

**EAST MOUNTAIN  
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT  
(CHIA)**

<b>Cottonwood/Wilberg Mine</b>	<b>C/015/019</b>
<b>Deer Creek Mine</b>	<b>C/015/018</b>
<b>Des-Bee-Dove Mines</b>	<b>C/015/017</b>
<b>Crandall Canyon Mine</b>	<b>C/015/032</b>

**Emery County, Utah**

**Updated March 3, 2003**



---

EAST MOUNTAIN AREA

---

## I INTRODUCTION

East Mountain and the East Mountain Cumulative Impact Area (CIA) are located in Emery County, Utah, west of the town of Huntington (Plate 1). There are currently two active mines in the East Mountain CIA, PacifiCorp's Deer Creek Mine and ANDALEX Resources' Crandall Canyon Mine. Application for expansion of the Deer Creek Mine into the Mill Fork, Joes Valley, and Crandall Canyon drainages and the anticipation that the coal in the South Crandall Canyon Coal Lease Tract will be leased in the near future have resulted in this update of the East Mountain Cumulative Hydrologic Impact Assessment (CHIA).

PacifiCorp has two inactive mines in the East Mountain CIA, the Des-Bee-Dove and Cottonwood-Wilberg Mines. Phase I reclamation at the Des-Bee-Dove Mines should be completed in 2003. PacifiCorp's inactive Trail Mountain Mine is to the west, just across Cottonwood Creek from East Mountain and outside the East Mountain CIA.

The CHIA is a findings document prepared by the Division. This CHIA finding complies with the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and subsequent federal regulatory programs under 30 CFR 784.14(f), and with Utah regulatory programs established under Utah Code Annotated 40-10-et seq. and the attendant State Program rules under R645-301-729.

A CHIA is a determination of whether existing, proposed, and anticipated coal mining and reclamation operations have been designed to prevent material damage to the hydrologic balance in the Cumulative Impact Area (CIA). The CHIA is not only a determination if coal mining operations are designed to prevent material damage beyond their respective permit boundaries when considered individually, but also if there will be material damage resulting from effects that may be acceptable when each operation is considered individually but are unacceptable when the cumulative impact is assessed.

The Division has the responsibility to assess the potential for mining impacts on and off the permit area. Proposed coal mining operations cannot be issued a permit by the Division if the probable, anticipated hydrologic impacts will create material damage to the hydrologic balance outside the mine permit area.

---

**EAST MOUNTAIN AREA**

---

The objective of a CHIA document is to:

1. Identify the Cumulative Impact Area (CIA) **(Part II)**
2. Describe baseline conditions in the CIA; identify hydrologic systems, resources and uses; and document baseline conditions of surface and ground-water quality and quantity. **(Part III)**
3. Identify hydrologic concerns. **(Part IV)**
4. Identify relevant standards against which predicted impacts can be compared **(Part V)**
5. Estimate probable future impacts of mining activity with respect to the parameters identified in 4 **(Part VI)**
6. Assess probable material damage **(Part VII)**
7. Make a statement of findings **(Part VIII)**

## **II. CUMULATIVE IMPACT AREA (CIA)**

Reviewing Permit Application Packages (PAP) and Mining and Reclamation Plans (MRP) alone is not sufficient to assess impacts to the geologic and hydrologic regimes. Specific knowledge of the geology and hydrology is crucial in assessing the dynamics and interactions of chemistry, surface- and ground-water movement, and associated subsidence impacts to a minesite. The Division uses pertinent information from many sources, including federal and state agencies, geological and hydrological reports, textbooks and other publications, site visits and a knowledge base built on experience and training.

Plate 2 delineates the CIA for current and projected mining in the East Mountain area. The CIA encompasses approximately 109 miles<sup>2</sup> centered around East Mountain: the area within the CIA that is above the base of the Blackhawk Formation is approximately 69 miles<sup>2</sup>, the approximate area covered by coal leases, including South Crandall Canyon Coal Lease Tract is 52 miles<sup>2</sup>, and mine workings have or will undermine roughly half of the leased areas. Huntington Canyon, Scad Valley, Joes Valley, and Cottonwood Canyon are the primary features bounding the CIA.

---

EAST MOUNTAIN AREA

---

## SCOPE OF MINING

There were several old, small mines on East Mountain - such as the Johnson and Helco Mines - that are not discussed here. Many of the disturbed areas associated with these old mines have been incorporated into the larger, more recent mines that have received mining permits under the Utah coal mine regulatory program.

### *PacifiCorp Mines*

The Cottonwood/Wilberg and Deer Creek permit areas overlap, and the Des-Bee-Dove permit area is immediately adjacent. Together, the three permit areas encompass approximately 29,000 acres. Utah Power and Light (UP&L), which was merged into PacifiCorp in 1989, acquired these mines from earlier operators. The mines are now permitted to PacifiCorp, a subsidiary of Scottish Power, and since 1990 the mines have been operated by Energy West Mining Company, a wholly owned subsidiary of PacifiCorp.

### Cottonwood/Wilberg Mine

The Cottonwood/Wilberg Mine permit area presently covers approximately 11,500 acres, a combination of fee lands and federal and state leases: some coal leases have been relinquished by PacifiCorp but the permit still includes those areas. Coal has been produced from the Hiawatha Seam, using both longwall and continuous methods.

Coal mining operations have existed in the Wilberg area since the 1890's. Cyrus Wilberg began operating the Wilberg Mine in 1945. UP&L acquired the Wilberg Mine in September 1977 from the Peabody Coal Company, which had acquired it in 1958. UP&L acquired a large, adjacent federal coal lease, called the South Lease, in 1982.

A tragic fire occurred in the Wilberg Mine in December 1984, and on July 1, 1985, the operation was divided into two separate and independent coal mines, the Cottonwood and the Wilberg Coal Mines. Each mine has a separate MSHA identification number; however, a single mining and reclamation permit (ACT/015/019) was issued to both mines because the surface facilities, on 20 acres at the head of Grimes Wash, are shared by both mines.

Mining resumed in the Wilberg Mine in September 1987 and the last coal was mined in January 1988. Longwall mining in the Cottonwood Mine ended in September 1995 and the equipment was moved to the Trail Mountain Mine. Total production to that time was 40 million tons, and remaining reserves in the Hiawatha Seam are estimated at 2 million tons. Portals for both mines are in the Hiawatha Seam, and only the Hiawatha Seam has been mined. There are Blind Canyon reserves, but there currently is no plan to recover these through the Cottonwood/Wilberg Mine.

---

**EAST MOUNTAIN AREA**

---

After mining ceased in the Cottonwood/Wilberg Mine in 1995, a conveyor through the Cottonwood Mine continued to transport coal from the Trail Mountain Mine through East Mountain and to the truck load-out at the Cottonwood Mine surface facilities. After operations ceased at the Trail Mountain Mine in 2001, the Cottonwood/Wilberg Mine was placed in temporary cessation.

Deer Creek Mine

Coal mining operations had taken place on fee land in Deer Creek Canyon prior to 1946, when the first federal coal lease was issued in this area. Peabody Coal Company acquired leases on the Deer Creek property and began operations in 1969. UP&L purchased the Deer Creek Mine in 1977 from Peabody. The current Deer Creek Mine permit area is approximately 24,600 acres, including approximately 5,560 acres added by the Mill Fork Extension.

The Deer Creek Mine surface facilities are located on a 25-acre site at the junction of Deer Creek and Elk Canyons, side canyons in the Huntington drainage. The portals are in the Blind Canyon Seam. In the southern portion of the Deer Creek Mine, the underground workings are in the Blind Canyon Seam only, and they overlap but are separate from the Cottonwood/Wilberg Mine workings in the Hiawatha Seam. In the Rilda Canyon area, rock slopes from the Blind Canyon Seam provide access to the Hiawatha Seam.

Entry to the Mill Fork Lease will be by entries advanced from the Hiawatha Seam through Lease Modification #3, a 65.7-acre area that has been added to Lease U-06039 for this purpose. Coal will be mined in both the Blind Canyon and Hiawatha Seams. The Blind Canyon is to be mined first, accessed from the Hiawatha through rock slopes that are to be built within the Mill Fork Lease area. Total cumulative vertical extraction from both seams will not exceed 20 feet. The full extraction methods to be used are anticipated to cause subsidence that can be planned and controlled.

All currently planned coal mine operations in the Mill Fork Extension will be underground. The only potential surface facility associated with the Mill Fork Extension is a possible ventilation breakout in Crandall Canyon, upstream of the existing Crandall Canyon Mine. The need for the breakout will be evaluated and the design and request for permit modification will be made based on future coal exploration.

The majority of the Deer Creek Mine utilizes the longwall mining method. All underground operations, including the Mill Fork Extension, are projected to end around the year 2032.

**EAST MOUNTAIN AREA**

---

Table CHIA-1 - Annual Production - Deer Creek Mine	
Data are from the Utah Energy Office, except for 2001, which is from MSHA.	
1997	4.5
1998	3.7
1999	3.8
2000	4.2
2001	4.3

Des-Bee-Dove Mines (Deseret, Beehive and Little Dove Mines)

The Des-Bee-Dove mines are located in an unnamed narrow, steep canyon that is part of the Grimes Wash drainage system. Mining began in the canyon in 1898 as the Griffith Mine. From 1936 to 1938, mine workings were operated by the Castle Valley Fuel Company, owned by Messrs. Edwards and Broderick. The Church of Jesus Christ of Latter-day Saints (LDS Church) acquired 400 acres adjacent to the Castle Valley Fuel Company mine in 1938, and the adjoining properties were mined by both operators from 1938 to 1947. The LDS Church purchased Castle Valley Fuel Company in 1947, and Deseret Coal Company operated the mines for the church. UP&L acquired the Des-Bee-Dove Mine complex in 1972.

The Des-Bee-Dove Mine permit area, a combination of fee land and state and federal leases encompassing over 2,800 acres, contains two mineable coal seams - the Hiawatha and Blind Canyon. The Dove and Beehive mines accessed the Blind Canyon Seam and the Deseret Mine the Hiawatha Seam. Mining was done by a series of continuous room and pillar sections. A series of north-south trending faults dictated mine layout. The mines were very dry, requiring importation of water to operate.

The three mines ceased operations on February 6, 1987 and the portals were sealed. Before operations ceased, the Des-Bee-Dove Mines was producing 725,000 tons per year. Reclamation of the entire Des-Bee-Dove site began in 1999 and Phase I is scheduled for completion in 2003.

Associated Sites

Underground development waste, sediment from sedimentation ponds, and other coal mine waste from the Des-Bee-Dove and Cottonwood/Wilberg Mines are stored at two waste rock disposal areas located on BLM right-of-ways a couple of miles south of the Cottonwood/Wilberg Mine.

---

**EAST MOUNTAIN AREA**

---

- BLM ROW U-37642 was issued in 1977. Approximately 14 acres of ROW U-37642 were relinquished to Texaco for coal-bed methane operations, 14 acres have been reclaimed, and 21 acres remain disturbed. This waste rock disposal site has reached its designed capacity. Phase I Bond Release was granted on July 22, 1999.
- ROW-UTU-65027 was granted in 1990 to replace ROW-U37642. Total area is approximately 26 acres, with 17 acres disturbed. ROW-UTU-65027 has also been modified to accommodate a Texaco coal-bed methane well.

The Cottonwood/Wilberg Mine has a sewer absorption field that is part of the permitted area. It is located on a BLM right-of-way outside the main permit area boundary. This field also is designed to handle the Trail Mountain Mine sewage, which has been piped through the Cottonwood/Wilberg Mine along a path similar to that followed by the Trail Mountain Mine coal conveyor.

The Des-Bee-Dove sedimentation pond and associated access road are now separated from the main permit area. The coal-haul road was transferred to Emery County and removed from the permit, isolating the pond from the rest of the permitted area.

*Huntington Canyon #4 (Beaver Creek Coal Company)*

The Huntington Canyon #4 Mine permit area contained 1,320 acres. The underground operations utilized room and pillar mining methods in the Blind Canyon and Hiawatha coal seams in Federal Lease No. U-33454 and SL-064903. All underground mine operations ceased November 1, 1984.

The mine working trended north-east where they crossed through several faults of the Mill Fork Graben. According to Dan Guy, Engineering Manager for the mine (personal communication, February 26, 2003) stated that the mine closed because of economic condition related to coal quality. As mining moved into the Dellenbach Lease oxidized coal was contacted which could not be economically processed. The mine intercepted faults and some water sources, but Dan does not recollect large inflows to the mine. Dan speculated that the oxidation was the result of ancient activities and did not know if it was related to the recharge source to Little Bear Spring. Beaver Creek Coal Company commissioned a study by Vaughn Hansen and Associates (1977), who studied Little Bear Spring. They did not find a connection between the mine and the spring.

Beaver Creek Coal Company reclaimed the site during the period of August 15, 1985 through September 30, 1985. Three portals and one opening were sealed. The disturbed area including the access road was backfilled and regraded. Soil was replaced and reseeded. The reclamation bond was released in May 1998.

---

EAST MOUNTAIN AREA

---

*Crandall Canyon Mine (Genwal Coal Company)*

Coal for local, domestic use was mined from Crandall Canyon from November 1939 to September 1955. Approximately 35,000 tons were mined from the Hiawatha Seam (Crandall Canyon Mine MRP, p. 4-6 and 4-7). There was no reclamation done.

Genwal Coal Company (also known as Genwal Resources, Inc.) began mining in this area in 1983. Some of the older workings have been incorporated into the Genwal Mine. Genwal Resources and the mine were purchased by ANDALEX Resources, Inc. and Intermountain Power in 1995, and ANDALEX is the operator. Both continuous and longwall mining methods are currently used. Pillars will be fully extracted unless they are needed for safety or to protect the outcrop.

Table CHIA-2 - Annual Production - Crandall Canyon Mine	
Data are from the Utah Energy Office, except for 2001, which is from MSHA.	
1997	2.7
1998	3.5
1999	3.8
2000	3.9
2001	4.0

The permit area for the Crandall Canyon Mine contains approximately 5,200 acres in Huntington Canyon in Emery County, Utah. Approximately 11 acres are disturbed. In February 1993, Genwal applied to lease 4,053 acres of unleased Federal coal lands adjacent to the Crandall Canyon Mine, initiating the process that led to the leasing of the Mill Fork tract; however, PacifiCorp won the bid for the lease.

*The South Crandall Canyon Coal Lease Tract - Lease U-78953*

The South Crandall Canyon Coal Lease Tract was deleted from the Mill Fork tract because of the concerns that were raised regarding Little Bear Spring. This area is being reevaluated for possible leasing in the near future. If this tract is leased, it is likely that it will be mined from the Crandall Canyon Mine. The tract covers 880 acres.

**EAST MOUNTAIN AREA**

---

**III. DEFINE BASELINE CONDITIONS; IDENTIFY HYDROLOGIC SYSTEMS and USES; and DOCUMENT BASELINE CONDITIONS of SURFACE and GROUND-WATER QUALITY and QUANTITY.**

**BASELINE CONDITIONS**

East Mountain is located in Emery County, Utah, west of the town of Huntington and approximately 20 miles southwest of Price (Plate 1). It is in the Wasatch Plateau Coal Field. The eastern margin of the Wasatch Plateau is a rugged escarpment that overlooks Castle Valley and the San Rafael Swell to the east. Elevations along the eastern escarpment of the Wasatch Plateau range from approximately 6,500 to over 9,000 feet. The climate of the Wasatch Plateau has been classified as semiarid to subhumid. Precipitation varies from 40 inches at higher elevations to less than 10 inches at lower elevations, and ranges from 10 to 30 inches per year within the CIA (Danielson and others 1981).

East Mountain is a north-south trending ridge, bounded by Huntington Canyon on the northeast and north, Left Fork of Huntington Canyon and Scad Valley on the north and northwest, Joes Valley and upper Cottonwood Canyon on the west, and lower Cottonwood Canyon on the south. The southeast side of the mountain is part of the Wasatch Plateau escarpment that separates the plateau from Castle Valley. Elevations in the East Mountain CIA range from 7,000 in the canyon bottoms to over 10,700 feet along the crest of East Mountain. Much of the surface is steep and dissected by steep, narrow canyons with heavy vegetation and barren cliffs.

*Soils - based on information in the EA (1997)*

Shallow to very deep soils on the lease tract have developed primarily from sandstone and shale parent materials. Rock outcrops are common, especially with the Castlegate Formation. Because of the steepness of the slopes and rapid runoff, most soils are well drained.

Soils derived from sandstone are typically cobbly or stony with textures of loamy sand, sandy loam, or loam. Clay loam, silty clay loam, and clay are common in soils derived from North Horn Formation. Subsoils often have a higher clay content than the surface, and are prone to slope failures because they have high water holding capacities. These clayey soils typically have high self-healing capabilities, which can minimize the effects of subsidence cracks at the surface.

Topsoil development is most pronounced under aspen vegetation types. It is commonly 10 to 20 inches thick and has a relatively high organic matter and nutrient content. On the steep, north facing slopes that support a spruce-fir type, topsoil thickness may vary from about three to ten inches.

---

## EAST MOUNTAIN AREA

---

Limitations on soils include high erosion potentials, slope instability, cold temperatures and short growing season, stoniness, and droughty conditions at lower elevations and on south-facing slopes. The elevation range, steep slopes, and contrasting aspects account for large soil temperature and moisture differences. Soils on the lower-elevation south-facing slopes are hot and dry, and those at the higher elevations and north facing slopes are cool and moist. Soil temperature regimes include cryic (cold) and frigid, and the soil moisture regimes are udic (moist) and ustic (semiarid). The aspen and spruce-fir vegetation types are characteristic of the cryic/udic environment and the lower elevation mountain brush with some pinyon-juniper is characteristic of the frigid/ustic situation

### *Vegetation*

Vegetation of the Wasatch Plateau area is classified within the Colorado Plateau floristic division (Cronquist and others 1972). The area occupies parts of both the Utah Plateaus and the Canyonlands floristic sections. Vegetation communities of the area include desert shrub (shadscale) at the lowest elevations through sagebrush, sagebrush-grassland, pinyon-juniper, mountain brush, Douglas fir-white fir-blue spruce, and Engleman spruce-subalpine fir.

Desert shrub communities are sparsely vegetated shrublands that, depending on elevation and soils, may be dominated by shadscale (*Atriplex confertifolia*), fourwing saltbush (*A. canescens*), Castle Valley clover (*A. cuneata*) or mat saltbush (*A. corrugata*) and may include winterfat (*Ceratoides lanata*), Mormon tea (*Ephedra* spp.), budsage (*Artemisia spinescens*), miscellaneous buckwheats (*Eriogonum* spp.), Indian ricegrass (*Oryzopsis hymenoides*), galleta grass (*Hilaria jamesii*), grama grass (*Bouteloua* spp.), needle and thread grass (*Stipa comata*), sand dropseed (*Sporobolus cryptandrus*) and squirreltail (*Sitanian hystrix*). Greasewood (*Sarcobatus vermiculatus*) - saltgrass (*Distichlis stricta*) may dominate bottomlands.

Many sagebrush communities of the area are relatively dense shrub stands of (*Artemisia tridentata*) with very little understory growth. In relatively undisturbed sagebrush communities, rabbitbrush (*Chrysothamnus nauseosus* or *C. viscidiflorus*), Mormon tea, and several perennial grasses may be common, including thickspike and western wheatgrass (*Agropyron dasystachyum* and *A. smithii*), basin wildrye (*Elymus cinereus*), Indian ricegrass and dropseed species.

In the sagebrush-grassland type, the typical big sage may give way to *Artemisia tridentata* var. *vaseyana* (mountain big sage) with a co-dominant perennial grass understory. Salina wildrye (*Elymus salinus*) may be co-dominant in these communities and may dominate an herbaceous grassland type. Black sage (*A. nova*) with Salina wildrye or western wheatgrass understory is also common.

Pinyon-juniper woodlands occupy drier sites often with stony to very rocky soils. *Pinus edulis* and *Juniperus osteosperma* are co-dominant in the overstory. Understory vegetation ranges from sparse to moderate ground cover on range sites in poor to excellent condition.

---

EAST MOUNTAIN AREA

---

Understory species include sagebrush, mountain mahogany (Cercocarpus montanus), snowberry (Symphoricarpus oreophilus), and several perennial grasses including slender wheatgrass (Agropyron trachycaulum), Salina wildrye, junegrass (Koeleria cristata) and Indian ricegrass.

Dominant shrubs of the mountain brush communities will vary depending on elevation and aspect. The drier south and west-facing slopes may support dense stands of Gambel oak (Quercus gambellii). Other dominants of this community may include serviceberry (Amelanchier utahensis), mountain mahogany (Cercocarpus montanus or C. Ledifolius), bitterbrush (Purshia tridentata) and snowberry.

The range of the Douglas fir-white fir-blue spruce community is about 8,000 to 10,000 feet. Douglas fir (Pseudotsuga mensiesii) usually the dominant tree with white fir (Abies concolor) and blue spruce (Picea pungens) usually limited to the most mesic sites, often along streams. With dense canopies, understory vegetation may be sparse. Common shrubs include serviceberry (Amelanchier spp.), Oregon grape (Berberis repens), chokecherry (Prunus virginiana), Rocky Mountain maple (Acer glabrum), mountain lover (Pachistima myrsinites) and snowberry. Bluebunch wheatgrass (Agropyron spicatum), mountain brome (Bromus carinatus), and Kentucky bluegrass (Poa pratensis) are common grasses. Aspen stands (Populus tremuloides) can be found throughout the zone, particularly in mesic sites and as successful communities.

Engelman spruce (Picea engelmannii) and subalpine fir (Abies lasiocarpa) dominate the spruce-fir zone at the highest elevations of the hydrologic impact area. While receiving about the same precipitation as the Douglas fir communities, lower vapor-transpiration with cooler temperatures can permit a more lush vegetation in the spruce-fir zone. Limber pine (Pinus flexilis) often occupies steep or rocky, drier sites of this zone.

Small riparian communities are found at all elevations within the impact assessment area. With greater water availability and cooler temperatures, the riparian zone often includes more mesic species, (e.g., those from a higher vegetation zone). Shrub species from the mountain shrub type may be found at most elevations.

Additional riparian zone shrubs include Narrowleaf cottonwood (Populus angustifolia), red osier dogwood (Cornus stolonifera), skunkbush (Rhus trilobata), river birch (Betula occidentalis) and various willows (Salix spp.). Grass species from the mesic zones may be represented (mountain shrub and higher zones) along with fescues (Festuca spp.) and miscellaneous sedges (Carex spp). Small wet areas around springs and seeps will often support a dense growth of grasses, sedges and willows.

*Aquatic Species - based on information in the USFS 1997 Environmental Assessment (EA 1997).*

---

## EAST MOUNTAIN AREA

---

The stream channels in the CIA support naturally-reproducing trout fisheries and typical coldwater, mountain-environment aquatic communities, including aquatic plants, insect populations, periphyton, and zooplankton. Information provided by the Utah Division of Wildlife Resources and cited in the EA indicates that in addition to trout, it is likely that there are speckled dace, mottled sculpin, bluehead suckers, and mountain suckers. The EA cites evidence that tiger salamanders, western toads, and Great Basin spadefoot toads probably inhabit the area.

High-gradient streams in the CIA are characterized by rock and wood-created step-pools, deeply incised channels, occasional beaver ponds; riparian zones are composed of spruce-fir/aspen communities and thick willows. Spawning gravels are patchy and distributed in lower-gradient reaches. Adult cutthroat trout and sculpins are likely present in spring spawning habitats in headwater areas of the intermittent channels only during the spring reproductive period. Successful spawning requires the presence of clean, well-oxygenated spawning gravels, so protecting these channels from excessive erosion and sedimentation is a high priority. In the past, stream channels throughout the area were degraded by livestock grazing and erosion from the high runoff that occurred in 1983-84.

Small seep or pothole-type wetlands act as water reserves and provide baseflows that can support aquatic communities during low water periods. Potholes, small ponds and marshy areas provide subsurface flow that supplements direct water sources like springs and run-off. These wet areas also provide important habitat for invertebrate and amphibian populations. Wet areas need to be protected from soil compaction, disturbance, and the removal of woody material to maintain existing habitat quality and quantity for aquatic organisms.

### *Geology*

#### Stratigraphy

Consolidated strata of the Wasatch Plateau Coal Field range in age from Late Cretaceous to Tertiary (Eocene), as seen in Figure 1 and Plate 5. There are no major disconformities exposed in this area. The oldest exposed rocks are upper members of the Mancos Shale. The Cretaceous Mesaverde Group, which in the Wasatch Plateau consists of the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation, overlies the Mancos. Above the Mesaverde Group are the Paleocene North Horn Formation and Flagstaff Limestone: the Flagstaff is the youngest and uppermost consolidated formation exposed in the CIA. Unconsolidated Quaternary colluvium, alluvium, and soils have been formed by weathering and erosion and are found on terraces, along canyon bottoms, and at the base of escarpments.

Upper Price River and North Horn Formations are exposed on the west side of Joes Valley. North Horn Formation is exposed on the floor of uppermost Joes Valley, but most of the valley floor consists of thick deposits of alluvium and colluvium.

**EAST MOUNTAIN AREA**

The rock record displays an overall regressive sequence from marine (Mancos Shale) through littoral (Star Point Sandstone) and lagoonal (Blackhawk Formation) to fluvial (Castlegate Sandstone, Price River Formation and North Horn Formation) and lacustrine (Flagstaff Limestone) depositional environments. Oscillating depositional environments within the overall regressive trend are represented by intertonguing lithologies, especially within the Blackhawk Formation and Star Point Sandstone. The Star Point consists of three main tongues - in ascending order, the Panther, Storrs, and Spring Canyon. The major coal-bearing unit in the Wasatch Plateau Coal Field is the Blackhawk Formation. The commercial coal seams are usually near the base of the Blackhawk, and in the East Mountain area the lowest seam, the Hiawatha, is often directly on or just above the Spring Canyon Sandstone. The Hiawatha Seam is mined in both the Genwal and PacifiCorp mines, but the Blind Canyon seam is mined only in the PacifiCorp mines.

System	Series	Stratigraphic Unit		Thickness (feet)	Description
Tertiary	Eocene	Green River Formation		-	Greenish-gray and white claystone and shale, also contains fine-grained and thin-bedded sandstone. Shales often dark brown, containing carbonaceous matter. Full thickness not exposed.
		Colton Formation	Wasatch Formation	300 - 2,000	Colton consist of brown and dark-red lenticular sandstone, shale, and siltstone, thins westward and considered a tongue of the Wasatch.
	Flagstaff Limestone	3,000		Wasatch predominantly sandstone with interbedded red and green shales with basal conglomerate. Found in east part of field and equivalent to Colton and Flagstaff in west.	
	Paleocene			0 - 500	Flagstaff mainly gray and cream colored limestone, variegated shale, and fine-grained, reddish-brown sandstone.
		North Horn Formation	Tucher Formation	350 - 2,500	North Horn Formation - Gray and gray-green calcareous and silty shale, tan to yellow-gray fine-grained sandstone, and minor conglomerate. Unit thickens to the west.
	<i>MINOR COAL</i>			Tucher Formation - Light gray to cream-white friable massive sandstone and subordinate buff to gray shale that exhibits light greenish cast. Contains minor conglomerate and probably represents lower part of North Horn, only present in east part of coal field.	
Cretaceous	Danian			0 - 200	
	Maestrichthian	Price River Formation <i>MINOR COAL</i>		500 - 1,500	Yellow-gray to white medium-grained sandstone and shaley sandstone with gray to olive green shale. Contains carbonaceous shale with minor coal and thickens along east edge of field.
		Castlegate Formation <i>MINOR COAL</i>		100 - 500	White to gray, fine-grained sandstone, argillaceous massive resistant sandstone thinning eastwardly with subordinate shale. Carbonaceous east of Horse Canyon but coal is thin and lignitic.
	Campanian	Blackhawk Formation <i>MAJOR COAL SEAMS</i>		600 - 1,100	Cyclical littoral and lagoonal deposits with six major cycles. Littoral deposits mainly thick-bedded to massive cliff-forming yellow-gray, fine- to medium-grained sandstone, individual beds separated by gray shale. Lagoonal facies consist of thin- to thick-bedded yellow-gray sandstones, shaley sandstones, shale, and coal. Coal beds of Wasatch Plateau and Book Cliffs Coal Fields. Unit thins eastward, grading into the Mancos Shale.
		Star Point Sandstone		0 - 580	Yellow-gray, massive medium- to fine-grained littoral sandstone tongues projecting easterly, separated by gray marine shale tongues projecting westerly.
		Masuk Tongue	Mancos Shale		4,300 - 5,050
	Emery				

**EAST MOUNTAIN AREA**

	Santonian	Sandstone		2 - 126	Gray marine shale, locally heavily charged with carbonaceous material, slightly calcareous and gypsiferous, nonresistant forming flat desert surfaces and rounded hills and badlands. Separated mainly to into tongues by westward projecting littoral; sandstone that eventually grade into shale. Sandstones are fine- to medium-grained, yellow-gray to tan, and medium-bedded to massive and cliff-forming.
	Coniacian	Garley Canyon Sandstone			
		Blue Gate Shale			
	Turonian	Ferron Sandstone <i>MINOR COAL</i>			
		Tununk Shale			
Cenomanian	Dakota Sandstone			Heterogeneous sandstone, conglomerate, and shale, thin resistant cuesta former.	

**Figure 1 - General Stratigraphy of the Wasatch Plateau Coal Field (after Doelling, 1972)**

Typical representations of major stratigraphic units on maps and cross-sections can give the impression that these units are massive and homogeneous. The reality is that throughout each major stratigraphic unit there is almost always a wide range of sedimentary textures or fabrics related to the mineralogy of the sediments, the range of sizes of the sedimentary particles (sorting), the spatial distribution of the different sediment-sizes (grading), shape and orientation of the sediment particles and the way the particles were arranged at the time of deposition (packing), and properties acquired or altered as the sediments were lithified. These inhomogeneities - variations and discontinuities - can either impede or facilitate ground-water storage and movement.

“Regional aquifer” is a common phrase used by mine operators in Carbon and Emery Counties. In such usage, “regional aquifer” usually refers to any water found in the Star Point Sandstone and Blackhawk Formation irrespective of quality, quantity, use, storage, flow and transport, and discharge. In some contexts "regional aquifer" is a useful term where water resources emanate from these geologic units and are readily used for a specific purpose. In preparing this CHIA, the Division has adhered to the definition of "aquifer" as found in the Coal Mining Rules (R645-100-200), and the term "regional aquifer" has been deliberately used or avoided, as appropriate, throughout this CHIA. After evaluating the geologic and hydrologic evidence, the Division does not consider the saturated strata in the Blackhawk and associated formations in the East Mountain Cumulative Impact Area (CIA) to be a regional aquifer.

Hydraulic Conductivity and Permeability

Based on slug tests and determinations from core samples, hydraulic conductivity of the Star Point Sandstone is typically low, so movement of ground water through the unfractured sandstone is slow and unfractured Star Point Sandstone is not generally considered to be an aquifer. However, hydraulic conductivity values in the Star Point Sandstone vary through several

**EAST MOUNTAIN AREA**

---

orders-of-magnitude, and locally, unfractured units in the Star Point Sandstone can transmit sufficient ground-water to sustain small springs or wells.

Strata above the Star Point Sandstone have hydraulic conductivities that are generally as low or lower than those in the Star Point Sandstone.

EAST MOUNTAIN AREA

Table CHIA-3						
HYDRAULIC PROPERTIES of STRATA in the WASATCH COAL FIELD, UTAH						
		Price River	North Horn	Blackhawk	Star Point	
USGS Lab Measurements on Cores (Lines 1985)	17-6 27bda <i>Horizontal</i>			Ss $1.5 \times 10^{-3}$ ft/day ( $-5.3 \times 10^{-6}$ cm/sec)		
				Silt $9.3 \times 10^{-8}$ ft/day ( $-3.3 \times 10^{-11}$ cm/sec)		
				Ss $1.1 \times 10^{-2}$ ft/day ( $-3.9 \times 10^{-6}$ cm/sec)		
				Shale $1.1 \times 10^{-8}$ ft/day ( $-3.9 \times 10^{-12}$ cm/sec)		
				Silt $2.0 \times 10^{-9}$ ft/day ( $-7.0 \times 10^{-11}$ cm/sec)		
					Ss $3.1 \times 10^{-2}$ ft/day ( $1.1 \times 10^{-5}$ cm/sec)	
	17-6 27bda <i>Vertical</i>			Ss $3.7 \times 10^{-2}$ ft/day ( $-1.3 \times 10^{-6}$ cm/sec)		
				Silt $1.2 \times 10^{-11}$ ft/day ( $-4.2 \times 10^{-11}$ cm/sec)		
				Ss $3.9 \times 10^{-3}$ ft/day ( $-1.4 \times 10^{-6}$ cm/sec)		
				Not measured		
				Silt $2.2 \times 10^{-7}$ ft/day ( $-7.8 \times 10^{-10}$ cm/sec)		
					Ss $1.1 \times 10^{-2}$ ft/day ( $3.9 \times 10^{-6}$ cm/sec)	
USGS Recovery or Drawdown Test (Lines 1985)	17-6 24dcd			2 ft <sup>2</sup> /day ( $2.2 \times 10^{-2}$ cm <sup>2</sup> /sec ~ $3.9 \times 10^{-6}$ cm/sec)		
	17-6 27bda			8 ft <sup>2</sup> /day ( $8.6 \times 10^{-2}$ cm <sup>2</sup> /sec ~ $4.8 \times 10^{-6}$ cm/sec)	6 ft <sup>2</sup> /day ( $6.4 \times 10^{-2}$ cm <sup>2</sup> /sec ~ $2.6 \times 10^{-6}$ cm/sec)	
	17-6 28bad	0.8 ft <sup>2</sup> /day ( $8.6 \times 10^{-3}$ cm <sup>2</sup> /sec ~ $5.6 \times 10^{-6}$ cm/sec)				
	17-6 34dda		10 ft <sup>2</sup> /day ( $1.1 \times 10^{-3}$ cm <sup>2</sup> /sec ~ $7.8 \times 10^{-5}$ cm/sec)			
				0.7 ft <sup>2</sup> /day ( $7.5 \times 10^{-3}$ cm <sup>2</sup> /sec ~ $1.6 \times 10^{-5}$ cm/sec)		
	18-6 4bac			100 ft <sup>2</sup> /day ( $1.07$ cm <sup>2</sup> /sec ~ $5.8 \times 10^{-5}$ cm/sec)		
Genwal Mine Slug Tests	Genwal MRP	MW-1 (1987)			0.1 ft/day ( $3.5 \times 10^{-5}$ cm/sec)	
		MW-4 (1992)			0.6 ft/day ( $2.1 \times 10^{-4}$ cm/sec)	
		MW-5 (1992)			2.5 ft/day ( $8.8 \times 10^{-4}$ cm/sec)	
	Mayo and Assoc. 1997c	MW-2 Spg Cyn				4.8 to $4.9 \times 10^{-8}$ ft/sec ( $1.5 \times 10^{-6}$ cm/sec)
		MW-6a Spg Cyn				4.4 to $5.9 \times 10^{-8}$ ft/sec ( $1.3$ to $1.8 \times 10^{-6}$ cm/sec)
		MW-7 Spg Cyn				$7.4 \times 10^{-8}$ ft/sec ( $2.2 \times 10^{-6}$ cm/sec)
		MW-6 Panther				6.2 to $7.4 \times 10^{-8}$ ft/sec ( $1.9$ to $2.2 \times 10^{-6}$ cm/sec)

**EAST MOUNTAIN AREA**

<b>Table CHIA-3</b>					
<b>HYDRAULIC PROPERTIES of STRATA in the WASATCH COAL FIELD, UTAH</b>					
		Price River	North Horn	Blackhawk	Star Point
Trail Mountain Mine	TM-3				$5.1 \times 10^{-3}$ cm/sec
Skyline Mine (Vaughn Hansen Associates 1979)				$2.4 \text{ ft}^2/\text{day}$ ( $2.6 \times 10^{-2}$ cm <sup>2</sup> /sec)	
Bear Canyon Mine Slug Tests	Panther Tongue	DH-1A			$5.5 \times 10^{-1}$ cm <sup>2</sup> /sec ( $2.6 \times 10^{-4}$ cm <sup>2</sup> /sec)
		DH-2			$2.4 \times 10^{-2}$ cm <sup>2</sup> /sec ( $8.8 \times 10^{-6}$ cm <sup>2</sup> /sec)
		DH-3			$7.4 \times 10^{-2}$ cm <sup>2</sup> /sec ( $3.4 \times 10^{-5}$ cm <sup>2</sup> /sec)
		DH-4			-
	Storrs Tongue	DH-1A			$3.2 \times 10^{-3}$ cm <sup>2</sup> /sec ( $\sim 1.1 \times 10^{-5}$ cm <sup>2</sup> /sec)
		DH-2			89.3 cm <sup>2</sup> /sec ( $\sim 2.7 \times 10^{-2}$ cm <sup>2</sup> /sec)
		DH-3			$7.5 \times 10^{-3}$ cm <sup>2</sup> /sec ( $\sim 2.8 \times 10^{-6}$ cm <sup>2</sup> /sec)
		DH-4			-
	Spring Canyon Tongue	DH-1A			$1.4 \times 10^{-1}$ cm <sup>2</sup> /sec ( $\sim 5.1 \times 10^{-5}$ cm <sup>2</sup> /sec)
		DH-2			$1.5 \times 10^{-2}$ cm <sup>2</sup> /sec ( $\sim 4.2 \times 10^{-6}$ cm <sup>2</sup> /sec)
		DH-3			$4.0 \times 10^{-2}$ cm <sup>2</sup> /sec ( $\sim 2.0 \times 10^{-5}$ cm <sup>2</sup> /sec)
		DH-4			$3.1 \times 10^{-1}$ cm <sup>2</sup> /sec ( $\sim 5.7 \times 10^{-5}$ cm <sup>2</sup> /sec)

Swelling Clays

The interbedded claystones, siltstones, and sandstones of the Wasatch Plateau are rich in swelling clay minerals of the montmorillonite or smectite group. Clays of this type absorb water, and in soil and rock their volume can expand as much as 50 percent of their dry volume. These clays reduce the hydraulic conductivity of the rocks, and contribute to the rapid closing or “healing” of tension fractures resulting from subsidence. Material from the Blackhawk Formation was examined by X-ray diffraction and found to contain 3 to 34 percent smectite, with an average of 24 percent. Siltstones and shales in the Castlegate average 19 percent montmorillonite, and the Price River Formation 15 percent montmorillonite. Non-swelling clays constitute an additional 1 to 6 percent of the rock volume (Crandall Canyon Mine MRP, App. 7-41).

Coal

The Blackhawk Formation contains the primary economic coal resource in the Wasatch Plateau Coal Field. The Hiawatha and Blind Canyon are the only seams in the East Mountain area that can be mined economically. Coal washing facilities at the Hunter Power Plant allow

---

## EAST MOUNTAIN AREA

---

lower-quality and higher-ash coal to be mined. The Cottonwood Seam, which lies between the Hiawatha and Blind Canyon Seams, has been determined by UP&L and the BLM to be unminable: temperatures indicate it may be burning in areas.

The lowest coal seam is the Hiawatha, characteristically lying on or just above the Star Point Sandstone. This seam has been mined in the Cottonwood/Wilberg, Deer Creek, Des-Bee-Dove, and Genwal Mines. The Hiawatha Seam thins to less than 5 feet in the north end of the Cottonwood/Wilberg Mine, but then thickens again to the north, where it is mined in the Rilda Canyon area by way of rock slopes down from the Deer Creek Mine. Access to this seam in the Mill Fork Extension will be by entries advanced from the Deer Creek Mine through the 65.7-acre lease modification added to Lease U-06039. The Hiawatha Seam reaches a thickness of 12 feet in the Crandall Canyon Mine.

The Blind Canyon Seam lies approximately 40 to 100 feet above the Hiawatha Seam. It has been mined in the Deer Creek and Des-Bee-Dove Mines, but is too thin to mine economically at the Crandall Canyon and Cottonwood/Wilberg Mines. In the Mill Fork Extension, this seam will be accessed by way of rock slopes from the Hiawatha Seam.

Overburden is up to 2,600 feet under East Mountain but as little as 600 feet along Joes Valley Fault. Of course, because mines are accessed by portals into the coal outcrops along canyon walls, overburden is very thin over workings nearest the portals.

### Structure

The East Mountain CIA is characterized by cliffs, narrow canyons and high plateaus. Strata in the Wasatch Plateau were tilted in response to the rise of the San Rafael Swell and modified by subsequent erosional, tectonic and orogenic events. Strike of the beds is generally parallel to the face of the Wasatch Plateau escarpment, and dip is usually less than 5 degrees, whether it is regional or caused by local structural deformation. Major structural features associated with East Mountain are:

- Flat Canyon Anticline;
- Crandall Canyon Syncline;
- Straight Canyon Syncline;
- Mill Fork Fault Graben or Fault Zone;
- Roans Canyon Fault Graben;
- Deer Creek Fault;
- Pleasant Valley Fault; and
- Joes Valley Graben, Joes Valley Fault, and other related faults

---

## EAST MOUNTAIN AREA

---

In the area of the Genwal mine, strata dip at less than 5° on both flanks of a gently south-plunging, unnamed anticline that terminates in the Crandall Canyon Syncline. Because the axis of this fold is near the Joes Valley Fault, the west flank of this anticline is limited in extent and may simply be a drag-fold caused by movement on the Joes Valley Fault.

PacifiCorp has mapped the Flat Canyon anticline as a gentle fold that begins at the Joes Valley Fault and trends northeast and then north before dying-out in upper Mill Fork Canyon. The EA prepared by the Forest Service and BLM described this anticline as simply having a north-south orientation.

The Crandall Canyon Syncline is oriented northeast-southwest on the Joes Valley side of East Mountain but curves and trends northwest-southeast and crosses Little Bear Canyon near Little Bear Spring on the Huntington Canyon side. This syncline terminates at approximately a right angle against the Mill Fork Fault Graben. Straight Canyon Syncline extends southwest to northeast from Trail Mountain, across Cottonwood Canyon, and then terminates between the upper forks of Meetinghouse Canyon; its axis is just south of and parallel to Roans Canyon Graben.

The Mill Fork Fault Graben or Zone is a northeast-southwest trending series of faults. This zone has been mapped by PacifiCorp as branching from the Roans Canyon Fault Graben at Trail Mountain and extending to Huntington Canyon. In places, the faults that mark this zone can be mapped from features visible at the surface, but the zone has been extended across the CIA based on underground encounters in the Deer Creek and Huntington #4 mines and a geophysical study performed by PacifiCorp in the Rilda Canyon area. Offset is approximately 25 to 30 feet on the faults on both sides of the graben. The faults are exposed in Little Bear Canyon, where Little Bear Spring flows from the fault that forms the west side of the graben.

Roans Canyon Graben, a series of several normal faults, also extends from Trail Mountain to Meetinghouse Canyon. Maximum displacement on the faults is 150 feet. Where the Deer Creek Mine crosses the graben at the 3<sup>rd</sup> North crossing, strata north of the graben are 40 feet lower than those south of the graben, the floor of the graben has been dropped 114 feet, and gouge in the four main faults ranges from none up to 30 feet thick (1988 PacifiCorp Annual Report). Experience in the Deer Creek Mine indicates this zone prevents ground-water movement across the graben but provides good vertical and horizontal flow-paths parallel to the graben.

The Deer Creek and Pleasant Valley Faults trend north – south along the southeast side of East Mountain. They are representative of a series of en-echelon faults that extend from the south end of Gentry Mountain and across Huntington Canyon to East Mountain. These faults are the southern end of a group of major north-south faults that includes the Pleasant Valley, Trail Canyon, and Bear Canyon Faults. Layout of the Des-Bee-Dove Mines was dictated by a system of these north – south faults, and the Deer Creek Fault separates the Des -Bee-Dove Mines from

---

## EAST MOUNTAIN AREA

---

the Deer Creek and Wilberg Mines. Fault displacements are generally less than 30 feet and not more than approximately 200 feet.

Joes Valley lies west of East and Trail Mountains in Joes Valley Graben. Joes Valley Graben and its bounding faults are regional features that run north-south for roughly 80 miles and extend both north and south well beyond East and Trail Mountains and Joes Valley. Joes Valley Fault is the eastern edge of Joes Valley Graben; down-to-the-west offset on this fault produced the steep western flank of East Mountain. It is a normal fault with up to 3,000 feet of vertical offset, but maximum offset in the CIA is approximately 1,500 feet.

The North Horn Formation is exposed on Bald Ridge and Middle Mountain on the west side of Joes Valley, on the upthrown side of the unnamed fault that forms the west side of Joes Valley Graben. Between Joes Valley Fault and this unnamed fault, Joes Valley is surfaced with a westward thinning wedge of alluvium that has been deposited by the streams draining the steep west flank of East Mountain. The floor of Joes Valley is above 8,500 feet elevation and slopes south to Joes Valley Reservoir, which is located several miles south of the CIA. Indian Creek does not flow down the middle of Joes Valley: having been displaced by deposition of the alluvial wedge, it flows near the trace of the unnamed fault on the west side of Joes Valley, near the contact between the alluvium and North Horn Formation at the base Bald Ridge and Middle Mountain.

Jointing, which affects hydrologic characteristics, is significant in the rocks of the Mill Fork Lease area. As the Crandall Canyon Mine workings neared the Joes Valley Fault, a series of subsidiary tensional fractures was encountered. The dominant joints in the area parallel the Joes Valley Fault, trending predominantly north-south to north  $10^{\circ}$  east, and a few secondary fracture sets follow other orientations (Mill Fork Extension, R845-301-624).

### *Climate*

Temperatures range from  $32^{\circ}$  to  $90^{\circ}$  F in the summer and  $-10^{\circ}$  to  $40^{\circ}$  F in the winter. Potential evapotranspiration has been estimated to be 18 to 21 inches per year (Crandall Canyon Mine MRP, p. 7-24).

Prevailing winds are from the west and northwest. The average velocity at the Crandall Canyon Mine, based on information from the Utah State Climatological Office, is 12 mph (Crandall Canyon Mine MRP, p. 7-24).

Recharge has been estimated to be 3 to 8 percent (Danielson and Sylla 1983) and 9 percent (Waddell and others 1986) of the average annual precipitation for areas in the Wasatch Plateau and Book Cliffs coal fields. Snowmelt provides most of the ground-water recharge.

**EAST MOUNTAIN AREA**

Annual precipitation ranges from 10 to 30 inches per year in the CIA (Danielson and others 1981). Table 1 shows variation is not strictly controlled by elevation; for example, the Crandall Canyon Mine averages 40 percent more precipitation than PacifiCorp’s higher elevation East Mountain station. At the East Mountain station, there are two wet-dry cycles during the year. June is typically the driest month, with another low in December. Precipitation peaks in March and September, but no month averages over 1.5 inches. June is also the driest month at the Crandall Canyon Mine, but the five months from November through March each average over 2 inches of precipitation, with December averaging over 3 inches. August also has over 2 inches of precipitation from the late-summer “monsoon” rains typical of the region.

Table CHIA-4				
	Annual Precipitation (inches)	Water Years	Elevation (feet)	Source of Information
Crandall Canyon Mine	20		8,000	Crandall Canyon Mine MRP, p. 7-21.
Hunter Power Plant*	8	1976 – 2001	5,800	2001 PacifiCorp Annual Report
Huntington Power Plant	10	1971 – 2001	6,500	
Electric Lake*	24	1971 - 2001	8,350	
East Mountain	14	1980 - 2001	9,000	

\* - Located outside the East Mountain CIA

The East Mountain CIA straddles the boundary between Palmer Hydrologic Drought Index (PHDI) Regions 4 and 7 and near Region 5; Figure 2 shows the PHDI for 1978 through 2001. The area has been in a mild to moderate drought since 2000.

EAST MOUNTAIN AREA

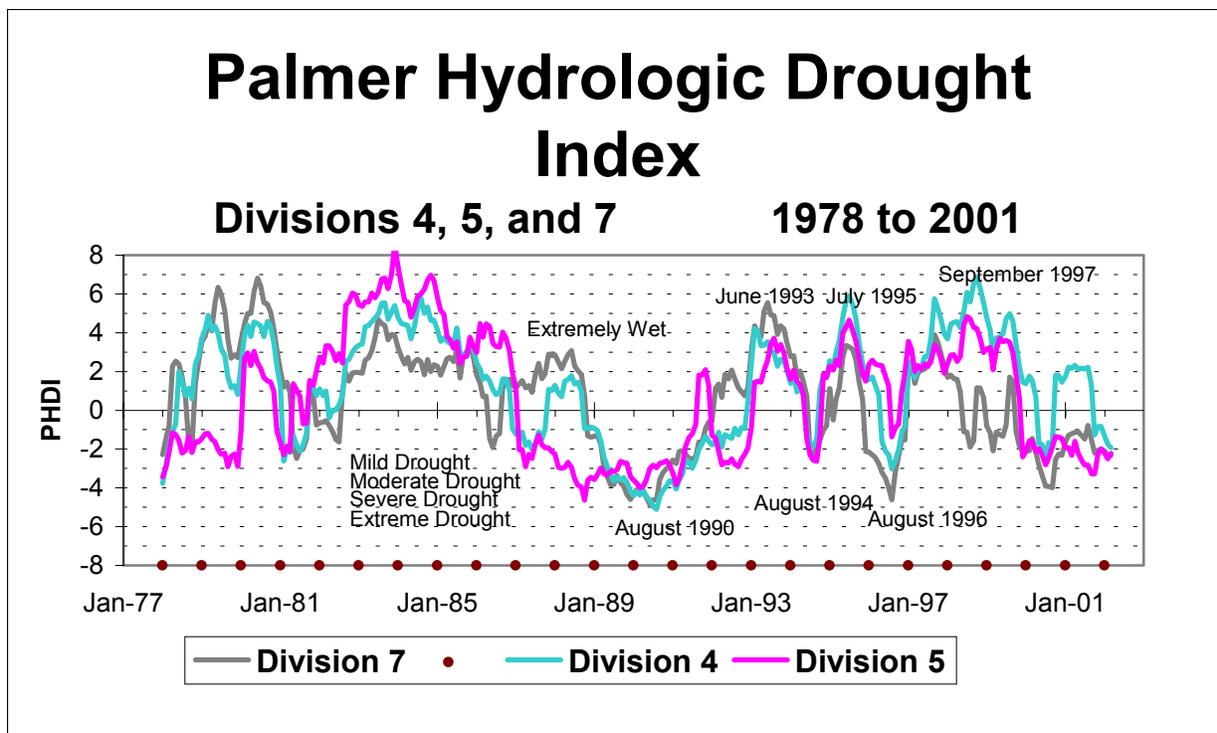


Figure 2 - PHDI, Divisions 4, 5, and 7

HYDROLOGIC SYSTEMS and USES

*Ground Water*

Ground-water regimes within the CIA are dependent upon climatic and geologic parameters that establish systems of recharge, movement and discharge. Snowmelt at higher elevations provides most of ground-water recharge. Well-developed soils and permeable or fractured lithologies exposed at the surface facilitate recharge. Once recharge enters the ground, the rate and direction of ground-water flow is governed mainly by gravity and geology. Lateral ground-water flow dominates in the gently-dipping Tertiary and Cretaceous strata of the Wasatch Plateau, where layers of low-permeability rock that impede downward movement are common. Both lateral and vertical flow may be channeled through faults and fractures, but plastic or swelling clays that can seal faults and fractures are abundant.

Ground water tends to flow more readily through shallower systems because hydraulic conductivities are generally larger than those of deeper systems due to weathering and fracturing. Much of the ground-water flow continues both laterally and downward through these shallower systems until it intercepts the surface and is discharged at a spring or seep, enters a stream as baseflow, is transpired by vegetation, or simply evaporates to the atmosphere; however, some of

---

**EAST MOUNTAIN AREA**

---

the ground water follows deeper and slower flow-paths where it becomes isolated from the surface and is stored, in effect, for long periods of time.

Ground water in the CIA, as is typical of ground water throughout the Price River basin, occurs under both confined and unconfined conditions. Ground water occurs under conditions that often form a system of local, perched aquifers and associated springs and seeps.

Strata of the Mesaverde Group do not readily receive recharge from surface water because they contain claystones and siltstones that have low permeability. Reservoir lithologies are predominantly higher permeability sandstone. Sandstone reservoirs occur as lenticular and tabular channel and overbank deposits. The sandstones are laterally discontinuous, individual sandstone units being separated by low-permeability clays and silts and pinching-out over short distances.

The Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, Flagstaff Limestone, and Quaternary deposits are potential reservoirs or conduits for ground water in the CIA, although there may be large volumes of these strata that are unsaturated or even dry. Locally, significant ground-water resources can be associated with the North Horn Formation and Price River Formation. There are some isolated Flagstaff Limestone outcrops on East Mountain with reservoir properties that have developed through dissolution and fracturing.

Shale, siltstone and cemented sandstone beds act as aquacludes to impede ground-water movement. The Mancos Shale is considered a regional aquaclude that limits downward flow within and adjacent to the CIA. Localized aquitards occur within all stratigraphic units, but particularly in the North Horn, Price River, Castlegate and Blackhawk Formations.

The USGS has identified the Star Point and Blackhawk Formations as an aquifer (Danielson and others 1981), and Lines (1984) designated these formations as a regional aquifer. "Regional aquifer" is a common phrase used by mining operators in the Carbon and Emery County coal fields. In such usage, "regional aquifer" usually refers to any water found in the Star Point Sandstone and Blackhawk Formation irrespective of quality, quantity, use, storage, flow and transport, and discharge. The Division has adhered to the definition of "aquifer" as found in the Coal Mining Rules (R645-100-200). Although there may be aquifers in the Star Point and Blackhawk strata, the Division does not consider the Star Point Sandstone and Blackhawk Formation to constitute a regional aquifer.

Faults and fractures act as effective conduits for ground water and allow unsaturated downward flow. The Roans Canyon Fault Graben appears to act as a significant vertical conduit for ground water. Drilling from within the Deer Creek Mine in advance of mining operations identified two major hydrogeologic units associated with the graben. Aquifer testing indicated the horizontal flow component within the graben is towards the east and suggests discharge

**EAST MOUNTAIN AREA**

occurs into the Huntington Creek drainage (1988 PacifiCorp Annual Report)

There are numerous seeps and springs within the CIA. PacifiCorp identified 198 seeps springs in and adjacent to the Mill Fork Tract in their 2000-2002 baseline survey, and another 83 are listed in Volume 9 of the Deer Creek, Des-Bee-Dove, Cottonwood-Wilberg, Trail Mountain PAP lists. Although there is probably some duplication with springs listed by PacifiCorp, the Genwal PAP lists 357 seeps and springs in Crandall and Horse Canyons. One hundred sixty-seven of these springs and seeps have been monitored. The total of the average discharges from the monitored spring exceeds 3,000 gpm; however, the discharge volumes given below in Table CHIA-5 are very general because not all sources were monitored over the same time period. Based on data from the springs that have been monitored, spring discharge is distributed roughly as follows:

Table CHIA-5

<u>Lithologic Unit</u>	<u>Number of Springs Listed by Permittee</u>	<u>Number of Springs Monitored</u>	<u>Total Average Discharge</u>
Flagstaff Limestone	17	8	45 gpm
North Horn Formation	243	100	2610 gpm
Price River Formation	127	34	109 gpm
Castlegate Sandstone	32	3	2.7 gpm
Blackhawk Formation	83	12	103 gpm
Star Point Sandstone	19	2	200 gpm
Alluvium	120	8	190 gpm
<b>Total</b>	<b>641</b>	<b>167</b>	<b>3259.7</b>

Water quality progressively decreases from the Flagstaff Limestone to the Star Point Sandstone.

Piezometric data from the Crandall Canyon Mine indicate ground water moves from northwest to southeast; from the crest of East Mountain towards Huntington Canyon in the Spring Canyon Member of the Star Point Sandstone, but as with other units of the Star Point, the Spring Canyon Member generally has low permeability and produces water only where permeability has been enhanced by fracturing, erosion, or weathering. Although the Star Point Sandstone is often treated or discussed as a homogeneous sandstone body, it consists of sandstones Intertongued with finer-grained rock, and discreet sandstone bodies have limited lateral continuity.

Water is encountered in the Star Point Sandstone in open joint-systems in some fault zones - mainly the Roan Canyon fault zone. However, culinary water-supply well MW-1 at the Crandall Canyon Mine flows from apparently unfractured Star Point Sandstone, from a zone

---

**EAST MOUNTAIN AREA**

---

noted by the driller as being coarser-grained than the rest of the unit (Crandall Canyon Mine MRP, p. 7-7). The water-bearing sandstone was 290 to 335 feet below the surface. When initially completed, MW-1 flowed in excess of 175 gpm, but intermittent flow, used for culinary water by the mine, is now 0.5 to 1 gpm. Tritium and radiogenic carbon values have not been reported for this water.

When operations in the Trail Mountain Mine exposed the Spring Canyon Member of the Star Point Sandstone in the down-plunge end of the Straight Canyon Syncline, ground water under pressure entered the mine at a rate of 200 to 300 gpm until the Spring Canyon Member was depressurized (Mill Fork Tract MRP, Appendix 700-B). The sandstone was not described as fractured.

The Huntington #4 Mine crossed the Mill Fork Graben. Offset is approximately 25 to 30 feet on the faults on both sides of the graben. Within the graben and at the bounding faults, only minor amounts of ground water were encountered - as roof drippers (Mill Fork Tract PAP, Section R645-301-731. A. 3. g.), and flow at Little Bear Spring was not measurably impacted. Either the mine was above the potentiometric surface or there is an aquitard - perhaps one of the coal seams - that isolated the mine from the water.

At an exploratory hole in Dairy Canyon (SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  Sec 3, T. 17 S., R 6 E.) on Trail Mountain, water from the Blackhawk Formation flowed to the surface at 150 gpm from a depth of 129 feet, approximately 500 feet above the Star Point Sandstone (Davis and Doelling 1977, p. 36).

#### Mine Inflow

Water that flows into the mines in the CIA is ground water that has been stored in the Blackhawk Formation and Star Point Sandstone or that is either stored in or flowing along faults and fractures. A substantial portion of the water that enters the mines is discharged as water vapor during mine ventilation. No discharge occurs at the reclaimed Huntington #4 Mine.

In the Crandall Canyon Mine, little water was encountered before 1996, and water was pumped from Crandall Creek to supply water for mine operations. In late 1966, ground-water inflow increased as mining progressed westward, and water no longer needed to be pumped into the mine; rather, excess water was discharged directly to Crandall Creek under a UPDES permit. The mine operator reported discharges of approximately 550 to 700 gpm from November 1996 through 1999, and 900 to 1,200 gpm from Jan 2000 through mid-2002: the UPDES reports show discharge rates of approximately 200 to 600 gpm and 600 to 750 gpm for these same periods. Water mainly dripped from fractures and channel-sandstones exposed in the roof, but there was also slow leakage through the floor from the underlying Spring Canyon Member of the Star Point Sandstone.

**EAST MOUNTAIN AREA**

Estimated inflow to all the PacifiCorp mines (2000 Annual Report) totaled  $1.03 \times 10^9$  gal., or roughly 2,000 gpm. Of this total,  $57 \times 10^6$  gal. were discharged as water vapor during mine ventilation and  $15 \times 10^6$  gal. diverted for various “domestic” uses in the mines. Mine water was never discharged at the Des-Bee-Dove Mines.

At the Cottonwood/Wilberg Mine, which partially overlaps with the Deer Creek Mine, estimated discharge to the Left Fork of Grimes Wash in 2000 was  $52.9 \times 10^6$  gal (100 gpm). An estimated additional  $23.3 \times 10^6$  gal (60 gpm) were consumed by mine operations and evaporation (2000 PacifiCorp Annual Report). The Cottonwood/Wilberg Mine was placed in temporary cessation in May 2001, and pumping within the mine and discharge to Grimes Wash ceased. The UPDES permit was modified and water now drains by gravity to the Trail Mountain Access Tunnel in Cottonwood Canyon, where it discharges to Cottonwood Creek. Discharge at the new point has averaged 28 gpm since June 2001.

The ventilation portals in Miller Canyon were permanently sealed in 1987, but 2-inch drainpipe was placed through one of the seals. The Miller Canyon portal area was reclaimed in 1999. A small volume of water still seeps out of the mine, bypassing the seals by way sandstones that underlie the coal seam, but so far volumes have been too small to reach the UPDES monitoring point at the confluence of Miller Canyon with Cottonwood Creek (Cottonwood/Wilberg Mine MRP, Appendix XXII).

PacifiCorp has estimated that inflow to the Mill Fork Extension will be similar to what has occurred in the Deer Creek Mine. Since 1992, when the 4<sup>th</sup> South area was sealed and water production dropped significantly, the rate of discharge has trended back up, which PacifiCorp attributes to several factors, but largely to mining having progressed into areas dominated by channel-sandstones in the roof. Between 1992 and 2001, discharge from the Deer Creek Mine averaged roughly  $2 \times 10^6$  gal/day, or 1,400 gpm (2001 Annual Report). Total discharge in 2001 was estimated at  $844.5 \times 10^6$  gal (1,600 gpm), a 14 percent increase from 2000, and an additional  $25.3 \times 10^6$  gal (50 gpm) were consumed by mine operations and evaporation (2001 Annual Report). In the past, discharge from the Deer Creek Mine went directly to the Huntington Power Plant, but currently the power plant is not accepting water from the mine and all discharge goes to Deer Creek (Dennis Oakley, personal communication, January 7, 2003).

Table CHIA-6. Estimated Ground-water Discharge from Mines. East Mountain CIA.

Genwal	900 to 1,200 gpm
Deer Creek Mine	1,600 gpm
Cottonwood/Wilberg Mine	
Trail Mountain Mine	
Total	2,500 to 2,800 gpm

---

EAST MOUNTAIN AREA

---

Little Bear Spring

Little Bear Spring in Little Bear Canyon, east of the Mill Fork Lease, is an important source of water for the Castle Valley Special Services District (CVSSD), supplying 65 percent of the culinary water to the residents of Huntington, Cleveland, and Elmo. The only treatment required before use is chlorination. It is probably the largest and most consistently flowing spring in the region.

Little Bear Spring flows from the Panther Tongue of the Star Point Sandstone at the bounding faults on the west side of the Mill Fork Graben. Several investigations - including isotope analyses (Mayo and Associates 1997a and 1997d), geophysical studies (Sunrise Engineering 2001a and 2001b; WTR 1999), dye-tracer tests (Mayo and Associates 2001c), and analyses of piezometric, chemical, and flow data - indicate that the ultimate recharge area for Little Bear Spring is upper Mill Fork Canyon. Precipitation runoff, snowmelt, and discharge from numerous springs collect in both the channel and alluvium of Mill Fork, and the water is diverted to Little Bear Spring through the Mill Fork Graben. PacifiCorp added a stream-monitoring point in Mill Fork, upstream of the Mill Fork Graben, at the request of the USFS.

At Little Bear Spring, Danielson (Danielson and others 1981) measured flows of 110 to 165 gpm between April 1978 and March 1979, apparently before the spring was developed as a culinary water source by CVSSD. CVSSD has measured flow at Little Bear Spring monthly since 1982, and regularly monitors the quality of the water. Recent water-quality and isotopic analyses (Mayo and Associates 1997a) show the water from Little Bear Spring is similar to waters in Huntington and Little Bear Creeks. The high tritium and modern carbon in water from Little Bear Spring show the water is of modern origin, indicating regional flow through unfractured, low-permeability Star Point Sandstone is not a significant source of water for this spring.

Average flow measured by CVSSD has been approximately 340 gpm. Flow varies seasonally, one indication of a shallowly circulating ground-water system, but minimum flows have never dropped significantly below 200 gpm. This sustained baseflow indicates that the system has considerable storage capacity, probably in the channel-bottom alluvium of Mill Fork Canyon and in the fractures of the Mill Fork Graben, and possibly some as "in bank" storage in the Star Point Sandstone exposed along the fractures.

There is a small possibility that mining in the Mill Fork tract, especially in the Crandall Canyon Syncline, could impact some portion of the flow at Little Bear Spring. Recharge to Little Bear Spring from the Star Point Sandstone and Blackhawk Formation is generally discounted because of low hydraulic conductivity and permeability (Mayo and Associates 1997c). However, even with low permeabilities, the large area exposed by the fractures in the graben could provide some recharge to Little Bear Spring from the Star Point Sandstone and Blackhawk Formation.

---

## EAST MOUNTAIN AREA

---

The down-plunge end of the Crandall Canyon Syncline, which could concentrate or enhance ground-water flow, intercepts the Mill Fork Graben between Mill Fork and Little Bear Canyons.

### Rilda Canyon Springs

North Emery Water Users Association (NEWUA) has developed springs in lower Rilda Canyon. Studies performed by PacifiCorp indicate that approximately 80 percent of the recharge to these springs originates in the Right Fork of Rilda Canyon.

### Joes Valley

Joes Valley Fault separates Joes Valley from East Mountain and the Mill Fork Lease. This fault runs generally north-south. It is a normal fault with up to 2,300 feet of vertical offset, downthrown on the west side. The fault and graben are regional features that extend both south and north of the East Mountain area. Offset is 1,500 feet adjacent to the Mill Fork Lease. The fault forms the eastern edge of Joes Valley Graben and the steep escarpment along the western flank of East Mountain.

North Horn and Upper Price River Formations are exposed on the floor of Joes Valley, with thick alluvium and colluvium deposits overlying these formations adjacent to the fault and escarpment. Most of the springs in Joes Valley flow from the alluvium along Indian Creek or from the North Horn Formation exposed west of the creek. Springs also flow in the small canyons that have been eroded into the fault scarp: these springs appear to be less numerous in the northern part of the Mill Fork tract where the fault and the mountain ridge are close to each other, and to become more numerous towards the south as the distance between the scarp and ridge increases. This indicates ground-water flow is directly proportional to the surface area exposed for recharge.

Most of the springs in Joes Valley flow from the alluvium along Indian Creek or from the North Horn Formation exposed west of the creek. Springs also flow in the small canyons that have been eroded into the west side of East Mountain: these springs appear to be less numerous in the northern part of the Mill Fork tract where the Joes Valley Fault and the mountain ridge are close to each other, and to become more numerous towards the south as the distance between the scarp and ridge increases (Mill Fork Tract PAP, Plate 1 and Drawing MFU1823D).

Wetlands in the Indian Creek drainage are supported in part from ephemeral flow from drainages on the west flank of East Mountain. These wetlands often support diverse communities of amphibians, macroinvertebrates, and other flora and fauna.

Sample of water associated with Joes Valley Fault were collected at two locations near the Joes Valley Fault inside the Crandall Canyon Mine (at the end of the West Mains and the end of 5<sup>th</sup> West) and from well MW-7, which was drilled inside the mine, approximately 200 feet

---

## EAST MOUNTAIN AREA

---

from the fault, into the Star Point Sandstone. There was a small amount of tritium (0.95 TU) in the 5<sup>th</sup> West sample but none in the other two. Mean residence time determined from radiocarbon dating was 2,000 to 5,000 years. Mining within 200 to 300 feet of the Joes Valley Fault could intercept modern water, recharged from the surface, but the “active” zone near the fault may include deeper, older water (Mayo and Associates 1997a; Mill Fork Tract PAP, Appendix B). A stipulation in the Mill Fork tract coal lease does not allow full extraction mining within a 22 degree angle-of-draw of the fault.

### *Surface Water*

Surface runoff from the Wasatch Plateau area flows either to the Price River Basin or the San Rafael River Basin. Drainage from the East Mountain CIA flows to the San Rafael River.

The Price River Basin, which includes about 1,800 square miles in six counties, is located primarily in Carbon and Emery Counties in east-central Utah. Headwaters of the Price River are the drainages around Scofield Reservoir and Soldier Summit. The river flows southeasterly and joins the Green River approximately 15 miles north of the town of Green River, Utah. The drainage is bounded by the Book Cliffs on the northeast, the Wasatch Plateau on the west and the San Rafael Swell on the south.

The San Rafael River Basin lies south of the Price River Basin. Headwaters are in the Wasatch Plateau. This basin includes about 2,300 square miles in three counties, but is located mainly in Emery Country. The San Rafael River Basin occupies part of two physiographic sections of the Colorado Plateau - the High Plateaus to the north and west and Canyonlands to the south and east (Fenneman 1946). Principal streams in the basin are Huntington and Cottonwood Creeks, which merge to form the San Rafael River, and Ferron Creek, which joins the San Rafael River within a mile of the Cottonwood - Huntington confluence. The San Rafael River also flows in a southeasterly direction to eventually join the Green River.

Sixty-five percent of runoff in Huntington Creek occurs from April to July as a result of snowmelt. Water-content of the April 1 snowpack correlates well with annual discharge (Danielson and others 1981, p. 11)

Crandall, Little Bear, Mill Fork and Rilda Creeks drain the east slope of East Mountain and generally flow west to east into Huntington Creek. Cottonwood Creek drains the canyon that separates Trail and East Mountains, and the west slopes of East and Trail Mountains drain to Indian Creek through a number of short but steep tributaries. Indian Creek flows south to Lowry Water and then to Joes Valley Reservoir, which discharges to Cottonwood Creek by way of Straight Canyon.

Under the Standards of Quality for Waters of the State of Utah (UC R-317-2), waters in Huntington and Cottonwood are classified as 1C, 2B, 3A and 4.

---

**EAST MOUNTAIN AREA**

---

- 1C - protected for domestic use with prior treatment,
- 2B - protected for recreational uses except swimming,
- 3A - protected for cold water aquatic life, and
- 4 - protected for agricultural uses.

All waters on US Forest Service lands are designated as High Quality Water Category 1 (no point-source UPDES discharge), except part of Deer Creek is designated as High Quality Water Category 2 (UPDES discharge permitted but no degradation of quality allowed).

Water quality of both the Price and San Rafael Rivers is good in the mountainous headwater tributaries, but deteriorates rapidly as flow traverses the Mancos Shale. The shale lithology typically has low permeability, is easily eroded and contains large quantities of soluble salts that are major contributors to poor water quality. Depending on the duration of contact, water quality degrades downstream to where Total Dissolved Solids (TDS) levels of 4,000 mg/L are not uncommon. The predominant ion leached from the Mancos Shale is sulfate (SO<sub>4</sub>) with values over 1,000 mg/L common in the lower reaches of the Price River.

The CIA has been divided into 14 drainage basins (Plate 4). The CIA encompasses drainage to Huntington Creek and Cottonwood Creek, both draining to the San Raphael River Basin.

Left Fork of Huntington Creek (1)

This drainage, including the major tributary, Scad Valley Creek, delineates the north and northwestern-most boundary of the CIA. There is little, if any, surface or subsurface drainage to these surface waters from areas potentially affected by mine operations.

Horse Canyon (2)

The two forks of upper Horse Canyon are intermittent, but from where the forks join down to the confluence with Huntington Creek, the stream appears to be perennial.

Blind Canyon (3)

The stream in Blind Canyon is intermittent. In July 1991 Genwal installed a 12-inch Parshall flume near the mouth of Blind Canyon. As of December 2002, maximum flow was 488 gpm (May 2002), but the stream has frequently been dry. TDS has ranged from 234 to 450 mg/L, and TSS from 5 to 54 mg/L.

The coal beneath Blind Canyon has been retreat mined and the effects of subsidence on watershed erosion and stream flow were to have been studied under the direction of the USFS Intermountain Research Station. In addition to determining effects of retreat-mining induced

**EAST MOUNTAIN AREA**

---

subsidence on stream flow and interconnectivity of surface and ground water, goals were to determine changes in channel relief and morphology, watershed erosion, and sediment routing. The final report was due September 1995. The report on this study has never been received by the Division, and the study, or at least the write-up of the study, may have never been completed.

Crandall Canyon (4)

Crandall Canyon drainage encompasses 4,100 acres. The Crandall Canyon Mine underlies 2,200 acres, and the Mill Fork Lease includes 1,200 acres. The average gradient of Crandall Creek is 16 percent. Immediately below the mine the channel is steeper than 4 percent and has a boulder or bedrock channel (EA 1997). Crandall Creek flows east into Huntington Creek and is perennial upstream to where the two main forks join, and maybe farther.

The USGS measured streamflow at station 09317919 at the mouth of the canyon on a seasonal basis - typically May through November - from October 1977 to September 1984. Daily mean streamflow from Crandall Creek ranged from no-flow during a one-week period in November 1977 to 88 cfs in May 1983, and averaged 5.4 cfs. Except for the winter of 1978-1979, values for flow were not reported during winters, presumably because the gauge and stream were frozen: during the 1978 - 1979 winter, flow was 0.4 to 0.9 cfs. About 80 percent of streamflow in Crandall Creek occurs between April and July as a result of snowmelt, peak flow usually occurring in late May. Suspended sediment concentration in Crandall Creek in 1978 and 1979, when there was no mining in the canyon, ranged from 15 to 60 mg/L, which equaled a calculated daily load of 0.08 to 0.41 tons/day (Danielson and others 1981, p. 17).

Genwall has measured water quality at sites located upstream and downstream of the mine since October 1983. The flumes equipped with automatic continuous recorders were installed in 1986: flow values were reported at least monthly from July 1986 to December 1992, and have been reported quarterly since. Before 1996, water was pumped from Crandall Creek to supply water for mine operations, which is one explanation of why, in Table CHIA-7, flow measured above the mine is greater than that below.

<b>Table CHIA-7</b>						
ID in Database	Description	First and Last Measurement		Flow in gpm		
				Min	Max	Avg
UPF-2	Crandall Cyn. Upper Flume	7/86	9/02	0	12,900	1,080
LOF-1	Crandall Cyn. Lower Flume	7/86	9/02	0	10,200	660

The Crandall Canyon Mine is in the lower reaches of the canyon and involves approximately 11 acres of surface disturbance. All surface disturbance is treated by maintained sediment controls. Because Crandall Creek has a boulder and bedrock channel, there have been no observed changes to the channel morphology from the discharge of mine-water to the creek.

**EAST MOUNTAIN AREA**

---

Little Bear Canyon (5) and Mill Fork Canyon (6)

Approximately 4,800 acres are drained by Little Bear Canyon (800) and Mill Fork Canyon (4,000) combined. The average gradient of Little Bear Creek is 30 percent and the average gradient for Mill Creek is 13 percent. PacifiCorp leases underlie approximately 2,300 acres in Mill Fork Canyon but do not extend into Little Bear Canyon.

The old Huntington #4 Mine underlies approximately 1,300 acres in these two canyons. The 12 acres of surface disturbance for the #4 Mine, all in Mill Fork Canyon, has been reclaimed and bond has been released.

Little Bear Creek is considered ephemeral; however, CVSSD diverts 200 to 400 gpm from Little Bear Spring, which provides culinary water to nearly 2,500 residents in the towns of Huntington, Cleveland and Elmo. The flow from Little Bear Spring is perennial and has not dropped below 190 gpm since CVSSD began keeping records in 1982. Flows in Little Bear Creek in 1978 and 1979, measured by Danielson at the point the stream discharges to Huntington Creek, are shown in Table 2 (Danielson and others 1981, Tables 5 and 6): it is not known if Little Bear Spring was being diverted at the time Danielson made these measurements.

Table CHIA-8 – Flow in Little Bear Stream.	
	Flow in cfs
October 13, 1978	0.24
October 18, 1978	0.5 (est.)
July 19, 1979	1.0
October 16, 1979	0.75
October 30, 1979	0.24

The USFS excluded the area covered by the South Crandall Canyon Coal Lease Tract, which includes part of Little Bear Canyon, from the Mill Fork Lease because of concerns for potential adverse impacts to Little Bear Spring. These concerns are being reevaluated in the EA for the South Crandall Canyon Coal Lease Tract.

Mill Creek is considered perennial in its lower reaches. Field observations by Forest Service personnel in August 1996 found that Mill Fork Creek was dry at the lower forks in Section 17, T. 16 S., R. 7 E., but flow was observed emanating from the creek bottom approximately 0.5 mile downstream of the forks. In the seep and spring inventory done by Genwal for the EA, 49 springs in the head of Mill Fork Canyon were identified. Flows ranged from seeps to 50 gpm, with most flows below 5 gpm. The occurrences were classed as follows (EA 1997, p. III-6):

**EAST MOUNTAIN AREA**

Table CHIA-9

Flow in gpm	Number of Springs
>25	4
20-25	0
15-19	4
10-14	5
5- 9	7
0- 4	29

Utah Division of Wildlife Resources has identified cutthroat and rainbow trout in Mill Fork and Little Bear Creeks, and consider them as likely habitat for non-game fish as well (Mill Fork Tract PAP, p. 3-8).

Rilda Creek (7)

Lower Rilda Creek is perennial, mainly due to several large springs found in the middle reaches of the creek just below the confluence of the left and right forks; however, several of these large springs have been developed by NEWUA, so some of what naturally flowed down the stream is now diverted for use in the NEWUA culinary water system. The average gradient of Rilda Creek is 11 percent.

Rilda Canyon drains approximately 5,100 acres, and the PacifCorp permit area covers 3,600 acres of this drainage. The Right Fork is drains about 2,114 acres and is the larger of the two main forks. The Left Fork joins the Right Fork above the NEWUA springs.

Flow is measured at six locations, which are shown on Plate 6. Maximum, minimum, and average flow for the streams and NEWUA springs is summarized in Table CHIA-10.

**Table CHIA-10 Rilda Canyon Flow**

ID in Database	Description	First and Last Measurement		Flow in gpm		
				Min	Max	Avg
RCF-1	Upper Right Fork Flume, just downstream of the Mill Fork Graben	4/89	9/02	0	4,500	250
RCF-2	Flume Above the NEWUA Springs	4/89	8/02	0	5,100	260
RCF-3	Flume Below the NEWUA Springs	4/89	8/02	0	5,050	290
RCW-4	Flume Above the confluence with Huntington Creek	4/89	9/02	0	7,000	330
RCLF-1	Lower Left Fork	12/89	9/02	0	400	15
RCLF-2	Upper Left Fork	10/95	9/02	0	160	19

**EAST MOUNTAIN AREA**

NEWUA Meter-2		9/90	9/02	0.5	20	5
NEWUA Meter-3		9/90	9/02	30	210	93

Genwal's spring and seep inventory found 41 springs and seeps in the Right Fork of Rilda drainage, 25 of which reached the stream (EA 1997, p. III-7).

Table CHAI-11

Flow in gpm	Number of Springs
>25	4
20-25	3
15-19	4
10-14	7
5- 9	4
0- 4	19

Near the NEWUA springs, surface disturbance from the Helco Mine was reclaimed by the Division's Abandoned Mine Reclamation Program (AMRP) in 1991, with additional reclamation work done in late 2002.

Meetinghouse Canyon (8) and Deer Creek Canyon (9)

Meetinghouse Creek is considered ephemeral and Deer Creek is considered perennial. The average gradient of Meetinghouse Creek is 12 percent and the average gradient of Deer Creek is 13 percent. The approximate areas of Meetinghouse and Deer Creek Canyons are, respectively, 5,500 acres and 4,000 acres: PacifiCorp's permit area includes approximately 5,000 acres in Meetinghouse Canyon and 3,700 acres in Deer Creek Canyon.

Deer Creek Mine operations have disturbed approximately 30 acres in the middle of Deer Creek Canyon. An additional 49 acres have been disturbed for the waste rock disposal site located near the Huntington Power Plant. Runoff from surface facilities is treated by sediment controls. All coal produced at the mine is conveyed to the Huntington Power Plant, which is located near the bottom of Deer Creek Canyon and adjacent to Huntington Creek.

Discharges from the Deer Creek Mine have averaged 1,400 gpm, and the maximum reported discharge was 3,680 gpm in December 1990. Prior to December 1990, all discharge was piped to the Huntington Power Plant and none entered the natural drainages. A temporary discharge permit was issued in November 1990 because of high inflows into the mine at the Roans Fault crossing, and 1990 and 1991 was a period of consistently high discharge rates (Figure 3). Currently, the power plant is not accepting water from the mine (Dennis Oakley, personal communication, January 7, 2003). Water is now diverted to abandoned mine sections

**EAST MOUNTAIN AREA**

and used underground for mine operations, and only excess water is discharged directly to Deer Creek at UPDES discharge point UT0023604-002: excess water from the Mill Fork Extension will also be discharged through this point.

<b>Table CHIA-12 Flow in Deer Creek</b>						
ID in Database	Description	First and Last Measurement		Flow in gpm		
				Min	Max	Avg
DCR01	Deer Creek above the mine.	5/78	5/02	0	2,900	140
DCR04	Deer Creek as it leaves the permit area	6/84	9/02	0	2,900	570
DCR06	Deer Creek at confluence with Huntington Creek	5/78	9/02	0	2,900	500

Maple Gulch (10) and Danish Bench (11)

Approximately 5,400 acres of Maple Gulch and 4,600 acres of the Danish Bench drainages are associated with the CIA. Both areas are primarily Mancos Shale flats draining away from the southern end of East Mountain, so steep, deeply incised canyons are not as prominent as in the other drainages in the CIA. Danish Bench drains to Cottonwood Creek with an average gradient of 12.5 percent. Maple Gulch drains to Huntington Creek and has an average gradient of 17 percent. Permitted areas of the PacifiCorp mines encompass 840 acres of Maple Gulch and 250 acres of Danish Bench. Neither drainage contains any surface disturbance associated with mining, but most of the Des-Bee-Dove underground workings are beneath Maple Gulch drainage.

Grimes Wash (12)

Approximately 8,400 acres are associated with the Grimes Wash drainage, and PacifiCorp's permit area covers 4,600 acres. The average gradient of Grimes Wash is 14 percent. The Cottonwood/Wilberg Mine surface facilities have disturbed 31 acres of the surface, and sediment controls treat runoff from the disturbed area. The Des-Bee-Dove mine portals, located at the head of a small, narrow canyon in the Grimes Wash drainage, disturbed 24 acres. Reclamation of the Des-Bee-Dove mines began in 1999 and grading and reseeded are scheduled for completion in 2003.

Cottonwood Creek (13)

This area encompasses approximately 11,000 acres that drain to Cottonwood Creek along the southwest edge of the CIA. The portion of PacifiCorp's permit area contained in this drainage is approximately 5,200 acres. The Cottonwood Creek drainage has many small tributary canyons.

---

**EAST MOUNTAIN AREA**

---

This drainage contains 12 acres of surface disturbance associated with the Cottonwood Fan Portal area of the Cottonwood/Wilberg Mine: this area has been reclaimed but has not been released from reclamation bond. There is also a reclaimed portal area in Miller Canyon; although the portals are sealed, drainage in the mine apparently accumulates behind the seals and periodically discharges through the sandstones that underlie the coal seam. The discharge drains to Miller Canyon and potentially can reach Cottonwood Creek. There is a UPDES discharge point where the Miller Canyon stream meets Cottonwood Creek, but, to date, the discharge has been insufficient to reach that point.

Indian Creek (14)

The EA reported that the USFS measured Indian Creek flows ranging from 1 cfs and 30 cfs (450 to 13,500 gpm) from 1972 to 1975. Since 1996, Genwal has monitored Indian Creek quarterly at a flume located approximately one-half mile south of the USFS guard station, near the common corner of Sections 15, 16, 21, and 22, T. 16 S., R. 6 E., next to the east-west road that crosses the creek. The flume is rarely accessible during the late fourth quarter and the entire first quarter. Flow measured during the other three quarters has ranged from 3.5 gpm in November 1999 to 7,070 gpm in October 1996. The valley contains a large, marshy wetland area.

Numerous unnamed short, steep channels or gulleys flow down the west side of East Mountain to Indian Creek. These channels cross Joes Valley Fault at the base of the mountain, and have laid down a westward thinning deposit of alluvium across Joes Valley.

Most flow in Indian Creek appears to originate from these East Mountain drainages, both as direct surface flow during snowmelt and as recharge to the numerous valley-floor springs and seeps, which flow from the alluvium and from the North Horn bedrock exposed on the west side of the valley.

Water from these ephemeral drainages could be intercepted if subsidence focused along the Joes Valley Fault or if ground movement produced fractures at the surface. A stipulation in the Mill Fork Tract lease does not allow full extraction mining within a 22 degree angle-of-draw of the fault, so the possibility of such interception is very small.

Only the north end of the Indian Creek drainage, upstream of the Genwal flume, is included in the CIA. The drainage continues south of the flume for roughly 8 miles. Indian Creek flows into Lowry Water, which then flows to Joes Valley Reservoir. The Genwal and Mill Fork leases occupy 3,100 acres in this drainage.

## BASELINE CONDITIONS

### *Surface-Water Quality And Quantity*

In the Wasatch Plateau, water quality is good in headwater areas, where rocks contain only small amounts of readily soluble material; TDS concentrations are typically less than 500 mg/L, and dominant ions are calcium, magnesium and bicarbonate. TDS concentrations increase at lower elevations, where streams flow onto more saline marine sediments, especially the Mancos Shale, and sodium and sulfate ions become more common: diversion of low-TDS water for irrigation, return drainage of irrigation water from saline soils, and inflow of sewage and other pollutants add to the natural increase of dissolved solids in the lower elevation reaches of these streams. The lowest dissolved solids concentrations are associated with high flows from snowmelt, and highest concentrations with low-flows during late summer through winter. Sediment yields in the Upper Huntington Creek drainage were estimated at 0.1 acre-feet per square mile, and increasing to 3 acre-feet per square mile at lower elevations where rocks are predominantly shale and sandstone (Waddell and others 1981, p. 17, 25-26, 28, Plate 6).

### *Ground-Water Quality And Quantity*

Ground water occurs in all of the strata exposed in the Wasatch Plateau, but the units are not saturated uniformly. It is unlikely that large amounts of recharge infiltrate from the surface through the Star Point Sandstone, Blackhawk Formation and overlying units due to low permeability materials that impede downward migration of water. Ground water is found on several modes:

- Laterally discontinuous, perched, local water-bearing zones where permeable layers of sandstone overlie less permeable layers of shale, mudstone or clay;
- A more continuous saturated zone in the Star Point Sandstone;
- Alluvial materials in canyon bottoms; and
- Faults and fractures in the local strata.

According to Lines (1985), the Blackhawk Formation and Star Point Sandstone contain a regional ground-water system in the Trail Mountain area. In the East Mountain CIA, it does not appear that the Blackhawk contains large quantities of water. The Division adheres to the definition of "aquifer" as found in the Coal Mining Rules (R645-100-200); although there are local or perched aquifers in the Star Point and Blackhawk strata at East Mountain, the quality, quantity, use, storage, flow and transport, and discharge of ground water do not indicate a regional aquifer. Mine inflow is from channel-sandstones in the Blackhawk Formation that are exposed in the mine roof, discharges from the Star Point Sandstone through the floor, and in fault zones.

---

EAST MOUNTAIN AREA

---

Perched Water-bearing Zones

Precipitation occurs mainly as snow, augmented by intense thundershowers during late summer. Steep slopes drain excess water away quickly and prevent infiltration over a long period of time, so most water from snowmelt and thundershowers runs off rather than percolating into the ground. Thin soils with high clay content are rapidly saturated by runoff and reject additional infiltration from snowmelt and thundershowers. Only an estimated 3 percent to (Danielson and Sylla 1983) 9 percent (Waddell and others 1986) of the average annual precipitation goes to ground-water recharge, and most of this is retained in the shallow, local, perched water-bearing zones. Recharge percolates into permeable rocks, flows vertically until it hits an impermeable layer, then flows laterally. Impermeable layers present in the local strata tend to impede downward migration of flow, except locally through fractures or faults. Some water does infiltrate along flow paths that slowly carry it to deeper strata, where it becomes, in effect, stored water.

Springs associated with perched water-bearing units generally exhibit their highest flow during or immediately after snowmelt and recede to a baseflow condition or cease flowing by late summer or fall. The rapid response indicates that the springs are close to their recharge sources.

The water may be either confined or unconfined. At an exploratory hole in Dairy Canyon (SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  Sec 3, T. 17 S., R 6 E.) on Trail Mountain, water from the Blackhawk Formation flowed to the surface at 150 gpm from a depth of 129 feet, approximately 500 feet above the Star Point Sandstone (Davis and Doelling 1977, p. 36).

Perched water-bearing zones and associated springs are typically in the North Horn Formation, at the North Horn - Price River contact, or at the base of the Castlegate Sandstone. A cluster of springs at the head of Little Bear Canyon issue from the base of the Castlegate sandstone or are associated with landslides: these flow from 0.25 to 2 gpm. Numerous other springs on the west flank of East Mountain drain towards Indian Creek. Most of these springs issue from the Price River Formation or the Castlegate Sandstone, and range from seeps to 10 gpm, with typical flows ranging from 1-2 gpm. A linear alignment of springs in the Indian Creek drainage are likely associated with the colluvial and alluvial deposits from East Mountain. These springs and seeps occur in the North Horn Formation and contribute flow to Indian Creek. Flows measured in these springs range from 0.5 to 50 gpm, with most springs flowing approximately 1 to 2 gpm (EA 1997).

North Emery Water Users Association (NEWUA) has developed springs and collection galleries in the alluvial materials in lower Rilda Canyon. Springs higher in the basin contribute flow to the creek and likely support the shallow ground-water flow in the alluvial deposits. Studies performed by PacifiCorp indicate that approximately 80 percent of the recharge to the NEWUA springs originates in the Right Fork of Rilda Canyon.

---

## EAST MOUNTAIN AREA

---

Similarly, springs in upper Mill Fork Canyon contribute to ground water in the alluvium in the lower canyon, which produces flow in the lower canyon and also is a major source of recharge to Little Bear Spring by way of the Mill Fork Fault Graben.

### Ground Water in the Star Point Sandstone

The Hiawatha Seam and the Spring Canyon Member of the Star Point Sandstone are separated by a variable amount of shale and sandstone. Water levels in monitoring wells in the Genwal Mine workings and in the southernmost portion of the Genwal tract indicate an east-southeast flow direction in the Spring Canyon member. Local geologic structures, such as the South Crandall Syncline or the Flat Canyon Anticline, likely influence flow directions in the Star Point.

Water in the sandstone is under confining pressure in places. Water-supply well MW-1, completed in the Spring Canyon Member of the Star Point Sandstone near the portals of the Genwal Mine, flowed into the mine. Unfractured coal and fine-grained sediments under the coal seam are an effective aquiclude. Unless they are fractured, under-coal shaley rocks will continue to confine the water after the coal is removed. In 1997, operations in the Trail Mountain Mine were in the down-plunge end of the Straight Canyon Syncline, where the Hiawatha Seam was directly on the Star Point Sandstone. Water flowed through the floor of the Trail Mountain Mine at 200 to 300 gpm until the Star Point Sandstone was depressurized.

Lines (1985) reported that the Star Point Sandstone has very low permeabilities in the vicinity of Trail Mountain, southwest of the CIA. Values of hydraulic conductivity in the Star Point Sandstone, measured at a number of locations and using different methods, range from  $2.7 \times 10^{-2}$  cm/sec to  $5.3 \times 10^{-6}$  cm/sec (Table CHIA-3). In general the Star Point is not a good aquifer, and exhibits aquifer characteristics only locally, usually where fracturing causes secondary permeability and at outcrop faces. Age dating of ground water from wells completed in the Star Point Sandstone from inside the Crandall Canyon Mine indicates a mean residence time of about 15,000 years (Mayo and Associates 1999), which supports the concept that flow rates through the sandstone are very slow. The exact recharge mechanism for the Star Point sandstone is not known but it is more likely that recharge reaches the sandstones mainly through faults and fractures rather than by infiltration through overlying strata.

### Faults

Hydraulic function of faults in the area is not well defined. The series of faults encountered in the Huntington #4 mine were reported to be dry at the mine level, with just minor roof drippers associated with the faults (Mill Fork Tract PAP, R645-301-731. A. 3. g.). The Roans Canyon Fault intercepted by the Deer Creek Mine workings initially yielded water at up to 5,000 gpm, but flow eventually dropped to 150 gpm or less (Mill Fork Extension MRP, Appendix B, p. 75-76). Synthetic faults associated with the Joes Valley Fault zone yielded water

---

EAST MOUNTAIN AREA

---

at a rate of 30 gpm when intercepted in the Crandall Canyon Mine; flow subsequently reduced to approximately 10 gpm. Isotopic dating of water samples collected near this fault, from channel-sandstones in the mine roof, were age dated, indicate the water has a mean residence time of 2,000 years or more (Mayo and Associates 1999). Faults in this area, as elsewhere on the Wasatch Plateau, are generally thought to act as barriers to horizontal ground-water flow, but can act as conduits for parallel flow. In the area along the Joes Valley fault, the strata dip to the west along the upthrown side of the fault, and the Joes Valley Fault could be contributing to the spring system supporting flow in Indian Creek (Hansen, Allen and Luce 1997).

### Little Bear Spring

Little Bear Spring is one of the largest springs in the Wasatch Plateau. It flows from a fracture in the Panther Member of the Star Point Sandstone on the west side of the Mill Fork Graben, at the contact with the Mancos Shale. The elevation of the spring is 7,650 feet, approximately 100 to 150 feet below the Hiawatha coal bed. Little Bear Spring is developed and maintained by CVSSD and provides 65 percent of the culinary water for the cities of Huntington, Cleveland and Elmo. Water in the spring is of good quality, requiring only chlorine treatment before it is suitable for consumptive use.

Little Bear spring flows continuously, with average monthly discharge ranging from 200 to 440 gpm. Flow varies seasonally, with a typical increase of 20-40 percent in response to spring runoff. The lowest average monthly baseflow recently measured was 198 gpm in April 1995. Isotopic analyses to evaluate the age of the water indicate that the spring discharges modern water that is isotopically similar to water in both Crandall and Huntington Creeks (Mayo and Associates 1997a). Chemical analyses show the water is very similar to surface water in both Little Bear and Huntington Creeks.

Several investigations - including isotope analyses (Mayo and Associates 1997a and 1997d), geophysical studies (Sunrise Engineering 2001a and 2001b; WTR 1999), dye-tracer tests (Mayo and Associates 2001c), and analyses of piezometric, chemical, and flow data - indicate that the ultimate recharge area for Little Bear Spring is upper Mill Fork Canyon. Precipitation runoff, snowmelt, and discharge from numerous springs collect in both the channel and alluvium of Mill Fork, and the water is diverted to Little Bear Spring through the Mill Fork Graben.

The hydraulic conductivity of the Star Point Sandstone is low, so movement of ground water through the sandstone is slow, and flow through unfractured Star Point Sandstone is not generally considered to be the source of water discharging at Little Bear Spring. Assuming a 5,000 foot capture zone along the Mill Fork Graben, a total saturated thickness of 50 feet in the Star Point Sandstone, and lateral hydraulic conductivity of  $5.0 \times 10^{-6}$  cm/sec, the potential flow available for discharge at the spring would be only 18.4 gpm; however, it's easy to see that the flow estimate is very sensitive to the assumed value of hydraulic conductivity, and based on slug

---

**EAST MOUNTAIN AREA**

---

tests and determinations from core samples, hydraulic conductivity values in the Star Point Sandstone vary through at least a one order-of-magnitude range.

Rilda Canyon - NEWUA Springs

NEWUA has developed the springs in Rilda Canyon as a culinary water supply. Based on investigations by PacifiCorp, approximately 80 percent of the discharge at the springs originates as snowmelt and precipitation runoff that percolates into the alluvium in the Right Fork of Rilda Canyon; above the Rilda springs, the stream is ephemeral, losing water to the alluvium, and below the springs it is perennial. Additional water comes from nearby faults. Estimated ground-water yield from the Rilda Canyon basin is on the order of 400 gpm during high flow (Hansen, Allen and Luce 1997). Reported discharges from the NEWUA system averaged 164 gpm from 1990-2001, and ranged from 25 gpm to 340 gpm (PacifiCorp 2001 Annual Hydrologic Report, Table 34). Water quality from the spring system is good, with major constituents being calcium, bicarbonate and magnesium. Isotope data show the water is recent or modern in age.

Ground Water Intercepted by Mining

Water intercepted in mines on the Wasatch Plateau typically has been stored in channel-sandstones that are exposed in the roof of the mine as mining progresses; when mining is in areas where the roof is of finer-grained rock, inflows are much lower than when the roof is sandstone (1987 Cottonwood/Wilberg Mine Annual Report, 2001 PacifiCorp Annual Report). These sandstones drain for a few weeks, but flow declines rapidly and eventually ceases. These characteristics indicate sources very limited in size and without extensive interconnection. Water is also encountered in saturated fractures or faults, and seeps up through the floor from the Star Point Sandstone. Available information indicates that most of the water intercepted in mines is not in direct communication with surface or near-surface ground water. Isotopic analyses taken from water coming from the Crandall Canyon mine roof showed the water has a mean residence time of over 14,000 years (Mayo and Associates 1997a).

In 1996, water was sampled where the Deer Creek Mine crosses the Roans Canyon Graben, and isotopic analyses indicate this was modern water; however, these samples were taken after water had flowed from the fault for seven years and the original water out of the fault when it was breached in 1989 might have been older water stored in the fault. Water temperatures were 4 degrees cooler than other ground waters in the Deer Creek Mine. Fractures rocks in the fault were iron-stained, indicating oxygen in the water from communication with the atmosphere. These all indicate, that at the time the samples were collected, the water entering the mine at the Roans Canyon fault crossing in the Deer Creek Mine was in recent connection with the surface, probably through the nearby highly-fractured cliff faces. Mayo and Associates (1997b) collected a sample of gob-water that included water that entered the mine where the 1<sup>st</sup> and 2<sup>nd</sup> Right entries intercepted the fault, a location more remote from the outcrops; isotopic

---

**EAST MOUNTAIN AREA**

---

analysis indicated water in the fault at locations more distant from the outcrop is older water and likely is not in communication with recent or shallow ground water (Mayo and Associates 1997b).

Water intercepted as the Genwal Mine approached Joes Valley Fault was a mixture of old and modern water, as indicated by a minor tritium content in one of three samples, but <sup>14</sup>C indicated a mean residence time of 2,500 to 5,000 years (Mill Fork Extension MRP, Appendix B). Water has apparently infiltrated from the surface through synthetic fractures associated with the Joes Valley Fault.

#### **IV. IDENTIFY HYDROLOGIC CONCERNS**

##### **SUBSIDENCE**

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow. Potential changes include increased flow rates along fractures that have "opened", and diverting flow along new fractures or within permeable lithologies. Increased flow rates along fractures would reduce ground-water residence time and potentially improve water quality. Subsurface flow diversion may cause the depletion of water in certain localized aquifers and potential loss of flow to springs that will be undermined.

Subsidence due to mining in the Blind Canyon Seam is expected to be similar to that which has been experienced at other mines in the East Mountain area. Mining in the area has been by both room-and-pillar and longwall methods, and both will be used in future mining. Surface cracks are common above mines on East Mountain, especially along faults and in shallow overburden areas. Subsidence is likely only over longwall panels, over room-and-pillar areas where second mining is done, and in surrounding areas within the expected angle-of-draw.

The predicted angle-of-draw is 15 degrees for most of the Mill Fork Lease, which is based on experience of PacifiCorp and other operators on East Mountain. The USFS feels the greatest potential for cracks in the CIA would be along the Joes Valley Fault because of the possibility of subsidence fractures propagating to the surface along existing fault fractures. Because of this, the USFS has stipulated a 22 degree angle-of-draw adjacent to the Joes Valley Fault. Based on the angle-of-draw calculations, there will be some subsidence outside the permit area, along the common boundary with the Genwal Mine; however, based on PacifiCorp's experience, subsidence will remain inside the permit boundary (Mill Fork Extension MRP p. 5-37).

---

## EAST MOUNTAIN AREA

---

Within the Genwal permit area, subsidence from mining in the Hiawatha Seam has been less than anticipated. Layout of the Genwal Mine has not allowed longwall-mining of large blocks (2000 Crandall Canyon Mine Annual Report), and therefore critical width - at which maximum subsidence occurs - has not been reached. Also, an overlying, competent 30-foot thick sandstone limits rubblelization and subsidence by acting as a structural beam that bridges the voids left by mining.

In the Mill Fork tract, the plan is to mine adjacent long-wall panels, which should result in critical width and maximum subsidence similar to that at other PacifiCorp mines at East and Trail Mountains. Mining in the Mill Fork tract has been planned so that subsidence will occur as a general lowering of the surface over broad areas, which will limit change or damage to the land surface, land uses, and renewable resources. Based on PacifiCorp's experience, the surface will stabilize in most areas after two years. Based on a total combined thickness 20 feet of coal removed, maximum predicted subsidence for the Mill Fork tract is 75 percent or 15 feet (Mill Fork Extension MRP R645-301-525, Mining Methods and Subsidence). Actual subsidence is anticipated to be less than the predicted maximum because of the sandstone layers above the coal. Subsidence of the ground surface over other PacifiCorp operations on East Mountain has typically been at or below the predicted amount, although in one area it exceeded the predicted displacement by 84 percent (2001 PacifiCorp Annual Report, p. 131).

Tension cracks occur along the edges of full-extraction areas under shallow overburden on canyon slopes. The Castlegate Sandstone yields to subsidence by fracturing, so fracturing and spalling from tension cracks occur at Castlegate outcrops. Where overburden is thick, the clay-rich strata yield by plastic deformation, reducing the impacts of subsidence at the surface for most of the area (2001 PacifiCorp Annual Report, p. 134). With the exception of cracks in the Castlegate Sandstone, cracks are expected to heal naturally over a period of 2 to 5 years (EA 1997, p. IV-2). Only limited and isolated surface cracks are reasonably foreseeable in other areas.

### GROUND WATER

The greatest mining-related potential for impacting ground-water resources in the CIA comes from dewatering and subsidence. Under the currently proposed mine layout for the Mill Fork Tract, mining will occur beneath numerous seeps and springs. Seventeen springs are being monitored within the Mill Fork Tract area, and another six in the adjacent area. (Mill Fork Tract MRP, Drawing MFS1830D). These are representative of water rights. In addition to the 200 to 400 gpm flowing from Little Bear Spring, the other sixteen springs had a combined average flow of 40 gpm during the 2001- 2002 baseline period, the largest average being 20 gpm from MF-213. Overburden thickness averages more than 1,000 feet beneath areas where springs are located. Diversion of spring flow is considered to be at overall low risk.

---

## EAST MOUNTAIN AREA

---

Changes in vegetation will have minimal impact on ground-water recharge because mining will disturb less than 150 acres of the 44,000-acre CIA. Probability of disturbance of phreatophytic vegetation, primarily cottonwood and some willow, is negligible.

The Cottonwood/Wilberg Mine Waste Rock Storage area is located below the coal resource on Quaternary sediment gravel that directly overlies the Masuk member of the Mancos Shale. Inasmuch as the Mancos Shale is considered a regional aquiclude, the storage facility presents a low risk for impacting ground-water resources.

Intercepted ground water is used in the mine underground, disposed of underground in sumps, or discharged to the surface. There are no developed wells in the lease tract that use ground water from the area. Ground water encountered in the Crandall Canyon mine has been determined to have mean residence times of 2,500 years to over 14,000 years. Except for the modern water at TW-10, water intercepted in the PacifiCorp mines has mean residence times of 1,000 to 12,000 years.

Water users have expressed concerns that water intercepted underground may be discharged into a watershed other than the one where the ground water was originally destined. Underground mining may result in some transbasinal diversions of intercepted ground water; however, water intercepted in the mines is typically isolated from springs, seeps, and streams, does not contribute to surface flows in the area, and is typically not connected to the hydrologic systems associated with water rights. The State Engineer has indicated that ground water intercepted in the mines and isolated from surface waters is not included in existing water rights, and a water-right cannot be filed until the water is discharged to the surface.

### *Dewatering*

Plate 2 delineates the CIA for current and projected mining in the East Mountain area. The CIA encompasses approximately 70,000 acres (109 miles<sup>2</sup>) centered around East Mountain: the area within the CIA that is above the base of the Blackhawk Formation is approximately 44,000 acres (69 miles<sup>2</sup>), the approximate area covered by coal leases, including South Crandall Canyon Coal Lease Tract is 33,000 acres (52 miles<sup>2</sup>), and mine workings have or will undermine roughly half of the leased areas.

Discharge occurs directly to perennial streams where channels intersect ground water within the Blackhawk Formation and Star Point Sandstone. Horse, Crandall, Little Bear, Mill Fork, Rilda, Deer, Cottonwood, Huntington, and Indian Creeks are the perennial streams in the CIA. All of these streams except Indian Creek intersect the lower Blackhawk Formation and Star Point Sandstone. A study conducted along Miller Creek in the adjacent Gentry Mountain area indicated streamflow substantially increases (from 8 to 115 gpm) as a result of discharge from the Blackhawk Formation and Star Point Sandstone (Cyprus-Plateau Mining Company, Star Point Mine PAP, pages 783-40). The results from the Miller Creek Study suggest perennial

**EAST MOUNTAIN AREA**

---

streams that traverse the Blackhawk Formation and Star Point Sandstone receive similar base-flow recharge; accordingly, total base-flow recharge to the eight perennial streams that cross the Blackhawk Formation and Star Point Sandstone in the CIA can be roughly estimated to be on the order of 100 to 1,000 gpm.

The volume of water that coal-mining operations within the CIA are withdrawing from the ground-water system, including evaporation from mine ventilation, is approximately 2,500 to 2,800 gpm.

Table CHIA-13A. Estimated Ground-water Discharge to Perennial Streams and from Mines. East Mountain CIA.

Discharge to Perennial Streams	<u>100 to 1,000</u> gpm
Discharge from Crandall Canyon, Deer Creek, and Cottonwood/Wilberg Mines	<u>2,500 to 2,800</u> gpm
Total	<u>2,600 to 3,800</u> gpm

Approximately 44,000 acres within the CIA are a potential recharge area for the strata above the coal seams (Plate 5). Using 20 inches as the average annual precipitation over this potential recharge area, the estimated total annual precipitation over the outcropping recharge area is 73,000 acre-feet.

Table CHIA-13B compares the number of springs from rock units overlying the coal seams with area of outcrop and estimated precipitation. Values for Total Precipitation on Outcrop are probably skewed because 20-inches of precipitation/year was used for all strata; although the amount of precipitation is not strictly related to elevation, this estimate of Precipitation on Outcrop is probably low for the Flagstaff and North Horn formations because these strata are at the highest elevations, and probably high for the Blackhawk Formation because this formation is at lower elevations. Overall greater precipitation at higher elevations is undoubtedly an important factor as to why the number of springs and discharge are so much greater in the Flagstaff and North Horn formations than in lower strata.

Springs that issue from the Star Point Sandstone (most notably Little Bear Spring that flows from the lower Star Point Sandstone and is not recharged from adjacent strata) and those that issue from alluvium are not accounted for in Table CHIA-13B. Little Bear Spring discharges 200 to 400 gpm, and the 8 monitored alluvial springs (of 120 total) add 190 gpm.

Flows have been measured at only about one-third of the known seeps and springs; however, monitored springs are those with the greatest and most consistent flow, so the flow

**EAST MOUNTAIN AREA**

from the unmeasured springs and seeps is a fraction of measured flow. Using 50 percent of the measured flow is a fair estimate of the flow at unmonitored seeps and springs, a rough estimate of ground-water discharge to seeps and springs in the CIA is 5,000 to 5,500 gpm

Table CHIA-13B. Precipitation and Springs for Areas Above the Blackhawk coal seams - East Mountain CIA.

Lithologic Unit	Outcrop Area	Total Precipitation on Outcrop (20-inches/year)	Seeps and Springs Identified	Seeps and Springs Monitored	Total Average Measured Discharge
	(acres)	(acre-feet)			
Undivided - Flagstaff Limestone, North Horn Fm.	17,600	29,000	260	108	2,655 gpm
Price River Fm.	9,400	16,000	127	34	109 gpm
Castlegate Sandstone	5,000	8,000	32	3	2.7 gpm
Blackhawk Formation	12,000	20,000	83	12	103 gpm
Totals	44,000	73,000	502	157	~2,900 gpm

Total ground-water discharge within the CIA is therefore estimated to be about 7,600 to 9,300 gpm, where 5,000 to 5,500 gpm of the total represents natural discharge to streams and springs and 2,600 to 3,800 gpm results from mining activities.

Inflow to the Deer Creek Mine increased in the late 1980's as mining progressed northward (Figure 1). The increased flow into the mine was attributed partially to better record keeping, but also to the increasing amount of sandstone being exposed in the mine roof and coal recovery in the trough of the Straight Canyon Syncline and near the Roans Canyon Fault Graben.

To access coal reserves for the Deer Creek Mine, PacifiCorp drove a rock tunnel across the Roans Canyon Fault Graben in 1989 and 1990. Prior to advancing the tunnels, a drilling and testing program identified two water-bearing fracture zones within the graben (HIS 1988). The operator minimized inflow during development of the rock tunnels by dewatering the zone prior to development and by pressure grouting the water-bearing zones during development. Predicted

---

## EAST MOUNTAIN AREA

---

potential inflow to the tunnels was as much as 500 gpm (HIS 1988). There are no data on what the actual inflow was from the tunnel construction, but mine discharge increased significantly during construction of the tunnels (Figure 1). When work was completed, inflow to the tunnels was 50 gpm (1990 PacifiCorp Annual Report).

Also in 1990, mining operations unexpectedly breached the Roans Canyon Fault Graben at two locations in the 4<sup>th</sup> North section. The first penetration was in January 1990 in the 1<sup>st</sup> Right entries, where several hundred gallons per minute entered through the mine roof. The next breach was in April when the 2<sup>nd</sup> Right entries intercepted a small sympathetic fault; the mine operator estimated peak discharge to be as much as 5,000 gpm initially, but flow had declined to 125 gpm by March 1991 (Mayo and Associates 1997b; 1990 PacifiCorp Annual Report).

Mining in the Mill Fork Extension will not cross any major structures such as the Roans Canyon Fault, so the only expected inflows are drippers from channel-sandstones in the roof. These flows may increase when operations reach the trough of the Crandall Canyon Syncline. Planned mining operations should remain far enough from the Joes Valley Fault zone that there will be no significant increase in flows.

Following the cessation of mining, the discharge of ground water to streams, the Huntington Power Plant and the atmosphere will cease and workings will flood. Complete flooding of the abandoned mine workings will probably never occur because hydraulic head will increase as the mines flood until it reaches equilibrium with water within the surrounding rock. Mine flooding will conceivably recharge storage and re-establish the natural ground-water conduit system that was operational prior to mining, and restore stream baseflow that might have been lost.

## SURFACE WATER

Increased discharge, especially from disturbed areas, could alter flow volumes, water quality, and runoff and flood patterns in creeks. Mining in the Mill Fork Extension is not expected to increase discharge from the Deer Creek Mine.

Subsidence could affect the character of drainages within lease tracts by altering the natural slope of the channel; however, large-scale impacts are unlikely because of the thick overburden, which is projected to be from 600 to 2,600 feet thick, between the mine operations and the drainages.

Headwaters of Crandall, Rilda, and Mill Fork creeks are in the Mill Fork tract, but full extraction mining is not planned under any perennial reaches of these streams. Thinnest overburden - 600 feet - is projected to be in the Right Fork of Mill Fork Canyon above the 8<sup>th</sup> North Mains in the Blind Canyon Seam. Where full extraction of both seams is planned under this drainage, minimum overburden thickness will be 800 feet for a small area, but the

---

EAST MOUNTAIN AREA

---

overburden thickens rapidly upstream because of the steep gradient. Minimum overburden thickness in Rilda Canyon will be 1,200 feet, above the access tunnels; the minimum will be 1,800 to 2,000 over longwall panels, and 2,200 feet over areas where both seams are mined. Only a small area of the Left Fork of Crandall Canyon will be involved, and minimum thickness is projected to be 800 to 1,000 feet. Mining under perennial drainages was monitored at the Skyline Mine (Sidle 1995), where single-seam longwall mining under drainages where 600 or more feet of overburden is present has not produced permanent adverse effects at the surface. Surface cracks are possible above the areas subsided, but because the thickness of overburden present in the CIA, conductivity between surface cracks and the rubbelized zone is not likely.

The potential for cracks to divert water underground is limited by the self-healing characteristics of the formations, which consist of interbedded claystone, siltstone, and sandstone that are rich in montmorillonite clays. Fractures at the surface are prone to heal rapidly because of the expanding nature of these clays. Material from the Blackhawk Formation was examined by X-ray diffraction and found to contain up to 58 percent montmorillonite clays. These clays absorb water and their volume can expand as much as 50 percent even when they are associated with other soil and rock materials.

The cumulative impacts associated within the CIA has been summarized by individually discussing impacts associated with the Crandall Canyon Mine, Huntington #4 Mine, Deer Creek Mine, Cottonwood/Wilberg Mine, Des-Bee-Dove Mine, and Mill Fork Extension. Creeks and drainage areas discussed are shown on Plate 4, Surface Water Drainage Map.

#### *Cottonwood/Wilberg Mine*

The Cottonwood/Wilberg Mine is located in Grimes Wash. Grimes Wash drainage quality is greatly affected by the influx of the Right Fork. The Right Fork originates in the North Horn Formation (interbedded shale, siltstones, and sandstones), which is abundant with calcareous material. As a result, the Right Fork contributes a relatively high amount of suspended solids to the Grimes Wash drainage.

As reported in 1985, the TDS level increased slightly at the location below the mine. Two possible factors stated for the rise were Cottonwood/Wilberg Mine discharge and Mancos Shale seeps. Due to the fact that no water was discharged from the mine during 1985 through 1988 (one exception in August 1986), seeps emanating from the Mancos Shale probably have the greatest influence upon the level. Periodic sampling during 1986 and early 1987 confirmed the seeps' contribution to the TDS level. The average for the four samples collected was 1,188 mg/l, representing a nearly 3.3 fold increase over the historical averages for the Right and Left Forks. (Annual Hydrologic Monitoring Report for 1988, pg. 24).

All surface facilities are treated by sediment controls and as such, potential impacts from sediments generated from disturbed areas are minimized.

---

EAST MOUNTAIN AREA

---

Waste Rock Disposal Site

Waste rock generated from the Des-Bee-Dove and Cottonwood/Wilberg Coal Mines is disposed of in a series of seven interconnected storage cells at a waste rock disposal site (Plate 3). The waste rock storage site is at an elevation of 6,800 feet. Annual precipitation is approximately 14 inches, and the vegetation surrounding the waste rock storage area is the pinyon-juniper community type.

Each complete waste rock containment structure consists of over four feet of shot and crushed coal, sandstone, and mudstone rock. The anticipated waste rock was approximately 70 percent sandstone, 20 percent interbedded mudstone and siltstone, and 10 percent bony coal. Roof and floor materials are sandy loam to loamy sand in nature. Analyses of roof and floor material indicate high Sodium Adsorption Ratios (SAR) (Mean = 17.36, Standard Deviation = 25.14), and movement of sodic materials is typically associated with hydroscopic rise and leaching processes. High SAR in the waste rock storage area should not be a concern to water quality because drainage from the storage site should be minor.

Analyses from Drill Hole EM-23C, indicates low pH (3.3, 2.9, 3.7) within the mudstones and siltstones directly below the Hiawatha Coal Seam. Analyses of roof and floor samples indicate that Fe<sub>2</sub> in pyrite and marcasite averages 8.15% (Standard Deviation = 10.82%). However, the colluvium and Mancos Shale that underlie the waste rock storage area are calcareous and should be sufficient to neutralize any acidic seepage from within the waste rock storage site.

Most water associated with the Cottonwood/Wilberg Waste Rock Storage Area will evaporate, but some will inevitably percolate through the storage cells and underlying colluvium deposits. Drainage from the waste rock storage site should have little down-gradient effect: it will eventually contact the Mancos Shale, where waters have naturally high TDS, mainly sodium, chloride, and sulfate ions.

*Deer Creek Mine*

Referencing Table 3D, it is apparent that the quality of Deer Creek runoff degrades from the upper to lower sampling points. The quality of the lower point is dominated by chloride, sulfate and sodium. In addition to the mine and sedimentation pond discharges, quality is affected by the Mancos Shale at the lower end of the mine site.

Surface water originating from undisturbed lands upstream of the facilities area is controlled and diverted around the operation. Surface drainage facilities are designed to safely control water and sediment runoff from all disturbed areas. Storm runoff from 25 acres of disturbed land within the mine facilities area is collected in a system of open ditches, bermed

**EAST MOUNTAIN AREA**

roadways and culverts, then temporarily detained in the Deer Creek Mine sedimentation pond and released to Deer Creek at UPDES discharge point UT0023604-001. The sedimentation pond is designed to detain the 10-year, 24-hour storm event. When the 10-year, 24-hour design event is exceeded, sediment detention times are reduced, leading to a slightly higher sediment load in Deer Creek. Surface-water impacts associated with the Deer Creek Mine operations have been minimal. The Deer Creek sedimentation pond discharge exceeded UPDES limits for TDS in May 1990 during an emergency discharge from the mine; otherwise it has been within limits.

Table CHIA-13D. Deer Creek Water Quality (1984 – 2002).

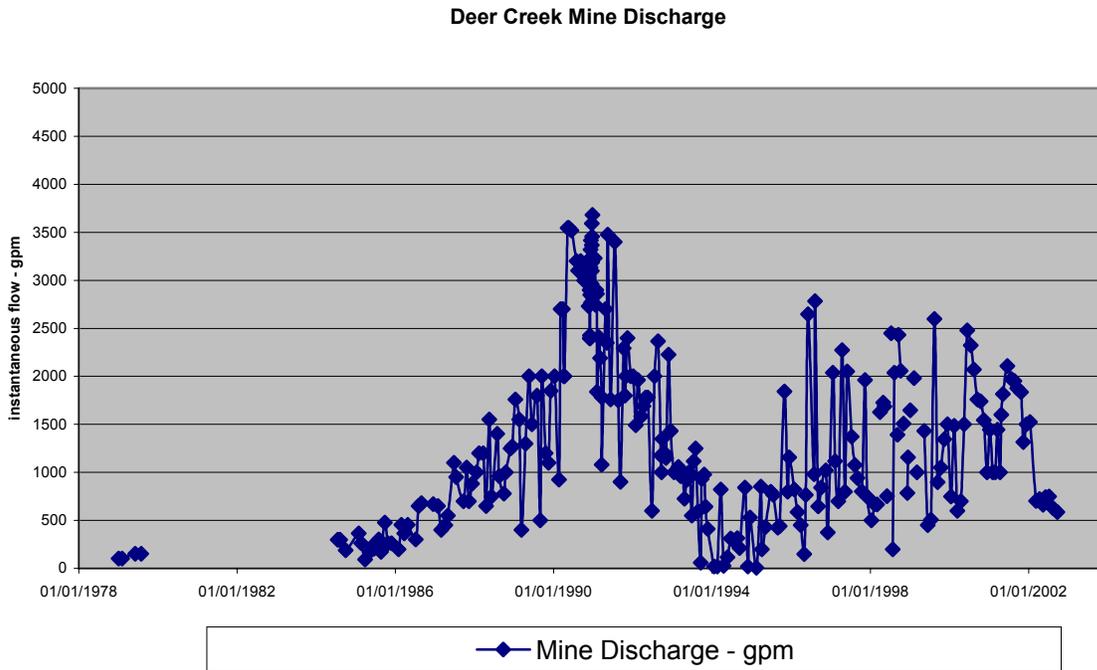
		<u>Calcium</u>	<u>Chloride</u>	<u>Conductivity</u>	<u>Magnesium</u>	<u>Sodium</u>	<u>Sulfate</u>	<u>TDS</u>	<u>TSS</u>
Above Mine DCR01	Max	53	176	1,140	33	45	255	897	162
	Mean	44	17	566	28	34	61	342	21
Mine Discharge (UPDES 002)	Max	150	1,460	1,380	90	150	520	3,300	2,780
	Mean	90	40	850	50	30	200	630	70
At Permit Boundary DCR04	Max	96	1,093	7,000	56	728	560	2,340	547
	Mean	66	85	1,059	42	113	146	590	31

Discharges from the Deer Creek Mine have been reported as early as 1978, and discharge has been almost continuous since 1980 (Figure 1). Discharge has averaged 1,400 gpm, and the maximum reported discharge was 3,700 gpm, in December 1990. The minimum was 6 gpm, in February 1995. Prior to December 1990, all discharge was piped to the Huntington Power Plant and none entered the natural drainages. A temporary discharge permit was issued in November 1990 because of high inflows into the mine at the Roans Fault crossing, and 1990 and 1991 was a period of consistently high discharge rates. Currently, the power plant is not accepting water from the mine (Dennis Oakley, personal communication, January 7, 2003). Water is now diverted to abandoned mine sections and used underground for mine operations, and only excess water is discharged directly to Deer Creek at UPDES discharge point UT0023604-002: excess water from the Mill Fork Extension will also be discharged through this point.

Reclamation of the drainage at the Deer Creek Mine will consist of removing the temporary drainage system, diversion and sedimentation pond. Permanent channels will be constructed over the fill and into a splash basin. All channels are designed to pass the 100-year, 24-hour runoff peak flow. The proposed surface-water reclamation plan will have negligible impact on water quantity or quality of Deer Creek and its tributaries.

EAST MOUNTAIN AREA

---



**Figure 3 - Discharge of Deer Creek Mine**

*Des-Bee-Dove Mine*

The Des-Bee-Dove Mine complex ceased operations in February 1987 for economic reasons. The mines were dry and water for mine operations was piped from springs higher on East Mountain.

Reclamation began in 1999, and Phase I reclamation is scheduled for completion in 2003. All surface drainage is treated by a sedimentation pond and released to an ephemeral wash. Because there are no active operations other than reclamation, and because all surface water is treated by a sedimentation pond, the effects of the Des-Bee-Dove Mine operations on the hydrologic balance are negligible.

*Huntington #4 Mine*

The old workings of the Huntington #4 Mine underlie approximately 1,300 acres in Mill Fork and Little Bear Canyons. There were 12 acres of surface disturbance in Mill Fork Canyon. The mine is reclaimed and bond has been released. There is no anticipated impact to Mill Creek from the Huntington #4 Mine due to the lack of potential sources.

---

EAST MOUNTAIN AREA

---

*Crandall Canyon Mine*

This mine is located in Crandall Canyon. The U.S. Geological Survey established a gauging station at the mouth of Crandall Canyon in 1978. Flow data collected at the gauging station are not complete for the winter in most years, due presumably to the gauge or flume freezing. However, the limited data indicate that most of the flow of Crandall Canyon Creek occurs in the period of May through July. For the periods when flows were recorded, maximum flow was 39,000 gpm, the average was 2,400 gpm, and there were short periods when there was no flow. Assuming an average of 0.5 gpm for the period when records were missing, the average annual flow for the six-year period of data would be approximately 2,800 acre-feet.

Surface water quality data collected from Crandall Canyon Creek by Genwal Coal Company since 1985 indicate that the dominant ions are calcium and bicarbonate. TDS concentrations in the stream have varied from 180 to 286 mg/L, with lower concentrations normally occurring during the high flow season.

Suspended sediments are the main concern for water quality deterioration downstream from the minesite. Since 1985, TSS in Crandall Canyon Creek has varied from 0.5 to 208.0 mg/L. Highest suspended solids concentrations generally occur during periods of highest flow. A portion of suspended sediments can be attributed to surface disturbances such as the roads and mine pad area. Impacts associated with mining in Crandall Canyon are minimized by a sedimentation pond and other sediment surface control methods.

*Mill Fork Extension*

Headwaters of Rilda, Mill Fork, and Crandall Creeks are in the Mill Fork tract, but full extraction mining is not planned under the main channels of these streams (Mill Fork Extension MRP p. 5-23). The lease impinges on the perennial reach of Crandall Canyon, but no mining is planned for this area.

The short, steep tributaries of Indian Creek that are on the west side of the tract could be influenced by surface subsidence. Cracks on the surface along the Joes Valley Fault trace might divert water from these tributaries, and such loss of water could reduce the flow that supports the streamflow and wetlands in Joes Valley. Under the proposed mine plan, active workings would extend within approximately 500 feet of the Joes Valley Fault at the mine level; however, no full extraction mining is to be done in the areas nearest the fault, as determined by the 22 degree angle-of-draw stipulated by the USFS. Projections of subsidence effects indicate there should be no subsidence or tension cracking involving the Joes Valley Fault zone, so the potential for adverse impacts to the tributaries that cross this fault is very small.

**EAST MOUNTAIN AREA**

---

**AQUATIC HABITAT**

Intermittent channels provide aquatic habitat when water is present, including spring spawning habitat for cutthroat trout and sculpins. The intermittent streams probably contribute invertebrates to Huntington Creek, an important sports fishery in the region. Aquatic habitat could be lost or degraded if the character or quantity of streams and streamflows change as a result of subsidence. Only intermittent headwaters will be undermined and subsided; no perennial reaches will be undermined or subsided by planned mine operations in the CIA.

Because flows in these small streams decrease in late summer and early fall, their primary use by fish will be as spawning and rearing streams. If present at all, adult fish are likely present in headwater areas only during the spring reproductive period.

Gravels suitable for spawning are patchy in lower-gradient reaches of the tributaries to Huntington Creek. Because successful spawning requires the presence of clean, well-oxygenated spawning gravels, the USFS considers it a high priority to protect these channels from excessive erosion and sedimentation (EA 1997). Studies in Burnout Canyon (Sidel 1995) are inconclusive but suggest that subsidence may cause fragmentation of riffles into cascades, so spawning habitat in low-gradient riffles could become inaccessible due to step-like fragmentation of the longitudinal profile of the stream: drops of twelve inches or more are considered barriers for inland trout species. It is conceivable that subsidence could shift the stream substrate enough to present barriers to the movement of spawning fish; however, none of the lower reaches of streams will be subsided in the Mill Fork CIA.

Crandall Creek has a year-round population of adult cutthroat trout. Prior to expansion of the Genwal Mine pad, the fish were in the beaver ponds immediately adjacent to the mine portal. Expansion of the pad and culverting of the stream required mitigation to protect this population: the mitigation is described in Appendix 3-12 of the Crandall Canyon Mine MRP.

Water withdrawals within the Colorado River Basin impact habitats of four endangered fish species in the Colorado River and its tributaries: the Colorado squawfish, razorback sucker, bonytail chub, and humpback chub. Annual water withdrawals in excess of 75 acre-feet could trigger consultation requirements with the US Fish & Wildlife Service. The mines in the CIA discharge more water than they consume.

**V. IDENTIFY RELEVANT STANDARDS AGAINST WHICH PREDICTED IMPACTS CAN BE COMPARED**

The UPDES permits for the PacifiCorp and Genwal Mines provide some standards for water quality in the area.

---

EAST MOUNTAIN AREA

---

Utah water quality standards exist for numerous parameters other than those discussed below, but at this time there is no evidence to indicate nor reason to believe that those parameters are of concern in the East Mountain CIA. However, additional parameters recommended for routine monitoring in UDOGM directive Tech-004 are included in the water-monitoring plans of the PacifiCorp and Crandall Canyon Mine operations.

*Flow:* There is no standard for flow in the Utah water quality standards. The UPDES permits for the PacifiCorp and Crandall Canyon Mines contain no limit on flow. Discharge is to be measured monthly, and the duration of intermittent discharge is to be reported along with flow. Characteristics such as stream morphology, vertebrate and invertebrate populations, and water chemistry can be affected by changes in flow and therefore can provide an indirect standard for flow.

*Oil and Grease:* There is no State water quality standard for oil and grease, but the limit in the PacifiCorp and Crandall Canyon Mines UPDES permits is 10 mg/L, which is typical of UPDES permits for coal mines in the Wasatch Plateau and Book Cliffs. One grab-sample a month is required to measure oil and grease at the Crandall Canyon Mine. Oil and grease are not analyzed routinely at the PacifiCorp Mines, but any observation of visual sheen requires a sample be taken immediately.

A 10 mg/L oil and grease limit does not protect fish and benthic organisms from soluble oils such as those used in longwall hydraulic systems, and UDWR has recommended soluble oils be limited to 1 mg/L (Darrell H. Nish, Acting Director UDWR, letter dated April 17, 1989 to Dianne R. Nielsen, Director UDOGM).

*Total Dissolved Solids (TDS) concentrations:* TDS is commonly used to indicate general water quality with respect to inorganic constituents. There is no state water quality standard for TDS for Classes 1, 2, and 3, but 1,200 mg/L is the limit for agricultural use (Class 4).

The Crandall Canyon Mine UPDES permit allows a daily maximum concentration of 723 mg/L TDS, to be determined by one grab sample per month. TDS allowances vary for the PacifiCorp mines:

**EAST MOUNTAIN AREA**

Table CHIA-14

Mine		Maximum Loading lbs/day	Quantity or Concentration Average	Quantity or Concentration Daily Max.
Des-Bee-Dove		2,000		Report Daily Max.
Deer Creek 001	001	2,000	Report 30-day Average	5,000 mg/L
	002		800 mg/L Quarter Average	1,000 mg/L
Trail Mountain 001	001	2,000		5,000 mg/L
	002			1,200 mg/L
Cottonwood/Wilberg	001	2,000		
	002, 003, and 005	2,000 (Combined)		
	004	2,000		

*pH*: Allowable pH ranges are 6.5 to 9.0 under State water quality standards for all Classes, and also under the UPDES permits.

*Total Suspended Solids (TSS) and Settleable Solids*: the PacifiCorp and Crandall Canyon Mine UPDES permits have the following allowable limits on TSS: 30-day average, 25 mg/L; 7-day average, 35 mg/L; daily maximum, 70 mg/L. TSS is to be determined by a monthly grab sample.

There is no State water quality standard for solids in the water, but an increase in turbidity is limited to 10 NTU for Class 2A, 2B, 3A, and 3B waters and to 15 NTU for Class 3C and 3D waters.

Under the current UPDES permits, all samples collected during storm water discharge events are to be analyzed for settleable solids. Samples collected from increased discharge, overflow, or bypass that is the result of precipitation that does not exceed the 10-year, 24-hour precipitation event may comply with a settleable solids standard of 0.5 ml/L daily maximum rather than the TSS standard, although TSS and the other UPDES parameters are still to be determined. If the increased discharge, overflow, or bypass is the result of precipitation that exceeds the 10-year, 24-hour precipitation event, then neither the TSS nor settleable solids standard applies.

---

EAST MOUNTAIN AREA

---

*Iron and Manganese:* UPDES limits on daily maximum total iron, determined by a monthly grab sample, are:

State water quality standards (UDWQ 1994) allow a maximum of 1,000 µg/L (1 mg/L) dissolved iron in Class 3A, 3B, 3C, and 3D waters, with no standard for Class 1, 2, and 4 waters.

Monitoring of total manganese is required by SMCRA and the Utah Coal Mining rules, but there is no UPDES or Utah water quality standard for either total or dissolved manganese.

Crandall Canyon Mine	1.3 mg/L
Trail Mountain Mine	1.4 mg/L
Deer Creek Mine	1.0 mg/L
Cottonwood/Wilberg Mine	1.8 mg/L at 001 and 002 1.0 mg/L at 003, 004, and 005
Des-Bee-Dove Mine	1.0 mg/L

*Macroinvertebrates:* Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Baseline studies of invertebrates (Lines and Plantz, 1981; USGS, 1980, 1981, and 1982; and Price and Plantz, 1987) provide standards against which actual conditions in Huntington, Crandall, and Cottonwood Creeks can be evaluated if desired.

*Whole effluent testing - chronic toxicity:* Requirements for biological testing with Ceriodaphnia and fathead minnows have been recently added to the UPDES permits for outfall 002 at the Crandall Canyon Mine and outfall 001 at the Cottonwood/Wilberg Mine.

## MATERIAL DAMAGE

Material damage to the hydrologic balance would possibly manifest itself as an economic loss to the current and potential water users, would result in quantifiable reduction of the capability of an area to support fish and wildlife communities, or would cause other quantifiable adverse change to the hydrologic balance outside the permit area. The basis for determining material damage may differ from site-to-site within the CIA according to specific site conditions. Surface-water and ground-water concerns have been identified for CHIA evaluation.

The Division of Oil, Gas and Mining received comments from NEWUA and Huntington-Cleveland Irrigation Company, plus from several individuals who receive water from

---

**EAST MOUNTAIN AREA**

---

these companies regarding permitting of the Mill Fork Extension. The main concern was that flows from streams and springs, in particular Little Bear Spring, would be diminished by mining operations in the Mill Fork Extension.

*Parameters for surface-water quantity and quality*

The potential material-damage concerns this CHIA focuses on are changes of surface flow rates and chemical composition that would physically affect the off-permit stream channel systems as they presently function and affect aquatic and wildlife communities. There is no farming in the CIA; however, there is livestock production. Therefore, water-quality and quantity criteria are intended to identify changes in the present discharge regime that might be indicators of economic loss to the water users and grazing-right owners, of significant alteration to the channel size or gradient, or of loss of capacity to support existing fish and wildlife communities within the CIA. In order to assess the potential for material-damage to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site: low-flow discharge rate, TDS, and sediment load.

Low-Flow Discharge Rate

Measurements provided by mine operators are generally of instantaneous flow and provide some indication of long-term trends, but are probably no more accurate either individually or as a whole than the "poor" USGS measurements. In the Wasatch Plateau, Waddell and others (1981) found that correlating three years of low-flow records (September) at stream sites against corresponding records from long-term monitoring sites would allow the development of a relationship that could be used to estimate future low-flow volumes at the stream sites within a standard deviation of approximately 20 %. Ten years of measurements reduced the standard deviation to 16 - 17 % and 15 years of data reduced it to about 15 %. This relationship indicates that a change in low-flow rates of less than 15 to 20 % probably would not be detectable. A 20 % decrease in the low-flow rate will provide a threshold indicator that decreased flows are persisting and that an evaluation for material damage is needed. However, because flow in many streams is intermittent, material damage due to loss of flow is very unlikely, and the intermittent nature of the flow will also make any such loss almost impossible to detect. Any such apparent change in discharge would need to be correlated against precipitation and a drought index such as the PHDI.

Monitoring of mine-water discharge rates will provide a means to evaluate effects of the mine discharge on the receiving streams. The potential for material damage by mine discharge water is tied to the effect of that discharge on the flow in the receiving streams, and that effect will be most pronounced during low-flow. Water from disturbed areas will be monitored at the discharge from the sedimentation ponds.

---

EAST MOUNTAIN AREA

---

Total Dissolved Solids (TDS)

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. Wildlife and livestock use is the designated post-mining land use for the CIA, so established dissolved solids tolerance levels for wildlife and livestock have been adopted as the thresholds beyond which material damage may occur. The state standard for TDS for irrigation of crops and stockwatering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L in springs, UPDES discharges, or receiving streams, it will be an indication that evaluation for potential material damage is needed.

Sediment Load

Sediment is a common constituent of ephemeral stream flow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Sediment load measurement error is, at a minimum, the same as the flow measurement error because sediment load is directly dependent on flow and in practice cannot be measured more accurately than the flow.

TSS is the indicator parameter initially chosen for evaluating the sediment hazard to stream-channel stability and irrigation. Threshold values have initially been set as the greater of 1 standard error above the baseline mean TSS value or 120 % of the baseline mean TSS value (by analogy with the low-flow discharge rate measurement accuracy and assuming that the error in TSS will contribute equally to the error in flow when determining mean sediment load). If TSS concentrations persistently exceed these threshold values it will be an indication that evaluation for material damage from sediment load in the streams might be needed.

Parameters for ground-water quantity and quality

The potential material-damage concerns this of CHIA are intended to limit changes in the quantity and chemical composition of water from ground-water sources to magnitudes that:

- Will not cause economic loss to existing or potential agricultural and livestock enterprises;
- Will not degrade domestic supplies;
- Would not cause structural damage to aquifers; and
- Will maintain adequate capacity for existing fish and wildlife communities.

---

**EAST MOUNTAIN AREA**

---

To assess the potential for material damage to these elements of the ground-water hydrologic system, the following indicator parameters were selected for evaluation: seasonal flow from springs and TDS concentration in spring and mine-discharge water.

Ground-water concerns will be monitored at numerous springs, wells, and UPDES discharge points. Locations are identified on Plate 6. If UDOGM finds that inflow to the mine is significant or persistent, UDOGM can require monitoring of mine inflow.

Seasonal flow from springs

Maintain potentiometric heads that sustain average spring discharge rates, on a seasonal basis, equal or greater than 80 % of the mean seasonal baseline discharge, or in other words baseline minus 20 % probable measurement error. The 20 % measurement error is based on analogy with the accuracy of measuring low-flow surface discharge rates. A 20 % decrease in flows, determined on a seasonal basis, will indicate that decreased flows are probably persisting and that an evaluation for material damage is needed.

TDS concentration

The concentration of total dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks the water passes through. Ground-water quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock, and those are the designated postmining users most likely to be impacted. There is no water quality standard for TDS for aquatic wildlife. The state standard for TDS for irrigation of crops and stockwatering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L it will be an indication that evaluation for material damage is needed.

**VI. ESTIMATE PROBABLE FUTURE IMPACTS OF MINING ACTIVITY WITH RESPECT TO THE PARAMETERS IDENTIFIED IN V.**

**GROUND WATER**

Dewatering and subsidence related to mining have the greatest potential for impacting ground-water resources in the CIA.

---

EAST MOUNTAIN AREA

---

*Dewatering*

Underground mining removes the support to overlying rock, causing caving and fracturing of overlying strata. In areas where fracturing is extensive, subsidence induced caving and fracturing can create conduits that allow ground water to flow into the mine. Dewatering caused by fracturing may decrease ground-water storage. Ground water in storage is not a major recharge source to springs. Fracturing of overlying strata will only intercept some of the deep ground-water storage. These areas will eventually drain and dry up because most of the beds have low hydrologic conductivities. In the CIA, it is unlikely that fractures will reach shallower perched aquifers that supply springs because of the thickness of the overlying strata over most areas to be mined is well over 600 feet. Water discharged downstream from the mines is at times of better quality than natural spring flow or base flow.

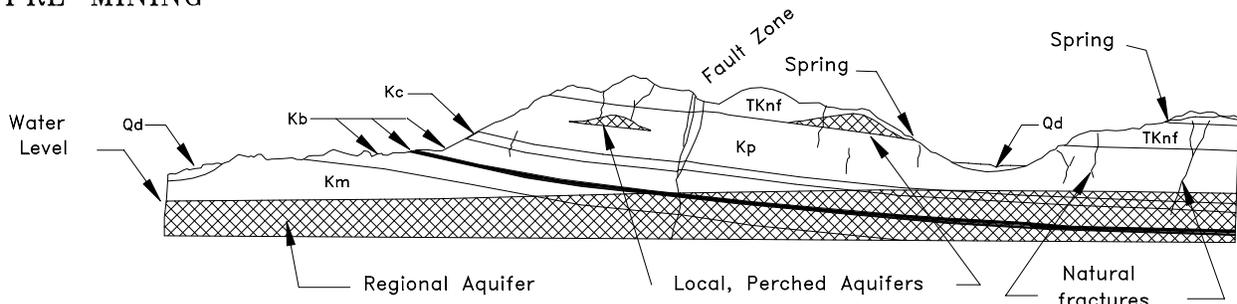
Total ground-water storage above the Blackhawk coal seams in the Mill Fork Tract can be estimated by assuming an area of 5,544 acres and a large storage coefficient of 0.10. Over much of the Mill Fork Lease Tract, cover above the coal seams reaches 2,600, so 1,000 feet is a reasonable estimate of potentially saturated thickness. Using these estimates as input, total ground-water storage above possible Mill Fork Extension workings could be as much as 554,400 acre-feet.

Annual average ground-water recharge for the 52 miles<sup>2</sup> above the PacifiCorp and Crandall Canyon Mines permit areas and the South Crandall Canyon Coal Lease Tract is roughly estimated to be 5,000 acre-feet, using 9 percent as the average infiltration factor and 20 inches as the average precipitation. Because of hydrologic isolation between the Blackhawk Formation and the surface, neither an increase in recharge rates nor a decrease in discharge rates at the surface is a probable consequence of dewatering deeper strata. A notable or measurable increase in recharge is also unlikely because recharge is generally available only for a few months during spring snowmelt and for very brief periods during summer thundershowers. During these seasonal, relatively short events the soils reach saturation quickly and reject most available water.

The Blackhawk Formation is probably saturated in most areas (Waddell and others, 1986, p. 41) and the Mill Fork Extension might be expected to produce water at rates similar to those observed in the Crandall Canyon Mine and the other PacifiCorp Mines. Most water entering mines comes from ground water stored in the overlying strata after fracturing of the rock immediately above the mine. Due to the great amount of strata between the Mill Fork Extension and springs on the surface, the springs or their recharge sources are not expected to be affected. The mobility and expanding characteristics of clays, shales and mudstones in the overlying strata should also help seal conduits created by fracturing (Figure 5).

EAST MOUNTAIN AREA

PRE-MINING



POST-MINING

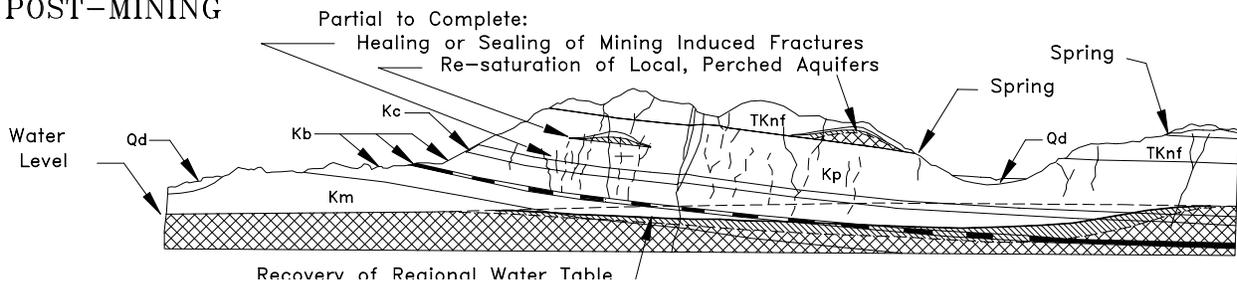


Figure 5. A diagrammatic cross-section of the Wasatch Plateau showing the relationship between mining, geologic strata and ground water before and after mining.

*Subsidence*

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow.

Potential changes include decreased flow through existing fractures that close, increased flow rates along existing fractures that open further, and the diverting of ground-water flow along new fractures or within newly accessible permeable lithologies. Subsurface flow diversion may cause the depletion of water in local aquifers and loss of flow to springs that are undermined.

A 22-degree angle-of-draw along the west side of the Mill Fork Extension should be more than adequate to avoid interaction between mine-induced subsidence and the fractures of

---

EAST MOUNTAIN AREA

---

the Joes Valley Fault system.

The Castlegate Sandstone and thick overburden are responsible for minimizing surface subsidence over mines in the CIA. It is anticipated that similar thicknesses of the same formations over the Mill Fork Extension will also prevent subsidence. Annual reports for the PacifiCorp Mines indicate surface subsidence over current permit areas is as much as 75 percent of the thickness of the extracted coal. Under much of the Mill Fork Extension, mining will be done in two seams, with a combined thickness of up to 20 feet removed. Thickness of strata above the Mill Fork Extension ranges from 600 feet to 2,600 feet.

## SURFACE WATER

Changes in flow volume and in water quality have the greatest potential for impacting water resources in the CIA. Sites that have been or are currently being used to monitor surface and ground water are shown on Plate 1.

### *Water Quality*

Uncontrolled runoff from the disturbed lands and waste piles could increase sediment concentrations and alter the distribution and concentration of dissolved solids in the receiving streams. Sedimentation controls are already in place for receiving streams at the Crandall Canyon and PacifiCorp mines. There will be no additional surface disturbance with the Mill Fork Extension.

Monitoring of ephemeral and perennial flows will continue in the major perennial and ephemeral drainages tributary to Huntington Creek. Indian Creek, a perennial tributary to Cottonwood Creek, will also continue to be monitored. Discharges directly from mines and from sedimentation ponds will be monitored when they occur.

If it becomes necessary to discharge water from the Mill Fork Extension, the water will discharge into Deer Creek at the existing UPDES discharge point and will be subject to monthly monitoring stipulated by a UPDES permit. In addition, Deer Creek is monitored above and below the mine discharge and the sedimentation pond, which controls sedimentation from the mine disturbed area.

### *CIA Sediment Control*

Sedimentation controls are already in place at the Crandall Canyon Mine and PacifiCorp mines. The Helco and Huntington #4 mines have been reclaimed and are no longer under reclamation bond. The Des-Bee-Dove mine is being reclaimed, but the sedimentation pond is still in place and the permitted area is bonded. Portions of the Cottonwood/Wilberg Mine and Deer Creek Mine permit areas have been reclaimed, and Phase I bond release has been approved.

---

**EAST MOUNTAIN AREA**

---

*Water Quantity*

If it becomes necessary to discharge water from the Mill Fork Extension, the water will discharge into the Deer Creek drainage. Discharged water will be subject to monthly monitoring stipulated by a UPDES permit, and flow volumes will also be measured below the discharge point, at the Deer Creek Mine disturbed area boundary.

Upon termination of mining operations, discharge will be discontinued and the mines will begin to flood. There will be a reduction in surface flow because of the loss of the mine discharge. There is little or no baseflow to the intermittent streams, and surface flow will probably be unaffected by a return to pre-mining conditions as the mines flood. The time required for mine flooding will depend not only on the rate of water inflow but also on the amount of caving and the void space remaining after caving. Complete flooding of the mines may never occur because flow out of the mines through the roof, floor, and ribs and into the surrounding rock will increase as flooding increases the hydraulic head within the abandoned workings.

It is anticipated that discharge of water from the Mill Fork Extension mine operations will be similar what has been observed or predicted at the Deer Creek Mine. Upon termination of mining operations, workings will probably flood to some extent, but because the formations slope back away from the mine portals there will be no gravity discharge from the mine.

It is anticipated that no acid or toxic mineral contamination will take place during or anytime after mining. Soils and bedrock surrounding the coal contain buffering compounds of calcium carbonates and bicarbonates. All rock and coal waste having a potential of acid or toxic forming materials will be buried at least four feet deep at the waste rock disposal site. All disturbed area runoff will be contained, monitored, and treated if required before discharge to ensure water quality standards are met.

**ALLUVIAL VALLEY FLOORS**

There are no alluvial valley floors within the CIA.

**VII. ASSESS PROBABLE MATERIAL DAMAGE**

**FIRST FIVE YEAR PERMIT TERM – Mill Fork Extension**

Planned operational monitoring will document any measurable changes in the surface- and ground-water systems. Surface disturbances and UPDES permitted discharges are not

---

**EAST MOUNTAIN AREA**

---

expected to degrade surface- or ground-water quality. There is no AVF to be impacted. Sediment control measures should continue to effectively prevent diminution of water quality in the receiving drainages.

The Mill Fork Extension is expected to have water inflow similar to that in the existing workings under East Mountain. Overburden thickness of 600 to 2,600 feet will minimize surface impacts of subsidence. No adverse impacts to streams or springs are anticipated from subsidence.

#### **FUTURE MINING**

Increased rates of dewatering may in the future result in depletion of ground-water storage in some beds above the coal seams. Upon cessation of mining, ventilation losses and mine water discharge, if there has been any, will be discontinued. Ground-water conditions similar to those that existed before mining will probably be established as the mine workings flood.

Drainage from surface disturbance due to coal mining and reclamation operations will be managed through appropriate sediment controls. Waste rock storage areas will be adequately covered with topsoil and all disturbed areas will be stabilized and revegetated to prevent surface water contamination.

#### **VIII. STATEMENT OF FINDINGS**

The Utah Division of Oil, Gas and Mining finds that the proposed coal mining and reclamation operation in the Mill Fork Extension of the Deer Creek Mine has been designed to prevent material damage to the hydrologic balance outside the permit area. No evidence of material damage from actual mining operations in the CIA has been found. No probability of material damage from other anticipated mining operations in the CIA has been found.

---

EAST MOUNTAIN AREA

---

**REFERENCES**

Crandall Canyon Mine MRP

Cronquist, A., Holmgren, A. H. Holmgren, N. H., and Reveal, J. L., 1972. Intermountain Flora, Volume I. Hafner Publishing Company.

Cyprus-Plateau Mining Company, Star Point Mine PAP.

Danielson, T. W., Re Millard, M. D., and Fuller, R. H., 1981. Hydrology of the Coal-Resources Areas in the Upper Drainages of Huntington and Cottonwood Creeks, Central Utah: U.S. Geological Survey, Water-Resources Investigations Report 81-539.

Danielson, T. W., and Sylla, D. A., 1983, Hydrology of Coal-Resource Areas in Southern Wasatch Plateau, Central Utah: USGS Water-Resource Investigations Report 82-4009.

Crandall Canyon Mine 2000 Annual Report, 2001, Genwal Coal Company.

Davis, F. D. and Doelling, H. H., 1977, Coal drilling at Trail Mountain, North Horn Mountain, and Johns Peak areas, Wasatch Plateau, Utah. Series in Utah Geological and Mineral Survey Bulletin 112. Salt Lake City, Utah: Utah Geological and Mineral Survey, 1977.

Doelling, H. H. 1972, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery: Utah Geological and Mineral Survey, Monograph Series. No. 3.

EA, 1997 (June), Mill Fork federal coal lease tract UTU-71307 – Environmental Assessment – Lease-by-application no. 11, USDA Forest Service, Region 4, Manti-La Sal National Forest, Ferron/Price Ranger District, Emery County, Utah, *and* USDI, Bureau of Land Management, Utah State Office.

Fenneman, N. M., 1946, Physical Divisions of the United States: U.S. Geological Survey Map, Scale 1:7,000,000.

Genwal MRP, Genwal Coal Company, Crandall Canyon Mine, Permit Application Package, 1989.

Hansen, Allen and Luce, 1997, Probable hydrologic consequences draft evaluation of the Crandall Canyon Mine.

HIS, 1988(?), Hydrogeologic investigation and evaluation of ground water dewatering at the Deer Creek Mine, consultants report prepared for Utah Power and Light Mining Division,

---

EAST MOUNTAIN AREA

---

Huntington, Utah.

Lines, G., 1984. The Ground-Water System and Possible Effects of Underground Coal Mining in the Trail Mountain Area. Central Utah: U.S. Geological Survey, Open-File Report 84-067.

Mayo and Associates, 1997a, Supplemental hydrogeologic information for LBA #11, 18 March 1997, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 1997b, Investigation of surface-water and groundwater systems in the PacifiCorp Lease area, East and Trail Mountains, Emery County, Utah – probable hydrologic consequences of coal mining in the Trail Mountain LBA and recommendations for surface-water and groundwater monitoring, 20 October 1997, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 1997c, Results of in-mine slug tests on the Star Point Sandstone, 07 November 1997, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 1997d, Summary of new isotopic information for LBA 11, 07 November 1997, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 1999, Investigation of groundwater and surface-water systems in the vicinity of Genwal's existing permit area and the Mill Fork Tract, Emery county, Utah, 21 June 1999, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 2001a, Investigation of the potential for Little Bear Spring recharge in Mill Fork Canyon, Emery County, Utah, 23 February 2001, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 2001b, Investigation of the alluvial groundwater system in Mill Fork Canyon with implications for recharge to Little Bear Spring, 24 February 2001, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

\_, 2001c, Determination of the recharge location of Little Bear Spring by means of fluorescent dye tracing, 20 November 2001, consultants report prepared for GENWAL Resources, Inc., Huntington, Utah.

Sunrise Engineering, 2001a, Resistivity survey, Sunrise project no. E9692.48, January 16, 2002, consultants report prepared for Genwal Resources, Inc.

Sunrise Engineering, 2001b, Aquatrack survey, Little Bear Spring, Huntington, Utah, consultants

---

EAST MOUNTAIN AREA

---

- report prepared for Genwal Resources, Inc.
- PacifiCorp/Utah Power and Light Company, Cottonwood/Wilberg Mine, Permit Application Package.
- PacifiCorp/Utah Power and Light Company, Deer Creek Mine, Permit Application Package.
- PacifiCorp/Utah Power and Light Company, Des-Bee-Dove Mine, Permit Application Package.
- PacifiCorp/Utah Power and Light Company, Hydrologic Monitoring Program, Annual Reports for 1987, 1988, 1989, 1990, 2000, and 2001.
- Sidle, R. C. 1995, Changes in stream channel characteristics and hydraulic parameters related to surface subsidence, Interim Report No. 2. USDA-Forest Service Intermountain Research Station, Logan, Utah.
- Star Point Mine PAP, Plateau Mining Corporation.
- WTR, 1999, Aqua-Track survey - Little Bear Spring study, Huntington Canyon, Utah, Water Technology and Research (WTR), consultants report prepared for UDOGM and others.
- Lines, G. C. and Plantz, G. C., 1981, Hydrologic Monitoring of the Coal Fields of Central Utah, August 1978 - September 1979, USGS Water-Resources Investigations Open-File Report 81-138, 56 p.
- Price, D. and Plantz, G. G., 1987, Hydrologic Monitoring of Selected Streams in Coal Fields of Central and Southern Utah--summary of data collected, August 1978-September 1984: USGS Water Resources Investigations Report 86-4017, 102 p.
- UDWQ, Utah Department of Water Quality, 1994, Standards for Quality for Waters of the State - R317-2 UAC, Utah Department of Environmental Quality.
- USGS, U. S. Geological Survey, 1980, Water Resources Data for Utah, water year 1979, USGS Water-Data Report UT 79-1, 604 p.
- USGS, 1981, Water Resources Data for Utah, Water Year 1980, USGS Water-Data Report UT 80-1, 684 p.
- USGS, 1982, Water Resources Data, Utah, Water Year 1981, USGS Water-Data Report UT 81-1, 708 p.

---

**EAST MOUNTAIN AREA**

---

Vaughn Hansen Associates, 1979, Hydrologic inventory of the Skyline property and adjacent areas, Carbon and Emery Counties, Utah, consultants report prepared from Coastal States Energy Company, Houston, TX *in* Skyline Mine MRP, Volume A-1, HAL – Hydrogeology tab.

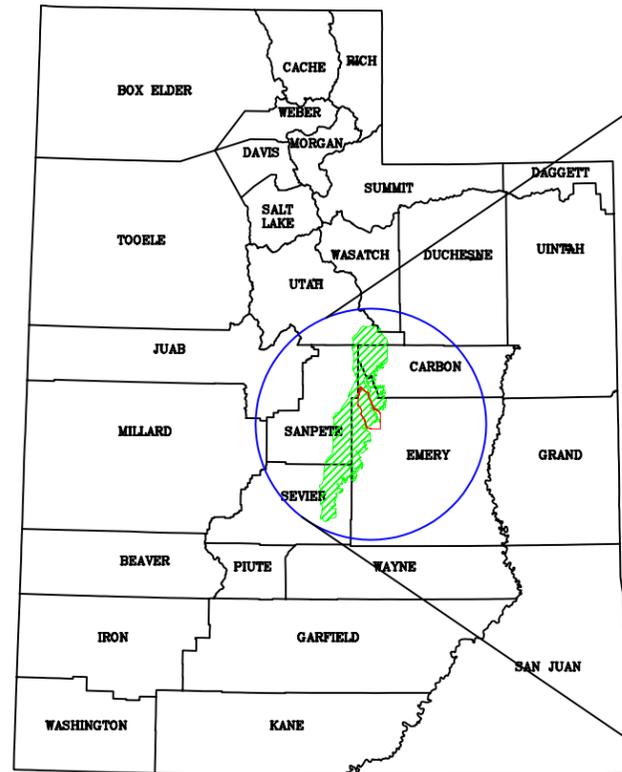
Waddell, K. M., Contratto, P. K., Sumison, C. T., Butler, J. R., 1981, Hydrologic Reconnaissance of the Wasatch Plateau-Book Cliffs Coal Field Area, Utah: USGS Water Supply Paper 2068.

Waddell, K. M., Dodge, J. E., Darby, D. W., and Theobald, S. M., 1986, Hydrology of the Price River basin, Utah, With Emphasis on Selected Coal-Field Areas, USGS Water Supply Paper 2246.

NEWUA  
UDWR  
USGS United States Geological Survey

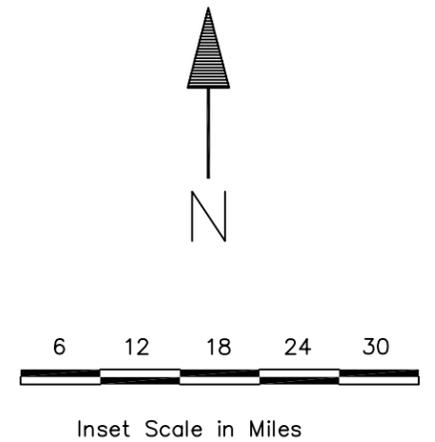
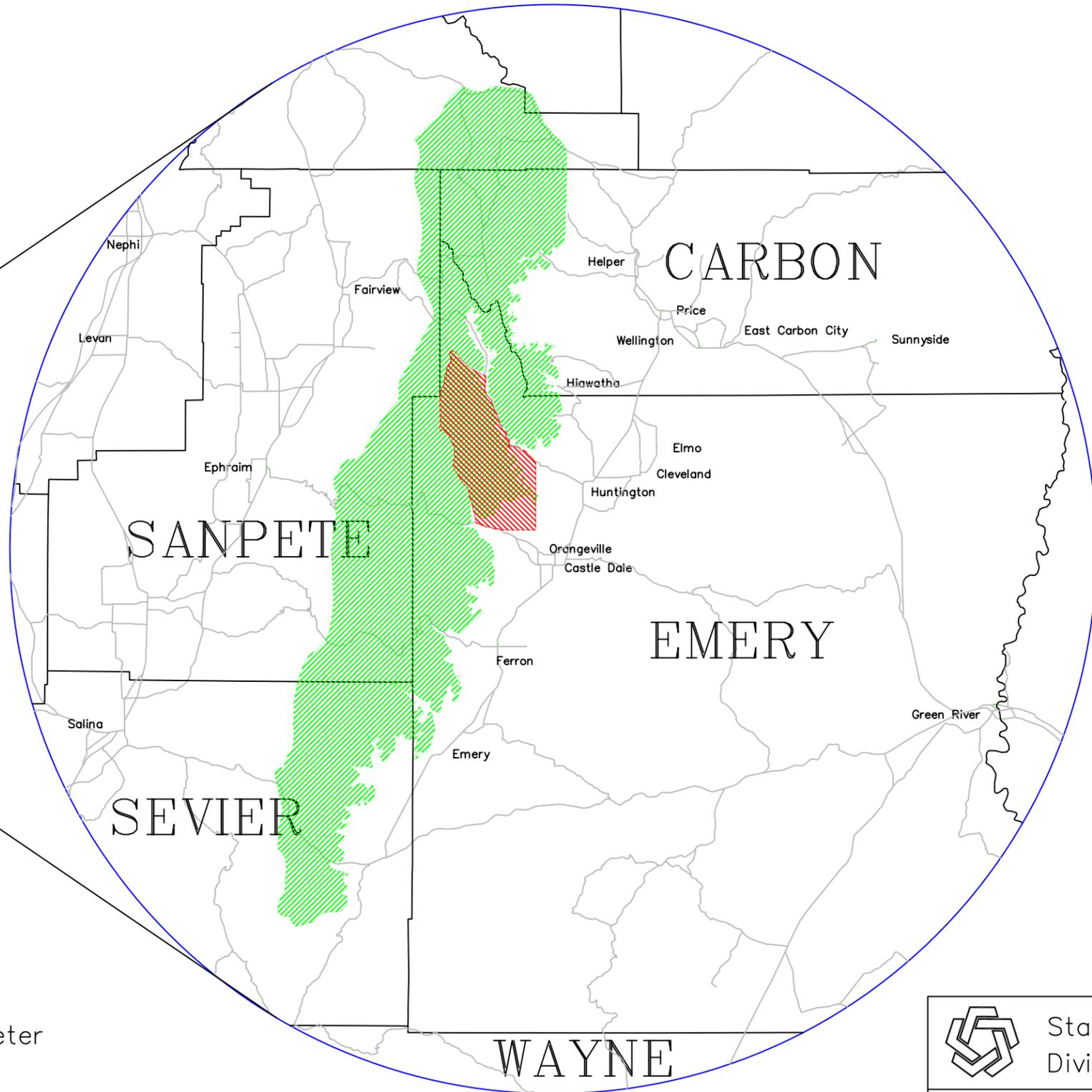
North Emery Water Users Association  
Utah Division of Water Resources

# PLATE 1: Wasatch Plateau Coal Field



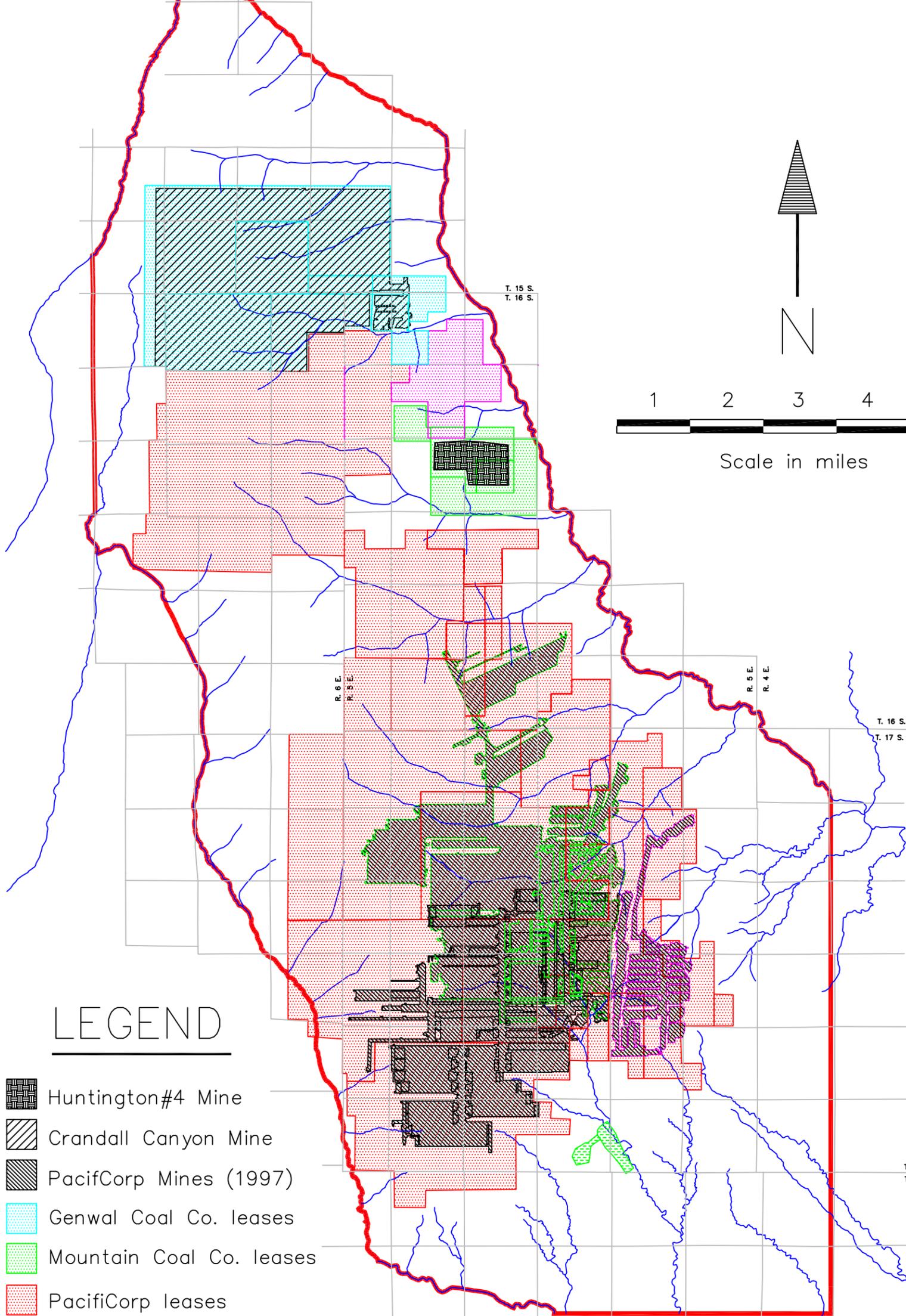
## LEGEND

- County Boundaries
- East Mountain CHIA Perimeter
- Roads
-  Wasatch Plateau Coal Field
-  East Mountain CIA



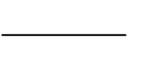
 State of Utah Division of Oil, Gas & Mining	
<b>EAST MOUNTAIN CHIA</b> Wasatch Plateau Coal Field	
FILE: O:/CHIA/East-Mtn/Figures/jdsEastPlate1.dwg	
DRAWN BY: KWW UPDATED BY: JDS	DATE: 9/23/94 3/3/03

# PLATE 2: CIA & Mining Map



Scale in miles

## LEGEND

-  Huntington#4 Mine
-  Crandall Canyon Mine
-  PacifiCorp Mines (1997)
-  Genwal Coal Co. leases
-  Mountain Coal Co. leases
-  PacifiCorp leases
-  South Crandall Tract Lease U-78593
-  PacifiCorp Waste Rock Disposal Areas
-  Deer Creek Mine workings
-  Des-Bee-Dove Mine workings
-  Cottonwood/Wilberg Mine workings
-  Streams
-  CHIA Boundary



State of Utah  
Division of Oil, Gas & Mining

## EAST MOUNTAIN CHIA CIA and Mining Map

FILE: 0: /CHIA/East-Mtn/Figures/jdsEastPlate2.dwg

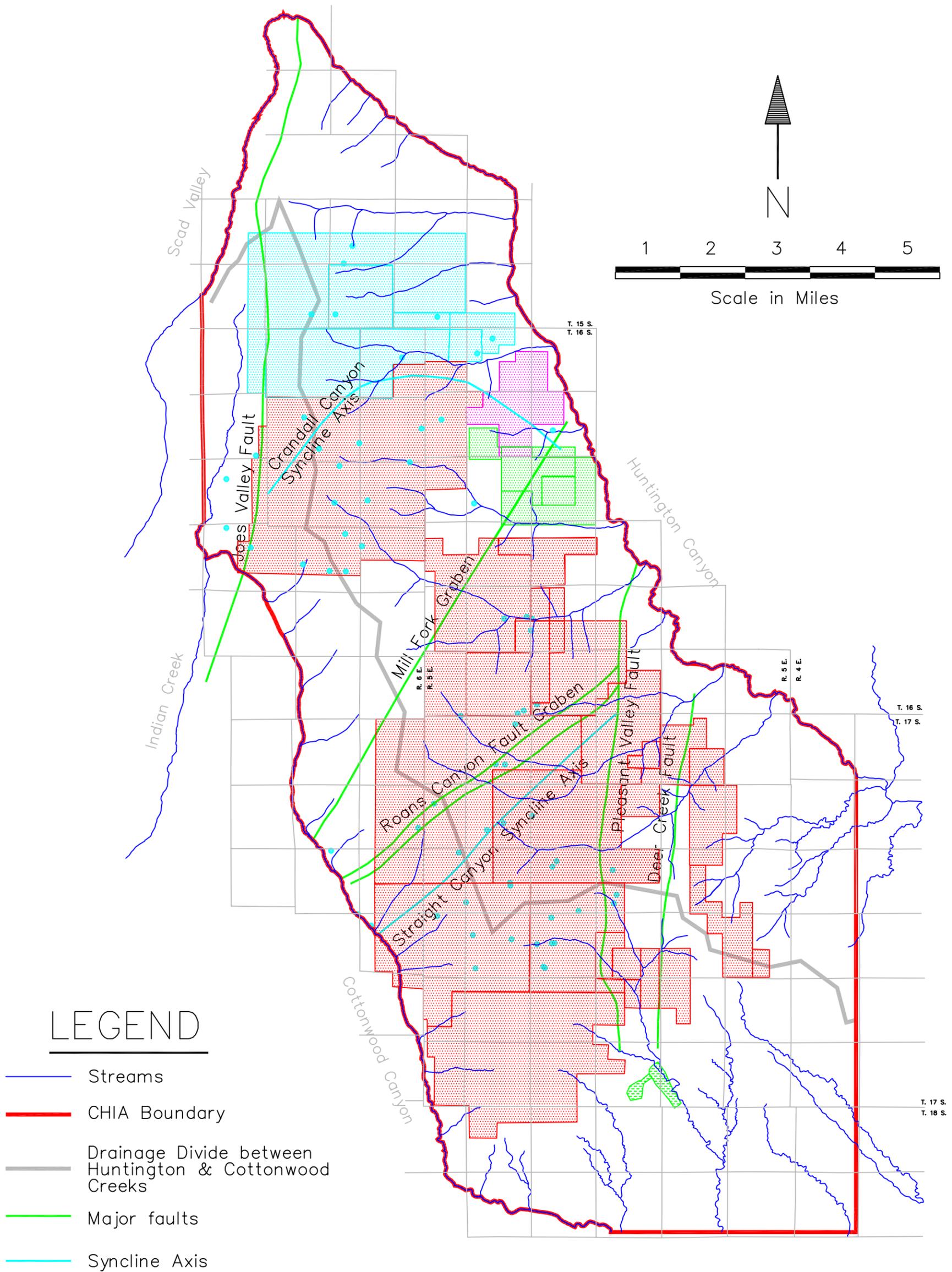
DATE: 9/23/94

DRAWN BY: KWW

DATE: 03/03/03

UPDATED BY: JDS

# PLATE 3: Major Hydrogeologic Features



## LEGEND

- Streams
- CHIA Boundary
- Drainage Divide between Huntington & Cottonwood Creeks
- Major faults
- Syncline Axis
- Monitored Springs
- Genwal Coal Co. leases
- Mountain Coal Co. leases
- PacifiCorp leases
- South Crandall Tract Lease U-78593
- PacifiCorp Waste Rock Disposal Areas



State of Utah  
Division of Oil, Gas & Mining

## EAST MOUNTAIN CHIA Major Hydrogeologic Features

FILE: O: /CHIA/East-Mtn/Figures/jdsEastPlate3.dwg

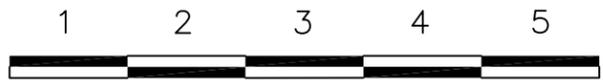
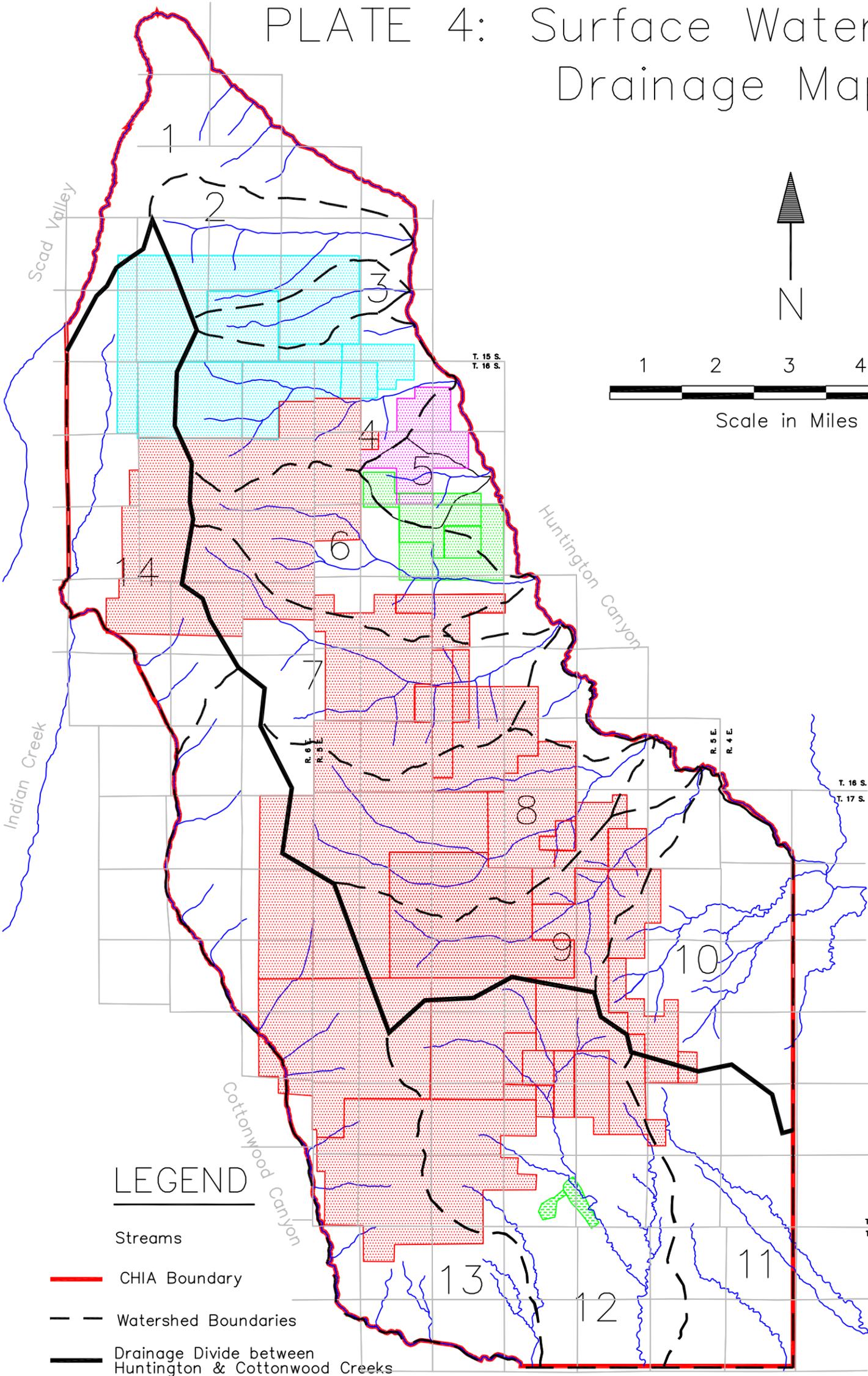
DATE: 9/23/94

DRAWN BY: KWW

DATE: 03/03/03

UPDATED BY: JDS

# PLATE 4: Surface Water Drainage Map



Scale in Miles

## Watersheds

(Referenced by number)

- 1: Left Fork of Huntington Creek
- 2: Horse Canyon
- 3: Blind Canyon
- 4: Crandall Canyon
- 5: Little Bear Canyon
- 6: Mill Fork Canyon
- 7: Rilda Canyon
- 8: Meetinghouse Canyon
- 9: Deer Creek
- 10: Maple Gulch
- 11: Danish Bench
- 12: Grimes Wash
- 13: Cottonwood Creek
- 14: Indian Creek

## LEGEND

Streams

-  CHIA Boundary
-  Watershed Boundaries
-  Drainage Divide between Huntington & Cottonwood Creeks

-  Genwal Coal Co. leases
-  Mountain Coal Co. leases
-  PacifiCorp leases
-  South Crandall Tract Lease U-78593
-  PacifiCorp Waste Rock Disposal Areas



State of Utah  
Division of Oil, Gas & Mining

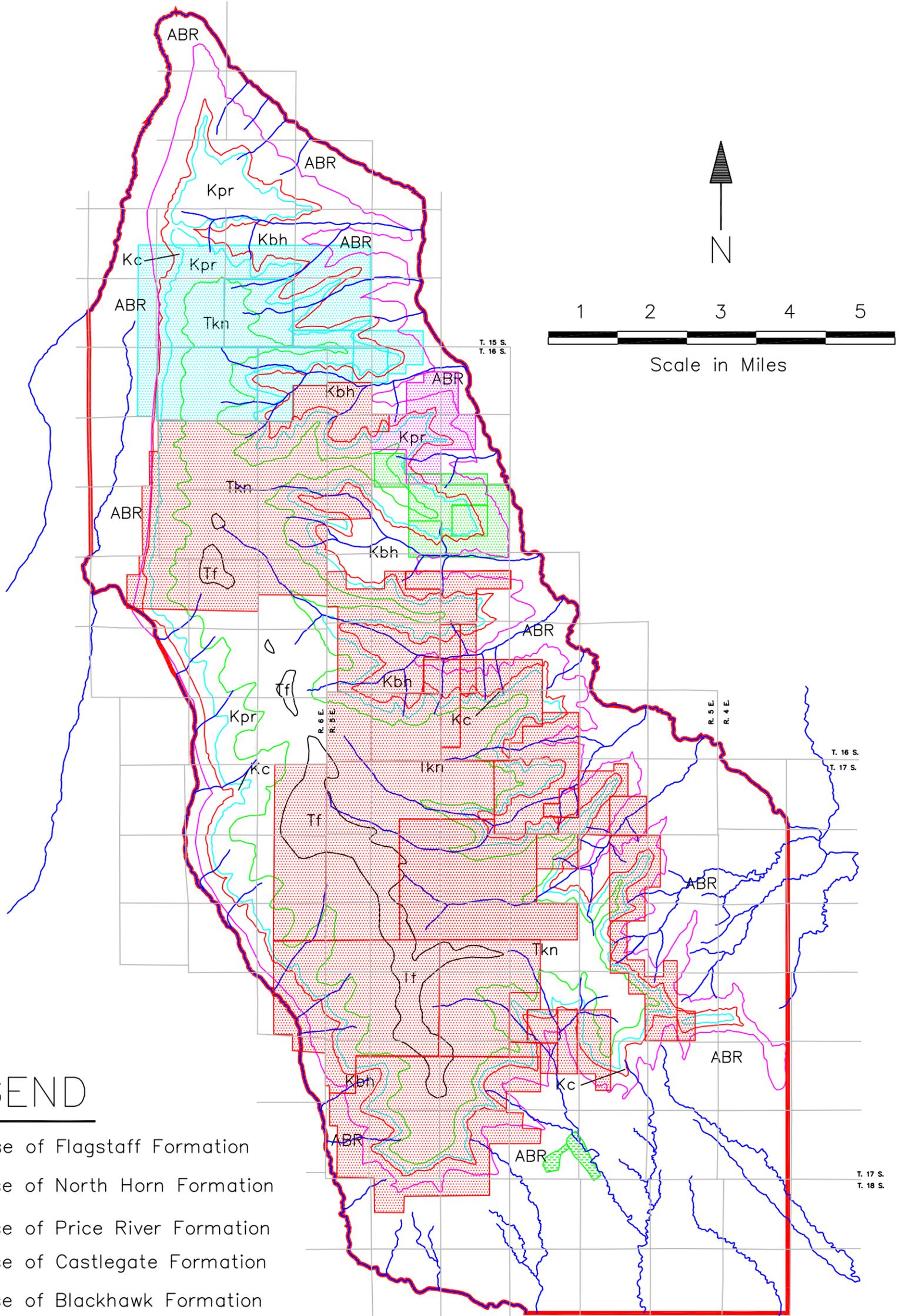
## EAST MOUNTAIN CHIA Major Hydrogeologic Features

FILE: O:/CHIA/East-Mtn/Figures/jdsEastPlate4.dwg

DATE: 9/23/94  
DATE: 03/03/03

DRAWN BY: KWW  
UPDATED BY: JDS

# PLATE 5: Potential Recharge Areas Above the Coal Resource



## LEGEND

- Base of Flagstaff Formation
- Base of North Horn Formation
- Base of Price River Formation
- Base of Castlegate Formation
- Base of Blackhawk Formation
- ABR Areas below the Coal resource
- Genwal Coal Co. leases
- Mountain Coal Co. leases
- PacifiCorp leases
- South Crandall Tract Lease U-78593
- PacifiCorp Waste Rock Disposal Areas



State of Utah  
Division of Oil, Gas & Mining

## EAST MOUNTAIN CHIA

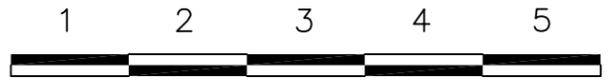
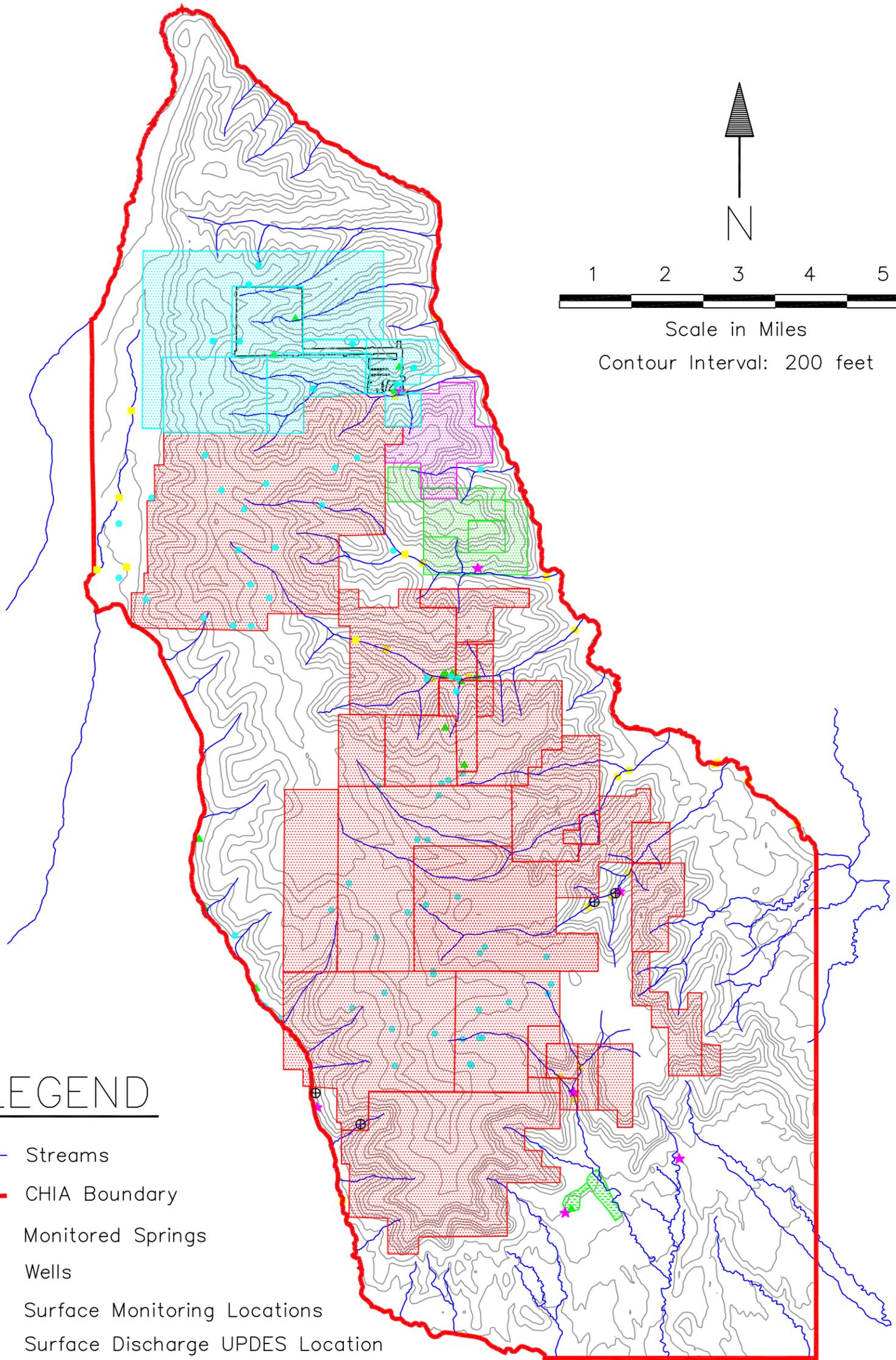
Potential Recharge Areas  
Above the Coal Resource

FILE: O: /CHIA/East-Mtn/Figures/jdsEastPlate5.dwg

DATE: 9/23/94  
DATE: 03/03/03

DRAWN BY: KWW  
UPDATED BY: JDS

# PLATE 6: Water Monitoring Locations



Scale in Miles  
Contour Interval: 200 feet

## LEGEND

-  Streams
-  CHIA Boundary
-  Monitored Springs
-  Wells
-  Surface Monitoring Locations
-  Surface Discharge UPDES Location
-  Mine Water Discharge UPDES Location
-  Genwal Coal Co. leases
-  Mountain Coal Co. leases
-  PacifiCorp leases
-  South Crandall Tract Lease U-78593
-  PacifiCorp Waste Rock Disposal Areas



State of Utah  
Division of Oil, Gas & Mining

### EAST MOUNTAIN CHIA Water Monitoring Locations

FILE: O: /CHIA/East-Mtn/Figures/jdsEastPlate6.dwg

DATE: 9/23/94  
DATE: 03/03/03

DRAWN BY: KWW  
UPDATED BY: JDS