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TAILING IMPOUNDMENT SITE SELECTION STUDY

Report #2

MT. TAYLOR PROJECT

GULF MINERAL RESOURCES CO.

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
ROCKY MOUNTAIN REGION

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1.0 INTRODUCTION

At the request of Gulf Mineral Resources Co., Woodward-Clyde Consultants (WCC) conducted a tailing disposal site selection study for a uranium mine and mill in New Mexico, near Mt. Taylor. Site recommendations encompassed both environmental and engineering considerations, with the latter based on both technical and economic factors.

Input to the site selection study was obtained from a previous baseline report by the New Mexico Environmental Institute (1974), from an ongoin; engineering study of mine water utilization by another firm, and from limited field reconnaissance.

Our study identified the predominant siting criteria for tailing disposal and inventoried the full range of possible sites within a reasonable distance from the mine. The decision-making steps in our analysis are listed below:

Steps	Description
1	Define the study area limits
2	Determine exclusionary areas
3	Identify desirable areas by site visitation
4	Select candidate sites
5	Rank candidate sites
6	Prepare sensitivity analyses using appropriate factors
7	Recommend tailing disposal site

2.0 PROJECT DESCRIPTION

The evaluations presented in this report are based on project information from Gulf, field reconnaissance, and other consultants' engineering studies.

Gulf plans to operate a uranium mine and mill just north of the town of San Mateo, New Mexico, approximately 30 miles northeast of the town of Grants (see Figure 2.1). The mine will be underground, with the main shaft located on fee land less than 1/2 mile west of Cibola National Forest. Initial planning calls for mining of some 4,500 tons of ore per day for a 20-year period. Approximately half of this material will be deposited as tailing in the vicinity of the mine, and the coarser half (larger than 60 mesh) will be used for mine backfill. Planning calls for enlarging or constructing new tailing dams, as necessary, at 5-year intervals if this is feasible.

A weight value of 1-1/2 tons per yard of tailing has been used in our computations; thus, about 1500 cubic yards per day will be transported to the tailing disposal site, accumulating to approximately 7,000 acre-feet in 20 years. Since the coarse fraction of the tailing will not be available for dam construction, we have assumed an earth dam would be constructed for retention of the tailing.

It is anticipated that the tailing will have a pH of about 1.5 and be slightly radioactive. It will be transported to the site by closed pipelines. At least three adjacent surface lines will be used. Two lines will transport the tailing slurry, and the third line will recycle decanted water to the mill.

N

0 50 100

APPROXIMATE SCALE IN MILES

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS
AND ENVIRONMENTAL SCIENTISTS
ROCKY MOUNTAIN REGION – DENVER, COLORADO

VICINITY MAP

PREPARED BY : P.D.K.	DATE : 4/5/76
JOB NO. 18456	

FIG. 2.1

3.0 APPROACH TO SITE SELECTION

3.1 RATIONALE

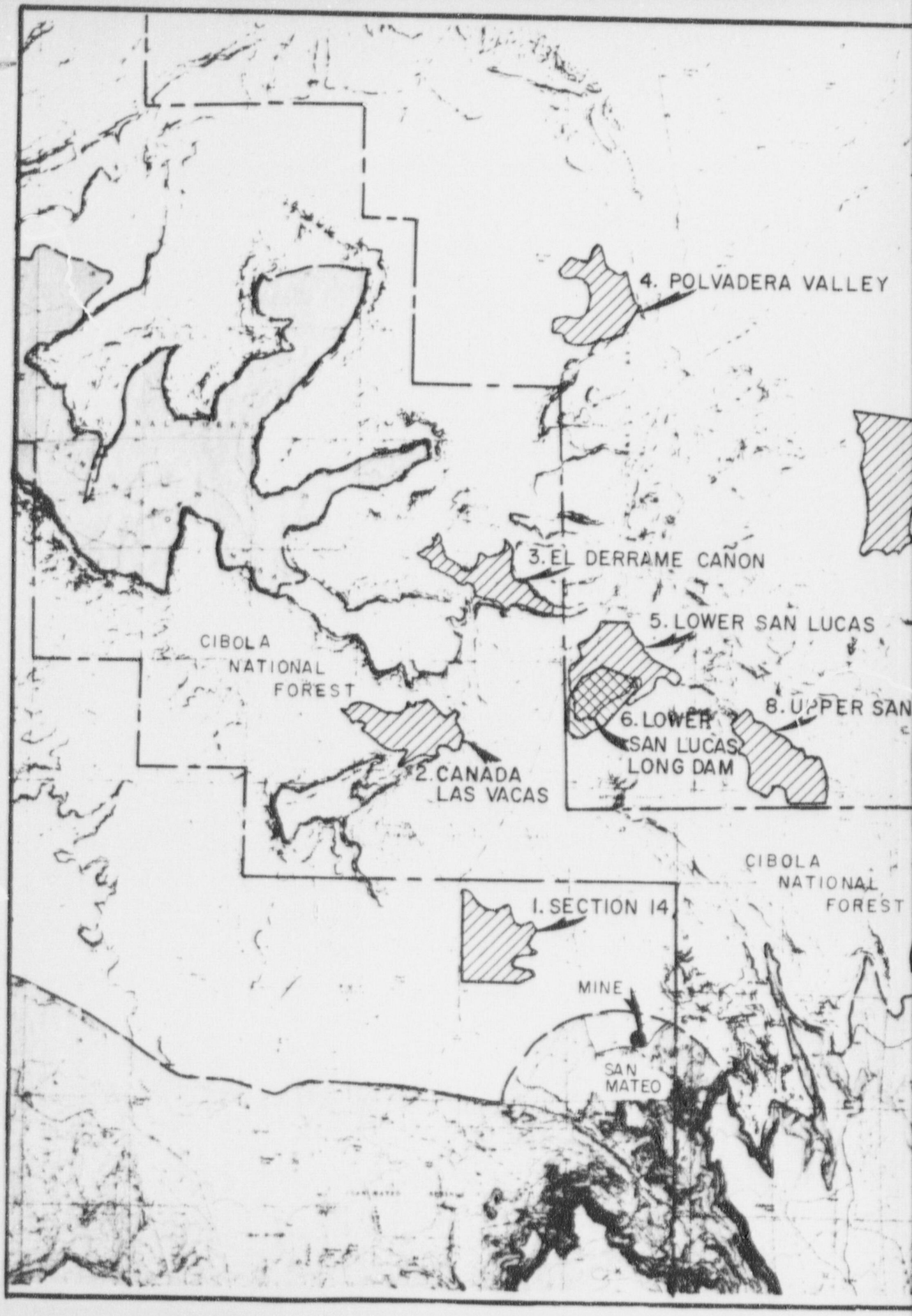
The basic objective of this study was to identify tailing sites which would be acceptable to the public, to involved Federal and state agencies, and to Gulf. To satisfy this broad spectrum of interests we conducted the study in a manner that allowed consideration of environmental, engineering and project economic factors. The study was conducted by an interdisciplinary group of professionals experienced in environmental evaluation, site location planning, tailing and mine water disposal, and storage dam construction.

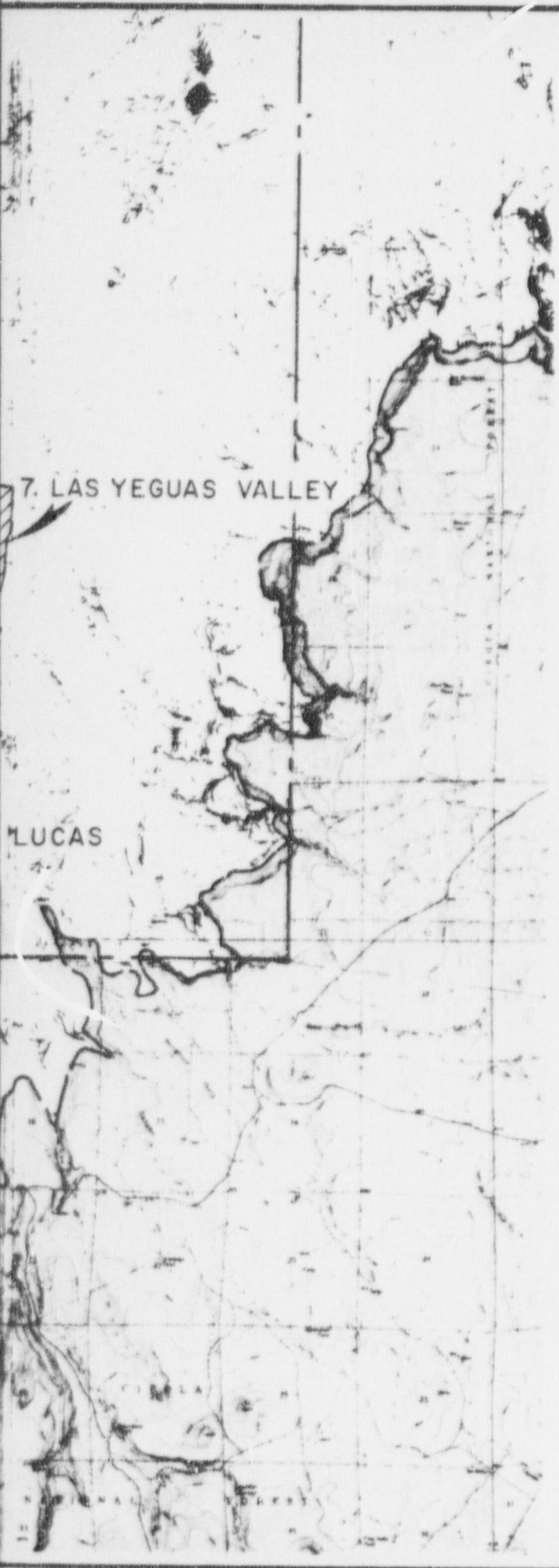
3.2 METHODOLOGY

The study methodology focused on systematically locating and ranking potential sites. Project needs were first considered in the decision sequence, and areas unsuitable for engineering or operational reasons were excluded.

The first decision was to set limits to the study area. Based on past experience, it was determined that the maximum economic pipeline length would be about seven miles; therefore, all areas within this radius from the mine were considered as potential sites (see Figure 3.1).

Within this radius, certain areas were clearly unsuitable as potential sites owing to high elevations, existing land uses, and other factors. The next step was to identify and map these


4. POLVADERA VALLEY
3. EL DERRAME CAÑON
5. LOWER SAN LUCAS
CIBOLA
NATIONAL
FOREST
8. UPPER SAN
6. LOWER
SAN LUCAS
LONG DAM
2. CANADA
LAS VACAS
CIBOLA
NATIONAL
FOREST
1. SECTION 14
MINE
SAN
MATEO



N

SCALE 1" = 6000'

LEGEND

ULTIMATE IMPOUNDMENT AREA

AREA EXCLUDED FROM CONSIDERATION

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WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
ROCKY MOUNTAIN REGION – DENVER, COLORADO

STUDY AREA

PREPARED BY	DATE 3/25/76
JOB NO. 18456	

FIG. 3.1

areas and exclude them from further consideration. Land ownership patterns were not considered exclusionary at this time.

Next, we examined the remaining acceptable areas for features that would fulfill most or all of the positive criteria listed in the following section. In doing this, certain sites appeared particularly appropriate and were considered as candidate sites. The candidate sites are listed and described in the following section.

Finally, we established a key list of environmental and engineering factors relating to location of the tailing impoundment. To each factor, a weight was assigned which reflected the combined judgment of the project team. Next, a relative score for each candidate site for each factor was established, using a scoring scale of 1 to 5. The sum of the weight-score products for each candidate site determined our initial (base-case) ranking. We then applied a sensitivity technique to this ranking that allowed two comparisons. The first compared variations in environmental and engineering weights. The second compared the influence of land ownership. In this way, the decision maker could examine the influence of each of these major factor groups on the base ranking. The sensitivity analyses are presented in Section 5.4.

4.0 SELECTION OF CANDIDATE SITES

4.1 DEFINITION OF STUDY AREA

The study area boundary was based primarily on tailing transport considerations. Potentially suitable sites undoubtedly exist outside the area considered; however, project economics necessitated location of a suitable site within a nominal 7-mile radius.

4.2 EXCLUSIONARY AREAS

Certain areas within the study boundaries were clearly unsuitable for engineering or environmental reasons. The primary disqualifying factors were topography and land use.

4.2.1 Topography

Areas with elevations above 8000 feet, approximately 700 feet above the mine opening were excluded because of extraordinary disposal costs. Although it is physically possible to pump tailing to such elevations, the pumping energy would be excessive. The areas excluded for this reason are indicated on Figure 3.1.

4.2.2 Land Use

Land use precluded some areas from consideration as tailing sites. The first area so excluded was the town of San Mateo and an arbitrary area one-half mile beyond the boundaries of the town. The area south of State Highway 53 was also excluded because of existing mining claims, the highway itself and the "archeologically rich nature" of the area, according to the New Mexico State Museum at Santa Fe.

Three ownership patterns exist in the non-exluded areas. Gulf owns Section 14, T13N, R8W. U.S. Forest Service property lies to the north, the northwest and the east; and it will subsequently be shown that part or all of several candidate sites are within the Forest Service boundaries. The balance of the study area is private land. The Gulf property would appear most suitable for a tailing site; however, its proximity to the town of San Mateo and other land developments is a major detraction. Federal ownership presents the problem of obtaining a Federal permit. This factor represents potential delay and could necessitate commitments for studies that privately-owned sites may not require. The use of private land depends on the cooperation of the owner. It was concluded that ownership should not be a reason for exclusion, but that additional sensitivity analyses would be utilized to evaluate the final rankings in this respect.

4.3 IDENTIFICATION OF DESIRABLE AREAS

Desirable areas were defined as those that would best accommodate the construction and operation of the proposed tailing disposal facility. Desirable characteristics included the following:

1) Elevations near or below 7300 feet.

2) Areas that could contain the final tailing volume estimated at 7000 acre feet.

3) Valley type situations requiring small or moderate dams.

4) Proximity to the mine.

5) Environmental and engineering acceptability by Gulf and others.

6) Appropriate land use and land ownership patterns.

Not every candidate site satisfied each category, but the matrix evaluation provided the necessary quantitative comparison.

4.4 SELECTION OF CANDIDATE SITES

Candidate sites were selected by examining the areas not excluded and applying the criteria for desirable sites. Figure 3.1 shows the eight candidate sites selected. The sites are listed below:

1) Section 14

2) Canada Las Vacas Valley

3) El Derrame Canon

4) Polvadera Valley

5) Lower San Lucas Valley

6) Lower San Lucas Long Dam

7) Las Yeguas Valley

8) Upper San Lucas Valley

Site Number 1 is owned by Gulf and could readily contain the volume of tailing material with a long dam on the western and southern edges. The site has the obvious advantage of ownership by Gulf, but the disadvantage of close proximity to the town of San Mateo and the Lee Ranch. It is located in the San Mateo Creek drainage pattern, which is a disadvantage compared to

the other seven candidate sites, which have drainage patterns to the north.

Site Number 2, Canada Las Vacas Valley, is located on National Forest land (Cibola National Forest) in a large valley with a canyon exit which could accommodate a narrow dam. However, two high voltage power lines would have to be moved if this were to be a tailing site.

Site Number 3, El Derrame Canon, would require a very narrow dam, but it lies entirely within the National Forest.

Site Number 4, Polvadera Valley, is farthest from the mine, is located entirely on fee land and has a very large storage area.

Site Number 5, Lower San Lucas Valley, would necessitate a dam above the existing one. This site is on fee land and could contain the entire volume of tailing without impinging on the National Forest. However, flood control would entail extensive diversion channels.

Site Number 6, Lower San Lucas Long Dam, was considered because the dam location would avoid the potential flood hazard of site number 5. This site has a very small watershed and the upper portion would require a berm to prevent overlap onto the National Forest.

Site Number 7, Las Yeguas Valley, is north of Upper San Lucas. This location would require lifting the tailing over the intervening ridge, a definite technical and economic disadvantage. It is located entirely on fee land.

Site Number 8, Upper San Lucas Valley, is located on fee land and would need a low berm along the fee boundary to prevent intrusion into the National Forest.

Other potential sites within the seven-mile radius were deemed inferior in terms of potential tailing storage, volume elevation differential and distance from the mine.

5.0 RANKING OF CANDIDATE SITES

5.1 MATRIX EVALUATION

5.1.1 Use of a Matrix in Siting

For a matrix evaluation, relative scores for each of a selected group of factors (siting considerations) are assigned to each site, using a consistent value scale. The factors are subsequently assigned relative weights of importance. Multiplying the scores and weights and summing the resulting products for each site will produce a series of numbers indicating a tentative ranking of the sites. Generally, the initial ranking is based upon the assumption that all of the environmental factors are equal in importance to all of the engineering and economic factors. This produces what we have termed the "base case." In addition, the relative weights of importance can be varied, to represent different viewpoints concerning the importance of siting considerations. In this manner, the matrix technique can be used to identify sites which consistently receive higher relative preferences or which may be insensitive to engineering or environmental bias.

We recognize that assigning relative factor weights and site scores relies, in part, on subjective professional judgments and that the resulting site rankings must therefore be carefully interpreted. When used with care, the matrix is a simple and effective tool, and it provides a common basis for discussion of the relative merits of the candidate sites.

5.1.2 Implementation of the Matrix Approach

The considerations influencing selection of a site were divided into two basic groups: environmental and engineering (see Table 5.1). For each group, a list of the factors influencing site selection was prepared, and a numerical weight was assigned each factor, to indicate its relative importance in relation to other factors in the group. The arithmetic sum of all the weights in the two groups was arbitrarily limited to a total of 1.0. The weight distribution was developed by consensus of the professional staff members participating in the study and was designed to portray their most realistic judgment concerning the actual relationships between the factors. This initial weight allocation was termed the "base case".

For each factor, each site was given a relative score on a numerical scale from 1 to 5, with 1 defined as the score assigned to the least desirable site and 5 as the score assigned to the most desirable site. For environmental factors, a 5 indicated the site expected to suffer the least adverse environmental impact; for engineering it generally represented the lowest cost. Using this method, scores for each site were assigned relative only to the other sites considered, not relative to a standard; thus, there was always a score of 1 and a score of 5 for each factor.

Table 5.1 lists the scores assigned for each factor at each candidate site. The rationale for the assignment of these numbers

TABLE 5.1

SITE SELECTION MATRIX, BASE CASE

Siting Factor	Weight	CANDIDATE SITES 1 Section 14	2 Canada Las Vacas Valley	3 El Derrame Canon	4 Polvadera Valley	5 Lower San Lucas Valley	6 Lower San Lucas Long Dam	7 Las Yeguas Valley	8 Upper San Lucas Valley
		Relative Scores							
ENVIRONMENTAL:									
1. Meteorology	0.12	3	1	1	5	1	2	4	1
2. Groundwater Quality	0.11	1	4	5	5	4	5	2	4
3. Surface Water Quality	0.06	1	5	5	3	4	3	2	3
4. Ecology	0.08	5	2	2	3	3	4	3	1
5. Scenic	0.05	2	2	1	3	3	3	5	2
6. Access Road	0.03	5	3	3	3	1	4	5	3
7. Geology	0.05	5	2	1	3	3	3	3	2
Subtotal	0.50								
ENGINEERING:									
1. Dam Size	0.09	2	5	4	4	5	1	3	5
2. Tailing Delivery	0.09	5	4	3	2	3	4	1	3
3. Reclamation	0.02	3	4	5	3	1	3	1	3
4. Dam Foundation	0.01	1	5	5	4	4	2	5	5
5. Borrow	0.01	5	3	2	4	3	5	1	3
6. Seepage Control	0.14	3	4	5	3	1	3	1	3
7. Hydrology	0.14	3	4	4	2	1	5	3	1
Subtotal	0.50								
TOTAL	1.00								
WEIGHT X SCORES: TOTAL		3.02	3.40	3.38	3.34	2.46	3.41	2.61	2.53
RANK		5	2	3	4	8	1	6	7
OWNERSHIP SCORES:		5	1	1	5	5	5	5	5

is discussed in the Appendix. Separate subsections of the Appendix discuss the environmental and engineering factors which for various reasons, were excluded from this evaluation.

For each candidate site, the factor weight was multiplied by the score to obtain a product. The products were summed to arrive at a total site score. Site preference was indicated by total site score.

5.2 FACTOR WEIGHT ASSIGNMENT

The factors considered in evaluating the relative suitability of the candidate sites were arranged in two groups: those pertaining to the natural environment; and those pertaining to engineering aspects of the project. There are obvious overlaps between the groups. Pipeline length, an important engineering factor, also affects biological factors and scenic evaluations. Similarly, different borrow requirements could disturb particular ecosystems. Such overlapping did not complicate our evaluation, however, because the group headings were used primarily as a check to insure that the total list of factors considered was comprehensive, rather to arbitrarily categorize any single factor.

The highest environmental weight (0.12) was given meteorology. This factor was considered most important owing to the slightly radioactive nature of the tailing, the small particle size of the material, and the tendency of the area to experience occasional strong wind. Ground water was given a weight of 0.11. This factor was also considered highly important, inasmuch as tailing water

would be contaminated and could create a potential for contamination of the ground water.

Other environmental weights included the following: ecology (0.08), surface water quality (0.06), scenic (0.05), and geology (0.05). Ecological habitat values on these sites vary considerably, but are not highly unique nor critical for New Mexico. Surface water quality was given a slightly lower value in view of the mitigatory measures that could be taken to reduce or prevent downstream contamination. Geology was considered as an environmental value because of landslides, earthquakes, and scientific value, and it received additional consideration within certain engineering factors as well. Scenic quality is pronounced at certain sites; thus, it was awarded the same value as geology. The lowest weight was assigned access roads which are used for both recreation and land management purposes. Construction and dams at certain sites would cover the roads and temporarily impede access. While not overly serious, it was felt the factor required a weight of 0.03.

The seven engineering factors varied substantially in their weights, based essentially on cost estimates. The two most important factors, were seepage control and hydrology. The weight assigned for seepage control was high, as extensive lining at certain sites (e.g. 1 and 6) is necessary. The hydrology weight was high because large watersheds exist behind certain sites. In such areas, storms could generate large surface flows, which would necessitate very large diversion channels.

Other significant factors were dam size and tailing delivery systems. Dam size costs are directly related to the amount of fill required for the dam. Tailing delivery systems are based primarily on the length and operational costs of required pipelines. The other three factors, foundation, borrow, and reclamation were assigned weights of 0.02 or less.

5.3 BASE CASE RESULTS

The results of summing the weight score products in the base case are shown in the bottom two rows of Table 5.1. The four highest-ranked sites have similar totals and rank higher than the other four sites. These sites are listed in order of decreasing rank: Lower San Lucas Long Dam (site No. 6); Canada Las Vacas (2); El Derrame Canon (3); and Polvadera Valley (4). The next highest is Section 14 (1), but the rank is considerably lower than the above. The other three sites, 5, 7 and 8, ranked well below the first five, and were discarded from further consideration. The reasons for their low ranking can be determined through examination of Table 5.1, and further explanations are given in the appendix.

Inasmuch as the four highest-ranking sites were closely bunched, the next step was to conduct a sensitivity analysis that varied the percentage given to the environmental group versus the engineering group; and second, another sensitivity analysis in which land ownership factors were applied. These analyses were applied to the top five sites and are detailed in the next sections.

5.4 SENSITIVITY ANALYSES

As noted above, base case weights were assigned (by consensus) in order to represent our judgment concerning realistic relationships between the various factors considered in the matrix analyses. We realize, however, that the real importance of these factors depends largely upon the opinions and values of several different segments of the population, including Gulf management, interested citizens, environmental action groups, regulatory agencies, and others. Frequently, the environmental concerns of these groups and engineering considerations are in conflict. Therefore, in order to take into account these diverse interests, the matrix was deliberately biased by assigning different arrays of weights to favor environmental factors over engineering factors and vice versa. This additional evaluation, or sensitivity analysis, highlights each site's sensitivity to changes in relative weight emphasis assigned the factor groups. Rank order in site preference, based upon different relative emphasis in environmental and engineering considerations, can then be compared and contrasted with the base case.

Results from the initial sensitivity analysis are shown in Table 5.2 and graphically in Figure 5.1. Of all five sites listed on Table 5.2, only site 6 (Lower San Lucas Long Dam, which is first in the base case,) ranks third or higher in every case. All of the sites drop to fourth or fifth when either the environmental or the engineering factor weight totals approach zero. This is shown graphically in Figure 5.1 which shows only the top 5 sites.

TABLE 5.2 SENSITIVITY: ENVIRONMENTAL AND ENGINEERING

SITES	ENVIRONMENTAL: ENGINEERING PERCENTAGE				
	0:100 (Rank)	30:70 (Rank)	50:50 (Rank)	70:30 (Rank)	100:0 (Rank)
6. L.S.L Long Dam	3.40 (3)	3.41 (3)	3.41 (1)	3.41 (2)	3.42 (2)
3. El Derrame	4.12 (2)	3.68 (2)	3.38 (3)	3.08 (4)	2.64 (4)
2. Las Vacas	4.18 (1)	3.71 (1)	3.40 (2)	3.09 (3)	2.62 (5)
4. Polvadera	2.76 (5)	3.11 (4)	3.34 (4)	3.57 (1)	3.92 (1)
1. Section 14	3.18 (4)	3.08 (5)	3.02 (5)	2.96 (5)	2.86 (3)

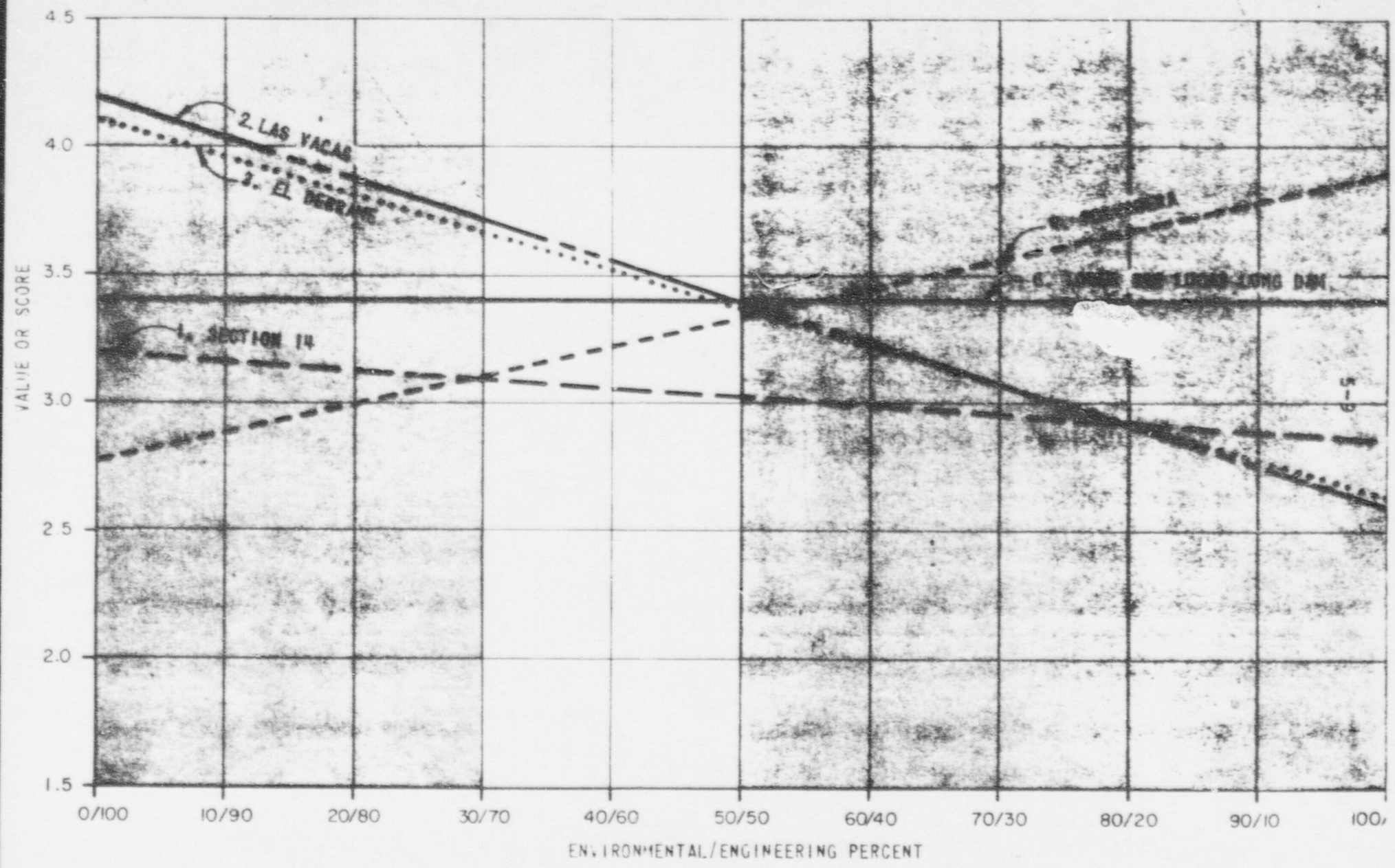

FIG. 5.1 SENSITIVITY: ENVIRONMENTAL AND ENGINEERING

At the left side of the graph the environmental factor weights total 0, while the corresponding engineering values are 100%. The reverse is true of the right side. Both Canada Las Vacas (2) and El Derrame (3) rank highest when the environmental values are low, but their rank decreases in actual value throughout the spectrum and is lowest when environmental values are highest. Polvadera Valley (4) ranks lowest at high engineering values and highest at maximum environmental values, where it has the highest rank. Lower San Lucas Long Dam (6) is relatively insensitive to changes in environmental and engineering percentages and ranks well throughout the spectrum.

The top five sites were then subjected to the second sensitivity analysis, in which ownership is considered along with environmental and engineering. Total sums for this analysis are given in Table 5.3 and shown figuratively in Figure 5.2. For this analysis candidate sites located on U.S. Forest Service land and were given a score of 1, while the remaining sites, all on private land, were given a score of 5. (The scoring was done in this fashion due to both uncertainties and possible time-delays involved in development of public lands.) At the left edge of the graph in Figure 5.2, 0% is given to this ownership, while at the right side the ownership percentage is 70. Environmental and engineering percents remain equal throughout as in the base case. The values indicated on the left vertical axis is the same as the base case environmental/engineering results. Moving to the right from this point, ownership values are increased, and

TABLE 5.3 SENSITIVITY: OWNERSHIP,

ENVIRONMENTAL AND ENGINEERING

SITES	OWNERSHIP: ENVIRONMENTAL: ENGINEERING PERCENTAGE			
	0:50:50 (Rank)	30:35:35 (Rank)	50:25:25 (Rank)	70:15:15 (Rank)
6. L.S.L. Long Dam	3.41 (1)	3.89 (1)	4.20 (1)	4.52 (1)
3. El Derrame	3.38 (3)	2.67 (5)	2.19 (5)	1.71 (5)
2. Las Vacas	3.40 (2)	2.68 (4)	2.20 (4)	1.72 (4)
4. Polvadera	3.34 (4)	3.84 (2)	4.17 (2)	4.50 (2)
1. Section 14	3.02 (5)	3.61 (3)	4.01 (3)	4.41 (3)

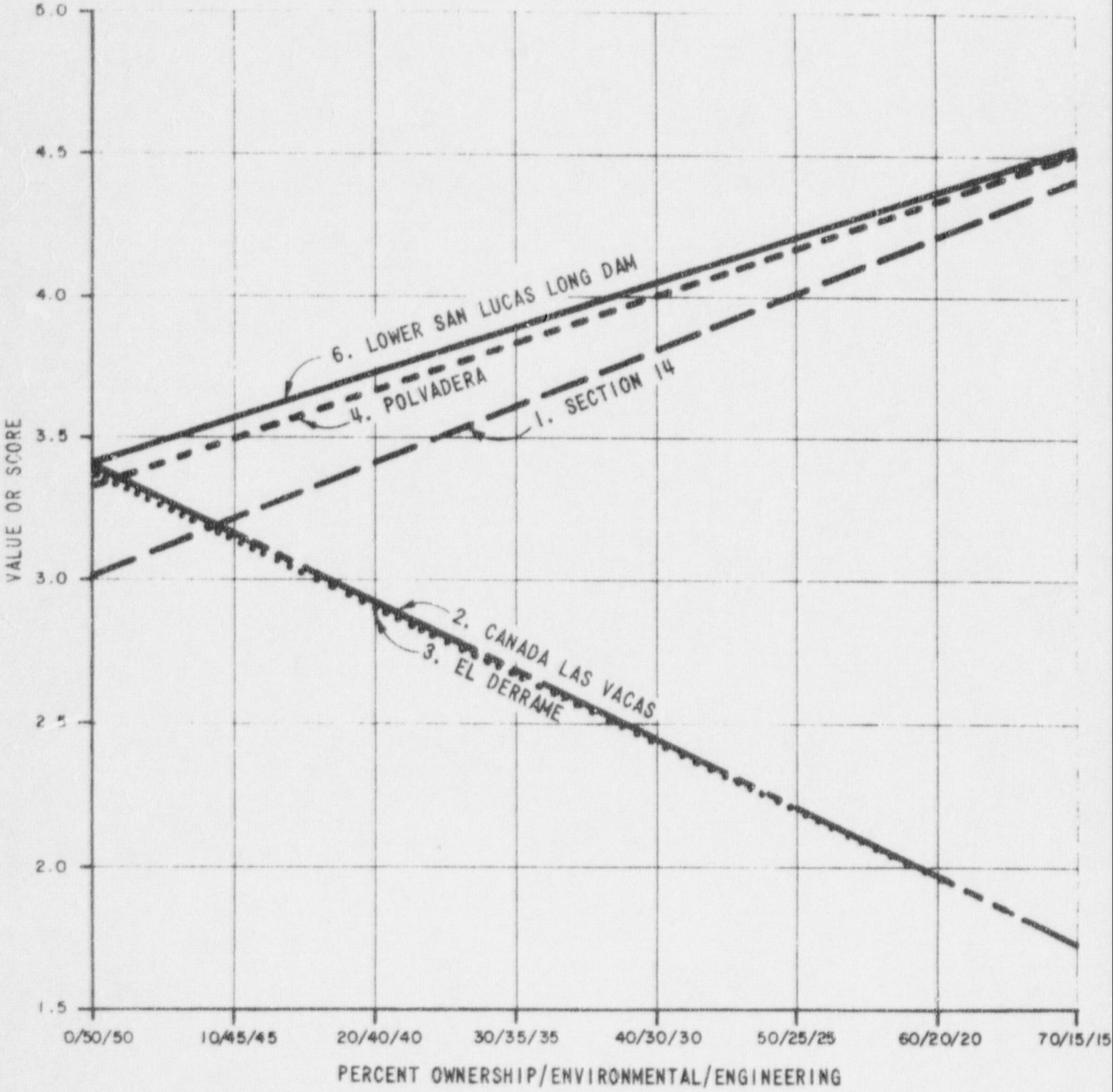

FIG. 5.2 SENSITIVITY: OWNERSHIP, ENVIRONMENTAL AND ENGINEERING

it is quickly demonstrated that Canada Las Vacas (2) and El Derrame (3), both on Forest Service land, decline markedly relative to the other sites. At the same time the other three sites actually increase in value. In this fashion separation of site 6 from sites 2 and 3 is rapidly made. While the precise percentage that should be accorded the ownership factor is highly subjective, we would suggest that at least 20% is reasonable.

The two sensitivity analyses indicate that while Lower San Lucas Long Dam (6) candidate site is the most suitable, a close second choice, when environmental and ownership features are considered, is Polvadera Valley (4). The other candidate sites, though they often score well for certain factors and weight situations, possess environmental or ownership weaknesses that make them considerably less desirable.

6.0 SUMMARY AND CONCLUSION

Our objectives at the outset of this study were to locate candidate sites for the proposed uranium tailing dam and impoundment that would best satisfy the predominant environmental and engineering considerations. Following selection of appropriate candidate sites we then evaluated these sites and, where possible, selected the best dam and impoundment site. The procedure is detailed below.

The study area was confined to a seven-mile radius, centered on the Gulf mine near San Mateo. In sequence, our approach to the site selection study was as follows:

1) define the study area and conduct a limited multi-disciplinary reconnaissance to identify its environmental characteristics.

2) identify undesirable areas from an environmental and engineering standpoint and exclude them from further consideration.

3) locate possible candidate sites that would be suitable from both an engineering and environmental standpoint.

4) perform an environmental and engineering comparison of these candidate sites.

The environmental and engineering evaluation of candidate sites was conducted in three steps. The first step involved identification of applicable factors that would have a determining influence on site selection. Factors at all sites having the same scores, or lacking data for complete evaluation, were not utilized in the study. After completion of the list, each

applicable factor was weighted in terms of its importance relative to other factors. Finally the factors were assigned scores at each candidate site reflecting their relative desirability. The sum of weight and score cross-products determined each site score, higher totals indicating site perference.

After determining scores and weights for each factor, sequential computer runs were conducted to vary the emphasis on the environmental and engineering factors and to determine the sensitivity of each site to this adjustment. The next step was to utilize a third variable in the sensitivity analysis, namely ownership. With this approach, we were able to eliminate two sites that ranked close to site number 6, Lower San Lucas Long Dam, in the base case.

We concluded that the Lower San Lucas Long Dam (6) tailing impoundment area ranks first and that Polvadera Valley (4) is the 2nd choice, when environmental, engineering, and ownership features are considered together.

7.0 GENERAL INFORMATION AND CREDITS

7.1 GENERAL INFORMATION

Professional judgments on both engineering and environmental factors are presented in this report. These are based on our evaluation of technical information, on our understanding of the characteristics of the facility being planned, and on our general experience in the area. We guarantee that our siting work and judgments rendered meet the standard of care of our profession.

7.2 CREDITS

Data collected for this report were analyzed by Messrs. Frank Holliday, John Patterson, Herbert Edson, Paul Kilburn, Lynn Brown, Ted Johnson, Al Gibson, Don Frevert and Dan Rabinowitz. These personnel also prepared portions of the appendix. Information on the proposed project was provided by Messrs. Harry Smith, Doyle Whitmer, Jack Muirhead, Fred Whitaschek, Ken Barnhill, Frank Mesaros and Ms. Karen Rasmussen, all of Gulf Mineral Resources Co. This report was reviewed by the undersigned.

If we may be of further service in discussing the contents of this report, please call.

William R. Anderson

By _____
William R. Anderson
Vice President

PDK:jef
(5 copies sent)

APPENDIX

DETERMINATION OF VALUES FOR SITE SELECTION MATRIX

APPENDIX

DETERMINATION OF VALUES FOR SITE SELECTION MATRIX

A.1 INTRODUCTION

This appendix to the Gulf Mt. Taylor Site Selection Study was prepared to present the rationale for: (1) inclusion of the 14 factors used in the site ranking matrix; and (2) assignment of relative scores to the eight candidate tailing pond sites, for each factor. The factors are listed are on Table 5.1 in Section 5.1 of the report and are divided into two major categories: "environmental", referring to the project's potential influence on existing conditions at the candidate sites; and "engineering", relating to the influence of existing conditions on project design.

The environmental and engineering categories shown in Table 5.1 of the report are divided into subheadings of factors arranged by professional disciplines participating in the study. The appendix organization follows this same order. Factors within the purview of more than one discipline were assigned to the discipline of either dominant interest or highest public visibility, depending upon the relative significance attached to each in the context of this project.

Two factors that often influence the selection of sites for industrial projects were not included in the matrix. These were socio-economic considerations and archeology. The former factor was not included because no habitations were located

within a half-mile of any of the candidate sites. In addition, socio-economic factors were considered in the meteorological and scenic scoring.

The archeological factor was not included because only two of the candidate sites, Section 14 (1) and Las Vacas (2), have been examined by archeological site reconnaissance. It was not possible to rate the other sites; consequently, no scores were assigned.

A.2 ENVIRONMENTAL EVALUATIONS

The matrix evaluated seven environmental factors. Meteorology was given the highest weight owing to the importance attached to slight radioactivity, coupled with the inherent dusting potential of the tailing material, and subject to the effect of high winds. These features could combine to have an adverse impact on biological receptors. Ground water quality had almost as high a weight, due to the poor quality and slight radioactivity of the tailing water. It was not weighted higher owing to easier control of this factor.

Slightly lower weights were assigned to ecology, evaluated in terms of vegetation, aquatics and surface water contamination, big game and wildlife. The moderate ecological weight assigned represented our consideration that ecosystems and species in this region are not as unusual or unique as they are in other parts of the west. The surface water quality weight was also moderate, reflecting the reduction of contamination

risk by providing engineering protection for flood control. This factor is evaluated in the engineering category.

The other environmental factors received weights below those described above. These included geology, scenics and the impact of an impoundment on the existing road system. Following the assignment of weights for each factor, scores or values from 1 to 5 were assigned for each factor at each candidate site. The final score given is a composite of an analysis of one to many subfactors.

A.2.1 Meteorology/Air Quality

The tailing area is one of the significant sources of radiological emissions in the overall uranium mine and mill complex. As specified in NRC Regulatory Guide 3.8, dispersion modelling should be accomplished for significant radiological sources in order to provide the necessary radiological dose rate calculations. Selection of the best tailing site or sites, from an atmospheric dispersion standpoint, consequently provides an opportunity to minimize potential dose rates to important receptors. In addition to this radiological-safety aspect, consideration should be given in tailing site selection to the environmental effects of fugitive dust during strong wind situations; also consideration should be given to differences in evaporative rates among candidate sites from a design standpoint. These effects are included in the meteorology/air quality factor described below.

Within the overall meteorology/air quality factor, a number of subfactors have been delineated which are important from the site selection viewpoint (and for which differences appear to exist between the eight candidate sites). Following is a list of these subfactors:

1) Variability of wind direction

2) Wind speed

3) Topographical constraints to dispersion

4) Atmospheric stability

5) Potential for severe winds from synoptic scale influences

6) Potential for severe winds from thunderstorms

7) Distance and direction from human receptors

8) Distance and direction from important food chain receptors

9) Evaporation rate.

Because such a large number of subfactors were somewhat unwieldly in the ranking matrix and because the data did not warrant this detail, these subfactors were grouped into the following four general categories for ranking purposes:

1) Dispersion potential (Subfactors 1-4, above)

2) Potential for severe winds (Subfactors 5 and 6, above)

3) Distance and direction from important receptors (Subfactors 7 and 8, above)

4) Evaporation rate (Subfactor 9, above)

There are a number of other subfactors which are important from a uranium tailing site selection viewpoint but which could

not be distinguished between the candidate sites. For instance, the potential for severe winds from tornadoes is believed to be an important subfactor. However, since all of the candidate sites are located in a relatively small area, no difference in the potential for tornadoes could be distinguished between sites.[1] Likewise the potential for atmospheric stagnation episodes would be an important consideration, except that this characteristic is also indistinguishable between sites.[2]

The meteorology/air quality site evaluations are based upon available meteorological data for the area[3], and meteorological judgments and evaluations obtained during the site reconnaissance visit. In addition, consideration was given to climatological data pertaining to thunderstorm frequency, tornado frequency, inversion frequency, prevailing wind directions and maximum wind speeds characteristic of the Mount Taylor area. Detailed topographic maps of the area were utilized in the evaluations

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1 The tornado strike probability, according to Nuclear Regula- Commission Publication "Wash-1300," is only a .00011 strikes per year in the site area.

2 Based on the EPA Publication by Holzworth entitled "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," about 20 episode days per year (with mixing heights 1000m, wind speeds 4.0 m/sec, and no significant precipitation) can be expected in the site area.

3 These include wind and temperature information obtained from the New Mexico Environmental Institute Mount Taylor Baseline Study and other site selection and environmental studies prepared by WCC in the general vicinity of the Mount Taylor project.

involving terrain considerations. The available information provides a reasonable basis to delineate certain air quality characteristic differences among the candidate sites.

The overall meteorology/air quality site rankings which resulted from these evaluations are indicated in Table A.2.1. It should be noted that these rankings depend heavily upon the precise location of the site. That is, a slight change in site location could change its position with respect to topographical features, wind channeling and blocking effects, as well as distance from potential receptors. Consequently, a seemingly small move in site location could cause a significant change in the rankings.

In general terms, the characteristics which should be exhibited by a desirable site are: 1) good dispersion potential to aid in reducing radiological dose rates, 2) low potential for severe winds to minimize fugitive dust, 3) large distance from, and direction other than upwind of, important receptors also to reduce dose rates, and 4) good evaporation rate to eliminate as much contaminated water as possible. The weights assigned to these four subfactors in Table A.2.1 indicate the relative importance of each of these subfactors in the determination of the overall meteorology/air quality factor. We believe that the dispersion potential is most important (50%); the distance and direction from receptors next (25%); the severe wind potential third (15%); and evaporation rate least important (10%).

TABLE A.2.1

METEOROLOGY/AIR QUALITY EVALUATION

SUB-FACTOR:	DISPERSION POTENTIAL	SEVERE WIND POTENTIAL	DISTANCE & DIRECTION FROM RECEPTORS	EVAPORATION RATE	OVERALL SCORE
WEIGHT (%):	50%	15%	25%	10%	100%
SITE					
1. Section 14	5	2	1	5	3
2. Las Vacas Valley	2	3	3	2	1
3. El Derrame Canon	1	5	4	1	1
4. Polvadera Valley	4	4	5	4	5
5. Lower San Lucas Valley	3	1	2	3	1
6. L. San Lucas Long Dam	3	2	2	3	2
7. Las Yeguas Valley	4	2	4	4	4
8. Upper San Lucas Valley	2	3	3	2	1

A score of 5 represents the best location for a tailing impoundment; a 1 represents the worst location.

Overall, Polvadera Valley (4) appears to be most desirable from the combined meteorology/air quality viewpoint. The next best site is Las Yeguas Valley (7) followed by Section 14 (1), and Lower San Lucas Long Dam Site (6). The remaining four sites Canada Las Vacas (2), El Derrame Canyon (3), Lower San Lucas Valley (5), and Upper San Lucas Valley (8) all appear to be relatively less desirable than the first three sites.

Specifically, Polvadera Valley (4) appears to be the best site from the viewpoint of distance and direction from important receptors. It is about 7.25 miles from San Mateo which is the furthest of any of the sites. The dispersion potential in that area appears to be good because of relatively open terrain in most directions. The potential for severe winds appears to be relatively low because of the terrain protection to the southwest afforded by San Mateo Mesa. Evaporation rate should be relatively good because of the moderate average wind speed that is expected in that area and the relatively large surface area of the tailing pond.

The rankings indicate that the next most desirable site is Las Yeguas Valley (7) which appears to have slightly better dispersion potential than Polvadera because of even more open terrain and potentially higher variability of wind direction. The evaporation rate was judged to be approximately the same. The distance and direction from important receptors factor was scored lower than Polvadera because it was closer to San Mateo. Also, the potential for severe winds in the Las Yeguas

Valley seems somewhat greater because of the lack of protective terrain in the important southwest and southeast directions.

Section 14 (1) appears to be the third most desirable from the overall meteorology/air quality criteria. This site was judged to have the best dispersion potential of any of the sites and the highest evaporation rate because of the openness of the terrain and therefore the potentially highest average wind speed and most variable wind direction. However, because of the lack of protective terrain, to the southwest in particular, this site was not judged good in terms of protection from severe winds. Also, the Section 14 site is closest to the town of San Mateo and the mine itself making it the poorest selection from the standpoint of distance and direction from important receptors.

Canada Las Vacas Valley (2) was judged to have relatively poor dispersion potential because of the high surrounding terrain and the resulting low wind speed and poor directional variability expected, and also a relatively low evaporation rate. The severe wind potential appears to be moderate because of the east-west orientation of the valley which on occasion might allow strong westerly winds. The site exhibits an intermediate distance from important receptors and was therefore judged average in this respect.

The El Derrame Canyon Site (3) appears to be best protected of all of the sites from the standpoint of severe wind potential.

Also, the distance and direction from important receptors appears good because of the relatively large distance from San Mateo and the remoteness and inaccessibility of the canyon. However, the dispersion potential and evaporation rate were both judged to be the poorest of any of the sites because of the steepness and confining nature of the surrounding terrain.

Lower San Lucas Valley (5) appears to have the highest potential for severe winds because of the openness of the terrain in the important southwest direction and also from the east-southeast through San Lucas Canyon. The distance and direction from important receptors was judged poor because of the site location with respect to existing roads. Both the dispersion potential and evaporation rate were judged moderate at this site due to an expected moderate average wind speed and the existence of some confining terrain features, particularly to the northeast and southeast.

Lower San Lucas Long Dam (6) was judged to be the same as Lower San Lucas Valley with respect to dispersion potential, distance and direction from important receptors, and evaporation rate. It was judged somewhat better in terms of protection from severe winds because it would not be as strongly affected by southeast winds blowing through San Lucas Canyon.

The Upper San Lucas Valley Site (8) was judged to have a moderate potential for severe winds because of contrasts in topography that includes open terrain to the southeast in contrast to the relative protection to the southwest. The distance

and direction from important receptors was also judged to be moderate at this site. Dispersion potential and evaporation rate were both judged relatively poor at this site because of the large terrain barrier.

A.2.2 Ground Water Quality

Four major factors were considered in evaluating the potential impact of a tailing dam and impoundment on the ground water environment. The factors considered are listed below:

1) Low permeability of the overburden, which was considered a positive feature in the scoring. We have used the term overburden to be synonymous with agricultural soil.

2) Close proximity of the proposed site to the ground water recharge area was considered a negative feature in the scoring.

3) The greater the thickness of the unsaturated zone the higher the score that was allotted this factor.

4) The closer the distance to the nearest ground water discharge point (such as wells and springs), the lower the score that was assigned.

Two additional factors that are important considerations in this area could not be utilized quantitatively because of lack of data. These were the local ground water quality, and the ion exchange properties of the overburden and the unsatueated zone above the water table.

The literature utilized in this evaluation is cited at the close of this section. Maps of local soils, geology, and wells and springs were closely examined, and references to these sources are also listed.

The following sections discuss our evaluations of each candidate site. The scoring and ranking of the ground water factors are presented in Table A.2.2.

Section 14 (1) is located in the San Mateo Creek drainage basin. Most of the area has a soil depth greater than 60 inches with low to moderate permeability. These soils are underlain by shales, siltstones and sandstones of the Menefee Formation. The site is in the recharge area for the Menefee and the valley alluvium. A perched water table in the alluvium may be within a few feet of the surface. The water table in the Menefee is between 30 and 75 feet below ground surface. There are several wells located within one mile of the site (Figure A.3.1). Almost all of these wells are in either the alluvium or the Menefee Formation. The site is the least suitable for tailing disposal and was given a score of 1.

Canada Las Vacas Valley (2) drains into San Lucas Canyon. The site has a relatively thick soil cover, greater than 60 inches, with low to moderate permeability. The west edge of the site has a soil cover 4 to 20 inches in depth, with moderate to high permeability. The east edge has a moderately thick soil cover of low to moderate permeability. Most of the bedrock underlying the site is in the Menefee Formation and has a moderate permeability, but on the west edge of the site is underlain by Point Lookout Sandstone and has high permeability. The west edge of the site is a recharge area for the Point Lookout Sandstone, and most of the remainder of the site is a recharge

TABLE A.2.2

GROUND WATER QUALITY EVALUATION

Site	Permeability of Overburden	Proximity to Recharge Area	Thickness of Unsaturated Zone	Distance to Nearest Well or Spring	Total Points	Score
1 - Section 14	2	2	1	2	7	1
2 - Las Vacas Valley	2	2	3	5	12	4
3 - El Derrame Canon	2	3	4	5	14	5
4 - Polvadera Canyon	4	4	5	2	15	5
5 - Lower San Lucas Valley	2	2	3	5	12	4
6 - Lower San Lucas Valley Long Dam	3	2	4	5	14	5
7 - Las Yeguas Valley	2	3	2	2	9	2
8 - Upper San Lucas Valley	4	2	4	3	13	4

All factors weighted equally. A score of 5 represents the best (relatively) location for a tailing impoundment; a 1 represents the worst location.

area for the Menefee Formation. There is probably no permanent water table in the soil cover. The depth to water in the bedrock probably exceeds 75 feet. The fault through the valley, shown on the geologic map (Figure A.3.6) does detract somewhat from this otherwise favorable condition. There are no wells or springs in or near the site. The site is a relatively good one for tailing disposal, and was assigned a score of 4.

Surface water from El Derrame Canon (3) drains into San Lucas Canyon. The site is covered by only 4 to 20 inches of soil of high permeability. It is underlain by bedrock with a low permeability. An outcrop of the Point Lookout Sandstone on the south and east edges of the site is visible. The sandstone formation has a high permeability and is a recharge area for an aquifer. There is probably no permanent water table in the soil and the depth to water in the bedrock is probably greater than 100 feet. There are no wells or springs in or near the site. The site was considered very favorable for tailing deposition. It received a total of 14 points in the evaluation and was assigned a score of 5.

Surface water from Polvadera Valley (4) drains into the San Lucas Canyon drainage. The site is covered with a moderately thick soil cover, 20 to 60 inches, of low permeability and underlain by bedrock of low permeability (Crevasse Canyon Formation and Mancos Shale). No portion of the site is a recharge area for sandstone aquifers. There is probably no permanent water table in the soil, and the water table in the

bedrock is probably greater than 100 feet below the surface. There is one well in the vicinity of the site, but it is over 1,000 feet deep. The site was one of two that received the highest total and was given a score of 5.

Surface water from Lower San Lucas Valley (5) drains into the San Lucas Canyon. The southwestern section of the site is underlain by a thick soil cover greater than 60 inches with low to moderate permeability. The central portion of the site is underlain by 20 to 60 inches of soil cover with low permeability. The southeast portion of the site is underlain by 20 to 40 inches of soil cover with low to medium permeability. The bedrock underlying the site is from the Menefee Formation, with a moderate permeability; there is Point Lookout Sandstone on the west edge of the site and Tertiary Basalt at higher elevations on the south and northeast edges of the site. The site is in the recharge are of the Menefee Formation. There may be a permanent water table in some of the soil cover. The depth to the water table in the bedrock is probably greater than 75 feet. There are no wells or springs in or near the site. The site was considered highly favorable and received a score of 4.

Surface water from Lower San Lucas Long Dam (6) drains into San Lucas Canyon. The site is almost entirely underlain by 20 to 40 inches of soil cover with low to moderate permeability. There is a small portion of the site, however, covered with loose sand having a high permeability. The underlying

bedrock is the Menefee Formation which has a moderate permeability. The site is in the recharge area of the Menefee Formation. There is probably no permanent water table in the soil cover and the depth to the water table in the bedrock is probably greater than 75 feet. There is some Tertiary Basalt on the north and south edges of the site. There are no wells or springs in the vicinity of the site. The site was considered one of the two best for tailing disposal and received a score of 5.

Surface water from Las Yeguas Valley (7) drains into Las Yeguas Canyon. The site is underlain by a moderately thick soil cover, 20 to 60 inches, of low permeability. The underlying bedrock is the Menefee Formation, with moderate permeability. The site is in the recharge area of the Menefee Formation. There is probably a permanent or semi-permanent water table in the soil at this location. The depth to the water table in bedrock (Menefee Formation) is probably between 50 to 75 feet (a well at 1.5 miles north of the proposed site is reported at 58 feet total depth). There are no wells in or within one mile of the site but there is one spring in the site area. The site was considered relatively poor for tailing disposal and received a score of 2.

Surface water from Upper San Lucas Valley (8) drains into San Lucas Canyon. The site is underlain by a thin to moderately thick soil cover, 20 to 40 inches, of low to moderate permeability. The site is mostly underlain by the Menefee Formation,

having a moderate permeability. The site is in the recharge area of the Menefee. There is probably no permanent water table in the soil and the depth to the water table in bedrock is probably greater than 75 feet. There are no wells in or near the site. The one spring near the southeastern edge of the site is at 800 feet. The site was considered good for tailing disposal and received a score of 4.

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A.2.3 Surface Water Quality and Human Danger

The various sites were analyzed to determine the potential for both contamination of downstream surface water supplies and loss of life from a potential dam failure. The first consideration in estimating the contamination potential was the proximity of springs, diversion structures and surface water storage reservoirs in a downstream direction from the tailing

dam site. The second consideration was the length and the height of the dam, which correlates closely with seepage through an earth dam. These figures are given in Table A.3.1.

The major consideration in evaluating potential loss of life from a dam failure was the proximity and extent of residential development downstream from the dam site.

Locations of candidate sites, water sources subject to contamination, and human habitations that could be flooded by a dam failure are shown on Figure 3.1. The scores are given in Table A.2.3.

Section 14 (1) has a high potential for contamination of downstream surface water, in view of the Buck Tank and Bridge Spring, located within approximately 1.5 miles of the site. Another possible source of water which could be contaminated is the Campbell Tank, located approximately 4 miles downstream and near San Mateo Creek. The relative length of this proposed dam would make it among the more difficult from which to control seepage.

The potential for loss of life in the event of a dam failure at this location would also be relatively high. The Lee Ranch, located less than one-half mile to the southwest of the site, would probably be inundated in the event of a dam failure. The Marcus Ranch, located approximately 6 miles downstream, could also suffer damage.

We believe the relatively high risk of surface water contamination and the relatively high danger of loss of life at this

TABLE A.2.3

SURFACE WATER EVALUATION

SITE	POTENTIAL FOR CONTAMINATION	POTENTIAL FOR LOSS OF LIFE	OVERALL SCORE
1	High	High	1
2	Low - Moderate	Low	5
3	Low - Moderate	Low	5
4	Moderate - High	Low	3
5	Moderate	Low	4
6	High	Low	3
7	High	Moderate	2
8	Moderate - High	Low	3

A score of 5 represents the lowest risk of contamination and/or loss of life; a score of 1 indicates the highest risk of contamination and/or loss of life.

site make it among the least desirable from a surface water environmental point of view. We therefore rate it at 1.

At Canada Las Vacas (2) the potential for contamination of downstream surface water supplies is among the lowest of any of the candidate sites. The Leopoldo Diversion Dam and the San Lucas Spring are located approximately 5 to 6 miles downstream and appear to be the only sources in the immediate vicinity in any danger of contamination. The relatively short dam length at this proposed location would make it among the easier sites from which to control seepage.

The chance of loss of life in the event of a dam failure at this site appears to be relatively low, as well, owing to an absence of residential development downstream of this site for a distance of at least 15 miles.

The relatively low chances of surface water contamination and loss of life in the event of a dam failure make this among the more desirable sites from a surface water environmental point of view, and we have scored it at 5.

At El Derrame Canon (3) the chances of contamination of surface water supplies appear to be relatively low. The Leopoldo Diversion Dam and the San Lucas Spring are located approximately 3 to 4 miles downstream from this site and appear to be the only major sources of water that could suffer contamination in the event of seepage from the dam. The short length of this dam would make it relatively easy to control this potential seepage.

The risk of loss of life in the event of a dam failure also appears to be relatively low at this site. There are no dwellings for a distance of at least 10 miles downstream from this location.

The small risk of contamination of surface water supplies and the low danger of loss of life in the event of failure at this location make it a highly desirable site, and we have scored it at 5.

La Polvadera Valley (4) has a relatively high potential for contamination of surface water supplies, due to the Leopoldo Diversion Dam, immediately downstream, and the San Lucas Spring, less than 2 miles downstream from the site. The relatively long dam has a high seepage potential.

The potential for loss of life in the event of failure of this structure would be very low. No dwellings currently exist in the area downstream of the site for some distance.

We feel that the relatively high risk of contamination of surface water sources at this area is offset by the relatively low risk of loss of life in the event of a dam failure and have scored it at 3.

Lower San Lucas Valley (5) has a moderate potential for contamination of surface water sources in comparison with other sites. The Leopoldo Diversion Dam and the San Lucas Spring are located approximately 3 to 4 miles downstream of the site and could conceivably be contaminated by seepage from the dam.

Furthermore, the proposed dam is relatively large and has a correspondingly high seepage potential. We believe the chance of loss of life in the event of failure of this structure to be relatively low. No dwellings currently exist for 10 miles downstream of the site. In summary, we consider the site desirable and have scored it at 4.

Lower San Lucas Long Dam (6) has an average potential for surface water supply contamination. The Leopoldo Diversion Dam and the San Lucas Spring, located 3 to 4 miles downstream, could be contaminated by seepage from the dam. The relatively long dam length (Table A.3.1) has a high potential for seepage.

The risk of loss of life in the event of failure at this site is low, as no dwellings currently exist for at least 10 miles downstream.

The relatively high risk of contamination of surface water supplies is offset by the relatively low risk of loss of life in the event of dam failure, and we have scored this site at 3.

Las Yeguas Canyon (7) is located approximately one-half mile upstream from its confluence with San Miguel Canyon. A spring, located immediately south of the San Miguel Ranch, would most likely be contaminated by seepage from this dam. The dam itself is long, by comparison with those proposed for other sites, and would be among the more difficult to protect from seepage.

The risk of loss of life in the event of failure of this structure is moderate, in view of the fact that the San Miguel

Ranch is located approximately 1 mile downstream of the site, and it is quite probable that this ranch would be inundated in the event of a dam failure.

The relatively high potential for contamination of downstream water supplies and the risk of loss of life in the event of failure of the dam make this a relatively undesirable site, and we have scored it at 2.

Upper San Lucas (8) has a relatively high potential for contamination of surface water sources, in view of seasonal springs which we understand exist immediately below the dam site. The dam length would be average in comparison with other sites.

The risk of loss of life in the event of failure of this structure is relatively low, inasmuch as no dwellings are currently located for at least 10 miles downstream.

We feel that the relatively high risk of contamination of surface water sources is offset by the relatively low risk of loss of life in the event of failure, and we have scored this site at a 3.

A.2.4 Ecology

The ecological evaluation includes an assessment of inherent ecological values of each site based on four distinct subfactors, which include vegetation, wildlife, big game, and aquatics. These features were selected as being the main ecological parameters affected by the utilization of different sites. All were weighted the same in Table A.2.4, and all included an

TABLE A.2.4

ECOLOGICAL EVALUATION

	SITES	VEGETATION	AQUATICS	BIG GAME	WILDLIFE	SCORE
1.	Section 14	5	5	5	5	5
2.	Las Vacas	2	3	2	2	2
3.	El Derrame	2	3	1	1	2
4.	Polvadera	3	3	3	3	3
5.	Lower San Lucas	4	3	2	4	3
6.	Lower San Lucas Long Dam	4	5	4	4	4
7.	Las Yeguas	3	5	3	3	3
8.	Upper San Lucas	1	1	1	1	1

All factors weighted equally. Score of 5 indicates lowest ecological value (most desirable for tailing); score of 1 indicates highest ecological value.

evaluation of the ecological factors of disturbance and diversity. In general, the greater the disturbance the less the ecological value. Diversity implies a greater number of species within an ecosystem, and the greater the diversity the higher the value that is attributed to a site. Both of these measures were utilized in addition to the ones described below in the assessment of each of the four subfactors.

The vegetation rating summarizes the values of the existing vegetation in terms of structure, coverage, uniqueness, biological productivity and aesthetic impact. In this study the highest scores were given to the areas most disturbed by grazing, agriculture and human intrusions. The lowest scores, and hence, those least suitable for tailing deposition, were given to Upper San Lucas (8) and El Derrame (3).

The aquatic subfactor summarizes the ecological values of the streams, marshes and adjacent riparian vegetation in candidate tailing deposition areas. Inasmuch as most streams in the area are ephemeral, the values of the aquatic system itself are low. There are particular areas, as in Upper San Lucas (8), where aquatic riparian vegetation communities are established and add ecological value to the site. Scores for this subfactor approximated those for the vegetation.

The big game ratings asssociated with the sites are keyed particularly to past and potential human disturbance, and access to summer and winter grazing habitat. For this reason El Derrame (3), Upper San Lucas (8) and Las Vacas (2) all rated low scores.

Section 14 (1) had high ratings and were most suitable for tailing deposition owing to the open nature of the terrain and frequent human disturbance. Polvadera (4), and Las Yeguas (7) and both Lower San Lucas sites (5 and 6) were scored with intermediate values.

The wildlife subfactor includes an evaluation of the site for mammals other than big game, and includes birds and other vertebrates, including snakes and lizards. This factor received ratings similar to those given for big game with lowest scores given to the more isolated locations and the highest scores for Section 14 (1).

Two other features were considered but not used in the matrix analysis. Uniqueness, a feature denoting the rareness of particular species or habitats, is an important factor, but not considered significant in this study inasmuch as existing data indicate that no rare species have been found in the study area. Raptors (birds of prey) an important biological group, were not evaluated separately owing to the lack of site-specific information.

In summary, for the ecology factor Section 14 (1) had the highest scores and the lowest ecological value. From a biological point of view this was the best site for tailing disposal. The next best site was Lower San Lucas Long Dam (6), followed closely by Polvadera (4) and Lower San Lucas Valley (5). The most valuable ecological site was Upper San

Lucas (8), while Las Vacas (2) and El Derrame (3) were slightly less valuable ecologically.

A.2.5 Scenic Resources

Three features of the visual environment were utilized to develop a rating of each site. These three features were: variety, sensitivity, and scenic impact. The first two features are essentially baseline measures and are evaluated in the same way as the system developed by the U.S. Forest Service. The latter factor assesses the impact of the feature described, in this case a tailing impoundment, on the scenic baseline.

Variety can be defined as the amount of diversity found in vegetational patterns, land forms, rock formations, and water forms (the components of the landscape). These components are perceived by the viewer in terms of their elements (form, line, color, and texture). The individual prominence of the component within a landscape is determined by an interaction of elements.

An evaluation of the variety of the seven sites (Table A.2.5) indicated a considerable range in scenic values, ranging from the fairly flat and uninteresting Section 14 (1) to the scenic, picturesque and isolated El Derrame (3) and Upper San Lucas Valleys (8). The variety measure of the other four sites were graded between these extreme values.

The second factor in determining a landscape's value is sensitivity. Sensitivity is dependent upon the number of people who view the landscape and the duration of their view. In

TABLE A.2.5

SCENIC EVALUATION

SITES	VARIETY	SENSITIVITY	IMPACT	SCORE
1. Section 14	5	1	2	2
2. Las Vacas Valley	2	2	3	2
3. El Derrame Canon	1	3	1	1
4. Polvadera Valley	3	3	3	3
5. Lower San Lucas Valley	4	2	5	3
6. L. San Lucas Long Dam	4	2	4	3
7. Las Yeguas Valley	4	5	4	5
8. Upper San Lucas Valley	1	3	2	2

A score of 5 represents the least scenic impact and hence the best location for a tailing impoundment; a 1 represents the reverse.

this situation, the most sensitive area is Section 14 (1) which can be seen from State Highway 53, from the town and from the mine. By far the greater number of viewers can and do view this site with regularity. In contrast to this is Las Yeguas Canyon (7) which is so isolated that it is viewed only by those venturing in that direction. The other sites fall in between these two extreme values.

One additional feature, scenic impact, is necessary to complete the scenic score. This score is based on the effect of a tailing impoundment on the view. The strongest impact, which rated 1, was El Derrame (3) which would have much of its aesthetic appeal eliminated by a tailing impoundment. In contrast to this is Lower San Lucas Valley (5) which has a dam and the kind of terrain which would make a tailing impoundment of minimal scenic impact. Other sites ranged between these two values.

To summarize these values and achieve a final score, sensitivity was first multiplied by the impact score. To this was added the variety score. The totals were then divided by five to arrive at the final one to five score. The results can be seen in Table A.2.5 and reveal the lowest scenic value score to be El Derrame (3) and the highest to be Las Yeguas (7). Again, other values fell in between. Photographs 1-7 illustrate an aerial view of each of these sites.

A.2.6 Existing Access Roads

This factor was scored according to the impact rating that would result from the potential location of the tailing impoundment at each site. In several cases the impoundment would block a road utilized for business or recreational access. For example, the road into Upper San Lucas provides ready access not only to the valley but to the uplands beyond. A tailing impoundment covering the road in this location would be a rather severe impact. Most severe of all, however, would be a tailing impoundment at Lower San Lucas (5). It would present a serious bottleneck to northward and southward traffic movement which is necesssary for management of the range and for recreational access.

The results indicate that both Section 14 (1) and Las Yeguas (7) have no access problems affected by a potential impoundment and, consequently, received a score of 5. The greatest impedance to accessibility would be at Lower San Lucas Valley (5), and this site received a score of 1. Lower San Lucas Long Dam (6) would not block existing roads, but was scored a 4 because of the possible congestion during operations. The other five sites were scored between these values.

A.2.7 Geology

The geological subfactors incorporated in the environmental evaluation of the candidate sites include landslide and earthquake potential and unique geologic features (see Figure A.3.6).

Landslides occur in rock and soil when the stress on a failure plane exceeds the strength of material along that plane. Many factors enter into the evaluation of a slope's landslide potential, but for the majority of landslides, ground water constitutes the most important single contributory cause. In addition to ground water, other geologic factors that contribute to landslides are the topography, attitude and spacing of fractures and bedding planes, and the type and characteristics of the material. Using these factors, we made a subjective evaluation of the landslide potential at each candidate site. A high ranking indicates the site is the least susceptible to landslides.

Damage from earthquakes to the proposed structures is controlled by many factors, such as the energy received at the site from an earthquake, faults, and the type and characteristics of the foundation material. We conclude from our analysis that there is only a remote possibility that ground accelerations greater than 0.035g (Modified Mercalli Intensity V to VI) will affect the proposed tailings dam sites. We did, however, evaluate each of the candidate sites on their foundation conditions and the occurrence of faults that have been mapped in the area. The variation in bedrock and surficial materials between each of the sites is minimal and hence, did not enter significantly into the evaluation of each site. A high value in our ranking indicates essentially an absence of faults, whereas a low number indicates the occurrence of faults.

Unique geologic features, as we used them in our evaluation of the various sites, implies, by its name, an uncommon feature of geologic circumstances and/or erosion. In the general area of the candidate sites, the uniqueness value was related more to distinctive structure, i.e., faults, folds, and bold outcrops of the canyon variety. For example, we considered flat-lying sedimentary strata with occasional mesa-top landscape to have less unique value than sharp canyons cut into resistant rock that has been either faulted and/or folded. In our ratings of each candidate site, a high value indicates little or no uniqueness.

We utilized the U.S.G.S. geologic map as well as the Gulf map prepared by J.B. Cooper in our evaluations. Within the subdivisions of environmental geology, we considered the landslide potential to have the greater impact and earthquake potential and the uniqueness of geologic features to have the least impact in site selection. This is reflected in their weighted portions within the site selection matrix. The environmental geology differences between each of the candidate sites are small and hence, the weighted value used in the site selection matrix is correspondingly low.

Our analysis of the environmental geology factors shown in Table A.2.7 indicates that Section 14 (1), was the most favorable and El Derrame (3), was the least desirable. The other six sites were intermediate between these two sites.

TABLE A.2.7

GEOLOGICAL EVALUATION

Sites	RANKING			Score
	Landslide (.6)	Earthquake Potential (.2)	Unique Features (.2)	
1. Section 14	5	5	5	5
2. Las Vacas	3	1	3	2
3. El Derrame	1	3	1	1
4. Polvadera	4	2	2	3
5. Lower San Lucas	3	4	3	3
6. Lower San Lucas Long Dam	3	5	4	3
7. Las Yeguas	3	5	4	3
8. Upper San Lucas	2	4	3	2

A score of 5 represents the best location for a tailing impoundment; a 1 represents the worst location.

A.3 ENGINEERING EVALUATIONS

The engineering evaluation utilized in the ranking of candidate tailing dam sites considered several factors, including: (1) dam size; (2) dam location; (3) reclamation; (4) dam foundation; (5) borrow material; (6) underseepage; and (7) flood potential and control. Information gathered during our analyses is presented in Table A.3.1. Our judgment-based weights for these factors and the assigned site scores are indicated in Table A.3.2. Generally, the values used to rate the sites were obtained by comparing the quantitative information shown on Table A.3.1 and applying judgment and rough comparative cost estimates.

Two weights are shown on Table A.3.2. The first set shows the weights utilizing a lined reservoir to minimize the risk of ground water contamination. The second set of weights considered an unlined reservoir. The matrix was run with both sets of weights to assess the influence of lining on site ranking. Figures A.3.2, A.3.3, A.3.4 and A.3.5 present potential tailing dams for each of the candidate sites.

A.3.1 Dam Size

The scores assigned to dam size are primarily related to the size and cost of compacted earth dam(s) that would be associated with tailing impoundment. The score of 1 represents the largest dam(s) and hence, higher cost, at the candidate sites. A score of 5 represents the smallest dam and least

TABLE A.3.1

ENGINEERING DATA SUMMARY

Site	TAILING DAM							DELIVERY AND DECANT LINES		
	Crest Length (Feet)	Crest Elevation (MSL)	Foundation Elevation at Low Point (MSL)	Maximum Height (Feet)	Volume (Thousand Cubic Yards)	Cutoff Volume (Thousand Cubic Yards)	Filled Pond Surface Area (Acres)	Elevation Differing Mill to Crest Dam (Feet)	Average Delivery Line Grade (%)	Delivery Line Length (Hundred Feet)
No. 1 Section 14	7350	7150	7094	56	1600	126	250	-150	1.56	96
No. 2 Las Vacas Valley	980	7335	7237	98	460	13	220	+ 35	0.17	208
No. 3 El Derrame Canon	520	7280	7142	138	540	19	140	- 20	0.75	256
No. 4 Polvadera Valley	1390	7055	6990	65	470	41	260	-245	0.64	380
No. 5 Lower San Lucas Valley	1400	7170	7106	64	360	36	330	-130	0.54	242
No. 6 L. San Lucas Long Dam	9090	7210	7128	82	2404	104	180	- 90	0.39	228
No. 7 Las Yeguas Valley	3480	6945	6860	85	750	15	330	-355	0.76	470
No. 8 Upper San Lucas Valley	870	7405	7300	105	380	9	260	+105	0.33	276

\+ Indicates Dam Crest Above Mill

\- Indicates Dam Crest Below Mill

TABLE A.3.2

ENGINEERING EVALUATION

	FACTORS						
	Dam Size	Dam Location	Reclamation	Dam Foundation	Borrow Material	Underseepage	Hydrology
Weights							
With Lining	9	9	2	1	1	14	14
Without Lining	12	12	3	2	2	0	19
Sites							
No. 1 Section 14	2	5	3	1	5	3	3
No. 2 Las Vacas Valley	5	4	3	5	3	3	4
No. 3 El Derrame Canon	4	3	5	5	2	5	4
No. 4 Polvadera Valley	4	2	3	4	4	3	2
No. 5 Lower San Lucas Valley	5	3	1	4	3	1	1
No. 6 L. San Lucas, Long Dam	1	4	4	2	5	4	5
No. 7 Las Yeguas	3	1	1	5	1	1	3
No. 8 Upper San Lucas Valley	5	3	3	5	3	3	1

A score of 5 represents the best location for a tailing impoundment; a 1 represents the worst location.

cost. The following is a brief discussion of the factors contributing to the dam volumes for the individual sites.

A dam located in Las Vacas Valley (2) would be moderately high and have a relatively short crest length due to the narrow steep-sided canyon. Less earthwork would be necessary than at many of the other sites. Thus it received the highest score of 5.

El Derrame (3) is relatively narrow and steep sided. Thus the dam would be the highest of the alternatives considered and also the shortest. The dam volume would be near the middle of the range, and the site received a relatively high score of 4.

A dam in Polvadera Valley (4) would have a moderate crest length and would be near the low end of the height range in relation to the other sites considered. The site is relatively broad in comparison to the other canyon sites. The earthwork volume involved would be near the middle of the range, and the site was given a score of 4.

The Lower San Lucas Valley (5) is relatively broad in comparison to the other canyon sites. The dam would not be high in relation to the other sites and would also be relatively short in comparison to some of the longer dams. This site requires the least volume of earth work for dam construction and thus received the maximum score of 5.

The Lower San Lucas Long Dam (6) is relatively flat in comparison to the other sites and would require the highest

volume of earthwork of all the alternatives considered. The dam would not be high in relation to the others but due to the relatively flat topography would be long. It received a score of 1.

Las Yeguas Valley (7) is located in a broad flat valley necessitating a relatively long dam crest and a moderate height dam. It would require considerably more dam volume than the other sites considered with the exception of Section 14 (1). It received a score of 3.

The Upper San Lucas (8) is located in a narrow canyon. The dam would be relatively high and have a moderate crest length. The dam volume is low in comparison to the other sites. It was given a score of 5.

A.3.2 Dam Location

The values associated with the dam location relative to the mill are primarily concerned with the tailing delivery system. In determining the values we based our judgment primarily on length of the tailing delivery system and the return water system.

Section 14 (1) requires the shortest delivery and return system, hence it received the highest score of 5. The Lower San Lucas Long Dam (6), Las Vacas Valley (2), El Derrame Canyon (3), Polvadera Valley (4), Upper San Lucas Valley (8) and Lower San Lucas Valley (5) sites are moderate distances from the mill and thus received medium values. The Las Yeguas site (7)

is furthest from the mill and received the lowest score of 1. Its value is further lessened by difficult transport condition, owing to its position behind a high ridge.

A.3.3 Reclamation

Reclamation values are directly related to the areal extent of the ultimate tailing dam. We assumed reclamation would be done upon the abandonment of the dam. The El Derrame (3) site covers the least area and will require minimal reclamation effort. Thus it received the highest score of 5. The Lower San Lucas Valley (5) and Las Yeguas Valley (7) sites would cover large areas and received scores of 1. The remaining sites including the Upper San Lucas Valley (8), Lower San Lucas Long Dam (6), Polvadera Valley (4), Las Vacas Valley (2) and Section 14 (1) were intermediate and received scores of 3-4.

A.3.4. Dam Foundation

The foundation conditions are similar at all sites. Generally the value assigned is directly related to the volume of earthwork needed to provide a cutoff beneath the dam(s). The significance of the cutoff is low since minimal earthwork is required in comparison to the dam volume. Section 14 (1) received the lowest value of 1, since more earthwork would be needed to provide a cutoff. Lower San Lucas Long Dam (6) also received a relatively low score of 2, since it also requires a relatively large volume of earthwork. The Las Vacas Valley (2), El Derrame Canon (3), Upper San Lucas Valley (8) and Las Yeguas Valley (7) sites received the highest values of 4-5,

as the volume of earth work was lower than other candidate sites. The Polvadera Valley (4) and Lower San Lucas Valley (5) sites were assigned relatively high values although considerable earthwork would be required for cutoff.

A.3.5 Borrow Material

Borrow material for dam construction should be available from within or near the sites. The general area lacks sand and gravel for drain construction; hence these materials will have to be imported from off-site.

Section 14 (1) was given high value since materials are available close to the dam in the tailing area.

Las Vacas Valley (2) was given a relatively high value as materials are reasonably close to the dam and available within the reservoir area. Mancos Shale outcrops in the vicinity of the Las Vacas site and could provide relatively impervious material for dam construction.

El Derrame Canon (3) was given a relatively low value since borrow materials, while available in the tailing area, will probably be relatively distant from the dam in comparison to the other alternatives.

Polvadero Valley (4) received a relatively high value as the materials for dam construction are available in the tailing area close to the dam. Mancos Shale also outcrops near the Polvadera Valley site, thus relatively impervious material may be available near the dam.

Lower San Lucas Valley (5) received a medium value as materials for dam construction are available in the reservoir area but would have to be transported a moderate distance.

Lower San Lucas Long Dam (6) was given a high value since materials are available close to the dam and in the tailing area.

Las Yeguas Valley (7) received the lowest value since borrow material is probably available in the tailing area but is probably scattered throughout the tailing area.

Borrow material is available in the reservoir area at a moderate haul, thus the Upper San Lucas Valley (8) site received a medium value.

A.3.6 Underseepage

Lining the tailing area will probably be required to minimize underseepage. The underseepage values are directly related to the areal extent of the tailing dam. The weight associated with the underseepage control is relatively high. The El Derrame Canon (3) site received the highest value since it has the least area. Section 14 (1), Lower San Lucas Long Dam (6), Las Vacas (2), Polvadera Valley (4) and Upper San Lucas Valley (8) received moderate values, since the areas to be lined were near the middle range of values. The Lower San Lucas Valley (5) and Las Yeguas Valley (7) sites received the lowest values as they had large areas that would need to be lined.

A.3.7 Hydrology

The radioactive nature of uranium tailing and the long half-life of the material indicate to us that the tailing must be protected from any foreseeable flood threat. We understand that the party responsible for construction of such a dam would be responsible for damages to anyone resulting from a failure of the dam. We believe the Probable Maximum Precipitation (PMP) to be realistic design criteria for projects such as this. The PMP value is the theoretical maximum precipitation which could occur in a six-hour period and at this location is estimated by the Soil Conservation Service[1] to range between 18 and 19 inches. We are familiar with several cases in the arid west where estimated PMP values have been exceeded in recent years.

Estimates of the flow resulting from the probable maximum precipitation (PMP) were prepared for all major watersheds tributary to each of the eight sites, using the SCS[1] method of computation. Estimated flows from the major watersheds were added for each site[2]. These estimates are summarized in Table A.3.7.1.

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[1] Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology (1964).

[2] Totals are for rough comparisons between sites and do not necessarily reflect recommended design flows.

TABLE A.3.7.1

ESTIMATED PROBABLE FLOOD PEAKS

SITE	SUB-WATERSHED[1]		AREA (Square Miles)		ESTIMATED PROBABLE MAXIMUM FLOOD PEAK[2] (000 cfs)
1	1		6.0		18
	2		1.8		9
	3		1.7		8
		TOTAL	9.5	TOTAL	35
2	1		0.4		3
	2		0.6		3
	3		2.7		9
	4		0.4		3
		TOTAL	4.1	TOTAL	18
3	1		0.3		2
	2		1.3		7
	3		0.8		6
		TOTAL	2.4	TOTAL	15
4	1		5.2		18
	2		0.2		2
	3		2.1		9
	4		0.5		3
		TOTAL	8.0	TOTAL	32
5[3]	1		5.7		17
	2		0.7		4
	3		0.8		4
	4		22.6		47
		TOTAL	29.8	TOTAL	72
6	1		0.8		5
7	1		1.0		6
	2		2.3		13
	3		2.7		12
		TOTAL	6.0	TOTAL	31
8	1		10.9		26
	2		10.3		25
		TOTAL	21.2	TOTAL	51

1 As identified on Figure 3.7.1.

2 Assuming coincidence of peak flows from all sub-watersheds; peak flows slightly less than additive for total areas exceeding 10 square miles. These totals are tabulated for rough comparisons only and do not necessarily represent recommended design flows.

3 Sub-watersheds for Sites 5, 6 and 8 included as sub-watersheds for Site 5.

The watersheds were examined by field reconnaissance and USGS topographic sheet analyzed to assess means to protect the tailing dam from flooding, both through channel diversion and possible locations for detention reservoirs. Figure A.3.1 shows the watershed boundaries, sub-watershed boundaries and major drainage channels. A site-by-site discussion of our analysis follows. An overall point score of 1 to 5 has been assigned each candidate site; with 1 indicating the site rated least favorable for flood potential and ease of flood control, and 5 the site most favorably rated for these factors. These scores are shown in Table A.3.7.2.

Section 14 (1) is located on Marquez Canyon, immediately upstream from its confluence with San Mateo Creek. Moderate flood potential is expected on this watershed with the major contribution expected from Marquez Canyon shown as watershed 1, Site 1, Figure A.3.1.

The sum of estimated PMP peak flows from sub-watersheds approximates 35,000 cubic feet per second (cfs).

Channel diversion is not difficult at this location. Diversion distances from the stream channels to points downstream from the dam are reasonable, and gentle topography is conducive to the construction of ditches, dams and other diversion structures, as can be seen on Figure A.3.1.

Some detention ponds for flood control purposes might be located in the steep, narrow canyons of Sections 18, 19,

TABLE A.3.7.2

FLOOD POTENTIAL AND CONTROL EVALUATION

SITE	OVERALL FLOOD RISK[1]	COST OF ESTABLISHMENT OF BYPASS STRUCTURES	AVAILABILITY OF SITES FOR DETENTION PONDS	OVERALL SCORE[2]
1	Moderate	Low	Fair	3
2	Low	Moderate	Poor	4
3	Low	Moderate - High	Poor - Fair	4
4	Moderate	Moderate - High	Fair	2
5	High	Moderate	Fair - Good	1
6	Low	Low - Moderate	Poor	5
7	Moderate	Low - Moderate	Fair	3
8	High	Moderate	Fair	1

1 "Low" refers to total flows less than 25,000 cfs from maximum peak PMP.

"Moderate" refers to total flows between 25,000 and 40,000 cfs from maximum peak PMP.

"High" refers to total flows in excess of 40,000 cfs from maximum peak PMP.

2 A score of 5 represents the lowest risk of contamination and/or loss of life; a score of 1 represents the highest risk of contamination and/or loss of life.

20 and 29, T13N, R7W and Section 24, T13N, R8W, although sites in this area could control only a fraction of the contributing watershed.

Our analysis of the above factors indicates that this site is average relative to the others, and we have given this site a score of 3.

Canada Las Vacas (2) is approximately 2 miles upstream from its confluence with San Lucas Canyon (Figure A.3.1). Relatively low flood potential, by comparison with most other sites, is expected here, as shown in Table A.3.7.2. Estimated peak PMP flows of the various sub-watersheds at this site total approximately 18,000 cfs.

Construction of diversion structures around the main dam, especially from sub-watersheds 2 and 3, would be difficult, although not excessively expensive, owing to the rough topography and distances required (Figure A.3.1). A possible location for a detention pond was found in Section 29, T14N, R8W, but it controls only a small portion of the total drainage area. Such ponds may not be required if satisfactory diversion structures are built. Our analysis is that this location is among the more favorable of the candidate sites for flood potential and control, and we have given it a score of 4.

The El Derrame (3) is located approximately one-half mile upstream from San Lucas Canyon, as can be seen from Figure A.3.1. Smaller PMP flood peaks are expected at this location than at most other candidate sites. At this location estimated

PMP peak flows of the various sub-watersheds total approximately 15,000 cfs.

Construction of diversion structures at this location presents moderate difficulty, owing to distance from the channels to the dam site and the steep topography in the area immediately upstream from the dam site. These difficulties can probably be overcome with moderate expense. Several possible detention pond locations are found in Sections 28, 33, 34 and 35, T14N, R8W, but these would control only small portions of the watersheds and are of marginal potential value. We consider this site favorable from the flood potential and control standpoint and have scored it at 4.

La Polvadera Canyon (4) is approximately one-half mile upstream from its confluence with San Lucas Canyon. This location has a moderate flood potential. The estimated peak PMP flows from the various sub-watersheds at this location total approximately 32,000 cfs.

Construction of diversion works could present considerable difficulty, owing to distances from the various channels to the dam site and relatively steep topography surrounding the area. A possible detention pond site was noted in Sections 21 and 22, T14N, R8W which could control several hundred acres of the contributing watershed. The remainder of the drainage area does not appear controllable by detention ponds. Our analysis of the above factors rates this site as less than average, and we have scored it at 2.

Lower San Lucas Canyon Site (5) is immediately upstream from the San Lucas Dam. Flood potential at this location is considered the highest of any site. Estimated peak PMP flows for the various sub-watersheds total approximately 72,000 cfs. Construction of diversion control structures around the tailing reservoir would be a major expense, owing to the channel distance and capacity requirements dictated by the flood potential.

We believe that large detention reservoirs might be constructed in Section 3, T13N, R8W at the Las Vacas (2) proposed tailing site. These reservoirs could control the majority of the drainage tributary to Site 5, but would be a major expense. We feel that the large flood potential at this site and the high cost necessary to insure control of flooding make it among the least desirable from a flood potential and control viewpoint, and we have scored it at 1.

The Lower San Lucas Long Dam (6) is located immediately south of the confluence of Canada Las Vacas with San Lucas Canyon. Flood potential at this site is largely avoided by dam placement and construction of a long dam.

A total peak PMP flood flow of 5,000 cfs is estimated for this drainage. Diversion distances are moderate, but the topography is relatively flat at this site and appears favorable for construction of diversion structures. There appears little need for detention ponds, owing to the small contributing watershed. We consider this site the most favorable for flood potential and control and therefore scored it at 5.

Las Yeguas Canyon (7) is located about one mile upstream from the San Miguel Ranch. Moderate flood potential is expected at this site. Estimated peak PMP flows from the various sub-watersheds total approximately 31,000 cfs.

Our study indicates that diversion of flood flows around this tailing reservoir site can be accomplished with only moderate difficulty and at reasonable cost. Although distances from some of the channels to the dam site are significant, the moderate topography presents no major problem.

A few possibly feasible sites for small detention ponds are in the southern and western portions of the watershed, but these would control only a small portion of the watershed. We feel that this is an average site from a flood potential and control perspective and have scored it at 3.

Upper San Lucas Canyon (8) is located approximately 1.5 miles upstream of Site 5. We expect PMP flood peaks at this location to be of major proportions. Estimated PMP flood peaks for the sub-watersheds total 51,000 cfs.

Suitable diversion works would be a major expense, due to the long distances from the major channels to the dam site, the unfavorable topography surrounding the dam area and the large capacity required.

Several possible detention pond sites might be found in Sections 27, 28, 33, and 34, T13N, R7W and Sections 3 and 4, T12N, R7W, but these ponds would still leave major portions

of the drainage uncontrolled. The high flood potential and high cost required for flood control make this site highly unfavorable, and we have scored it at 1.

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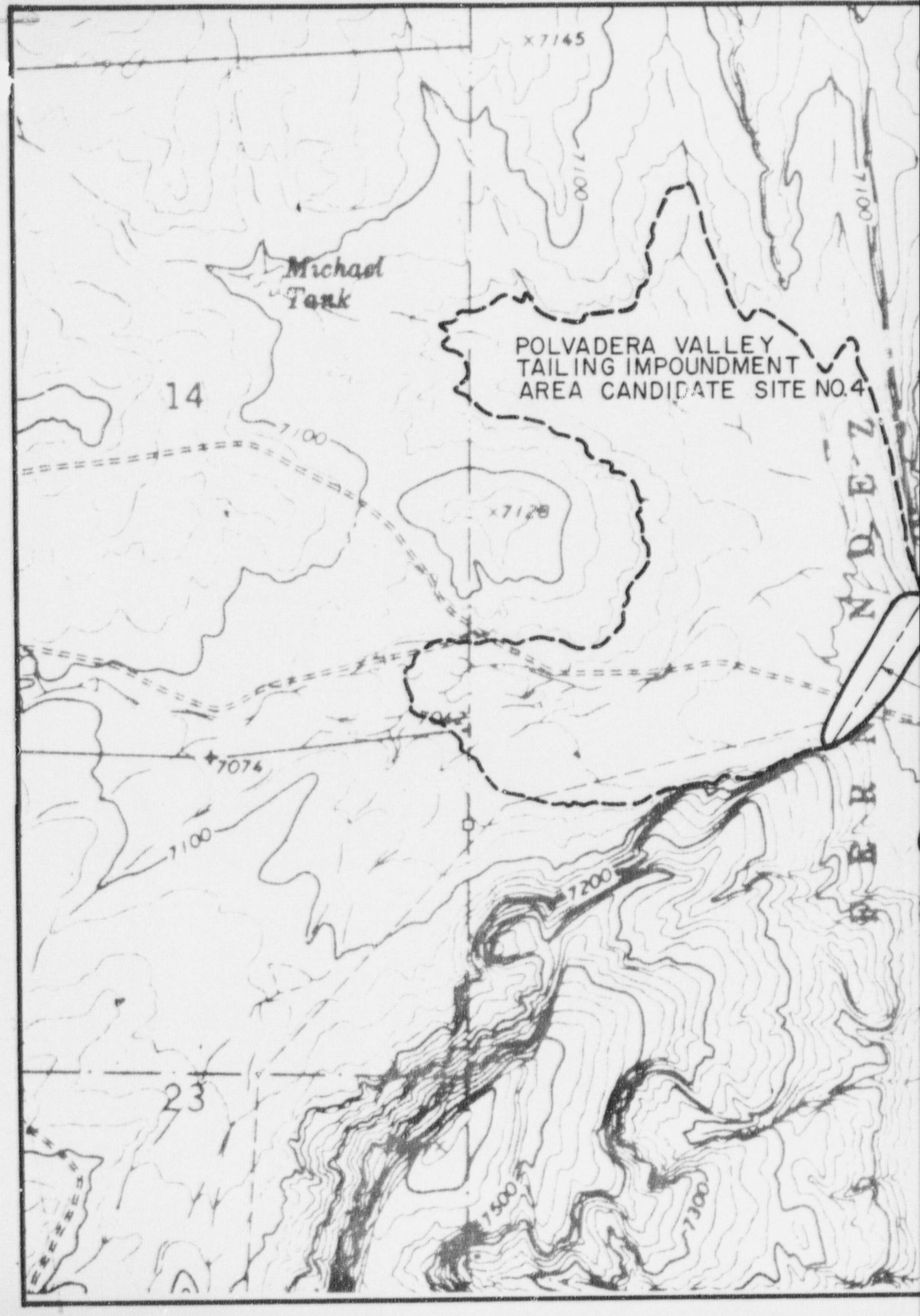

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7100
Michael Tank
POLVADERA VALLEY
TAILING IMPOUNDMENT
AREA CANDIDATE SITE NO.4
14
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7074
7100
7200
23
7500
7300

N

SCALE 1" = 1000'

LEGEND

DAM EMBANKMENT

ULTIMATE TAILING LIMIT

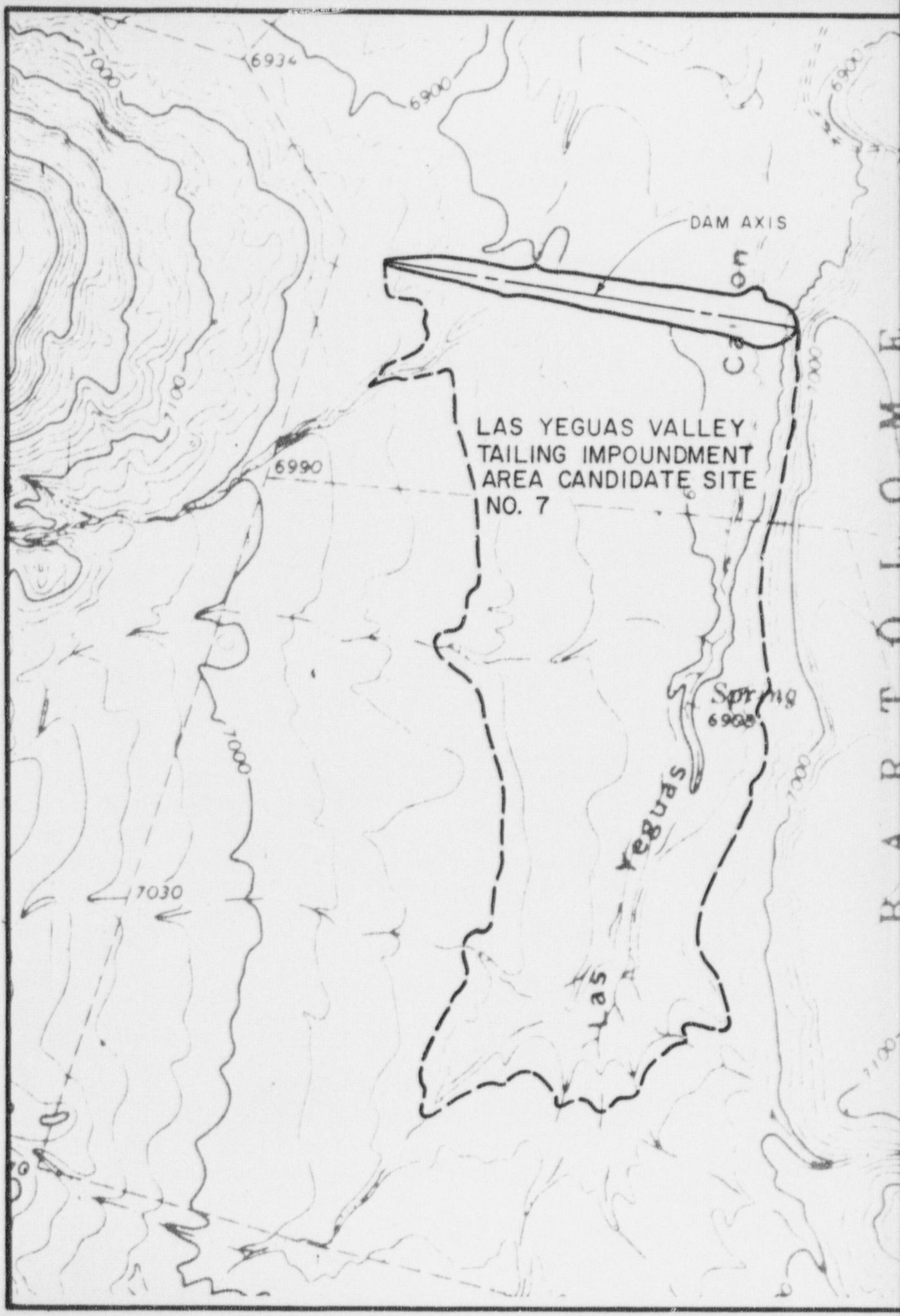
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS
AND ENVIRONMENTAL SCIENTISTS
ROCKY MOUNTAIN REGION - DENVER, COLORADO

SITE MAP

TAILING IMPOUNDMENT
CANDIDATE SITE NO.4

PREPARED BY : D.L.J.	DATE : 3/4/76
JOB NO. 18456	

FIG. A-3.4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LAS YEGUAS VALLEY
TAILING IMPOUNDMENT
AREA CANDIDATE SITE
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Las Yeguas
Las Yeguas

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SCALE 1" = 1000'

LEGEND

DAM EMBANKMENT

ULTIMATE TAILING LIMIT

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ROCKY MOUNTAIN REGION – DENVER, COLORADO

SITE MAP

TAILING IMPOUNDMENT CANDIDATE SITE NO. 7

PREPARED BY : D.L.J.	DATE : 3/4/76
JOB NO. 18456	

FIG. A-3.5

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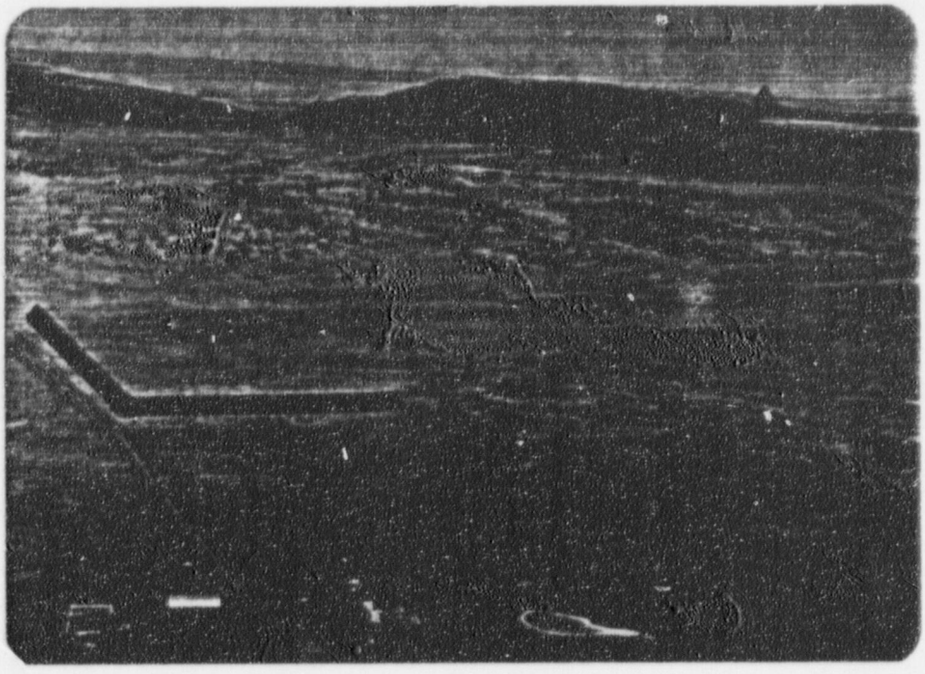

PHOTO NO. 1. Section 14, Candidate Site #1, looking northeast.

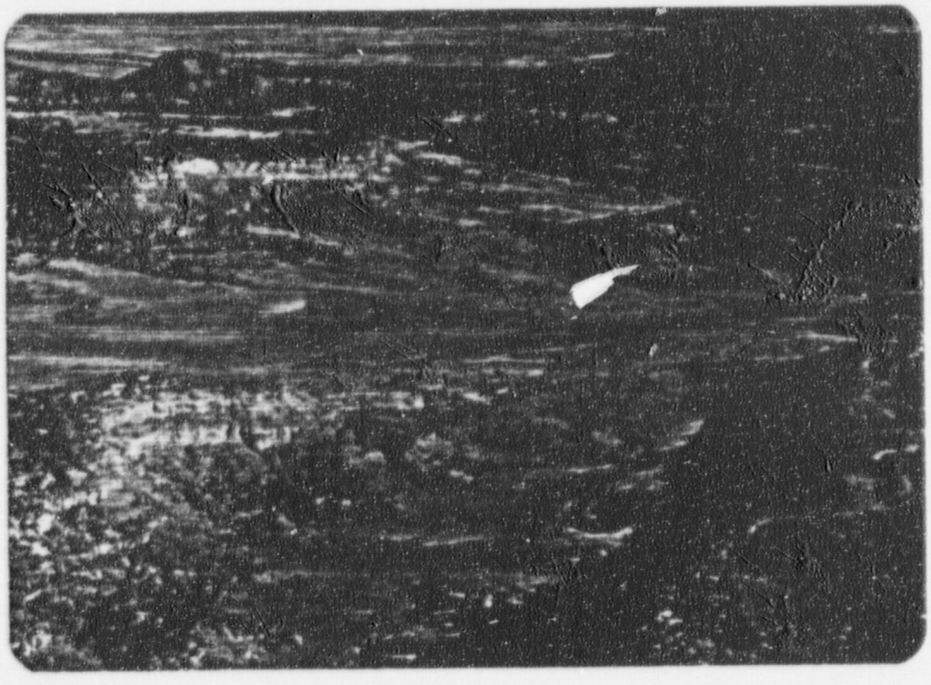

PHOTO NO. 2. Canada Las Vacas, Candidate Site #2, looking easterly.

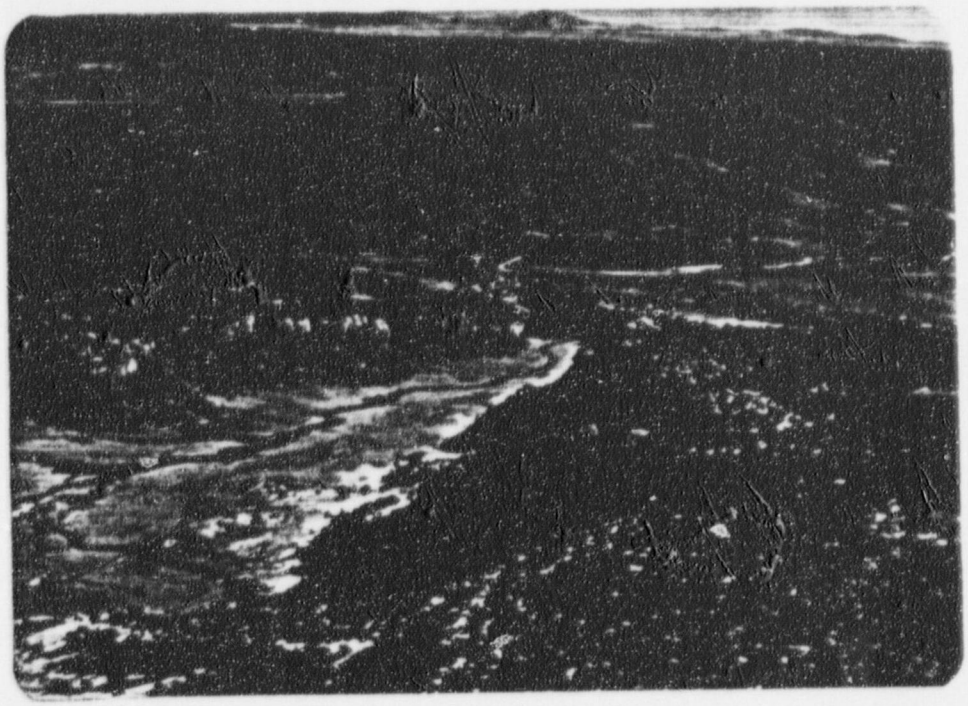

PHOTO NO. 3. El Derrame Canyon, Candidate Site #3, looking east.

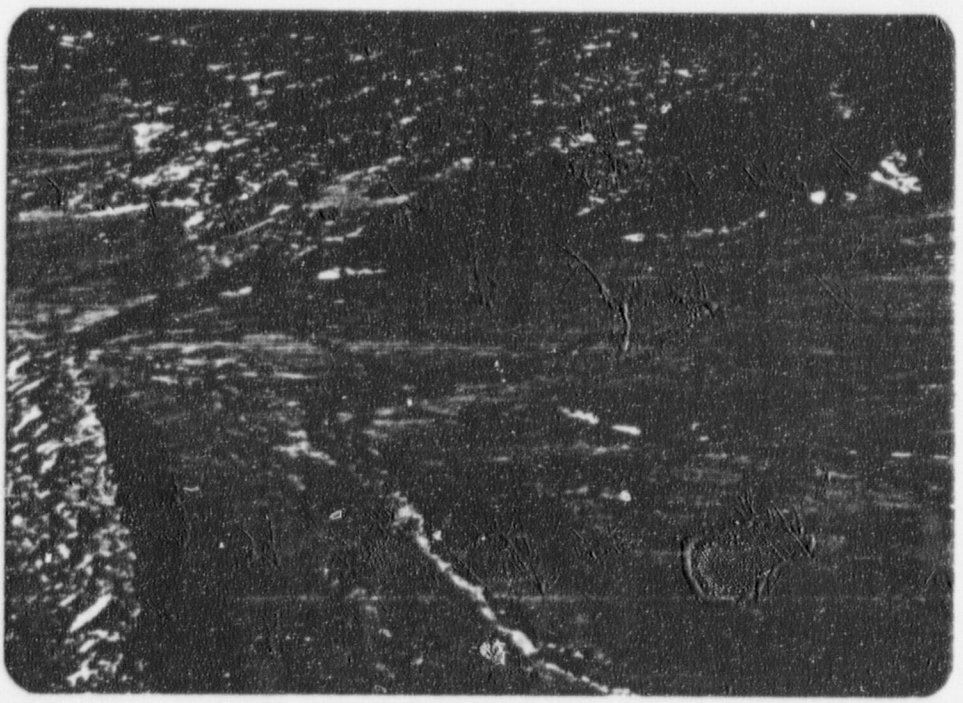

PHOTO NO. 4. Polvadera Valley, Candidate Site #4, looking south.

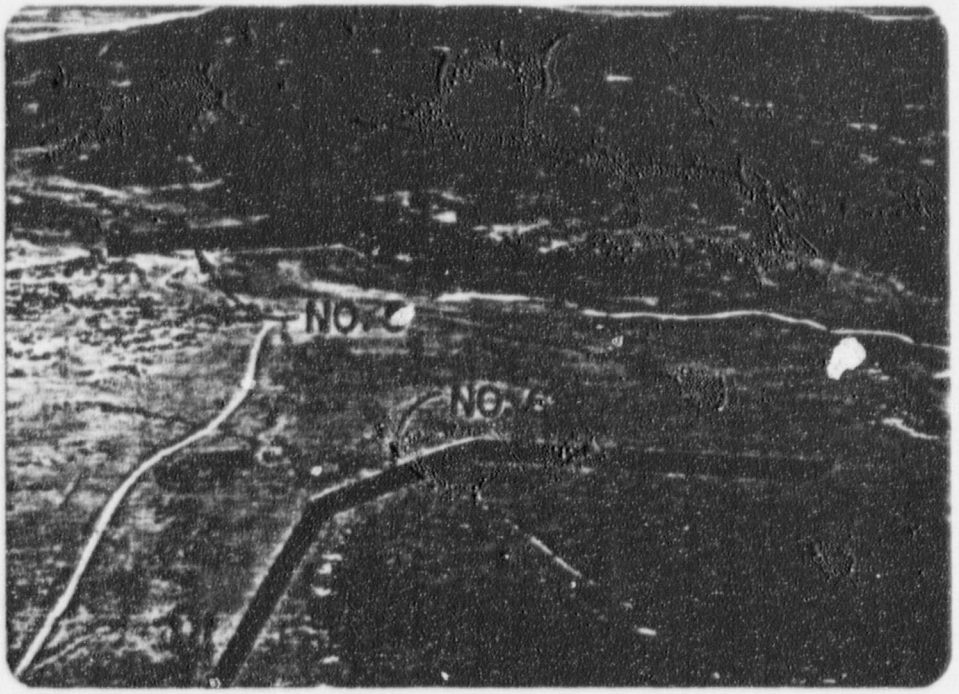

PHOTO NO. 5. Lower San Lucas Valley, Candidate Sites #'s 5 and 6, looking northeast.

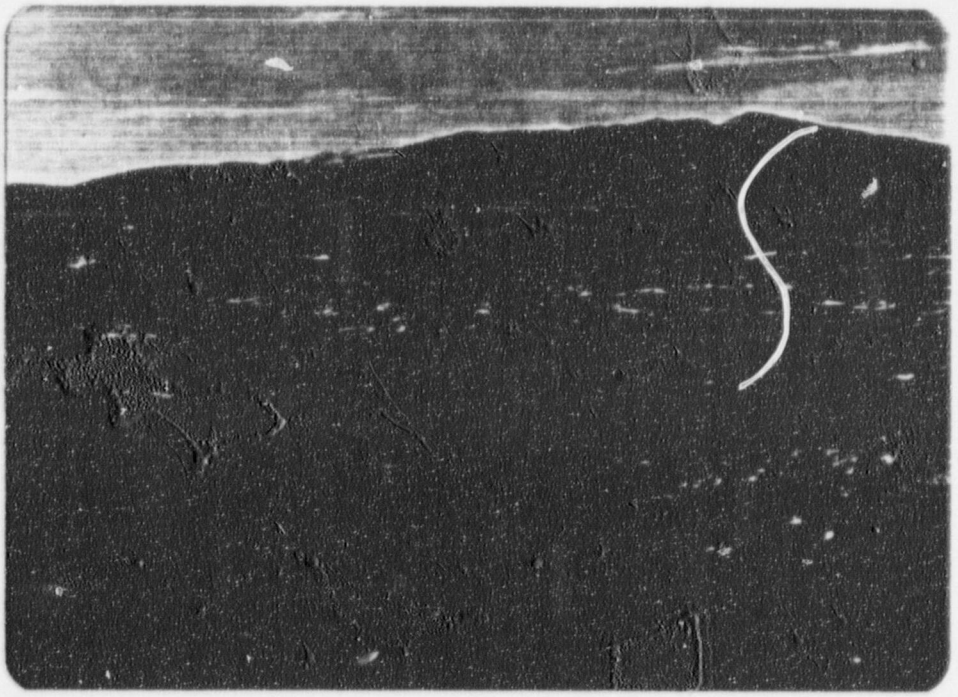

PHOTO NO. 6. Las Yeguas Valley, Candidate Site #7, looking south.

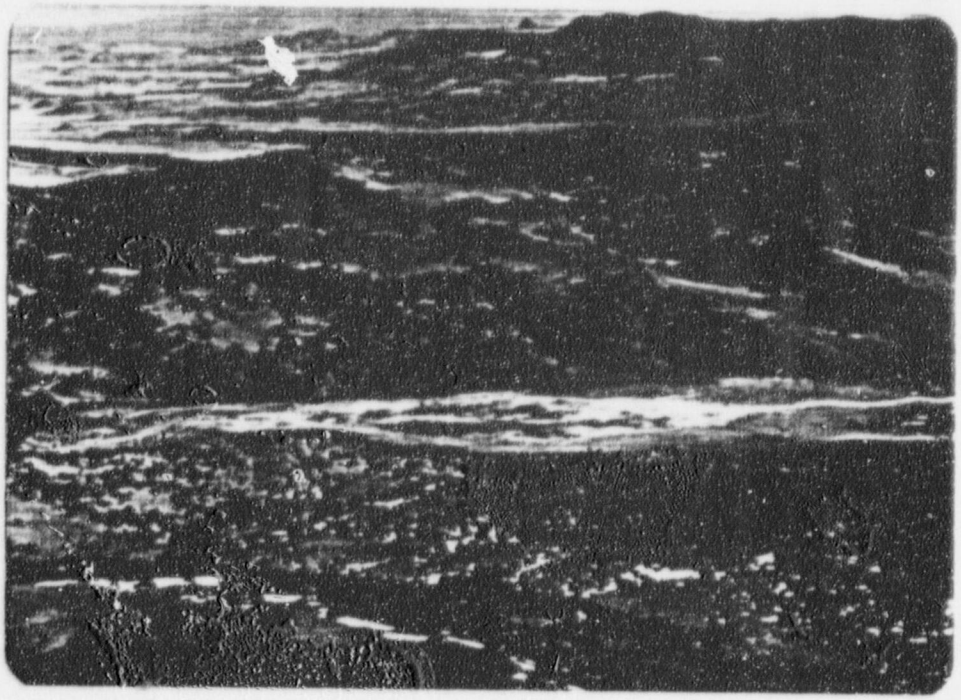

PHOTO NO. 7. Upper San Lucas Valley, Candidate Site #8, looking northeast.

PHOTO NO. 8. Mt. Taylor, looking southwest.