Bull Canyon Dinosaur National Monument, Adjacent-North, Area

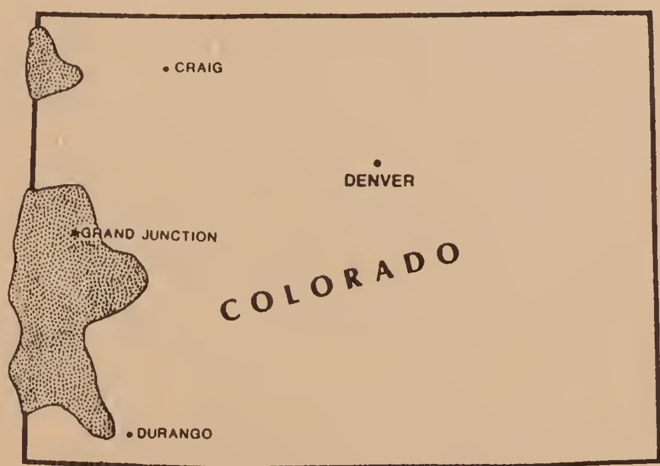
GEOLOGICAL RESOURCE AREA (GRA) 2

FINAL REPORT

PHASE 1: GEM

(GEOLOGICAL, ENERGY and MINERALS)

RESOURCE ASSESSMENT FOR REGION 4, COLORADO PLATEAU



SUBMITTED TO:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
DENVER SERVICE CENTER
DENVER, COLORADO 80225

MSME/WALLABY ENTERPRISES
A JOINT VENTURE OF
MOUNTAIN STATES MINERAL ENTERPRISES, INC.
and WALLABY ENTERPRISES, INC.

FINAL REPORT

PHASE 1: GEM

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RESOURCE ASSESSMENT FOR REGION 4, COLORADO PLATEAU

BULL CANYON

DINOSAUR NATIONAL MONUMENT ADJACENT - NORTH, AREA

GRA 2

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TABLE OF CONTENTS

FOREWORD

This report is one of a series of eleven reports addressing the Wilderness Study Areas (WSA's) located in what has been designated as the Colorado Plateau, Region 4, by the Bureau of Land Management (BLM), Denver Federal Center. The study was under the direction of Mr. Robert J. Coker, the Contracting Officer's Authorized Representative (COAR).

The WSA's have been segregated into eleven G-E-M (Geology, Energy, Minerals) Resources Areas (GRA's). Each designated GRA constitutes one report. The purpose of these reports is to assess the potential for geology, energy and mineral (GEM) resources existing within a WSA and GRA. This information will then be used by BLM geologists in completing the assessment for GEM resources potential within the WSA's, and for the integration with other resource data for the decision on suitability for recommendation of the respective WSA.

The reports were developed and prepared by the Joint Venture team of MSME/Wallaby Enterprises, Tucson, Arizona, by Patricia J. Popp (Geologist), and Barbara J. Howie (Geologist) under the direction of Eric A. Nordhausen (Project Manager) and Richard Lundin (Principal Investigator), under BLM Contract No. YA-553-CT2-1041.

Consulting support was provided by a highly specialized geological team composed of: Ted Eyde, Dr. Paul Gilmour, Dr. Robert Carpenter, Dr. Donald Gentry, Dr. Edger Heylmun, Dr. Larry Lepley, Annon Cook, Walter Heinrichs, Jr., and Charles Campbell. Their contribution is both acknowledged and appreciated. The work of Dr. Gilmour, Dr. Carpenter and Dr. Lepley should receive special acknowledgement. It was from the work of these consultants that this report on the Bull Canyon/Dinosaur National Monument Adjacent-North GRA was able to be completed.

EXECUTIVE SUMMARY

The BLM has adopted a two-phase procedure for the integration of geological, energy and minerals (GEM) resources data for suitable/nonsuitable decisions for Wilderness Study Areas (WSA's). The two-phased approach permits termination of a GEM resources data gathering effort at the end of Phase One. The objective of this Phase One GEM resources assessment is the evaluation of existing data (both published and available unpublished data) and their interpretation for the GEM resources potential of the WSA's incuded in each region. Phase Two is designed to generate new data needed to support GEM resources recommendations.

Over 10 million acres of WSA's require GEM resources data input. These WSA's are unequally distributed in eleven western states of the coterminous United States. The WSA's are grouped in six large regional areas. The WSA's within the western part of Colorado, and a few crossing into Utah, were included as Region 4, also known as the Colorado Plateau Region. Except for one small area at the southwest extreme of the region and another at the north extreme, the region is within the northern half of the known Colorado Plateau physiographic province.

The 32 WSA's within Region 4 encompass 474,620 acres. These have been geographically segregated within 11 designated GEM Resource Areas (GRA's). This report addresses the Bull Canyon/Dinosaur National Monument Adjacent-North area, GRA 2. Within the GRA is the Bull Canyon WSA (CO-010-001 & UT-080-419), and Dinosaur Adjacent-North (Unit 224: CO-010-224; Unit 224A: CO-010-224A; Unit 226: CO-010-226; Unit 228: CO-010-228; Unit 229D: CO-010-229D).

The geology of the GRA consists of gentle mountain and valley areas, cut in part by the Yampa River. The rocks are mostly sedimentary, containing mineralized areas. In addition, faults in the area have acted to mineralize base and precious metals.

The mineral resources of the GRA include coal, uranium, base and precious metals, construction stone, clay, and sand and gravel. The coal, uranium, construction stone, and clay occur in various formations of sedimentary rocks. Copper, lead, zinc, iron, manganese, and silver are found localized by faults that occur in the GRA.

The WSA's (see Figure 1-1 and Overlay A) in the GRA consist mostly of sedimentary formations with little or no mineralization. Unit CO-010-226, which contains copper mineralization in a faulted zone, is the only block in Dinosaur Adjacent-North WSA to have mineralization. Bull Canyon WSA does not have any known deposits.

The classification for the occurrences of leasable minerals, locatable and salable resources varies. Due to lack of published literature and geologic field information, there is an unknown potential for leasable resources in the GRA. There is moderate favorability for locatable resources (base and precious metals) in the Dinosaur AdjacentNorth WSA, and an unknown potential in Bull Canyon. Dinosaur Adjacent- North WSA has a high favorability for salable dimension stone, cement rock, and moderate favorability for mineral pigments and high calcium limestone. Bull Canyon WSA has low favorability for salable resources.

Overall, it is recommended that each WSA in the GRA receive additional work to determine the full economic potential of each area. This work should include further research in the unpublished and proprietary literature, a detailed program of geologic mapping and sampling, and additional geochemical and stratigraphic studies to confirm the occurrence or lack of occurrence of geology, energy or mineralized commodities.

SECTION I

INTRODUCTION

The Bull Canyon/Dinosaur National Monument Adjacent-North GRA (Figure I-1) is located in western Moffat County, Colorado and eastern Uintah Counties, Utah. The GRA encompasses six WSA's; CO-010-001/UT-080-419, CO-010-224, CO-010-224A, CO-010226, CO-010-228 and CO-010-229D.

The GRA area is located approximately 100 miles northwest of Grand Junction, Colorado, and 20 miles east of Vernal, Utah. Located within the GRA are a number of settlements that are local supply centers for agriculture, ranching, and mining activities in the area. The towns are supplied by road networks from Grand Junction and Vernal, the nearest regional supply centers. These towns (Dinosaur, Wiley's Resort, Blue Mountain, Skull Creek, and Massadonia), are also local supply centers for the oil and gas operations in the area.

The GRA encompasses all or portions of Townships 3-8 North, Ranges 99-104 West; and Townships 3-7 South, Range 26 West in Utah. The entire area is bounded by west Longitudes 108° 28' 03" and 109° 08' 00" and north Latitudes 40° 15' 00" and 40° 36' 05". It contains approximately 801.2 square miles (2155 square kilometers or 512,770 acres) of Federal, state and private lands. The Bureau of Land Management portion of these holdings are under the jurisdiction of the Little Snake and White River Resource Area Offices of the Craig District Office.

The specific WSA's within the GRA have a total of 34,937 acres of Federal land. The acreages of the various contained WSA's are:

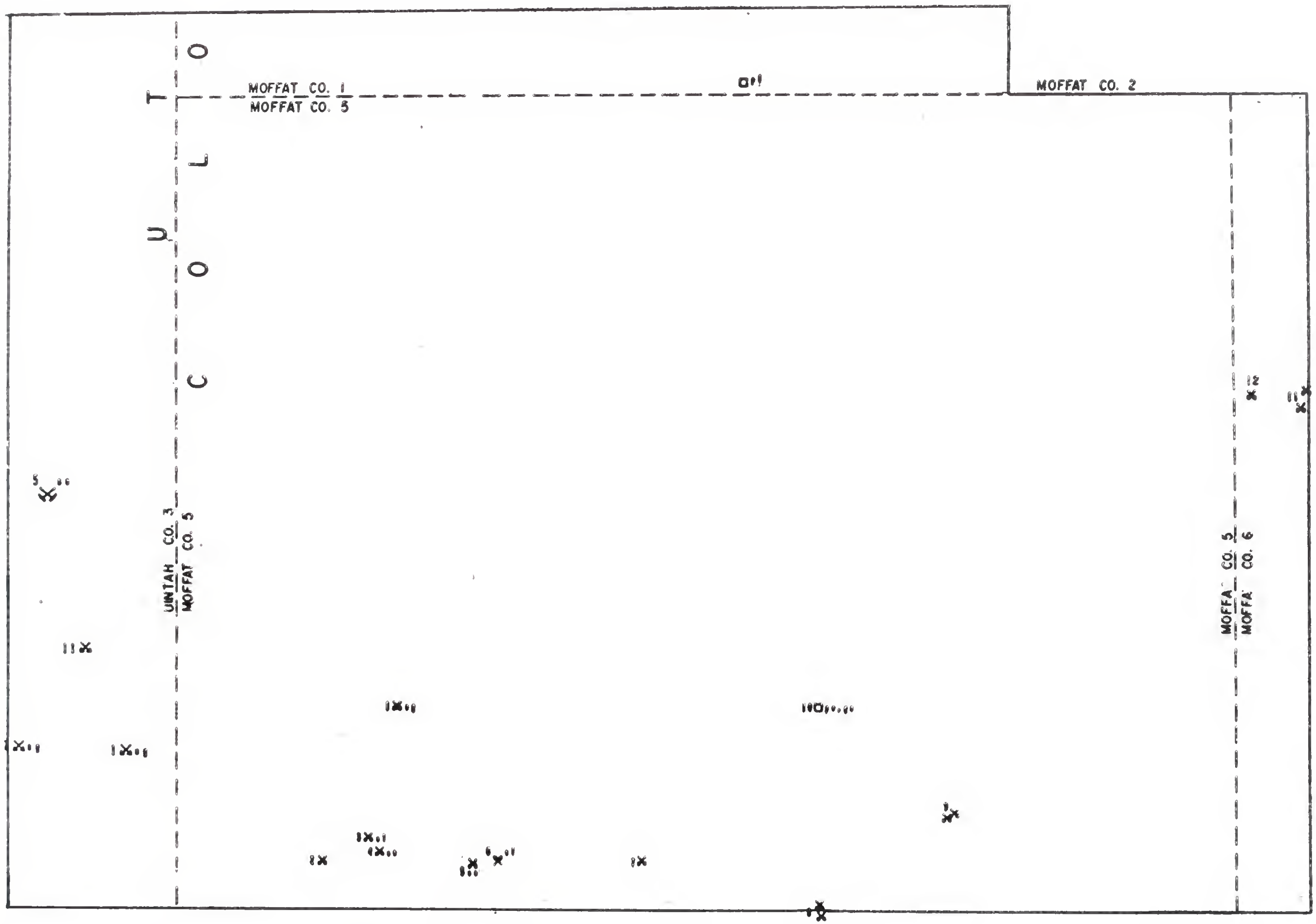
Bull Canyon WSA (CO-010-001/UT-080-419) - 12,297 acres
Dinosaur Adjacent-North WSA's:
- (CO-010-224) - 4,340 acres
- (CO-010-224A) - 1,320 acres
- (CO-010-226) - 4,880 acres
- (CO-010-228) - 5,200 acres
- (CO-010-229D) - 6,900 acres

The Bull Canyon WSA is located in the southwestern part of the GRA and is adjacent to the western boundary of Dinosaur National Monument. The rest of the WSA units are in the northeastern portion of the GRA and are directly adjacent to the northern boundary of Dinosaur National Monument (See Overlay A).

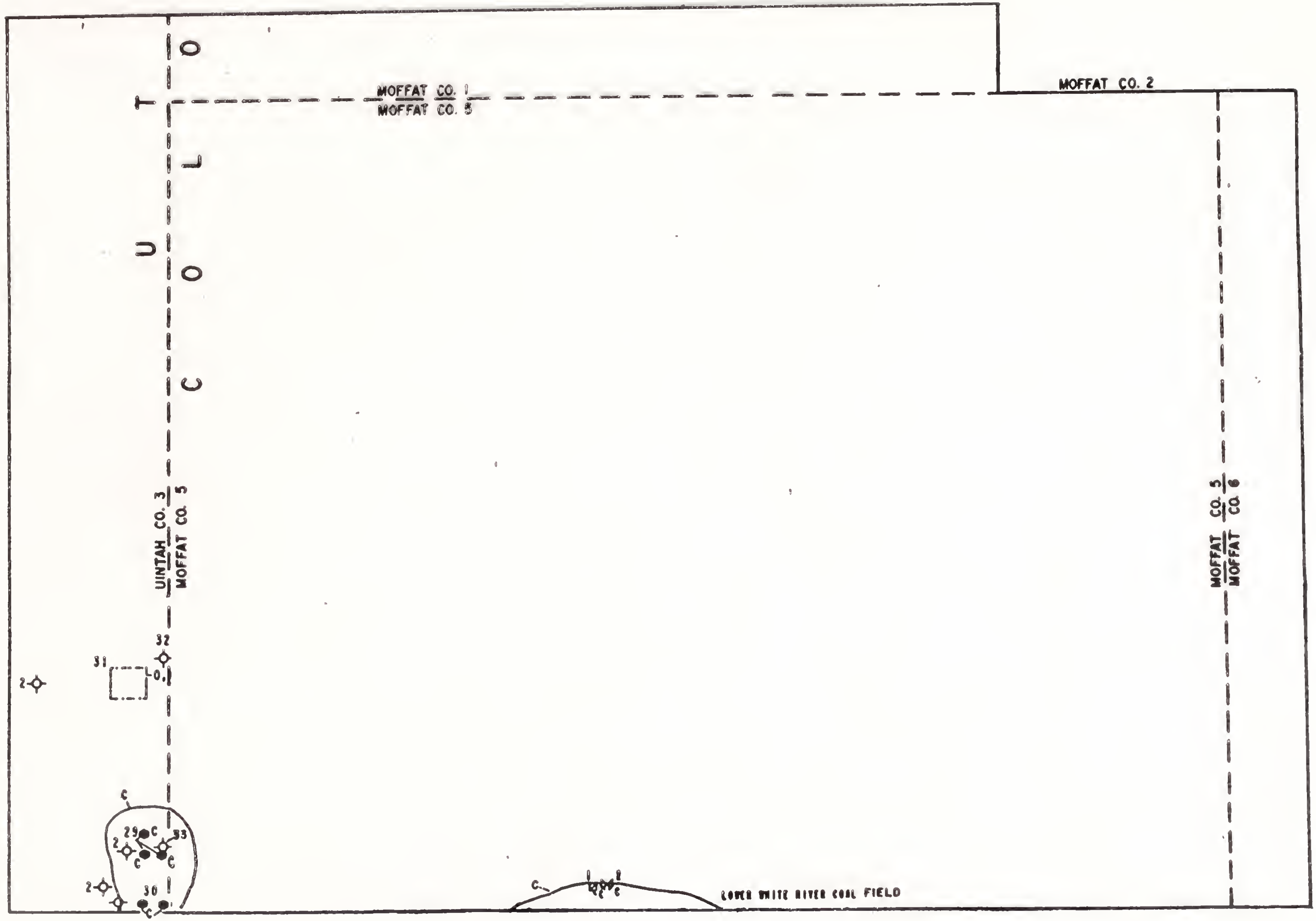
Due to the lack of available data on each WSA, emphasis was placed on gaining an understanding of the mineral potential of each WSA within the GRA. Information on the mineral resources of GRA was utilized to extrapolate and estimate the potentials of the contained WSA's from the existing data that in most cases, referred only indirectly to the WSA's. The purpose of this contract was to utilize the known geological information within each WSA and GRA to ascertain the GEM resource potential of the WSA's. The known areas of mineralization and claims have been plotted as overlays to Figure I-1.

The information contained in this report was obtained from published literature, computerized data base sources, Bureau of Land Management File Data, company files and returned data sheets. The information was compiled into a series of files on each WSA and a series of maps that covered the entire western portion of Colorado. After a thorough review of the existing data, a program of field checking was carried out by MSME/Wallaby's team of experts. Field investigations in the GRA were carried out by Dr. Paul Gilmour, and Dr. Robert Carpenter on September 2, 1982.

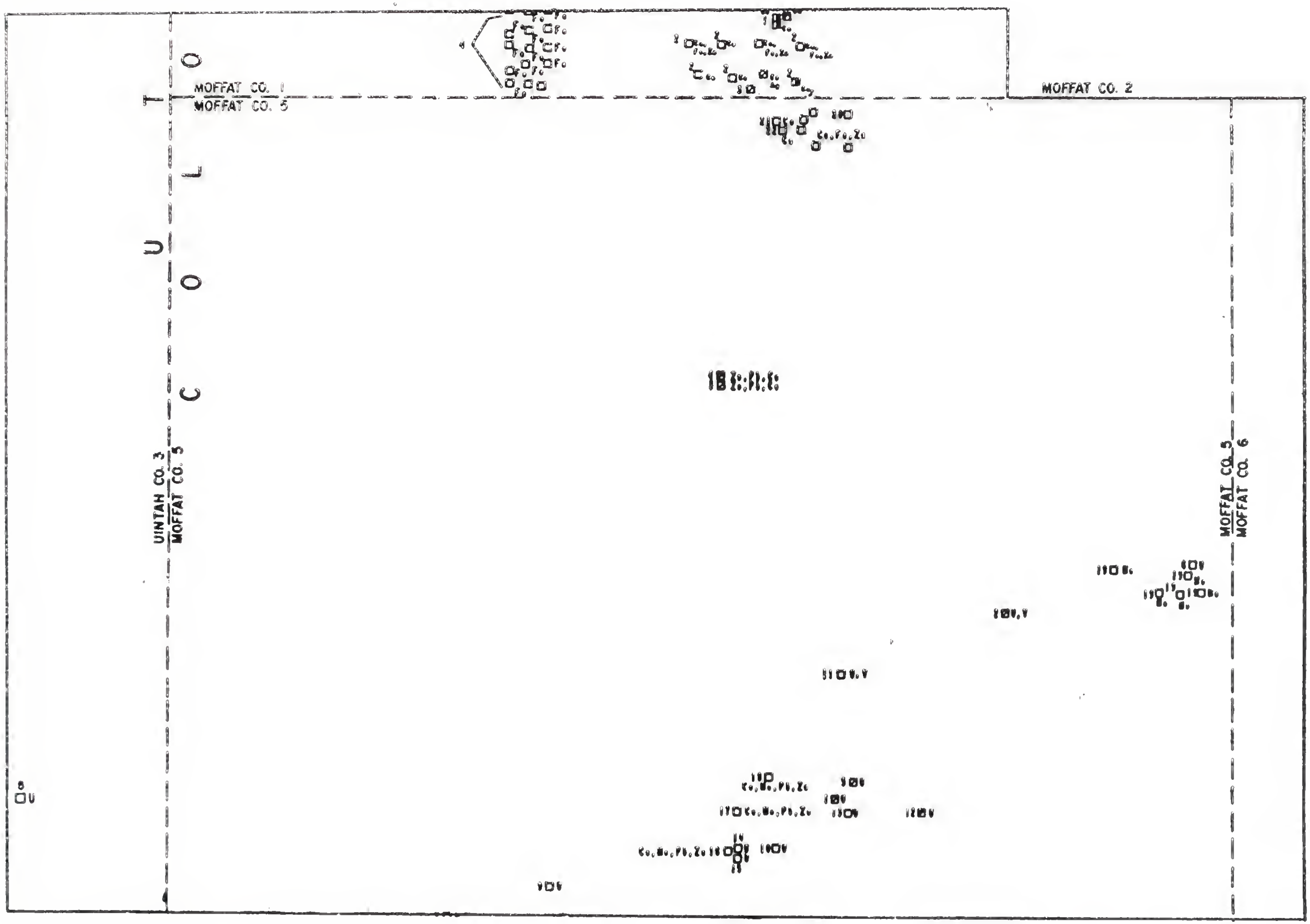
Both of these individuals are registered professional geologists and associates of MSME/Wallaby. Further analysis and study was provided through the photographic interpretation services of BLM 1:24,000 aerial photos by Dr. Larry Lepley, registered professional geologist and remote sensing specialist. The aerial photos used are included in Appendix A.



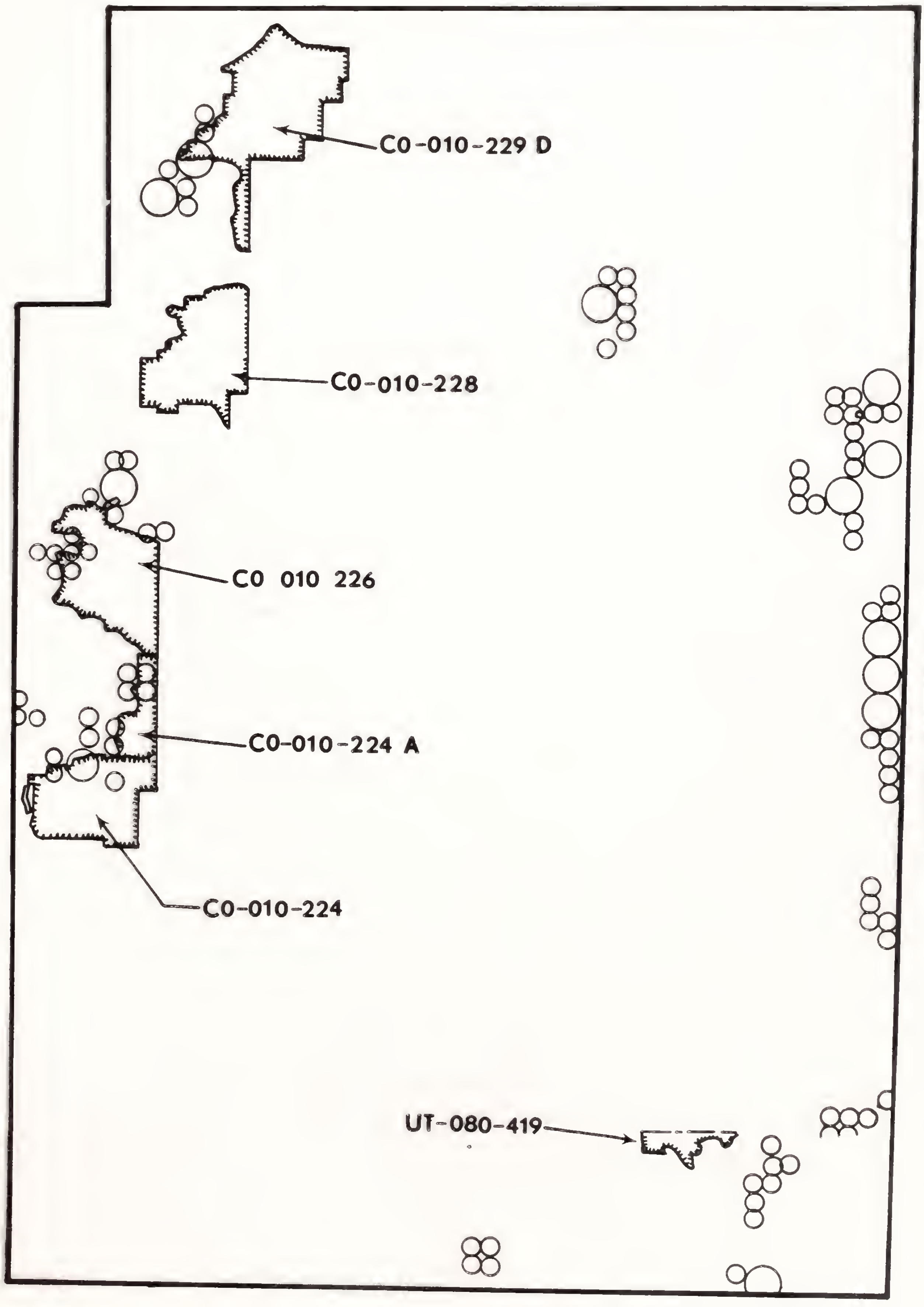
OVERLAY D
SAND, GRAVEL AND
INDUSTRIAL MINERALS



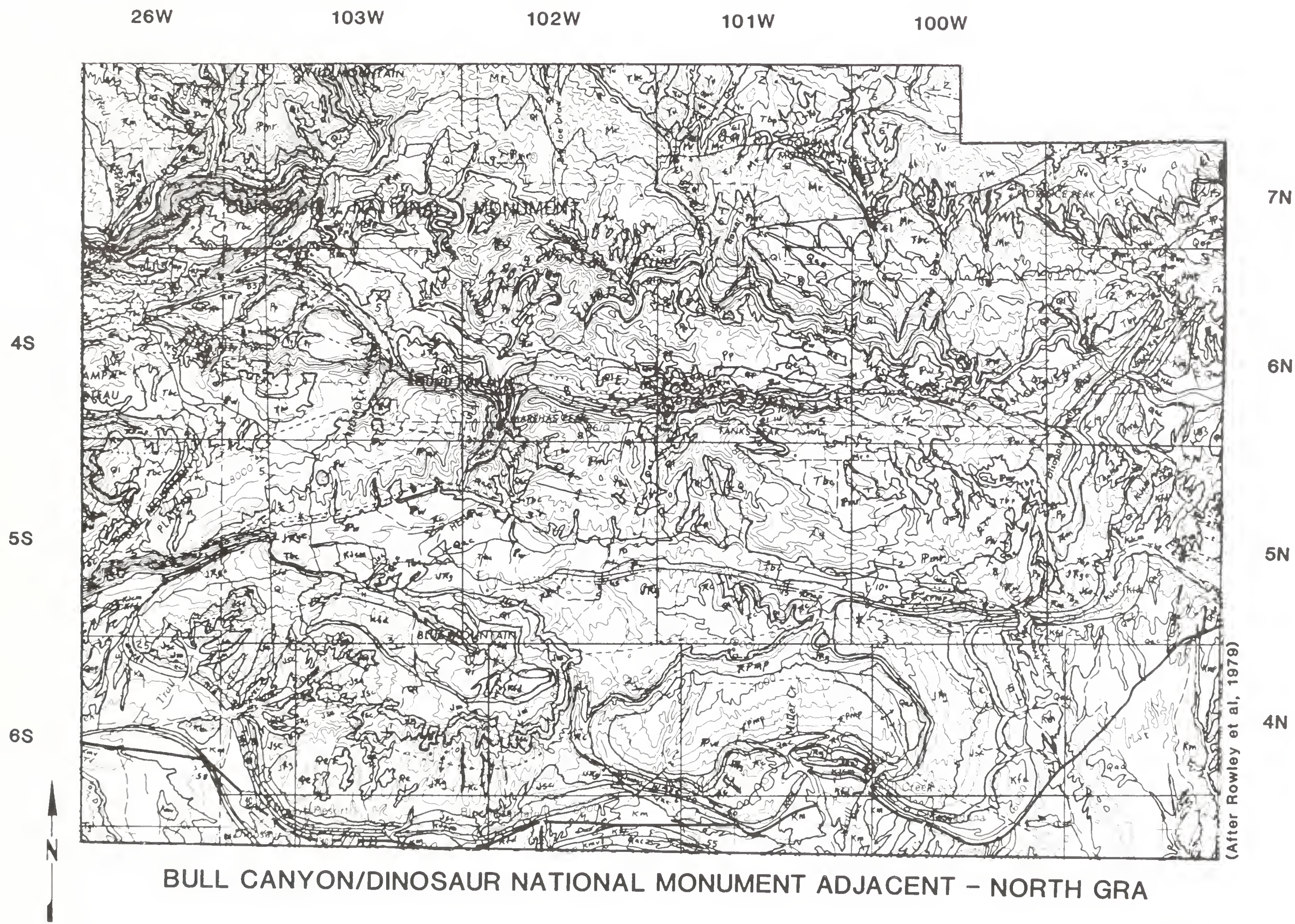
OVERLAY C
COAL, OIL AND GAS



OVERLAY B
MINES, PROSPECTS
AND MINERAL OCCURENCES



OVERLAY A
PATENTED AND UNPATENTED
CLAIMS AND WSA BOUNDARIES



BULL CANYON/DINOSAUR NATIONAL MONUMENT ADJACENT - NORTH GRA

SCALE 1:250,000

FIGURE I-1
GEOLOGIC MAP

EXPLANATION

Quaternary (Approximately 2 million years before present (mybp) to present)	Qe	Eolian deposits
	Qa	Alluvium
	Qac	Alluvium and colluvium
	QP	Piedmont-slope deposits
	Qf	Fan deposits and colluvium
	Ql	Land slide deposits
	Qr	River-terrace deposits
	Qop	Old piedmont-slope deposits
	Qtg	Old gravel deposits
Tertiary (Approximately 62-2 mybp)	Tbb	Browns Park Formation and/or Bishop Conglomerate
	Tbp	Browns Park Formation
	Tbc	Bishop Conglomerate
	Tds	Duchesne River Formation, Starr Flat Member
	Tdl	Duchesne River Formation, LaPoint Member
	Tdd	Duchesne River Formation, Dry Gulch Creek Member
	Tdb	Duchesne River Formation, Brennan Basin Member
	Tu	Uinta Formation
	Tuu	Uinta Formation-upper part
	Tul	Uinta Formation-lower part
	Tb	Bridger Formation
	Tbu	Bridger Formation-upper part
	Tbl	Bridger Formation-lower part
	Tg	Green River Formation
	Tgp	Parachute Creek Member
	-m-	Mahogany ledge
	Tgl	Garden Gulch, Douglas Creek, and Anvil Points Members
	Tgla	Laney Member
	Tgw	Wilkins Peak Member
	Tgt	Tipton Tongue
	Tglu	Luman Tongue
	Tw	Wasatch Formation
	Twc	Cathedral Bluffs Tongue
	Twn	Niland Tongue
	Twm	Main body
	Tf	Fort Union Formation
Cretaceous (Approximately 135-62 mybp)	Kmvg	Mesaverde Group, undivided
	Kmvu	Mesaverde Group-upper unit
	Kmvc	Mesaverde Group-coal unit
	Kmvl	Mesaverde Group-lower unit
	Kmv	Mesaverde Group-upper, coal, and lower unit
	Ksc	Sego Sandstone, Buck Tongue of Mancos Shale, and Castlegate Sandstone
	Kbc	Buck Tongue of Mancos Shale and Castlegate Sandstone
	Kw	Williams Fork Formation
	Ki	Iles Formation
	Kla	Lance Formation and Fox Hills Sandstone

EXPLANATION (cont)

Cretaceous (cont)	Kle	Lewis Shale
	Km	Mancos Shale
	Kh	Hilliard Shale
	Kfd	Frontier Sandstone and Mowry Shale Members of Mancos Shale, and Dakota Sandstone
	KJcm	Cedar Mountain Formation (lower Cretaceous) and Morrison Formation (upper Jurassic)
	Kc	Cedar Mountain Formation
Cretaceous and Jurassic	KJmsc	Cedar Mountain Formation, Morrison Formation, Stump Formation, Entrada Sandstone, and Carmel Formation
Jurassic (Approximately 195-135 mybp)	JM	Morrison Formation
	Jmsc	Morrison Formation, Stump Formation and Entrada Sandstone
	Jmsc	Morrison Formation, Stump Formation, Entrada Sandstone, and Carmel Formation
	Jsc	Stump Formation, Entrada Sandstone, and Carmel Formation
	Jsc	Stump Formation and Entrada Sandstone
Lower Jurassic and Upper Jurassic	JTrgc	Glen Canyon Sandstone and Chinle Formation
	JTrg	Glen Canyon Sandstone
Triassic (Approximately 225-195 mybp)	Trc	Chinle Formation - Gartra Member
	TrPmp	Moenkopi Formation (lower Triassic) and Park City Formation (Permian)
	Trm	Moenkopi Formation
	Trmd	Moenkopi Formation and Dinwoody Formation
	Trd	Dinwoody Formation
Permian (approximately 280-225 mybp)	Pp	Park City Formation
Pennsylvanian (Approximately 320-280 mybp)	PPw	Weber Sandstone
	PPM	Morgan Formation
	PPmr	Morgan Formation and Round Valley Limestone
Mississippian (Approximately 342-320 mybp)	Mr	Mississippian rocks
Cambrian (Approximately 600-500 mybp)	C	Lodore Formation
Precambrian Approximately 3400-600 mybp)	Yu	Uinta Mountain Group
	Wr	Red Creek Quartzite

LEGEND

- -O OIL FIELD
- -G GAS FIELD
- -Os OIL SHALE
- -C COAL REGION
- OIL WELL
- OIL & GAS WELL
- GAS WELL
- SHOW OF GAS
- SHOW OF OIL
- SHOW OF OIL & GAS
- -C COAL DEPOSIT
- -C COAL OCCURRENCE
- SHUT-IN WELL
- CO_2 OR He=HELIUM -RICH WELL
- DRY WELL-ABANDONED
- MILL
- PLANT
- NATURAL GAS PROCESSING PLANT
- REFINERY

- MINERAL OREBODY
- MINERAL DEPOSIT
- MINERAL OCCURRENCE
- PROSPECT
- ACCESSIBLE ADIT
- INACCESSIBLE ADIT
- VERTICAL SHAFT
- INCLINED SHAFT
- MINE TYPE UNKNOWN
- ACTIVE OPEN PIT, OR QUARRY
- INACTIVE OPEN PIT, OR QUARRY
- ACTIVE GRAVEL OR CLAY (Cl) PIT
- INACTIVE GRAVEL OR CLAY (Cl) PIT
- EXPLORATION HOLE WITH DATA AVAILABLE
- EXPLORATION HOLE WITHOUT DATA AVAILABLE
- UNPATENTED MINING CLAIM
- PATENTED MINING CLAIM
- MINERAL OR OIL & GAS LEASE

O	OIL	Cb	LIGNITE	Ds	DIMENSION STONE
G	GAS	Cp	PEAT	Fe	IRON
Os	OIL SHALE	Ag	SILVER	Mn	MANGANESE
Ot	TAR SANDS	Au	GOLD	Pb	LEAD
Gi	GILSONITE	Cu	COPPER	U	URANIUM
C	COAL	Cl	CLAY	V	VANADIUM
				Zn	ZINC

SECTION II

GEOLOGY

PHYSIOGRAPHY

Within the GRA boundary (see Figure I-1) are mountain and valley areas adjacent to Dinosaur National Monument. The valley of the Yampa River is the prominent topographic figure cutting through the National Monument. The course of the Yampa divides the GRA into two distinct north and south portions. The area directly north of the National Monument consists of ridges and draws that drain northward into the Rye Grass Creek and Douglas Draw areas. Also within this area are a series of southward draining tributaries of the Yampa River. The topographic relief is approximately 2,000 feet. South of the river, the terrain consists of valleys with occasional mountain ridges and mesa tops. A prominant east-west valley cuts through the area in the south-central portion of the GRA. A few north-south and northeast trending stream systems cut through the southern portion of the GRA and isolate some of the more prominent topographic features (Round Top Mountain, Martha's Peak, Tanks Peak and Blue Mountain). These drainage systems (Disappointment Draw, Hell's Canyon and Wolf's Creek), have canyons associated with them where they cut through ridge or mesa top areas. The vertical relief in this southern portion of the GRA ranges from 200 to 2,000 feet.

The following addresses the physiography of each of the WSA's in the Bull Canyon-Dinosaur National Monument Adjacent-North GRA.

BULL CANYON WSA (CO-010-001/UT-080-419)

This WSA includes a small portion of the upper drainage of Cliff Trail Creek and is characterized by a shallow canyon along the creek drainage. The vertical relief within the WSA is less than 500 feet. This unit, located in Utah, is 20 miles southeast of Vernal, Utah.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

These WSA's are located upland from Dinosaur National Monument's river canyons along Douglas Mountain. They consist primarily of portions of ridges, draws, and gently rolling valley areas. Some of the units have high, prominent ridges that rise to 8,000 feet in elevation. All of the units are directly adjacent to the northern boundary of Dinosaur National Monument, and are approximately 50-75 miles northeast of Vernal, Utah. Vertical relief within the unit areas is approximately 3,000 feet.

ROCK UNITS

Within the Bull Canyon/Dinosaur National Monument Adjacent-North, GRA is found a variety of rock units that represent a large part of Precambrian, Paleozoic, Mesozoic and Cenezoic time.

The Precambrian is mainly represented by the marine sandstone and silty shale units of the younger Precambrian Uinta Mountain Group. This series of units unconformably overlies the Red Creek Quartzite. The Red Creek Quartzite outcrops within the GRA but has only been mapped north and west of Browns Park (Rowley et al, 1979), and is considered to be the underlying basement complex. The Red Creek Quartzite is composed of deformed beds of metaquartzite, amphibolite, minor marble and intrusive felsic igneous rocks (Rowley et al, 1979; Gilmour, Personal Communication, 1982). Spotty copper-iron and uranium mineralization has been reported from this unit in Utah. (Unterman et al, 1954).

The Cambrian Lodore Formation outcrops in the northeast portion of the GRA and consists of a series of marine sandstone, shale and conglomerate units that are occasionally fossiliferous at or near the Lodore-Madison contact in other areas of Colorado (Rowley et al, 1979; Carpenter, Personal Communication, 1982; Gilmour, Personal Communication, 1982).

The Mississippian Madison Formation is usually found in contact with the Lodore and is characterized as a fossiliferous and cherty marine limestone with local dolomitic units (Rowley et al, 1979). In areas near Douglas Mountain, small base and precious metal replacement deposits have been noted in this unit (Unterman et al, 1954; Carpenter, Personal Communication, 1982). Other Missippian units that outcrop within the GRA include the shale, sandstone and limestone units of the Humbug Formation and the continental and marine shale-sandstone-limestone members of the Doughnut Shale (Rowley et al, 1979).

The Pennsylvania Round Valley Formation represents a sequence of marine limestone units with interbedded shale. The unit is moderately fossiliferous and is directly overlain by the sandstone, shale and fossiliferous limestone members of the Morgan Formation. The Morgan Formation is known to contain base and precious mineralization (mainly copper-silver-iron-manganese) within the GRA in basal conglomerate units (Unterman et al, 1954; Carpenter, Personal Communication, 1982; Rowley et al, 1979; Vanderwilt, 1947). It is considered to be a marine sequence that is in conformable contact with the overlying Pennsylvania Weber Sandstone Formation. The Weber consists of a series of eolian and marine sandstone units that are thought to represent a near-shore dune environment (Rowley et al, 1979; Unterman et al, 1954).

Outcrops of the Permian Park City Formation are found in the extreme southwest corner of the GRA. This formation, deposited in areas to the west of the GRA, is composed of a series of limestone, sandstone, shale, siltstone, dolomite and phosphatic shale units that represent a period of marine deposition in a restricted basin environment (Rowley et al, 1979; Unterman et al, 1954). Commercial thicknesses of the phosphate bearing units have been reported in areas to the west and south of the GRA (Unterman et al, 1954; Eyde, Personal Communication, 1982). In the northeast portion of the GRA, the Park City is absent from the section and the Pennsylvania section is directly overlain by the Mesozoic section.

Pre-Cretaceous Mesozoic units that are known to exist within the GRA are the Triassic Moenkopi and Chinle Formations, the Triassic-Jurassic Glen Canyon Formation, and the Jurassic Stump, Entrada Sandstone, Carmel and Morrison Formations (Rowley et al, 1979). The Triassic Moenkopi Formation consists of a series of shale and siltstone units that are thought to be of continental and marine origin. Minor gypsum beds are locally found within sandy portions of the stratigraphy (Rowley et al, 1979). Directly overlying the Moenkopi is the Chinle Formation. In northern Colorado and Utah, the Chinle is a fine grained series of fluvial and lacustrine siltstones, sandstones, claystones and shale. Within the GRA the basal Gartra Member is usually found as a cross-bedded fluvial sandstone and conglomerate unit. The Gartra Member may be equivalent to the Triassic Shinarump Formation of southern Utah and Arizona, known to contain significant uranium-vanadium deposits (Rowley et al, 1979; Unterman et al, 1954). The Triassic-Jurassic Glen Canyon Formation crops out in only the northeast part of the GRA and is a strongly bedded eolian sandstone unit (Rowley et al, 1979).

The (pre-Mesaverde) Cretaceous units that crop out within the GRA include the Cedar Mountain, Dakota Sandstone, Mowry Shale, Frontier Sandstone, Hilliard Shale, and Mancos Shale Formations or Members. The Cedar Mountain Formation consists of a series of fluvial mudstone, shale, siltstone, conglomerate and limestone units. The overlying Dakota Sandstone is made up of sandstone, shale and conglomerate units with thin beds of coal and carbonaceous shale. The coal units of the Dakota Sandstone are locally important but thin and discontinuous (Gentry, Personal Communication, 1982; Rowley et al, 1979; Unterman et al, 1954). The Mowry Shale Member of the Mancos Shale is a siliceous marine shale with abundant fossil material. The Frontier Sandstone Member of the Mancos Shale is a crossbedded sandstone unit that contains minor carbonaceous shale and coal beds which are of minor economic important (Rowley et al, 1979; Gentry, Personal Communication, 1982). The Hilliard Shale Formation consists of a single thick marine shale unit with minor sandstone. The overlying Mancos Shale Formation is also a single thick marine shale unit. It contains minor siltstone and sandstone units (Rowley et al, 1979).

Within the GRA the Mesaverde Formation crops out as a series of shale, carbonaceous shale, sandstone and coal units (Rowley et al, 1976). Within the GRA and in other areas of Colorado the coal members of this unit are being mined (Vanderwilt, 1947; Gentry, Personal Communication, 1982).

Tertiary units that crop out within the GRA include units of the Wasatch, Green River, Bishop Conglomerate and Browns Park Formations (Rowley et al, 1979). The Wasatch Formation units that crop out within the GRA include shale, siltstone, claystone, coal, sandstone and carbonaceous shale units which are thought to be of fluvial or lacustrine origin. The Wasatch Formation intertongues with the Green River sequence of marlstone, shale, oil shale, limestone, siltstone, sandstone and fluvial conglomerate units (Rowley et al, 1979). The Bishop Conglomerate consists of sandstone, conglomerate siltstone, rhyolitic tuff, and limestone units and is thought to represent a volcanic unit that was reworked in a fluvial and eolian environment. The Browns Park Formation directly overlies the Bishop Conglomerate and consists of sandstone, tuff and limestone units and is thought to be a part of volcanic cycle that was active in Miocene time. The clastic units appear to be reworked volcanic material and locally contain minor amounts of uranium and vanadium mineralization in association with devitrified tuffaceous unit (Rowley et al, 1979; Carpenter, Personal Communication, 1982).

Quaternary piedmont, alluvial, landslide, and river terrace deposits are found overlying the exposed Precambrian, Paleozoic, Mesozoic and Tertiary stratigraphy.

STRUCTURAL GEOLOGY AND TECTONICS

Tectonic features found within the GRA include a few mapped high angle faults and joint systems in the northeast and east-central portions of the GRA. These west-northwest and east-northeast striking features parallel the axial planes of the numerous anticlinal and synclinal structures that are found in the area (Rowley et al, 1979). Some of the fold features mapped in the area of the GRA may have importance in the localization of oil, gas, and uranium deposits (Heylmun, Personal Communication, 1982; Carpenter, Personal Communication, 1982).

In the Blue Mountain and Skull Creek areas faulting may have localized copper, lead, zinc, manganese and uranium deposits (Aurand, 1920; Carpenter, Personal Communication, 1982).

In the southern portion of the GRA, the Split Mountain, Blue Mountain (Willow Creek), and the Skull Creek (Blue Mountain) anticlinal structures have arched portions of the Paleozoic and Mesozoic sections, and may have been caused by the low angle thrust fault that has been mapped in the vicinity of Round Top Mountain (Robinson et al, 1975; Rowley, et al, 1979).

The thrusting that occurred in the GRA is thought to be related to a period of Tertiary deformation which caused the Precambrian and portions of the Paleozoic section to be thrust over younger units. Deformation and thrusting have obscured the true stratigraphic sequence in much of the GRA. It appears that Tertiary units lie directly and unconformably upon the exposed Precambrian, Paleozoic and Mesozoic sections (Rowley et al, 1979; Robinson et al, 1975; Heylmun, Personal Communication, 1982; Carpenter, Personal Communication, 1982).

Mineral resources that are thought to be of economic significance have been found in the Douglas Mountain area (See Overlay B). Mineralization consists of copper-silver-iron-lead-zinc mineralization associated with faults in the Mississippian Humbug Formation (Rowley et al, 1979; Robinson et al, 1975; Carpenter, Personal Communication, 1982; Gilmour, Personal Communication, 1982). Some of these faults may have localized the mineralization and caused some enrichment of values (Gilmour, Personal Communication, 1982; Carpenter, Personal Communication, 1982).

The following descriptions address the structural and tectonic characteristics of each of the individual WSA's within the Bull Canyon/Dinosaur National Monument Adjacent-North GRA.

BULL CANYON WSA (CO-010-001/UT-080-419)

Structural features found within the WSA include northeast striking high angle joint systems, the westward extension of the Blue Mountain (Willow Creek) anticlinal structure, and a portion of a mapped low angle thrust plate. Deformation and thrusting have obscured the true stratigraphic sequence within the WSA. No known unconformities are thought to exist within the WSA.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224,224A, 226, 228, 229D)

Structural features found within the WSA units include high angle, east-northeast striking fault and joint systems that may localize copper-silver-iron-lead-zinc mineralization or have caused significant enrichment of values within these deposits (Gilmour, Personal Communication, 1982; Carpenter, Personal Communication, 1982). The areas lie on the southern flank of the Browns Park Syncline. Minor fault and joint systems that parallel the trace of the axial plane of the Browns Park Anticline cut through the area and have a west-northwest orientation. These may be a factor in localization of oil, gas, and copper-silver-iron-lead-zinc deposits within the WSA's and in adjacent areas (Gilmour, Personal Communication, 1982; Heylmun, Personal Communication, 1982).

Deformation has obscured the true stratigraphic sequence within the WSA's but it appears from the evidence at hand that there are no major unconformities within the areas. Within the stratigraphic section, the entire Ordovician-Devonian strata is missing, representing a probable unconformity. Locally, the Tertiary Browns Park Formation and the Bishop Conglomerate overlie portions of the Precambrian and Paleozoic sections that were exposed in Tertiary time (Rowley et al, 1979). The Browns Park Formation is known as a past producer of uranium (Robinson et al, 1975), and may have deposits associated with the basal conglomerate that unconformably overlies the Precambrian Uinta Formation in unit 228 (Carpenter, Personal Communication, 1982).

PALEONTOLOGY

Paleontological resources in the GRA are known from past studies of the oil, gas, and mineral potential of the region. In addition, specific studies of the paleontological resource potential of Dinosaur National Monument (Sears, 1962; Unterman et al, 1954; NPS File Data, 1982), and the general stratigraphy of the area were carried out by Federal, state and local governments and oil companies (Sears, 1962; Unterman et al, 1954; Robinson et al, 1975; NPS File Data, 1982; Rowley et al, 1979).

Within the boundaries of the GRA, the Cambrian Lodore Formation is known to contain trilobite, brachiopod, gastropod and marine plant fossils (Unterman et al, 1954).

The Mississippian Madison and Deseret Formations are also known to have fossiliferous units that contain coral, brachiopod, gastropod and crinoid remains (Unterman et al, 1954; NPS File Data, 1982). The Pennsylvanian Morgan and Round Valley Limestone Formations are also known to contain fossil bryozoa, crinoid, sponge, echinoderm, brachiopod and foraminifera material, and may contain algal reef material (Unterman et al, 1954; Rowley et al, 1979). Other fossiliferous units have been reported from the Permian Park City Formation. These units contain oolites and other fossil material, and have been mined in other areas of western United States for the phosphate content (Unterman et al, 1954; Rowley et al, 1979).

The Triassic section that is exposed within the GRA is known to contain fossil material and reptile tracks. The Moenkopi Formation is a well known locality for fossil reptile tracks in Arizona, Utah and Western Colorado (Unterman et al, 1954; NPS File Data). The overlying Chinle Formation is known to contain amphibian, reptile, and coprolite material. Within the GRA and in other areas of Colorado, Utah and Arizona, petrified wood is associated with this unit and the basal Shinarump Conglomerate (Unterman et al, 1954; NPS File Data, 1982).

The Jurassic Carmel, Curtis and Morrison Formations are known fossil localities within the GRA (Unterman et al, 1954; NPS File Data; Rowley et al, 1979). Pelecypods and gastropods have been identified from the Carmel Formation in areas west of the GRA. (Unterman et al, 1954). The Curtis Formation contains fossiliferous units which contain saurian, reptile, gastropod, oyster, and belemite remains (Unterman et al, 1954; NPS File Data, 1982). The Morrison Formation contains the most significant fossil resource known to exist within the GRA. The paleontological remains may include saurian reptile, bird, and mammal remains (Unterman et al, 1954; NPS File Data, 1982). Over 150 species of fossil material have been identified from this unit (NPS File Data, 1982).

The Cretaceous section also contains several units that contain fossil material within the GRA. Plant impressions and fossil plant material has been noted in the Dakota Sandstone in association with coal seams and carbonaceous shale units (NPS File Data, 1982; Unterman et al, 1954; Rowley et al, 1979). The Mowry Shale Member of the Mancos Shale is also reported to contain abundant fish scales (NPS File Data, 1982; Rowley et al, 1979). Plant fossils, sharks teeth, oyster shells, and brachiopods are commonly found in certain beds of the Frontier Formation of the Mancos Shale (Unterman et al, 1979; NPS File Data, 1982). Marine fishes and mollusks are also commonly associated with the Upper Cretaceous Mancos Shale and Mesaverde Group units (NPS File Data, 1982). Carbonaceous material and fossil plant remains have been identified from both of these units in association with coal seams (NPS File Data, 1982).

Tertiary units that are known to contain mammal fossils are the Bishop Conglomerate Formation and the Browns Park Formation. Early mammal remains have been recovered from these units and the Uinta Formation in areas outside of the GRA.

The following addresses the paleontology of each of the WSA's in the Bull Canyon-Dinosaur National Monument Adjacent-North GRA.

BULL CANYON WSA (CO-010-001/UT-080-419)

The Jurassic and Cretaceous rock units that outcrop within this area are not known to contain paleontological resources of major scientific importance (NPS File Data, 1982). The Jurassic Morrison is well known for reptile, bird and mammal fossil material. Reported major fossil occurrences within this unit are found a short distance away in Dinosaur National Monument (NPS File Data, 1982).

The Cretaceous Frontier and Dakota Sandstone Formations crop out along the southern portion of the WSA, and may contain fossil plant and marine fish remains (NPS File Data, 1982). Saurian reptile remains have been tentatively identified in the Cretaceous Cedar Mountain Formation. This occurrence is some distance away from the WSA in Dinosaur National Monument (NPS File Data, 1982).

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

Within these areas the Cambrian, Mississippian, Pennsylvanian and Permian units are not known to contain paleontological resources of major scientific importance (NPS File Data, 1982). The Cambrian Lodore Formation contains a few fossils in the Douglas Mountain Area (Units 010-226 & 228) (NPS File Data, 1982), that are useful for correlation of this unit. These remains (brachiopods and trilobite pieces) are not considered of particular scientific interest as there are other, better localities for this faunal assemblage (NPS File Data, 1982; Carpenter, Personal Communication 1982). The Mississippian Humbug and Madison Limestone Formations are thought to be fossiliferous within one or more of the units under study but have not been extensively studied (NPS File Data, 1982; Unterman et al, 1954). The Pennsylvanian Morgan Formation units that crop out in unit 229D are also reported to contain fossil material (Bryozoans, crinoids brachiopods and echinoderms) that is not well preserved (NPS File Data, 1982).

There are no reported fossil localities within the Mesozoic and Tertiary sections that are exposed within the various WSA's.

Potential for paleontological resources of major scientific interest is thus limited to the few outcrops of the Tertiary Browns Park Formation that are found in unit 229D. These units may contain early mammal remains and, thus, may be quite important (NPS File Data, 1982).

HISTORICAL GEOLOGY

During middle and younger Precambrian time the entire GRA was receiving sediments from both cratonic and island arc sources (Gilmour, Personal Communication, 1982). It appears that this was a time of persistent volcanism and tectonic activity. Marine deposition of eugeosynclinal sediments was interrupted by the ebb and flow of cratonic and island arc volcanism, and a period of extreme deformation was caused by plate collisions and regional uplifting. These older Precambrian units were metamorphosed, deformed, and intruded by a series of younger Precambrian mafic and felsic bodies. In this study area, the exposed older Precambrian rocks are mainly quartzites interbedded with gneiss and schist material. Base and precious metal deposit types known as exhalative deposits, are commonly found in Precambrian lithologies. These exhalative deposits, found in association with marine basins and rhyolitic volcanic systems, and are commonly associated with the older Precambrian lithologies.

The Precambrian sequence is relatively unstudied in this areas and has only been partially correlated with other areas of Colorado (Unterman et al, 1954). In this area, the younger Precambrian is preserved, and consists of a thick section of clastic sediments. These lithologies represent a period of clastic deposition in a marine environment. From the information that is currently available, it appears that the younger Precambrian units of this area were deposited in a deep, marine basin that persisted through Paleozoic time (Unterman et al, 1954).

The period of early and middle Paleozoic deposition was characterized by the formation of a series of shallow basins. It is thought that these basins were progressively filled by Cambrian and Mississippian sediments (Unterman et al, 1954).

During most of the Paleozoic, the basins teemed with plant and animal life. Reef communities were formed on shallow bedrock highs in association with algal bioherms. Northwest striking faults and shear systems were active within the basins, and caused much up and down movement of the basement blocks that formed the floor of these basins.

In the Mesozoic, the area was the site of fluvial and lacustrine deposition in a terrestrial environment. The Triassic Moenkopi Formation overlies the Paleozoic units throughout much of the GRA, and is thought to represent an era when shallow, fresh water lake and enclosed basins were subjected to periods of dessication and shallow water, clastic deposition. The Moenkopi Formation is known for its saurian tracks and vertebrate fossils in other areas of western Colorado. Thus, it is reasonable to assume the amphibian and reptile life may have existed within the GRA during this period (NPS File Data, 1982). The Chinle Formation of the Glen Canyon Group represents a time of Triassic sedimentation in a near-shore environment with episodes of eolian deposition of well cross-bedded beach and dune sand deposits.

Certain fluvial and shallow water lacustrine deposits have also been identified in this sequence of sandstone, shale, siltstone, mudstone, limestone and conglomerate. It appears that the Triassic units were deposited along the margins of great, open seas and restricted inland basins that had existed since Paleozoic time. As the shorelines of these seas moved in response to orogenic episodes and basin fillings, the specific environments in the GRA changed from marine to terrestrial. During this time, shallow-water and near shore swamps were formed. In other areas of Colorado, these Upper Triassic near-shore sediments are the host for copper-silver "redbed" deposits that were deposited in areas of rapidly changing Eh-pH conditions.

The Navajo Sandstone outcrops in the western portion of the GRA and is thought to represent a period of inland sand dune accumulation in a terrestrial desert environment (Carter et al, 1965). This Triassic-Jurassic unit thins to the east.

The unconformity between the Navajo Sandstone and the overlying Jurassic Carmel and Entrada Formations is probably a local feature that represents a period of non-deposition. The Navajo is known to exist only in selected, desert environments or basins, and may have never been deposited in some areas. The Jurassic Entrada, however, is thought to have been deposited during a period of terrestrial fluvial and eolian deposition in small, restricted basins that eventually coalesced and buried the majority of the resistant Precambrian Highland features. The Jurassic Summerville and Morrison Formations were being deposited in near-shore lagoonal environments, or shallow water marine and fluvial systems. Some fresh water lacustrine and fresh water fluvial deposits have also been identified from these rocks. As in the earlier Triassic section, mineral deposits are commonly found associated with limey sandstones, shales, and siltstones, deposited in shallow, neritic basins that have fluvial channels meandering through them. Fossil plant material from this period is indicative of a tropical environment that was adjacent to an active fluvial or lacustrine system.

During Cretaceous time, the GRA was the site of shallow water deposition in a lagoonal or swamp environment. The Lower Cretaceous Burro Canyon Formation appears to have been deposited in a series of meandering river systems with adjacent terrestrial lakes. The terrestrial, clastic nature of this formation is thought to be characteristic of a beach or littoral environment (Young, 1955). The Upper Cretaceous Dakota Sandstone unconformably overlies the Burro Canyon Formation. Clastic portions of the Dakota are found as channel fillings in the Burro Canyon paleosurface. From fossil evidence, it appears that the lower sections of the Dakota were deposited in shallow basins or stream channels. The carbonaceous shales of the Dakota are known to contain abundant plant remains, and were probably deposited in a near-shore swamp or lacustrine environment. Thin coal seams are known to exist within the Dakota and may have economic potential.

During upper Cretaceous time, the thickest marine deposition occurred to the southeast and spread westward grading laterally into coarser sediments derived from the west and which are thought to signify the initial impulses of the "Early Laramide" deformation in the Uinta Range.

This deformation of the region brought about a gradual downwarping of the Uinta and Bridger Basins with a consequent development of small lakes and ponds which in time became extensive fresh-water bodies into which accumulated thousands of feet of fine sediment, now believed to be a source of some of the oil of the region. As deformation abated, the lake basins were gradually filled by the streams, eventually creating extensive flood plains on which additional thousands of feed of conglomerate, sandstone and shale accumulated (Bridger, Washakie and Uinta, Eocene; and Duchesne River, Oligocene) which have been the source of vast quantities of fossil material, including mammal, reptile, insect and plant remains.

Units of the Cretaceous Mancos Shale have been described as being sandstone and shale units deposited in a near-shore environment, and have local coal bearing horizons in the section.

The Cretaceous Mesaverde Group units crop out throughout the northeastern portions of the GRA and represent a period of cyclical deposition of shale, coal, limestone units in a near-shore marine environment adjacent to the deep-water basins where the bulk of the Mancos Shale unit was deposited. Coal bearing units of the Mesaverde Group are found in the lower portions of the Williams Fork and Iles Formations and are considered a major energy resource (Vanderwilt, 1947).

The Mesaverde Group is overlain by the Tertiary Wasatch, Uinta, Green River and Browns Park Formations. This unconformity may represent a period of uplift and erosion prior to the formation of the Uinta sedimentary basin. The Wasatch, Uinta, and Green River Formations found in the GRA represent periods of shallow water terrestrial lacustrine deposition. These units intertongue and contain known oil shale resources. The shallow water basins existed to the east of the GRA on the flank of the Uinta Arch. The Tertiary Brown's Park Formation was deposited in a series of structural basins that formed adjacent to the Uinta Arch and along it's axis. These reworked, volcanic and sedimentary units locally contain uranium-vanadium deposits (Nelson-Moore et al, 1979). The Bishop conglomerate also crops out within the GRA and is thought to represent eroded material from the exposed Precambrian and Paleozoic units.

The area was uplifted and subjected to erosion in Middle Tertiary times with the formation of the ancestral Green River Valley. Quaternary pediment, Terrace gravel and eolian deposits formed on the exposed Precambrian-Tertiary surfaces and alluvial deposits were formed along the various fluvial systems that were established.

BULL CANYON WSA (CO-010-001/UT-080-419)

Little information is available that directly pertains to the historical geology of the WSA. Within the boundaries of the WSA, the Upper Jurassic and Lower Cretaceous section crops out as a folded sequence of shale, siltstone, and sandstone units. The entire Precambrian-Lower Jurassic stratigraphy is thought to underlie the WSA, but does not crops out in the nearby vicinity. The units that crop out have been uplifted and eroded since the Laramide Orogeny. Quaternary alluvial material directly overlies the outcropping Mesozoic stratigraphy (Rowley et al, 1976).

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

Within these areas the Cambrian Lodore Formation directly overlies the Uinta Mountain Group sedimentary sequence of shales, sandstone, quartzite and gneiss. It is thought that the Uinta Mountain Group underlies all of the units of the WSA and was laid down in a marine environment. The Lodore Formation consists of sandstone, quartzite, shale and siltstone units that are thought to have been deposited in off-shore marine environment (Unterman et al, 1954; Rowley et al, 1976). The Lodore and the overlying Mississippian Madison Formation are known to contain lead, zinc, iron, copper, gold and silver deposits within various units of the WSA and in adjacent areas. The nature of this mineralization suggests a structural control within a series of favorable host lithologies (Gilmour, Personal Communication, 1982; Carpenter, Personal Communication, 1982). The Madison Formation lies directly and conformably upon the Lodore and it is thought that the Ordovician, Silurian and Devonian units that are found in other areas of western United States were never deposited in this portion of Colorado (Unterman et al, 1954). Within the boundaries of most of the units of the WSA, the Madison Formation is a dense, fine-grained limestone that is thought to be of marine origin. During Lower Paleozoic time the area of the WSA was a part of a major marine basin and contained abundant marine life.

Cropping out in adjacent areas of Dinosaur National Monument is the Mississippian Deseret Limestone Formation. This unit consists of a series of fossiliferous limestone and dolomite units and is thought to be of marine origin (Unterman et al, 1954). This unit and the overlying Mississippian Humbug Formation may represent favorable host lithologies for base and precious metal mineralization similar to what has been found in the Lodore and Madison Formations (Gilmour, Personal Communication, 1982; Carpenter, Personal Communication, 1982).

All of the Lower and Middle Paleozoic units that crop out within the units of the WSA are thought to have been deposited in a marine environment. It is thought that a complete sequence of post-Mississippian lithologies was deposited within the areas of the WSA, and that these units were uplifted and eroded during the Laramide Orogeny. Currently, in most of the units of the WSA the Precambrian-Mississippian section is all that outcrops. In unit 229 the Tertiary Browns Park Formation was deposited in a local basin after tectonism an erosion had taken place. Unlike other areas of Colorado, this Formation does not have any reported occurrences of uranium-vanadium mineralization (Nelson-Moore et al, 1979; Unterman et al, 1982).

Directly overlying all of the exposed stratigraphy are a series of eolian and alluvial deposits of Quaternary age (Rowley et al, 1976).

Figures II-1 through II-6 illustrate the geology and geomorphology of the GRA.

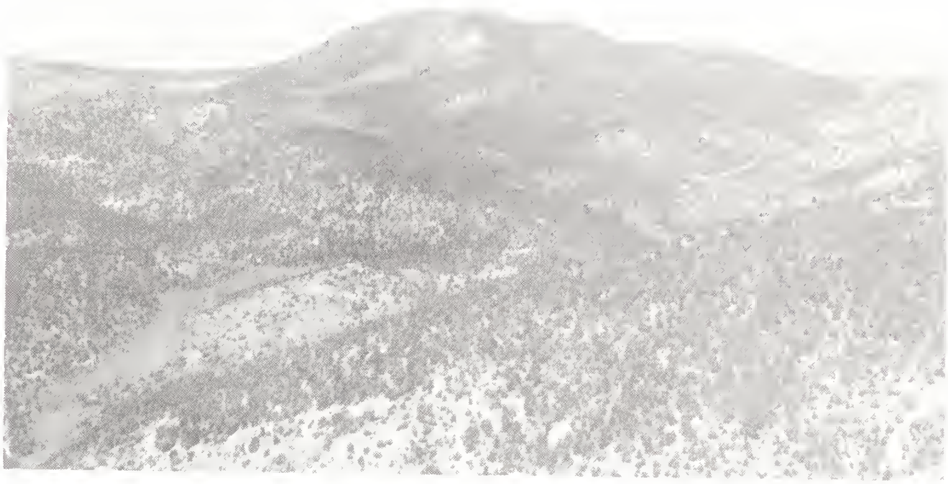


FIGURE II-1
Looking N.
Note ranch trails.

DINOSAUR NATIONAL MONUMENT

FIGURE II-2
Madison (?)
limestone
in foreground.
Cambrian (?)
quartzite in middle.

DINOSAUR NATIONAL MONUMENT

FIGURE II-3
Photo looking S, Douglas Mountain mine. Mineralization at or near contact between quartzite (in foreground), and carbonates above.

DINOSAUR NATIONAL MONUMENT

FIGURE II-4
Douglas Mountain mine from S. (Looking NNE). Limestone outlier overlying quartzite.

DINOSAUR NATIONAL MONUMENT

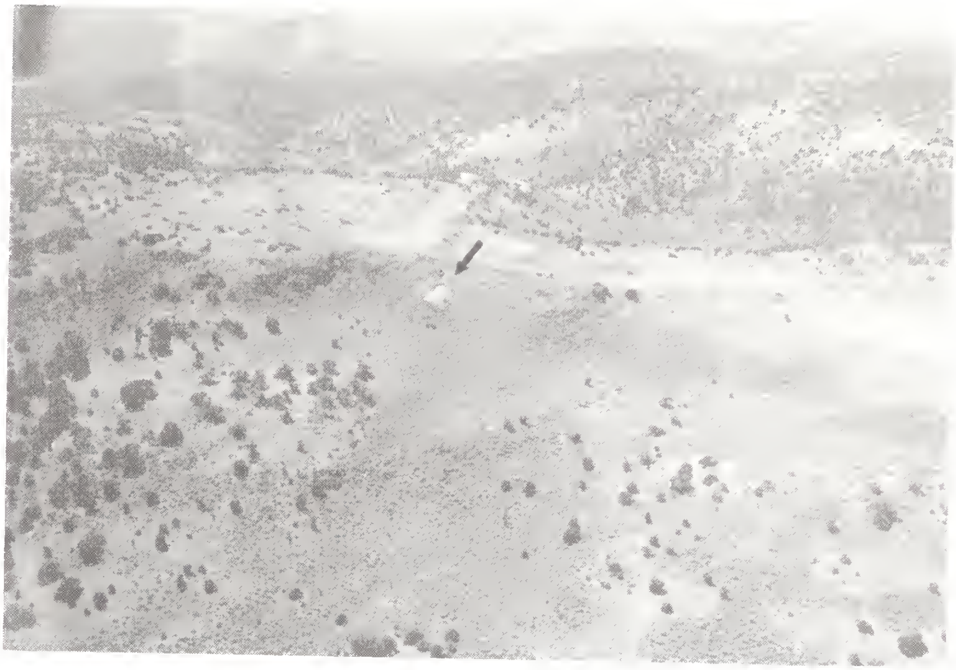


FIGURE II-5
Prospect (labeled "mine" on 1:24,000 topo sheet) located to SE of Douglas Mountain mine. Mineralization associated with contact between limestone "cap" and underlying quartzite.

DINOSAUR NATIONAL MONUMENT

FIGURE II-6
"Mine" in foreground: Douglas Mountain mine in back (looking NW).

DINOSAUR NATIONAL MONUMENT

SECTION III

ENERGY AND MINERAL RESOURCES

KNOWN MINERAL DEPOSITS

The known deposits in the Bull Canyon/Dinosaur National Monument Adjacent-North GRA can be grouped into three categories: 1) energy minerals; 2) metals; and 3) sand, gravel and industrial minerals. The following summarizes the known deposits:

Commodity	Number of Deposits
Coal mines	2
Uranium mines	2
Copper-iron-zinc mines	2
Copper-lead-zinc mines	2
Iron with assoc. silver mines	2
Sand and gravel pits	13
Clay pits	2
Sandstone quarries	3

Coal has been produced from the Blue Flame and Les Ash mines which are located in the extreme northern portion of the Lower White River Coal Field in T3N, R102W (Overlay C).

The three known uranium mines in the GRA are the Skull Creek Coalition Mines Blue Mtn. No. 4, Skull Creek mine and Biles' Shaft, located in T4N, R100 and 101W (Overlay B). The current operating status of the Blue Mtn. No. 4 and Skull Creek mine is unknown. The Biles' Shaft, however, has been abandoned.

The base metal mines are located in T7N, R101W in the Douglas Mountain District (Overlay B). The primary commodities produced were copper and iron.

The sand, gravel and industrial mineral deposits are located in the southwestern and southern portion of the GRA (Overlay D).

BULL CANYON WSA (CO-010-001/UT-080-419)

There are no known deposits in the Bull Canyon WSA.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228 & 229D)

In block CO-010-226 of the Dinosaur National Monument WSA, there are two copper mines located in sections 15 and 16, T7N, R101W (Appendix A, topographic maps). The Bromide shaft is located at the northern edge of block CO-010-226 in section 9, T7N, R101W. The Bromide mine appears to have been worked intermittently over a considerable period of time (Appendix A, field notes).

KNOWN PROSPECTS, MINERAL OCCURRENCES AND MINERALIZED AREAS

The following table summarizes the known prospects and mineral occurrences in the Bull Canyon/Dinosaur National Monument Adjacent-North GRA:

Commodity	Number of Prospects or Occurrences
Oil and gas dry wells	6
Coal	6 prospects
Uranium	8 occurrences
Manganese	5 occurrences
Copper	5 occurrences
Copper, Manganese, Lead, Zinc	3 occurrences
Copper, Iron, Zinc	9 occurrences
Iron	12 occurrences
Petrified Wood	1 occurrence

The coal, oil and gas prospects are located in the southwestern portion of the GRA in T5 and 6S, R25E (Overlay C).

The manganese occurrences are all located in T5N, R99W in the east central portion of the GRA. One uranium occurrence is found in the vicinity of the manganese occurrences, however, uranium occurrences are primarily found in the Skull Creek Area in T4N, R101W.

The base metal occurrences are noted in the Douglas Mountain District and the Skull Creek Area in the north central and south central portion of the GRA, respectively (Overlay B).

Copper mineralization, noted in the field, was found in the Douglas Mountain District and vicinity (Appendix A, field notes).

Vertebrate paleo remains occur in the Browns Park Formation.

BULL CANYON WSA (CO-010-001/UT-080-419)

There are no known prospects, mineral occurrences or mineralized areas in the Bull Canyon WSA.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

There are no known prospects in the Dinosaur Adjacent-North WSA's; however, there are several known occurrences.

The CO-010-224 block contains 7 known iron occurrences located in sections 9, 16 and 21, T7N, R102W (Overlay B). The CO-010-226 block contains known copper occurrences in sections 16, 17 and 18, T7N, R101W. In addition to these occurrences, copper mineralization was observed in the field along a northwest trending fault zone in the vicinity of the Bromide shaft in section 16, T7N, R101 (Appendix A, field notes).

MINING CLAIMS, LEASES AND MATERIAL SITES

There are 705 unpatented lode claims and 1 unpatented placer claim in this GRA, of which 53 lode claims are within the WSA's (Overlay A). The claims are primarily situated in the extreme northern and southern portion of the GRA. Two major corporations, Molycorp and Gulf Oil Company, hold claims in the GRA. The unpatented claim data was compiled from the Bureau of Land Management's June 14, 1982, Geographic Index (Appendix C).

There are 8 patented mining claims located in the GRA, specifically in sections 5 and 8, T7N, R102W; section 16, T7N, R101W; sections 15, 22 and 23, T7N, R101W; and sections 23 and 24, T7N, R101W (Overlay A and Master Title Plats, Appendix A). This information was obtained from the BLM's Surface Management Quads and Master Title Plats.

Data on leases was not obtained for the entire GRA. Please refer to the Oil and Gas Plats in Appendix A.

BULL CANYON WSA (CO-010-001/UT-080-419)

As of June 14, 1982, there were no patented or unpatented mining claims contained with the WSA.

Data on oil and gas leases was not available for the Bull Canyon WSA.

DINOSAUR ADJACENT NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

There are approximately 53 unpatented lode mining claims located within the five WSA's (Overlay A). Specifically, there are 15 lode claims located in CO-010-224, 6 lode claims in CO-010-224A, 9 lode claims in CO-010-226, no claims in CO-010-228 and 23 lode in CO-010-229D. The unpatented claim data was compiled from the Bureau of Land Management's June 14, 1982, Geographic Index (Appendix C). An exact number of mining claims located within the WSA's cannot be derived from the Geographic Index since claims are only located to within a quarter-section. However, an exact number of claims can be obtained through researching the claim location notices recorded with the BLM by the claimant.

There are two patented mining claims located in WSA CO-010-226, section 16, T7N R101W (Overlay A). The patented claim data was obtained from the BLM's Surface Management Quads and Master Title Plats (Appendix A).

For information on oil and gas leases, please refer to the oil and gas plats in Appendix A.

MINERAL DEPOSIT TYPES

The Bull Canyon/Dinosaur National Monument Adjacent-North GRA contains known deposits of coal, uranium, base and precious metals, construction stone, clay, and sand and gravels.

The Lower White River Field contains the known coal deposits in the GRA. Coal for local use has been mined from the thin discontinuous coal beds in the Dakota Sandstone. Coal deposits of economic significance are derived from the Williams Fork Formation of the Cretaceous Mesaverde Group (Landis, 1959). The Mesaverde group is composed of shale, carbonaceous shale, sandstone and coal beds. The coal is ranked as high-volatile C bituminous and is noncoking (Landis 1959).

The uranium deposits usually occur in the Jurassic Morrison Formation. In the Morrison Formation carnotite, a uranium and vanadium oxide, is the principal ore mineral. Carnotite is a secondary mineral deposited by waters that were in contact with primary uranium and vanadium minerals. Uranium and vanadium mineralization occurs in the Salt Wash Member and the Brushy Basin Member of the Morrison Formation. The Salt Wash Member consists of interstratified sandstone and claystone units. The unit was formed as a large alluvial fan by an aggrading system of braided streams (Craig et al, 1955). The Brushy Basin Member consists of variegated claystones with few lenticular conglomeratic sandstone strata. The Brushy Basin was formed in fluvial and lacustrine environments with large amounts of clay (Craig et al, 1955). As a whole, the sandstone beds of the Morrison Formation are light gray to buff, fine to medium grained, lenticular, crossbedded and irregularly bedded (Molenaar, 1981). It is thought the introduction of the ore was done by mineral-bearing solutions that seeped through the permeable layers after sediments accumulated. The source of the primary minerals is currently under dispute (Craig et al, 1955).

The Douglas Mountain district contains replacement deposits of copper, lead, zinc, iron, manganese and silver. These deposits are found in the Cambrian Lodore Formation at or near its contact with the Mississippian Madison Formation (Rowley et al, 1979; Gilmour, Personal Communication, 1982). The Lodore Formation is composed of a fine grained, silty, fossiliferous quartzitic sandstones, a glauconitic middle sandstone, and sericitic shale beds (Unterman et al, 1954). The fossiliferous Madison Formation consists of limestone and dolomite at the base, which is overlain by cherty marine limestone, dolomite and marlstone beds. The principal ore minerals consist of hematite, limonite, malachite and azurite. Lead, zinc, manganese and silver minerals are found to a lesser extent (Unterman et al, 1954). Mineralization was localized by faulting.

Copper-silver-iron mineralization occurs in the Precambrian Red Creek Quartzite units in areas to the northwest of the GRA. This mineralization may be syngenetic and associated with favorable host lithologies.

Clay has been derived from the Mancos Formation, Dakota Sandstone and the Mesaverde Formation.

Pediment gravels from the Yampa River and its tributaries have been exploited, as a source of sand and gravel. Sandstone has been quarried in the past. The source formation of this material is unknown.

BULL CANYON WSA (CO-010-001/UT-080-419)

There are no known mineral deposits in the Bull Canyon WSA, therefore, any description of deposit types would be theoretical.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

There are two known copper deposits in unit CO-010-226. These deposits are found at or near the contact of the Cambrian Lodore Formation and the Mississippian Madison Formation. Please refer to the aforementioned description on copper deposit type.

MINERAL ECONOMICS

The inherent nature of discussing the economics of the minerals existing within the Bull Canyon/Dinosaur National Monument Adjacent-North GRA and its WSA's can only provide for a general approach inasmuch as there are many economic factors that enter into the development of an ore body. These include access, market value, grade, transportation, recovery and extraction methods, etc. Therefore, the discussion herein addresses the U.S. and Colorado demand and production status of each of the existing minerals in the WSA's.

The mineral resources in the GRA include coal, uranium, base and precious metals, construction stone, clay, and sand and gravel.

Coal is found in the Lower White River Field. There are two coal mines and six prospects of which the operating status and production are not known. Coal production for Colorado mines is currently at an all time high. Approximately 20,000,000 tons of high-grade low-sulphur coal was produced from surface mines and underground operations (Colo. Div. Mines Rept., 1980; and Schwochow, 1978). The future looks encouraging for coal as more and more utilities are switching back to coal for power generation (Schowochow, 1978; Colo. Div. Mines Rept., 1980). Changes in technology and improvements in combustion/distillation techniques will increase the demand for Colorado coal, and coal byproducts (Gentry, Personal Communication, 1982).

The uranium deposits occur in the Jurassic Morrison Formation. Three uranium mines, and eight occurrences are found in the GRA. One mine has been abandoned, and the operating status of the other two is not known. In addition, production statistics from all three are not known. Current production is down from past production levels due to a general drop in the price of uranium (Eng. and Mining Journal, Dec., 1982). Uranium and vanadium are currently being produced at very little or no profit by many of the major mining operations in Colorado (Carpenter, Personal Communication, 1982). Future demand for uranium and vanadium is dependent on foreign production and the needs of the nuclear generating industry (Schwochow, 1978).

Base and precious metals in the form of copper, lead, zinc, iron, manganese and silver occur as replacement deposits in Cambrian formations. Currently, a strong demand for precious metals exists in the U.S. and Colorado. Production and demand for base metals, however, is down from past levels due to a general down-turn in the U.S. and world economy (Eng. and Mining Journal, Dec. 1982). Commodities such as copper, lead, zinc, manganese, and iron are not being currently produced at a substantial profit by any of the major mining operations in Colorado (Eng. and Mining Journal, DEc. 1982; Carpenter, Personal Communication, 1982).

Construction stone, common clay, and sand and gravel are considered "high place value" industrial minerals. These minerals are of economic value only when the deposits are readily accessible, and in close proximity to a market.

The economic viability of the mineral resources in the WSA's in the Bull Canyon-Dinosaur National Monument Adjacent-North GRA are summarized as follows:

WSA	MINERAL POTENTIAL	ACCESSIBILITY	ECONOMIC POTENTIAL [a]
Bull Canyon (UT-080-419)	This WSA has no known mineral/economic potential.		
Dinosaur Adjacent-North WSA (CO-010 224, 224A, 226, 228, 229D)	Oil, Gas	Poor	Poor
	Base Metals	Good	Good
	Uranium &	Poor	Poor
	Precious Metals*	Poor	Poor

*No known deposits or occurrences in WSA. Refer to Section IV for explanation of the economic potential.

[a] The economic potential rating is notwithstanding market demand fluctuations.

SECTION IV

LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

After thoroughly reviewing the existing literature and data base sources, MSME/Wallaby personnel plotted all known and documented mineral occurrences, mines, prospects, oil and gas fields, sand and gravel operations, processing facilities, mining claims, mineral leases, and the locations of anomalous geochemical samples from the National Uranium Resource Evaluation-Hydrological and Stream Sediment Reconnaisance-Airborne Radiometric and Magnetic (NURE-HSSR-ARMS) programs. This plotted information and the data bases on each WSA were made available to a multi-faceted team of experts which made three successive evaluations of the GEM resource potential of each of the WSA's.

The team or panel of geological experts was comprised of:

Dr. Paul Gilmour: Base and precious metal deposits in western U.S. and Canada, expert on Precambrian mineral resources.

Mr. Ted Eyde: Base and precious metal deposits in western U.S., expert on industrial mineral resources.

Mr. Annan Cook: Base and precious metal deposits in western U.S., expert on porphyry deposits and mine evaluation.

Mr. Edward Heylmun: Oil, gas and oil shale deposits of western U.S.

Dr. Robert Carpenter: Mineral deposits of Colorado and western U.S., expert on geology of Colorado.

Dr. Donald Gentry: Expert in coal and oil shale deposits of Colorado and western U.S.

Dr. Larry Lepley: Expert in remote sensing and geothermal resources;

Mr. Walter E. Heinrichs: Geophysics and base and precious metal deposits of western U.S., expert on porphyry copper deposits.

As indicated earlier, Dr.Gentry, and Carpenter made certain field investigations as result of the base data analysis phase. The purpose of the field investigations was to either verify the existing data or assess relatively unknown areas. Dr. Lepley reviewed all aerial photographs for observable anomalies, which were then investigated by the field team, or verified against the existing base data.

The evaluations were then made on the basis of examination of the data bases, field investigations and the individual experiences of the members of the panel in such areas as base and precious metal, industrial and energy mineral deposits; oil and gas deposits; and geothermal resources. In the course of these evaluations, every attempt was made to objectively rate the potential for a particular commodity within the respective study area. In this effort, the evaluation criteria proposed by the Bureau was rigorously used. The classification scheme used is shown in Table IV-1. In many cases the lack of information did not allow for a full determination

TABLE IV-1
RESOURCE RATING CRITERIA

CLASSIFICATION SCHEME

1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.

2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.

3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.

4. The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

LEVEL OF CONFIDENCE SCHEME

A. The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.

B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidence in support or refute the possible existence of mineral resource.

of the GEM resource potential and the panel was forced to leave some areas unranked or classified for some commodities. The situation thus arises where there is an area that has been unclassified for a commodity, despite a reported occurrence, because it is next to an area where there is insufficient data to make a meaningful attempt at classification. Nonetheless, each resource has been additionally rated as to what level of confidence the panel of experts attached to the selected classification level. This is denoted by the letter associated with each rate classification. These are defined in Table IV-1.

A further restraint on this classification and delineation effort comes in the area of the lack of subsurface information. Some areas are very well known from past exploration efforts and have an abundance of subsurface information. Other areas are practically unknown due to an absence of any past exploration or development efforts.

The WSA's, for the most part, are not well known geologically. For this reason, our expert team had to extrapolate geologic information from adjacent areas to make any sort of reasonable classification with some level of confidence. The following pages address those resources considered to be leasable, locatable and/or salable with associated maps locating the resource area (Figures IV-1 through 3):

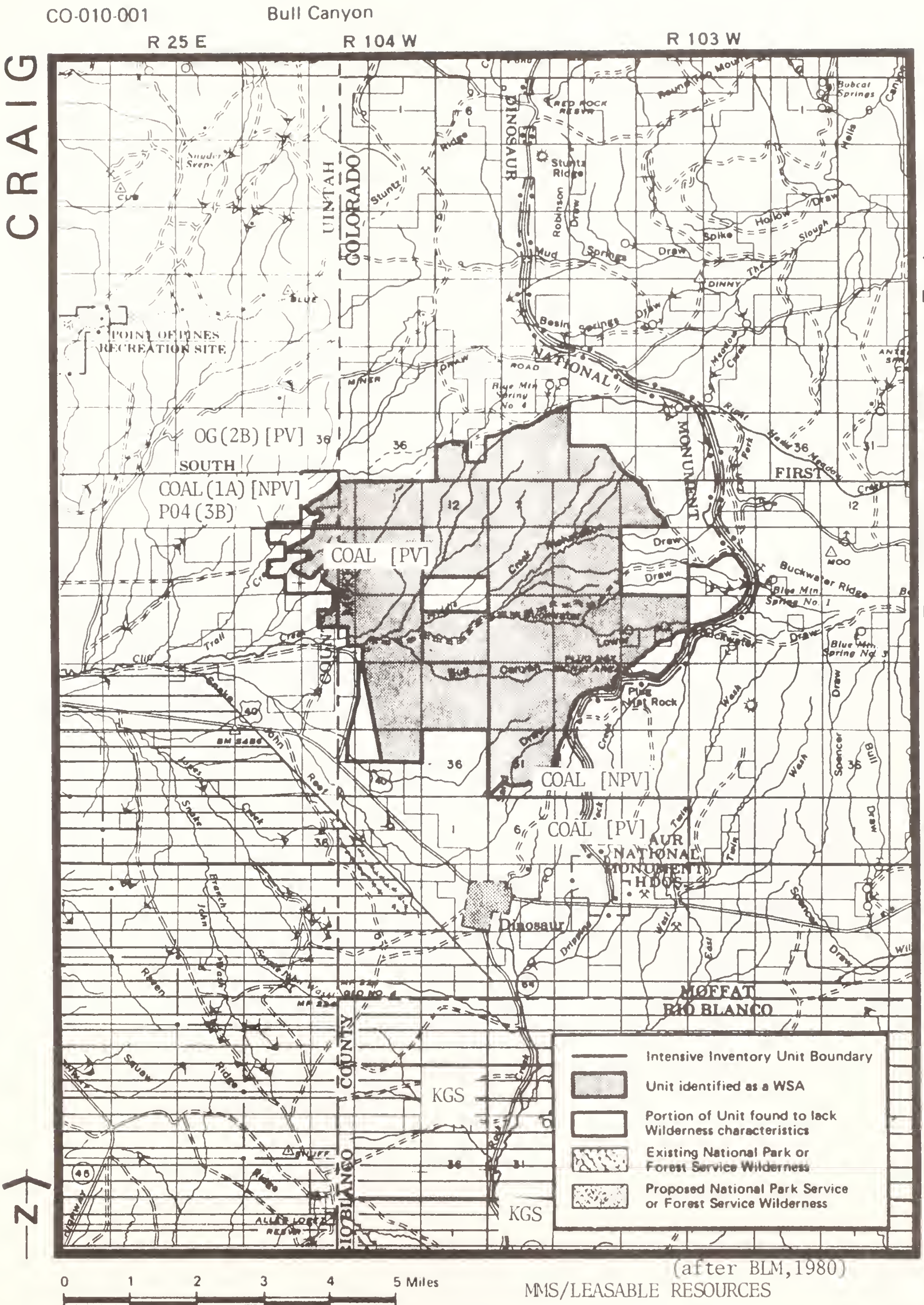
LEASABLE RESOURCES

BULL CANYON WSA (UT-080-419)

Resource	Classification	Comments
Oil and Gas	2B	The WSA contains a thin Paleozoic section.
Coal	1D	Lacks coal-bearing formation.
Phosphate	3B	Permian Phosphoria Formation underlies area

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

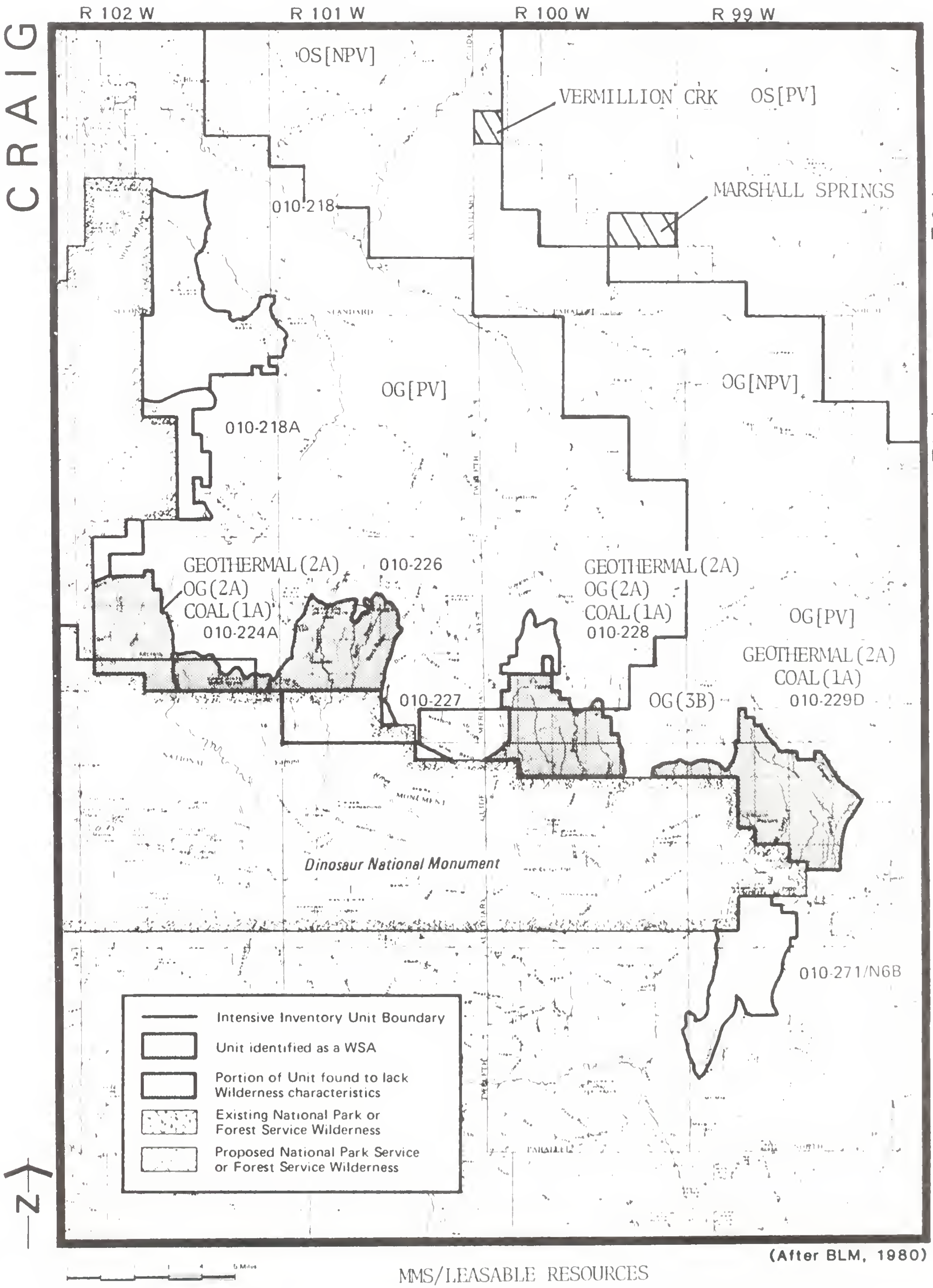
Oil and Gas	CO-010-224	2A	Unknown Precambrian overthrust potential
	CO-010-224A	2A	Unknown Precambrian overthrust potential
	CO-010-226	2A	Unknown Precambrian overthrust potential
	CO-010-228	2A	Unknown Precambrian overthrust potential
	CO-010229D	3B	Cretaceous and Paleozoic section is present
Coal	CO-010-224	1D	Coal-bearing formations lacking
	CO-010-224A	1D	Coal-bearing formations lacking
	CO-010-226	1D	Coal-bearing formations lacking
	CO-010-228	1D	Coal-bearing formations lacking
	CO-010-229D	1D	Coal-bearing formations lacking



(after BLM,1980)

MMS/LEASABLE RESOURCES

Figure IV-1a

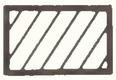


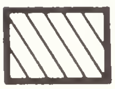
(After BLM, 1980)

MMS/LEASABLE RESOURCES
Figure IV-1b

LEGEND FOR MINERALS MANAGEMENT SERVICE CLASSIFICATIONS

 Defined KGS and/or Coal Leasing Areas

 Areas Prospectively Valuable for Sodium or Potassium

 Defined Oil Shale Leasing Area

Coal [PV] OG[PV] — Areas Identified as Prospectively Valuable for Coal or Oil, Gas

Coal [NPV] OG [NPV] — Areas Identified as Not Being Prospectively Valuable for Coal, or Oil, Gas

LOCATABLE MINERALS

BULL CANYON WSA (UT-080-419)

Resource	Classification	Comments
Precious Metals:	(2A)	Ag mineral potential associated with Precambrian Uinta Group units.
Base Metals	(2A)	Cu mineral potential associated with Precambrian Uinta Group units.
Locatable Energy Minerals:	(2A)	Uranium-vanadium potential associated with Precambrian Uinta Group units.
Other Locatable Minerals:	Unknown	

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

Precious Metals:		
CO-010-224	4D	Au-Ag mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement-skarn deposits in Limestone units. Numerous prospects, production.
	2B	Ag mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-224A	3D	Au-Ag mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement-skarn deposits in Limestone units. Few prospects, little production.
	2B	Ag mineralization potential associated with Precambrian Uinta Group units.
CO-010-226	4D	Au-Ag mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement-skarn deposits in Limestone units. Few prospects, little production.
	2B	Ag mineralization potential associated with Precambrian Uinta Mountain Group units.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D) (cont'd)

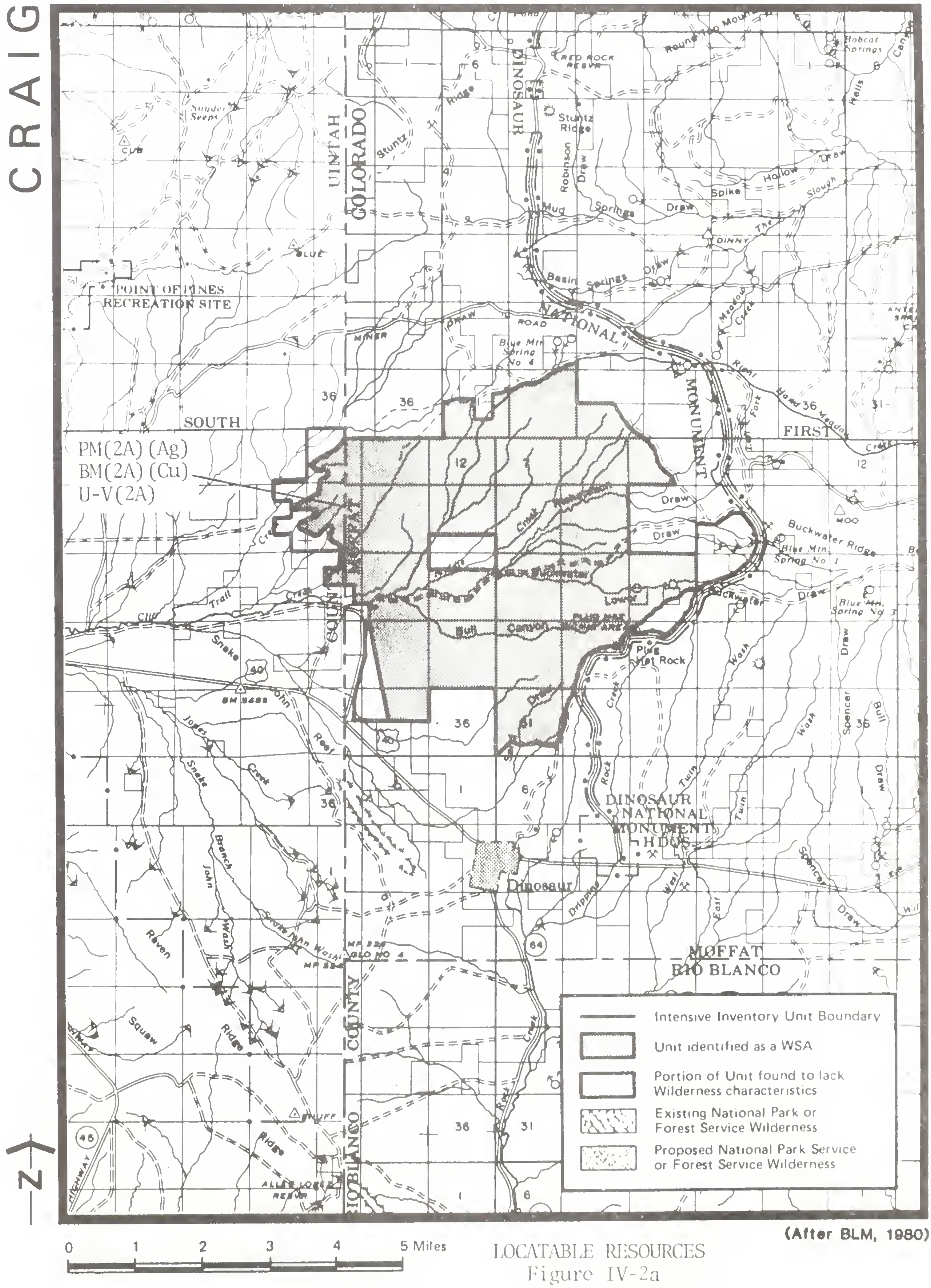
CO-010-228	3D	Au-Ag mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement-skarn deposits in Limestone units. Few prospects, no recorded production.
	2B	Ag mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-229D	3C	Au-Ag mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement-skarn deposits in Limestone units. No prospects but favorable lithologies.
	2A	Ag mineralization potential associated with Precambrian Uinta Mountain Group units. Lack of outcropping section.
Base Metals: CO-010-224	4D	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. Numerous prospects, production.
	2B	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-224A	4D	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. Few prospects, no recorded production.
	2B	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)
(cont'd)

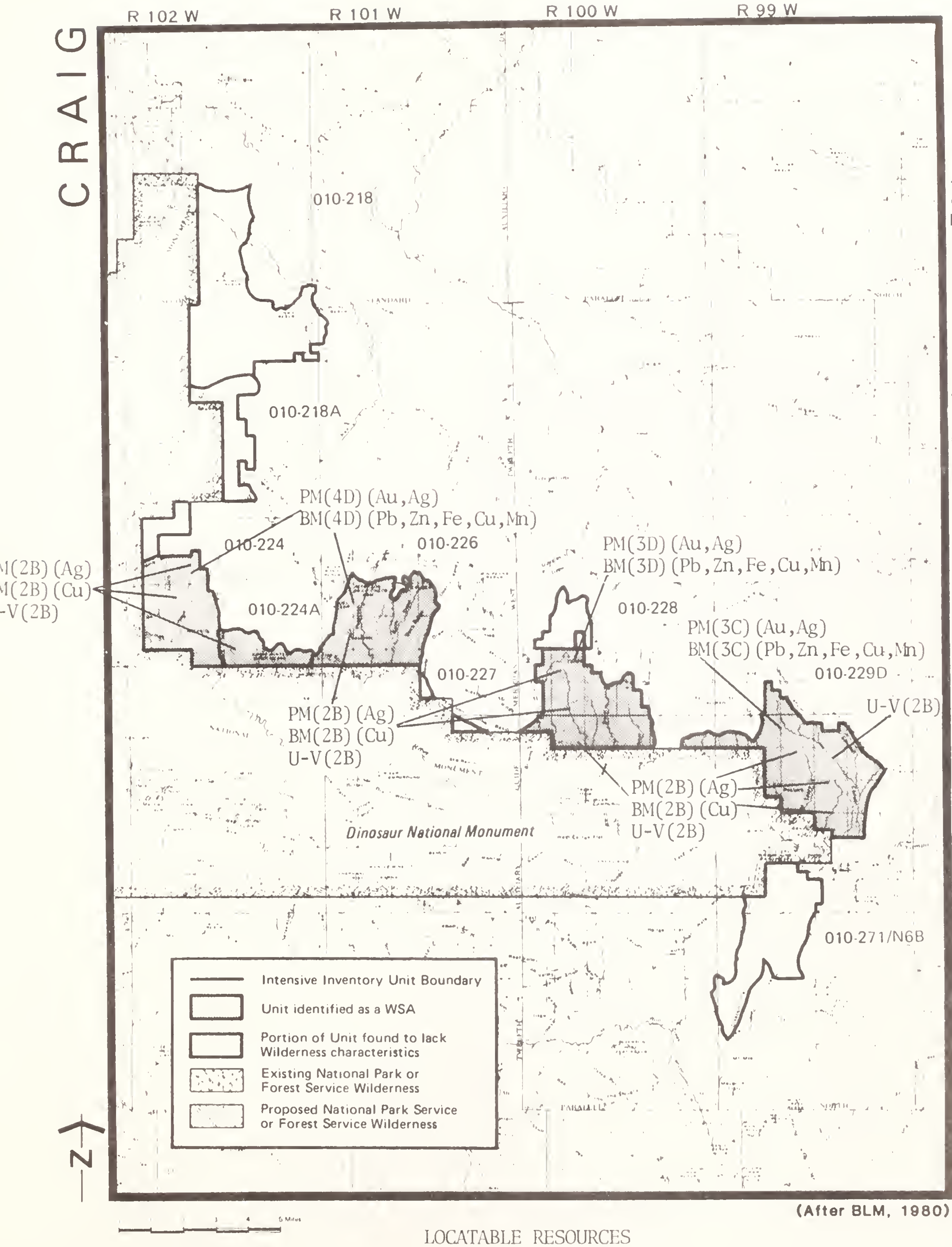
Resource	Classification	Comments
CO-010-226	4D	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. Few prospects, no recorded production. Prospects, some production.
	2B	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-228	3D	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. Few prospects, no recorded production.
	2B	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-228	3D	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. Few prospects, no recorded production.
	2B	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.
CO-010-229D	3C	Pb-Zn-Fe-Cu-Mn mineralization in Mississippian Madison Formation and Cambrian Lodore Formation in association with fault controlled replacement skarn deposits in Limestone units. No prospects but favorable lithologies.
	2A	Cu mineralization potential associated with Precambrian Uinta Mountain Group units.

DINOSAUR ADJACENT NORTH-WSA'S (CO-010-224, 224A, 226, 228, 229D)
(cont'd)

Resource	Classification	Comments
Energy Minerals:		
CO-010-224	2B	Uranium-vanadium potential in Precambrian Uinta Mountain Group.
CO-010-224A	2B	Uranium-vanadium potential in Precambrian Uinta Mountain Group.
CO-010-226	2B	Uranium-vanadium potential in Precambrian Uinta Mountain Group.
CO-010-228	2B	Uranium-vanadium potential in Precambrian Uinta Mountain Group.
CO-010-229D	2D	Uranium-vanadium potential in Tertiary Browns Park Formation
CO-010-229D	2B	Uranium-vanadium potential in Precambrian Uinta Mountain Group.
Other Locatable Minerals:	Unknown	



LOCATABLE RESOURCES
Figure IV-2a



LOCATABLE RESOURCES
Figure IV-2b

SALABLE RESOURCES

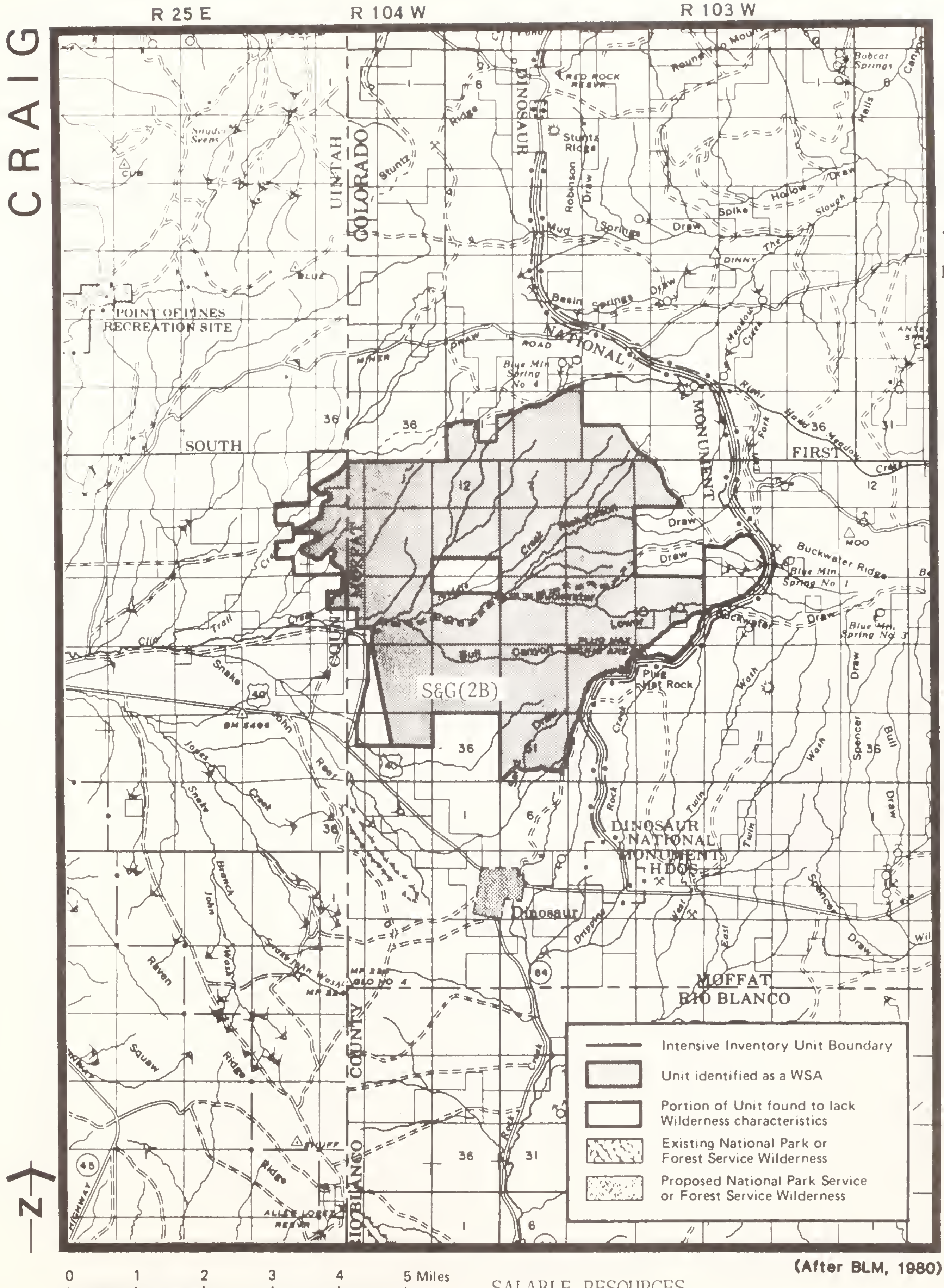
BULL CANYON WSA (UT-080-419)

Resource	Classification	Comments
Sand and Gravel	2B	

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

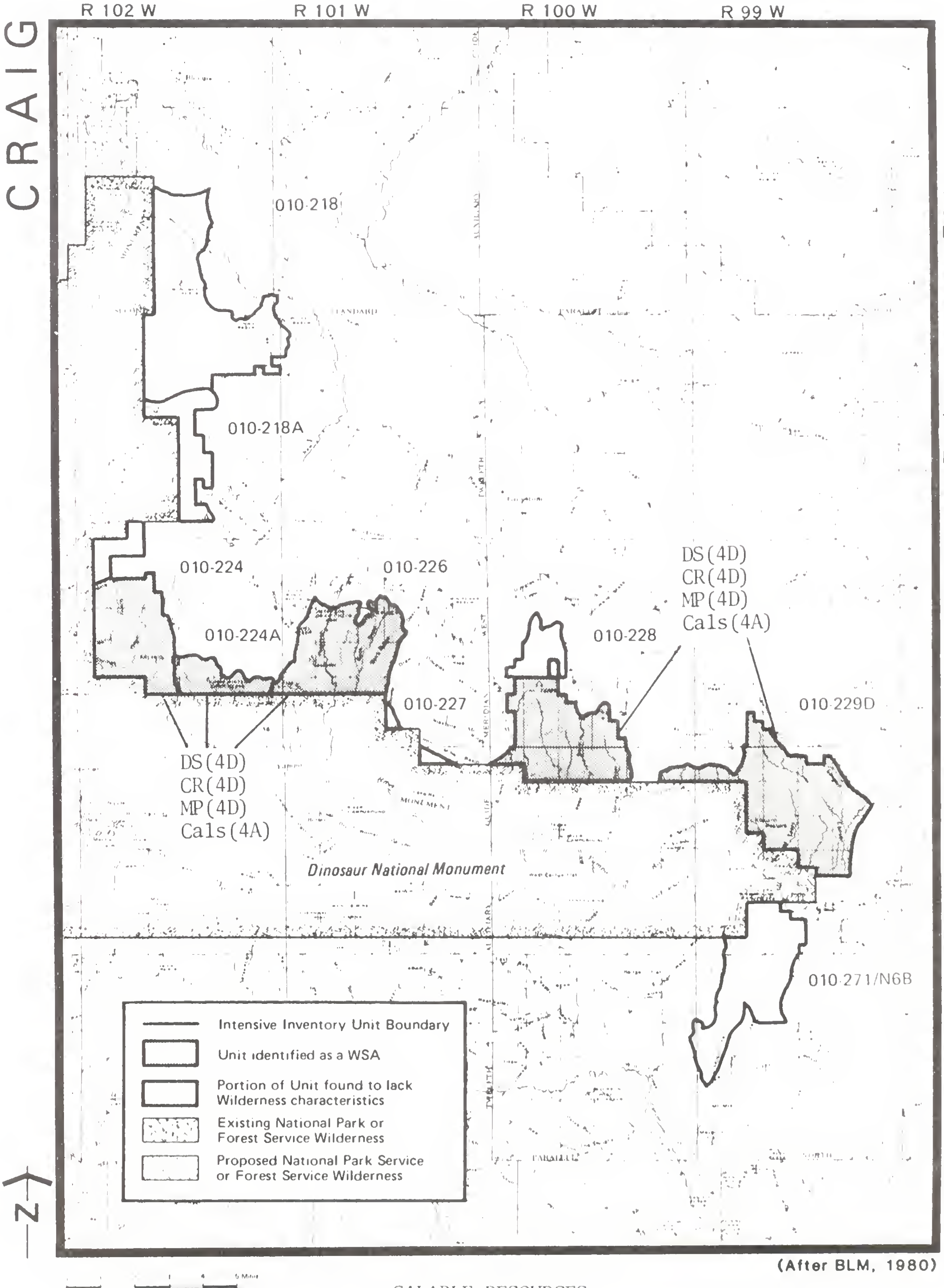
Resource	Classification	Comments
Dimension Stone	4D	Favorable formations are found within the WSA: Precambrian Uinta Quartzite, Marble in PC, Weber Sandstone, Lodore Limestone, Park City, Madison Limestone.
Cement rock	4D	Derived from the Ladore Limestone, Park City, Madison Limestone
Mineral Pigments	4A	Pigment production is from the Madison-Lodore (?). Mineral pigments have a high unit value therefore moderate potential.
High Calcium Limestone	4A	Derived from the Madison formation
Phosphate	3B	The Phosphoria Formation is a favorable host for phosphate deposits

CO-010-001 Bull Canyon



(After BLM, 1980)

SALABLE RESOURCES
Figure IV-3a



SALABLE RESOURCES
Figure IV-3b

SECTION V

RECOMMENDATIONS FOR FURTHER STUDY

In the course of analyzing, assessing and evaluating each of the WSA's in the Bull Canyon/Dinosaur National Monument Adjacent-North GRA - both in the field and in available data - certain unknowns were uncovered that should be investigated in order that each WSA's GEM resources be more fully documented. This section recommends the type of studies and data gathering that should be made to inventory more completely each WSA.

Since this area is known to have minor potential for oil and gas resources, it is recommended that every effort be made to ascertain the full extent of this potential. Cooperative agreements should be made with various oil and gas producers to obtain proprietary information not available to this study. Such information as the projected reserves of the area, the importance of structural zones in localizing oil and gas oils, and the exact identification of pay zones within the generally favorable lithologies is of vital importance in the exact areal delineation of sub-surface potential.

In addition, a detailed program of geologic mapping and sampling should be carried out to fully delineate the extent of the coal bearing horizons in the Cretaceous section. Any sampling carried out under such a program must include analysis of the coal material for the ash and sulphur content as well as Btu content. Much work has already been done on lithofacies reconstruction in the Cretaceous in adjacent areas. Studies of this nature would be useful in determining the probable extent of the coal measures and thus, the viability of the coal as a minable resource.

The outcrops of the Jurassic Morrison Formation should be sampled for their uranium-vanadium content, and correlated to other units in northwestern Colorado and eastern Utah. Examination of the Morrison units should be made by paleontologists for environments favorable for the preservation of vertebrate remains.

From the work to date and the material compiled in the course of ths project, it appears that this area has significant potential for GEM resources.

DINOSAUR ADJACENT-NORTH WSA'S (CO-010-224, 224A, 226, 228, 229D)

In this area the potential for GEM resources is largely unknown. Detailed geologic and geochemical studies are warranted to ascertain the mineral potential of the Precambrian and Paleozoic lithologies. Special attention should be paid to possible sedimentary lithologic assemblages associated with Precambrian base and precious metal systems. Of equal importance is the potential for base metal mineralization in the Cambrian Lodore and Mississippian Madison Formations. Stratigraphic and lithofacies mapping should be carried out to determine if any environments with characteristics exist. A relatively low-cost way to accomplish these goals is to conduct a stream sediment and outcrop sampling program in conjunction with a geologic mapping effort.

All existing mines, prospects and known mineral occurrences should be mapped and thoroughly sampled to delineate the full extent of the existing mineralization and the potential of the host lithologies. This is of particular importance in the determination of the copper, lead, zinc, gold, silver, manganese, and iron potential of the Mississippian Madison Formation and the underlying Cambrian Lodore Formation. With regard to these specific units, a detailed study should be made of facies changes within these units, and the correlations with other units in western Colorado and eastern Utah. In other areas of Utah, these units have significant potential GEM resources and thus, should be studied in those areas where there is available information. Though the airborne and ground NURE-HSSR-ARMS information does not delineate any areas with anomalous base or precious metal values, ground radiometrics in conjunction with the geological-geochemical studies would be helpful in identifying any areas of mineral potential.

Stream sediment samples should be analyzed for their copper, molybdenum, lead, arsenic, uranium, vanadium and gold content. This data will supplement the existing NURE-HSSR information.

Since some of the Precambrian units have been used in the past as a source of local road building and dimension stone material, it would be wise to do further work on the demand for this material.

In conclusion, from the work to date and the material compiled in the course of this project, it appears that the potential for GEM resources in this area is largely unknown.

SECTION VI

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