3.0 AFFECTED ENVIRONMENT

3.1 GEOLOGY AND MINERALS

3.1.1 Physiography and Topography

The Uinta Basin is a bowl-shaped structural and sedimentary basin located in northeast Utah. The basin trends roughly east-west, is approximately 115 miles wide at the widest part, and narrows toward the west. The Uinta Basin is bounded on the east by the Douglas Creek Arch, on the south by the Book Cliffs, on the west by the Wasatch Plateau and to the north by the Uinta Mountains.

The Project Area lies primarily within the Central Badlands Topographic District of the Uinta Basin (Figure 3.1-1). It is one of five described topographic districts within the basin (Clark, 1957). The Central Badlands district comprises badland topography consisting of steep erosional slopes, narrow ridges, gullies, and dry washes. There are also broad areas of pediment and plateau adjacent to the badlands within this topographic district.

A portion of the Project Area lies within the Green River Valley Topographic District, which bisects the eastern portion of the Project Area. Within the Green River Valley district, the topography is dominated by nearly flat-lying flood plains of the Green River approximately ½ to 1½ miles wide. The flood plains are bounded by low cliffs, ledges, steep erosional slopes, pediment slopes and small tributary alluvial fans.

3.1.2 Stratigraphy

The majority of the Uinta Basin is underlain by sandy shale of the Eocene-Oligocene aged Duchesne River Formation, which erodes into low bluffs and ridges (Figure 3.1-2). The Duchesne River formation is fossiliferous in places and contains small mammal fossils. The underlying rocks which would be intercepted by the proposed drilling include the Eocene Green River Formation, the Eocene Wasatch/Colton Formation, the Cretaceous Mesaverde Formation and Mancos Shale, and the Jurassic Dakota/Cedar Mt. Formation (Figure 3.1-2). Figure 3.1-3 presents a geologic cross-section of the basin.

Gravelly and sandy pediment slopes, sandy washes, low bluffs and cliffs, and ledges and ridges of sandstone and sandy shale characterize the surface exposures within much of the Project Area. Quaternary alluvium and colluvium occurs in drainage bottoms and dry washes, and as small alluvial fans within the confines of the Green River Valley canyon. In places, older alluvial deposits comprised of sand, gravel and rounded cobbles cover these surface exposures, particularly on benches and mesa tops.

Eolian (wind-blown) deposits of sand are present in the southern portion of the Project Area, where they form dunes. Some of these dunes are active, but many have been anchored by vegetation.

3.1.3 Structure

The Uinta Basin is a structural basin that has been partially filled with sediments. Structural characteristics of the Uinta Basin developed during the Laramide Orogeny, mainly during the early Eocene (Clark, 1957). The structural axis of the basin generally trends west-northwest and plunges gently to the northwest, as shown on Figure 3.1-2. The Duchesne River follows a course parallel to and 10 miles south of the structural axis. The Project Area falls directly over the structural axis in the eastern portion of the basin. Three large-scale folds are the dominant structural features within the basin (Figure 3.1-2). The northern flank of the basin is bounded by faults in many places.

The bedrock strata generally dip about one to three degrees to the north in the central portion of the basin to greater than 30 degrees near the northern flank of the basin. Within the project area, strata are nearly flat to sub-horizontal showing a general shallow dip to the northeast south of the structural axis and a general shallow to moderate dip to the southwest north of the structural axis.

3.1.4 Mineral and Energy Resources

Mineral and energy resources within the Project Area with known, proven economic reserves are largely limited to oil and gas hydrocarbons. The Uinta Basin contains extensive deposits of oil and natural gas. Existing gas and oil fields within and near the Project Area include the Red Wash, Wonsits Valley, White River, Brennan Bottom, and Coyote Basin oil fields, and the Horseshoe Bend and Chapita Wells gas fields (Figure 3.1-4).

In addition to oil and gas reserves, the Uinta Basin also contains deposits of "Gilsonite" (also known as asphaltum, uintaite or uintahite) several miles southeast of the Project Area (Figure 3.1-2). Gilsonite is composed of black, brittle hydrocarbon resins that resemble tar or asphalt. The deposits occur in vertical to near-vertical, long, thin northwest-trending veins that occur primarily in the Green River, Uinta, and lower Duchesne River Formations. The "Rainbow" Gilsonite vein is 14 miles long and some veins are up to fourteen feet thick (Osmond, 1992). These veins are mined primarily by shaft and stoping, and open pit methods. Gilsonite has not been observed in commercial quantities at the surface within the Project Area and it appears unlikely that there are commercially recoverable amounts of these minerals within the Project Area boundaries.

Uranium and other metals are not known to exist in recoverable quantities within the Project Area. The Uinta Basin appears to have a low potential for the occurrence of these minerals (Pera et al. 1977).

The Uinta Basin produces some stone derived from the Green River Formation that is used as decorative building materials. Small quantities of sand and gravel are also mined from several dry washes.

3.2 WATER RESOURCES

3.2.1 Physiography and Climate

The GDBR lies completely in the Uinta structural basin of northeastern Utah. The Uinta Basin has an area of approximately 10,890 miles and is bounded to the north by the Uinta Mountains and the Wyoming border, to the east by the Colorado border, and to the south and west by portions of the Wasatch Range and the Roan Cliffs. The highest point in the basin is King Peak in the Uinta Mountains at an elevation of 13,528 feet above mean sea level (amsl), and the lowest point is about 4,040 ft amsl on the Green River.

The climate within the basin varies widely. Average precipitation ranges from 6 inches per year to over 40 inches in the surrounding Uinta Mountains. The basin generally has short, warm summers and long, cold winters, especially at higher elevations.

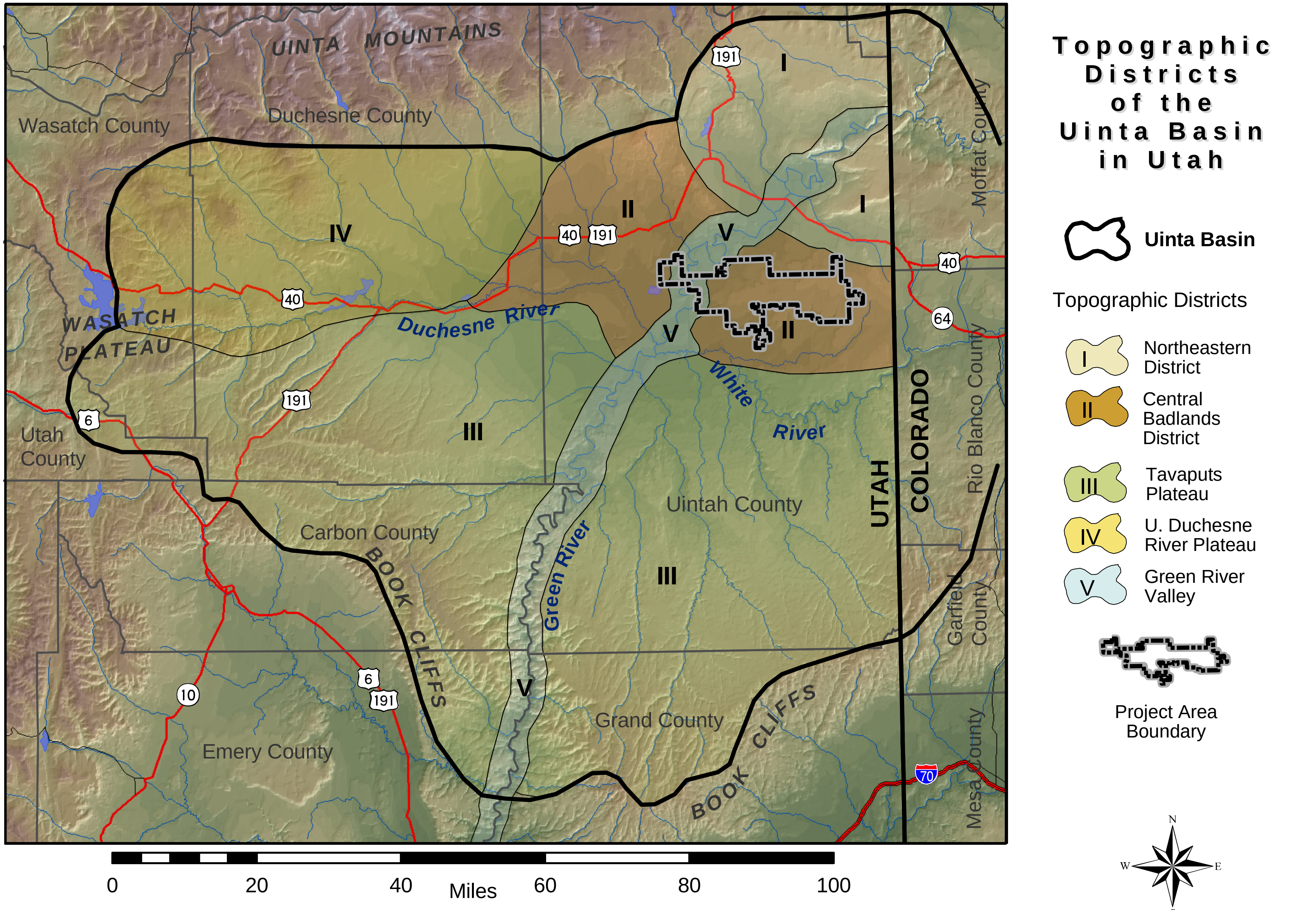


Figure 3.1-1. Topographic Districts Of the Uinta Basin (From Clark, 1957).

This page intentionally left blank.

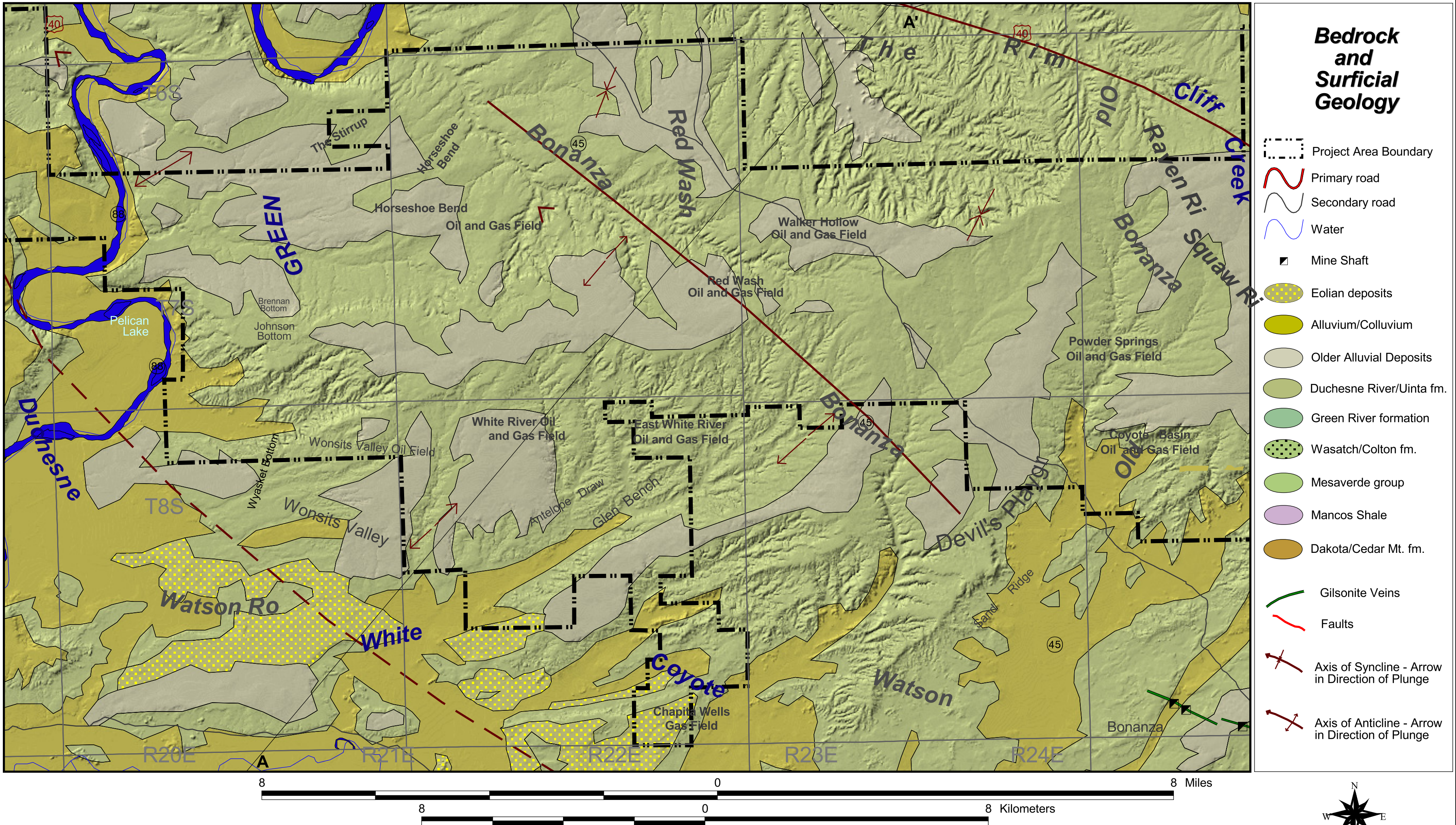


Figure 3.1-2. Geology within and near the Greater Deadman Bench Project Area (from Hintze, 1980).

This page intentionally left blank.

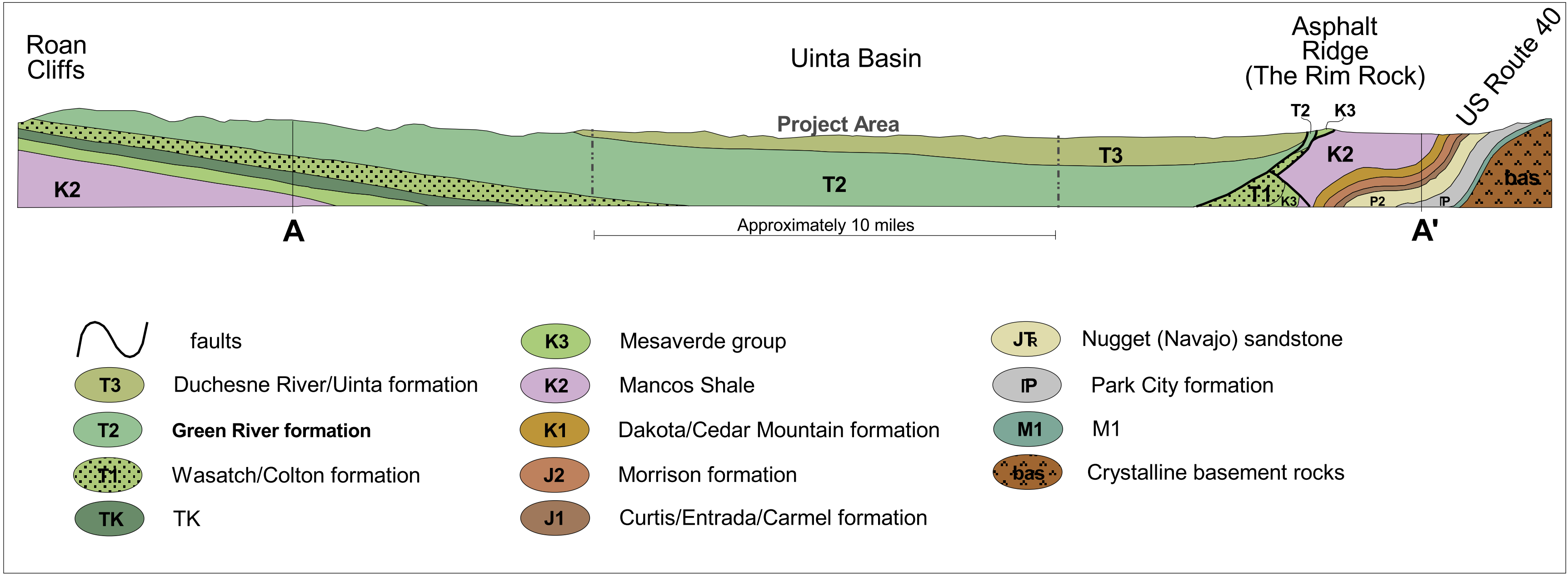


Figure 3.1-3. Geologic Cross-section.

This page intentionally left blank.

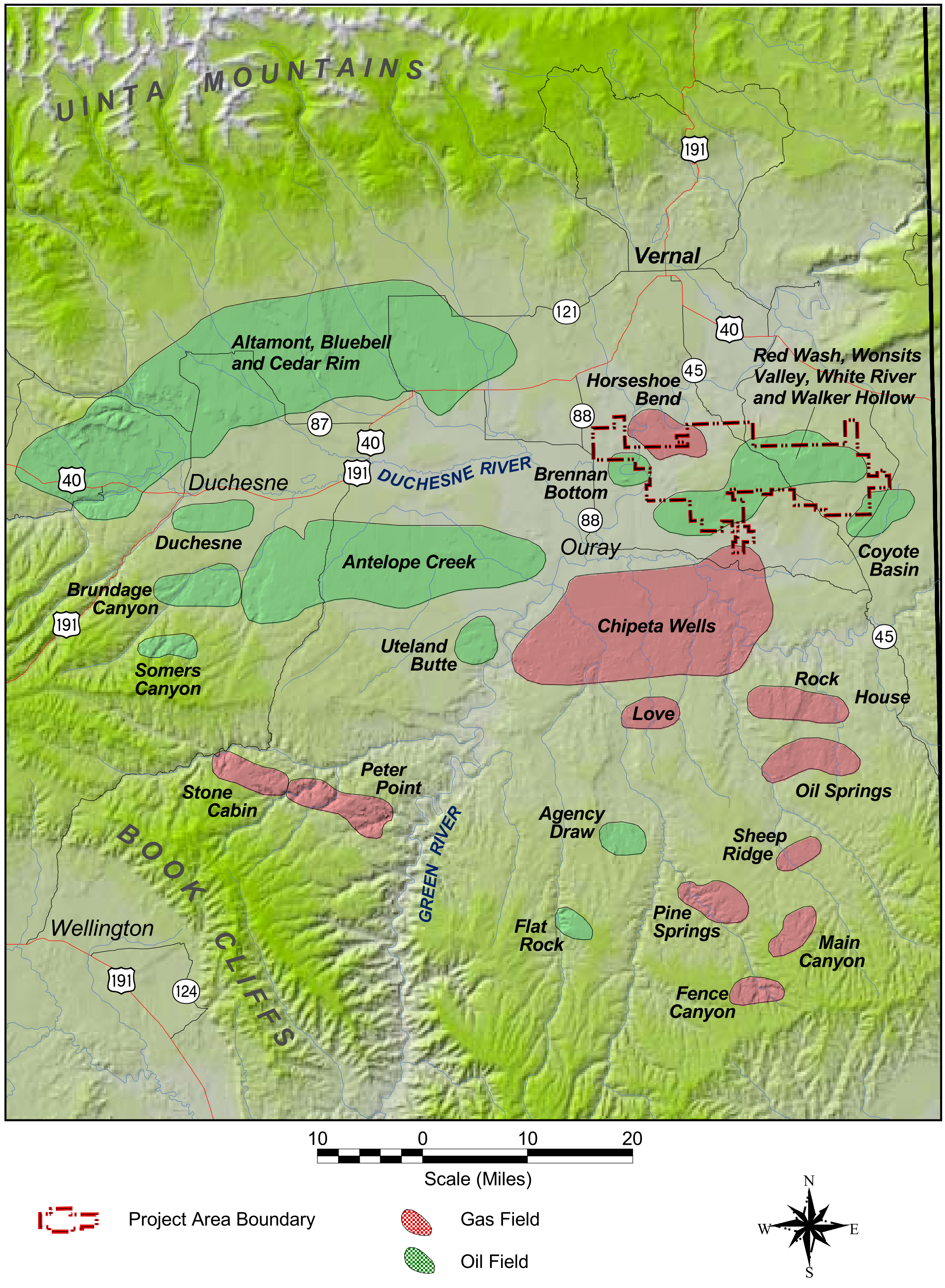


Figure 3.1-4. Oil and Gas Fields in and near the Project Area (from Spencer, 1988).

This page is intentionally left blank.

3.2.2 Hydrologic Setting

The Uinta Basin is drained by the Green River and its tributaries. Major tributaries include the Duchesne River and the White River. The White River drains the eastern portion of the basin, including those portions of the basin within Colorado. Within the Uinta Basin, the State of Utah has classified five drainages as hydrological sub-units: the Upper Green, the Green, the Ashley-Brush, the Duchesne/Strawberry, and the White River (Utah Division of Water Resources, 1999). The GDBR lies within the White River sub-unit.

Geologic formations in the basin include Tertiary and Cretaceous age sediments which consist mainly of lacustrine deposits containing clay, silt, and lime with lenses of fluvial sands, conglomerates and evaporites. Several of these consolidated rock formations are considered to be important aquifers in the region.

3.2.3 Surface Water

Figure 3.2-1 shows the two perennial rivers, the ephemeral washes within and near the GDBR, and the watersheds of the washes. The GDBR mostly lies east of the Green River in the north-central portion of the Uinta Basin. The Green River is a major river in the western United States. It originates in Wyoming along the Continental Divide and joins the Colorado River south of the GDBR. The flow in the Green River is partially controlled by the Flaming Gorge Dam. From 1947 to 2005, the flow in the Green River at Jensen averaged 3,058,696 acre-feet/year (acft/yr) and ranged from a maximum annual flow of 5,634,674 acft/yr in 1984 to a minimum flow of 1,054,827 in 1963 (USGS 2006).

In the northern and western portions of the GDBR, the ephemeral washes flow directly to the Green River. Streams which drain the GDBR and flow into the Green River include:

- The north-flowing Powder Springs Wash in the east portion of the GDBR;
- The northwest-flowing Walker Hollow Right Fork in the north-central portion of the GDBR;
- The northwest-flowing Baeser Wash in the northwestern-central portion of the GDBR; and
- Several small washes that flow west directly into the Green River.

These streams are mainly ephemeral and only flow in direct response to rainfall events. During certain portions of the year, streams on the west side of the Green River may flow with irrigation return water. They have developed a dendritic drainage pattern and are incised with rills and gullies typical of badland topography. Two irrigation canals (the Ouray Valley Canal and the Ouray Park Canal), which carry water from the Ouray Valley to the Green River, are located in the western portion of the GDBR.

The White River originates in Colorado and is a tributary of the Green River. It is a free flowing river except for a small reservoir in western Colorado. The southern portion of the GDBR is drained mainly by ephemeral washes that flow southwest to the White River. As illustrated in Figure 3.2-1, the southeastern portion of GDBR is drained by Coyote Wash which flows into the White River. The Coyote Wash watershed has an area of approximately 228 square miles; about 57 square miles are within the GDBR.

The main tributaries to Coyote Wash which drain the GDBR include Kennedy Wash and Red Wash. Kennedy Wash drains approximately 18 square miles of the east-central portion of the GDBR. Red Wash drains about 12.5 square miles of the western portion of the GDBR. The southwestern portion of the

GDBR is drained primarily by Antelope Wash, which has a watershed area of approximately 51 square miles.

All of the streams that drain the GDBR to the White River are ephemeral and only flow in direct response to rainfall events. These streams have developed a dendritic drainage pattern with up to 5 orders of tributaries, which indicates that the area is a sediment source area. The streams are incised with rills and gullies typical of badland topography.

3.2.3.1 Surface Water Flow

The United States Geological Survey (USGS) maintains several gauging stations on the Green River. The most representative USGS gauging station (Station Number 09307000) to the GDBR is located near Jensen approximately 15 miles north of the GDBR. The elevation at this station is 4,758 ft amsl and the drainage area it gauges covers approximately 29,660 square miles. The period of record for this station is from October 1, 1946 to the present. Figure 3.2-2 shows the hydrograph for this station covering flow from October 1992 through September 2003. During this period, peak flows ranged from less than 5,000 cubic feet per second (cfs) to more than 25,000 cfs during spring runoff in response to snow melt.

Since 1923, the USGS has maintained a surface water gauging station on the White River just off Highway 45 near Watson, Utah, approximately 7 miles south of the GDBR. This station gauges a drainage basin area of approximately 4,020 square miles. The White River is considered perennial in Utah with high flows occurring in spring responding to snow melt in the mountains of Colorado. In summer, high flows occur due to short duration, high intensity thunderstorms. Figure 3.2-3 shows the hydrograph for the White River at the Watson Gauging Station for the 10-year period from October 1992 to October 2003. During this period, peak flows ranged from 500 to 4,600 cfs during peak spring runoff. The mean daily average flow during this period was 695 cfs.

The USGS also maintained a gauging station (Station Number 09306878) on Coyote Wash between October 1976 and October 1983. Figure 3.2-4 shows the hydrograph for this station and illustrates the ephemeral nature of the stream, with flows up to 600 cfs only occurring in direct response to rainfall events. The vertical nature of the peaks also indicates that the stream is susceptible to flash flooding.

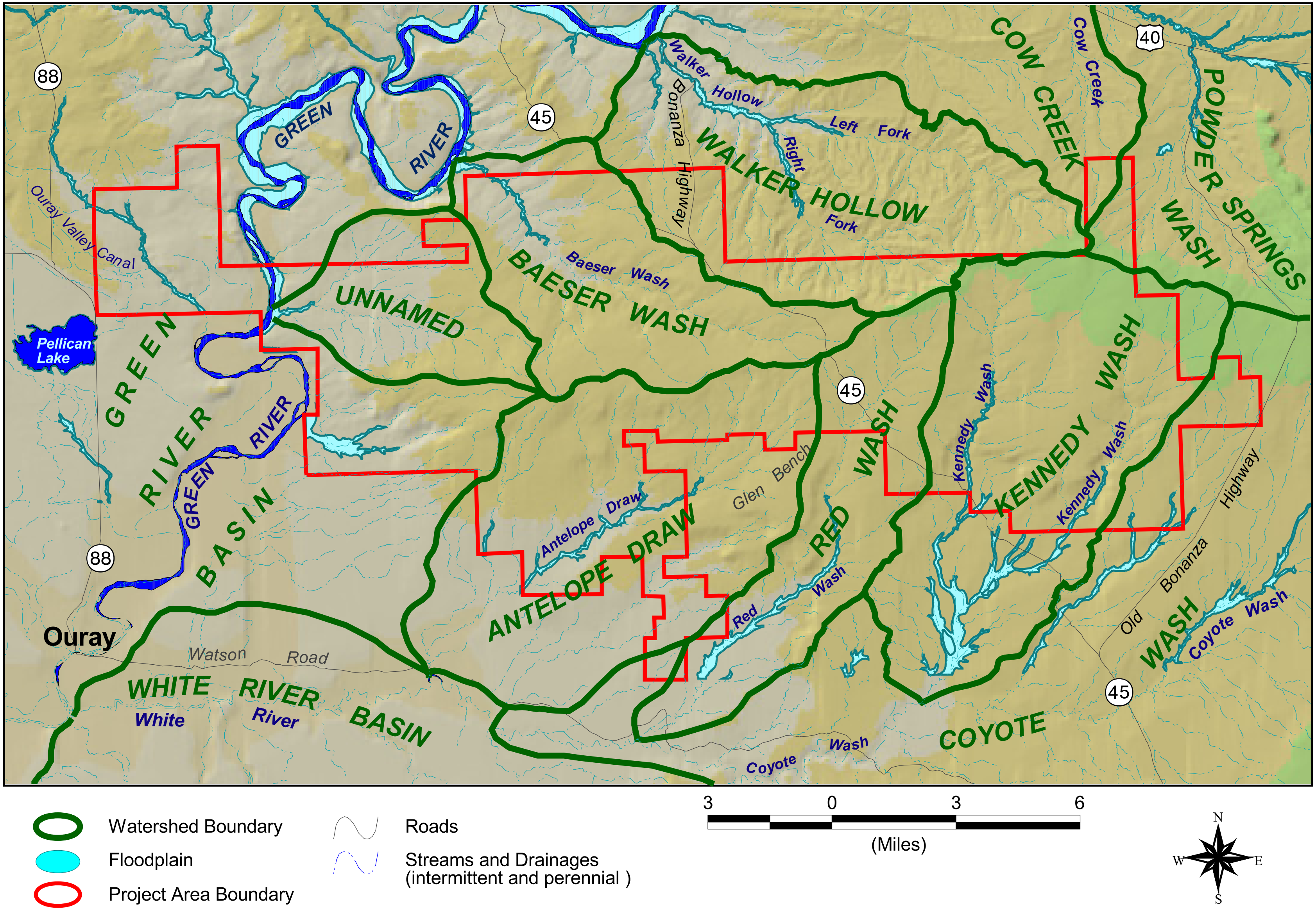


Figure 3.2-1. Mapped Hydrologic Basins and Floodplains within the GDBR.

This page intentionally left blank

Figure 3.2-2 Hydrograph for the Green River near Jensen (USGS Station 09261000) for October 1992 through September 2003

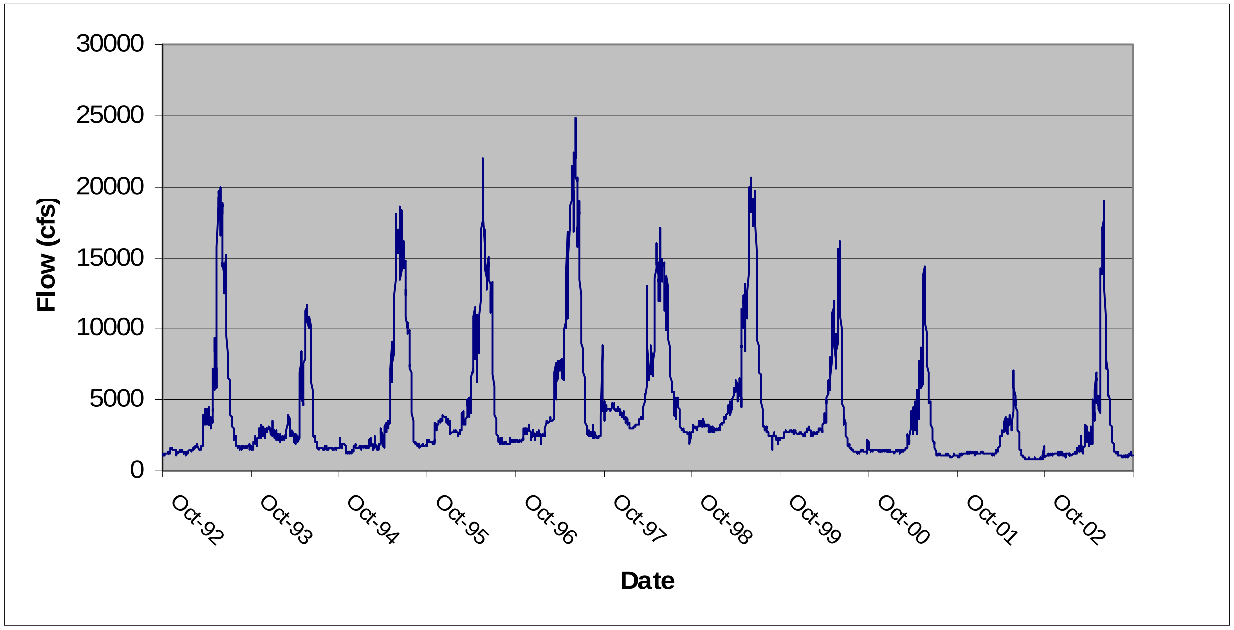


Figure 3.2-3 Hydrograph for the White River near Watson, Utah (USGS Station 9306500) for October 1992 to September 2003

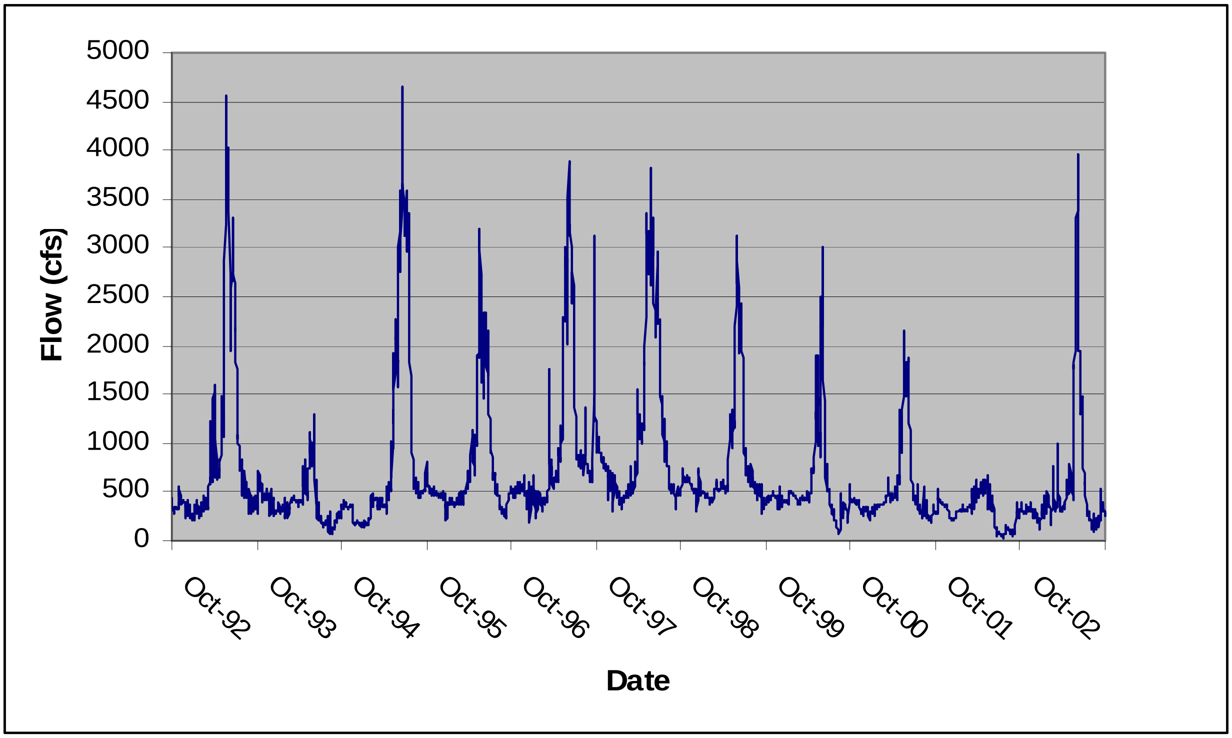
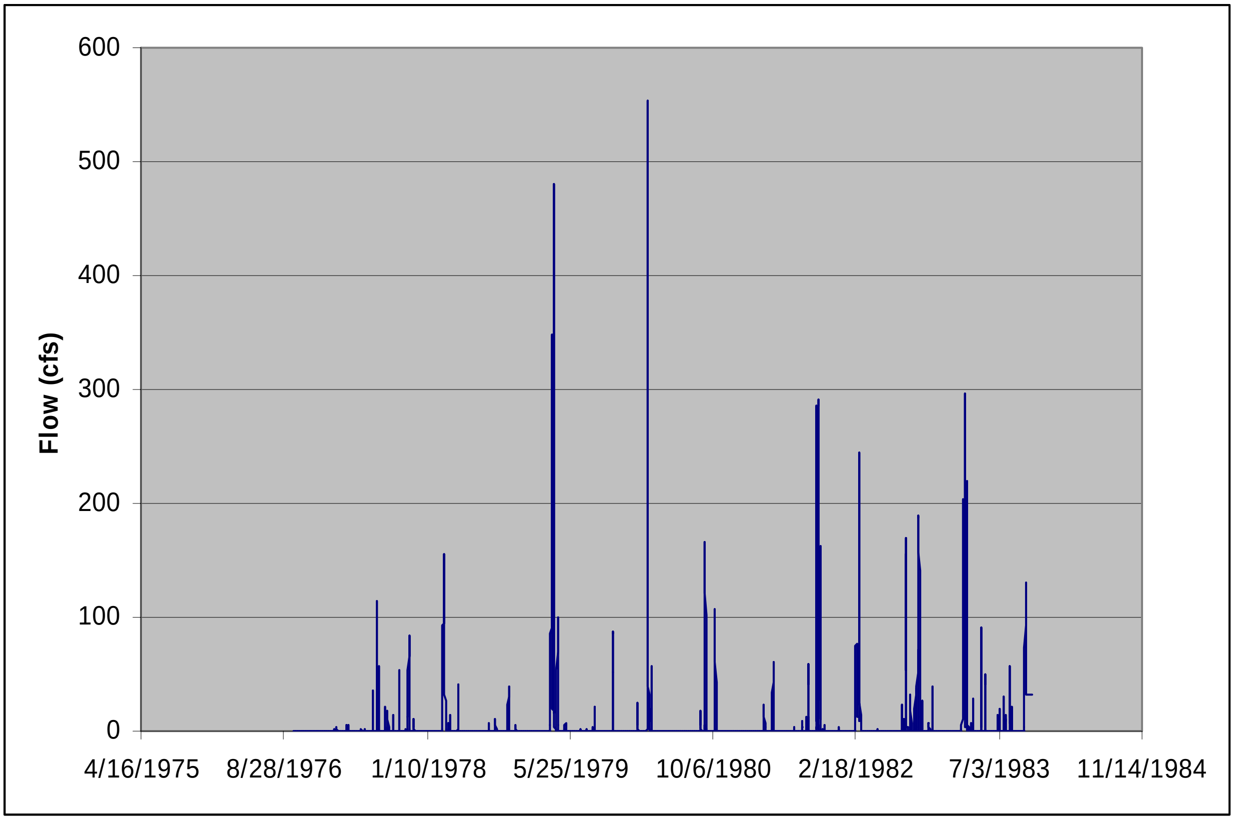


Figure 3.2-4 Hydrograph for Coyote Wash near Ouray Utah (USGS Station 09306878) for October 1976 through October 1983.



3.2.3.2 Surface Water Quality

The Utah Division of Water Quality monitors and assesses the Green and White Rivers on a regular basis to determine if the rivers are supporting their beneficial uses. Water quality data is collected from the Green River at station number 49370 and from the White River at station number 493352. Both stations are located south of the GDBR where the rivers cross Utah State Highway 88 near Ouray.

Tables 3.2-1 and 3.2-2 present a summary of water quality data from these stations for the period November 2000 through December 2002. Waters of the Green and White Rivers are similar in chemical nature with the predominant cations and anions being calcium, magnesium, and sulfate. These rivers in general meet Utah Water Quality Standards for domestic, agricultural and recreational use.
The Utah Administrative Code under Title 317 has developed Water Quality Standards for waters in the State of Utah. Under this Title, the Green River and its tributaries (except where exempted) are classified as follows:

Class 1C: Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water;

Class 2B: Protected for secondary contact recreation such as boating, wading, or similar uses;

Class 3: Protected for use by aquatic wildlife;

Class 3B: Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain; and

Class 4: Protected for agricultural uses including irrigation of crops and stock.

The White River and tributaries, from confluence with Green River to the state line is classified 2B, 3B, and 4.

For the Green River, dissolved solids range from 232 to 490 mg/L with an average of 393 mg/L. Total dissolved solids are somewhat higher for the White River and range between 248 and 692 mg/L with an average of 542 mg/L. Mean total suspended solids concentrations are 152 mg/L for the Green River and 258 mg/L for the White River.

Water quality data are not available for washes within the GDBR. When flowing in response to snowmelt or precipitation, these streams are expected to carry elevated levels of total suspended solids.

Table 3.2-1. Green River Water Quality Summary – November 2000 to December 2001 - Station Number 49370

Chemical Parameter	Number of Samples	Minimum	Maximum	Mean
Field Parameters				
Dissolved oxygen (DO) (mg/L)	8	6.81	11.7	9.3
Dissolved oxygen saturation (%)	7	78.6	102.8	92.4
pH (Standard Units)	16	7.77	8.59	8.3
Temperature (degrees Centigrade)	8	0.13	29.26	10.2
Turbidity (NTU)	8	7.86	225	79.1
Specific conductivity (umhos/cm)	16	342	722	560.4
Major Ions				
Alkalinity, Carbonate as CaCO3 (mg/l)	8	94	175	144.3
Carbonate (mg/L)	8	0	0	0.0
Carbon dioxide (mg/L)	8	1	4	1.9
Chloride (mg/L)	8	Nd	27.6	19.1
Bicarbonate (mg/L)	8	114	214	175.9
Sulfate (mg/L)	8	73.7	615	200.7
Hydroxide (mg/L)	8	0	0	0.0
Potassium (mg/L)	8	1.81	3.14	2.5
Magnesium (mg/L)	8	12.7	25.9	22.0
Sodium (mg/L)	8	23.9	58.4	46.7
Calcium (mg/L)	8	34.4	62.5	52.5
General Water Quality Indicators				
Hardness (mg/L)	8	138.1	258.2	221.6
Salinity (ppt)	7	0.18	0.4	0.3
Total Dissolved Solids (mg/L)	8	232	490	392.8
Total Suspended Solids (mg/L)	8	10	386	151.8
Nutrients				
Ammonia (mg/L)	5	Nd	Nd	Nd
Phosphorus (mg/L)	13	Nd	0.319	0.1
Trace Metals				

Chemical Parameter	Number of Samples	Minimum	Maximum	Mean
Aluminum (ug/L)	5	Nd	162	78.4
Arsenic (ug/L)	5	Nd	Nd	Nd
Barium (ug/L)	5	72	156	89.8
Cadmium (ug/L)	5	Nd	Nd	Nd
Chromium (ug/L)	5	Nd	5.2	1.7
Copper (ug/L)	5	Nd	Nd	Nd
Iron (ug/L)	5	Nd	96.7	56.0
Lead (ug/L)	5	Nd	Nd	Nd
Manganese (ug/L)	5	Nd	5	1.0
Mercury (ug/L)	5	Nd	Nd	Nd
Selenium (ug/L)	5	1	1.8	1.4
Silver (ug/L)	5	Nd	Nd	Nd
Zinc (ug/L)	5	Nd	30.5	6.1

nd - not detected
ug/L - micrograms per liter
mg/L - milligrams per liter

Table 3.2-2. White River Water Quality Summary – November 2000 to December 2001 - Station Number 493362

Chemical Parameter	Number of Samples	Minimum	Maximum	Mean
Field Parameters				
Dissolved oxygen (mg/L)	14	5.51	12.31	9.0
Dissolved oxygen saturation (%)	13	77.4	145.1	95.8
pH (Std. Units)	27	8.1	8.66	8.35
Temperature (deg C)	14	0.02	27.61	12.6
Turbidity (NTU)	14	20.8	9,970	825.1
Specific conductivity (umhos/cm)	27	249.7	1,010	747.4
Major Ions				
Alkalinity, Carbonate as CaCO3 (mg/L)	14	123	225	193.7
Carbonate (mg/L)	14	0	0	0.0
Carbon dioxide (mg/L)	14	1	3	1.8
Chloride (mg/L)	15	0	27	15.6
Bicarbonate (mg/L)	14	150	274	236.4
Sulfate (mg/L)	14	59.6	312	224.8
Hydroxide (mg/L)	14	0	0	0.0
Potassium (mg/L)	14	1.51	3.63	2.1
Magnesium (mg/L)	14	14.4	42.8	30.2
Sodium (mg/L)	14	19.5	104	75.1
Calcium (mg/L)	14	41.6	73.9	61.6
General Water Quality Indicators				
Hardness (mg/L)	13	214.2	358.7	286.1
Salinity (ppt)	13	0.12	0.5	0.4
Total Dissolved Solids (mg/L)	14	248	692	542.1
Total Suspended Solids (mg/L)	14	25.5	914	258.0

Chemical Parameter	Number of Samples	Minimum	Maximum	Mean
Nutrients				
Nitrite + Nitrate (mg/L)	14	0.1	0.45	0.23
Phosphorus (mg/L)	15	0.021	0.676	0.250
Trace Metals				
Aluminum (ug/L)	4	0	151	65.8
Arsenic (ug/L)	1	0	0	0.0
Barium (ug/L)	10	55	115	78.8
Cadmium (ug/L)	1	0	0	0.0
Copper (ug/L)	1	0	0	0.0
Iron (ug/L)	5	30.1	207	74.1
Lead (ug/L)	1	0	0	0.0
Manganese (ug/L)	2	0	7	3.5
Selenium (ug/L)	8	1.0	1.8	1.3
Silver (ug/L)	1	0	0	0.0

3.2.4 Floodplains

The U.S. Department of Housing and Urban Development (HUD) and the Federal Emergency Management Agency (FEMA) inventoried public and state lands in Uintah County in 1977 (Wright pers. comm. 2005). Based on the survey, 100-year floodplains were designated in six drainages within the GDBR along with the main floodplain along the Green River. The floodplains, shown on Figure 3.2-1, include the east and west branch of Kennedy Wash, Red Wash, Antelope Draw, Baeser Wash, and an unnamed wash leading to the Green River on the west side of the GDBR.

3.2.5 Public Water Reserve

Public water reserves are parcels of land, withdrawn from settlement, mineral location, sale, or entry, that contain a spring or water hole which is reserved for public use. Public water reserves were established by Executive Order Number 107 dated April 17, 1926. Two public water reserves occur in the GDBR: a 120-acre parcel is in T7S, R23E, Section 17, and a 40-acre parcel in T8S, R22E, Section 11. The Book Cliffs RMP designated all public water reserves with a No Surface Occupancy lease stipulation. Therefore, well pads, roads, or pipelines can't be constructed within these public water reserves.

3.2.6 Groundwater

Groundwater aquifers beneath the GDBR are present in formations dating in age from Cambrian to recent. Water-bearing zones are found in nearly all formations in the area, but the principal aquifers include alluvial deposits along the White and Green Rivers, the Uinta Formation, the Green River Formation, sandstone beds within the Mesa Verde Formation, and the Frontier Sandstone (Schlotthauer 1981). The alluvial aquifers are usually unconfined whereas the consolidated aquifers are generally unconfined near outcrops and confined down dip. The primary permeability of these aquifers is generally low; however, fractures, bedding planes, and faults produce relatively high secondary permeability. General characteristics of these aquifers are presented in Table 3.2-3.

This page intentionally left blank

Table 3.2-3. Hydrogeologic Description of Aquifers in the GDBR

Age	Geologic Unit	Approximate Thickness (ft)	Lithology	Water Bearing Characteristics
Quaternary	Alluvium	<1 – 700	Unconsolidated deposits of alluvial sand and gravels, colluvial debris including landslide and pediment deposits, glacial till and eolian sands. Often reworked into well sorted deposits of sand and gravel stratified with fine sand, silts, and clay over-bank deposits.	Principal aquifer in the region; yields small to very large in clean sand and gravel floodplain deposits.
Tertiary	Duchesne River Fm	<1 - 500	Lacustrine, fluvial, and alluvial deposits of boulders, cobbles, gravel, sand, silts, and clay. Red, gray, buff sandstone, conglomerate, and sandy shale.	Permeability generally low to moderate in sandstone beds, but locally high where fractured. Yields small to large.
	Uinta Fm	2,000 – 3,000	Reddish fluvial and lacustrine sandstone, siltstone, shale, conglomerate, and limestone.	
	Crazy Hollow Fm	ND	Red and orange sandstone, siltstone, and shale, light gray sandstone, and salt and pepper sandstone with local conglomerate and limestone.	
	Green River Formation	<1 – 700	Massive to thin bedded lacustrine shale and freshwater limestone. Minor lenses and interbeds of sandstone and conglomerate; shale, gray to green gray and limestone white to tan.	Low primary permeability in shale but moderate permeability in sandstone; acts as a barrier to groundwater flow in most places. High permeability where fractured in shale and limestone zones.
	Wasatch Fm	300 – 9,000	Limestone containing irregularly interbedded shale, siltstone, sandstone, and conglomerate.	Sandstone have low to moderate permeability and yield small to moderate quantities of water to wells and springs.
Cretaceous	Mesa Verde Fm	<1 – 2,000	Sandstone, very fine grained to coarse grained, porous, massive, interbedded with siltstone, shale, and coal.	Well yields as much as several hundred gpm. Dissolved solids range between 1,000 and 5,000 mg/L
	Castlegate SS	<1 – 400	Light colored deltaic sandstone	
	Mancos Shale	ND	Predominately shale with some sandstone	Poor water producer.
	Frontier Fm	600 – 1,000	Shale and sandstone. Shale is black, partly carbonaceous.	Yields as high as 50 gpm are possible. Dissolved solids range between 1,000 and 5,000 mg/L.
	Mowry Shale	700 – 900	Black and silver gray siliceous shale.	Low well yields of around 10 gpm with dissolved solids of greater than 2,000 mg/L.
	Dakota Sandstone	<1 – 250	Thin beds of conglomerate, sandstone, shale and coal.	Too thin to produce water in quantity.

Age	Geologic Unit	Approximate Thickness (ft)	Lithology	Water Bearing Characteristics
	Cedar Mountain – Burro Canyon Fms	<1 – 700	Sandstone and Shale.	Poor quality water – high in dissolved salts.
Jurassic	Morrison Fm	110 – 1,300	Sandstone, conglomerate, mudstone, claystone, and limestone.	Poor quality water – high in dissolved salts.
	Curtis Fm	<1 – 600	Evenly bedded gray sandstone and shaly sandstone with pebbles.	Sandstones may be water bearing locally, but many beds are thin or discontinuous and poorly sorted, most do not produce significant amounts of water.
	Entrada SS	<1 – 100	Massive cross bedded sandstone.	
	Carmel Fm	<1 – 230	Red shaly sandstone interbedded with red or buff fine grained sands.	Poor quality water.
Triassic	Navajo Sandstone	00	Massive cross bedded, fine grained, well-sorted, eolian sandstone.	Major aquifer in the region. Yields moderate to large amounts of water.

Source: Schlotthauer 1981

In the direct vicinity of the GDBR, the unconsolidated materials present in valley fill and stream channel deposits form the principal aquifers in the area. These aquifers range in thickness from about 50 to 70 feet within the stream channels to about 200 feet near the months of canyons. These alluvial aquifers can produce significant quantities of water (up to 1,000 gpm) from the floodplain deposits of the Green and White Rivers but generally produce lesser quantities from deposits located along the ephemeral or intermittent streams (Hood 1978, Schlotthauer 1981).

The Uinta Formation aquifer consists of sandstones, siltstones, shale, and limestone, and has a maximum thickness of about 4,000 ft. Hydraulic conductivities range between less than 0.5 feet/day to more than 500 feet/day. The hydraulic conductivity is enhanced by faults and fractured systems in some locations (Schlotthauer 1981).

The Green River Formation is wide spread throughout the area. It is often considered an aquiclude and prevents downward movement of groundwater, however, some zones within the formation are considered to be aquifers. The Birds Nest Aquifer, which is present beneath the GDBR, lies between the upper part of the Parachute Creek Member and the Mahogany Zone. This aquifer is characterized by nodules of nahcolite (natural sodium bicarbonate) set in marlstone overlain by thin, brittle, shale beds and fine-grained sandstone called the Horse Bench Sandstone. The aquifer is generally 90 to 205 ft. thick, with an average thickness of about 115 ft. The hydraulic conductivity of the aquifer is enhanced by the dissolution of the nahcolite and fracturing of the sandstones. Well yields from the Birds Nest Aquifer range from about 10 to 700 gallons per day (BLM 2003).

Deeper aquifers in the GDBR include sandstone zones in the Mesa Verde Formation and the Triassic Navajo Sandstone. Hydraulic conductivity of the Mesa Verde aquifers ranges from about 0.5 to 500 feet per day. Well yields from this formation can be substantial. The Navajo Sandstone aquifer has similar hydraulic conductivity as the Mesa Verde aquifers. Because of its thickness (up to 1,100 feet) and its extent in the region, it is considered to be a major aquifer (Schlotthauer 1981).

3.2.6.1 Recharge and Discharge of Aquifers

Recharge to the groundwater aquifers is principally from precipitation that falls within the basin. Most recharge occurs during the spring during snowmelt. Little recharge occurs during short duration, high intensity thunderstorms during the summer (Hood, 1978). Groundwater recharge of the consolidated aquifers occurs mainly in the mountains and flows down dip into the basin. Relatively small quantities of recharge also come from the Green and White rivers. In areas where irrigation is taking place, such as in the western portion of the GDBR, irrigation water from canals and sprinkler systems infiltrates and recharges the shallow groundwater systems.

Groundwater in shallow deposits generally flows toward and discharges into streams and the major rivers. Discharge from the consolidated bedrock aquifers is from springs and seeps to the surface, from seepage into streambeds, by upward leakage into the overlying formations, and by downward leakage into underlying formations (BLM 2003).

3.2.6.2 Groundwater Quality

Groundwater in the northern Uinta Basin ranges in chemical quality from relatively good to briny. Fresh to slightly saline water can be found in the shallow aquifers. The highest quality water occurs near the mountains which surround the basin. As the groundwater moves down gradient in the basin, it becomes increasingly saline.

Water quality from the consolidated aquifers is generally high in dissolved solids. According to Hood (1978), the principal ions in groundwater within the Uinta and Green River formations are bicarbonate, carbonate, calcium, magnesium, and sodium. Away from outcrop areas, water quality generally is poorer and becomes much higher in dissolved solids with depth. Groundwater in the Green River Formation beneath the GDBR is most likely very high in dissolved solids (>3,000 mg/L) and, for the most part, not usable. Groundwater in unconsolidated deposits generally reflects the overall water quality of the streams, river, or the recharge sources (i.e. irrigation canal).

In the GDBR, water quality data are virtually nonexistent. According to the Utah Division of Natural Resources (UDNR), all wells drilled to about 300 feet below ground surface have been dry. Therefore, water quality analyses are not available from these wells.

3.2.6.3 Groundwater Use

In the GDBR, permitted groundwater wells are held by private land owners and industries. These rights are issued for wells which are completed in shallow bedrock or unconsolidated alluvial material. Each well permitted has been dry and abandoned. A listing of these rights is presented in Table 3.2-4. Use of groundwater from the Uinta and Green River Formations is limited to livestock watering and industrial uses because of its poor quality in terms of total dissolved solids and hardness.

Table 3.2-4. Groundwater Rights in the GDBR

Applicant	Water Right Number	Point of Diversion	Total Depth of Well (feet)	Geological Unit
QEP	49-251	T8S R21E Section 6	39	NA
QEP	49-279	T8S R21E Section 6	39	NA
QEP	49-280	T8S R21E Section 6	39	NA
QEP	49-296	T8S R20E Section 6	39	NA
QEP	49-297	T8S R20E Section 1	39	NA
NA	NA	T7S, R20E, Section 13	110	Clay (abandoned)
Harvey Burfield	43554512147	T7S, R20E, Section 15	NA	NA
NA	NA	T7S, R21E, Section 20	325	Sandstone
Deseret Generation and Transmission Coop	254357899000 William Curry	T7S, R22E, Section 13	320	Clay and Sand (dry)
Techni-Cor	8012803324A	T7S,R23E, Section 23	300	Uinta Fm (dry)
Deseret Generation and Transmission Coop	254357899000 William Curry	T7S, R23E, Section 17	300	Clay, (dry)
Techni-Cor	8012803324A	T7S, R23E, Section 18	NA	NA
Chevron U.S.A. Production Co.	264357814300 M.E. Alexander	T7S, R23E, Section 21	250	Clay and Sand (dry)
Deseret Generation and Transmission Coop	254357899000 William Curry	T7S, R23E, Section 21	320	Clay and Sand (dry)

Source: http://nrwrtl.nr.state.ut.us/wellinfo/default.htm

3.3 CLIMATE AND AIR QUALITY

Climate and meteorology, the magnitude and spatial distribution of local and regional air pollution sources and chemical properties of pollutants combine to influence the air quality of a region. Within the lower atmosphere, synoptic and local scale air masses interact with regional topography to influence atmospheric dispersion and transport of pollutants. The following sections summarize the climatic conditions and existing air quality in the vicinity of the GDBR.

3.3.1 Climate

The GDBR is located in the Uintah Basin, a semiarid mid-continental climate regime typified by dry windy conditions and limited rainfall. The topography across the GDBR ranges in elevation from about 4,600 to 5,900 feet above sea level. A network of badlands and drainages encompass the area.

The closest climate measurements were recorded at Bonanza, Utah from 1948 to 1993. The Bonanza station is located approximately 16 miles southeast of the GDBR at an elevation of 5,460 feet amsl (Western Regional Climate Center 2003). Table 3.3-1 shows the mean temperature range, mean total precipitation, and mean total snowfall by month.

Air masses originating from the Pacific Ocean are typically interrupted by the western mountain ranges before reaching the Uintah Basin. As a result, the area receives relatively moderate amounts of precipitation. Summer thunderstorms can provide greater amounts of rainfall to the higher elevations of the southern portion of the Basin. The annual mean precipitation at Bonanza is 8.87 inches, and ranges from a minimum of 4.14 inches recorded in 1958, to a maximum of 13.23 inches recorded in 1957. February is the driest month with a monthly mean precipitation of 0.43 inches, and October is the wettest month with a monthly mean precipitation of 1.05 inches. The annual average snowfall is 25 inches. December, January and February are the snowiest months. A maximum annual snowfall of 38.7 inches was recorded in 1951.

The area is typically mild, with an annual mean temperature of 48.1 °F. However, abundant sunshine and rapid nighttime cooling result in a wide daily range in temperature. Average winter temperatures range from 11°F to 34°F, while average summer temperatures range from 54°F to 89°F. Recorded extreme temperatures are minus 32°F in 1990 and 106°F in 1981.

Table 3.3-1. Temperature and Precipitation and Snowfall at Bonanza, Utah (1948-1993)

Month	Average Temperature Range (° Fahrenheit)	Average Total Precipitation (inches)	Average Total Snowfall (inches)
January	7.3 – 30.4	0.58	6.4
February	13.4 – 37.2	0.43	5.3
March	25.1 – 49.9	0.70	4.3
April	34.1 – 63.3	0.79	1.0
May	42.1 – 73.3	1.03	0.0
June	50.1 – 85.3	0.73	0.0
July	57.0 – 92.3	0.83	0.0
August	54.6 – 89.6	0.91	0.0
September	46.5 – 80.9	0.83	0.0
October	35.5 – 66.2	1.05	0.5
November	23.6 – 48.3	0.49	1.7
December	12.7 – 34.8	0.52	5.3
Annual Average	**33.5 – 62.6**	**8.87**	**24.5**

Source: Western Regional Climate Center (2003). Data collected at Bonanza, Utah from 1948 to 1993.

Wind speed and direction, along with vertical profiles of temperature in the lower atmosphere, greatly affect the transport and dispersion of air pollutants. The potential for atmospheric dispersion is relatively high for the area due to the frequency of strong winds and warm temperatures. However, calm periods and nighttime cooling may enhance air stability, thereby inhibiting air pollutant transport and dilution. The area can experience frequent temperature inversions in winter when cold stable air masses settle into the valleys and snow cover and shorter days inhibit ground-level warming. During periods of atmospheric stability, cold air tends to be trapped at the surface and vertical mixing of pollutants is limited. Temperature inversions are less common during the summer months when daytime ground-level heating rapidly leads to inversion break-up and increased vertical mixing.

The nearest comprehensive meteorological data recorded near Bonanza, Utah were available for 1985, 1986, 1987, and 1992 (Utah Department of Environmental Quality - Division of Air Quality 1998). Atmospheric stability can be categorized by stability classes “A” through “F”. The “A” stability class represents a high degree of atmospheric turbulence and a very good pollutant dispersion condition. The “F” stability represents a high degree of atmospheric stability and the worst pollutant dispersion condition. The “D” stability represents a neutral atmosphere. As illustrated in Table 3.3-2, the frequency distribution favors a stable atmosphere (stability classes F and E) the majority of the time, a neutral atmosphere, and turbulent atmosphere.

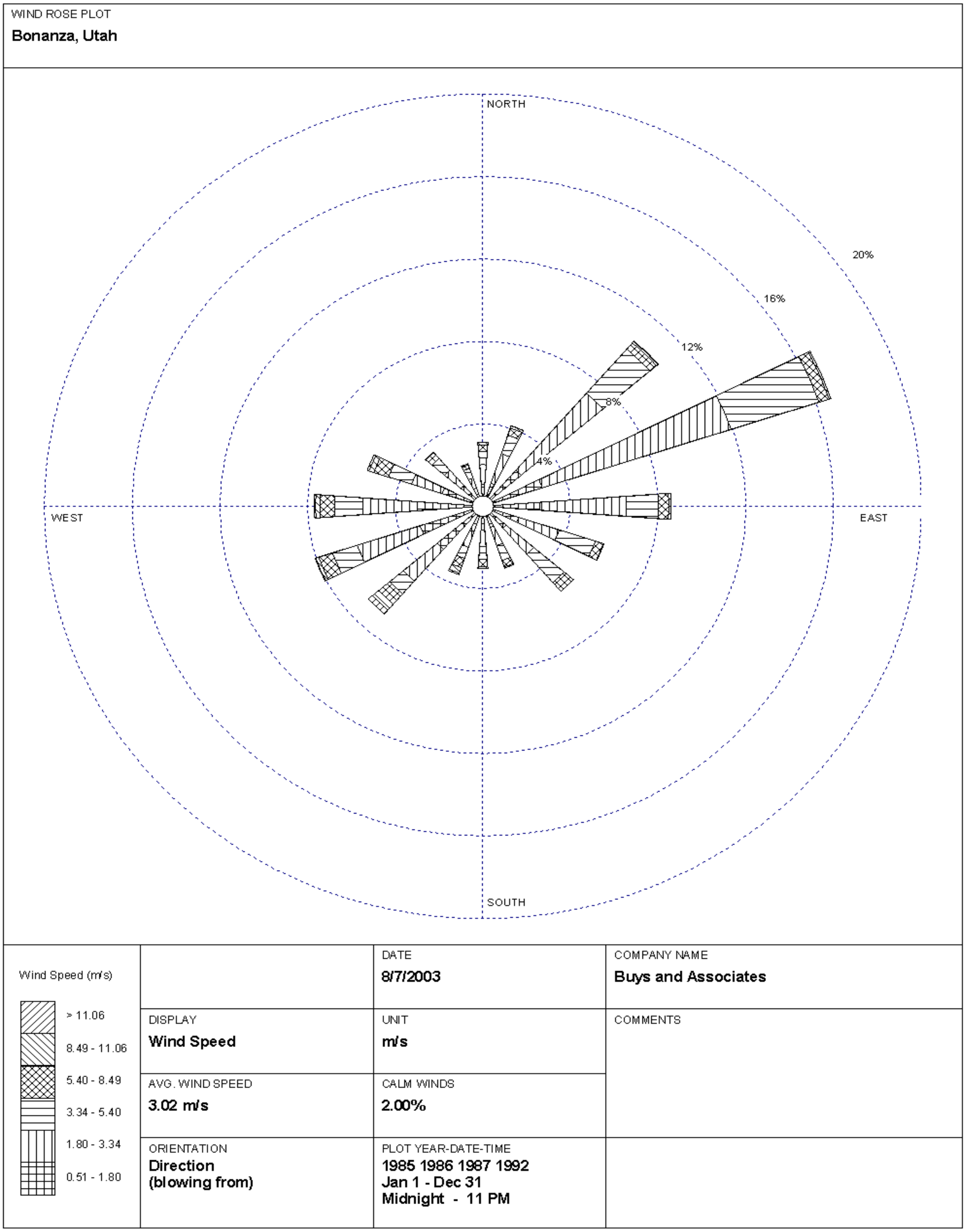
The wind data are shown on Figure 3.3-1, a wind rose depicting wind speed and direction for all four years of data. Note that the data represent the direction from which the wind is blowing. For example, winds blowing from the north would transport pollutants to the south. As shown, winds originate predominately from the east-northeast 16.7 percent of the time. The average measured wind speed is 6.8 miles per hour (3.02 meters/second).

Table 3.3-2. Atmospheric Stability Class Frequency Distribution

Stability Class	Percent Occurrence
A	9.6%
B	6.4%
C	8.3%
D	26.7%
E	31.1%
F	16.0%

Source: Utah Department of Environmental Quality - Division of Air Quality (1998). Meteorological data collected near Bonanza, UT at the Deseret Generating and Transmission power plant for the years 1985, 1986, 1987 and 1992.

Figure 3.3-1 Windrose for Bonanza, Utah



WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com

This page intentionally left blank.

3.3.2 Air Quality

3.3.2.1 Regulatory Environment

The Environmental Protection Agency (EPA) has primary regulatory authority for implementing various environmental statutes established by Congress. EPA retains the authority for implementing the Federal Clean Air Act (CAA) and the permitting and operational compliance of air emission sources within the GDBR.

National and Utah Ambient Air Quality Standards have been promulgated for the purpose of protecting human health and welfare with an adequate margin of safety. Pollutants for which standards have been set include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 10 or 2.5 microns in effective diameter (PM_{10} and $PM_{2.5}$). Existing air quality in the region is acceptable based on standards set for the protection of human health. Uintah County is designated as an attainment area, meaning that the concentration of criteria pollutants in the ambient air is less than the National Ambient Air Quality Standards (NAAQS). Site-specific air quality monitoring data are not available for the GDBR. However, background criteria pollutant concentrations for Uintah County (Table 3.3-3) are relatively low and consistent with a rural area having low levels of industrial development (UDAQ 2003).

Under the Prevention of Significant Deterioration (PSD) provisions, incremental increases of specific pollutant concentrations are limited above a legally defined baseline level. Many national parks and wilderness areas are designated as PSD Class I. The PSD program protects air quality within Class I areas by allowing only slight incremental increases in pollutant concentrations. Areas of the state not designated as PSD Class I are classified as Class II. For Class II areas, greater incremental increases in ambient pollutant concentrations are allowed as a result of controlled growth. The PSD increments for both Class I and II areas are presented in Table 3.3-3.

Table 3.3-3. Ambient Criteria Pollutant Concentrations, National and State Ambient Air Quality Standards, and PSD Increments

Pollutant	Averaging Period(s)	Uintah County Background Concentration[a] ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	PSD Class I Increment ($\mu g/m^3$)	PSD Class II Increment ($\mu g/m^3$)
SO_2	Annual 24-hour 3-hour	5 10 20	80 365 1,300	2 5 25	512 91 20
NO_2	Annual	10	100	2.5	25
PM_{10}	Annual 24-hour	10 28	50 150	4 8	30 17
CO	8-hour 1-hour	1,111 1,111	10,000 40,000	None None	None None

[a] Source: Dave Prey, Utah Division of Environmental Quality - Division of Air Quality (UDAQ), Personal Communication, November 30th, 2005. Data represent UDAQ estimates for rural areas within the Uintah Basin.
[b] Source: EPA AirData Air Pollution Database. PM_{10} Tribal Monitor, Myton, UT, Site ID 490137011. Annual Data from 2002 through 2005 (EPA 2005). 24-hour PM_{10} represents the average of 1st maximum 24-hour values from 2002 though 2005. Annual PM_{10} represents the annual average from 2002 through 2005.

The GDBR and surrounding region is federally designated as a PSD Class II area. The nearest PSD Class I areas are Flat Tops and Maroon Bells Wilderness Areas in Colorado, and Arches and Canyonlands National Parks in Utah. Figure 3.3-2 shows the location of the GDBR with respect to Class I areas and other designated areas of special concern.

Hazardous air pollutants (HAPs) are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental impacts. The EPA has classified 189 air pollutants as HAPs. Examples of listed HAPs include formaldehyde, BTEX compounds (benzene, toluene, ethylbenzene, isomers of xylene), and normal-hexane (*n*-hexane).

The CAA requires EPA to regulate emissions of toxic air pollutants from a published list of industrial sources referred to as "source categories." As required under the Act, EPA has developed a list of source categories that must meet control technology requirements for these toxic air pollutants. Under section 112(d) of the CAA, the EPA is required to develop regulations establishing national emission standards for hazardous air pollutants (NESHAP) for all industries that emit one or more of the pollutants in major source quantities. These standards are established to reflect the maximum degree of reduction in HAP emissions through application of maximum achievable control technology (MACT). Source categories for which NESHAPs have been implemented include Oil and Natural Gas Production and Natural Gas Transmission and Storage.

HAPs associated with oil and gas development include BTEX (benzene, toluene, ethylbenzene, and xylene), formaldehyde and hydrogen sulfide. There are no applicable federal ambient air quality standards for these pollutants. Therefore, reference concentrations (RfC) for chronic inhalation exposure and Reference Exposure Levels (REL) for acute inhalation exposures are applied as significance criteria. Table 4.3-6 shows the RfCs and RELs. RfCs represent an estimate of the continuous (i.e. annual average) inhalation exposure rate to the human population (including sensitive subgroups such as children and the elderly) without an appreciable risk of harmful effects. The REL is the acute (i.e. one-hour average) concentration at or below which no adverse health effects are expected. Both the RfC and REL guideline values are for non-cancer effects.

3.3.2.2 Pollutant Sources and Characteristics

Sources of Air Pollution

Existing sources of air pollution within the GDBR and surrounding region include:

- exhaust emissions, primarily CO, oxides of nitrogen (NO_x), and HAP from existing natural gas fired compressor engines used in production and transportation of natural gas;
- natural gas dehydrator still-vent emissions of BTEX and *n*-hexane;
- gasoline and diesel-fueled vehicle tailpipe emissions of volatile organic compounds (VOC), NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$;
- fugitive dust (PM_{10} and $PM_{2.5}$) from construction activities, vehicle traffic on unpaved roads, wind erosion in areas of soil disturbance, and road sanding during winter months;
- NO_x, SO_2, CO, and PM_{10} emissions from the Bonanza coal-fired power plant; and
- long-range transport of pollutants from distant sources contributing to regional haze.

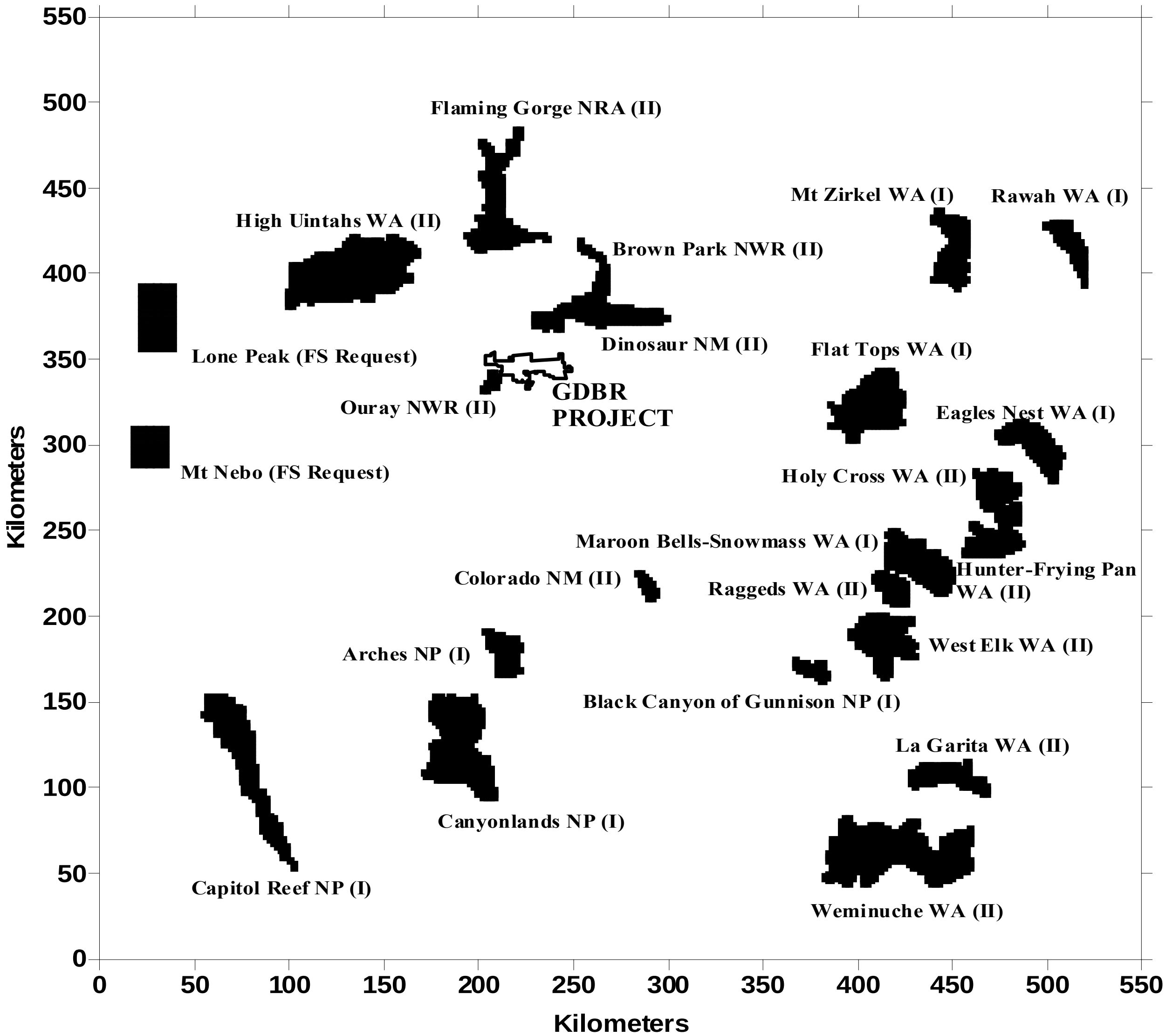


Figure 3.3-2

Nearest Class I/II Areas to GDBR

Criteria Air Pollutants

The term NO_X is used to describe the combination of nitrogen monoxide (NO), NO_2, and other nitrogen oxides including dinitrogen oxide (N_2O). The National Ambient Air Quality Standard refers only to NO_2, rather than all species of NO_X. Nitrogen oxides are by-products from the combustion of fossil fuels. The primary sources of anthropogenic NO_X include automobiles and power plants. Furnaces and gas stoves also contribute to NO_X emissions. Most NO_X emissions are emitted in the form of NO, which is not stable in the atmosphere and is eventually converted to NO_2. Nitrogen dioxide is a toxic, reddish-brown gas that is reactive in the atmosphere and plays a role in the formation of smog. Short-term human exposures (e.g. less than 3 hours) to elevated levels of NO_2 may lead to changes in airway responsiveness and lung function in individuals with pre-existing respiratory illness. Long-term human exposure to NO_2 may lead to increased susceptibility to respiratory infection and may cause alterations in the lung. Nitrogen oxides also contribute to the formation of acid rain and to visibility impairment.

Carbon monoxide is formed when fossil fuels are not burned completely. Nation-wide, the primary source of CO is automobile emissions. Other sources of CO include industrial processes, non-transportation fuel combustion and forest fires. Carbon monoxide is a colorless, odorless gas that is poisonous in high concentrations. When humans are exposed to CO, the gas enters the bloodstream through the lungs and reduces oxygen delivery to the body’s organs and tissues. Reduced work capacity, reduced manual dexterity, poor learning capacity and difficulty in performing complex tasks are associated with exposure to elevated levels of CO.

Sulfur dioxide belongs to the family of sulfur oxide gases (SO_x). These gases are highly soluble in water. Sulfur is prevalent in many raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SO_x gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil or metals are extracted from ore. SO_2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and the environment. Health effects of SO_2 exposure range from short-term breathing difficultly to longer-term respiratory illness. SO_2 also contributes to the formation of acid rain and to visibility impairment.

Ground-level O_3 is not directly emitted as a pollutant from industrial sources. Rather, it is a gas created by a chemical reaction between NO_X and VOCs in the presence of heat and sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOC that help to form ozone. Sunlight and hot weather cause ground-level ozone to form in high concentrations in the air. As a result, it is generally known as a summertime air pollutant. Ozone can be transported great distances and therefore contributes to air pollution issues on a regional scale. Primary health effects from O_3 exposure range from breathing difficulty to permanent lung damage. Ground-level ozone also contributes to plant and ecosystem damage.

Particulate matter, or PM**,** is the term for particles found in the air, including dust, dirt, soot, and smoke. Particulate matter is further classified as total suspended particulates (TSP), particulate matter less than 10 microns in diameter (PM_{10}) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). Particulate matter may be emitted directly to the atmosphere from mobile and stationary sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and wood burning. Additionally, PM may be generated from secondary chemical reactions in the atmosphere involving oxides of nitrogen and sulfur. The primary health hazard stems from inhalation of fine particulate matter or $PM_{2.5}$. Environmentally, particulate matter in the form of atmospheric sulfates and nitrates, organics, and elemental carbon (soot), represents the primary source of visibility impairment and contributes to acid deposition.

Hazardous Air Pollutants

Formaldehyde is an irritant to humans. Acute (short-term) and chronic (long-term) exposures can result in eye, nose and throat irritation and respiratory symptoms including coughing, wheezing and bronchitis. In addition, the Environmental Protection Agency (EPA) has classified formaldehyde as a Group A, probable human carcinogen of medium carcinogenic hazard (EPA 1994). The highest levels of airborne formaldehyde have been found in indoor air, where it is released from various consumer products (EPA 2002). One survey (EPA 1988) reports measured formaldehyde levels in homes ranging from 0.10 to 3.68 parts per million (ppm), or 122 to 4,520 $\mu g/m^3$.

Benzene emissions typically result from coal and oil combustion, volatilization from gasoline service stations, and motor vehicle exhaust. Acute inhalation exposure to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia. Adverse reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidences of leukemia (cancer of the tissues that form white blood cells) have been observed in humans occupationally exposed to benzene. EPA has classified benzene as a Group A, human carcinogen (EPA 1994).

Additional BTEX compounds including toluene, ethylbenzene, and xylene, as well as *n*-hexane, are of concern for both acute and chronic health effects. EPA has classified these compounds as a Group D, not classifiable as to human carcinogenicity (EPA 1994). These compounds are released to the atmosphere through a variety of pathways, including volatilization through their use as solvents, as fugitive emissions from industrial sources, and through automobile exhaust.

3.3.2.3 Air Quality Related Values

Class I areas and some Class II areas of special concern are monitored for Air Quality Related Value (AQRV) impacts. These AQRVs include acidic deposition and visibility impairment.

Atmospheric Deposition

Atmospheric deposition refers to the processes by which air pollutants are removed from the atmosphere and deposited on terrestrial and aquatic ecosystems, and is reported as the mass of material deposited on an area in a period of time (kilograms per hectare per year or kg/ha/yr). Air pollutants are deposited by wet deposition (precipitation) and by dry deposition (gravitational settling of particles and adherence of gaseous pollutants). Total deposition refers to the sum of airborne material transferred to the Earth’s surface by both wet and dry deposition.

Acid Neutralization Capacity

Aquatic bodies such as lakes and streams are important resources in most Class I areas. Acid deposition resulting from industrial emissions of sulfur and nitrogen based compounds has a direct effect on the acid neutralization capacity (ANC) of sensitive lake ecosystems. Table 3.3-4 shows background ANC data for lakes identified by the USDA – Forest Service within PSD Class I and II area located in the project region.

Table 3.3-4. Measured Acid Neutralizing Capacity of Sensitive Lakes Within Nearby PSD Class I and II Areas

Location	Sensitive Lake	Background ANC (µeq/l)	Watershed Area (acres)
Eagle's Nest WA	Booth	84.1	138
Flat Tops WA	Ned Wilson	38.0	124
Holy Cross WA	Blodget	36.9	127
Maroon Bells WA	Moon	51.5	397
Raggeds WA	Deep Creek #1	44.3	360
West Elk WA	S. Golden	111.0	112

µeq/l – microequivalents per liter
Source: USDA-Forest Service (2001)

Visibility

Visibility is characterized by three parameters; standard visual range (SVR), the light-extinction coefficient (b_{ext}), and impairment expressed as deciview. The visual range parameter represents the greatest distance that a large dark object can be seen. The light extinction coefficient represents the attenuation of light per unit distance due to scattering and absorption by gases and particulate matter in the atmosphere. Good visibility conditions are represented by long visual ranges and low light extinction values, while poor visibility conditions are represented by short visual ranges and high light extinction.

Visibility impairment is expressed in terms of deciview (dv). The deciview index was developed as a linear perceived visual change. A change in visibility of 1.0 dv represents a "just noticeable change" by the average person under most circumstances. Increasing deciview values represent proportionately larger perceived visibility impairments.

Visibility conditions within the Uintah Basin are reported to be very good. No background visibility data is available specifically for the Project Area. However, the nearest measurements, recorded at nearby Class I areas, are available from the FLAG (2000) report. An average annual visual range of 251 km (b_{ext} of 15.6) is reported for Arches and Canyonlands National Parks (representative of central and eastern Utah), and 249 km (b_{ext} of 15.7) for Flat Tops Wilderness Area (representative of western Colorado). These areas are considered to have good visibility conditions.

3.4 SOIL RESOURCES

Elevation within the GDBR ranges from approximately 4,664 to 5,862 feet above mean sea level (amsl). The two major drainages in the GDBR include Baser Wash and Kennedy Wash. The Green River flows along the western side of the GDBR. Annual precipitation within the GDBR is less than 10 inches (Western Regional Climate Center 2003).

Soils within the GDBR are distributed according to the major soil forming factors. In this arid environment, the factors primarily include climate (effective moisture and temperature), parent material, and topographic position and slope. Baseline soil information was obtained from county-wide data (USDA-NRCS 1997) based on potential or existing agricultural mapping prompted by the 1995 Farm Bill. According to Order 3 level soil survey maps (USDA-NRCS 1981 and 1982), there are 43 soil associations within the GDBR. The distribution of these soil types is shown on Figure 3.4-1. Some of these associations are composed of the same soil series components but occur on different slopes. Table 3.4-1 summarizes the 43 soil units identified in the Order 3 mapping and lists the map symbol, map classification, soil name, slope, drainage class, water capacity, hydrological group, runoff class, pH range, wind erodibility group, and potential erosion hazard.

The Uintah Area Soil Survey rates each of the soil series as having a slight, moderate, or severe water and wind erosion hazard. These ratings were developed using soil erodibility, water capacity, and runoff and drainage classes, as defined in the National Soil Survey Handbook (NRCS 2003). The erosion hazards become critical issues when protective vegetation is removed during and following construction activities such as road and well pad construction. Typically, soils found on steeper slopes have a high erosion hazard and soils found on gentler slopes have a low erosion hazard. Soils with more fines are at greater risk of wind erosion, and soils with more gravel and/or stones have a lower risk of wind erosion.

Hydrologic groups are used to estimate precipitation runoff where soils are not protected by vegetation. The groups (labeled A through D) are based on infiltration of water when soils are thoroughly wet. In general, the runoff amount increases with a slower the rate of infiltration. Group A soils have high rates of infiltration when thoroughly wet; Group B soils have moderate rates of infiltration; Group C soils have a slow rate of infiltration; and Group D soils have a very slow rate of infiltration. Within the GDBR, 1,520 acres have Group A characteristics, 52,340 acres have Group B characteristics, 547 acres are categorized Group C, and the remaining 47,086 acres are designated Group D. Therefore, approximately 46 percent of the GDBR has soils that demonstrate a low rate of precipitation infiltration and therefore a high rate of precipitation runoff.

Soil suitability for reclamation is described by the USFS (1979). A soil is defined as “having poor potential for reclamation” if it meets any of the following criteria:

- Clay content greater than 60 percent;
- Coarse fragments greater than 35 percent by volume;
- pH less than 4.5 or greater than 9.1; or
- Salinity greater than 9 mmhos/cm.

The soils in the GDBR have the following characteristics:

- Fourteen of the 43 soil units in the GDBR have soils that are classified as hydrological Group D;
- Eleven of the 43 soil units in the GDBR have soils that are rated as having severe erosion hazard potential;
- Seven of the 43 soil units in the GDBR are found on slopes greater than 40%;
- Six of the 43 soil units in the GDBR have soils that are rated as having a high wind erodibility factor; and
- Sixteen of the 43 soil units in the GDBR have soils that are classified as unsuitable for reclamation, based on strongly alkaline (pH > 9) soil factors.

Combining all of these soil characteristics, the erosion potential within the GDBR is severe on 47,375 acres, moderate on 37,918 acres, and slight on 13,582 acres.

BLM has developed Standards and Guidelines for Healthy Rangelands. One category of these standards includes soils management. The standard states that upland soils should exhibit permeability and infiltration rates that sustain or improve site productivity, considering the soil type, climate, and landform. Criteria to indicate the success is:

- Sufficient cover and litter to protect the soil surface from excessive water and wind erosion, promote infiltration, detain surface flow, and retard soil moisture loss by evaporation;

- The absence of indicators of excessive erosion such as rills, soil pedestals, and actively eroding gullies; and

- The appropriate amount, type, and distribution of vegetation reflecting the presence of the Desired Plant Community where identified in a land use plan or where the Desired Plant Community is not identified, a community that equally sustains the desired level of productivity and properly functioning ecological conditions.

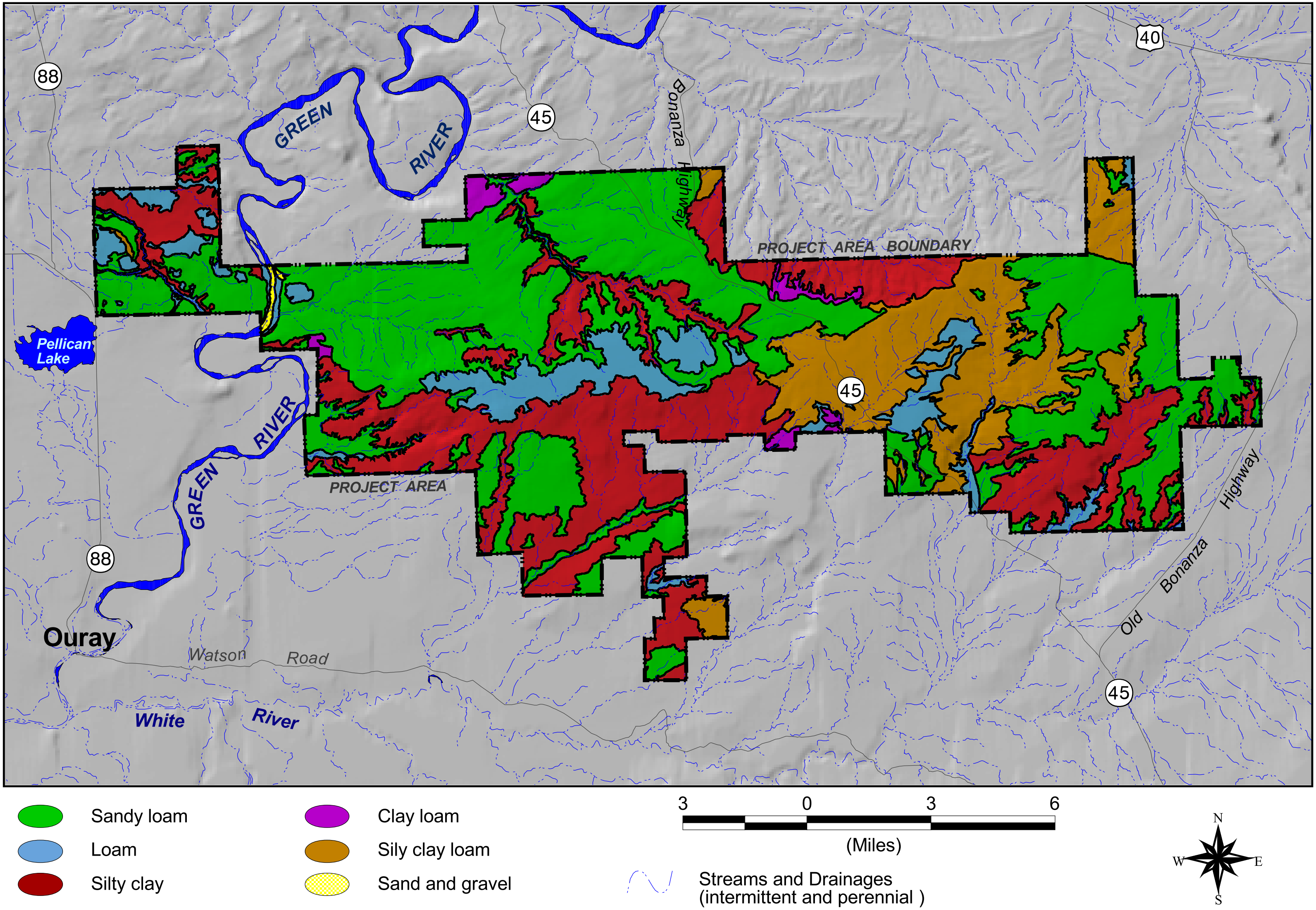


Figure 3.4-1. Mapped Soil Types within the Greater Deadman Bench Project Area.

This page intentionally left blank

Table 3.4-1. Soil Characteristics of the GDBR

Map Symbol	Map Classification Unit	Soil Name	Slope	Drainage Class	Water Capacity	Hydrological Group	Runoff Class	pH Range	Wind Erodibility Group	Potential Erosion Hazard
8	Badland-Denco complex	Denco	4 to 25%	WD	Moderate	D	Very High	7.9-9	4l	Severe
9	Badland-Montwel complex	Montwel	50 to 90%	WD	Moderate	C	Very High	7.9-9	4L	Severe
15	Badland-Wentridge complex	Wentridge	50 to 80%	WD	Low	C	High	7.9-8.4	4L	Severe
65	Denco silty clay loam	Denco	8 to 25%	WD	Moderate	D	Very High	7.9-9	4L	Severe
66	Denco-Gerst complex	Denco	4 to 25%	WD	Moderate	D	Very High	7.9-9	4L	Severe
66	Denco-Gerst complex	Gerst	4 to 40%	WD	Very Low	D	Very High	7.9-9	4L	Severe
94	Greybull-Utaline-Badland complex	Greybull	20 to 50%	WD	Low	C	High	7.9-9	6	Severe
94	Greybull-Utaline-Badland complex	Utaline	8 to 25%	WD	Low	B	Med	7.9-9	6	Severe
95	Hanksville silty clay loam	Hanksville	2 to 25%	WD	Low	C	Very High	7.9-9	4L	Severe
137	Mikim loam	Mikim	3 to 15%	WD	High	B	Med	7.9-9	4L	Severe
142	Milok-Montwel-Badland association	Montwel	4 to 25%	WD	Moderate	C	High	7.9-9	4L	Severe
149	Montwel-Tipperary-Rock outcrop association	Montwel	4 to 25%	WD	Moderate	C	High	7.9-9	4L	Severe
208	Shotnick-Ioka complex	Shotnick	4 to 25%	WD	Moderate	B	Low	7.9-9	2	Severe
2	Abracon loam	Abracon loam	3 to 8%	WD	High	B	Med	7.9-9	4L	Moderate
13	Badland-Tipperary association	Tipperary	1 to 8%	SED	Low	A	Very Low	7.9-9	2	Moderate
64	Denco silty clay loam	Denco	2 to 8%	WD	Low	D	Very High	7.9-11	4L	Moderate
102	Hideout-Badland-Rock outcrop complex	Hideout	2 to 8%	WD	Very Low	D	Very High	7.9-8.4	3	Moderate
141	Milok fine sandy loam	Milok	3 to 8%	WD	Moderate	B	Low	7.9-9	3	Moderate
142	Milok-Montwel-Badland association	Milok	3 to 8%	WD	Moderate	B	Low	7.9-9	3	Moderate
149	Montwel-Tipperary-Rock outcrop association	Tipperary	1 to 8%	SED	Low	A	Very Low	7.9-9	2	Moderate

Map Symbol	Map Classification Unit	Soil Name	Slope	Drainage Class	Water Capacity	Hydrological Group	Runoff Class	pH Range	Wind Erodibility Group	Potential Erosion Hazard
160	Nakoy loamy fine sand	Nakoy	1 to 5%	WD	Moderate	B	Very Low	7.9-9	2	Moderate
163	Nolava-Nolava wet complex, 2 to 4% slopes	Nolava	2 to 4%	WD	High	B	Low	7.9-9	4L	Moderate
163	Nolava-Nolava wet complex, 2 to 4% slopes	Nolava wet	2 to 4%	MWD	High	B	Low	7.9-9	4L	Moderate
167	Ohtog-Parohtog complex, 2 to 4% slopes	Ohtog	2 to 4%	WD	High	B	Low	7.9-9	4L	Moderate
167	Ohtog-Parohtog complex, 2 to 4% slopes	Parohtog	2 to 4%	MWD	High	B	Low	7.9-9	4L	Moderate
174	Pariette loam	Pariette	2 to 4%	WD	Low	C	Med	7.9-11	4L	Moderate
206	Shotnick loamy sand, 2 to 4% slopes	Shotnick	2 to 4%	WD	Moderate	B	Very Low	7.9-9	3	Moderate
208	Shotnick-Ioka complex	Ioka	4 to 25%	ED	Very Low	A	Low	7.9-9	6	Moderate
213	Solirec-Abracon-Begay complex	Solirec	3 to 8%	WD	High	B	Med	7.4-9	3	Moderate
213	Solirec-Abracon-Begay complex	Abracon loam	3 to 8%	WD	High	B	Med	7.9-9	4L	Moderate
213	Solirec-Abracon-Begay complex	Begay	2 to 15%	WD	Moderate	B	Low	7.9-9	3	Moderate
229	Tipperary loamy fine sand	Tipperary	1 to 8%	SED	Low	A	Very Low	7.9-9	2	Moderate
241	Turzo complex	Turzo	2 to 4%	WD	High	B	Med	7.9-9	4L	Moderate
241	Turzo complex	Turzo	2 to 4%	WD	Moderate	B	Med	8.5-9	4L	Moderate
23	Blackston loam	Blackston	0 to 2%	WD	Low	B	Low	7.9-9	4L	Slight
88	Green River loam (occasionally flooded)	Green River	0 to 2%	MWD	Low	C	Low	8.5-9	4L	Slight
89	Green River loam (rarely flooded)	Green River	0 to 2%	MWD	Low	C	Low	7.9-9	4L	Slight
104	Hiko Springs fine sandy loam	Hiko Springs	0 to 2%	WD	Low	B	Very Low	7.9-11	3	Slight
120	Jenrid sandy loam	Jenrid	0 to 2%	WD	Low	B	Low	7.9-11	3	Slight
121	Jenrid-Eghelm complex	Jenrid	0 to 2%	WD	Low	B	Low	7.9-11	3	Slight
121	Jenrid-Eghelm complex	Eghelm	1 to 3%	WD	Low	B	Low	7.9-8.4	4L	Slight

Map Symbol	Map Classification Unit	Soil Name	Slope	Drainage Class	Water Capacity	Hydrological Group	Runoff Class	pH Range	Wind Erodibility Group	Potential Erosion Hazard
162	Nolava-Nolava wet complex, 0 to 2% slopes	Nolava	0 to 2%	WD	High	B	High	7.9-9	4L	Slight
162	Nolava-Nolava wet complex, 0 to 2% slopes	Nolava wet	0 to 2%	MWD	High	B	Low	7.9-9	4L	Slight
166	Ohtog-Parohtog complex, 0 to 2% slopes	Ohtog	0 to 2%	WD	High	B	Low	7.9-9	4L	Slight
166	Ohtog-Parohtog complex, 0 to 2% slopes	Parohtog	0 to 2%	MWD	High	B	Low	7.9-9	4L	Slight
176	Parohtog loam	Parohtog	0 to 2%	SPD	Moderate	C	Low	7.9-9	4L	Slight
205	Shotnick loamy sand, 0 to 4% slopes	Shotnick	0 to 4%	WD	Moderate	B	Very Low	7.9-9	2	Slight
209	Shotnick-Walkup complex	Shotnick	0 to 2%	WD	Moderate	B	Very Low	7.9-9	3	Slight
209	Shotnick-Walkup complex	Walkup	0 to 2%	MWD	Moderate	B	Very Low	7.4-8.4	3	Slight
242	Turzo loam	Turzo	0 to 4%	WD	Moderate	B	Med	8.5-11	4L	Slight
243	Turzo-Umbo complex	Turzo	0 to 2%	WD	High	B	med	7.9-9	4L	Slight
243	Turzo-Umbo complex	Umbo	0 to 2%	MWD	High	B	med	7.9-9	4L	Slight
248	Uffens loam	Uffens	0 to 3%	WD	Moderate	C	Med	8.5-11	4L	Slight
275	Wyasket loam	Wyasket	0 to 2%	PD	Moderate	D	Med	7.4-9	4L	Slight
283	Yonic sandy loam	Yonic	0 to 2%	SPD	High	C	Very Low	7.9-9	4L	Slight
8	Badland-Denco complex	Badland	4 to 25%	SED	Very Low	D	Very High	7.9-11	4	NR
9	Badland-Montwel complex	Badland	50 to 90%	SED	Very Low	D	Very High	7.9-11	4	NR
12	Badland-Rock outcrop complex	Badland	1 to 100%	SED	Very Low	D	Very High	7.9-11	4	NR
12	Badland-Rock outcrop complex	Rock outcrop	1 to 100%	SED	Very Low	D	Very High	7.9-11	8	NR
13	Badland-Tipperary association	Badland	1 to 8%	SED	Very Low	D	Very High	7.9-11	4	NR
15	Badland-Wentridge complex	Badland	50 to 80%	SED	Very Low	D	Very High	7.9-11	4	NR
94	Greybull-Utaline-	Badland	8 to 50%	SED	Very Low	D	Very	7.9-11	4	NR

Map Symbol	Map Classification Unit	Soil Name	Slope	Drainage Class	Water Capacity	Hydrological Group	Runoff Class	pH Range	Wind Erodibility Group	Potential Erosion Hazard
	Badland complex						High			
102	Hideout-Badland-Rock outcrop complex	Badland	2 to 8%	SED	Very Low	D	Very High	7.9-11	4	NR
102	Hideout-Badland-Rock outcrop complex	Rock outcrop	1 to 100%	SED	Very Low	D	Very High	7.9-11	8	NR
142	Milok-Montwel-Badland association	Badland	3 to 25%	SED	Very Low	D	Very High	7.9-11	4	NR
149	Montwel-Tipperary-Rock outcrop association	Rock outcrop	1 to 100%	SED	Very Low	D	Very High	7.9-11	8	NR
181	Gravel Pits	Gravel Pits	0 to 3%	NR	Very Low	A	NR	NR	8	NR
191	Riverwash	Riverwash	0 to 4%	NR	Very Low	D	NR	NR	1	NR

Drainage Classes: PD - Poorly Drained; SWD - Somewhat Poorly Drained; MWD - Moderately Well Drained; WD - Well Drained; SED - Somewhat Excessively Drained; ED - Excessively Drained.
Hydrological Groups: A - soils have high rates of infiltration when thoroughly wet; B - soils have moderate rates of infiltration; C - soils have a slow rate of infiltration; and D - soils have a very slow rate of infiltration.
Wind Erodibility Groups: 1-3 = low; 4-5 = medium; 6-8 = high

3.5 VEGETATION

3.5.1 Regional Overview

Various vegetative communities exist primarily because of the variation in elevation in the Uintah Basin. Arid and semi-arid desert shrub communities, primarily consisting of saltbush, shadscale, rabbitbrush, greasewood and horsebrush are found within the lower elevation areas of the Uintah Basin. As the plateau gently rises, the vegetation generally shifts to sagebrush, pinyon-juniper woodlands, and then to mixed coniferous forests. Riparian corridors and grasslands also occur along perennial streams and springs throughout the basin.

The composition and extent of native plant communities within the Uinta Basin have been modified primarily by livestock grazing and by the development and extraction of oil and gas resources. Livestock grazing has decreased native plant species composition and has promoted establishment of annual weeds such as cheatgrass, Russian thistle and halogeton. Noxious weeds such as Russian knapweed have been found in the unit in association with the oil and gas activities and existing roads. In general, while populations of undesirable weedy species are common where native plant communities have been disturbed or removed, they vary in density within undisturbed communities, depending on the health and species diversity of the native vegetative community. Past grazing and drought have also contributed to the loss of shrubs in the Desert Shrub Community type.

3.5.2 Vegetative Communities

The vegetation communities identified in this section are described using the existing Automated Geographic Reference Center (AGRC 1987) vegetative distribution data. Elevation in the GDBR ranges from 4,700 to 5,800 feet, and vegetative communities are directly related to these fluctuations. Seven vegetative communities occur within the GDBR: pinyon-juniper woodlands, sagebrush shrub, desert shrub, grassland, riparian, badlands, and desert sands (Figure 3.5-1). Each community type is described in detail below.

3.5.2.1 Pinyon-Juniper Woodlands

The higher elevation areas of the GDBR from 5,500 to 5,800 feet support mature stands of Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus edulis*), which occurs on almost all slopes and aspects at these elevations. At lower elevations, density of these species decrease, and Utah juniper dominates pinyon pine. Associated understory species include black sage (*Artemisia nova*), Wyoming big sagebrush (*Artemisia tridentate* ssp. w*yomingensis*) and shadscale (*Atriplex confertifolia*). The pinyon-juniper vegetation community is generally rooted in shallow, stony soil primarily in the northern portions of the GDBR near Walker Hollow and the head of Baeser Wash.

3.5.2.2 Sagebrush Shrub

At lower elevations in the GDBR, pinyon-juniper woodlands develop into sagebrush dominated shrublands. These shrublands contain mostly Wyoming big sagebrush and black sagebrush This community may be co-dominant with a variety of perennial grasses such as Sandburg bluegrass (*Poa secunda*), needle-and-thread grass (*Stipa comata*), sand dropseed (*Sporobolus cryptandrus*), western wheatgrass (*Agropyron smithii*), Indian ricegrass (*Stipa hymenoides*), galleta grass (*Hilaria jamesii*), and localized populations of cheatgrass (*Bromus tectorum*). The sagebrush shrub community is found in the eastern half of the GDBR primarily on the ridge tops of Kennedy Wash and on the southern portions of Walker Hollow.

3.5.2.3 Desert Shrub

The desert shrub vegetative community tends to be variable in its composition and dominance by shadscale (*Atriplex confertifolia*), fourwing saltbush (*Atriplex canescens*), rabbitbrush (*Chrysothamnus viscidiflorus*), and greasewood (*sacrobatus vermiculatus*). Soils in this community group range from shallow clay loam to deep sands, which along with soil chemistry have set the pattern of shrub dominance and species composition on various sites. Winter grazing by sheep has also changed species composition in some areas of the unit, increasing the density of greasewood, snakeweed (*Guiterrezia microphala*), and horsebush (*Tetradymia glabrata*) within the community type. The desert shrub community is the most dominant and variable vegetative community in the GDBR and is found throughout its' landscape. Transition areas of this community with Badlands and Rock Outcropping tend to have shallow soils, have low water holding capacity and are sparsely vegetated.

3.5.2.4 Riparian Corridors

Plant species found with the GDBR riparian habitats include Fremont cottonwood (*Populus fremontii*), cattails (*Typha sp*.), some willow species (*Salix sp*.), as well as characteristic sedges (*Carex sp*.), rushes (*Juncus sp*.), and saltgrass. Tamarisk (*Tamarix ramosissima*) is a County listed noxious plant that has become a dominant species in the riparian community. Russian olive (*Elaeagnus angustifolia*) and perennial pepperweed (*Lepidium latifolium*) are also becoming dominant weed species in the riparian communities, especially along the Green River. Riparian habitat is associated with the Green River, which passes through the western edge of the GDBR.

3.5.2.5 Badlands

Badlands are areas of severe erosion, usually found in semi-arid climates characterized by countless gullies, steep ridges, and sparse vegetation. Steep eroding slopes are generally devoid of vegetation except for a few annuals that emerge in the spring when moisture conditions are favorable. Gardner's saltbush (*Atriplex gardneri*) and mat saltbush (*Atriplex corrugate*) grow on the toe slopes and areas of sediment deposition. The Badlands consist of unconsolidated siltstone and claystone that are highly erodible by the generally short, heavy showers that sweep away the loose soil surfaces. Depressions gradually deepen into gullies. These areas are present throughout the central portions of the GDBR primarily around Baesar Wash and the Wonsits Valley.

3.5.3 Invasive and Noxious Weeds

Undesirable, weedy, herbaceous species occur to varying degrees within disturbed areas throughout the GDBR. The BLM Weed Management Program of inventory mapping and control measures currently shows occurrences of noxious weeds in the GDBR listed by the State of Utah including Canada thistle (*cirsium arvense*), field bindweed (*Convolvulus arvensis*), hoary cress (*Cardaria draba*), Russian knapweed (*Centaurea repens*), and perennial pepperweed (*Lepidium latifolium*). Salt cedar (*Tamarix ramosissima*) is a Uintah County listed noxious weed that occurs in the GDBR along drainages, ponds, and sites where water collects along roads. Occurrences of Canada thistle, Russian knapweed, field bindweed, and hoary cress are associated with facilities, pads and roads in the GDBR as a result of oil and gas development. Vehicles and construction equipment are the primary vectors for the seed of these species entering the area. The BLM and Uintah County work together to control weeds. Additionally, industry also controls weeds on lands they develop.

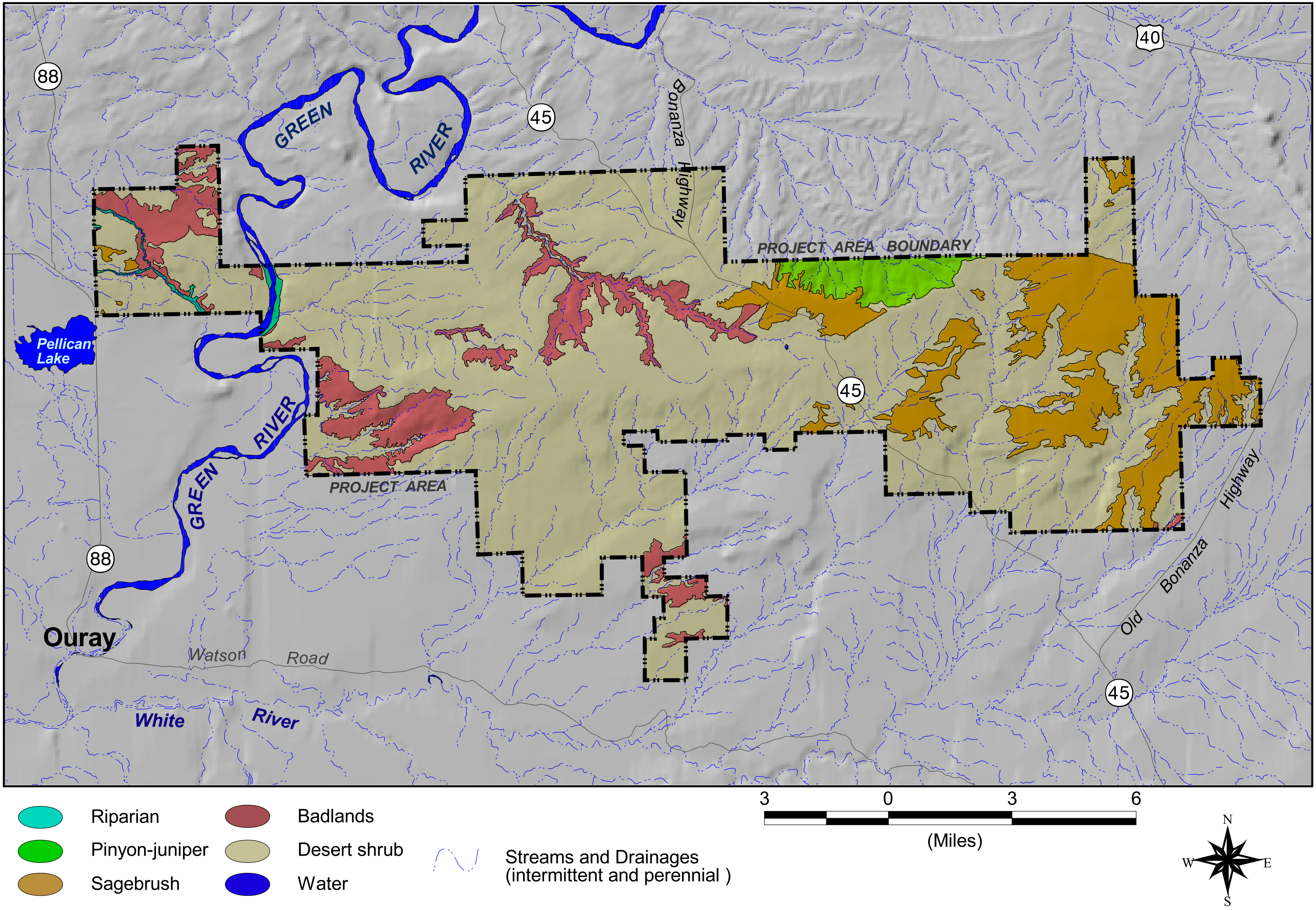


Figure 3.5-1. Vegetation Communities within the Greater Deadman Bench Project Area.

This page intentionally left blank