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LAND MANAGEMENT

UNIT FOUR

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Albuquerque, New Mexico.

ENGINEERING REPORT

SUBMITTED BY:
ALLEN STAMM
ENGINEERING AIDE

UNM 904

CV-6417-201 NN005941

N A V A J O S E R V I C E

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I General Description of Unit

Land Management Unit 4 occupies the major portion of Black Mesa which is situated in the approximate center of the Navajo Reservation occupying parts of Navajo and Coconino counties in Arizona. Its greatest east and west spread is about 60 miles and the distance from north to south is approximately 40 miles. Roughly the Unit lies between the 109°50' and 111°00' meridians of longitude and the 35°50' and 36°30' parallels of latitude. The total area of the Unit according to the present boundary line is 1,139,354 acres. The present and proposed boundaries are fully covered in the report by McKinney and will not be discussed here.

Topography and Drainage

The topography of this Unit is characterized by a southwesterly alignment of the principal features which have a pronounced effect on the soil and vegetative development. The entire Unit is included within the watershed of the Little Colorado River and is drained by five main washes which flow almost directly southwesterly. From east to west these washes are the Polacca, Wepo, Oraibi, Dinnebito and Moencopi

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which flows through Blue Canyon. The headwaters of each of these drainage systems reach to the escarpment of Black Mesa which drops as much as 2000' to the plains below and forms a very effective barrier to travel and movement of livestock.

These drainage systems have cut innumerable valleys and gorges through the parent formations of the mesa, exposing ever deepening and widening valleys from the headwaters to the southern boundary of the Unit. Each of these washes and especially the Oraibi and the Moencopi have developed spectacular canyons of vertical sandstone cliffs and steep semi-badland shale slopes.

Geology and Soils

The plane of the entire mesa has a pronounced tilt to the southwest probably due to the more rapid erosion of the lower parts which have been subjected to a more accelerated streamflow scour through long periods of time. Thus the northern part of the Unit is capped by the uppermost strata of the original Mesa Verde sandstone while the lower portions of the area exhibit many outcrops of the underlying formations such as the Mancos shales which are found as small badland areas adjoining the Howell Mesa. Lying immediately under the Mancos

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shales are found the Dakota sandstone and the white and pink McElmo sandstone. This entire sequence may be seen in the spectacular Coal Canyon region.

The soils of the Unit bear a natural relationship to the geological picture as it has been sketched plus a certain amount of modification by wind, water, and vegetation. The higher lying area, mesa tops, and ridges are characteristically stony and gravelly residual soils derived primarily from the coarser constituents of the Mesa Verde formation while its shale component has been more or less separated and deposited as deep valley fills. The rolling residual soils are very permeable to water and their water retention ability great. They are light in surface texture and are capable of producing good crops of range grasses and shrubs. Wind erosion might become very damaging with a further depletion of vegetative cover; in some sections it is rather serious now.

The valley fills are typically very heavy in texture, resistant to water penetration and are impregnated with salts in localized spots. This leads to a generally low productive capacity although native plants produce a normal growth. The type of soil in these fills is highly erodible and range depletion within recent times has led to very

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spectacular gullying in the valley floors and an almost continuous network of smaller gullies in the tributaries. Wind erosion has modified the surface soils especially of that portion of the area toward Howell Mesa and nearby. This particular section has a much lighter texture than any other portion of the Unit. In general, the soils of the southern third are definitely more friable than in the upper two thirds of the Unit.

Erosion

The Black Mesa country in the steeper portions is very badly eroded by water due to the rough terrain and little cover, the extreme precipitation, and the low permeability of the soil, Rapid erosion is normal upon the steep slopes but the present condition places it in an accelerated class.

Of the five main drainages mentioned, the Moencopi, Dinnebito and the Oraibi are from forty to one hundred feet wide and twenty to fifty feet deep along the upper parts and proportionally wider and deeper below as their drainage areas increase. The Wepo fans in places and can be controlled while the Polacca, from twenty to seventy feet wide and fifteen to thirty feet deep can only be spread along its upper reaches. From these main washes, innumerable heads and gullies are cutting back into the side valleys and unless these are controlled

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many thousand acres of valuable range land are threatened.

Gullies, heads, and sheet erosion will generally be found in all valleys where the Concho Soil Series is present. From major side washes, small gullies branch off and from these additional gullies head--in fact, we have recommended treatment over almost all of the Unit since sheet and gully erosion cover the greatest part. Sheet erosion is particularly severe on the hills and slopes and, during heavy rains, washes and gullies carry great quantities of silt into the main drainages. This condition has been present for some time and has resulted in the removal of the soil mantle and exposure of the parent sandstone and shale over large portions of the Unit.

Vegetation and Vegetative Depletion

The vegetation of this Unit has developed into very characteristic types according to the influence of the environment discussed above. In general, four major plant forms are found: grassland, sage brush, browse, and coniferous woodland. The most striking feature as one travels over this Unit is the advanced stage of vegetative depletion which more than any other factor has contributed to the critical conservation problem on this district. This condition is directly attributable

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to long continued and extreme overgrazing. This overstocking has included all classes of stock and so has affected all types of forage although the sheep and goat damage has been most severe.

The rugged country with a low grazing value is difficult to reach, very badly damaged by erosion and plant depletion, and extremely slow to recuperate. Use of these ridges is difficult with the result that stock drifts into the valleys and lower slopes at every opportunity, leaving little chance for vegetative re-growth. Movement of stock through the valleys is further increased since it is here that the roads are located. As it discussed in more detail in the range management report, this movement is largely the result of driving to saltbush, water, dipping vats, seasonal shifts, and driving to market.

The Oraibi valley is typical of such misuse. Its normal vegetation is mainly chamiso, blue grama, and winter fat. Although the soils are not of an especially desirable texture, they are capable of producing very thrifty plant growth. This nearly level, half mile wide valley is now so depleted that the chamiso is either dead or dying, winter fat plants are an inch high, and grass can scarcely be found, while Russian Thistle covers the entire area. Within recent times, a huge arroyo has cut through the alluvial soil to bed rock for the entire length of this valley and similar ones.

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As an indication of the effects of proper range control in restoring and bringing back vegetation over such a depleted area, the results secured within Range Management Study Plot No. 10 may be observed. This plot of two and one-half acres has recovered remarkably; grass is six to twelve inches high; numerous winter fat plants may be found; and sage and other browse is abundant. After seeing and observing this plot, one can only then begin to realize what can be accomplished by stock control and range management.

II Precipitation and Runoff

Although no meteorological records are available within Unit 4, a complete set of records has been kept at Chin Lee, St. Michaels, Fort Defiance, Kayenta, Keams Canyon, Winslow, and Tuba City during the years past. Records for Chin Lee (Elevation 6090) extend from 1909-1928; St. Michaels (Elevation 6950) does not show when the data was taken; Fort Defiance (Elevation 6950) has records covering the periods from 1852-1860, 1897-1905, 1929-1930; Kayenta (Elevation 5000) with data from 1915-1930; Keams Canyon (Elevation 6600) 1894-1895, 1906-1921, 1928-1930; Winslow (Elevation 4848) 1880-1889, 1892-1893, 1898-1900, and 1908-1930; and Tuba City (Elevation 4500) has records from 1897-1930. From these records an average monthly precipitation chart has been compiled

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or, in other words, an average to be expected each month at each of these stations. The last two columns show the average annual temperature which may be expected and the number of years the records were kept.

It must be realized that these stations do not compare topographically or otherwise with most of Unit 4. However, assuming that those portions of the Unit with comparable elevations can be given like rainfall expectations and by comparison of vegetative growth on this area with those localities having previous runoff records, we have arrived at the following figures which we believe are approximately correct.

Elev. 5800-6500' -- 9" - 12" Average Annual Rainfall

Elev. 6500-7200' -- 12" - 15" Average Annual Rainfall

Elev. 7200-7900' -- 15" - 20" Average Annual Rainfall

Prevailing winds are generally from the southwest while the growing season varies from ninety to 100 days in the higher reaches of the Unit to 135 to 140 days in the lower parts, with an average of 115 to 120 days. Temperature ranges from -15 to 100 degrees at elevations of 5800 to 6500 feet, -20 to 95 degrees at elevations of 6500 to 7200 feet, and -25 to 90 degrees at elevations of 7200 to 7900 feet.

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	Average Monthly Precipitation													Average Annual Temperature	Years Records Taken
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual		
Chin Lee	.41	.52	.45	.44	.29	.46	1.92	1.44	1.02	.85	.41	.54	8.75	49.9	17
St. Michaels	.96	.97	.95	.51	.38	.43	2.44	2.39	1.32	1.11	.68	1.01	13.15	47.2	20
Fort Defiance	1.03	1.07	.90	.79	.75	.76	2.05	2.34	1.62	.60	1.03	.74	13.68	46.1	10
Kayenta	.63	.43	.64	.42	.36	.38	1.45	1.58	.75	.91	.64	.61	8.80	52.5	14
Keams Canyon	1.31	.95	.90	.66	.33	.27	2.41	1.81	.70	1.25	.70	1.08	12.43	50.0	16
Winslow	.56	.40	.47	.46	.26	.36	1.62	1.72	.78	.52	.52	.93	8.60	55.0	22
Tuba City	.55	.54	.43	.53	.19	.34	.93	.84	.68	.78	.53	.58	6.92	54.8	29

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Runoff

In arriving at runoff expectations, two methods were used; first, Kutter's formula with field observations to determine maximum water section, the grade of the channel, hydraulic radius, and the roughness factor; and second, runoff factors were assumed which, multiplied by the drainage area in acres, gave the runoff in second feet. On large erosion control projects which were estimated on a per acre basis, no computations were made of maximum flow expected or annual expectancy. Special erosion control projects and farm developments usually needed estimates of runoff. In the field, old residents of that vicinity were contacted whenever possible, and from them we attempted to determine maximum flood sections and average annual sections. Where debris lines and high water marks showed, these were often used. The grade of the channel was then taken; a coefficient of roughness assumed; and the hydraulic radius or area in square feet divided by the wetted perimeter was computed. Then, from the Bureau of Reclamation's "Hydraulic and Excavation Tables", given those three factors; grade, hydraulic radius, and coefficient of roughness, a direct velocity was taken which, multiplied by the cross-sectional area, gives the flow in cubic feet per second. Assuming a maximum flood to flow at its peak for three hours, it will usually equal the total flow, or since one second foot of water in twenty-four hours is two acre feet, it follows that, by dividing the maximum

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flood in second feet by four, the maximum acre feet expectancy will be determined closely.

As a check, the drainage area above the point in question was planimetered in the office and, by using a set of runoff factors which were multiplied by the drainage area in acres, a rough check was so made. To obtain the annual water supply, the expectancy factor was multiplied by the drainage area in acres and this divided by three to give a conservative minimum expectancy in acre feet.

The maximum runoff factors mentioned and the annual expectancy factors were taken from those compiled at the Mexican Springs Experiment Station with a correction, of course, to fit local conditions. It is assumed that a two inch rain falling for one hour on the entire drainage area will produce the runoff calculated by the Mexican Springs studies. The estimate cards give maximum floods expected and acre foot expectancy when these figures are needed.

III General Structural Treatment

The Moencopi Wash along the western boundary of the Unit is exceedingly deep and wide, and sufficient spreading ground for an entire diversion is not available. The Dinnebito

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and Oraibi are somewhat smaller—20 to 30 feet deep and 30 to 100 feet wide—but they too offer no chance for a full diversion since spreading ground is very limited and soils are fairly heavy. On the Burnt Corn Wash, very little in the way of a complete diversion is possible and it is only when we reach the Little Wepo, Big Wepo, and the Polacca that we plan on spreading the entire wash. These will be taken up later under Water Spreading and Irrigation Projects.

Major side drainages have in almost all cases reached the grade of the main washes and often show active heads above. The majority of the side drainages will be very difficult to handle since they are quite deep and carry enormous quantities of silt-laden water. Our treatment will be confined to smaller gullies and washes, usually three to five feet deep where plenty of spreading ground is to be found below the diversion. Usually on slopes greater than one and one-half percent, a wire and rock masonry stabilizer will be found needed with a series of spreaders below. Further up the side slopes, sandier soil often will be located and in these places better absorption is possible. Where opportune diversion to farms can be utilized, it is suggested that we cooperate fully with the agronomist in his recommendations.

Small structures, rock drops and checks, log and brush work in a limited quantity, small earth diversion dykes and plugs, often with end protections, and in some cases expensive masonry

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and rock spillways and drops are suggested. These latter structures are justified only where valuable farms are threatened or extensive grassla will be s ed. Often extensive work is planned at stock tanks or in the drainage area above to reduce the silt being washed into the basin. These special erosion control projects are more fully explained later, and listed in the Index and on the individual cards.

The conventional numbering system has been used; whole numbers assigned to the main arroyos; the Moencopi is given 1, the Dinnebito 2, the Oraibi 3, and the Polacca 4. Proceeding upstream, the drainages on the left side of the Moencopi are progressively numbered, 1.1, 1.3, 1.5, etc., while those washes on the right side are numbered 1.2, 1.4, 1.6, etc. Any gullies of any size flowing into the side washes are given one more decimal and then numbered the same way, so the first gully flowing into 1.1 from the left is given 1.1.1, the second on the left is 1.1.3, while those on the right are 1.1.2, 1.1.4, 1.1.6, etc.

IV Erosion Control and Water Spreading Projects

Due to the limited time available for this survey, approximately 100 square miles had to be covered each day. To allow representative estimates, large portions of the Unit were

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lumped together and a cost per acre assigned to the entire area. A standard was chosen varying from $.15 to $.50 per acre, and, after careful examination of each project and comparison with the others, the estimates were made.

It must be remembered that treatment will be possible only in the valleys, on gentle slopes, and in some cases the mesa tops. This actual cost of treatment per acre may run from $2.00 to $4.00 on land actually treated with indirect benefits to the steeper slopes and rougher land. We all feel that, since it was impossible to visit all portions of Unit 4 and so locate all special jobs, this per acre standard was necessary. Many isolated heads have been missed; these heads will, however, be treated with money allocated to the entire project. It is hoped that our estimates are high enough to allow for this.

Water Spreading Projects

As mentioned in Part II, no water spreading can be accomplished on the Moencopi or Dinnebito. On the upper Dinnebito, however, a possible water spreading project #13 has been outlined on Card #3. This is contingent upon a storage project four miles above it and a diversion project at the intersection of the Dinnebito and East Fork of the Dinnebito being unfeasible.

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Should these two projects (see Cards #1 and #2) be turned down, this waterspreading project will then be constructed.

Water spreading project #28, Quad. 8 on Card #15, will divert water from small gullies along drainage 3.40 and spread runoff to 500 acres of farm land and 50 acres of cultivated land. Card #20 shows a partial water spreading project diverting runoff from an actively cutting gully on drainage 2.75, Card #63, Quad. 11, outlines a large water spreading project about two and one-half miles east of Pinon located on the Big Wepo which will be extensively developed should the irrigation project be rejected there. Excellent soil and good slopes should make this a fine project with nearly a thousand acres receiving water. With the irrigation project approved, extensive water spreading can be accomplished with excess flood waters. Quad. 12 contains project #71 on Card #66 and project #60 on Card #67. A possible storage dam is located about one and one-half miles above the spreading ground and, should this be impractical, drainage 4.30 will be diverted for W.S. #71 and drainage 4.00 will be diverted for W.S. 60. Since approximately $2400.00 is to be spent on these two projects, we recommend a topographic survey. Topographic surveys are also recommended on Cards #63 and #3.

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It should be remembered that almost all of the large Erosion Control Projects also serve as water spreading projects. As seen in the index, approximately one fifth of the total costs are charged to water spreading. It is impossible to make an accurate estimate of acreage affected by water spreading so no attempt has been made to do so.

V Special Erosion Control Projects

Part II explains the method in which runoff was computed for the special erosion control projects. Twenty-five of these have been outlined and cover all types of treatment. Costs per acre benefited range from about $.50 to $2.00 and average $.92. As seen from the index, a number of stock tanks, both Indian and E.C.W., will be benefited, large heads threatening valuable farms and grasslands will be stopped, drops and dikes will be constructed, and otherwise a varied type of work will be performed on these projects.

VI Farm Developments and Diversions

Where deep gullies were found cutting through farm lands and where a rather large diversion costs was expected we, with the agronomist, estimated a diversion cost to the present farms or proposed expansions. Sixteen of these [redacted]

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have been shown as seen by the index ranging from $80 on 8 acres to $2500 on 60 acres. The majority of the larger projects should require topographic surveys since whenever the total cost of diversion and subjugation totals four or five hundred dollars, a topographic survey is usually needed to determine the best methods of diversion and subjugation.

Special head protections were found on three farms, the cost per acre on this ran $3 to $8 an acre. No diversion estimate has been made on the majority of the farms since we and the Agronomist feel that subjugation will in many cases cover the expenses of small dams and dikes. Often we assumed that the Indian himself could with shovel and slip handle the smaller work on his individual farm. Subjugation costs of each farm are not included in this report, only on those farms which will require a definite allocation. A summary of those costs, together with those of the Erosion Control, and Special Erosion Control projects are given in Part IX.

VII Roads

An accompanying chart shows the approximate mileage of secondary roads which will require treatment from side erosion. A total of 728 miles are shown, only about half of this figure represents mileage which will actually be treated. 728 miles with a total appropriation of $9245 allows a per mile post of $1270, assuming half of this will actually be treated allows a per mile cost of $25. We feel that this is sufficient since only small thank-u-mams and drainage ditches will be needed.

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No estimate of mileage of E.C.W. truck trails is given, should no money be available from E.C.W. or Indian Service funds, for treatment of the side slopes and gullies, an additional appropriation should be allocated from our funds for this purpose.

In addition several bridges, culverts, drains, and other drainage structures are needed on the several E.C.W. truck trails; no estimate has been made of these structures. The primary road from Oraibi to Pinon also needs treatment along the side ditches and slopes. In one place ten miles from Pinon where an arroyo has badly flooded and cut the grade, we have estimated the project above will diminish the floods so they can easily be handled. We feel that treatment of this primary road can be covered by present projects outlined along the vicinity.

Proposed Treatment on Secondary Roads

Quad	Miles	Cost	Remarks
96	55	$1000	Very little work needed
95	10	$ 200	Sandy - cutting is limited
97	75	$ 900	Erosion scattered but not extensive
104	105	$1375	About half of this will be treated
98	10	$ 200	Erosion more extensive
7	0	0	No treatment
10	125	$1625	About half of this will be treated
9	40	$ 480	Rough with erosion scattered
14	0	0	With present boundary no mileage to be treated
13	65	$ 650	Erosion less extensive
12	40	$ 480	About half of this will be treated
11	125	$1250	Erosion less extensive
8	75	$1025	About half of this will be treated
56	3	$ 60	Erosion more extensive
	728	$9245	or per mile cost at $12.70. Each mile

treated will, however, be about $25.

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VIII Agriculture

About 2,617 acres are being farmed on this Unit, or approximately 2 % of the total. Potential land which can be developed comprises 3,094 acres or a total of 5,711 acres, classified as agricultural land and included in 395 tracts. This land can be classified as below:

	Present				Potential		Total
	A	B	C	D	A	B	
Irrigated					*		
Flood Irrigated	2,060	191	72	12	2,291	303	5,429
Rainfall or Dry	275	6	1				282
						Total Acres	5,711

* No potential land has been given but probably 300 to 500 acres will be developed on one or two projects which are to be surveyed as soon as possible. See IX - Irrigation Projects - Present and Proposed.

For crops raised, farming facilities, yields, suggested crops, etc. see Agricultural Report by E. A. Nicholson.

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IX Irrigation Projects - Present and Proposed

A. Present Hard Rocks Diversion. A masonry diversion structure with sluice way, this project was constructed about three years ago by the Indian Irrigation Service. The main canal is badly silted and no use has ever been made of this project since it was constructed. Mr. Harry Jones of the S.C.S. mentions this diversion in a report made by him December 4, 1935 on the Tolani Lakes Development. No extensive study has been made of this project since our present boundary excludes it from Unit 4 and the study party assigned to Unit 6 should take it up in detail.

B. Lower Dinnebito Project. This project is now being constructed by the Indian Irrigation Service and consists of a beam on supports type of diversion located on a sandstone outcropping. The weir section is 160' x 7' designed for 10,000 second feet of water with the canal carrying 33 second feet. Approximately 900 acres of Grade A land are under the diversion and about 800 acres of Grade B land. This project is so located to utilize the spring runoff from melting snows in the Black Mountain country and will theoretically handle about 1,000 acres with an extended spring runoff. In my mind it is very questionable whether more than 300 acres will ever be subjugated since the duration of the spring runoff is varied and ordinarily no one will be in attendance to operate the gates, sluiceway and silt traps.

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C. Proposed Diversion at Hard Rocks Dipping Vat. This is to be the same type of diversion structure as that now under construction at Lower Dinnebito, a beam on supports with a spillway of 30' x 7' to pass floods of 5,000 second feet. Canal as in the Lower Dinnebito Project will be designed for 33 second feet. Land below the Project consists of about 350 acres of Grade A land and about 200 acres of a poorer clay loam type. Should money be available after the Lower Dinnebito Project and this project are completed, it will be spent on the repair and maintenance of the present Hard Rocks Diversion. It is proposed to raise the weir, head walls, clean the canal and otherwise put it in shape for use next spring.

D. Storage Dam on East Fork of Dinnebito. See Card #1. This proposed project will extend from the intersection of the two forks of the Dinnebito to the possible storage site approximately four miles above the intersection. Irrigable land will lay on the south side of the east fork and be limited by the water which can be impounded. A drainage area of 20,000 acres will furnish maximum floods of 6,000 second feet and an annual expectancy of 500 to 600 acre feet. To obtain a dam of this capacity possibly $6,000 must be spent, $4,000 for the earth fill and $2,000 for the spillway. The canal must extend three to four miles and will need protection from flood waters to the south. Silt deposition in the storage reservoir may be critical and a careful estimate of this should be made by whoever determines the feasibility of the project. We recommend a survey be first made of the storage site to determine the amount of water which can be economically

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impounded. If this survey shows that storage costs will not be excessive a topographic survey should be made to locate the irrigable land and best canal alignment.

E. Upper Dinnebito. See Card #2. Should it be found impractical to construct the storage dam on the east fork of the Dinnebito there is a possibility of a diversion project at the intersection of the east fork and the main Dinnebito. This project was originally surveyed by C. Moyes and W. Mitchell who estimated the total cost of diversion without subjugation to be $9,500. 190 acres of land can be irrigated under the project. Since maximum floods of 8,000 second feet may be expected it is necessary to by pass most of the water and only divert a small amount of it to handle the irrigable land. A masonry diversion was planned when this estimate of $9,500 was made. The project was rejected since it was assumed that this expenditure would not be justified under these conditions.

During our study of Unit 4 in November, Mr. Wilbur Perkinson of the U. S. Indian Irrigation Service examined the diversion site and made an estimate of $7,000 to 7500 utilizing the beam on supports diversion. He made no detailed estimate but suggests that his figures of $7000 to 7500 would probably be divided as follows:

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Several cutoffs along the soft sandstone spillway	$ 500
Blasting sandstone to secure additional spillway	$ 700
Reinforced concrete weir (Beam on support type)	$4000
Sluice gate and structure	$ 700
Headgate	$ 100
Earth fill dyke along south head wall	$1000
	$7000

It is emphasized that only with very good supervision can the diversion be constructed at this figure. Weather conditions must be ideal and labor supervision excellent. Since labor costs are such a large part of all construction jobs it follows that 10% to 15% of the total cost can be saved when a close watch is kept over the labor crew.

F. Storage Dam and Irrigation Project on Wepo 2 1/2 miles East of Pinon.

Card 762. This project has been suggested by several persons and all had planned on locating the storage dam at the mouth of the Wepo about five miles from Pinon where the side ridges offered a possible site. This location was examined by W. Perkinson of the U.S. Indian Irrigation Service, C. Moyes and myself and we all rejected it for several reasons. Grade in

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The basin above is rather excessive for an impounding reservoir and an extremely high dam would be necessary to hold the water which would be needed. Excessive blasting would be needed for an adequate spillway and silt deposition would probably be very critical. The Wepo above this suggested site is very deep and banks are vertical and not at all stabilized. Silt would probably run from 15% - 30% during cloudbursts and for this reason it would be very problematical that a storage dam would be constructed at this location.

After rejecting this site we found a dry lake about two miles below on the east side of the Wepo and after a reconnaissance decided that a possible storage dam could be located here for the Irrigation Project. An eighteen foot to twenty foot fill would be needed at the lower end of the lake which should impound nearly 800 acre feet. Possibly a higher dam would be impractical to store 1100 to 1200 acre feet if it is estimated that sufficient water is usually available for this size dam.

Water from the Wepo would be diverted above the dry lake and desilted as it flowed down. Possibly a limited amount would be taken out with the balance spreading over the land on the west side of the Wepo. Part of this excess water on the west side of the diversion might be used for agricultural purposes with the rest for water spreading. No close cost estimate has been made of the project since we all feel a topographic

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survey is necessary. 200 to 300 acres of good land will be available below the storage dam with about this same amount extending between the dry lake and the diversion above. 500 to 600 acres is also available for spreading the excess water. Should the total cost not exceed $30,000 the project may be possible since with this amount of agricultural and water spreading land we may be able to justify the expenditure.

Should this project be unsound a very elaborate and extensive water spreading area will be contemplated here, see Card #63. The topographic survey should extend over all portions of this vicinity which may come under the Irrigation or water spreading project.

G. Storage Dam on Upper Polacca. See Card #66. A possible storage site exists on drainage 4.30 about 1 1/2 miles above its intersection with the main Polacca. No rock outcropping exists here and an earth diversion would be necessary. 175 to 225 acres of good land lies below the storage site which would necessitate nearly 1000 acre feet of water to handle this land. Silt deposition here is very critical and vertical eroding banks above will raise the silt content to an extreme point during large floods.

UNM 931

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_ plane table survey should first be made of the damsite to determine if water can economically be impounded; if this shows the project will be feasible the survey should be extended below to cover the irrigable land and to determine the best canal alignment. If it is found that this storage project is unsound a water spreading project will be planned below, see Card #66 which in itself should require a topographic survey. Water spreading project, #60, see card #67, below the intersection of drainage 4.30 and the Polacca also shall require a topographic survey and with W.S. 70 should be planned and worked as one Unit.

UNM 932

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X Cost Summary and Proposed Work Plan

From the agricultural report by E. A. Nicholson, the cost of farm developments will be $73,050. This represents bordering, leveling or terracing, small outlet structures, and is exclusive of diversion costs which are covered in this report. This total of $73,050 has been segregated as below:

	Acres	Cost per Acre	Total
Present Flood Irrigated Land	1,536	$15.70	$24,130
Potential Flood Irrigated Land	2,925	$16.72	$48,920
Total	4,461	$16.39	$73,050

UNM 933

From the index with this engineering report these estimates have been taken:

SUMMARY

ENGINEERING ESTIMATES

	Acres Benefited	Cost Chg. To Erosion Control	Cost Chg. To Water Spreading	Cost Chg. To Farm Diversions	Total estimated Cost	Estimated Cost Per Acre
Erosion Control Projects	809,975	$184,365	$49,300		$233,665	.29
Special Erosion Control Projects	21,442	$ 19,710			$ 19,710	.92
Diversions to Farms	441			$9598	$ 9,598	$21.80
Total of Engineering Estimates					$262,973	

COST SUMMARY OF ENGINEERING, AGRICULTURAL, ROAD PROTECTION, AND PROPOSED IRRIGATION PROJECTS

Engineering	$262,973
Agricultural Subjugation	73,050
Road Protection	9,245
Proposed Irrigation Projects (E.F.C.)	50,000 *
	$395,268

* This estimate may be 50% off, depending on the feasibility of these irrigation projects which will be determined after topographic surveys are made.

UNM 934

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Proposed Work Plan

Special Erosion Control Projects, Road Protection, and headcuttings, included in the Erosion Control Projects can all be classified as work which should be done as soon as possible. This total cost will be around $35,000, segregated into $9245 for road protection, $19,710 for the Special Erosion Control Projects, and the balance allowed for head protections and dikes at the better spreading areas.

As shown in the Index, most all of the large Erosion Control Projects cannot be said to need immediate treatments over the entire project. Only head cuttings and better spreading grounds, as explained above should be now treated with the balance left until two to four years of range management allows a recovery in vegetation. It is very imperative that this be done, for with a large density and volume increase after several years of stock control, all water spreading will be proportionally more effective and danger from gullying at the lower end of the spreading grounds will be materially decreased.

Agricultural development as covered in the report by E. A. Nicholson, can be planned as a long time program with some farms to be treated at once and with treatment on the balance to be left for a later date. This work can be planned to extend over any arbitrary number of years; possibly a six, eight, or ten year program might be best.

UNM 935

CV-6417-201 NN005972

Plane table surveys have been recommended on several water spreading projects, on three irrigation projects and on a number of the large farm developments. An immediate survey is suggested on the project 2½ miles east of Pinon, see Card #62, with later surveys on the other irrigation and water spreading projects. The topographic surveys on the farm developments can wait until these others are completed.

OUTLINE OF PROPOSED WORK PLAN

A. Immediate Treatment on Head Cuttings and those Special Erosion Projects where the needs of the land the the people are the greatest.

B. Secondary Treatment on balance of Special Erosion Control Projects with those utilizing spreading ground to be left until several years of range management allows a recovery in the vegetation.

C. Immediate Treatment on Erosion Control Projects at Heads and where vegetation on spreading ground is of sufficient volume and density to handle the water expected.

D. Balance of Erosion Control Projects to be treated after two to four years of stock control allows sufficient vegetative recovery on spreading grounds.

E. Gradual development of farm lands to meet the needs of the inhabitants.

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F. Careful topographic surveys to be made of proposed irrigation projects and full utilization and careful maintenance of those projects completed and those to be constructed.

G. A planned maintenance program to be carried on in conjunction with annual checks of new erosion developments and a careful watch to be made of range recovery and gully healing as affecting those projects suggested in this report or any new projects which may develop.

H. Immediate erosion protection along roads and a sound policy of road construction with carefully planned drainage structures and erosion protection features.

XI Index and Maps

The index should be self-explanatory, all projects having been given a separate card with each card numbered. On the large 1" to the mile prints the projects are outlined in red pencil with their numbers and card numbers included. Locations of the smaller Special Erosion Control Projects or the Farm Developments can be found by taking the coordinates from the respective card and scaling the proper distance from the northwest corner of the quadrangle. The 1/4" to the mile map gives this same data with the outlines sketched in black ink. Included also is a reconnaissance map made by the Geological Service a number of years ago with contour intervals of 200 feet and a scale of 4 miles to the inch.

UNM 937

CV-6417-201 NN005974

All of the other departments have given their full cooperation in both the field and office toward the preparation of this report. Particular credit is due the agronomy and range divisions for their help in choosing the various projects outlined. Field work was done by C. Moyes and Stamm with the estimates prepared by both. Part 1, General Description of the Unit was taken for the most part from that written by J. Deppa for the integrated report.

UNM 938

NN005975

CV-6417-201

UNM 939

Erosion Control and Water Spreading Projects

Card No.	Quad No.	Project No.	Acres	Cost Per Acre	Estimated Cost Erosion Control	Estimated Cost water spreading	Priority	Description Project
8	104	1	2,000	32½	$650		Immediate	Small structures to check gully heads and Lower silt carried into BCW Reservoir.
9	104	2	1,000	40¢	$400		Heads immediate balance after R.C.*	Dykes and spreader fences as gully head protections.
10	104	3	2,200	25¢	$550		" " "	Protect small gullies and check incipient gully heads.
11	104	4	40,000	40¢	$12000	$4000	" " "	Treatment above M-56 dykes and diversions around heads.
12	104	5	38,000	21¢	$6000	$2000	" " "	Treatment small heads and shallower gullies Ground for spreading limited.
13	104	6	38,000	26.3¢	$7500	$2500	" " "	This is Black Mountain Country. S.G. is fairly ample. Most treatment small structure.
24	8	1	54,000	29.6¢	$12000	$4000	" " "	Diversion of smaller gullies most of structures will be earth dykes and wire spreaders
25	8	2	20,000	22½¢	$4000	$ 500	" " "	Spreading ground limited. Most of treatment small checks and drops.
28	9	1	90,000	20¢	$14000	$4000	" " "	Black Mountain Country. Most treatment in Valleys and side drainages. Small structures
32	97	1	58,000	15½¢	$9000		Secondary	Small widely scattered jobs on mesa top.
33	97	2	35,000	30¢	$10500		Heads-immediate balance after R.C.	Treatment at side drainages to Dinnebito Wash. Protection Irrigation Project.
36	98	1	20,000	20¢	$4000		Secondary	Small spreaders, dykes, checks to be constructed on mesa top and gentler slopes.
40	10	1	46,000	45.6¢	$21000		Heads-immediate balance after R.C.	Dyke gullies as high as possible on the small drainages. Check gully erosion.

S.G. - Spreading Ground
W.S. - Waterspreading
R.C. - Range Control

32

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NN005976

Erosion Control and Water Spreading Projects

Card No.	Quad No.	Project No.	Acres	Cost Per Acres	Estimated Cost Erosion Control	Estimated Cost water spreading	Priority	Description Project
41	10	2	18,000	30¢	$ 4000	$14000	Needs immediate balance after R.C.	Some work diverting water to farms along Big Wepo. S.G. available most side gullies
42	10	3	31,000	22.4¢	$ 6000	$ 2500	" " "	S.G. is ample along most of the side drainages. Gullies are shallow and can be handled
43	10	4	22,000	35¢	$ 5700	$ 2000	" " "	Same type treatment as card 42. Begin treatment high on drainage and work down.
44	10	5	48,000	37½¢	$13000	$ 5000	" " "	Most work concentrated at Hard Rocks Dipping Vat. Side drainages to be well worked.
54	11	2	1,000	33¢	$ 330		Secondary	Dyke above gully heads to divert and spread water.
55	11	3	22,000	25¢	$ 4000	$ 1500	Needs immediate balance after R.C.	Most of side drainages are fanning and treatment will prevent concentration of water.
56	11	4	36,500	40¢	$10000	$ 4000	" " "	Spread east drainage on flat above main wash. Do not divert two main washes.
57	11	5	22,700	31¢	$ 5500	$ 1500	" " "	No chance to spreading main wash. Side drainages can be spread on farm in places.
58	11	6	15,700	20.4¢	$ 2500	$ 700	Immediate	Main gully too deep for any diversion. Most money spent on lower part project.
59	11	7	15,000	50¢	$ 5000	$ 2500	Needs immediate balance after R.C.	Will need rather extensive treatment spreading ground is abundant and plenty of water.
04	12	1	35,000	28.7¢	$ 7000	$ 2000	" " "	Earth dams and dykes across side gullies Number farms can be benefited by dykes and spreaders.

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NN005977

Erosion Control and Water Spreading Projects

Card No.	Quad No.	Project No.	Acres	Cost Per Acre	Estimated Cost Erosion Control	Estimated Cost Water spreading	Priority	Description Project
65	12	2	12,000	.33¢	$ 2500	$ 1500	Secondary	Only treat main wash of head. Some side washes dam. Those don't divert and spread.
66	12	W.S. 71	125	$8.00		$ 1000	Only if storage site impractical	Make a plane table survey of proposed dam site and irrigible land. If impossible then this.
67	12	W.S. 60	750	$1.78	$ 235	$ 1100	Secondary	Make a plane table survey to determine proper location dykes and shunts.
69	13	1	40,000	.20¢	$ 6000	$ 2000	Heads immediate balance after R.C.	Small dykes and dams as spreaders on site washes. No spreading ground lower reaches.
72	56	1	46,000	30.4¢	$11000	$ 3000	" " "	Large arroyos can not be touched and work must be confined to side slopes and small S.C.

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NN005978

Special Erosion Control Projects

Card No.	Quad. No.	Project No.	Acres	Cost Per Acre	Total Estimated Cost	Priority	Feasibility	Description Project
3	104	13	Grass-1160 Farm 50		$1746	Secondary	A	Dykes and spreaders across several small gullies as water spreading project. See Card #1, #2.
4	104	1	100	$1.87	$ 187	Secondary	B	Dyke to divert and spread water from an active gully.
5	104	2	450	$1.61	$ 722	to be done start at once		Dyke to spread water from two active gully heads.
6	104	3	300	.50	$ 150	Immediate	A	Dyke to spread water around large gully head.
7	104	4	2,000	.50	$1000	Immediate Treatment Imperative	A	Treatment by small structures to desilt water flowing into L-36.
15	8	28	500	.50	$ 250	Secondary		Water diverted from small gullies and spread onto range land.
16	8	1	250	.44	$ 110	Secondary		To check head cutting at gully.
17	8	2	700	.45	$ 315	Secondary		Earth dykes above head cutting on drainage 3.49
18	8	3	300	.20	$ 60	Immediate	A	Gully progressing [illegible] 300 acre valley. Entire Project worked as one Unit.
19	8	4	20	$1.80	$ 36	Secondary	B	Too check small head cutting. Job unimportant unless crew in this vicinity.
20	8	5	1,480	.50	$ 740	Secondary		To spread water from an actively cutting gully.
21	8	6	150	.54	$ 81	Secondary		Rock sausage drop in an actively cutting gully head.

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CV-6417-201

NN00059

Special Erosion Control Projects

Card No.	Quad No.	Project No.	Acres	Cost Per Acre	Total Estimated Cost	Priority	Feasibility	Description Project
22	8	7	10		$ 586	Secondary	B	Repair an old Indian stock tank as an erosion control measure.
23	8	8	300	.66	$ 198	Immediate		Drop in a large gully head which is progressing up a 300 acre valley.
29	9	1	300	.50	$ 150	Secondary	B	Increase storage capacity and provide spillway for an old Indian stock tank.
31	97	1	400	$1.10	$ 440	Immediate		Repair of stock tank as an erosion control measure and for stock water benefit K-04.
37	10	1	7,500	.60	$4500	Secondary		Spread gullies on smaller drainages and particularly where they will benefit farm land.
38	10	2	700	.45	$ 315	Secondary		Dyke from an active gully to a sandstone spillway.
39	10	3	12	$39.10	$ 470	Immediate		Dyke below farm to cut off a gully head.
49	11	1	600	$1.24	$ 745	Immediate		To protect gully heads below reservoir and to direct water into reservoir.
50 51	11	2 3			$2115	Immediate	"B"	Several deep heads 1 1/2 miles apart. Lower one should be constructed first. Investigate first.
52	11	4	400	$2.45	$ 980	Secondary	"B"	A headcutting into valuable grass land. Spillway 22' x 5 1/2' and dyke as auxilary spillway.
53	11	5	225	$1.93	$ 435	Immediate		Repair of tank K-44 and spread water to the east.

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CV-6417-201

NN005980

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Special Erosion Control Projects

Card No.	Quad. No.	Project No.	Acres	Cost Per Acre	Total Estimated Cost	Priority	Feasibility	Description Project
68	96	1	750	.99	$ 740	Immediate	A	An earth dyke connecting with a rock and wire drop in a gully 8 ft. deep. Also protect 10 acre farm.
71	13	1	2,200	.63	$1390	Secondary	B	$620 to be spent on a water spreading dam. Balance $770 as erosion control measure.

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CV-6417-201

NN005981

Farm Developments and Head Protections

Card No.	Quad. No.	Farm No.	Acres Benefited Diversion	Estimated Cost Diversion	Acres to be subjugated	Estimated Cost Subjugation	Total areas benefited erosion control	Estimated Cost Erosion control	Feasibility	Description Project
14	104	6	10	$ 200						
15	8		50	$1150						Water to be diverted from small gullies and spread over farm land.
18	8	19	12	$ 310		$ 300	300		A	Gully progressing up 300 acre valley and threatening 12 acre farm.
26	8	8	20	$ 200						
27	8	21	3	$ 100						
30	95	3	50	$ 110						Farm is on sandy fan, 1,000 feet spreader all that is needed.
34	97	7			30	$ 600	225	$ 700		Dyke around a gully head below a farm # 7 to spread water on adjacent rangeland
35	97	6	25	$ 500						
45	10	48 50	60	$1200	73	$1221				We recommend a topographic survey to determine best method of diversion.
46	10	53 54 56 57	60	$2500	112	$1935				We recommend a topographic survey to determine best method of diversion.
47	10	71	8	$ 90						
48	10	75	30	$ 300						

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NN005982

Farm Developments and Head Protections

Card No.	Quad. No.	Farm No.	Acres Benefited Diversion	Estimated Cost Diversion	Acres to be sub-jugated	Estimated Cost Sub-jugation	Total areas benefited erosion control	Estimated cost erosion control	Feasibility	Description Project
60	11	27 28	28	$ 398	28	$ 508				Strengthen and raise diversion above farms and dyke along side wash below diversion.
61	11	18	15	$ 450						
70	13	51					60	$ 480	A	Head protection farm #51 Spillway will bypass 300 sf. and balance spread over range land.
73	56	13	70	$2100	70	$1050				Plenty water available and soil good. We recommend a plane table survey here.

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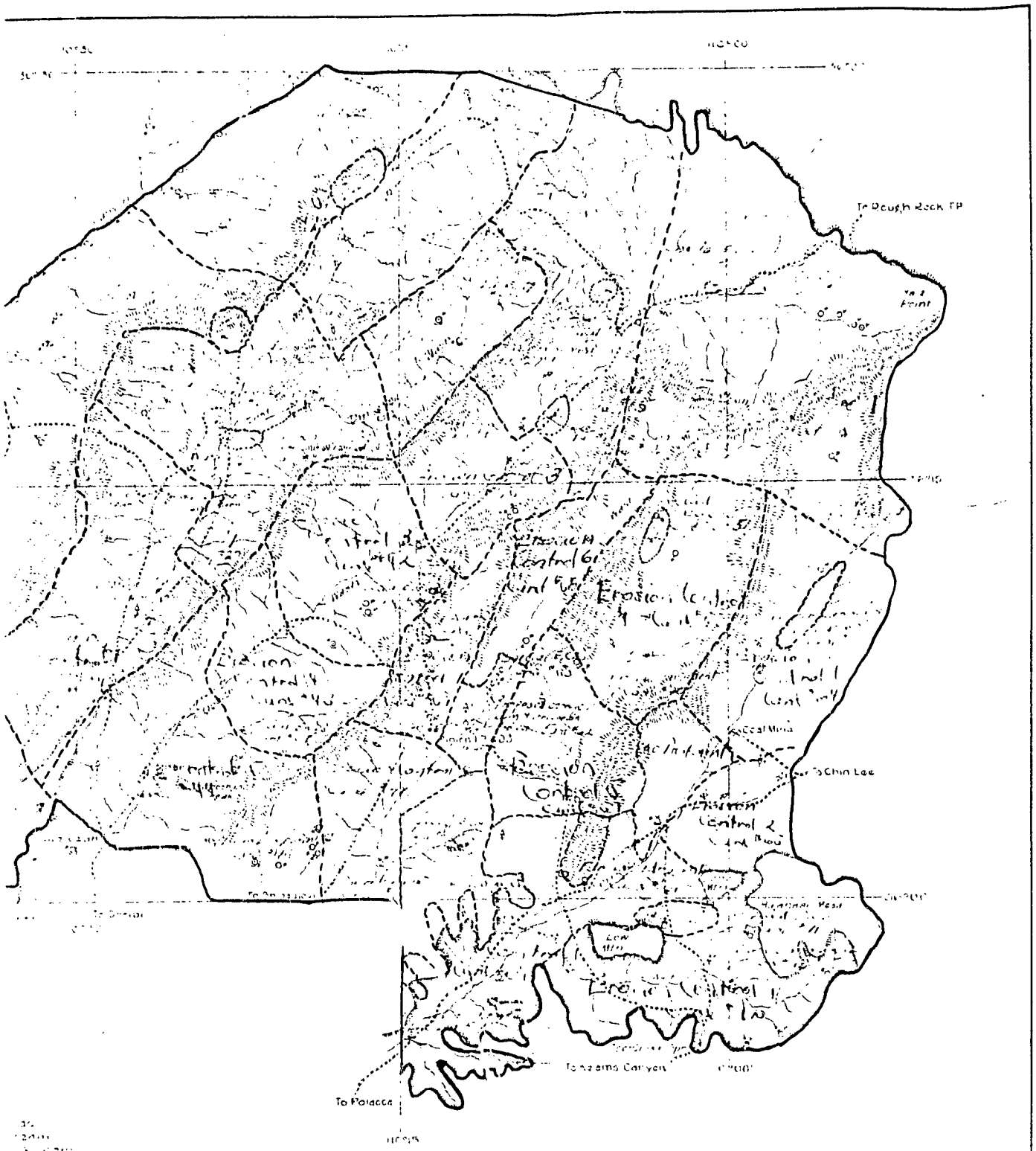
CV-6417-201

NN005983



Engineering Report

UNM 947

UNIT-4			
NAVAJO DISTRICT			
DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE H.H. BENNETT DIRECTOR			
REFERENCE			
SUBMITTED		APPROVED	
COMPILED	TRACED	CHECKED DATE	R-477
Range	J.Williams	1014-36	

Scale ¼"=1 Mile 0 1 2 3 4

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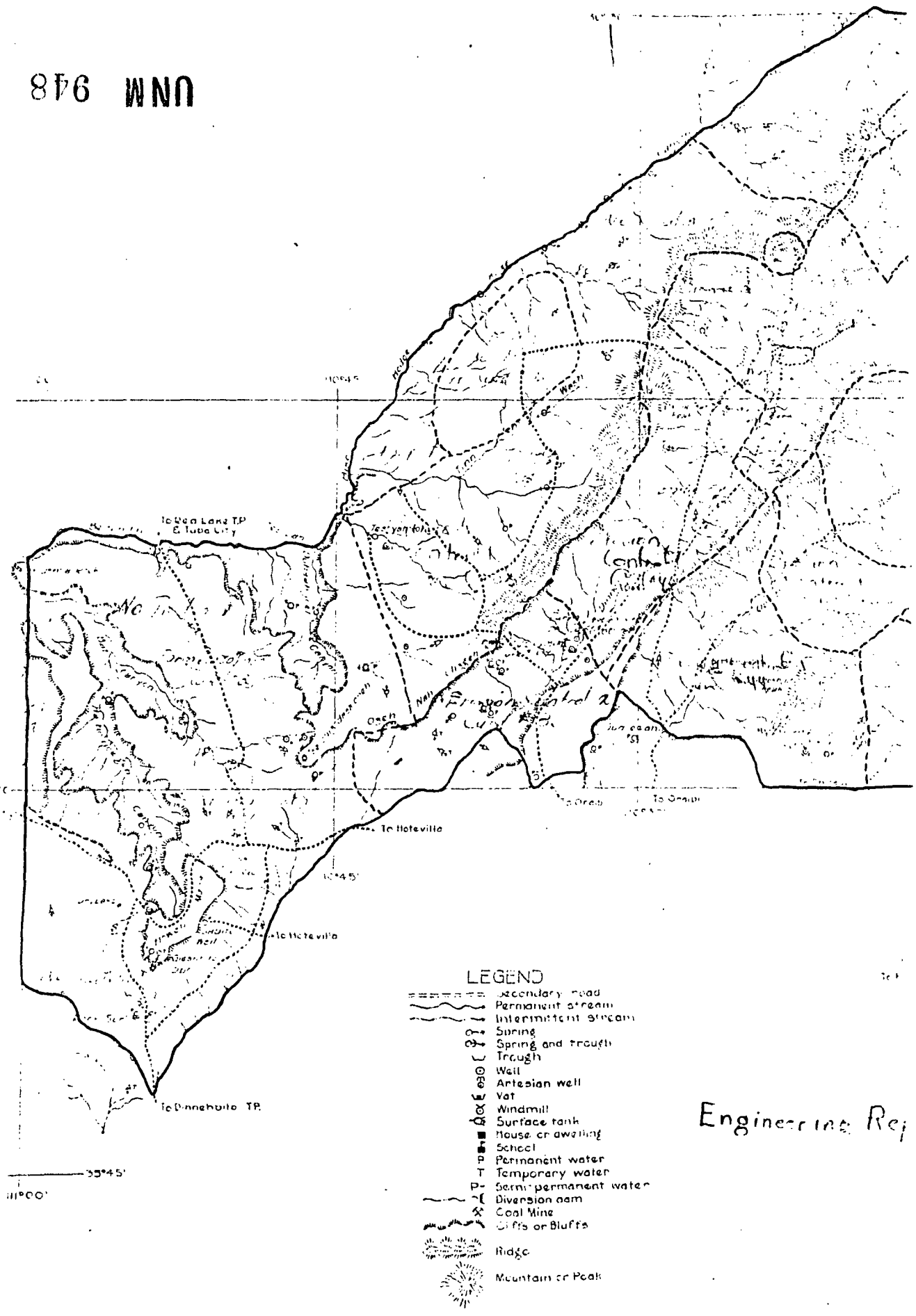
Inside
Front

UNM 948



Engineering Rep

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