.900	0.000	0.00
61	05/30/68	3217	124.00	5590.00	6.4	0	0	0	0	0	0	0.00	0	0	0.0	0	1.820	0.000	0.00
61	06/30/68	3217	124.00	5590.00	6.2	0	0	0	0	0	0	0.00	0	0	0.0	0	1.840	0.000	0.00
61	08/30/68	3217	0.00	0.00	6.1	0	0	0	0	0	0	0.00	0	0	0.0	0	2.240	0.000	0.00
61	09/16/68	3217	0.00	0.00	6.1	0	0	0	118	0	0	0.00	0	0	0.0	0	1.460	0.000	0.00

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZIN (mg/
K61	09/30/68	3217	0.00	0.00	6.1	0	0	0	0	0	0	0.00	0	0	0.0	0	1.460	0.000	0.0
K61	11/30/68	3217	0.00	0.00	6.2	0	0	0	0	0	0	0.00	0	0	0.0	0	1.150	0.000	0.0
K61	02/28/69	3217	122.00	5592.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.0
K61	03/09/71	3217	110.00	5604.00	6.4	1880	0	0	80	0	0	0.00	0	0	0.0	0	0.240	0.000	0.0
K61	04/30/71	3217	105.00	5609.00	6.0	2590	0	0	120	0	0	0.00	0	0	0.0	0	0.360	0.000	0.0
K61	06/15/71	3217	103.00	5611.00	4.7	35200	0	30000	200	0	0	0.00	0	0	0.0	0	32.000	0.000	0.0
K61	11/12/71	3217	95.00	5619.00	5.8	32200	0	0	550	0	0	0.00	0	0	0.0	0	6.500	0.000	0.0
K61	12/14/71	3217	93.00	5621.00	5.9	30500	0	18400	1300	0	0	0.00	0	0	0.0	0	8.000	0.000	0.0
K61	01/19/72	3217	95.00	5619.00	4.4	44900	0	22000	260	0	0	0.00	0	0	0.0	0	43.000	0.000	0.0
K61	02/10/72	3217	93.00	5621.00	6.0	40700	0	26000	300	0	0	0.00	0	0	0.0	0	1.720	0.000	0.0
K61	03/10/72	3217	94.00	5620.00	5.4	25800	0	13000	400	0	0	0.00	0	0	0.0	0	9.300	0.000	0.0
K61	04/19/72	3217	93.00	5621.00	4.5	31900	0	13000	0	0	0	0.00	0	0	0.0	0	37.000	0.000	0.0
K61	05/19/72	3217	104.00	5610.00	4.1	32900	0	13000	320	0	0	0.00	0	0	0.0	0	55.000	0.000	0.0
K61	06/15/72	3217	100.00	5614.00	4.6	23100	0	15000	210	0	0	0.00	0	0	0.0	0	15.700	0.000	0.0
K61	07/11/72	3217	99.00	5615.00	4.2	28100	0	12000	390	0	0	0.00	0	0	0.0	0	11.000	0.000	0.0
K61	08/31/72	3217	98.00	5616.00	4.1	29700	0	12900	112	0	0	0.00	0	0	0.0	0	62.000	0.000	0.0
K61	09/25/72	3217	99.00	5615.00	4.1	14700	0	8000	100	0	0	0.00	0	0	0.0	0	8.200	0.000	0.0
K61	10/28/72	3217	99.00	5615.00	4.6	18200	0	11200	110	0	0	0.00	0	0	0.0	0	33.200	0.000	0.0
K61	12/05/72	3217	102.00	5612.00	5.0	9740	0	8200	123	0	0	0.00	0	0	0.0	0	14.300	0.000	0.0
K61	04/16/73	3217	110.00	5604.00	5.4	18600	0	13000	33	0	0	0.00	0	0	0.0	0	9.500	0.000	0.0
K61	05/15/73	3217	98.00	5616.00	6.1	7990	0	5000	100	0	0	0.00	0	0	0.0	0	2.150	0.000	0.0
K61	07/09/73	3217	150.00	5564.00	4.5	21300	0	10500	78	0	0	0.00	0	0	0.0	0	36.000	0.000	0.0
K61	07/20/73	3217	105.00	5609.00	4.9	16700	0	7600	102	0	0	0.00	0	0	0.0	0	10.000	0.000	0.0
K61	08/23/73	3217	95.00	5619.00	4.6	16400	0	9400	102	0	0	0.00	0	0	0.0	0	10.800	0.000	0.0
K61	09/21/73	3217	105.00	5609.00	4.3	16300	0	10500	88	0	0	0.00	0	0	0.0	0	19.600	0.000	0.0
K61	10/17/73	3217	100.00	5614.00	4.8	15500	0	9000	98	0	0	0.00	0	0	0.0	0	13.500	0.000	0.0
K61	11/13/73	3217	105.00	5609.00	4.3	18300	0	14000	84	0	0	0.00	0	0	0.0	0	11.000	0.000	0.0
K61	12/12/73	3217	100.00	5614.00	5.1	15800	0	7300	86	0	0	0.00	0	0	0.0	0	7.700	0.000	0.0
K61	01/24/74	3217	100.00	5614.00	6.2	9170	0	5400	77	0	0	0.00	0	0	0.0	0	1.060	0.000	0.0
K61	03/26/74	3217	102.00	5612.00	6.5	7640	0	4300	70	0	0	0.00	0	0	0.0	0	0.610	0.000	0.0
K61	07/02/76	3217	90.00	5624.00	4.8	46500	0	17800	63	0	0	0.00	0	0	0.0	0	6.070	0.000	0.0

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZIN (mg/
:78	06/30/64		104.00	5609.00	4.0	0	0	0	0	0	0	0.00	0	0	0.0	0	127.00	0.000	0.0
:78	07/31/64		103.00	5610.00	4.1	0	0	0	0	0	0	0.00	0	0	0.0	0	69.800	0.000	0.0
:78	08/30/64		102.00	5611.00	4.1	0	0	0	0	0	0	0.00	0	0	0.0	0	32.400	0.000	0.0
:78	01/31/66		118.00	5595.00	4.4	0	0	0	0	0	0	0.00	0	0	0.0	0	16.000	0.000	0.0
:78	02/28/66		120.00	5593.00	4.1	0	0	0	0	0	0	0.00	0	0	0.0	0	13.400	0.000	0.0
:78	03/30/66		120.00	5593.00	3.9	0	0	0	0	0	0	0.00	0	0	0.0	0	14.000	0.000	0.0
:78	04/30/66		118.00	5595.00	3.6	0	0	0	0	0	0	0.00	0	0	0.0	0	19.800	0.000	0.0
:78	05/30/66		118.00	5595.00	3.4	0	0	0	0	0	0	0.00	0	0	0.0	0	14.200	0.000	0.0
:78	06/30/66		120.00	5593.00	3.7	0	0	0	0	0	0	0.00	0	0	0.0	0	13.500	0.000	0.0
:78	07/31/66		120.00	5593.00	3.4	0	0	0	0	0	0	0.00	0	0	0.0	0	12.800	0.000	0.0
:78	08/31/66		98.00	5615.00	4.3	0	0	0	0	0	0	0.00	0	0	0.0	0	14.100	0.000	0.0
:78	09/30/66		122.00	5591.00	3.2	0	0	0	0	0	0	0.00	0	0	0.0	0	11.300	0.000	0.0
:78	10/31/66		98.00	5615.00	3.3	0	0	0	0	0	0	0.00	0	0	0.0	0	11.600	0.000	0.0
:78	11/30/66		121.00	5592.00	3.6	0	0	0	0	0	0	0.00	0	0	0.0	0	10.600	0.000	0.0
:78	12/31/66		123.00	5590.00	3.9	0	0	0	0	0	0	0.00	0	0	0.0	0	9.000	0.000	0.0
:78	01/31/67		124.00	5589.00	3.1	0	0	0	0	0	0	0.00	0	0	0.0	0	7.250	0.000	0.0
:78	02/28/67		125.00	5588.00	3.2	0	0	0	0	0	0	0.00	0	0	0.0	0	5.560	0.000	0.0
:78	03/30/67		122.00	5591.00	3.3	0	0	0	0	0	0	0.00	0	0	0.0	0	3.080	0.000	0.0
:78	04/30/67		122.00	5591.00	3.2	0	0	0	0	0	0	0.00	0	0	0.0	0	2.650	0.000	0.0
:78	05/30/67		122.00	5591.00	3.3	0	0	0	0	0	0	0.00	0	0	0.0	0	1.660	0.000	0.0
:78	10/30/67		150.00	5563.00	3.1	0	0	0	0	0	0	0.00	0	0	0.0	0	4.250	0.000	0.0
:78	03/30/68		152.00	5561.00	3.2	0	0	0	0	0	0	0.00	0	0	0.0	0	2.930	0.000	0.0
:78	04/30/68		152.00	5561.00	3.7	0	0	0	0	0	0	0.00	0	0	0.0	0	6.630	0.000	0.0
:78	05/31/68		150.00	5563.00	4.5	0	0	0	0	0	0	0.00	0	0	0.0	0	9.260	0.000	0.0
:78	06/30/68		145.00	5568.00	4.5	0	0	0	0	0	0	0.00	0	0	0.0	0	7.150	0.000	0.0
:78	08/30/68		0.00	0.00	4.4	0	0	0	0	0	0	0.00	0	0	0.0	0	6.740	0.000	0.0
:78	09/16/68		0.00	0.00	4.3	0	0	0	1300	0	0	0.00	0	0	0.0	0	4.100	0.000	0.0
:78	09/30/68		0.00	0.00	4.3	0	0	0	0	0	0	0.00	0	0	0.0	0	4.100	0.000	0.0
:78	11/30/68		0.00	0.00	4.6	0	0	0	0	0	0	0.00	0	0	0.0	0	3.000	0.000	0.0
:78	01/31/69		150.00	5563.00	4.7	0	0	0	0	0	0	0.00	0	0	0.0	0	1.530	0.000	0.0
:78	02/28/69		158.00	5555.00	2.8	0	0	0	0	0	0	0.00	0	0	0.0	0	2.200	0.000	0.0

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

ELL UMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l
3	03/30/69		152.00	5561.00	4.6	0	0	0	1310	0	0	0.00	0	0	0.0	0	3.000	0.000	0.00
3	04/30/69		126.00	5587.00	4.7	0	0	3150	1130	0	0	0.00	0	0	0.0	0	0.340	0.000	0.00
3	05/30/69		140.00	5573.00	4.4	0	0	3300	975	0	0	0.00	0	0	0.0	0	0.360	0.000	0.00
3	06/30/69		142.00	5571.00	4.7	5960	0	2400	2030	0	0	0.00	0	0	0.0	0	0.520	0.000	0.00
3	07/31/69		143.00	5570.00	4.6	0	0	2770	673	0	0	0.00	0	0	0.0	0	0.280	0.000	0.00
3	08/31/69		143.00	5570.00	4.4	0	0	3880	1400	0	0	0.00	0	0	0.0	0	0.280	0.000	0.00
3	09/30/69		141.00	5572.00	5.0	6940	0	2830	1300	0	0	0.00	0	0	0.0	0	0.360	0.000	0.00
3	10/31/69		141.00	5572.00	4.7	7250	0	2910	0	0	0	0.00	0	0	0.0	0	0.380	0.000	0.00
3	11/30/69		140.00	5573.00	4.6	7220	0	2600	1990	0	0	0.00	0	0	0.0	0	0.280	0.000	0.00
3	03/09/71		137.00	5576.00	3.1	12500	0	7800	75	0	0	0.00	0	0	0.0	0	7.790	0.000	0.00
3	04/30/71		130.00	5583.00	3.0	19200	0	11000	600	0	0	0.00	0	0	0.0	0	85.000	0.000	0.00
3	06/15/71		128.00	5585.00	3.0	15500	0	10000	680	0	0	0.00	0	0	0.0	0	9.000	0.000	0.00
3	11/12/71		118.00	5595.00	2.9	9190	0	7900	800	0	0	0.00	0	0	0.0	0	5.500	0.000	0.00
3	12/14/71		115.00	5598.00	3.0	12100	0	8600	750	0	0	0.00	0	0	0.0	0	13.200	0.000	0.00
3	01/19/72		116.00	5597.00	2.9	13000	0	8000	700	0	0	0.00	0	0	0.0	0	7.600	0.000	0.00
3	02/10/72		119.00	5594.00	3.0	0	0	0	730	0	0	0.00	0	0	0.0	0	8.000	0.000	0.00
3	03/10/72		119.00	5594.00	3.1	14000	0	9400	850	0	0	0.00	0	0	0.0	0	11.000	0.000	0.00
3	04/19/72		120.00	5593.00	2.9	11600	0	7100	750	0	0	0.00	0	0	0.0	0	10.000	0.000	0.00
3	05/07/72		130.00	5583.00	2.8	12400	0	0	600	0	0	0.00	0	0	0.0	0	7.800	0.000	0.00
3	06/15/72		120.00	5593.00	2.7	14600	0	6400	820	0	0	0.00	0	0	0.0	0	10.600	0.000	0.00
3	07/11/72		124.00	5589.00	2.7	13700	0	9200	1420	0	0	0.00	0	0	0.0	0	12.600	0.000	0.00
3	08/31/72		125.00	5588.00	2.9	14000	0	8000	950	0	0	0.00	0	0	0.0	0	15.000	0.000	0.00
3	09/25/72		124.00	5589.00	3.2	15300	0	5300	550	0	0	0.00	0	0	0.0	0	9.200	0.000	0.00
3	10/28/72		122.00	5591.00	3.1	14000	0	8900	750	0	0	0.00	0	0	0.0	0	10.300	0.000	0.00
8	12/05/72		129.00	5584.00	3.6	6710	0	5100	420	0	0	0.00	0	0	0.0	0	4.440	0.000	0.00
8	04/16/73		190.00	5523.00	3.5	12900	0	7300	1050	0	0	0.00	0	0	0.0	0	8.750	0.000	0.00
8	05/15/73		125.00	5588.00	3.3	13400	0	8700	1150	0	0	0.00	0	0	0.0	0	9.140	0.000	0.00
8	07/20/73		130.00	5583.00	3.2	12900	0	5400	370	0	0	0.00	0	0	0.0	0	9.280	0.000	0.00
8	08/23/73		120.00	5593.00	2.8	12300	0	7100	470	0	0	0.00	0	0	0.0	0	9.150	0.000	0.00
8	09/21/73		130.00	5583.00	2.9	10800	0	5900	400	0	0	0.00	0	0	0.0	0	7.500	0.000	0.00
8	10/17/73		125.00	5588.00	2.9	10200	0	5900	430	0	0	0.00	0	0	0.0	0	7.170	0.000	0.00

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)
K78	11/13/73		125.00	5588.00	3.1	13000	0	5900	400	0	0	0.00	0	0	0.0	0	6.150	0.000
K78	12/12/73		125.00	5588.00	3.4	10000	0	5100	55	0	0	0.00	0	0	0.0	0	10.300	0.000
K78	01/24/74		125.00	5588.00	2.9	9780	0	6100	210	0	0	0.00	0	0	0.0	0	7.880	0.000
K78	03/26/74		130.00	5583.00	2.9	13200	0	8600	230	0	0	0.00	0	0	0.0	0	11.200	0.000
K80	08/16/66	32 7cac	57.00	5778.00	6.6	5950	0	0	0	0	0	0.00	0	0	0.0	0	0.010	0.000
K80	09/09/66	32 7cac	56.00	5779.00	6.9	6270	0	0	0	0	0	0.00	0	0	0.0	0	0.590	0.000
K80	11/17/66	32 7cac	56.00	5779.00	7.4	5810	0	0	0	0	0	0.00	0	0	0.0	0	0.293	0.000
K80	03/16/67	32 7cac	56.00	5779.00	6.7	3430	0	0	0	0	0	0.00	0	0	0.0	0	0.050	0.000
K80	04/28/67	32 7cac	56.00	5779.00	7.2	4410	0	0	0	0	0	0.00	0	0	0.0	0	0.013	0.000
K80	08/25/67	32 7cac	55.00	5780.00	6.5	4980	0	0	0	0	0	0.00	0	0	0.0	0	0.032	0.000
K80	10/23/67	32 7cac	57.00	5778.00	4.3	4930	0	970	0	0	0	0.00	0	0	0.0	0	0.257	0.000
K80	11/06/67	32 7cac	57.00	5778.00	6.3	0	0	0	0	0	0	0.00	0	0	0.0	0	0.070	0.000
K80	02/07/68	32 7cac	0.00	0.00	5.6	3800	0	1300	1480	6	1	1.00	346	335	9.0	241	0.005	0.000
K80	03/06/68	32 7cac	57.00	5778.00	6.2	5370	0	0	0	0	0	0.00	0	0	0.0	0	0.088	0.000
K80	07/30/68	32 7cac	12.00	5823.00	8.0	6630	0	0	0	0	0	0.00	0	0	0.0	0	0.240	0.000
K80	11/08/68	32 7cac	57.00	5778.00	7.1	4600	0	1600	1550	0	0	0.00	0	0	0.0	0	0.200	0.000
K80	03/14/69	32 7cac	0.00	0.00	6.7	5310	0	1200	1400	0	0	0.00	0	0	0.0	0	0.200	0.000
K80	04/23/69	32 7cac	47.00	5788.00	7.0	2500	0	620	0	0	0	0.00	0	0	0.0	0	0.020	0.000
K80	05/21/69	32 7cac	0.00	0.00	7.1	8130	0	560	0	0	0	0.00	0	0	0.0	0	0.010	0.000
K80	06/13/69	32 7cac	53.00	5782.00	6.6	2430	0	660	2000	0	0	0.00	0	0	0.0	0	0.600	0.000
K80	07/09/69	32 7cac	0.00	0.00	7.4	2590	0	405	700	0	0	0.00	0	0	0.0	0	0.750	0.000
K80	08/21/69	32 7cac	0.00	0.00	6.6	2460	0	425	0	0	0	0.00	0	0	0.0	0	0.070	0.000
K80	09/20/69	32 7cac	0.00	0.00	6.6	2160	0	700	0	0	0	0.00	0	0	0.0	0	0.060	0.000
K80	10/22/69	32 7cac	0.00	0.00	6.2	3240	0	357	1400	0	0	0.00	0	0	0.0	0	0.030	0.000
K80	01/28/70	32 7cac	0.00	0.00	6.8	2740	0	800	0	0	0	0.00	0	0	0.0	0	0.010	0.000
K80	02/19/70	32 7cac	0.00	0.00	6.5	4010	0	1640	0	0	0	0.00	0	0	0.0	0	0.130	0.000
K80	03/31/70	32 7cac	0.00	0.00	6.4	4900	0	1430	1550	0	0	0.00	0	0	0.0	0	0.130	0.000
K80	04/16/70	32 7cac	0.00	0.00	6.4	4920	0	1250	0	0	0	0.00	0	0	0.0	0	0.040	0.000
K80	06/23/70	32 7cac	0.00	0.00	6.4	0	0	1200	0	0	0	0.00	0	0	0.0	0	0.020	0.000
K80	08/18/70	32 7cac	56.00	5779.00	4.6	4060	0	1000	0	0	0	0.00	0	0	0.0	0	0.110	0.000
K80	01/27/71	32 7cac	0.00	0.00	6.4	5770	0	1360	0	0	0	0.00	0	0	0.0	0	0.020	0.000

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZIN (mg/
:80	02/08/71	32 7cac	0.00	0.00	6.2	5030	0	1600	1650	0	0	0.00	0	0	0.0	0	0.120	0.000	0.(
:80	03/08/71	32 7cac	51.40	5783.60	6.4	5770	0	1100	0	0	0	0.00	0	0	0.0	0	0.270	0.000	0.(
:80	04/12/71	32 7cac	0.00	0.00	7.2	6620	0	1300	1550	0	0	0.00	0	0	0.0	0	0.400	0.000	0.(
:80	05/10/71	32 7cac	65.00	5770.00	0.0	4560	0	1400	1700	0	0	0.00	0	0	0.0	0	0.800	0.000	0.(
:80	06/07/71	32 7cac	40.40	5794.60	4.6	5170	0	1600	1320	0	0	0.00	0	0	0.0	0	0.010	0.000	0.(
:80	07/14/71	32 7cac	0.00	0.00	4.7	5210	0	1700	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.(
:80	08/09/71	32 7cac	0.00	0.00	6.3	5640	0	1400	1000	0	0	0.00	0	0	0.0	0	0.040	0.000	0.(
:80	09/13/71	32 7cac	53.80	5781.20	6.5	4910	0	1700	1100	0	0	0.00	0	0	0.0	0	0.010	0.000	0.(
:80	10/11/71	32 7cac	54.30	5780.70	5.7	4570	0	1300	1700	0	0	0.00	0	0	0.0	0	0.200	0.000	0.(
:80	11/08/71	32 7cac	54.00	5781.00	6.7	5350	0	1800	0	0	0	0.00	0	0	0.0	0	0.450	0.000	0.(
:80	01/11/72	32 7cac	53.70	5781.30	6.3	5440	0	1400	1450	0	0	0.00	0	0	0.0	0	0.130	0.000	0.(
:80	02/14/72	32 7cac	53.80	5781.20	6.1	6080	0	1500	1660	0	0	0.00	0	0	0.0	0	0.100	0.000	0.(
:80	05/16/73	32 7cac	46.70	5788.30	7.0	3300	0	710	750	0	0	0.00	0	0	0.0	0	0.300	0.000	0.(
:80	06/12/73	32 7cac	49.10	5785.90	6.7	3460	0	615	650	0	0	0.00	0	0	0.0	0	0.500	0.000	0.(
:81	08/16/66	3230ddd	123.00	5602.00	7.2	0	0	0	0	0	0	0.00	0	0	0.0	0	0.027	0.000	0.(
:81	09/09/66	3230ddd	115.00	5610.00	7.7	0	0	0	0	0	0	0.00	0	0	0.0	0	0.150	0.000	0.(
:81	11/17/66	3230ddd	118.00	5607.00	7.6	0	0	0	0	0	0	0.00	0	0	0.0	0	0.200	0.000	0.(
:81	07/30/68	3230ddd	0.00	0.00	7.9	0	0	228	0	1	1	0.00	52	3800	8.0	175	0.015	0.000	0.(
:81	11/08/68	3230ddd	9.00	5716.00	7.5	6180	0	190	337	0	0	0.00	0	0	0.0	0	0.440	0.000	0.(
:81	03/14/69	3230ddd	0.00	0.00	7.2	1590	0	134	165	0	0	0.00	0	0	0.0	0	0.220	0.000	0.(
:81	05/21/69	3230ddd	0.00	0.00	7.4	645	0	260	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.(
:81	06/13/69	3230ddd	188.00	5537.00	7.5	637	0	160	190	0	0	0.00	0	0	0.0	0	0.640	0.000	0.
:81	07/09/69	3230ddd	0.00	0.00	7.4	654	0	230	400	0	0	0.00	0	0	0.0	0	0.000	0.000	0.
:81	08/21/69	3230ddd	0.00	0.00	7.1	0	0	142	0	0	0	0.00	0	0	0.0	0	0.530	0.000	0.
:81	09/16/69	3230ddd	0.00	0.00	7.6	816	0	190	280	0	0	0.00	0	0	0.0	0	0.040	0.000	0.
:85	04/16/66	3216bcb	33.00	5212.00	0.0	0	0	0	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.
:85	04/25/66	3216bcb	0.00	0.00	3.6	0	0	14500	0	0	0	0.00	0	0	0.0	0	350.00	0.000	0.
:85	04/27/66	3216bcb	0.00	0.00	3.4	0	0	0	0	0	0	0.00	0	0	0.0	0	363.00	0.000	0.
:85	04/28/66	3216bcb	0.00	0.00	3.4	0	0	0	0	0	0	0.00	0	0	0.0	0	362.00	0.000	0.
:85	04/29/66	3216bcb	0.00	0.00	3.3	0	0	0	0	0	0	0.00	0	0	0.0	0	356.00	0.000	0.
:85	05/02/66	3216bcb	0.00	0.00	3.7	0	0	0	0	0	0	0.00	0	0	0.0	0	303.00	0.000	0.

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL UMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZINC (mg/l
15	07/23/75	3216bcb	23.60	5221.40	3.4	64600	13100	43000	0	0	0	0.00	0	0	0.0	0	107.00	0.000	0.0
15	08/15/75	3216bcb	24.30	5220.70	3.5	58200	14600	47700	0	0	0	0.00	0	0	0.0	0	122.00	0.000	0.0
15	09/27/75	3216bcb	38.30	5206.70	3.0	56300	16300	51300	0	0	0	0.00	0	0	0.0	0	94.000	0.000	0.0
15	10/16/75	3216bcb	50.60	5194.40	2.8	57700	12500	31200	0	0	0	0.00	0	0	0.0	0	96.000	0.000	0.0
15	11/12/75	3216bcb	50.60	5194.40	2.8	59800	12500	47300	0	0	0	0.00	0	0	0.0	0	98.000	0.000	0.0
15	12/10/75	3216bcb	39.20	5205.80	3.6	55700	10800	48000	0	0	0	0.00	0	0	0.0	0	93.000	0.000	0.0
15	01/15/76	3216bcb	39.30	5205.70	3.5	57700	8200	47000	0	0	0	0.00	0	0	0.0	0	99.000	0.000	0.0
15	04/29/76	3216bcb	40.80	5204.20	3.0	61400	18400	46200	20	0	0	0.00	0	0	0.0	0	97.000	0.000	0.0
15	08/24/76	3216bcb	49.10	5195.90	3.4	59600	20000	50700	73	0	0	0.00	0	0	0.0	0	84.400	0.000	0.0
15	11/17/76	3216bcb	53.90	5191.10	2.8	58600	17200	46200	70	0	0	0.00	0	0	0.0	0	98.000	0.000	0.0
15	01/13/77	3216bcb	48.30	5196.70	3.3	47700	14600	46200	175	0	0	0.00	0	0	0.0	0	85.000	0.000	0.0
15	04/22/77	3216bcb	51.60	5193.40	3.2	58500	13600	44700	130	0	0	0.00	0	0	0.0	0	88.000	0.000	0.0
15	09/15/83	3216bcb	37.90	5207.10	3.3	72900	21500	36300	187	1	1	0.00	72	0	1.0	26	125.00	0.004	217.
02	09/16/68	00 0	0.00	0.00	7.2	1450	0	33	90	0	0	0.00	0	0	0.0	0	0.040	0.000	0.0
02	10/03/68	00 0	0.00	0.00	6.3	0	0	0	0	0	0	0.00	0	0	0.0	0	17.000	0.000	0.0
02	03/20/69	00 0	330.00	5691.00	6.8	807	0	250	505	0	0	0.00	0	0	0.0	0	0.480	0.000	0.0
02	04/03/69	00 0	315.00	5706.00	6.9	425	0	60	101	0	0	0.00	0	0	0.0	0	0.270	0.000	0.0
02	04/16/69	00 0	0.00	0.00	7.1	771	0	185	0	0	0	0.00	0	0	0.0	0	2.640	0.000	0.0
02	04/24/69	00 0	299.00	5722.00	7.4	1030	0	53	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.0
02	05/08/69	00 0	0.00	0.00	6.7	0	0	130	0	0	0	0.00	0	0	0.0	0	2.800	0.000	0.0
02	05/22/69	00 0	300.00	5721.00	6.7	858	0	43	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.0
02	06/06/69	00 0	0.00	0.00	6.6	0	0	90	0	0	0	0.00	0	0	0.0	0	0.020	0.000	0.0
02	06/13/69	00 0	0.00	0.00	0.0	0	0	74	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.0
02	06/19/69	00 0	306.00	5715.00	7.1	475	0	70	160	0	0	0.00	0	0	0.0	0	0.300	0.000	0.0
02	06/26/69	00 0	306.00	5715.00	6.7	579	0	80	148	0	0	0.00	0	0	0.0	0	1.920	0.000	0.0
02	07/03/69	00 0	312.00	5709.00	7.1	0	0	80	138	0	0	0.00	0	0	0.0	0	3.700	0.000	0.0
102	07/10/69	00 0	306.00	5715.00	7.5	426	0	45	180	0	0	0.00	0	0	0.0	0	0.360	0.000	0.0
102	07/17/69	00 0	307.00	5714.00	7.5	0	0	50	0	0	0	0.00	0	0	0.0	0	1.760	0.000	0.0
102	07/31/69	00 0	313.00	5708.00	7.9	500	0	27	190	0	0	0.00	0	0	0.0	0	5.020	0.000	0.0
102	08/06/69	00 0	315.00	5706.00	7.8	509	0	81	190	0	0	0.00	0	0	0.0	0	3.130	0.000	0.0
102	08/21/69	00 0	0.00	0.00	7.0	0	0	98	190	0	0	0.00	0	0	0.0	0	34.000	0.000	0.0

KENNECOTT WELL INVENTORY DATA BASE
WATER QUALITY AND LEVELS

WELL NUMBER	SAMPLE DATE	LOCATION T R S QRT	DEPTH TO WATER (feet)	ELEV. OF WATER (msl)	pH (units)	TDS (mg/l)	CONDUC-TIVITY (umhos/cm)	SULFATE (mg/l)	CHLORIDE (mg/l)	BICAR-BONATE (mg/l)	CARBONATE (mg/l)	NITRATE AS N (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	POTASSIUM (mg/l)	SODIUM (mg/l)	COPPER (mg/l)	SELENIUM (mg/l)	ZI (mg/
K102	09/05/69	00 0	306.00	5715.00	6.7	702	0	240	130	0	0	0.00	0	0	0.0	0	4.220	0.000	0.
K102	09/25/69	00 0	0.00	0.00	7.3	373	0	0	120	0	0	0.00	0	0	0.0	0	0.020	0.000	0.
K102	09/29/69	00 0	0.00	0.00	0.0	0	0	51	0	0	0	0.00	0	0	0.0	0	0.000	0.000	0.
K102	11/09/69	00 0	0.00	0.00	0.0	0	0	0	70	0	0	0.00	0	0	0.0	0	0.000	0.000	0.
K102	11/24/69	00 0	305.00	5716.00	6.7	1580	0	135	68	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K102	03/09/71	00 0	290.00	5731.00	6.9	520	0	38	50	0	0	0.00	0	0	0.0	0	0.120	0.000	0.
K102	04/30/71	00 0	320.00	5701.00	6.2	471	0	60	50	0	0	0.00	0	0	0.0	0	0.240	0.000	0.
K102	06/15/71	00 0	300.00	5721.00	7.8	410	0	90	70	0	0	0.00	0	0	0.0	0	0.360	0.000	0.
K102	11/12/71	00 0	295.00	5726.00	6.5	505	0	130	110	0	0	0.00	0	0	0.0	0	4.300	0.000	0.
K102	12/14/71	00 0	295.00	5726.00	7.8	634	0	120	90	0	0	0.00	0	0	0.0	0	3.200	0.000	0.
K102	01/19/72	00 0	299.00	5722.00	6.6	597	0	130	78	0	0	0.00	0	0	0.0	0	0.600	0.000	0.
K102	02/11/72	00 0	305.00	5716.00	7.1	678	0	210	79	0	0	0.00	0	0	0.0	0	1.150	0.000	0.
K102	03/10/72	00 0	309.00	5712.00	7.9	563	0	120	100	0	0	0.00	0	0	0.0	0	2.050	0.000	0.
K102	04/24/72	00 0	314.00	5707.00	5.5	636	0	140	92	0	0	0.00	0	0	0.0	0	1.390	0.000	0.
K102	05/16/72	00 0	319.00	5702.00	5.9	1060	0	350	88	0	0	0.00	0	0	0.0	0	8.300	0.000	0.
K102	07/11/72	00 0	318.00	5703.00	7.0	913	0	280	105	0	0	0.00	0	0	0.0	0	8.500	0.000	0.
K102	08/31/72	00 0	314.00	5707.00	6.5	549	0	160	117	0	0	0.00	0	0	0.0	0	3.860	0.000	0.
K102	09/25/72	00 0	319.00	5702.00	7.1	536	0	50	95	0	0	0.00	0	0	0.0	0	3.160	0.000	0.
K102	10/28/72	00 0	315.00	5706.00	6.3	775	0	260	100	0	0	0.00	0	0	0.0	0	0.470	0.000	0.
K102	12/05/72	00 0	320.00	5701.00	6.9	652	0	310	90	0	0	0.00	0	0	0.0	0	2.850	0.000	0.
K102	01/08/73	00 0	318.00	5703.00	7.4	828	0	380	80	0	0	0.00	0	0	0.0	0	29.000	0.000	0.
K102	01/20/73	00 0	318.00	5703.00	8.1	534	0	110	85	0	0	0.00	0	0	0.0	0	8.890	0.000	0.
K106	01/06/71	3215bab	0.00	0.00	6.9	1560	0	140	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K106	01/20/71	3215bab	0.00	0.00	6.7	1390	0	200	0	0	0	0.00	0	0	0.0	0	0.260	0.000	0.
K106	01/27/71	3215bab	0.00	0.00	6.9	1640	0	290	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K106	02/04/71	3215bab	0.00	0.00	7.2	346	0	124	370	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K106	02/09/71	3215bab	0.00	0.00	7.3	1210	0	200	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K106	02/18/71	3215bab	0.00	0.00	6.8	1370	0	230	0	0	0	0.00	0	0	0.0	0	0.010	0.000	0.
K106	02/23/71	3215bab	0.00	0.00	6.6	1470	0	0	0	0	0	0.00	0	0	0.0	0	0.839	0.000	0.
K106	03/02/71	3215bab	0.00	0.00	6.8	1440	0	230	0	0	0	0.00	0	0	0.0	0	0.839	0.000	0.
K106	03/08/71	3215bab	0.00	0.00	7.7	1510	0	160	0	0	0	0.00	0	0	0.0	0	0.120	0.000	0.

TABLE D-2

BARNEYS CANYON

FIELD WATER QUALITY DATA(1)

Sample Site Designation	Date	pH	Conductivity umhos/cm	Temperature °C
Bancroft Spring	12-11-87	8.24	1200	9
Barneys Canyon Mine Adit	12-11-87	8.55	900	10.2
BC-69	01-12-88	8.05	1100	3.5
BC-71	01-12-88	8.34	850	2.7
BC-148	01-08-88	7.19	1100	8.4
BC-150	01-07-88	7.50	1610	8.3

(1) Measured by Dames & Moore in the field

TABLE D-3

REPORT OF ANALYSIS

NMD-RE DATE 04/06/88
SHEET NO - 0734508 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	PH	TEMP	COND	TDS	TSS
0709677	BANCROFTSPRINGT		8.24	9.0	1200 MH/CM	783 MG/L	45.8 MG/L
0709678	BANCROFTSPRINGD						
0709679	BARNEYSMINPRTLT		8.55	10.2	900 MH/CM	567 MG/L	1.8 MG/L
0709680	BARNEYSMINPRTLD						

LAB.NO.	DESCR	ELEM	SB	AS	BA	B	CD
0709677	BANCROFTSPRINGT		< .01 MG/L	0.032 MG/L	0.11 MG/L	< 0.01 MG/L	.009 MG/L
0709678	BANCROFTSPRINGD		< .01 MG/L	0.017 MG/L	0.09 MG/L	< 0.01 MG/L	< .005 MG/L
0709679	BARNEYSMINPRTLT		< .01 MG/L	0.019 MG/L	0.09 MG/L	< 0.01 MG/L	.005 MG/L
0709680	BARNEYSMINPRTLD		< .01 MG/L	0.010 MG/L	0.09 MG/L	< 0.01 MG/L	< .005 MG/L

LAB.NO.	DESCR	ELEM	CA	CR	CU	FE	PB
0709677	BANCROFTSPRINGT		96. MG/L	< 0.01 MG/L	< 0.01 MG/L	0.59 MG/L	.013 MG/L
0709678	BANCROFTSPRINGD			< 0.01 MG/L	< 0.01 MG/L	< 0.01 MG/L	.006 MG/L
0709679	BARNEYSMINPRTLT		80. MG/L	< 0.01 MG/L	0.04 MG/L	0.24 MG/L	.046 MG/L
0709680	BARNEYSMINPRTLD			< 0.01 MG/L	< 0.01 MG/L	< 0.01 MG/L	< .005 MG/L

LAB.NO.	DESCR	ELEM	MG	MN	HG	NI	K
0709677	BANCROFTSPRINGT		52.7 MG/L	0.04 MG/L	< 0.0001 MG/L	0.06 MG/L	3.1 MG/L
0709678	BANCROFTSPRINGD			0.01 MG/L		0.03 MG/L	
0709679	BARNEYSMINPRTLT		43.2 MG/L	< 0.01 MG/L	< 0.0001 MG/L	0.07 MG/L	3.0 MG/L
0709680	BARNEYSMINPRTLD			< 0.01 MG/L		0.03 MG/L	

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0709677	BANCROFTSPRINGT		.005 MG/L	< 0.01 MG/L	123. MG/L	0.01 MG/L	169 MG/L

TABLE D-3 (Continued-2)

REPORT OF ANALYSIS

NMD-RE DATE 04/06/88
SHEET NO - 8734508 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0709678	BANCROFTSPRINGD		< .004 MG/L	< 0.01 MG/L		< 0.01 MG/L	
0709679	BARNEYSMINPRTLT		< .004 MG/L	< 0.01 MG/L	74. MG/L	0.02 MG/L	194 MG/L
0709680	BARNEYSMINPRTLD		< .004 MG/L	< 0.01 MG/L		< 0.01 MG/L	

LAB.NO.	DESCR	ELEM	CL	CN(E)	F	HD	NO3-N
0709677	BANCROFTSPRINGT		168 MG/L	< .005 MG/L	0.10 MG/L	326 MG/L	0.49 MG/L
0709678	BANCROFTSPRINGD						
0709679	BARNEYSMINPRTLT		95.7 MG/L	< .005 MG/L	0.14 MG/L	314 MG/L	0.57 MG/L
0709680	BARNEYSMINPRTLD						

LAB.NO.	DESCR	ELEM	SO4	NO2-N	MPN-F	MPN-T
0709677	BANCROFTSPRINGT		159 MG/L	< 0.02 MG/L	42	42
0709678	BANCROFTSPRINGD					
0709679	BARNEYSMINPRTLT		138 MG/L	< 0.02 MG/L	23	1100
0709680	BARNEYSMINPRTLD					

TABLE D-3 (continued-3)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 8801208 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	PH	TEMP	COND	TDS	TSS
0800142	WELL BC-69	TOT	8.05	3.5	1100 MH/CM	521 MG/L	32.7 MG/L
0800143	WELL BC-69	DIS					
0800144	WELL BC-71	TOT	8.34	2.7	850 MH/CM	450 MG/L	3899 MG/L
0800145	WELL BC-71	DIS					

LAB.NO.	DESCR	ELEM	SB	AS	BA	B	CD
0800142	WELL BC-69	TOT	< .01 MG/L	.005 MG/L	0.03 MG/L	< 0.01 MG/L	0.007 MG/L
0800143	WELL BC-69	DIS	< .01 MG/L	< .004 MG/L	0.03 MG/L	< 0.01 MG/L	0.007 MG/L
0800144	WELL BC-71	TOT	< .01 MG/L	.100 MG/L	0.38 MG/L	0.04 MG/L	0.006 MG/L
0800145	WELL BC-71	DIS	< .01 MG/L	.016 MG/L	0.11 MG/L	< 0.01 MG/L	0.006 MG/L

LAB.NO.	DESCR	ELEM	CA	CR	CU	FE	PB
0800142	WELL BC-69	TOT	78. MG/L	< 0.01 MG/L	0.02 MG/L	0.93 MG/L	< 0.005 MG/L
0800143	WELL BC-69	DIS		< 0.01 MG/L	0.01 MG/L	0.04 MG/L	< 0.005 MG/L
0800144	WELL BC-71	TOT	68. MG/L	0.08 MG/L	0.12 MG/L	17.5 MG/L	0.211 MG/L
0800145	WELL BC-71	DIS		0.01 MG/L	0.02 MG/L	0.13 MG/L	< 0.005 MG/L

LAB.NO.	DESCR	ELEM	MG	MN	HG	NI	K
0800142	WELL BC-69	TOT	37. MG/L	0.08 MG/L	< 0.0001 MG/L	0.03 MG/L	1.9 MG/L
0800143	WELL BC-69	DIS		0.05 MG/L		0.02 MG/L	
0800144	WELL BC-71	TOT	41. MG/L	0.54 MG/L	< 0.0001 MG/L	0.10 MG/L	10.9 MG/L
0800145	WELL BC-71	DIS		0.12 MG/L		0.03 MG/L	

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0800142	WELL BC-69	TOT	< 0.004 MG/L	< 0.01 MG/L	55. MG/L	0.03 MG/L	125 MG/L

TABLE D-3 (Continued-4)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 8801208 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0800143	WELL BC-69	DIS	< 0.004 MG/L	< 0.01 MG/L		0.02 MG/L	
0800144	WELL BC-71	TOT	< 0.004 MG/L	< 0.01 MG/L	45. MG/L	0.59 MG/L	196 MG/L
0800145	WELL BC-71	DIS	< 0.004 MG/L	< 0.01 MG/L		0.02 MG/L	

LAB.NO.	DESCR	ELEM	CL	CN(E)	F	HD	NO3-N
0800142	WELL BC-69	TOT	76 MG/L	.005 MG/L	0.07 MG/L	231 MG/L	0.2 MG/L
0800143	WELL BC-69	DIS					
0800144	WELL BC-71	TOT	56 MG/L	.008 MG/L	0.09 MG/L	257 MG/L	0.3 MG/L
0800145	WELL BC-71	DIS					

LAB.NO.	DESCR	ELEM	SO4	NO2-N	AL	BI	MO
0800142	WELL BC-69	TOT	95 MG/L	< 0.02 MG/L	0.5 MG/L	< .005 MG/L	0.11 MG/L
0800143	WELL BC-69	DIS			< 0.1 MG/L	< .005 MG/L	0.11 MG/L
0800144	WELL BC-71	TOT	65 MG/L	< 0.02 MG/L	20.0 MG/L	.005 MG/L	0.12 MG/L
0800145	WELL BC-71	DIS			0.7 MG/L	< .005 MG/L	0.10 MG/L

LAB.NO.	DESCR	ELEM	PO4O	P	MPN-T	MPN-F	SIO2
0800142	WELL BC-69	TOT	0.20 MG/L	0.7 MG/L	< 3 MG/L	< 3 MG/L	10 MG/L
0800143	WELL BC-69	DIS					
0800144	WELL BC-71	TOT	4.43 MG/L	5.0 MG/L	< 3 MG/L	< 3 MG/L	10 MG/L
0800145	WELL BC-71	DIS					

LAB.NO.	DESCR	ELEM	ACD	S-2
0800142	WELL BC-69	TOT	24 MG/L	
0800143	WELL BC-69	DIS		

TABLE D-3 (Continued-5)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 0801208 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	ACD		S-2
0800144	WELL BC-71	TOT		33 MG/L	
0800145	WELL BC-71	DIS			

TABLE D-3 (Continued-6)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 8800805 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	PH	TEMP	COND	TDS	TSS
0800096	BC148	880108T	7.19	8.4	1100 MH/CM	904 MG/L	2191 MG/L
0800097	BC148	880108D					
0800098	BC150	880107T	7.50	8.3	1610 MH/CM	825 MG/L	4029 MG/L
0800099	BC150	880107D					

LAB.NO.	DESCR	ELEM	SB	AS	BA	B	CD
0800096	BC148	880108T	.01 MG/L	.372 MG/L	0.93 MG/L	0.19 MG/L	0.021 MG/L
0800097	BC148	880108D	< .01 MG/L	.014 MG/L	0.41 MG/L	0.02 MG/L	< 0.005 MG/L
0800098	BC150	880107T	< .01 MG/L	.442 MG/L	0.47 MG/L	0.21 MG/L	0.016 MG/L
0800099	BC150	880107D	< .01 MG/L	.013 MG/L	0.12 MG/L	0.05 MG/L	< 0.005 MG/L

LAB.NO.	DESCR	ELEM	CA	CR	CU	FE	PB
0800096	BC148	880108T	167. MG/L	0.14 MG/L	0.32 MG/L	0.56 MG/L	1.20 MG/L
0800097	BC148	880108D		0.02 MG/L	0.02 MG/L	0.05 MG/L	0.010 MG/L
0800098	BC150	880107T	156. MG/L	0.22 MG/L	0.30 MG/L	64. MG/L	.48 MG/L
0800099	BC150	880107D		0.01 MG/L	0.02 MG/L	0.06 MG/L	< 0.005 MG/L

LAB.NO.	DESCR	ELEM	MG	MN	HG	NI	K
0800096	BC148	880108T	66. MG/L	1.20 MG/L	< 0.0001 MG/L	0.13 MG/L	12.0 MG/L
0800097	BC148	880108D		0.30 MG/L		0.03 MG/L	
0800098	BC150	880107T	68. MG/L	1.35 MG/L	< 0.0001 MG/L	0.15 MG/L	13.3 MG/L
0800099	BC150	880107D		0.28 MG/L		0.02 MG/L	

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0800096	BC148	880108T	< 0.004 MG/L	0.01 MG/L	67. MG/L	0.48 MG/L	195 MG/L

TABLE D-3 (Continued-7)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 0800805 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	SE	AG	NA	ZN	ALK
0800097	BC148	880108D	< 0.004 MG/L	< 0.01 MG/L		0.03 MG/L	
0800098	BC150	880107T	< 0.004 MG/L	< 0.01 MG/L	117. MG/L	0.47 MG/L	95 MG/L
0800099	BC150	880107D	< 0.004 MG/L	< 0.01 MG/L		0.01 MG/L	

LAB.NO.	DESCR	ELEM	CL	CN(E)	F	HD	NO3-N
0800096	BC148	880108T	314 MG/L	.01 MG/L	0.26 MG/L	551 MG/L	0.7 MG/L
0800097	BC148	880108D					
0800098	BC150	880107T	314 MG/L	.006 MG/L	0.41 MG/L	362 MG/L	0.2 MG/L
0800099	BC150	880107D					

LAB.NO.	DESCR	ELEM	SO4	NO2-N	AL	BI	MO
0800096	BC148	880108T	88 MG/L	< 0.02 MG/L	3.5 MG/L	.051 MG/L	0.13 MG/L
0800097	BC148	880108D			< 0.1 MG/L	< .005 MG/L	0.12 MG/L
0800098	BC150	880107T	80 MG/L	< 0.02 MG/L	7.2 MG/L	.019 MG/L	0.13 MG/L
0800099	BC150	880107D			< 0.1 MG/L	< .005 MG/L	0.11 MG/L

LAB.NO.	DESCR	ELEM	PO40	P	MPN-T	MPN-F	SIO2
0800096	BC148	880108T	1.01 MG/L	3.1 MG/L	4 MG/L	< 3 MG/L	50 MG/L
0800097	BC148	880108D					
0800098	BC150	880107T	2.03 MG/L	2.3 MG/L	9 MG/L	< 3 MG/L	27 MG/L
0800099	BC150	880107D					

LAB.NO.	DESCR	ELEM	ACD	S-2
0800096	BC148	880108T	55 MG/L	
0800097	BC148	880108D		

TABLE D-3 (Continued-8)

REPORT OF ANALYSIS

MMD-RE DATE 02/29/88
SHEET NO - 8800805 SUBM - EEC W/C - 203 CHG NO - 203531 ORIGIN - NMD DISP - D

LAB.NO.	DESCR	ELEM	ACD	S-2
0800098	BC150	880107T	30 MG/L	
0800099	BC150	880107D		

APPENDIX C-I

SOIL PROFILE DESCRIPTIONS

Agassiz Series

A1-0 to 7 inches, dark grayish-brown (10YR 4/2) very cobbly silt loam, very fine and fine, granular structure; soft, very friable, slightly sticky and slightly plastic; common fine roots; 50 percent cobblestones and gravel; moderately alkaline (pH 8.4); clear, wavy boundary.

C1-7 to 15 inches, brown (10YR 5/3) very cobbly slit loam, dark brown (10YR 3/3) when moist; very weak, medium, subangular blocky structure and moderate, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots; 60 percent cobblestones and gravel; slightly calcareous; lime disseminated and lime coatings on coarse fragments; moderately alkaline (pH 8.4); abrupt, irregular boundary.

R-15 inches, calcareous sandstone and limestone.

Bradshaw Series

A11-0 to 9 inches, grayish-dark (10YR 5/2) very cobbly silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and very fine, granular structure; soft, very friable, slightly sticky and slightly plastic; common fine and very fine roots and few medium roots; many fine pores; 50 percent cobblestones and gravel; mildly alkaline (pH7.6); clear, smooth boundary.

A12-9 to 20 inches,brown (10YR 5/3) very cobbly silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and very fine; granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine foots and few medium roots; many fine pores; 55 percent cobblestones and gravel; mildly alkaline (pH 7.6); gradual wavy boundary.

B2-20 to 52 inches, brown (10YR 5/2) very cobbly silt loam, brown (10YR 4/3) when moist; weak, medium and fine, subanguler blocky structure parting to moderate,fine, granular; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine foots and few medium roots; many fine and micro pores; 60 percent cobblestones and gravel; mildly alkaline (pH 7.6); gradual; wavy boundary.

C1-52 to 72 inches, brown (10YR 5/3) very cobbly silt loam, brown (10YR 4/3) when moist; massive; slightly hard, firm, slightly sticky and slightly plastic; 70 percent cobblestones and gravel; moderately calcareous; lime occurs as thick coats on bottoms of coarse fragments and moderately thick to thin coats on the sides and tops of coarse fragments; moderately alkaline (pH 8.2).

Copperton Series

A11-0 to 6 inches, dark grayish-brown (10YR 4/2) very gravelly loam, very dark brown (10YR 2/2) when moist; weak, thin, platy structure parting to moderate, fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; common fine and large roots; 50 percent gravel and cobblestones; mildly alkaline (pH 7.8); clear, smooth boundary.

A12-6 to 13 inches, dark grayish-brown (10YR 5/2) very cobbly heavy loam, very dark grayish-brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure parting to moderate, fine and very fine, granular; hard,friable, sticky and slightly plastic; common fine and large roots; 55 percent cobblestones and gravel; moderately alkaline (pH 8.2); abrupt, smooth boundary.

AC-13 to 19 inches, grayish-brown (10YR 5/2) very cobbly heavy loam, dark brown (10YR 3/3) when moist; weak, fine, subangular blocky structure parting to moderate, very fine, granular; hard, friable, sticky and slightly plastic; common fine and large roots; 55 percent cobblestones and gravel; strongly calcareous; moderately alkaline (pH 8.3); abrupt, smooth boundary.

C1ca-19 to 42 inches, very pale brown (10YR 5/2) very gravelly loam, light yellowish brown (10YR 8/3) when moist; massive; extremely hard, very firm, nonsticky and nonplastic; few fine and large roots; 60 percent gravel and cobblestones; very strongly calcareous; weakly cemented; strongly alkaline (pH 8.5); abrupt, smooth boundary.

C2-42 to 60 inches, pale-brown (10YR 6/3) very cobbly fine sandy loam, yellowish brown (10YR 5/4) when moist; massive; hard, friable nonsticky and nonplastic; few fine roots; 75 percent cobblestones and gravel; strongly calcareous; moderately alkaline (pH 8.3).

Dry Creek Series

Ap-0 to 6 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, thick, platy structure parting to moderate, medium and fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; common very fine roots; common very fine and micro pores; neutral (pH 7.3) ; abrupt, smooth boundary.

A1-6 to 11 inches, grayish-brown (10YR 5/2) heavy silt loam,very dark grayish brown (10YR 3/2) when moist; weak, very thick, platy structure; hard, friable, sticky and slightly plastic; common very fine roots; many fine, very fine, and

micro pores; weak tillage pan gives the surface of this horizon a troweled appearance; neutral (pH 6.9); clear, smooth boundary.

B2t-15 to 29 inches, silty clay, brown (7.5YR 5/4) when crushed and brown (10YR 5/3) on faces of peds, brown (7.5YR 4/4) when moist and crushed, dark brown (7.5YR 3/3) when moist; strong, medium, prismatic structure and strong, medium, angular blocky; extremely hard, firm, sticky and very plastic; few very fine roots; few fine pores and many micro pores; thick, continuous clay films; slightly calcareous in lower 6 inches; moderately alkaline (pH 8.4); gradual, smooth boundary.

B3tca-29 to 42 inches, brown (10YR 5/3) silty clay loam, brown (7.5YR 5/4) when crushed, brown (10YR 5/3) when moist, brown (7.5YR 5/4) when moist crushed; moderate, medium prismatic structure and moderate, medium, subangular blocky; very hard, friable, sticky and slightly plastic; few very fine roots; many fine and very fine pores; few moderately thick clay films; slightly calcareous, lime is soft and occurs as streaks and coatings on vertical ped faces; strongly alkaline (pH 8.8); gradual, smooth boundary.

Cca-42 to 60 inches, light-gray (10YR 7/2) heavy silt loam, brown (10YR 5/3) when moist; massive; very hard, friable, sticky and slightly plastic; very few very fine roots; few cobblestones; strongly calcareous, lime is disseminated and in streaks and splotches; very strongly alkaline (pH 9.2).

Fitzgerald Series

02-2 inches to 0, very dark grayish brown (10YR 3/2) litter of partially decomposed leaves, grass, and other plant residue, very dark brown (10YR 2/2) when moist.

A11-0 to 4 inches, very dark grayish-brown (10YR 3/2) gravelly loam, very dark brown (10YR 2/2) when moist; moderate, very fine, granular structure; soft, very friable, nonsticky and nonplastic; common fine, medium, and large roots; neutral (pH 6.8); clear, smooth boundary.

A12-4 to 7 inches, dark grayish-brown (10YR 4/2) gravelly loam, very dark brown (10YR 2/2) when moist; moderate, very fine, granular structure; soft, very friable, slightly sticky and nonplastic; common fine, medium, and large roots; neutral (pH 6.8); abrupt, wavy boundary.

A2-7 to 18 inches, light yellowish-brown (10YR 6/4) very gravelly silt loam, yellowish brown (10YR 5/4) when moist; moderate, fine, granular structure; soft, very friable, slightly sticky and nonplastic; common fine, medium, and large roots; neutral (pH 6.6); gradual, irregular boundary.

B&A-18 to 34 inches, mixed B2t and A2 horizons; B2t part is brown (7.5YR 5/4) very gravelly loam, brown (10YR 4/3) when moist; massive; soft, very friable, slightly sticky and nonplastic; few thin clay films; A2 material is like that in the A2 horizon; few fine and large roots; neutral (pH 6.6); clear, wavy boundary.

B2t-34 to 70 inches, reddish-yellow (7.5YR 6/6) very gravelly sandy clay loam, yellowish brown (10YR 5/5) when moist; moderate, medium, subangular blocky structure; very hard, friable, sticky and plastic; few moderately thick clay films on peds and thin, continuous clay films on coarse fragments; few fine and large roots; neutral (pH 6.6).

Gappmayer Series

01-2 inches to 0, undecomposed to slightly decomposed litter of oak leaves and grass.

A1-0 to 10 inches, very dark grayish-brown (10YR 3/2) very cobbly loam, very dark brown (10YR 2/2) when moist; moderate, very fine, granular structure; soft, very friable, nonsticky and nonplastic; many fine and medium roots and few large roots; common fine pores; neutral (pH 6.6); clear, wavy boundary.

A12-10 to 16 inches, grayish-brown (10YR 5/2) very gravelly silt loam, dark grayish brown (10YR 4/2) when crushed, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine and medium roots and few large roots; common fine pores; neutral (pH 6.6); abrupt, wavy boundary.

A2-16 to 20 inches, pale-brown (10YR 6/3) very gravelly silt loam, dark brown (10YR 4/3) when moist; moderate, fine and medium, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine pores' neutral (pH 6.6); abrupt, wavy boundary.

B21t-20 to 26 inches. pale-brown (10YR 6/3) gravelly silty clay loam, grayish brown (10YR 5/2) when crushed, brown (7.5YR 4/4) when moist. brown (7.5YR 4/3) when moist and crushed; moderate, medium and fine. subangular blocky structure; hard, friable, sticky and plastic; common fine roots and few medium and large roots; moderately thick, continuous clay films on most peds and coarse fragments; some peds coated with bleached sand; neutral (pH 6.8); clear, wavy boundary.

B22t-26 to 44 inches, light yellowish-brown (10YR 6/4) very gravelly clay loam, dark yellowish brown (10YR 4/4) when moist; moderate, medium and fine, subangular blocky structure; very hard, friable, sticky and plastic; common fine roots and few medium and large roots; thin, continuous

clay films on coarse fragments; neutral (pH 6.8); clear, wavy boundary.

C1-44 to 72 inches, pale-brown (10YR 6/3) very gravelly silt loam, brown (10YR 4/3) when moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots and few medium roots; below depth of 60 inches this horizon has thin lime coatings on undersides of coarse fragments; matrix noncalcareous; neutral (pH 7.2).

Harkers Series

A1-0 to 14 inches, very dark grayish-brown (10YR 3/2) heavy loam, very dark brown (10YR 2/2) when moist; moderate, medium and fine, granular structure; slightly hard, friable, sticky and plastic; common large, medium, fine, and very fine roots; common very fine pores and few fine pores; neutral (pH 7.0); clear, smooth boundary.

B1t-14 to 19 inches, grayish-brown (10YR 5/2) gravelly clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; hard, firm, sticky and plastic; common large and medium roots and few fine and very fine roots very few very fine pores; neutral (pH 7.0)' clear, smooth boundary.

B21t-19 to 42 inches, reddish-brown (5YR 5/4) gravelly clay, dark reddish brown (5YR 3/4) when moist, brown (7.5YR 4/3) when moist and crushed; strong, medium, prismatic structure parting to strong, medium, blocky; very hard, extremely firm, very sticky and very plastic; few large, medium, fine, and very fine roots; very few very fine pores; common moderately thick clay films on ped faces; neutral (pH 7.2); diffuse, smooth boundary.

B22t-42 to 58 inches, reddish-brown (5YR 5/4) very gravelly clay, dark reddish brown (5YR 3/4) when moist, brown (7.5YR 4/3) when moist and crushed; strong, medium, prismatic structure parting to strong, medium, blocky; very hard, extremely firm, very sticky and very plastic; few fine and very fine roots; very few very fine pores; common moderately thick clay films on ped faces; neutral (pH 7.0); clear, smooth boundary.

C1ca-58 to 80 inches, light yellowish-brown (10YR 6/4) very gravelly clay loam, brown (7.5YR 5/4) when moist; massive; very firm, very sticky and plastic; very few fine and very fine roots; few fine pores; slightly calcareous; neutral (pH 7.0).

Wallsburg Series

A1-0 to 5 inches, grayish-brown (10YR 5/2) very cobbly loam, very dark grayish brown (10YR 3/2) when moist; weak, thin; platy structure parting to moderate, fine, granular; hard, very friable, slightly sticky and slightly plastic; common fine roots; 50 percent cobblestones and gravel; neutral (pH6.6); clear, wavy boundary.

B1t-5 to 9 inches, grayish-brown (10YR 5/2) very cobbly silty clay loam, very dark grayish brown (10YR 3/2) when moist, dark brown (7.5YR 3/2) when moist and crushed; very hard, friable, sticky and slightly plastic; common fine roots; 60 percent cobblestones; thin, continuous clay films; neutral (pH 6.6); clear, wavy boundary.

B2t-9 to 17 inches, brown (7.5YR 5/4) very cobbly light silty clay, dark brown (7.5YR 3/3) when moist; brown (7.5YR 4/3) when moist and crushed; strong, medium and fine, angular blocky structure; extremely hard, firm sticky and plastic; common fine roots; 70 percent cobblestones; thin, continuous clay films; neutral (pH 6.6); clear, irregular boundary.

R-17 inches, fractured bedrock.

APPENDIX C-II

SOIL QUALITY DATA

CHEMTECH

CHEMICAL AND BACTERIOLOGICAL ANALYSES

367 SOUTH COMMERCE LOOP
OREM, UTAH 84057
(801) 226-8822

2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023484

LOCATION: Barney's Canyon - BC-RAP-11

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	7.28
CEC Meq/100g	26.6
Chloride as Cl, mg/Kg	106
Organic Matter, %	1.31
Nitrate as NO_3-N, mg/Kg	990
Phosphorus as PO_4-P, mg/Kg	1.9
Potassium as K, mg/Kg	184
Calcium as Ca, mg/Kg	1,020
Magnesium as Mg, mg/Kg	809
Zinc as Zn, mg/Kg	0.8
Copper as Cu, mg/Kg	5.1
Sulfate as SO_4, mg/Kg	1,730
Sodium as Na, mg/Kg	181
Iron as Fe, mg/Kg	284
Conductivity, umhos/cm^3	416
% Saturation	84.5

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023484

LOCATION: Barney's Canyon - BC-RAP-11

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL	
Sieve Analysis:			
Sieve Size:	40, % Retained	71.1	
	60, % Retained	8.2	28
	100. % Retained	7.6	26
	200, % Retained	6.9	24
	200, % Passed	6.2	21

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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OREM, UTAH 84057
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2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023477

LOCATION: Barney's Canyon - BP-4, 6-9"

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.89
CEC Meq/100g	17.7
Chloride as Cl, mg/Kg	74
Organic Matter, %	3.75
Nitrate as NO_3-N, mg/Kg	1,400
Phosphorus as PO_4-P, mg/Kg	4.9
Potassium as K, mg/Kg	552
Calcium as Ca, mg/Kg	1,370
Magnesium as Mg, mg/Kg	359
Zinc as Zn, mg/Kg	10.9
Copper as Cu, mg/Kg	5.8
Sulfate as SO_4, mg/Kg	2,330
Sodium as Na, mg/Kg	28
Iron as Fe, mg/Kg	113
Conductivity, umhos/cm^3	272
% Saturation	67.5

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls We
Cedar City, UT 8 20

LAB NO: U023477

LOCATION: Barney's Canyon - BP-4, 6-9"

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	79.3
	60, % Retained	10.8
	100. % Retained	6.3
	200, % Retained	2.3
	200, % Passed	0

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023478

LOCATION: Barney's Canyon - BP-1, 0-4"

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.55
CEC Meq/100g	24.5
Chloride as Cl, mg/Kg	180
Organic Matter, %	1.64
Nitrate as NO_3-N, mg/Kg	1,270
Phosphorus as PO_4-P, mg/Kg	11.7
Potassium as K, mg/Kg	588
Calcium as Ca, mg/Kg	1,210
Magnesium as Mg, mg/Kg	349
Zinc as Zn, mg/Kg	16.6
Copper as Cu, mg/Kg	65.2
Sulfate as SO_4, mg/Kg	904
Sodium as Na, mg/Kg	44
Iron as Fe, mg/Kg	180
Conductivity, umhos/cm^3	183
% Saturation	59.3

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023478

LOCATION: Barney's Canyon - BP-1, 0-4"

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	78.3
	60, % Retained	5.9
	100, % Retained	3.5
	200, % Retained	4.0
	200, % Passed	8.3 38%

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023480

LOCATION: Barney's Canyon - BC - Leach Pad Subsoil

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	7.73
CEC Meq/100g	7.89
Chloride as Cl, mg/Kg	125
Organic Matter, %	0.605
Nitrate as NO_3-N, mg/Kg	745
Phosphorus as PO_4-P, mg/Kg	1.1
Potassium as K, mg/Kg	32
Calcium as Ca, mg/Kg	1,280
Magnesium as Mg, mg/Kg	263
Zinc as Zn, mg/Kg	0.8
Copper as Cu, mg/Kg	2.2
Sulfate as SO_4, mg/Kg	505
Sodium as Na, mg/Kg	30
Iron as Fe, mg/Kg	13.4
Conductivity, umhos/cm^3	311
% Saturation	47.2

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023480

LOCATION: Barney's Canyon - BC - Leach Pad Subsoil

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	75.1
	60, % Retained	11.1
	100. % Retained	10.3
	200, % Retained	2.3
	200, % Passed	0

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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OREM, UTAH 84057
(801) 226-8822

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SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023485

LOCATION: Barney's Canyon - BC-RAP-17 OC

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	7.48
CEC Meq/100g	15.5
Chloride as Cl, mg/Kg	190
Organic Matter, %	0.551
Nitrate as NO_3-N, mg/Kg	1,730
Phosphorus as PO_4-P, mg/Kg	1.8
Potassium as K, mg/Kg	105
Calcium as Ca, mg/Kg	1,500
Magnesium as Mg, mg/Kg	324
Zinc as Zn, mg/Kg	1.1
Copper as Cu, mg/Kg	7.6
Sulfate as SO_4, mg/Kg	216
Sodium as Na, mg/Kg	38
Iron as Fe, mg/Kg	56.2
Conductivity, umhos/cm@	309

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

Rex Henderson

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CHEMTECH

CHEMICAL AND BACTERIOLOGICAL ANALYSES

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2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023486

LOCATION: Barney's Canyon - BC-RAP-18

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	7.01
CEC Meq/100g	15.3
Chloride as Cl, mg/Kg	58
Organic Matter, %	0.841
Nitrate as NO_3-N, mg/Kg	1,150
Phosphorus as PO_4-P, mg/Kg	4.7
Potassium as K, mg/Kg	154
Calcium as Ca, mg/Kg	1,540
Magnesium as Mg, mg/Kg	528
Zinc as Zn, mg/Kg	<.1
Copper as Cu, mg/Kg	2.0
Sulfate as SO_4, mg/Kg	1,450
Sodium as Na, mg/Kg	71
Iron as Fe, mg/Kg	38.6
Conductivity, umhos/cm^3	267

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CHEMTECH

CHEMICAL AND BACTERIOLOGICAL ANALYSES

367 SOUTH COMMERCE LOOP
OREM, UTAH 84057
(801) 226-8822

2875 MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023481

LOCATION: Barney's Canyon - BC-RAP-2

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	5.78
CEC Meq/100g	19.2
Chloride as Cl, mg/Kg	119
Organic Matter, %	1.58
Nitrate as NO_3-N, mg/Kg	705
Phosphorus as PO_4-P, mg/Kg	2.3
Potassium as K, mg/Kg	291
Calcium as Ca, mg/Kg	1,460
Magnesium as Mg, mg/Kg	168
Zinc as Zn, mg/Kg	14.2
Copper as Cu, mg/Kg	20.8
Sulfate as SO_4, mg/Kg	757
Sodium as Na, mg/Kg	31
Iron as Fe, mg/Kg	234
Conductivity, umhos/cm^3	171
% Saturation	51.9

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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SUITE #101
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(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023481

LOCATION: Barney's Canyon - BC-RAP-2

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	56.4
	60, % Retained	8.2
	100. % Retained	7.7
	200, % Retained	13.7
	200, % Passed	13.9 32

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023479

LOCATION: Barney's Canyon - BC - Leach Copperton, 0-19"

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.24
CEC Meq/100g	22.8
Chloride as Cl, mg/Kg	74
Organic Matter, %	3.03
Nitrate as NO_3-N, mg/Kg	1,390
Phosphorus as PO_4-P, mg/Kg	2.9
Potassium as K, mg/Kg	456
Calcium as Ca, mg/Kg	1,230
Magnesium as Mg, mg/Kg	456
Zinc as Zn, mg/Kg	7.6
Copper as Cu, mg/Kg	51.1
Sulfate as SO_4, mg/Kg	305
Sodium as Na, mg/Kg	42
Iron as Fe, mg/Kg	81.2
Conductivity, umhos/cm^3	161
% Saturation	49.4

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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SUITE #101
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(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023479

LOCATION: Barney's Canyon - BC - Leach Copperton, 0-19"

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	84.6
	60, % Retained	3.4
	100. % Retained	2.3
	200, % Retained	3.3
	200, % Passed	6.4 47%

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023474

LOCATION: Barney's Canyon - BC-RB-4

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.94
CEC Meq/100g	18.1
Chloride as Cl, mg/Kg	77
Organic Matter, %	4.30
Nitrate as NO_3-N, mg/Kg	990
Phosphorus as PO_4-P, mg/Kg	13.1
Potassium as K, mg/Kg	644
Calcium as Ca, mg/Kg	1520
Magnesium as Mg, mg/Kg	211
Zinc as Zn, mg/Kg	11.2
Copper as Cu, mg/Kg	16.6
Sulfate as SO_4, mg/Kg	360
Sodium as Na, mg/Kg	42
Iron as Fe, mg/Kg	142
Conductivity, umhos/cm^3	324
% Saturation	47.7

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023474

LOCATION: Barney's Canyon - BC-RB-4

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	59.4
	60, % Retained	9.1
	100. % Retained	6.7
	200, % Retained	10.5
	200, % Passed	14.2 34%

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023483

LOCATION: Barney's Canyon - BC-RAP-8

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.36
CEC Meq/100g	21.4
Chloride as Cl, mg/Kg	129
Organic Matter, %	5.08
Nitrate as NO_3-N, mg/Kg	1,250
Phosphorus as PO_4-P, mg/Kg	4.8
Potassium as K, mg/Kg	392
Calcium as Ca, mg/Kg	1,640
Magnesium as Mg, mg/Kg	194
Zinc as Zn, mg/Kg	9.2
Copper as Cu, mg/Kg	15.4
Sulfate as SO_4, mg/Kg	372
Sodium as Na, mg/Kg	49
Iron as Fe, mg/Kg	176
Conductivity, umhos/cm^3	318
% Saturation	45.5

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023483

LOCATION: Barney's Canyon - BC-RAP-8

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	65.9
	60, % Retained	9.6 28
	100. % Retained	6.1
	200, % Retained	7.8
	200, % Passed	10.6 31

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023482

LOCATION: Barney's Canyon - BC-RAP-5

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.28
CEC Meq/100g	16.2
Chloride as Cl, mg/Kg	484
Organic Matter, %	3.07
Nitrate as NO_3-N, mg/Kg	860
Phosphorus as PO_4-P, mg/Kg	2.4
Potassium as K, mg/Kg	361
Calcium as Ca, mg/Kg	1,550
Magnesium as Mg, mg/Kg	152
Zinc as Zn, mg/Kg	11.3
Copper as Cu, mg/Kg	26.2
Sulfate as SO_4, mg/Kg	180
Sodium as Na, mg/Kg	32
Iron as Fe, mg/Kg	127
Conductivity, umhos/cm^3	204
% Saturation	45.2

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023482

LOCATION: Barney's Canyon - BC-RAP-5

CERTIFICATE OF ANALYSIS

PARAMETER			LEVEL	
Sieve Analysis:				
Sieve Size:	40, % Retained		51.0	COARSE SAND %
	60, % Retained	M. SAND	10.1	
	100. % Retained	F. SAND	8.4	
	200, % Retained	VF SAND	14.2	
	200, % Passed		16.3	30.6 %

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023476

LOCATION: Barney's Canyon - BC-RB-9

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.15
CEC Meq/100g	25.6
Chloride as Cl, mg/Kg	244
Organic Matter, %	1.91
Nitrate as NO_3-N, mg/Kg	1,140
Phosphorus as PO_4-P, mg/Kg	4.1
Potassium as K, mg/Kg	356
Calcium as Ca, mg/Kg	1,830
Magnesium as Mg, mg/Kg	1,860
Zinc as Zn, mg/Kg	9.6
Copper as Cu, mg/Kg	23.6
Sulfate as SO_4, mg/Kg	389
Sodium as Na, mg/Kg	41
Iron as Fe, mg/Kg	176
Conductivity, umhos/cm^3	251
% Saturation	50.3

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023476

LOCATION: Barney's Canyon - BC-RB-9

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	53.9
	60, % Retained	12.4
	100. % Retained	9.7
	200, % Retained	12.0
	200, % Passed	12.5 27%

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023475

LOCATION: Barney's Canyon - BC-RB-6

CERTIFICATE OF ANALYSIS

PARAMETER	LEVEL
pH Units	6.82
CEC Meq/100g	23.9
Chloride as Cl, mg/Kg	116
Organic Matter, %	1.67
Nitrate as NO_3-N, mg/Kg	1,490
Phosphorus as PO_4-P, mg/Kg	3.2
Potassium as K, mg/Kg	618
Calcium as Ca, mg/Kg	1,550
Magnesium as Mg, mg/Kg	1,740
Zinc as Zn, mg/Kg	12.4
Copper as Cu, mg/Kg	34.4
Sulfate as SO_4, mg/Kg	282
Sodium as Na, mg/Kg	40
Iron as Fe, mg/Kg	176
Conductivity, umhos/cm^3	355
% Saturation	46.5

Note: Metals (Cu, Fe, Zn, Ca, K, Mg) determined on DPTA extract.

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CHEMICAL AND BACTERIOLOGICAL ANALYSES

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OREM, UTAH 84057
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SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

CLIENT: JBR Consultants
865 So. Cedar Knolls West
Cedar City, UT 84720

LAB NO: U023475

LOCATION: Barney's Canyon - BC-RB-6

CERTIFICATE OF ANALYSIS

PARAMETER		LEVEL
Sieve Analysis:		
Sieve Size:	40, % Retained	62.2
	60, % Retained	9.1
	100. % Retained	6.9
	200, % Retained	9.1
	200, % Passed	12.6 33

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The Following Material Was Included in
The Revision and Was Titled Appendix A

For The Purposes of This Combined
Document, The Material Has Been
Included At The End Of Appendix C-II

APPENDIX A
LABORATORY ANALYSIS REPORTS FOR TOPSOIL SAMPLES

CHEMTECH

ANALYTICAL LABORATORY

6100 S. STRATLER
MURRAY, UTAH 84107
PHONE: (801) 262-7299
FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070250 - BC-MELCO-#1, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.4
Sodium as Na (Water Soluble), mg/Kg	17
Calcium as Ca (Water Soluble), mg/Kg	91
Magnesium as Mg (Water Soluble), mg/Kg	28
pH Units	5.97
CEC, meq/100g	44.2
Chloride as Cl, mg/Kg	98
% Organic Matter	4.78
Nitrate as NO_3-N, mg/Kg	15.4
Phosphate as PO_4-P, mg/Kg	151
Potassium as K, mg/Kg	1,300
Calcium as Ca, mg/Kg	1,360
Magnesium as Mg, mg/Kg	1,980
Zinc as Zn, mg/Kg	40.0
Copper as Cu, mg/Kg	70.0
Sulfate as SO_4, mg/Kg	370
Sodium as Na, mg/Kg	171
Iron as Fe, mg/Kg	8,500
Conductivity 1:1, umhos/cm	211
% Saturation	52.0

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ANALYTICAL LABORATORY

6100 S. STRATLER
MURRAY, UTAH 84107
PHONE: (801) 262-7299
FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070251 - BC-MELCO-#2, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.5
Sodium as Na (Water Soluble), mg/Kg	17
Calcium as Ca (Water Soluble), mg/Kg	46
Magnesium as Mg (Water Soluble), mg/Kg	27
pH Units	6.53
CEC, meq/100g	60.9
Chloride as Cl, mg/Kg	32
% Organic Matter	6.60
Nitrate as NO_3-N, mg/Kg	12.1
Phosphate as PO_4-P, mg/Kg	768
Potassium as K, mg/Kg	2,780
Calcium as Ca, mg/Kg	1,650
Magnesium as Mg, mg/Kg	3,320
Zinc as Zn, mg/Kg	108
Copper as Cu, mg/Kg	50.5
Sulfate as SO_4, mg/Kg	<50
Sodium as Na, mg/Kg	108
Iron as Fe, mg/Kg	14,500
Conductivity 1:1, umhos/cm	180
% Saturation	52.5

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PHONE: (801) 262-7299
FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070252 - BC-MELCO-#3, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.6
Sodium as Na (Water Soluble), mg/Kg	25
Calcium as Ca (Water Soluble), mg/Kg	88
Magnesium as Mg (Water Soluble), mg/Kg	39
pH Units	6.52
CEC, meq/100g	52.4
Chloride as Cl, mg/Kg	189
% Organic Matter	6.09
Nitrate as NO_3-N, mg/Kg	36.4
Phosphate as PO_4-P, mg/Kg	558
Potassium as K, mg/Kg	2,240
Calcium as Ca, mg/Kg	1,270
Magnesium as Mg, mg/Kg	2,280
Zinc as Zn, mg/Kg	54.0
Copper as Cu, mg/Kg	49.6
Sulfate as SO_4, mg/Kg	91
Sodium as Na, mg/Kg	105
Iron as Fe, mg/Kg	13,650
Conductivity 1:1, umhos/cm	742
% Saturation	54.4

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6100 S. STRATLER
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FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070253 - BC-MELCO-#4, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.1
Sodium as Na (Water Soluble), mg/Kg	5.0
Calcium as Ca (Water Soluble), mg/Kg	91
Magnesium as Mg (Water Soluble), mg/Kg	28
pH Units	6.44
CEC, meq/100g	100
Chloride as Cl, mg/Kg	37
% Organic Matter	13.0
Nitrate as NO_3-N, mg/Kg	30.5
Phosphate as PO_4-P, mg/Kg	552
Potassium as K, mg/Kg	1,686
Calcium as Ca, mg/Kg	2,850
Magnesium as Mg, mg/Kg	2,210
Zinc as Zn, mg/Kg	52.0
Copper as Cu, mg/Kg	46.7
Sulfate as SO_4, mg/Kg	<50
Sodium as Na, mg/Kg	58
Iron as Fe, mg/Kg	10,900
Conductivity 1:1, umhos/cm	189
% Saturation	75.8

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FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070254 - BC-MELCO-#5, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.2
Sodium as Na (Water Soluble), mg/Kg	9.0
Calcium as Ca (Water Soluble), mg/Kg	72
Magnesium as Mg (Water Soluble), mg/Kg	50
pH Units	6.92
CEC, meq/100g	45.6
Chloride as Cl, mg/Kg	87
% Organic Matter	3.11
Nitrate as NO_3-N, mg/Kg	12.5
Phosphate as PO_4-P, mg/Kg	372
Potassium as K, mg/Kg	2,154
Calcium as Ca, mg/Kg	1,460
Magnesium as Mg, mg/Kg	2,300
Zinc as Zn, mg/Kg	54.5
Copper as Cu, mg/Kg	47.0
Sulfate as SO_4, mg/Kg	263
Sodium as Na, mg/Kg	57
Iron as Fe, mg/Kg	12,250
Conductivity 1:1, umhos/cm	263
% Saturation	45.2

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FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070255 - BC-MELCO-#6, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.2
Sodium as Na (Water Soluble), mg/Kg	7.0
Calcium as Ca (Water Soluble), mg/Kg	44
Magnesium as Mg (Water Soluble), mg/Kg	40
pH Units	6.21
CEC, meq/100g	46.7
Chloride as Cl, mg/Kg	41
% Organic Matter	2.67
Nitrate as NO_3-N, mg/Kg	17.3
Phosphate as PO_4-P, mg/Kg	380
Potassium as K, mg/Kg	2,460
Calcium as Ca, mg/Kg	520
Magnesium as Mg, mg/Kg	2,230
Zinc as Zn, mg/Kg	54.5
Copper as Cu, mg/Kg	71.0
Sulfate as SO_4, mg/Kg	140
Sodium as Na, mg/Kg	98
Iron as Fe, mg/Kg	15,450
Conductivity 1:1, umhos/cm	78
% Saturation	37.5

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FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070256 - BC-MELCO-#7, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	0.1
Sodium as Na (Water Soluble), mg/Kg	5.0
Calcium as Ca (Water Soluble), mg/Kg	70
Magnesium as Mg (Water Soluble), mg/Kg	37
pH Units	6.93
CEC, meq/100g	44.3
Chloride as Cl, mg/Kg	26
% Organic Matter	3.29
Nitrate as NO_3-N, mg/Kg	20.3
Phosphate as PO_4-P, mg/Kg	661
Potassium as K, mg/Kg	1,916
Calcium as Ca, mg/Kg	1,900
Magnesium as Mg, mg/Kg	2,080
Zinc as Zn, mg/Kg	52.8
Copper as Cu, mg/Kg	36.5
Sulfate as SO_4, mg/Kg	<50
Sodium as Na, mg/Kg	61
Iron as Fe, mg/Kg	12,300
Conductivity 1:1, umhos/cm	130
% Saturation	50.6

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ANALYTICAL LABORATORY

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MURRAY, UTAH 84107
PHONE: (801) 262-7299
FAX: (801) 262-7378

DATE: 11-27-91

TO: JBR Consultants
8160 So. Highland Dr. STE A-4
Sandy, Utah 84093

SAMPLE ID: Lab #U070257 - BC-MELCO-#8, 10-25-91

DATE SUBMITTED: 10-30-91

CERTIFICATE OF ANALYSIS

PARAMETER	DETECTED
SAR	1.1
Sodium as Na (Water Soluble), mg/Kg	40
Calcium as Ca (Water Soluble), mg/Kg	72
Magnesium as Mg (Water Soluble), mg/Kg	20
pH Units	6.90
CEC, meq/100g	60.5
Chloride as Cl, mg/Kg	69
% Organic Matter	8.55
Nitrate as NO_3-N, mg/Kg	14.8
Phosphate as PO_4-P, mg/Kg	852
Potassium as K, mg/Kg	2,680
Calcium as Ca, mg/Kg	2,100
Magnesium as Mg, mg/Kg	3,020
Zinc as Zn, mg/Kg	69.3
Copper as Cu, mg/Kg	52.5
Sulfate as SO_4, mg/Kg	66
Sodium as Na, mg/Kg	107
Iron as Fe, mg/Kg	14,600
Conductivity 1:1, umhos/cm	195
% Saturation	65.1

Rex Henderson

APPENDIX C-III

ACID/BASE POTENTIAL LABORATORY REPORTS

COLORADO ANALYTICAL LABORATORY

SOIL WATER ENVIRONMENTAL

RECEIVED

JAN 13 1988

KENNECOTT EXPLORATION
Salt Lake City, Utah

LAB NO: 7270

REPORT TO: Jay Hamitt
BP Minerals America
1515 Mineral Square
Salt Lake City, UT 84112

BILL TO: BP Minerals America
Attn: Lynn Hutchinson
1515 Mineral Square
Salt Lake City, UT 84112

DATE RCVD: 12-23-87

REPORTED: 1-11-87

P.O. #:

ANALYSIS REQUESTED:

3 Samples for Acid Base Potential

ANALYSIS REPORT:

ABBR	ANALYTE	UNITS	METHOD REFERENCE	
pH	Hydrogen Ion Activity	units	EPA	3.2.2
AP(T)	Acid potential from total sulfur	T/1000T	EPA	3.2.4
	Neutralization potential	T/1000T	EPA	3.2.3
ABP	Acid/Base potential	T/1000T	EPA	1.3.1

+ = basic balance, - = acid balance
AP, NP and ABP are all reported in Tons/1000Tons $CaCO_3$ equivalent.

In Sobeks procedure for assessing acid-toxicity the material is classified as acid toxic if any of the following conditions prevail:

1- The material in a 1:5 slurry with distilled water has a pH of < 4.0

2- The Acid Potential of the nitric acid extractable sulfur (mostly pyritic sulfur) less the Neutralization Potential is > 5 T/1000T Calcium Carbonate equivalent.

The Acid Potential of the Total Sulfur is first calculated. (This worst case condition is based on the assumption that all sulfur is in pyritic form). If this yields an ABP of > 5, then the actual forms of the sulfur are determined and the ABP is recalculated based on the Nitric Acid extractable fraction only.

240 S. Main Street • Brighton, Colorado 80601 • (303) 659-2313
Mailing Address: P.O. Drawer 507, Brighton, CO 80601

LABORATORY RESULTS

	Sample ID	pH	NP	AP(T)	ABP	Comments
#1	BC-85 5-60 90-145 220-275	8.9	+563.	-7.	+556.	Non-Toxic
#2	MC-25 5-95 135-140 155-165 245-255	8.6	-1.	-3.	-4.	Non-Toxic
#3	MC-25 375-500 550-570	6.3	-1.	-3.	-4.	Non-Toxic

Additional Comments

Sample #1 is very high in lime thus giving it a high "basic forming" potential.

Sample #'s 2 and 3 are only slighty acid forming.

Analysis Supervised By

Data Approved for Release By

240 S. Main Street • Brighton, Colorado 80601 • (303) 659-2313
Mailing Address: P.O. Drawer 507, Brighton, CO 80601

APPENDIX D-I

OPERATIONAL IMPOUNDMENT STAGE CAPACITY CURVES

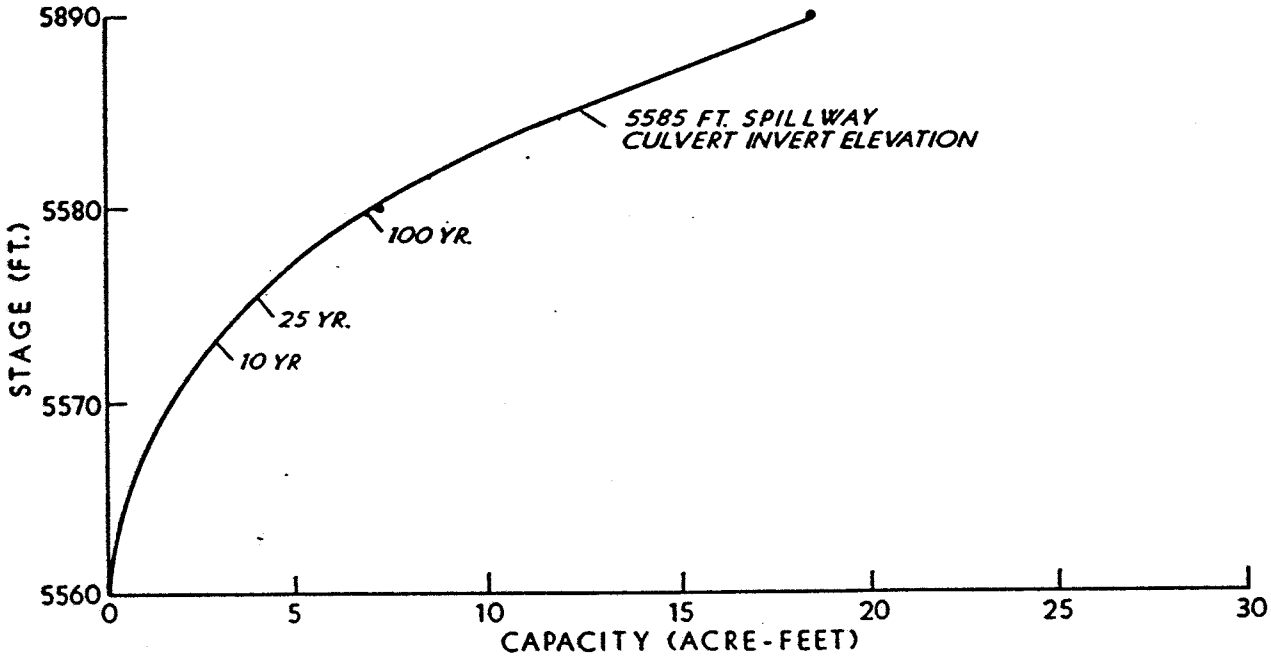
Table 3.12-2 Barneys Canyon Project Impoundment Containment Volumes

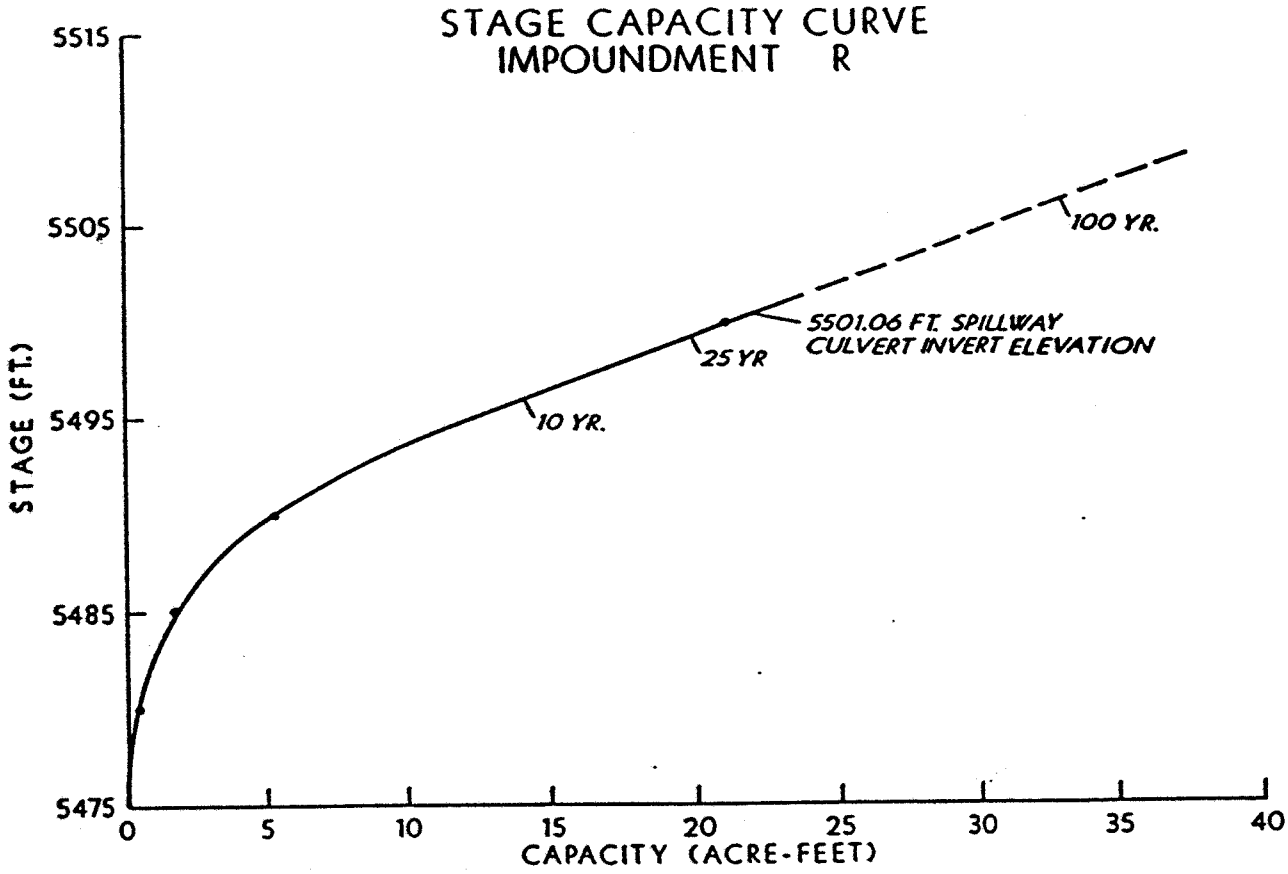
Runoff Volumes (Acre-feet)

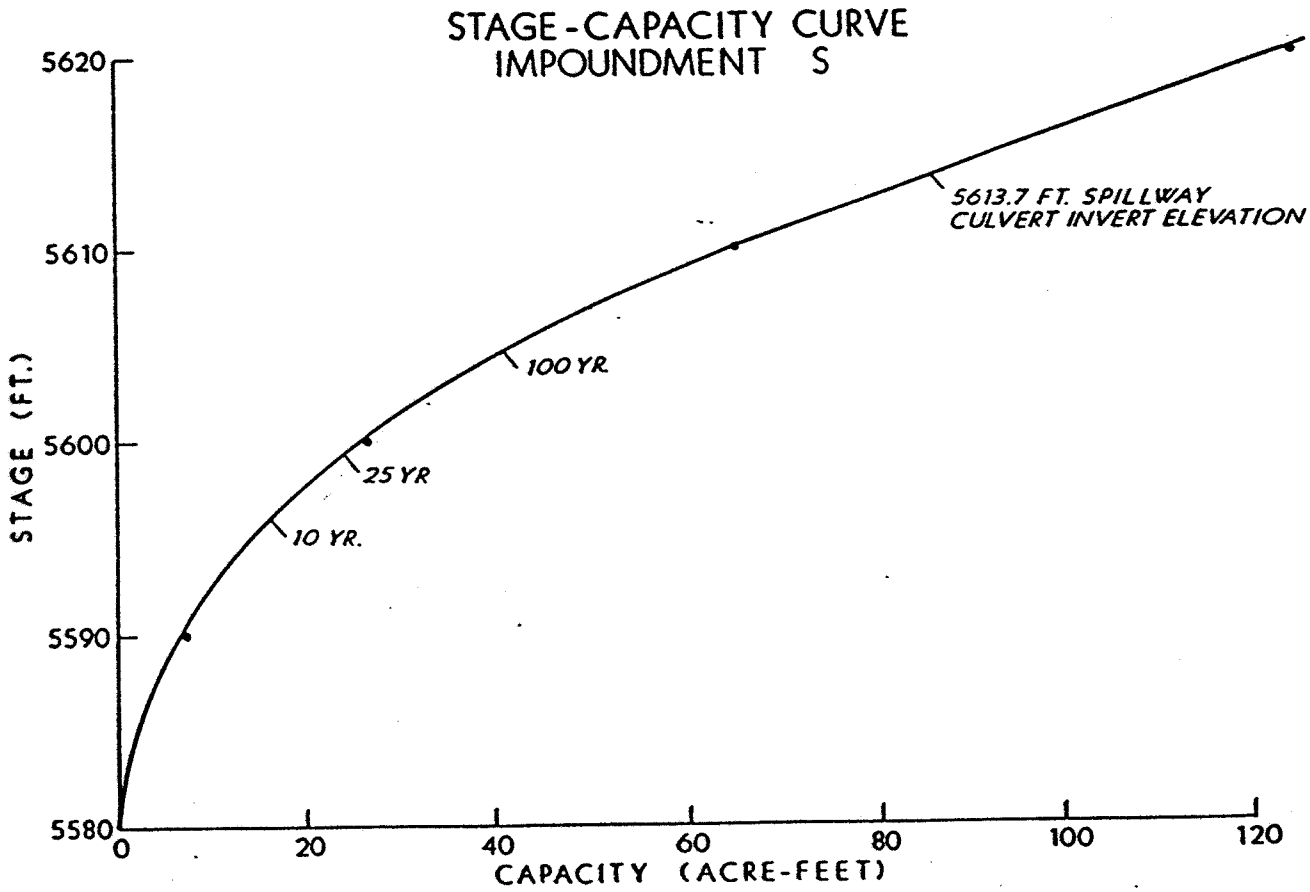
Impoundment/ Basin I. D.	Watershed Area (ac)	Impoundment Capacity (AF)	10yr 24hr	25yr 24hr	100yr 24hr
M	56.5	47.0	5.8	7.1	10.3*
P	332.0	23.5	10.5	14.1	23.8
Q	96.0	12.4	3.0	4.1	6.9
R	462.0	21.0	14.6	19.6	33.1
S	580.0	85.4	18.4	24.7	41.6
T	37.8	9.0	1.2	1.6	2.7
Mel-Co	43.5	80.0	1.4	1.8	3.1
Dump 6500 A	28.1	51.9	0.9	1.2	2.0
Dump 6500 B	30.2	13.2	1.0	1.3	2.2

Runoff volumes are based on the weighted curve numbers for each watershed.
* Runoff volumes cited for M include runoff from the adjacent waste dumps.

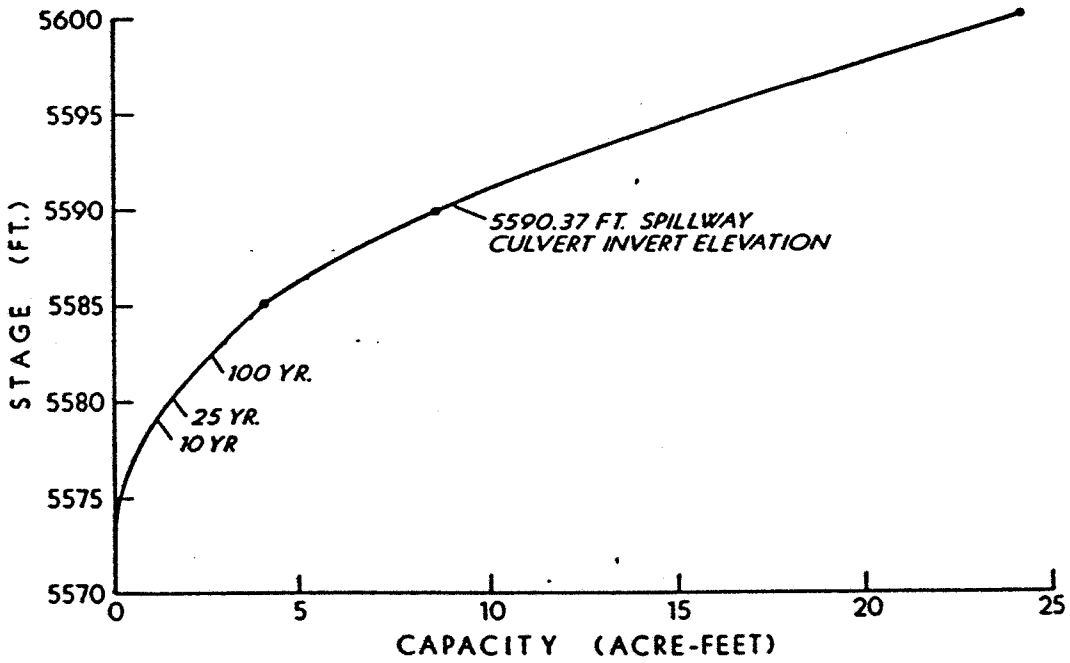
STAGE-CAPACITY CURVE
IMPOUNDMENT Q



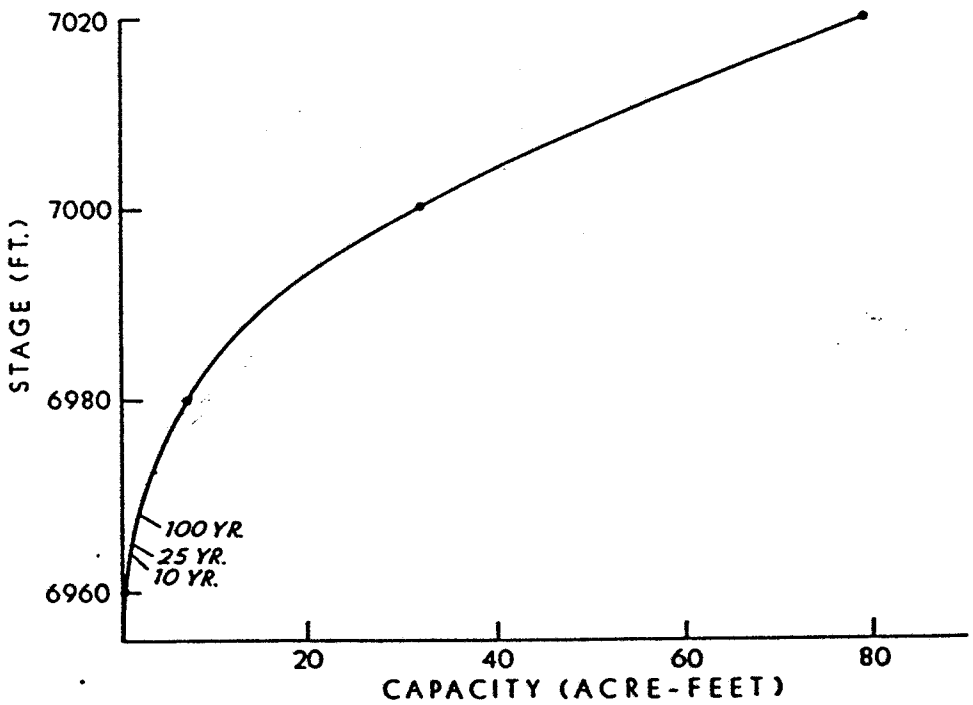

STAGE CAPACITY CURVE
IMPOUNDMENT R
STAGE (FT.)
5515
5505
5495
5485
5475
0
5
10
15
20
25
30
35
40
CAPACITY (ACRE-FEET)
100 YR.
5501.06 FT. SPILLWAY
CULVERT INVERT ELEVATION
25 YR
10 YR.


STAGE-CAPACITY CURVE
IMPOUNDMENT S
STAGE (FT.)
5620
5610
5600
5590
5580
0
20
40
60
80
100
120
CAPACITY (ACRE-FEET)
5613.7 FT. SPILLWAY
CULVERT INVERT ELEVATION
100 YR.
25 YR
10 YR.

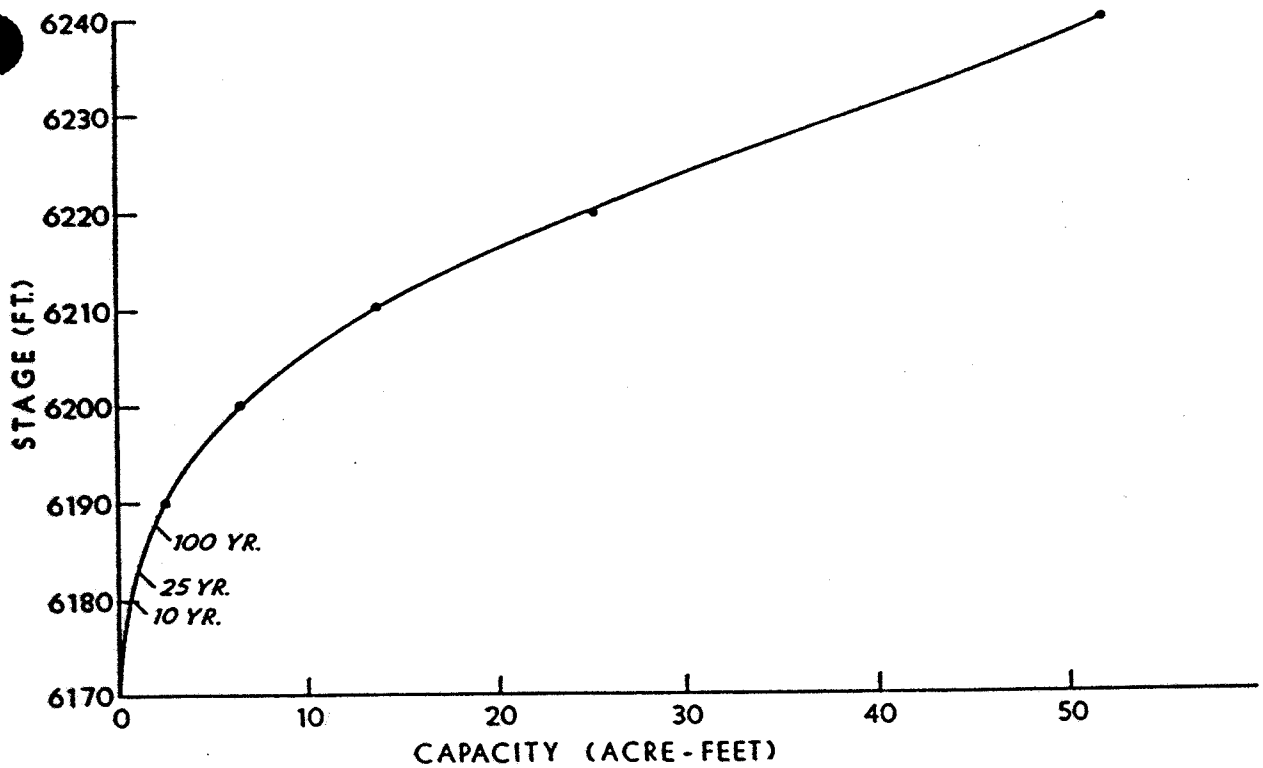
IMPOUNDMENT T



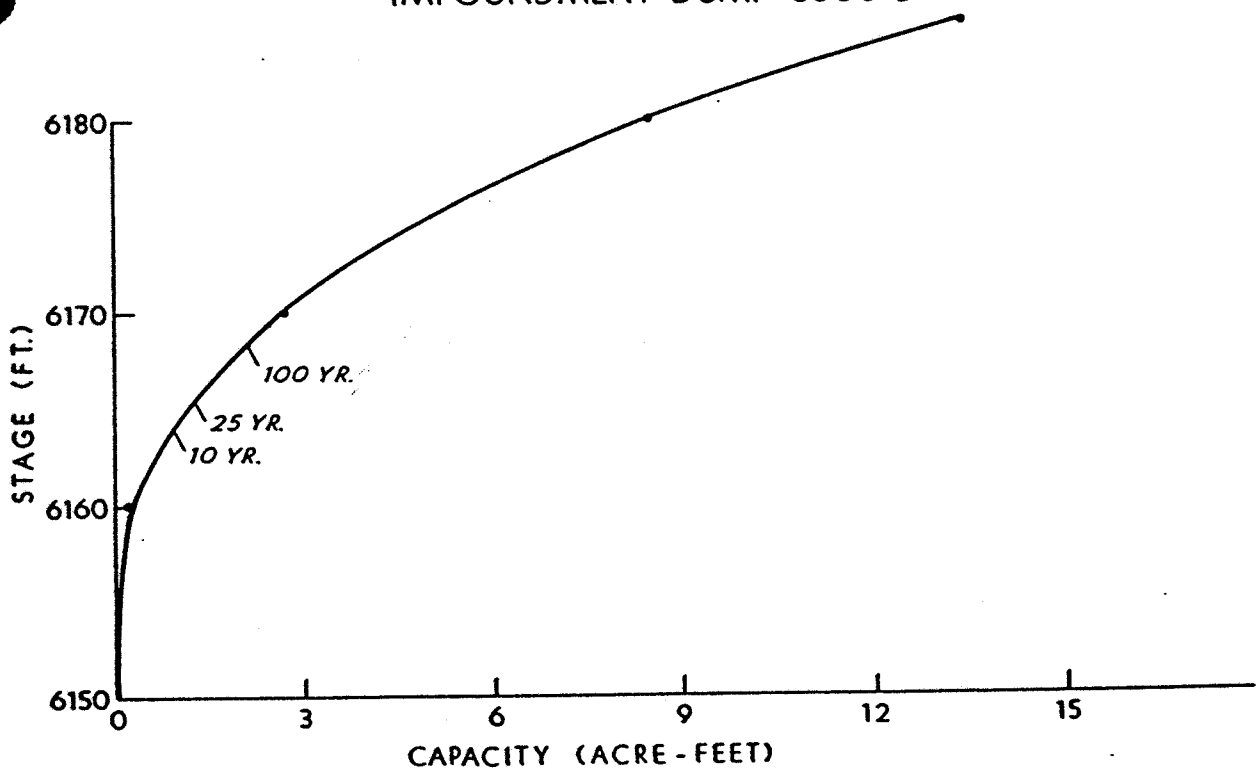
STAGE-CAPACITY CURVE
MEL-CO IMPOUNDMENT

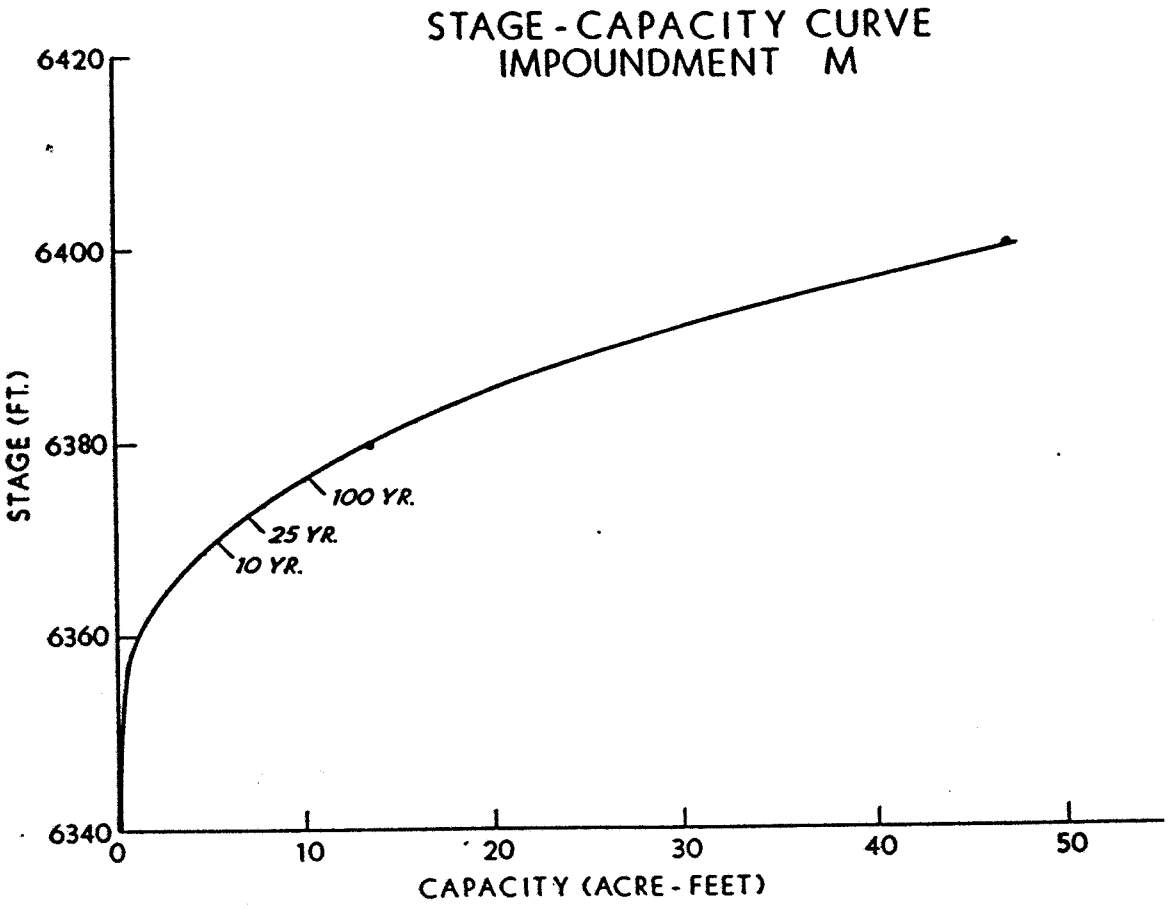


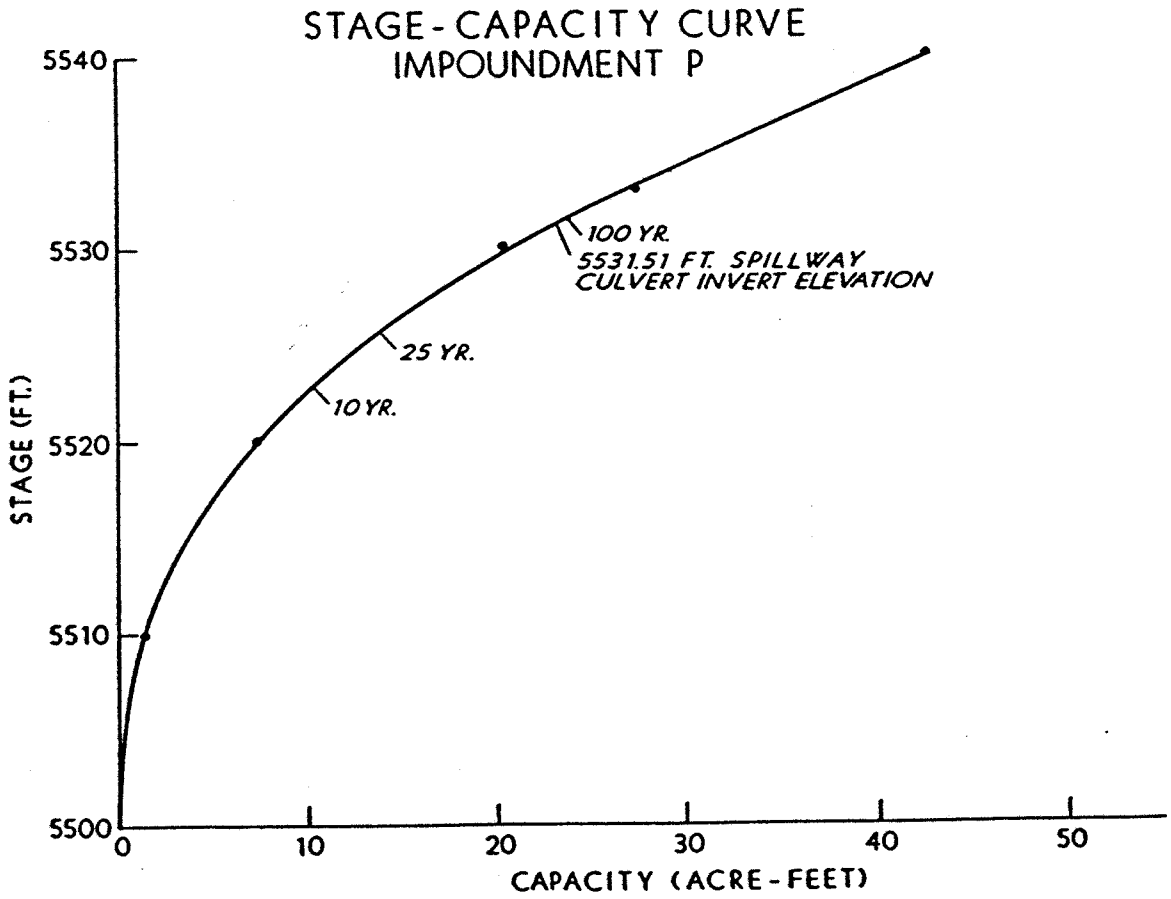
STAGE CAPACITY CURVE
IMPOUNDMENT DUMP 6500 A



STAGE CAPACITY CURVE
IMPOUNDMENT DUMP 6500 B




STAGE-CAPACITY CURVE
IMPOUNDMENT M
6420
6400
6380
6360
6340
STAGE (FT.)
100 YR.
25 YR.
10 YR.
0
10
20
30
40
50
CAPACITY (ACRE-FEET)


STAGE-CAPACITY CURVE
IMPOUNDMENT P
5540
5530
5520
5510
5500
STAGE (FT.)
100 YR.
5531.51 FT. SPILLWAY
CULVERT INVERT ELEVATION
25 YR.
10 YR.
0
10
20
30
40
50
CAPACITY (ACRE-FEET)

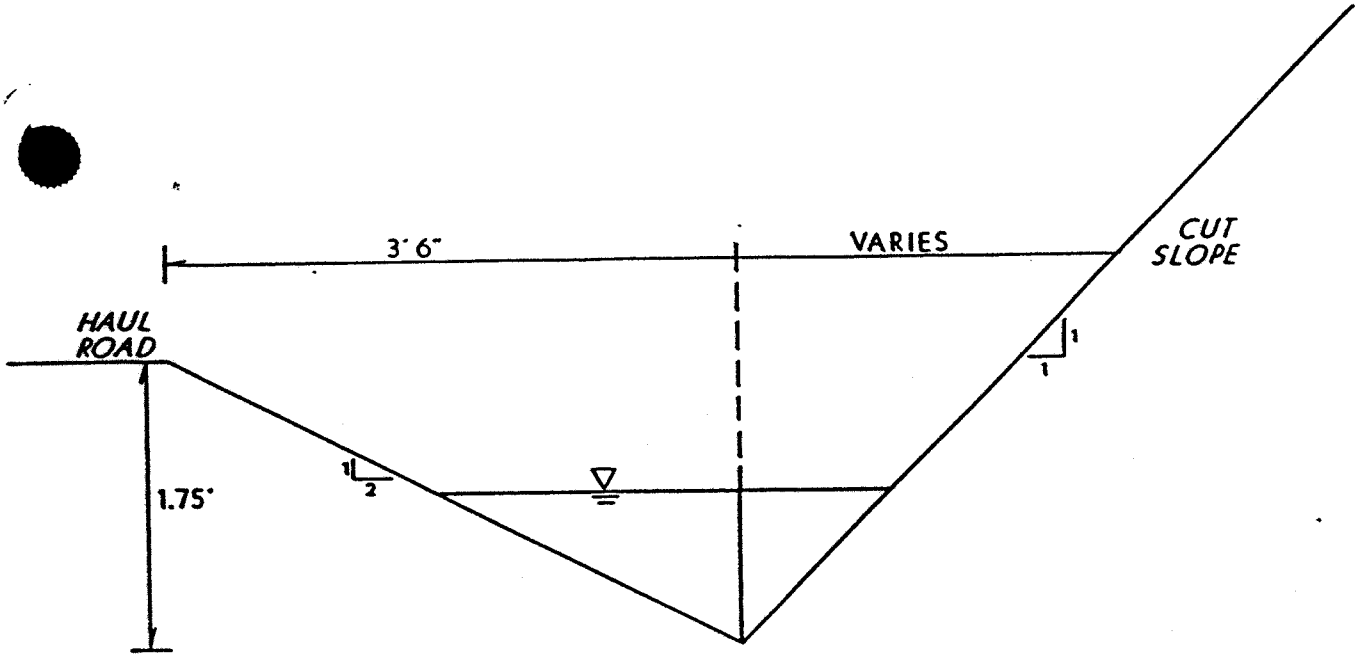
APPENDIX D-II

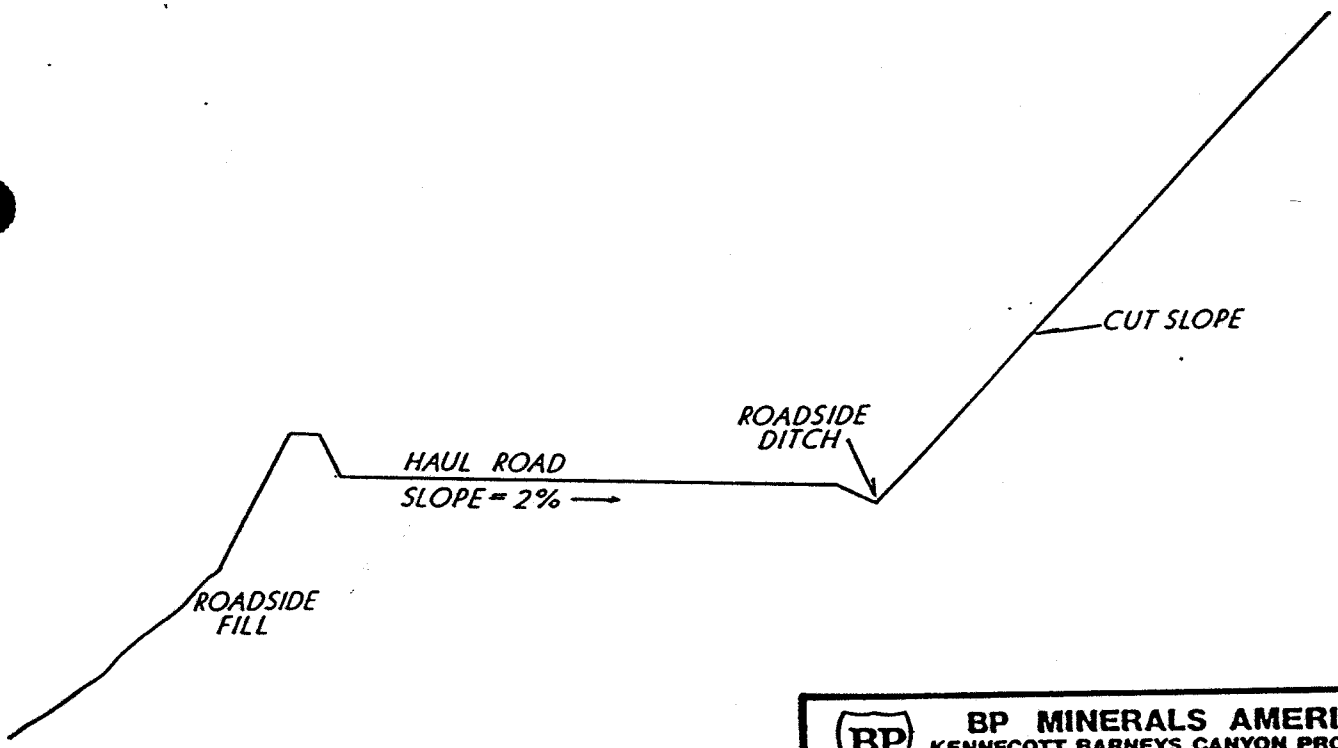
DESIGN SPECIFICATIONS FOR CHANNELS AND ROADSIDE DITCHES

Barneys Canyon Culvert Design

Reach/ Basin I. D.	Basin Area (acres)	Peak Flow (cfs)	Minimum Diameter (inches)	Minimum Headwater (inches)
O	45.2	0.1	12	8
N	118.0	0.3	12	8
Barneys Cyn.	1430.0	4.0	12	18
M	31.5	9.9	18	29
Mel-Co A	2.6	0.0	12	8
Mel-Co B	13.6	4.0	12	18
Upper Mel-Co	18.8	5.7	12	25
Lower Mel-Co	10.4	2.8	12	16

In addition to the culverts specified above, the Mel-Co to Barneys haul road has a number of 24-inch culverts placed at intervals of approximately 1,200 feet apart (Plate III). Drainage area O and the Barneys Canyon watershed are the only watersheds along this access route where culverts were designed specifically for runoff from the upland watershed. All designed culverts already installed are larger diameter than specified above and will carry runoff from storms larger than the 10-year events. Culverts have also been placed along the haul road leading from the Barneys Canyon pit to the crusher area. Two 36-inch culverts were installed (one in each drainage) beneath the road at the entrance to the Barneys Canyon pit to permit interim water drainage from the watersheds to be occupied by the pit. These culverts will be installed for the full length of the of project but will convey little water following pit excavation.



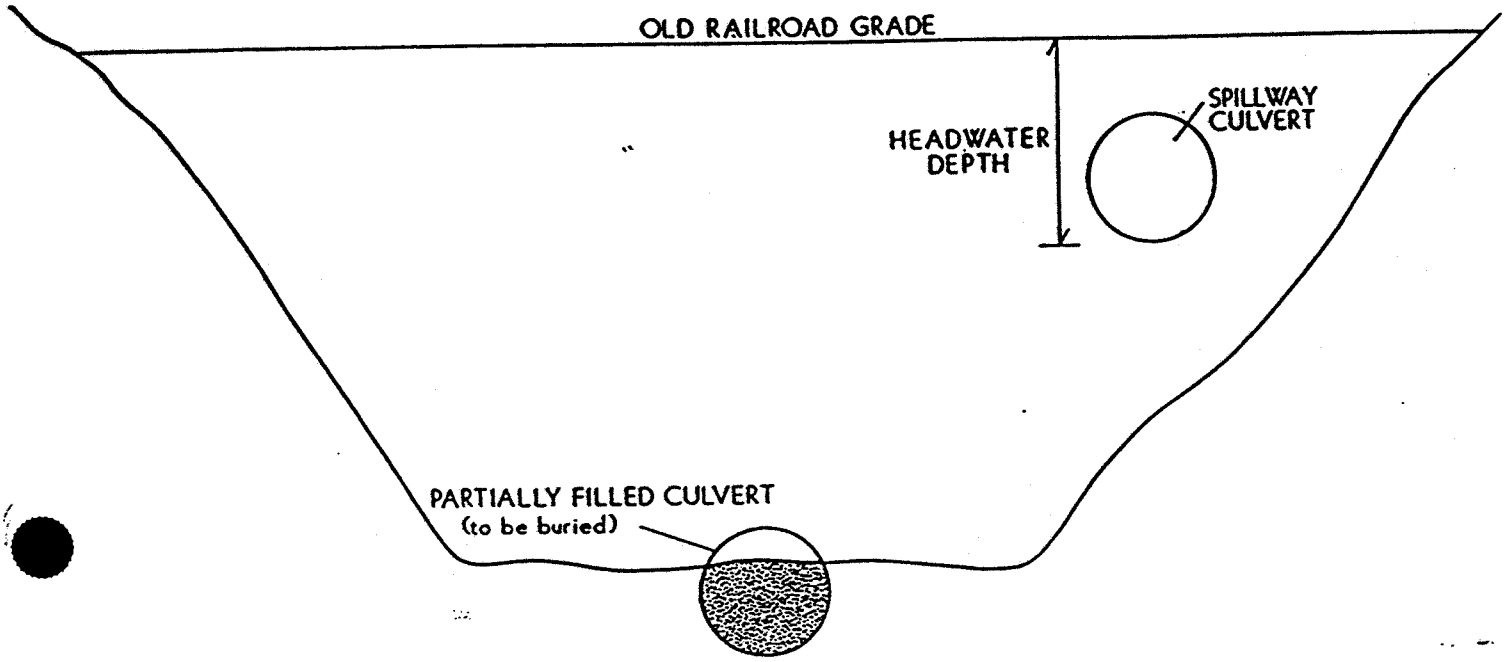


BP MINERALS AMERICA
KENNECOTT BARNEYS CANYON PROJECT
Salt Lake County, Utah

TYPICAL ROADSIDE DITCH DESIGN

jbr CONSULTANTS GROUP
SALT LAKE CITY, UTAH

DESIGNED BY:	DRAFTED BY:	DATE:
R.A.P.	C.L.P.	6/26/89



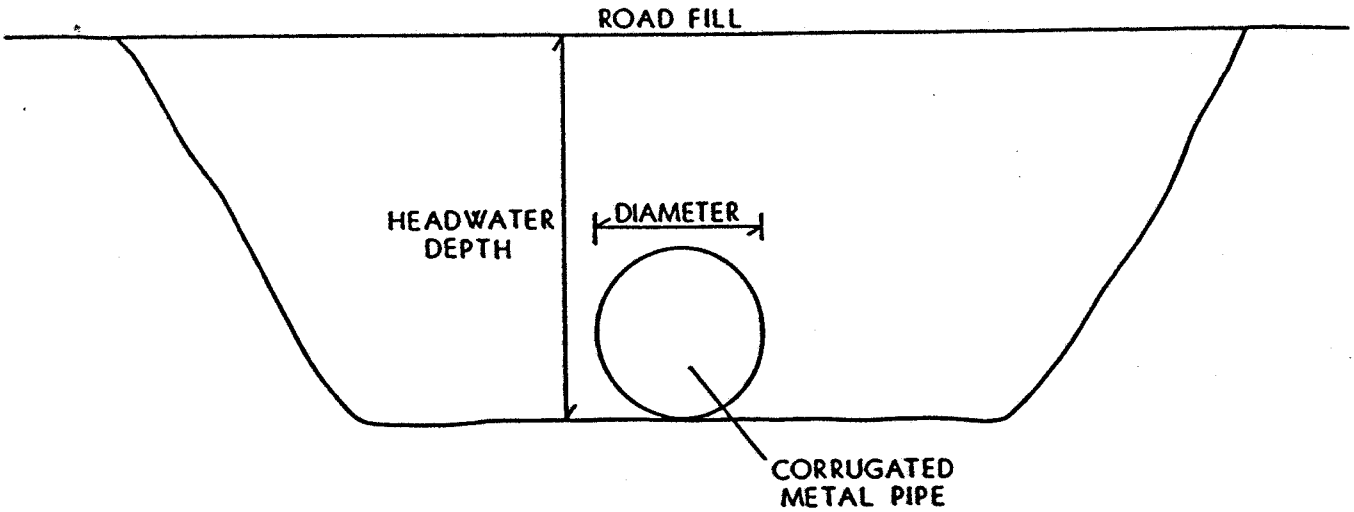
BP MINERALS AMERICA
KENNECOTT BARNEYS CANYON PROJECT
Salt Lake County, Utah

TYPICAL RAILROAD IMPOUNDMENT CROSS SECTION

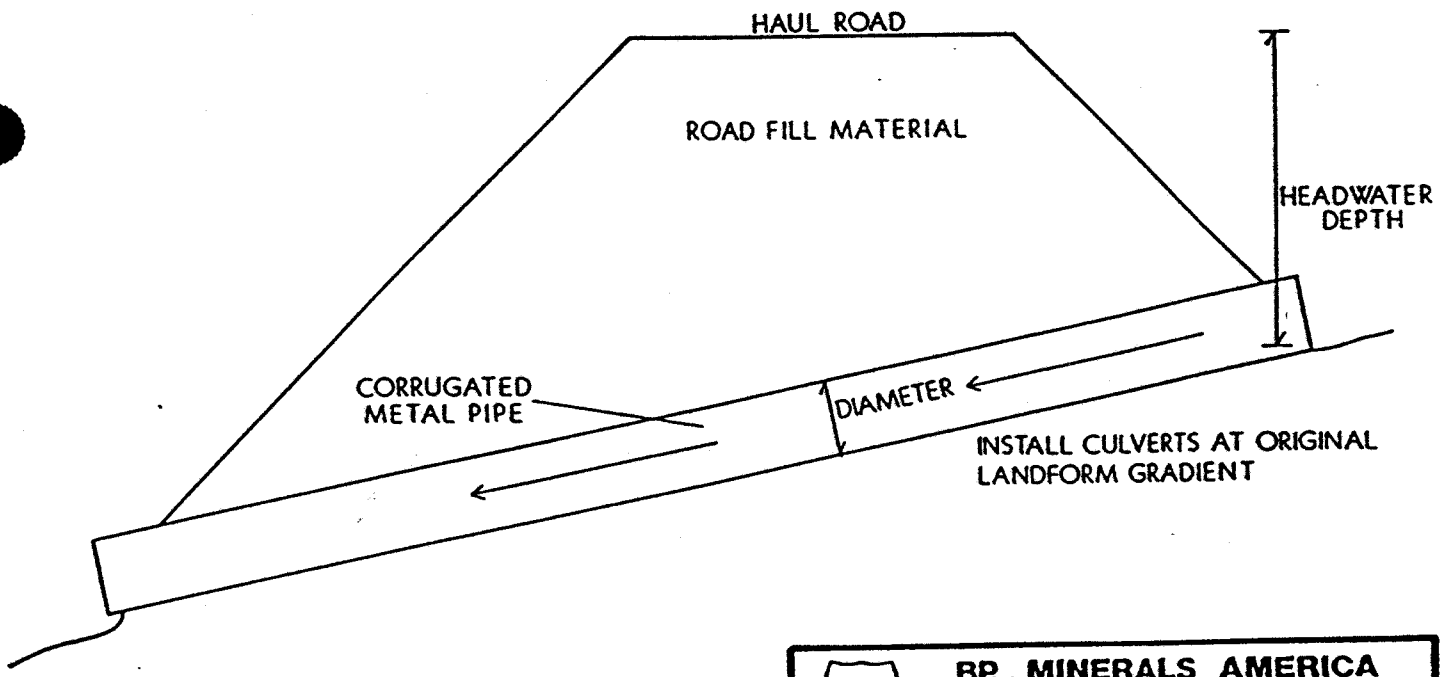
CONSULTANTS GROUP
SALT LAKE CITY, UTAH

DESIGNED BY:	DRAFTED BY:	DATE:
R.A.P.	C.L.P.	6/26/89

TYPICAL END SECTION



TYPICAL CROSS SECTION



BP MINERALS AMERICA
KENNECOTT BARNEYS CANYON PROJECT
Salt Lake County, Utah

CULVERT PLACEMENT AND DESIGN

CONSULTANTS GROUP
SALT LAKE CITY, UTAH

DESIGNED BY:	DRAFTED BY:	DATE:
R.A.P.	C.L.P.	6/26/89

TIME OF CONCENTRATION CALCULATIONS

KENT'S FORMULA

Time of Concentration (Kent's)

WS Ident=Barneys Canyon S

65 = CURVE NUMBER
7160 = MAX ELEV
5570 = MIN ELEV
1590 = ELEV DIF
580 = WS AREA (ACRES)
1400 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	5967.5	6600
LC 50	6365	3480
LC 75	6762.5	1860

0.187856 = y
0.146161 = L
0.243601 = Tc

WS Ident=Barneys Canyon O

48 = CURVE NUMBER
7657 = MAX ELEV
6720 = MIN ELEV
937 = ELEV DIF
45.2 = WS AREA (ACRES)
2000 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6954.25	1600
LC 50	7188.5	1400
LC 75	7422.75	400

0.404513 = y
0.20407 = L
0.340117 = Tc

Time of Concentration (Kent's)

WS Ident=Barneys Canyon P

65 = CURVE NUMBER
6500 = MAX ELEV
5520 = MIN ELEV
980 = ELEV DIF
332 = WS AREA (ACRES)
7440 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	5765	3720
LC 50	6010	4860
LC 75	6255	1440

0.169749 = y
0.585053 = L
0.975088 = Tc

WS Ident=Barneys Canyon Q

65 = CURVE NUMBER
5860 = MAX ELEV
5540 = MIN ELEV
320 = ELEV DIF
96 = WS AREA (ACRES)
2540 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	5620	2900
LC 50	5700	3000
LC 75	5780	1740

0.146159 = y
0.266867 = L
0.444779 = Tc

Time of Concentration (Kent's)

WS Ident=Barneys Canyon N

48 = CURVE NUMBER
7700 = MAX ELEV
6300 = MIN ELEV
1400 = ELEV DIF
118 = WS AREA (ACRES)
3200 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6650	2350
LC 50	7000	3050
LC 75	7350	1350

0.459623 = y
0.278831 = L
0.464718 = Tc

WS Ident=Barneys Canyon R

65 = CURVE NUMBER
8436 = MAX ELEV
5475 = MIN ELEV
2961 = ELEV DIF
462 = WS AREA (ACRES)
14820 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6215.25	3000
LC 50	6955.5	3960
LC 75	7695.75	3720

0.392844 = y
0.667436 = L
1.112393 = Tc

Time of Concentration (Kent 5)

WS Ident=Lower Mel-Co

65 = CURVE NUMBER
7400 = MAX ELEV
7240 = MIN ELEV
160 = ELEV DIF
10.4 = WS AREA (ACRES)
2200 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	7280	1020
LC 50	7320	1200
LC 75	7360	1560

0.333757 = y
0.157421 = L
0.262369 = Tc

WS Ident=Upgrad. BC pit haul road

76.3 = CURVE NUMBER
7160 = MAX ELEV
6500 = MIN ELEV
660 = ELEV DIF
31.5 = WS AREA (ACRES)
1800 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6665	1800
LC 50	6830	1620
LC 75	6995	600

0.483405 = y
0.081793 = L
0.136321 = Tc

Time of Concentration (Kent's)

WS Ident=Barneys Canyon Basin

48 = CURVE NUMBER
8600 = MAX ELEV
6340 = MIN ELEV
2260 = ELEV DIF
1430 = WS AREA (ACRES)
11500 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6905	15100
LC 50	7470	26300
LC 75	8035	16000

0.520639 = y
0.728973 = L
1.214955 = Tc

WS Ident=Barneys Canyon M

65 = CURVE NUMBER
7130 = MAX ELEV
6350 = MIN ELEV
780 = ELEV DIF
56.5 = WS AREA (ACRES)
1800 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6545	2340
LC 50	6740	1800
LC 75	6935	1380

0.437358 = y
0.117122 = L
0.195204 = Tc

Time of Concentration (Kent's)

WS Ident=Upgrad. BC pit haul road

65 = CURVE NUMBER
7160 = MAX ELEV
6500 = MIN ELEV
660 = ELEV DIF
31.5 = WS AREA (ACRES)
1800 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	6665	1800
LC 50	6830	1620
LC 75	6995	600

0.483405 = y
0.111405 = L
0.185674 = Tc

WS Ident=Upper Mel-Co

65 = CURVE NUMBER
7520 = MAX ELEV
7320 = MIN ELEV
200 = ELEV DIF
18.9 = WS AREA (ACRES)
1720 = LENGTH OF THE LONGEST CHANNEL (ft)

	ELEV	CONTOUR LENGTH
LC 25	7370	1340
LC 50	7420	2200
LC 75	7470	2380

0.359536 = y
0.124564 = L
0.207607 = Tc

RUNOFF PEAK CALCULATIONS

CURVE NUMBER METHOD

INPUT SUMMARY FOR: Barneys Canyon Basin

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 1430.00 acres
depth = 2.70 inches	cn = 48.00
duration = 24.00 hrs	time conc = 1.210 hrs

OUTPUT SUMMARY FOR: Barneys Canyon Basin

runoff depth	0.02502	inches	
initial abstr	2.16667	inches	
peak flow	3.98	cfs	(0.00276 iph)
at time	20.489	hrs	

INPUT SUMMARY FOR: Dump adjacent to pit

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 15.10 acres
depth = 2.70 inches	cn = 89.00
duration = 24.00 hrs	time conc = 0.567 hrs

OUTPUT SUMMARY FOR: Dump adjacent to pit

runoff depth	1.63097	inches	
initial abstr	0.24719	inches	
peak flow	17.05	cfs	(1.11991 iph)
at time	12.247	hrs	

INPUT SUMMARY FOR: Dump 6300

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 29.60 acres
depth = 2.70 inches	cn = 89.00
duration = 24.00 hrs	time conc = 0.785 hrs

OUTPUT SUMMARY FOR: Dump 6300

runoff depth	1.63097	inches	
initial abstr	0.24719	inches	
peak flow	27.60	cfs	(0.92475 iph)
at time	12.455	hrs	

INPUT SUMMARY FOR: Upper Mel-Co ditch/culverts

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 18.85 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.207 hrs

OUTPUT SUMMARY FOR: Upper Mel-Co ditch/culverts

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	5.70	cfs	(0.30005 iph)
at time	12.089	hrs	

INPUT SUMMARY FOR: Lower Mel-Co ditch/culverts

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 10.40 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.262 hrs

OUTPUT SUMMARY FOR: Lower Mel-Co ditch/culverts

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	2.81	cfs	(0.26839 iph)
at time	12.122	hrs	

INPUT SUMMARY FOR: Upper BC pit haul road

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 31.50 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.185 hrs

OUTPUT SUMMARY FOR: Upper BC pit haul road

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	9.90	cfs	(0.31160 iph)
at time	12.062	hrs	

INPUT SUMMARY FOR: Dump 6500

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 14.00 acres
depth = 2.70 inches	cn = 89.00
duration = 24.00 hrs	time conc = 0.463 hrs

OUTPUT SUMMARY FOR: Dump 6500

runoff depth	1.63097	inches	
initial abstr	0.24719	inches	
peak flow	17.54	cfs	(1.24232 iph)
at time	12.161	hrs	

INPUT SUMMARY FOR: Dump 6500

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 14.00 acres
depth = 3.00 inches	cn = 89.00
duration = 24.00 hrs	time conc = 0.463 hrs

OUTPUT SUMMARY FOR: Dump 6500

runoff depth	1.89983	inches	
initial abstr	0.24719	inches	
peak flow	20.43	cfs	(1.44754 iph)
at time	12.161	hrs	

INPUT SUMMARY FOR: Dump 6500

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 14.00 acres
depth = 3.70 inches	cn = 89.00
duration = 24.00 hrs	time conc = 0.463 hrs

OUTPUT SUMMARY FOR: Dump 6500

runoff depth	2.54265	inches	
initial abstr	0.24719	inches	
peak flow	27.27	cfs	(1.93173 iph)
at time	12.161	hrs	

INPUT SUMMARY FOR: Barneys Canyon N

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 118.00 acres
depth = 2.70 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.465 hrs

OUTPUT SUMMARY FOR: Barneys Canyon N

runoff depth	0.02502	inches	
initial abstr	2.16667	inches	
peak flow	0.34	cfs	(0.00288 iph)
at time	20.088	hrs	

INPUT SUMMARY FOR: Barneys Canyon N

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 118.00 acres
depth = 3.00 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.465 hrs

OUTPUT SUMMARY FOR: Barneys Canyon N

runoff depth	0.05952	inches	
initial abstr	2.16667	inches	
peak flow	0.78	cfs	(0.00654 iph)
at time	15.190	hrs	

INPUT SUMMARY FOR: Barneys Canyon N

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 118.00 acres
depth = 3.70 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.465 hrs

OUTPUT SUMMARY FOR: Barneys Canyon N

runoff depth	0.19012	inches	
initial abstr	2.16667	inches	
peak flow	4.85	cfs	(0.04074 iph)
at time	12.710	hrs	

INPUT SUMMARY FOR: Barneys Canyon O

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 45.20 acres
depth = 2.70 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.340 hrs

OUTPUT SUMMARY FOR: Barneys Canyon O

runoff depth	0.02502	inches	
initial abstr	2.16667	inches	
peak flow	0.13	cfs	(0.00291 iph)
at time	20.083	hrs	

INPUT SUMMARY FOR: Barneys Canyon O

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 45.20 acres
depth = 3.00 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.340 hrs

OUTPUT SUMMARY FOR: Barneys Canyon O

runoff depth	0.05952	inches	
initial abstr	2.16667	inches	
peak flow	0.30	cfs	(0.00666 iph)
at time	15.096	hrs	

INPUT SUMMARY FOR: Barneys Canyon O

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 45.20 acres
depth = 3.70 inches	cn = 48.00
duration = 24.00 hrs	time conc = 0.340 hrs

OUTPUT SUMMARY FOR: Barneys Canyon O

runoff depth	0.19012	inches	
initial abstr	2.16667	inches	
peak flow	1.87	cfs	(0.04102 iph)
at time	12.557	hrs	

INPUT SUMMARY FOR: Barneys Canyon P

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 332.00 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.975 hrs

OUTPUT SUMMARY FOR: Barneys Canyon P

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	40.29	cfs	(0.12036 iph)
at time	12.740	hrs	

INPUT SUMMARY FOR: Barneys Canyon P

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 332.00 acres
depth = 3.00 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.975 hrs

OUTPUT SUMMARY FOR: Barneys Canyon P

runoff depth	0.50607	inches	
initial abstr	1.07692	inches	
peak flow	59.83	cfs	(0.17872 iph)
at time	12.740	hrs	

INPUT SUMMARY FOR: Barneys Canyon P

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 332.00 acres
depth = 3.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.975 hrs

OUTPUT SUMMARY FOR: Barneys Canyon P

runoff depth	0.85924	inches	
initial abstr	1.07692	inches	
peak flow	115.68	cfs	(0.34554 iph)
at time	12.740	hrs	

INPUT SUMMARY FOR: Barneys Canyon Q

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 96.00 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.445 hrs

OUTPUT SUMMARY FOR: Barneys Canyon Q

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	19.15	cfs	(0.19786 iph)
at time	12.282	hrs	

INPUT SUMMARY FOR: Barneys Canyon Q

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 96.00 acres
depth = 3.00 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.445 hrs

OUTPUT SUMMARY FOR: Barneys Canyon Q

runoff depth	0.50607	inches	
initial abstr	1.07692	inches	
peak flow	28.64	cfs	(0.29591 iph)
at time	12.282	hrs	

INPUT SUMMARY FOR: Barneys Canyon Q

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 96.00 acres
depth = 3.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.445 hrs

OUTPUT SUMMARY FOR: Barneys Canyon Q

runoff depth	0.85924	inches	
initial abstr	1.07692	inches	
peak flow	55.33	cfs	(0.57161 iph)
at time	12.223	hrs	

INPUT SUMMARY FOR: Barneys Canyon R

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 462.00 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 1.112 hrs

OUTPUT SUMMARY FOR: Barneys Canyon R

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	51.40	cfs	(0.11034 iph)
at time	12.899	hrs	

INPUT SUMMARY FOR: Barneys Canyon R

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 462.00 acres
depth = 3.00 inches	cn = 65.00
duration = 24.00 hrs	time conc = 1.112 hrs

OUTPUT SUMMARY FOR: Barneys Canyon R

runoff depth	0.50607	inches	
initial abstr	1.07692	inches	
peak flow	75.76	cfs	(0.16263 iph)
at time	12.899	hrs	

INPUT SUMMARY FOR: Barneys Canyon R

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 462.00 acres
depth = 3.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 1.112 hrs

OUTPUT SUMMARY FOR: Barneys Canyon R

runoff depth	0.85924	inches	
initial abstr	1.07692	inches	
peak flow	148.87	cfs	(0.31957 iph)
at time	12.751	hrs	

INPUT SUMMARY FOR: Barneys Canyon S

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 580.00 acres
depth = 2.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.244 hrs

OUTPUT SUMMARY FOR: Barneys Canyon S

runoff depth	0.37593	inches	
initial abstr	1.07692	inches	
peak flow	162.40	cfs	(0.27768 iph)
at time	12.102	hrs	

INPUT SUMMARY FOR: Barneys Canyon S

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 580.00 acres
depth = 3.00 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.244 hrs

OUTPUT SUMMARY FOR: Barneys Canyon S

runoff depth	0.50607	inches	
initial abstr	1.07692	inches	
peak flow	238.29	cfs	(0.40744 iph)
at time	12.102	hrs	

INPUT SUMMARY FOR: Barneys Canyon S

STORM :	WATERSHED :
dist =SCS Type II - 24 Hr	area = 580.00 acres
depth = 3.70 inches	cn = 65.00
duration = 24.00 hrs	time conc = 0.244 hrs

OUTPUT SUMMARY FOR: Barneys Canyon S

runoff depth	0.85924	inches	
initial abstr	1.07692	inches	
peak flow	438.83	cfs	(0.75035 iph)
at time	12.102	hrs	

APPENDIX D-II(a)

EAST BARNEYS FLOW CALCULATIONS

BARNEYS CANYON MINE
EAST BARNEYS CANYON FLOW CALCULATIONS

Assumptions

- All culvert and ditch design criteria based on data from Mining and Reclamation Plan, KBCMC, submitted to Utah Division of Oil, Gas and Mining, Volume II Appendices D II.
- Use peak flow (cfs) 4.0 (p.81)
- Use triangular ditch type
- Ditch to be an erodible channel - nonvegetated
- Ditch will be construct in both alluvial and hardpan type materials. Limiting velocity will be the lower value of the two.

BC MINE EAST
EAST B.C. FLOW CALCULATIONS

From Table 3.2 Limiting Velocities for open chambers.

$V_p = 5$ fps, $n = 0.025$

$V_p = \frac{1.49}{n} R^{2/3} S^{1/2}$ (Manning's Equation)

$R = \left(\frac{V_p \, n}{1.49 \, S^{1/2}}\right)^{3/2} = \frac{(5(.025))}{1.49\,(0.5)^{1/2}}^{3/2} = 0.23$

$A = Q/V_p = 4/5 = 0.80 \text{ ft}^2$

$R = \frac{A}{P} = \frac{Zd^2}{2d\,Zd^2+1} = \frac{2d^2}{2d\;2d^2+1} = \frac{d}{(5)^{1/2}} = 0.23$

$A = Zd^2 = 2d^2 = 0.80 \text{ ft}^2$

Solving for d,

$d = \underline{0.51} \text{ ft}$

$2d^2 = 0.80, \quad d^2 = \frac{0.80}{2}, \quad d = \underline{0.63} \text{ ft}$

<u>Check</u> use $d = 0.63$ ft

$R = \frac{d}{5} = \frac{.63}{5} = 0.28$

$V = \frac{1.49}{n} R^{2/3} S^{1/2} = \frac{1.49}{.025} (.28)^{2/3} (.050)^{1/2} = 5.68$

Velocity will be close to the limiting velocity. Velocity is ok.

$A = 2d^2 = 2(0.63)^2 = 0.79$

$Q = VA \quad = \quad 5(0.79) = 3.95 \text{ cfs} \simeq 4 \text{ cfs}$

The capacity is ok.

Add 0.5 feet of freeboard to get design of 1.0 ft. We will use a ditch of a total depth of 1.5 ft versus the 1.0 ft calculated due to operational factors..

Design

V_p = fps, n = 0.025,

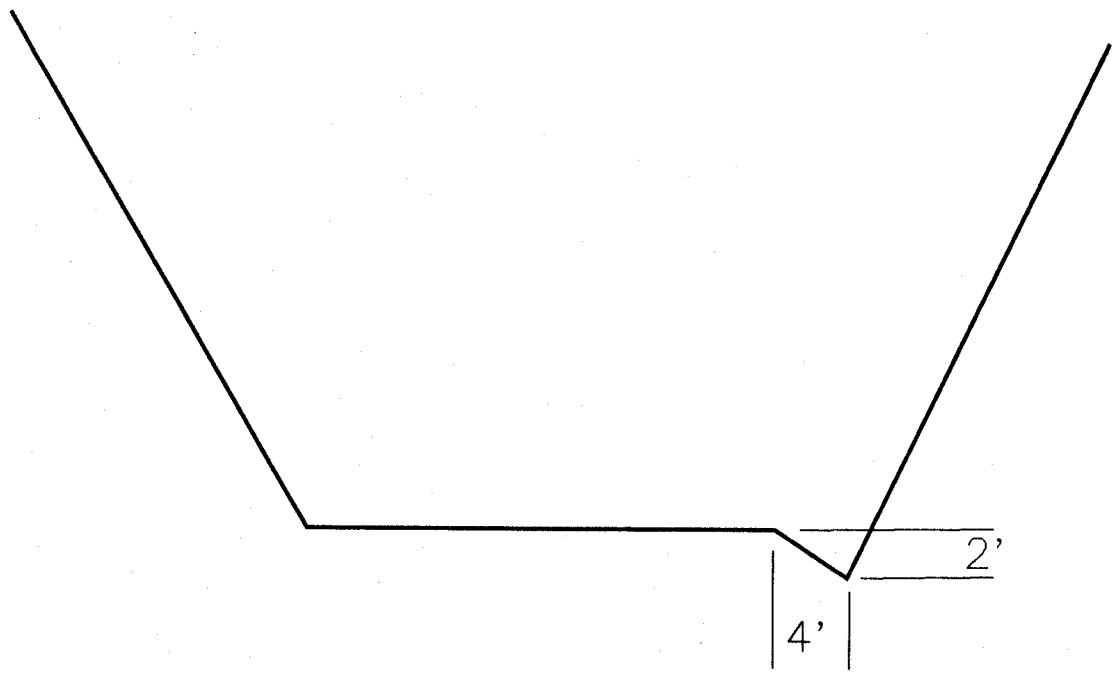
@ d = 1'

$$V_p = \frac{1.49}{0.025} (0.45)^{2/3} (0.05)^{1/2}$$

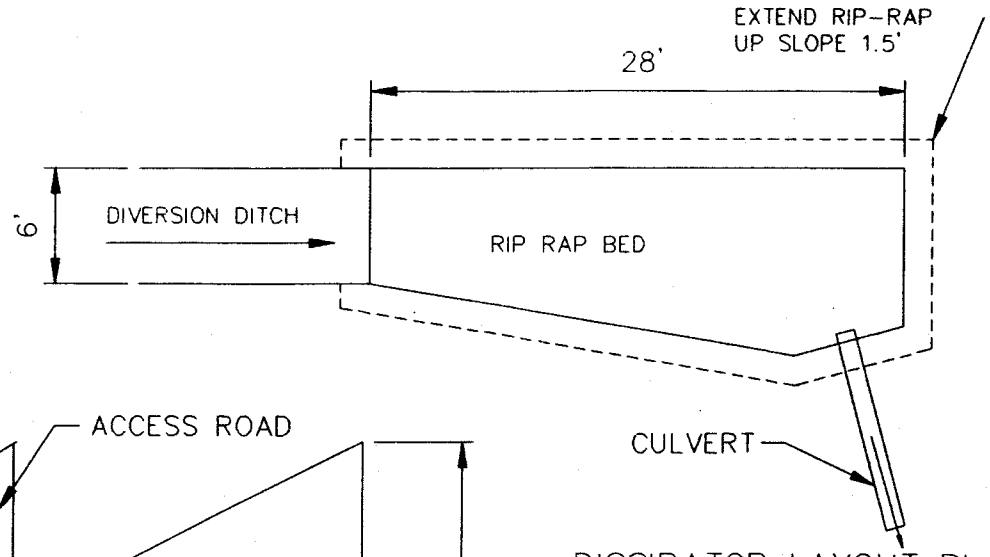
= 7.81 fps (Ditch can handle more flow than required)

$V_{AVG} = Q/A = 4/2 = 2$ ft/sec <5 ft/sec

$Q = VA = 7.81\ (2) = \underline{15.62}\ ft^3/sec > 4.0\ ft^3/sec$

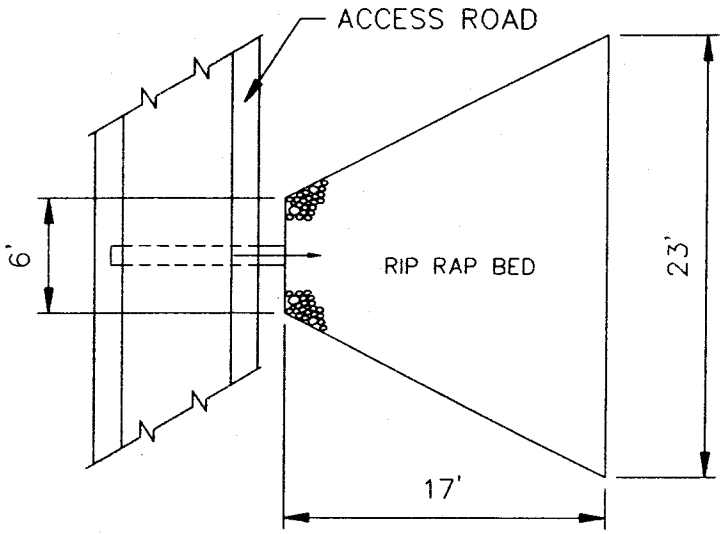


East Barneys Mine
Typical Drainage Ditch Design

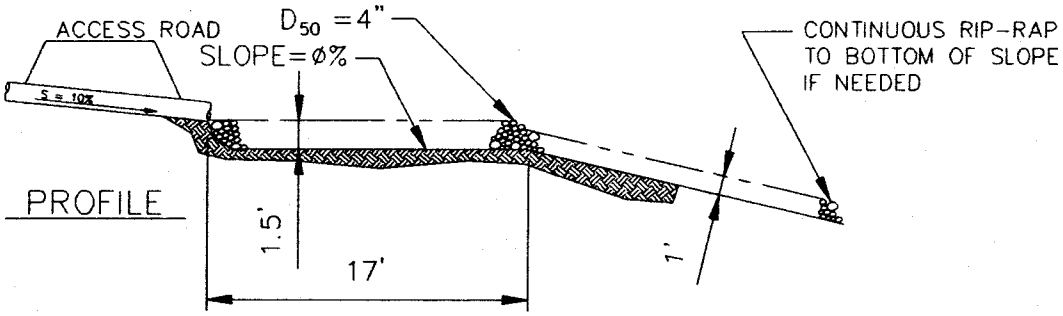


DISSIPATOR LAYOUT PLAN

SCALE 1"=10'



PLAN



PROFILE

ACCESS ROAD CULVERT OUTLET PROTECTION

SCALE: 1"=10'

BARNEYS CANYON MINING COMPANY

BARNEYS CANYON MINE

EAST BARNEYS PIT
DIVERSION RIP RAP DESIGN

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

DESIGN BY	DRAWN BY	CH'D BY	SCALE	DATE DRAWN	REVISION
BWB	CLP		NOTED	2/12/97	

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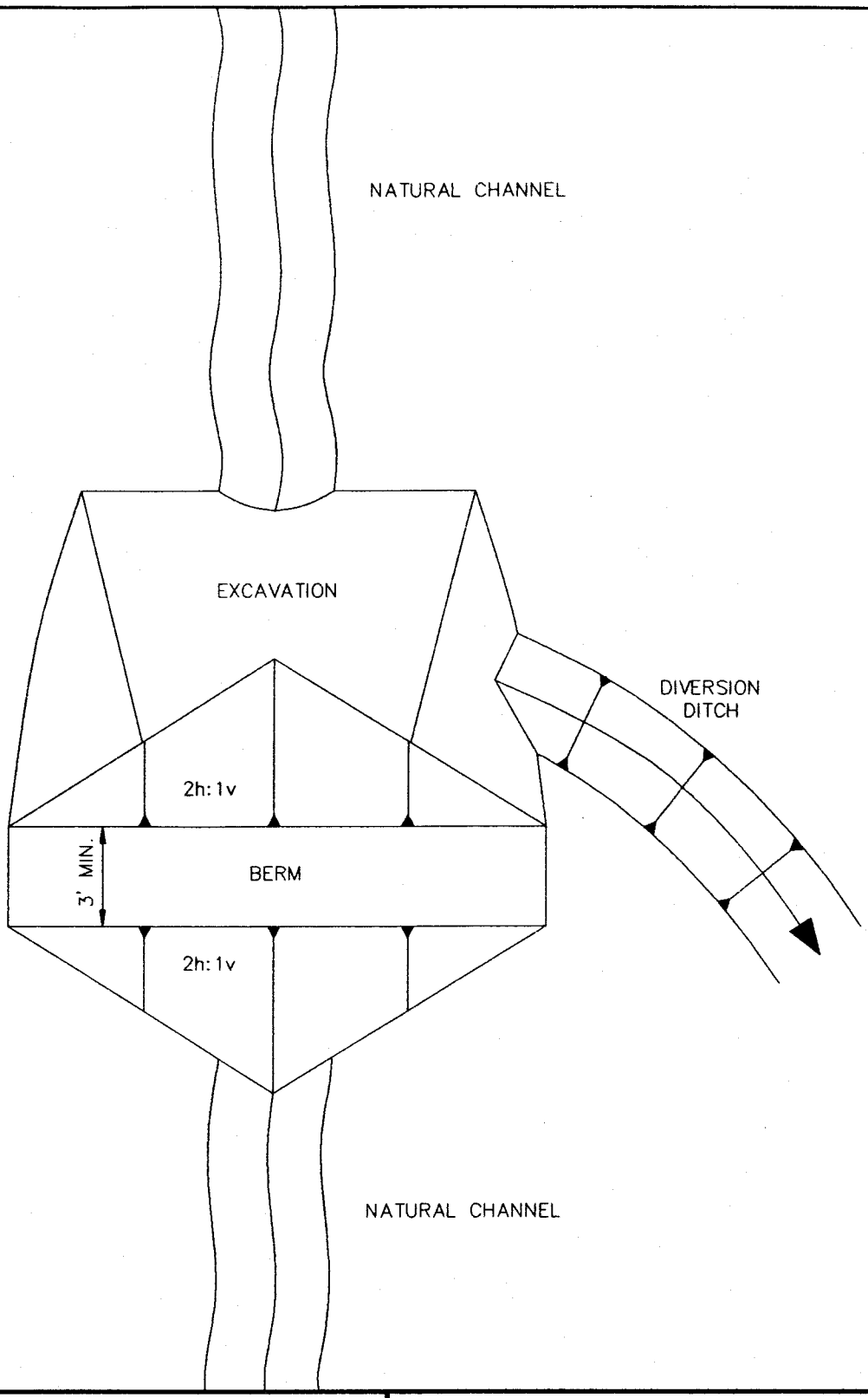
APPENDIX D-II(b)

DIVERSION BERM DESIGN



NOTE: ELEVATION OF TOP OF BERM SHALL BE AT LEAST 1.5' ABOVE BOTTOM OF DIVERSION DITCH AT ENTRANCE TO SAME.

BARNEYS CANYON MINING COMPANY
BARNEYS CANYON MINE

EAST BARNEYS PIT
DRAINAGE DIVERSION BERM

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

DESIGN BY	DRAWN BY	CH'D BY	SCALE	DATE DRAWN	REVISION
BWB	CLP		NTS	2/12/97	

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APPENDIX D-II(c)

DRAINAGE CHANNEL DESIGN AND FLOW CALCULATIONS

SEDCAD+ RIPRAP CHANNEL DESIGN

Barney Canyon

INPUT VALUES:

Shape	TRAPEZOIDAL	
Discharge	195.00 cfs	
Slope	33.00 %	
Sideslopes (L and R)	2.00:1	2.00:1
Bottom Width	8.00 feet	
Freeboard	1 ft	

RESULTS:

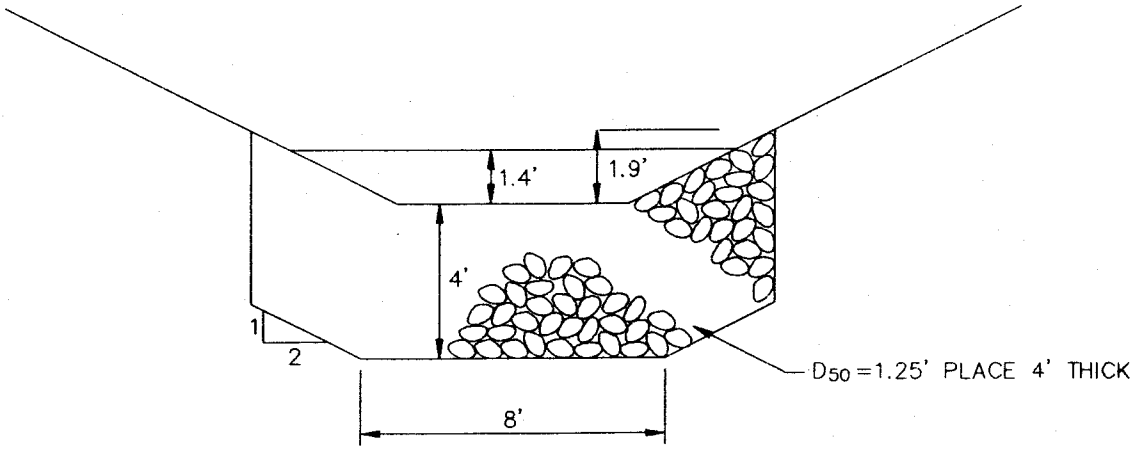
Steep Slope Design - PADER Method

Depth	1.39 ft
with Freeboard	2.39 ft
Top Width	13.55 ft
with Freeboard	17.55 ft
Velocity	13.03 fps
Cross Sectional Area	14.97 sq ft
Hydraulic Radius	1.05 ft
Manning's n	0.068
Froude Number	2.19
Dmax	1.563 ft (18.75 in)
D50	1.250 ft (15.00 in)
D10	0.417 ft (5.00 in)

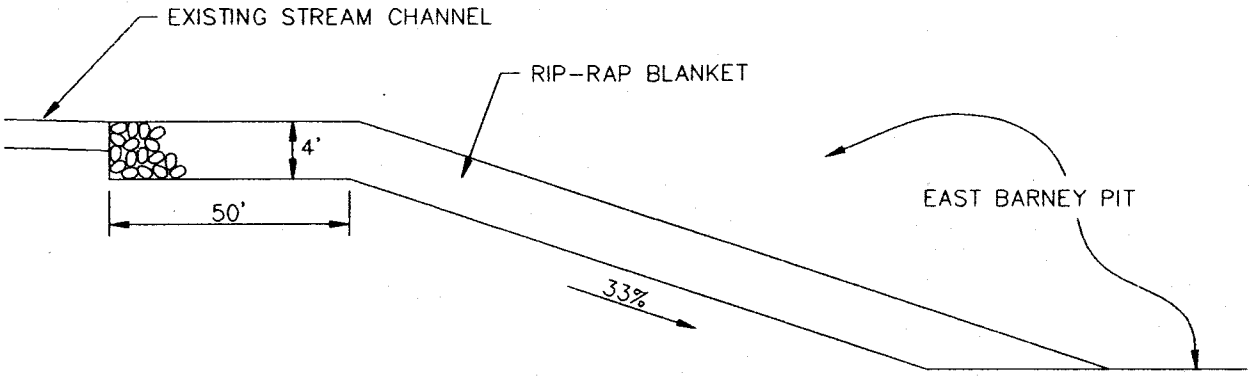
```
INPUT FOR: Barneys Canyon Basin
-------------------------------------------------------------
     STORM :                              WATERSHED :
   dist =SCS Type II - 24 Hr            area =  1430.00   acres
   depth =  3.70   inches                 cn = 57.00
   duration = 24.00  hrs                time conc =  1.210  hrs
  number of lines      164
-------------------------------------------------------------

 OUTPUT FORMAT: 1=short, 2=long
? 1

OUTPUT SUMMARY
-------------------------------------------------------------
    runoff depth       0.49321    inches
    initial abstr      1.50877    inches
     peak flow=       195.43     cfs   (  0.13553  iph )
   at time    13.068    hrs
-------------------------------------------------------------
```



CROSS SECTION



PROFILE

BARNEYS CANYON MINING COMPANY
BARNEYS CANYON MINE

EAST BARNEYS PIT CHANNEL
CROSS SECTION AND PROFILE

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

DESIGN BY	DRAWN BY	CH'D BY	SCALE	DATE DRAWN	REVISION
BWB	CLP		NTS	2/12/97	

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APPENDIX E

GRADING FOUNDATION SPECIFICATIONS

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
Salt Lake County, Utah

TECHNICAL SPECIFICATION - No: 87105-01

SITE WORKS

LEACH PAD AND POND CONSTRUCTION

ACCESS ROADS

PREPARED BY: A. PATWARDHAN
MINE AND MILL ENGINEERING, INC.
June 27, 1988

Reviewed: Paul Kaplan - (SHB)

Zip Zavodni - (BPMA)

Robert Parker - (BPMA)

Approved: _____
BP Minerals America

Rev. No.	Date	Revisions	By	Approved
0	6/28/88	Released for Construction	AP	

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
SALT LAKE COUNTY, UTAH

INDEX

SPECIFICATION FOR SITE WORKS LEACH PAD AND POND CONSTRUCTION ACCESS ROADS

SPECIFICATION NO: 87105-01

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2.0 DEFINITIONS OF MATERIALS	1
3.0 CLEARING, GRUBBING AND STRIPPING	2
4.0 EXCAVATION	3
5.0 STOCKPILING	5
6.0 BACKFILL MATERIALS	5
7.0 PLACEMENT OF BACKFILL	9
8.0 DRAINAGE AND WATER CONTROL	12
9.0 ROAD MAINTENANCE AND DUST CONTROL	13
10.0 CONTRACTOR'S QUALITY CONTROL	13
11.0 INSPECTION AND EVALUATION OF WORK	13

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
SALT LAKE COUNTY, UTAH

SPECIFICATION FOR SITE WORKS LEACH PAD AND POND CONSTRUCTION ACCESS ROADS

1.0 SURVEY

1.1 The Contractor will establish the control lines based on benchmarks and monuments shown and shall be responsible for all surveying to control the work.

1.2 All survey work will be subject to checking by the Owner's Representative.

2.0 DEFINITIONS OF MATERIALS

The materials for earthwork and embankment construction are defined in detail as follows:

2.1 Rock: A solid mass of material exceeding one cubic yard in volume, which cannot be effectively loosened or broken down by ripping in a single pass with a late model dozer mounted hydraulic ripper equipped with a single digging point; of standard manufacturers design adequately sized for use with and rated at a minimum 410-net flywheel horsepower operating in low gear.

2.2 Soil: The superficial mantle of unconsolidated or partially consolidated material that nearly everywhere covers the rock may be of natural or man-made origin (fill).

2.3 Soil Components:

2.3.1 Clay: Plastic soil which passes a U.S. Standard #200 sieve.

2.3.2 Silt: Nonplastic soil which passes a U.S. Standard #200 sieve.

2.3.3 Sand: Solid mineral grains which pass a U.S. Standard #4 sieve and retained on a #200 sieve, non cohesive.

2.3.4 Gravel: Solid mineral masses which are retained on a U.S. Standard #4 sieve, and are less than three inches in maximum dimensions.

2.3.5 Cobbles: Solid mineral masses which are not greater than 12 inches but are larger than three inches in maximum dimensions.

2.3.6 Boulders: Solid mineral masses which are not greater than one cubic yard in volume, but are larger than 12 inches in maximum dimension.

2.4 Topsoil

For purposes of this Specification, topsoil shall be defined as soil of any gradation or degree of plasticity which contains significant quantities of visually-identifiable vegetative matter, sod, roots, or humus. As a minimum, the upper six inches of soil below the natural ground surface shall be considered topsoil. Topsoil depths shall be as defined in the Geotechnical Report, or as defined by the Owner's Representative. Topsoil as defined herein is not suitable for use as compacted embankment fill material, and shall be stripped from all foundation surfaces.

3.0 CLEARING, GRUBBING AND STRIPPING

3.1 Clearing, grubbing and stripping shall be performed as required and as directed by Owner's Representative.

3.2 Clearing will consist of removal and disposal of all trees, brush, logs, limbs, wood, grass, rubbish, structures and all other obstructions resting on the surface of the original ground. Also included is the removal of brush and grass root material which compose approximately the top 6 inches of surface material in some non-agricultural areas. Unless otherwise shown, clearing shall be performed within the following limits:

- Within the limits of and 10 ft. outside the limits of the excavation, fills and stockpiles.

- Along roadways 30 feet minimum on each side of the center line or 5 ft. beyond the cut shoulder or toe of fill.

3.3 Grubbing will consist of the removal and disposal of all stumps, buried logs, stubs and roots larger than 1-1/2 inch in diameter within the areas cleared to a depth of 2.0 feet below original ground. Within areas to be filled, stump holes and depressions shall be backfilled and compacted. Within areas to be excavated, stump holes may be left open.

3.4 Stripping will consist of the removal of the topsoil as defined in paragraph 2.4.

3.5 All clearing, grubbing and stripping operations shall include the preservation from injury or defacement of all trees, vegetation and objects located beyond or outside the work limits.

4.0 EXCAVATION

4.1 Scope of Work

This Specification covers the required excavation, the removal and proper utilization or disposal of all excavated material and the shaping and finishing of all excavation work to the required lines, grades, and cross sections as shown on the drawings.

4.2 Classification of all excavated materials shall be included in the following:

a. Common excavation shall include all materials except those defined as rock or topsoil.

b. Rock excavations include all materials which cannot be removed as defined in section 2.1 except by blasting and all detached masses of this material exceeding one cubic yard each. The presence of such boulders or rock fragments shall not in itself be considered sufficient cause to change the classification of the surrounding material.

4.3 The class of excavation shall be determined by the Owner or its designated representative on the basis of his determination of the character of the materials to be excavated and the prevailing site conditions.

4.4 Suitable excavated materials shall be utilized in backfills. Unsuitable or excess excavated material shall be disposed of at waste locations indicated by the Owner's Representative.

4.5 Pockets of unsuitable materials within the limits of excavation shall be removed and wasted. The excavation shall be finished to the lines, grades, and typical sections shown on the drawings or as directed by the Owner's Representative.

4.6 The method of excavation shall not weaken surrounding areas or damage structures or parts thereof that are completed or under construction. Existing structures and utilities adjacent to excavations shall be protected and supported to prevent settlement.

4.7 During grading operations, the surface of the excavated area shall be maintained in such condition so as to ensure adequate drainage. Water in excavations shall be controlled and removed. Discharge from pumps shall be wasted at locations as directed. Springs or seepage encountered shall be reported immediately and controlled as directed.

4.8 After initial clearing and grubbing, excavation of any softer soils to the contact of relatively firm soils shall be performed only at the direction of the Owner's representation. If required, overexcavation shall be performed in embankment foundations and base areas for the leach pad, ponds, and perimeter dike foundation areas. Confirmation of adequate sub-excavation and exposure of firm soils shall be made by the Owner's Representative

4.9 Except as otherwise shown, grading tolerances shall be zero to minus 0.1 ft. for horizontal and sloped planes of common excavation and zero to minus 0.5 ft. for horizontal and sloped planes of rock excavation. Rock cut slopes shall be sealed of all loose rocks and fragments, and left in a neat, safe and workmanlike condition.

5.0 STOCKPILING

5.1 Different classes of backfill material shall be stockpiled separately at designated areas. Stockpiled materials include topsoil, common backfill, select backfill, sand backfill and unsuitable materials. Classification of these materials shall be in accordance with Section 2.0 and shall be performed by the Owner's Representative.

5.2 Stockpiles and unsuitable materials shall be placed in such a manner to provide natural drainage and a stable embankment.

5.3 Stockpiles shall be constructed with a maximum height not exceeding 40 ft.

6.0 BACKFILL MATERIALS

6.1 Backfill materials shall be obtained from required excavations and shall be free from deleterious substances such as expansive clay, snow, ice, frozen ground, rubbish, organic, perishable or uncompactable material.

6.2 When backfill materials are not available from required excavations, these materials shall be obtained from borrow pits at locations shown or as directed, or from off-site sources. Backfill materials shall include common backfill, select backfill, pervious backfill, impervious backfill, and sand backfill.

6.3 Common backfill materials shall conform to the following requirements:

a. Maximum size rock shall be no larger than the layer thickness.

b. Plasticity index when tested in accordance with ASTM - D4318 shall be less than 15.

6.4 Select backfill materials shall conform to the following requirements.

a. When tested in accordance with ASTM D422, material shall be well graded with 100 percent less than six inch size and a maximum of 15 percent passing the No. 200 sieve.

b. Plasticity index when tested in accordance with ASTM - D4318 shall be less than 15.

6.5 Pervious backfill, (general usage) to be used as a drainage material as indicated on the drawings shall be a free draining material consisting of rounded, hard, durable and tough stone or gravel conforming to the following gradations:

Sieve Size	Percent	Passing
2-1/2 inch	100	
1-1/2 inch	80-96	100
1/2 inch	58-74	50-80
No. 4	36-52	30-65
No. 40	9-17	10-30
No. 200	0-3	0-3

6.6 Sand backfill, to be used where specified as a blanket material to protect membrane liners shall be non-plastic clean sand, free of clay, organic matter and other deleterious material.

The drain sand material to be specifically used in the Leachate Collection and Recovery System (LCRS) either on leach pads or leachate retention ponds shall conform to the following requirements:

Sieve Size	% Passing by Weight
3/4 inch	100
1/2 inch	100
No. 4	50-100
No. 40	20-70
No. 200	0-5

Plasticity Index: Nonplastic
Permeability: $K = 1 \times 10^{-3}$ cm/sec

6.7 Sand Cushion Mix for Water and Process Tank Bases (Where Applicable)

Sand shall be fine, clean, granular material with at least 95% of material passing a #4 sieve. It shall be thoroughly saturated with a heavy oil at a rate of approximately 1/2 gallon per square foot of sand. The oil shall have a viscosity of not less than 800 SSU at 122 degrees F. Cut-back asphalts, may also be used, provided that the rate of application is increased to approximately 3/4 gallon per sq. foot of sand and the tank bottom plates are placed within 48 hours after mixing the sand and asphalt.

6.8 Impervious backfill for leach pads, leachate collection ponds, mill catch basins and related water retention areas shall mean naturally occurring materials, mechanically modified as needed and conforming to the following specifications. All material shall be classified according to the Unified Soil Classification System (USCS) and must meet one of the following classifications: CH, CL, MH, ML, or SC. The Owner's Representative may allow deviations from these specifications if, in his judgement, the material will perform equal to or better than the specified material for the intended use.

Materials:

All materials used in the construction of clay liners shall conform to the following requirements.

Sieve Size	% Passing by Weight
3 inch	100
No. 4	50-100
No. 200	25-100
Plasticity Index:	20 min (as per ASTM D4318)

Materials which do not meet these criteria will require addition of commercial grade bentonite to reduce permeability.

The site clay soils shall be blended with a minimum of 1 percent bentonite by weight in either a powdered or sand size granular form.

The bentonite shall be placed over the surface of a uniform 8-inch loose thickness of soil spread over the area of the soil liner with distributor equipment capable of controlling the rate of application. Thorough mixing of the soil and bentonite shall then be performed using a disk, rotary hoe, rototiller or similar equipment to uniformly blend the bentonite and soil. The blended material shall then be moisture conditioned to near optimum moisture and compacted with a sheepsfoot-type roller to a minimum of 95 percent of the maximum dry density as determined by ASTM D1557. Subsequent lifts shall be placed, blended and compacted in a similar manner.

The Contractor shall be responsible for maintaining the soil liner at optimum moisture content until the liner is placed. Any area which becomes dry or desiccated shall be scarified, moisture conditioned and recompacted.

Bentonite utilized for the soil liner shall be a commercial grade sodium montmorillonite material with a minimum free swell index of 100. The material shall have a liquid limit of greater than 100 and a plasticity index of greater than 80, when tested in accordance with ASTM D4318.

6.9 Rip-Rap

Rip-Rap shall conform to the following requirements:

Sieve Size	% Passing by Weight
18 inch	90-100
9 inch	40- 60
No. 200	0- 12

6.10 Wear Course

Material generally referred to as the wear course for access and plant service roads including parking lots shall be bank run screened material or crushed mine waste rock free of clay.

All material shall meet the following requirements:

Sieve Size	% Passing by Weight
3 inch	100
1-1/2 inch	95-100
3/4 inch	80- 90
1/2 inch	70- 80
No. 4	50- 60
No. 16	25- 35
No. 200	5- 10

The percentage of wear when subjected to the Los Angeles abrasion test (ASTM C131) shall be no more than 40.

The percent loss when subjected to the sodium sulfate soundness test shall be no more than 12.

6.11 All backfill shall conform within the tolerances specified to the lines, grades, sections and elevations shown.

6.12 Except as otherwise shown, grading tolerances shall be plus or minus 0.2 ft. for all exposed surfaces of backfill.

6.13 Backfill materials shall not be placed on snow, ice or frozen ground surfaces. All excavations to receive backfill shall be cleaned of all trash and debris. All foundations for embankments shall be free from any organic matter. All foundation excavations shall be approved by the Owner's Representative prior to placing any fill material.

7.0 PLACEMENT OF BACKFILL

Embankments and fills shall be constructed to the lines and grades shown on the construction drawings.

The fill shall be placed in approximately horizontal layers not exceeding eight inches in loose thickness. The distribution of materials within the fill shall be such that no lenses, pockets, or streaks of material differing substantially in gradation or texture from surrounding material in the fill zone exist. The various fill zones in the embankment shall be carried up together such that the surfaces of the zones at adjacent sections do not vary in elevation by more than three feet. If the surface of the fill becomes too dry or hard to permit suitable bonding with the subsequent layer, the material shall be loosened by scarifying or disc harrowing, moistened, and recompacted before an additional lift is placed. Under no circumstances shall any fill be placed in standing or ponded water. Fill shall not be placed upon a frozen surface, nor shall snow, ice, or frozen soil be incorporated into the fill. During construction, the surface of the fill shall be maintained with a crown or cross-slope that will ensure effective surface drainage.

Where fill is to be placed against existing slopes steeper than 6 to 1 (horizontal to vertical), the slope shall be benched at least 8 feet horizontally for every 2 feet of fill height so as to prevent a weakened slip plane between the fill and natural ground.

7.1 Finish Grading Tolerances

Finish grading and excavation shall be performed to within plus or minus 0.1 ft. of the lines, grades, elevations, and sections shown except that subgrades of roads and parking areas shall be graded to within 0.05 ft. of the lines, grades, elevations, and sections shown.

7.2 Moisture Control

During the compaction operation of all fill material, the surface of the fill and the material being placed will be maintained within the moisture content range required to permit proper compaction to the specified density. The moisture content will be distributed uniformly throughout each layer of fill. Average placement moisture will be at or slightly above the optimum moisture content. The moisture content during compaction shall be maintained within the limits of 1% below to 3% above optimum moisture content as determined in accordance with ASTM D1557. Any material compacted drier than this will be scarified, moisture conditioned to the proper moisture content, and recompacted. Material to be aerated by blading, discing, harrowing or as approved to hasten the drying process. Compaction tests will be made by the Owner's Representative during the placement of the fill, and optimum moisture and Maximum Dry Densities will be determined. Water may be added to the material by sprinkling on the placed fill material and shall be mixed uniformly throughout the layer immediately prior to compaction. If any admixtures are used, the optimum moisture content and Maximum Dry Density will be determined with the admixtures in the soil.

Compaction tests will be made by the Owner's Representative during placement of the fill. In place testing of compacted fills may be performed by the Nuclear Method in accordance with ASTM D3017 and ASTM 2922.

7.3 Compaction

The Contractor shall furnish and operate the necessary type of equipment required to obtain the compacted density specified herein. After each layer of fill material has been placed and contains the required moisture content, it shall be compacted by passing compaction equipment over the entire surface a sufficient number of times to obtain the density specified. Tests of original ground, fill, embankment, and soil liner materials will be made at the following suggested minimum rates:

1) One field density test for each 1500 square yards of original ground surface prior to placing fill or floor slab construction.

2) One field density test for each 500 cubic yards of fill placed or each layer of fill for each work area, whichever is the greater number of tests.

3) One moisture-density curve for each type of material used, as indicated by sieve analysis and plasticity index.

7.4 Each layer of common backfill, select backfill, pervious and impervious backfill, and sand backfill, sand cushion mix and wear course shall be compacted to not less than the percent of maximum dry density set forth below:

Backfill Material	Percent of Maximum Dry Density to ASTM D-1557
Common Backfill	90
Select Backfill	95
Pervious Backfill	90
Impervious Backfill	95
Sand Backfill	90
Sand Cushion Mix	95
Wear Course	90

7.5 Special attention must be given to areas designed as heap leaching pads and solution containment ponds protected with synthetic membranes. All such surfaces which shall come in contact with these liners, should be free of all angular gravel, gravel over 1-1/2 inches, sticks, roots, sharp objects and debris of any kind.

7.6 Improvement to existing roadways, shoulders, parking lots as indicated on the design drawings shall be undertaken as follows:

The upper 6" shall be thoroughly broken up with a disc plow or harrow and the soil recompacted with water addition to 90 percent of maximum dry density as determined by ASTM D1557.

7.7 Wear course shall be a nominal 8" thick, spread and compacted to 90 percent of maximum dry density as determined by ASTM D1557.

8.0 DRAINAGE AND WATER CONTROL

8.1 Pipes for culverts shall be as shown on drawings. Material and installation requirements for culverts shall be in accordance with specification for "Supply and Installation of Culverts and Miscellaneous Drainage Items".

8.2 Contractor shall take measures to control soil erosion from the construction areas for the duration of the Contract. Such measures shall include berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains and other erosion control devices or methods.

8.3 Water in excavations shall be controlled and removed. Discharge from pumps shall be wasted at locations as directed. Springs or seepage encountered shall be reported immediately and controlled as directed.

8.4 Contractor shall maintain in a clean and sound condition all culverts, ditches and temporary drainage features for the duration of the Contract.

9.0 ROAD MAINTENANCE AND DUST CONTROL

9.1 Contractor shall ensure that roads crossing and to the site are kept passable and shall be responsible for repairing damage to these roads caused by its operations. Repair materials and workmanship shall conform to the existing construction.

9.2 Contractor shall perform all work in such a manner as to minimize fugitive dust emissions, including but not necessarily limited to application of water to roads. Failure to control fugitive dust emissions could result in a stop work order from the State of Utah, Salt Lake County, or the Owner's Representative until adequate controls are instituted. Such work stoppage shall not relieve the Contractor of its contractual responsibilities nor be cause for claims against Owner's Representative.

10.0 CONTRACTOR'S QUALITY CONTROL

10.1 Within 20 calendar days of Contract award, Contractor shall submit for approval its Project specific quality control program. The program shall include the following data.

10.1.1 Surveying - Specify equipment to be used and general procedures to be followed.

10.1.2 Compaction - Contractor shall submit an acceptable plan to achieve fill compaction as specified herein. The plan shall include proposed equipment and procedures for rolling and moisture conditioning.

10.2 Contractor shall designate its representative with direct responsibility for quality control.

11.0 INSPECTION AND EVALUATION OF WORK

11.1 The work will be inspected in progress as well as at completion of various operations by the Owner's Representative as follows:

11.1.1 To inspect and approve foundation surface prior to placement of fill.

11.1.2 To arrange for in-place density and moisture content tests on compacted fill to verify conformance to this specification and any other field or laboratory testing as may be required.

APPENDIX F

LINER SPECIFICATIONS

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
Salt Lake County, Utah

TECHNICAL SPECIFICATION - No: 87105-04

HIGH DENSITY POLYETHYLENE LINING

(HDPE)

PREPARED BY: A. PATWARDHAN
MINE AND MILL ENGINEERING, INC.
June 28, 1988

Reviewed: Robert Parker - (BPMA)

Paul Kaplan - (SHB)

Z. Zavodni - (BPMA)

Approved: _____
BP Minerals Amer

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Rev. No.	Date	Revisions	By	Approved
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SALT LAKE COUNTY, UTAH

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SPECIFICATION FOR HIGH DENSITY POLYETHYLENE LINING (HDPE)

SPECIFICATION NO: 87105-04

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BP MINERALS AMERICA
BARNEYS CANYON PROJECT
SALT LAKE COUNTY, UTAH

SPECIFICATION FOR HDPE LINING MATERIAL INSTALLATION

1.0 GENERAL

1.1 This specification defines the requirements for High Density Polyethylene (HDPE) lining membranes, materials, installation and quality control.

1.2 Lining materials samples, manufacturer's certificates of compliance for materials and specifications for installation, shall be submitted with the Contractor's bid for review. A copy of the manufacturer's Quality Control Manual shall be submitted for approval or alterations.

Recommendation for methods and equipment to place materials on top of the HDPE lining materials shall also be included.

1.3 Any alternatives or exceptions to this specification shall be submitted in writing to Owner's Representative and shall receive Owner's written approval prior to implementation in the work.

1.4 At least two weeks prior to commencement of liner installation, the contractor shall submit shop drawings showing as a minimum:

A. Layout of liner system.

B. Details of joining liner system and liner anchorage.

2.0 LINING MATERIAL

2.1 The membrane liner shall be a high quality formulation, containing approximately 97% polymer and 2% carbon black with anti-oxidants and heat stabilizers. It shall be resistant to ultra violet rays.

2.2 The membrane liner shall be comprised of HDPE material manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

2.3 The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. The contractor shall be responsible for visually inspecting the sheet surface during unrolling. Any faulty areas or defects shall be marked. Any such defect shall be repaired using the extrusion fusion welding technique approved by the Owner's Representative.

2.4 The material provided as high density polyethylene (HDPE), 60 mil liner shall meet or exceed the minimum requirements as stated in the National Sanitation Foundation (NSF) Standard Number 54 as well as the manufacturers published minimum specifications. Certification shall be proved of compliance to the following minimum standard.

2.5 Prior to delivery of the HDPE material to the job site, the fabricator or manufacturer shall submit certificates of compliance with the HDPE material properties requirements of this specification, for compliance and acceptance, to the Owner's Representative.

PROPERTY	TEST METHOD	VALUE	UNITS
a) Density (min)	ASTM D-1505	0.940	gm/ccm
b) Thickness	ASTM D-1593	60 mils (min)	
c) Strength & Properties (min)	ASTM D-638 Type IV		
Tensile			
@ Break		180	lb/in of width
@ Yield		120	
Elongation			
@ Break		500	%
@ Yield		10	%
Modulus of Elasticity	ASTM D-882	80,000	lb/sq.in.
d) Tear Resistance Initiation (min)	ASTM D-1004 Die C	30	lb
e) Puncture Resistance	FTMS 101B	175	lb.
f) Coefficient of Linear Expansion	ASTM D-696	0.00012	per degree C
g) Hydrostatic Resistance	ASTM D-571 Method A Procedure 1	315	psi
h) Water Absorption	ASTM D-570	0.1	max % weight change
i) Melt Index (max)	ASTM D-1238	0.3	Grams/ 10 min.
j) Environmental Stress Crack	ASTM D-1693	500	hours
k) Carbon Black Content	ASTM D-1603	2.0% (min)	

3.0 INSTALLATION

3.1 Subgrade preparation for the leach pads and ponds shall be undertaken by the Contractor who must insure that the surfaces to be lined shall be smooth and free of all rocks, stones, sticks, sharp objects and debris. The Contractor shall certify that the surface on which the membrane is to be installed is acceptable before commencing work. Installation shall be performed under the direction of a Field Engineer who has installed a minimum of 2,500,000 square feet of HDPE flexible lining material. The Field Engineer shall be provided by the Contractor, and shall be in absolute charge of the installation.

To compensate for wrinkles, shrinkage/expansion, material overlap, Contractor must indicate at time of tendering a percentage allowance computed in his material take-off.

3.2 Field Seams

3.2.1 Individual panels of HDPE liner material shall be laid out and overlapped prior to welding. Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer. All sheeting shall be welded together by an extrusion fusion process or an approved equivalent method. Contractor shall define and detail method used in fusion of panels proposed for liner installation. A sample weld shall be made by each welder prior to commencement of field welding each day. The weld samples shall be tested in shear and peel. Two samples minimum shall be taken during each shift.

3.2.2 The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material, to ensure changes in environmental conditions will not affect the integrity of the weld.

3.2.3 No "fish mouths" shall be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped, and an overlap extrusion weld shall be applied. All welds on completion of the work shall be tightly bonded. Any membrane area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of HDPE membrane at the expense of the Contractor.

3.2.4 The Contractor shall take into account that rapid weather changes are very possible, resulting in delays in construction of field seams. Fusion of panels and repairs will only be permitted under weather conditions allowing such work, and within the warranty limits imposed by the liner manufacturer.

4.0 FIELD SEAM TESTING/QUALITY CONTROL

4.1 The installer shall employ on-site physical non-destructive testing on all welds to ensure watertight homogeneous seams on a continuous basis as installation proceeds. Each seam shall, under the observation of the Owner's Representative, be tested by vacuum methods with a minimum vacuum pressure of 6 psi, by electrical arc testing, or by an approved equivalent method. Visual inspection alone is unacceptable.

4.2 A Quality-Control Technician or Field Engineer shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with approved HDPE repair procedures.

4.3 A test weld three (3) feet long from each welding machine shall be run each day prior to liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of the weld shall be cut from the test weld and tested in shear and peel. Welds shall have seam strength of 90 percent of the tensile strength of the parent material. Peel tests shall have a film tearing bond failure. Seams shall be stronger than the material. The weld sample shall be kept for subsequent testing on laboratory tensometer equipment in accordance with the applicable ASTM standards. Random weld samples may be removed from the installed welded sheeting at a frequency of 1 foot per 500 lineal feet of seam and shall be tested in accordance with the aforementioned procedures.

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
Salt Lake County, Utah

TECHNICAL SPECIFICATION - No: 87105-02

NON-WOVEN GEOTEXTILE MATERIAL

AND

GEOGRID DRAINAGE NETTING

PREPARED BY: A. PATWARDHAN
MINE AND MILL ENGINEERING, INC.
June 28, 1988

Reviewed: Paul Kaplan - SHB

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Zip Zavodni - BPMA

Approved: _____
BP Minerals America

Rev. No.	Date	Revisions	By	Approved
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FOR REVIEW
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SPECIFICATION FOR NON-WOVEN GEOTEXTILE MATERIAL AND GEOGRID DRAINAGE NETTING

SPECIFICATION NO: 87105-02

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BP MINERALS AMERICA
BARNEYS CANYON PROJECT
SALT LAKE COUNTY, UTAH

SPECIFICATION FOR NON-WOVEN GEOTEXTILE MATERIAL AND GEOGRID DRAINAGE NETTING

1.0 GENERAL

1.1 This specification defines the requirements for non-woven geotextile material, including needled, spun or heat bound, stapled, and for geogrid material.

2.0 APPLICABLE SPECIFICATIONS AND REGULATIONS

2.1 The following publications of the latest issue are a part of this specification, except where modified or replaced by local codes or ordinances having jurisdiction, in which case the more stringent shall govern.

2.1.1 Occupational Safety and Health Adminis-tration, General Industry and Health Standards - OSHA 2206 (29 1910).

2.1.2 Mine Safety and Health Administration (MSHA)-Code of Federal Regulations - Title 30 (Mineral Resources).

2.1.3 American Society for Testing and Materials (ASTM).

2.1.4 Federal Test Method Standards (FTMS).

2.1.5 Army Corps of Engineers Test Methods.

2.1.6 AASHTO-AGC-ARTBA-Task force 25

3.0 MATERIAL PROPERTIES

3.1 Material supplied as a geotextile shall be of new first-quality non-woven (needled, heat of spun bound, or stapled) polymer of 100% polyethylene, 100% polyester, 100% polypropylene, or polyester/ polypropylene blend, designed and manufactured specifically for the purpose of tensile reinforcement, planar flow, and filtration. Material composition to be such as to inhibit deterioration by UV radiation.

3.2 Geotextile material shall be produced so as to be free of holes, undispersed raw materials, broken needles, or any sign of contamination by foreign matter.

3.3 Geotextile and geogrid material shall be uniform in color, thickness, size, and texture.

3.4 Geogrid supplied for use as drainage netting shall be non-deformed nets constructed of extruded and/or formed polyethylene rods. Geogrid material shall be of new, first quality pure low or high density polyethylene, UV stabilized with carbon black. The material may be extended by frothing with air.

3.5 The finished product shall be supplied as prefabricated rolls custom designed for this project so as to minimize field seaming.

3.6 Geotextile material supplied shall meet or exceed the following minimum standards:

Property	Test Method (see note 1)	Units (see note 2)	Value		
Fabric weight	D-3776	oz/sq yd	4.0	8.0	12.0
Mechanical Properties: (see note 3)					
Grab Strength	D-4632	lbs	90	180	275
Elongation	D-4632	%	50	50	50
Burst	D-3786	psi	250	425	600
Trap Tear	D-4533	lbs	45	75	105
Puncture	D-3787 (Mod)	lbs	70	130	140
Hydraulic Properties:					
EOS/AOS	COE-CW02215	sieve size	70-100	70-100	70-100
Water Perm	D-4491	cm/sec	0.2	0.2	0.2

3.8 Geogrid material supplied for use as a hydraulic medium shall meet or exceed the following minimum standards:

Property	Value	Units
Thickness	.20	inches
Weight	.16	psf
Specific Gravity	.94	--
Tensile strength (mach./cross direction)	70/55	ppi
Elongation @ Break	100	%
Porosity	.80	--
Carbon Black	(2.0 - 3.0)	%
Melt Index	.26	

Notes:

(1) Test methods are ASTM or Corps of Engineers, as modified by AASHTO Task Force 25.

(2) Minimum values - lot mean minus two standard deviations - when sampled and tested according to AASHTO-AGC-ARTBA-Task Force 25 Recommended Guidelines.

(3) Minimum of machine and cross-machine direction.

4.0 TESTING AND INSPECTION

4.1 The supplier of geotextiles used in this work shall take random samples from the roll goods in a quantity sufficient to show compliance with the material properties section of these specifications. Samples shall be tested by a qualified laboratory by methods specified in Section 3.0 or weight and grab, tear, burst, and puncture strength. Sampling and testing shall conform to the Recommended Guidelines of AASHTO-AGC-ARTBA-Task Force 25. Contractor shall submit results of all testing to Owner's Representative.

4.2 All roll goods shall be inspected on both sides for unmixed or poorly dispersed ingredients, the presence of contaminants or foreign particles, broken needles, holes, or any other defects and all defects or impurities shall be removed or repaired before shipment.

4.3 A log shall be maintained of all above and additional testing performed showing lot number, roll number, and results. This log shall be made available to the Owner's Representative.

5.0 SUBMITTALS

5.1 The following items will be submitted to the Owner's Representative for approval prior to acceptance of proposal:

5.1.1 Sample of the geotextile and geogrid materials showing seaming methods. (If applicable).

5.1.2 Detailed schedule of fabrication and roll width.

5.1.3 Shop Drawings showing as a minimum the layout of the geotextile system and details of overlap, jointing and anchorage methods. (If applicable).

5.1.4 Details of recommended installation procedures, including seaming methods and temporary anchorage against wind.

5.1.5 Manufacturer affidavit that the material he offers to furnish will meet in every aspect the requirements set forth in these specifications.

5.2 Prior to delivery of the geotextile or geogrid material to the job site, the fabricator shall submit certificates of compliance with the geotextile material properties requirements of this specification, for compliance and acceptance, to the Owner's Representative

6.0 SHIPPING AND MARKING

6.1 Prominent and indelible markings or labels on each roll shall identify the manufacturer, roll number, length and width of roll, and material thickness.

6.2 Each roll shall be securely packaged for shipment so as to prevent the unraveling of material during handling and shipping.

BP MINERALS AMERICA
BARNEYS CANYON PROJECT
Salt Lake County, Utah

TECHNICAL SPECIFICATION - No: 87105-03

FIELD QUALITY CONTROL FOR EARTHWORK AND FLEXIBLE MEMBRANE LINER (FML)

PREPARED BY: A. PATWARDHAN
MINE AND MILL ENGINEERING, INC.
June 28, 1988

Reviewed: Z. Zavodni - BPMA

Paul Kaplan - SHB

R. Parker - BPMA

Approved: _____
BP Minerals America

Rev. No.	Date	Revisions	By	Approved
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SPECIFICATION FOR FIELD QUALITY CONTROL FOR EARTHWORK AND FLEXIBLE MEMBRANE LINER (FML)

SPECIFICATION NO: 87105-03

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BP MINERALS AMERICA
BARNEYS CANYON PROJECT
SALT LAKE COUNTY, UTAH

SPECIFICATION FOR FIELD QUALITY CONTROL FOR EARTHWORK AND FLEXIBLE MEMBRANE LINER (FML)

1.0 SCOPE

In addition to the manufacturing facilities quality control program, as established by the fabricator, a comprehensive program for field quality control shall be provided. This program is in continuation of and supplements the plants program. All field sampling and testing shall be done by the installer as directed by the Owner's Representative and under the direct supervision of the Owner's Representative.

2.0 SUBGRADE REQUIREMENTS

Liner installation shall not begin until the subgrade has been approved by the Owner's Representative. The acceptance criteria shall be as follows:

The subgrade shall consist of a smooth, uniform surface free of gravel, roots, and other items which may puncture the liner. Surface roughness in excess of 1/2 inch (vertically) per 2 inches (horizontal) shall not be allowed. The surface of the subgrade shall be finished rolled with a smooth steel drum roller.

All fill placed below a FML and the upper 12 inches in cut areas shall be compacted to at least 95% relative compaction, as determined by the ASTM D1557 test method.

3.0 TESTING PROGRAM

The field installation test program consists of periodic visual observations, continuity and strength tests.

3.1 Periodic Tests

These tests are to be made routinely and are automatic regardless of the test level required. The procedure is as described below:

3.2 Earthwork

3.2.1 Material Testing

The Owner's Representative shall arrange to perform testing to classify each specified construction material type. Tests performed shall consist of grain-size distributing analyses and Atterberg Limits testing to classify each material type for its specified use in construction. Additionally, moisture content, moisture-density relationships (Modified Proctor) and in-place density and moisture tests shall be performed to verify the construction conforms to the plans and specifications. Observations and tests performed by the Owner's Representative shall not relieve the Contractor of responsibility for providing adequate quality control measures nor of responsibility for damage to or loss of material before acceptance.

3.2.2 Test Procedures

All tests performed shall be in accordance with the 1988 edition of the ASTM Testing Standards as indicated below.

1. Grain-size distribution analysis - ASTM D422.

2. Atterberg Limits - ASTM D4318.

3. Moisture content - ASTM D2216.

4. Moisture-density relationship - ASTM D1557.

5. In-place density and moisture - ASTM D1556 or ASTM D2922.

3.2.3 Testing Frequency

Tests of original ground, fill, embankment, and soil liner materials will be made at the following suggested minimum rates:

1) One field density test for each 1500 square yards of original ground surface prior to placing fill or floor slab construction.

2) One field density test for each 500 cubic yards of fill placed or each layer of fill for each work area, whichever is the greater number of tests.

3) One moisture-density curve for each type of material used, as indicated by sieve analysis and plasticity index.

The Owner's Representative will submit the results of field density tests required by these specifications.

3.3 Liner Testing

3.3.1 Field installation, welding and seam testing shall be performed under the full time observation of the Owner's Representative. Suspected discrepant areas shall be identified with a contrasting marker.

Destructive shear and peel tests shall be performed on field seams every 500 lineal feet of seam. Actual location of seam tests will be randomly determined in the field by the Owner's Representative. Copies of the results of these tests shall be submitted to the Contractor and the Owner's Representative prior to coverage of the liner by overliner materials.

The Contractor's inspector shall mark, log and identify each type and location of the repair to be made at all discrepant areas.

The Owner's Representative shall have the right to reject any field made seam for cause. Cause shall be defined to include poor workmanship, defective welds and insufficient overlap of panels. Any field made seam rejected for cause shall be repaired or replaced to the satisfaction of the Owner's Representative.

The entire length of each field welded seam shall, under the observation of the Owner's Representative, be tested by vacuum methods with a minimum vacuum pressure of 6 psi, by electric arc testing or by an equivalent method approved by the Owner's Representative.

3.3.2 Procedure for non-passing seams

Visually inspect the entire seam for excessive overlap, poor squeeze out, wrinkles, or other items which may indicate poor seam quality. If rupture is located, patch and retest. If rupture cannot be located visually, the leak must be isolated by sealing portions of the seam and repeating the test. Alternatively, the entire seam can be rewelded and retested. Coupon sample and peel test the seam in at least three (3) locations within the repaired area.

APPENDIX G

SEEPAGE CALCULATIONS

Objective is to calculate all heads and vertical flows through the various natural and constructed layers in the leach pad. Methodology is that presented in, "Landfill and Surface Impoundment Performance Evaluation", EPA SW-869, 1983. The equations have been modified from those presented in SW-869 by removal of the porosity factor "n". This follows advice by Mike Roulier, EPA SW-869 Project Officer, and Charles Moore, SW-869 author. Also following the same person's advice, "L" as used in SW-869 equation (3) should represent twice the drain pipe spacing for a uniformly inclined (no crown between pipes) liner.

INPUTS

Annual Precipitation: 15" (38.1 cm) = 1.2×10^{-6} cm/sec

Solution Application Rate: 0.003 gpm/ft^2 = 5.0×10^{-5} gps/ft^2
= 6.6×10^{-6} ft^3/s/ft^2 = 2.04×10^{-4} cm/sec

Solution Evaporation Rate: 10%

Total Average Heap Recharge Rate: 1.2×10^{-6} cm/sec + ($0.9 \times 2.04 \times 10^{-4}$ cm/sec)
= 1.85×10^{-4} cm/sec

Slope of Pad and all Layers: 9% = 5.1°

Ore Permeability: Because crushed / agglomerated ore will be poorly sorted, fragments will vary from 1½" to silt size. This will sort itself when stacked, with coarse material on bottom of heap and fines on the top. The pile will be non-homogeneous w/ respect to permeability (K). K is expected to vary from 1×10^{-3} cm/sec toward top of heap to 0.1 cm/sec in the bottom 3-4 inches with 1×10^{-2} cm/sec in middle.

Blanket Permeability: Blanket will be -½" crushed ore w/ no agglomeration. It will be spread 2' thick w/ a dozer. This is expected to produce material sorting and non-homogeneity w/ respect to K. K is expected to vary from 1×10^{-5} cm/sec on top surface to 1×10^{-2} cm/sec in bottom 1".

Plastic Liner Permeability: 60 mil HDPE has a K of 1×10^{-12} cm/sec (manufacture

Clay Liner Permeability: Onsite clay soil when compacted to 95% mdd (modified proctor) is 5×10^{-7} cm/sec.

LIQUID ROUTING DIAGRAM

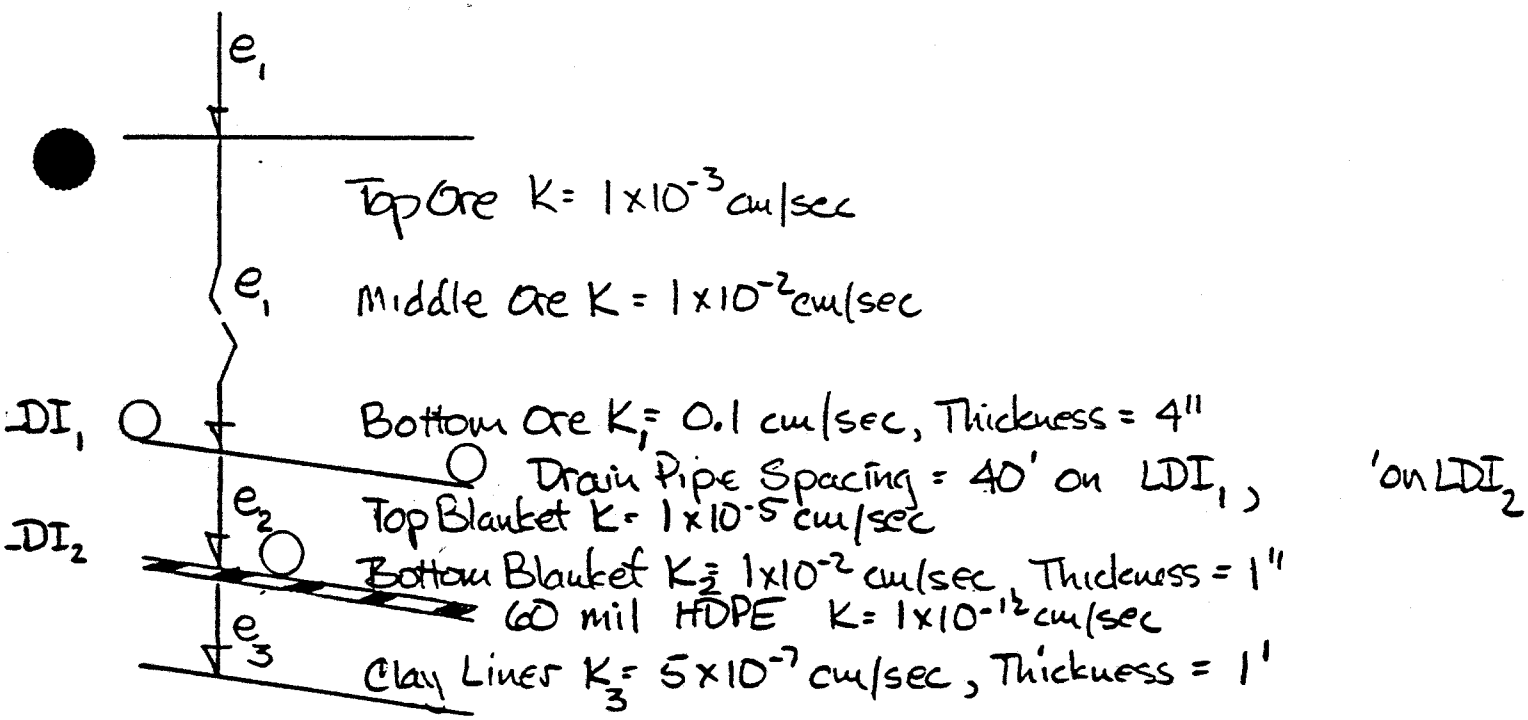


Figure 1

Seepage analysis through clay liner:

Using Darcy's Law:

$$V = \left(\frac{0.22 + 1.0}{1.0}\right) 5 \times 10^{-7} \text{ cm/sec}$$

$$V = 6.1 \times 10^{-7} \text{ cm/sec}$$

$$\text{Annual Seepage} = (6.1 \times 10^{-7} \text{ cm/sec})(31.54 \times 10^{6} \text{ sec/yr})$$
$$= 19.24 \text{ cm/year}$$
$$= 7.57 \text{ in/year}$$

Assuming all head can be removed from top of clay liner:

$$V = (5 \times 10^{-7} \text{ cm/sec})(31.54 \times 10^{6} \text{ sec/yr})$$
$$= 15.77 \text{ cm/yr}$$
$$= 6.2 \text{ in/yr}$$

From above, assuming the head on the clay is as calculated using SW-869, the required clay liner thickness to prevent breakthrough is:

$$(7.57 \text{ in})(3 \text{ yrs}) = 22.7''$$

for the no-head case, the required thickness is:

$$(6.2 \text{ in/yr})(3 \text{ yr}) = 18.6''$$

If the native soil were upgraded to reduce K to 1×10^{-7} cm/sec, with 0.22' of head the seepage rate is:

$$V = (1.22)(1 \times 10^{-7} \text{ cm/sec})(31.54 \times 10^{6} \text{ sec/yr}) = 3.9 \text{ in/yr}$$

1) Calculate maximum height of solution mound on Liquid Diversion Interface No. 1 (LDI_1) on Figure 1.

$$h_{1max} = \frac{L}{2}\left[\sqrt{\frac{e_1}{K_1} + \tan^2\alpha} - \tan\alpha\right]$$

from: "Landfill and Surface Impoundment Performance Evaluation" EPA SW-869, April 1983. (modified to delete n correction as per EPA instruction from M.H. Roulier)

where L = (2) pipe spacings
L = 80'

$$h_{1max} = \frac{80\,ft}{2}\left[\sqrt{\frac{1.85\times10^{-4}\,cm/sec}{K_1} + .008} - 0.089\right]$$

TABLE OF RESULTS

Solution for K_1 0.1 cm/sec = 0.41 ft

K_1 (cm/sec)	$h_{1\,max}$ (ft)
1	0.06
0.1	0.41
0.01	2.95
0.001	14.01

2) Calculate the efficiency of LDI_1 using methods in Wong, J. 1977 "Design of a System for Collecting Leachate from a Lined Landfill Site", Water Resources Research Vol 13, No. 2.

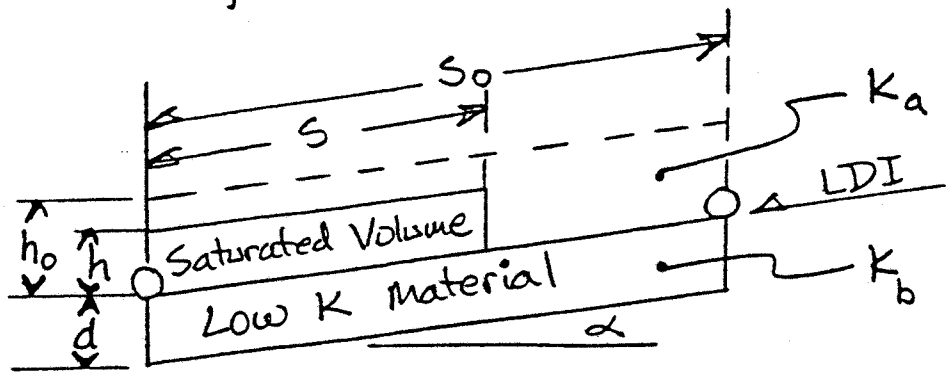


Figure 2

Fraction of solution moving to drain pipe in time t_1:

$$S/S_0 = 1 - t/t_1$$

Fraction of solution moving into low K material in time t_1:

$$h/h_0 = \left(1 + \frac{d}{h_0 \cos\alpha}\right) e^{-C\, t/t_1} - \frac{d}{h_0 \cos\alpha}$$

where:

$$t_1 = \frac{S_0}{K_a \sin\alpha}$$

$$C = \left(\frac{S_0}{d}\right)\left(\frac{K_b}{K_a}\right) \cot\alpha$$

for LDI_1 $S_0 = 40$ ft, $K_a = 0.1$ cm/sec, $K_b = 1\times10^{-5}$ cm/sec

Calculate value for t_1 at LDI_1:

$$t_1 = \frac{(40\text{ ft})(30.48\text{ cm/ft})}{(0.1\text{ cm/sec})(\sin 5.1)(2678400\text{ sec/mo})}$$

$$t_1 = \frac{1219\text{ cm}}{2381\text{ cm/mo}}$$

$$t_1 = 0.51\text{ mo}$$

4) Calculate value for C at LDI_1

$$C = \left(\frac{1219\text{ cm}}{61\text{ cm}}\right)\left(\frac{1\times10^{-5}\text{ cm/sec}}{0.1\text{ cm/sec}}\right) 11.21$$

$$C = (19.98)(1\times10^{-4})(11.21)$$

$$C = 0.0224$$

5) Calculate h_0 for one month for LDI_1:

$$h_0 = (1.85 \times 10^{-4}\ cm/sec)(2678400\ sec/mo)$$
$$= 49.6\ cm/mo$$

6) Calculate N for one month for LDI_1:

$$N_1 = \left(1 + \frac{d}{h_0 \cos\alpha}\right) e^{-c} - \frac{d}{h_0 \cos\alpha}$$

$$N_1 = \left(1 + \frac{61\ cm}{(49.6\ cm/mo)(0.996)}\right) 0.978 - \frac{61\ cm}{(49.6)(0.996)}$$

$$N_1 = 2.19 - 1.24$$

$$N_1 = 0.95$$

7) Calculate E for LDI_1:

$$E_1 = \frac{1+N}{2}$$

$E_1 = 0.98$ = portion of solution diverted on LDI_1

8) Calculate N' for LDI_1:

$$N_1' = \left(1 + \frac{d}{h_0 \cos\alpha}\right) e^{-c\,t/t_1} - \frac{d}{h_0 \cos\alpha}$$

$$N_1' = (2.24)(0.957) - 1.24$$

$$N_1' = 0.90$$

9) Calculate E' for LDI_1:

$$E_1' = \frac{1+N_1'}{2}$$

$$E_1' = 0.95$$

10) Calculate rate of seepage into LDI_1 (e_2):

$$e_2 = (1 - E_1')\, h_{o_1}$$

$$e_2 = (1 - 0.95)(49.6 \text{ cm/mo})$$

$$e_2 = 2.48 \text{ cm/mo}$$

$$e_2 = \frac{2.48 \text{ cm/mo}}{267840 \text{ sec/mo}}$$

$$e_2 = 9.2 \times 10^{-6} \text{ cm/sec}$$

11) Calculate h_{max2} at LDI_2:

$$h_{max2} = \frac{80}{2}\left[\sqrt{\frac{e_2}{K_2} + \tan^2\alpha} - \tan\alpha\right]$$

$$= 40\left[\sqrt{\frac{9.2 \times 10^{-6} \text{ cm/sec}}{1 \times 10^{-2} \text{ cm/sec}} + 0.008} - 0.089\right]$$

$$= 0.22 \text{ ft}$$

12) Calculate value for t_1 at LDI_2:

$$t_1 = \frac{1219 \text{ cm}}{(1 \times 10^{-2} \text{ cm/sec})(\sin 5.1)(267840 \text{ sec/mo}}$$

$$= 5.1 \text{ mos}$$

13) Calculate value for c at LDI_2:

$$c = \left(\frac{S_o}{d_{HDPE}}\right)\left(\frac{K_{HDPE}}{K_2}\right)\cot 5.1$$

$$c = \left(\frac{1219\ cm}{0.15\ cm}\right)\left(\frac{1\times10^{-12}\ cm/sec}{1\times10^{-2}\ cm/sec}\right)11.21$$

$$c = (8127)(1\times10^{-10})(11.21)$$

$$c_2 = 9\times10^{-6}$$

14) Calculate h_o at LDI_2:

$$h_{o2} = (c_2)(267840\ sec/mo)$$

$$= (9.2\times10^{-6}\ cm/sec)(267840)$$

$$= 2.48\ cm$$

15) Calculate N at LDI_2:

$$N_2 = \left(1 + \frac{d_{HDPE}}{(2.48\ cm)(\cos 5.1)}\right) - \frac{d_{HDPE}}{(2.48)(\cos 5.1)}$$

$$N_2 = (1.06)(0.999) - 0.06$$

$$N_2 = 0.999$$

16) Calculate E at LDI_2:

$$E_2 = \frac{1+N_2}{2}$$

$E_2 = 0.9999$ This is portion of solution diverted to drain pipes at LDI_2

17) The upper bound of the seepage through the HDPE liner can be calculated w/ Darcy's Law as follows:

$$e_3 = \left(\frac{0.15\,cm + 6.71\,cm}{0.15\,cm}\right) 1 \times 10^{-12}\ cm/sec$$

$$e_3 = 45.7 \times 10^{-12}\ cm/sec$$

18) Assuming each leach pad operates for 3 years, the total seepage amount will be:

$$= (45.7 \times 10^{-12}\ cm/sec)(31.54 \times 10^{6}\ sec/yr)(3)$$

$$= 0.004\ cm$$

$$= 0.002\ inches$$

This volume of seepage can easily be stored in the underlying clay liner

APPENDIX H-I

RECLAMATION COST ESTIMATE

Barneys Canyon Mine
Reclamation Summary Costs
Contractor Costs

RECLAMATION COST SUMMARY

Costs are based on utilizing contractors equipment and personnel. Costs are based on current operating equipment costs as furnished by Ames Construction . Loading costs = $250/hr, Hauling costs = $ 225/hr , Dozing costs = $175/hr, Spreading costs = $175/hr , Seed costs = $600/ac or $850/ac (hydroseed), Tube costs = $350/ac

	Area Acres	Loading Costs	Hauling Costs	Dozing Costs	Sprding Costs	Seed Costs	Tube Costs	Costs $
Barneys 6300	37.0	11,844	29,221	4,174	6,726	22,200	12,950	87,115
6400/6500 West	46.0	13,419	35,693	10,668	7,620	27,600	16,100	111,100
UBW 6600	18.0	5,251	15,589	4,174	2,982	10,800	6,300	45,097
South Barneys	7.0	2,217	5,964	696	1,259	4,200	2,450	16,785
Melco 7480	12.1	3,886	11,536	1,391	2,207	7,260	4,235	30,515
Melco 7460	16.0	5,251	15,589	2,319	2,982	9,600	5,600	41,341
Melco 7300	83.0	25,963	77,081	6,957	14,743	49,800	29,050	203,595
Melco 7200	38.0	11,669	34,643	2,319	6,626	22,800	13,300	91,357
Melco 7100	47.0	14,819	43,997	4,406	8,415	28,200	16,450	116,288
Melco 6920	104.0	32,322	98,832	7,885	18,355	62,400	36,400	256,194
Melco Sulfide Repository	12.0	3,501	10,393	2,783	1,988	7,200	4,200	30,064
NBCS Sulfide Repository	8.0	2,334	6,929	1,855	1,325	4,800	2,800	20,043
Melco South Dumps	135.0	22,462	66,688	5,798	12,755	75,285	47,250	230,239
Total Dumps	563.1	154,938	452,155	55,428	87,982	332,145	197,085	1,279,732
BC # 1	38.0	11,085	48,070	13,931	6,295	22,800		102,181
BC # 2	35.0	10,210	24,680	12,711	5,798	21,000		74,399
BC # 3	62.0	18,087	66,706	20,154	10,271	52,700		167,917
BC # 4	32.0	9,335	25,689	13,196	5,301	27,200		80,721
BC # 5	45.0	13,127	32,388	16,211	7,454	38,250		107,431
Solution Ponds	7.0	2,042	6,408	1,623	1,160	5,950		17,183
Total Leach Pads	219.0	63,886	203,942	77,827	36,278	167,900		549,833
BC/SBC Haul Road	31.0	9,043	34,601	0	5,135	26,350		75,130
Process Roads	10.7	3,121	8,590	0	1,773	9,095		22,579
Main Access Road	4.6	1,342	4,174	0	762	3,910		10,188
BC Pit Area	11.0	3,209	8,831	0	1,822	9,350		23,212
Runaway Ramp	1.2	350	1,339	12,500	199	1,020		15,408
West Melco Haul Road	11.0	3,209	9,527	0	1,822	9,350		23,908
Melco East Haul Roads	18.0	5,251	15,589	0	2,982	15,300		39,122
SBC/NBC Haul Road	8.0	2,334	6,277	0	1,325	6,800		16,736
Melco Haul Road (SBC-Melco)	27.0	7,876	23,384	0	4,473	22,950		58,683
Melco-NBCS HR	32.0	9,568	29,257	928	5,433	27,200	11,200	83,587
East Barneys	19.0	5,543	16,455	0	3,147	11,400		36,546
Total Roads	173.5	50,847	158,026	13,428	28,874	142,725	11,200	405,099
Admin Building	3.0	875	2,722	0	497	1,800		5,895
Process Bldg	13.0	3,792	10,436	8,375	2,154	7,800		32,557
Crushing/Screening	8.0	2,334	7,046	0	1,325	4,800		15,505
Shop	9.0	2,625	8,028	16,675	1,491	5,400		34,219
Potable Water Storage	2.0	583	1,784	0	331	1,200		3,899
Ore Stockpile	18.0	5,251	15,852	0	2,982	10,800		34,885
Gravel/Clay Pit #1	0.0	0	0	0	0	0		0
Clay Pit #2	2.5	729	2,062	16,250	414	1,500		20,956
Clay Pit #3	2.5	729	2,062	16,250	414	1,500		20,956
SBC High Wall	9.0	5,251	14,850	0	2,982	5,400		28,483
SBC Pit Fill	9.0	2,625	7,425	2,125	1,491	5,400		19,066
Upper B.C. Disturbance	14.0	4,084	11,550	0	2,319	8,400		26,353
Topsoil Piles	49.4	0	0	0	8,183	29,640		37,823
Misc Costs								404,780
Total Admin/Proc/Shop	139.4	28,880	83,819	59,675	24,583	83,640		685,377
Subtotal	1095.0	298,551	897,941	206,358	177,717	726,410	208,285	2,920,041
Mob/Demob Costs								45,000
Contingency @ 10.0%								292,004
Supervision Costs @ 10.0 %								292,004
Subtotal							(1996 $$)	3,549,050
Escalation @ 2.58 %								91,565
Total Reclamtion Costs							(2000 $$)	3,640,615

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

TOPSOIL PLACEMENT

Loading Cycle
992D Cat Loader, 14.0 CY Capacity, at 56 per cent efficiency.
Assume 6 inch depth of topsoil required. 15 per cent additional CY added for handling loss.

	Area Acres	Quantity CY	Production CY/Hr	Time Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	37.0	37,663	795	47.4	5.9	11,844
6400/6500 West	46.0	42,673	795	53.7	6.7	13,419
UBW 6600	18.0	16,698	795	21.0	2.6	5,251
South Barneys	7.0	7,050	795	8.9	1.1	2,217
Melco 7480	12.1	12,356	795	15.5	1.9	3,886
Melco 7460	16.0	16,698	795	21.0	2.6	5,251
Melco 7300	83.0	82,562	795	103.9	13.0	25,963
Melco 7200	38.0	37,107	795	46.7	5.8	11,669
Melco 7100	47.0	47,125	795	59.3	7.4	14,819
Melco 6920	104.0	102,785	795	129.3	16.2	32,322
Melco Sulfide Repository	12.0	11,132	795	14.0	1.8	3,501
NBCS Sulfide Repository	8.0	7,421	795	9.3	1.2	2,334
Melco South Dumps	72.0	71,430	795	89.8	11.2	22,462
Total Dumps	500.1	492,701		619.8	77.5	154,938
BC # 1	38.0	35,251	795	44.3	5.5	11,085
BC # 2	35.0	32,468	795	40.8	5.1	10,210
BC # 3	62.0	57,515	795	72.3	9.0	18,087
BC # 4	32.0	29,685	795	37.3	4.7	9,335
BC # 5	45.0	41,745	795	52.5	6.6	13,127
Solution Ponds	7.0	6,494	795	8.2	1.0	2,042
Total Leach Pads	219.0	203,159		255.5	31.9	63,886
BC/SBC Haul Road	31.0	28,758	795	36.2	4.5	9,043
Process Roads	10.7	9,926	795	12.5	1.6	3,121
Main Access Road	4.6	4,267	795	5.4	0.7	1,342
BC Pit Area	11.0	10,204	795	12.8	1.6	3,209
Runaway Ramp	1.2	1,113	795	1.4	0.2	350
West Melco Haul Road	11.0	10,204	795	12.8	1.6	3,209
Melco East Haul Roads	18.0	16,698	795	21.0	2.6	5,251
SBC/NBC Haul Road	8.0	7,421	795	9.3	1.2	2,334
Melco Haul Road (SBC-Melco)	27.0	25,047	795	31.5	3.9	7,876
Melco-NBCS HR	32.0	30,427	795	38.3	4.8	9,568
East Barneys	19.0	17,626	795	22.2	2.8	5,543
Total Roads	173.5	161,692		203.4	25.4	50,847
Admin Building	3.0	2,783	795	3.5	0.4	875
Process Lab	13.0	12,060	795	15.2	1.9	3,792
Crushing/Screening	8.0	7,421	795	9.3	1.2	2,334
Shop	9.0	8,349	795	10.5	1.3	2,625
Potable Water Storage	2.0	1,855	795	2.3	0.3	583
Ore Stockpile	18.0	16,698	795	21.0	2.6	5,251
Gravel/Clay Pit #1	0.0	0	795	0.0	0.0	-
Clay Pit #2	2.5	2,319	795	2.9	0.4	729
Clay Pit #3	2.5	2,319	795	2.9	0.4	729
SBC High Wall	9.0	16,698	795	21.0	2.6	5,251
SBC Pit Fill	9.0	8,349	795	10.5	1.3	2,625
Topsoil Piles	0.0	0	795	0.0	0.0	-
Upper B.C. Disturbance	14.0	12,987	795	16.3	2.0	4,084
Total Admin/Proc/Shop	90.0	91,839		115.5	14.4	28,880
Total for Loading	982.6	949,391		1,194.2	149.3	298,551

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

TOPSOIL PLACEMENT

Hauling Cycle
Cat 777C, 61.4 CY Capacity, at 70 per cent efficiency.
Assume 6 inch depth of topsoil required. 15 per cent additional CY added for handling loss.

	Area Acres	Quantity CY	Maximum CY/Hr	Actual CY/Hr	Time Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	37.0	37,663	414	290	129.9	16.2	29,221
6400/6500 West	46.0	42,673	384	269	158.6	19.8	35,693
UBW 6600	18.0	16,698	380	241	69.3	8.7	15,589
South Barneys	7.0	7,050	380	266	26.5	3.3	5,964
Melco 7480	12.1	12,356	344	241	51.3	6.4	11,536
Melco 7460	16.0	16,698	344	241	69.3	8.7	15,589
Melco 7300	83.0	82,562	344	241	342.6	42.8	77,081
Melco 7200	38.0	37,107	344	241	154.0	19.2	34,643
Melco 7100	47.0	47,125	344	241	195.5	24.4	43,997
Melco 6920	104.0	102,785	335	234	439.3	54.9	98,832
Melco Sulfide Repository	12.0	11,132	344	241	46.2	5.8	10,393
NBCS Sulfide Repository	8.0	7,421	344	241	30.8	3.8	6,929
Melco South Dumps	72.0	71,430	344	241	296.4	37.0	66,688
Total Dumps	500.1	492,701			2,009.6	251.2	452,155
BC # 1	38.0	35,251	236	165	213.6	26.7	48,070
BC # 2	35.0	32,468	423	296	109.7	13.7	24,680
BC # 3	62.0	57,515	277	194	296.5	37.1	66,706
BC # 4	32.0	29,685	372	260	114.2	14.3	25,689
BC # 5	45.0	41,745	414	290	143.9	18.0	32,388
Solution Ponds	7.0	6,494	326	228	28.5	3.6	6,408
Total Leach Pads	219.0	203,159			906.4	113.3	203,942
BC/SBC Haul Road	31.0	28,758	267	187	153.8	19.2	34,601
Process Roads	10.7	9,926	372	260	38.2	4.8	8,590
Main Access Road	4.6	4,267	329	230	18.6	2.3	4,174
BC Pit Area	11.0	10,204	372	260	39.2	4.9	8,831
Runaway Ramp	1.2	1,113	267	187	6.0	0.7	1,339
West Melco Haul Road	11.0	10,204	344	241	42.3	5.3	9,527
Melco East Haul Roads	18.0	16,698	344	241	69.3	8.7	15,589
SBC/NBC Haul Road	8.0	7,421	380	266	27.9	3.5	6,277
Melco Haul Road (SBC-Melco)	27.0	25,047	344	241	103.9	13.0	23,384
Melco-NBCS HR	32.0	30,427	335	234	130.0	16.3	29,257
East Barneys	19.0	17,626	344	241	73.1	9.1	16,455
Total Roads	173.5	161,692			702.3	87.8	158,026
Admin Building	3.0	2,783	329	230	12.1	1.5	2,722
Process Lab	13.0	12,060	372	260	46.4	5.8	10,436
Crushing/Screening	8.0	7,421	338	237	31.3	3.9	7,046
Shop	9.0	8,349	335	234	35.7	4.5	8,028
Potable Water Storage	2.0	1,855	335	234	7.9	1.0	1,784
Ore Stockpile	18.0	16,698	338	237	70.5	8.8	15,852
Gravel/Clay Pit #1	0.0	0	361	253	0.0	0.0	-
Clay Pit #2	2.5	2,319	361	253	9.2	1.1	2,062
Clay Pit #3	2.5	2,319	361	253	9.2	1.1	2,062
SBC High Wall	9.0	16,698	361	253	66.0	8.2	14,850
SBC Pit Fill	9.0	8,349	361	253	33.0	4.1	7,425
Topsoil Piles	0.0	0	361	253	0.0	0.0	-
Upper B.C. Disturbance	14.0	12,987	361	253	51.3	6.4	11,550
Total Admin/Proc/Shop	90.0	91,839			372.5	46.6	83,819
Total for Hauling	982.6	949,391			1,981.3	247.7	897,941

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

TOPSOIL PLACEMENT

Spreading Cycle
D-10 Cat Dozer, Assume 70 % efficiency of Cat Handbook production, (980 LCY/HR)
Assume 6 inch depth of topsoil required. 15 per cent additional CY added for handling loss.

	Area Acres	Quantity CY	Production CY/Hr	Time Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	37.0	37,663	980	38.4	4.8	6,726
6400/6500 West	46.0	42,673	980	43.5	5.4	7,620
UBW 6600	18.0	16,698	980	17.0	2.1	2,982
South Barneys	7.0	7,050	980	7.2	0.9	1,259
Melco 7480	12.1	12,356	980	12.6	1.6	2,207
Melco 7460	16.0	16,698	980	17.0	2.1	2,982
Melco 7300	83.0	82,562	980	84.2	10.5	14,743
Melco 7200	38.0	37,107	980	37.9	4.7	6,626
Melco 7100	47.0	47,125	980	48.1	6.0	8,415
Melco 6920	104.0	102,785	980	104.9	13.1	18,355
Melco Sulfide Repository	12.0	11,132	980	11.4	1.4	1,988
NBCS Sulfide Repository	8.0	7,421	980	7.6	0.9	1,325
Melco South Dumps	72.0	71,430	980	72.9	9.1	12,755
Total Dumps	500.1	492,701		502.8	62.8	87,982
BC # 1	38.0	35,251	980	36.0	4.5	6,295
BC # 2	35.0	32,468	980	33.1	4.1	5,798
BC # 3	62.0	57,515	980	58.7	7.3	10,271
BC # 4	32.0	29,685	980	30.3	3.8	5,301
BC # 5	45.0	41,745	980	42.6	5.3	7,454
Solution Ponds	7.0	6,494	980	6.6	0.8	1,160
Total Leach Pads	219.0	203,159		207.3	25.9	36,278
BC/SBC Haul Road	31.0	28,758	980	29.3	3.7	5,135
Process Roads	10.7	9,926	980	10.1	1.3	1,773
Main Access Road	4.6	4,267	980	4.4	0.5	762
BC Pit Area	11.0	10,204	980	10.4	1.3	1,822
Runaway Ramp	1.2	1,113	980	1.1	0.1	199
West Melco Haul Road	11.0	10,204	980	10.4	1.3	1,822
Melco East Haul Roads	18.0	16,698	980	17.0	2.1	2,982
SBC/NBC Haul Road	8.0	7,421	980	7.6	0.9	1,325
Melco Haul Road (SBC-Melco)	27.0	25,047	980	25.6	3.2	4,473
Melco-NBCS HR	32.0	30,427	980	31.0	3.9	5,433
East Barneys	19.0	17,626	980	18.0	2.2	3,147
Total Roads	173.5	161,692		165.0	20.6	28,874
Admin Building	3.0	2,783	980	2.8	0.4	497
Process Lab	13.0	12,060	980	12.3	1.5	2,154
Crushing/Screening	8.0	7,421	980	7.6	0.9	1,325
Shop	9.0	8,349	980	8.5	1.1	1,491
Potable Water Storage	2.0	1,855	980	1.9	0.2	331
Ore Stockpile	18.0	16,698	980	17.0	2.1	2,982
Gravel/Clay Pit #1	0.0	0	980	0.0	0.0	-
Clay Pit #2	2.5	2,319	980	2.4	0.3	414
Clay Pit #3	2.5	2,319	980	2.4	0.3	414
SBC High Wall	9.0	16,698	980	17.0	2.1	2,982
SBC Pit Fill	9.0	8,349	980	8.5	1.1	1,491
Topsoil Piles	49.4	45,827	980	46.8	5.8	8,183
Upper B.C. Disturbance	14.0	12,987	980	13.3	1.7	2,319
Total Admin/Proc/Shop	139.4	137,665		140.5	17.6	24,583
Total for Spreading	1,032.0	995,217		1,015.5	126.9	177,717

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

FINAL OUTSLOPE PREPARATION

Dozing Cycle
D-10 Cat Dozer, Assume 50 efficiency of Cat Handbook for 200 ft push, (700 LCY/HR) Doze on 2.5 : 1 slope.

	Area Acres	Quantity CY	Production CY/Hr	Time Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	18	16,698	700	23.9	3.0	4,174
6400/6500 West	46	42,673	700	61.0	7.6	10,668
UBW 6600	18	16,698	700	23.9	3.0	4,174
South Barneys	3	2,783	700	4.0	0.5	696
Melco 7480	6	5,566	700	8.0	1.0	1,391
Melco 7460	10	9,277	700	13.3	1.7	2,319
Melco 7300	30	27,830	700	39.8	5.0	6,957
Melco 7200	10	9,277	700	13.3	1.7	2,319
Melco 7100	19	17,626	700	25.2	3.1	4,406
Melco 6920	34	31,541	700	45.1	5.6	7,885
Melco Sulfide Repository	12	11,132	700	15.9	2.0	2,783
NBCS Sulfide Repository	8	7,421	700	10.6	1.3	1,855
Melco South Dumps	25	23,192	700	33.1	4.1	5,798
Total Dumps		221,712		316.7	39.6	55,428
BC # 1	38.0	35,251	700	50.4	6.3	8,813
BC # 2	35.0	32,468	700	46.4	5.8	8,117
BC # 3	62.0	57,515	700	82.2	10.3	14,379
BC # 4	32.0	29,685	700	42.4	5.3	7,421
BC # 5	45.0	41,745	700	59.6	7.5	10,436
Solution Ponds	7.0	6,494	700	9.3	1.2	1,623
Total Leach Pads		203,158		290.2	36.3	50,789
BC # 1 Perimeter		20,475	700	29.3	3.7	5,119
BC # 2 Perimeter		18,375	700	26.3	3.3	4,594
BC # 3 Perimeter		23,100	700	33.0	4.1	5,775
BC # 4 Perimeter		23,100	700	33.0	4.1	5,775
BC # 5 Perimeter		23,100	700	33.0	4.1	5,775
Total Leach Pads		108,150		154.5	19.3	27,038
Runaway Ramps		50,000	700	71.4	8.9	12,500
Process Bldg		33,500	700	47.9	6.0	8,375
Shop		66,700	700	95.3	11.9	16,675
Gravel/Clay Pit #1		0	700	0.0	0.0	-
Clay Pit #2		65,000	700	92.9	11.6	16,250
Clay Pit #3		65,000	700	92.9	11.6	16,250
Melco-NBCS HR	4	3,711	700	5.3	0.7	928
SBC Pit Fill		8,500	700	12.1	1.5	2,125
Total Other		292,411		417.7	52.2	73,103
Total for Dozing		825,430		1,179.2	147.4	206,358

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

REVEGETATION TREATMENT

Seed Preparation Cycle
Utilize the pitter/seeding equipment, 10 to 15 acres per 8 hours operation rate.
Rip to twenty four inches depth prior to applying one application of fertilizer.

	Area Acres	Rate AC/Hr	Rip Hours	Rate AC/Hr	Ferlilzr Hours	Total Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	37.0	1.25	29.6	1.88	19.7	49.3	6.2	11,100
6400/6500 West	46.0	1.25	36.8	1.88	24.5	61.3	7.7	13,800
UBW 6600	18.0	1.25	14.4	1.88	9.6	24.0	3.0	5,400
South Barneys	7.0	1.25	5.6	1.88	3.7	9.3	1.2	2,100
Melco 7480	12.1	1.25	9.7	1.88	6.4	16.1	2.0	3,630
Melco 7460	16.0	1.25	12.8	1.88	8.5	21.3	2.7	4,800
Melco 7300	83.0	1.25	66.4	1.88	44.1	110.5	13.8	24,900
Melco 7200	38.0	1.25	30.4	1.88	20.2	50.6	6.3	11,400
Melco 7100	47.0	1.25	37.6	1.88	25.0	62.6	7.8	14,100
Melco 6920	104.0	1.25	83.2	1.88	55.3	138.5	17.3	31,200
Melco Sulfide Repository	12.0	1.25	9.6	1.88	6.4	16.0	2.0	3,600
NBCS Sulfide Repository	8.0	1.25	6.4	1.88	4.3	10.7	1.3	2,400
Melco South Dumps	135.0	1.25	108.0	1.88	71.8	179.8	22.5	40,500
Total Dumps	563.1		450.5		299.5	750.0	93.8	168,930
BC # 1	38.0	1.88	20.2	1.88	20.2	40.4	5.1	11,400
BC # 2	35.0	1.88	18.6	1.88	18.6	37.2	4.7	10,500
BC # 3	62.0	1.88	33.0	1.88	33.0	66.0	8.2	34,100
BC # 4	32.0	1.88	17.0	1.88	17.0	34.0	4.3	17,600
BC # 5	45.0	1.88	23.9	1.88	23.9	47.9	6.0	24,750
Solution Ponds	7.0	1.88	3.7	1.88	3.7	7.4	0.9	3,850
Total Leach Pads	219.0		116.5		116.5	233.0	29.1	102,200
BC/SBC Haul Road	31.0	1.88	16.5	1.88	16.5	33.0	4.1	17,050
Process Roads	10.7	1.88	5.7	1.88	5.7	11.4	1.4	5,885
Main Access Road	4.6	1.88	2.4	1.88	2.4	4.9	0.6	2,530
BC Pit Area	11.0	1.88	5.9	1.88	5.9	11.7	1.5	6,050
Runaway Ramp	1.2	1.88	0.6	1.88	0.6	1.3	0.2	660
West Melco Haul Road	11.0	1.88	5.9	1.88	5.9	11.7	1.5	6,050
Melco East Haul Roads	18.0	1.88	9.6	1.88	9.6	19.1	2.4	9,900
SBC/NBC Haul Road	8.0	1.88	4.3	1.88	4.3	8.5	1.1	4,400
Melco Haul Road (SBC-Melco)	27.0	1.88	14.4	1.88	14.4	28.7	3.6	14,850
Melco-NBCS HR	32.0	1.25	25.6	1.88	17.0	42.6	5.3	17,600
East Barneys	19.0	1.25	15.2	1.88	10.1	25.3	3.2	5,700
Total Roads	173.5		106.0		92.3	198.2	24.8	90,675
Admin Building	3.0	1.88	1.6	1.88	1.6	3.2	0.4	900
Process Lab	13.0	1.88	6.9	1.88	6.9	13.8	1.7	3,900
Crushing/Screening	8.0	1.88	4.3	1.88	4.3	8.5	1.1	2,400
Shop	9.0	1.88	4.8	1.88	4.8	9.6	1.2	2,700
Potable Water Storage	2.0	1.88	1.1	1.88	1.1	2.1	0.3	600
Ore Stockpile	18.0	1.88	9.6	1.88	9.6	19.1	2.4	5,400
Gravel/Clay Pit #1	0.0	1.88	0.0	1.88	0.0	0.0	0.0	-
Clay Pit #2	2.5	1.25	2.0	1.88	2.0	4.0	0.5	750
Clay Pit #3	2.5	1.25	2.0	1.88	2.0	4.0	0.5	750
SBC High Wall	9.0	1.25	7.2	1.88	7.2	14.4	1.8	2,700
SBC Pit Fill	9.0	1.25	7.2	1.88	7.2	14.4	1.8	2,700
Topsoil Piles	49.4	1.25	39.5	1.88	39.5	79.0	9.9	14,820
Upper B.C. Disturbance	14.0	1.25	11.2	1.88	11.2	22.4	2.8	4,200
Total Admin/Proc/Shop	139.4		97.3		97.3	194.6	24.3	41,820
Total for Seed Preparation	1,095.0		770.2		605.6	1,375.8	172.0	403,625

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

REVEGETATION TREATMENT

Seeding Cycle
Utilize pitter/ripper seeding equipment, 10 to 15 acres per 8 hours rate.
Assume seeding is performed at least two weeks after area has been ripped and one application of fertilizer has been applied.

	Area Acres	Rate AC/Hr	Time Hours	Duration 8 Hr/Day	Costs $
Barneys 6300	37.0	1.25	29.6	3.7	11,100
6400/6500 West	46.0	1.25	36.8	4.6	13,800
UBW 6600	18.0	1.25	14.4	1.8	5,400
South Barneys	7.0	1.25	5.6	0.7	2,100
Melco 7480	12.1	1.25	9.7	1.2	3,630
Melco 7460	16.0	1.25	12.8	1.6	4,800
Melco 7300	83.0	1.25	66.4	8.3	24,900
Melco 7200	38.0	1.25	30.4	3.8	11,400
Melco 7100	47.0	1.25	37.6	4.7	14,100
Melco 6920	104.0	1.25	83.2	10.4	31,200
Melco Sulfide Repository	12.0	1.25	9.6	1.2	3,600
NBCS Sulfide Repository	8.0	1.25	6.4	0.8	2,400
Melco South Dumps*	135.0	1.25	108.0	13.5	34,785
Total Dumps	563.1		450.5	56.3	163,215
BC # 1	38.0	1.88	20.2	2.5	11,400
BC # 2	35.0	1.88	18.6	2.3	10,500
BC # 3	62.0	1.88	33.0	4.1	18,600
BC # 4	32.0	1.88	17.0	2.1	9,600
BC # 5	45.0	1.88	23.9	3.0	13,500
Solution Ponds	7.0	1.88	3.7	0.5	2,100
Total Leach Pads	219.0		116.5	14.6	65,700
BC/SBC Haul Road	31.0	1.88	16.5	0.1	9,300
Process Roads	10.7	1.88	5.7	0.3	3,210
Main Access Road	4.6	1.88	2.4	0.3	1,380
BC Pit Area	11.0	1.88	5.9	0.7	3,300
Runaway Ramp	1.2	1.88	0.6	0.1	360
West Melco Haul Road	11.0	1.88	5.9	0.7	3,300
Melco East Haul Roads	18.0	1.88	9.6	1.2	5,400
SBC/NBC Haul Road	8.0	1.88	4.3	0.5	2,400
Melco Haul Road (SBC-Melco)	27.0	1.88	14.4	1.8	8,100
Melco-NBCS HR	32.0	1.25	25.6	3.2	9,600
East Barneys	19.0	1.25	15.2	1.9	5,700
Total Roads	173.5		106.0	10.9	52,050
Admin Building	3.0	1.88	1.6	1.2	900
Process Lab	13.0	1.88	6.9	0.3	3,900
Crushing/Screening	8.0	1.88	4.3	0.5	2,400
Shop	9.0	1.88	4.8	0.6	2,700
Potable Water Storage	2.0	1.88	1.1	0.1	600
Ore Stockpile	18.0	1.88	9.6	1.2	5,400
Gravel/Clay Pit #1	0.0	1.88	0.0	0.0	-
Clay Pit #2	2.5	1.88	1.3	0.2	750
Clay Pit #3	2.5	1.88	1.3	0.2	750
SBC High Wall	9.0	1.88	4.8	0.6	2,700
SBC Pit Fill	9.0	1.88	4.8	0.6	2,700
Topsoil Piles	49.4	1.88	26.3	3.3	14,820
Upper B.C. Disturbance	14.0	1.88	7.4	0.9	4,200
Total Admin/Proc/Shop	139.4		40.4	5.4	22,800
Total for Seed	1,095.0		713.4	87.2	303,765

Barneys Canyon Mine
Reclamation Cost Estimate
Contractors Costs

MISC COSTS

ITEM	Cost	Comments
Construct Safety Berms	4,360	Barneys Pit, Melco
Removal of Pond Sludge	51,600	
Pond Liners	3,875	
Runoff Control	17,500	
Remove Culverts	24,375	
Remove Silt Fences	2,400	
Sulfide Caps	100,670	Melco, NBCS
Building Demolition	200,000	
Subtotal	404,780	
Total Cost	404,780	

Barneys Canyon Mine
Reclamation Summary Costs
Contractor Costs

RECLAMATION COST SUMMARY

Costs are based on utilizing contractors equipment and personnel. Costs are based on current contractors' operating equipment costs.
Loading Costs = $ 250/Hr , Hauling Costs = $ 225/Hr, Dozing Costs = $ 175/Hr
Spreading Costs = $ 175/Hr, Seed Costs = $ 600/Ac or $ 850/Ac (Hydroseed)
Tube Costs = $ 350/Ac

Current Reclaimable Disturbance	Acres		Costs
Dumps	516.1		$ 1,172,918
Leach Pads	186.0		$ 466,982
Roads	133.5		$ 311,704
Admin/Proc/Shop	125.4		$ 616,544
Subtotal	961.0		$ 2,568,148
1996 Proposed Reclaimable Disturbance			
Dumps	47.0		$ 106,815
Leach Pads	33.0		$ 82,852
Roads	40.0		$ 93,395
Admin/Proc/Shop	14.0		$ 68,833
Subtotal	134.0		$ 351,894
Mob/Demob			$ 45,000
Contingency @ 10.0 %			$ 292,004
Supervision Costs @ 10.0 %			$ 292,004
Subtotal		(1996 $$)	$ 3,549,050
Escalation @ 2.58 %			$ 91,565
Total Reclamation Costs		(2000 $$)	$ 3,640,615
Total Cost/Acre			$ 3,325

APPENDIX H-1

RECLAMATION COST ESTIMATE SPREADSHEET

BARNEYS CANYON PROJECT
RECLAMATION COST ESTIMATE
SEPTEMBER 1989

TOPSOIL PLACEMENT

LOADING

Material: Topsoil
Equipment: Cat 992C
Capacity (LCY): 13.50

Job Efficiency: 0.56
Equipment Cost ($/hr): 189.00

	Area acres	Quantity CY	Maximum Production CY/hr	Actual Production CY/hr	Time hours	Cost $
Roads	72.0	116160	1300	728	160	30157
Admin Bldg	3.4	5485	1300	728	8	1424
Process/Lab/Substation	21.1	34041	1300	728	47	8838
Ore Stockpile/Crusher	17.3	27911	1300	728	38	7246
Shop/Water Storage	13.3	21457	1300	728	29	5571
Gravel/clay pit #1	1.5	2420	1300	728	3	628
Clay pit #2	2.5	4033	1300	728	6	1047
Alt. Clay pit	1.4	2259	1300	728	3	586
BC Pit road fill dump	5.4	8712	1300	728	12	2262
MD 6500	45.1	72761	1300	728	100	18890
MD 6400	27.3	44044	1300	728	60	11434
MD 6300	65.8	106157	1300	728	146	27560
Mel-Co dump surfaces (3)	33.2	53563	1300	728	74	13906
Mel-Co Dump Outslopes	26.2	42269	1300	728	58	10974
Leach Pad BC-1	56.9	91799	1300	728	126	23832
Leach Pad BC-2	43.5	70180	1300	728	96	18220
Leach Pad BC-3	50.8	81957	1300	728	113	21277
Leach Pad BC-4	60.2	97123	1300	728	133	25215
Leach Pad M-1	30.1	48561	1300	728	67	12607
Leach Pad M-2	19.7	31783	1300	728	44	8251
Future Leach Pad	19.4	31299	1300	728	43	8126

Total Cost (1989 Dollars): 258051

HAULING

Material: Topsoil
Equipment: Cat 773B
Capacity (LCY): 37.50

Job Efficiency: 0.83
Equipment Cost ($/hr): 105.00

	Area acres	Depth feet	Quantity CY	Haul Dist feet	Cycle Time min	Maximum Prod. CY/hr	Actual Prod. CY/hr	Time hours	Cost $
Mel-Co Roads	21.6	1.00	34848	2400	8.6	262	217	160	16850
Barneys/Mel-Co Access Road	28.8	1.00	46464	3300	9.8	230	191	244	25602
Barneys Roads	21.6	1.00	34848	3300	12.7	177	147	237	24883
Admin Bldg	3.4	1.00	5485	3900	10.1	223	185	30	3115
Process/Lab/Substation	21.1	1.00	34041	2400	8.8	256	212	160	16843
Ore Stockpile/Crusher	17.3	1.00	27911	3750	9.8	230	191	146	15379
Shop/Water Storage	13.3	1.00	21457	3900	9.9	227	189	114	11944
Gravel/clay pit #1	1.5	1.00	2420	2100	9.1	247	205	12	1238
Clay pit #2	2.5	1.00	4033	1050	7.5	300	249	16	1701
Alt. Clay pit	1.4	1.00	2259	1800	8.1	278	231	10	1029
BC Pit road fill dump	5.4	1.00	8712	2300	10.0	225	187	47	4898
MD 6500	45.1	1.00	72761	1500	7.4	304	252	288	30273
MD 6400	27.3	1.00	44044	1620	8.5	265	220	200	21049
MD 6300	32.9	1.00	53079	1800	7.8	288	239	222	23278
Mel-Co dump surfaces (3)	33.2	1.00	53563	3300	9.6	234	195	275	28911
Mel-Co Dump Outslopes	26.2	1.00	42269	3300	9.6	234	195	217	22815
Leach Pad BC-1	56.9	1.00	91799	3000	14.5	155	129	713	74840
Leach Pad BC-2	43.5	1.00	70180	1350	7.6	296	246	286	29989
Leach Pad BC-3	50.8	1.00	81957	5400	12.2	184	153	535	56218
Leach Pad BC-4	60.2	1.00	97123	2100	8.8	256	212	458	48054
Leach Pad M-1	30.1	1.00	48561	1200	7.8	288	239	203	21297
Leach Pad M-2	19.7	1.00	31783	9000	10.2	221	183	174	18227
Future Leach Pad	19.4	1.00	31299	2400	8.6	262	217	144	15134

Total Cost (1989 Dollars): 513567

SPREADING

Material: Topsoil Job Efficiency: 0.90
Equipment: Cat D8L Equipment Cost ($/hr): 132.00

	Area acres	Depth feet	Quantity CY	Doze Dist feet	Max Prod CY/hr	Job Eff %	Act Prod CY/hr	Time hours	Cost $
Roads	72.0	1.00	116160	50	1800	0.9	1620	72	9465
Admin Bldg	3.4	1.00	5485	50	1800	0.9	1620	3	447
Process/Lab/Substation	21.1	1.00	34041	50	1800	0.9	1620	21	2774
Ore Stockpile/Crusher	17.3	1.00	27911	50	1800	0.9	1620	17	2274
Shop/Water Storage	13.3	1.00	21457	50	1800	0.9	1620	13	1748
Gravel/clay pit #1	1.5	1.00	2420	50	1800	0.9	1620	1	197
Clay pit #2	2.5	1.00	4033	50	1800	0.9	1620	2	329
Alt. Clay pit	1.4	1.00	2259	50	1800	0.9	1620	1	184
BC Pit road fill dump	5.40	1.00	8712	50	1800	0.9	1620	5	710
MD 6500	45.1	1.00	72761	50	1800	0.9	1620	45	5929
MD 6400	27.3	1.00	44044	50	1800	0.9	1620	27	3589
MD 6300	65.8	1.00	106157	50	1800	0.9	1620	66	8650
Mel-Co dump surfaces (3)	33.2	1.00	53563	50	1800	0.9	1620	33	4364
Mel-Co Dump Outslopes	26.2	1.00	42269	50	1800	0.9	1620	26	3444
Leach Pad BC-1	56.9	1.00	91799	50	1800	0.9	1620	57	7480
Leach Pad BC-2	43.5	1.00	70180	50	1800	0.9	1620	43	5718
Leach Pad BC-3	50.8	1.00	81957	50	1800	0.9	1620	51	6678
Leach Pad BC-4	60.2	1.00	97123	50	1800	0.9	1620	60	7914
Leach Pad M-1	30.1	1.00	48561	50	1800	0.9	1620	30	3957
Leach Pad M-2	19.7	1.00	31783	50	1800	0.9	1620	20	2590
Future Leach Pad	19.4	1.00	31299	50	1800	0.9	1620	19	2550

Total Cost (1989 Dollars): 80991

TOPSOIL PLACEMENT COST SUMMARY

Loading	258100
Hauling	513600
Spreading	81000
Total	852700

CONSTRUCT SAFETY BERMS AROUND PITS

Material:	Rock and Soil	Equipment:	Cat D8L-U
Density (lb/cy):	2900	Equipment Cost ($/hr):	132.00
Job Efficiency:	0.59		
X-sect. Area (SF)	24		
Doze Distance (Ft)	200		

	Length feet	Quantity CY	Maximum Prod. CY/hr	Actual Production CY/hr	Actual Time hours	Cost $
Barneys Pit	6000	5333	620	366	14.58	1925
Mel-Co Pit	4500	4000	620	366	10.93	1443

Total Cost (1989 Dollars): 3368

FILL SLOPE REGRADING

Material:	Sandstone	Equipment:	Cat D9N-U
Density (lb/cy):	2550	Equipment Cost ($/hr):	142.00
Job Efficiency:	0.504		
Ave Doze Dist:	200		

	Volume CY	Max Prod CY/hr	Act Prod CY/hr	Time hours	Cost $
Dump 6500 upper lift	78400	980	494	158.73	22540
Dump 6500 middle lift	84900	980	494	171.89	24408
Dump 6500 lower lift	58800	980	494	119.05	16905
Dump 6400	75100	980	494	152.05	21591
Dump 6300	434500	980	494	879.70	124917
Road fill North of BC Pit	36200	980	494	73.29	10407
Leach Pad BC-1	23200	980	494	46.97	6670
Leach Pad BC-2	21400	980	494	43.33	6152
Leach pad BC-3	20100	980	494	40.69	5779
Leach pad BC-4	27100	980	494	54.87	7791
Leach pad M-1	17300	980	494	35.03	4974
Leach Pad M-2	12000	980	494	24.30	3450
Future pad	10100	980	494	20.45	2904
Mel-Co top	15100	980	494	30.57	4341
MD-7300 top	22700	980	494	45.96	6526
MD-7200 top	30200	980	494	61.14	8682
S of ore stockpile	97900	980	494	198.21	28146
Shop	66700	980	494	135.04	19176
BC-1 Ore	50500	980	494	102.24	14519
BC-2 Ore	46600	980	494	94.35	13397
BC-3 Ore	43700	980	494	88.48	12564
BC-4 Ore	58300	980	494	118.04	16761
M-1 Ore	37900	980	494	76.73	10896
M-2 Ore	26200	980	494	53.05	7532
Future Pad	22300	980	494	45.15	6411

Total Cost (1989 Dollars): 407439

RIPPING TOPSOILED SURFACES

Material:	Topsoil	Equipment Cost:	142.00
Equipment	Cat 16G	Ripping Width (ft):	9.77
Velocity (mph):	4.00		

	Area acres	Time hours	Cost $
Roads	72.0	15.20	2158
Admin Bldg	3.4	0.72	102
Process/Lab/Substation	21.1	4.45	633
Ore Stockpile/Crusher	17.3	3.65	519
Shop/Water Storage	13.3	2.81	399
Gravel/clay pit #1	1.5	0.32	45
Clay pit #2	2.5	0.53	75
Alt. Clay pit	1.4	0.30	42
BC Pit road fill dump	5.4	1.14	162
MD 6500	45.1	9.52	1352
MD 6400	27.3	5.76	818
MD 6300	65.8	13.89	1972
Mel-Co dump surfaces (3)	33.2	7.01	995
Mel-Co Dump Outslopes	26.2	5.53	785
Leach Pad BC-1	56.9	12.01	1706
Leach Pad BC-2	43.5	9.18	1304
Leach Pad BC-3	50.8	10.72	1523
Leach Pad BC-4	60.2	12.71	1805
Leach Pad M-1	30.1	6.35	902
Leach Pad M-2	19.7	4.16	591
Future Leach Pad	19.4	4.10	582
Total Cost (1989 Dollars)			18469

LEACH PAD PERIMETER AND POND REGRADING

Material:	Rock and Soil	Equipment:	Cat D9N-U
Density (lb/CY):	2900.00	Equipment Cost ($/hr):	142.00
Job Effeciency:	0.59		

	Volume CY	Doze Dist feet	Max Prod CY/hr	Act Prod CY/hr	Time hours	Cost $
Leach Pad BC-1	20475	50	2200	1298	15.77	2240
Leach Pad BC-2	18375	50	2200	1298	14.16	2010
Leach Pad BC-3	18375	50	2200	1298	14.16	2010
Leach Pad BC-4	23100	50	2200	1298	17.80	2527
Leach Pad M-1	15750	50	2200	1298	12.13	1723
Leach Pad M-2	12600	50	2200	1298	9.71	1378
Future Leach Pad	10500	50	2200	1298	8.09	1149
Solution Ponds	53500	100	1200	708	75.56	10730

Total Cost (1989 Dollars): 23768

LEACH PAD AND SOLUTION POND LINERS

Manual Labor ($/hr):	12.50
Number of Laborers:	2

	Time hours	Cost $
Leach Pad BC-1	25.00	625
Leach Pad BC-2	25.00	625
Leach Pad BC-3	25.00	625
Leach Pad BC-4	25.00	625
Leach Pad M-1	25.00	625
Leach Pad M-2	25.00	625
Future Leach Pad	25.00	625
Solution Ponds	20.00	500

Total Cost (1989 Dollars): 4875

RUNOFF CONTROL	Lump Sum Cost
Install Waterbars	14200
Remove Culverts	8400
Remove Silt Fences	2400

Total Cost (1989 Dollars): 25000

REVEGETATION TREATMENTS

S. CARKEY

	Item	Cost ($/ac)
1	Topsoiled Areas Seed Cost	199
2	Non-topsoiled Areas Seed Cost	191
3	Riparian Areas Seed Cost	203
4	Seeding with Range Drill	100
5	Hydroseeding (application only)	800
6	#1 Container Stock (45/ac)	180
7	#1 Container Stock (135/ac)	608
8	Fertilizer Cost	47
9	Fertilizer Application	30
10	Urea Cost	22
11	Urea Application	15
12	Mulch Cost	100
13	Mulch Application	30
14	Mulch Crimping	70
15	Seed Broadcasting	100

Revegetation Treatment I: Topsoiled Areas less than 2:1
Items 1, 4, 6 and 8 - 13
Total Cost ($/ac): 723

	Area acres	Cost $
Roads	72.0	52056
Admin Bldg	3.4	2458
Process/Lab/Substation	7.5	5423
Ore Stockpile/Crusher	9.9	7158
Shop/Water Storage	4.6	3326
Gravel/clay pit #1	1.5	1085
Clay pit #2	2.5	1808
Alt. Clay pit	1.4	1012
MD 6500	17.7	12797
MD 6400	18.7	13520
MD 6300	26.0	18798
Mel-Co dump surfaces (3)	33.20	24004
Leach Pad BC-1	12.50	9038
Leach Pad BC-2	10.0	7230
Leach Pad BC-3	18.5	13376
Leach Pad BC-4	20.2	14605
Leach Pad M-1	9.60	6941
Leach Pad M-2	5.8	4193
Future Leach Pad	1.60	1157
Total Cost (1989 Dollars)		199982

Revegetation Treatment II: Topsoiled Areas at 2:1 Slope
Items 1, 5, 6, 8 and 10 - 14
Total Cost ($/ac): 1463

	Area acres	Cost $
Process/Lab/Substation	13.6	19897
Ore Stockpile/Crusher	7.4	10826
Shop/Water Storage	8.7	12728
MD 6500	27.40	40086
MD 6400	8.60	12582
MD 6300	39.80	58227
Mel-Co Dump Outslopes	26.20	38331
Leach Pad BC-1	44.40	64957
Leach Pad BC-2	33.50	49011
Leach Pad BC-3	32.30	47255
Leach Pad BC-4	40.00	58520
Leach Pad M-1	20.50	29992
Leach Pad M-2	13.90	20336
Future Leach Pad	17.80	26041
Total Cost (1989 Dollars):		488788

Revegetation Treatment III: Non-topsoiled Slopes
Items 2, 5, 7, 8 and 10 - 12
Slopes will be hydroseeded twice
Total Cost ($/ac): 2583

	Area acres	Cost $
MD 7100 & 7200 Slopes	18.9	48819
Total Cost (1989 Dollars):		48819

Revegetation Treatment IV: Interim Topsoil Stockpile Seeding
Items 1 & 15
Total Cost ($/ac): 299

	Area acres	Cost $
Topsoil Stockpiles	49.9	14920
Total Cost (1989 Dollars):		14920

Revegetation Total Cost 752509

EQUIPMENT MOBILIZATION/DEMOBILIZATION

Assume $ 840 per piece of equipment (except 992C)

Job Description	Equip	#	Cost
Load Topsoil	Cat 992C	1	3150
Haul Topsoil	Cat 773B	5	4200
Spread Topsoil	Cat D8L	1	840
Slope Regrading and Ripping	Cat D9N-U	4	3360
Rip Topsoil Surfaces	Cat 16G	1	840
Runoff Control Construction	Cat 235B	1	840
	Total Cost (1989 Dollars):		13230

RECLAMATION COST SUMMARY

	Total Cost 1989 U S Dollars
Topsoil Placement	
Loading	258051
Hauling	513567
Spreading	80991
Construct Safety Berms Around Pits	3368
Fill Slope Regrading	407439
Ripping Topsoiled Surfaces	18469
Leach Pad Perimeter & Pond Regrading	23768
Fold Leach Pad and Sol'n Pond Liners	4875
Runoff Control	25000
Revegetation Treatments	
Less than 2h:1v slope	199982
2h:1v slopes	488788
Non-toposiled slopes	48819
Interim Topsoil seeding	14920
Equipment Mob/Demob	13230
Subtotal	$2,101,270
Supervision (5% of Subtotal)	105064
Grand Total	$2,206,330

APPENDIX H-II

RECLAMATION COST ESTIMATE ASSUMPTIONS

Topsoil Placement

Loading Cycle

Assume * use 992D loader
* 14 cy capacity @ 56 percent efficiency
* 6 inch topsoil required
* 15 percent handling loss
* loader will be full staffed with trucks
* cost $250/hr as per Ames.

From Table on page 12-68 (CAT Handbook, 26th edition), a 14.0 cy bucket can load 1,415-2,060 cy/60 min use 1,415 cy

1,415 X .56 = 795 cy/hr

Hauling Cycle

Assume * use 777C haul trucks
* 61.4 cy capacity @ 79 percent efficiency
* 6 inch topsoil required
* 15 percent handling loss
* sufficient trucks to staff loader with reasonable cycle time
* cost $225/hr as per Ames

Cycle time varies according to length and slope of travel required.

Spreading Cycle

Assume * D10N dozer
* 200 ft. Push
* 70 percent efficiency
* Max 1,400 cy/hr

From table on page 1-54 (CAT Handbook, 26th edition), @ D10N can push 1,400 cy/hr for 200 ft. push.

Revegetation Treatment

Seed Preparation Cycle

Assume * Ripping rate @ 1.25 acre/hr
(Len Marrs, UCD)
* Fertilizing rate @ 1.88 acre/hr
(Len Marrs, UCD)
* $300/acre for ripping and fertilizing

Seeding Cycle

Assume * Pitting rate @ 1.25 acre/hr
(Len Marrs, UCD)
* Hydroseeding @ 1.88 acre/hr
(Len Marrs, UCD)
* $100/acre for pitting
* $200/acre for seed mixture
* $850/acre for hydroseeding

Tube Stock

Assume * 2 men/crew
* 100-150 tubes/acre
* $350/acre (D. Morrey)

Miscellaneous Costs

Safety Berms

Assume
* Use data supplied by J. Switzer (7/7/94)
* Highwall extends around entire pit
* Melco at 13,614 feet
* Barneys at 6,000 feet
* Doze 200 feet

Berm X-Section

$$A = 2 \times 4 + (0.5 \times 4 \times 4) = 24\ ft^2$$

$$(13{,}614 + 6{,}000)\ \frac{24}{27} = 17{,}435\ cy$$

$$\frac{17{,}435\ cy}{700\ cy\ hr} = 25\ hr \times \$175/hr = \$4{,}358$$

$$= \underline{\$4{,}360}$$

Runoff Control

Assume
* Length of all roads 60,000 ft.
* Average water bar spacing, 300 ft.
* 200 water bars to be built
* 1/2 hr per water bar

$$.5\ hr \times 200 = 100hr \times \$175/hr = \underline{\$17{,}500}$$

Miscellaneous Costs (cont)

Removal of Pond Sludge

Assure * Ponds are 25 percent full of sludge

$$\text{Vol} = \frac{15{,}200{,}000 \text{ gal}}{7.5 \text{ gal/ft}^3}$$

$$= \frac{2{,}2026{,}666}{27} = \frac{75{,}100 \text{ cy}}{4}$$

Assume: $2.75/cy to load and dispose

18,775 X $2.75/cy = 51,631
= $51,630

Pond Liners

Assume * manual labor, 2 laborers
@$12.50/hr

25 hrs/leach pad X 5 = 125
10 hrs/pond X 3 = 30
155

155 X 2 = 310 man-hr X $12.50/hr = $3,875

Culvert Removal

Assume * 30 culverts
* 5 hrs/culvert to remove
* use cat 235 backhoe, $115/hr and truck to haul, $35/hr
* 1 laborer $12.50/hr

30 X 5 = 150 hrs X $162.50/hr = $24,375

Miscellaneous Costs (Cont)

Removal Silt Fences

Assume * 2 laborers
* 600 ft/day
* 7,200 ft total fences

$\frac{7,200}{600}$ = 12 days X 8 hrs/day X 2 X $12.50/hr

= $2,400

Sulfide Caps

Assume * 9 inch clay cap
* 12 inch coarse sand material
* 12 inch graded material
* $25,000 quality control
* $23/cy to place and construct

$\frac{20 \text{ acres} \times 1,613.33 \times .75}{27}$ = 900 cy (clay layer)

(20 acres X $\frac{1,613.33}{27}$ X 1)2 = 2,390 cy (material layers)

900 cy (clay) X $23/cy = $20,700

2,390 cy (material) X $23/cy = $54,970

$100,670

Building Demolition

Assume * salvage value package
* $200,000 cost

Escalation Factor

2.58 percent as per DOGM

Mob/DeMob Costs

Based on current BC-5 leach pad contract and similar equipment utilized.

Supervision/Contingency

10 percent

BACK UP DATA

SITE	ACRES
Roads	
BC-SBC Haul Road	
Slope	16
Top	15
Process Roads	
Main Access Road	4.6
BC Pit Area	11
Runnaway Ramp	1.2
West Melco Haul Road	11
Melco East Haul Road	18
SBC-NBC Haul Road	8
Melco Haul Road (SBC-Melco)	
Slope	17
Top	10
East Barneys	19
Admin/Process/Shop	
Administration Building	3
Process Lab	13
Crushing/Screening	8
Shop	9
Pottable Water Storage	2
Ore Stockpile (Lean Ore and Coarse Ore)	18
Gravel/Clay Pit #1	2.5
Clay Pit #2	2.5

Clay Pit #3	2.5
SBC High wall	9
SBC Pit wall	9
Upper BC Disturbance	14
Wast Dumps	
Barneys 6300	
Slope	18
Top	19
6400/6500 West	46
UBW 6600	18
South Barneys	
Slope	3
Top	4
Melco 7480	
Slope	6
Top	6
Melco 7460	
Slope	10
Top	6
Melco 7300	
Slope	30
Top	53
Melco 7200	
Slope	10
Top	28
Melco 7100	

Slope	19
Top	28
Melco 6920	
Slope	34
Top	70
Melco-NBCS	
Slope	4
Top	28
Melco Sulfide Repository	12
NBCS Sulfide Repository	8
Melco South Dumps	
Sulfide West	12
South Dump Slope	63
7240 East Top	19
7240 West/7300 West Top	10
7000 Top	6
South Dump 2;1 Slope	25
Leach Pads	
BC-1	38
BC-2	35
BC-3	62
BC-4	32
BC-5	45
Solution Ponds	7

APPENDIX H-2

RECLAMATION COST ESTIMATE ASSUMPTIONS

7/7/94
Pencil'd changes

Safety Berm Around Pit Highwalls

Assume: highwalls extend around entire pit.

Mel-Co - 4500' 13,614 ft @ .75 = 10,210'

Barneys - 6000'

Material Decomposed Rock 50% Rock 50% earth soil

Density 2900 lb/cy ~~CPH page 888~~

Equip: D8L - U blade

Equip cost: ~~$132/hr~~ - (WW Clyde) owning & operating $143/hr

Job Correction factors 0.59

Ave operator 0.75 WW Clyde contractor = $150/hr

Material 1.0

50 min/hr 0.83

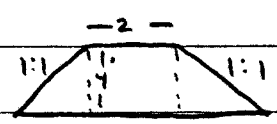
Grade 0% 1.0

Weight $\frac{2300}{2900}$ = 0.79 (.75 · .83 · .79 · 1.2) = .59

Slot Dozing 1.2

Doze Distance: Assume 200' max (Probably closer to 50-100' but this considers large dis to get onsite material

Berm X-sectional Area



$A = 2 \times 4 + 2(0.5 \times 4 \times 4) = 24\ ft^2$

Quantity = length x (x-sect area) 620 cy/hr

Max Prod = from CPH page ~~58~~ 1-57 ~~600~~ cy/hr

Actual Prod = 600 cy/hr x 0.59 = 354 cy/hr

Leach Pad Perimeters and Pond Regrading.

Assumptions:

0% grade

All material will be available on-site

Material 50% Rock, 50% Earth

Density 2900 lbs/Cy

Equipment D9L-V

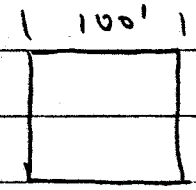
Cost ~~$142/hr~~

D9N
owning + oper
lo bar

62/hr
35
$97/hr

(Low Clyde Contractor: $176/hr)

Job Correction factor = 0.59



Perimeter = 400'

∴ Avg Doz = 100'

Assume Doze distance of 50' for Dump perimeters

Volume of material for Ponds 10,785,300 gal ÷ 7.481 gal/ft³ ÷ 27 ft³/cy = 53,396 C

Volume of material for Leach Pads from Bayer assumption of 3.5 cy / linear foot

53,500 cy material for Both Soln ponds

PAD ID.	length	Vol
BC-1	5850	20,475
BC-2	5250	18,375
BC-3	5250	18,375
BC-4	6600	23,100
m-1	4500	15,750
m-2	3600	12,600
Future	3000	10,500

Runoff Control

Length of All Roads 60,000 feet

Assume 300' AVG spacing for waterbars

200 waterbars to be built.

Assume it takes 1/2 hr to build with a D9N,

Equip Cost ~~$142/hr~~ 176/hr (WW Clyde Rem free 9N = 176/hr)

Cost / bar = ~~$71~~ > 88

Total Cost ~~$14,200~~ 17,600

Culvert Removal

Assume : equipment CAT 225-235

will Require / laborer ~~$12.5/hr~~ $23/hr

Equip Cost ~~$85/hr~~ 110 > 39 + 35 = 74/hr (CPM pg 17-47) (WW Clyde 235 B = 110/hr)

laborer ~~$12.50/hr~~ 23

~~$97.50/hr~~ 133 Say ~~$100/hr~~ $133/hr

Assume 3 hrs / small culvert ~~$300~~ 400

Total = 26 x ~~300~~ 400 = ~~$7800~~ 10,374

Assume 6 hrs / large culvert ~~$600~~ 800

Total 1 x 600 = $600 800

Total Cost ~~$8400~~ 11,174

Remove Silt Fences

Assume work done by 2 laborers @ 25/hr

Assume 8 hrs / day

CAN Remove 600 feet / DAY

$$\frac{7200 \text{ feet of silt Fence}}{600 \text{ feet / DAY}} = 12 \text{ DAYS}$$

TOTAL $2400

7/7/94

All costs escalated by 1.16 factor per Bank. 1919-1994 dollars

Revegetation Unit Costs

Seed		Maple leaf 1989 costs
- Topsoiled Areas	19.25 pls/ac	$199.25/ac
- Non-topsoiled Areas	12 pls/ac	$191/ac
- Riparian	21 pls/ac	$203/ac

Plantings		Maple leaf
Topsoiled Areas	45/ac	$112.5/ac
Non-topsoiled Areas	135/ac	$337.5/ac
Riparian Areas	45/ac	$112.5/ac

Drill Seeding	$100/ac	
Hydroseeding	$800/ac	
#1 Container stock	$180/ac	45/ac
#1 Container stock	$608/ac	135/ac
Fertilizer	$47/ac	
Fert Appl.	$30/ac	
Urea 46-0-0	110 lbs/ac	$22/ac
Urea Appl.		$15/ac
Mulch	$100/ac	
Mulch Appl.	$30/ac	
Mulch Crimping	$70/ac	
Seed Broadcasting	$100/ac	

All other costs based on JBR Experience. Joe Jarvis spoke with Maple Leaf and found that there was no increase in seed, plant and application prices between 1988 and 1989.

Reclamation Treatments

Topsoil Placement
- loading w/992C
- hauling w/773B
- spreading w/D8L

Loading Costs: based on assumption that loader will be in production full time and that there will be enough haul trucks on the job to assure this.

From table on page 572 CPH 2019 at 13.5 CY bucket can load 1240-1350 CY/60min

SAY 1300 CY/60min

Job correction factors = 0.56

45min/60min = 0.75

Avg operator = 0.75

Actual Production = 728 CY/hr

992C Cost (1989) $189/hr (Pers. comm WW Clyde and LABRAND)

Hauling Cost

equipment 773B 37.5 CY capacity

Job correction factor $\frac{50min}{60min} = 0.83$

Cycle time - see scraper pages

773B Cost $105/hr (WW Clyde LABRAND)

Contractors Hourly Rates

1988 Rates (equip & operator)

Equipment	LeGrand Johnson		Lowbermilk		WW Clyde	
	Rate	Mob/Demob	Rate	Mob/Demob	Rate	Mob/Demob
992C	$180/hr	$4500	$160/hr	$2000	$230/hr	
773B	$95/hr	$600-700			$105/hr	
D8L	$112/hr	$600-700	$140/hr	$700-800	$125/hr	
D9N-U	$120/hr	$600-700	$130-140/hr	$700-800		
16G			$150/hr	$700-800	$120/hr	

For 1989 Rates - Called 8/24/89

LeGrand Johnson - Larry Jardine

Add 3-3.5% to 1988 rates

WW Clyde - Paul Clyde

Add 5% to 1988 Rates

Say 5% increase between 1988-1989 Rates

Maple Leaf - Assume no increase in rates

Ripping Topsoiled Surface

Equipment 16G Cost $142/hr

Rippers 12" Deep, 12" Apart

Assume will travel in 3rd Gear or 4 mph CPH-pg

(pers. comm Wheeler Equip)

Overall Width = 117.2" = 9.77 feet

$1 \text{ Acre} = \frac{43{,}560 \text{ ft}^2}{9.77 \text{ ft}} = 4.459 \text{ ft}$ Rip Distance/Acre

4.0 mph = 21,120 ft/hr

$\frac{4.459 \text{ ft}}{21120 \text{ ft/hr}} = 0.211$ hrs/Acre Rip time

Liner Folding

Assume: manual labor 2 laborers at $12.50/hr/laborer

25 hrs/each pond = $2500

10 hr/pond $1000

Removal of Ponds Sludge

Assume: Ponds are full of sludge

Vol = 4,000,000 gal ÷ 7.5 gal/ft³

= 53,333 ft³ ÷ 27 ft³/cy

= 19,750 cy

Assume $2.75/cy to load, haul, and dispose of sludge

Total Costs = $54,312.50

Say ($55,000)

Slope Regrading

Volumes – See accompanying page QTRS spreadsheet

Material – sandy dolomite, sandstone + calcareous sandstone

Density – 2550 lb/CY ~~CPH pg 888~~

Equipment · D9N-U

Equipment Cost : ~~142.00~~/hr (labor) (estimate)

1.6 Correction factors TOTAL = 0.503

Avg operator	0.75
Blasted Rock	0.60
Slot Dozing	1.20
50 min/hr	0.83
Grade = 50%	1.25
Weight $\frac{2300}{2550}$	0.9

$ 0.29/CY

Doze Distance = ~~200'~~ 150'

Maximum production = ~~780~~ 900 CY/hr (CPH 1-57)

Act prod. ~~800 x 0.503~~ = ~~494~~ CY/hr

900 x .503 = 454 cy/hr

Time = Quantity / Act Production

Cost = Time x Unit Cost

SPREADING

1989

equipment D8L Cost $132/hr (WW Clyde LAGRAND)

Job Correction factors

AVG operator : 0.75

material : Loose stockpile 1.2

Slot Dozing : 1.2

$\frac{50 \text{ min}}{60 \text{ min}}$ = 0.83

Grade : varies with site

Total = 0.90 × Grade Correction factor

Grades – Flat, Level = 1.0

Leach, Dump slopes 50% = 1.25

Assume : Universal Blade

Doze Distance = 50 feet AVG

from CPH page 58

Production = 1800 LCY/hr

APPENDIX H-III

GOLDER REPORT #953-2891 RECLAMATION PRACTICES (TEST PLOT STUDIES)

Golder Associates Inc.

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Lakewood, CO USA 80228
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A REVIEW OF RECLAMATION PRACTICES FOR THE ESTABLISHMENT OF PERSISTENT VEGETATION COVER ON WASTE ROCK SURFACES AT THE BARNEYS CANYON MINE

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1.0 INTRODUCTION

The original Notice of Intention (NOI) to mine and subsequently reclaim areas of disturbance at the Barneys Canyon Mine was submitted to the State of Utah, Department of Natural Resources, Division of Oil, Gas and Mining (DOGM), in September 1989. The NOI described reclamation practices for the establishment of appropriate vegetation cover on land disturbed by mining activities. The reclamation strategy for waste rock can be summarized as:

- Regrading selected waste rock slopes to 27° (2:1).
- Constructing 10-foot width terraces at 100-foot vertical intervals.
- Covering with approximately 1 foot of topsoil.
- Establishing vegetation as appropriate.

A revised NOI submitted to DOGM indicated that an average topsoil depth of 1 foot would be replaced on disturbed surfaces, and that a reclamation standard based upon cover alone would require vegetation to develop a cover of 0.7 x pre-disturbance cover. This standard adheres to the Amended and New Rules of the Minerals Reclamation Program, R647-1 through R647-5, revised January 1992.

Further to the NOI recommendations and the regulatory requirements prescribed by DOGM, Barneys Canyon Mine stipulated the following reclamation requirements:

- A growth medium of soil, soil-like, or a cultivable material should be developed on all disturbed surfaces upon which vegetation is to be established.
- The cultivable material should not be susceptible to compaction or erosion.
- The cultivable material should be of appropriate thickness and quality to support a persistent and self-sustaining cover of vegetation which is compatible with prescribed post-reclamation land use.

- For an ecologically-oriented land use, the vegetation cover should comprise ecologically appropriate species of such density and diversity, to facilitate natural ecological succession and long-term ecological stability.
- Surface restoration should be performed in such a way as to promote habitat diversity as well as species diversity.

In doing so, Barneys Canyon Mine has prescribed a reclamation strategy which conforms to current advances in ecological science, and to corporate codes of practice demanded by Kennecott Minerals.

2.0 RECLAMATION RESEARCH AND DEVELOPMENT AT BARNEYS CANYON MINE

The methods prescribed in the NOI (1989 and 1992) were based upon *a priori* technical recommendations provided to the mine by external consultants and DOGM. By definition and without the hindsight of empirical data from site investigation, the recommendations were best regarded as tentative and subject to confirmation. To this end, Barneys Canyon Mine commissioned a series of field-based reclamation research projects to confirm or modify the suggested reclamation strategy, and to determine the feasibility of its application to selected areas of disturbance at the mine.

The field program commenced in the summer season of 1993, and was scheduled to run for a 3-year period, finishing in the fall of 1996. A definitive statement upon methodology and feasibility was to be submitted by November 1996, at the latest.

The overall aim of the program was to determine the most cost-effective and practical methods for establishing persistent vegetation cover of ecological value onto waste rock slopes and surfaces. Implicit in this aim was the identification of best-available practices not entailing excessive cost, to achieve the stated goal. Therefore, investigations were designed to evaluate:

- Topsoil requirement.
- Fertilization Requirement.
- Alternative ameliorants.
- Appropriate species mixtures.
- Environmental strategies for erosion protection.

Annual monitoring data and the results of erosion/sediment-yield modeling work since 1993 have allowed significant refinement of the original NOI specifications. To date, the most significant biological findings have related to plant species selection, fertilization strategy, and topsoil requirements. In general, semi-quantitative data have indicated that:

- Low N:P ratio fertilization is most appropriate for development of grass:legume cover and acceptable species richness.
- Differences in species composition and vegetation cover between plots supporting topsoil at 6-inch and 12-inch depths are ecologically and functionally insignificant.
- Invasive forbs (ruderal species) establish as a result of topsoil placement and soil seed-bank activation.
- Grasses and forbs are not competitively displaced on appropriately amended waste rock, without topsoil cover.
- The integration of organic sludge and waste rock promotes and supports adequate vegetation cover, without topsoil.

In addition to these biological observations, results of mathematical modeling, laboratory flume experiments, and additional empirical data from the Soil Conservation Service have proven the following concepts:

- Vegetation establishment on angle of repose waste rock, amended with organic sludge, is more extensive than on 2:1 rock slopes.
- The stream power of surface water runoff is greatest on shallow (3:1) slopes than on steeper (2:1/1.5:1) slopes.

- Erosion and sediment yield are higher on 3:1 slopes than 2:1 > 1.5:1 slopes.
- Soils stripped and stockpiled at Barneys Canyon Mine are more susceptible to erosion and sediment yield than waste rock.
- Appropriately vegetated waste rock will be adequately protected from erosion.

A summary of this work, its findings, and conclusions is provided in Appendix A. A summary of the reclamation and revegetation monitoring data is provided in the following sections.

3.0 FIELD-BASED RECLAMATION RESEARCH

3.1 Pit Bench Trials

Details of the rationale and design of the field trials constructed on the "football field" bench at the Barneys Canyon pit may be found in SRK report No. 29505/2 (December 1992). Based upon a regulatory standard of 70 percent of pre-disturbance vegetation cover, the mine is expected to achieve a vegetation cover of 46 percent, on all reclaimed areas. In this context, the monitoring program focused upon cover performance assessment and used a plotless sampling technique with the Domin-scale for estimating total vegetation cover and the relative abundance of key species. The assessment of vegetation cover was to be performed over a 3-year monitoring period. The most recent quantitative monitoring data may be referred to in Golder Associates' report no. 943-2744 (October 1994), a summary of which is provided below.

An overview of cover performance after 1 year's growth and establishment is shown in Table 1.

TABLE 1

MEAN COVER PERFORMANCE OF VEGETATION AND MAJOR VEGETATION TYPES ON VARYING TOPSOIL DEPTHS, n=4

Topsoil Depth (inches)	Total Cover	Grasses	Legumes	Forbs
0	10	23	70	7
6	45	36	53	11
12	64	53	43	4

The results indicated that the most developed cover in the first season following planting occurred on the 12-inch topsoil cover plots. This cover comprised mostly ruderal weed species, and was attributed to the seedbank contained in the topsoil, and the darker color of the topsoil material which promoted early spring growth. The 6-inch and non-topsoiled plots showed up to 15 percent cover (no topsoil, 4,000 pounds alfalfa/ac, 310 pounds 18-46-0/ac). While not achieving the same quantity of vegetation growth as the 12-inch topsoiled plots, amended waste rock was demonstrated to support adequate vegetation in the first growing season to control erosion. The quality of vegetation on the non-topsoiled plots was predicted to be higher in the following seasons due to the absence of invasive, weedy species which were abundant on the 12-inch topsoiled plots.

Table 2 shows the effects of fertilizer treatment on the average vegetation cover percentage and the proportional cover of the three predominant groups of species, after one growing season.

TABLE 2

EFFECTS OF FERTILIZATION ON MEAN VEGETATION COVER, n=3

Fertilizer	Total Cover	Grasses	Legumes	Forbs
NOI 1992 (Urea)	35	27	63	10
SRK 1992	38	40	53	7
NOI 1989 (18-46-0)	47	58	41	1
Control	33	17	38	45

The lowest vegetation cover was achieved on surfaces which were untreated and remained as control plots. The best results were achieved on the plots treated with the NOI 1989 formulation (18-46-0), in terms of total vegetation cover, grass cover, and balance of grass and legume species. The NOI 1992 specification yielded results which did not differ significantly from the untreated control plots. These observations support the hypothesis that bare waste rock treated with an organic amendment and 18-46-0 fertilizer can produce vegetation which controls erosion and meets or exceeds the success criterion.

Further study was suggested in which 10 tons per acre (dry mass) sludge would be added to two of the "Football Field" test plots. The specification included ripping the sludge into the plots to a depth of 6 to 12 inches.

From the observations of first-year growth and development, it was inferred that:

- Naturally occurring ruderal (weed) species predominated where topsoil has been placed over waste rock.
- Some commercial grasses were competitively displaced by ruderal weeds on topsoiled areas.
- Grass species predominated on blocks of waste rock which have not received topsoil cover.
- Throughout all blocks, cells which received 18-46-0 compound fertilizer supported the most extensive vegetation cover.
- No biologically or functionally significant differences existed in the vegetation cover and species composition of 6-inch topsoil and 12-inch topsoil blocks.

Semi-quantitative measurements of vegetation re-emergence and cover were recorded in the spring of 1994, and supported the 1993 fall observations. However, it was seen that the commercial varieties of *Elymus elymoides, Agropyron spicatum, Medicago sativa,* and *Melilotus officinalis*, had not been competitively displaced by the ruderal (weed) species which had germinated from the topsoil seedbank.

Overall, it was concluded that some commercial varieties of grass and legume species included in the prescribed species mixture were suited to establishment on both topsoiled and uncapped waste rock at Barneys Canyon Mine. However, it was clear that, at least in the initial stages of emergence, growth and establishment, commercial varieties sown onto topsoil were compromised as a result of competition from native ruderal species. As yet, the long-term effect of competition between commercial and ruderal species is unknown.

The potential problems rising from interspecific competition on topsoiled areas were not apparent on the waste rock which had not been capped with topsoil. In each cell, particularly that treated with 18-46-0 fertilizer, only commercial grass and legume species had emerged. As a consequence of concretion and compaction of an unripped surface, overall cover on uncapped waste rock was low. Therefore, waste rock conditioning with organic sludge and subsequent overseeding was performed. Subsequent observations of vegetation growth, establishment, and cover redevelopment on sludge-treated waste rock indicated that more than adequate cover could be achieved rapidly, without topsoil, and with minimum fertilization.

3.2 Fall of 1994 Football Field Test Plot Monitoring Data

Meteorological records for 1994 indicated low rainfall and a net soil water deficit at Barneys Canyon Mine for the summer season. Consequently, vegetation cover across the "Football Field" plot developed slowly during 1994. Although seasonally brown, residual shoot cover across each of the blocks was visually acceptable. As a consequence of the dormancy of the vegetation, particularly the grasses which remained as stems without leaves or heads, accurate species identification was difficult. However, alfalfa remained vigorous across all blocks, as expected of a deep-rooted species.

Results of the subjective assessment of vegetation cover and relative species abundance are summarized in Table 3.

BIOTRACE LABORATORIES

3440 SOUTH 700 WEST, SALT LAKE CITY, UTAH 84119-4194 (801) 262-7946

CLIENT NUMBER 3035 | FINAL | PAGE: 1

STEVEN D LACKEY C I H
BARNEYS CANYON MINE ***
P O BOX 311
BINGHAM CANYON UT 840060311

NAME/I.D.# C-1 SOIL, 39735
(3035)000-03-9735

AGE: UNK
SEX: UNK

DATE COLLECTED 05NOV93 1615
DATE RECEIVED 08NOV93 1615
DATE PRINTED 03MAY94 0256

SENT BY:

ORDERED TESTS: SOIL\REPRINT REQ 5-2-94

ANALYSIS	RESULT NORMAL	RESULT OUT OF RANGE	REFERENCE RANGE	UNITS

OTHER

MISCELLANEOUS — SEE NOTE

MISCELLANEOUS.. 05NOV93 1615

		ANALYST	DATE ANALYZED
AS	<.10 ppm	VPK	23NOV93
CD	.05 ppm	VPK	23NOV93
CR	<.10 ppm	VPK	23NOV93
CU	.11 ppm	VPK	23NOV93
FE	1.6 ppm	VPK	23NOV93
HG	<.05 ppm	VPK	23NOV93
MO	<.10 ppm	VPK	23NOV93
NI	.11 ppm	VPK	23NOV93
PB	.15 ppm	VPK	23NOV93
SE	<.10 ppm	VPK	23NOV93
ZN	2.4 ppm	VPK	23NOV93

Performed at AEC, 3422 South 700 West, Salt Lake City, UT 84119

CEC	2.5	meq/100g
ELECTRO-CONDUCT	0.7	mmhos/cm
K	47	mg/kg
KJELDAHL NITROGEN	0.010	%
NO3/NO2	2.5	mg/kg
ORGANIC CONTENT	0.45	%
P	23	mg/kg
PH	8.5	pH
SATURATION %	28.0	%
SODIUM ABSORP RATE	1.1	

---- H2O SOLUBLE ----

CA	3.1
MG	2.8
NA	1.9

Performed at Utah State University, Logan, UT

Accession Number: 93-312-3126

END OF REPORT

Laboratory Director: Steve R. Hawerth, Ph.D.

TABLE 3

SUMMARY OF THE EFFECTS OF FERTILIZER AND TOPSOIL TREATMENTS ON THE ESTABLISHMENT OF COMMERCIAL PLANT SPECIES ON WASTE ROCK

Treatment		Total Cover (percent)	Agropyron	Alfalfa	Clover
B1	C1	75	0.6	0.15	0.15
	C2	50	0.5	0.10	0.30
	C3	40	0.4	0.15	0.15
	C4	50	0.6	0.10	0.20
B2	C1	65	0.6	0.20	0.10
	C2	55	0.5	0.10	0.35
	C3	50	0.6	0.20	0.20
	C4	35	0.3	0.20	0.40
B3	C1	20	0.6	0.40	
	C2	5	0.4	0.40	
	C3	-	-	-	-
	C4	-	-	-	-

Notes: B1 = 12-inch topsoil; B2 = 6-inch topsoil; B3 = 0-inch topsoil
C1 = 18-46-0 fertilizer; C2 = Urea; C3 = Ammonium nitrate + superphosphate; C4 = No fertilizer

The codes which have been assigned to the variously treated blocks and cells follow those originally described in the 1992 design document.

Block 1 (12-inch topsoil)

The most extensive cover of vegetation across all blocks was recorded in the cell where topsoil had been fertilized with the NOI 89 recommendation of 18-46-0 fertilizer. This approximate 75 percent cover comprised a mixture of *Agropyron spicatum* (bluebunch wheatgrass), and the legume species *Medicago sativa* (alfalfa) and *Melilotus officinalis* (yellow sweet clover), each sown from commercial stock. These species were associated with several species of forbs (non-grasses), including *Artemesia tridentata* (sagebrush) and *Chrysothamnus nauseosus* (rubber rabbitbrush).

This vegetation is more than adequate for achieving the desired reclamation cover of 0.7 x native vegetation cover, on surrounding land. Recent surveys of native vegetation, at elevations, slope angles, and aspects similar to those at Barneys Canyon Mine, show mean cover to be 55 percent. This suggests that the final reclaimed surfaces should support a mean vegetation cover of 0.7 x 66 = 46 percent. Results of studies performed elsewhere have proven a minimum basal cover of 15 percent to be effective in reducing surface erosion, significantly.

Lowest vegetation cover (approximately 40 percent) was achieved on topsoil treated with the mixture of ammonium nitrate and superphosphate, with approximately 50 percent shoot cover being achieved on the control (unfertilized) cell, and topsoil treated with urea formaldehyde. Each of the cells supported similar associations of commercial grass and legume species, with ruderal forbs (invasive weeds).

Block 2 (6-inch topsoil)

Topsoil treated with 18-46-0 compound fertilizer produced the most extensive vegetation cover (approximately 65 percent), comprising the same commercial varieties of species, and native forbs found in the 12-inch topsoil block. The abundance of grasses and legumes established in the 6-inch topsoil layer was similar to that recorded for the 12-inch topsoil layer. The small reduction in overall vegetation cover on 6-inch topsoil, was accounted for in the reduced diversity and relative abundance of the ruderal species, some of which are invasive. In the 6-inch block, only one aggressive species of the Cruciferae was established, the other colonists comprising native forbs. The cover performance of *Agropyron spicatum* on 6-inch topsoil was the same as that recorded for 12-inch topsoil. However, legume cover was found to be higher, in general, on 6-inch topsoiled cells, probably due to reduced competition from invasive ruderal species.

Cells treated with an ammonium nitrate/superphosphate mixture, or with urea formaldehyde, produced similar results in terms of overall vegetation cover (approximately 50 percent to 55

percent), and the contribution by grass and legume species. However, the urea formaldehyde treatment enhanced the establishment of a diversity of ruderal species, whereas the ammonium nitrate/superphosphate mixture supported commercial species only.

Lowest cover (approximately 35 percent) was achieved in the unfertilized control cell.

Block 3 (uncapped waste rock)

This block was difficult to assess because of the mechanical disturbance to the surface created by sludge application. Cells C3 and C4 had been covered with sludge, and awaited even incorporation and overseeding. The remains of cells C1 and C2 (18-46-0, and control, respectively) still supported vegetation cover. Irrespective of prolonged dry conditions and other limiting factors created by cementation and compaction, *Agropyron spicatum* and *Medicago sativa* were established in both cells. Acceptable growth of residual patches of both species was especially evident in cell C1, which had been treated with 18-46-0 fertilizer. A total cover of 20 percent was achieved in this cell and indicated the potential for enhanced growth on waste rock if mechanically prepared and conditioned with organic sludge.

3.3 Spring of 1994 6500 Dump Reclamation Trial Monitoring Data

A more formal field trial was constructed at the 6500 waste rock dump to compare the performance of vegetation on waste rock conditioned with organic sludge, and rock covered with 6-inch topsoil. Comparisons of vegetation establishment on varying slope angles and aspects were also made.

The 6500 dump trial was seeded in the fall of 1993. Informal observations of the 6500 dump blocks were recorded in the spring of 1994. At that stage, only initial emergence of vegetation had occurred across the blocks, on both north- and south-facing slopes. On topsoiled areas, development of commercial vegetation cover was more advanced than on sludged areas. The slower emergence on sludged blocks was thought to result from the

adverse effects of ammonia being released from the newly deposited and still volatile sludge. It was recommended that future sludge applications be left to stabilize for several weeks before seeds are applied. The following observations were made:

- Grasses had started to emerge on the southern aspect of the 6500 dump. This was thought to be a result of early snowmelt on the warmer, south slope.
- Emergence was more advanced on topsoiled strips than on sludge-amended strips. This was likely a result of higher surface temperatures occurring on darker, topsoiled strips, relative to the cooler strips of waste rock.
- Vegetation had not emerged on north-facing slopes, probably due to snow cover persisting to the beginning of May.

Subsequent observations in 1995 indicated that adequate vegetation cover had developed on both sludge-amended plots, and on plots covered with topsoil to a depth of 6 inches. Unexpectedly, vegetation performance was better on sludge-amended plots at angle of repose, rather than on shallower, 2:1 slopes. Conversely, vegetation cover and density was higher on topsoiled plots of 2:1 slope, than on angle of repose slopes. This result was thought to be indicative of topsoil erosion and seed losses being greater than waste rock mixed with a colloidal organic conditioner.

3.4 Summary

Overall, satisfactory vegetation cover had established on topsoiled areas, irrespective of topsoil depth. Initial results also indicated significant potential for establishment and development of grass and legume cover on appropriately conditioned and mechanically prepared waste rock surfaces, without topsoil. Although best vegetation cover on 12-inch topsoil was 10 percent greater than the most extensive cover established on 6-inch topsoil, the difference was due to the greater abundance of ruderal weed species on the 12-inch layer. This extra cover component is not seen to be an ecological or functional advantage. Also,

the cost benefit of applying 12-inch topsoil, relative to 6-inch topsoil, has not been demonstrated.

The differences in the extent and quality of commercial grass/legume cover between cells and blocks have become less significant over time. This suggests that the initially visible differences between treatments were due to transient effects of fertilization. However, it is clear that applications of 18-46-0 fertilizer have been the most beneficial to the development of total shoot cover, on each substrate.

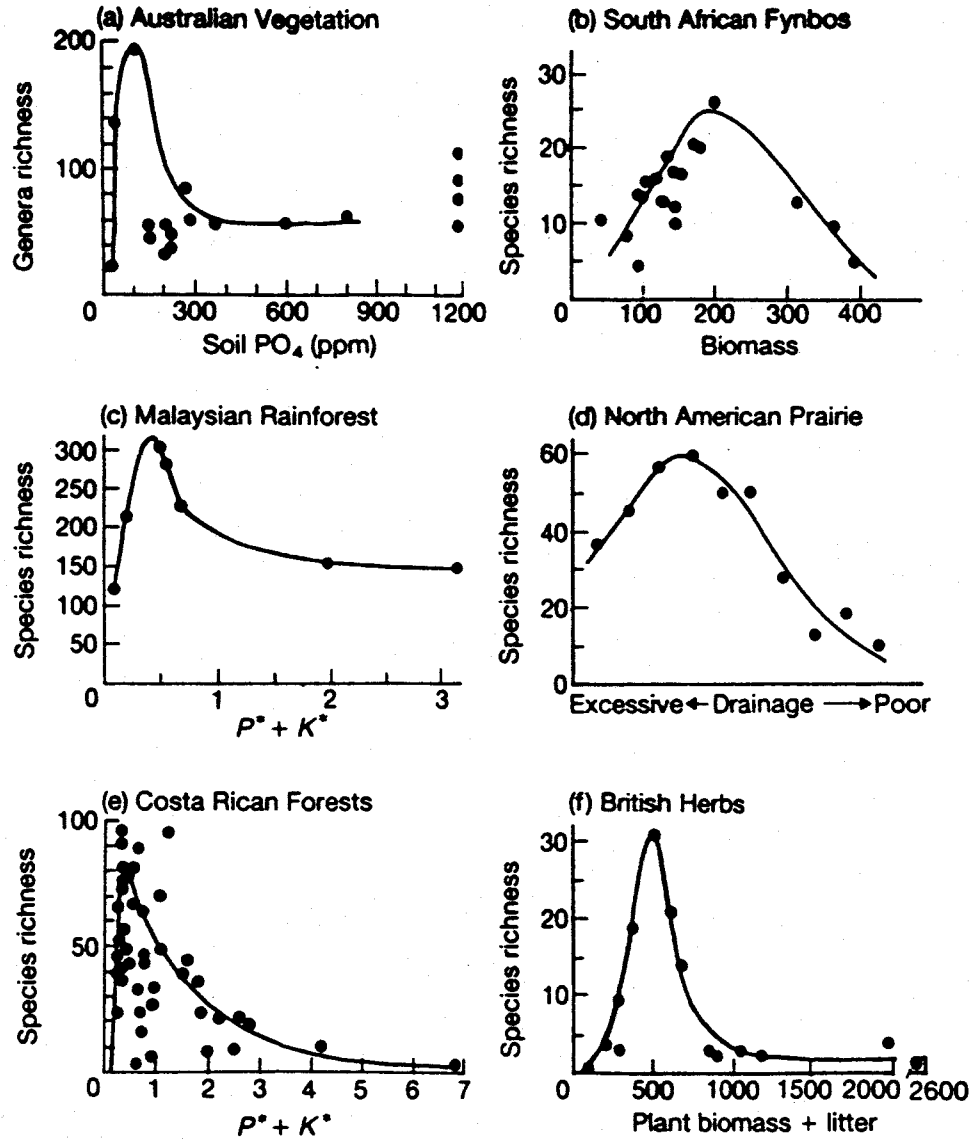
It seems that applications of ammonium nitrate and superphosphate to topsoiled areas enhanced the establishment of commercial species, over ruderal species. The generally higher vegetation cover on topsoiled areas has been achieved at the expense of vegetation quality. With the exception of cells fertilized with the ammonium nitrate/superphosphate mixture, the combination of fertilization and topsoil cover has triggered the vigorous growth and establishment of ruderal forbs. In some cells, only the ruderal species component has contributed to the apparently enhanced vegetation cover. This is especially evident where urea formaldehyde has been applied to both 6-inch and 12-inch topsoil. Further monitoring will be necessary to prove this unequivocally.

4.0 SCIENTIFIC CONSIDERATIONS

It is well established that the species richness (number of species/unit area) varies inversely with stand productivity. This relationship is a logical consequence of the fact that under low stress and high fertility conditions, potentially competitive species will rapidly consume environmental resources and produce biomass sufficient to exclude non-competitive species. This type of dominance leads to extremely low diversity, if not monoculture, stands of vegetation which are ecologically unstable.

The aim of the surface restoration program at the Barneys Canyon Mine is to establish a persistent, self-sustaining vegetation cover which must be ecologically stable. In order to

achieve this goal, competitive dominance of aggressive species must be limited, thus allowing coexistence and diversity. The vegetation and soil management strategy at Barneys Canyon Mine is based upon the common observation that, irrespective of geoclimatic zone and ecosystem type, a corridor of high diversity is achieved when environmental stress is maintained at a significant level. In the case of the Barneys Canyon environment, the aim is to maintain a degree of soil moisture deficit and relatively low fertility, to prevent competitive dominance by any species. A series of diversity curves which cover a range of environmental stress gradients are shown in Figures 1a through 1f, to characterize this type of relationship (Crawley 1986).



The dependence of plant community diversity on resource richness (or some measure of resource richness) for a variety of habitats. Figures redrawn from: (*a*) Beadle (1966); (*b*) Bond (1983); (*c*) Tilman (1982) based on data in Ashton (1977); (*d*) Dix & Smeins (1967); (*e*) Tilman (1982) based on data in Holdridge *et al.* (1971); and (*f*) Al-Mufti *et al.* (1977). Note that Bond estimated above-ground plant biomass (in arbitrary units) by using the area under a plant foliage-height profile. Tilman normalized the data of Ashton & Holdridge *et al.*, on soil phosphorus (P) and potassium (K) levels, and then used the summation of these normalized variables as a measure of soil resource richness. Dix & Smeins divided their study areas into drainage types which they ranked from those with the best drainage to those with the poorest. Al-Mufti *et al.*, estimated productivity by summing the total above ground plant biomass and the soil litter of each area. For all the figures it is assumed that the x axis is a measure of the availability of various limiting soil resources, with habitats with the greatest availability being at the right hand side of each graph.

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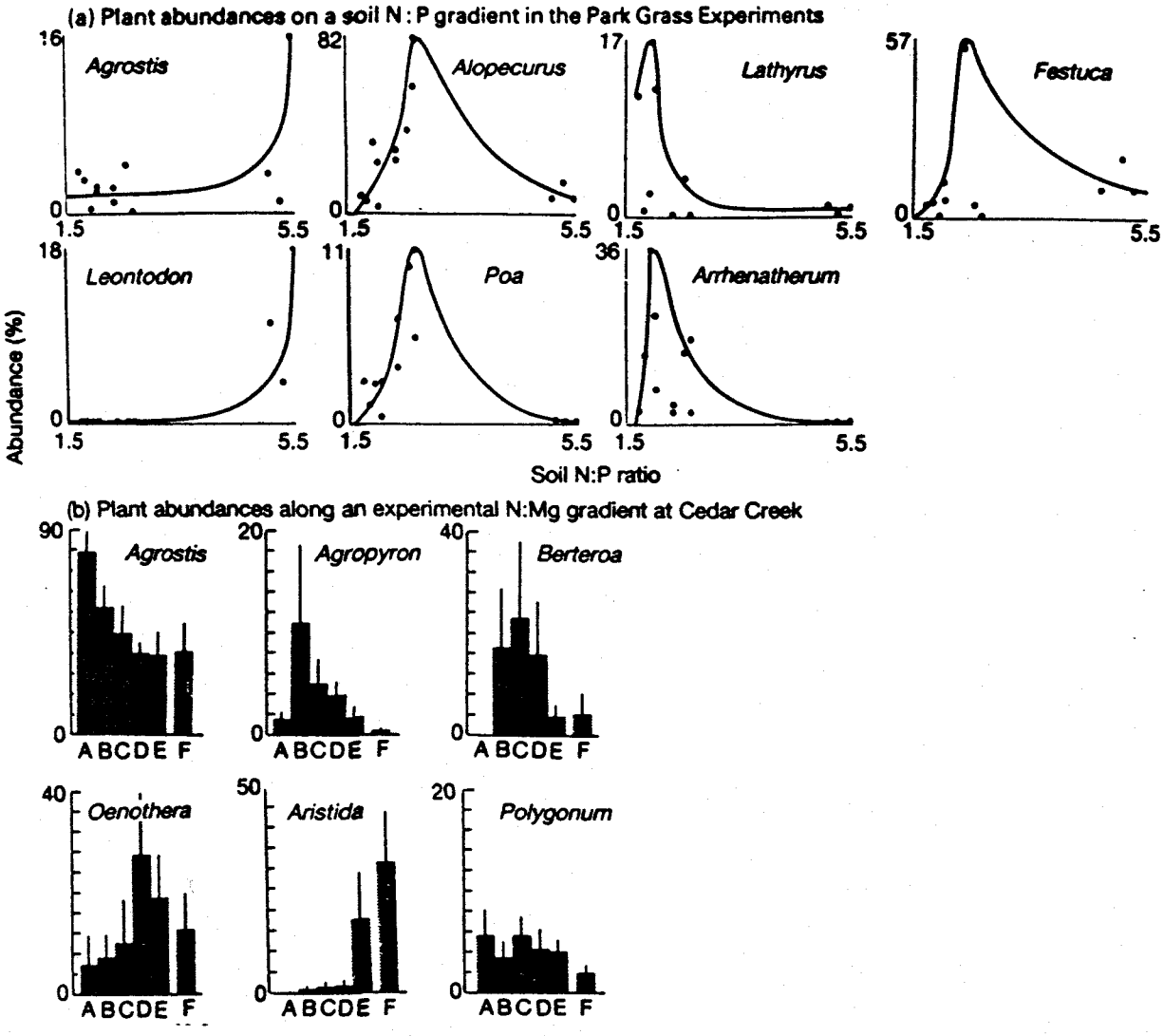
With specific reference to the Barneys Canyon reclamation strategy, the development of an adequate cover of species - rich vegetation is based upon low nitrogen input and moderated soil water retention. This is expected to be achieved by way of a low N fertilization scheme, and establishment of vegetation into either minimally amended waste rock, or minimally topsoiled waste rock.

The "proof of concept" supporting this approach is provided by the results of several pieces of published research. Some results from the Park Grass Experiment (Rothamsted, U.K.) are shown in Figure 2a, and from the Cedar Creek Natural History Area (MIN USA), in Figure 2b. These data clearly indicate the competitive growth response of several aggressive species (*Agrostis sp., Leontodon sp., Aristida sp.*) to increases in soil nitrogen. Conversely, other species show maximal abundance at levels of N which may be regarded as limiting. These results conform to the findings of Kirchner (1978) who measured a significant decrease in the diversity of North American prairie communities after a 3-year period of watering and fertilization.

This trend is clearly seen in Figures 3a through 3d, which show a consistent decrease in grassland diversity under agricultural-type soil management.

The most significant work which has demonstrated the relationships between environmental stress, reduced dominance and enhanced species diversity, is that of Grime (1979). Figure 4 provides a simplified overview of Grime's stress/diversity model. On this basis, it was proposed that field research is performed at Barneys Canyon Mine to determine the feasibility of using the following "stress-adaptation" strategy for establishing a more diverse and ecologically stable grassland - shrub system on disturbed areas:

- Minimal use of topsoil, if any.
- Minimal chemical amendment using low N:P fertilization.
- Amended seed mix to include more stress-adapted, native species.
- Zero maintenance.



(*a*) Distributions of the dominant species in the Park Grass Experiment at Rothamsted, England, in relation to soil N : P ratios. Note that pH ranges from 4.2–6.0 between different plots. Modified from Tilman (1982). (*b*) Distributions of the major species in a N/Mg fertilization experiment performed at the Cedar Creek Natural History Area. Bethel, Minnesota, USA. Letters A–F refer to points ranked along an experimental N : Mg fertilization gradient. Treatment A received the highest rate of application of N and the lowest rate of Mg, and there was a smooth gradation to Treatment E, which received the lowest rate of supply of N and the highest of Mg. Treatment F was a control receiving neither N nor Mg. Modified from Tilman (1984).

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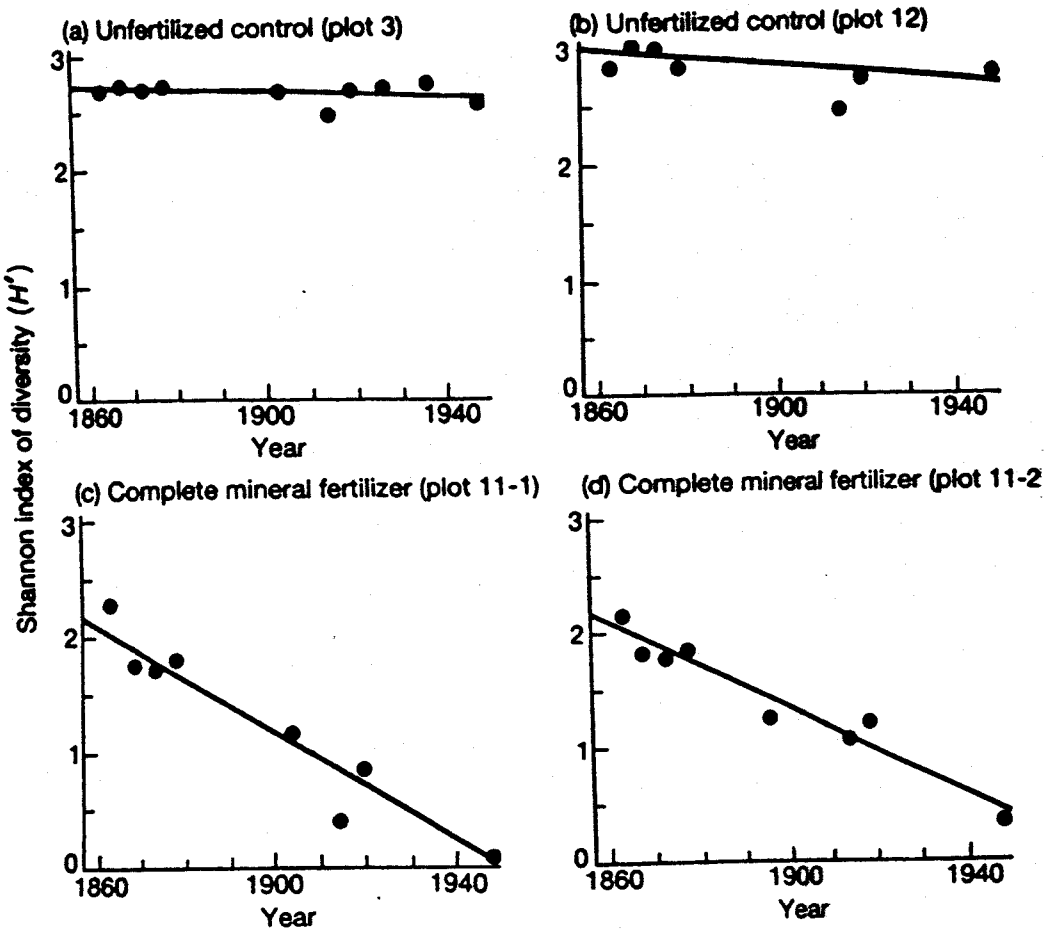

Effects of fertilization on the species diversity of the Park Grass Experiments at Rothamsted, England. The Shannon Index of species diversity, H', measures both the total number of species in the community and the evenness of their relative abundance distributions. The more equally dominant species are, and the more species there are, the greater the value of H'. (*a*) and (*b*) show that there were no significant changes in diversity during a 100 year period in the unfertilized control plots. (*c*) and (*d*) show that the diversity of plots fertilized with a complete mineral fertilizer containing N, P, K, Ca and Mg fell dramatically through time. Many of the grasses and forbs living in this regularly mowed pasture are long-lived perennial plants which have a large proportion of their biomass in below-ground storage organs. This may account for the slow rate of species displacement. Modified from Tilman (1982).

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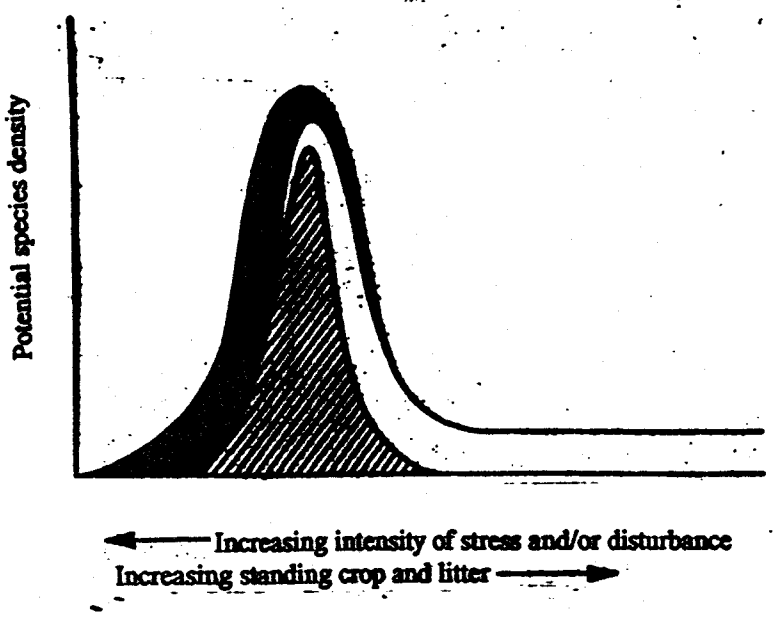
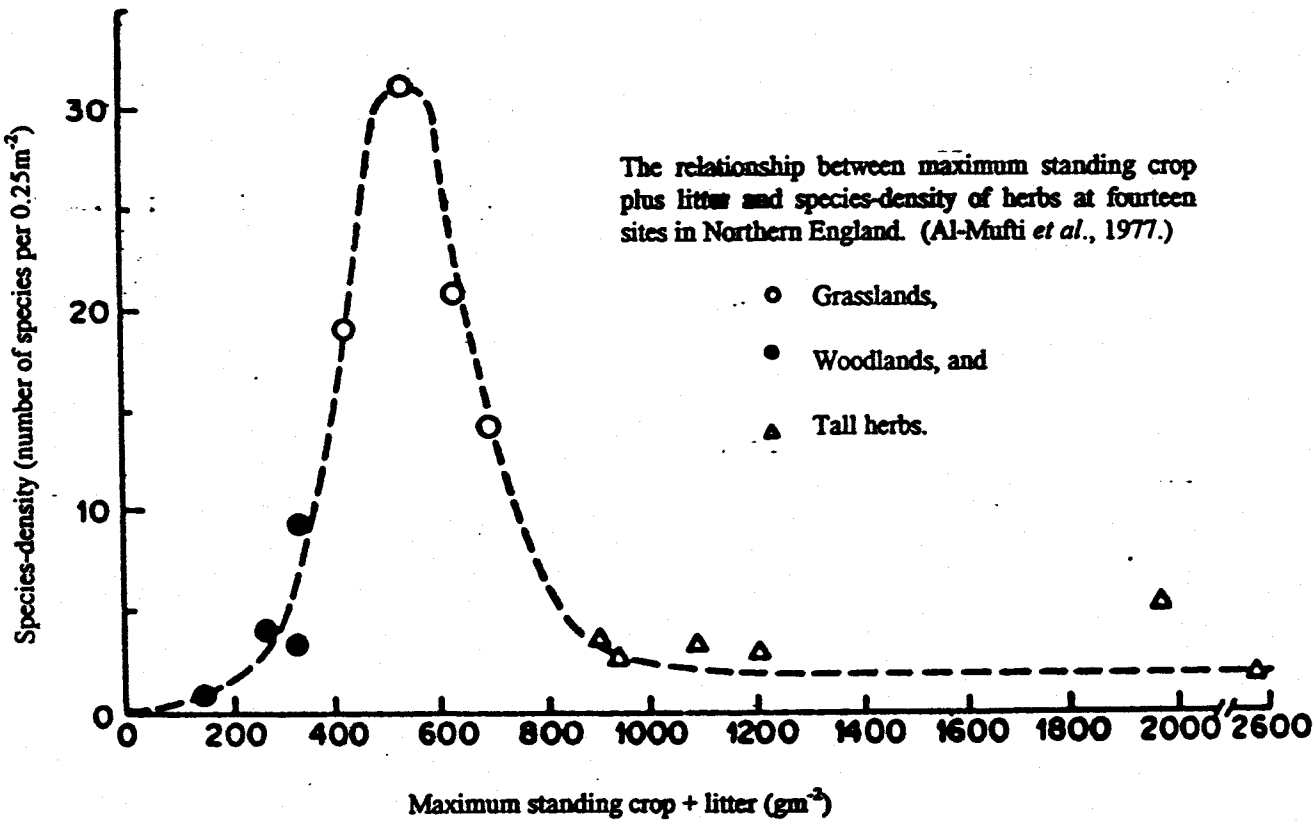


Model describing the impact of a gradient of increasing stress and/or disturbance upon the potential species density in herbaceous vegetation. (Reproduced by permission of Macmillan (Journals) Ltd.)

- Potential dominants,
- Species or ecotypes, highly adapted to the prevailing form(s) of stress or disturbance, and
- Species which are neither potential dominants, nor highly adapted to stress or disturbance (Grime, 1973).



The relationship between maximum standing crop plus litter and species-density of herbs at fourteen sites in Northern England. (Al-Mufti *et al.*, 1977.)

- ○ Grasslands,
- ● Woodlands, and
- △ Tall herbs.

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	REVIEWED	FILE NO.	FIGURE NO. 4

5.0 TOPSOIL HANDLING

A mass balance of topsoil requirement and availability (based upon 12-inch cover) was performed for the 1994 Reclamation Plan. Estimated availability amounted to approximately 1.23 M yd^3, with a reclamation requirement of 1.07 M yd^3. To date, topsoil has been stripped and stockpiled for subsequent reclamation use, in selected areas. Given a variance to NOI requirements, granted by DOGM, 300,000 yd^3 available topsoil have not been salvaged, due to practical difficulties. Consequently, insufficient material is available for total site reclamation, if an average of 12-inch depth is imposed. However, based upon the research and test plot results presented in this report, it is strongly recommended that the 12-inch requirement is replaced by the following options:

- Vegetation is established directly into amended waste rock in areas where access by agricultural and spreading machinery is limited.
- An average topsoil depth of 6 inches is used in areas of waste rock where access and topsoil placement is practically possible.
- Topsoil materials are generally reserved for areas where amendments alone will not provide suitable cultivable material (*e.g.*, coarse fractured rock at the South Barneys Canyon South mine).

It should also be noted that topsoil which has been stockpiled for longer than 1 year, at vertical heights greater than 2 m (about 6 feet), will be severely degraded. Studies performed elsewhere have proven that long-term topsoil management in high stockpiles causes:

- Loss of biogeochemical cycling.
- Loss of mycorrhizal activity.
- Significantly reduced bacterial activity.
- Change from aerobic to anaerobic conditions.
- Loss of soluble nutrients.

- Compaction.
- Degraded texture.

Results of agronomic analysis of three soil samples taken from stockpiles are presented in Appendix B. These data generally indicate low organic content, poor macronutrient status, and low cation exchange capacity.

These problems are aggravated by the fact that some stockpiled soils, particularly of the Harker and Dry Creek type, contain high clay contents, suffer significant compaction, and are difficult to handle. In this context, the advantage of using topsoil rather than organically amended waste rock is difficult to rationalize.

6.0 SUPPORT FOR VARIANCE OF AN APPROPRIATE THICKNESS OF TOPSOIL

Three main points have been established which support a request for variance from the requirement of 12 inches of topsoil on all reclaimed surfaces and slopes equal to or less steep than 2:1. These include:

- Data which support the hypothesis that adequate vegetation to control erosion can be established without the use of topsoil.
- Data indicating a diverse and higher quality vegetation stand can be achieved if topsoil cover is reduced to an average of 6-inch depth.
- An erosion study which indicates the use of topsoil over waste rock is detrimental to reducing erosion and sediment transport.

Each of these points is discussed further below.

The vegetation trials which have been conducted to date, and summarized above, have all indicated that the success criterion of 0.7 times the pre-existing cover can be achieved in a number of ways. The areas revegetated with a topdressing of 6 inches of topsoil were

similar in cover to the 12-inch topsoiled plots. The non-topsoiled plots achieved slightly lower vegetation cover values, but were revegetated to a degree sufficient to control erosion. With each year, the cover values have improved. In addition, the vegetation quality is better on the non-topsoiled areas which do not support an aggressive, ruderal community. Although preliminary, the plots where organic sludge was applied, indicate the success criteria can be met with this approach.

The most profound difference between the topsoiled versus non-topsoiled plots was in vegetation quality and diversity. The 12-inch topsoiled plots, though diverse, supported a variety of aggressive ruderal species. Seeds for these species most likely resided in the seedbank of the soil. The ambient levels of nitrogen, in conjunction with added nitrogen fertilizers, may also have contributed to this result. In addition, the 12-inch topsoiled plots contained fewer leguminous species in relation to grasses. Vegetation quality was more acceptable on 6-inch topsoil plots due to the enhanced diversity contributed by native forbs and the reduced presence of ruderals. The non-topsoiled plots, in contrast, consistently achieved a more balanced vegetation structure. In the first season, these plots were dominated by legumes and grass species beneficial to erosion control. In subsequent years, a more diverse stand has developed which includes legumes, native bunch and sod forming grasses, and non-aggressive forbs; Table 4 lists those species which were recorded as 1995 colonists of the plant community established on 6-inch topsoil treated with 18-46-0 compound.

The species richness of the plant community established upon 6-inch topsoiled waste rock amended with low N: high P fertilizer indicates an acceptable level of "pioneer" diversity, with sufficient gap cover to allow further successional development. Vegetation cover development has been enhanced by the establishment of native forbs other than those shown in Table 4, which have begun to colonize gaps. Also, manual planting of woody species, including *Cerocarpus ledifolius* and *Rosa woodsii* will enhance future diversity and stability. Following a letter of recommendation from DOGM to Kennecott Corporation, Barneys Canyon Mine (D.W. Hedberg, November 14, 1994), the mine has altered its seed mixture to

included *Elymus cinereus, Kochia prostrata,* and *Sanguisorba minor*, thereby increasing the potential for greater species richness on reclaimed areas of waste rock.

TABLE 4

COMMERCIAL SPECIES AND NATIVE FORB SPECIES RECORDED ON THE BENCH TRIALS (6-INCH TOPSOIL AND 18-46-0 COMPOUND) AT BARNEYS CANYON MINE - 1995

Commercial Grasses	Commercial Legumes	Native Forbs
Agropyron smithii	*Astragalus cicer*	*Achillea lanulosa*
Agropyron spicatum	*Medicago sativa*	*Artemesia tridentata*
Elymus elymoides	*Melilotus officinalis*	*Chrysothamnus nauseosus*
Festuca ovina		*Penstemon palmeri*
Poa canbyi		
Secale cereale		

The most important factor in the establishment of a well-balanced vegetation cover was demonstrated to be the addition of organic matter and a high phosphorus fertilizer, which facilitated the establishment of excellent vegetation cover on the "football field" block amended with sludge, and angle of repose slopes at the 6500 rock dump.

The erosion analysis, included as Appendix A, indicated that topsoil was more erodible than the waste rock and made the recommendation that all slopes be revegetated without the use of topsoil This analysis also indicated that more sediment would be lost from slopes graded to 3:1 than slopes graded to 2:1, or left at 1.33:1. The study provided root matrix diameter values which were used to prepare a seed mixture to control erosion. The data provided in the study can also be used to determine if adequate vegetation has been established to meet the criteria required to control erosion. The data recorded from the site monitoring indicates that the vegetation established on the non-topsoiled test plots meets this criteria and will be sufficient to control erosion.

The intent of mining reclamation regulations in the State of Utah are to establish vegetation cover sufficient to control erosion and provide stability in the long-term. The information provided above indicates that previous approvals of reclamation plans, and even approvals of variances, have met this intent. The importance of topsoil was strictly based on its benefit toward the goal of erosion control. Variances were approved which allowed surface roughness to take precedence over an even thickness of topsoil. The information provided in this document indicates that topsoiling at a depth of 12 inches is detrimental to the goals of reclamation for the site. Therefore, we request Barneys Canyon dumps which are configured at 2:1 or less, be held to a requirement to place sufficient topsoil or adequately amend the waste rock, to encourage appropriate vegetation of a quality and diversity able to be self-sustaining and control erosion. Furthermore, we recommend that DOGM is requested to review the technical merits of modifying the vegetation strategy on a case-by-case basis. In doing so, the mine will be able to optimize its vegetation establishment methods, to suit the specific environmental conditions which prevail on each of:

- More or less horizontal waste rock surfaces.
- Angle of repose slopes.
- Slopes of 2.5:1 and less.
- Slopes of varying aspects.
- Coarse rock and inaccessible ledges.

This approach will ensure that topsoil reserves are utilized in areas where growth medium is actually required, such as coarse rock faces, rather than cultivable, soil-like waste rock, where topsoil is not required.

MELCO OPERATION

EROSION ANALYSIS

DETERMINATION OF ROOT MATRIX DIAMETERS FOR ROOT ARCHITECTURE SPECIFICATION TO PREVENT EROSION ON THE WASTE ROCK DUMPS

December 1992
SRK Project No. 29505

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APPENDIX 1 SUMMARY OF CALCULATION PROCEDURES
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1.0 INTRODUCTION

Steffen Robertson and Kirsten (US) Inc (SRK) determined the required root matrix diameters for use in specifying the root architecture requirements of plants to prevent erosion on the rock dump at the MELCO operation. The method which was used is based on a relationship between a geomechanical erodibility index and stream power of rainfall impact and surface water runoff. This relationship was determined by making use of more than 100 field observations by the US Soil Conservation Service on the hydraulic erodibility of a variety of earth materials. The data base includes observations of the erodibility of bare and vegetated soils. The relationship was validated by making use of published laboratory observations of the initiation of sediment erosion from earth materials. (refer to Kirsten and Moore, in press).

In what follows, the technique is generically described and the findings of the investigation presented. The report concludes with a recommendation pertaining to the required root matrix diameters. This information was used by other members of the SRK team to determine vegetation requirements which comply with the root architecture specifications, to be tested under field trials conditions (refer to SRK Report 29505/2).

2.0 DESCRIPTION OF METHOD

2.1 General Description Of Erosion Process

Erosion is initiated by a process of progressive dislodgment, consisting of three components, viz.:

- Jacking;
- Dislodgement; and
- Transport.

The jacking effect is caused by pressure fluctuations in the soil/waste pore water close to the surface, and in water discharging over the surface. These fluctuations originate from turbulence which is generated as water discharges over or incident to a boundary. The higher the turbulence intensity, the greater the fluctuation in pressure. Pressures at the boundary surface can be as low as vapour pressure, while, at the same time, the pressures within the cracks and crevices of the material are still at hydrostatic pressure. These large pressure differentials essentially result in fluctuating net forces which cause the material to progressively move out of its position of rest. Once the material is at the threshold of instability,it is dislodged by the power of the discharging water and finally transported in a downstream direction.

Hydraulic erodibility is a threshold condition which can be expressed in terms of a graphical relationship or an equation. At the erodibility threshold the agitating agent and the capacity of the material to offer resistance to erosion are related in the following functional manner:

$P = f(Kn)$

where

P = the magnitude of the agitating agent

$f(Kn)$ = the capacity of the material to resist erosion.

The agitating agent in the case of the hydraulic erodibility of earth material is the power of rainfall and water discharging incident to or over the material. The capacity of the material to resist erosion can be described by means of an index which accounts for the relative contribution of the important elements determining the strength of the material.

If $P > f(Kn)$ the erodibility threshold has been exceeded and the material will erode. Conversely, if $P < f(Kn)$ the erodibility threshold is not exceeded, and erosion will not occur.

2.2 Agitating Agent, P

The magnitude of the agitating agent P should be a measure of the fluctuating pressure, characterized by the turbulence intensity of impinging rainfall and discharging water. Exact modeling of turbulence intensity is currently out of the realm of practical engineering. Therefore, a need was identified to define a parameter which adequately represents the essence of the hydraulic process. This parameter is required to be a measure of the magnitude of the pressure fluctuations resulting from the turbulence in impinging and flowing water. A measure of turbulence intensity will reasonably represent the magnitude of the pressure fluctuations in impinging and discharging water. Turbulence is essentially the major cause of energy losses in turbulent, discharging and impinging water; and the higher the turbulence intensity, the higher the rate at which energy is dissipated.

Stream power, defined as the rate at which energy is dissipated, is a measure of the turbulence intensity of discharging and impinging water and concomitantly provides a measure of the magnitude of pressure fluctuations. The higher the stream power, the greater the magnitude in pressure fluctuations in the water, and the greater the erosive impact.

Stream power, generally expressed as:

$$StreamPower = \gamma Q \Delta E$$

where

gamma = unit weight of water
Q = discharge rate of water/rainfall
delta E = energy loss

was used in this investigation as a measure of the magnitude of the agitating agent (P).

2.3 Capacity Of Material To Resist Erosion, $f(K_e)$

The capacity of earth material to resist erosion is a function of its strength. The strength of earth material is determined by its mass strength, particle/block size, interparticle bond strength, relative shape and orientation. A rigorous method to represent the relative strength of earth material is through the use of a geomechanical index. An index which represents the relative ability of earth material to resist erosion, known as the Erodibility Index, is expressed as:

$$K_e = K_m \times K_b \times K_d \times K_s$$

where

K_e = Erodibility Index

K_m = Mass strength factor

K_b = Particle/Block size factor

K_d = Interparticle bond strength factor

K_s = Relative shape and orientation factor

The mass strength of the material is the basic component determining the material's ability to resist agitating agents. The factor representing mass strength is directly related to the Unconfined Compressive Strength (UCS) of a material. The other factors essentially adjust this basic ability of the material to resist dislodgement by agitation.

Large particle/block sizes will provide more resistance to erosive power than would small sizes, whereas interparticle bonding further increases its strength. The resistance provided by the combined effect of cohesion and interparticle friction in soils is increased by the presence of roots. The effect of relative shape and relative orientation are combined in the factor K_s.

3.0 FINDINGS

The method used to index the materials, to determine stream power for rainfall falling onto and discharging off the slopes of the rock dump, and the method to determine the root matrix diameters are presented in detail in Appendix 1.

Five design storms, with recurrence intervals ranging from 1:2 to 1:50 years were used to calculate stream power on the rock dump slopes. The materials representing topsoil and the MELCO waste rock (assumed to be represented by the grading analysis of the MELCO crushed

ore which was provided to SRK) were calculated for all cases. A plot of the stream power estimates on a 37 degree waste rock dump slopes for the 1:10 year storm are shown on Figure 1. This comparison indicates that both topsoil and waste rock materials will erode, unless protection against erosion is provided. The relative positions of the coordinates of the materials indicate that the topsoil is significantly more erodible than the waste rock. Significantly less vegetation protection will be required to increase the strength of the waste rock material to resist erosion.

The median root matrix diameters (root clump sizes) which are required to inhibit erosion on three selected slopes were calculated and are recorded in Table 1. This table essentially indicates that the highest median root matrix diameter which will be required to prevent erosion is 0.2m. An approximately normal distribution of root diameter sizes about this median value is assumed. The table also shows that root matrix diameter requirements increase with decreasing slope. The reason for this phenomenon is that the contribution to stream power by the runoff dominates. Therefore, the milder the slope, the larger the area which is exposed to rainfall when discharging runoff between two fixed elevations. This larger area leads to increased runoff and, thus, stream power. There are obviously limitations imposed on this phenomenon, but it is valid in the range over which it has been applied in this investigation. (refer to Crawford and Kinsley, 1967; and Rooseboom and Mülke, 1982 - see Appendix 2).

TABLE 1
Calculated streampower values and median root clump sizes required to inhibit slope erosion

	Slope = 18.4 degrees (3:1)		Slope = 26.6 degrees (2:1)		Slope = 37 degrees (1.33:1)	
Storm Recurrence Interval (years)	Streampower (kW/m)	Median Root Clump Size (m)	Streampower (kW/m)	Median Root Clump Size (m)	Streampower (kW/m)	Median Root Clump Size (m)
2	.4457	.149	.2473	.109	.1551	.085
5	.5574	.168	.3092	.124	.1940	.095
10	.6568	.185	.3644	.134	.2286	.104
25	.7351	.192	.4078	.143	.2558	.113
50	.8125	.204	.4507	.151	.2828	.116

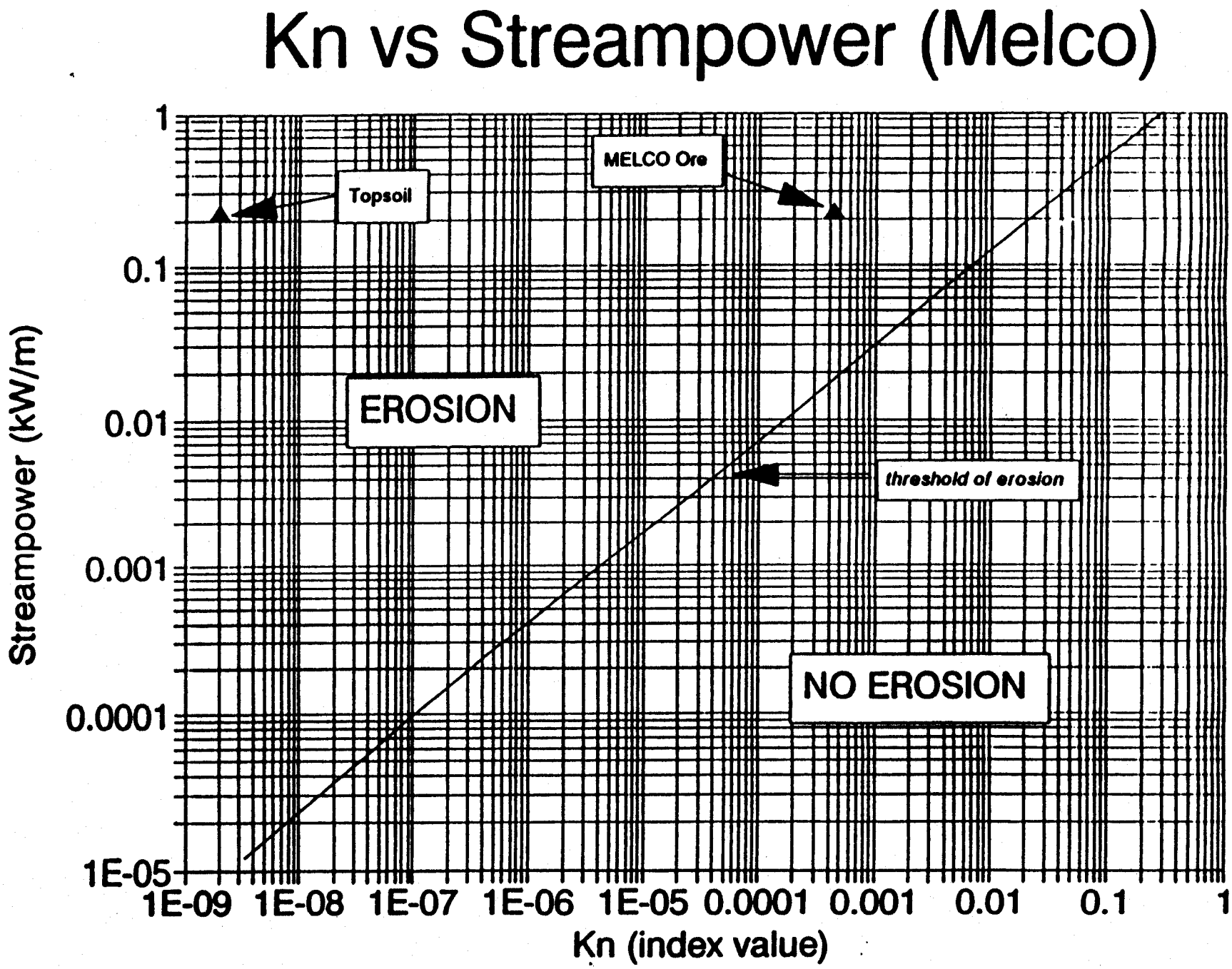
Kn vs Streampower (Melco)
Streampower (kW/m)
1
0.1
0.01
0.001
0.0001
1E-05
1E-09
1E-08
1E-07
1E-06
1E-05
0.0001
0.001
0.01
0.1
1
Kn (index value)
Topsoil
MELCO Ore
EROSION
threshold of erosion
NO EROSION

FIGURE 1

4.0 RECOMMENDATION

It is recommended that the vegetation cover over the rock dump should be planted directly onto the waste rock and that it should comply with the highest median root matrix diameter required for the 1:10 year rain storm. This is a practical root matrix diameter, which also limits the likelihood of erosion to an acceptably low level. Conservatively, one should aim to establish a median root matrix diameter of 18.5 cm, prescribed for 1:3 slopes, thus minimizing risk of erosion. Theoretically, a median root diameter of approximately 10 cm would be effective in controlling erosion on 37° slopes.

The following generic specifications therefore apply:

- The vegetation mix should be such that the median root matrix diameter in all directions is 18.5 (approximately 20) cm;

- The principal root systems would be generated by bunch grasses;

- The bunch grasses should be established in a way that will ensure that the root systems interlock;

- The ~~cover~~ content of bunch type vegetation can be reduced to the order of 65 % of the total mix, provided that sufficient plant material with laterally spreading rhizome type roots and/or fibrous lateral roots are located between the bunch type vegetation. This type of root system will protect the soil against erosion of material between the clumps. Sod-forming grasses will be used for this purpose. Further stability will be provided by deep, tap-rooted species;

- It is preferable to utilize plant species that can establish directly into the material on the waste rock dump. This material is more resistent to erosion than the topsoil. Less erosion will therefore occur from the waste rock dump during the period of vegetation establishment; and

- Straw mulch should be considered for placement on the rock dump slopes during the period of vegetation establishment.

George W. Annandale, D.Eng.
Corporate Consultant: Surface Water Engineering

APPENDIX 1
SUMMARY OF CALCULATION PROCEDURES

Barney's Canyon
MELCO Site Erosion Analysis

Objective:

To determine the root clump size necessary to prevent erosion on the slopes of the MELCO Site. (Slopes of 3:1, 2:1, and 37 degrees were tested)

Methodology:

1. The rainfall depths for 6-hour storms of recurrence intervals 1:2, 1:5, 1:10, 1:25, and 1:50 years were determined using the NOAA Precipitation Frequency Atlas for Utah. *(Miller et al., 1973)* The peak rainfall intensity for each storm was calculated using the approximation that .25 of the total rainfall depth for a storm falls in 0.5 hours. *(Goldman et al.)* The peak intensity (mm/hr) and associated median droplet sizes were used to determine the rainfall power per unit area for each storm. *(Gray & Leiser, 1982)*

2. The power and flow depth associated with the overland flow were calculated by using the following equations (*Rooseboom & Mülke, 1982.*):

$$E = \frac{74\ \rho\ g\ S_o\ D\ \sqrt{g\ D\ S_o}}{1000k}$$

E = streampower applied to a slope by flow (kW/m²)
ρ = density of water
g = acceleration due to gravity (m/s²)
S_o = slope (dimensionless)
D = flow depth (m)
k = absolute roughness (m)

$$D = \left[\frac{n\ I\ L^{2/3}}{C\ S_o\ 1/2}\right]^{3/5}$$

D = flow depth (m)
n = Manning coefficient of roughness
I = rainfall intensity (mm/hr)
L = slope length (m)
C = empirical coefficient (497000)
S_o = slope (dimensionless)

3. The rainfall power and the flow power were added to yield a total slope streampower.

4. The Erodibility Index (K_e) and Stream Power were related *(Annandale & Kirsten, unpublished)* by using more than 100 field data points. This relationship was used to determine the threshold K_e values for the relevant material on the mine.

5. The required block size to prevent erosion were determined using Kirsten's equation for the calculation of a K_e value:

$$K_e = K_m K_b K_d K_s$$

where:

K_m = mass strength number (for coarse sand)
K_b = block size ($1000D^3$) [must solve for D]
K_d = interparticle bonding (tan P)
K_s = orientation (1)

K_e = Kirsten's erodibility index (for coarse sand)

therefore, to calculate the block size D (m):

$$D = \left[\frac{K_e}{K_m K_s K_d 1000}\right]^{1/3}$$

6. The K_e values for the following two surface materials were determined by using Kirsten's $K_e = K_m \bullet K_b \bullet K_d \bullet K_s$:

Topsoil	= 1.99 E -9
MELCO ore	= 4.39 E -4

The corresponding streampower values (W/m) at the threshold of erosion levels for these materials are:

Topsoil	= .01 W/m
MELCO ore	= 18 W/m

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BIOTRACE LABORATORIES

3440 SOUTH 700 WEST, SALT LAKE CITY, UTAH 84119-4194 (801) 262-7946

CLIENT NUMBER 3035 | FINAL | PAGE: 1

STEVEN D LACKEY C I H
BARNEYS CANYON MINE AAA
P O BOX 311
BINGHAM CANYON UT 840060311

NAME/I.D.# S-1A SOIL, 39737 (3035)000-03-9737
AGE: UNK
SEX: UNK

DATE COLLECTED 02NOV93 1616
DATE RECEIVED 08NOV93 1616
DATE PRINTED 03MAY94 0256

SENT BY:

ORDERED TESTS: SOIL/REPRINT REQ 5-2-94

ANALYSIS	RESULT	REFERENCE RANGE	UNITS
	NORMAL / OUT OF RANGE		

OTHER

MISCELLANEOUS — SEE NOTE

MISCELLANEOUS.. 02NOV93 1616

		ANALYST	DATE ANALYZED
AS	<.20 ppm	UPK	23NOV93
CD	<.10 ppm	UPK	23NOV93
CR	<.20 ppm	UPK	23NOV93
CU	<.20 ppm	UPK	23NOV93
FE	1.5 ppm	UPK	23NOV93
HG	<0.5 ppm	UPK	23NOV93
MO	<.20 ppm	UPK	23NOV93
NI	<.20 ppm	UPK	23NOV93
PB	<.20 ppm	UPK	23NOV93
SE	<.20 ppm	UPK	23NOV93
ZN	.71 ppm	UPK	23NOV93

Performed at AEC, 3422 South 700 West, Salt Lake City, UT 84119

CEC	7.6 meq/100g
ELECTRO-CONDUCT	1.6 mmhos/cm
K	53 mg/kg
KJELDAHL NITROGEN	0.015 %
NO3/NO2	2.6 mg/kg
ORGANIC CONTENT	0.22 %
P	5.5 mg/kg
PH	8.0 pH
SATURATION %	36.5 %
SODIUM ABSORP RATE	2.7

----- H2O SOLUBLE -----

CA	6.3
MG	3.9
NA	6.1

Performed at Utah State University, Logan, UT

Accession Number: 93-312-3128 *END OF REPORT* Laboratory Director: Steve R. Hanorth, Ph.D.

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CLIENT NUMBER 3035 | FINAL | PAGE: 1

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BARNEYS CANYON MINE AAA
P O BOX 311
BINGHAM CANYON UT 84006311

NAME/I.D.#S-2, 39734 AGE: UNK
(3035)000-03-9734 SEX: UNK

DATE COLLECTED 08NOV93 1614
DATE RECEIVED 08NOV93 1614
DATE PRINTED 03MAY94 0256

SENT BY:

ORDERED TESTS: SOIL\REPRINT REQ 5-2-94

ANALYSIS		RESULT NORMAL	RESULT OUT OF RANGE	REFERENCE RANGE	UNITS
		OTHER			
MISCELLANEOUS		SEE NOTE			
MISCELLANEOUS.. 08NOV93 1614	KJELDAHL NITROGEN	0.020	%		
	NO3/NO2	16.8	mg/kg		
	ORGANIC CONTENT	0.19	%		
	P	3.4	mg/kg		
	PH	7.7	pH		

Performed at Utah State University, Logan, UT

Accession Number: 93-312-3129

END OF REPORT

Laboratory Director: Steve R. Hamorth, Ph.D.

LABORATORY REPORT

BIOTRACE LABORATORIES

3440 SOUTH 700 WEST, SALT LAKE CITY, UTAH 84119-4194 (801) 262-7946

CLIENT NUMBER 3035 | FINAL | PAGE: 1

STEVEN D LACKEY C I N
BARNEYS CANYON MINE AAA
P O BOX 311
BINGHAM CANYON UT 840060311

NAME/I.D.# S-1 SOIL, 39736 (3035)000-03-9736 | AGE: UNK | SEX: UNK

DATE COLLECTED 02NOV93 1616
DATE RECEIVED 03NOV93 1616
DATE PRINTED 03MAY94 0256

SENT BY:

ORDERED TESTS: SOIL/REPRINT REQ 5-2-94

ANALYSIS	RESULT		REFERENCE RANGE	UNITS
	NORMAL	OUT OF RANGE		

OTHER

MISCELLANEOUS — SEE NOTE

MISCELLANEOUS.. 02NOV93 1616

			ANALYZED	DATE ANALYZED
AS	<.50 ppm		WPK	23NOV93
CD	<.25 ppm		WPK	23NOV93
CR	<.50 ppm		WPK	23NOV93
CU	5.8 ppm		WPK	23NOV93
FE	95 ppm		WPK	23NOV93
HG	<.05 ppm		WPK	23NOV93
MO	<.50 ppm		WPK	23NOV93
NI	1.2 ppm		WPK	23NOV93
PB	4.5 ppm		WPK	23NOV93
SE	<.50 ppm		WPK	23NOV93
ZN	3.6 ppm		WPK	23NOV93

Performed at AEC, 3422 South 700 West, Salt Lake City, UT 84119

CEC	26.1	meq/100g
ELECTRO-CONDUCT	0.7	mmhos/cm
K	25.8	mg/kg
KJELDAHL NITROGEN	0.125	%
NO3/NO2	10.0	mg/kg
ORGANIC CONTENT	1.68	%
P	35	mg/kg
PH	7.7	pH
SATURATION %	70.3	%
SODIUM ABSORP RATE	1.0	

----- H2O SOLUBLE -----

CA	4.0
MG	1.0
NA	1.0

Performed at Utah State University, Logan, UT

Accession Number: 93-312-3127

END OF REPORT

Laboratory Director: Steve R. Haworth, Ph.D.

The Following Material Was Included in
The Revision and Was Titled Appendix B

For The Purposes of This Combined
Document, The Material Has Been
Included As Appendix I

APPENDIX B
HYDROLOGIC CALCULATIONS

JBR - K.L.L. 8-13-92

Drainage Area Data

Drainage ID	Area (ac)	L (ft)	H (ft)	Tc	CN
BC-South	126	4500	1100	0.2852	56
M-a	231	4500	725	0.1094	89
M-b	16.0	2200	425	0.0588	89
M-c	7.11	1200	200	0.0390	89

Calculations for 10-yr, 24-hr rainfall

Drainage ID	Runoff depth (in)	Peak flow (cfs)	Volume (AF)
BC-South	0.14	4.01	1.47
M-a	1.63	369	31.4
M-b	1.63	26.0	2.17
M-c	1.63	11.7	0.97

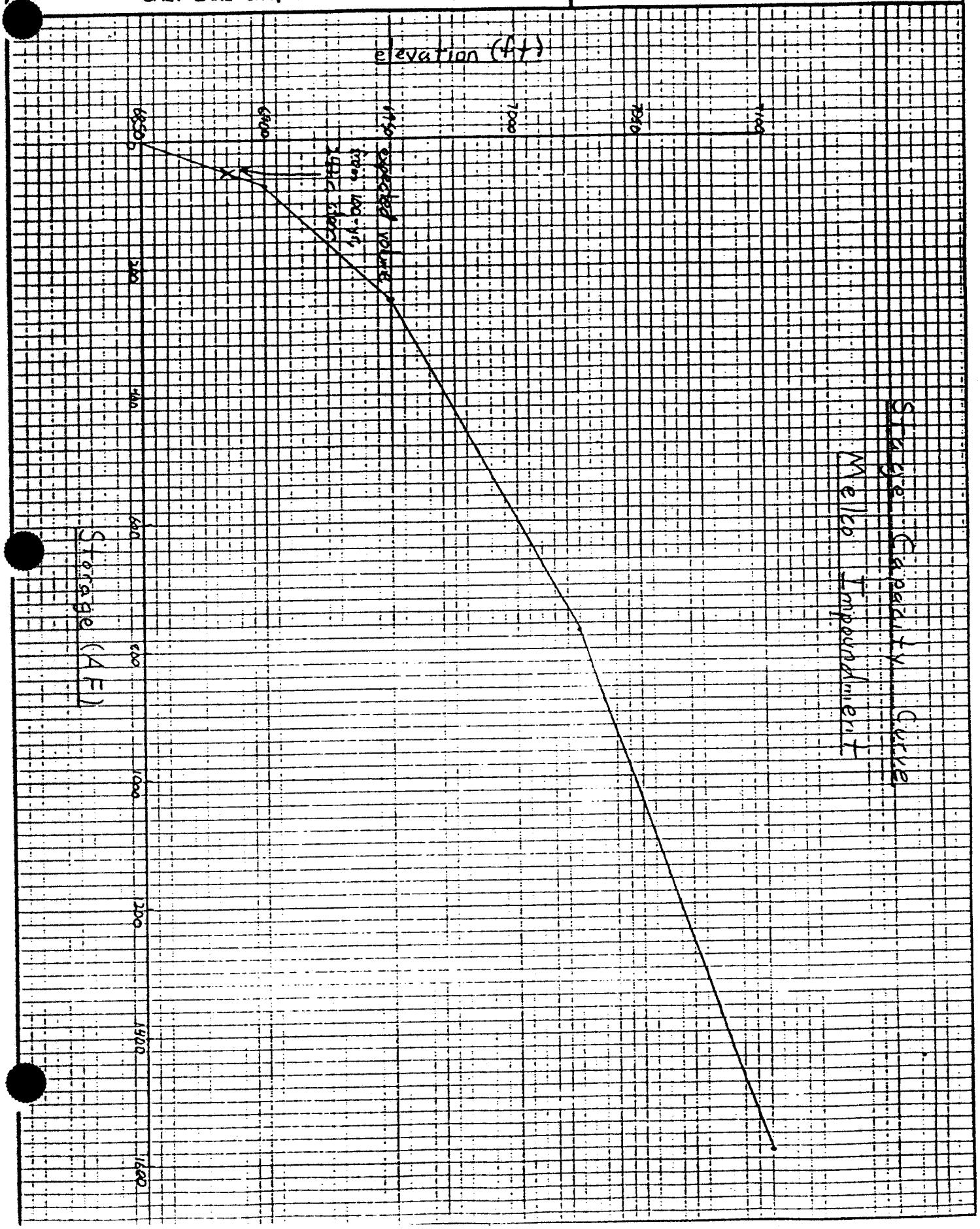
Calculations for 100-yr, 24-hr rainfall

Drainage ID	Runoff depth	Peak flow (cfs)	Volume (AF)
BC-South	0.45	36.6	4.73
M-a	2.54	556	48.9
M-b	2.54	39.0	3.38
M-c	2.54	17.4	1.50

CONSULTANTS GROUP

GEOLOGY ENGINEERING ENVIRONMENT HYDROLOGY
SALT LAKE CITY, UTAH RENO, NEVADA

PROJECT NO. Barney's Canyon
BY KLL DATE 8-6-92
CHK'D DATE
SHEET NO. 1 OF 1



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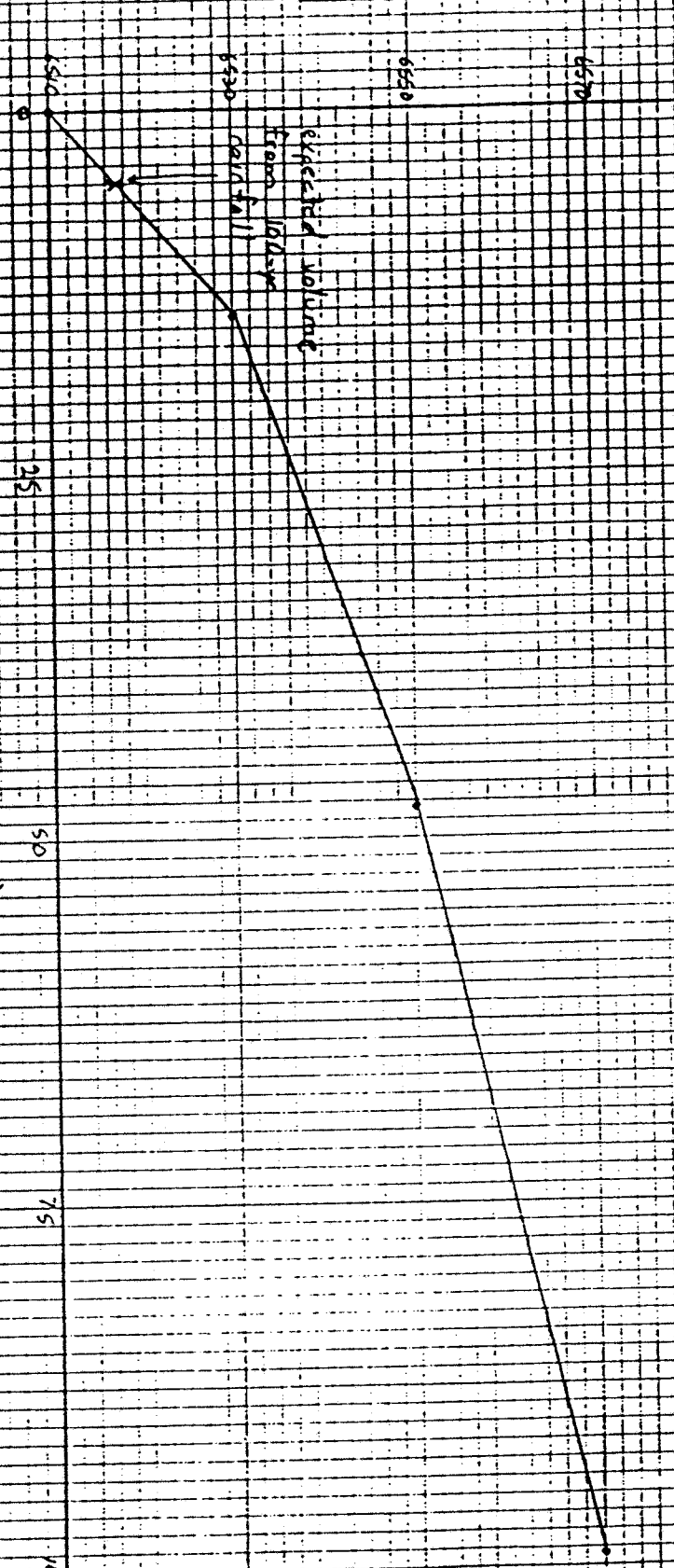
GEOLOGY ENGINEERING ENVIRONMENT HYDROLOGY
SALT LAKE CITY, UTAH RENO, NEVADA

PROJECT NO. Barney's Canyon
BY KLL DATE 8-6-92
CHK'D DATE
SHEET NO. 1 OF 1

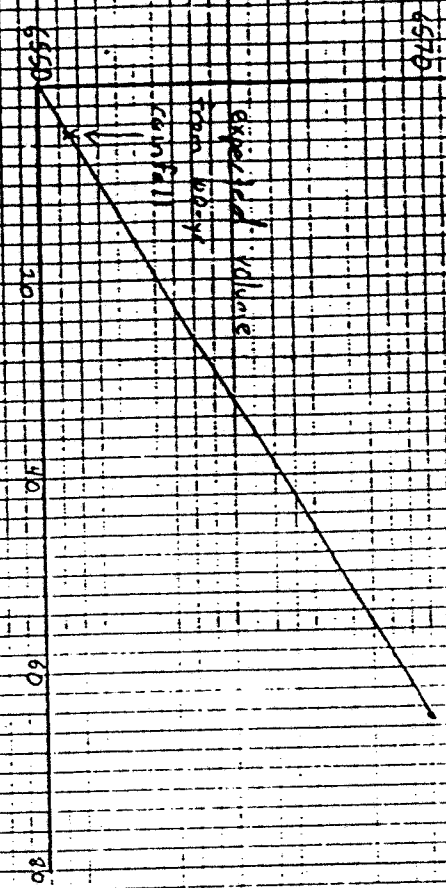


Stage-Capacity Curve
BC South Impoundment

CONSULTANTS GROUP

GEOLOGY ENGINEERING ENVIRONMENT HYDROLOGY
SALT LAKE CITY, UTAH RENO, NEVADA

PROJECT NO. Barney's Canyon
BY KLL DATE 8-7-92
CHK'D DATE
SHEET NO. 1 OF 1



Culvert for M-b drainage

Flow = 132 cfs

use 48" culvert

HW = 7.2' use 4' cover

LL = 400 psf

DL = 120 lb/ft³ (4) = 480 psf

P_v = 400 + 480 = 880 psf

C = 880 $\left(\frac{4}{2}\right)$ = 1760 lb/ft

from fig. 3-6

f_c = 19.2 ksi

$$A = \frac{C}{f_c} = \frac{1760 \text{ lb/ft}}{19{,}200 \text{ lb/in}^2} = 0.092 \text{ in}^2/\text{ft}$$

use 16 gauge, $2\frac{2}{3}'' \times \frac{1}{2}''$ A = 0.775 in²/ft OK
from Table 3-2

$$FF = \frac{D^2}{EI}$$

$$FF = \frac{(48 \text{ in})^2}{(30\times10^6 \text{ lb/in}^2)(.0227 \text{ in}^4/\text{ft})\left(\frac{\text{ft}}{12 \text{ in}}\right)} = .0406 < .0433 \quad \text{OK}$$

use 48" culvert $2\frac{2}{3}'' \times \frac{1}{2}''$ pitch x depth, 16 gauge cmp

culvert for M-a, M-λ drainages

flow = 41 cfs

use 36" culvert (AISI fig 4-28)

HW = 3'

Load = 600 psf

DL = 120 lb/ft³ (3 ft) = 360 psf

P_v = 600 + 360 = 960

C = 960 × 3/2 = 1,440 lb/ft

f_c = 19 ksi

$A = C/f_c = \frac{1440}{19,200} = .075$ (in²/ft)

check 16 gauge

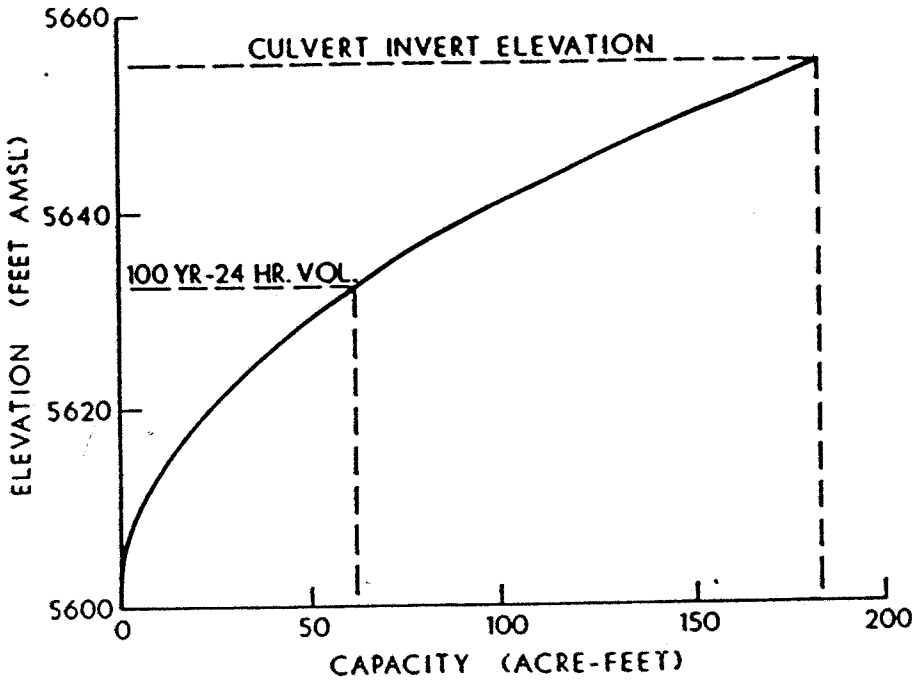
$FF = \frac{D^2}{EI} = \frac{36^2}{(30\times10^6)(.0237)} = .0019$

Maximum = .0433 OK

36" cmp

2⅔" x ½" Pitch x depth

16 gauge



TOTAL CAPACITY AT CULVERT INVERT AT 5655 = 182 AF
RUNOFF VOLUME FROM 100 YR - 24 HR STORM = 62 AF

BARNEYS CANYON
AT ROAD GRADE

STAGE CAPACITY CURVE
(ASSUMING WORST-CASE DISTURBED CONDITION)

jbr CONSULTANTS GROUP

3/27/92

Barney's Canyon | March 17, 1992 | kk

Area includes the upper Barney's Canyon watershed which was modeled by Rick previously.

Info from Rick's work:

Area	1430	
CN	48	
Precip	100year-24hr	3.6 in
	10 year-24hr	2.7 in
	25 yr-24 hr	3.0 in

Rick designed sed basins for 25yr-24 hr → do the same. Use Ricks CN for the part of new area which is comprised of the old modeled area. For remaining area, which is located downstream of old modeled area, derive CN based on Rick's determination of CN for same soil/veg types where types are same. If other area is of different soil/veg type than in Rick's work, derive CN using Van Haveren, 87.

Using veg map (Fig 2.5-1 dated 11/11/91) veg types in lower area are:

Oak woodlands
Oak/artr
North slope
Riparian (insignificant area - don't include)

Soils for the lower area (from SL. soil survey

GGG, GEG → HSG B
HDF, DRD, BVF → HSG C

Soil / veg types:	CN's	
North Slope B	48	(from Rick)
Oakwoodlands B	48	(from Rick)
* Oak/Artr B	48	
* Oak/Artr C	64	

* assume fair, 50% Oak/asp, 50% sagebrush, Va. Haveren.

Assume negligible disturbance for now.

Total Watershed Area (from original quads)

2680 acres

Weighted CN

250 acres @ CN = 64 → 9.3%
2430 acres @ CN = 48 → 90.7%
100 %

$$CN = (.093)64 + (.907)(48) = 50$$

Volume of Runoff

10 yr 24 hr $\quad 2680 \text{ ac} \times \frac{.04579 \text{ in}}{12} = 10.2 \text{ af}$

25 yr 24 hr $\quad 2680 \text{ ac} \times \frac{.09091 \text{ in}}{12} = 20.3 \text{ af}$

100 yr 24 hr. $\quad 2680 \text{ ac} \times \frac{.22069 \text{ in}}{12} = 49.2 \text{ af}$

Assume disturbance from prestripping all surfaces + road in place:

BC dump	24.4	*'s from Bob
S BC mine	34.7	
N BC south	18.4	
soil piles	7.0	
road	14.7	
	99.2 ac	~ 100 ac

Say 100 ac at 90 (worst case area, worst case CN)

100 ac at 90 → 3.7 %
2580 ac at 50 → 96.3 %
100 %

$CN = (.037)90 + (.963)(50) = 52$

Volume of Runoff

100 yr 24 hr $2680 \text{ ac} \times \frac{.28003 \text{ in}}{12} = 62 \text{ af}$

The Following Material Was Included in
The Revision and Was Titled Appendix C

For The Purposes of This Combined
Document, The Material Has Been
Included As Appendix J

APPENDIX C
CORRESPONDENCE WITH UTAH DIVISION OF WATER QUALITY
AND
RESULTS OF ACID/BASE POTENTIAL ANALYSES

BARNEYS CANYON MINE
P.O. Box 311
Bingham Canyon, Utah 84006-0311
(801) 569-7200
FAX (801) 569-7190

David I. Hodson

Kennecott

June 19, 1992

Mr. Don A. Ostler
Executive Secretary
Division of Water Quality
Utah Department of Environmental Quality
288 North 1460 West
Salt Lake City, Utah 84116

RE: Stockpiled Sulphide Ore

Dear Mr. Ostler:

In response to your letter of May 20, 1992, and subsequent discussion with Mack Croft, of the Division of Water Quality on June 18, 1992, Barneys Canyon Mine is submitting the following plan for disposal of sulfide material.

Mining activities to date at the Barneys Canyon and Melco pits have produced sulfide material which has been disposed of in oxide waste dumps or stockpiled separately on top of oxide waste dumps. Gold bearing sulfide material was stockpiled separately with the intention of finding an economical process to recover the gold. If an economic process is not found, the sulfide material will be covered with oxide waste material. Presently, there are three gold-bearing sulfide material stockpiles - two on the Melco oxide waste dump and one on the Barneys Canyon oxide waste dump.

Several alternatives have been evaluated to recover the gold from the stockpiled sulfide material during the last two years. The best option, which is in the final stages of evaluation, appears to be a process consisting of crushing, grinding and flotation. In this process, virtually all of the sulfur would be contained in a concentrate which would be shipped directly to a smelter. The sulfur-free tail would be heaped on the leach pads to recover the remainder of the contained gold.

Completion of a feasibility report and funding approval for the project is expected to take 12 to 18 months. An additional 6 to 12 months is anticipated for permitting and construction before

processing of sulfide ore can begin. Sulfide ore mined during that period will be stockpiled on top of oxide waste dumps. However, if this process is not implemented, all sulfide material stockpiled will be covered with oxide waste.

Sincerely,

D. I. Hodson
General Manager

cc: T. B. Braun
W. C. Dodge
S. D. Lackey
K. R. Miner (S.L. County)
D. Z. Skolasinski

Western Atlas International

CORE LABORATORIES

CORE LABORATORIES
A N A L Y T I C A L R E P O R T

Job Number: 920513
Prepared For:

BARNEY'S CANYON MINE
MICHAEL PAGEL
8200 SOUTH 9600 WEST
BINGHAM CANYON, UT 84006

Date: 04/21/92

PRELIMINARY REPORT

Signature

Date: 4/21/92

Name: David A. McWharter

Core Laboratories
1300 South Potomac, Suite 130
Aurora, CO 80012

Title: Laboratory Manager

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LABORATORY TESTS RESULTS
04/21/92

JOB NUMBER: 920513 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 1 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-1 REM:

SAMPLE NUMBER: 2 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-2 REM:

SAMPLE NUMBER: 3 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-3 REM:

SAMPLE NUMBER: 4 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-4 REM:

SAMPLE NUMBER: 5 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-5 REM:

SAMPLE NUMBER: 6 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-6 REM:

TEST DESCRIPTION	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	UNITS OF MEASURE
Syn. Prec. Leaching Procedure						0	
Total Sulfur (as S)	0.03	0.02	<0.01	<0.01	<0.01	0.01	%
Total Sulfur (Tons CaCO3/Kt)	0.9	0.6	<0.3	<0.3	<0.3	0.3	Tons CaCO3/Kt
Acid Neutralizing Potential	2.1	2.3	441	78.5	8.1	9.9	Tons CaCO3/Kt

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LABORATORY TESTS RESULTS
04/21/92

JOB NUMBER: 920513 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 7 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-7 REM:

SAMPLE NUMBER: 8 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-8 REM:

SAMPLE NUMBER: 9 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-9 REM:

SAMPLE NUMBER: 10 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NW-10 REM:

SAMPLE NUMBER: 11 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
[illegible]: BARNEY'S CANYON MINE SAMPLE: NP-1 REM:

SAMPLE NUMBER: 12 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-2 REM:

TEST DESCRIPTION	SAMPLE 7	SAMPLE 8	SAMPLE 9	SAMPLE 10	SAMPLE 11	SAMPLE 12	UNITS OF MEASURE
Total Sulfur (as S)	0.02	0.01	<0.01	<0.01	0.02	0.11	%
Total Sulfur (Tons CaCO3/Kt)	0.6	0.3	<0.3	<0.3	0.6	3.4	Tons CaCO3/Kt
Acid Neutralizing Potential	6.6	24.6	7.97	5.3	35.8	4.7	Tons CaCO3/Kt

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LABORATORY TESTS RESULTS
04/21/92

JOB NUMBER: 920513 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 13 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-3 REM:

SAMPLE NUMBER: 14 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-4 REM:

SAMPLE NUMBER: 15 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-5 REM:

SAMPLE NUMBER: 16 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-6 REM:

SAMPLE NUMBER: 17 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-7 REM:

SAMPLE NUMBER: 18 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: NP-8 REM:

TEST DESCRIPTION	SAMPLE 13	SAMPLE 14	SAMPLE 15	SAMPLE 16	SAMPLE 17	SAMPLE 18	UNITS OF MEASURE
Total Sulfur (as S)	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	%
Total Sulfur (Tons CaCO3/Kt)	0.9	<0.3	<0.3	<0.3	<0.3	<0.3	Tons CaCO3/Kt
Acid Neutralizing Potential	63.3	28.4	552	981	<0.1	14.5	Tons CaCO3/Kt

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LABORATORY TESTS RESULTS
04/21/92

JOB NUMBER: 920513 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 19 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: MP-9 REM:

SAMPLE NUMBER: 20 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SP-1 REM:

SAMPLE NUMBER: 21 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SP-5 REM:

SAMPLE NUMBER: 22 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SP-6 REM:

SAMPLE NUMBER: 23 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SP-7 REM:

SAMPLE NUMBER: 24 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SW-2 REM:

TEST DESCRIPTION	SAMPLE 19	SAMPLE 20	SAMPLE 21	SAMPLE 22	SAMPLE 23	SAMPLE 24	UNITS OF MEASURE
Syn. Prec. Leaching Procedure				0			
Total Sulfur (as S)	<0.01	<0.01	1.01	0.04	0.01	0.79	%
Total Sulfur (Tons CaCO3/Kt)	<0.3	<0.3	31.6	1.3	0.3	24.7	Tons CaCO3/Kt
Acid Neutralizing Potential	913	<0.1	36.0	38.9	38.9	3.9	Tons CaCO3/Kt

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LABORATORY TESTS RESULTS
04/21/92

JOB NUMBER: 920513 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 25 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SW-3 REM:

SAMPLE NUMBER: 26 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SW-4 REM:

SAMPLE NUMBER: 27 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SW-5 REM:

SAMPLE NUMBER: 28 DATE RECEIVED: 03/23/92 TIME RECEIVED: 11:15 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: BARNEY'S CANYON MINE SAMPLE: SS-1 REM:

TEST DESCRIPTION	SAMPLE 25	SAMPLE 26	SAMPLE 27	SAMPLE 28	E 30	UNITS OF MEASURE
Bicarbonate (Filt.)						
Carbonate (Filt.)						
Chloride (Filt.)						
Nitrogen, Nitrate (Filt.)						
pH (Filt.)						
Solids, Total Dissolved (TDS)						
Sulfate (Filt.)						
Total Sulfur (as S)	0.08	0.13	0.06	8.75		
Total Sulfur (Tons CaCO3/Kt)	2.5	4.1	1.9	273		Tons CaCO3/Kt
Acid Neutralizing Potential	18.8	0.8	6.4	<0.1		Tons CaCO3/Kt
Arsenic, Diss. (As)						
Ba[illegible] Diss. (Ba)						

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CORE LABORATORIES
A N A L Y T I C A L R E P O R T

Job Number: 921076
Prepared For:

BARNEY'S CANYON MINE
MICHAEL PAGETT
8200 SOUTH 9600 WEST
BINGHAM CANYON, UT 84006

Date: 06/23/92

Signature

Date: 6/23/92

Name: David A. McWharter

Core Laboratories
1300 South Potomac, Suite 130
Aurora, CO 80012

Title: LABORATORY MANAGER

Western Atlas International

CORE LABORATORIES

LABORATORY TESTS RESULTS
06/23/92

JOB NUMBER: 921076 CUSTOMER: BARKEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 1 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-06 REM:

SAMPLE NUMBER: 2 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-07 REM:

SAMPLE NUMBER: 3 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-08 REM:

SAMPLE NUMBER: 4 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-09 REM:

SAMPLE NUMBER: 5 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-10 REM:

SAMPLE NUMBER: 6 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-11 REM:

TEST DESCRIPTION	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	UNITS OF MEASURE
Total Sulfur (as S)	0.08	0.09	0.28	<0.01	0.32	<0.01	%
Total Sulfur (Tons CaCO3/Kt)	2.5	2.8	8.8	<0.3	10.0	<0.3	Tons CaCO3/Kt
Acid Neutralizing Potential	2.5	3.0	1.3	15.7	<0.1	8.0	Tons CaCO3/Kt

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LABORATORY TESTS RESULTS
06/23/92

JOB NUMBER: 921076 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 7 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-12 REM:

SAMPLE NUMBER: 8 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-13 REM:

SAMPLE NUMBER: 9 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-14 REM:

SAMPLE NUMBER: 10 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-15 REM:

SAMPLE NUMBER: 11 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-16 REM:

SAMPLE NUMBER: 12 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-17 REM:

TEST DESCRIPTION	SAMPLE 7	SAMPLE 8	SAMPLE 9	SAMPLE 10	SAMPLE 11	SAMPLE 12	UNITS OF MEASURE
Total Sulfur (as S)	0.09	0.41	0.38	<0.01	0.23	0.03	%
Total Sulfur (Tons CaCO3/Kt)	2.8	12.8	11.9	<0.3	7.2	0.9	Tons CaCO3/Kt
Acid Neutralizing Potential	<0.1	5.2	<0.1	40.4	0.1	5.6	Tons CaCO3/Kt

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CORE LABORATORIES

LABORATORY TESTS RESULTS
06/23/92

JOB NUMBER: 921076 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 13 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-18 REM:

SAMPLE NUMBER: 14 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-19 REM:

SAMPLE NUMBER: 15 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-20 REM:

SAMPLE NUMBER: 16 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-21 REM:

SAMPLE NUMBER: 17 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-22 REM:

SAMPLE NUMBER: 18 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-23 REM:

TEST DESCRIPTION	SAMPLE 13	SAMPLE 14	SAMPLE 15	SAMPLE 16	SAMPLE 17	SAMPLE 18	UNITS OF MEASURE
Total Sulfur (as S)	<0.01	0.09	0.10	0.45	<0.01	0.06	%
Total Sulfur (Tons CaCO3/Kt)	<0.3	2.8	3.1	14.1	<0.3	1.9	Tons CaCO3/Kt
Acid Neutralizing Potential	26.3	8.1	<0.1	4.1	<0.1	2.3	Tons CaCO3/Kt

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CORE LABORATORIES

LABORATORY TESTS RESULTS
06/23/92

B NUMBER: 921076 CUSTOMER: BARNEY'S CANYON MINE ATTN: MICHAEL PAGEL

SAMPLE NUMBER: 19 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :

PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-24 REM:

SAMPLE NUMBER: 20 DATE RECEIVED: 06/12/92 TIME RECEIVED: 11:30 SAMPLE DATE: / / SAMPLE TIME: :

PROJECT: SOUTH BCS WASTE ROCK SAMPLE: SW-25 REM:

TEST DESCRIPTION	SAMPLE 19	SAMPLE 20					UNITS OF MEASURE
Total Sulfur (as S)	0.05	0.07					%
Total Sulfur (Tons CaCO3/Kt)	1.6	2.2					Tons CaCO3/Kt
Acid Neutralizing Potential	<0.1	0.5					Tons CaCO3/Kt

1300 South Potomac, Suite 130
Aurora, CO 80012
(303) 751-1780

APPENDIX L

DIVISION OF WATER QUALITY CORRESPONDENCE
EAST BARNEYS WATER QUALITY IMPACT

RECEIVED
FEB 13 1997

State of Utah

DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF WATER QUALITY

Michael O. Leavitt
Governor

Dianne R. Nielson, Ph.D.
Executive Director

Don A. Ostler, P.E.
Director

288 North 1460 West
P.O. Box 144870
Salt Lake City, Utah 84114-4870
(801) 538-6146 Voice
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Water Quality Board
Keith W. Welch
Chairman
Lynn F. Pett
Vice Chairman
R. Rex Ausburn, P.E.
David S. Bowles, Ph.D., P.E.
Nan Bunker
Leonard Ferguson
Dianne R. Nielson, Ph.D.
Joe C. Nielson
K.C. Shaw, P.E.
J. Ann Wechsler
Leroy H. Wullstein, Ph.D.
Don A. Ostler, P.E.
Executive Secretary

February 11, 1997

Dennis Kerstiens
Kennecott Barneys Canyon Mining Company
PO Box 311
Bingham Canyon UT 84006-0311

Dear Mr. Kerstiens:

Subject: Waste rock from East Barneys Pit determined as De Minimis, and Solutions Found Between Liners in new Process Pond, Ground Water Permit No. UGW 270001

We received your company's letter dated January 13, 1997, prepared by Steve Lackey, regarding our request for more information concerning your proposed East Barneys Pit. The information was reviewed in conjuction with the waste rock management plan that was approved August 1, 1994. The waste rock plan is required by the ground water permit (Part II. H. 3). After our review, we believe this operation will have a de minimis actual or potential effect on ground water quality, because your drilling records and sulfur tests indicate there is little or no sulfide material in the pits, and the deposits are in the oxidation zone above the water table. The waste rock from the pit will have more than adequate neutralization capacity. A de minimis determination is granted upon the condition that should sulfide material containing more than 0.5% sulfur be found, Barneys Canyon will ship the sulfide to the smelter or haul the waste rock to the designated Melco Sulfide dump. The proposed pit is now considered as part of the waste rock management plan, and stipulations in the plan must be adhered to.

We also received a letter dated January 13, 1997 from Steve Lackey concerning the fluids found between the liners in your new process pond. The analysis you provided of the fluids suggest the fluids are storm water as you had indicated earlier in a telephone conversation. Although the analytical data was not in the format required by the QA/QC Plan, Steve Lackey indicated in a following telephone conversation that the analytical data was determined in the Kennecott laboratory by the required methods. No holes or tears were found in the liners during an inspection. Therefore, unless new information arises affecting the significance of these solutions, we consider this matter closed.

Sincerely,

Fred C. Pehrson

Fred C. Pehrson, P.E., Manager
Permits, Compliance & Monitoring Branch

FCP:MC:wfm

cc: DOGM
Salt Lake City/County Health Dept.

P:\WQ\PERMITS\MCROFT\WP\BARNEYS\EASCANPE.LTR