OPEN FILE REPORT 81-1

PRELIMINARY REPORT ON POTENTIAL SITES SUITABLE FOR RELOCATION AND/OR REPROCESSING OF THE DURANGO URANIUM MILL TAILINGS PILE

by

Colorado Geological Survey
with assistance from
Robert M. Kirkham and the
Four Corners Environmental Research Institute

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO
March, 1981

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1. INTRODUCTION

1.1. Purpose of Site Selection Report

Uranium ore was processed at a number of mills in Colorado during the 1940s, 1950s, and 1960s. Tailings from this milling was often dumped in unsuitable environments and now pose potential health hazards to the general public. Such hazards will persist into the future and possibly worsen because of increasing urban pressures and dispersion of the tailings materials by geologic, hydrologic, and meteorologic forces. The uranium mill tailings at Durango pose such a hazard.

In 1980 the Colorado Department of Natural Resources entered into an agreement with the Colorado Department of Health to cooperate in the evaluation of alternate site areas for the disposal of the Durango uranium tailings. This evaluation is a part of a larger project conducted by the U.S. Department of Energy (DOE) and entitled Uranium Mill Tailings Remedial Action Program (UMTRAP). This program, in response to the Uranium Mill Tailings Control Act of 1978, provides for the stabilization, disposal, and control in a safe and environmentally sound manner of inactive uranium tailings throughout the country. To aid in the accomplishment of this program, the Department of Energy requested that the State of Colorado identify candidate sites for the removal and permanent disposal of the Durango tailings. As a part of this indentification process, the Colorado Geological Survey in conjunction with Mr. Robert M. Kirkham and the Four Corners Environmental Research Institute has prepared this report.

The Preliminary Site Selection Report describes the State of Colorado's site selection process and presents background data and information regarding potential disposal sites within thirty miles of Durango. This data and information includes a description of the engineering and environmental factors that should be considered as a part of the site selection process. Additionally, the report describes geotechnical characteristics of each site and ranks the sites according to a grading matrix. The sites discussed in detail in this report appear to be geotechnically feasible, however, additional detailed studies are essential to verify this initial evaluation.

This report is intended for use by the Site Selection Committee as a foundation for their review and evaluation. The report should not be considered a final evaluation but should be considered as an initial step in the site selection process.

1.2. History of the Durango Uranium Mill Tailings Pile

Ford, Bacon and Davis Utah Inc. (1977) described the history of milling operations and processing of uranium and vanadium at the Durango Mill. The mill was built on the site of an old lead smelter just southwest of Durango by United States Vanadium Corporation (USV) in 1942. USV furnished vanadium to the Metals Reserve Company, a company formed by the federal government for the purchase of strategic materials needed in World War II. The mill operated until 1946 and was then shut down. In 1949 the mill was reopened when the Vanadium Corporation of America (VCA) contracted to sell uranium to the Atomic

Energy Commission (AEC). The mill permanently closed in March 1962. VCA retained ownership of the mill site and adjoining property until 1967 when VCA merged into Foote Mineral Company. During 1976 and 1977 Foote Mineral Company sold the tailings to Ranchers Exploration and Development Corporation. Ranchers, present owners of the tailings piles, proposed that the Durango tailings be relocated and reprocessed at the Long Hollow site. Their license application for this proposed project has been withdrawn from consideration.

While in operation, the Durango mill processed approximately 1.5 million tons of uranium ore. The amount of extracted uranium and vanadium is not known precisely, but the uranium values remaining within the Durango tailings are reported to be the richest in the country. Reprocessing of the tailings, therefore, must be considered not only for economic reasons, but also because of the mandate of the Uranium Mill Tailings Control Act of 1978.

1.3. Preferred Method of Tailings Disposal

Edward Landa (1980) in U.S. Geological Survey Circular 814, notes that uranium tailings constitute a technologically enhanced source of natural radiation exposure by virtue of the physical and chemical processing of the ore and redistribution of the contained radionuclides by wind and water transport. The philosophy expressed by Lush and others (1978) is worth considering as to the long-term containment of uranium mill tailings:

> "The development of a long-term waste management philosophy requires the acceptance of a basic set of management criteria. Our societies' approach has, as its basic tenets, that the present generation of waste managers should leave the wastes in such a manner that there is no foreseeable threat to future generations and future generations will not have to be involved in the care of the wastes. Implied is that the future bleed rate of contaminants from waste management sites should not exceed present regulatory levels, and not rely on continued monitoring to demonstrate that fact."

Radionuclides must be controlled for thousands of years by selecting disposal sites that optimize natural geologic, hydrologic, meteorologic, and geochemical conditions. To achieve this containment, the U.S. Nuclear Regulatory Commission (NRC) promulgated the recently enacted Uranium Mill Licensing Requirements. In Appendix A to 10 CFR Part 40, the NRC indicates that the "prime option" for disposal is placement of the tailings in trenches below the present ground surface. Additionally, the NRC recommends that dewatering of tailings by process devices and/or in-situ drainage systems be considered and that the tailings be covered with a minimum of 3 meters of material.

The Colorado Geological Survey considers disposal of dewatered tailings in trenches excavated into thick, relatively impervious shale as the most effective, practical method to meet the long-term containment objectives and the NRC regulations. The sites discussed in this report were chosen and evaluated with regard to this method of tailings disposal. If alternative methods are considered, the sites must be fully re-evaluated.

2. EXECUTIVE SUMMARY

This report describes the procedure and results of a regional search for sites that appear to be geotechnically suitable for the relocation and/or reprocessing of the Durango uranium mill tailings pile. This search identified nine potential sites within a 30 mile radius of the Durango uranium mill tailings pile. These nine sites are recommended to the Site Selection Committee for their review. In addition to these sites, the Site Selection Committee requested that additional information be gathered on the Bodo Canyon area. This information is contained in Appendix A.

General locations of the nine sites are shown on Plate 2 along with regional land ownership. Detailed site maps are included with the individual site descriptions in section 4. Site boundaries designated in this report are not permanently fixed. Some sites are relatively large, and only part of the designated area may be needed for the actual repository. Other factors, such as land use, ownership, geotechnical problems, and environmental aspects, may make it necessary to revise site boundaries during later investigations.

The geotechnical suitability of all nine sites was comparatively ranked using a rating matrix. All nine sites seem to be geotechnically acceptable, but certain sites are significantly better than others. Social, economic, environmental, and political aspects of each site were <u>not</u> evaluated as part of the rating matrix, as these parameters were generally not quantifiable at this phase of the investigation. The importance of these factors in the overall decision-making process must be addressed and evaluated by the Site Selection Committee.

Results of the geotechnical rating matrix evaluation, along with individual site scores are as follows:

1.	Maggie Rock site	- 124
2.	Junction site	- 122
3.	Long Hollow site	- 119
4., 5., & 6	Mud Creek, Mancos Valley, and Thompson Park sites	- 118
7.	Rabbit Mountain site	- 103
8.	State site	- 102
9.	Pine Ridge site	- 97

Two sites, the Junction and Maggie Rock sites, scored slightly higher than the other sites. Four sites, the Long Hollow, Mancos Valley, Mud Creek, and Thompson Park sites, received similar scores that were close to the scores of the top two sites. Three sites, the Rabbit Mountain, State, and Pine Ridge sites, scored noticeably lower than the other sites. These three sites appear to be less desirable for a tailings repository from geotechnical standpoints than are the six other sites.

The Junction site is geotechnically an excellent site. However, it is adjacent to an area that presently is being studied by the U.S. Bureau of Land Management as a possible wilderness area. The site also is irrigated agricultural land and is directly adjacent to recorded archaeological sites. The Maggie Rock site also is an excellent site from a geotechnical standpoint, but much of this site is owned by the Ute Mountain tribe, and it also is irrigated agricultural land.

The Mancos Valley, Long Hollow, Mud Creek, and Thompson Park sites all received similar matrix scores. The Mancos Valley site, however, has a higher erosion potential than the three other sites. Furthermore, the Mancos Valley site has a producing oil well on it, and Mesa Verde National Park and significant archaeological resources are only one-half mile from the site. Long Hollow site was proposed for use by Ranchers Exploration and Development Corporation as part of their attempt to reprocess the Durango tailings pile in 1978. Citizen opposition to utilization of this site centered around transportation problems related to the Wildcat Canyon route. The road through Ridges Basin could be upgraded and used as the haul route for the Long Hollow site to avoid this problem. The Thompson Park site is highly visible from U.S. Highway 160. Visual impacts would occur while the project is in progress. This site also is irrigated agricultural land.

Three sites, the Rabbit Mountain, State, and Pine Ridge sites, are apparently less desirable than other sites from a geotechnical standpoint. Rabbit Mountain and State sites are underlain by the Animas Formation, a "possibly suitable formation" that locally is an important source of ground water in the region. Rabbit Mountain site also has a high erosion potential on part of the site. Additionally, the site has some areas of excessive slopes, it is confined to a relatively narrow valley, and there may be some conflicts with natural gas recovery. The Pine Ridge site has only 50 to 100 feet of Lewis Shale beneath it. An anticline, syncline, and fault extend through or are near the Pine Ridge site. These features suggest bedrock fracturing may be high on the site. The Pine Ridge site is also close to an existing subdivision, and part of the site may be subdivided in the near future.

None of the sites are completely ideal when all relevant factors are considered. The Site Selection Committee must compare and weigh the advantages and disadvantages of each site and determine which sites are the most favorable. Paramount in this determination should be the safe, long-term disposal of the uranium tailings.

3. DESCRIPTION OF THE SITE SELECTION PROCESS

To insure the safe, long-term containment of uranium tailings material, a number of general placement objectives have been established for tailings disposal in Colorado. These placement objectives, which are compatible with the preferred method of tailings disposal (below-grade and dewatered), are as follows:

1. Tailings or waste disposal areas should be located at a relatively remote site so as to reduce potential population exposures and the likelihood of human intrusions to the maximum extent reasonably achievable.

2. Tailings or waste disposal areas should be located at a site where disruption and dispersion by natural forces are eliminated or reduced to the maximum extent reasonably achievable.

3. Tailings and waste should be placed below grade, in trenches or pits excavated into relatively impervious shale.

4. Tailings and waste should be covered with a minimum of three meters of earth materials that is calculated to reduce surface exhalation of radon from the tailings or waste to less than two piocuries per square meter per second above background levels and is designed to reduce root or animal penetration and salt migration.

5. Reclamation of the tailings or waste areas should include a full, self-sustaining vegetative cover or riprap to retard wind and water erosion. The final contour slopes should be as close as possible to the natural surface, but not steeper than 5h:1v.

6. Seepage of toxic materials to the ground or surface waters should be minimized to the maximum extent reasonably achievable so that ground water and other natural systems will not be degraded. Seepage control measures should include consideration of both physical and geochemical methods.

7. Tailings and waste should not adversely affect important mineral resources or unique historic, archaeologic, wildlife, or ecologic areas.

8. Tailings or waste should be confined in a single area to preclude the proliferation of numerous, small disposal areas.

9. The final disposition of the tailings and waste should be such that ongoing active maintenance is not necessary to preserve isolation and that monitoring will be minimized to the maximum extent reasonably achievable.

These objectives can be achieved and candidate sites can be determined and comparatively rated through a two-phase selection process. Phase I of this process consists of a series of elimination or filtering steps in which "potential sites" are delineated within a specific radius of the particular tailings pile of interest. For the Durango tailings pile, a 30-mile radius was used. Phase II involves review and evaluation of these potential sites by an appropriate committee that selects three to five "candidate sites" for further detailed study.

PHASE I: The first step in Phase I is to determine the geologic formations that possess acceptable permeability, thickness, and lateral lithologic continuity characteristics. The formation should have beds of low or very low permeability that are at least 150 feet thick and are laterally persistent for many square miles. Formations with these characteristics are herein called "suitable formations". Certain other geologic formations in Colorado may meet this criterion, but they generally are not as thick, as laterally persistent, or may contain aquifers. These formations are not obvious candidate formations, and are herein called "possibly suitable formations". In areas where there is insufficient area underlain by "suitable formations", the "possibly suitable formations" may become very important and in such cases should receive thorough evaluation. Detailed studies may eventually prove that some areas underlain by "possibly suitable formations" do meet the above specified siting requirements.

Distribution of suitable and possibly suitable formations in the Durango area are shown on Plate 1. In the area two formations meet the criteria for suitable formations. They are the Cretaceous Lewis Shale and Mancos Shale. Both formations are laterally continuous marine deposits that commonly are over 1,500 feet thick and are dominantly shale or claystone. The Lewis Shale contains some minor sandstone beds in its upper and lower transition zones. The Mancos Shale likewise has upper and lower sandy transition zones and also locally contains some thin sandstone and limestone beds. Both formations produce only minor amounts of generally poor quality water, and neither are important regional aquifers (Brogden and Giles, 1976; Brogden and others, 1979; Irwin, 1966). All but two of the recommended potential sites are underlain by either the Lewis Shale or Mancos Shale.

Several formations in the Durango study area are herein classified as possibly suitable formations. They include the Cretaceous-Tertiary Animas Formation and Tertiary San Jose and Nacimiento Formations. All three formations contain relatively thick shale or claystone sequences, but they also have interbedded channel sandstone and conglomerate beds that are randomly distributed throughout the formations. All three have important aquifers that serve as sources of water for many wells. Because a relatively large part of the 30-mile radius study area is underlain by suitable formations, the entire area underlain by possibly suitable formations was not evaluated in detail for suitability as potential sites.

The second step of Phase I consists of delineating areas of favorable slope that are underlain by suitable formations or, where necessary, by possibly suitable formations. The most favorable slopes range from two to five percent, but slopes of five to ten percent, or less than two percent may also be acceptable under certain conditions. Areas that are underlain by suitable formations or, where necessary, potentially suitable formations, and have acceptable slopes and size are considered to be target areas. A target area may contain more than one potential site.

A total of ten target areas was selected for the Durango study area. They are the Rabbit Mountain, Florida Mesa, Horse Gulch, Indian Creek, Long

Hollow, Pine Ridge, Thompson Park, Weber Mountain, Mancos Valley, and Mud Creek target areas. Locations of these target areas are shown on Plate 1.

The third step of Phase I involves the evaluation of target areas with regard to the following criteria and selection of potential sites by excluding areas that do not meet the criteria. All of the following areas are automatically disqualified as potential sites:

1) areas of insufficient size (a minimum of 200 to 300 acres for the Durango tailings pile);

2) areas subject to extensive flooding;

3) areas of critical ground-water resources or recharge;

4) areas of complex geologic structure (e.g. abundant faulting, folding, and jointing);

5) areas susceptible to geologic hazards that could disrupt the repository (e.g. active faulting, subsidence, potentially unstable slopes, etc.);

6) areas of high erosion,

7) areas of Quaternary glaciation,

8) areas of Quaternary igneous activity,

9) areas with critical mineral, geothermal, archaeologic, cultural, historic, wildlife, or ecologic resources that could be adversely impacted.

10) areas of critical surface water, springs, and present or planned large bodies of water,

11) areas of concentrated human habitation--towns, subdivisions, etc.

12) wilderness areas or wild and scenic river areas.

Consideration of these criteria in regards to the target areas results in the selection of potential sites. General locations of the recommended potential sites are illustrated on Plate 2 along with regional land ownership. Detailed site location maps are contained in a following section that describes each potential site. Site boundaries as assigned in this report should not be considered permanently fixed. It may be necessary to somewhat revise site boundaries because of ownership, land use, environmental, geotechnical, or other considerations.

Two potential sites were designated in the Thompson Park area. The Horse Gulch target area was eliminated because it did not contain a large enough area of acceptable slopes. Furthermore, this target area has a high erosion potential, and several deep gullies have recently cut through parts of the area. The Indian Creek target area was eliminated because of thick gravel layers on the site, possible shallow ground water, high erosion potential, mineral resource conflicts, and site proximity to the Animas River. Additionally, this site was located on Indian land, and the Southern Ute tribe has expressed disinterest in accepting the tailings on their land.

The potential sites recommended for relocation and/or reprocessing of the Durango uranium mill tailings, listed in order of distance from the pile are as follows:

A. State site
B. Pine Ridge site
C. Long Hollow site
D. Rabbit Mountain site
E. Maggie Rock site
F. Thompson Park site
G. Junction Site
H. Mud Creek site
I. Mancos Valley Site

The fourth and final step of Phase I is the geotechnical evaluation and ranking of the potential sites by use of a grading matrix. The grading matrix, shown in Figure 1, ranks each individual site by addressing a number of geologic, hydrologic, and meteorologic factors. Each factor is assigned a rank value from one to five in the matrix based on the characteristics of the particular site being evaluated. Some factors are more important than others and they are weighted twice the rank value. The total site score is calculated by adding all factor scores. A maximum score of 140 is possible. The result of Phase I is this preliminary report which describes all potential sites, presents data relative to the sites, and gives a geotechnical rank to the sites.

Figure 1. An example of the geotechnical matrix used to comparatively rate potential sites.

SITE DESIGNATION: ______________________ SITE LOCATION: ______________________

Factor group	FACTOR	RANK 1	2	3	4	5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	< 50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	> 500 ft.	2	
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	
	6. Land slope	> 10%		< 2% or 5% to 10%		2% to 5%	2	
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	
	8. Dip of underlying rocks	highly folded or > 45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	
	10. Distance from known faulting	< 1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	> 5 miles	1	
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	
	12. Long-term potential for future erosion	high		moderate		low	1	
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	
	16. Depth to 1st underlying important bedrock aquifer	< 50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	> 500 ft.	2	
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	
	19. Size of drainage basin above site	> 5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	< ½ sq. mile	1	
	20. Evaporation to precipitation ratio	< 1		1 to 2		> 2	1	

Total Site Score ______

Phase II. Potential sites are reviewed and further evaluated during Phase II by the Site Selection Committee. The Committee will recommend three to five potential sites to be candidate sites for further detailed analysis by the U.S. Department of Energy. Recommendations by the committee are based not only on the geotechnical matrix rating, but on other important additional factors that must be considered for an acceptable disposal site. These factors include, but are not limited to transportation elements, land use, land ownership, wildlife, archaeologic, historic, cultural, and ecologic impacts, local attitudes to particular sites, reclamation potential, economics, and site remoteness. The Site Selection Committee must incorporate all such important factors into the final selection of candidate sites. The findings and recommendations of the Committee are then submitted to the State of Colorado, specifically the Colorado Department of Health, for review and submittal to the U.S. Department of Energy. The candidate sites will be studied in greater detail by the U.S. Department of Energy and the results of this study will be used as the basis for an environmental report prepared on the proposed relocation project.

It must be emphasized that this report is a reconnaissance evaluation of the potential sites. The type of information needed to thoroughly examine all the relevant geotechnical, environmental, economic, political, and social parameters is not currently available. The data presented in section 4 of this report should provide a suitable foundation so that the committee members can satisfactorily select three to five candidate sites.

4. DESCRIPTION OF POTENTIAL SITES

Each potential site was evaluated in regards to the limiting criteria and the geotechnical rating matrix. Additionally, data was collected in regards to environmental and economic factors. Published information, data from State and Local agencies, and public comments were used in the preparation of this report.

A number of valuable reports and maps were used extensively to compile the data necessary for the site evaluation. Both La Plata County and Montezuma County have available a series of 7-1/2' quadrangle maps that generally describe geologic hazards, mineral resources, and surficial materials. These maps were used for initial study of target areas, but further study of each site area was conducted during this investigation.

Other reports and unpublished data were obtained from various State and Federal agencies and used in the preparation of this report. As indicated by Kirkham and Rogers (1978), no known potentially active faults exist within the entire study area. Nonetheless, several moderate-sized earthquakes have been reported within the general vicinity of the study area. A magnitude 5.5 earthquake and several magnitude 4.0 to 5.0 events occurred along the northeast flank of the San Juan basin about 20 miles south of Pagosa Springs. An intensity V earthquake occurred east of Durango in 1941 and apparently centered near the Rabbit Mountain site. Other earthquakes have been felt or instrumentally located in the San Juan Mountains. The potential for future seismicity and its possible affect on a repository should be further evaluated during the detailed studies to be conducted by the U.S. Department of Energy.

A small area with some geothermal potential lies just north of Durango, but none of the target areas are within this region. Mine records held by the Colorado Division of Mines and the Colorado Geological Survey indicate that none of the potential sites are undermined. Information on existing registered water wells was collected from the Colorado Division of Water Resources. Locations and status of oil and gas wells on or near the sites were provided by the Colorado Oil and Gas Conservation Commission and Petroleum Information, Inc. Both drillers' logs from water wells and geophysical logs from oil and gas wells aided stratigraphic and hydrologic interpretations. The Colorado State Historical Society, Colorado State Archaeologist, Colorado Division of Wildlife, and Colorado Natural Areas Program contributed valuable comments on historic sites and landmarks, archaeologic sites, and wildlife and ecologic areas.

Relative effects on wildlife for each of the twelve sites were briefly evaluated by making a broad comparative analysis of the wildlife impacts. Complete coverage of the environmental effects on wildlife was not feasible for this investigation. Our reconnaissance analysis is based on observation of the habitats, a knowledge of habitat needed by wildlife, and a discussion with Mike Zgainer (Durango District Supervisor, Colorado Division of Wildlife). It assumes grass revegetation and fencing at the project end. Thus, areas that are already grassland will experience the least change in wildlife species. Actually, the specific sites and the area as a whole may be improved for wildlife in general (with the exception of big game), because of the establishment of a large tract of undisturbed grassland, a habitat type now in short supply.

For these reasons, the total impact on wildlife in general will not be adverse. However, the larger, rarer, wider-ranging forms that are of special interest to man, particularly deer, elk, and turkey, may experience impacts which are described later for each proposed site.

No endangered wildlife species is likely to occur in any of the areas, but a peregrine falcon historic nesting area in Ridges Basin places the State site, Pine Ridge site, and Long Hollow site within hunting range of the falcon. No unique species that require special attention are known to be permanent residents of any site; however, bald eagles have been reported near several of the site areas.

The following factors were considered in the evaluation of sites for relative impact on deer, elk, and turkey: (1) general quality of natural habitat, (2) environmental diversity, (3) human habitation, and (4) hazards on the truck route to the site. These were evaluated in a matrix for the twelve sites and four alternative truck routes. Sites with the least impact on deer, elk, and turkey were the Long Hollow site (Wildcat Canyon Route), Long Hollow site (Ridges Basin Route), Junction site, Maggie Rock site, and Thompson Park site. Those with intermediate impact were State Site (Horse Gulch Route), Pine Ridge site (Ridges Basin Route), Pine Ridge site (Wildcat Canyon Route), and Weber site. Sites with greatest wildlife impact were the State site (Elmore's Store Route), Mancos Valley site, Mud Creek site, and Rabbit Mountain site.

A preliminary search of recorded cultural resources was conducted by the Colorado Historical Society. This search, which included both archaeological and historical records, identified documented resources near some of the proposed sites. The most abundant resources are at the sites located near Mesa Verde National Park. Details regarding these resources are further described on a site by site basis in this report. The Colorado Historical Society notes that the specific site areas have not been inventoried and that the data in these areas is incomplete. There is a possibility that unidentified cultural resources exist within the sites. A detailed, professional survey of the sites should be conducted during later investigations and the results submitted to the Colorado Historical Society.

Personnel with the Colorado Natural Areas Program indicated that the proposed sites were not within an inventoried natural area. However, additional data and studies are currently being compiled. The Colorado Natural Areas Program within the Colorado Department of Natural Resources should be contacted when detailed, site-specific studies are being conducted.

Important considerations in regards to the economic feasibility of sites include availability of water for reprocessing, of riprap and clay for liner and cap material, excavatibility of the host rock, and transportation elements. Since all potential sites are in shale or claystone host rocks, there is a readily available potential source of clay on and adjacent to each site. Possible riprap sources are mentioned in the site descriptions, and nearby gravel sources are indicated on the mineral resource map of each site. Detailed durability studies of these materials were not conducted during this investigation. Host rock excavatibility is an important factor, but because it is highly dependent on site specific subsurface conditions, it was not possible to evaluate this aspect during this phase of the project. Although the absence of ground water and distance from surface water are beneficial factors in regards to the environmental aspects of a site, a certain amount of water is needed for the project if reprocessing is to be carried out. Haul routes, road conditions, and approximate distances are discussed in each site description.

It should also be re-emphasized that the site boundaries herein designated are not permanently fixed. Boundaries may be somewhat revised to allow for problems related to land ownership, land use, or geotechnical aspects.

4.1. STATE SITE

4.1.1. General Site Description

4.1.1.1. Location

Location of the State site is shown in Figure 3. It is about four air miles east of the tailings pile. Most of the site lies on a drainage divide between several small, ephemeral creeks at the northernmost end of Florida Mesa in La Plata County. Parts of sections 25, 26, and 36, T.35N., R.9W., are included in the site. Ford, Bacon and Davis Utah Inc. (1977) selected part of this same general site as a potential site that they designated the Florida Mesa site.

4.1.1.2. Access

Access to the State site is southwesterly and westerly via Highways 550 and 160 eight miles from Durango to County Road 234 (Elmore's Store), thence northerly three miles to the northeast corner of Section 36. Approximately 3/4 mile of road would have to be constructed from the corner of the section to the center of the site. Construction of such a road would be across relatively flat lands and should not present any special difficulties. This haul route could cause a trafic hazard in the vicinity of Elmore's Store because of turning trucks.

An alternate access route is easterly five miles via Horse Gulch (County Road 257) to County Road 234, thence southerly two miles to the northeast corner of Section 36. Although this route is shorter than the highway route, the Horse Gulch road would have to be improved consideraby to support haulage trucks. Additionally, the trucks would have to travel through Durango to reach the Horse Gulch road.

4.1.1.3. Topographic Setting

The State site consists of gently rolling hills separated by small drainages. As shown on the slope map (Figure 3), most of the central part of the site has slopes that range from two to five percent. The outer parts of the site are somewhat steeper, mostly in the five to ten percent slope range. Because the site has small rolling hills on it, excavation costs will be somewhat higher for this site than other potential sites herein recommended. Maximum relief across the site is about 160 feet.

4.1.1.4. Land Use

Land use on and around the State site is shown on Figure 4. Most of the site is used as rangeland or unirrigated farm land. A thick stand of pinion and juniper trees along the southern portion of the site makes this area a favorite for hunters and hikers.

Several small acreage residences are present along County Road 234, and six are within 1/2 mile of the site. A proposal to use a portion of the State section for a land fill site about two years ago was strongly opposed by a large group of homeowners in the general Florida Mesa-Florida River area.

Most of the site is within Planning Sector 5 of a regional plan recently formulated by the La Plata County and Resource Management Program. According to this plan, the desired growth pattern in this immediate area is one unit per ten acres.

4.1.1.5. Land Ownership

Figure 4 illustrates that a part of the site is State of Colorado land, and part is privately owned. The State land is under the jurisdiction of the Colorado Board of Land Commissioners. The private land portions of the site are owned as follows:

A. Davey, Bruce F.
P.O. Box 4
Durango, CO 81301

B. Subsurface Machine and Subsurface Inc.
c/o Bruce Kirkpatrick
701 E. 2nd Avenue
Durango, CO 81301

C. Greenstreet, Dwane L.
2788 County Road 234
Durango, CO 81301

D. 1/2 Hawkins, J. W.
Drawer T-L
Cortez, CO 81321

1/2 Hubbs, Billy
c/o Ted Hubbs
367 County Road 129
Hesperus, CO 81326

4.1.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the State site is given in Figure 2. The site received a score of 102 and ranks eighth based on the evaluated geotechnical parameters.

4.1.2.1. Geology

As shown on Plate 3, about 200 to 500 feet of Animas Formation underlies most of the State site. The Animas Formation is a possibly suitable formation and may prove to be suitable upon detailed examination. This thickness estimate is based on structural projections of surface dips measured on or near the site. The northwestern part of the site may be underlain by less than 200 feet of Animas Formation, and the southeastern part of the site may be underlain by more than 500 feet. The Animas Formation consists of dark varicolored claystone and shale with interbedded sandstone and conglomerate of volcanic origin. The McDermott member of the Animas Formation, a reddish-brown to purple unit that consists of sandstone, breccia, conglomerate, and shale, forms the lower part of the formation. Formation thicknesses for the State site given above are to the top of McDermott member. Shale sequences within the Animas Formation are generally laterally persistent, but sandstone beds are often very lenticular.

The hills on the State site are primarily bedrock, but some intervening drainages are underlain by unconsolidated alluvial and colluvial deposits (Figure 5). Shallow gully exposures and test pits in these areas indicate the surficial materials are dominantly silty clay with thin sandy zones and occasional gravel clasts. Surficial materials thickness varies greatly, ranging from 0 to an estimated 15 feet.

Soils on the northwest half of the site are described as a Camborthids-Torriorthents-Haplargids association. They are warm, dominantly shallow, well drained, steep soils on hills, breaks, and canyons. Soils on the southeastern half of the site are classified as the Witt-Falfa-Potts association. They are warm, deep, well drained, gently sloping and sloping soils on uplands (U.S. Department of Agriculture, 1972).

Structurally, the State site lies just southeast of the monoclinal structural zone, the Hogback moncline, that bounds the north end of the San Juan Basin. Within the Hogback monocline, beds generally dip 20° to 60° southeast, but on the site beds dip only 2° to 10° southeast. Fracturing and jointing in the Animas Formation is variable. Bedrock exposures to the south of the site suggest the jointing is moderately spaced and open.

The nearest fault shown on published maps is about three miles from the site (Zapp, 1949). Recent unpublished mapping by U.S. Geological Survey (D. Moore, 1980, personal communication) shows faults just south of Grandview about two miles away. During field studies conducted for this investigation, a piece of slickensided bedrock was found lying on the surface about 1/4 mile south of the site, but we were unable to detect any faulting in nearby bedrock outcrops.

The present erosional rate of the State site varies with location. Rill erosion and sheet erosion predominates over part of the site, but moderate gullying appears to be migrating headward into the site. Because of the small (less than 1/2 square mile) drainage basin above the site and its hydrologic characteristics, the potential for flash floods severely eroding the site is low. The nature of the surficial materials and the headward eroding gullies suggest the long-term potential for future erosion is moderate (Figure 6).

No other significant geologic hazards are known to affect the State site. An area of potentially unstable slopes lies northwest of the site, but this area should cause no problems to a repository located on this site unless construction activities would alter the natural land slopes.

There are only minor conflicts between the site and mineral resources. The Menefee and Fruitland coal zones both underlie the site (Figure 7). The Menefee coal zone is greater than 3,000 feet deep beneath the site. The Fruitland coal zone is probably at least 2,000 feet deep below most of the site (Figure 7). Thickness of the Fruitland coal beds is variable. Mines to the northeast and north of the site worked Fruitland coal beds ranging in thickness from less than five feet to over twenty feet. One gas well has been completed in the general vicinity of the site (Figure 7). It encountered economic quantities of gas, but is currently shut-in. No other test wells in this area are on record with the Colorado Oil and Gas Conservation Commission. No significant gravel deposits exist on the site. Some riprap material could possibly be obtained on or near the site from sandstone or conglomerate beds in the Animas Formation, or from gravel deposits along Florida River.

4.1.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the site. An important irrigation ditch, the Florida canal does lie just downstream from the site. The site generally lies on a drainage divide between several small ephemeral streams, as depicted on the U.S.G.S. topographic maps. Drainages in the northern and eastern parts of the area lead into Florida River about one and one-half miles downstream from the site. A small area in the southwest part of the site drains into Wilson Gulch, which in turn empties into the Animas River about seven miles downstream from the site.

Surficial materials at the State site probably contain only very minor amounts of water that likely is of poor or average quality. Any water within the surficial materials probably occurs seasonally and may form local small springs.

Although the Animas Formation contains thick shale and claystone sequences, it is nonetheless considered to be an important aquifer (Brogden and Giles, 1976; Brogden and others, 1979; Hutchinson and Brogden, 1976). Several nearby wells within two miles of the site obtain water supplies from the Animas Formation. Records held by the Colorado State Engineer's office indicate these wells commonly yield five to thirty gpm and were drilled to depths ranging from about 60 to 150 feet. This suggests important water supplies could probably be obtained at relatively shallow depths in the site area. Well yields reported by the State Engineer's office may be somewhat high, because Brogden and others (1979) document that yields from the Animas Formation usually are on the order of one to ten gpm. Quality of water from the Animas Formation is variable, usually ranging from average to poor (Brogden and others, 1979; Hutchinson and Brogden, 1976).

4.1.3. Environmental Factors

The vegetation on the State site is dominantly pinon-juniper and oak, with other shrubs on the hills. Sagebrush and grass occur on the floors of the drainages. The surface is rolling and no houses occur on the site, although several homes are nearby. The area is an important deer and elk winter range. The site has good wildlife habitat, including wild turkey habitat, of a type that is uncommon in the vicinity. Road hazard using the Horse Gulch route is 1.9 deer kills and 0.00 elk kills per one million vehicle trips. Road hazard on the Elmore's Store route is 4.76 deer kills and 0.29 elk kills.

There are no documented archaelogic or historic resources within or adjacent to the State site. No significant inputs to cultural resources are anticipated.

Figure 2. Geotechnical rating matrix for the State site.

SITE DESIGNATION: State Site SITE LOCATION: Sec. 25, 26, & 36 T35N, R9W

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	8
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	6
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	6
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	4
	11. Present erosional/ depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	2
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	3
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	6
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	4
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	2
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	5
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 102

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

? Possible Fault

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

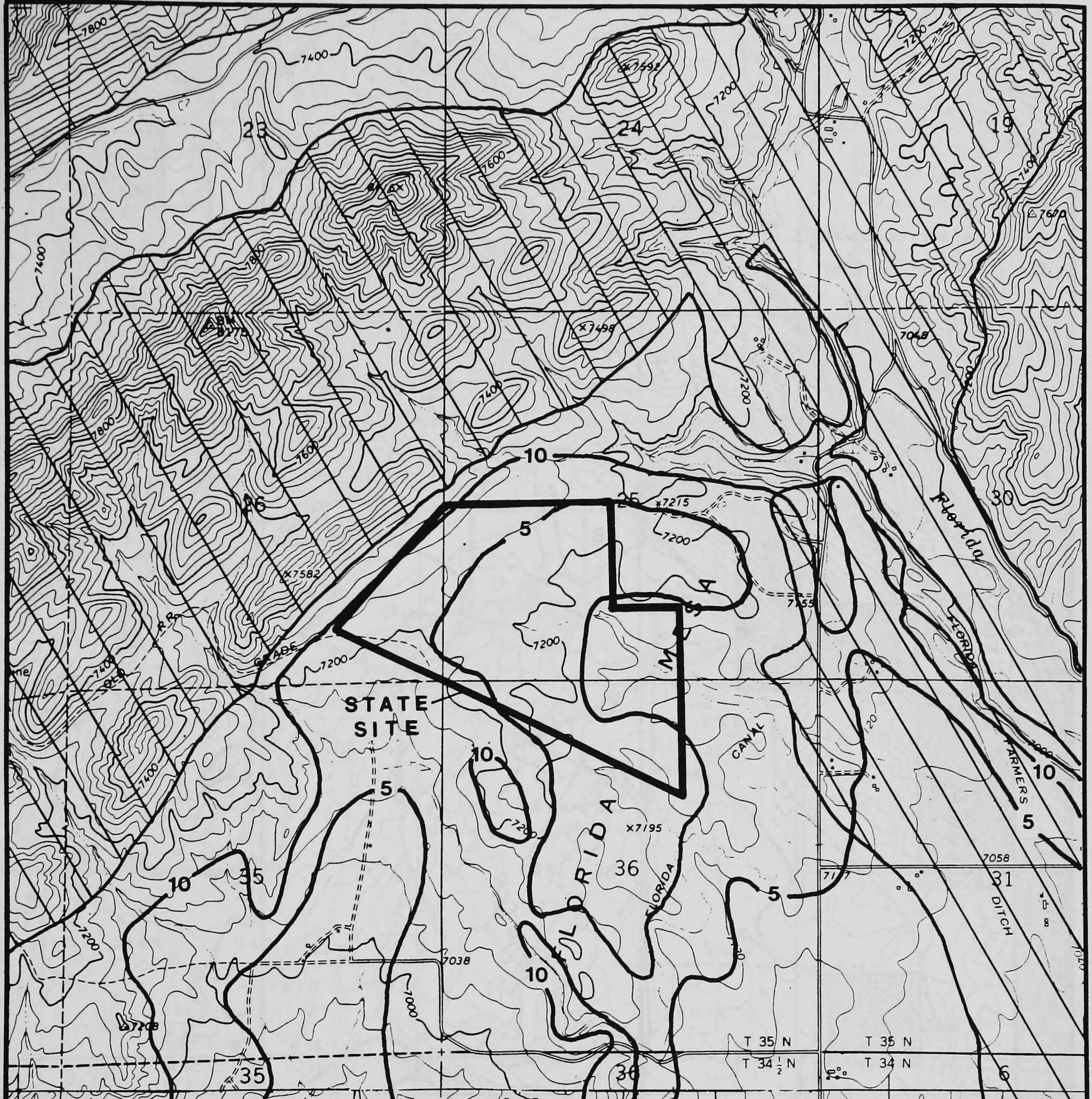

Figure 3. Suitable formation and slope map of the State site.

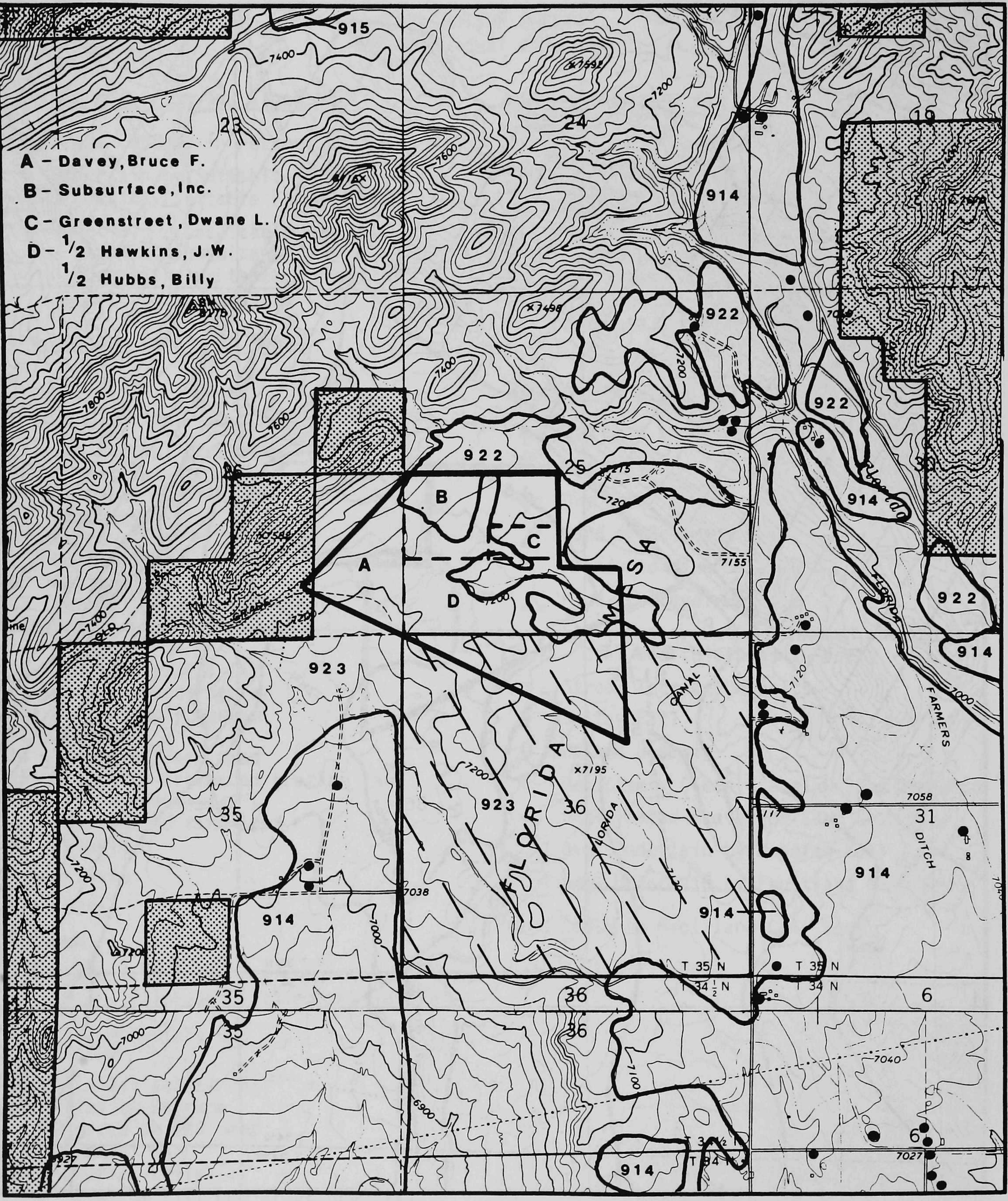

Figure 4. Land use and ownership map of the State site.

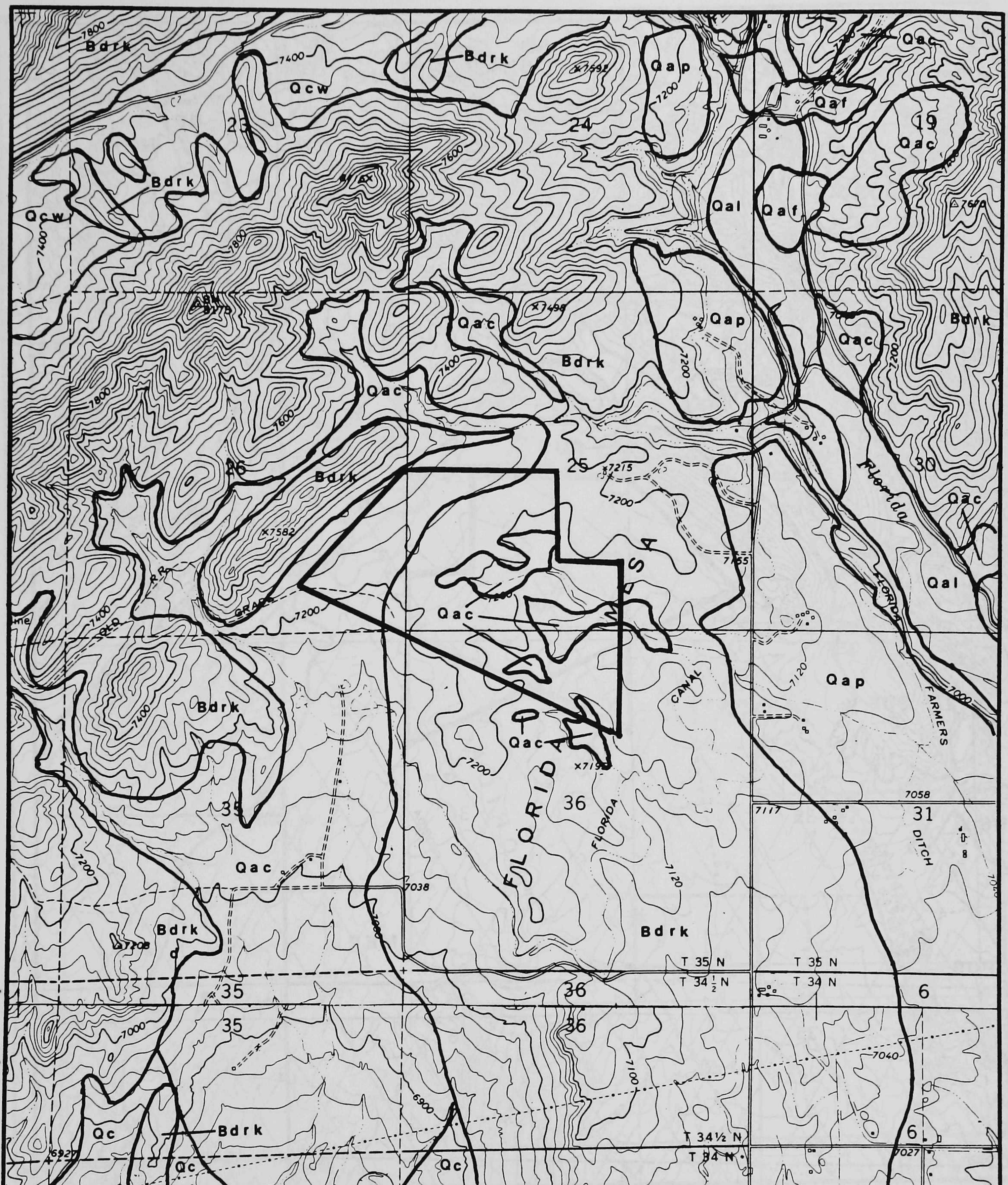

Figure 5. Surficial materials map of the State site.

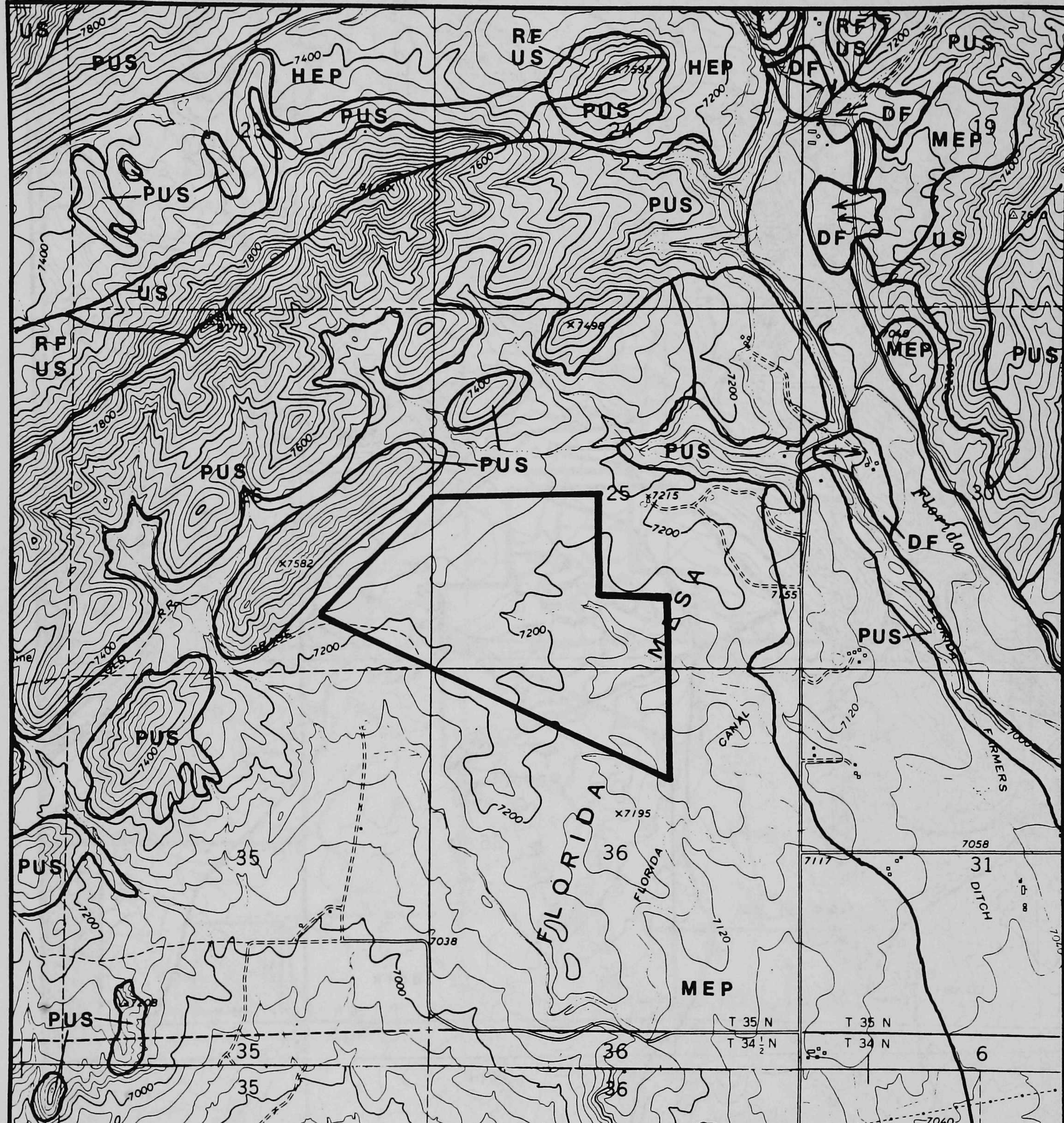

Figure 6. Geologic hazards map of the State site.

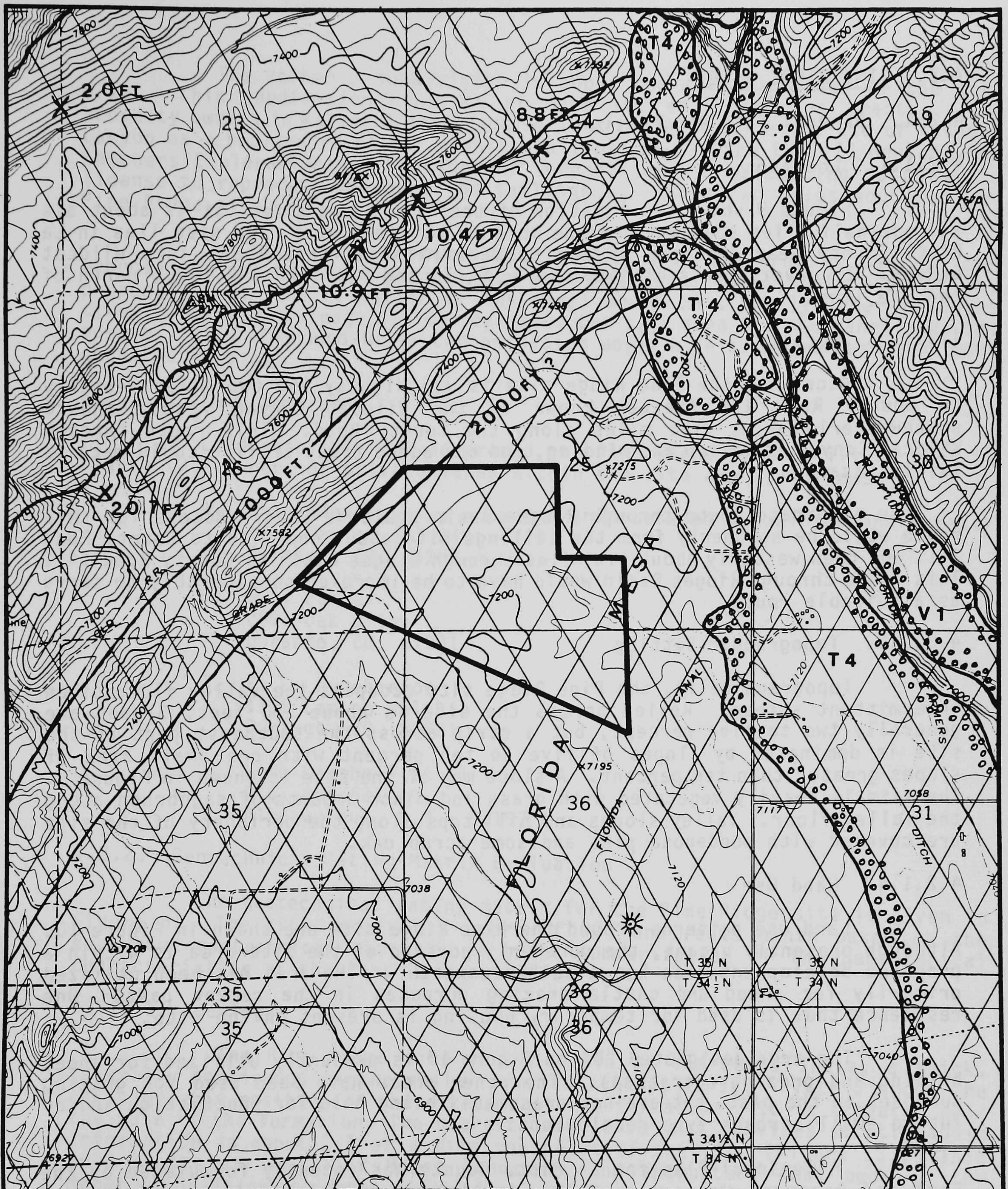

Figure 7. Mineral resources map of the State site.

4.2. PINE RIDGE SITE

4.2.1. General Site Description

4.2.1.1. Location

Figure 9 shows the location of the Pine Ridge site. It is about six and one-half miles southwest of the Durango tailings pile. The site lies in La Plata County near the head of one of the drainages that leads into Wildcat Canyon. It covers parts of sections 5, 6, 7, and 8, T.34N., R.10W., north of the Ute line.

4.2.1.2. Access

Access to the Pine Ridge site is via Highway 160 two miles westerly to County Road 141 (better known as the Wildcat Canyon road), thence southwesterly about five miles along the County Road. This route through Wildcat Canyon is narrow and winding, and the added truck traffic could make it fairly hazardous.

An alternate route through Ridges Basin could be used. Access for this route would be southerly from the tailings pile about one mile to County Road 211, and then westerly about six miles through Ridges Basin to County Road 141. This route through Ridges Basin would have to be improved considerably to serve as a suitable route.

4.2.1.3. Topographic Setting

Topographically, the Pine Ridge site occupies the valley floor of an intermittent stream. Relief across the site is about 150 feet. Slopes are generally two to five percent, but a strip across the southeast part of the site is dominated by slopes of five to ten percent with one small area of slopes greater than ten percent. A slope map of the site is shown in Figure 9. The site is heavily vegetated with grass and minor amounts of sagebrush along the valley floor. Valley slopes and hill tops along the periphery of the site are covered with ponderosa pine and some scrub oak.

4.2.1.4. Land Use

Land use patterns around the Pine Ridge site are shown in Figure 10. Although presently vacant, the northerly portion of the site area is within a proposed development area known as "Shenandoah". The area has been utilized primarily for sheep and cattle grazing purposes in the recent past. One residence that is used for temporary housing is present on the site.

The area designated "B" on Figure 10 is presently utilized for sheep holding and grazing operations. The other areas have been used for grazing purposes in the past, but are now presumably being held for speculation and/or future small acreage type development.

A Regional Plan for La Plata County was recently formulated by the Land and Resource Management Program. According to this plan the desired growth pattern for the site area is one unit per ten acres.

The Rafter J subdivision is about one mile northeast of the site area. This subdivision consists of over 100 small acreage tracts. The property owners in Rafter J expressed serious concerns about the use of Wildcat Canyon as a haulage route for uranium tailings during the 1977-78 period when Ranchers Exploration and Development Corporation was attempting to obtain a license to reprocess and bury the tailings at a site two miles south of the Pine Ridge site.

A canal to transport water to the Red Mesa area as part of the proposed Animas-La Plata project may be constructed immediately east of the proposed site. The elevation of the canal would be slightly lower than the site. A surface drainage divide separates the site area and the canal, but the possibilities of ground-water contamination would have to be addressed by more detailed studies.

4.2.1.5. Land Ownership

Land ownership on and around the Pine Ridge site is illustrated in Figure 10. Owners of private lands within the site are as follows:

A. Shenandoah, Ltd., a partnership between Hutchinson and Carmack
1111 Camino del Rio
Durango, CO 81301

B. Gary Farmer
2803 Oak Drive
Durango, CO 81301

C. E. L. Hutchinson
1111 Camino del Rio
Durango, CO 81301

D. Herb Campbell et al
P.O. Box 6217
Albuquerque, N.M. 87197

4.2.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Pine Ridge site is given in Figure 8. The site received a score of 97, and ranks ninth based on the evaluated geotechnical factors. A brief summarization of the geotechnical characteristics of the Pine Ridge site follows.

4.2.2.1. Geology

The Pine Ridge site is underlain by the Lewis Shale, a thick, laterally continuous marine shale formation (Zapp, 1949). Plate 3 shows the stratigraphic position of the site within the formation. It is situated near the base of the formation. The nearest drill hole that provides stratigraphic information is about 1/5 of a mile southeast of the site (Figure 13). This hole begins in the Cliff House Sandstone and encounters coal beds in the Menefee Formation at depths of 358 feet, 428 feet, and 546 feet. Based on this drill hole and on existing surface mapping, we estimate there is 50 to 100 feet of Lewis Shale beneath the Pine Ridge site. It is possible that there is less than 50 feet of Lewis Shale beneath parts of the site.

A thin layer of surficial materials, primarily alluvium and colluvium, blankets much of the site (Figure 11). Test holes drilled by Ranchers Exploration and Development Corporation and field examination during this investigation indicate the surficial materials are dominantly clay and slightly gravelly clay occasionally interbedded with sand. The valley floor tends to be more clay-rich than the valley slopes. A small corner of the northern end of the site is underlain by lag gravels that are remnants of former gravel terraces that used to be present in the site area. Thickness of the surficial materials varies from 0 to over 10 feet.

Soils on the Pine Ridge site are classified as a Argiustolls-Haploborolls association. They are described as cool, dominantly moderately deep and deep, well drained, sloping to steep soils on mountain slopes (U.S. Dept. of Agriculture, 1972a).

Structurally, the Pine Ridge site is situated on the northwest flank of the San Juan Basin. Beds generally dip less than 10° to the southeast in this area, but both the Perins Peak syncline and Durango anticline are beneath or very near the site. Proximity of these structures to the site causes local variations in dip from the regional trend. The nearest mapped fault shown on published maps is almost five miles away (Zapp, 1949), but unpublished mapping by the U.S. Geological Survey (D. Moore, 1980, personal communication) indicates a fault trends toward the site and may actually extend into the northeast corner of the site. Presence of these folds and faults on or very near the site suggest that the bedrock fracturing may be high.

The present erosion rate of the Pine Ridge site is low to moderate. Small rills are developed in most areas, but two to five feet deep gullies are present in a few scattered places along the valley floor. The potential for long-term erosion on the site is moderate (Figure 12).

A geologic hazards map of the Pine Ridge site is illustrated in Figure 12. No geologic hazards other than the above mentioned moderate erosion potential affect the site. An active landslide complex and sizeable area of unstable and potentially unstable slopes lies just west of the site along the flank of Red Mesa. If project-related activities avoid these areas, there should be no serious slope stability problems for this site during both the short term and long term.

Economically significant coal beds in the Menefee Formation probably underlie the site (Figure 13). There are no drill holes on the site that can be used to evaluate coal, but the aforementioned drill hole 1/5 mile southeast of the site encountered a 12 feet thick coal bed at 358 feet, a nine feet thick bed at 428 feet, and 12 feet thick bed at 546 feet. These beds probably extend into the site area, but they may be somewhat deeper (possibly 450 to 650 feet deep) and of different thickness. These coal beds are shallow enough that subsidence could occur above any underground workings and disrupt the tailings repository. Thus, if the Pine ridge site is selected for the repository, future extraction of underlying coal beds would probably be precluded.

Other mineral resources would not be affected by this site. No significant gravel deposits occur on the site. Poor quality lag gravel is found on a small area at the northern end of the site, but this deposit is economically unimportant. Riprap, however, could possibly be obtained near the site from Red Mesa. Several oil and gas test holes have been drilled northeast and southeast of the site, but all were dry or non-productive (Figure 13).

4.2.2.2. Hydrology

The Pine Ridge site lies near the head of a drainage that leads into Wildcat Canyon. Size of the drainage basin above the site is about one to two square miles. Wildcat Canyon joins Lightner Creek about 4 and 1/2 miles below the site, and Lighter Creek merges with the Animas River about two miles downstream from that point. There are no major streams, lakes, springs, or irrigation ditches on or near the site. All drainages on the site are ephemeral. Two small stock ponds are on the site and would probably have to be removed for the project.

Surficial materials on the site are dominantly clay and are expected to contain only minor amounts of water that probably is of poor quality. The Lewis Shale host rock generally contains only minor amounts of poor quality water (Brogden and Giles, 1976). Since the Lewis Shale may be highly fractured on the site because of proximity to faulting and folding, it is possible that the Lewis Shale, particularly at shallow depths, may carry moderate amounts of water. The possible presence of highly fractured rock would also be detrimental because of increased likelihood of fluid migration from the repository.

The first potentially important aquifer underlying the Pine Ridge site is the Cliff House Sandstone. No drill hole or water well data exist on the site to confirm the depth to this formation or its aquifer characteristics. Based on nearby drill holes and surface exposures, we estimate the top of the Cliff House Sandstone to be 50 to 100 feet below the land surface on most of the site. It may be shallower in certain parts of the site. Water quality in the Cliff House Sandstone generally ranges from average to very poor (Brogden and Giles, 1976; Hutchinson and Brogden, 1976). It is possible that the Cliff House Sandstone contains little or no water. Ground water may occur in the underlying Menefee Formation or Point Lookout Sandstone.

4.2.3. Environmental Factors

Vegetation on the Pine Ridge site is primarily grassland, with patches of oak and ponderosa pine on the upland areas. Topography is rolling with no houses on the site, though several homes are nearby to the north and northeast. The site is outside of key or critical deer and elk winter range. Two or three small ponds in the vicinity provide waterfowl habitat, and these may be affected by the project. Wildlife impacts are intermediate. Slight hazards exist for deer and elk along both the Ridges Basin and Wildcat Canyon truck routes. The road hazard index for the Ridges Basin route is 1.91 deer kills and 0.00 elk kills per one million vehicle trips, and for the Wildcat Canyon route it is 1.66 deer kills and 0.13 elk kills.

There are no documented archaeologic or historic resources within the Pine Ridge site. However, light lithic scatter is reported directly adjacent to the site (index number 5LP00194A).

Figure 8. Geotechnical rating matrix for the Pine Ridge site.

SITE DESIGNATION: Pine Ridge Site SITE LOCATION: Sec. 5 & 6 T34N R10W, N of Ute Line

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	4
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	6
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	1
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	1
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	1
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	4
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	4
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	2
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	3
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 97

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

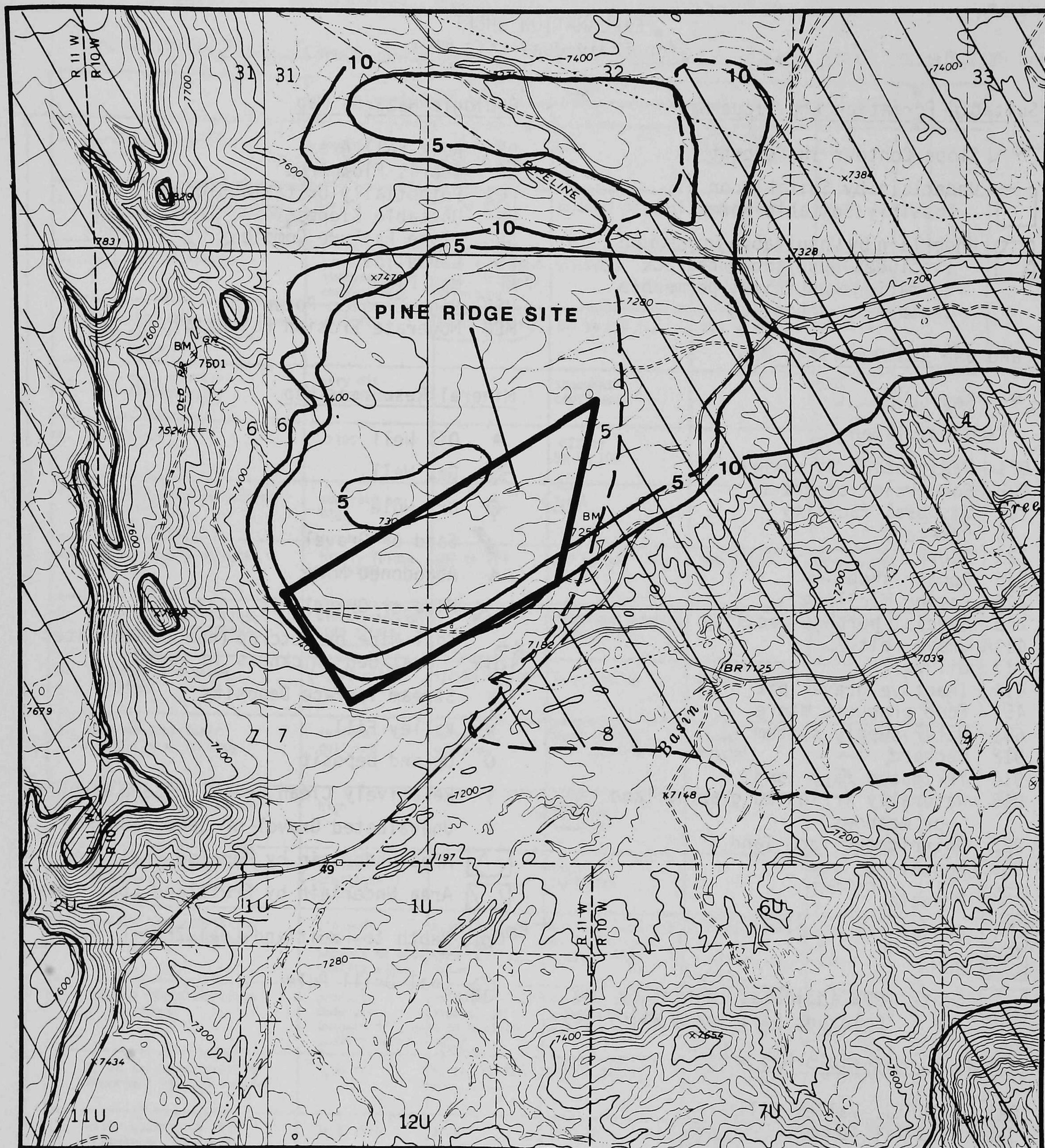

Figure 9. Suitable formation and slope map of the Pine Ridge site.

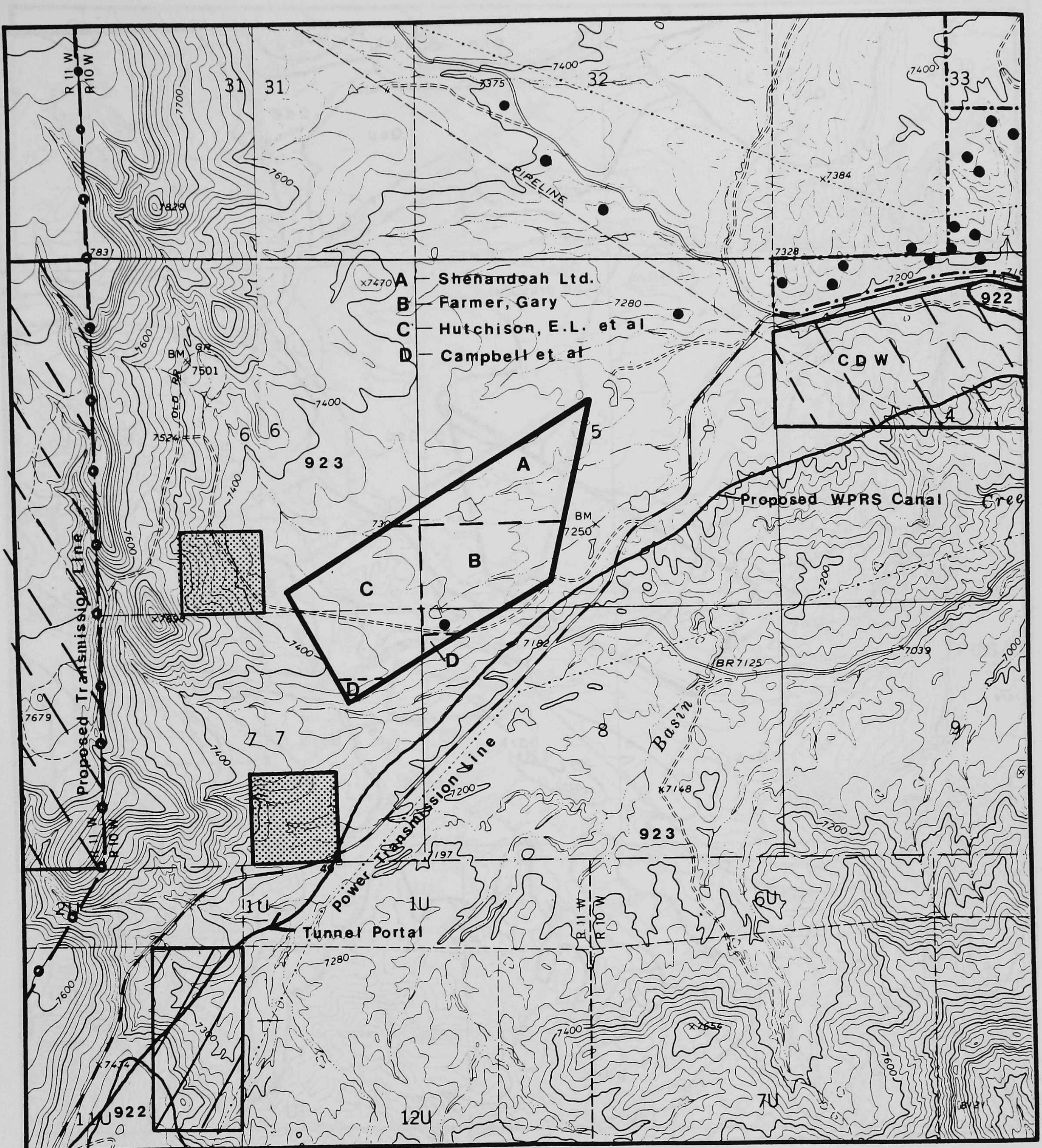

Figure 10. Land use and ownership map of the Pine Ridge site.

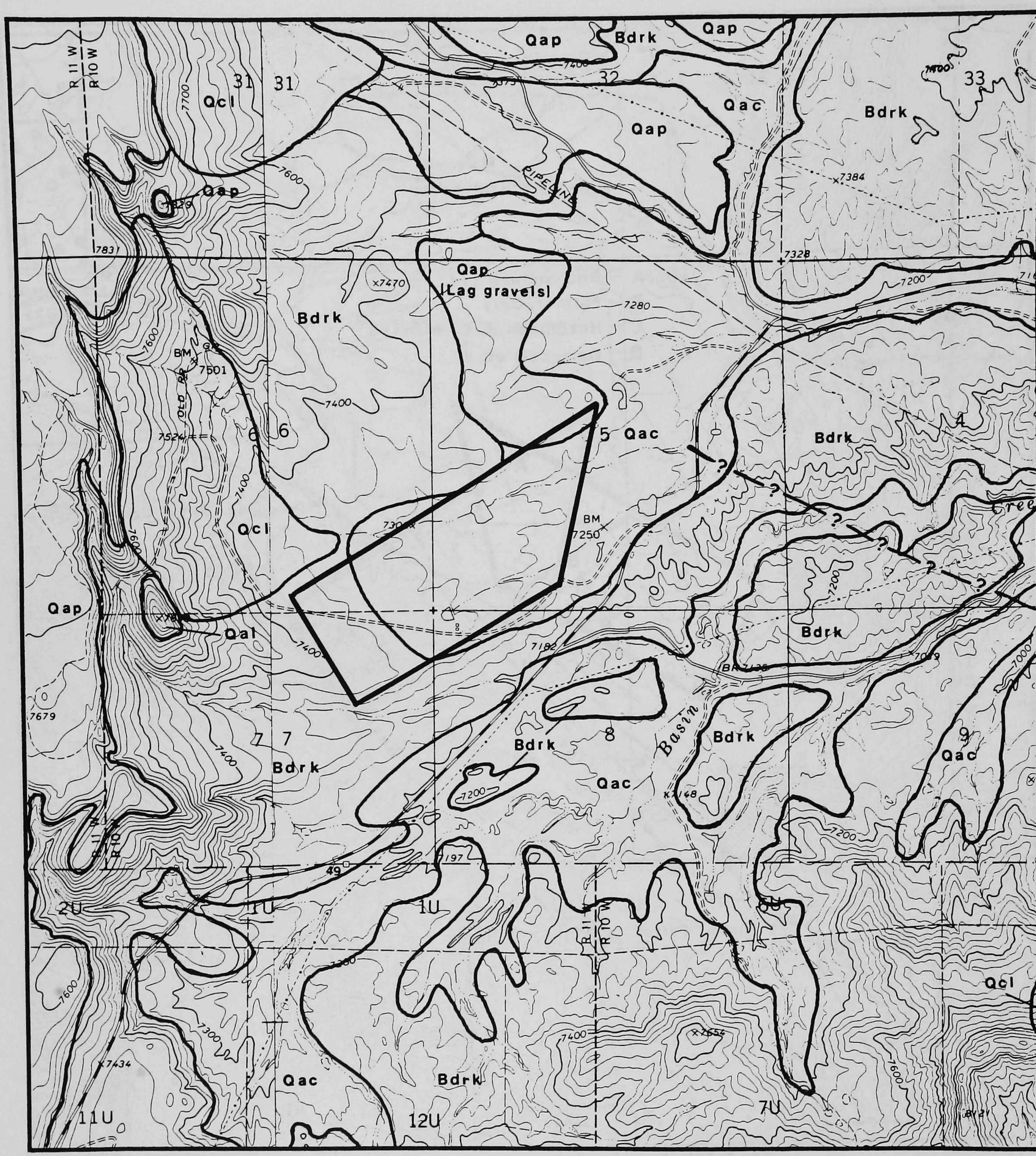

Figure 11. Surficial materials map of the Pine Ridge site.

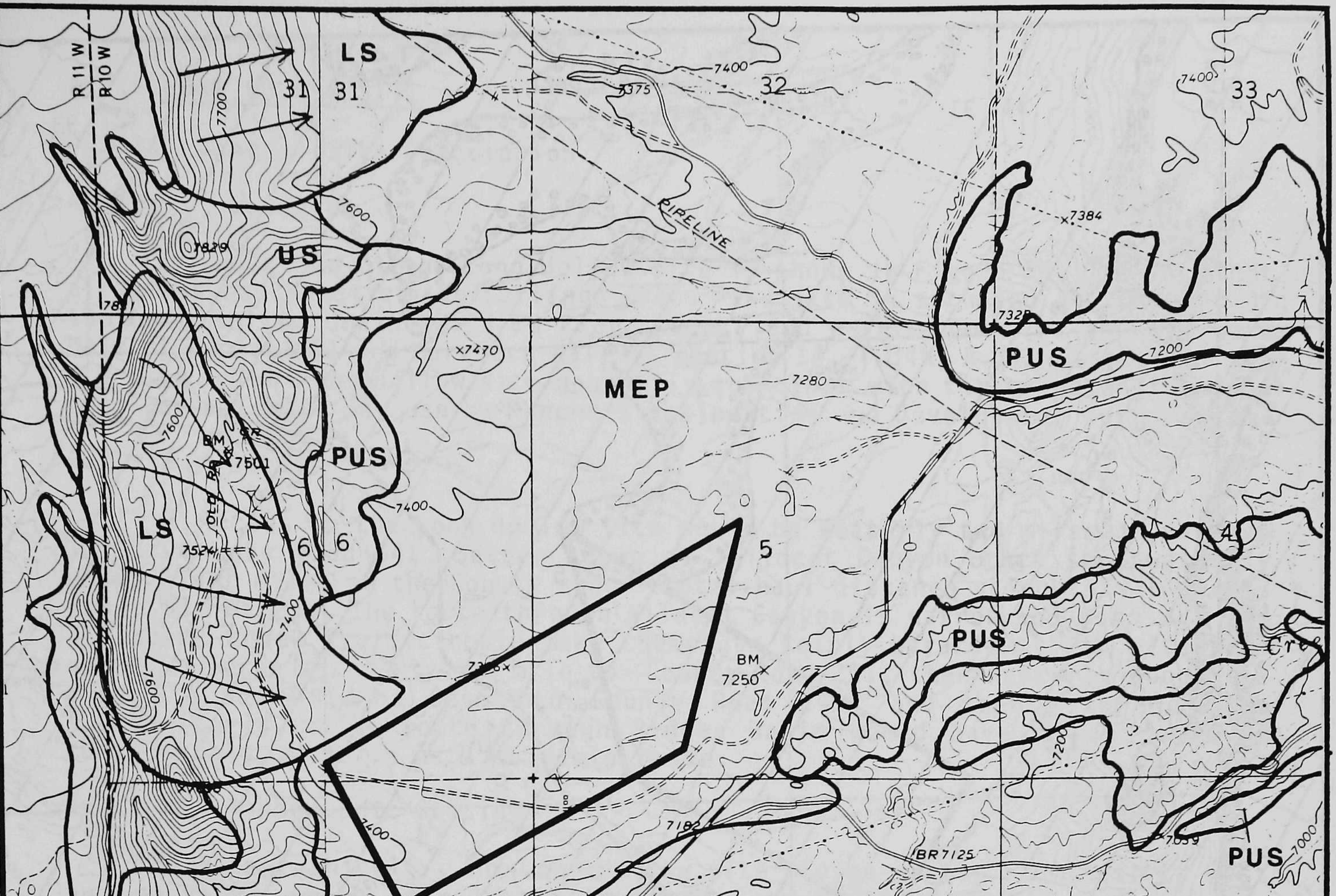

Figure 12. Geologic hazards map of the Pine Ridge site.

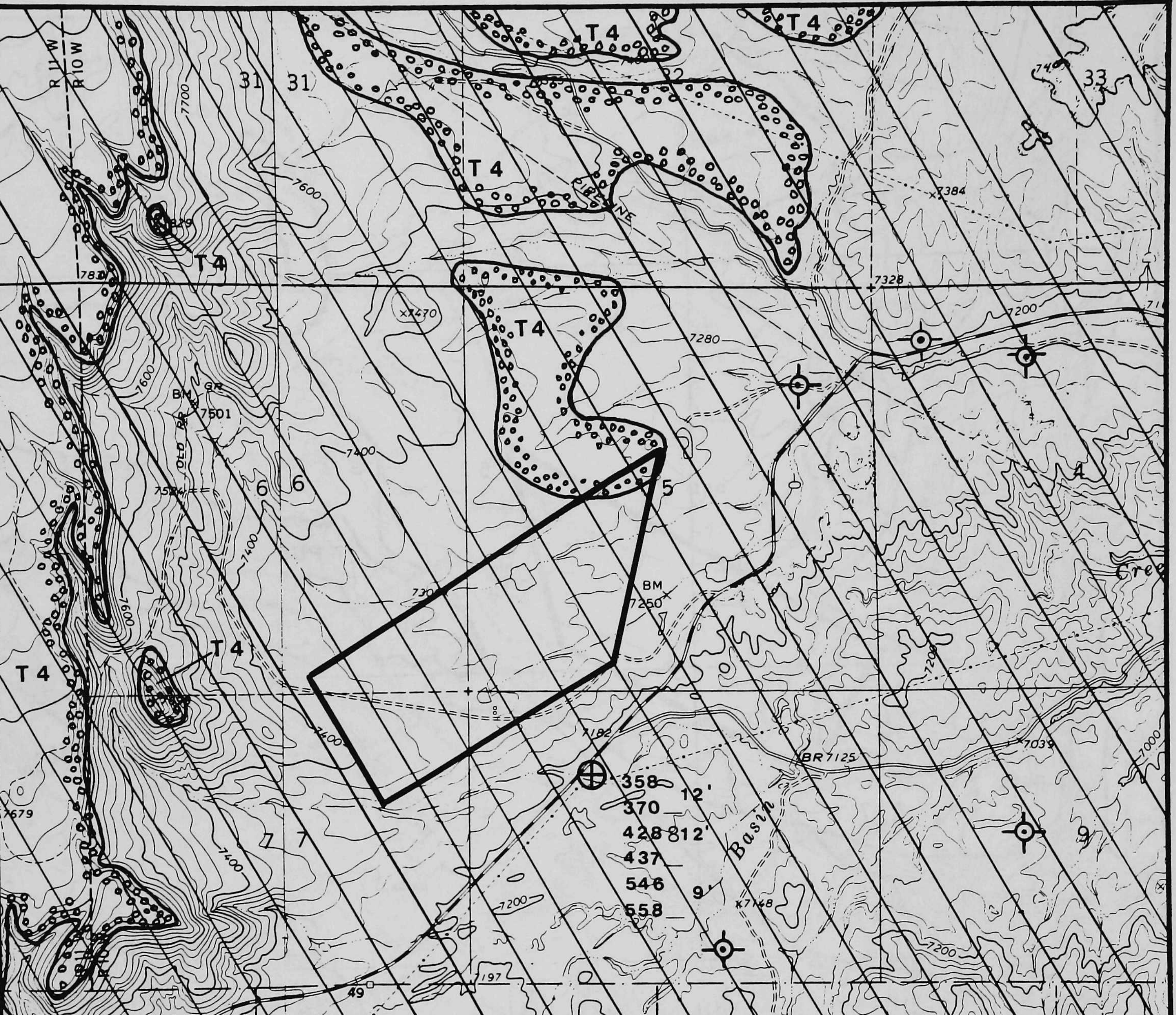

Figure 13. Mineral resources map of the Pine Ridge site.

4.3. LONG HOLLOW SITE

4.3.1. General Site Description

4.3.1.1. Location

Location of the Long Hollow site is shown in Figure 15. It is eight air miles southwest of the tailings pile. The site is situated at the head of the Long Hollow drainage in La Plata County and covers parts of the southern half of section 11 and northern half of section 14, T.34N, R.11W., south of the Ute line. The Long Hollow site generally coincides with the reprocessing site that was selected for use by Ranchers Exploration and Development Corporation.

4.3.1.2. Access

Access to the Long Hollow site would be westerly two miles on Highway 160 to County Road 141, better known as Wildcat Canyon, then southwesterly about eight miles on the County road. Total haul distance using this route is about ten miles. The route through Wildcat Canyon is narrow and winding, and the added truck traffic could make the route fairly hazardous. An alternate route would be southerly one mile to County Road 211, then westerly about six miles through Ridges Basin to County Road 141, and thence three miles southwesterly. The route through Ridges Basin would have to be improved considerably to serve as a suitable route.

4.1.1.3. Topographic Setting

Topographically, the Long Hollow site slopes gently from east to west and north to south. Gradients from north to south along the axis of the drainage basin average about one percent. From east to west the slopes are usually two to five percent, but occasionally along the outer flanks of the site, the gradients are up to ten percent. A slope map of the site is shown in Figure 15. Maximum relief across the site is about 100 feet.

4.3.1.4. Land Use

Land use on and around the Long Hollow site is shown in Figure 16. There are no buildings or other structures on or near the Long Hollow site. The area is presently utilized as a gathering and grazing area for sheep during the Spring and Fall.

A tunnel to transport waters from a proposed reservoir in Ridges Basin to the Red Mesa area will pass within a few hundred feet of the proposed site. This tunnel is part of the Animas-La Plata Water Project of the Water and Power Energy Resources services (formerly Bureau of Rreclamation) and may be constructed in the near future. The tunnel will be lined with concrete and will be below the grade of the proposed burial site.

4.3.1.5. Land Ownership

Ownership of the site is shown in Figure 16. The site is privately owned as follows:

A. Gary Farmer
2803 Oak Drive
Durango, CO 81301

B. Colorado-Ute Electric Assn.
Box 1149
Montrose, CO 81401

An option to purchase part of the site from the primary owner, Gary Farmer of Durango, was obtained by Ranchers Exploration and Development Corporation in 1978 for their proposed reprocessing operation in 1978, but it has now expired.

The Colorado-Ute land covers 160 acres in its entirety and was purchased about a year ago for a proposed substation site. The specific location of the substation has not been determined, but will probably be west of the existing transmission line and southerly from the area defined as the tailings site.

The adjoining lands are owned by local ranchers, land developers, and the Ute Indians. The nearest proposed subdivision is near Pine Ridge, about two miles north of the site. Lands adjoining the site to the west and north are suitable for subdivision into small (five to forty acres) tracts.

4.3.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Long Hollow site is given in Figure 14. The site received a score of 119, and ranks third based on the evaluated geotechnical factors. Following sections briefly summarize the geotechnical characteristics of the Long Hollow site.

4.3.2.1. Geology

As shown on Plate 3, about 600 to 800 feet of Lewis Shale underlie the entire Long Hollow site (FOCERI, 1978). The Lewis Shale consists of thick sequences of laterally persistent dark gray to black shale interbedded with thin, relatively sparse siltstone, limestone, and sandstone beds. Top of the Cliff House Sandstone is at a depth of about 700 feet below the site, top of the Menefee Formation is at about 1,000 feet, and top of the Point Lookout is at about 1,300 feet.

A relatively thin mantle of surficial materials blankets much of the Long Hollow site (Figure 17). Most of the surficial materials are alluvial or colluvial deposits and consist of clays with minor amounts of silt, sand, and gravel. Much of the coarse-grained materials are derived from the gravel capped terrace west of the site and are brought into the westernmost part of the site by slope wash. Mud flow deposits extend into part of the eastern side of the site. These deposits are a heterogeneous mass of clay, sand, and silt that is mixed with sandstone clasts derived from the hills east of the site.

Thickness of the surficial materials is variable. A numer of holes were drilled for Ranchers Exploration and Development Corporation at the Long

Hollow site (FOCERI, 1978). This drilling indicates that 0 to 23 feet of low to moderately plastic clay with some sand and gravel zones overlies weathered and unweathered bedrock (F.M. Fox & Associates, 1978).

Soils on the Long Hollow site are described as the Witt-Falfa-Potts association. They are warm, deep, well drained, gently sloping and sloping soils on uplands (U.S. Dept. of Agriculture, 1972a).

The Long Hollow site is situated on a gentle monocline on the northwest flank of the San Juan Basin. Regionally, the beds in this area dip about 6° to the southeast, away from the La Plata Mountains and towards the center of the basin. The Perins Peak syncline and Durango anticline are immediately north of the site. These features are minor structures that plunge to the south towards the Long Hollow site and may converge at or near it.

The nearest mapped fault is approximately four miles from the site (Zapp, 1949). Recent, unpublished mapping by the U.S. Geological Survey show a fault within 2 and 1/4 miles of the Long Hollow site (D. Moore, 1980, personal communication). FOCERI (1978) points out that anomalous steep dips occur in the Lewis Shale about one mile NNE from the site and that these may possibly be related to faulting.

Fracturing and jointing in the Lewis Shale host rock on the site is variable (F.M. Fox & Associates, 1978). Near the surface the formation ranges from unfractured to highly fractured shale. Most fractures are open.

The present erosional rate at the Long Hollow site is low. Small rills are present over some of the area, whereas other parts of the site are areas of deposition. Gullies have recently formed in some of the drainages to the east of the site, but these generally do not extend into the site area. The main drainage down Long Hollow has eroded into the valley floor to a limited degree, but the erosion is presently occurring at a relatively low to moderate rate on the site.

The potential for future erosion at the Long Hollow site is classified as moderate on Figure 18. This is based on the type of the surficial materials and bedrock at the site and the overall erosional characteristics of the Long Hollow drainage. The drainage just north of the site, the upper reaches of Basin Creek, is classified as an area with high erosion potential. The head of this drainage appears to be advancing towards the Long Hollow site by headward erosion. Rate of advancement should be considered when designing the layout of the Long Hollow site to avoid potential future erosion problems associated with Basin Creek. Immediately south of the site, the erosion potential is high along the main drainage, and this also must be considered in future studies.

Other geologic hazard areas that are relevant to the Long Hollow site are shown on Figure 18. An area of unstable slopes lies just west of the site. Future slope failure movements in this designated area should not affect the long-term security of a repository placed on the Long Hollow site. Such movements, however, could possibly affect access roads to the site, and precautions should be taken to avoid this minor problem. A small area of potentially unstable slopes that are associated with a bedrock hill is present just east of the site. This area should not cause stability problems unless it is disturbed by construction activities. Several mud flows extend from the hills east of the site into the site area. In the site area the mud flows are primarily in a depositional mode. Similar mud flows in the future should not disrupt the final repository. Such an event could actually be beneficial by placing additional material over the repository.

Only minor mineral resource conflicts are associated with the Long Hollow site. Figure 19 indicates the mineral resource distribution in the site area. Potentially economic coal beds occur in the Menefee Formation beneath the Long Hollow site, but these coal beds are probably 1,000 to 1,200 feet deep. Future extraction of these coals is possible, but unlikely. No economically significant gravel deposits occur on the site. The nearest possible source of riprap is immediately west of the site on Red Mesa. Oil or gas could be present beneath the site, but there is no evidence to indicate significant accumulations. The nearest hydrocarbon test wells are more than one mile away (sec. 8, T.34N., R10W., north of the Ute line, and sec. 27, T.34N., R.11W. south of the Ute line). None of these wells produced economically significant quantities of oil or gas.

4.3.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the Long Hollow site. The creek that drains Long Hollow is intermittent within the site area. A small stock pond is present on the north end of the site, but it often dries up in late summer or fall. Several small perennial ponds are one to two miles north and northeast of the site, but these are not within the Long Hollow drainage basin. The Long Hollow drainage joins the La Plata River about and 13 and 1/2 miles below the proposed site.

Surficial materials at the Long Hollow site contain only very minor amounts of generally poor quality water and this water is probably seasonal in nature. The Lewis Shale host rock generally produces a minor amount of poor quality water (Brogden and Giles, 1975). Detailed site studies by F.M. Fox & Associates (1978) identified a shallow zone of perched water that occurs within fractured Lewis Shale. The water-bearing zone is confined by weathered shale above and unfractured shale below, and is thought to be present only during the wet seasons (FOCERI, 1978). This perched water zone may present some problems for below grade disposal.

The first underlying potential aquifer that may be an important source of ground water is the Cliff House Sandstone. It lies about 600 to 800 feet below the ground surface. Water quality in this formation is variable, ranging from average to very poor (Brogden and Giles, 1976). This formation is not always a reliable source of water, and it may be necessary to go even deeper to find the first important underlying aquifer. A test well drilled by Ranchers Exploration and Development Corporation on the Long Hollow site encountered only very minor amounts of water in the Cliff House Sandstone and Menefee Formation. Even the Point Lookout Sandstone yielded only small quantities of water. This scarcity of ground water, though beneficial from an environmental standpoint, could cause water supply problems for reprocessing the tailings.

4.3.3. Environmental Factors

Vegetation at the Long Hollow site is primarily grassland and sagebrush with oakbrush at the east edge and pinon-juniper at the west edge. It is a flat area with little relief and no occupied dwellings nearby. The grassland is heavily grazed. The site provides very little wildlife habitat for any species, and especially little for deek, elk, and turkey. Use of this site would have little or no significant adverse impact on wildlife. Two small ponds provide some waterfowl habitat. The truck route to the site poses a slight hazard to deer and elk from collisions on U.S. Highway 160. Road hazard on the Ridge Basin route is 1.91 deer kills and 0.00 elk kills per one million vehicle trips. Wildcat Canyon route is 1.66 deer kills and 0.13 elk kills. Of the twelve sites, Long Hollow presents the least wildlife hazard.

While numerous small, unexcavated ruins of early American cultures are known to exist in the general region, particularly in Ridges Basin a few miles northeast of the Long Hollow site, no evidence of such ruins is apparent on the site. There are no potential or registered national landmarks on the site.

Figure 14. Geotechnical rating matrix for the Long Hollow site.

SITE DESIGNATION: Long Hollow Site SITE LOCATION: Secs. 11 & 14 U, T34N, R11W

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	5
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	6
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	4
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	3
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	4
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	4
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	3
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 119

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

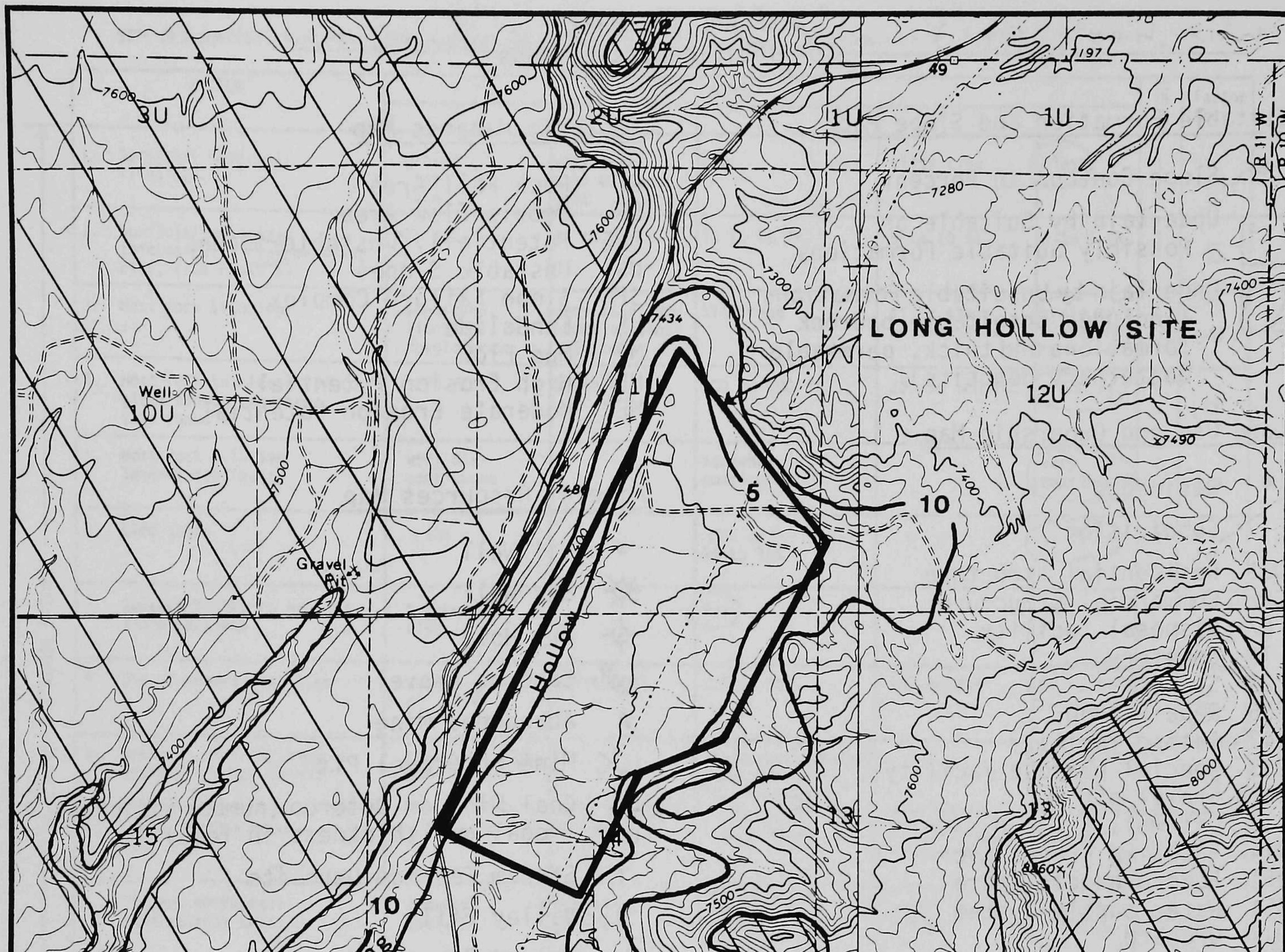

Figure 15. Suitable formation and slope map of the Long Hollow site.

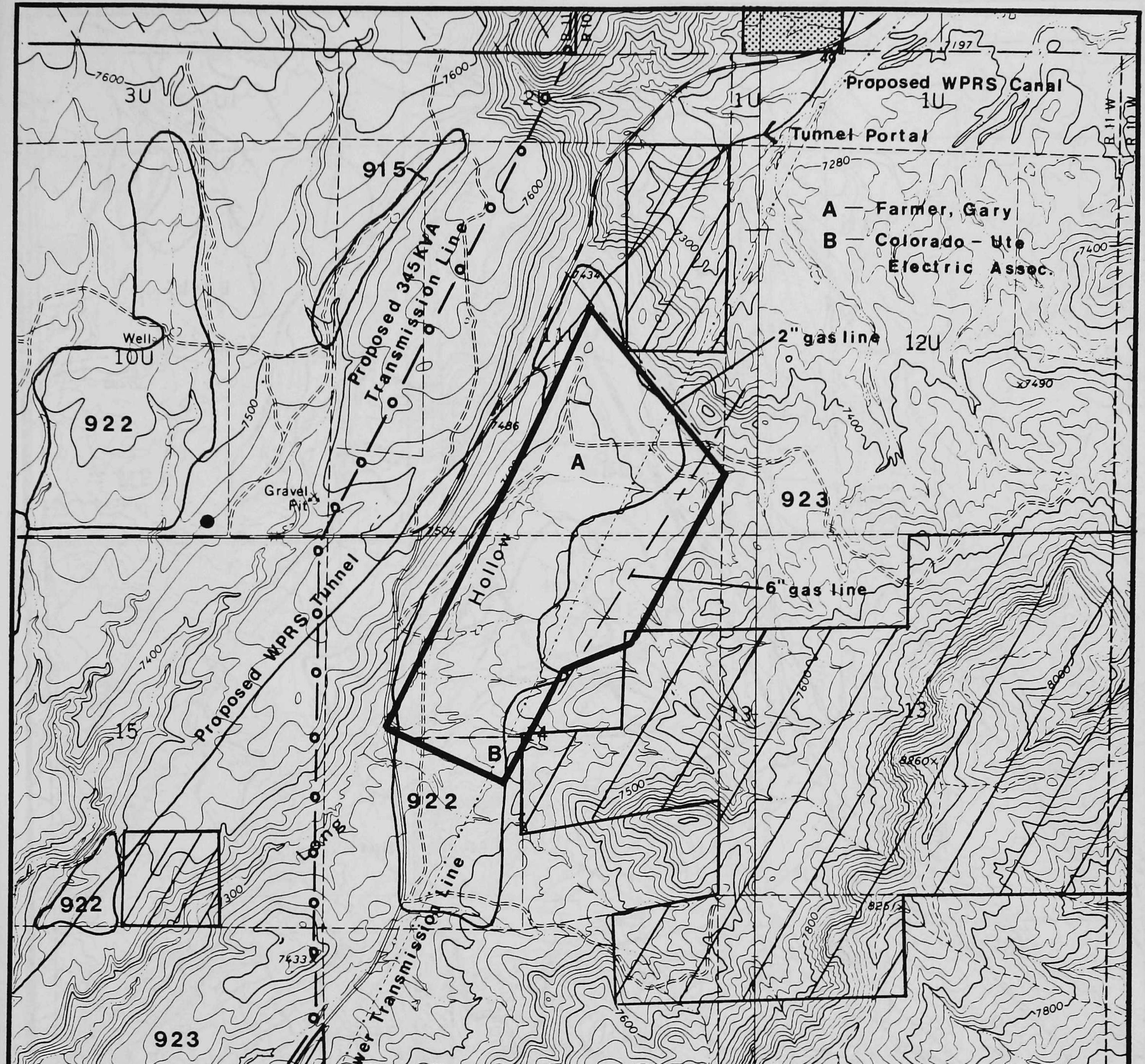

Figure 16. Land use and ownership map of the Long Hollow site.

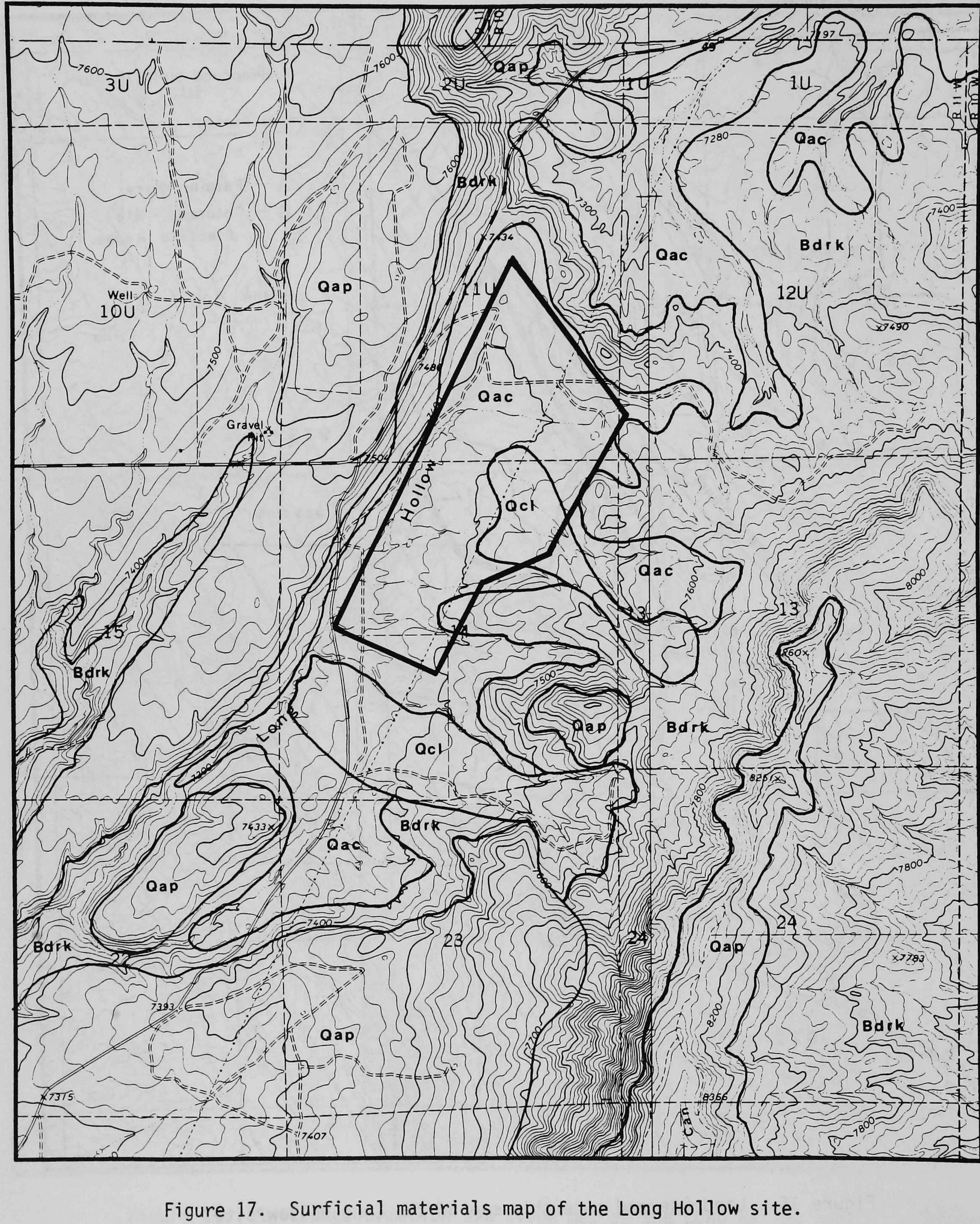

Figure 17. Surficial materials map of the Long Hollow site.

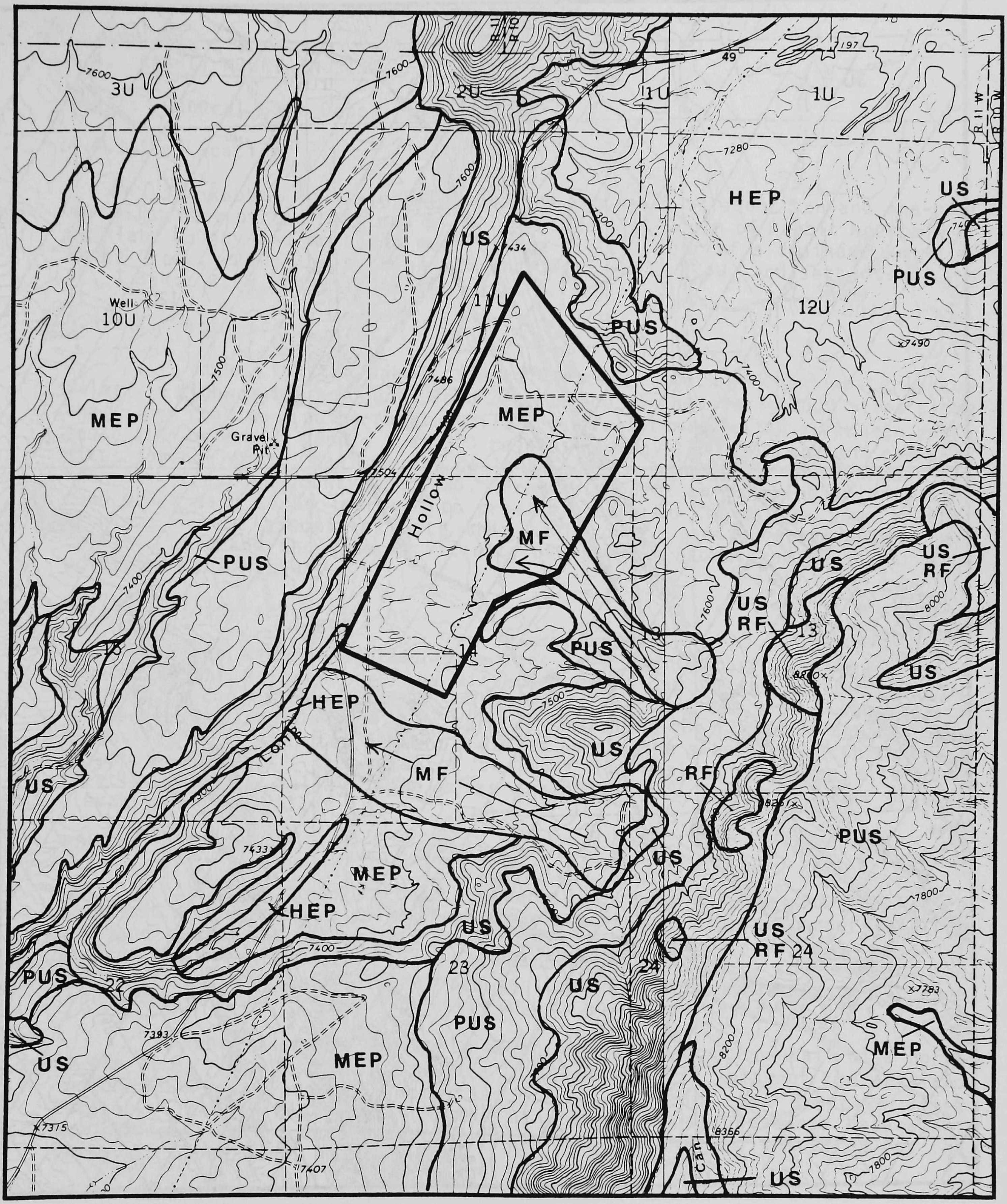

Figure 18. Geologic hazards map of the Long Hollow site.

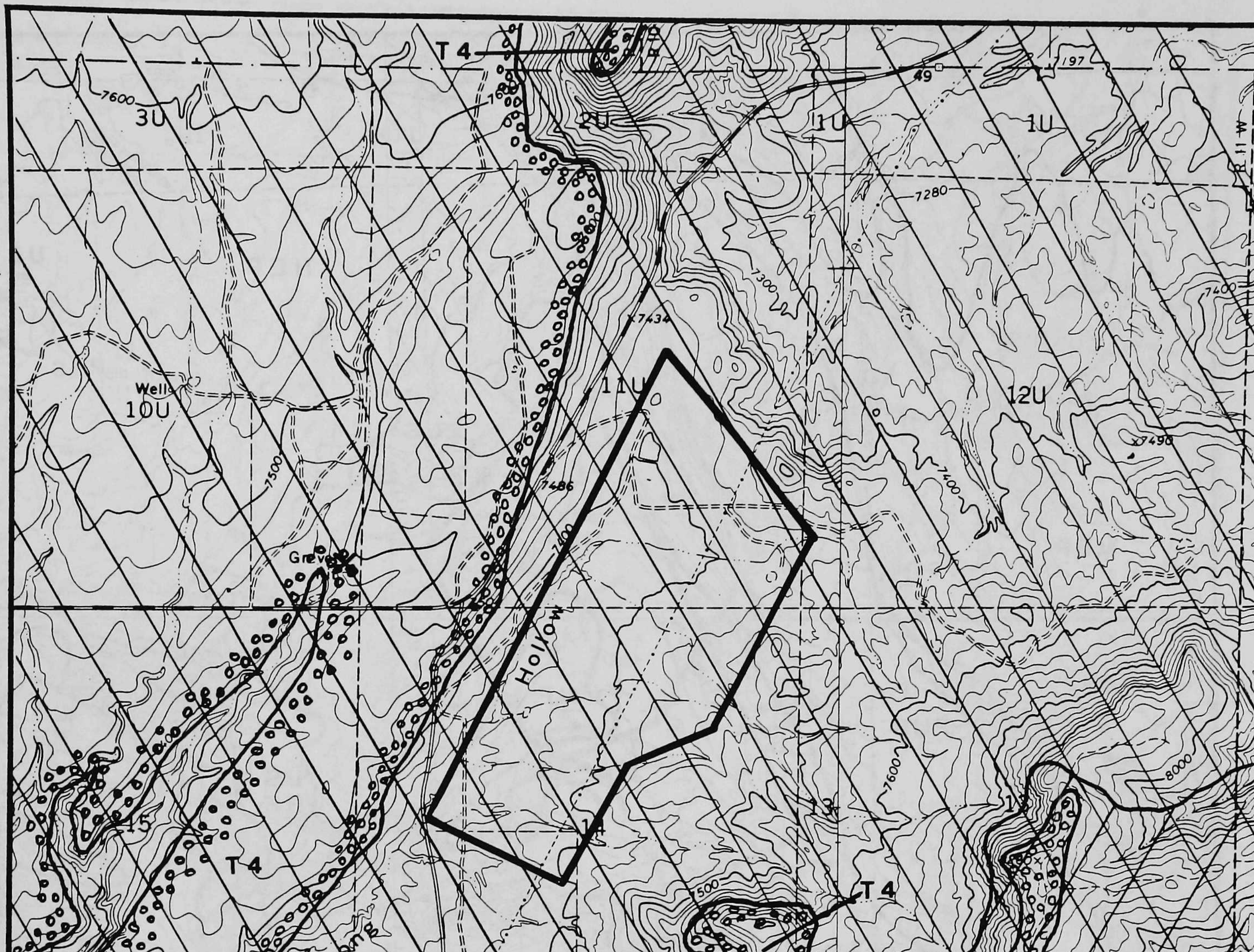

Figure 19. Mineral resources map of the Long Hollow site.

4.4. RABBIT MOUNTAIN SITE

4.4.1. General Site Description

4.4.1.1. Location

The Rabbit Mountain site shown on Figure 21 is about ten and one-half air miles east of the tailings pile. The site lies south of Rabbit Mountain in La Plata County and occupies most of the valley floor of a drainage known as Homer Creek. Parts of sections 25 and 36, T.35N., R.8W. and sections 30 and 31, T.35N., R.7W. constitute the site.

4.4.1.2. Access

Access to the Rabbit Mountain site is southerly and westerly ten miles via Highway 160 to County Road 223, thence northeasterly four miles along the County road to a point about a mile south from the site. An alternate route could also be used. County Road 223 rejoins Highway 160 about one and one half miles further east. Haul trucks could follow the highway to this turnoff and then back track on County Road 223. From this point an existing private dirt road would have to be improved to provide access to the site. Some traffic problems may be associated with this haul route, particularly between the tailings pile and the general vicinity of Elmore's Store, and at any trunoff point from the highway.

4.4.1.3. Topographic Setting

The Rabbit Mountain site lies in a fairly narrow valley that is bounded on the east and west by dissected mesas and on the north by Rabbit Mountain, a conical-shaped hill. The central part of the site slopes two to ten percent towards the valley center. Slopes along the flanks of the site are slightly greater than ten percent. Relief across the site from north to south is about 240 feet. The mesas on the east and west confine the site to a relatively narrow valley. The mesas are 300 to 500 feet above the general elevation of the valley floor.

4.4.1.4. Land Use

Land use on and around the Rabbit Mountain site is shown on Figure 22. Most of the site is unimproved rangeland with a cover of ponderosa pine, oak, and sagebrush, with pinon and juniper in the lower elevations. A small part of the area has been cleared and subjected to a small scale irrigation effort. Other evidences of previous habitation include the ruins of a dugout type homestead shelter near the site and an abandoned sawmill.

A subdivision is presently being developed about one-half mile north of the site. Other subdivisions are in the general vicinity of the area and include Foxfire, Tecolote, Homestead, Cedar Mountain, and Mountain Vista Estates. The Regional Plan for the La Plata Land and Resource Management Program sets forth a desired growth pattern of one unit per ten acres for the privately owned lands in this area.

4.4.1.5. Land Ownership

Land ownership of the area on and near the Rabbit Mountain site is shown in Figure 22. Private lands within the Rabbit Mountain site are owned by:

A. Richardson, Gene E. and Orin S.
   Burkett, James R.
   4611 Royene N.E.
   Albuquerque, N.M. 87110

As shown on the ownership plat (Figure 22), a small part of the site is within public domain lands administered by the BLM.

4.4.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Rabbit Mountain site is given in Figure 20. The site received a score of 102, and ranks seventh based on the evaluated geotechnical factors.

4.4.2.1. Geology

As shown on Plate 3, at approximately 1,000 feet of Animas Formation underlies the Rabbit Mountain site. This thickness estimate is based on outcrop data and structural projections using nearby surface dips, and on formation thicknesses and structure contour maps presented by Fassett and Hinds (1971) and Barnes (1953). The Animas Formation consists of dark varicolored claystone and shale interbedded with sandstone and conglomerate of volcanic origin. The aforementioned flat-topped hills or mesas that surround the Rabbit Mountain site are capped by well indurated sandstone beds. Shale sequences within the Animas Formation are generally laterally persistent, but sandstone beds are often very lenticular.

Most of the site is underlain by a wedge-like mantle of mixed colluvial and slope wash surficial deposits (Figure 23). The dominant lithology of these surficial deposits is silty clay, but some thin sandy zones and occasional gravel clasts are locally included. Maximum thickness of these deposits is about 20 to 25 feet, based on exposures in gullies on the south end of the site. The mixed colluvial and slope wash deposits pinch out over bedrock along the flanks of the drainage. A small part of the north end of the site may be underlain by colluvial deposits of landslide origin. These deposits are probably a mixed unit of clay, sand, and bedrock fragments.

Soils on the Rabbit Mountain site are classified as the Argiustolls-Haploborolls association. They are described as cool, dominantly moderately deep and deep, well drained, sloping to steep soils on mountain slopes (U.S. Dept. of Agriculture, 1972a).

Structurally, the Rabbit Mountain site lies within the San Juan Basin about four miles south of the Hogback monocline. On the site beds generally dip 1° to 3° south. Fracturing in the Animas Formation is variable. Bedrock exposures in the bottom of a few gullies suggest jointing at the site is moderately spaced and usually open. The nearest known faulting is over five miles from the site (Zapp, 1949; Barnes, 1953; Steven and others, 1974).

The present erosion rate is low to moderate over most of the site, particularly to the north of the small pond in the center of the site. No serious gullying was observed north of this pond, however to the south, the main drainage has cut deeply (15 to 20 feet) into the valley floor during the past few decades. The erosion potential for the entire site is classified as moderate (Figure 24), but the potential for future erosion is high along a narrow band adjacent to the main drainage below the small pond in the center of the site. This narrow area should probably be avoided if the site is selected as the final repository, but it may be possible to reduce this erosion problem be proper engineering.

Figure 24 shows other geologic hazards that could potentially affect the Rabbit Mountain site. A small part of the northern end of the site is mapped as a possible landslide area. Further work is needed to accurately evaluate this feature. Our reconnaissance work suggests the slope failure occured high on Rabbit Mountain above the site, and the released material was deposited on the site. Such an occurrence would actually be beneficial to the security of the site after completion of the project, because this process would add more cover over the repository. If additional studies indicate this landslide is detrimental to the repository, the site boundary could be moved southward out of the hazard area.

Figure 24 also indicates that the site is bounded on three sides by potentially unstable areas. These areas should cause no problem unless their equilibrium conditions are altered by construction activities associated with the repository. Because the site is fairly narrow and is confined by these potentially unstable slopes, this could be a problem that would have to be carefully approached during design phases and monitored during construction phases.

There are some conflicts between use of the site and mineral resources (Figure 25). Coal beds in both the Menefee and Fruitland Formations underlie the site, but they are over 1,500 feet deep. The site owners, however, indicated at the December 15, 1981 Site Selection Committee Meeting that the coal rights to section 36 have been recently leased.

The most significant mineral resource conflict relates to natural gas. In 1951 a shallow, dry oil test was drilled on the site. Within the past few months, however, a gas field has been discovered in this area. A number of gas wells have been recently completed in the general vicinity of the site. One planned well within this new field is located near the center of the site, and another lies to the north in section 25. The operator of this field plans to run a feeder pipeline through the site if the wells in sections 25 and 36 are successful.

No gravel deposits occur on or near the site. Local sandstone and conglomerate might possibly be used as riprap for the cap, but the nearest potential source of gravel is about four miles away.

Although this area is not a known geothermal area, there is some indication that geothermal resources may underlie the site. The 2,500 feet deep, dry oil test well in section 36 was converted to a warm water well that is artesian. The well has an adjudicated yield of 1,000 gpm and the water temperature is reportedly about 50°C. Our rough calculations suggest this temperature is warmer than what would be expected under normal gradient conditions.

4.4.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the site. The nearest important source of surface water is over two miles from the site. Homer Creek, an intermittent stream, runs through the site. An area of one to two square miles drains into the site. Homer Creek joins Dry Creek one mile downstream from the site. Dry Creek flows into the Los Pinos River about eight miles below this stream junction.

Surficial materials at the Rabbit Mountain site carry minor amounts of water that probably is of average to poor quality. Small springs occur on and near the site, but these dry up during prolonged dry periods. The springs on the site issue from the surficial materials at or near the contact with underlying bedrock, and are found at the bottom of the gully just south of the small stock pond. Total discharge from all the springs has been estimated at 10 gpm.

Although the Animas Formation contains thick shale and claystone sequences, it is nonetheless considered to be an important aquifer (Brogden and Giles, 1976; Brogden and others, 1979; Hutchinson and Brogden, 1976). Several wells within one to three miles of the site obtain water supplies from the Animas Formation. Records held by the Colorado State Engineer's office indicate these wells often yield one to fifteen gpm from depths generally ranging from 50 to 100 feet. Some wells are deeper than 100 feet, and a few are shallower than 50 feet. An unregistered well just north of the site is reportedly 185 feet deep. The aquifer tapped by this well is under confining pressures, as evidenced by the shallow depth to water in the well. Thus, important ground-water supplies could probably be obtained from relatively shallow depths beneath the site. Quality of water from the Animas Formation is variable, usually ranging from average to poor (Brogden and others, 1979; Hutchinson and Brogden, 1976).

4.4.3. Environmental Factors

Vegetation on the Rabbit Mountain site is primarily pinon-juniper-oak with considerable mature ponderosa pine in the northern part and some sagebrush areas at the south. Topography is rolling and no inhabited houses occur near the prime portion of the site. This is excellent wildlife habitat, especially for deer, elk, and turkeys. Approximately one hundred elk wintered in this area in 1979-1980. Road hazard is high, at 8.68 deer kills and 0.78 elk kills per one million vehicle trips. Owners of the site report that Bald Eagles have been observed on the site.

There are no documented archaeologic or historic resources within or adjacent to the Rabbit Mountain site according to the records of the Colorado Historical Society. No significant impacts to cultural resources are anticipated, however, the dugout homestead shelter just northwest of the site deserves further evaluation.

Figure 20. Geotechnical rating matrix for the Rabbit Mountain site.

SITE DESIGNATION: Rabbit Mountain SITE LOCATION: Secs. 25 & 36, T35N, R8W and Secs. 30 & 31, T35N, R7W

	FACTOR	RANK 1	2	3	4	5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	6
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	6
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	6
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	5
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	3
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	6
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	4
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	5
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	3
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 103

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

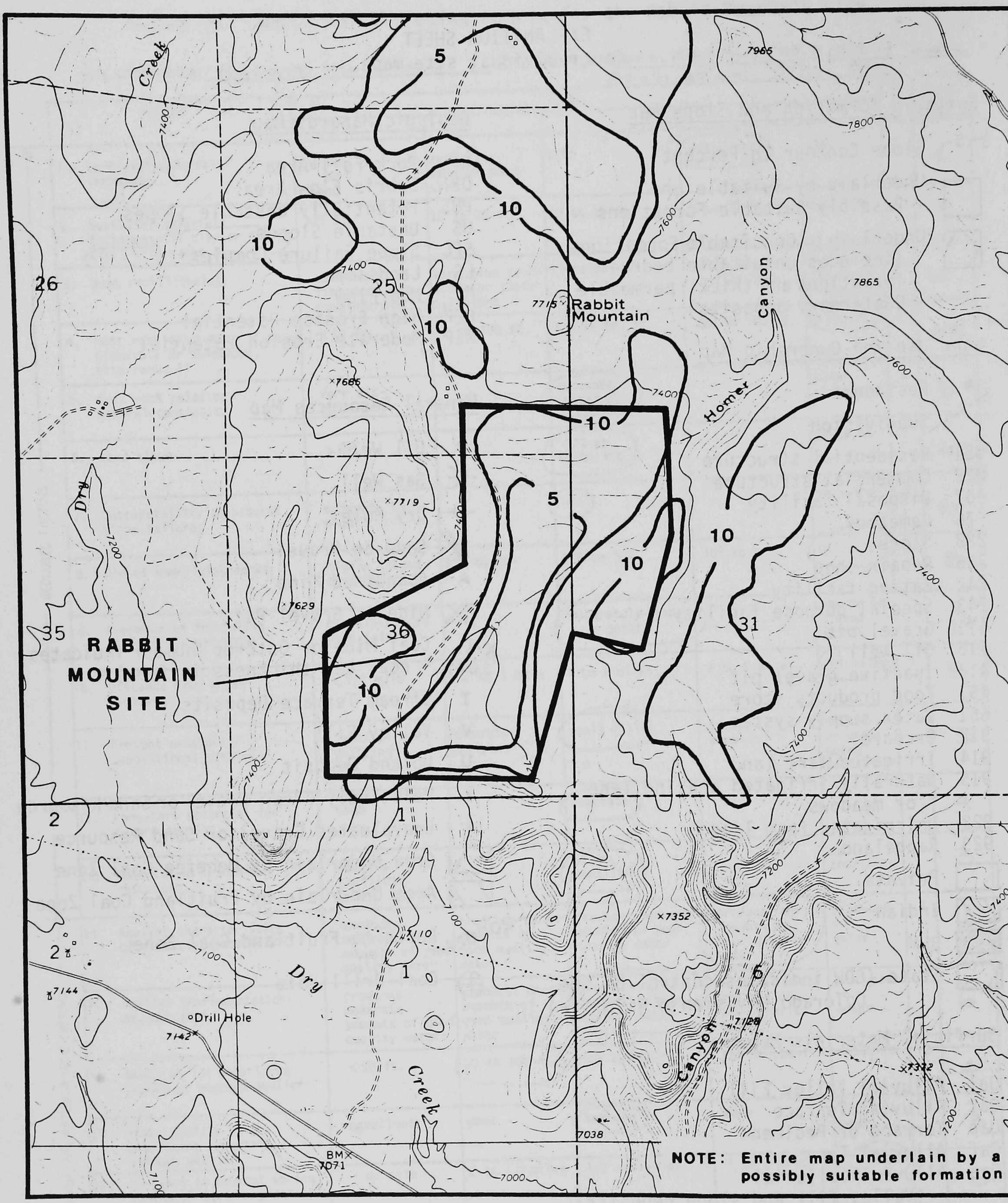

Figure 21. Suitable formation and slope map of the Rabbit Mountain site.

new homes may have recently been built
in this part of the subdivision

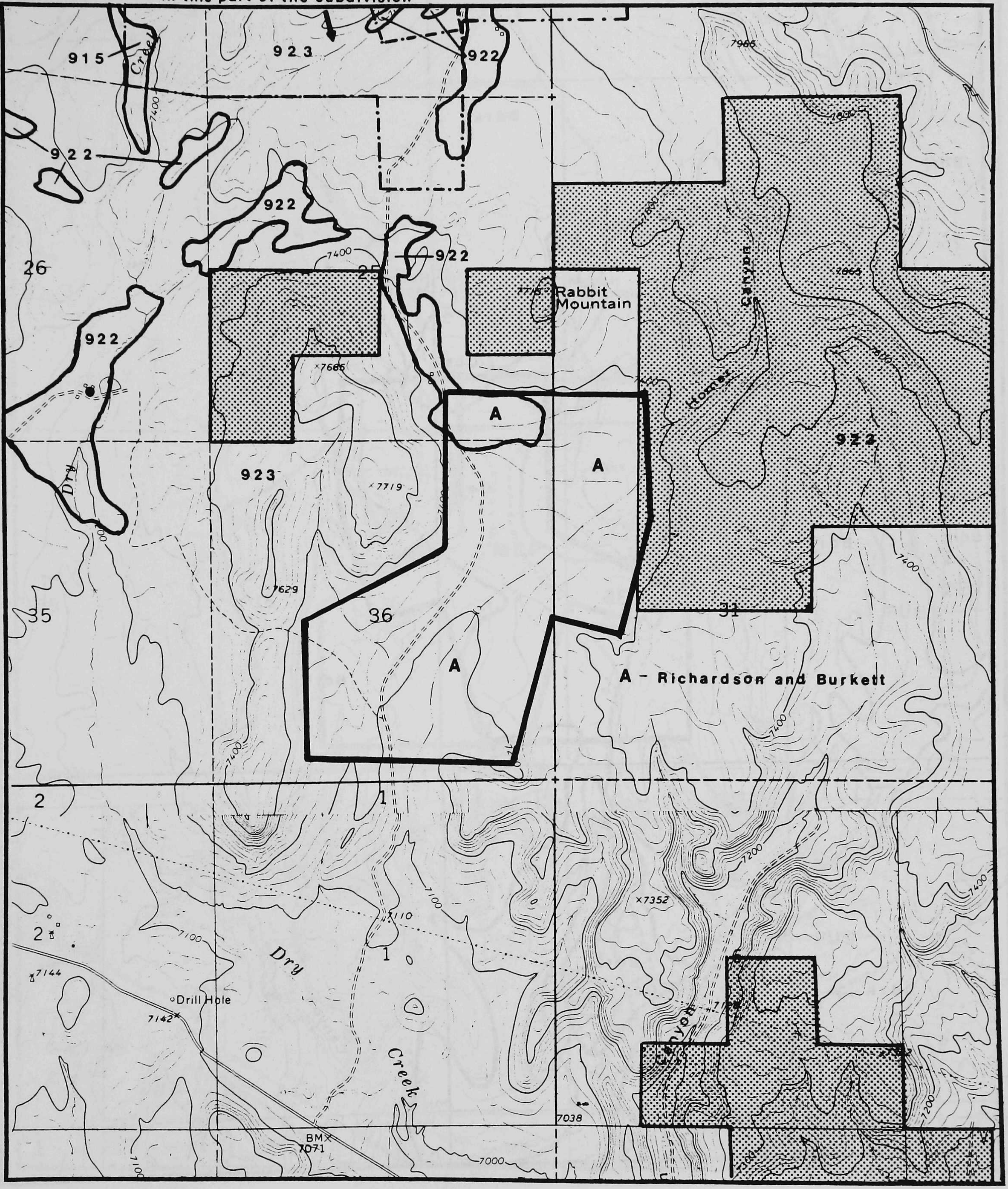

Figure 22. Land use and ownership map of the Rabbit Mountain site.

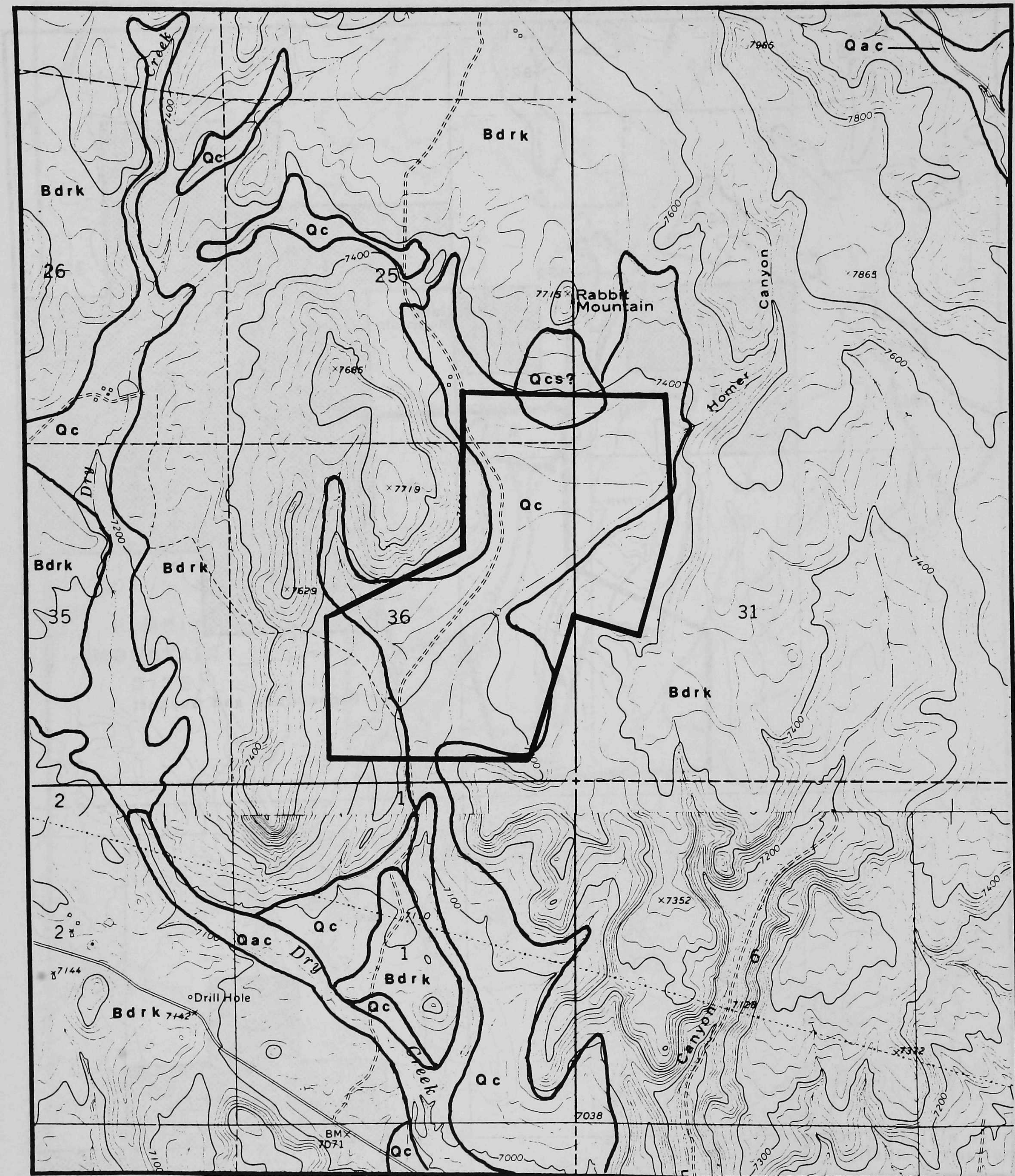

Figure 23. Surficial materials map of the Rabbit Mountain site.

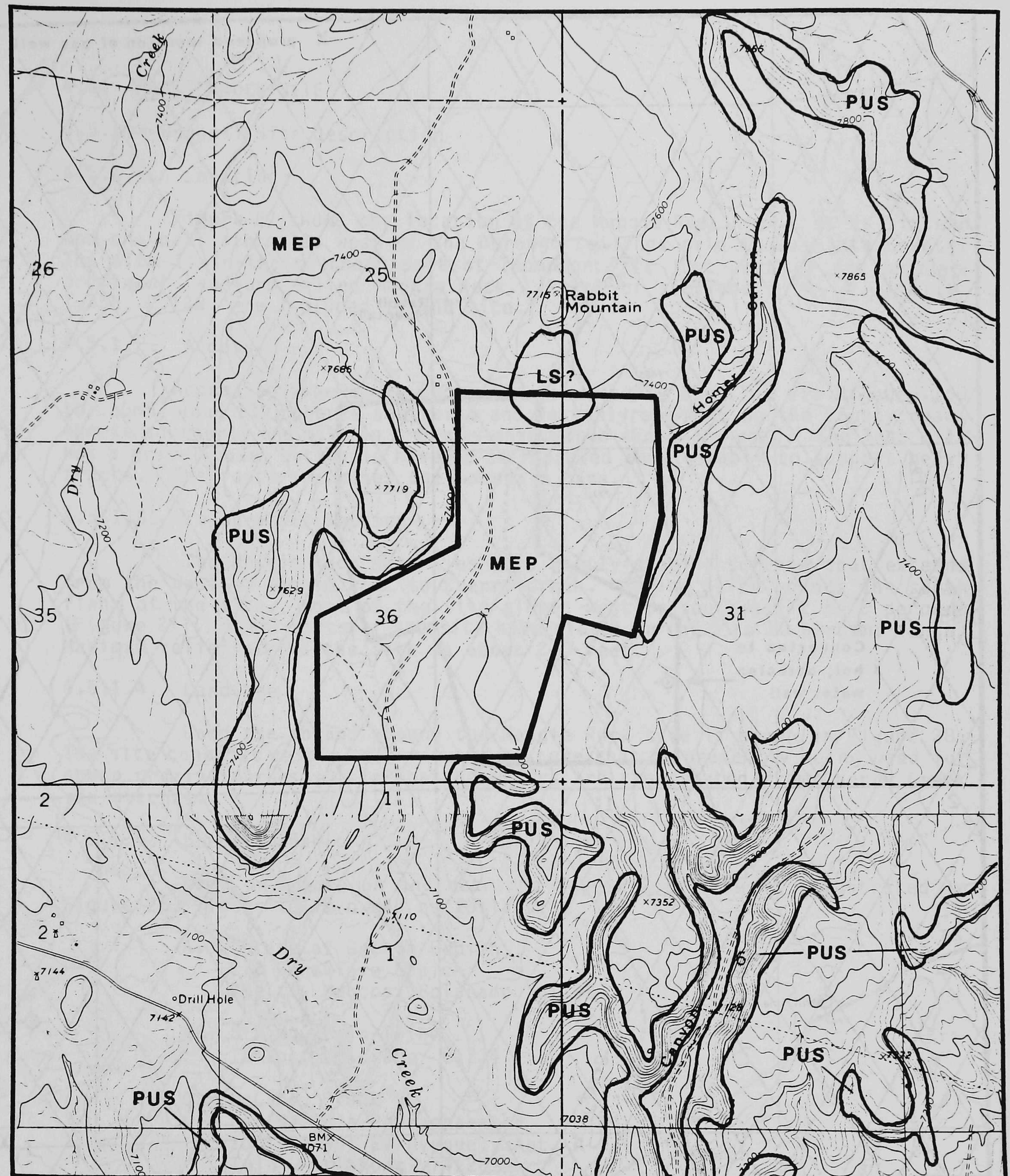

Figure 24. Geologic hazards map of the Rabbit Mountain site.

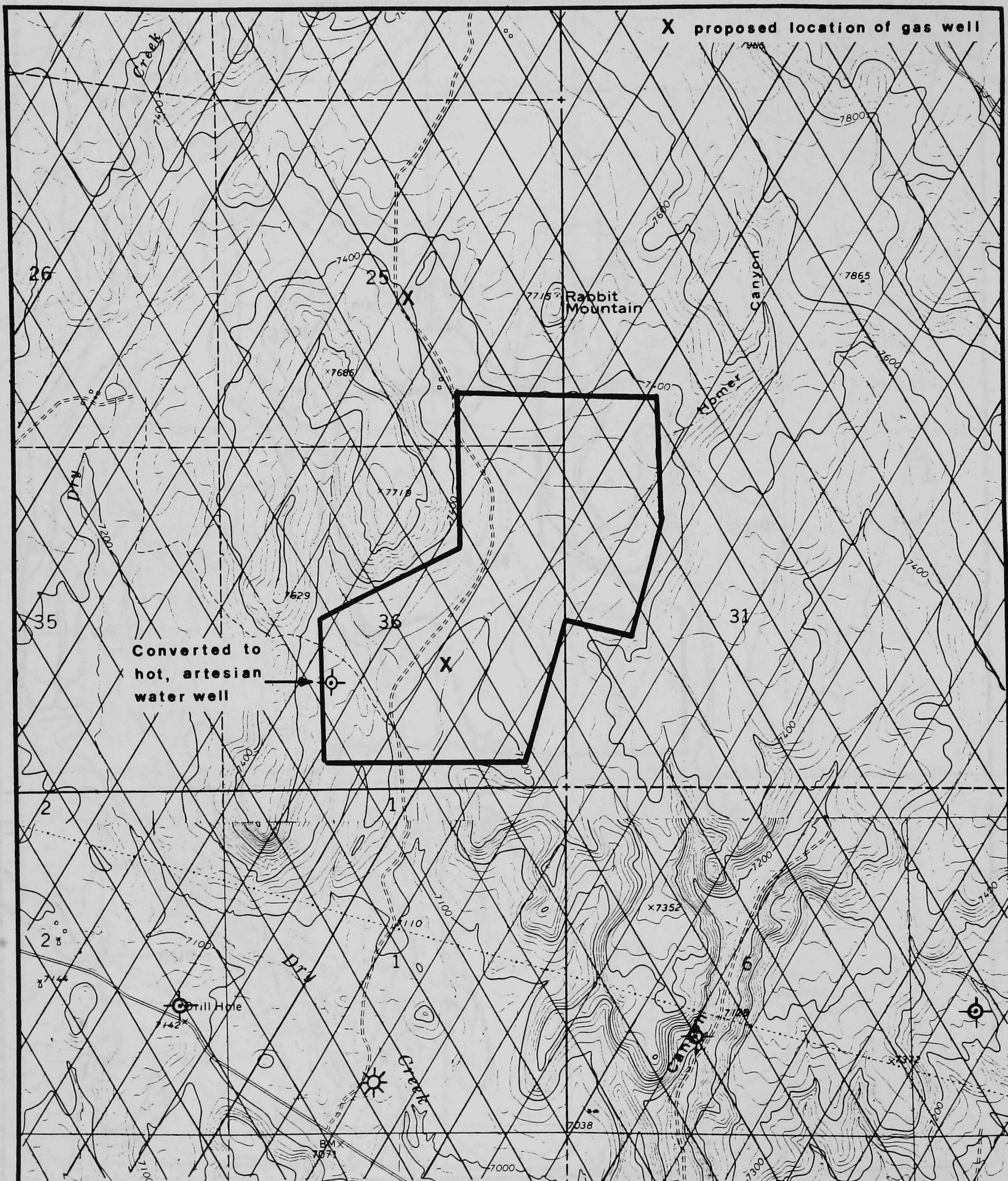

Figure 25. Mineral resources map of the Rabbit Mountain site.

4.5. MAGGIE ROCK SITE

4.5.1. General Site Description

4.5.1.1. Location

Figure 27 shows the location of the Maggie Rock site. It is sixteen and one-half air miles west of the Durango tailings pile in La Plata County. The site is in the southern part of Thompson Park just west of and below a prominent landform called Maggie Rock. Parts of sections 3, 4, 9, and 10, T.35N, R.12W. are included in the site.

4.5.1.2. Access

Access to the Maggie Rock site is westerly 19 miles via Highway 160 to County Road 139, thence southerly and westerly one mile on the County road, thence southerly one mile on a poorly maintained secondary road. The last mile has a gravel base, but would have to be improved considerably to support heavy trucks. The route traverses one mountain pass.

4.5.1.3. Topographic Setting

The Maggie Rock site lies on a gently sloping surface that extends from the base of Maggie Rock to Cherry Creek. Spring Gulch bounds the south flank of the site. Most of the site slopes west or southwest 2 to 5 percent (Figure 27). Small parts of the site have slopes in the 5 to 10 percent range. Maximum relief across the site is about 230 feet.

4.5.1.4. Land Use

Land use on and around the Maggie Rock site is shown in Figure 28. The site consists mostly of irrigated pasture that is presently being used for sheep grazing purposes. Irrigation waters are transported from Cherry Creek via ditches.

4.5.1.5. Land Ownership

Land ownership on and near the Maggie Rock site is illustrated in Figure 28. The site is owned as follows:

A. Estate of George Eppich
c/o Genevieve Eppich
Rte. 1, Mancos, Colorado 81328

B. Ute Mountain Tribe
Towaoc, Colorado 81334

C. McCabe, Frank S.
c/o Melinda Pouraghabager
1307 S. 107 E. Avenue., Apt. A
Tulsa, Oklahoma 74128

4.5.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Maggie Rock site is shown in Figure 26. The site received a score of 124 and ranks first based on the evaluated geotechnical parameters.

4.5.2.1. Geology

The Maggie Rock site is underlain by 1,100 to 1,400 feet of Mancos Shale, a thick, laterally persistent, marine shale formation (Plate 3). This thickness estimate is based on structural calculations using geophysical logs of nearby oil and gas test wells in the NE 1/4 sec. 17 and SE 1/4 sec. 8, T.35N., R.12W. and on bedrock dips recorded on the surface. Supportive calculations were made using structure contour maps and formation thickness data presented by Haynes and others (1972). A thickness estimate was also made by determining the elevation of the top of the Mancos Shale around the site, subtracting the thickness of the formation, and comparing this elevation with surface elevations on the site.

Most of the Maggie Rock site is mantled by mixed alluvial and colluvial deposits (Figure 29). A thin finger of modern stream alluvium extends into the western part of the site. These deposits are generally silty clays, but they also contain thin sandy zones and occasional gravel clasts. Some small hills on the site are capped by lag gravels. The surficial materials wedge out against bedrock highs around the site, but the maximum thickness of the surficial materials is unknown. Maximum thickness is estimated at 15 to 25 feet.

Soils on the Maggie Rock site are classified in the Argiborolls-Haplaquolls association (U.S. Dept. Agriculture, 1972a). They are described as cool, dominantly deep, moderately well drained to poorly drained, nearly level to sloping soils on mountain parks, valleys, and meadows.

The Maggie Rock site lies on the southwest flank of the La Plata dome. Bedrock formations on and near the site dip 7° to 10° southwest and generally strike N65°W. Nearby exposures in roadcuts and along gullies indicate bedrock fractures are moderately spaced and usually open. The nearest mapped fault is about four miles northeast of the site. (Haynes and others, 1972).

The present erosion rate of the Maggie Rock site is low. Small rills and sheet erosion are prevalent over most of the site. The small drainage that cuts across the west and north ends of the site has eroded only a few feet below adjacent surfaces. The long-term potential for future erosion is classified as moderate, but this site has one of the lower erosion potentials of all the sites.

Other geologic hazards near the Maggie Rock site are shown in Figure 30. An area of landsliding lies west of the site, but this poses no serious problem to the site. Potentially unstable slopes occur to the northeast and south of the site, but they should be no problem unless affected by construction activities.

No significant conflicts between the Maggie Rock site and mineral resources were identified (Figure 31). The site is underlain by the coal-bearing Dakota Sandstone, but in this area Dakota coals are economically insignificant (Zapp, 1949; Wanek, 1959). Several oil and gas test holes have been drilled near the site, but none encountered any important hydrocarbon accumulations. No gravel deposits occur on the site. A limited amount of riprap possibly could be obtained from gravel deposits within one mile of the site in Thompson Park. A large potential gravel source lies about two miles northwest of the site (Figure 31).

4.5.2.2. Hydrology

There are no major streams, lakes, or irrigation canals on or near the Maggie Rock site. Several small irrigation ditches, however, cross the site. The nearest perennial surface-water supply is over two miles away. An intermittent creek that drains a small area runs through the site. It joins Spring Gulch just below the site. Spring Gulch flows into Cherry Creek one mile below the site, and Cherry Creek eventually merges with the La Plata River about 13 miles downstream.

Surficial materials on the site probably carry only minor amounts of water on a seasonal basis. Part of this water is from extensive flood irrigation of the site. Quality of water in the surficial materials probably ranges from average to poor.

The Mancos Shale host rock contains only minor amounts of poor quality water (Irwin, 1966; Brogden and others, 1979; Brogden and Giles, 1976). The Dakota Sandstone is the first underlying potentially important aquifer. It is 1,100 to 1,400 feet deep below the site. Water from the Dakota Sandstone varies in quality, but usually ranges from average to poor (Brogden and Giles, 1976).

4.5.3. Environmental Factors

Vegetation on the Maggie Rock site is primarily pasture and hayland with oakbrush, scattered cottonwood, and a few ponderosa pine at the east edge. It is a scenic area with several nearby ranches. Key deer and elk winter range lies north of the site across U.S. Highway 160. Little wildlife habitat presently exists on the site because of the agriculture use. The road hazard is intermediate, with an index of 7.82 deer kills and 0.63 elk kills per one million vehicle trips.

There are no documented archaeologic or historic resources within or adjacent to the Maggie Rock site. No significant impacts to cultural resources are anticipated.

Figure 26. Geotechnical rating matrix for the Maggie Rock site.

SITE DESIGNATION: MAGGIE ROCK SITE SITE LOCATION: SECS. 3, 4, 9 & 10, T35N, R12W

	FACTOR	RANK 1	2	3	4	5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	4
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	5
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	5
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	3
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 124

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

● Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

● Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

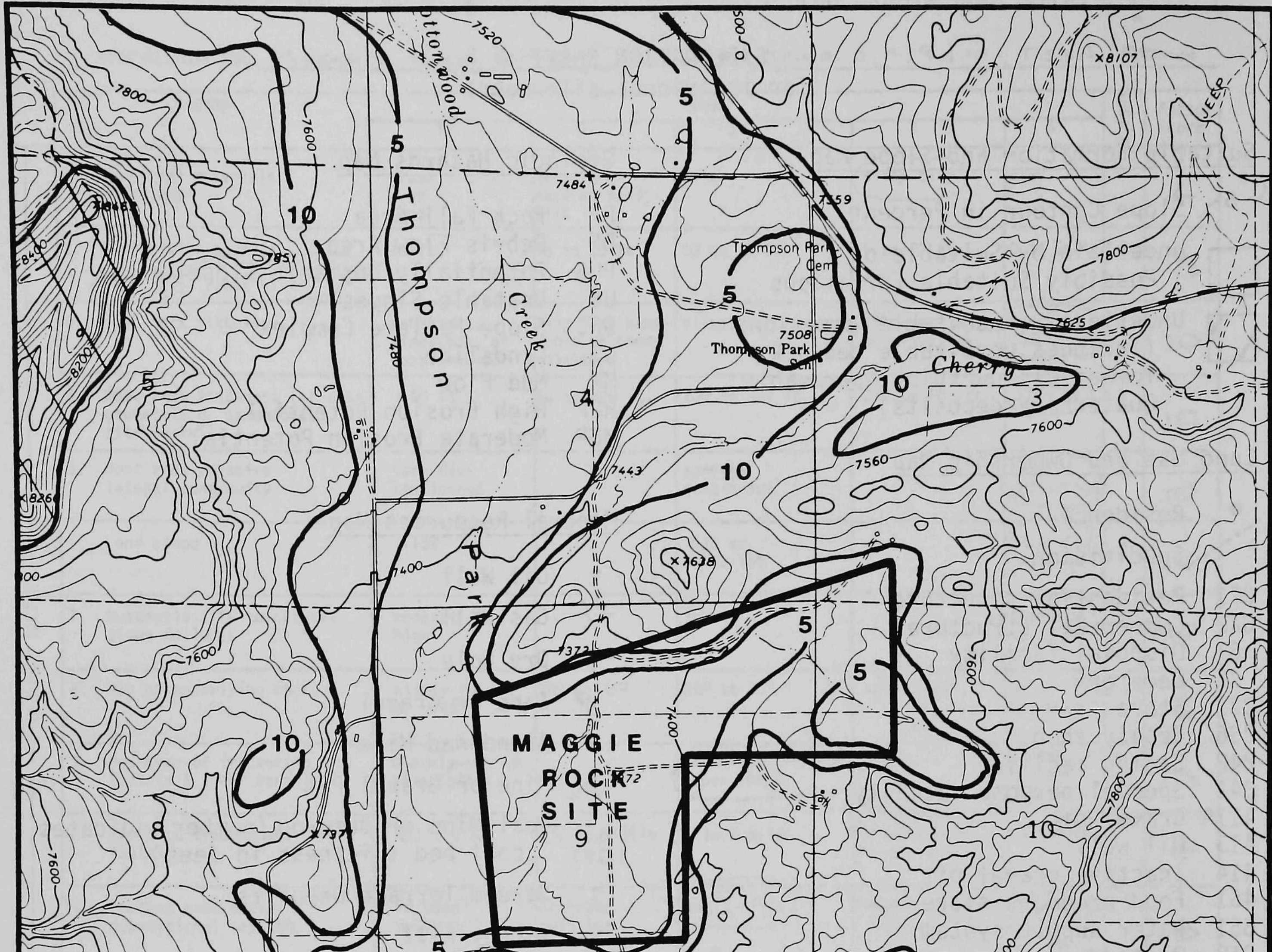

Figure 27. Suitable formation and slope map of the Maggie Rock site.

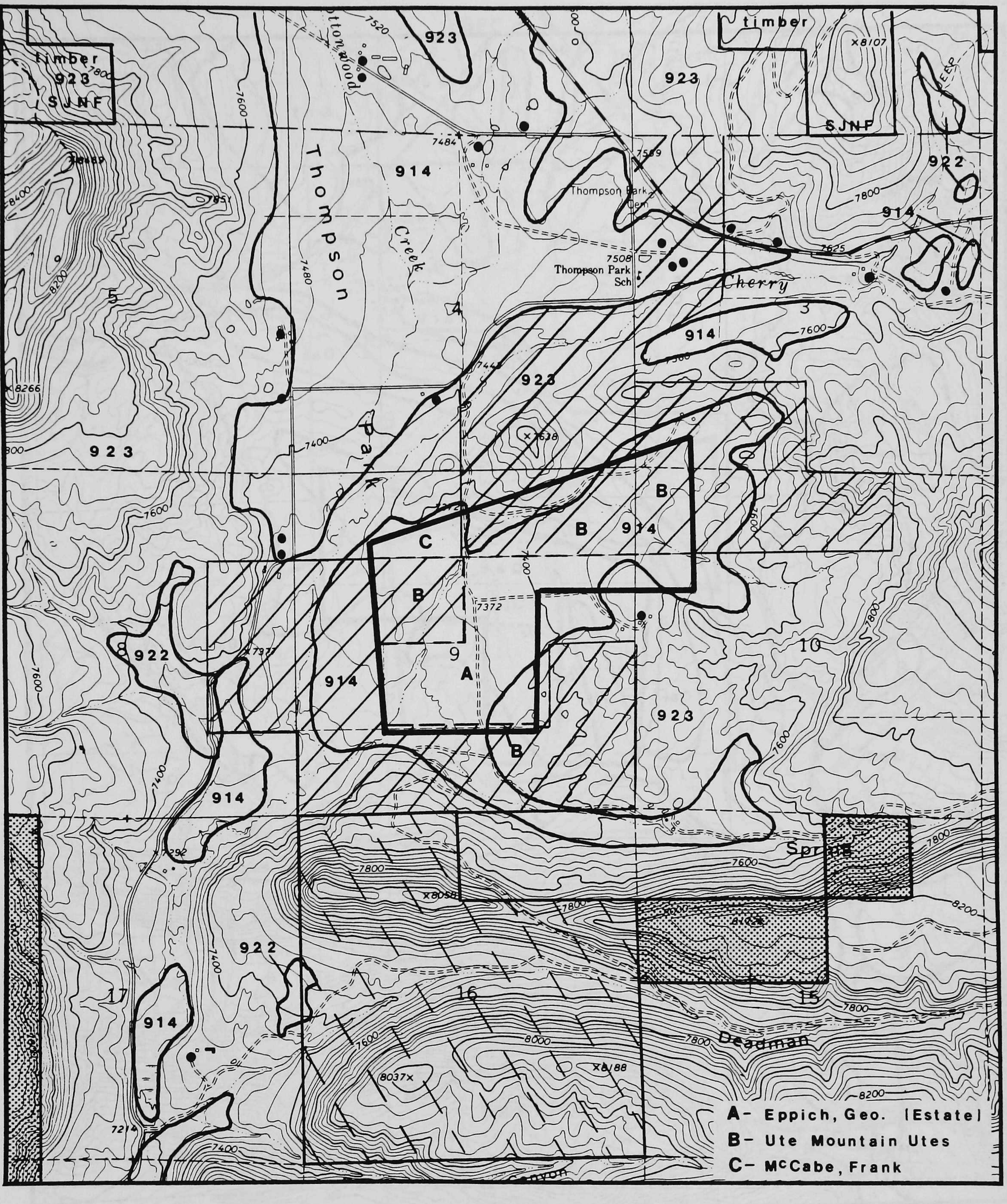

Figure 28. Land use and ownership map of the Maggie Rock site.

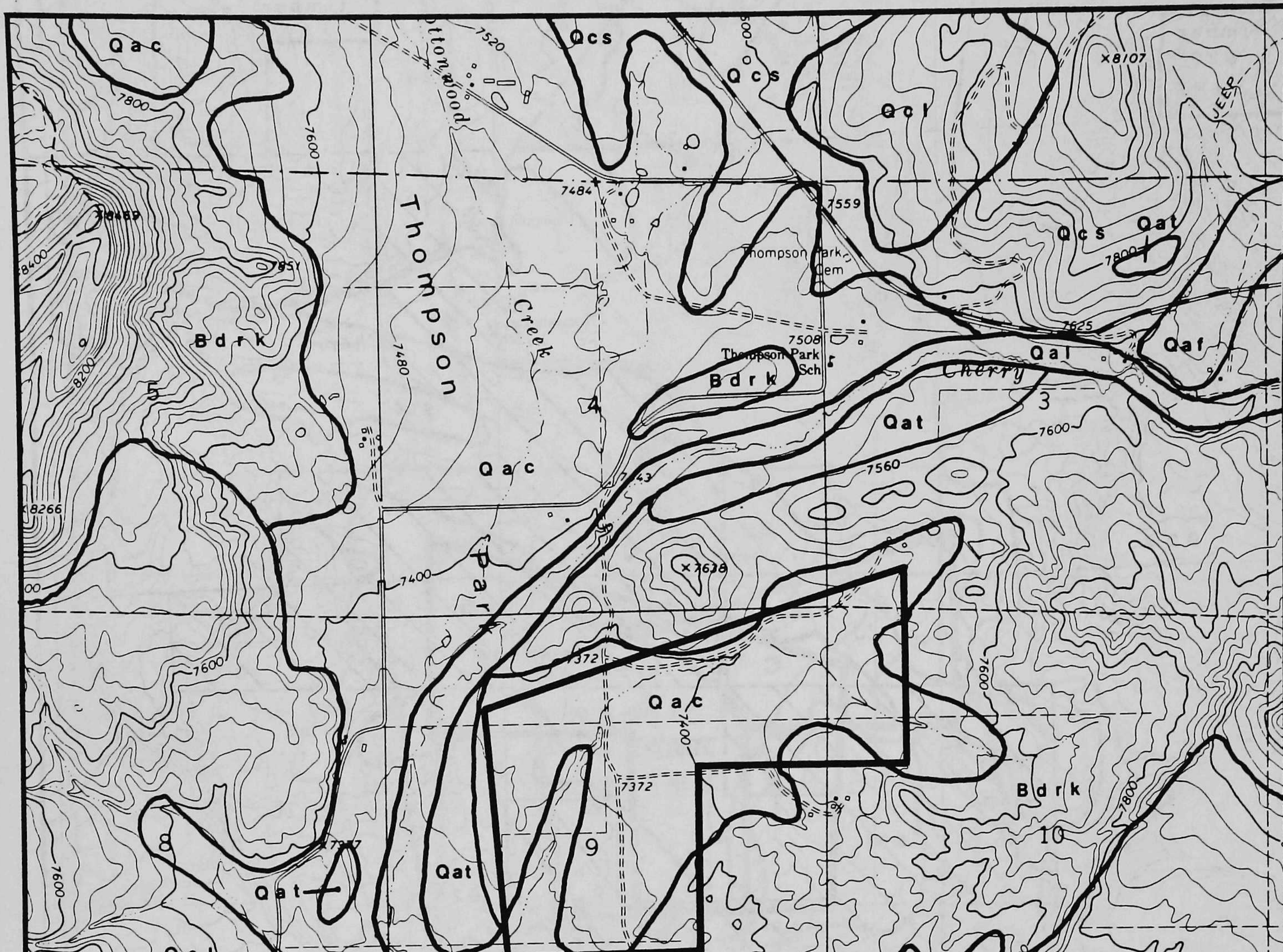

Figure 29. Surficial materials map of the Maggie Rock site.

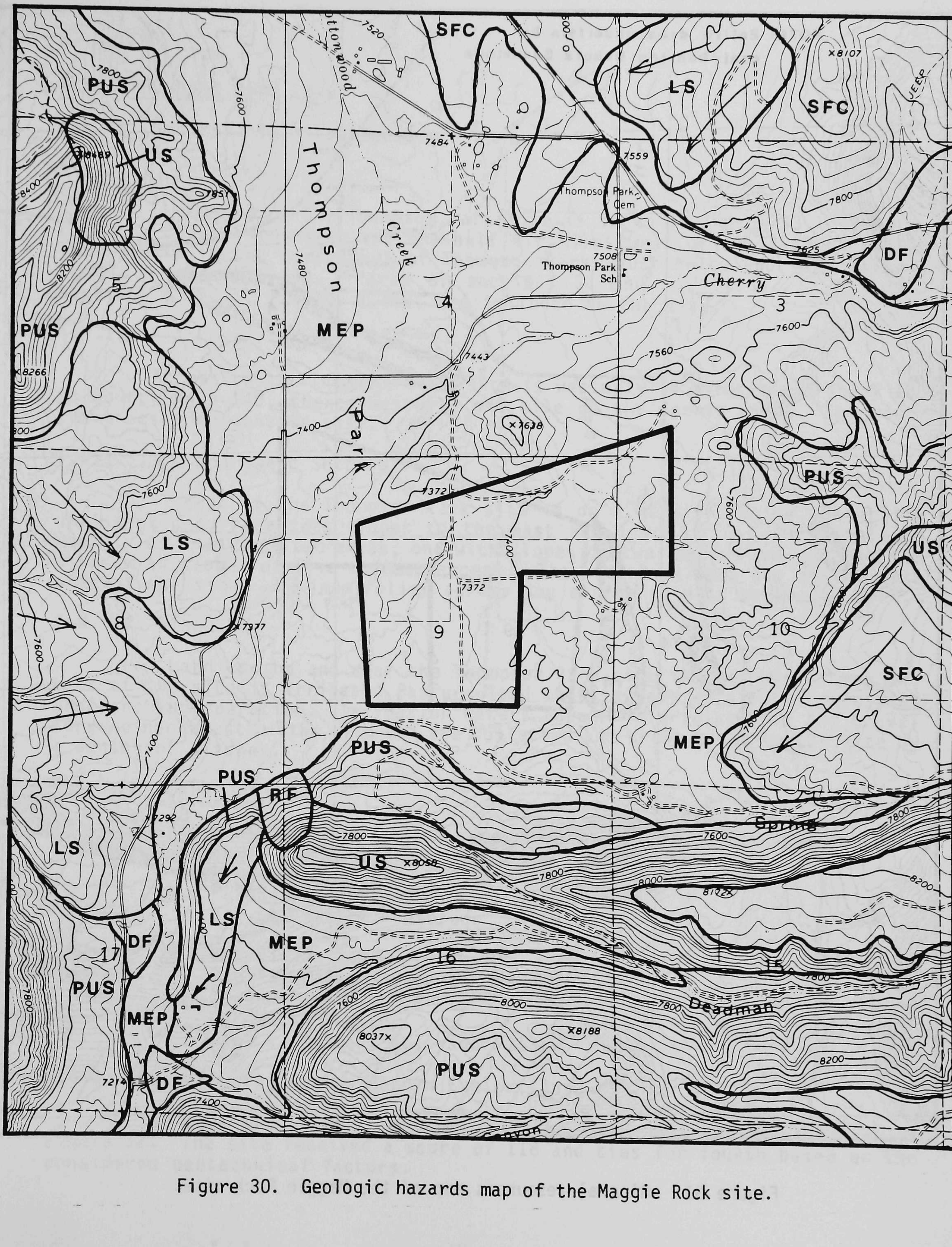

Figure 30. Geologic hazards map of the Maggie Rock site.

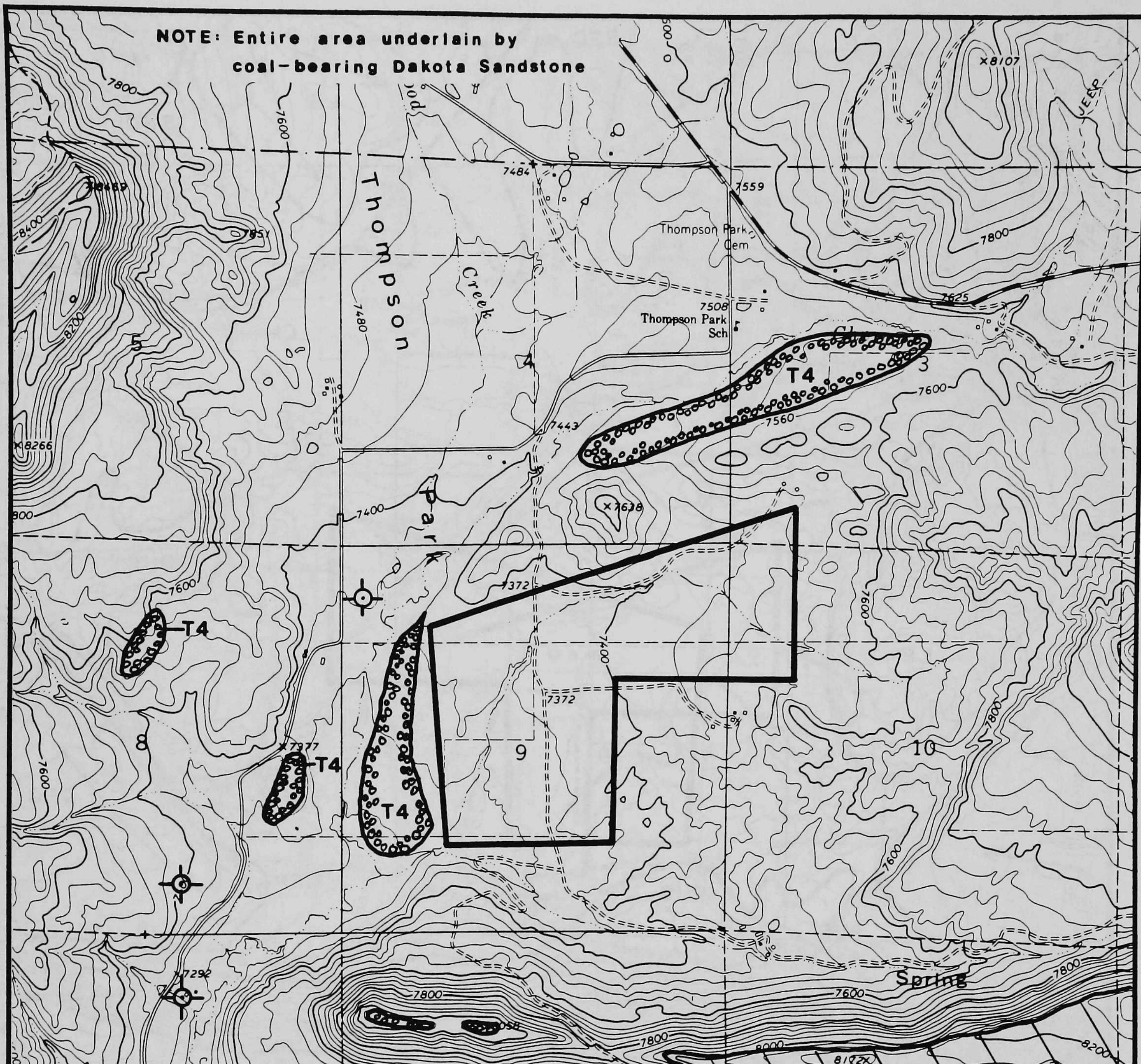

Figure 31. Mineral resources map of the Maggie Rock site.

4.6. THOMPSON PARK SITE

4.6.1. General Site Description

4.6.1.1. Location

Location of the Thompson Park site is shown in Figure 33. It is in La Plata County seventeen and one-half air miles west of the tailings pile. The site is in the north part of Thompson Park, just below and very visible from U.S. Highway 160. Parts of sections 32 and 33, T.36N., R.12W. and sections 4 and 5, T.35N., R.12W. are included in the site.

4.6.1.2. Access

Access to the Thompson Park site is westerly 19 miles via Highway 160 to County Road 140, thence westerly one mile on the County road. The route traverses one mountain pass.

4.6.1.3. Topographic Setting

Most of the Thompson Park site is on a gently sloping, generally undissected surface that slopes to the east and south. The site is almost equally divided into two areas; one with slopes of two to five percent and the other with slopes of five to ten percent. The steeper slopes are on the west side of the site. Maximum relief across the entire site is about 260 feet.

4.6.1.4. Land Use

Land use on and near the Thompson Park site is shown in Figure 34. Most of the site is irrigated pasture land that is part of a cattle breeding and ranching operation. Irrigation waters appear to originate in the gravel terrace northwest of the site and are collected and transported to the site by a series of ditches.

4.6.1.5. Land Ownership

Figure 34 illustrates land ownership on and around the Thompson Park site. Ownership of lands within the site is as follows:

A. Patcheck, Wallace
Rte. 1, Mancos, Colorado 81328

B. Bartel, Roland
Rte. 1, Mancos, Colorado 81328

C. Patcheck, Herman
Rte. 1, Mancos, Colorado 81328

4.6.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Thompson Park site is given in Figure 32. The site received a score of 118 and ties for fourth based on the considered geotechnical factors.

4.6.2.1. Geology

The Thompson Park site is underlain by 400 to 750 feet of Mancos Shale, a thick, laterally persistent, marine shale formation (Plate 3). This thickness estimate is based on a geophysical log from a drill hole in the NE1/4 section 32, T.36N., R.12W., and on structural projections using formation thickness, site elevation, and outcrop data.

A relatively thin layer of alluvial and colluvial deposits mantles almost all of the Thompson Park site (Figure 35). Weathered bedrock crops out in a small area on the west side of the site. Vertical exposures into the surficial deposits are rare. The mixed alluvium and colluvium are dominantly silty clay with some thin sandy zones and occasional gravel clasts. The surficial materials wedge out against bedrock highs, but the maximum thickness of the surficial deposits is unknown. A reasonable estimate based on similar geologic and topographic settings is on the order of 15 to 30 feet.

Three soil associations are described on the site (U.S. Dept. Agriculture, 1972a). Soils on the eastern part of the site are classified in an Argiborolls-Haploquolls association and described as cool, dominantly deep, moderately well drained to poorly drained, nearly level to sloping soils on mountain parks, valleys, and meadows. Soils on the southwest and northcentral parts of the site are classified in a Entroboralfs-rock outcrop-Haploborolls association and are described as cool, shallow and moderately deep, well drained, steep soils and rock outcrops on mountain slopes. A small area in the northwestern part of the site is classified in an Argiborolls-Haploborolls association and are described as cool, dominantly deep and moderately deep, well drained, moderately steep and steep soils on mountain slopes.

The Thompson Park site lies on the southwest flank of the La Plata dome. Bedrock formations on and near the site dip 9° to 13° southwest, and generally strike N55°W. Nearby exposures in roadcuts and along gullies indicate fractures are moderately spaced and usually open. The nearest mapped fault is about two and one-fourth miles north of the site (Haynes and others, 1972).

The present erosion rate of the Thompson Park site is low. Small rills and sheet erosion are prevalent over most of the area. Drainages associated with Cottonwood Creek have eroded into the surficial materials several feet, but this erosion is taking place at a relatively slow rate. No evidence of recent gullying was observed on the site. The western part of the site may actually be undergoing deposition, a beneficial phenomenon for a repository site. The long-term potential for future erosion is classified as moderate, but this site, along with the Junction and Maggie Rock sites, has a lower potential for future erosion than do other potential sites.

Figure 36 illustrates other geologic hazards near the Thompson Park site. Unstable and potentially unstable areas lie north and west of the site, and an area of complex slope failure occurs to the east. These areas of slope instability should be evaluated in regards to utilization of the site as a tailings repository, but they should cause no serious problems that cannot be avoided.

No significant conflicts between the Thompson Park site and mineral resources were recognized (Figure 37). The site is underlain by the coal-bearing Dakota Sandstone, but in this area Dakota coal beds are not economically important (Wanek, 1959; Zapp, 1949). Several oil and gas test holes have been drilled near the site, but none produced any important amounts of hydrocarbons. No gravel deposits occur on the site, but riprap could possibly be obtained from small gravel terraces in other parts of Thompson Park, or from a large gravel deposit on the drainage divide just northwest of the site.

4.6.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation canals on the Thompson Park site. Several small irrigation ditches cross the site, but the nearest perennial surface water is over two miles from the site. Runoff from the site flows into Cottonwood Creek. Cottonwood Creek merges with Cherry Creek about three-fourths mile downstream from the site. Cherry Creek joins the La Plata River thirteen and one-half miles below this junction.

Surficial materials on the Thompson Park site probably contain only minor amounts of water on a seasonal basis. Part of this water results from extensive flood irrigation of the site. Quality of water in the surficial deposits probably ranges from average to poor.

The Mancos Shale host rock produces only minor amounts of generally poor quality water (Irwin, 1966; Brogden and Giles, 1976; Brogden and others, 1979). The Dakota Sandstone is the first underlying potentially important aquifer. It is 400 to 750 feet deep below the site. Water from the Dakota Sandstone varies in quality, but usually ranges from average to poor (Brogden and Giles, 1976).

4.6.3. Environmental Factors

U.S. Highway 160 passes around the north side of the site. The view into Thompson Park from the highway is very scenic. Utilization of the Thompson Park site would cause serious visual impacts while the project was underway, and slight visual impacts after completion of the project.

The site is irrigated agricultural land used mainly as pasture and hayland. Scattered oakbrush occurs on the north and west edges of the site. Key deer and elk winter range lies north of this site across U.S. Highway 160. Little wildlife habitat exists on the site because of the agricultural use. Road hazard for the site is intermediate with an index of 8.14 deer and 0.63 elk kills per one million vehicle trips.

There are no reported archaeologic resources within the Thompson Park site. The Colorado Historical Society, however, indicates that the abandoned Rio Grande and Southern Railroad grade is directly north of the site and south of Highway 160. This area should be carefully surveyed to determine if cultural resources exist along this historic railroad grade.

Figure 32. Geotechnical rating matrix for the Thompson Park site.

SITE DESIGNATION: THOMPSON PARK SITE LOCATION: SECS. 32 & 33 T36N R12W AND SECS. 4 & 5 T35N R12W

FACTOR	RANK					WEIGHT	Factor Score
	1	2	3	4	5		
GEOLOGIC FACTORS							
1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	6
7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	4
9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	4
11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
12. Long-term potential for future erosion	high		moderate		low	1	3
13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	5
HYDROLOGIC AND METEOROLOGIC FACTORS							
14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	5
19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	2
20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 118

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10 FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000 FT Depth to Fruitland Coal Zone

Coal Drill Hole

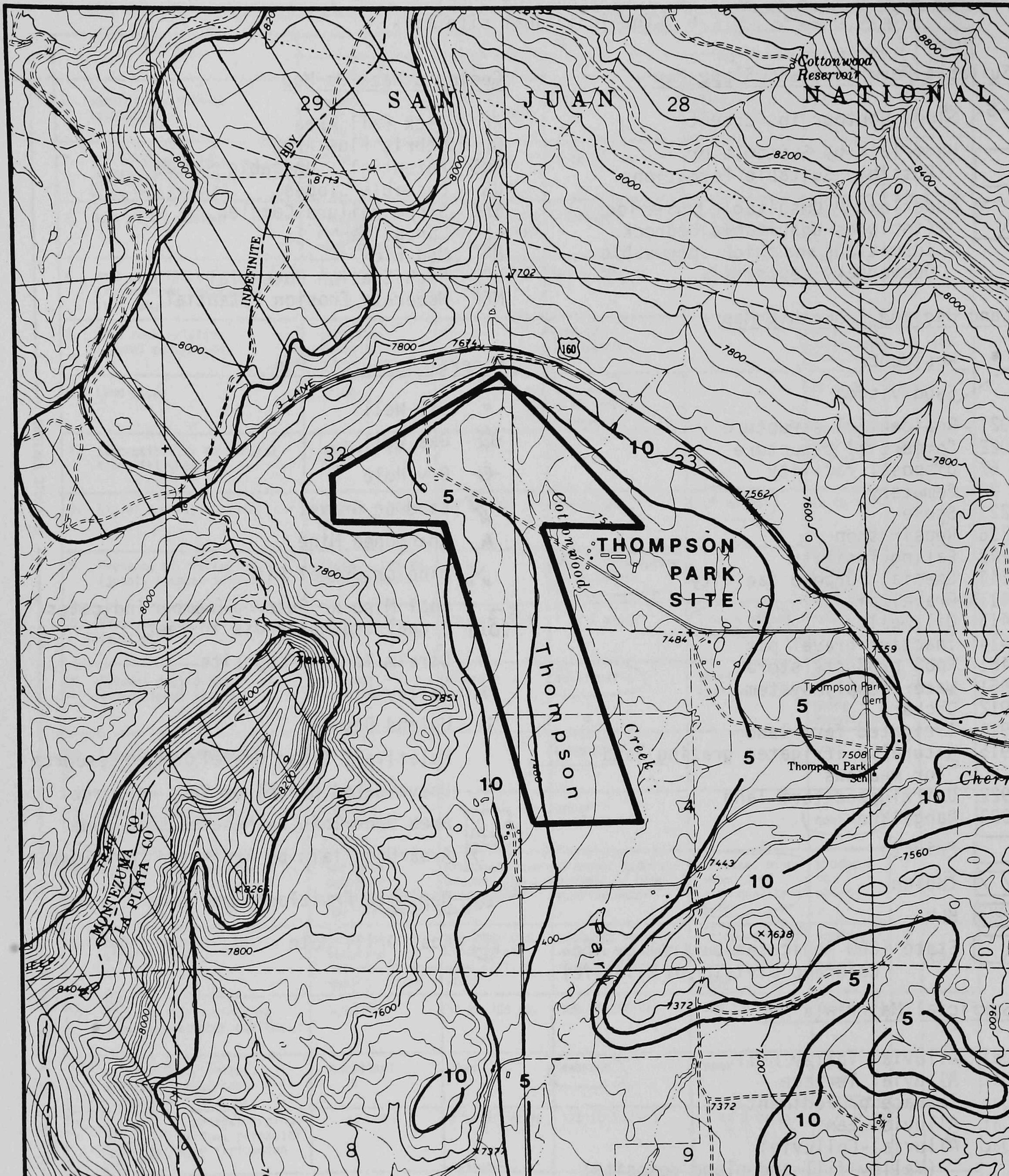

Figure 33. Suitable formation and slope map of the Thompson Park site.

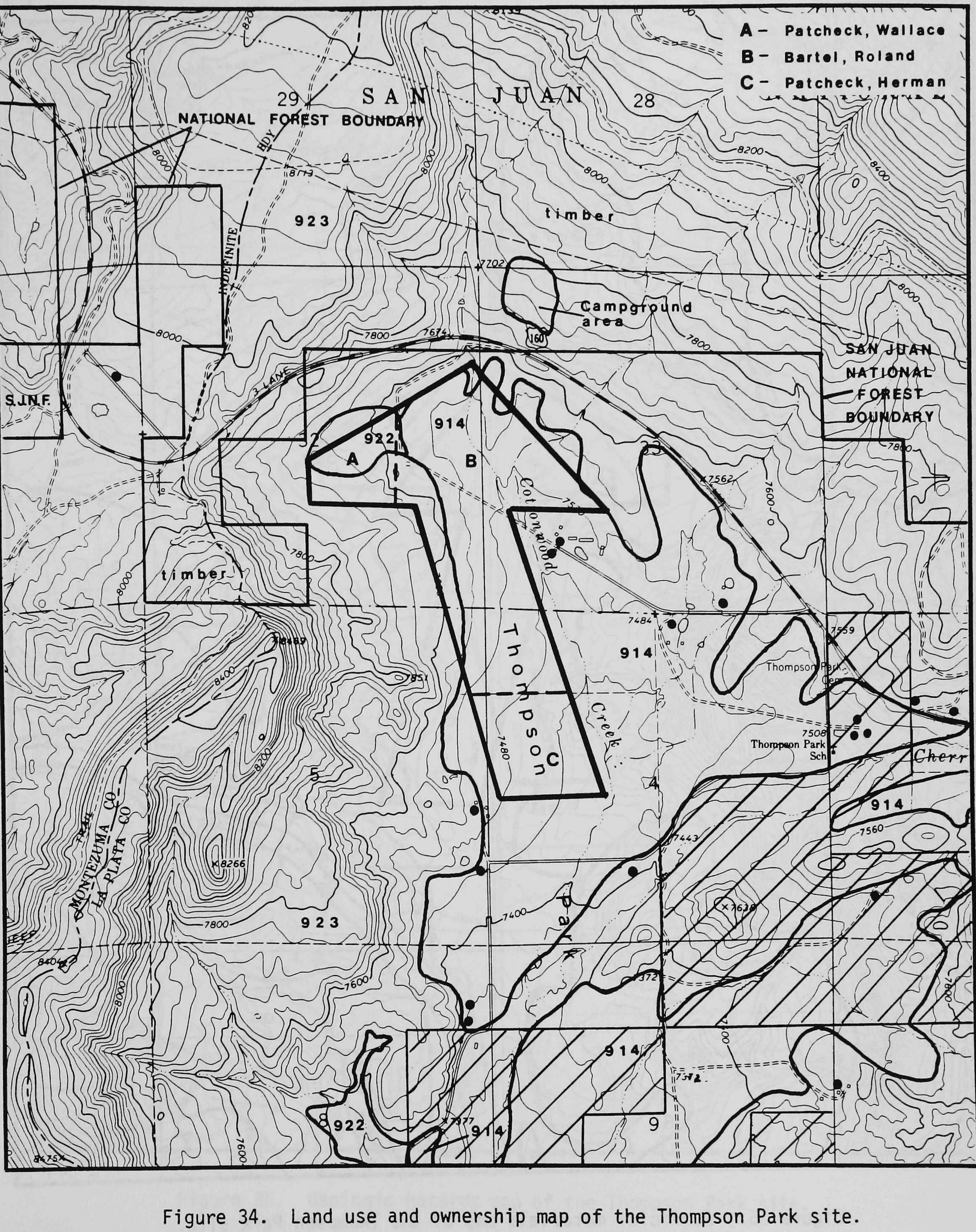

Figure 34. Land use and ownership map of the Thompson Park site.

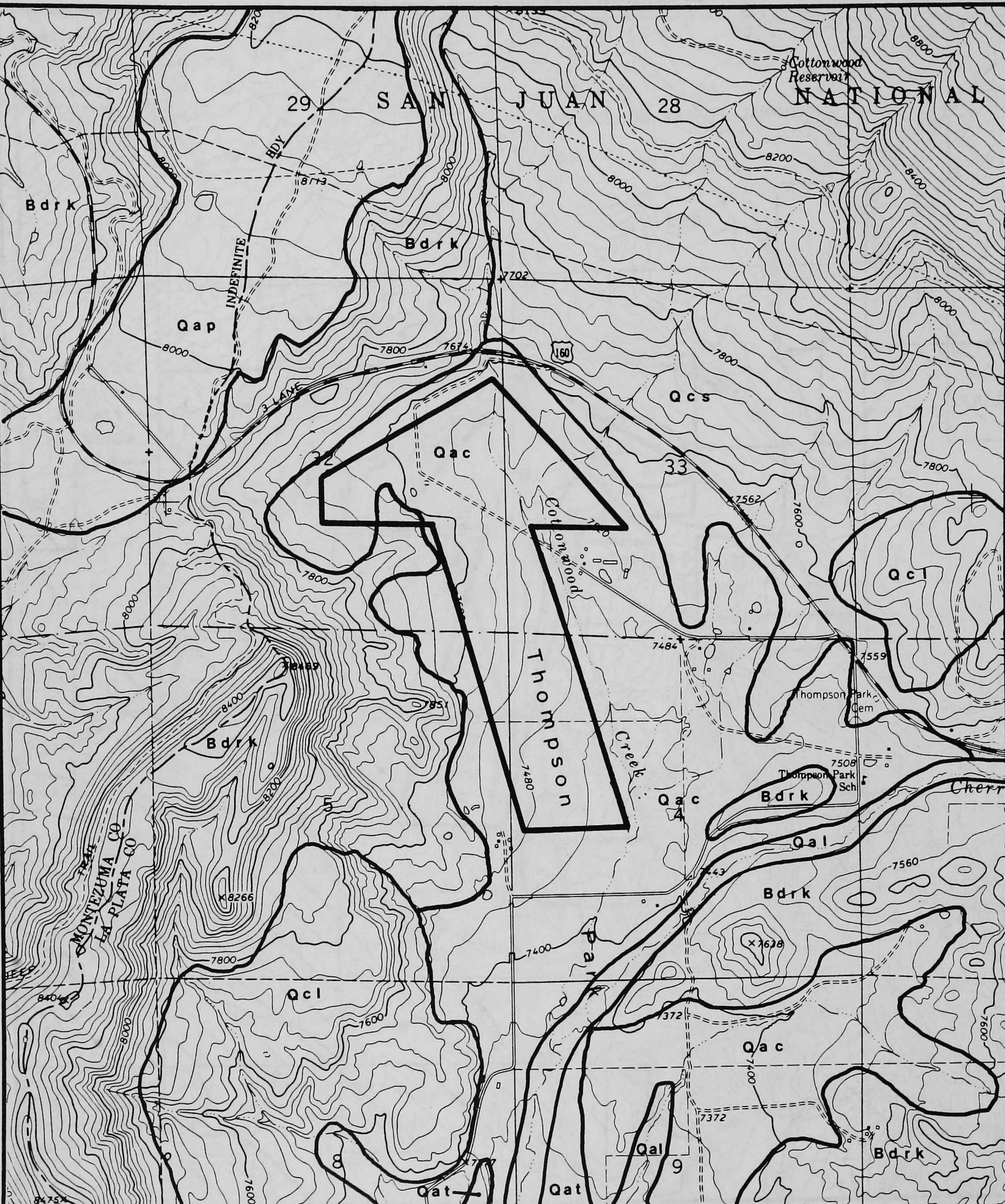

Figure 35. Surficial materials map of the Thompson Park site.

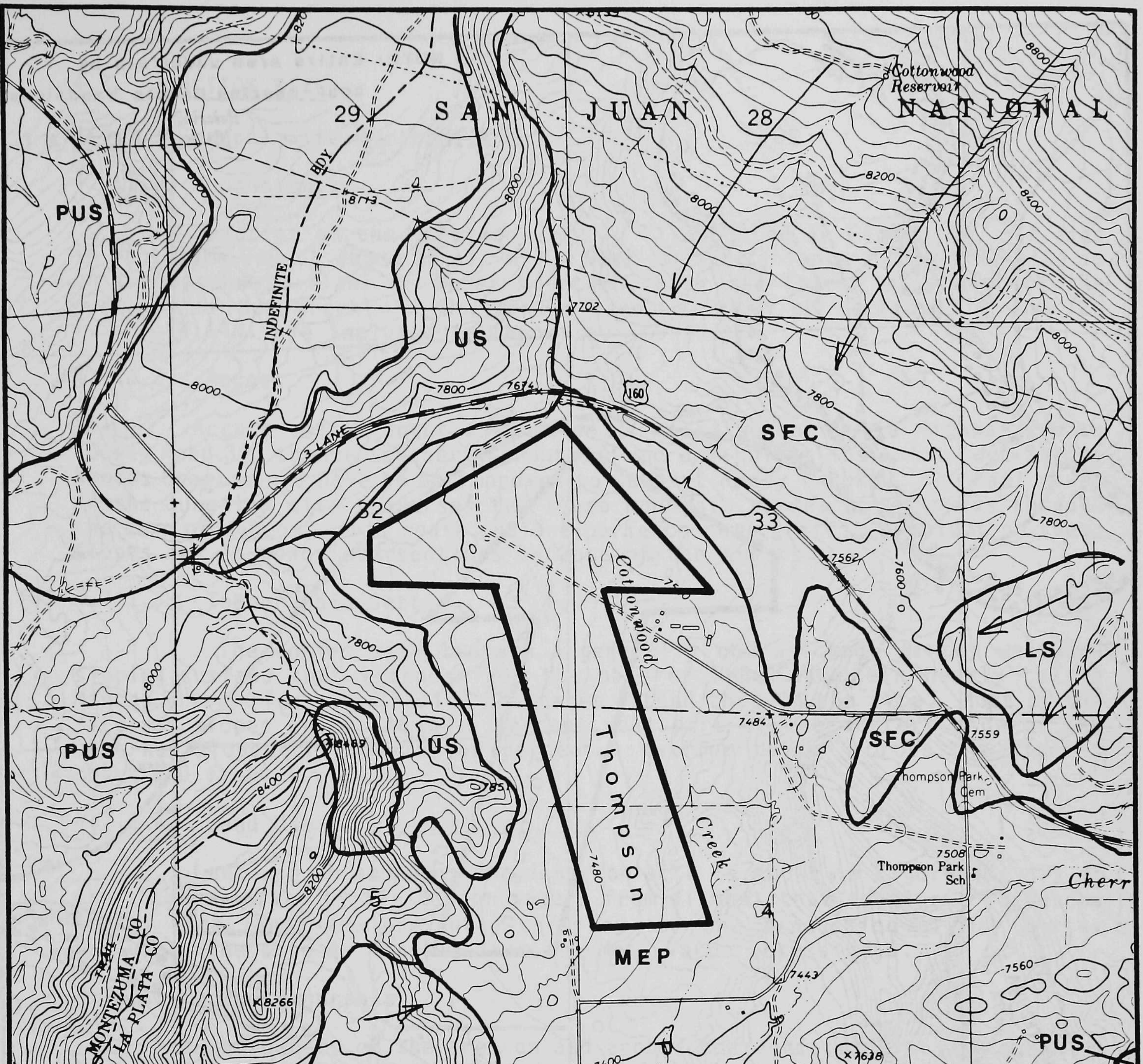

Figure 36. Geologic hazards map of the Thompson Park site.

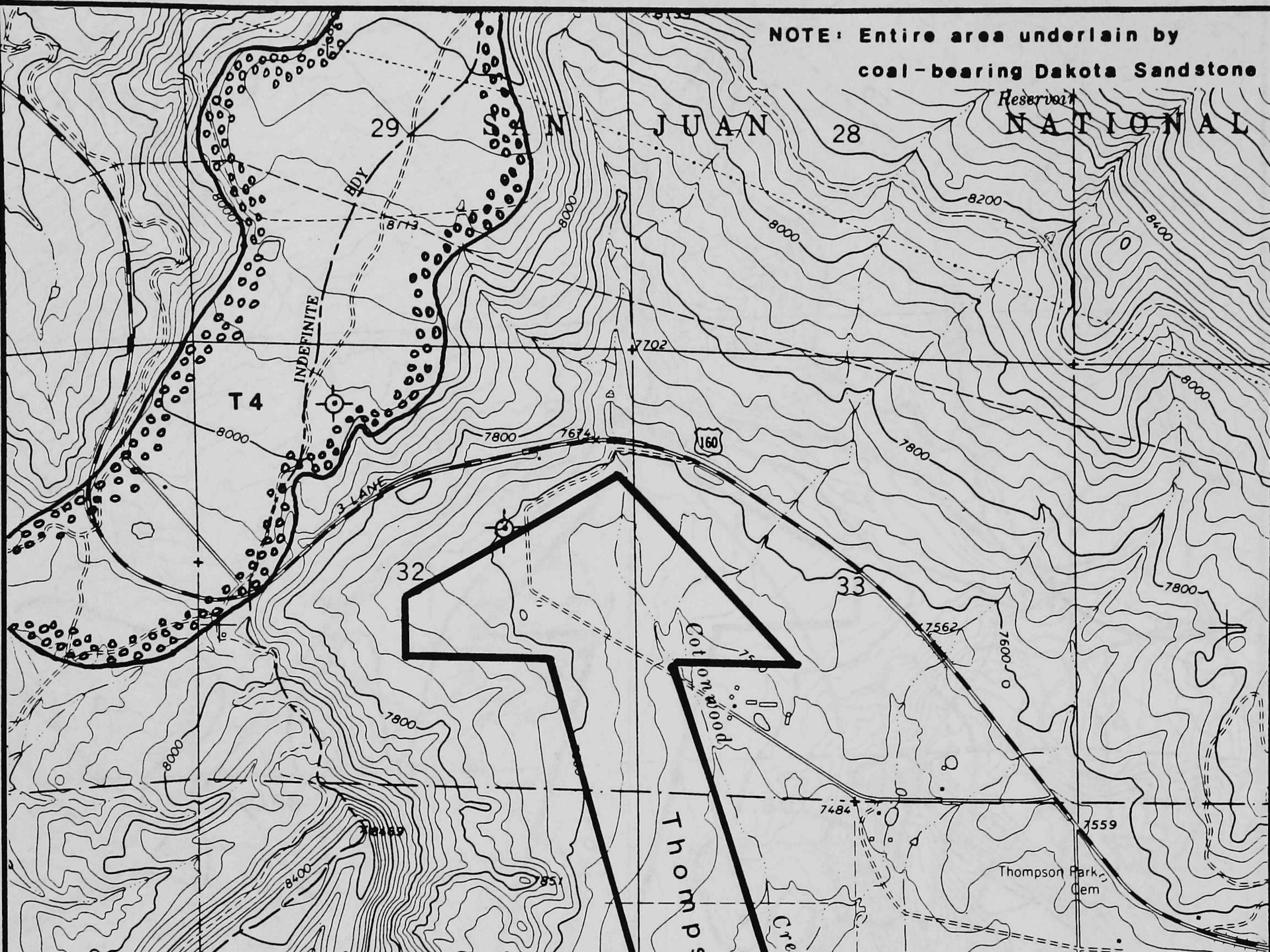

Figure 37. Mineral resources map of the Thompson Park site.

4.7. JUNCTION SITE

4.7.1. General Site Description

4.7.1.1. Location

Location of the Junction site is illustrated in Figure 39. It lies in Montezuma County about 25 air miles west of the tailings piles. The site is on the northwest flank of Weber Mountain about one-fourth mile east of the junction of Mud Creek and the Mancos River. Parts of sections 11 and 12, T.35N., R.14W. are included in the site.

4.7.1.2. Access

Access to the Junction site is 27 miles westerly via Highway 160 to County Road 39, thence southerly about two and one-half miles. A bridge across Mancos Creek would have to be improved to support heavy trucks. The haul route to the Junction site traverses two steep mountain passes and extends through the town of Mancos. This route could experience some traffic problems on steep slopes and at road intersections because of the trucks.

4.7.1.3. Topographic Setting

The entire site lies on a generally undissected, gently westward sloping surface that extends from the base of Weber Mountain nearly to the Mancos River. Two very shallow drainages extend through the site. Most of the site has slopes of two to five percent, but part of the western side of the site has slopes of five to ten percent. Maximum relief across the site is about 240 feet.

4.7.1.4. Land Use

Land use on and near the Junction site is shown in Figure 40. All of the site is served by irrigation waters from ditches that originate in Mancos Creek. The lands are presently utilized for the production of hay and as pasture. The site is visible from the Mesa Verde access road.

4.7.1.5. Land Ownership

Land owners of the area on and around the Junction site are shown on Figure 40. Ownership of the site is as follows:

A. Colbert, Thomas K. and Virginia N.
   6650 County Road 39
   Mancos, Colorado 81328

B. Wolcott, Dean F. and Betty B.
   Rte. 2, Box 183-A
   Mancos, Colorado

4.7.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Junction site is shown in Figure 38. The site received a score of 122 and ranks second based on the considered geotechnical factors.

4.7.2.1. Geology

About 1,000 to 1,300 feet of Mancos Shale underlies the Junction site (Plate 3). This thickness estimate is primarily based on geophysical logs from oil and gas wells within one mile of the site. A confirming calculation was made by determining the elevation of the top of the Mancos Shale above the site on Weber Mountain, subtracting the thickness of the Mancos Shale, and comparing this with ground elevations on the site. The Mancos Shale is a thick, marine shale unit that is very continuous laterally.

A layer of alluvial and colluvial surficial materials blankets the entire Junction site (Figure 41). There are virtually no exposures of this material on the site, but comparisons with similar areas suggest it dominantly is silty clay with some thin sandy zones and occasional gravel clasts comprised mainly of sandstone. Thickness of the alluvial and colluvial materials is unknown. We estimate the thickness probably ranges up to five to fifteen feet.

Soils on the Junction site are assigned to the Torrifluvents-Fluvaquents association (U.S. Dept. Agriculture, 1972b). They are described as warm, deep and moderately deep, well drained and poorly drained, nearly level soils on low terraces and flood plains.

The Junction site sits on a broad structural bench between the Hogback monocline, La Plata dome, and Ute Mountain uplift. Bedrock formations in the area generally dip 2° to 4° south and strike almost east-west. Bedrock joints on the site are probably moderately spaced and generally open. The nearest mapped fault is over five miles north of the site (Haynes and others, 1972).

The present erosion rate of the Junction site appears to be very low. Sheet erosion, locally accompanied by small rills, occurs over much of the site. Two very shallow washes cut through part of the site. As was indicated at the Site Selection Committee meeting on December 15, 1980, the site used to have deep gullies that cut into the surface. These gullies were backfilled with automobile bodies and other material by the U.S. Soil Conservation Service many years ago to mitigate the erosion problems. The long-term potential for future erosion is classified as moderate for the rating matrix.

Figure 42 illustrates other geologic hazards near the site. Two old landslide complexes extend to near the site boundary. These slope failures were released from high on Weber Mountain probably several thousand years ago. These older slide areas do not extend onto the site area. Reactivation of the slope failures could allow colluvial deposits to spread over small sections of the eastern and southeastern parts of the site. Such deposition, however, would probably be beneficial by adding more cover over the repository. Some areas of potentially unstable slopes are also near the site, but these should cause no problems if the slopes are not disturbed by construction activities.

There are minor conflicts between the site and mineral resources. Several producing oil and gas wells are scattered around the site, but no test wells have been drilled within the site boundaries (Figure 43). Gravel sources are not present on the site, but possible riprap material could be obtained at close distances directly west of the site. The entire area is underlain by the coal-bearing Dakota Sandstone, but coal beds within this formation are generally thin, impure, and not economically significant (Wanek, 1959). Also, overburden above any coal beds beneath the site would be a minimum of 1,000 feet thick.

4.7.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the Junction site. Small washes and rills on the site drain directly into the Mancos River, which is only about one-fourth mile from the site.

Because the site is presently irrigated heavily, the surficial materials are probably water saturated. If on-site irrigation is terminated and ground-water conditions return to normal, the surficial materials would probably produce only minor amounts of poor to average quality water. Springs have been reported on the site and would need detailed evaluation during any future investigations.

The Mancos Shale host rock contains only minor amounts of poor quality water (Irwin, 1966; Brogden and others, 1979; Brogden and Giles, 1976). It is not a regionally important aquifer. The first underlying potentially important source of ground water is the Dakota Sandstone. Top of the Dakota Sandstone is estimated to be 1,000 to 1,300 feet below ground level beneath the site. Quality of water from the Dakota Sandstone is variable, but it usually ranges from average to poor (Brogden and Giles, 1976). Dakota water may be contaminated by coal, oil, or gas within the formation.

4.7.3. Environmental Factors

Vegetation on the Junction site primarily is agricultural haylands and pastures with pinon-juniper and oakbrush along the east flank and some cottonwoods along the Mancos River just west of the site. It is flat, with several ranches in the general vicinity. Little deer, elk, or turkey habitat would be adversely impacted at this site. An intermittent pond provides occasional waterfowl habitat. The truck route to the site poses a significant hazard to deer, with a road hazard index of 12.49 deer kills and 0.63 elk kills per one million vehicle trips over the entire haulage route.

The Junction site is in part adjacent to an area that is currently being evaluated by the BLM for a possible wilderness area. Utilization of the Junction site should not seriously affect the suitability of the adjacent area as wilderness.

There are no reported archaeologic or historic resources directly within the Junction site. Numerous valuable sites, however, exist in the general vicinity of the site (index numbers SMT02135A, SMT04387A, SMT12796A, SMT02132A, SMT02133A, and SMT02134A). These cultural resources should be carefully evaluated in relation to utilization of this site.

Figure 38. Geotechnical rating matrix for the Junction site.

SITE DESIGNATION: Junction Site SITE LOCATION: Secs. 11 & 12, T35N, R14W

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	5
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	3
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	2
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	5
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 122

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021	Residential structure
022	Commercial structure
67	Disposal facility
76	Cemetery
223	Store
236	Repair shop
242	Eating facility
243	Special purpose facility
411A	Gravel pit
413	Oil well
414	Inactive gravel pit
451	Food products store
651	Water supply system
912	Orchard
914	Irrigated farm land
915	Naturally irrigated grazing land or meadows
922	Unirrigated farm land
923	Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal	Alluvial Valley Fill
Qat	Alluvial Terrace
Qap	Terrace or Pediment
Qaf	Alluvial Fan
Qac	Alluvial-Colluvial (Valley fill and slope deposits)
Qcw	Colluvial wedge
Qcl	Colluvial (landslide origin)
Qcs	Colluvial (slope failure origin)
Qct	Colluvial talus
Bdrk	Bedrock

Geologic Hazards Map

RF	Rock Fall Area
DF	Debris Flow Area
PUS	Potentially Unstable Slopes
US	Unstable Slopes
SFC	Slope Failure Complex
LS	Landslide
MF	Mud Flow
HEP	High Erosion Potential
MEP	Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

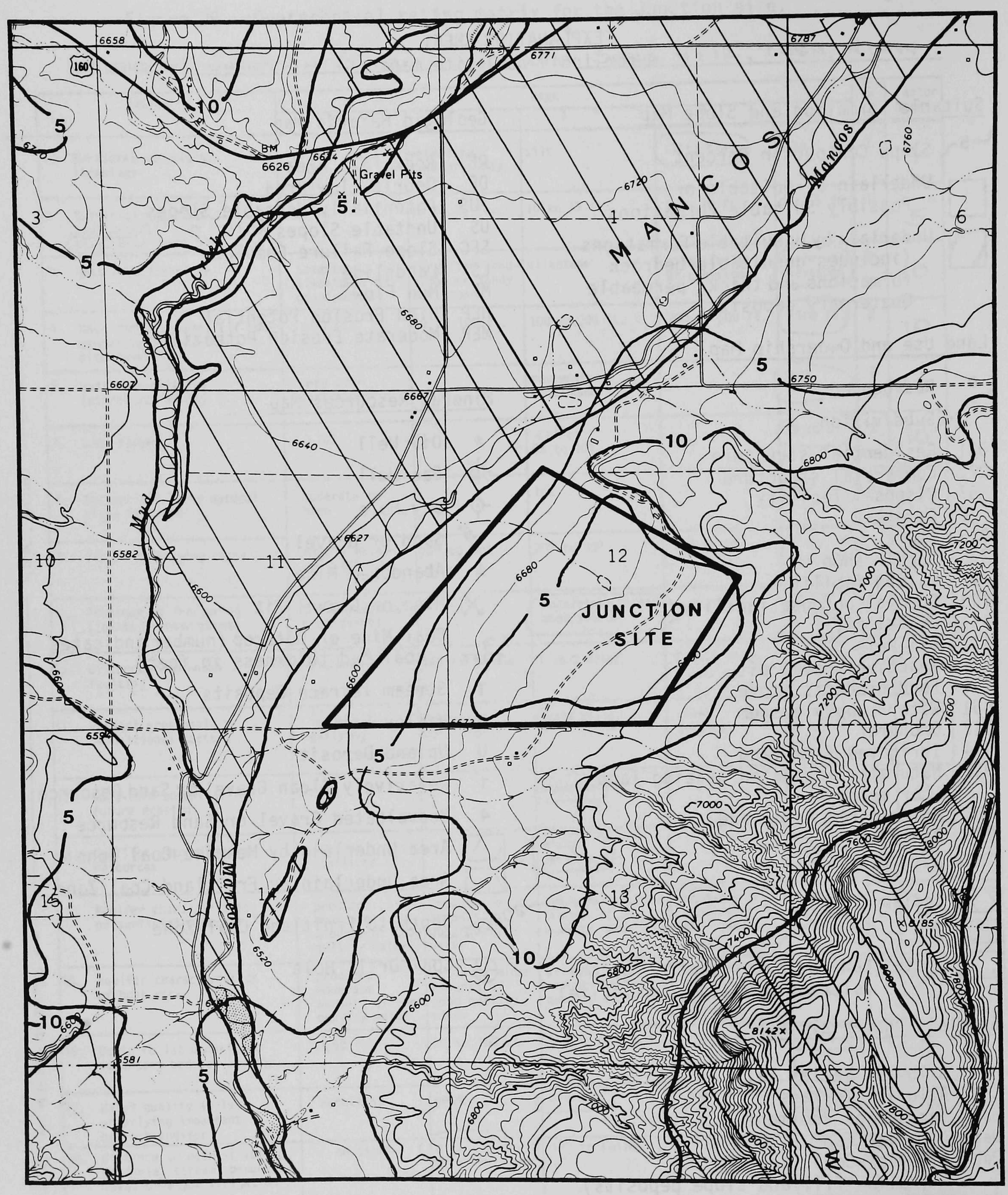

Figure 39. Suitable formation and slope map of the Junction site.

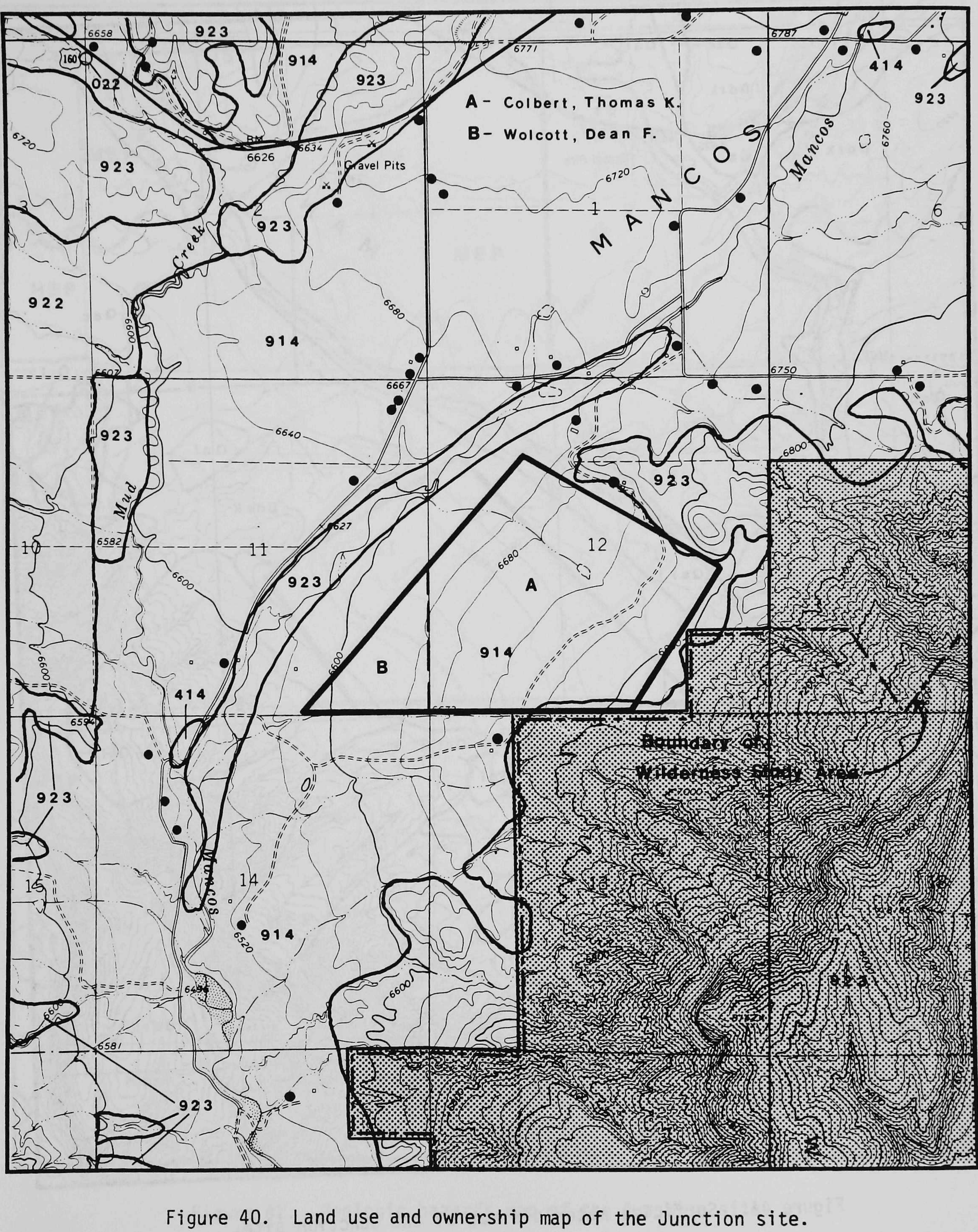

Figure 40. Land use and ownership map of the Junction site.

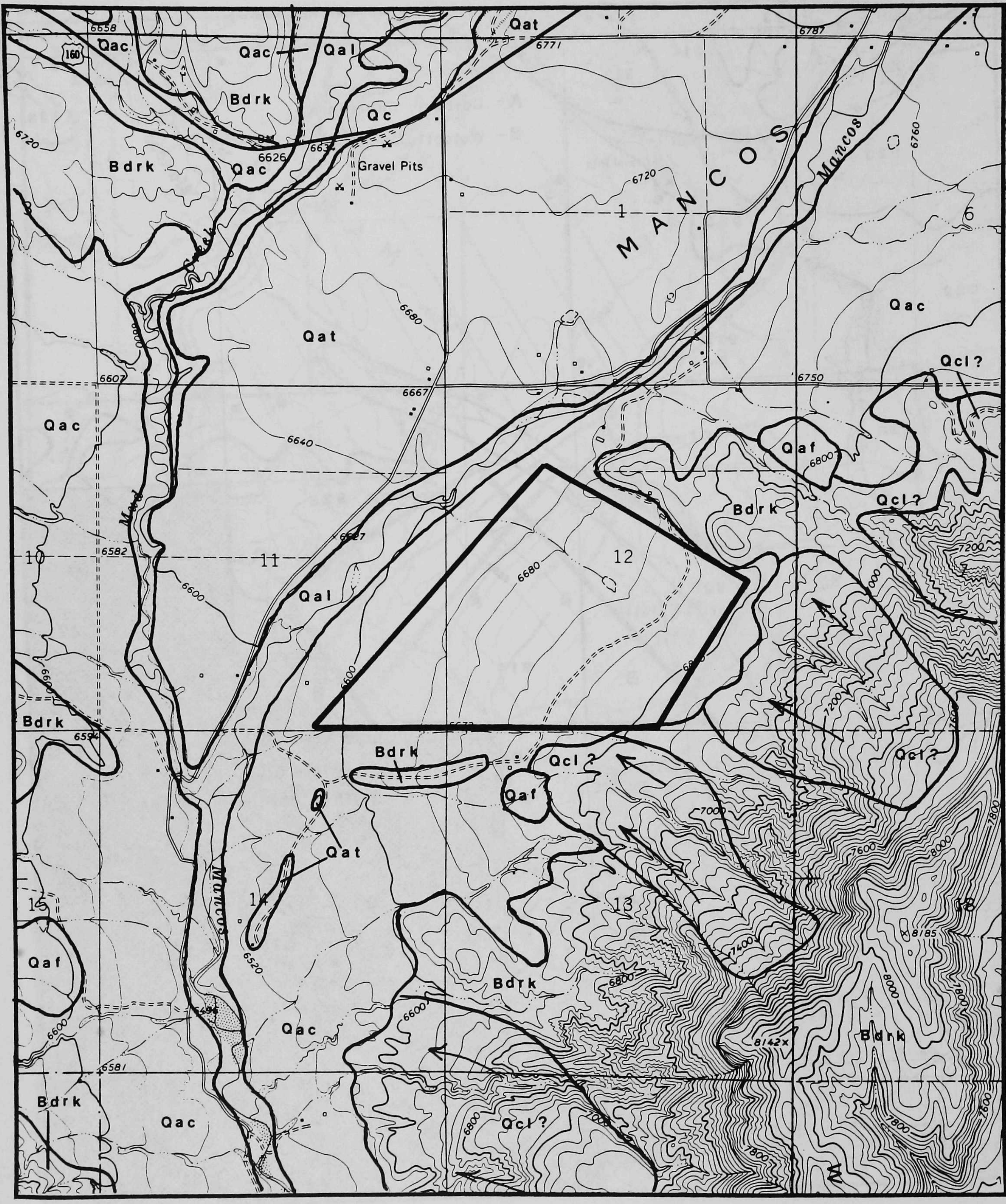

Figure 41. Surficial materials map of the Junction site.

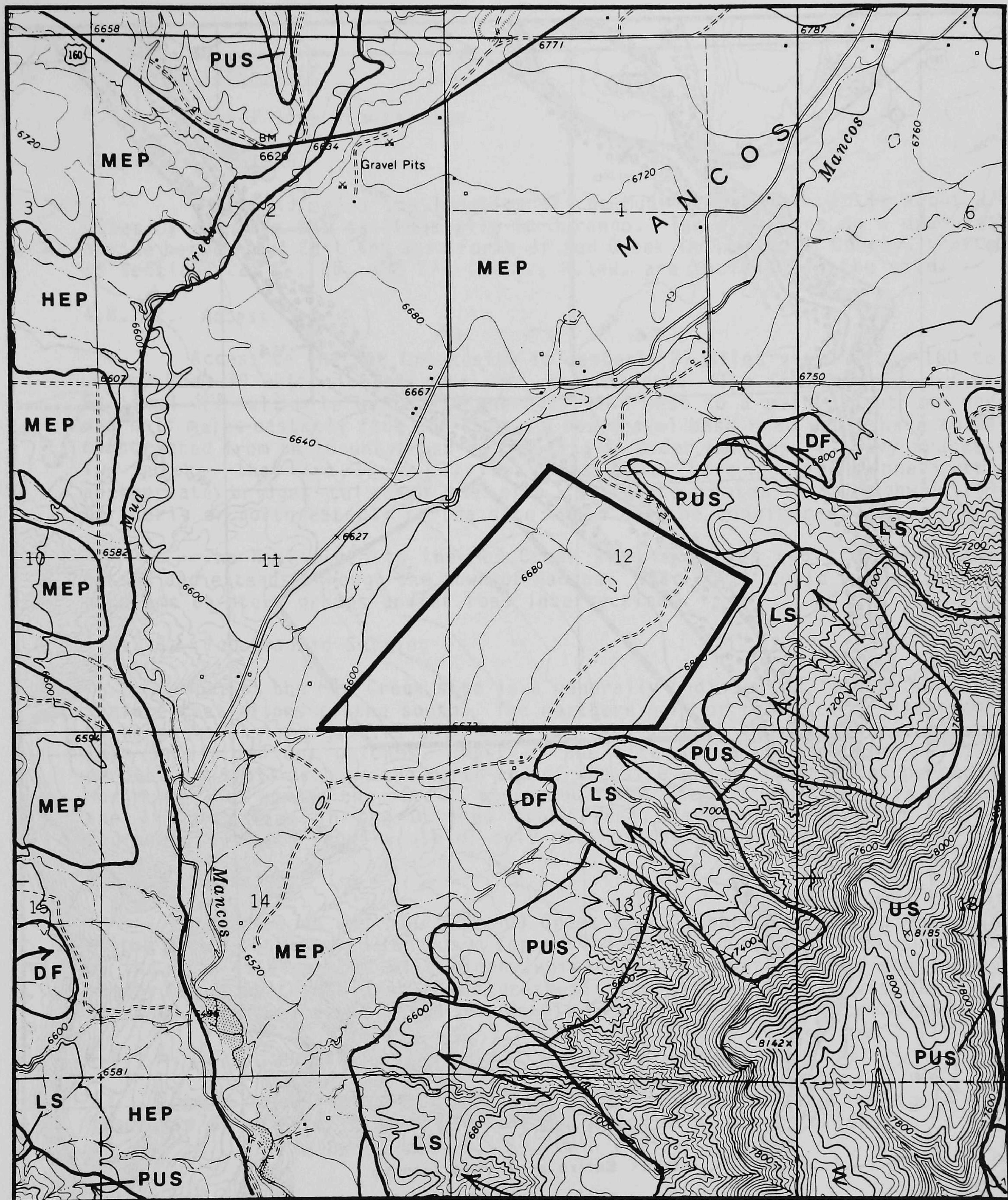

Figure 42. Geologic hazards map of the Junction site.

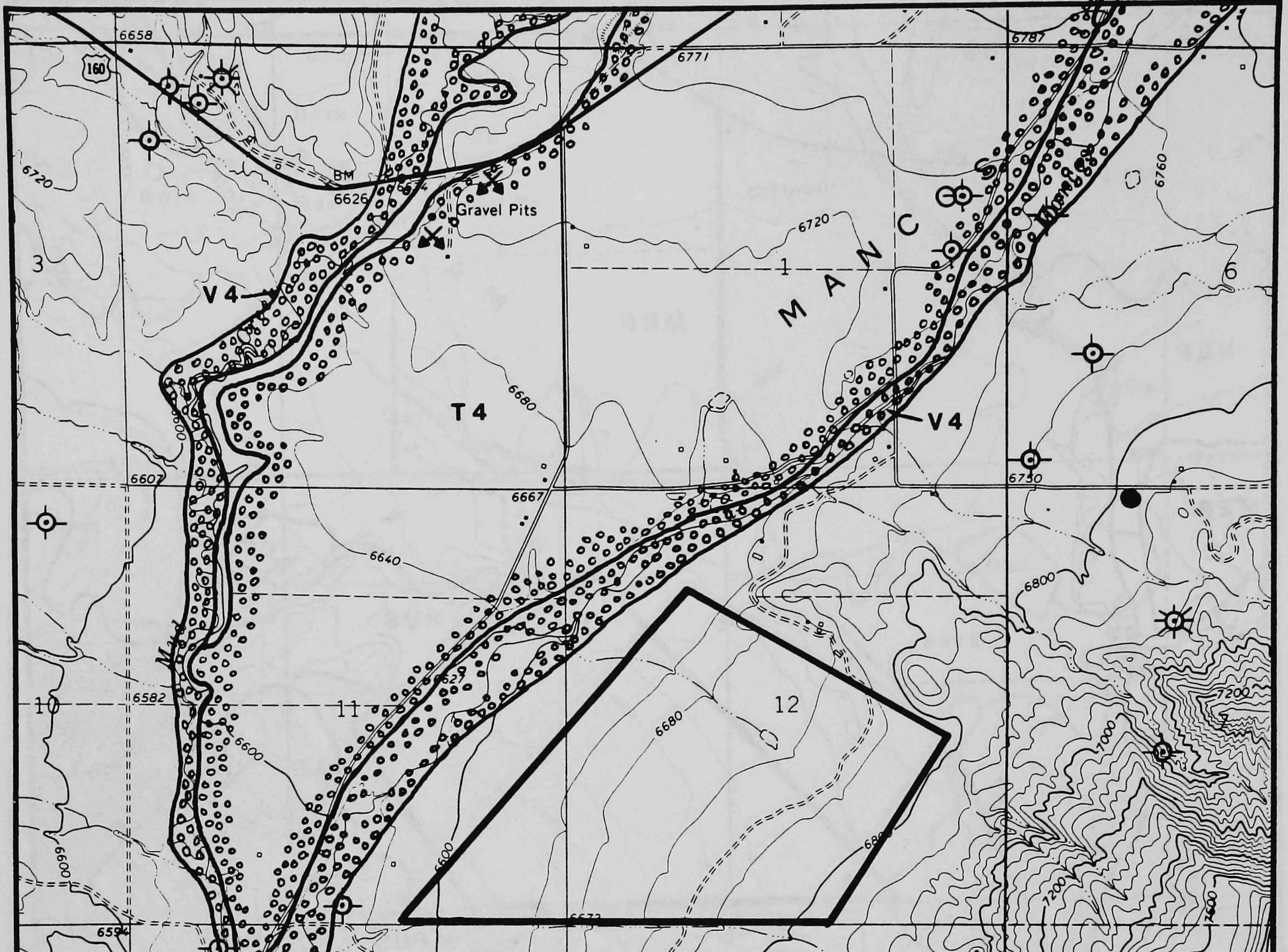

Figure 43. Mineral resources map of the Junction site.

4.8. MUD CREEK SITE

4.8.1. General Site Description

4.8.1.1. Location

Figure 45 shows the location of the Mud Creek site. It is about 27 miles by air from the tailings pile in Durango. The site lies on a drainage divide between the East and West Forks of Mud Creek in Montezuma County. Parts of sections 22, 23, 26, and 27, T.36N., R.14W. are included in the site.

4.8.1.2. Access

Access to the Mud Creek site is westerly 27 miles via Highway 160 to County Road 39 which is one mile west from Mancos. The County road may be followed one-half mile north and one-half mile west to a point about one and one-half miles easterly from the site. A new gravel base road would have to be constructed from the County road to the site in order to support heavy trucks. Two gulches that are 10 to 20 feet deep would have to be spanned with appropriate bridges to reach the site. Alternate routes from Highway 160 northerly or northwesterly to the site could also be considered.

The haul route to the Mud Creek site traverses two steep mountain passes and extends through the town of Mancos. This route could cause traffic problems on steep grades and at road intersections.

4.8.1.3. Topographic Setting

Most of the Mud Creek site is a generally undissected, gently sloping surface that slopes to the south. The northern part of the site is dissected by numerous shallow gullies and rills cut into bedrock that rapidly coalesce into only a few dry gulches. Most of the site has slopes of two to five percent. A small area on the north end of the site slopes five to ten percent. Maximum relief across the site is about 160 feet. The Mud Creek site is one of the largest sites in the Durango study area. Tailings relocation and/or reprocessing would require use of only part of the designated site area.

4.8.1.4. Land Use

Land use on and near the Mud Creek site is shown on Figure 46. Most of the site is unimproved land used for cattle grazing purposes. The north end of the site is vegetated with pinon-juniper and the south end is dominantly sagebrush, rabbitbrush, and mixed grasses. The site is barely visible from Highway 160; however, it would be visible from the Mesa Verde access road.

4.8.1.5. Land Ownership

Land ownership on or around the Mud Creek site is shown on Figure 46. Ownership of private lands within the Mud Creek site is as follows:

A. Altman, David et al, Trustee
c/o John M. Lebolt
35 N. State Street
Chicago, Illinois 60602

B. Bayles, Reed and Son
Box 203
Blanding, Utah 84511

Part of the site is on public domain lands administered by the BLM.

4.8.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Mud Creek site is given in Figure 44. The site received a score of 118 and ties for fourth based on the considered geotechnical parameters.

4.8.2.1. Geology

As shown on Plate 3, at least 250 to 600 feet of Mancos Shale underlies the Mud Creek site. This thickness estimate is based on structural calculations using measured bedrock dips on the site and the outcrop information presented in Haynes and others (1972). Geophysical logs of nearby oil and gas wells, and structure contour maps by Haynes and others (1972) support these estimates. It is possible that the Mancos Shale is over 500 feet thick beneath the entire site area. If it is, the rating matrix score for the Mud Creek site would be increased 122. The Mancos Shale is a thick, marine shale unit that is laterally very persistent. It contains some thin sandstone and limestone beds. Some of the highest hills on the Mud Creek site are capped by thin, fossiliferous limestone beds.

Bedrock crops out over most of the Mud Creek site (Figure 47). In many areas no soil or only very thin soil covers the bedrock at the surface. The southern part of the site is blanketed by a wedge-like deposit of alluvium and colluvium that predominantly is silty clay with occasional thin zones of shale and limestone chips. Thickness of surficial materials varies from 0 to an estimated 10 feet. The only vertical exposures of the surficial materials on the site occur in a shallow gully. Up to as much as eight feet of silty clay overlying the Mancos Shale is present in this gully. Exposures in gullies along the West Fork of Mud Creek indicate the alluvial and colluvial fill in the valley floor, which is not part of the site, may be up to 25 feet thick.

Soils on the northern part of the area are described as a Haplargids-Torriorthents-rock outcrop association (U.S. Dept Agriculture, 1972b). These soils are warm, deep to shallow, well drained, gently sloping and moderately steep soils and rock outcrops on mesas, benches, and canyons. Soils in the southern part of the area, which generally coincide with the alluvial and colluvial deposits, are classified as a Torrifluvent-Fluvaquents association. They are described as warm, deep and moderately deep, well drained and poorly drained, nearly level soils on low terraces and flood plains.

The Mud Creek site lies on a broad structural bench between the Hogback monocline, the La Plata dome, and the Ute Mountain uplift. On the site, beds generally dip 3° to 6° southwest and strike east-southeast. Fracturing in the Mancos Shale is variable. Closely spaced, open joints were observed in some exposed limestone beds on the tops of a few hills, but all shale exposures revealed only moderately spaced, open joints. The nearest mapped fault lies about one and one-half miles north of the site (Haynes and others, 1972).

The present erosion rate varies across the site. In the southern part of the site sheet erosion is the primary type of erosion. A few small gullies extend through the southern part of the site and collect runoff from the northern end of the site. Much of the north end of the site consists of shallow, moderately gullied areas of bedrock. The overall erosion rate was classified as small rills for the rating matrix.

Long-term potential for erosion on the Mud Creek site is moderate (Figure 48). Drainages that are peripheral to the site, however, have high potential for future erosion. Because the site has a very small drainage basin above it, there is only a very low potential for flash flooding and related erosion on the site.

Other geologic hazards that could possibly affect the Mud Creek site are shown on Figure 48. A small area in the northern part of the site is indicated to be potentially unstable. Our reconnaissance evaluation suggests the area has a relatively low potential for being unstable, but it should be further evaluated during future detailed studies. If these studies reveal that this area is indeed potentially unstable, the site boundary can be moved to the south without affecting its usefulness.

There are virtually no mineral resource conflicts related to the Mud Creek site (Figure 49). The coal-bearing Dakota Sandstone does underlie the site, but as Wanek (1959) points out, Dakota coals are generally thin and impure in this area, and are not considered important. Likewise, the potential for oil and gas is almost non-existent. Several dry holes have been drilled north and south of the site. No gravel resources exist on or near the site. The nearest potential source of riprap is about one mile from the site along the Mancos River.

4.8.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the Mud Creek site. Most of the site drains into the West Fork of Mud Creek immediately below the site. The East and West Forks of Mud Creek join just over one mile downstream from the site. Mud Creek drains into the Mancos River two and one-half miles below this junction. An aqueduct cuts across the southeast part of section 26 and is less than one-half mile from the site. The aqueduct is below the general elevation of the site.

Surficial materials on the Mud Creek site are dominantly silty clay and carry only minor amounts of water that is believed to be of poor to average quality. Any water witnin the surficial materials probably occurs seasonally.

The Mancos Shale host rock contains only minor amounts of generally poor quality water (Irwin, 1966; Brogden and others, 1979; Brogden and Giles, 1976). The Dakota Sandstone is the first underlying potentially important aquifer. It is 250 to 600 feet below ground level on the site. Quality of water from the Dakota Sandstone is variable, but it usually is average or poor (Brogden and Giles, 1976). Dakota water may be contaminated because of coal, oil, or gas present within the formation.

4.8.3. Environmental Factors

Vegetation on the Mud Creek site is primarily grassland with sagebrush and rabbitbrush in the lower areas, and pinon-juniper in the higher elevations. The site is critical deer and elk winter range and it lies on a major migration route. Route hazard is 12.58 deer kills and 0.63 elk kills per one million vehicle trips over the entire route. Local area residents reported at the Site Selection Committee meeting on December 15, 1980, that Bald eagles have been observed on this site and that endangered plant species may be present.

No archaeologic or historic sites have been reported within or adjacent to the Mud Creek site by the Colorado Historical Society. Impacts to cultural resources are anticipated to be limited.

Figure 44. Geotechnical rating matrix for the Mud Creek site.

SITE DESIGNATION: MUD CREEK SITE SITE LOCATION: SECS. 22, 23, 26 & 27, T36N, R14W

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	8
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	3
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	3
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	5
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	8
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	2
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	5
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 118

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

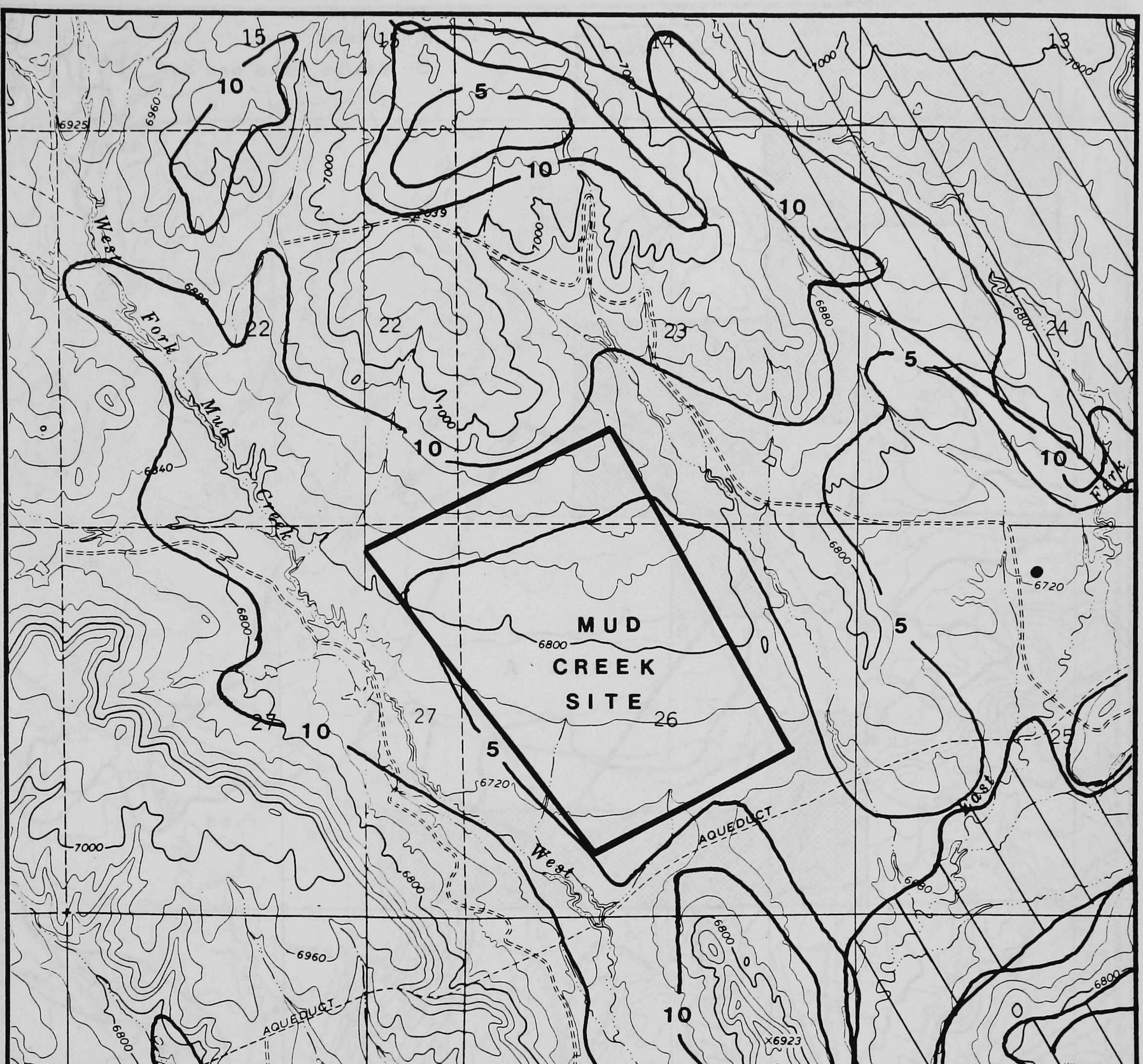

Figure 45. Suitable formation and slope map of the Mud Creek site.

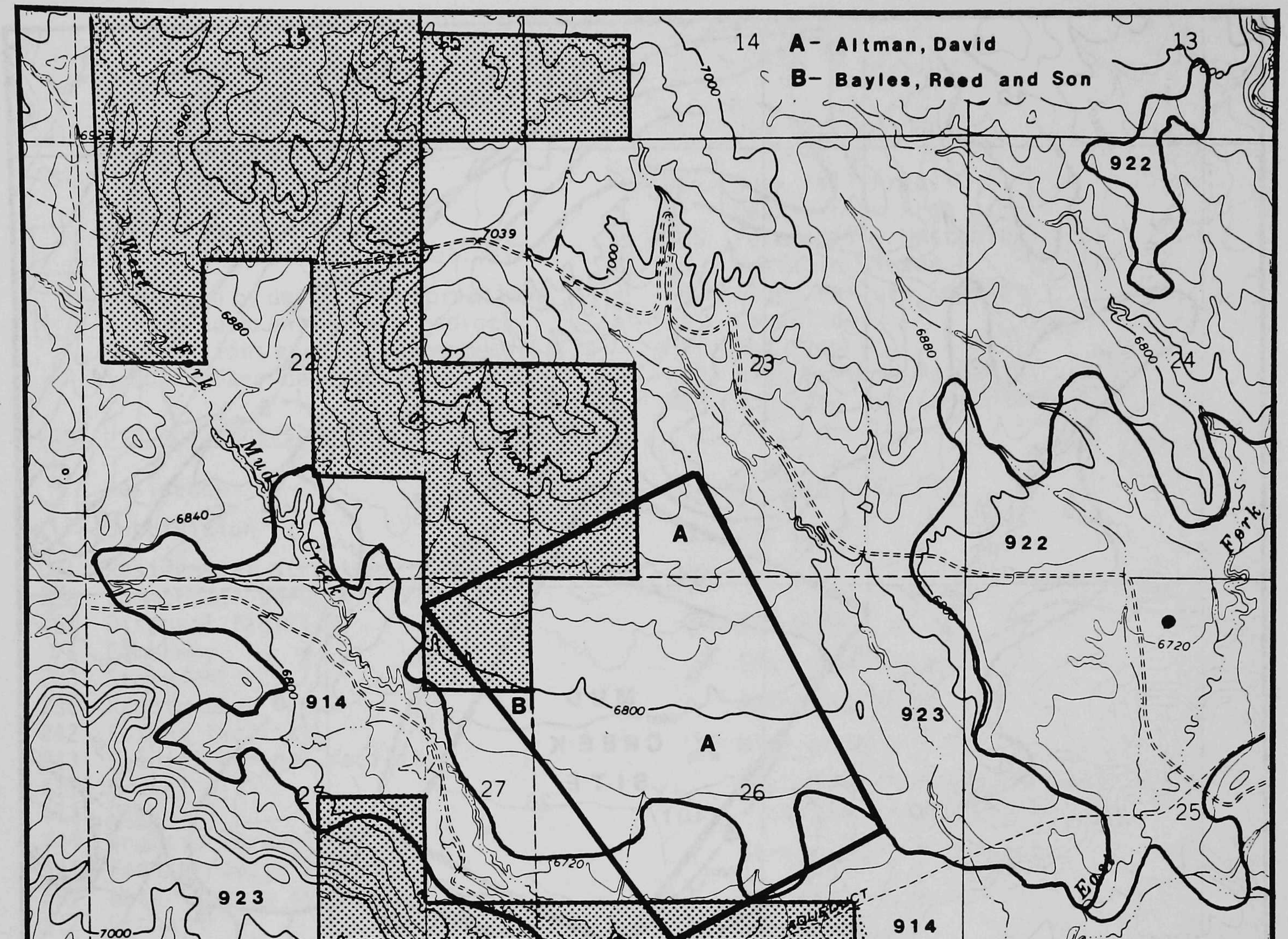

Figure 46. Land use and ownership map of the Mud Creek site.

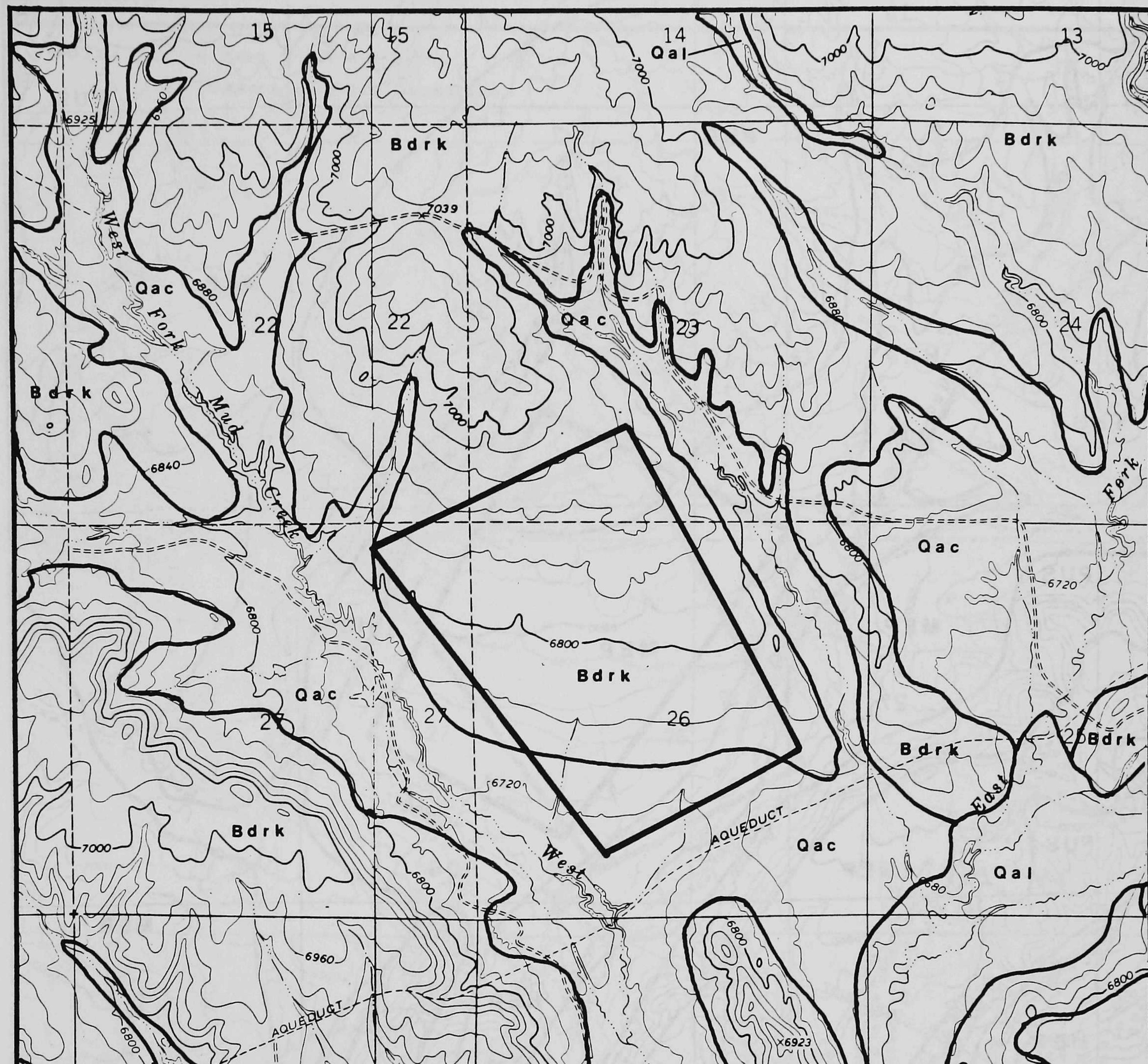

Figure 47. Surficial materials map of the Mud Creek site.

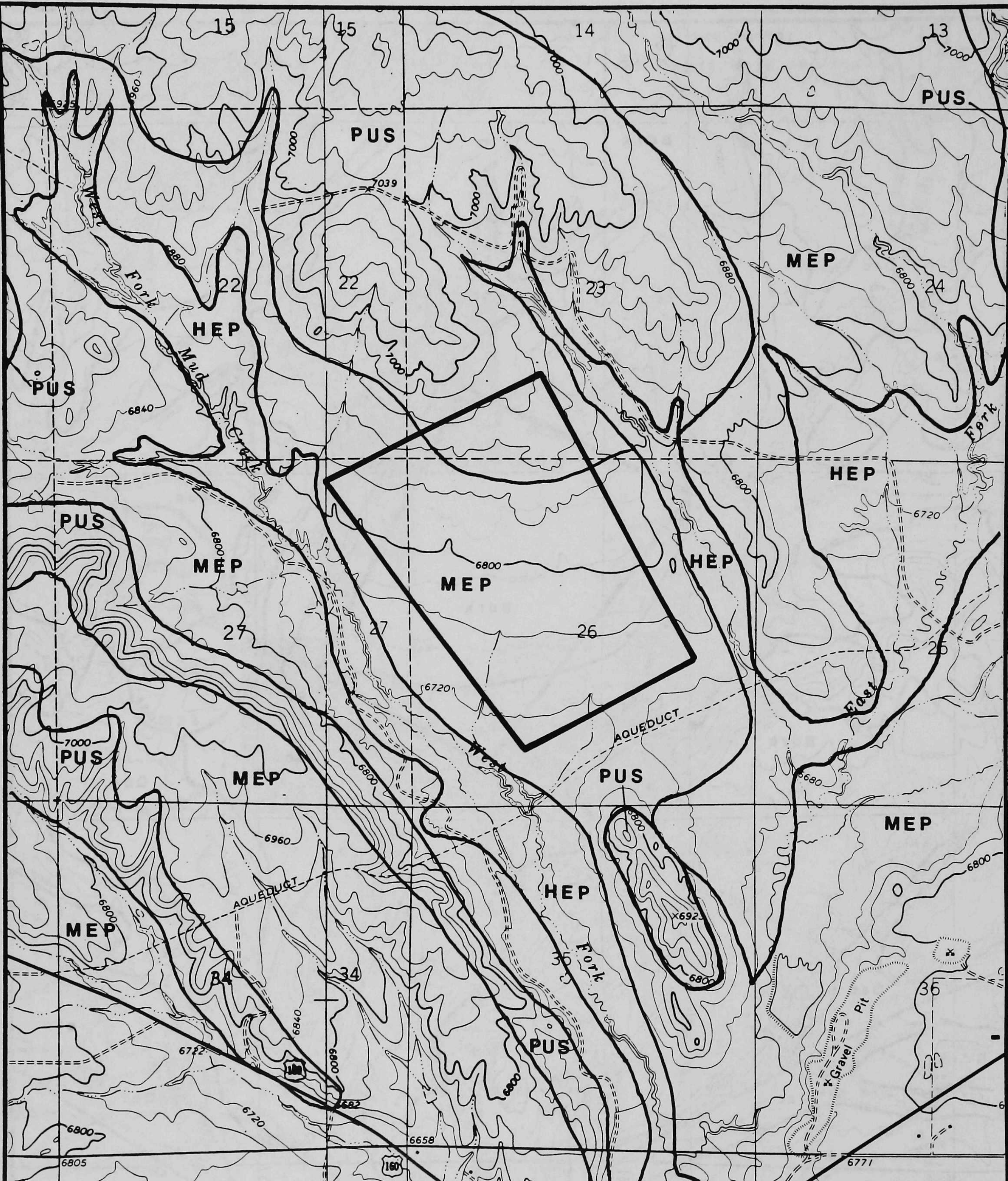

Figure 48. Geologic hazards map of the Mud Creek site.

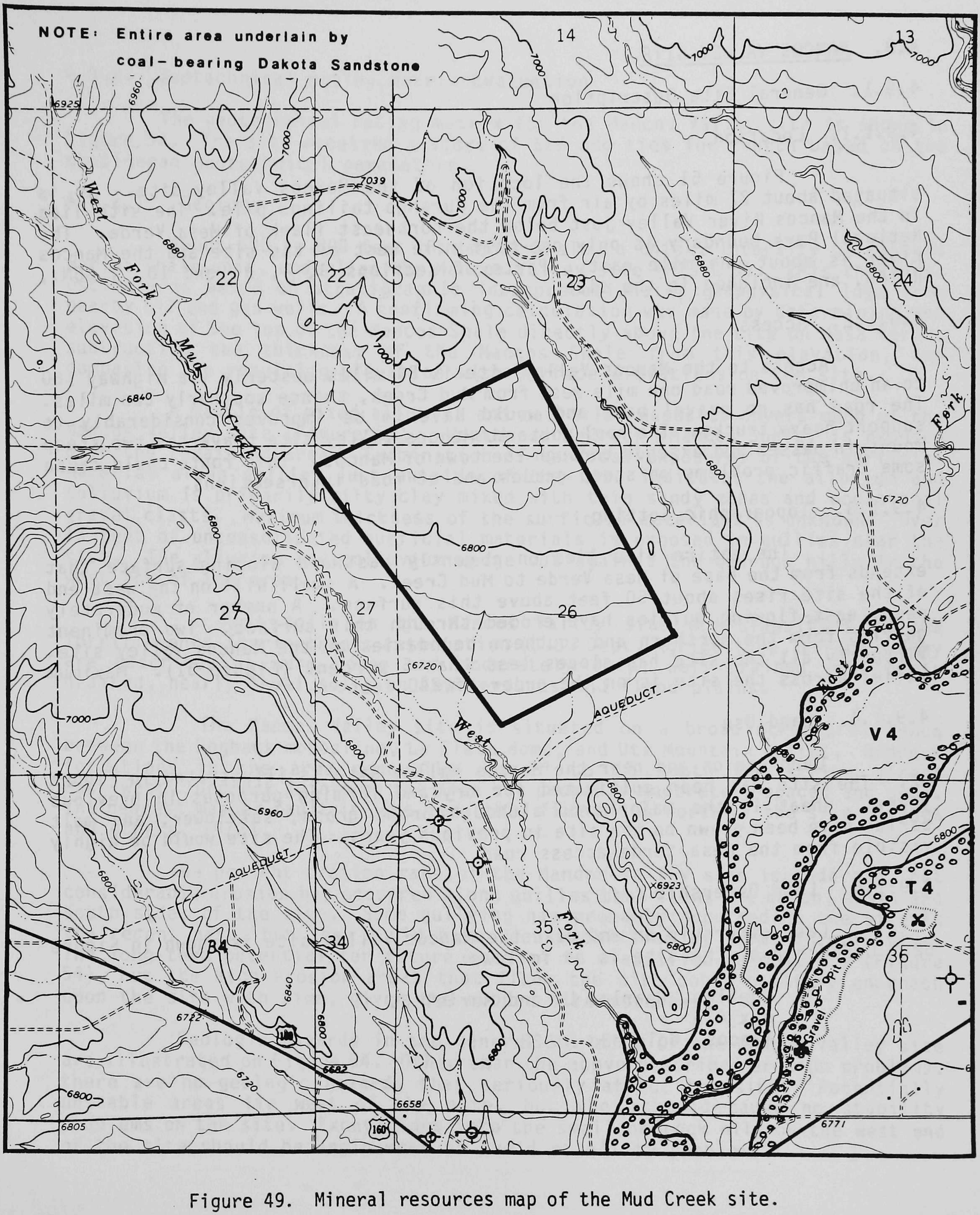

Figure 49. Mineral resources map of the Mud Creek site.

4.9. MANCOS VALLEY SITE

4.9.1. General Site Description

4.9.1.1. Location

Figure 51 shows the location of the Mancos Valley site. It is situated about 27 miles by air from the Durango tailings pile. The site lies in the Mancos River Valley just below the northeast flank of Mesa Verde. The National Park boundary is only one-half mile west of the site and the Mancos River is about one mile east. Parts of sections 3, 4, 9, and 10, T.35N., R.14W. are included in the site.

4.9.1.2. Access

Access to the Mancos Valley site is 30 miles westerly via Highway 160 to an unimproved road one mile west from Mud Creek, thence southerly two miles. The road has no gravel base and would have to be improved considerably to support heavy trucks. The haul route to Mancos Valley site traverses two steep mountain passes and extends through the town of Mancos. This route could cause some traffic problems on steep grades and at road intersections.

4.9.1.3. Topographic Setting

The entire site lies on a gently eastward sloping surface that extends from the base of Mesa Verde to Mud Creek. A small hill on the west end of the site rises about 50 feet above this surface. A number of moderately deep, east-flowing gullies have eroded through this surface. Two prominent gullies form the northern and southern boundaries of the Mancos Valley site. Virtually all the site has slopes less than 5 percent (Figure 51). Maximum relief across the site is on the order of 240 feet.

4.9.1.4. Land Use

Land use on and near the Mancos Valley site is illustrated in Figure 52. The site has been cultivated for dryland farming purposes in previous years. Wheat is the major crop although brome grass, safflower, and malt barley have been grown on the site in previous years. The site would be highly visible from the Mesa Verde access road.

4.9.1.5. Land Ownership

Land ownership on and near the Mancos Valley site is shown in Figure 52. Ownership of the site is as follows:

A. Luellan, Charles L. and Muriel E.
Box 475
Mancos, Colorado 81328

4.9.2. Geotechnical Rating Matrix Evaluation

The geotechnical rating matrix for the Mancos Valley site is shown in Figure 50. The site received a score of 118 and ties for fourth based on the considered geotechnical parameters.

4.9.2.1. Geology

About 600 to 800 feet of Mancos Shale, a thick, laterally persistent marine shale unit, underlies the Mancos Valley site (Plate 3). This thickness estimate is based on stratigraphic interpretations of geophysical logs from nearby oil and gas wells. A confirming calculation was made by determining the elevation of the top of the Mancos Shale directly above the site on Mesa Verde, subtracting the thickness of the Mancos Shale from this elevation, and comparing the resulting elevation with surface elevations on the site.

A mantle of mixed alluvial and colluvial deposits covers much of the Mancos Valley site (Figure 53). Weathered bedrock (Mancos Shale) is exposed over the remaining area. Examination of vertical exposures of the surficial material along gullies just outside of the site indicates the alluvium and colluvium is primarily silty clay mixed with thin sandy zones and occasional gravel clasts. Maximum thickness of the surficial materials is unknown. Over 15 feet of unconsolidated surficial materials is exposed in gullies near the site. The alluvium and colluvium wedge out against the bedrock hills in the west end of the area.

Most soils on the Mancos Valley site are classified in the Torrifluvents-Torriorthents association (U.S. Dept. Agriculture, 1972b). They are described as warm, deep and moderately deep, well drained and poorly drained, nearly level soils on low terraces and flood plains.

The Mancos Valley site is situated on a broad structural bench between the Hogback monocline, La Plata dome, and Ute Mountain uplift. Bedrock formations in the area generally dip 2° to 4° south and strike almost east-west. Bedrock joints on the site are probably moderately spaced and open. The nearest mapped fault is just less than five miles north of the site (Haynes and others, 1972).

The present erosion rate of the Mancos Valley site is moderate, but considerable erosion has occurred along gullies that flank the north, east, and south sides of the site. Some gullying has probably occurred on the site in the recent past, but they would have been backfilled by farming activities. The long-term potential for future erosion is classified as moderate (Figure 54), but the high erosion areas that flank the site could possibly encroach upon the site with time, given the proper circumstances.

Geologic hazards in the general vicinity of the Mancos Valley site are illustrated on Figure 54. Other than the above described erosion problems, there are no geologic hazards that seriously affect the site. Potentially unstable areas lie west of the site, but they should cause no stability problems on the site. Excavations into the small bedrock hill on the west end of the site should be engineered to avoid stability problems.

Serious conflicts between mineral resource development and utilization of the site exist (Figure 54). Two dry oil and gas test holes have been drilled on the site, but one well on the site produces oil, and some nearby wells produce gas. Additional test drilling is currently taking place on adjacent land. The abandoned dry holes on the site could possibly act as vertical conduits for leakage from the repository. Before attempting to use this site as the repository, these holes should be carefully examined to determine if they were properly plugged. No gravel deposits occur on the site. The nearest potential source of riprap lies just east of the site along Mud Creek. The entire site is underlain by the coal-bearing Dakota Sandstone, but soils in this formation generally are thin, impure, and non-economic (Wanek, 1959).

4.9.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on the site. Drainages on the site flow into Mud Creek about one-fourth mile below the site. Mud Creek joins the Mancos River about three-fourths mile downstream from this point.

Surficial materials on the site carry minor amounts of water that probably is of poor to very poor quality. Surface water present in the gullies around the site appears to be of very poor quality, as is suggested by its color and the amount of salts that precipitate around standing pools of water.

The Mancos Shale host rock contains only minor amounts of generally poor quality water (Irwin, 1966; Brogden and others, 1979; Brogden and Giles, 1976). The Dakota Sandstone is the first underlying potentially important aquifer. It is 600 to 800 feet deep below the site. Quality of water from the Dakota Sandstone is variable, but it usually is average to poor (Brogden and Giles, 1976). Coal, oil, or gas present within the formation may contribute to quality problems.

4.9.3. Environmental Factors

The Mancos Valley site is only one-half mile east of Mesa Verde National Park. Numerous significant archaeologic resources are present within and adjacent to the Park. Mr. Arthur C. Townsend, State Historic Preservation Officer, notes that this is an extremely sensitive area regarding archaeologic resources and that activities near the Park would likely encounter significant resources. Major time delays could occur if resources are discovered on the Mancos Valley site.

Most of the Mancos Valley site is unirrigated farmland. Pinon-juniper occurs on the higher elevations to the west and north. The general site vicinity is critical deer and elk winter range and it lies on a major migration route. Road hazard for the site is 12.83 deer kills and 0.63 elk kills per one million vehicle trips over the entire route. This is the highest index for any site, partially because it has the greatest haul distance.

Figure 50. Geotechnical rating matrix for the Mancos Valley site.

SITE DESIGNATION: MANCOS VALLEY SITE SITE LOCATION: SECS. 3, 4, 9 & 10 T35N R14W

	FACTOR	RANK 1	RANK 2	RANK 3	RANK 4	RANK 5	WEIGHT	Factor Score
GEOLOGIC FACTORS	1. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	4
	2. Surficial materials thickness (if clay or silty clay, site ranks 5)	>25 ft.	15 to 25 ft.	10 to 15 ft.	5 to 10 ft.	0 to 5 ft.	1	5
	3. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	10
	4. Host rock thickness (if conglomerate or sandstone, site ranks 1)	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	5. Host rock relative lateral continuity	very discontinuous		somewhat continuous		very continuous	2	10
	6. Land slope	>10%		<2% or 5% to 10%		2% to 5%	2	10
	7. Susceptibility to natural slope failures	moderate to high		low		very low	2	10
	8. Dip of underlying rocks	highly folded or >45°	30° to 45°	20° to 30°	10° to 20°	0° to 10°	1	5
	9. Presence of fracturing (joints & shear zones)	closely-spaced open joints		moderately-spaced open joints		sparse or closed joints	1	3
	10. Distance from known faulting	<1/2 mile	1/2 to 1 mile	1 to 2 miles	2 to 5 miles	>5 miles	1	4
	11. Present erosional/depositional setting	intense gullying	moderate gullying	small rills	sheet erosion	no erosion or undergoing deposition	1	2
	12. Long-term potential for future erosion	high		moderate		low	1	3
	13. Conflict with mineral resources	serious conflicts		minor conflicts		no conflicts	1	1
HYDROLOGIC AND METEOROLOGIC FACTORS	14. Aquifer characteristics of surficial materials	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	15. Aquifer characteristics of host rock	produces moderate amounts of good quality water	produces minor amounts of good quality water	produces moderate amounts of poor quality water	produces minor amounts of poor quality water	produces no water	2	8
	16. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 100 ft.	100 to 200 ft.	200 to 500 ft.	>500 ft.	2	10
	17. Water quality in 1st underlying important bedrock aquifer	excellent	good	average	poor	very poor	1	3
	18. Distance to nearest spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 miles	1/2 to 1 miles	1 to 2 miles	2 miles	1	2
	19. Size of drainage basin above site	>5 sq. miles	2 to 5 sq. miles	1 to 2 sq. miles	½ to 1 sq. miles	<½ sq. mile	1	5
	20. Evaporation to precipitation ratio	<1		1 to 2		>2	1	5

Total Site Score 118

EXPLANATION SHEET
for individual site maps

Suitable Formation and Slope Map

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations (includes unsuitable bedrock formations and thick, permeable Quaternary deposits)

Land Use and Ownership Map

Residence

Subdivision

021 Residential structure
022 Commercial structure
67 Disposal facility
76 Cemetery
223 Store
236 Repair shop
242 Eating facility
243 Special purpose facility
411A Gravel pit
413 Oil well
414 Inactive gravel pit
451 Food products store
651 Water supply system
912 Orchard
914 Irrigated farm land
915 Naturally irrigated grazing land or meadows
922 Unirrigated farm land
923 Rangeland

Private

Indian

BLM

State (CDW indicates control by the Colorado Division of Wildlife)

Surficial Materials Map

Qal Alluvial Valley Fill
Qat Alluvial Terrace
Qap Terrace or Pediment
Qaf Alluvial Fan
Qac Alluvial-Colluvial (Valley fill and slope deposits)
Qcw Colluvial wedge
Qcl Colluvial (landslide origin)
Qcs Colluvial (slope failure origin)
Qct Colluvial talus
Bdrk Bedrock

Geologic Hazards Map

RF Rock Fall Area
DF Debris Flow Area
PUS Potentially Unstable Slopes
US Unstable Slopes
SFC Slope Failure Complex
LS Landslide
MF Mud Flow
HEP High Erosion Potential
MEP Moderate Erosion Potential

Mineral Resources Map

Oil Well

Gas Well

Dry Hole

Sand or Gravel

A Abandoned Mine

Mine or Gravel Pit

X 10FT Coal Mine or Outcrop (number indicates coal bed thickness in feet)

T Stream Terrace Deposits

V Valley Fill

U Upland Deposit

1 Relatively Clean Gravel or Sand Resource

4 Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

2000FT Depth to Fruitland Coal Zone

Coal Drill Hole

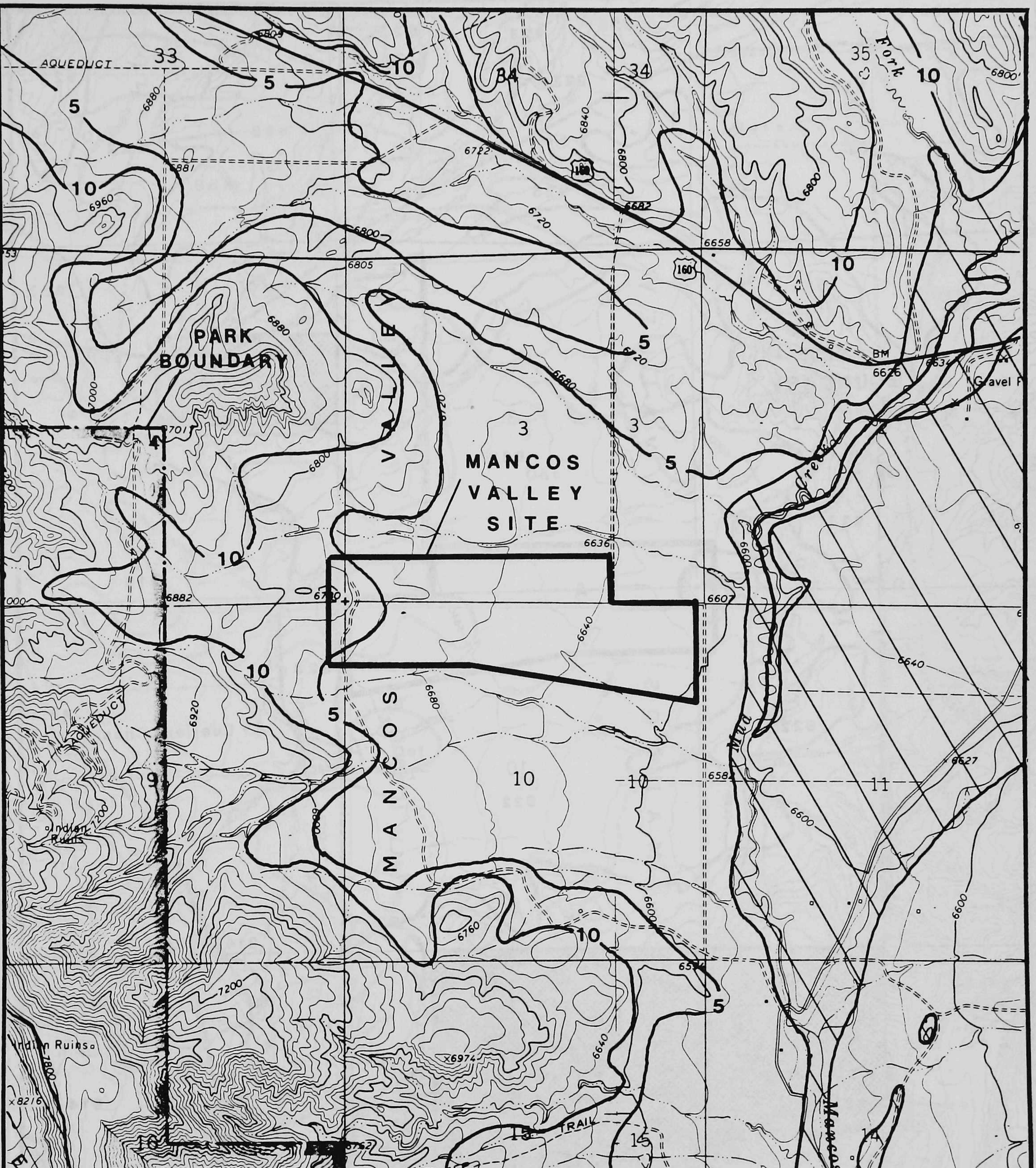

Figure 51. Suitable formation and slope map of the Mancos Valley site.

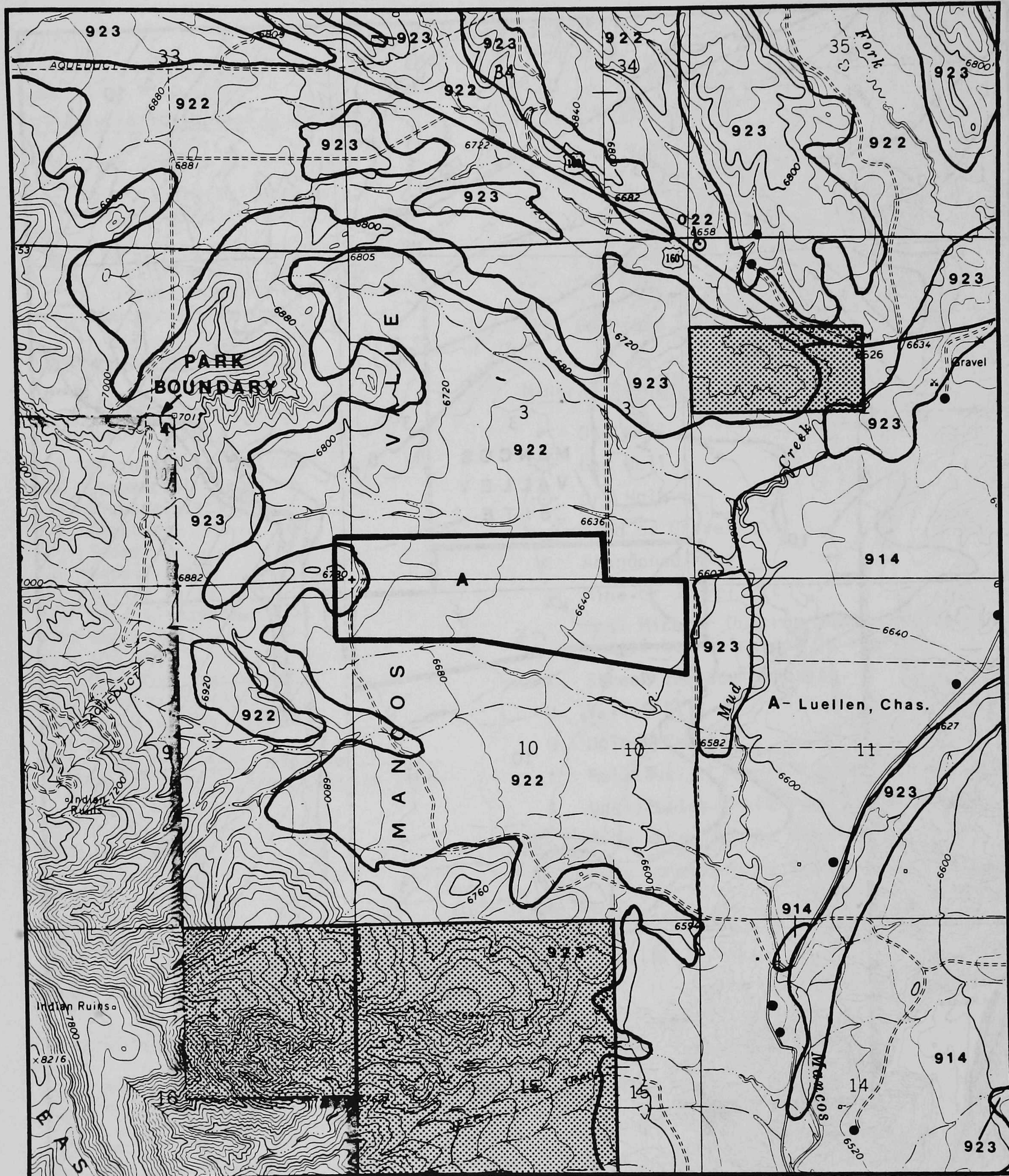

Figure 52. Land use and ownership map of the Mancos Valley site.

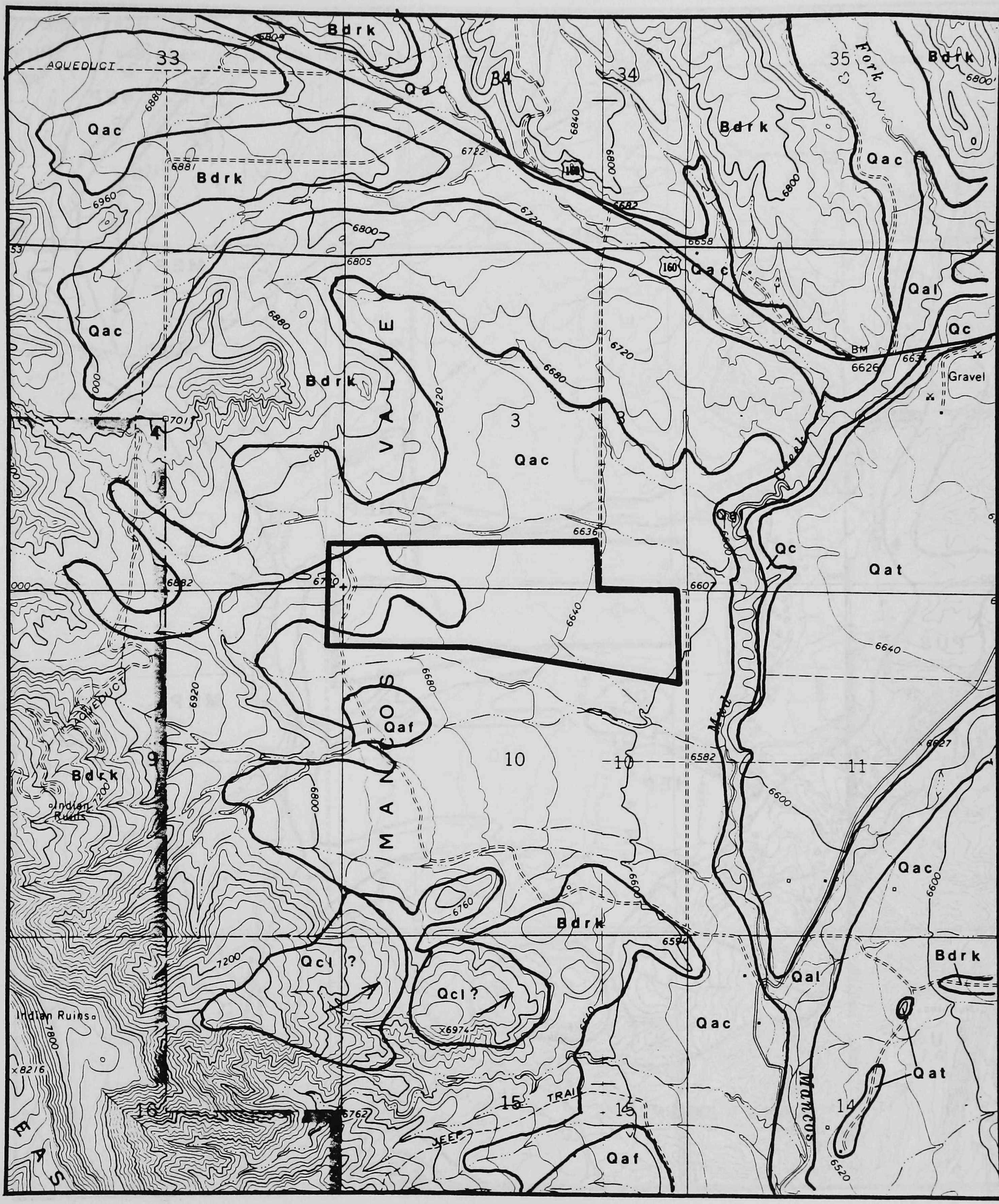

Figure 53. Surficial materials map of the Mancos Valley site.

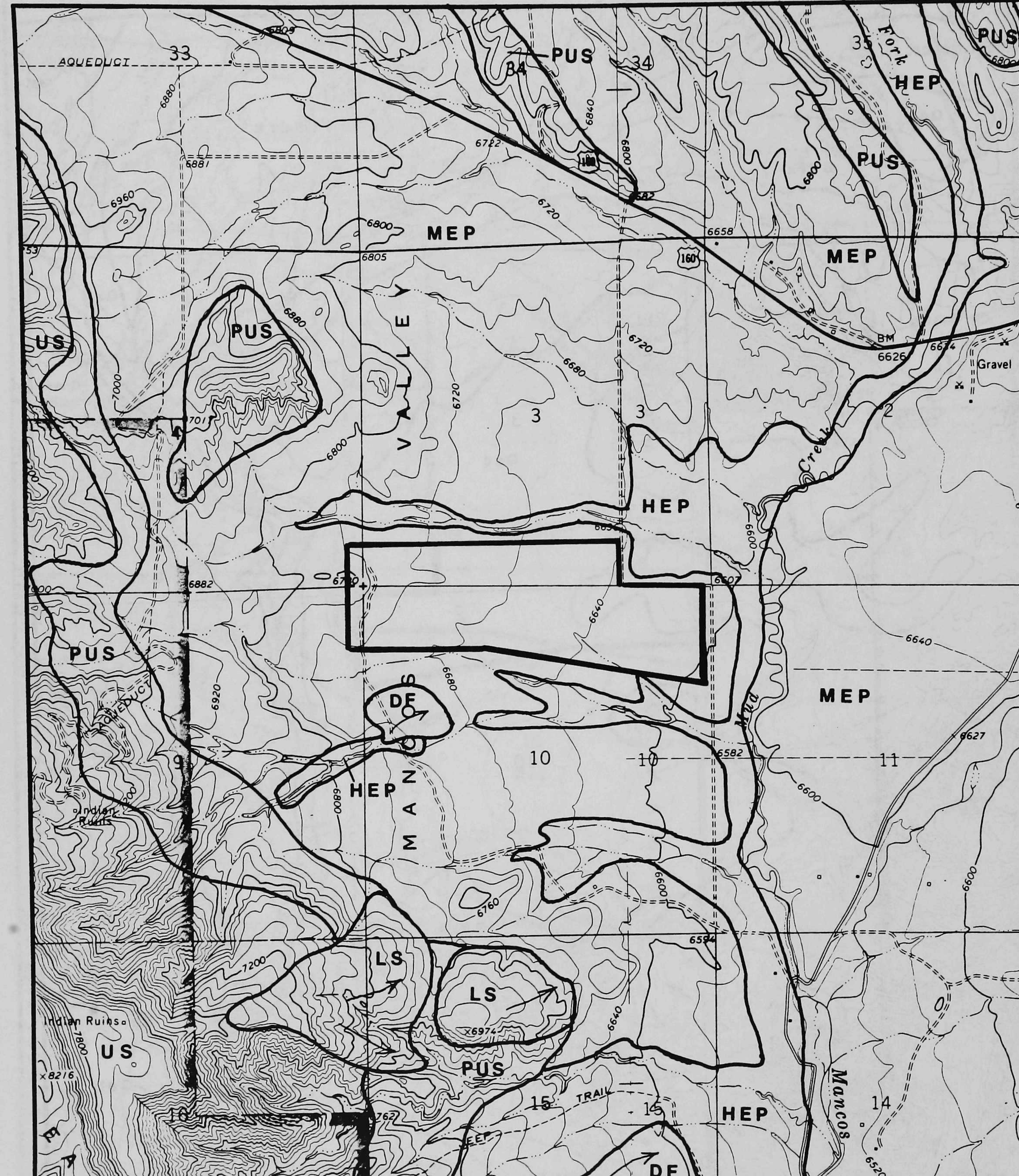

Figure 54. Geologic hazards map of the Mancos Valley site.

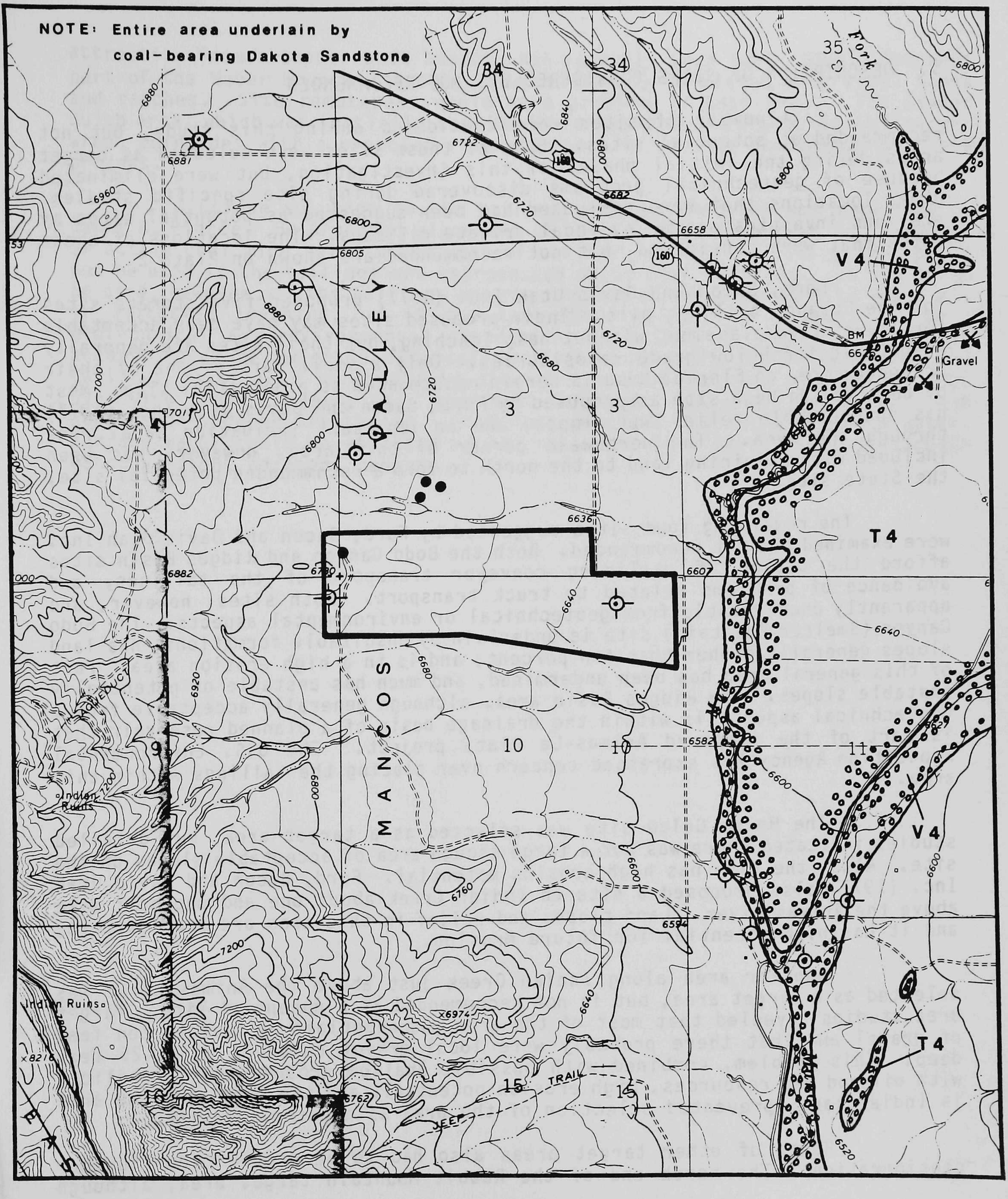

Figure 55. Mineral resources map of the Mancos Valley site.

5. DESCRIPTION OF SITES CONSIDERED BUT NOT RECOMMENDED

A number of sites were considered during this study, but not recommended as potential sites. Some of these sites were selected as target areas during the initial phases of this investigation, but were eliminated because of geotechnical problems discovered during site specific studies. Other locations that were evaluated had been suggested as potential sites by previous investigators or by local private citizens. The locations of these sites that were considered, but not recommended are shown on Plate 2.

Ford, Bacon and Davis Utah Inc. (1977) proposed five storage sites for the Durango tailings pile. Their proposed sites may have been acceptable for above grade placement without heap leaching, but their sites are generally unsuitable for below grade repositories. Only a small part of one of their proposed site on Florida Mesa is herein recommended as a potential site. Most of the Florida Mesa site as proposed by Ford, Bacon and Davis Utah Inc. (1977) has unacceptable relief and slopes, and an important irrigation canal runs through the area. The northwest corner of this area, however, has been included with adjoining land to the north to form a recommended potential site, the State site.

The remaining four sites suggested by Ford, Bacon and Davis Utah Inc. were examined but not recommended. Both the Bodo Canyon and Ridges Basin sites afford the option of utilizing conveyor transport of the tailings, and avoidance of problems related to truck transport. Both sites, however, are apparently unacceptable from geotechnical or environmental aspects. The Bodo Canyon (Smelter Mountain) site is underlain by unsuitable formations, has land slopes generally higher than ten percent, and is in a high erosion area. Part of this general area has been undermined, and much has unstable or potentially unstable slopes. The Ridges Basin area, although generally acceptable from a geotechnical aspect, is within the drainage basin of a planned reservoir that is part of the proposed Animas-La Plata project. The U.S. Environmental Protection Agency has expressed concern over placing the tailings within this area.

The Horse Gulch site was selected as a target area, but detailed studies indicated there was not a large enough area of acceptable slopes on the site. Also, the site has high erosion potential. Ford, Bacon and David Utah Inc. (1977) also proposed a site on Indian Creek about one and one-half mile above the Animas River. Land slopes and relief in this area are unacceptable, and it has high potential for future erosion.

Another area along Indian Creek just above the Animas River was selected as a target area, but is not recommended as a potential site. Target area studies revealed that most of the area was underlain by five to ten feet of gravel and that there probably were local gravel channels up to 25 feet deep. This problem, combined with possible shallow ground water, conflicts with oil and gas resources, high erosion potential, and the fact that the area is Indian land, prevented selection of the area as a potential site.

Parts of other target areas also had to be dropped from further consideration. The north end of the Rabbit Mountain target area, although attractive from a topographic aspect, has recently been subdivided. The east part of the Weber Mountain target area is densely populated with rural homes and ranches. Site remoteness would be a problem in this area. The Cinder Gulch area, which was initially considered for possible designation as a target area, coincides with a proposed reservoir that is part of the Animas-La Plata project.

A unique solution to the tailings disposal problem was suggested by Danny K. Pierce. He proposed placement of the tailings in worked out areas of an active coal mine seven miles west of the tailings pile. This method could not be used if the tailings are reprocessed using heap leaching. It could not be used, however, if the tailings are reprocessed on the present site using vat or agitation leaching, or if the tailings are not reprocessed. From a geotechnical and environmental standpoint, this type of disposal is not as acceptable as below grade disposal in thick shale beds. Raffinate from the tailings could leak horizontally through the coal bed and vertically into overlying or underlying aquifers through natural conduits and subsidence-induced fracturing. Such leakage could contaminate ground water. Surface water could be affected as the solutions leak to the surface through outcrops along adjacent canyons.

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APPENDIX A
RECONNAISSANCE EVALUATION OF THE SUITABILITY OF THE BODO CANYON AREA FOR TAILINGS DISPOSAL

A-1. Introduction

On December 15, 1980, the Site Selection Committee recommended that the Bodo Canyon area be further studied for tailing disposal suitability. Although the Bodo Canyon area does not meet the geotechnical criteria established by the Colorado Geological Survey, the Committee felt that the advantages afforded by shorter haul distances on less travelled roads or alternate transportation methods justified additional consideration of this area. Appendix A presents the results of a reconnaissance evaluation that was conducted to identify the major geotechnical problems that could affect a tailings disposal facility in the Bodo Canyon area.

Five tracts with the highest potential as disposal sites were identified in the Bodo Canyon area during this preliminary study (Figure A-1). Below grade disposal appears to be infeasible for all five sites because the sites have a very high erosion potential and none are large enough to readily accept all the tailings and associated material. Specialized design and construction techniques may increase the available storage volume for a particular site, but it is likely that two adjacent sites would have to be utilized to hold all the waste material. All five sites have severe potential geotechnical problems that must be carefully evaluated during later detailed studies if the site is to be further considered. These problems include surface and ground water contamination, severe erosion rates, unstable or potentially unstable slopes, and faulting. These problems must be carefully evaluated to determine the basic feasibility of the tracts within Bodo Canyon.

A-2. General Area Characteristics

A-2.1. Location

Figure A-1 shows the location of the Bodo Canyon area and the five designated tracts. The Bodo Canyon area is bordered by Smelter Mountain on the north, Carbon Mountain on the south, the Animas River on the east, and the drainage divide between Ridges Basin and Bodo Canyon on the west. The area is on the opposite side of Smelter Mountain from Durango and the tracts identified are about one and one-half air miles southwest of the tailings pile. Parts of Sec. 5 and 6, T34N (N. of Ute line), R9W, Sec. 25 and 36, T35N, R10W, Sec. 31 and 32, T34 1/2N, R9W, and Sec. 31 and 32, T35N, R9W are included in the Bodo Canyon area.

A-2.2. Storage Capacity

About 2 million tons of tailings and associated waste material must be moved as part of the Durango UMTRAP project. This tonnage approximately represents 2 million cubic yards of material. The below grade storage capacity of each of the five sites in Bodo Canyon was roughly estimated by Goff Engineering during this investigation. Volume calculations were made by assuming that 20 feet of tailings could be placed in the entire tract area outlined in Figure A-1.

The estimated storage volumes are as follows: Area A--300,000 cu. yd., Area B--500,000 cu. yd., Area C--1,000,000 cu. yd., Area D--700,000 cu. yd., Area E--1,000,000 cu. yd. Thus, none of the five areas appear to be readily capable of holding all the material that must be isolated. Utilization of certain engineering techniques could increase the storage volume of a particular area but could also increase long term vulnerability. Storage capacity of the most favorable disposal area in Bodo Canyon should be carefully re-evaluated in this manner during later detailed studies.

A-2.3. Access

An existing dirt road leads southward from the tailings piles along the east side of Smelter Mountain. This road could be improved and used as the haul route to County Road 211. County Road 211 leads into the Bodo Canyon, but it would have to be upgraded to support heavy truck traffic. A conveyor or slurry pipeline system could also be considered to transport the tailings to any site within the Bodo Canyon area but cost and risk of environmental contamination must be carefully evaluated to determine if this is a viable option. The most likely route for such a system would parallel the dirt road on the east side of Smelter Mountain and County Road 211. Existing unimproved roads would have to be upgraded or new roads constructed to provide access from County Road 211 to the disposal site.

A-2.4. Topographic Setting

The Bodo Canyon area occupies a drainage basin that covers about four to five square miles (Figure A-1). Most of the area consists of steep slopes that lead into small canyons or subbasins. Areas A through D lie in relatively small, severely gullied subbasins that drain northward. Slopes in these areas generally range from 10 to 20 percent. Area E lies in a small subbasin that has slopes of less than 15 percent. No severe gullying was observed in Area E.

A-2.5. Land Use

Land use in the Bodo Canyon area is illustrated in Plate A-1. Most of the area is currently classified as rangeland. Several electrical transmission lines and a gas pipeline cross the area, and an electrical substation lies between Areas D and E. No homes are within the immediate Bodo Canyon area. A proposed water pipeline that is part of the Animas-La Plata project runs through the area, and a proposed municipal water treatment plant lies on parts of Areas A and B.

A-2.6. Land Ownership

Land ownership in the Bodo Canyon area is shown on Plate A-1. The entire Bodo Canyon area is owned by the Colorado Division of Wildlife. This land was donated to the State by The Nature Conservancy. The Division of Wildlife stated that they would not be able to give or sell the acres needed for a site. Replacement land of equal value would have to be furnished. The Division of Wildlife would have to review and approve the exchange after obtaining approvals from The Nature Conservancy and the Bureau of Heritage and Outdoor Recreation, U.S.A. Whether such a land exchange could be made is uncertain.

A-3. Geotechnical Characteristics

A-3.1. Geology

A surficial geologic map of the Bodo Canyon area is shown in Figure A-3. A number of bedrock formations crop out in the area, but only one of these formations, the Lewis Shale, is designated as a suitable formation. Figure A-2 illustrates the distribution of suitable formations in the Bodo Canyon area. Four of the five designated disposal areas are at least partly underlain by Lewis Shale. The Cliff House Sandstone underlies the lower part of Area D and all of Area E. In the Bodo Canyon area this formation consists of interbedded sandstone and shale.

Bedrock or thin soil over bedrock is found in most of the Bodo Canyon area. Four of the designated sites, however, are underlain by relatively thin wedge-like deposits of mixed alluvium and colluvium. Bedrock is exposed at the surface over most of Area A. Up to 12 feet of dominantly silty clay was observed in Area B. Gully exposures in Area C reveal that up to as much as 20 to 25 feet of alluvium and colluvium is present in the center of this basin. Most of the unconsolidated material in Area C is silty clay, but locally it is interbedded with layers of mixed bedrock fragments (both sandstone and shale), sand, and silt. Area D has as much as 10 to 12 feet of silty clay in it. Some mud flow activity and landsliding may have occurred in both Areas C and D, particularly in their upper reaches. There are no significant gully exposures in the unconsolidated material in Area E. Since the bedrock in this area is Cliff House Sandstone, the alluvial and colluvial material that underlies the area probably consists of interbedded silty clay and silty sand with fragments of sandstone.

Although significant bedrock is exposed throughout the Bodo Canyon area, soils are primarily classified as a Camborthids-Torriorthents-Haplargids association (U.S Dept. of Agriculture, 1972a). They are described as warm, dominantly shallow, well drained, steep soils on hills, breaks and canyons.

Structurally, the Bodo Canyon area lies on the Hogback monocline, a major structure that bounds the north and northwest sides of the San Juan Basin. Most deformation associated with this structure is probably of Laramide age. Within the Bodo Canyon area rocks generally dip 5° to 15° southeast. Directly south of the area dips steepen to 15° to 40°.

The Ridges Basin-Bodo Canyon-Durango area is the only area along the northwest flank of the San Juan Basin where significant faulting has been reported (Figures A-3, A-4, and A-5). Several northeast-trending faults occur in the area. Numerous other small faults and fractures are also present within this zone of faulting. Displacements on individual faults are consistent with normal faulting. The faults are oriented in an en echelon pattern that suggests a minor amount of left-lateral movement over the entire zone of faulting.

None of the faults exhibit major amounts of total displacement. Maximum displacement on individual faults is not precisely known, but probably is on the order of 75 to 125 feet. This amount of displacement is indicated by the juxtapositioning of the upper part of the Point Lookout Sandstone against the upper part of the Menefee Formation on the fault that extends between Areas B and C, and on the fault that extends toward Area A along which the lower part of the Menefee Formation is faulted against the Cliff House Sandstone. The fault that runs through Ridges Basin appears to have experienced less displacement than the other two faults.

The mapped faults are not known to extend into any of the designated disposal areas. However, the exact terminus of these faults is not known and is difficult to determine particularly when the faulting is within the Lewis Shale. Furthermore, other small displacement faults and shear zones that can not be recognized from the surface may exist in the Bodo Canyon area. An example of this problem occurs just north of the electrical substation. Several faults and shear zones are present in the artificial cut on the north side of the substation. These faults are not recognizable on aerial photographs, nor can they be followed in either direction on the surface above the cut. Only a very minor amount of movement has occurred on these faults, but they still might act as vertical conduits for leakage from a disposal site. Additional detailed study of the faulting in the Bodo Canyon area is needed to ascertain if such fracture or shear zones coincide with the proposed disposal sites and to determine their age of movement and hydrologic significance.

Erosion appears to be a very major problem for most disposal sites in the Bodo Canyon area. Extensive gullying has occurred on Areas A, B, C, and D in the recent past. Only Area E has escaped severe gullying during the past few decades. Area C has experienced the deepest gullying. The gullies in this area have cut as deep as 25 to 30 feet into the unconsolidated basin fill and bedrock. The erosion potential for Areas A through D is classified as high. A moderate erosion potential is assigned to Area E. A detailed geomorphic evaluation of the erosion potential of the Bodo Canyon area should be conducted during future detailed studies.

Other geologic hazards that affect the Bodo Canyon area are illustrated in Figure A-5. Part of the Bodo Canyon area has been undermined by coal mining. Subsidence could threaten the security of a disposal facility build above these undermined areas. Added loads caused by the weight of the tailings increase the risk of subsidence. The five tracts considered in this report are outside of any known undermined areas. Mines records held by the Colorado Division of Mines and the Colorado Geological Survey indicate a few mines existed in this general area whose entry location and extent are not accurately known. These mines and related subsidence potential should be further investigated if the Bodo Canyon area is selected as a candidate disposal site.

Unstable or potentially unstable slopes also affect most disposal sites in the Bodo Canyon area (Figure A-5). Landslide slump blocks occur at the heads of Areas C and D. Excavations in the Bodo Canyon area may have to be specially designed to prevent slope instability problems during construction of trenches.

Coal beds in the Menefee Formation underlie most of the Bodo Canyon area (Figure A-6). Extensive underground mining of these beds in the past has occurred in parts of the area. Zapp (1949) indicates the Menefee coal beds in the Bodo Canyon area are generally less than five feet thick. The Menefee coal zone is probably 200 to 500 feet deep below Areas A through D and 100 to

300 feet deep below Area E. These depths are rough estimations based on stratigraphic and structure data gathered in the area.

Other mineral resources would probably not be affected by use of the Bodo Canyon area. No oil or gas test wells have been drilled in the immediate area, but test wells to the northeast and southwest encountered no significant resources. No significant gravel deposits occur in the Bodo Canyon area. The nearest possible source of riprap lies to the east along the Animas River.

A-3.2. Hydrology

The Bodo Canyon area comprises a four to five square mile drainage basin that drains directly into the Animas River. Four of the designated disposal areas drain into an intermittent, small creek within the basin, while Area E drains into a second intermittent creek within the basin. Distance from the proposed disposal areas to the Animas River ranges from one-half to one and one-half miles. There are no major streams, lakes, springs, or irrigation ditches in the Bodo Canyon area.

The surficial materials at Areas B through E probably carry minor amounts of water. A few small seeps were observed in some gullies, but these may have been related to the melting snow present at that time. Any water within the surficial deposits may be seasonal in nature. Surficial deposits in Area E may carry a little more water than the deposits in other areas, as is evidenced by the ponderosa pine that grows there.

There are no water wells in the Bodo Canyon area, thus the ground-water conditions are poorly known. Areas A through D are partly or completely underlain by the Lewis Shale. Shale thickness varies from site to site, and within a site from 0 to over 200 feet. The Lewis Shale usually carries only minor amounts of generally poor quality water. The Cliff House Sandstone, the first underlying potential aquifer, lies at the surface beneath all of Area E and parts of the lower ends of other areas. The Cliff House consists of interbedded sandstones and shales, possesses variable ground-water characteristics, and in some places carries no ground water.

The most significant potential ground-water problem in the Bodo Canyon area relates to Area E. As shown in Figure A-4, the sandstones that underlie the site dip towards and outcrop along the canyon to the south. Leakage from this disposal site could seep into the underlying sandstones, flow down dip, and leak to the surface along the canyon wall.

A-3.3. Potential Geotechnical Problems

The major potential geotechnical problems related to use of Areas A through D in Bodo Canyon are erosion, storage capacity, slope instability, faulting, and concern over surface and ground-water contamination. All four areas have experienced severe erosion during the past few decades and all have a high potential for future erosion. As previously described, none of these areas appear to be capable of readily holding all the waste material. Slope instability may cause additional problems that limit storage capacity or affect the security of the disposal facility. The concern over surface and ground-water contamination with Areas A through D primarily relates to fracture permeability associated with the faulting and the lack of optimum depth of underlying shale in the northern part of the tracts.

Storage capacity, surface and ground-water contamination, and availability of liner and cap material are the major geotechnical concerns with Area E. Although Area E appears to be more suitable for below grade disposal from a slope aspect, the size of the area still causes questions to be raised concerning its storage capacity. Because the sandstones that underlie the site dip toward and outcrop along a nearby canyon, there are serious concerns about both surface and ground-water contamination. Since the area is underlain by interbedded sandstone and shale, there is a problem with availability of cap and liner material. Suitable material will have to be excavated at another location and hauled to Area E.

A-4. Environmental Factors

The vegetation of the Bodo Canyon area is primarily a sagebrush and grass association with scattered pinion pine and juniper. Some clumps of oakbrush occur near all sites and within some of them. A few ponderosa pine are found at the fringes and on some sites. The area is critical, high-quality deer and elk winter range. It was acquired for this purpose by the Colorado Division of Wildlife. One hundred elk are now using the general study area. Black bear and mountain lion occur frequently in the area and a black bear was killed there by a hunter in the 1980 big game season. Golden eagles frequent the area, and occupy an active nest on the mountain just to the south. Bald eagles (an endangered species) hunt through the Bodo Canyon area because of its proximity to the Animas River. The area is also within the hunting range of an historical peregrine falcon eyrie. The Colorado Wildlife Commission must make any decisions on permission to enter on the area for exploratory purposes (this process takes two months), and the Commission must act on any proposed use of the area.

A search of the records of the Colorado Historical Society records indicates archaeological resources have been identified in the Bodo Canyon area. A professional archeological survey to identify the cultural resources must be conducted during detailed site evaluations.

EXPLANATION SHEET
for individual maps of the Bodo Canyon Area

SUITABLE FORMATION AND SLOPE MAP

5 Slope Contour in Percent

Underlain by Suitable or Possibly Suitable Formations

Underlain by Unsuitable Formations

SURFICIAL GEOLOGIC MAP

Unconsolidated Deposits

Q_{al}	Alluvial Valley Fill
Q_{ap}	Terrace or Pediment Deposits
Q_{af}	Alluvial Fan Deposits
Q_{ac}	Mixed Alluvial and Colluvial Deposits (valley fill and slope deposits)
Q_{cl}	Colluvial Deposits of Landslide Origin

Bedrock Formations

TK_a	Cretaceous-Paleocene Animas Formation (includes the McDermott member)
K_k	Cretaceous Kirtland Shale
K_f	Cretaceous Fruitland Formation
K_{pc}	Cretaceous Pictured Cliffs Sandstone
K_l	Cretaceous Lewis Shale
K_{ch}	Cretaceous Cliff House Sandstone
K_{mf}	Cretaceous Menefee Formation
K_{pl}	Cretaceous Point Lookout Sandstone
K_m	Cretaceous Mancos Shale

Fault; dashed where approximately located; dotted where concealed; ball on downthrown side; question mark indicates extent uncertain.

GEOLOGIC HAZARDS MAP

RF	Rock Fall Area
DF	Debris Flow Area
PUS	Potentially Unstable Slopes
US	Unstable Slopes
LS	Landslide
HEP	High Erosion Potential
MEP	Moderate Erosion Potential

S Approximate boundary of possible subsidence area over abandoned underground coal mines; question marks indicate extent of mine workings uncertain.

f Fault; dashed where approximately located; dotted where concealed.

MINERAL RESOURCE MAP

Dry Oil or Gas Exploration Hole

Sand or Gravel

A	Abandoned Mine
T	Stream Terrace
V	Valley Fill
1	Relatively Clean Gravel or Sand Resource
4	Unevaluated Gravel or Sand Resource

Area Underlain by Menefee Coal Zone

Area Underlain by Fruitland Coal Zone

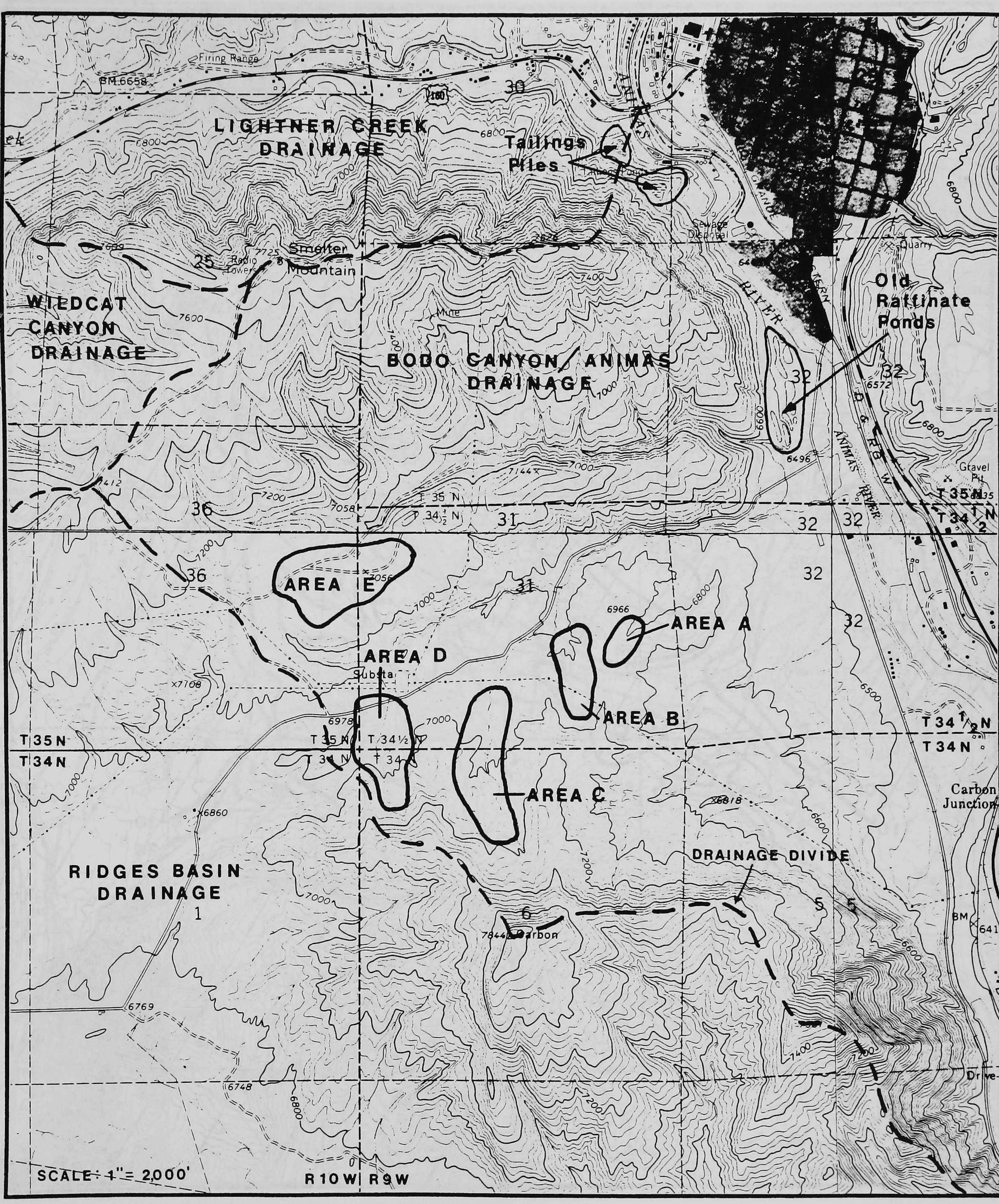


Figure A-1. Possible tailings disposal areas and drainage basins in the Bodo Canyon area.

Figure A-2. Suitable formation and slope map of the Bodo Canyon area.

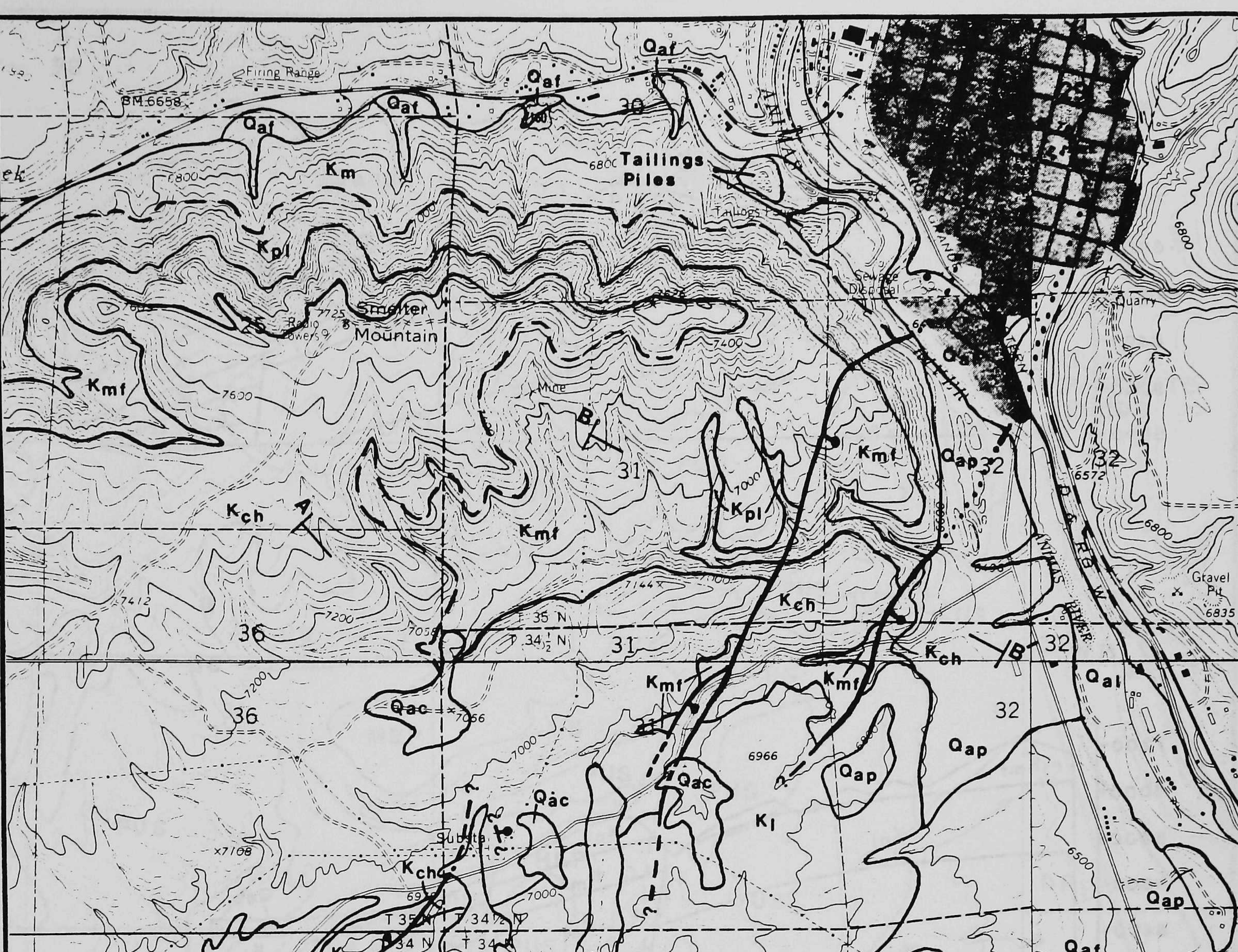
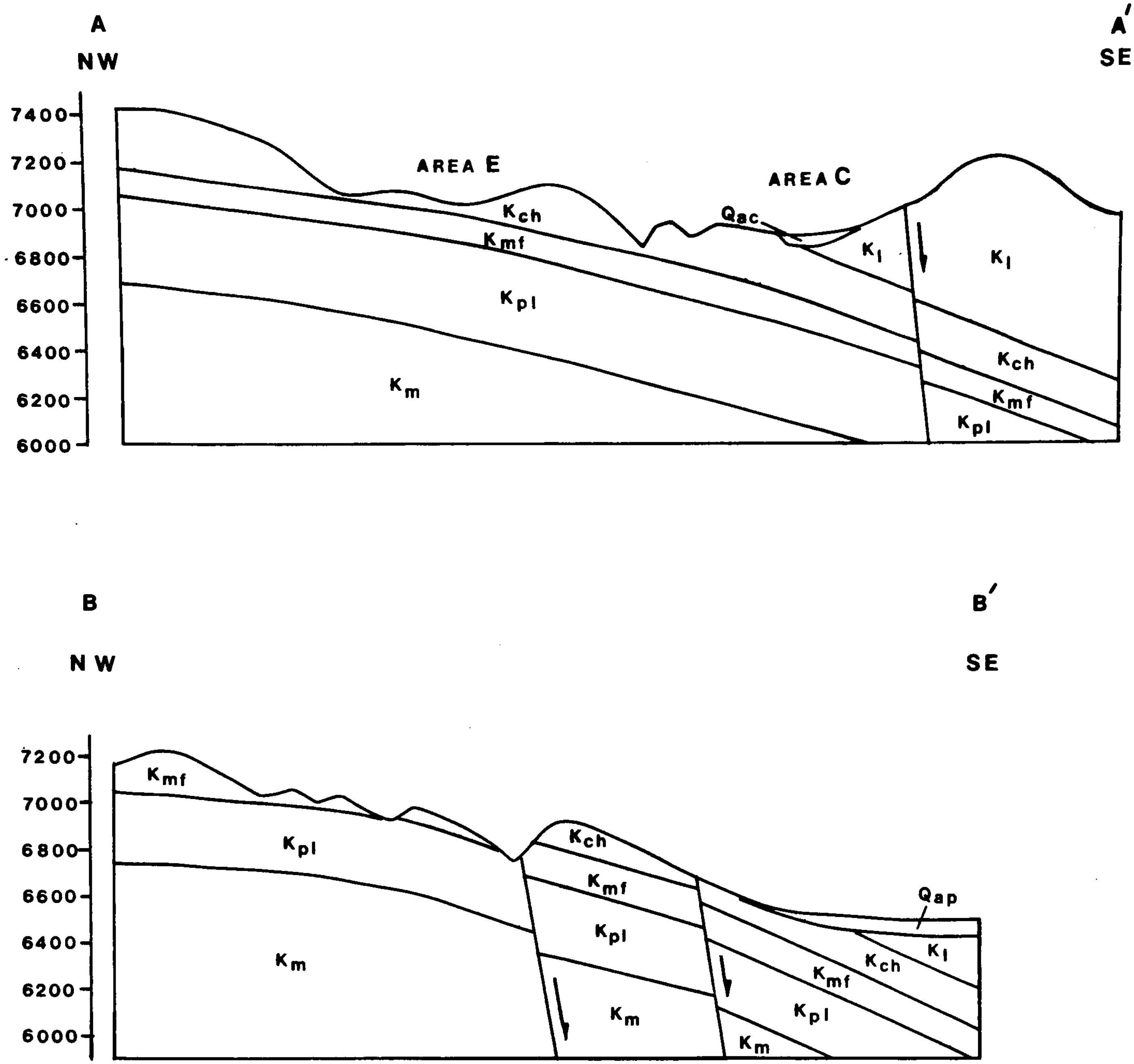


Figure A-3. Surficial geologic map of the Bodo Canyon area.



EXPLANATION

Qac Quaternary alluvium and colluvium

Qap Quaternary terrace or pediment deposits

Fault; arrow indicates direction of movement

Kl Cretaceous Lewis Shale

Kch Cretaceous Cliff House Sandstone

Kmf Cretaceous Menefee Formation

Kpl Cretaceous Point Lookout Sandstone

Km Cretaceous Mancos Shale

Horizontal Scale: 1" = 1,333'   Vertical Exaggeration: 2X

See Figure A-3 for cross section locations

Figure A-4. Geologic cross sections in the Bodo Canyon area.

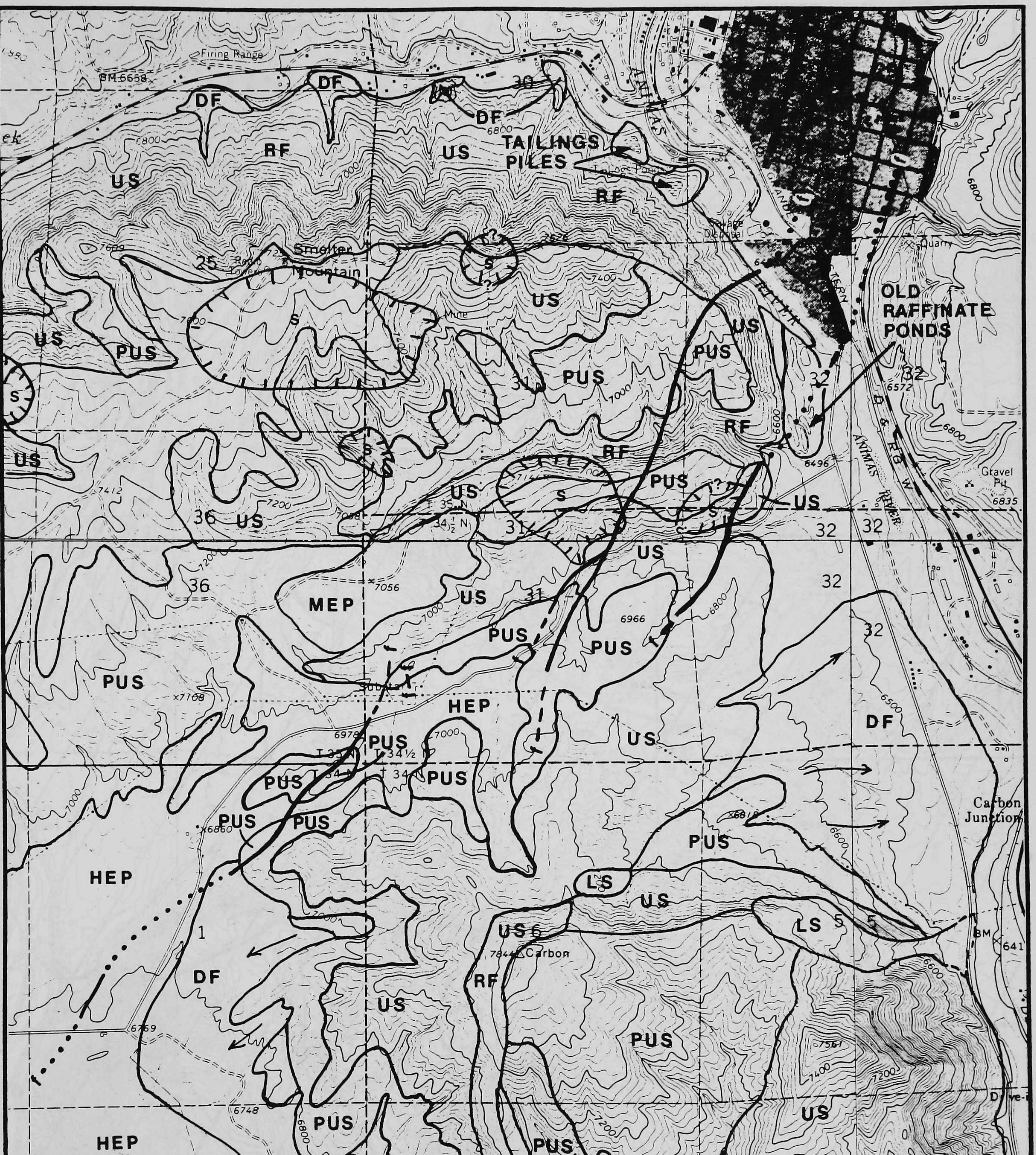


Figure A-5. Geologic hazards map of the Bodo Canyon area.

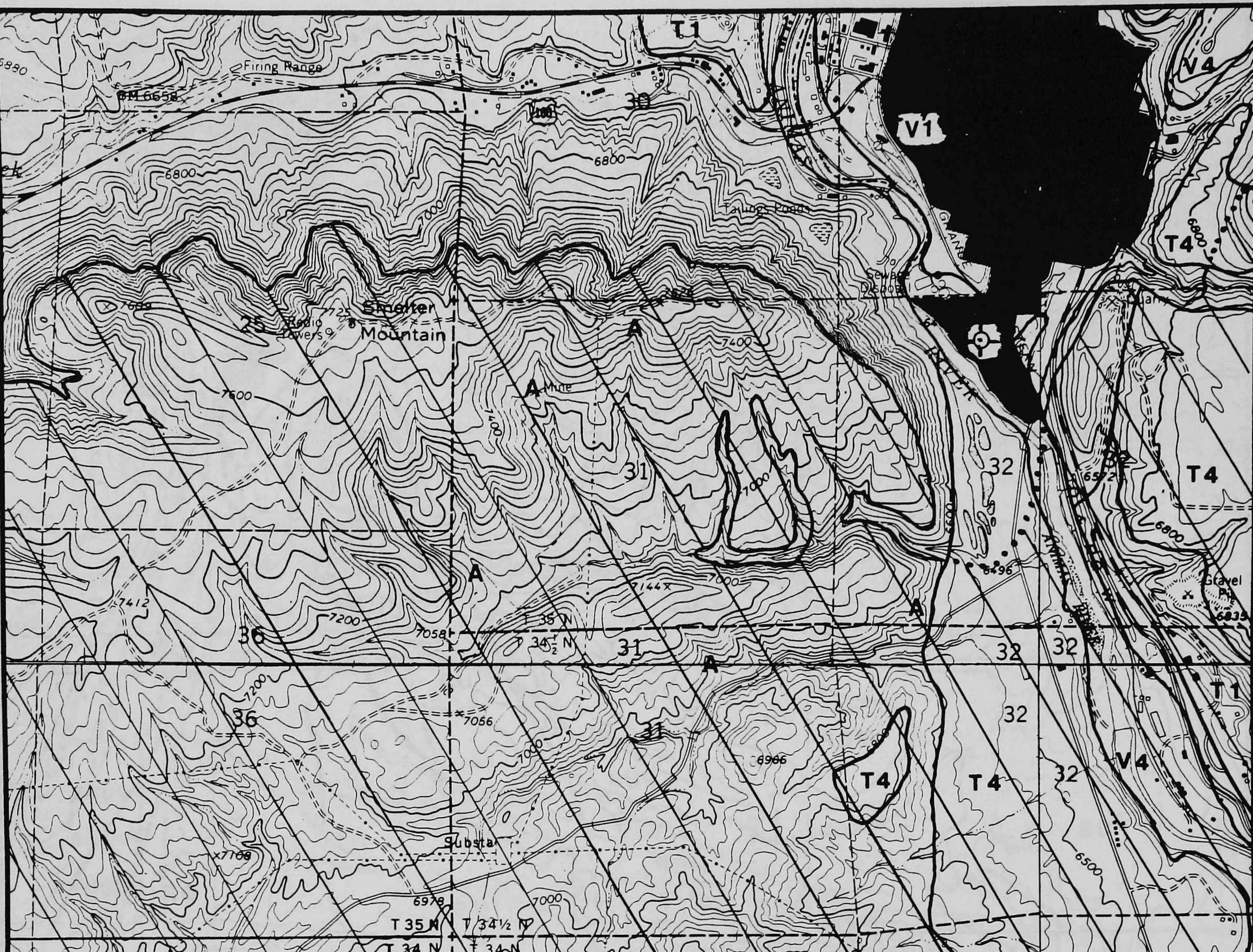


Figure A-6. Mineral resources map of the Bodo Canyon area.

APPENDIX B

CORRESPONDENCE

DURANGO URANIUM MILL TAILINGS REMEDIAL ACTION PROGRAM

RICHARD D. LAMM
GOVERNOR

STATE OF COLORADO

JOHN W. ROLD
Director

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
715 STATE CENTENNIAL BUILDING – 1313 SHERMAN STREET
DENVER, COLORADO 80203 PHONE (303) 839-2611

November 5, 1980

Dear Committee Member:

The Site Selection Committee was organized to evaluate potentially suitable sites for the reprocessing and permanent disposal of potentially hazardous uranium mill tailings located in the Durango area. It is the committee's responsibility to select the three or four best candidate sites for further, detailed evaluation by the Department of Energy. Paramount consideration in the site selection process is the safe long-term disposal of the tailings material.

To aid in the site-selection process, the attached report, titled "Preliminary Report on Potential Sites Suitable for Relocation and/or Reprocessing of the Durango Uranium Mill Tailings Pile" presents data and information on potential sites within 30 miles of Durango. Additionally, the report ranks the sites by geotechnical analyses according to a grading matrix. The site-selection recommendations by the committee should not be based solely on this geotechnical-rating matrix, but should include other important factors that must be considered in the selection of an acceptable disposal site. These factors include, but are not limited to, reclamation potential, tailings reprocessing, transportation elements, land use and land ownership, environmental impacts, economics, local opposition or support for particular sites, and need for future maintenance. This report is submitted to each committee member for review and as a foundation for their own analysis and evaluation. The committee should incorporate all important factors into the final selection of candidate sites. The report itself should not be considered final as it will be revised to include additional data or information from the committee members.

It is suggested that each committee member evaluate the proposed sites and rank them as to their acceptability. Such an evaluation and ranking may be a detailed, numerical sequence, or it may be a simple acceptable or not acceptable designation, depending on the specialty or the reviewer. In any case, the major considerations or potential problems for each site should be presented in written form to the committee chairperson so that they can be incorporated into the final report. In addition, each committee member should express the preferred type of tailings disposal method for safe and permanent isolation of the material.

Once the committee members have evaluated the sites, identified and written major considerations of the sites, and described preferred method of tailings disposal, another meeting of the committee will be held to make a final site selection and to summarize comments of the committee members. These recommendations will be incorporated into a final report to be submitted to the Colorado Department of Health by the Colorado Geological Survey.

The Colorado Department of Health and the Colorado Geological Survey request that this document be held in confidence. Land purchase options will have to be acquired on the candidate sites selected by this committee. To facilitate this action, it is requested that each committee member not release this information to the public. As soon as land options are acquired, public meetings will be held in order to receive appropriate response from the general public.

Sincerely,

W. P. Rogers

W. P. Rogers, Chief
Environmental and Engineering
Geology Section

STATE OF COLORADO

RICHARD D. LAMM
GOVERNOR

JOHN W. ROLD
Director

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January 9, 1981

Mr. Albert J. Hazle, Director
Radiation and Hazardous Waste Control Division
Colorado Department of Health
4210 East 11th Avenue
Denver, CO 80220

Dear Mr. Hazle: RE: DURANGO, UMTRAP

As requested in the December 15 Site Selection Committee meeting, committee members have submitted comments regarding major concerns and future studies needed to fully evaluate the four candidate sites. This letter summarizes those concerns and studies.

Paramount in the identification of major concerns and in determining future studies is the assumption of a specific tailings disposal method. The Committee unanimously recommended that the NRC criteria be used in the disposal of tailings. The tailings should be dewatered, disposed of below grade, covered with a minimum of 3 meters of earth cover, and properly reclaimed. If a different method of tailings disposal is proposed, the conclusions and recommendations of the committee must be reconsidered. The committee should be reconvened to determine the feasibility and acceptibility of this different disposal method.

The committee members in their review and evaluation of the sites noted specific concerns for each of the sites and recommended that further studies be conducted by the DOE and their consultants. These studies are deemed necessary to evaluate the feasibility of individual sites and to select a preferred alternative. It should be noted that the site boundaries depicted at this time should not be considered as fixed. The site boundaries should be adjusted, if necessary, as additional site data and information becomes available. The concerns and studies suggested by the committee follow:

RABBIT MOUNTAIN

Major Concerns

- oil and gas development
- coal resources
- surface and ground water hydrology
- transportation distance and haulage route
- proximity to population (subdivisions)
- wildlife impact
- erosion potential

Recommended Studies
- detailed resource study/impact evaluation
- hydrologic analysis/possible contamination pathways
- transportation study
- population density study
- wildlife study
- geomorphic study

PINE RIDGE

Major Concerns
- relatively shallow coal resources
- surface and ground water hydrology
- erosion rate
- proximity to population (subdivisions)
- transportation route and method
- thickness and permeability of bedrock

Recommended Studies
- coal resource evaluation/impact study
- hydrologic analysis/possible contamination
- detailed geomorphic analysis
- population density study
- transportation study of alternate route and slurry or conveyor methods

LONG HOLLOW

Major Concerns
- surface and ground water hydrology
- transportation route and method
- wildlife migrate

Recommended Studies
- hydrologic analysis/possible contamination pathways
- transportation study of alternate route and slurry or conveyor method
- wildlife study

BODO CANYON

Major Concerns
- slope instability
- rapid erosion rates
- transportation method
- faulting/fractured bedrock
- surface and ground water hydrology
- coal resource potential

Recommended Studies
- detailed geomorphic/slope-stability analysis
- alternative transportation study
- hydrologic analysis
- resource evaluation

In addition to these specific concerns and studies, committee members also requested information that applies to all of the sites. Specific items that should be addressed are as follows:

1. Determine the method of tailings disposal and dewatering.
2. Determine the location, amount, geochemical, and physical properties of the liner.
3. Determine the location, amount, physical properties, and design of the cover.
4. Determine the control measures for blowing tailings material during pile removal, along the haul route, and at the new site.
5. Investigate the possibility of reprocessing the slag beneath the present tailings pile for base and nobel metals.
6. Determine the feasibility of tailings disposal in existing mines near Durango or in New Mexico strip mines.
7. Assess the short and long-term social and economic costs and benefits including futures foregone, transportation, construction, and risk.
8. Address the feasibility of in-place stabilization and reclaimation.

In summary, the committee requests that additional investigations be conducted to determine site feasibility and to aid in determining the preferred site. We suggest that a priority be established for each of these studies so that critical factors can be addressed first and submitted to the committee. As these studies or other additional information becomes available, the Site Selection Committee will continue their work on selecting an adequate site for the disposal of the Durango tailings.

Sincerely,

Walter R. Junge
Chairman, Site Selection Committee

gp

RICHARD D. LAMM
GOVERNOR

STATE OF COLORADO

JOHN W. ROLD
Director

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
715 STATE CENTENNIAL BUILDING – 1313 SHERMAN STREET
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January 21, 1981

Dear Site Selection Committee Members: RE: DURANGO REMEDIAL ACTION PROGRAM

A meeting was held on January 16, 1980, with the Department of Energy, their consultants, and the Colorado Geological Survey to discuss technical aspects of the Durango Program. The site selection process and technical information on the candidate sites were discussed with the following people during the morning session:

Rahe Junge	Colorado Geological Survey
Steve Hart	Dames & Moore
Fred Ellenbecker	Bureau of Indian Affairs
Jim Formea	BIA - Southern Ute Agency
Bob Kirkham	FOCERI
Don Wickman	BIA Soils
Orin Richardson	Land Owner, Rabbit Mountain
Gene Richardson	" " " "
Tom Ann Casey	Geologist
Charles Butler	FOCERI
A. L. Gonzales	DOE/ALO - UMTRA
Michael DeWitte	Sandia
Felton Bingham	"
John McKiernan	"
Martin Tierney	"
Richard H. Campbell	DOE/ALO - UMTRA

During the afternoon session, a field trip was conducted to Bodo Canyon, Long Hollow, Pine Ridge, and Rabbit Mountain. The public participated and was well represented in this field review. Mr. and Mrs. Richardson and Mr. Gary Farmer, land owners, attended the field review. The geologic setting, advantages, and major concerns of each site were discussed during the field trip.

Certain studies were recommended as a first priority in the future work by Dames and Moore. These studies were designed to address the factors that are most critical in the determination of site feasibility and in selecting a preferred site. These recommended studies are as follows:

Bodo Canyon

1. Erosion and potential slope instability are major concerns for the long-term (10,000 years) containment of tailings in the Bodo Canyon area. Recently formed gullies 20 to 30 feet deep are common throughout the Lewis Shale. The geomorphic stability of the entire study area should be evaluated to determine past erosion rates and the long-term stability of the area.

2. Near-surface geologic and hydrologic conditions are largely unknown in the study area. A limited boring program in areas C and E (shown on the attached figure) should evaluate the near-surface conditions including such factors as lithology, permeability, near-surface water so that possible fluid migration pathways can be established.

3. Evaluate the potential areas in Bodo Canyon with regard to potential storage volumes for below grade disposal.

Long Hollow

1. Previous information indicates the presence of perched ground-water in the site area. This ground-water condition should be evaluated with regard to its impact on below grade disposal of the uranium tailings.

2. Truck haulage along Wildcat Canyon is a major concern of people in the Durango area. A transportation study of Wildcat Canyon and the alternate Ridges Basin route should be conducted. Safety and economics are specific aspects that should be analyzed for both the Long Hollow and Pine Ridge sites.

Pine Ridge

1. Ground-water hydrology, shale thickness, and permeability are major concerns in the site area. These characteristics should be investigated with a limited boring program.

2. Concerns have been expressed with regard to population density and land-use characteristics. Detailed analysis of these factors should be conducted.

Rabbit Mountain

1. Ground-water, land-use, and mineral resource information is being compiled by consulting geologists for Mr. and Mrs. Richardson and Mr. and Mrs. Burkett. This data will be assembled by the Colorado Geological Survey. Additional studies, if necessary, will be determined after this data is assembled.

2. Transportation costs and hazards associated with the anticipated haul route are considered major factors. These factors should be evaluated in detail.

The above studies should be considered as the most critical studies in the Site Selection Committee's further deliberations. Additional studies, as noted in a letter dated January 9, 1981, will be necessary when a specific site is included in the environmental impact statement. Please let me know if you need any additional site-specific study for either the selection of a preferred site or in the preparation of an environmental impact statement.

Sincerely,

Walter R. Junge
Chairman, Site Selection Committee

gp

COLORADO DEPARTMENT OF HEALTH

Richard D. Lamm
Governor

Frank A. Traylor, M.D.
Executive Director

February 5, 1981

Pat Rogers, Chief
Engineering Geology
Division of Geological Survey
Colorado Department of National Resources
715 Centennial Building
1313 Sherman St.
Denver, Colorado 80203

Dear Mr. Rogers:

This responds to your inquiry concerning criteria for tailings disposal under the Uranium Mill Tailings Remedial Action Program. As the designated liaison for the State of Colorado with the U.S. Department of Energy (DOE) and being charged with the responsibility for determining State concurrence in any final remedial action plan, as mandated, by PL 95-604, the Department will require that any new tailings disposal system in Colorado meet the same criteria as for active uranium mills. These criteria are currently found in Appendix A of Title 10 Code of Federal Regulations Part 40. The Health Department is currently in the process of proposing similar state regulations. In either case, the language and intent provide sufficient flexibility to take into account site specific considerations.

Sincerely,

Albert J. Hazle, Director
Radiation and Hazardous
Wastes Control Division

AJH:KKW:mh

cc: Richard Gamewell
Jake Jacobi
Ken Weaver
Mike Brown

4210 EAST 11TH AVENUE DENVER,COLORADO 80220 PHONE (303) 320-8333

STATE OF COLORADO

RICHARD D. LAMM
GOVERNOR

JOHN W. ROLD
Director

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
715 STATE CENTENNIAL BUILDING — 1313 SHERMAN STREET
DENVER, COLORADO 80203 PHONE (303) ~~892-2611~~ 866-2611

February 25, 1981

Dear Committee Member:

The Colorado Geological Survey is submitting to you the "Reconnaissance Evaluation of the Suitability of the Bodo Canyon Area for Tailings Disposal." This report contains the same type of information that was presented in the initial report for the other nine areas being considered and is to be incorporated into the final Colorado Geological Survey's report as an appendix. Because of the difficulty in evaluating a site in the Bodo Canyon area, field studies were emphasized during the investigation.

Five different tracts with the highest potential as disposal sites were identified in the Bodo Canyon area. It must be emphasized, that these areas do not meet the limiting criteria established in the initial report and applied to the other sites. Specific criteria that are not met include 1. slope, 2. size, 3. complex geologic structure, 4. geologic hazards, and 5. high erosion. These criteria indicate that the Bodo Canyon area probably cannot meet some of the placement objectives. Objectives that may not be met include:

1. Tailings or waste disposal areas should be located at a site where disruption or dispersion by natural forces are eliminated or reduced to the maximum extent reasonably achievable.

2. Tailings or waste should be placed below grade in trenches or pits excavated into relatively impervious shale in so far as it is environmentally practical.

3. Reclamation of the tailings or waste areas should include a full self-sustaining vegetative cover or riprap to retard wind and water erosion. The final contour slopes should be as close as possible to the natural surface, but not steeper than 5h:1v.

4. Seepage of toxic materials to the ground or surface waters should be minimized to the maximum extent reasonably achievable . . .

5. The final disposition of the tailings and waste should be such that ongoing active maintenance is not necessary to preserve isolation and that monitoring will be minimized to the maximum extent reasonably achievable.

The U.S. Nuclear Regulatory Commission states that in the selection of a disposal site primary emphasis shall be given to isolation of tailings or waste, a matter having long-term impacts, as opposed to considerations of short-term convenience or benefits such as minimization of transportation or land acquisition costs. The Bodo Canyon area has benefits related to short-term convenience. However, geologic investigations to date indicate that the Bodo Canyon area has certain adverse geologic conditions. These conditions affect long-term impacts and strongly suggest that the Bodo Canyon area is not suitable for disposal of the Durango Tailings.

The enclosed reconnaissance study recommends numerous detailed studies that should be conducted in order to further evaluate the feasibility of locating a suitable site within the Bodo Canyon study area. This catch-up study for the Bodo Canyon area clearly shows that it is not comparable to the other sites with regard to geotechnical feasibility. It must be understood that further detailed evaluation of the area will be expensive and the probability of proving up a viable site is rather low.

Sincerely,

William P. Rogers

William P. Rogers, Chief
Environmental and Engineering
Section

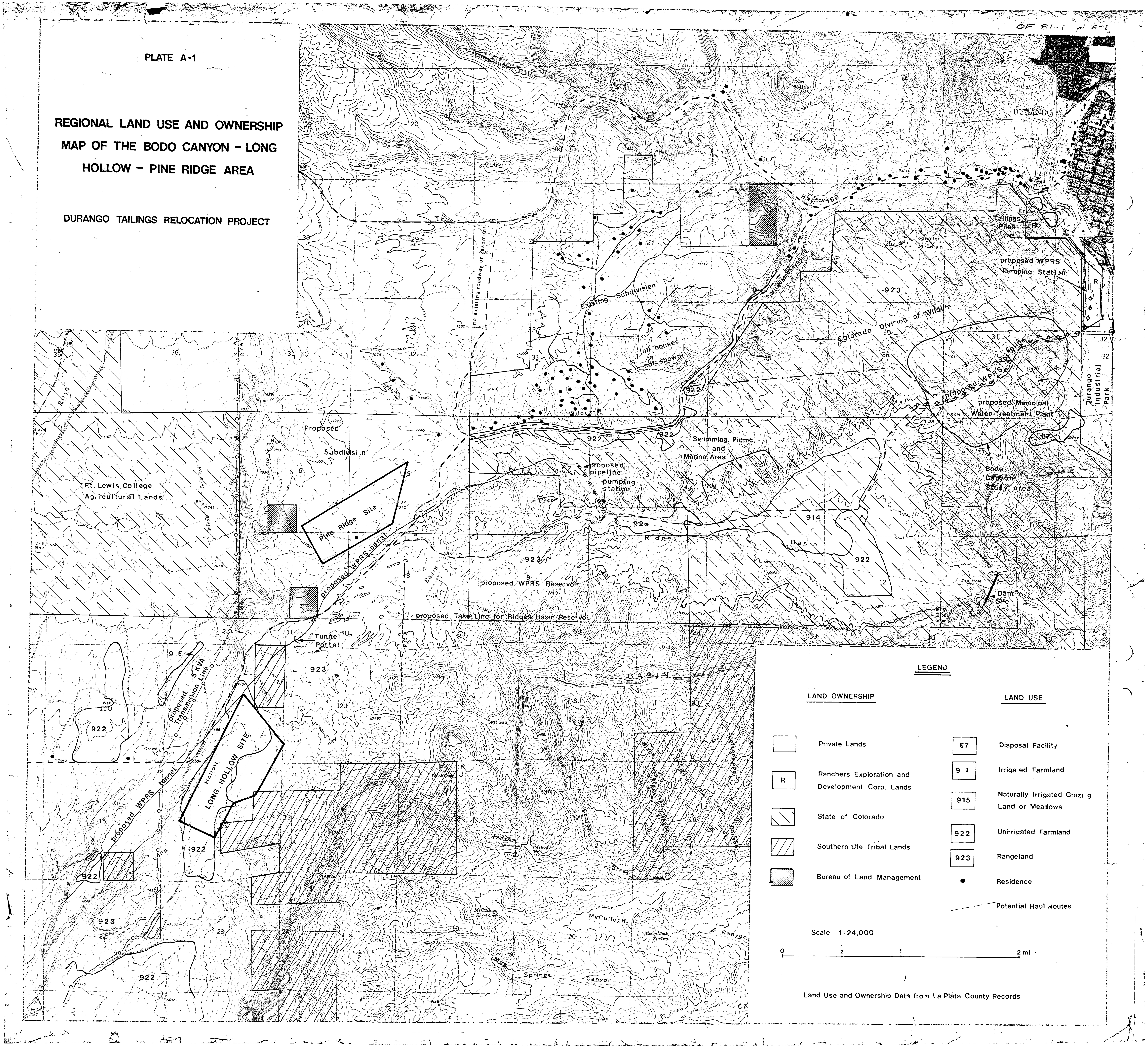
gp

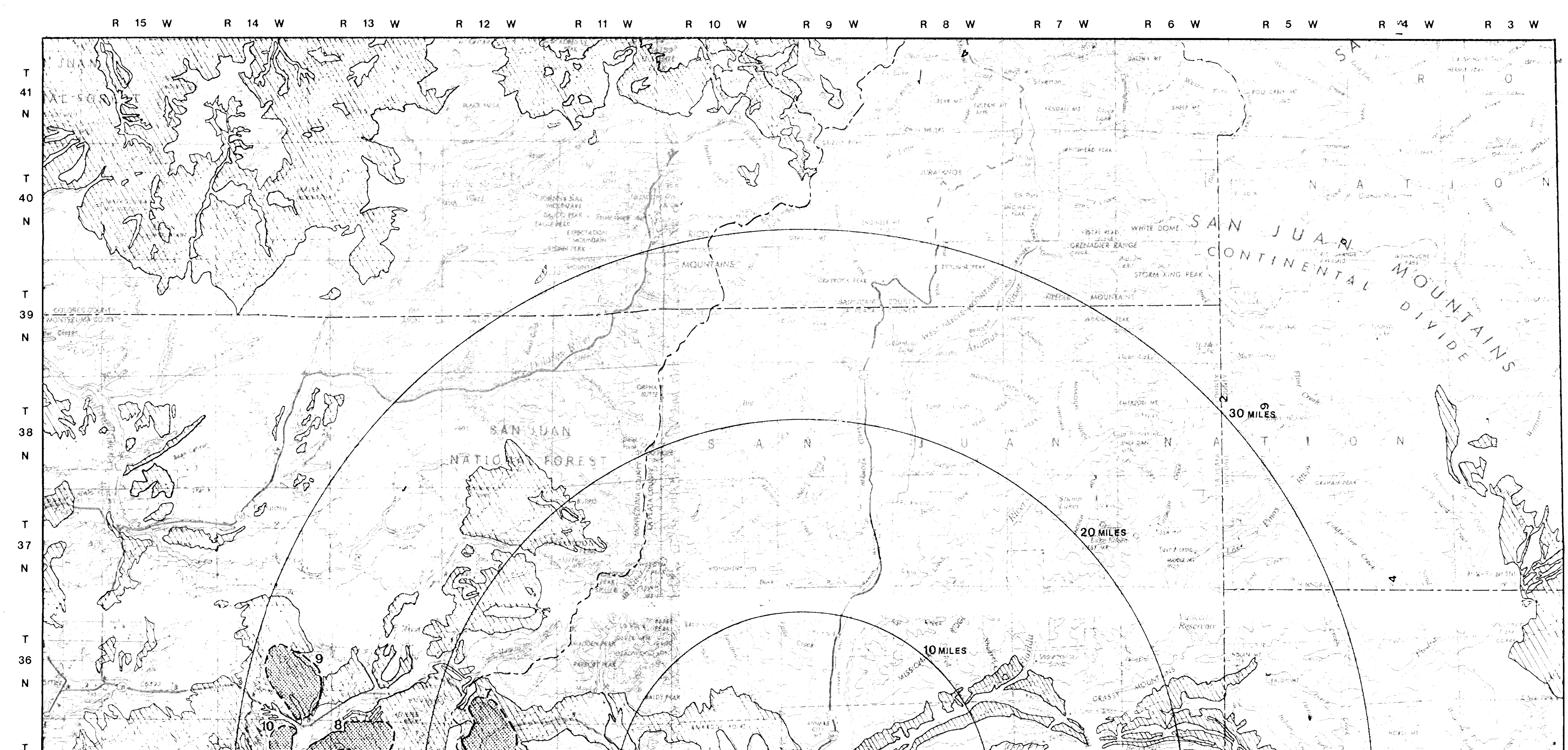
OF 81-1 pl A-1

PLATE A-1

REGIONAL LAND USE AND OWNERSHIP MAP OF THE BODO CANYON - LONG HOLLOW - PINE RIDGE AREA

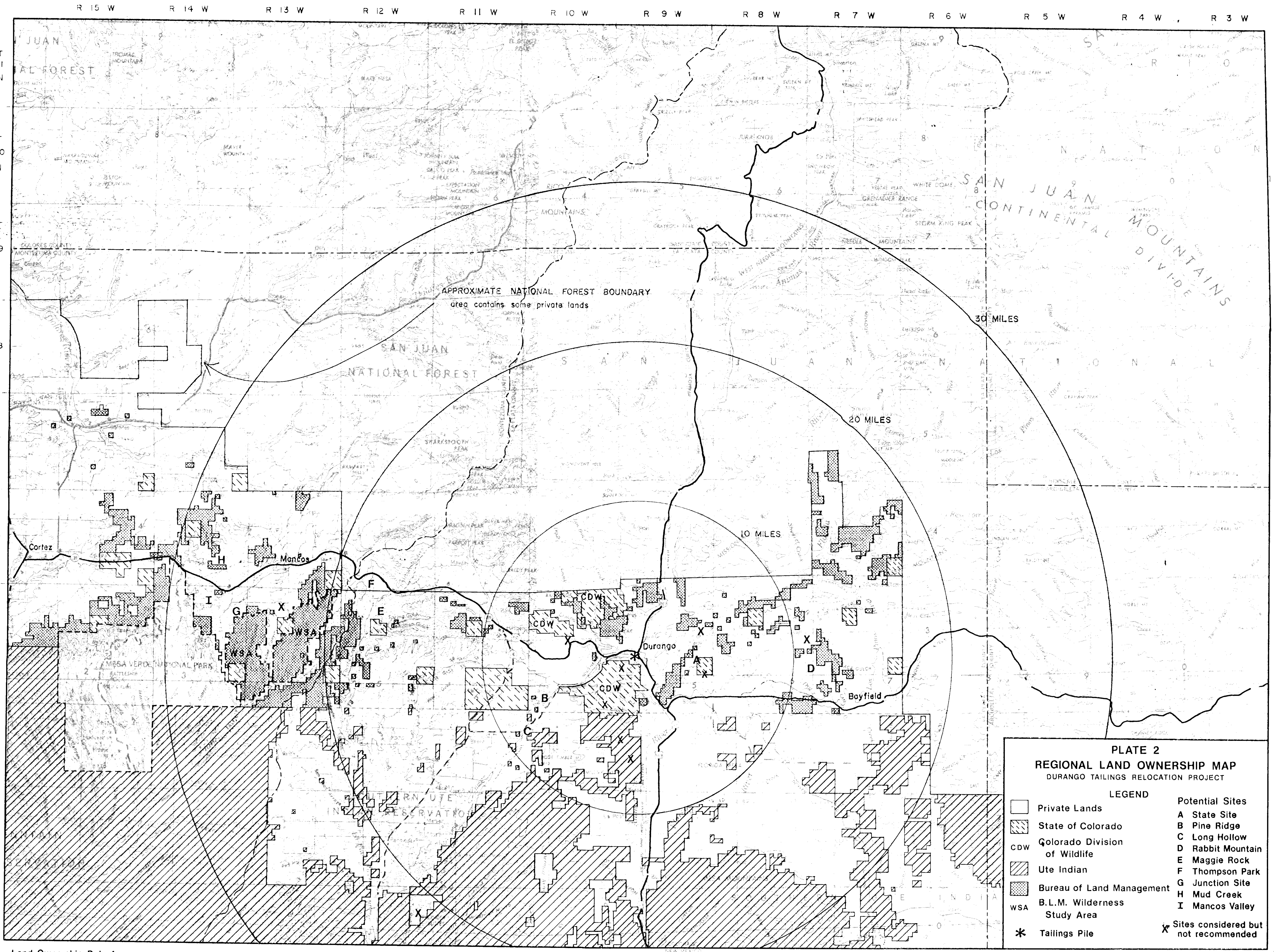
DURANGO TAILINGS RELOCATION PROJECT





Suitable Formation Data from
Steven and others (1974)
Haynes and others (1972)

Base map from
U.S. Geological Survey



Land Ownership Data from
U.S. Bureau of Land Management
Surface-Minerals Management Quads (1974-1975)

Scale 1:250,000

0 5 10 15 miles

Base map from
U.S. Geological Survey

O.F. 81-1, Pl. 5

PLATE 3

GENERALIZED STRATIGRAPHIC COLUMN
SHOWING THE APPROXIMATE STRATIGRAPHIC
POSITION OF THE POTENTIAL SITES

Sources : Modified from Zapp (1949) and Wood and others (1948)