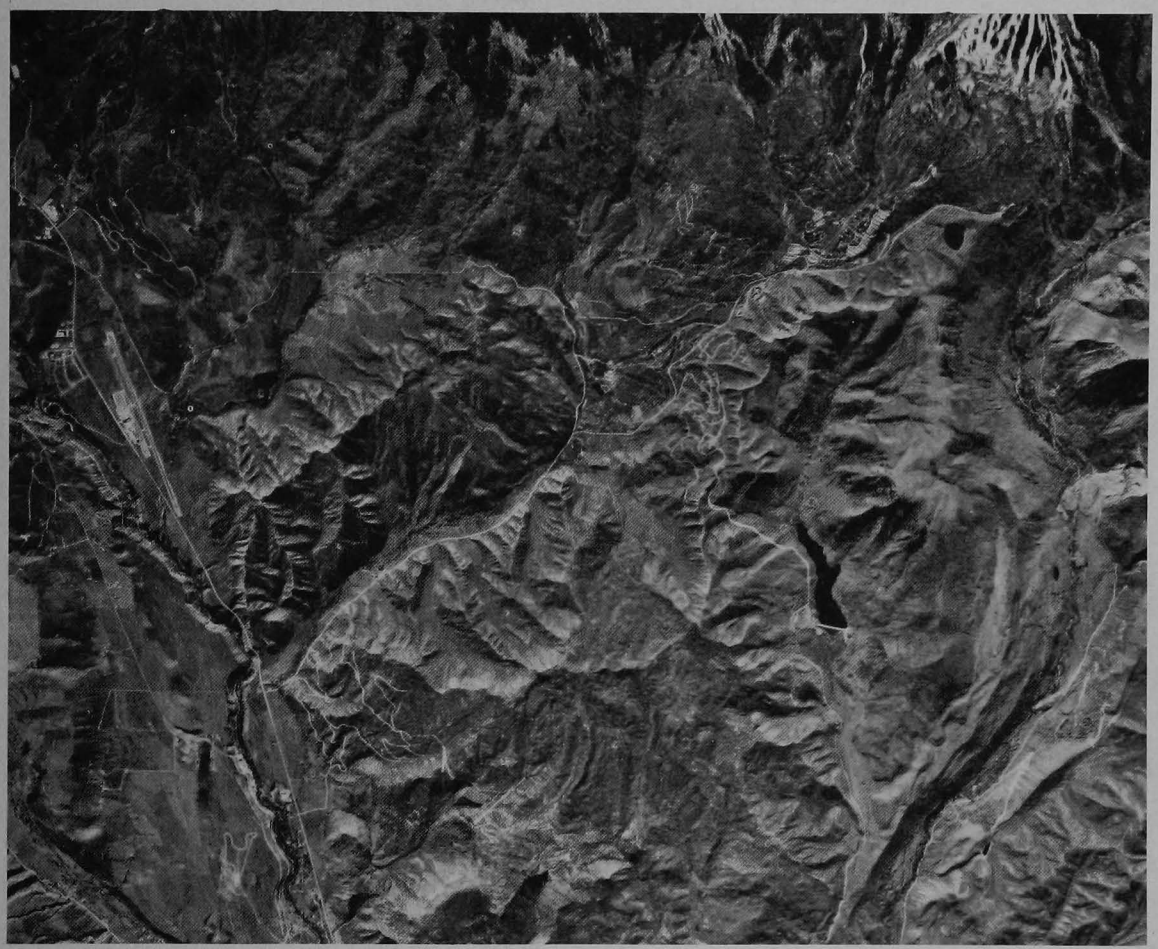
ENVIRONMENTAL GEOLOGY NO. 8

ROARING FORK AND CRYSTAL VALLEYS AN ENVIRONMENTAL AND ENGINEERING GEOLOGY STUDY

Eagle, Garfield, Gunnison and Pitkin Counties, Colorado



COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
AND
COLORADO DIVISION OF PLANNING
STATE OF COLORADO
DENVER, COLORADO

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PREPARED FOR

THE COLORADO GEOLOGICAL SURVEY

AND

THE COLORADO DIVISION OF PLANNING

BY

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SUMMARY

An environmental and engineering geology study has been made of the Roaring Fork and Crystal Valleys. The 300 square mile study area encompasses parts of four counties (Eagle, Garfield, Gunnison, and Pitkin) in west central Colorado. There, the diverse and complicated geology developed from geologic processes (such as erosion, sedimentation, deformation, intrusion, extrusion, and glaciation) which have been affecting the region for more than 600 million years. The geologic information compiled during this study is presented on a series of self explanatory maps to provide planners and other government officials with useable information.

The series of maps consists of the following: Plate 1, Geologic Map; Plate 2, Environmental and Geologic Constraints Map; and, Plate 3, Ground Water and Geologic Resources Map. All preliminary data were compiled on work maps having a scale of 1:24,000 (or 1" = 2000'). This map information was reduced photographically and is presented on a convenient scale of 1:48,000. Even at this final scale, the project area is sufficiently large to require that each plate be printed in two parts - a north and a south sheet respectively.

Plate 1 provides the framework for the other maps. The geology presented on these two sheets shows the history of the area and the relationships between the various components of that history. Plates 2 and 3 focus attention on certain attributes of the geology - geologic constraints and geologic resources respectively. The text which accompanies these maps provides additional information, explanation, and emphasis for the salient

features which have been identified by this study. Some of these topics are reviewed briefly as follows.

The need for soil investigations at proposed construction sites is stressed. Swelling or settling soils are found in many places in the study area, and rock materials having collapse potential are also present. The readers attention is called to Plate 2 where the Mesaverde, Mancos, Morrison and Eagle Valley formations are delineated as being especially troublesome. The life of any structure can be extended significantly by proper foundation design based on good soil engineering data.

Commonly, unstable surface conditions are found in areas having moderate or extreme topographic relief and abundant moisture. These conditions are too restrictive for certain formations found in the study area, such as the Mancos Shale and Eagle Valley Evaporite. These units can fail and produce landslides, mudflows, etc. even in areas of low topographic relief. Failures result from poor drainage, either naturally or artificially created. The potential for unstable surface conditions should be investigated at every proposed development site.

The geologic flood plains are depicted on Plate 2. These areas are subject to both flood and erosional hazards. The potential danger of these hazards may not be recognized owing to present population groupings and densities. However, an increase in population may result in more developments on the flood plains. This must be considered, and development of flood plains must be regulated.

Continued growth within the area will point up a variety of environmental and engineering problems which are related directly to geology.

These are shown on Plate 2 and mentioned in the report. Briefly, the following topics are included: avalanches, high water tables, rockfalls, waste disposal, and water pollution. Without exception these potential problems can be eliminated or avoided by having thorough geologic investigations made at all sites prior to starting development projects.

Time will create even greater demand for natural resources than those which exist today. Accordingly, it is probable that some resources will be discovered or further developed within the area. Because of the potential conflict for land use, consideration must be given to the diverse future needs in areas of high development potential. The broad spectrum of known resources are shown on Plate 3. Many of these are situated in growth areas and serve to point up the potential need for multiple land use programs.

INTRODUCTION

This report presents the results of an environmental and engineering geology study of the Roaring Fork and Crystal River Valleys in west central Colorado. The project was sponsored jointly by the Colorado Geological Survey and the Colorado Division of Planning with matching federal funds from the Department of Housing and Urban Development.

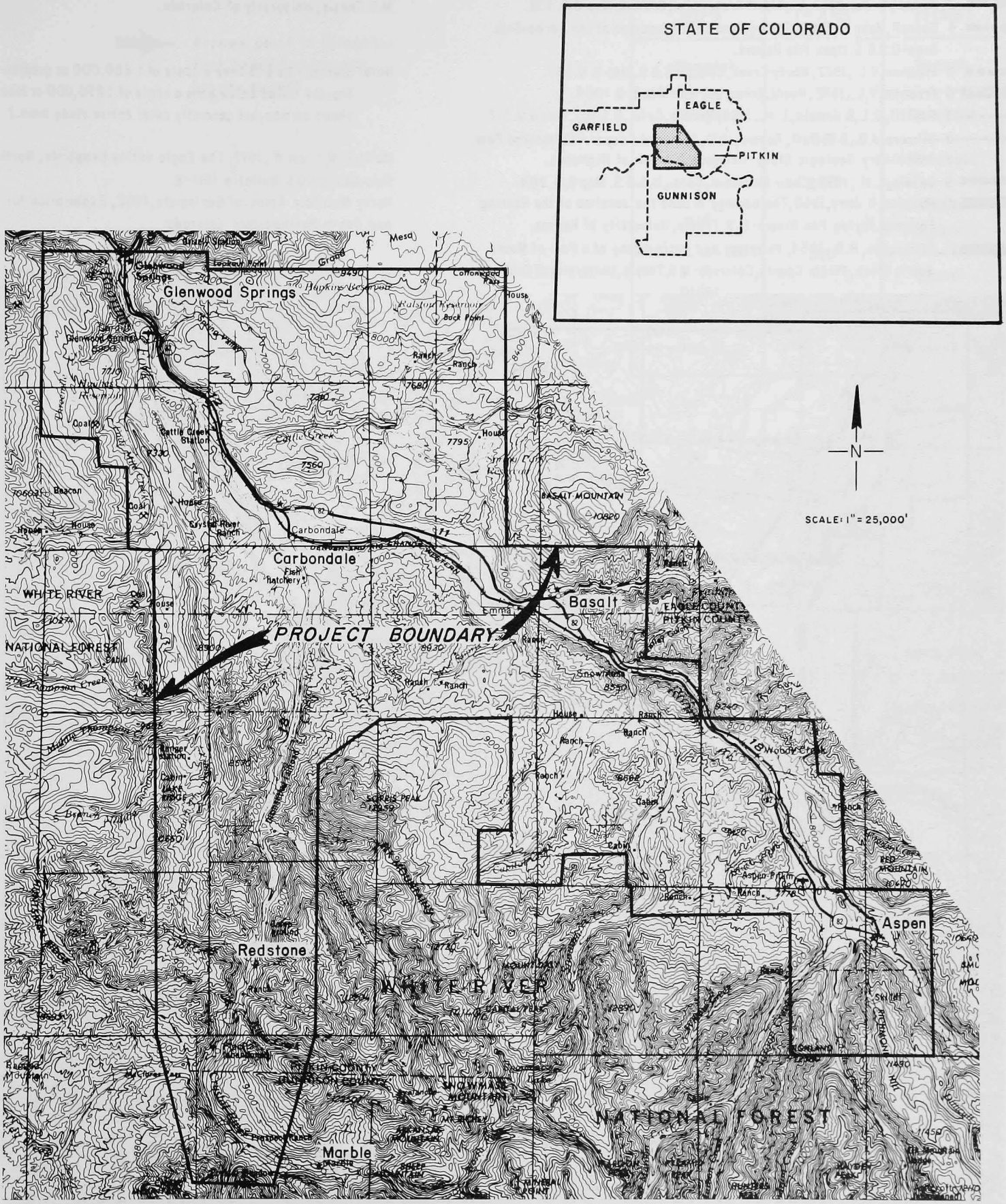
Purpose and Scope

The purpose of the study was to compile sufficient information to prepare comprehensive maps and text concerning the environmental and engineering geologic characteristics of the Roaring Fork Valley, from Glenwood Springs to Aspen, and the Crystal Valley, from Carbondale to the vicinity of Marble, Colorado.

Figure 1 shows the area of this investigation. The study area was defined to include the majority of the potentially developable private land in the vicinity of the aforementioned valleys. The major topics of the investigation include but are not limited to engineering geology, geologic hazards, ground water, mineral resources and surface geology. A large amount of geologic information, from a variety of sources, was studied and much pertinent data compiled to effectively evaluate this large area. Figure 2 shows the sources of pre-existing geologic map information which have been incorporated into this study. In addition, photogeologic studies were made using aerial photographs from three surveys to augment the geologic evaluations. Field geologists checked previous mapping and photo interpretations.

Physiographic Features

The project area, about 300 square miles, is located in the west central part of Colorado. The area encompasses part of four counties - Eagle, Garfield, Gunnison and Pitkin Counties. Elevations within the area studied range from approximately 6,000 to 11,000 feet above sea level. The mean elevation is approximately 7,500 feet. The north and northwesterly trending valleys of the Crystal and Roaring Fork Rivers serve as transportation, communication, and utility corridors for this rugged mountain region. The Roaring Fork River Valley extends nearly 45 miles from the southeastern to the northwestern corner of the study area. From the southwestern part of the area, the Crystal River follows a northerly course for approximately 27 miles where it joins the Roaring Fork near the town of Carbondale. The combined flow of these two rivers



PROJECT BOUNDARY INDEX MAP FIGURE 1.

1 Bass, N.W., & Northrop, S.A., 1963, Geology of Glenwood Springs quadrangle and vicinity. Northwest Colorado: U.S.G.S. Bulletin 1142-J.

2 Bryant, Bruce, 1971, Aspen, Colo., U.S.G.S. Map G.Q.933.

3 Bryant, Bruce, 1972, Highland Peak, Colo., U.S.G.S. Map G.Q.932.

4 Donnell, John R., 1962, Geology and Coal Resources of the Carbondale Area: U.S.G.S. Open File Report.

5 Freeman, V.L., 1972, Woody Creek, Colo., U.S.G.S. Map G.Q.967.

6 Freeman, V.L., 1972, Ruedi, Colo., U.S.G.S. Map G.Q.1004.

7 Gaskill, D.L., & Godwin, L.H., 1966, Marble, Colo., U.S.G.S. Map G.Q.512.

8 Gilmore, J.B., & Barrett, Robert, 1971, Glenwood Canyon – Cottonwood Pass, Priliminary Geologic Study: Colorado Division of Highways.

9 Godwin, L.H., 1968, Chair Mountain, Colo., U.S.G.S. Map G.Q.704.

10 Hodgden, H. Jerry, 1960, The Geology Around the Junction of the Roaring Fork and Frying Pan Rivers: M.S. Thesis, University of Kansas.

11 Pilkington, H.D., 1954, Petrology and Petrography of a Part of Mount Sopris Stock, Pitkin County, Colorado: M.S. Thesis, University of Colorado.

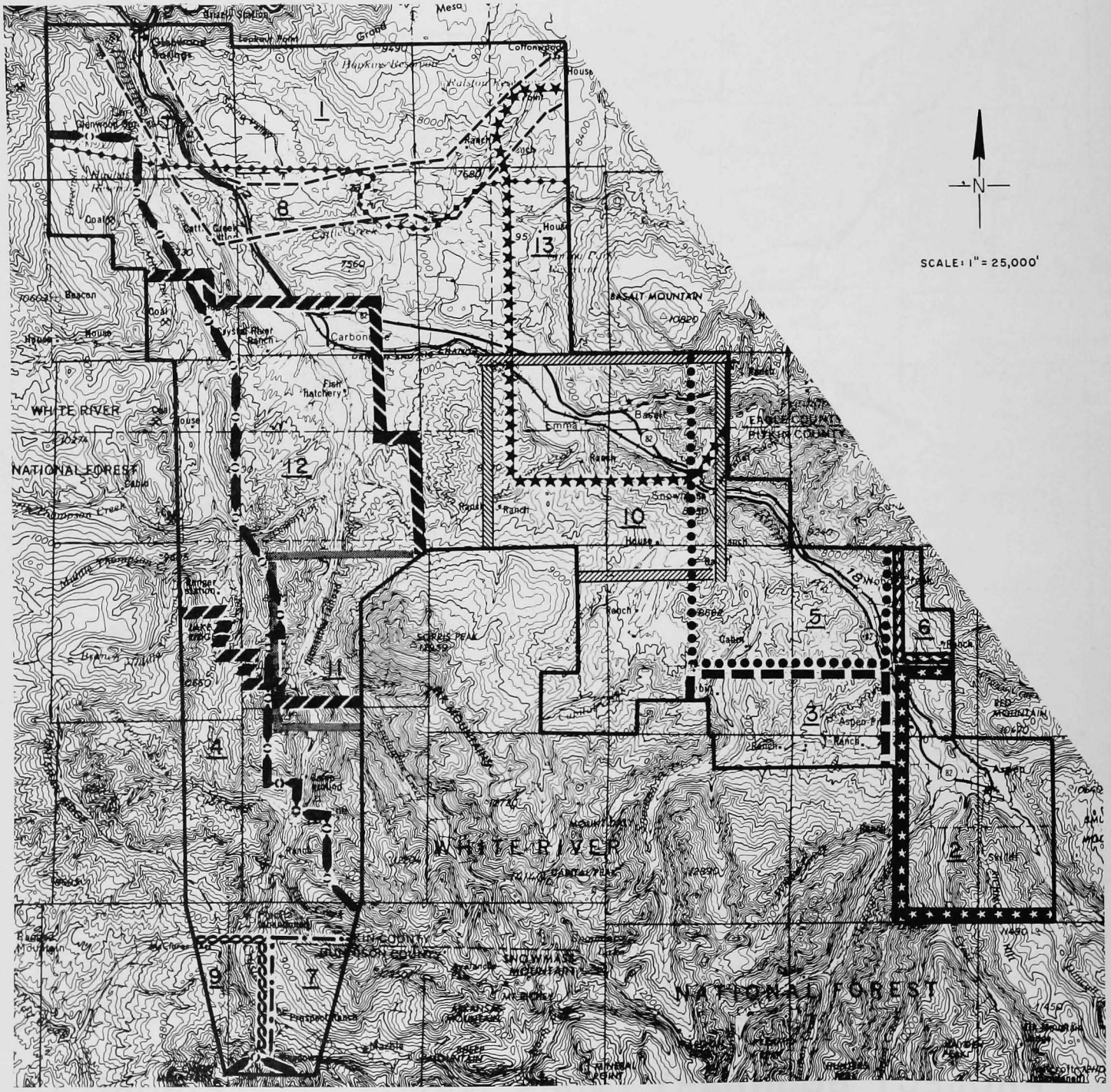
12 Poole, Forrest G., 1954, Geology of the Southern Grand Hogback: M.S. Thesis, University of Colorado.

13 Welder, George E., 1954, Geology of the Basalt Area, Colorado: M.S. Thesis, University of Colorado.

Note: Sources 1 thru 13 have a scale of 1:250,000 or greater. Sources listed below have a scale of 1:250,000 or less (not shown on map, but generally cover entire study area.)

Mallory, William W., 1971, The Eagle Valley Evaporite, Northwest Colorado: U.S.G.S. Bulletin 1311-E.

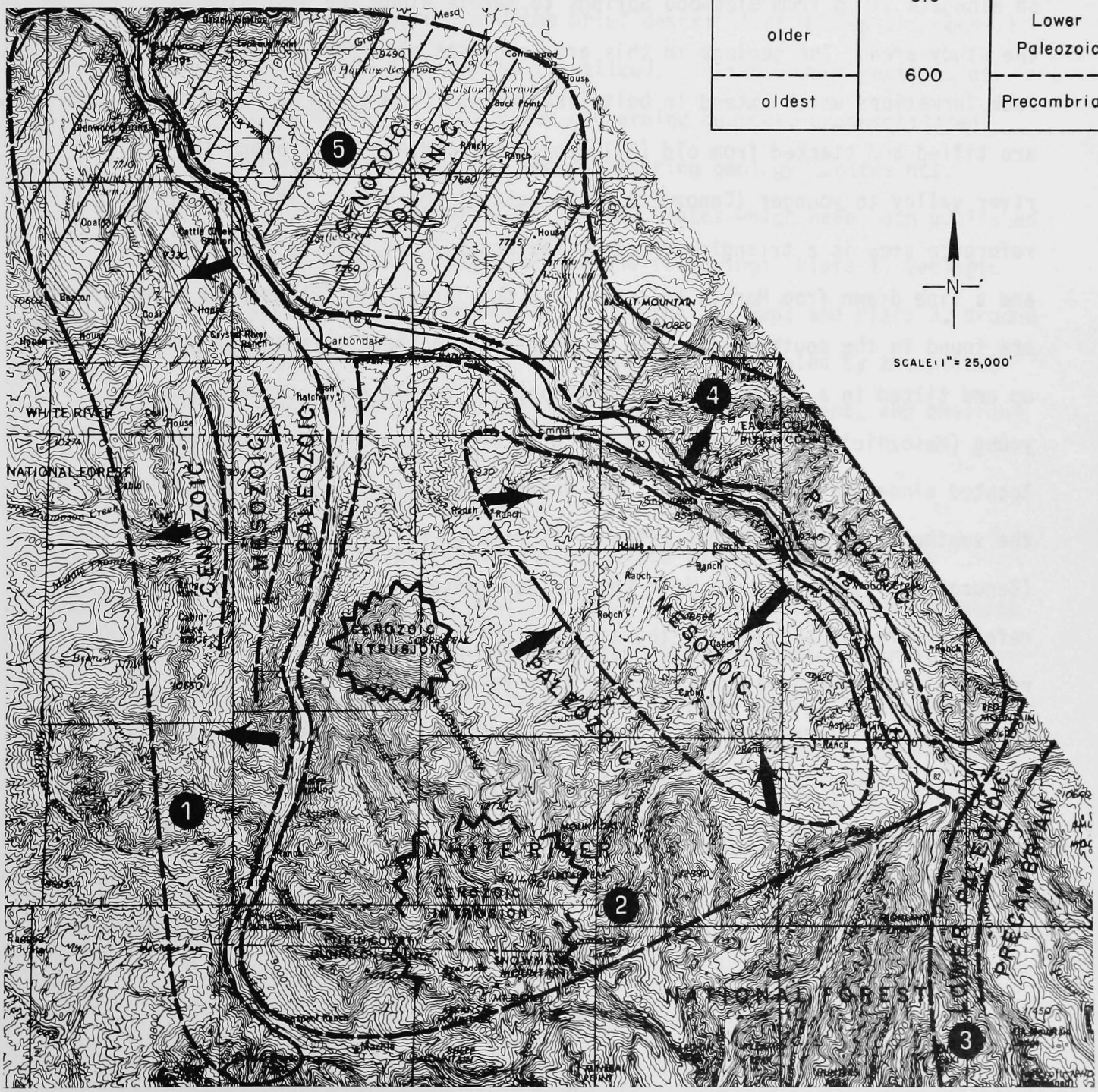
Rocky Mountain Assoc. of Geologists, 1962, Exploration for Oil and Gas in Northwestern Colorado.



SOURCES OF GEOLOGIC INFORMATION FIGURE 2.

SIMPLIFIED RELATIVE AGES	MILLIONS OF YEARS	GEOLOGIC ERA (time)
youngest	1	Recent
younger	50	Cenozoic
young	230	Mesozoic
old	310	Upper Paleozoic
older	600	Lower Paleozoic
oldest		Precambrian

Arrows point in direction that bedded rocks dip, (or are tilted).



SIMPLIFIED GENERAL GEOLOGY

FIGURE 3.

empties into the Colorado River at Glenwood Springs.

General Geology

The geology of the study area is very complex. To present a brief and simplified description of that geology, the project area is divided into five smaller areas as shown by Figure 3. The first reference area is an elongate strip from Glenwood Springs to Marble along the west side of the study area. The geology in this area consists of bedded, sedimentary rock formations which extend in belt-like fashion from north to south and are tilted and stacked from old (Paleozoic) sedimentary rocks along the river valley to younger (Cenozoic) rocks west of the river. The second reference area is a triangle formed by the Crystal and Roaring Fork Rivers and a line drawn from Marble to Aspen. In this area, old (Paleozoic) rocks are found in the southwestern part of the triangle where they are arched up and tilted in a northeasterly direction. These old rocks dip beneath young (Mesozoic) sedimentary rocks which occur in an oval shaped depression located along the western side of the Roaring Fork River. The arching in the southwestern part of this triangle is related to younger intrusions (Cenozoic) of igneous rocks into the old sedimentary rocks. The third reference area is situated to the east and south of Aspen. Here the oldest rocks in the study area (Precambrian) form an eastern core with a donut-like ring of older (Lower Paleozoic) sedimentary rocks lying between the core and the triangular area. The fourth reference area forms an elongate strip extending from Aspen to Glenwood Springs and lies along the eastern side of the Roaring Fork River. This area contains old (Paleozoic) sedimentary rocks which are gently arched. The axis of this broad uplift is essentially

parallel to the Roaring Fork River Valley. The fifth reference area is an overlapping feature which covers some of the northern parts of reference areas one and four. The feature comprises a caprock formed by younger (Cenozoic) volcanic rocks which were extruded on top of the sedimentary rocks found in areas one and four.

By referring to Figure 3 and the brief descriptions above, the general geology of the project area can be visualized. In subsequent sections of this report information will be given concerning bedrock, unconsolidated surficial deposits, environmental and engineering geology constraints. This text is intended to augment the special plates which have been published in color for this report. These include the following: Plate 1, Geologic Map; Plate 2, Environmental and Geologic Constraints Map; and Plate 3, Ground Water and Geologic Resources Map. The information presented by the plates and text will aid those responsible for making safe, efficient, and environmentally sound land use decisions.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

The information which follows is organized to provide continuity between the text and maps. A detailed explanation is presented on the north sheet of every plate. The legend for Plate 1 shows geologic information sequentially from top to bottom, the order of increasing age of the geologic units mapped. This geologic sequence is used as the framework for Plate 2, Environmental and Geologic Constraints Map. Accordingly, the same map unit sequence is followed here in the text.

Unconsolidated Surficial Deposits

Three general types of unconsolidated surficial deposits are shown

on the geologic map. These include colluvial, younger alluvial, and older alluvial deposits.

Colluvial Deposits. Colluvial deposits consist of unconsolidated materials which occupy a down-slope position where they have accumulated primarily by gravitational processes. There are many types of colluvial deposits and the age can range from perhaps two million years for some stabilized deposits to materials which have accumulated recently. Specific types of colluvial deposits are delineated on Plate 2. These include such deposits as wedges, landslides, mudflows, rockfalls, rock glaciers, slumps, and talus. Definitions for these and other geologic terms can be found in Appendix A. Colluvial deposits are characterized by unconsolidated, poorly sorted, rock debris. This debris may be angular and may range in size from large blocks to particles as small as clay. Colluvial deposits are widespread throughout the project area. These deposits are relatively thin, commonly less than 100 feet thick.

Colluvial deposits can be hazardous. They are commonly unstable, exhibit variable natural porosity, may be poorly drained, and are very susceptible to erosion and, in places, to hydrocompaction. All colluvial deposits should receive a thorough examination prior to any construction or development work. Many of these deposits are not suitable for development without specific remedial engineering work.

Younger Alluvial Deposits. The second general type of unconsolidated surficial deposit mapped is younger alluvium. These deposits consist of materials which have been transported by or accumulated in water, and for the most part, are being deposited at this time. Specific types of younger

alluvium shown on Plate 2 include alluvial fans, lake, and stream deposits. Younger alluvial deposits are characterized by unconsolidated rock waste which may be moderately sorted by the action of moving water. The material making up the younger alluvium commonly ranges in size from gravel to clay, and generally is better rounded than colluvial debris. These deposits are widespread in the study area, most commonly located along the principal and tributary valley floors, and are relatively thin (generally less than 100 feet thick).

Younger alluvial deposits are generally stable, but are commonly subject to high water tables and/or flood hazards. Comprehensive site investigations and proper engineering are required to provide protection against such hazards. These younger alluvial deposits are also a principal source of sand and gravel. Such resources may be amenable to development by sequential land use programs, but the nature of such a program will be determined in part by the water table in the sand or gravel.

Older Alluvial Deposits. The third general type of unconsolidated surficial deposit delineated by this study consists of older alluvial deposits. In addition to being water deposits, the older alluvial deposits are related, in part, to Pleistocene glacial action. In the study area the older alluvial deposits may be two million or more years old. The specific types of materials shown on Plate 2 include older alluvial fans, glaciofluvial deposits, glacial moraines, gravel terraces, and pediments. Because of the diversity of ways in which the older alluvial deposits have formed they are somewhat more difficult to characterize. In general, these deposits consist of unconsolidated rock debris which is moderately to poorly sorted. The materials commonly

range in size from boulders to clay particles and may consist of either rounded or angular fragments. The older alluvial deposits are widespread. These deposits tend to be somewhat thicker in the study area than the other two types of unconsolidated surficial deposits, and may be as much as 200 feet thick in some places.

Generally, the older alluvial deposits are not subject to flooding, but they are affected by erosion, and may be hazardous because of water table or drainage problems. Colluvial deposits commonly form or are derived from these older alluvial deposits. The older alluvial deposits can also yield construction materials and should be developed under special land use programs. These programs will be affected by the presence of a water table. Some of the high level terraces constitute the safest and most economical development sites in the study area.

Bedrock

Bedrock is defined as any type of solid rock or consolidated rock material which is exposed at the surface of the earth or overlain by unconsolidated material. In the project area there are many varieties of bedrock. For simplicity and convenience only the three major types of bedrock will be defined. However, explanations of many varieties of these three types are presented in Appendix A.

Igneous rocks form by solidification from an essentially molten state. Intrusive igneous rocks are those which have penetrated other rocks but have solidified before reaching the surface of the earth. The extrusive igneous rocks originate in the same manner, but flow out or are extruded onto the surface of the earth before solidifying. Both intrusive and extrusive igneous rocks are found within the study area.

The second major type of bedrock found in the project area consists of metamorphic rocks. These rocks are the resultant of a transformation of other rocks, brought about by great pressures, high temperatures and/or chemical changes. The metamorphic rocks in the project area are found in structurally deformed areas and in proximity to the intrusive igneous rocks.

The third major type of bedrock comprises sedimentary rocks. These rocks are layered accumulations of rock particles, plant or animal remains, products of chemical action or evaporation, or mixtures of these materials. The greater age and consolidated nature of the sedimentary rocks distinguishes them from the unconsolidated stratified surficial deposits.

These types of bedrock and the many varieties found in the project area are described in the order of increasing age, as mentioned before.

Extrusive Igneous Rocks (Lava flows). Lava flows or volcanic rocks are widespread in the northern part of the study area. There are probably more than ten separate flows with a composite thickness reported to be as much as 1,000 feet in the northwest. These rocks are predominantly dark gray, olivine basalt. The basalt is hard, partly vesicular, and exhibits columnar jointing in places. These rocks are commonly fractured, and the weathered surfaces are brownish.

Basalt flows have joint and fracture systems which facilitate water percolation, weathering, and erosion. These flows are susceptible to mass-wasting where they overlie clay or evaporite rocks. Development work, in such areas, should be away from all basalt escarpments. Blasting will be required to excavate or cut fresh surfaces in the basalt.

Intrusive Igneous Rocks. Of the younger intrusive rocks, outcrops are found in the southwest and southeast parts of the study area. These outcrops appear

to consist of relatively small intrusions such as stocks, laccoliths, phacoliths, sills, and dikes. The intrusive bodies found in the vicinity of the Elk Mountains consist of granodiorite and quartz monzonite. These rocks are typically light gray and medium grained. Porphyritic varieties are found near the contacts with host rocks. The outcrops found in the mountains south of Aspen are severely faulted. These intrusive rocks are predominantly quartz diorite and aplite porphry which are medium gray and light gray respectively. Except for the phenocrysts, these rocks are fine grained.

Most intrusive rocks are dense and hard. Drainages in and from the igneous rock areas present some danger of flash floods. These rocks tend to be stable and are commonly associated with rugged terrain. Fracture and joint systems facilitate weathering and, locally, rockfalls may be a hazard. Talus slopes and rock glaciers often form near the base of steep slopes of intrusive rocks. Blasting will be necessary for cutting or excavating fresh surfaces. The intrusive igneous rocks are a possible source for quarry aggregate and rip-rap.

Wasatch Formation. The Wasatch Formation crops out along the Grand Hogback in the western part of the study area. Here the formation varies in thickness from 600 feet in the south to more than 5,000 feet in the north. The Wasatch formation consists of claystone, shale and mudstone interbedded with siltstone, sandstone, and some conglomerate. The formation is white to multicolored. The coarser grained, bedded rocks such as sandstones and conglomerates tend to be arkosic, poorly sorted, and are commonly lenticular. The finer grained rocks tend to be soft and susceptible to erosion.

Local engineering problems exist because of the clay content of certain beds within the Wasatch Formation. These problems could include water seepage along bedding surfaces and susceptibility of the rocks to erosion. Cuts into natural slopes should be avoided unless the bedding dips away from the proposed cut. There are reports of swelling clays and foundation problems associated with the Wasatch Formation. In addition, hydrocompaction can occur in colluvium derived from this formation.

Ohio Creek Conglomerate. The distribution of this formation is similar to that of the Wasatch Formation. The thickness of the Ohio Creek Conglomerate is variable but is less than 500 feet. The formation consists of pebbly to conglomeratic sandstone with an interbedded sequence of sandstone, siltstone, and shale in the middle part of the formation. The Ohio Creek Conglomerate is light colored but weathers to shades of gray and brown. The sandstones are commonly feldspathic and contain quartz and chert pebbles.

The sandstone beds of the Ohio Creek Conglomerate are somewhat friable and susceptible to erosion. However this porous and permeable formation will not have drainage problems, and both natural and cut slopes should be stable. Locally, the formation may be an aquifer.

Mesaverde Formation. The Mesaverde Formation also occurs along the Grand Hogback. In addition, some outcrops are found east of the Crystal River near Marble. This formation varies in thickness from 2,700 feet in the south to 5,300 feet in the north. The Mesaverde consists of interbedded sandstone, siltstone, shale, and carbonaceous shale. The sandstone beds are commonly tan and the shale beds greenish gray. Economically significant coal beds are found in the lower third of the formation. Sandstone beds tend to be thick, resistant to erosion, and form ridges along the Grand Hogback.

Sandstone and siltstone beds of the Mesaverde Formation are generally stable and no serious problems are anticipated for these beds within the formation. However, shale and coal beds may cause some engineering problems. These rather impermeable types of rocks may cause localized drainage problems and are susceptible to erosion. In addition, both surface and ground water can be polluted by poorly regulated coal mining activities in the formation.

The three formations described above (Wasatch, Ohio Creek, and Mesaverde) are considered to be similar in terms of environmental and engineering geology, and have been mapped as a single unit on the Geologic Map (Plate 1). Plate 2, Environmental and Geologic Constraints Map, also shows the three formations as a single map unit, but on that plate attention has been brought to the Wasatch Formation because of the potentially troublesome clay beds found within the formation.

Mancos Shale. The Mancos shale is widespread within the project area. The thickness of the Mancos shale ranges from 4,000 feet in the southeast to as much as 6,000 feet in the central part of the project area. This formation is predominantly dark olive gray shale which is very susceptible to erosion. Bentonite, a swelling clay, is found within the formation, especially in the lower part. Lithologically, the formation can be divided into three parts. The upper 75 per cent of the formation consists of interlaminated shale and argillaceous siltstone with a prominent yellowish brown sandy zone near the middle. The next 15 per cent is comprised of interbedded calcareous shale and argillaceous limestone with limestone beds becoming more abundant toward the base of this interval. The lower 10 per cent of the formation consists of dark gray, carbonaceous shale with quartz sandstone interbeds near the top

and the base of the interval.

The Mancos shale is easily eroded where exposed to weathering, and under certain conditions, the high yield of weathered materials may result in a mudflow hazard. The shale can fail and produce landslides and other types of mass wasting on very steep slopes or on intermediate slopes where the Mancos Shale is overlain and loaded by a younger, dense rock. The bentonitic clays found in the formation also create hazards because of their swelling properties which can seriously affect foundations. The formation is also subject to hazards caused by the impermeable nature of the shale beds. These include seasonal high water tables, flooding of various types, and slope instability caused by water saturation. In addition, water from the formation is notably brackish, malodorous, and may be corrosive to concrete and metal (such as drainage culverts).

The Mancos formation is generally troublesome from a geologic engineering point of view. Accordingly, the formation is shown as a single map unit on the constraints map, Plate 2.

Dakota Sandstone and Burro Canyon Formations. The Dakota and Burro Canyon Formations have been mapped as a single unit because coarse talus from the Dakota Sandstone commonly obscures the contact between these formations in the field. These formations are found throughout much of the study area. The combined thickness of the Dakota and Burro Canyon ranges from 150 feet in the northwest to as much as 300 feet thick in the central part of the study area.

The Dakota Sandstone consists predominantly of hard, light gray, quartzose sandstone and pebble conglomerate, with shale and siltstone beds more abundant in the middle part of the formation. Weathered surfaces of the formation are

commonly rust brown. Resistant Dakota Sandstone beds form ridges and cliffs.

The Burro Canyon Formation is predominantly grayish sandstone and siltstone (with some pebbly streaks) with interbeds of softer, greenish gray claystone. The claystone beds are poorly exposed in the study area.

No serious problems are anticipated from the Dakota-Burro Canyon Formations. Natural and cut slopes should be stable in the well-cemented sandstones, and blasting may be required for excavations. Elsewhere in Colorado this unit is a significant aquifer, but primary porosity and permeability appear to have been altered and reduced in the project area. These hard rocks commonly form escarpments with associated talus slopes. In some places, these escarpments present rockfall hazards.

Morrison Formation. The Morrison Formation is widespread but outcrops are scattered. The formation thickness ranges from 300 to 600 feet, and appears to be thickest in the northwest part of the study area. The formation consists of interbedded pale green and pale red shale with lenticular interbeds of light greenish-gray sandstone and siltstone and dark gray limestone. Shale beds in the formation tend to be bentonitic. The sandstone beds are more common toward the base of the formation. Limestone is found throughout the formation. The Morrison Formation is relatively susceptible to erosion and, in places, to gravity-type movements (slumps or landslides).

Characteristics of the Morrison Formation are somewhat variable. Sandstone, siltstone, and limestone beds are generally stable and are not expected to cause any serious engineering problems. However, the shale beds

can be unstable and prone to slide. These clay beds tend to be bentonitic and have swelling potential. Locally, the clay beds can contribute to unstable surface conditions, erosion, and perched water tables.

Entrada Sandstone. The distribution of the Entrada Sandstone is similar to that of the overlying Morrison and Dakota Formations. The formation is widespread but outcrops are scattered. Thickness of the formation varies but is probably less than 150 feet in the study area. The Entrada is a cross-laminated, fine to medium grained, quartzose sandstone. The formation is yellowish to light olive gray and weathers to shades of orange and pinkish gray. These sandstones contain moderately abundant, coarse, spherical grains.

The Entrada Sandstone is well cemented with calcium carbonate and clay and is resistant to erosion. Topographically, the sandstone forms cliffs or escarpments. No serious problems are anticipated from this formation, but rockfalls and talus are common hazards at the base of escarpments. Porosity and permeability are generally restricted to fractures and joints. Blasting will be necessary for excavations and cuts.

The four formations described above (Dakota, Burro Canyon, Morrison, and Entrada Formations) are considered to have many similar geological engineering characteristics. These formations have been grouped together as a single unit on Plates 1 and 2. Plate 2, Environmental and Geologic Constraints Map, gives additional emphasis to the potential for hazards from certain clay beds which are found within the Morrison Formation. The emphasis is achieved by means of an over print pattern within the map unit.

Chinle Formation. The Chinle Formation is not found in the southwest part of the study area. Elsewhere, outcrops of the formation range from 300 to 1,000 feet thick. The Chinle Formation consists of interbedded and interlaminated siltstone and silty claystone, with some lenticular beds of pebble conglomerate. The formation is dark reddish brown, and is susceptible to erosion. Weathered surfaces of the Chinle Formation commonly show a hackly appearance.

The silty claystone and siltstone which make up much of the Chinle formation are susceptible to erosion. The process appears to be gradual and uniform, and it is believed that the formation will not present major engineering geology problems. Because of the high content of clay, local seasonal high water tables should be anticipated.

State Bridge Formation. The distribution of the State Bridge formation is similar to that of the overlying Chinle formation. The State Bridge is not found in the southwest part of the study area. The thickness of the State Bridge increases from 250 feet in the northwest to 2,700 feet in the central part of the project area. The formation is composed of interbedded siltstone, sandstone, and shale, with some lenticular beds of sandy limestone and pebble conglomerate. The formation is reddish brown and in places is mottled gray or purple.

The State Bridge formation is not expected to cause serious engineering problems. Locally, because of clay or carbonate cement, the formation may be impermeable and may cause some drainage problems. In general, the formation is hard and will require blasting, but both natural and cut slopes should be stable.

Schoolhouse Tongue of the Weber Sandstone. Outcrops of the Weber Sandstone are found along the Grand Hogback in the western part of the study area. This sandstone unit increases from a thickness of 12 feet in the southwest to more than 200 feet in the northwest. The formation consists of sandstone with some interbeds of shale and conglomerate. The sandstone beds are quartzose, gray, and are impregnated with black, solid hydrocarbons. In places, the surface of the formation weathers yellowish gray.

The "tongue" of Weber Sandstone is found only in the western-most part of the project area. No serious problems are anticipated for this sandstone. Cuts and excavations will require the use of explosives.

Maroon Formation. The Maroon Formation is found throughout most of the study area. The thickness of the formation ranges from 2,500 feet in the southwest to 12,000 feet in the southeast. The Maroon Formation consists of reddish, arkosic sandstone with interbeds of siltstone, claystone, and some conglomerate and limestone. Current marks or depositional structures are common in the sandstone beds. The rocks are generally calcareous and are moderately resistant to erosion. This formation makes up the scenic red cliffs near the town of Redstone.

Although the Maroon contains a wide variety of rocks (claystone to conglomerate) these beds are generally very hard and stable. Both matrix clay and cement reduce the permeability in these rocks creating conditions which can cause local water table problems. Frost heave, active in the fractures of these hard rocks, has produced large, isolated, rockfall blocks in many of the valleys.

Minturn and Gothic Formations. The Minturn and Gothic Formations are found in the southeastern part of the project area. The maximum thickness recorded for these formations is 2,800 feet. These rocks consist of grayish, lenticular sandstone and siltstone with interbeds of shale and limestone. The beds are commonly calcareous and weather to shades of orange or green.

The calcareous sedimentary rocks (limestone and dolomite) which make up the Minturn and Gothic Formations are generally dense and hard. These beds are considered to be relatively stable and no serious problems are anticipated with these formations. There is a possibility of localized rockfalls from steep escarpments.

Belden Formation. The Belden Formation crops out in the southeastern part of the project area where it is reported to be 800 feet thick. The Belden Formation is predominantly limestone and shale with some lenticular beds of sandstone and conglomerate. The rocks are commonly dark gray, calcareous, hard, and may be metamorphosed locally.

No serious problems are anticipated for the Belden Formation. These rocks are stable. Cuts and excavations will require the use of explosives.

The preceding seven formations (Chinle, State Bridge, Weber, Maroon, Minturn, Gothic, and Belden formations) are grouped together on Plates 1 and 2 as a single map color, but the formation contacts are shown. These rock units are considered to have similar environmental and engineering geological characteristics. As seen in the field, red is the persistent color for the rocks found in the upper formations. This color grades to greens and grays toward the base of the lowermost formation. Because of

the manner in which these sedimentary rock materials accumulated most of the contacts between the formations are not sharp, but are gradational.

Eagle Valley Evaporite. In describing the previous group of formations, one formation was omitted purposely from the total sequence. This formation, the Eagle Valley Evaporite, accumulated during a part of the same geologic time in which the Maroon and Minturn formations were also being deposited. However, the Eagle Valley Evaporite is lithologically distinctive and has such adverse geological engineering characteristics that it has been mapped as a separate unit on Plates 1 and 2.

Outcrops of Eagle Valley Evaporite are scattered, but are most common in the principal drainages (Roaring Fork and Crystal Rivers, Cattle Creek and Thompson Creek). The thickness of these evaporite beds is variable. The formation is believed to be more than 3,000 feet at Cattle Creek. The Eagle Valley Evaporite consists predominantly of interbedded gypsum and dark gray shale having admixtures of silt and salt. The formation is characterized by chaotic internal structure, barren yellowish gray weathered surfaces, and a strong susceptibility to erosion and solution.

The Eagle Valley Evaporite presents very serious engineering geologic problems. The formation is not suitable for construction or development without extensive engineering work. The physical characteristics of the formation make it prone to fail resulting in unstable slopes. Solution of the evaporitic material resulting from

movement of surface or ground water can produce serious subsidence problems such as surface collapse features. The minerals in this formation can contribute to chemical degradation or pollution of surface and ground water. In addition, colluvial deposits derived from this formation present serious problems and hazards to developments.

Leadville Limestone. The Leadville Limestone crops out in the southeastern part of the study area. A maximum thickness of 200 feet has been recorded for the formation. The Leadville Limestone is a sequence of thick-bedded limestone overlying an interbedded sequence of dolomite, limestone, and some sandstone. These rocks are grayish, hard, and exhibit some solution features. The Leadville Limestone is metamorphosed in places. At Marble, Colorado, strongly metamorphosed limestone has been quarried from this formation.

Parts of the formation are reported to meet chemical grade specifications for limestone. In addition, much of the formation is a potential source for construction aggregate. Environmental and geologic constraints for the Leadville Limestone will be described later in this report.

Chaffee Formation. Outcrops of the Chaffee Formation are found in the southeastern part of the project area. A maximum thickness of 200 feet is reported for the formation. The Dyer Dolomite member of the Chaffee Formation consists of gray, bedded dolomite with shale partings and some interbeds of gray limestone. This member may be metamorphosed in places. The Parting member consists of an interbedded sequence of tan, quartzose sandstone, gray shale and siltstone, and some grayish dolomite. Locally this member may be metamorphosed.

Manitou Dolomite. The Manitou Dolomite is reported to be as much as 250 feet thick. This formation crops out in the southeastern part of the study area. The formation is grayish dolomite which has some irregular bedding surfaces, and contains nodules and lenses of white chert. Locally the Manitou is metamorphosed.

Peerless Formation. Exposures of the Peerless Formation are restricted to the southeastern part of the project area. The formation has a maximum thickness of 150 feet. It consists of interbedded, dolomitic, grayish orange, sandstone and yellowish gray shale. The formation is metamorphosed in places.

Sawatch Quartzite. Outcrops of the Sawatch Quartzite are found in the southeastern part of the study area where the formation is approximately 250 feet thick. The Sawatch consists predominantly of white quartzite with some interbeds of brownish, dolomitic sandstone, and a quartz pebble conglomerate at the base of the formation.

The five formations described above (Leadville, Chaffee, Manitou, Peerless, and Sawatch) have similar environmental and engineering geological characteristics. These formations have been mapped as a single unit on Plates 1 and 2. The remarks which follow, pertain to the geologic and engineering constraints which are generally applicable to all five formations. In the study area, these rock units are found in the rugged terrain of the southeastern part. Without exception the rocks are dense, hard, and are resistant to erosion. Primary hazards associated with these old sedimentary rocks are gravity (colluvial) deposits which have been or are being derived from the formations. As with most dense,

resistant, and jointed or fractured formations, rockfall hazards are present near cliffs or steep slopes. In addition, avalanches and flash floods can follow the drainage coarses. Excavations will be expensive because of the need to use explosives.

Precambrian Complex. Precambrian outcrops are found only in the southeastern part of the study area, near Aspen. These consist primarily of quartz monzonite, but also include some granite and granodiorite and, locally, some schist and gneiss.

The geologic engineering characteristics of the five formations described above are applicable to the Precambrian rocks. These dense, hard, ancient rocks are generally very stable with the exception of areas that are intensely sheared or faulted. In general the orientation of fractures or joints will be the critical factor in designing an angle for a cut slope.

GROUND WATER AND GEOLOGIC RESOURCES

Many of the natural resources found in the project area are shown on Plate 3, Ground Water and Geologic Resources Map. These resources include: construction materials, fossil fuels, ground water, metallic and non-metallic minerals. Where known, specific locations are shown for the various resources (such as mines, springs, etc.), and resource prospects are also shown where possible.

Ground Water

Three basic ground water provinces are recognized in the study area. A large amount of diverse ground water data has been obtained and used in preparation of this report. This information has been synthesized to

delineate the three provinces which define general hydrologic conditions throughout the study area. The data came from three sources: 1) Field study of the geologic conditions; 2) evaluation and interpretation of the various studies previously conducted in the area; and 3) compilation, collation and evaluation of basic water well data on file with the Colorado State Engineers Office. Basic well data has been corrected and updated and is presented as Appendix B, and by special symbols on Plate 3.

Plate 3 shows known spring locations, streams, and other surface water features. Although the field investigation included a search for obvious thermal springs or other indications of geothermal activity, no significant new geothermal features were noted.

The other water related features shown on Plate 3 refer to the various ground water provinces. These are described as follows:

Alluvium. Water wells located in alluvium (which includes most stream alluvium and older terrace deposits as well as some glacial material) are expected to yield from 0 to 500 gallons per minute (gpm) and vary in depth from a few feet to more than 200 feet. Water in these aquifers occur in openings and voids between the various constituent particles. Porosity and permeability are commonly quite high but can be affected locally by poor sorting (the presence of very fine grained clay material). Depths to ground water in this material will vary with topography, type of soil cover, recharge area, and especially with seasonal precipitation and runoff. This water would, in general, be considered tributary to the Colorado River and would be subject to prior appropriation.

Interstitial Porosity. For the purposes of this report, the occurrence

of ground water in the Mesaverde and younger consolidated formations is considered to be controlled by interstitial porosity. This means that water is contained and transmitted through interconnected pore spaces between grains within the sedimentary bedrock. Although some of the older formations also exhibit interstitial porosity, it is not considered the controlling ground water feature of the older rocks.

Although there are no wells of record in this ground water province, partly because of the rugged terrain where these rocks occur, yields would probably vary between 0 and 50 gpm, and average 10 gpm. Depths to water production will vary according to the area, site geology and individual requirements. Most of this water would probably be considered non-tributary, especially if derived from depths greater than 300 feet.

Fracture Porosity. Most of the study area falls within the ground water province of fracture porosity where the rock characteristics controlling the occurrence of ground water are fractures, faults, and related features. This province includes all igneous, metamorphic, and those sedimentary rocks older than the Mesaverde Formation. These rocks are extremely variable in appearance, origin, and composition; and are generally considered incapable of storing and transmitting water except through fracture systems. Wells in this province yield from 0 to 100 gpm but average less than 5 gpm. Records of wells drilled in the province show some total depths in excess of 400 feet. Water is commonly found in fracture systems as deep as 150 feet; however, fracture porosity is known to extend to even greater depths. Considerable geologic investigation would be necessary to locate

significant fracture porosity at depths greater than 400 feet.

Water produced from fracture porosity is commonly considered tributary and subject to prior appropriation. Local conditions may exist whereby non-tributary water could be obtained from rocks in this province, but this would have to be demonstrated for individual cases.

Geologic Resources

In addition to water, Plate 3 shows other resources found within the study area. Mines, quarries, and prospect pits are located on the map. The legend on Plate 3 lists (by county) resources, active mines, and gravel operations found within the study area, and gives a summary of mineral production in the Aspen district.

Locations of potential sand and gravel sources are evaluated and classified into three broad catagories. They are: 1) potential source areas where ground water is within 20 feet of the ground surface; 2) source areas where ground water is deeper than 20 feet; and 3) limited amounts of aggregate or sand and gravel, or deposits of questionable economic value. Each of these three units are described briefly, as follows.

In general, potential sand and gravel source areas are found in stream valleys and on terraces where the materials were deposited by water and subject to reworking and sorting action of running water. In this report a differentiation is made between gravel sources that are saturated with ground water or lie not more than 20 feet above the water table and those that are situated more than 20 feet above the water table.

Ground water provides a means for washing gravels to remove fine particles. Washed sand and gravel can be used for drains and specification concrete and asphalt mixes. Gravels located well above the water table, without convenient means for washing, can be used for special backfill, road base, and lower grade asphalt mixes.

Local sources or deposits of questionable economic value encompasses the remaining aggregate or sand and gravel areas not covered by the previous two catagories. This unit includes areas of broken rock (talus) and areas where sand and gravel are present in small but useable quantities. Development of such resource areas would be feasible only for local supplies and values would be determined by accessibility and by proximity to the project site.

CONCLUSION

The Roaring Fork and Crystal Valleys and vicinity can be developed safely and economically if the geology of the area is considered during planning efforts and if specific site investigations are conducted prior to starting design or construction work. The information provided by this study is comprehensive and should be used as guidelines for land use and planning decisions. The geologic characteristics, both environmental and engineering, of the study area are presented in the report and on the maps.

The reader is urged to study this information and become familiar with the geologic factors that should affect land use and planning decisions. Such efforts will help to achieve better use and protection of our environment and result in more selective and economical siting and development of both public and private facilities.

GLOSSARY

Acidic water - water in which excessive acid-forming constituents have been dissolved. Example: water passing through rock formations containing sulfide picks up these materials and becomes acidic. This water, as a result, is capable of deteriorating certain types of concrete and polluting water supplies.

Alluvium - clay, silt, sand, gravel or mixtures of these rock particles which have accumulated during Recent geologic time and are characteristically unconsolidated. Alluvium differs from colluvium in that alluvium is deposited by water (or ice) while colluvium is primarily a gravity deposit.

Altered rock - a rock that has undergone physical and/or chemical changes. Metamorphic rocks are examples of altered rocks.

Aplite porphry - a variety of intrusive igneous rock.

Aquifer - a porous rock formation that bears ground water which can be recovered through wells.

Argillaceous - a term applied to rocks containing a significant amount of clay.

Arkosic - a term describing a sedimentary rock composed of material derived from the disintegration of certain types of igneous rocks.

Avalanche (snow) - a sudden fall of snow from a high elevation to a lower one. Avalanches commonly follow avalanche "chutes" (long, steep paths down a mountain side, barren of trees or other growth).

Basalt - a variety of extrusive igneous rock, commonly called lava.

Bedded formation - a rock unit which shows successive beds, layers or strata, owing to the manner in which it was formed (such as the layers seen in sedimentary rocks).

Bedrock - any solid rock exposed at the surface of the earth or overlain by unconsolidated material (A.G.I.*).

Bentonite - a montmorillonite-type clay formed by the decomposition of volcanic ash. Bentonite swells when wetted which can cause foundation problems.

Calcareous - containing calcium carbonate (A.G.I.*).

Cambrian - the geologic period which began about 600 million years ago at the close of the Precambrian time. The Cambrian period lasted about 100 million years and is part of the Paleozoic era.

Carbonaceous - rocks including original organic matter and their derivitives (A.G.I.*)

Carbonates - sedimentary rocks consisting mainly of calcareous material (compounds with the radical CO_3).

*American Geological Institute Glossary of Geology

Cenozoic - the most recent geologic era which began some 60 million years ago and includes the present. The Cenozoic era saw the extinction of dinosaurs, the ice age and the coming of man.

Chert - a dense rock consisting almost entirely of silica; flint is a form of chert.

Clay - an earthy, extremely fine grained material (particle diameter less than .005 mm). Clay becomes plastic when wet and hard upon drying.

Claystone - a sedimentary rock comprised mainly of clay sized material which has been consolidated by compaction or cementation.

Colluvial deposits (gravity deposits) - deposits formed by materials moving or falling from an unstable position to a more stable one. Common types of colluvial deposits include landslides, mudflows, rockfalls, and talus.

Columnar jointing - a breaking of rocks into column like forms; columnar jointing is usually found in basalt and is considered to be formed as the rock cools.

Compaction - a decrease in volume of soil or rock particles caused by the action of external forces applied to the material.

Conglomerate - a sedimentary rock consisting of large, rounded particles, such as gravel and sand, cemented together.

Consolidation - the process by which loose and/or soft material becomes hard.

Cretaceous - a geologic period lasting about 72 million years, during the Mesozoic era.

Crystalline rock - a general term for igneous and metamorphic rock in contrast to sedimentary rocks (A.G.I.*).

Dense - a term describing the texture of a very fine grained rock. The grain size in such a rock is generally less than .05 to .1 mm in diameter and cannot be seen by the naked eye.

Deposition - the natural accumulation of material deposited by water, wind, glacial or gravity action.

Detrital - sedimentary deposits consisting of particles derived from other rocks. (This is in opposition to a chemical rock - such as salt.)

Devonian - a geologic period lasting about 60 million years in the Paleozoic era.

Dip - the angle at which a bedded rock formation is tilted from the horizontal.

Dip slope - a slope on the surface of the land that has approximately the same angle as the underlying formation.

Dolomite - a calcareous sedimentary rock, similar in appearance to limestone. (See carbonates.)

*American Geological Institute Glossary of Geology

Dike - a tabular body of igneous rock that cuts across the structure of adjacent rocks (A.G.I.*).

Engineering geology - the application of the geological sciences to engineering practice for the purpose of assuring that the geologic factors affecting the location, design, construction, operation and maintenance of engineering works are recognized and adequately provided for (A.G.I.*).

Environmental geology - the study of geology as it relates to man's activities and their impacts on the environment. Flood areas, unstable land conditions, and other geologic hazards are considered under environmental geology.

Era - a division of geologic time of the highest order, made up of one or more periods.

Erosion - the wearing away of rock or soil and the movement of these rock particles. Wind, water, ice and gravity movements cause erosion.

Evaporite - a sedimentary rock consisting mainly of materials, formerly in solution deposited by the evaporation of water. Example: rock salt is formed by the evaporation of sea water, leaving the dissolved salts behind.

Evapo-transpiration - a method for disposing of waste fluids either by evaporation or by transpiration from vegetation, or a combination of both.

Extrusive - a term applying to igneous rocks which formed by the cooling and solidification of lavas flowing out on the surface of the earth. All volcanic rocks are extrusive.

Fan, alluvial - a fan shaped alluvial deposit formed by a stream descending from a steep slope to a more gentle slope and depositing material on the more gentle slope. On an alluvial fan, the apex points upstream to the steeper slope and the fan portion spreads out on the gentle slope.

Fault - a fracture or zone of fractures along which there has been movement parallel to the plane of breakage.

Feldspathic - containing the mineral feldspar as a principal constituent.

Flood plain - a level area adjacent to a river or stream covered by materials deposited by the stream during stages of flooding.

Fractures - breaks in a solid rock along which there has been little or no movement. Fractures commonly form in association with faulting and folding.

Friable - easily crumbled, as would be the case with rock that is poorly cemented (A.G.I.*).

Frost heave - the movement of a surface by the freezing of moisture within the soil or cracks of rocks. Water upon freezing, expands and provides the force for this movement.

*American Geological Institute Glossary of Geology

Geology - a science that deals with the history of the earth, especially as recorded in the rocks (A.G.I.*).

Glacial deposits - unconsolidated material deposited as a result of glacial activity. Particle sizes vary from boulders which the glaciers "plucked" from a valley floor to very fine "rock flour" resulting from constant grinding.

Glacier (mountain) - a body of ice moving in a mountain valley. Glaciers form by the compaction and remelting of snow which builds up and begins to slowly move down a mountain to the valley. Glaciers were widespread in the Rocky Mountains during the Quaternary period.

Glaciofluvial - pertaining to streams flowing from glaciers or to the deposits made by such streams (A.G.I.*).

Gneiss - a variety of banded metamorphic rock.

Granite - a variety of coarse-grained intrusive igneous rock.

Granodiorite - a variety of intrusive igneous rock, slightly different from granite in mineral composition.

Ground Water - water located in pore spaces or fractures of rock or surficial deposits.

Hackly - a form of breakage or weathering in which the rock forms jagged points.

Hydrocompaction - the compaction or settling of material by the reorientation of particles in the presence of water.

Igneous - a rock formed by the cooling and solidification of a molten mass. This may occur within the earth or on the surface.

Impervious - a term used to describe any dense material through which fluids cannot pass.

Interlaminated - a mixture of two or more materials such as sand, clay, or silt, in layer form.

Intrusive - an igneous rock formed by the cooling of a molten mass beneath the surface of the earth.

Joint - a term for a planar fracture in a solid rock along which little or no movement has taken place.

Jurassic - a geologic period of about 46 million years during the Mesozoic era.

Laccolith - an intrusive body that has domed up the overlying rocks and also has a floor that is generally horizontal (A.G.I.*).

*American Geological Institute Glossary of Geology

Land movements (massive) - landslides.

Lava - molten rock which has flowed out on the surface of the Earth until it cools and solidifies. All lavas are classified as extrusives.

Leach field - a subsurface area of porous material into which liquid wastes are drained and purified by percolation.

Lenticular - having a lens-like form, thin at the edges and thicker in the center.

Limestone - a sedimentary rock comprised mainly of calcium carbonate ($CaCO_3$) formed in water by the gradual settling of calcium carbonate particles. Limestone is usually a hard, resistant rock.

Lithological - a description of a rock according to the physical characteristics.

Marble - a metamorphosed limestone or other calcareous rock; marble is usually a very hard, resistant rock, often with distinctive color patterns which makes it a popular building stone.

Mass-wasting - a general term for a variety of processes by which large masses of earth material are moved by gravity either slowly or quicky from one place to another (A.G.I.*).

Matrix - in a rock in which certain grains are much larger than the others; the grains of smaller size comprise the matrix (A.G.I.*).

Mesa - a flat topped mountain, surrounded wholly or partially by steep cliffs. A mesa can result when a hard, resistant rock overlies a weak, erosive rock.

Moraine - a constructional (built up) landform deposited by direct activity or wasting of glacier ice. Usually composed of loose rock material of highly variable sizes.

Mesozoic - a geologic era lasting approximately 170 million years. The Mesozoic era saw the flourishing of dinosaurs. The close of this era saw the extinction of the dinosaurs and the rapid development of mammals.

Metamorphic - a rock formed from another rock that has undergone changes due to increased temperatures and pressures or changes in the chemical environment while buried beneath the surface of the earth.

Mississippian - a geologic period lasting about 35 million years in the Paleozoic era.

Mudflow - a flowage of heterogeneous debris lubricated with a large amount of water usually following a former stream course (A.G.I.*).

Mudstone - a general geologic term applied to any extremely fine grained sedimentary rock. Clayey siltstone or silty claystone can be loosely termed as mudstone.

*American Geological Institute Glossary of Geology

Nonstratified - a term applied to formations that have no distinct bedding.

Olivine basalt - a variety of fine-grained, basic extrusive igneous rock.

Ordovician - a geologic period lasting about 75 million years in the Paleozoic area.

Outcrop - the exposure of bedrock at the surface of the Earth.

Paleozoic - a geologic era lasting about 370 million years. The Paleozoic era saw the widespread evolution of life, the first land plants and the first land animals.

Pediment - a sloping plain at the intersection of a valley floor and a mountain front. Pediments are bedrock with a thin veneer of alluvium in places.

Pennsylvanian - a geologic period that lasted about 30 million years in the Paleozoic era.

Percolation - movement of water through soil and rock by means of pore spaces between grains, cracks in the rock and along bedding planes. Percolation is limited to small openings and does not include movement of water through such openings as caves.

Period - a classification of time in the geologic time scale - the length of each period is different; however, there is continuity of events within a period over a widespread portion of the earth.

Permeability - the ability of a material to transmit water, oil or other fluids due to the pore spaces within the rock and the degree to which these spaces are connected.

Permian - a geologic period lasting about 50 million years; this is the last period in the Paleozoic era.

Phacolith - an intrusive body that intruded into previously folded beds; as a result, the phacolith has a curved shape - top and bottom are both curved in the same manner.

Phenocryst - found in igneous rocks, a phenocryst is a large and conspicuous crystal set in a much finer ground mass.

Physiographic - referring to the surface and land-form features of a region.

Planes of weakness - a two dimensional area between two objects that is subject to failure or movement because of weak or nonexistent bonds. Example - a sedimentary rock showing bedding will probably break along these planes rather than across them because they are relative planes of weakness.

Pleistocene - the earlier of the two epochs comprised in the Quaternary period, also called Glacial epoch. (A.G.I.*).

Porosity - the ratio of the aggregate volume of interstices in a rock or soil to its total volume (A.G.I.*).

*American Geological Institute Glossary of Geology

Porphyritic - a textural term for those igneous rock in which large crystals (phenocrysts) are set in a finer groundmass (A.G.I.*).

Precambrian - all rocks formed before Cambrian time (more than 600 million years old). The Precambrian is divided into two eras, the Early and Late Precambrian (A.G.I.*).

Quartz diorite - a variety of coarse-grained, intrusive igneous rock. For a geologic description see a basic geology text.

Quartz monzonite - a variety of coarse-grained, intrusive igneous rock. For a geologic description see a basic geology text.

Quartzose - containing quartz as a principal ingredient (A.G.I.*).

Quaternary - the most recent geologic period extending from about 2-1/2 million years ago to the present.

Recent - a subdivision of the Quaternary period which began at the close of the Ice Age (about 10,000 years ago) and extends to the present.

Recharge area - an area of permeable rock and soil which allows the downward movement of surface water and the replenishment of ground water.

Replacement - chemically and physically new material formed in the place occupied by the original matter by simultaneous solution and deposition. This occurs at the molecular level. Example - petrified wood is a replacement in which the mineral, silica, has taken the place of the wood leaving the structure intact.

Rippability - ease of excavation.

Rock glaciers - a tongue-like body of angular boulders, resembling a small glacier, generally occurring at high altitudes in rugged terrain (A.G.I.*).

Sandstone - a rock comprised mainly of sand-size particles that have been compacted or cemented.

Sanitary landfill - a system of solid waste disposal in which waste is placed in a closed environment and covered daily. A properly constructed sanitary landfill will decompose and not pollute the environment.

Schist - a variety of metamorphic rock.

Sedimentary - a geologic term describing rocks formed by the accumulation or deposition of particles. These are commonly laid down by water, such as rivers, lakes and seas, but can also be deposited by winds (i.e., dunes).

Seepage pits - a method of liquid waste disposal in which the waste is deposited in a pit and is purified as it percolates down through the soil.

Shale - a rock comprised mainly of clay size particles which have been compacted or cemented. Shale is usually well stratified and in some cases, is weak and crumbly.

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Sill - an intrusive body of igneous rock of approximately uniform thickness, and relatively thin compared with its lateral extent, which has been emplaced parallel to the bedding or schistosity of the intruded rocks (A.G.I.*).

Silt - a sediment particle with a diameter between 0.005 mm. and 0.05 mm. (a size between sand and clay). Silt is unconsolidated and is a common type of river alluvium.

Siltstone - a rock comprised mainly of silt-size particles which have been compacted or cemented.

Silurian - a geologic period that lasted about 20 million years during the Paleozoic era.

Slippage - gradual, slight movements along a plane of weakness.

Slump - the downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as several subsidiary units, usually with a backward rotation (A.G.I.*).

Solubility - a measure of the concentration potential for a material dissolved in a liquid at equilibrium when there is undissolved material also in contact with the liquid; the greatest amount of a material that can be dissolved in a fluid at a specific temperature and pressure.

Stock - a large body of intrusive rock less than 40 square miles in area.

Stratification - the bedded or layered appearance of sedimentary rocks which results from the depositional origin. However, not all sedimentary rocks show well-defined stratification.

Subsidence - a sinking or down warping of the earth's crust. This occurs over a wide portion of the crust and is very gradual. During geologic history, seas commonly filled the depressions formed by subsidence. The term "subside" can also be used to describe a smaller feature - such as the subsidence of land over an underground mine where the overburden is collapsing into the mine cavity.

Surficial deposits - unconsolidated material deposited on the ground surface; may be alluvium or colluvium, or of other origins.

Swelling soils - soils containing clay minerals which have the ability to absorb water into their structures and expand in size. The water can be released through drying, allowing the soil to return to the original size. In general, swelling clays are derived from volcanic ash.

Tailing dump - piles of loose debris and ore of a quality too poor to be used, usually found near a mine. When located on a slope these tailings can be very unstable.

*American Geological Institute Glossary of Geology

Talus - a pile of broken rock fragments found at the foot of a steep cliff or escarpment which results from the weathering of the cliff.

Terrace - a step like feature located on a slope; the terrace itself is flat or gently sloping and bounded above and below by steeper slopes. Terraces are generally considered to consist of alluvium and flank each side of a river valley.

Tertiary - a period lasting about 62 million years in the Cenozoic era.

Thermal springs - springs whose temperatures are warmer than the average surface temperature. The source of the heat is molten magma located below the surface of the Earth.

Topography - the relief of the surface of an area and the expression of this relief on a map using one line to represent one elevation.

Triassic - a period lasting about 49 million years, the first period of the Mesozoic era.

Unconsolidated - a term used for materials that are loose; rock particles that are not cemented or compacted are considered unconsolidated.

Undercutting - removal by erosion (generally wind, stream or wave action) of the lower portion of a steep escarpment, resulting in a steeper face or even an overhanging cliff.

Uplift - elevation of a part of the Earth's surface relative to some other area (A.G.I.*). In geologic history uplift has taken place slowly, generally lasting millions of years.

Vesicular - containing many small cavities (A.G.I.*).

Volcanic rock - the class of igneous rocks derived from volcanoes. Volcanic rocks are basically of two types -- 1) rocks that were formed by flowing lava, and 2) rocks that were formed by materials ejected through the air, such as ash.

Water table - the upper boundary of water saturated formations or soils. Where the water table intersects the ground surface, a surface body of water is found (i.e., marsh).

Weathering - changes undergone by rocks due to the forces of wind, rain, and ice, and/or chemical changes.

*American Geological Institute Glossary of Geology

WATER WELL DATA

To use the following, it is necessary to understand what the various headings and abbreviations mean.

Permit # (Permit No.) the number assigned to the well permit by the State Engineers Office, Ground Water Division. These permits include both domestic (exempt) water wells and fee (irrigation, municipal or commercial) wells. Fee wells are defined by the suffix "F". Wells that are registered but not decreed through water court are defined by the suffix "N".

Location: the location of the well in accordance with the Bureau of Land Management location procedure. This defines the largest area first, then the next smallest and so on down to the nearest quarter-quarter section (40 Acres). For example the well location designated SC 02 83 16 BD is found as follows:

SC - in quadrant C of the 6th (Sixth) principal meridian, quadrant C is west of that meridian and south of the controlling parallel (in this area, the 40th parallel)

02 - defines township number (south of parallel)

83 - defines range number (west of meridian)

24 - Section number in the defined township and range.

BD - B designates the Northwest 1/4 of the section.
D designates the Southeast 1/4 of the quarter section.

This designation would read "the Southeast 1/4 of the Northwest 1/4 of Section 24, Township 2 South, Range 83 West of the 6th Principal Meridian" if it were all converted to the more cumbersome "legal" description.

Aquifer: not defined for this report.

Yield: Well capacity in gallons per minute.

Depth: Depth of well in feet below ground surface.

Level: Depth to static water level below ground surface.

Date: Either the date the well was drilled or date the permit was granted, month-day-year.

F. M. FOX & ASSOCIATES INC.

GEOLOGY DIVISION

COLORADO WELL DATA

SORTED BY LOCATION

6-25-74

PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
046824	SC 02 83 06 AA. .		50	8	3	6 --39
006566	SC 02 83 16 BD. .		11	60	25	7-24-60
030699	SC 02 83 16 DB. .		10	60	32	5 -6-67
022136	SC 03 86 13 CD. .		20	25	6	10-28-64
022137	SC 03 86 13 CD. .		20	21	5	10-29-64
022198	SC 03 86 13 DA. .		30	40	14	11 -3-64
014081	SC 03 86 23 AA. .		20	28	8	2-26-63
004872F	SC 04 86 09 AB. .		90	30	12	10-12-63
044388	SC 04 86 31 AC. .		25	50	20	3 --71
031269	SC 04 87 30 DD. .		10	27	14	6-14-67
009869	SC 05 86 04 BB. .		15	60	45	9-20-61
025636	SC 05 86 04 BC. .		20	63	40	8-23-65
030851	SC 05 86 05 AB. .		20	118	67	5-11-67
010565	SC 05 87 15 BD. .		20	45	24	11-31-61
030224	SC 05 88 16 DD. .		10	41	18	2-19-67
025490	SC 06 87 06 CD. .		6	207	15	10 -1-65
031599	SC 06 88 28 CA. .		20	172	100	8 -1-67
031598	SC 06 88 35 BB. .		8	240	180	8 -3-67
032891	SC 06 88 35 DD. .		10	80	32	1-28-68
042419	SC 06 88 36 CB. .		15	170	130	8-10-70
000066N	SC 06 89 01 AA. .		24	57	38	6 --39
031319	SC 06 89 01 AB. .		20	160	110	7-14-67
031320	SC 06 89 01 AB. .		30	165	125	7-13-67
020100	SC 06 89 01 AC. .		15	36	18	6 -4-64
030751	SC 06 89 01 BA. .		10	185	100	5-10-67
006094	SC 06 89 01 BA. .		12	60	39	6-12-60
019059	SC 06 89 02 CA. .		6	115	65	3-10-64
033834	SC 06 89 16 BA. .		10	60	19	4-24-68
028971	SC 06 89 16 DB .		15	45	95	9-30-66
037865	SC 06 89 21 AB. .		15	110	65	6-22-69
043873	SC 06 89 21 AB. .		10	100	80	12-21-70
034663	SC 06 89 21 AB. .		15	46	23	7-23-68
002151F	SC 06 89 21 AD. .		120	30	4	5 --61
047436	SC 06 89 22 CB. .		50	60	29	5-14-65
024961	SC 06 89 22 CD. .		20	60	29	9-21-65
009890	SC 06 89 26 BC. .		15	132	92	10-14-61
044074	SC 06 89 26 BC. .		12	102	60	4 -1-71
021358	SC 06 89 26 CB. .		30	112	80	7-30-64
013563	SC 06 89 27 AA. .		30	73	50	10-30-62
021111	SC 06 89 27 AC. .		20	113	74	7-18-64
012492F	SC 06 89 27 AD. .		50	73	28	11 -5-67
034788	SC 06 89 27 BB. .		20	80	18	8 -3-68
012980	SC 06 89 27 DD. .		30	140	37	6-28-62
024949	SC 06 89 28 AB. .		17	100	28	8-20-65
047256	SC 06 89 28 AB. .		14	110	70	7-15-57
022574	SC 06 89 28 AB. .		15	51	UNKWN	9 --53
046740	SC 06 89 28 AB. .		15	12	6	12 -1-54
023992	SC 06 89 28 AC. .		8	30	6	5 -7-65
029159	SC 06 89 28 BA. .		5	6	70	10-21-66
025704	SC 06 89 28 BC. .		1	120	FLOWG	10 -8-65
046518	SC 06 89 34 CD. .		15	72	38	6-24-71
034009	SC 06 89 34 CD. .		10	184	68	6 -7-68
040482	SC 06 89 35 BC. .		10	75	31	3-24-70
046799	SC 06 89 35 CD. .		15	90	40	--62
046787	SC 06 89 35 CD. .		15	90	40	--62

COLORADO WELL DATA
SORTED BY LOCATION

PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
014103	SC 06 89 35 CD. .		10	60	20	11-10-59
023991	SC 06 89 36 CC. .		8	60	42	5-30-65
026305	SC 06 89 36 CC. .		10	50	35	1-25-66
001809	SC 06 89 36 CC. .		15	50	30	7-29-58
018146	SC 06 89 36 DA. .		4	100	60	8-22-63
007840	SC 07 87 01 BC. .		30	38	23	1-27-61
032244	SC 07 87 03 BB. .		10	150	85	10-14-67
048977	SC 07 87 07 DC. .		15	345		9-24-71
010570	SC 07 87 11 BB. .		40	31	5	10-29-61
030221	SC 07 87 11 BD. .		10	51	20	3 -1-67
035754	SC 07 87 12 AD. .		10	35	11	11 -8-68
007560	SC 07 87 15 AB. .		50	81	34	11-30-60
031600	SC 07 87 17 CC. .		20	160	115	7-28-67
037300	SC 07 87 18 BA. .		10	245	156	4-10-69
036583	SC 07 87 18 BA. .		10	242	136	2 -5-69
012969	SC 07 87 18 BB. .		20	188	156	6-20-62
006622	SC 07 87 18 DC. .		20	195	180	8-28-60
023996	SC 07 87 19 BB. .		10	120	70	6 -5-65
017473	SC 07 87 19 CC. .		10	192	92	9 -3-63
005323	SC 07 87 19 DB. .		30	222	174	4 -4-60
041657	SC 07 87 20 AA. .		25	127	100	6-21-70
031601	SC 07 87 20 CC. .		10	270	210	6-24-67
032391	SC 07 87 27 AB. .		10	400	290	9 -6-67
023050	SC 07 87 27 AC. .		20	265	210	2-10-65
023995	SC 07 87 27 DB. .		10	260	220	6-15-65
035484	SC 07 87 27 DB. .		10	235	187	10 -4-68
027488	SC 07 87 28 BC. .		30	260	160	3-10-66
025703	SC 07 87 28 CC. .		20	250	180	11-10-65
035279	SC 07 87 29 AC. .		10	215	130	9 --68
030835	SC 07 87 29 BB. .		10	260	200	5-22-67
013562	SC 07 87 30 AB. .		30	160	102	10-31-62
039740	SC 07 87 30 CA. .		10	160	100	11-28-69
007839	SC 07 87 30 CD. .		15	168	90	1-25-61
012977	SC 07 87 31 AA. .		30	46	8	7 -7-62
057559	SC 07 87 31 AB. .		3	39		2-28-59
021113	SC 07 87 31 AC. .		20	44	10	8 -2-64
043871	SC 07 87 31 BB. .		10	55	15	12-14-70
010560	SC 07 87 31 BD. .		50	44	4	6 -4-61
010561	SC 07 87 31 BD. .		50	44	4	6 -5-61
044990	SC 07 87 31 DA. .		50	25	10	7-15-67
024947	SC 07 87 32 AC. .		20	49	19	8-16-65
025695	SC 07 87 32 AC. .		20	41	15	10-30-65
025693	SC 07 87 32 AC. .		20	51	14	10-28-65
025694	SC 07 87 32 AC. .		20	42	16	10-29-65
022471	SC 07 87 32 BB. .		20	50	18	10 -6-64
042875	SC 07 87 32 BC. .		10	45	16	9 -5-70
019066	SC 07 87 32 DA. .		10	42	12	8 -7-64
019068	SC 07 87 32 DA. .		10	44	6	8 -8-64
043869	SC 07 87 32 DA. .		10	45	15	12 -3-70
027485	SC 07 87 32 DB. .		10	46	22	4-22-66
025702	SC 07 87 33 AB. .		9	225	120	11 -7-65
005879	SC 07 87 33 AC. .		20	40	21	5-16-60
015800	SC 07 87 33 DB. .		10	60	45	6 -6-63
033836	SC 07 87 33 DC. .		10	45	15	3 -4-69
033837	SC 07 87 33 DC. .		10	45	13	7-20-68

F. M. FOX & ASSOCIATES INC.

GEOLOGY DIVISION
COLORADO WELL DATA
SORTED BY LOCATION

PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
030834	SC 07 87 34 BA. .		20	270	190	5-18-67
044619	SC 07 87 34 CA. .		50	85	18	3-12-71
031191	SC 07 87 34 CC. .		45	58	21	6-20-67
040496	SC 07 87 34 DD. .		30	101	73	3 -5-70
024951	SC 07 87 35 CC. .		20	118	95	8-25-65
005401	SC 07 88 01 DB. .		30	66	14	4 -3-60
036767	SC 07 88 04 BA. .		10	75	48	6-12-69
011896F	SC 07 88 04 CB. .		300	220	120	5 -2-67
015803F	SC 07 88 04 CB. .		100	250	76	2-24-67
015801F	SC 07 88 04 CB. .		400	300	80	5 -8-67
030830F	SC 07 88 04 CB. .		100	250	70	2-27-67
030831F	SC 07 88 04 CB. .		40	265	78	3 -4-67
015802F	SC 07 88 04 CB. .		40	300	76	3 -4-67
018148	SC 07 88 04 CD. .		20	160	118	9 -3-63
018147	SC 07 88 05 AA. .		300	260	200	8-22-63
032895	SC 07 88 06 CA. .		10	195	160	2-24-68
016994	SC 07 88 06 CC. .		15	104	90	6-23-63
006054	SC 07 88 07 AC. .		12	82	53	6 -7-60
002256	SC 07 88 07 DB. .		12	86	64	11-18-58
023054	SC 07 88 08 CC. .		10	52	16	3-24-65
036874	SC 07 88 08 DC. .		10	125	65	5-10-69
039051	SC 07 88 09 CC. .		10	85	34	8-30-69
036053	SC 07 88 10 CD. .		10	55	23	11-12-68
025777	SC 07 88 10 DA. .		12	50	36	11 -9-65
043872	SC 07 88 10 DB. .		10	60	27	12-18-70
041658	SC 07 88 11 AC. .		6	450	350	6-17-70
062462	SC 07 88 11 DA. .		202	2020	2020	6-30-64
039606	SC 07 88 11 DC. .		3	120	65	10-16-69
020095	SC 07 88 13 AB. .		20	222	155	3-16-64
022486	SC 07 88 13 AD. .		20	190	140	11 -2-64
034021	SC 07 88 13 CA. .		7	200	130	6 -1-68
028238	SC 07 88 13 CC. .		20	190	110	7-25-66
062863	SC 07 88 13 CC. .		20			9-20-68
055723	SC 07 88 13 CD. .		140	200		9 -1-65
028237	SC 07 88 14 BC. .		30	280	170	7-20-66
040494	SC 07 88 14 BC. .		6	312	150	3-31-70
040495	SC 07 88 14 CC. .		4	450	375	4-17-70
032390	SC 07 88 14 DA. .		12	560	360	10 -1-67
057619	SC 07 88 15 AC. .		25	263		1 -1-68
024946	SC 07 88 17 BB. .		12	25	2	8-13-65
025217	SC 07 88 17 BD. .		12	60	49	9 -9-65
019748	SC 07 88 17 DB. .		20	20	6	5-17-64
022470	SC 07 88 18 AC. .		20	214	148	10-31-64
002755	SC 07 88 20 BC. .		15	85	50	6 -1-59
023055	SC 07 88 20 CD. .		20	70	26	3-20-65
015287	SC 07 88 22 BC. .		5	380	320	6-21-63
041391	SC 07 88 23 AD. .		16	256	227	5-26-70
035483	SC 07 88 23 DB. .		12	257	162	10 -4-68
008000	SC 07 88 24 AB. .		60	180	113	2-14-61
028240	SC 07 88 24 AC. .		15	120	70	8 -1-66
017474	SC 07 88 24 AD. .		30	80	70	9-12-63
027495	SC 07 88 24 BB. .		10	250	210	6-19-66
027494	SC 07 88 24 BC. .		20	200	118	6-14-66
062885	SC 07 88 26 CB. .		8			8 -1-48
056374	SC 07 88 27 CA. .		15	63		6-30-59

F. M. FOX & ASSOCIATES INC.

GEOLOGY DIVISION
COLORADO WELL DATA
SORTED BY LOCATION

PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
037726	SC 07 88 27 DA.		10	85	35	6-11-69
008849	SC 07 88 27 DB.		16	63	30	6 -7-61
017368	SC 07 88 27 DB.		15	91	48	7-31-63
000022N	SC 07 88 27 DD.		5	27	5	9 --57
043874	SC 07 88 28 AC.		10	100	80	12-25-70
006695	SC 07 88 28 CA.		30	56	26	8-14-60
005402	SC 07 88 28 CB.		15	61	49	3-31-60
005743	SC 07 88 28 CB.		20	59	39	4-30-60
005403	SC 07 88 28 CB.		15	67	48	4 -2-60
048787	SC 07 88 28 CB.		50	55	22	6-25-50
039050	SC 07 88 28 CC.		10	35	8	8-28-69
003855	SC 07 88 28 CD.		10	75	35	7-15-59
000016N	SC 07 88 28 DB.		20	84	39	- -
012469F	SC 07 88 28 DC.		30	80	31	10 -8-67
032136	SC 07 88 28 DC.		10	80	42	10-29-67
040483	SC 07 88 32 CC.		10	170	140	3 -7-70
040484	SC 07 88 32 DA.		10	125	22	3 -5-70
006694	SC 07 88 33 BA.		40	67	4	8-12-60
004157	SC 07 88 33 CA.		20	65	20	11 -1-59
013561	SC 07 88 33 CD.		20	40	16	11 -2-62
001815	SC 07 88 33 DA.		15	50	30	8-28-58
002204F	SC 07 88 34 AC.		20	70	35	4-28-59
045166	SC 07 88 34 BB.		25	18	8	1 -3-73
005913	SC 07 88 34 BD.		30	56	16	5-23-60
021112	SC 07 88 34 BD.		20	55	26	7-10-64
007841	SC 07 88 34 CB.		20	60	27	1 -2-61
044485	SC 07 88 34 CC.		10	60	34	2-25-71
031265	SC 07 88 35 AC.		10	35	8	6-16-67
037728	SC 07 88 35 AC.		10	35	4	6 -5-69
031266	SC 07 88 35 AC.		10	36	6	6 -3-67
034295	SC 07 88 35 BD.		10	37	8	6-28-68
037727	SC 07 88 35 BD.		10	35	8	6 -8-69
023983	SC 07 88 35 CA.		10	41	8	4 -4-65
023985	SC 07 88 35 CA.		10	37	18	4-12-65
023984	SC 07 88 35 CA.		10	40	6	4 -5-65
022485	SC 07 88 35 CB.		20	37	16	10-27-64
018283	SC 07 88 35 DB.		10	34	9	12 -3-63
038319	SC 07 88 35 DB.		10	35	4	7 -7-69
039739	SC 07 88 35 DB.		10	34	8	12 -1-69
031594	SC 07 88 35 DC.		10	130	90	7-20-67
039741	SC 07 88 35 DC.		10	30	8	11-26-69
028053	SC 07 88 36 AB.		10	37	25	7-25-66
008209	SC 07 88 36 CC.		3	150	48	3-18-61
006580F	SC 07 89 01 AA.		12	152	127	12-30-64
027496	SC 07 89 01 AA.		20	140	118	6-21-66
013324	SC 07 89 01 AA.		20	106	80	9-10-62
023051	SC 07 89 01 AA.		20	182	148	3-10-65
013323	SC 07 89 01 AA.		20	99	75	9-26-62
044989	SC 07 89 01 AA.		6	180	30	3-27-71
023997	SC 07 89 01 AA.		15	210	160	6-16-65
017152	SC 07 89 01 AA.		6	146	115	9 -2-63
023987	SC 07 89 01 AB.		10	55	35	5-14-65
032890	SC 07 89 01 AB.		10	90	41	1-26-68
000459N	SC 07 89 01 AC.		15	80	40	9-15-52
007610	SC 07 89 01 AC.		40	54	26	12 -6-61

F. M. FOX & ASSOCIATES INC.

GEOLOGY DIVISION
COLORADO WELL DATA
SORTED BY LOCATION

PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
028065	SC 07 89 01 AD. .		10	133	80	7-15-66
062794	SC 07 89 01 AD. .		15			7 -1-52
000464	SC 07 89 01 BB. .		12	89	30	7 -5-57
021596	SC 07 89 01 BB. .		15	21	10	8-26-64
057555	SC 07 89 01 BB. .		15	55		9-14-60
028055	SC 07 89 01 BC. .		10	37	15	7-25-66
034294	SC 07 89 01 DA. .		10	90	53	6-29-68
007027	SC 07 89 01 DB. .		20	62		9-11-60
033832	SC 07 89 01 DB. .		10	80	57	5-21-68
043875	SC 07 89 01 DB. .		10	80	58	1 -2-71
007026	SC 07 89 01 DB. .		15	100	13	9 -7-60
008295	SC 07 89 01 DB. .		12	78	27	4-14-61
035278	SC 07 89 01 DB. .		10	75	21	9 --68
017116	SC 07 89 01 DB. .		15	54	16	7-30-63
042874	SC 07 89 01 DB. .		10	84	43	9 -4-70
034292	SC 07 89 01 DB. .		10	85	46	7 -4-68
031706	SC 07 89 01 DB. .		10	110	37	9-25-67
019067	SC 07 89 01 DC. .		10	44	36	11 -6-63
037315	SC 07 89 01 DD. .		5	56	12	4-18-69
011258F	SC 07 89 01 DD. .		20	145	75	7-29-66
011214F	SC 07 89 02 AA. .		300	80	40	9 -9-66
008848	SC 07 89 02 AB. .		30	90	50	4-16-61
012970	SC 07 89 02 BB. .		50	80	38	6-14-62
038320	SC 07 89 03 BA. .		10	52	32	7 -3-69
031593	SC 07 89 03 BB. .		20	150	80	7-16-67
031592	SC 07 89 03 BB. .		20	150	86	7-18-67
034355	SC 07 89 03 BB. .		40	100	48	6-15-68
047284	SC 07 89 03 BB. .		30	180	100	9-16-67
036054	SC 07 89 03 BC. .		10	90	71	12-10-68
033830	SC 07 89 03 CA. .		10	60	21	5-18-68
034993	SC 07 89 03 CB. .		10	70	46	8-24-68
032058	SC 07 89 06 CC. .		10	130	40	9-13-67
017582	SC 07 89 07 AB. .		20	90	68	9-27-63
005881	SC 07 89 09 DA. .		15	32	6	5-15-60
032065	SC 07 89 18 BA. .		10	75	21	8-26-67
034661	SC 07 89 22 AB. .		18	200	95	8-27-68
045881	SC 07 89 23 CB. .		15	100	57	5 -5-71
030832	SC 07 89 24 AA. .		10	45	27	2 -2-67
028235	SC 08 86 01 AC. .		15	230	195	7 -7-66
038338	SC 08 86 01 BC. .		10	96	72	7-15-69
036918	SC 08 86 01 BC. .		10	86	62	3-29-69
034874	SC 08 86 01 BC. .		14	65	48	8 -6-69
041017	SC 08 86 01 CA. .		15	203	125	5-26-70
008294	SC 08 86 01 CA. .		9	30	22	4-15-61
039361	SC 08 86 01 CC. .		10	115	75	9-25-69
009893	SC 08 86 02 AC. .		20	46	31	10 -1-61
022482	SC 08 86 02 AD. .		9	242	150	12-10-64
028236	SC 08 86 02 AD. .		15	260	195	7-12-66
025700	SC 08 86 02 BC. .		15	152	UNKWN	10-31-65
022479	SC 08 86 02 CA. .		10	110	86	11-19-64
037015	SC 08 86 03 BB. .		10	72	51	5-21-69
017370	SC 08 86 03 DD. .		25	60	44	8-21-63
036872	SC 08 86 07 DC. .		10	35	10	2-29-69
044044	SC 08 86 07 DD. .		50	52	12	1 -7-71
040237	SC 08 86 08 BB. .		10	70	42	3-26-70

COLORADO WELL DATA
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PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
021362	SC 08 86 08 CC. .		20	38	18	9 -2-64
001814	SC 08 86 11 CC. .		10	31	15	10-30-58
023053	SC 08 86 13 BB. .		10	90	62	3-14-65
032453	SC 08 86 17 BD. .		10	105	46	10-12-67
027499	SC 08 86 17 CA. .		20	82	50	6 -1-66
027497	SC 08 86 17 CA. .		3	160	90	6-26-66
034996	SC 08 86 17 CA. .		10	42	18	8-28-68
007836	SC 08 86 17 CA. .		30	60	41	2 -3-61
030222	SC 08 86 17 CB. .		10	70	20	2 -7-67
027498	SC 08 86 17 DB. .		20	230	165	6 -3-66
042877	SC 08 86 17 DC. .		15	60	31	9 -7-70
041870	SC 08 86 17 DD. .		15	105	82	7-27-70
039153	SC 08 86 17 DD. .		15	195	60	8-28-69
036056	SC 08 86 18 AA. .		10	37	18	12-20-68
026304	SC 08 86 18 BA. .		50	27	10	1-30-66
036581	SC 08 86 18 BA. .		10	35	12	2-23-69
040486	SC 08 86 18 BB. .		10	38	12	3-16-70
010562	SC 08 86 20 AA. .		8	31	12	6 -7-61
060572	SC 08 86 20 AA. .		30			8-16-66
027500	SC 08 86 20 AA. .		20	80	42	6 -7-66
040950	SC 08 86 20 AA. .		10	52	31	5 --70
031000	SC 08 86 21 BA. .		10	55	20	5-25-67
033833	SC 08 86 21 BA. .		10	50	13	5-19-68
016279	SC 08 86 21 DB. .		14	52	39	6 -3-63
027491	SC 08 86 21 DB. .		10	26	18	6 -3-66
040948	SC 08 86 22 CC. .		10	28	14	4-27-70
004228	SC 08 86 22 CD. .		25	27	20	8-27-59
044486	SC 08 86 25 BD. .		10	35	12	2-28-71
020103	SC 08 86 25 CA. .		12	35	16	5-30-64
005878	SC 08 86 26 AB. .		30	54	34	5-20-60
000284	SC 08 86 26 AC. .		7	46	15	10-15-57
040488	SC 08 86 27 AB. .		10	67	23	3-19-70
041019	SC 08 86 27 AB. .		25	49	21	5-10-70
020097	SC 08 86 27 AC. .		10	54	32	3-24-64
039743	SC 08 86 27 DA. .		10	147	100	1-18-70
035281	SC 08 86 27 DB. .		10	50	UNKWN	6-18-69
036580	SC 08 86 27 DB. .		3	100	82	2 -2-69
031595	SC 08 86 29 CC. .		15	80	55	5-15-67
017117	SC 08 86 34 AB. .		10	58	46	9-22-63
038383	SC 08 86 34 AB. .		8	60	40	7 -1-69
020099	SC 08 86 34 AC. .		8	56	26	4 -6-64
037723	SC 08 86 34 BB. .		10	127	60	5 -8-69
001685	SC 08 86 36 BA. .			90		8-16-58
019062	SC 08 87 02 BB. .		10	59	42	9-10-63
045493	SC 08 87 02 BB. .		25	50	20	12-24-42
047700	SC 08 87 02 BB. .		10	59	45	9-19-63
019057	SC 08 87 03 AA. .		10	60	47	11 -7-63
046871	SC 08 87 03 AA. .		50	128	118	6 -5-64
014001F	SC 08 87 03 AB. .		300	110	40	8 -1-69
027486	SC 08 87 03 AB. .		30	91	52	3 -4-66
003624F	SC 08 87 03 BA. .		400	116	41	- -
036055	SC 08 87 03 BA. .		10	70	46	12-15-68
015052F	SC 08 87 03 BA. .		300	105	44	6-10-70
024950	SC 08 87 03 BA. .		25	92	40	8-22-65
013192F	SC 08 87 03 BA. .		130	114	61	2-10-69

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PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
014002F	SC 08 87 03 BB. .		300	100	35	6-16-69
032243	SC 08 87 03 BB. .		10	165	100	10-16-67
027487	SC 08 87 03 DD. .		20	36	21	3 -7-66
033343	SC 08 87 04 AD. .		10	55	21	4 -9-68
031709	SC 08 87 07 CA. .		10	53	11	8-17-67
041700	SC 08 87 07 CC. .		15	31	1	6-20-70
028715	SC 08 87 07 CD. .		10	34	10	9 -4-66
012972	SC 08 87 10 AA. .		50	32	4	6-16-62
048133	SC 08 87 10 AA. .		15	42	26	5-29-52
041396	SC 08 87 10 CA. .		20	70	35	6 --70
015049F	SC 08 87 11 AC. .		25	72	41	5-28-70
042451	SC 08 87 11 AC. .		12	73	50	8-20-70
022468	SC 08 87 11 AD. .		10	160	142	11-10-64
032059	SC 08 87 11 BA. .		10	37	12	9-10-67
009898	SC 08 87 11 BB. .		20	31	6	10 -2-61
019056	SC 08 87 11 BD. .		10	57	40	8-27-63
031708	SC 08 87 11 CA. .		10	90	31	8-19-67
034291	SC 08 87 11 CC. .		10	110	46	7 -7-68
022467	SC 08 87 11 DB. .		20	77	47	10-18-64
041018	SC 08 87 11 DC. .		20	94	49	5 -1-70
032456	SC 08 87 11 DD. .		10	70	26	9-28-67
000143	SC 08 87 13 AA. .		7	70	30	8-30-57
016280	SC 08 87 13 AC. .		15	84	54	7 -7-63
042635	SC 08 87 13 BA. .		15	72	48	9 -8-70
032454	SC 08 87 13 BA. .		10	80	31	10 -5-67
018180	SC 08 87 13 BA. .		4	90	52	10 -5-63
008208	SC 08 87 13 BB. .		9	82	57	3-21-61
012976	SC 08 87 13 BB. .		20	85	52	6-24-62
030408	SC 08 87 13 BB. .		10	95	40	3-24-67
043200	SC 08 87 13 BB. .		15	94	56	9-30-70
044618	SC 08 87 13 CD. .		20	145	104	3 -7-71
005456	SC 08 87 14 AA. .		30	106	56	4 -8-60
042878	SC 08 87 14 BA. .		10	60	32	9-12-70
005618	SC 08 87 14 BB. .		30	110	78	4-24-60
032635	SC 08 87 14 BB. .		50	125	88	10 -2-67
030829	SC 08 87 18 BB. .		10	70	32	12-27-66
030219	SC 08 87 20 BA. .		10	160	115	3 -5-67
038614	SC 08 87 22 AC. .		15	45	12	10 -1-69
038147	SC 08 87 23 AC. .		7	205	48	6-12-69
022475	SC 08 87 24 AB. .		10	66	47	10-28-64
036737	SC 08 87 24 BA. .		10	171	55	2-15-69
039362	SC 08 87 24 BA. .		5	250	48	9-24-69
038322	SC 08 87 24 BB. .		10	45	12	6-24-69
008212	SC 08 87 24 BD. .		30	80	53	3-24-61
043878	SC 08 87 28 CC. .		10	40	14	1-21-71
034293	SC 08 87 28 DB. .		10	50	14	7 -2-68
044401	SC 08 87 31 CD. .		15	77	47	2-10-71
030828	SC 08 87 32 AA. .		10	45	6	12-20-66
028056	SC 08 87 32 DA. .		10	47	15	7-24-66
028060	SC 08 87 34 AC. .		10	148	95	7-20-66
026307	SC 08 87 34 BA. .		10	56	36	1-15-66
028062	SC 08 87 35 AD. .		10	137	88	7-16-66
031001	SC 08 88 02 CC. .		10	210	150	5-28-67
042876	SC 08 88 03 AB. .		10	75	35	2 -2-71
003929	SC 08 88 03 DD. .		20	220		8-12-59

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044484	SC 08 88 03 DD. .		6	95	54	2-20-71
040487	SC 08 88 07 DC. .		10	37	10	3-13-70
043870	SC 08 88 09 AB. .		10	240	200	12 -6-70
044489	SC 08 88 09 BA. .		4	197	20	3 --71
015808F	SC 08 88 10 AC. .		190	40	30	7-20-72
015807F	SC 08 88 10 AD. .		1335	45	85	7 -4-72
032455	SC 08 88 10 CC. .		10	45	10	10 -4-67
012974	SC 08 88 11 AB. .		50	260	150	6-15-62
037316	SC 08 88 11 BB. .		10	180	150	4-14-69
023993	SC 08 88 11 CD. .		12	200	160	6 -2-65
046725	SC 08 88 13 CC. .		15	335	290	7-19-71
010563	SC 08 88 15 DC. .		10	38	26	8-18-61
038321	SC 08 88 22 AB. .		10	50	14	6-29-69
043879	SC 08 88 22 AB. .		10	41	17	1-24-71
039747	SC 08 88 22 AC. .		10	50	22	11-19-69
042879	SC 08 88 22 CA. .		10	45	18	9-16-70
010569	SC 08 88 27 AB. .		14	42	25	11-23-61
032395	SC 08 88 27 AC. .		10	210	160	6-19-67
032395	SC 08 88 27 AC. .		10	210	160	6-19-67
030752	SC 08 88 27 BB. .		10	35	10	5-11-67
057382	SC 08 88 27 BB. .		5	20		--12
054368	SC 08 88 27 BC. .		15	33		--99
020101	SC 08 88 27 CA. .		20	34	18	6 -5-64
041745	SC 08 88 27 CD. .		10	63	19	6-29-70
035753	SC 08 88 27 DC. .		10	47	18	11-10-68
039750	SC 08 88 27 DC. .		10	75	21	11-12-69
039748	SC 08 88 27 DC. .		10	60	32	11-16-69
039749	SC 08 88 27 DC. .		10	98	52	11-14-69
040953	SC 08 88 27 DC. .		10	32	12	5-19-70
040952	SC 08 88 27 DC. .		10	100	64	5-14-70
039553	SC 08 88 27 DD. .		20	180	80	10 -8-69
033348	SC 08 88 33 DB. .		4	50	27	4-26-68
004112F	SC 08 88 34 AB. .		15	35	11	5-10-63
041392	SC 08 88 34 BB. .		8	112	60	6 -1-70
035280	SC 08 88 34 CB. .		10	30	12	9 --68
031267	SC 08 88 35 AB. .		10	8	35	6-22-67
032061	SC 08 88 35 AC. .		10	35	7	9 -5-67
033345	SC 08 88 35 AC. .		10	37	8	4-16-68
032062	SC 08 88 35 AC. .		10	38	7	9 -3-67
032063	SC 08 88 35 AD. .		10	35	6	9 -1-67
031710	SC 08 88 35 BA. .		10	80	21	8-14-67
028054	SC 08 88 35 BC. .		10	36	21	7-26-66
031711	SC 08 88 35 BD. .		10	35	8	8-12-67
028306	SC 08 88 35 DD. .		10	52	18	8-11-66
032568	SC 08 89 14 BB. .		20	200	150	10-10-67
029081	SC 08 89 20 BC. .		20	30	12	10-18-66
029209	SC 08 89 23 AC. .		20	190	100	10-23-66
028304	SC 08 89 33 AC. .		10	58	20	8 -3-66
032389	SC 08 89 33 AC. .		12	360	80	10 -4-67
029210	SC 08 89 33 AC. .		20	160	85	10-24-66
030827	SC 08 89 33 AC. .		10	160	65	5-18-67
028305	SC 08 89 33 AC. .		10	107	80	8 -6-66
030999	SC 08 89 35 BD. .		10	37	6	5 -8-67
040024	SC 09 84 07 CD. .		10	46	8	1-16-70
035152	SC 09 84 12 AB. .		10	77	30	9-28-68

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007354	SC 09 85 01 CB. .		60	40	4	10 -8-60
031272	SC 09 85 05 BA. .		10	45	21	7 -1-67
015555F	SC 09 85 05 CC. .		50	67	50	4 -6-72
015556F	SC 09 85 05 CD. .		50	67	50	4 -6-72
006481	SC 09 85 05 CD. .		20	65	28	7-28-60
015554F	SC 09 85 05 CD. .		50	77	57	4 -6-72
043877	SC 09 85 05 CD. .		15	55	32	1-20-71
012443	SC 09 85 06 BC. .		30	155	44	5-18-62
031271	SC 09 85 06 BD. .		10	75	31	7 -1-67
034789	SC 09 85 06 BD. .		17	80	3	7-31-68
007838	SC 09 85 06 BD. .		7	74	49	1-13-61
036873	SC 09 85 06 CA. .		10	50	27	3 -7-69
008853	SC 09 85 06 DA. .		4	40	4	5 -6-61
033349	SC 09 85 06 DB. .		8	195	132	4 -5-68
010568	SC 09 85 07 CC. .		30	33	16	11-21-61
041698	SC 09 85 07 CD. .		15	46	20	6-28-70
012445	SC 09 85 08 AB. .		50	92	4	6 -8-62
024960	SC 09 85 08 AB. .		6	116	14	8-14-65
032894	SC 09 85 08 AC. .		10	57	31	2-14-68
022484	SC 09 85 08 AC. .		20	86	40	10-26-64
020096	SC 09 85 08 AD. .		10	68	35	3-18-64
013754F	SC 09 85 08 AD. .		30	85	51	3-20-69
007576	SC 09 85 09 CB. .		30	76	57	12 -4-60
040792	SC 09 85 09 CC. .		15	80	50	4-10-70
027501	SC 09 85 09 CC. .		30	66	42	7 -1-66
024957	SC 09 85 09 CC .		30	80	40	9-15-65
013915	SC 09 85 09 CC. .		20	74	50	12-20-62
012444	SC 09 85 09 CC. .		30	42	18	6 -2-62
037319	SC 09 85 09 CC. .		10	75	47	4-11-69
012441	SC 09 85 09 CC. .		30	80	44	5 -8-62
005619F	SC 09 85 09 CD. .		100	71	50	8 -8-61
040949	SC 09 85 09 DB. .		10	95	32	5 -3-70
038677	SC 09 85 10 AA. .		8	125	95	8-10-69
038678	SC 09 85 10 AA. .		10	116	91	8 -4-69
008431	SC 09 85 10 AC. .		16	94	63	5 -3-61
037317	SC 09 85 10 AC. .		10	53	24	4-15-69
033831	SC 09 85 10 BA. .		10	55	21	5-17-68
046628	SC 09 85 10 BB. .		5	195	70	6-13-71
020104	SC 09 85 10 BD. .		10	36	10	5-28-64
032517	SC 09 85 10 CA. .		10	75	18	11 -2-67
035347	SC 09 85 10 CA. .		10	75	44	9-28-68
011213F	SC 09 85 10 CC. .		150	115	66	9-15-66
023990	SC 09 85 10 CC. .		15	80	55	5-26-65
044058	SC 09 85 12 BD. .		15	37	10	12 -9-70
043544	SC 09 85 13 AC. .		15	31	8	11 -8-70
005880	SC 09 85 14 AB. .		10	38	28	5-18-60
032270	SC 09 85 14 CD. .		12	220	140	5-12-67
037730	SC 09 85 14 DC. .		10	50	8	6-15-69
021116	SC 09 85 15 AB. .		14	74	45	6-22-64
041743	SC 09 85 15 AB. .		10	33	3	7-11-70
034989	SC 09 85 15 AB. .		10	73	51	9-23-68
032892	SC 09 85 15 AD. .		10	105	80	2 -2-68
024954	SC 09 85 15 BA. .		25	44	22	9 -4-65
002046	SC 09 85 15 CD. .		20	59		9-25-58
032271	SC 09 85 15 DD. .		8	400	190	5 -4-67

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031707	SC 09 85 16 AB. .		10	50	18	10-27-67
007256	SC 09 85 16 AC. .		28	50	34	12-11-60
013570	SC 09 85 16 BA. .		40	80	59	8-26-62
013571	SC 09 85 16 BA. .		50	78	56	9 -1-62
034995	SC 09 85 16 BA. .		10	62	37	8-27-68
046872	SC 09 85 16 BA. .		50	81	56	5 --65
039053	SC 09 85 16 BA. .		10	62	32	8-20-69
032060	SC 09 85 16 BA. .		10	40	15	9 -7-67
037318	SC 09 85 16 BB. .		5	50	12	4-10-69
009918	SC 09 85 16 BD. .		30	38	9	10 -5-61
017679	SC 09 85 16 BD. .		40	35	21	10-23-63
027489	SC 09 85 16 BD. .		20	42	31	3-16-66
020102	SC 09 85 16 BD. .		20	35	18	6 -7-64
017819	SC 09 85 16 CA. .		2	35	6	9-28-63
039052	SC 09 85 16 CA. .		10	127	2	8-23-69
023989	SC 09 85 16 CA. .		7	40	5	5-14-65
024956	SC 09 85 16 CA. .		8	100	50	9-16-65
016259	SC 09 85 16 DB. .		15	32	20	7-18-63
041742	SC 09 85 16 DC. .			110	73	7-15-70
046724	SC 09 85 16 DC. .		15	60	28	7-26-71
022766	SC 09 85 16 DD. .		999	126	41	2 -9-65
024958	SC 09 85 21 AB. .		20	60	25	9-17-65
040795	SC 09 85 21 AD. .		8	248	160	3-30-70
031596	SC 09 85 21 CC. .		15	165	90	5-10-67
004431	SC 09 85 21 DB. .		1	53		9-23-59
012447	SC 09 85 21 DB. .		6	180	98	3-24-62
009894	SC 09 85 22 AC. .		20	240	170	10 -8-61
009895	SC 09 85 22 DA. .		20	108	89	8-14-61
000478	SC 09 85 23 BA. .		20	38		10-19-57
028988	SC 09 85 24 DB. .		10	106	35	10 -3-66
009897	SC 09 85 27 AD. .		20	142	120	7 -1-61
042418	SC 09 85 28 AA. .		16	127	85	8 -7-70
041744	SC 09 85 28 BA. .		10	120	60	7 -4-70
040025	SC 09 85 28 BD. .		10	110	80	1-23-70
041038	SC 09 85 31 AC. .		5	241	180	4-15-70
003985	SC 09 85 34 AC. .		20	141	125	9-30-59
025418	SC 09 85 34 AD. .		15	145	132	9-24-65
007355	SC 09 85 34 BD. .		9	142	130	11-10-60
027492	SC 09 86 02 BD. .		20	120	40	6 -6-66
027493	SC 09 86 02 DD. .		20	46	22	6-20-66
037729	SC 09 86 03 AB. .		10	71	41	6 -2-69
000200	SC 09 86 03 BA. .		9	50	22	9-12-57
040485	SC 09 86 05 BC. .		10	50	UNKWN	3-17-70
028987	SC 09 86 06 BA. .		10	220	55	10 -6-66
030377	SC 09 86 06 BC. .		10	193	165	6 -3-67
012188F	SC 09 86 07 AA. .		20	100	42	1 -8-67
012187F	SC 09 86 07 CA. .		20	110	70	3 -1-67
028058	SC 09 86 09 AC. .		10	85	50	7-21-66
032057	SC 09 86 11 AD. .		10	55	14	9-17-67
033344	SC 09 86 11 AD. .		4	95	40	4-12-68
042417	SC 09 86 14 CA. .		12	220	200	8-17-70
038010	SC 09 86 15 DD. .		4	137	60	6 -4-69
011306F	SC 09 86 21 CB. .		20	60	8	10-18-66
011307F	SC 09 86 21 CB. .		20	55	8	10-12-66
042880	SC 09 86 22 BD. .		10	67	31	9-19-70

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006604	SC 09 86 25 DD. .		20	135	110	8 -8-60
029079	SC 09 86 26 AD. .		20	31	12	10-14-66
047866	SC 09 86 27 BB. .		3	195	120	8 -6-71
041699	SC 09 86 28 BD. .		10	98	75	7-10-70
032889	SC 09 86 34 DC. .		10	55	26	2-20-68
030220	SC 09 86 34 DD. .		10	50	12	3 -8-67
020105	SC 09 87 05 BA. .		40	46	8	6-10-64
038743	SC 09 87 24 AD. .		3	90	50	7-25-69
034289	SC 09 88 03 BB. .		10	65	24	7-14-68
035282	SC 09 88 04 AD. .		10	75	18	10 --68
031002	SC 09 88 10 CD. .		10	52	35	5-26-67
031705	SC 09 88 16 BB. .		10	30	10	9-24-67
021114	SC 09 88 16 BD. .		20	36	16	6-28-64
032064	SC 09 88 16 BD. .		10	115	41	8-29-67
021115	SC 09 88 16 BD. .		20	38	13	7 -1-64
027490	SC 09 88 16 CA. .		50	130	70	3-20-66
040951	SC 09 88 21 BC. .		10	34	12	5 -9-70
039554	SC 09 88 29 AC. .		7	137	60	10-12-69
026303	SC 09 88 29 BB. .		20	74	50	2 -2-66
017369	SC 09 88 33 AA. .		60	40	30	8-22-63
032269	SC 09 89 03 BB. .		14	130	80	9-22-67
011873F	SC 10 84 04 CA. .		999	50	UNKWN	6 -3-68
011874F	SC 10 84 05 AC. .		30	60	15	6-11-68
011871F	SC 10 84 05 DC. .		999	35	UNKWN	7-27-68
011872F	SC 10 84 05 DD. .		999	215	UNKWN	5 -1-68
014271	SC 10 84 06 BA. .		8	145	115	3 -9-63
014272	SC 10 84 06 BA. .		6	400	120	3-14-63
033881	SC 10 84 06 CD. .		5	172	32	5-30-68
007842	SC 10 84 07 AC. .		10	20	7	2 -1-61
015285	SC 10 84 07 AC. .		8	266	130	5-15-63
002735F	SC 10 84 07 BA. .			87	29	8-25-60
008733	SC 10 84 07 BB. .		30	42	2	5-28-61
022473	SC 10 84 07 BB. .		18	83	46	12-14-64
034992	SC 10 84 07 BB. .		10	68	34	8-21-68
022472	SC 10 84 07 BB. .		8	120	55	12 -8-64
002025	SC 10 84 07 BC. .		30	36		10-10-58
025697	SC 10 84 07 BC. .		2	103	40	11 -5-65
025696	SC 10 84 07 BD. .		15	40	10	11 -2-65
004332	SC 10 84 07 CA. .		20	23	8	9-15-59
024995	SC 10 84 07 CA. .		15	42	10	9 -6-65
036582	SC 10 84 07 CA. .		10	50	14	2-10-69
002792F	SC 10 84 07 CB. .			82	14	10 -6-60
007753F	SC 10 84 07 CC. .		50	91		9-13-57
007182	SC 10 84 07 DB. .		20	66		10 -7-60
030225	SC 10 84 07 DC. .		10	79	40	2-21-67
015286	SC 10 84 14 BB. .		10	160	80	7-10-63
006393	SC 10 84 17 CC. .		28	30	5	7-18-60
035071	SC 10 84 17 CC. .		10	85	52	9 -6-68
008928F	SC 10 84 18 AD. .		20	70		6-27-58
000346	SC 10 84 18 BA. .		20	70	40	10 -3-57
002497F	SC 10 84 18 BA. .		300	159	25	4-17-60
004595	SC 10 84 18 BC. .		20	168	145	10-19-59
007184	SC 10 84 18 DD. .		30	77	46	10-10-60
035892	SC 10 84 20 AA. .		10	131	75	11-29-68
034988	SC 10 84 20 AB. .		10	70	32	8-28-68

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035070	SC 10 84 20 BA. .		10	109	33	9 -2-68
035072	SC 10 84 20 BA. .		5	54	39	9 -2-68
024959	SC 10 84 20 CA. .		8	135	50	9-20-65
035283	SC 10 84 20 CC. .		10	54	UNKWN	9-29-68
017373	SC 10 84 28 CC. .		35	44	16	9 -5-63
017367	SC 10 84 28 DB. .		12	56	48	7-14-63
028088	SC 10 85 01 BD. .		10	75	25	7-26-66
028302	SC 10 85 01 BD. .		10	72	32	8 -1-66
020108	SC 10 85 01 CA. .		12	59	8	7 -4-64
020109	SC 10 85 01 CA. .		12	68	14	6-28-64
003684	SC 10 85 01 CB. .		4			6-19-59
015391	SC 10 85 01 CB. .		10	81	77	4-11-63
012440	SC 10 85 01 CB. .		30	65	14	5 -2-62
023052	SC 10 85 01 CB. .		10	92	35	3-12-65
010567	SC 10 85 01 CB. .		50	37	20	12-18-61
007177	SC 10 85 01 CB. .		30	38	3	10-17-60
010566	SC 10 85 01 CB. .		20	107	40	12-16-61
023994	SC 10 85 01 CB. .		20	66	8	5 -3-65
001219	SC 10 85 01 CC. .		40	130		5-30-58
013569	SC 10 85 01 CC. .		30	110	60	8-20-62
013568	SC 10 85 01 CC. .		30	105	82	8-10-62
021110	SC 10 85 01 CD. .		10	42	18	6-18-64
028089	SC 10 85 01 CD. .		10	71	28	7-28-66
010368F	SC 10 85 02 CA. .		4	140	10	10 -5-65
001355	SC 10 85 02 CC. .		10	71		7-15-58
004423	SC 10 85 02 CC. .		40	37	25	9-12-59
020107	SC 10 85 02 DB. .		18	64	8	5-27-64
025698	SC 10 85 02 DB. .		15	105	FLOWG	11 -4-65
043876	SC 10 85 03 BD. .		10	55	18	1 -6-71
033835	SC 10 85 03 CD. .		10	117	93	5-24-68
004573	SC 10 85 03 DA. .		80	40	15	10-12-59
012446	SC 10 85 03 DB. .		40	120	20	6-20-62
017818	SC 10 85 04 AD. .		1	35	19	10 -6-63
021156	SC 10 85 04 DD. .		20	134	58	6-22-64
021759	SC 10 85 05 CC. .		50	400	260	8 -6-64
037845	SC 10 85 06 AC. .		10	85	UNKWN	5-18-69
006321	SC 10 85 10 AA. .		50	140	49	7 -8-60
034665	SC 10 85 10 BB. .		12	165	65	7 --68
014284F	SC 10 85 10 CD. .		20	150	85	10-10-69
002047	SC 10 85 10 DD. .		10	331		10-11-58
012438	SC 10 85 11 AB. .		20	120	85	2-14-62
021360	SC 10 85 11 AB. .		30	105	58	9-12-64
030750	SC 10 85 11 AC. .		10	105	80	5 -6-67
020098	SC 10 85 11 BB. .		3	54	21	4 -3-64
005330	SC 10 85 11 CA. .		15	90	52	3-20-60
020106	SC 10 85 12 AA. .		6	65	32	6-18-64
006401	SC 10 85 12 AB. .		20	82	18	7 -9-60
030880	SC 10 85 12 AD. .		10	75	27	5-18-67
028061	SC 10 85 12 BC. .		10	157	54	7-18-66
010559	SC 10 85 12 BD. .		40	33	4	6 -1-61
022477	SC 10 85 12 BD. .		8	34	24	10 -6-64
000065	SC 10 85 12 CA. .		35	110		8-14-57
004841F	SC 10 85 12 CA. .		60	43	28	11 -8-63
017303	SC 10 85 12 CA. .		15	28	20	8-27-63
007181	SC 10 85 12 CB. .		20	67	40	10-15-60

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PERMIT#	LOCATION	AQUIFER	YIELD	DEPTH	LEVEL	DATE
004515R	SC 10 85 12 DD. .		10			9-13-57
001998	SC 10 85 13 AA. .		100	157		9-24-58
034991	SC 10 85 13 BA. .		10	35	7	8-20-68
008852	SC 10 85 14 CB. .		45	42	18	5-29-61
005466	SC 10 85 14 DD. .		20	12	7	9-15-58
032392	SC 10 85 15 CC. .		8	120	70	9 -1-67
006093	SC 10 85 15 DB. .		32	165	49	6-18-60
007028	SC 10 85 18 DB. .		15	78	50	9-30-60
038941	SC 10 85 20 BA. .		6	84	7	8-13-69
006279	SC 10 85 22 BB. .		15	227	178	6-30-60
039742	SC 10 85 22 BB. .		10	145	120	1 -5-70
035755	SC 10 85 23 AA. .		10	35	8	10-16-68
004853	SC 10 85 23 AA. .		10	12		9-15-57
001955	SC 10 85 23 AB. .		25	114		9-26-58
017371	SC 10 85 23 CC. .		12	233	180	7-25-63
022483	SC 10 85 26 AA. .		9	150	26	10-16-64
006486	SC 10 85 26 DD. .		12	73	61	9-22-60
008854	SC 10 85 26 DD. .		10	34	14	6 -3-61
011278F	SC 10 85 27 CA. .		50	55	8	10 -1-66
007837	SC 10 85 28 AA. .		30	76	35	1 -6-61
017114	SC 10 85 35 AD. .		20	194	155	7-18-63
028063	SC 10 86 06 BC. .		5	91	75	7-16-66
028064	SC 10 86 06 BC. .		2	90	75	7-18-66
011279F	SC 10 86 21 DD. .		50	38	8	10-27-66
021117	SC 10 88 04 AC. .		10	48	7	6 -4-64
031712	SC 10 88 04 BD. .		10	55	18	8 -9-67
017630	SC 10 88 04 CA. .		20	27	11	9-29-63
017979	SC 10 88 04 CA. .		10	44	28	9-14-63
019063	SC 10 88 04 CD. .		10	31	21	8 -1-63
026072	SC 10 88 04 CD. .		20	62	8	12 -5-65
026101	SC 10 88 09 BA. .		20	31	12	12 -7-65
019064	SC 10 88 09 BB. .		12	155	110	8-16-63
041746	SC 10 88 09 CB. .		10	53	19	6-25-70
013567	SC 10 88 09 CC. .		12	93	68	10 -6-62
013560	SC 10 88 16 BB. .		10	93	60	11 -6-62
005970	SC 10 88 17 AD. .		10	68	40	5-28-60
003879F	SC 10 88 17 DC. .		30	50	22	1 -8-63
015045F	SC 10 88 17 DD. .		20	50	4	6 -2-70
056781	SC 10 88 29 BB. .		5			11-20-70
041074	SC 10 88 29 BC. .		15	40	4	5-26-70
037320	SC 10 88 29 CB. .		1	155	85	6 -3-69
046153	SC 10 88 29 CC. .		12	350	100	6 -6-71
039239	SC 10 88 29 CD. .		1	360	175	9 -9-69
041393	SC 10 88 30 AD. .		1	352	114	6 -6-70
034664	SC 10 89 07 DB. .		8	130	65	7-23-68
035063	SC 10 89 10 DD. .		4	62	45	8-28-68
022450	SC 11 85 02 AA. .		70	10	UNKWN	--36
039745	SC 11 85 02 AC. .		10	45	26	11-23-69
039746	SC 11 85 02 AD. .		10	30	8	11-21-69
028301	SC 11 85 02 DD. .		10	47	22	7-29-66
031704	SC 11 85 02 DD. .		10	35	8	9-21-67
034288	SC 11 85 05 BC. .		10	60	47	7-17-68
028986	SC 11 85 28 BB. .		10	40	18	9-28-66
009891	SC 11 88 07 AA. .		10	33	25	10 -7-61
046722	SC 11 88 26 AD. .		15	29	12	7-10-71

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046723	SC 11 88 26 CB. .		15	90	39	7-13-71
062106	SC 11 88 26 DB. .		15			7 -1-60
044487	SC 11 88 27 AD. .		10	50	28	3 -2-71
044488	SC 11 88 28 AA. .		10	97	48	3 -4-71
046516	SC 11 88 28 AD. .		15	115	73	6-19-71
025114	SC 11 89 29 BB. .		1	97	61	6-31-65
031268	SC 11 89 29 CC. .		10	40	12	6-26-67
050079	SC 13 86 02 AC. .		2	38	8	12 -9-71
003649F	SC 13 86 23 AA. .		1	40	16	7-12-62
003383F	SC 13 86 26 AA. .		20	69	65	10-13-61
047768	SC 13 86 27 CC. .			50	UNKWN	9 -6-71
006304	SC 13 87 35 DA. .			202	4	7-27-60
002495F	SC 13 89 08 AA. .			15	5	12 --58
002496F	SC 13 89 08 AA. .			16	8	2 --59
024922	SC 14 85 18 BA. .		20	150	100	8-13-65
004872	SC 14 85 18 DA. .			139	93	6 -3-60
043382	SC 14 85 23 AD. .		18	48	24	10-13-70
048369	SC 14 85 24 AA. .		6	20		7-14-72
046446	SC 14 85 27 AB. .		15	70	27	6-11-71
021220	SC 14 85 27 CA. .		20	73	52	8 -4-64
019038	SC 14 85 28 BA. .		20	60	46	4-14-64
028483	SC 14 85 33 BC. .		20	23	9	8 -8-66
042428	SC 14 85 34 AA. .		20	55	38	8-10-70
042988	SC 14 85 34 AA. .		20	55	38	9-11-70
043383	SC 14 85 34 AD. .		20	56	33	10-13-70
038783	SC 14 85 34 BA. .		20	60	39	8 -1-69
032041	SC 14 85 34 BB. .		20	63	43	9 -1-67
007945	SC 14 85 34 DB. .			57	41	2-14-61
020936	SC 14 85 34 DB. .		25	60	23	7-30-64
043045	SC 14 86 01 CC. .		20	40	19	9-18-70
043201	SC 14 86 02 BC. .		1	30	21	10-16-70
047953	SC 14 86 02 BC. .		15	45	12	8-21-71
048991	SC 14 86 03 AA. .		15	40	12	10-11-71
048992	SC 14 86 03 AA. .		15	45	18	10 -1-71
005580	SC 14 86 03 AC. .			25	14	4-16-60
016330R	SC 14 86 03 BD. .		450			--94
016333R	SC 14 86 03 BD. .		900			--81
016332R	SC 14 86 03 BD. .		160			--83
047548	SC 14 86 12 BA. .		10	26	8	7-23-71
038860	SC 14 86 12 BB. .		18	21	6	8 -5-69
038782	SC 14 86 12 CA. .			70	UNKWN	7-28-69
016334R	SC 14 87 16 BB. .		450			1 --87
008445	SC 15 84 02 DB. .			30		5-23-61
005851F	SC 15 84 12 BB. .		40	51	21	6-27-64
020671	SC 15 84 12 BB. .		10	41	26	6 -2-64
012740F	SC 15 84 15 CA. .		9	47	10	3-11-68
029321	SC 15 84 15 CA. .		10	49	33	9 -6-66
049259	SC 15 84 22 BC. .		15	48	26	12-18-71
046482	SC 15 84 22 BD. .		10	56	44	6-10-71
025953	SC 15 84 22 CB. .		999	50	39	12 -5-65
001577	SC 15 84 22 CC. .			47	19	7-14-58
011324	SC 15 84 22 CC. .		20	65	38	5 -2-62
028294	SC 15 84 22 CC. .		20	28	12	8 -3-66
029991	SC 15 84 27 BB. .		50	12	8	6-26-68
032769	SC 15 84 27 BB. .		50	50	35	12-19-67

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035383	SC 15 84 27 BB. .		16	35	20	10-14-68
046254	SC 15 84 27 BB. .		15	17	5	8 -3-71
032478	SC 15 84 28 AC. .		9	33	8	11-10-67
024303	SC 15 84 28 AD. .		10	41	20	6 --65
010689	SC 15 84 28 DB. .		20	60	42	2-14-62
024134	SC 15 85 02 CC. .		25	58	27	6 -8-65
007946	SC 15 85 11 DB. .			41	30	2 -7-61
028852	SC 15 85 13 BD. .		200	850	FLOWG	7-15-64
025829	SC 15 85 22 CD. .		7	57	33	11 -6-65
019215	SC 15 85 23 AB. .		20	51	31	4 -3-64
019214	SC 15 85 23 DA. .		25	39	21	4 -2-64
020246	SC 15 85 25 BC. .		1	42	13	6-11-64
014135	SC 15 85 25 CB. .		30	34	24	2-15-63
014280F	SC 15 85 26 AC. .		30	685	FLOWG	5-29-69
013428F	SC 15 85 26 DC. .		120	80	10	5-29-69
025496	SC 15 85 26 DD. .		25	60	40	10-12-65
030717	SC 15 85 26 DD. .		30	42	11	5 -6-67
027855	SC 15 85 26 DD. .		20	60	24	6 -6-66
027856	SC 15 85 26 DD. .		20	60	24	6 -6-66
014290	SC 15 86 17 BD. .			77	UNKWN	3 -2-63
030587	SC 15 86 20 AA. .		20	60	12	4-26-67
032798	SC 15 86 20 CC. .			2546	UNKWN	1-29-68
036470	SC 15 86 20 DD. .			3506	300	1 -1-69
014100	SC 15 86 28 CA. .			108		2-16-63
014101	SC 15 86 28 CA. .		1	43	11	2-19-63
003594	SC 15 86 32 CB. .			55		6-10-59
008924F	SC 15 89 22 BC. .		20	74	31	10-21-65
012676F	SC 15 89 22 BC. .		18	65	40	11-12-68

B I B L I O G R A P H Y

Barnes, Joe G., 1968, Basalt Project, Colorado Missouri Heights Dam Feasibility Geology Report: U.S. Dept. of the Interior, Bureau of Reclamation.

Bartleson, B. L., Bryant, Bruce, and Mutschler, F. E., 1968, Permian and Pennsylvanian stratigraphy and nomenclature of the Elk Mtns., Colorado: U.S.G.S. Professional Paper 600-C.

Bartram, J. G., 1939, Summary of Rocky Mountain geology: Bulletin of the Amer. Assoc. of Petrol. Geologists, vol. 23, no. 8, p. 1131-1152.

Bass, N. W., 1956, Geology of the White River uplift in northwestern Colorado (summary): Tulsa Geol. Soc. Digest, vol. 24, p. 67-69.

-----, 1958, Pennsylvanian and Permian rocks in the southern half of the White River uplift Colorado: Rocky Mtn. Assoc. Geologists, Symposium on Pennsylvanian rocks of Colorado and adjacent areas, p. 91-94.

Bass, N.W., and Northrop, S. A., 1950, South Canyon Creek dolomite member, a unit of Phosphoria age in Maroon formation near Glenwood Springs, Colorado: Amer. Assoc. Petrol. Geologists Bull., vol. 34, p. 1540-1551.

-----, 1953, Dotsero and Manitou formations, White River Plateau, Colorado,with special reference to Clinetop algal limestone member of Dotsero formation: Amer. Assoc. Petrol. Geologists Bull., vol. 37, p. 889-912.

-----, 1955, Lower Paleozoic rocks of the White River uplift Colorado: Intermountain Assoc. Petroleum Geologists, Guidebook, 6th Ann. Field Conf. 1955, p. 3-9.

-----, 1963, Geology of Glenwood Springs quadrangle and vicinity, northwest Colorado: U.S. Geol. Survey Bull. 1142-J.

Bassett, C. F., 1938, Graptolites from Cambrian strata in Glenwood Canyon of the Colorado (abs): Geol. Soc. America Proc. 1937, p. 304-305.

Bastin, E. S., 1923, Observations on the rich silver ores of Aspen, Colorado: U.S. Geol. Survey Bull. 750, Part I, p. 41-62.

Benson, J. C., and Bass, N. W., 1955, Eagle River anticline, Eagle County, Colorado: Amer. Assoc. Petrol. Geologists Bull., vol. 39, no. 1, p. 103-106.

Bissell, H. J., and Childs, O. E., 1958, The Weber Formation of Utah and Colorado: Rocky Mtn. Assoc. Geologists: Symposium on Pennsylvanian rocks of Colorado and adjacent areas, p. 26-30.

Boggs, Sam, Jr., 1966, Petrology of Minturn Formation, east-central Eagle County, Colorado: Amer. Assoc. Petrol. Geologists Bull., vol. 50, no. 7, p. 1399-1422.

Brill, K. G., 1944, Late Paleozoic stratigraphy, west-central and northwestern Colorado: Geol. Soc. America Bull. vol. 55, p. 621-655.

-----, 1952, Stratigraphy in the Permo-Pennsylvanian zeugogeosyncline of Colorado and northern New Mexico: Geol. Soc. American Bull., vol. 63, p. 809-880.

Bryant, Bruce, 1966, Possible window in the Elk Range thrust sheet near Aspen, Colorado: U.S. Geol. Survey Prof. Paper 550-D.

-----, 1966, Preliminary geologic map of the Lenado mining district, Pitkin County, Colorado: U.S. Geol. Survey Open File.

-----, 1969, Geologic map of the Maroon Bells quadrangle, Pitkin and Gunnison Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 788.

-----, 1969, Geologic map of the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Open File.

-----, 1970, Geologic map of the Hayden Peak quadrangle, Pitkin and Gunnison Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 863.

-----, 1971, Geologic map of the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Geologic Quadrangle 933.

-----, 1971, Movement measurements on two rock glaciers in the eastern Elk Mtns., Colorado: U.S. Geol. Survey Prof. Paper 750-B.

-----, 1972, Geologic map of the Highland Peak quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Geologic Quadrangle 932.

-----, 1972, Map showing areas of selected potential geologic hazards in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-A.

-----, 1972, Map showing ground water potential in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-B.

-----, 1972, Map showing relative ease of excavation in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-C.

-----, 1972, Map showing mines, prospects, and areas of significant silver, lead, and zinc production in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-D.

-----, 1972, Slope map of the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-E.

-----, 1972, Map showing relative permeability of rocks and surficial deposits of the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-F.

-----, 1972, Map showing avalanche areas in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-G.

-----, 1972, Map showing types of bedrock and surficial deposits in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Misc. Geologic Investigations I-785-H.

Burchard, E. F., 1910, Gypsum deposit in Eagle County, Colorado: U.S. Geol. Survey Bulletin 470, p. 354-365.

Cadigan, R. A., 1967, Tabulated petrologic data from a study of the Morrison formation in the Colorado Plateau region: U.S. Geol. Survey Open File.

Chamberlain, R. T., 1919, The building of the Colorado Rockies: Jour Geol. vol. 27, p. 145-164, 225-251.

Collins, Bruce A., 1970, Geology of the coal-bearing Mesaverde formation (Cretaceous), Coal Basin area, Pitkin County, Colorado: M.S. Thesis, Colorado School of Mines.

Craig, L. C., and others, 1955, Stratigraphy of the Morrison and related formations, Colorado Plateau region, a preliminary report: U.S. Geol. Survey Bulletin 1009-E, p. 125-168.

Dept. of the Army Corps of Engineers, 1973, Flood Plain Information, Roaring Fork River and Castle and Hunter Creeks, Aspen, Colorado.

Donnell, J. R., 1954, Tongue of Weber sandstone in Maroon formation near Carbondale and Redstone, northwestern, Colorado: Amer. Assoc. Petrol. Geologists Bull., vol. 38, no. 8., p. 1817-1821.

-----, 1962, Geology and coal resources of the Carbondale area: U.S. Geol. Survey Open File.

Donner, H. F., 1949, Geology of the McCoy area, Eagle and Routt Counties, Colorado: Bull. Geol. Soc. America, vol. 60, p. 1215-1248.

Emmons, S. F., 1894, Description of Elk Mtns. in Anthracite-Crested Butte (quadrangles, Colorado): U.S. Geol. Survey Geol. Atlas Folio 9.

Freeman, V. L., 1970, Geologic map of the Woody Creek and southwest part of the Reudi quadrangle, Pitkin County, Colorado: U.S. Geol. Survey Open File Report.

-----, 1971, Permian deformation in the Eagle basin, Colorado: U.S. Geol. Survey Prof. Paper 750-D, p. D80.

-----, 1971, Stratigraphy of the State Bridge Formation in the Woody Creek quadrangle, Pitkin and Eagle Counties, Colorado: U.S. Geol. Survey Bulletin 1324-F, p. F1-F17.

-----, 1972, Geologic map of the Woody Creek quadrangle, Pitkin and Eagle Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 967.

-----, 1972, Geologic map of the Reudi quadrangle, Pitkin and Eagle Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 1004.

Gale, H. S., 1907, Coal fields of the Danforth Hills and Grand Hogback, in northwestern Colorado: U.S. Geol. Survey Bulletin 316, p. 264-301.

-----, 1909, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geol. Survey Bulletin 341, p. 283-315.

-----, 1910, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geol. Survey Bulletin 415.

Gaskill, D. L. and Godwin, L. H., 1966, Geologic map of the Marble quadrangle, Gunnison and Pitkin Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 512.

George, R. D., 1913, Geological relations in the Brush Creek region: Mining Science, vol. 67, pp. 148-149.

Gilmore, J. B. and Barrett, Robert K., 1971, Combined Report of Preliminary Geologic Investigations, Glenwood Canyon-Cottonwood Pass: Colorado Division of Highways.

Godwin, L. H., 1968, Geologic map of the Chair Mountain quadrangle, Gunnison and Pitkin Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle 704.

Godwin, L. H. and Gaskill, D. L., 1964, Post-Paleocene West Elk laccolithe cluster, west central Colorado: U.S. Geol. Survey Prof. Paper 501-C, p. C66.

Greene, K. and Volin, M. E., 1941, Plan and profile, Roaring Fork, Colorado from Colorado River to Mile 55: U.S. Dept. of Geol. Survey Sheet 2.

Hallgarth, W. D., 1959 (1960), Stratigraphy of Paleozoic rocks in northwestern Colorado: U.S. Geol. Survey Oil and Gas Investigations Chart - 59.

Hallgarth, W. E., and Skipp, B. A. L., 1962, Age of the Leadville Limestone in the Glenwood Canyon, western Colorado: U.S. Geol. Survey Prof. Paper 450-D, p. D37.

Hanks, T. L., 1962, Geology and coal deposits, Ragged Chair Mountain area, Pitkin and Gunnison Counties, Colorado: M. S. Thesis, Brigham Young Univ.

-----, 1962, Geology and coal deposits. Ragged Chair Mountain area, Pitkin and Gunnison Counties, Colorado: Brigham Young Univ. Studies, vol. 9, pt. 2, p. 137-160.

Hayden, F. V., 1876, Geology of the northwest portion of the Elk Range: U.S. Geol. and Geog. Survey of the Territories, 8th Ann. Report.

Hills, R. C., 1887, Circulation of water through the strata of the Upper Cretaceous coal measure of Gunnison County: Colo. Sci. Soc. Proc. vol. 2, pt. 2, p. 127-133.

Hodgden, H. Jerry, 1960, The geology around the junction of the Roaring Fork and Frying Pan Rivers, Eagle and Pitkin Counties, Colorado: M. S. Thesis, University of Kansas.

Horn, G. H., and Adair, J. S., 1959, Geologic map of Ragged Mountain coal area, Gunnison County, Colorado: U.S. Geol. Survey Open File Report.

Hubert, J. F., 1954, Geology of the Brush Creek area, Eagle County, Colorado: M. S. Thesis, Univ. of Colorado.

Iradji, Amir H., 1955, The Geology of the Northern Lenado Area, Pitkin County, Colorado: M. S. Thesis, Colorado School of Mines.

Johnson, J. H., 1944, Paleozoic stratigraphy of Sawatch Range: Bull. Geol. Soc. America, vol. 55, p. 303-378.

-----, 1945, Calcareous algae of the upper Leadville limestone near Glenwood Springs, Colorado: ibid, vol. 56, p. 829-847.

Katich, P. J., Jr., 1958, Stratigraphy of the Eagle evaporites: Rocky Mtn. Assoc. Geologists, Symposium on Pennsylvanian rocks of Colorado and adjacent areas, p. 106-110.

Knopf, Adolph, 1926, Recent developments in the Aspen District, Colorado: U. S. Geol. Survey Bull. 785, pt. 1, p. 1-28.

Landon, R. E., and Thurman, F. A.,1955, Pennsylvanian of northwest Colorado: Guide-book to the Geology of Northwest Colorado, Intermountain Assoc. of Petrol. Geol. and Rocky Mtn. Assoc. Geol., p. 12-15.

Langenheim, R. L., Jr., 1954, Correlation of Maroon Formation in Crystal River valley, Gunnison, Pitkin, and Garfield Counties, Colorado: Bull. Amer. Assoc. Petrol. Geologists, vol. 36, no. 8, p. 1748-1779.

Lawrence, F. F., 1953, Water Power resources of Crystal River, Colorado: U.S. Geol. Survey Circular 292.

Lee, W. T., 1912, Coal fields of Grand Mesa and the West Elk Mountains, Colorado: U.S. Geol. Survey Bulletin 510.

Lewandowski, Edward R., and Zlaten, Alexander, 1969, Foundation problems of Reudi Dam and Reservoir: Bureau of Reclamation, U. S. Dept. of the Interior.

Lipman, P. W., Mutschler, F. R., Bryant, Bruce, and Steven, T. A., 1969 (1970), Similarity of Cenozoic igneous activity in the San Juan and Elk Mountains, Colorado and its regional significance: U.S. Geol. Survey Prof. Paper 650-D.

Lovering, T. S., and Mallory, W. W., 1962, The Eagle Valley Evaporite and its relation to the Minturn and Maroon Formations, northwest Colorado: U.S. Geol. Survey Prof. Paper 450-D, p. D45-D48.

MacQuown, W. C., 1945, Structure of the White River Plateau near Glenwood Springs, Colorado: Bull. Geol. Soc. America, vol. 56, p. 877-892.

Mallory, W. W., 1960, Outline of Pennsylvania stratigraphy of Colorado: Rocky Mtn. Assoc. Geologists Guide to the Geology of Colorado, p. 23-33.

-----, 1966, Cattle Creek Anticline, A salt diapir near Glenwood Springs, Colorado: U. S. Geol. Survey Prof. Paper 550-B.

-----, 1971, The Eagle Valley Evaporite, Northwest Colorado - A Regional Synthesis: U.S.G.S. Bulletin 1311-E.

Mallory, W. W., Post, E. V., Ruane, P. J., and Lehmbeck, W. L., U.S. Geol. Survey, and Stotelmeyer, R. B., U.S. Bureau of Mines, 1966, Mineral resources of the Flat Tops primitive area, Colorado: U.S. Geol. Survey Bulletin 1230-C, p. C1-C30.

McCarthy, J. H., Jr., and Gott, G. B., 1966, The distribution of Ag, Pb, Zn, Sb, As, and Hg in soils at Lenado, Aspen quadrangle: U.S. Geol. Survey Open File Report.

Murray, Frederick N., 1966, The stratigraphy and structural geology of the Grand Hogback Monocline, Colorado: PhD Dissertation, Univ. of Colo.

Mutschler, F., 1969, Geologic map of the Snowmass Mountain quadrangle, Gunnison and Pitkin Counties, Colorado: U.S. Geol. Survey Open File Report.

-----, 1970, Geologic map of the Snowmass Mountain quadrangle, Gunnison and Pitkin Counties, Colorado: U.S. Geol. Survey Geologic Quadrangle GQ 853.

Nelson, R. L., 1952, Glacial Geology of the Frying Pan River Drainage, Colorado: PhD Dissertation, Cal. Tech.

-----, 1954, Glaciation of the Frying Pan drainage, Colorado: Journal Geol., vol. 62, no. 4, p. 325-343.

O'Boyle, C. C., 1955, The Cretaceous rocks of northwest Colorado: Guidebook to the Geology of Northwest Colorado, Intermountain Assoc. Petrol. Geol. and Rocky Mountain Assoc. of Geol., p. 32-35.

Pilkington, Harold Dean, 1954, Petrography and Petrology of a Part of Mount Sopris Stock, Pitkin County, Colorado: M.S. Thesis, Univ. of Colo.

Pillmore, Charles L., 1954, Petrography and Petrology of a Part of Mount Sopris Stock, Pitkin County, Colorado: M.S. Thesis, Univ. of Colo.

Poole, Forrest G., 1954, Geology of the Southern Hogback area, Garfield and Pitkin Counties, Colorado: M.S. Thesis, Univ. of Colo.

Poole, F. G., and Stewart, J. H., 1964, Chinle Formation and Glen Canyon Sandstone in northeastern Utah and northwestern Colorado: U.S. Geol. Survey Prof. Paper 501-D, p. D30.

Rocky Mtn. Assoc. Geologists, 1958, Symposium on Pennsylvanian Rocks of Colorado and Adjacent Areas.

-----, 1962, Exploration for oil and gas in northwestern Colorado.

Rocky Mtn. Assoc. Geologists and Intermountain Assoc. of Petroleum Geologists, 1955, Guidebook to the Geology of Northwest Colorado.

Sharp, W. N., 1970, Extensive zeolitization associated with hot springs in central Colorado: U.S. Geol. Survey Prof. Paper 700-B, B14.

Spurr, J. E., 1898, Geology of the Aspen Mining District, Colorado: U.S. Geol. Survey, Mon 31.

-----, 1909, Ore deposition at Aspen, Colorado: Econ. Geol. vol. 4, no. 4, p. 301-320.

Spurr, J. E., Garrey, G. H., and Ball, S. H., Economic geology of the Georgetown quadrangle: U.S. Geol. Survey Prof. Paper 63.

Thien, Maung, 1963, a Petrologic study of the Permo-Pennsylvanian Red Beds of Central Colorado with special reference to the development of red color: M.S. Thesis, Northwestern.

Thomas, C. R., McCann, F. T., and Ranacn, N. D., 1945, Mesozoic and Paleozoic stratigraphy in northwestern Colorado and northeastern Utah: U.S. Geol. Survey Oil and Gas Investigations Chart 16.

Tweto, Ogden, 1949, Stratigraphy of the Pando area, Eagle County, Colorado: Colorado Sci. Soc. Proc. vol. 15, p. 149-235.

-----, 1960, Relation of the Colorado Mineral Belt to Precambrian structure: U.S. Geol. Survey Prof. Paper 400-B, B8.

Vandervilt, J. W., 1935, Revisions of structure and stratigraphy of the Aspen District, Colorado, and its bearing on the ore deposits: Econ. Geol., vol. 30, p. 223-241.

-----, 1937, Geology and mineral deposits of the Snowmass Mountain area, Gunnison County, Colorado: U.S. Geol. Survey Bull. 884, p. 1-184.

-----, 1947, Geology and mineral deposits of the Snowmass Mountain area, Gunnison County, Colorado: Colo. Mtn. Reserves Board Bulletin, pp. 446-451.

Warner, Don L., 1961, Stratigraphy of Mancos-Mesa Verde (Cretaceous) Intertonguing, Southeast Piceance Basin, Colorado, and Geology of a Portion of the Grand Hogback: M.S. Thesis, Colorado School of Mines.

Welder, George E., 1954, Geology of the Basalt Area, Eagle and Pitkin Counties, Colorado: M.S. Thesis, Univ. Colorado.

Yeend, Warren E., 1969, Quarternary Geology of the Grand and Battlement Mesas Area, Colorado: U.S.G.S. Professional Paper 617.

OTHER RESEARCH (IN PROGRESS)

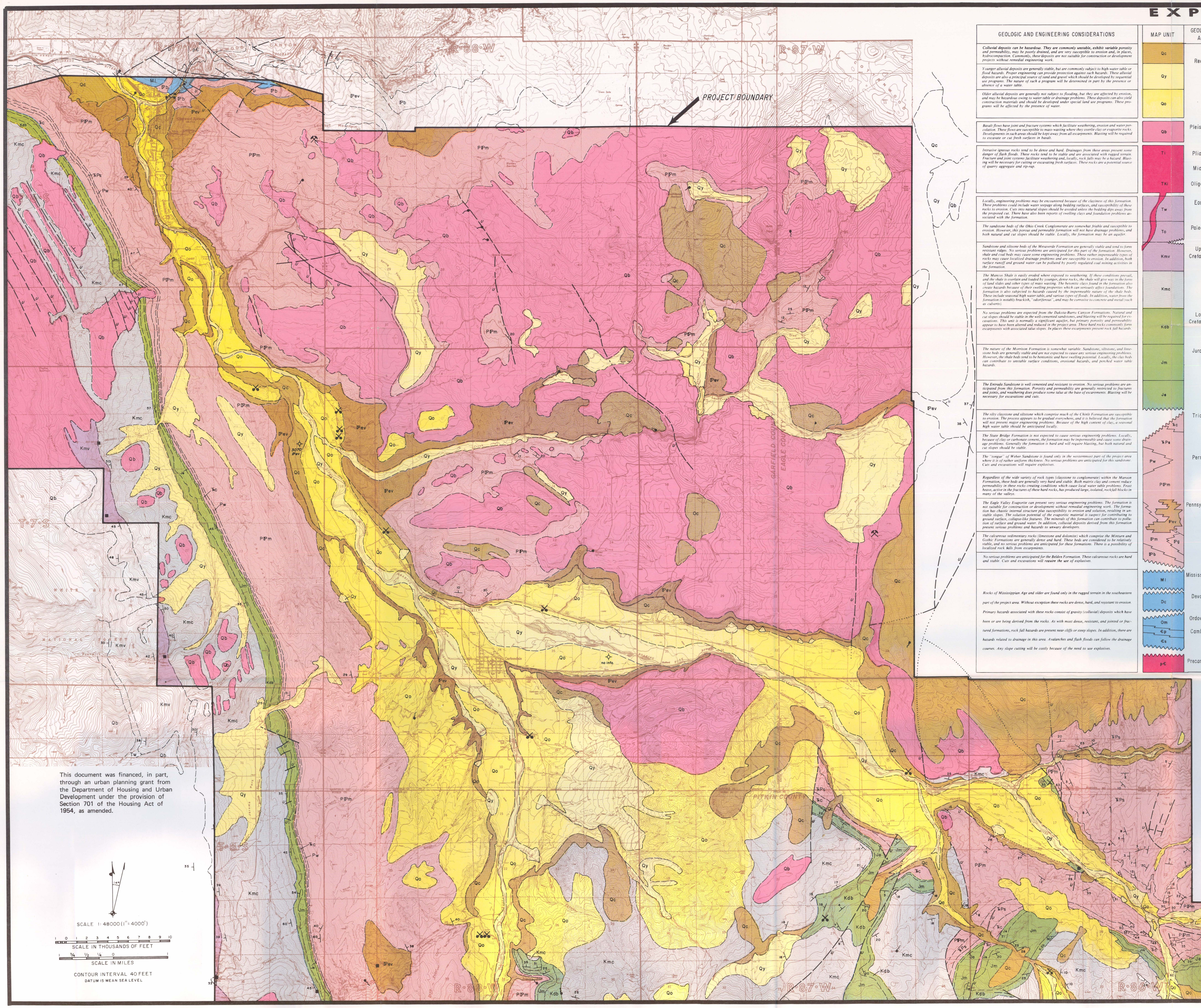
ARMY CORPS OF ENGINEERS

The Army Corps of Engineers is preparing a report in conjunction with the Colorado Water Conservation Board concerning flooding of the Roaring Fork River. This flood plain study will be similar to one released by the Corps of Engineers in June 1973 concerning flooding in the Aspen area along the Roaring Fork River and Castle and Hunter Creeks.

However, the more recent report will delineate flood plains of the Roaring Fork for a mile and three quarters beyond the previous report and will contain no history of flooding in the area as did the previous report. The report is due to come out in the late summer of 1974.

COLORADO DEPARTMENT OF HEALTH

The State Health Department is sponsoring a water quality management study conducted by Wright and McLaughlin for the purpose of establishing guidelines and proposals for waste disposal in the Roaring Fork River basin. This study, due to be completed in the late spring of 1974, is concerned with the feed back and ideas of the local people of the Roaring Fork Valley as well as specific proposals outlined in the report.



EXPLANATION

GEOLOGIC AND ENGINEERING CONSIDERATIONS	MAP UNIT	GEOLOGIC AGE	GEOLOGIC UNIT	DESCRIPTION	THICKNESS AND DISTRIBUTION WITHIN PROJECT AREA
Colluvial deposits can be hazardous. They are commonly unstable, exhibit variable porosity and permeability, may be poorly drained, and are very susceptible to erosion and, in places, hydrocompaction. Commonly, these deposits are not suitable for construction or development projects without remedial engineering work.	Qc	Recent	UNCONSOLIDATED SURFICIAL DEPOSITS — (Qc) COLLUVIAL (gravity prime moving force)	*Colluvial wedge, landslide, mudflow, rock fall, rock glacier, slump, and other colluvial deposits are characterized by unconsolidated, poorly sorted, rock debris which may be angular, and range in size from large blocks to clay particles.*	*Unconsolidated surficial deposits are widespread but relatively thin.*
Younger alluvial deposits are generally stable, but are commonly subject to high-water table or flood hazards. Proper engineering can provide protection against such hazards. These alluvial deposits are also a principal source of sand and gravel which should be developed by sequential use programs. The nature of such a program will be determined in part by the presence or absence of a water table.	Qy		(Qy) YOUNGER ALLUVIAL (water, prime moving force)	*Alluvial fan, lake, stream, swamp, and other younger alluvial deposits are characterized by unconsolidated rock waste which may be moderately sorted by size. This material commonly ranges in size from gravel to clay particles, and generally is better rounded than colluvial debris.*	
Older alluvial deposits are generally not subject to flooding, but they are affected by erosion, and may be hazardous owing to water table or drainage problems. These deposits can also yield construction materials and should be developed under special land use programs. These programs will be affected by the presence of water.	Qo		(Qo) OLDER ALLUVIAL (water & ice, prime moving forces)	*Alluvial fan, glaciofluvial, gravel terrace, glacial moraines (ground, lateral, and terminal), and other types of older alluvial deposits are characterized by unconsolidated rock debris which is generally poorly sorted. These materials commonly range in size from boulders to clay particles and may consist of rounded or angular fragments.*	
Basalt flows have joint and fracture systems which facilitate weathering, erosion and water percolation. These flows are susceptible to mass-wasting where they overlie clay or evaporite rocks. Developments in such areas should be kept away from all escarpments. Blasting will be required to excavate or cut fresh surfaces in basalt.	Qb	Pleistocene	(Qb) LAVA FLOWS	*Dark gray, olivine basalt. Hard, commonly vesicular, exhibiting columnar jointing in places. Commonly fractured, weathered surfaces are brownish.*	*Outcrops are widespread north of Latitude 39° 21' N. Probably more than 10 separate flows with composite thickness up to 1000 feet in northwest.*
Intrusive igneous rocks tend to be dense and hard. Drainages from these areas present some danger of flash floods. These rocks tend to be stable and are associated with rugged terrain. Fracture and joint systems facilitate weathering and, locally, rock falls may be a hazard. Blasting will be necessary for cutting or excavating fresh surfaces. These rocks are a potential source of quarry aggregate and rip-rap.	Ti	Pliocene / Miocene	(Ti) IGNEOUS ROCKS	*Primarily granodiorite and quartz monzonite which tend to be light gray and medium grained. Porphyritic varieties are found commonly near contacts with host rocks.*	*Outcrops consist of relatively small intrusions (i.e., stocks, laccoliths, phacoliths, sills, and dikes) which are found near or along the Elk Mountains. Mt. Sopris is an example of a stock.*
	TKi	Oligocene	(TKi) IGNEOUS ROCKS	*Predominantly quartz diorite and aplite porphyry which are medium gray and light gray respectively. Except for phenocrysts, these rocks tend to be fine grained.*	*Outcrops are found only in the Aspen Mountain area, and these are severely faulted.*
Locally, engineering problems may be encountered because of the clayiness of this formation. These problems could include water seepage along bedding surfaces, and susceptibility of these rocks to erosion. Cuts into natural slopes should be avoided unless the bedding dips away from the proposed cut. There have also been reports of swelling clays and foundation problems associated with the formation.	Tw	Eocene	(Tw) WASATCH FORMATION (or Ruby Formation of Wasatch Group)	*Claystone, shale and mudstone interbedded with siltstone, sandstone, and some conglomerate. Formation is white to variegated. Coarser grained rocks tend to be arkosic and poorly sorted, and these beds are commonly lenticular. Finer grained rocks tend to be soft and susceptible to erosion.*	*Maximum thickness of 600 feet recorded in southwest, and 5000 feet in northwest. Formation is not found east of the Crystal River.*
The sandstone beds of the Ohio Creek Conglomerate are somewhat friable and susceptible to erosion. However, this porous and permeable formation will not have drainage problems, and both natural and cut slopes should be stable. Locally, the formation may be an aquifer.	To	Paleocene	(To) OHIO CREEK CONGLOMERATE	*Pebbly to conglomeratic sandstone with interbedded sequence of sandstone, siltstone, and shale in middle part of formation. Formation is light colored but weathers gray and brown. Sandstones are commonly feldspathic, contain quartz and chert pebbles, and are somewhat friable.*	*Thickness is variable. 200 feet reported in northwest, and 440 feet in southwest. Formation is not found east of the Crystal River.*
Sandstone and siltsone beds of the Mesaverde Formation are generally stable and tend to form resistant ridges. No serious problems are anticipated for this part of the formation. However, shale and coal beds may cause some engineering problems. These rather impermeable types of rocks may cause localized drainage problems and are susceptible to erosion. In addition, both surface runoff and ground water can be polluted by poorly regulated coal mining activities in the formation.	Kmv	Upper Cretaceous	(Kmv) MESAVERDE FORMATION	*Interbedded sandstone, siltstone, shale, and carbonaceous shale. Sandstone is commonly tan and shale greenish gray. Economically significant coal beds are found in the lower third of the formation. Sandstone beds tend to be thick and resistant to erosion forming ridges along the Grand Hogback.*	*Variable thickness—2700 feet reported in southwest, and 5300 feet northwest of Glenwood Springs. With exception of area near Marble, formation is not found east of the Crystal River.*
The Mancos Shale is easily eroded where exposed to weathering. If these conditions prevail, and the shale is overlain and loaded by younger, dense rocks, the shale will give way in the form of land slides and other types of mass wasting. The betonitic clays found in the formation also create hazards because of their swelling properties which can seriously affect foundations. The formation is also subjected to hazards caused by the impermeable nature of the shale beds. These include seasonal high water table, and various types of floods. In addition, water from the formation is notably brackish, "odoriferous", and may be corrosive to concrete and metal (such as culverts).	Kmc		(Kmc) MANCOS SHALE (equivalent formations: Pierre, Niobrara, Benton)	*Predominantly olive gray shale which is very susceptible to erosion. Bentonite present, especially in lower part. Lithologically, the formation can be divided into three parts. Upper 75% consisting of interlaminated shale and argillaceous siltstone with a prominent, yellowish brown, sandy zone near middle. Next 15% comprised of interbedded calcareous shale and argillaceous limestone with limestone beds becoming more abundant at base. Lower 10% consisting of dark gray, carbonaceous shale with quartz sandstone interbeds near top and base of interval.*	*Formation is widespread. Maximum thickness of 4000 feet recorded in southeast, 4400 feet in southwest, 5000 feet in northwest and may be up to 6000 feet in central area. With exception of areas near Basalt and Woody Creek, formation is not found north or east of Roaring Fork River.*
No serious problems are expected from the Dakota-Burro Canyon Formations. Natural and cut slopes should be stable in the well-cemented sandstones, and blasting will be required for excavations. This unit is normally a significant aquifer, but primary porosity and permeability appear to have been altered and reduced in the project area. These hard rocks commonly form escarpments with associated talus slopes. In places these escarpments present rock fall hazards.	Kdb	Lower Cretaceous	(Kdb) DAKOTA SANDSTONE AND BURRO CANYON FORMATION	*Dakota Sandstone. Predominantly hard, light gray, quartzose sandstone, and pebble conglomerate, with shale and siltstone beds more abundant in middle part of formation. Weathered surfaces are commonly rust brown. Resistant sandstone beds commonly form ridges and cliffs.* *Burro Canyon Formation. Predominantly grayish sandstone and siltstone (containing pebbly streaks) with softer interbeds of greenish gray claystone. Claystone beds are poorly exposed.*	*Formations are grouped because coarse talus from Dakota Sandstone commonly obscures contact. Maximum (combined) thicknesses reported: 150 feet in northwest, 215 feet in southwest, 240 feet in southeast, and possibly more than 300 feet thick in central area. With exceptions as noted above, formations are not found north or east of Roaring Fork River.*
The nature of the Morrison Formation is somewhat variable. Sandstone, siltstone, and limestone beds are generally stable and are not expected to cause any serious engineering problems. However, the shale beds tend to be bentonitic and have swelling potential. Locally, the clay beds can contribute to unstable surface conditions, erosional hazards, and perched water table hazards.	Jm	Jurassic	(Jm) MORRISON FORMATION (in places, includes Curtis Formation)	*Interbedded pale green and pale red shale with lenticular interbeds of light greenish gray sandstone and siltstone and dark gray, limestone. Shale beds tend to be bentonitic. Sandstone beds are more common toward base. Limestone is found throughout formation. Formation is relatively susceptible to erosion and, in places, gravity-type movements such as slumping or sliding.*	*Formation is widespread but outcrops are scattered. Distribution is similar to that of the overlying (Dakota Burro Canyon) formations. Maximum thickness in central area approximately 325 feet. Recorded thickness increases to southeast (530 feet) and to northwest (600 feet).*
The Entrada Sandstone is well cemented and resistant to erosion. No serious problems are anticipated from this formation. Porosity and permeability are generally restricted to fractures and joints, and weathering does produce some talus at the base of escarpments. Blasting will be necessary for excavations and cuts.	Je		(Je) ENTRADA SANDSTONE	*Cross laminated, fine to medium grained, quartzose sandstone, yellowish to light olive gray weathering orange or pinkish gray. Coarse grains commonly exhibit high sphericity. Formation generally well cemented with calcium carbonate and clay, and outcrops often form escarpments.*	*Distribution of scattered outcrops is similar to that of overlying Morrison and Dakota Formations. Maximum thicknesses: 40 feet reported in the south (east and west), 100 feet in the northwest, and as much as 150 feet in the central area.*
The silty claystone and siltstone which comprise much of the Chinle Formation are susceptible to erosion. The process appears to be gradual everywhere, and it is believed that the formation will not present major engineering problems. Because of the high content of clay, a seasonal high water table should be anticipated locally.	TRc	Triassic	(TRc) CHINLE FORMATION	*Interbedded and interlaminated siltstone and silty claystone, with some lenticular beds of pebble conglomerate. Formation is dark reddish brown, susceptible to erosion, and weathered surfaces commonly have hackly appearance.*	*Variable thickness: 325 feet reported in northwest, 400 feet in southeast, and up to 1000 feet in the central part of the area. The formation is not found in the southwest.*
The State Bridge Formation is not expected to cause serious engineering problems. Locally, because of clay or carbonate cement, the formation may be impermeable and cause some drainage problems. Generally the formation is hard and will require blasting, but both natural and cut slopes should be stable.	TRPs		(TRPs) STATE BRIDGE FORMATION	*Interbedded siltstone, sandstone, and shale, with some lenticular beds of sandy limestone and pebble conglomerate. Formation is reddish brown and mottled grayish or purplish, in places.*	*Thickness is variable. Maximum of 250 feet recorded in northwest. 1000 feet in southeast, and 2700 feet in central part of area. Formation is not found in southwest.*
The "tongue" of Weber Sandstone is found only in the westernmost part of the project area where it is of rather uniform thickness. No serious problems are anticipated for this sandstone. Cuts and excavations will require explosives.	Pw	Permian	(Pw) SCHOOLHOUSE TONGUE OF WEBER SANDSTONE	*Sandstone with some interbeds of shale and conglomerate. Sandstone is quartzose, gray, and is impregnated with black, solid hydrocarbons. In places, surface weathers to yellowish gray.*	*With exception of area near Marble, formation is not found east of Crystal River. Maximum thickness of 12 feet recorded in southwest and more than 200 feet in northwest.*
Regardless of the wide variety of rock types (claystone to conglomerate) within the Maroon Formation, these beds are generally very hard and stable. Both matrix clay and cement reduce permeability in these rocks creating conditions which cause local water table problems. Frost heave, active in the fractures of these hard rocks, has produced large, isolated, rockfall blocks in many of the valleys.	Pℙm		(Pℙm) MAROON FORMATION	*Reddish, arkosic sandstone with interbeds of siltstone, claystone, and some conglomerate and limestone. Rocks are generally calcareous and moderately resistant to erosion. Current depositional structures are common. This formation comprises the scenic red cliffs near Redstone.*	*Formation is widespread. Exposed thickness is variable: maximum of 2500 feet reported in southwest, 3000 feet in northwest, up to 5000 feet in west, and from 5000 to 12000 feet in southeast.*
The Eagle Valley Evaporite can present very serious engineering problems. The formation is not suitable for construction or development without remedial engineering work. The formation has chaotic internal structure plus susceptibility to erosion and solution, resulting in unstable slopes. The solution potential of the evaporitic material is suspect for contributing to ground surface, collapse-like features. The minerals of this formation can contribute to pollution of surface and ground water. In addition, colluvial deposits derived from this formation present serious problems and hazards to unwary developers.	ℙev	Pennsylvanian	(ℙev) EAGLE VALLEY EVAPORITE (or Paradox Formation)	*Predominantly interbedded gypsum and dark gray shale with admixtures of silt and salt. Formation characterized by chaotic internal structure, barren, yellowish gray weathered surfaces and strong susceptibility to erosion and solution.*	*Outcrops are scattered but most common in principal drainages (Roaring Fork and Crystal Rivers, Cattle and Thompson Creeks). Thickness is variable: reported to be more than 3000 feet at Cattle Creek.*
The calcareous sedimentary rocks (limestone and dolomite) which comprise the Minturn and Gothic Formations are generally dense and hard. These beds are considered to be relatively stable, and no serious problems are anticipated for these formations. There is a possibility of localized rock falls from escarpments.	ℙm / ℙg		(ℙm) MINTURN FORMATION AND (ℙg) GOTHIC FORMATION	*Grayish, lenticular sandstone and siltstone, with interbeds of shale and limestone. Rocks are commonly calcareous and weather orangish or greenish gray.*	*Outcrops are found in the southeastern part of project area. Maximum thickness recorded, 2800 feet.*
No serious problems are anticipated for the Belden Formation. These calcareous rocks are hard and stable. Cuts and excavations will require the use of explosives.	ℙb		(ℙb) BELDEN FORMATION	*Predominantly limestone and shale with some lenticular beds of sandstone and conglomerate. Rocks are commonly dark gray, calcareous, hard, and may be metamorphosed, locally.*	*Outcrops are seen in the southeastern part of the area. A maximum thickness of 800 feet is reported.*
Rocks of Mississippian Age and older are found only in the rugged terrain in the southeastern part of the project area. Without exception these rocks are dense, hard, and resistant to erosion. Primary hazards associated with these rocks consist of gravity (colluvial) deposits which have been or are being derived from the rocks. As with most dense, resistant, and jointed or fractured formations, rock fall hazards are present near cliffs or steep slopes. In addition, there are hazards related to drainage in this area. Avalanches and flash floods can follow the drainage courses. Any slope cutting will be costly because of the need to use explosives.	Ml	Mississippian	(Ml) LEADVILLE LIMESTONE	*Sequence of thick-bedded limestone overlying interbedded sequence of dolomite, limestone and some sandstone. Rocks are grayish, hard, exhibit some solution features, and may be metamorphosed. Quarries at Marble were extracting stone from strongly metamorphosed limestone.*	*Formation is exposed in southeastern part. Maximum thickness of 200 feet recorded.*
	Dc	Devonian	(Dc) CHAFFEE FORMATION	*Dyer Dolomite Member: gray, bedded dolomite with shale partings and some interbeds of gray limestone. Locally, may be metamorphosed.* *Parting Member: interbedded, tan, quartzose sandstone, gray shale and siltstone, and some grayish dolomite. Locally, may be metamorphosed.*	*Formation crops out in southeastern part of area. A maximum thickness of 200 feet is reported.*
	Om	Ordovician	(Om) MANITOU DOLOMITE	*Grayish dolomite having irregular bedding surfaces, and containing nodules and lenses of white chert. Locally, may be metamorphosed.*	*Rocks are found in southeastern part of project area. Maximum thickness reported, 250 feet.*
	Єp	Cambrian	(Єp) PEERLESS FORMATION	*Interbedded, dolomitic, grayish orange, sandstone and yellowish gray shale. May be metamorphosed, in part.*	*Exposures are restricted, as above. Maximum thickness 150 feet.*
	Єs		(Єs) SAWATCH QUARTZITE	*Predominantly white quartzite with some interbeds of brownish, dolomitic sandstone, and a quartz-pebble conglomerate at the base.*	*Distribution, as above. Maximum thickness 250 feet.*
	pЄ	Precambrian	(pЄ) PRECAMBRIAN COMPLEX (Igneous & Metamorphic)	*Primarily quartz monzonite. Includes some granite and granodiorite and, locally, schist and gneiss.*	*Precambrian outcrops are found only in the southeastern part of the project area, near Aspen.*

GEOLOGIC MAP

ROARING FORK and CRYSTAL VALLEYS
Eagle, Garfield, Gunnison and Pitkin Counties, Colorado

An Environmental and Engineering Geology Study

Prepared For
Colorado Geological Survey
and
Colorado Division Of Planning

Prepared By
F. M. Fox and Associates Inc.
Geology Division
Olander, Lamm and Florquist

Base Map Compiled From
USGS 7 1/2' Quadrangle Maps

Drafting By
leRoi Enterprises

This document was financed, in part, through an urban planning grant from the Department of Housing and Urban Development under the provision of Section 701 of the Housing Act of 1954, as amended.

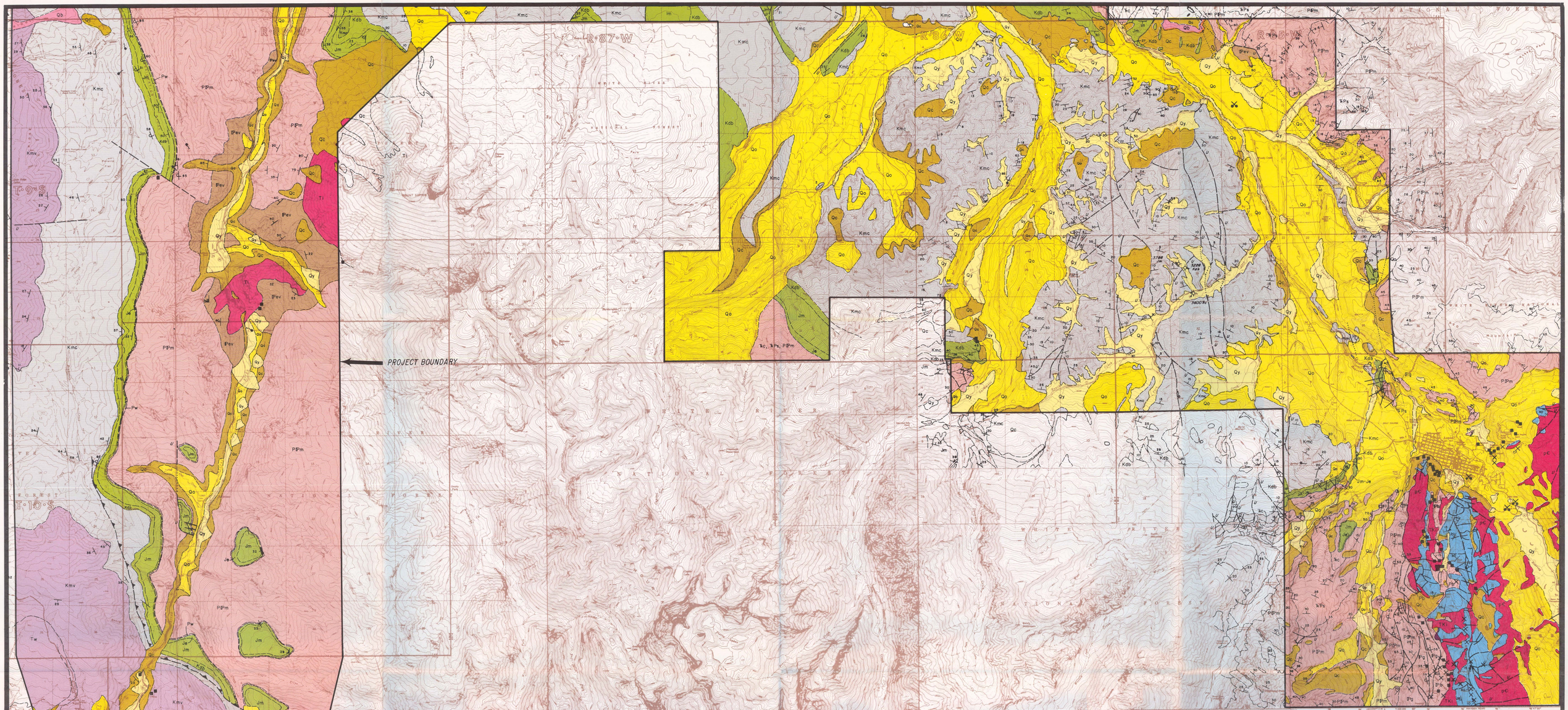
SCALE 1:48000 (1" = 4000')

SCALE IN THOUSANDS OF FEET

SCALE IN MILES

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

North Part of Plate I



SCALE 1" = 4800 (1" = 400')

SCALE IN THOUSANDS OF FEET

SCALE IN MILES

CONTOUR INTERVAL 40 FEET

DATUM IS MEAN SEA LEVEL

PRINCIPAL SOURCES OF GEOLOGIC DATA USED IN COMPILING MAP

See text for specific information

1 Boss, N.W. & Northrop, S.A., 1963, Geology of Glenwood Springs quadrangle and vicinity, Northwest Colorado: U.S.G.S. Bulletin 1142-J.
2 Bryant, Bruce, 1971, Aspen, Colo., U.S.G.S. Map G.Q.933.
3 Bryant, Bruce, 1972, Highland Peak, Colo., U.S.G.S. Map G.Q.932.
4 Donnell, John R., 1962, Geology and Coal Resources of the Carbondale Area: U.S.G.S. Open File Report.
5 Freeman, V.L., 1972, Woody Creek, Colo., U.S.G.S. Map G.Q.967.
6 Freeman, V.L., 1972, Ruedi, Colo., U.S.G.S. Map G.Q.1004.
7 Gaskill, D.L. & Godwin, L.H., 1966, Marble, Colo., U.S.G.S. Map G.Q.512.
8 Gilmore, J.B., & Barrett, Robert, 1971, Glenwood Canyon,-Cottonwood Pass, Preliminary Geologic Study: Colorado Division of Highways.
9 Godwin, L.H., 1968, Chair Mountain, Colo., U.S.G.S. Map G.Q. 704.
10 Hodgden, H. Jerry, 1960, The Geology Around the Junction of the Roaring Fork and Frying Pan Rivers: M.S. Thesis, University of Kansas.
11 Pilkington, H.D., 1954, Petrology and Petrography of a Part of Mount Sopris Stock, Pitkin County, Colorado: M.S. Thesis, University of Colorado.
12 Poole, Forrest G., 1954, Geology of the Southern Grand Hogback: M.S. Thesis, University of Colorado.
13 Welder, George E., 1954, Geology of the Basalt Area, Colorado: M.S. Thesis, University of Colorado.

Note: Sources 1 thru 13 have a scale of 1:250,000 or greater. Sources listed below have a scale of 1:250,000 or less (not shown on map, but generally cover entire study area.)

Mallory, William W., 1971, The Eagle Valley Evaporite, Northwest Colorado: U.S.G.S. Bulletin 1311-E.
Rocky Mountain Assoc. of Geologists, 1962, Exploration for Oil and Gas in Northwestern Colorado.

LINE SYMBOLS

Dashed where approximately located; dotted where concealed

Contact

Fault
U, upthrown side

Thrust Fault
Sawteeth on upper plate

PLANAR FEATURES

20 Inclined — Vertical — 40 Overturned

Strike and Dip of Beds

OTHER SYMBOLS

Gravel Pit

Quarry

Mine Shaft or Tunnel Entrance

Prospect Pit

Spring Location

5070Pv Dry Hole
Showing total depth in feet and formation at bottom of hole

GEOLOGIC MAP

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South Part of Plate I

EXPLANATION

Symbols	Description	Geologic and Engineering Considerations
I. Surficial Deposits		
Colluvium (Qc)		
Qcw colluvial wedge Qcl landslide Qcm mudflow Qcr rock fall Qcg rock glacier Qcs slump Qct talus Qco other	*Colluvial wedge, landslide, mudflow, rock fall, rock glacier, slump, talus and other colluvial deposits are characterized by unconsolidated, poorly sorted, rock debris which may be angular and range in size from large blocks to clay particles.*	*Colluvial deposits can be hazardous. They are commonly unstable, exhibit variable porosity and permeability, may be poorly drained, and are very susceptible to erosion, and in places to hydrocompaction. Commonly, these deposits are not suitable for construction, and development projects may require extensive remedial engineering work.*
Younger Alluvium (Qy)		
Qyf alluvial fan Qyl lake alluvium Qys stream alluvium Qyo other alluvium	*Active alluvial fan, lake, stream and other younger alluvial deposits are characterized by unconsolidated rock fragments which may be moderately to well sorted by size. This material commonly ranges in size from gravel to clay particles, and generally is better rounded than colluvial debris. Many alluvial fans contain mudflow as well as water-borne stream deposits.*	*Younger alluvial deposits are generally stable, but are commonly subject to high-water table or flood hazards. Proper engineering can provide protection against such hazards. These alluvial deposits are also a principal source of sand and gravel which should be developed by sequential use programs. The nature of such a program will be determined in part by the presence or absence of a water table.*
Older Alluvium (Qo)		
Qof alluvial fan Qog glaciofluvial Qom glacial moraines Qot gravel terrace Qop pediment	*Older alluvial fan, glaciofluvial, gravel terrace, glacial (ground, lateral, and terminal moraines), and pediment deposits are characterized by unconsolidated rock debris which is generally poorly sorted. These materials commonly range in size from boulders to clay particles and may consist of either rounded or angular fragments.*	*Older alluvial deposits are generally not subject to flooding, but they are affected by erosion, and may be locally hazardous owing to water table or drainage problems and pollution of shallow aquifers. These deposits can also yield construction materials and should be developed under special land use programs. Reclamation planning will be affected by the presence of a water table. Steep terrace edges are subject to slumping and erosion but well chosen sites on older terraces are among the better areas for development within the area studied.*
II. Specific Rock Formations		
Mancos Shale Kmc	*Predominantly olive-gray shale which weathers rapidly and is very susceptible to erosion. Watersheds in Mancos terrain may produce severe mudflows. Bentonite present, especially in lower part. Lithologically, the formation can be divided into three parts. Upper 75% consisting of interlaminated shale and argillaceous siltstone with a prominent, yellowish brown, sandy zone near middle. Next 15% comprised of interbedded calcareous shale and argillaceous limestone with limestone beds becoming more abundant at base. Lower 10% consisting of dark gray, carbonaceous shale with quartz sandstone interbeds near top and base of interval.*	*The Mancos Shale is easily eroded where exposed to weathering. When the shale is overlain and loaded by younger, dense rocks or becomes water saturated it will be subject to land sliding and other types of severe mass-wasting. The bentonitic clays found in the formation also create hazards because of their swelling properties which can seriously affect foundations; special engineering designs will be required for this problem. The formation is also subject to hazards caused by the impermeable nature of the shale beds. These include seasonal high water table and various types of floods including mudflows. In addition, water from the formation is notably brackish, "odoriferous", and may be corrosive to concrete and metal (such as culverts).*
Eagle Valley Evaporite PPev	*Predominantly interbedded gypsum and dark gray shale with admixtures of silt and halite (salt). Formation characterized by chaotic internal structure, barren, yellowish gray weathered surfaces and strong susceptibility to erosion and solution.*	*The Eagle Valley Evaporite presents very serious engineering problems. The formation is not suitable for construction or development except with extensive remedial engineering work. The formation has chaotic internal structure plus susceptibility to erosion and solution, resulting in unstable slopes. Solution of the evaporitic material produces ground surface collapse features (sinkholes). The minerals of this formation can contribute to chemical degradation of surface and ground water. In addition, colluvial deposits derived from this formation can present serious problems and hazards.*
III. Clay Beds Within a Formation		
Wasatch Formation (Tw) Tw Wasatch Formation To Ohio Creek Conglomerate Kmv Mesaverde Formation	*Claystone, shale and mudstone interbedded with siltstone, sandstone, and some conglomerate. Formation is white to variegated. Coarser grained rocks tend to be arkosic and poorly sorted, and these beds are commonly lenticular. Finer grained rocks tend to be soft and susceptible to erosion.*	*Locally, engineering problems may be encountered within clay-rich units of this formation. These problems could include water seepage and sliding along bedding surfaces, and susceptibility of these rocks to erosion. Cuts into natural slopes should be avoided unless the bedding dips away from the proposed cut. There have also been reports of swelling clays and foundation problems associated with the formation and with colluvial soils derived from it.*
Kdb Jm Je	*Interbedded pale green and pale red shale with lenticular interbeds of light greenish gray sandstone and siltstone and dark gray limestone. Shale beds tend to be bentonitic. Sandstone beds are more common toward base. Limestone is found throughout formation. Formation is relatively susceptible to erosion and, in places, gravity-type movements such as slumping or sliding.*	*The character of the Morrison Formation is somewhat variable. Sandstone, siltstone, and limestone beds are generally stable and are not expected to cause any serious engineering problems. However, the shale beds tend to be bentonitic and have swelling potential. Locally, the clay beds can contribute to unstable surface conditions, erosional hazards, and perched water table hazards. Association of steep slopes, and water saturation produces extreme instability in claystone units.*
IV. Other		
Geologic Flood Plain	*Includes land adjacent to major streams that would probably be affected by a major flood or flash flood. Younger stream alluvium underlies this area with the exception of alluvial fans, outlined on the map. Fans, both isolated and adjacent to flood plains, are subject to flash flooding. The remaining area indicates low lying land normally subject to flooding and areas where occasional flooding is expectable. The area outlined indicates the approximate extent of a very large flood and smaller floods will affect only portions of the area.*	*Low lying land adjacent to the river will be subject to floods. Higher areas can be affected by a build up in water, which can occur in the following ways: 1) a natural constriction such as a narrow canyon can create a "bottle-neck" effect; 2) debris carried by flood waters can build at bridges, damming up water behind; and 3) the junction of two flooding rivers can result in an unusual build up of flood water. Extensive areas not directly affected by surface water may experience a shallow water table during heavy runoff. Construction in these areas should be strictly controlled and in compliance with local, state, and federal guidelines. Detailed hydrologic studies should be performed as necessary in cases of specific land use proposals in possible flood areas. Alluvial fans are outlined to indicate an area of potential flash flooding. Construction should be limited in these areas as high velocity flooding and movement of large amounts of debris is not uncommon.*
Areas of Potential Avalanches and/or Areas of Rock Falls	*Areas with a slope of approximately 45% or steeper where avalanches could possibly occur under optimum conditions. Some very steep cliff faces are included although snow accumulation here is probably insufficient to create a hazard.*	*In addition to steepness of slope, the ground cover, amount of snowfall, temperature changes, wind conditions, and degree of winter snowmelt will affect avalanche potential. Higher mountainous areas experience more avalanches than do areas of lower elevation with less snow accumulation. Avalanches generally occur on slopes of 60% to 100%, on the leeward side of a mountain, in steep gullies or treeless slopes, and along the paths of previous avalanches. Such potential avalanche areas are a hazard to construction and recreation and should be avoided. Not all areas on the map indicate a hazard area; however, they do indicate areas where the slope is great enough for avalanches to occur.*
	Areas of rock falls are most likely to occur within the same general areas designated as avalanche areas due to the steepness of slope and vigorous mechanical weathering. Major rock fall areas are along the steep canyons in the Crystal River, in areas where highly fractured rock is found on steep slopes, and on the slopes beneath outcrops of Dakota Sandstone, basalt, or intrusive rocks.	*Rock falls can vary from the movement of small boulders in a talus slope to the dislocation of large blocks of rock from weathering. Conditions such as steep slopes in combination with highly fractured rock or resistant rock underlain by a more erodible rock can result in rock falls. Construction beneath rock fall areas should be limited and any roads built in such areas would require constant maintenance. Steep cuts into a highly broken rock could also result in a rock fall potential and should be avoided in construction.*

PROJECT BOUNDARY

R·88·W R·87·W R·86·W T·7·S T·8·S

This document was financed, in part, through an urban planning grant from the Department of Housing and Urban Development under the provision of Section 701 of the Housing Act of 1954, as amended.

SCALE 1:48000 (1" = 4000')

SCALE IN THOUSANDS OF FEET

SCALE IN MILES

CONTOUR INTERVAL 40 FEET

DATUM IS MEAN SEA LEVEL

ENVIRONMENTAL AND GEOLOGIC CONSTRAINTS MAP

ROARING FORK and CRYSTAL VALLEYS

Eagle, Garfield, Gunnison and Pitkin Counties, Colorado

An Environmental and Engineering Geology Study

Prepared For
Colorado Geological Survey
and
Colorado Division Of Planning

Prepared By
F. M. Fox and Associates Inc.
Geology Division
Olander, Lamm and Florquist

Base Map Compiled From
USGS 7½' Quadrangle Maps

Drafting By
leRoi Enterprises

North Part of Plate II

PROJECT BOUNDARY

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1 Bass, N.W., & Northrop, S.A., 1963, Geology of Glenwood Springs quadrangle and vicinity, Northwest Colorado: U.S.G.S. Bulletin 1142-J.
2 Bryant, Bruce, 1971, Aspen, Colo., U.S.G.S. Map G-Q 933.
3 Bryant, Bruce, 1972, Highland Peak, Colo., U.S.G.S. Map G-Q 932.
4 Donnell, John R., 1962, Geology and Coal Resources of the Carbondale Area: U.S.G.S. Open File Report.
5 Freeman, V.L., 1972, Woody Creek, Colo., U.S.G.S. Map G-Q 967.
6 Freeman, V.L., 1972, Ruedi, Colo., U.S.G.S. Map G-Q 1004.
7 Gaskill, D.L., & Godwin, L.H., 1966, Marble, Colo., U.S.G.S. Map G-Q 512.
8 Gilmore, J.B., & Barrett, Robert, 1971, Glenwood Canyon,--Cottonwood Pass, Preliminary Geologic Study: Colorado Division of Highways.
9 Godwin, L.H., 1968, Chair Mountain, Colo., U.S.G.S. Map G-Q 704.
10 Hodgden, H. Jerry, 1960, The Geology Around the Junction of the Roaring Fork and Frying Pan Rivers: M.S. Thesis, University of Kansas.
11 Pitkington, H.D., 1954, Petrology and Petrography of a Part of Mount Sopris Stock, Pitkin County, Colorado: M.S. Thesis, University of Colorado.
12 Poole, Forrest G., 1954, Geology of the Southern Grand Hogback: M.S. Thesis, University of Colorado.
13 Welder, George E., 1954, Geology of the Basalt Area, Colorado: M.S. Thesis, University of Colorado.

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Rocky Mountain Assoc. of Geologists, 1962, Exploration for Oil and Gas in Northwestern Colorado.

LINE SYMBOLS

Dashed where approximately located; dotted where concealed

Contact

Fault
U, upthrown side

Thrust Fault
Sawteeth on upper plate

PLANAR FEATURES

Inclined 20 · Vertical · Overturned 60

Strike and Dip of Beds

OTHER SYMBOLS

Gravel Pit

Quarry

Mine Shaft or Tunnel Entrance

Prospect Pit

Spring Location

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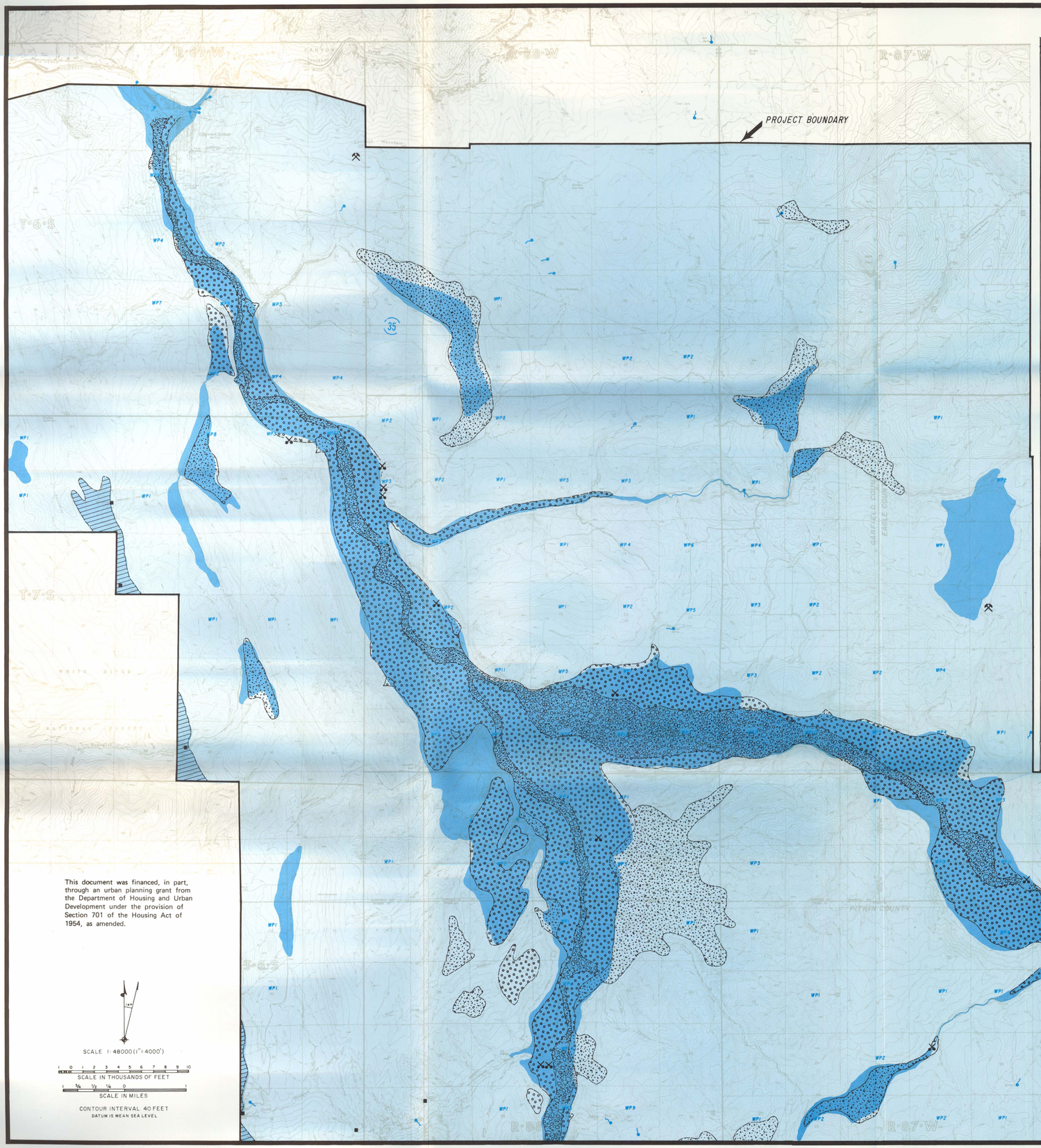
South Part of Plate II



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CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

EXPLANATION

Ground Water

ALLUVIUM (unconsolidated deposits): mainly stream alluvium, terraces, and some glacial material. Gravel, sand, silt, and clay, the main constituents of alluvium, vary in amounts depending on depositional history. This variation, recharge, total use, and seasonal fluctuations result in a wide range of well yields within a given area. Most wells in the study area are in this category and depths range from a few feet to over two hundred feet. Expected yields range from 0 to 500 gallons per minute (gpm).

Note: The boundary for this category does not indicate all alluvium but that which may contain developable water. The boundaries are from a comparison of well logs and data, drainage patterns, and aerial photo study. The boundaries are arbitrary and subject to seasonal and yearly fluctuations.

The outlined area within this designation generally lies within major stream valleys, but contain some small isolated deposits of alluvium. However, the western half of T8S, R87W and the eastern third of T8S, R88W exhibit a large mass of glacial outwash. Thirteen wells (T8S, R88W, Sec. 35 and T8S, R87W, Sec. 7, 18) have been drilled for water with good results, indicating that this area does contain usable ground water. There is insufficient information about this area to make predictions of well depths, yields or water levels.

INTERSTITIAL POROSITY (Mesaverde and younger sedimentary formations): Ground water is transmitted through interconnected pore spaces between grains within the sedimentary bedrock. Expected well yields vary from 0 to 50 gpm and average 10 gpm. There are no water wells located within this category in the study area.

FRACTURE POROSITY (remaining bedrock): Igneous intrusive; volcanic, metamorphic, and sedimentary rocks (Mancos Shale and older) in which ground water is transmitted through fractures in the bedrock. These rocks vary widely in origin, composition, and appearance and are incapable of transmitting ground water other than by fractures in the rock itself. All recorded wells in the study area that are not alluvial wells are fracture porosity wells. These wells produce from 0 to 100 gpm but average less than 5 gpm; depths range to over 400 feet. Water is commonly encountered below 150 feet.

SPRING LOCATIONS: Perennial and ephemeral springs and seeps.

WP2 **NUMBER OF WELL PERMITS PER SECTION:** In accordance with the records of the State Engineers Office. Permit numbers, yield, depth, and depth to ground water can be found in Appendix B by township, range, and section.

Potential Sand and Gravel Resources

POTENTIAL SAND AND GRAVEL SOURCE AREAS: GROUND WATER WITHIN 20 FEET OF GROUND SURFACE: This unit is mainly stream alluvium but includes some lower terraces. The water table is within 20 feet and subject to seasonal fluctuations. Gravels within this designated area can be easily washed for removal of fines. The remaining sand and gravel can be used for drains, concrete and asphalt mixes and other uses requiring specifically graded materials. One gravel pit is located in this designation. Because of expected water table conditions, these areas have limited sequential use possibilities.

POTENTIAL SAND AND GRAVEL SOURCE AREAS: GROUND WATER AT 20 FEET OR MORE: This unit is mainly higher terrace deposits with some stream alluvium. Unwashed gravels at these sites can be used for fill purposes. Fifteen gravel pits are located within this designation. This area is the most economical source of aggregate unless washing is required to meet particular specifications. In addition, this area is generally amendable to reclamation and sequential land use.

LIMITED LOCAL AGGREGATE AND/OR SAND AND GRAVEL SOURCES OF QUESTIONABLE ECONOMIC VALUE: Limited amount of sand, gravel and aggregates may be developed for local needs only. Generally, this area contains no economically developable sources. Four gravel pits have been used in this designated area.

NOTE: The above described units of potential sand and gravel sources do not outline actual deposits but designate areas of deposits within which economic amounts of sand and gravel may be found. The three units are classified according to the nature of the deposits and their relationship to the water table. To locate and evaluate each sand and gravel deposit of economic value is beyond the scope of this report; accordingly, the various areas shown indicate the most probable locations for deposits of sand and gravel, and briefly describe characteristics which will affect their development and use.

Location of Mines, Quarries, and Gravel Pits

Gravel Pits: locations of known producing and inactive gravel pits active as of 1972 are:

Name	Location	Product	Property
Benedict Pit	Aspen	Sand	Pit
Hemann-Woody Creek	Woody Creek	Sand & gravel	Pit and plant
Jaffe Pit	Woody Creek	Sand & gravel	Pit
Homeward Bound, Inc.	Basalt	Sand & gravel	Pit and plant
Zemlock & Son	Glenwood Springs	Sand & gravel	Pit and plant

QUARRIES: Location of inactive operations; there are no active quarring operations within the study area as of 1972. In several cases, rock was temporarily quarried to obtain material for nearby projects.

MINE SHAFT OR TUNNEL ENTRANCE: Locations of mine shafts or tunnels, most being inactive. The only operating mine within the study area as of 1972 is the Down Under Mine in Woody Creek producing silver and lead.

PROSPECT PIT: found mainly in the Aspen area.

Other Resources

COAL BEARING ROCKS: Easterly boundary line indicates the contact of the Mesaverde and the underlying Mancos Shale.

OTHER RESOURCES LOCATED BY COUNTY WITHIN STUDY AREA ARE:

Garfield County
1) clay suitable for brick and tile near the Old Wheeler Station on the Roaring Fork
2) coal: Grand Hogback in Mesaverde formation. Carbondale field—high volatile C bituminous to anthracite
3) lime: limestone near Glenwood Springs
4) sandstone: quarry near Glenwood Springs
5) brick clay: near Glenwood Springs

Eagle County
1) perlite: on the southern and eastern flanks of Basalt Mountain, north of Basalt
2) volcanic cinders (pumice) located near Carbondale

Pitkin County
1) coal: Thompson Creek Numbers 1, 2, and 3 by Thompson Creek Coal and Coke Corporation, coal along the Grand Hogback
2) precious and base metals: gold, silver, lead, zinc; from Frying Pan, Roaring Fork, and Snowmass areas
3) uranium: mined in the Aspen area
4) stone: gray marble near Aspen
   granite quarry ten mines south of Aspen
   gypsum
   sandstone
5) high refractory clays

Gunnison County
1) Yule Colorado marble (out of area)
2) coal—Carbondale Field

Mineral Production

Pitkin County is the only county that has base and precious metal mining districts within the limits of this study. The districts, as listed in the 1947 edition of **Mineral Resources of Colorado** are: Ashcroft, Avalanche, Frying Pan (Homestake), Independence, Lincoln Gulch, Roaring Fork (Aspen, Richmond Hill, Lenado) and Snowmass. Ashcroft, Frying Pan, Independence, and Lincoln Gulch are out of the study area. Production in the Avalanche, Frying Pan, Ashcroft and Snowmass districts is either very small or not reported. The Roaring Fork district is the most productive and includes the area around Aspen, Richmond Hill, (four miles to the south of Aspen), and Lenado, (six miles to the north of Aspen on Woody Creek).

The Aspen district has produced silver, lead, and zinc and only minor amounts of pyrite and gold. Total production of the Roaring Fork district as of 1947, has been $105,000,000, most of this coming from the Aspen area where the major production is from the contact of the Leadville Dolomite and the overlying Weber Shale and Leadville Limestone. In the Richmond Hill area, silver-lead ore is found in the Weber Shale.

The following charts show mine production of Pitkin County for the years 1880 through 1958 and the production of gold, silver, copper, lead and zinc in the Roaring Fork District for the years 1932 through 1945. As of 1972 there was only one operating silver and lead mine (Down Under Mine at Woody Creek) in Pitkin County.

References

Colorado Division of Mines, 1973, A Summary of Mineral Industry Activities in Colorado, 1972.
State of Colorado, Mineral Resources Board, 1947, Mineral Resources of Colorado, prepared under the supervision of John W. Vanderwilt.
——, 1960, Mineral Resources of Colorado, First Sequel, prepared under the supervision of S. M. Del Rio.
United States Department of the Interior Bureau of Mines, 1967, Minerals Yearbook, 1965, Area Reports: Domestic.

Mine Production in Pitkin County and the Roaring Fork District

Pitkin County

Mine Production of Gold, Silver, Copper, Lead, and Zinc in Terms of Recovered Metals

Year	Ore Sold or Treated (short tons)	Mines Producing Yearly: Lode	Mines Producing Yearly: Placer	Gold (fine ounces): Total	Silver (fine ounces): Total	Copper (pounds)	Lead (pounds)	Zinc (pounds)	Total Value
1880-08				27,829	89,556,879	844,345	565,555,316	13,176,766	$85,366,416
1909-23	1,545,969			131	8,051,343	284,118	168,310,361	3,665,236	15,591,291
1924-31	146,930	7	10	95	1,075,493	1,000	14,329,963	2,285,000	1,846,305
1932-41	28,228	2	6	127	1,680,041	7,300	5,235,300	1,545,000	1,468,225
1942-45	67,731	4	5	8	793,111	4,800	2,116,800	1,245,000	858,353

Reference: *Mineral Resources of Colorado*, State of Colorado Mineral Resources Board, 1947

Pitkin County

Production of Gold, Silver, Lead, Zinc, and Coal

Year	Lode Mines	Gold Ozs.	Silver Ounces	Lead Pounds	Zinc Pounds	Coal Short Tons	Total $-Value
1946	2	1	41,630	215,000	18,000	——	59,303[1]
1947	2	4	27,757	220,000	23,000	563	59,940[1]
1948	5	9	35,618	218,000	60,000	890	79,553[1]
1949	3	——	32,692	164,000	98,000	4,327	67,652[1]
1950	4	14	30,869	134,000	42,000	6,798	52,482[1]
1951	5	17	10,142	114,000	58,000	7,730	75,610[1]
1952	4	8	1,043	38,000	——	7,328	42,516[2]
1953	3	1	4,392	18,000	4,000	35,928	181,797[2]
1954	2	1	110	4,000	——	88,606	Withheld
1955	1	——	128	2,000	——	91,909	703,517[2]
1956	1	——	497	71,900	——	153,979	1,141,846[2]
1957	1	——	48	200	——	Withheld	Withheld
1958	——	——	——	——	——	Withheld	Withheld

[1] Precious and base metal production value only.
[2] Value of precious and base metals and coal production.

Reference: *Mineral Resources of Colorado First Sequel*, State of Colorado Mineral Resources Board, 1960.

Pitkin County

Roaring Fork (Aspen, Richmond Hill, Lenado) District

Mine Production of Gold, Silver, Copper, Lead, and Zinc in Terms of Recovered Metals

Year	Mines Producing: Lode	Mines Producing: Placer	Ore Sold or Treated (short tons)	Gold (fine ounces): Lode	Gold (fine ounces): Placer	Silver (fine ounces): Total	Silver (fine ounces): Lode	Copper (pounds)	Lead (pounds)	Zinc (pounds)	Total Value
1932	1	1	4,100		2	2	45,901	45,901	228,000		$ 19,833
1933	2	1	3,677	1	7	8	69,840	68,880	178,000		30,849
1934	5		9,784				121,094	121,094	411,000	233,000	103,581
1935	3		15,880				174,208	174,208	543,300	250,000	157,944
1936	2		26,692				198,311	198,311	666,000	200,000	194,228
1937	5		35,431				165,404	165,404	832,000	150,000	167,198
1938	4		27,934				190,500	190,000	500	150,000	151,188
1939	4		34,330				210,138	210,138	1,200	530,200	176,835
1940	4		37,483				266,614	266,614	2,000	585,000	228,652
1941	5		24,088				238,773	238,773	2,000	807,000	235,079
1942	5		16,842	1		1	286,131	286,131	1,000	629,800	284,000	272,235
1943	4		17,746	2		2	302,386	302,386	2,800	686,000	408,000	310,952
1944	5		14,625	5		5	126,232	126,232	1,200	465,000	352,000	187,430
1945	5		18,518				78,362	78,362		336,000	201,000	107,735

Reference: *Mineral Resources of Colorado*, State of Colorado Mineral Resources Board, 1947

GROUND WATER AND GEOLOGIC RESOURCES MAP

ROARING FORK and CRYSTAL VALLEYS
Eagle, Garfield, Gunnison and Pitkin Counties, Colorado

An Environmental and Engineering Geology Study

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Base Map Compiled From
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Drafting By
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North Part of Plate III

PROJECT BOUNDARY

R·87·W

R·86·W

T·10·S

T·11·S

PITKIN COUNTY

GUNNISON COUNTY

WHITE RIVER NATIONAL FOREST

PRINCIPAL SOURCES OF GEOLOGIC DATA USED IN COMPILING MAP

See text for specific information

1 Bass, N.W.,& Northrop, S.A., 1963, Geology of Glenwood Springs quadrangle and vicinity, Northwest Colorado: U.S.G.S. Bulletin 1142-J.
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5 Freeman, V.L., 1972, Woody Creek, Colo., U.S.G.S. Map G.Q. 967.
6 Freeman, V.L., 1972, Ruedi, Colo., U.S.G.S. Map G.Q. 1004.
7 Gaskill, D.L.,& Godwin, L.H., 1966, Marble, Colo., U.S.G.S. Map G.Q. 512.
8 Gilmore, J.B.,& Barrett, Robert, 1971, Glenwood Canyon,-Cottonwood Pass, Preliminary Geologic Study: Colorado Division of Highways.
9 Godwin, L.H., 1968, Chair Mountain, Colo., U.S.G.S. Map G.Q. 704.
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