WORK REPORT

RECONNAISSANCE CONSERVATION SURVEY

LAND MANAGEMENT UNIT NO. I

NAVAJO PROJECT

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INTRODUCTION.

Land Management Unit 1 is an irregular area located in Coconino County, Arizona, in the northwest portion of the Navajo Reservation. It is approximately 60 miles long and varies from about 20 to 40 miles in width. The boundary coincides with natural physiographic features, such as Echo Cliffs, the Colorado River, Crooked Ridge, the north point of Preston Mesa, the north point of Little White Mesa, the Begashibito Wash, Blue Canyon Wash, a portion of the drainage divide of Black Mountain and its north slope, and the west rim of Navajo Canyon.

The Unit embraces approximately 1,618 square miles, or 1,035,540 acres. The survey was started April 5, 1937, and completed May 1, 1937.

Roads, Schools, Hospitals, etc.

The Tuba City-Kayenta road, which traverses the southeastern portion of the Unit, is the only road maintained the year round. A bladed road extends from Red Lake to Kaibito and Inscription House. All of the Unit except a small area in the extreme north is accessible by automobile.

The only day school located within the Unit is at Kaibito. The nearest hospital is at Tuba City, 50 miles south of Kaibito, in Unit 3.

Population and Economic Factors

There are at present 1176 Navajos living within the Unit, representing 157 consumption groups. These people gain their livelihood principally from livestock production but income is also derived from wage work, agricultural products, handmade rugs and jewelry. At present there are 0.69 acres per capita being farmed. This can be increased to 0.96

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acres by the subjugation of proposed potential land. Population concentrations are few and small. The principal centers are located near Red Lake, Cow Springs and Kaibito.

Topography and Drainage

Land Management Unit No. 1 occupies the Kaibito Plateau, a slightly dissected plateau on strong sandstone surmounted by mesas. The topographic expression of the Unit is generally that of huge domes and rounded masses to almost sheer cliffs of mesas rising from surrounding broad, smooth, gently sloping or rolling uplands and valleys. The typical surface is hummocky from wind erosion.

The main physiographic features of the Unit are: Echo Cliffs in the western portion; Mormon Ridges in the central portion; Antelope Canyon, Glen Canyon and the Colorado River in the northern portion; Kaibito Canyon and Navajo Canyon in the northeast portion; White Mesa in the eastern portion; Black Mountain, Blue Canyon, Preston Mesa and Wild Cat Peak in the southern portion.

Range types of vegetation predominate with intermittent stands of woodland types.

The Unit is well drained. Kaibito Wash and Antelope Wash drain the Unit to the north into the Colorado River. The southeast portions of the Unit drain into Red Lake or the Moenkopi Wash via the Shonto and Begashibito washes. The steep terrain on the west slopes of Black Mountain and the east slopes of White Mesa are conducive to rapid runoff and have produced a higher degree of erosion on both the slopes and the alluvial fans below. The western portion of the Unit is drained by small intermittent drainages. The permeable sandy soils which prevail over the greater part of the Unit make runoff very low and moisture penetration rapid.

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Climate

Elevations in the Unit vary from approximately 5600 feet at the Kaibito Trading Post in the east-central portion to 6500 feet on the top of White Mesa in the southeast portion.

No climatological data within the Unit were available, but data from three stations within a short distance show that the average annual precipitation varies from 6.80 to 9.07 inches. Temperature records at these stations show a variation in the mean annual temperature of 52.2 to 61.5 degrees. The maximum is 109° and the minimum +2°F.

The average length of the growing season in the Unit has not been recorded, but records at the same stations show a variation between 169 and 231 days.

Temperature

Temperature records were available from only two stations near the Unit, Tuba City and Lee's Ferry. Records were taken from Kayenta and Grand Canyon for comparative value.

Table I TEMPERATURE RANGE

Year	Station	Temperature Range Maximum	Minimum	Average
1935	Tuba City	104°	+3°	55.9°
1935	Lee's Ferry	109°	+13°	61.5°
1935	Kayenta	100°	+2°	52.2°
1935	Grand Canyon	91°	-6°	49°

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Southwest winds prevail in the area. A wind station at Lee's Ferry, immediately outside the Unit boundary, recorded an average annual wind movement of 2.11 miles per hour. Records from the same station give the annual average rate of evaporation as 88.95 inches.

Rainfall - Following is the record observed at Tuba City over a 29-year period:

Table II — Minimum, Maximum and Average Monthly Precipitation - Tuba City, Arizona.

Month	Driest Year 1924	Wettest Year 1906	Average
December	.82 inches	2.32 inches	.58 inches
January	.16 "	.53 "	.55 "
February	.00 "	.34 "	.54 "
March	.12 "	1.59 "	.54 "
April	.09 "	.19 "	.43 "
May	.02 "	.34 "	.53 "
June	.00 "	.00 "	.19 "
July	.00 "	1.73 "	.34 "
August	.10 "	1.26 "	.93 "
September	.14 "	1.37 "	.84 "
October	.13 "	.27 "	.68 "
November	.00 "	2.92 "	.78 "
Totals	1.58 "	12.57 "	6.92 "

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Table III

Evaporation in Inches and Wind Movement in Miles per Hour.

			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Ann. Prec.
	Oct. 1921	Evap.	1.69	3.11	5.70	7.93	11.86	13.64	13.78	11.27	8.97	6.15	2.94	1.91	88.95	6.80
's Ferry	Dec. 1928	*WM	1.36	1.80	2.76	2.70	2.72	2.49	2.18	1.95	1.83	1.73	1.47	2.29	2.11	

*WM = Wind Movement in Miles per Hour

Table III-A

Average Annual Evaporation in Inches (1921 - 1930)

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Annual
s's Ferry	2.076	3.088	5.773	7.967	11.594	12.773	13.359	1[illegible].083	8.917	6.112	2.945	1.928	87.615

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Table IV — Normal Monthly and Annual Precipitation

	Elev.	Length Record yrs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kayenta	5800	12	.74	.46	.69	.39	.33	.44	1.44	1.46	.68	.98	.64	.82	9.07
Lee's Ferry	3143	8	.37	.58	.41	.70	.26	.7	.74	1.07	.67	.69	.63	.51	6.80
Tuba City	4500	26	.53	.55	.43	.54	.18	.36	.94	.81	.69	.77	.52	.62	6.94

Table V — Dates of Killing Frost in Spring and Autumn and Length of Growing Season

	Length of Record	Av. Date Last Killing Frost In Spring	Av. Date First Killing Frost In Autumn	Latest Date Killing Frost In Spring	Earliest Date Killing Frost In Autumn	Ave. Length Growing Season
Kayenta	12 yrs.	April 27	October 13	May 23	September 21	169 days
Lee's Ferry	5 "	March 21	November 7	April 9	October 26	231 "
Tuba City	24 "	April 23	October 19	May 9	September 19	179 "

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Agriculture

The soils of Unit 1 are adapted primarily to grazing. Farm land occupies a minor portion of the Unit, and is confined to favorably located alluvial soils. Prior to 1933, agriculture was limited to small restricted flood-irrigated gully fans and to some dry farming. In 1933 the United States Indian Irrigation Service constructed an outlet from a natural storage lake southwest of Cow Springs to irrigate approximately 350 acres of potential farm land below. However, only 20 acres were subjugated at the time.

Farm land is now concentrated at Cow Springs and Red Lake. Scattered flood-irrigated farms are located on numerous small gully fans. The practice of farming these tracts for a few years and then moving to others has materially aggravated an already severely wind-eroded condition of the farm lands.

Approximately 75 acres were dry farmed at one time, but the climate is so unfavorable that the present acreage is negligible.

Cultural Practices

"The farming methods of the people within the Unit are mostly primitive with very few modern improvements. Most of the Navajos own hand plows and the horse-drawn blade which is used for weeding and cultivating, but other farm machinery is lacking. Corn, which is the principal crop grown, is planted and harvested by hand. Other crops are likewise produced principally by hand labor.

*Agronomy Branch Report L.M.U. #1.

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"On the irrigated land, the border method is used for irrigation and each owner irrigates his field according to his turn. On the flood-irrigated farms, the water usually is allowed to take its own course due primarily to the variations in the size of the flow of the gullies. Some of the owners are trying to check the small head erosions which endanger their farms, but when it becomes very serious, the field is abandoned. Practically no effort is made to check the serious wind erosion which affects all the farms within this unit."

Suggested Improvements

Suggested improvements include: (1) bordering and spreading water more effectively on flood-irrigated farms, in order to protect valuable soil; (2) abandonment of some of the non-irrigated farms in order to effect stabilization of areas now subject to severe wind erosion; (3) increasing the storage facilities at the Cow Springs reservoir to increase the present farm acreage; and (4) controlling flood waters at Red Lake to check excessive flooding and silting of the present farm land.

EROSION

Strong southwest winds, low rainfall and light soils, in conjunction with moderate to severe over-utilization of the vegetative cover, are responsible for the predominance of wind erosion in this Unit. Wind erosion is most severe on the light-textured soils of the Kayenta and Todilto series. Partially stabilized sand dunes, ranging in depth from 36 inches to several feet, are common west of Kaibito. Small active sand dunes are sparsely distributed throughout the Unit, but are more frequent in the

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south and southeast portions.

Extensive areas of barren sandstone dissected by deep canyons are common to the north portions of the Unit. A shallow, severely wind-blown, intermittent soil cover, spotted with accumulations of active dune sand and with inadequate vegetative cover, occupies the northwest portion.

Heavy impervious Hunt clays and clay loams northeast of Kaibito are affected by sheet erosion.

Sheet and gully erosion are common on the steep slopes of Black Mountain and White Mesa. The extreme southeast portion of Black Mountain, because of severe sheet erosion and steep slopes, consists of almost barren geologic material with an intermittent shallow soil cover composed principally of soils of the Floy and related series.

Recommendations for Erosion Control

Soils of the Unit are typically loose, coarse-textured, highly permeable, and have a moderately high water-holding capacity. Their susceptibility to wind erosion reduces their productive value. Insofar as low annual rainfall will permit, these soils will respond readily to a range-management program. Recovery of a normal soil and vegetative cover will naturally be slow on the severely wind-modified areas. Critically eroded areas, discussed in detail elsewhere, will warrant restriction of livestock or a deferred grazing program.

Mechanical treatment of alluvial valleys along Black Mountain and White Mesa, and immediate control of gully heads which are endangering range land east of Kaibito, are recommended. Gully heads invading valuable farm land south of Kaibito and in the vicinity of Cow Springs

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and Red Lake should also be treated if practical from an engineering standpoint.

Improved road-maintenance practices are needed on all main roads in this Unit.

Range Utilization

The present inadequate supply of stock water handicaps any range-management program on Unit No. 1. The present permanent water supply has divided the Unit into two general areas from a range-utilization standpoint. Adequate stock water and concentration of agriculture in the southern, central and eastern portions of the Unit have subjected range resources to severe overutilization and have exposed the soil to severe wind erosion. Enforced seasonal use in the north and west portions of the area because of lack of permanent stock water has resulted in proper range utilization and maintenance of vegetative cover on otherwise erosive soils.

Development and distribution of stock water to facilitate proper distribution of livestock should result in conservative utilization of all forage resources and insure an adequate vegetative cover.

Artificial Revegetation

Low annual precipitation limits possibilities for revegetation in Unit 1. Protection of Cow Springs reservoir from encroaching active sand dunes warrants an investigation of soil conditions in relation to planting possibilities. Adequate moisture will allow intensive tree planting in the Kaibito Wash to prevent further gullying and bank cutting.

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Due consideration must be given vegetative adaptation to soil conditions and other environmental features in all planting sites to insure satisfactory results from artificial plantings.

Artificial Structures

The need for artificial structures is confined largely to the Red Lake-Cow Springs area. Detention structures are important in the program of soil and water conservation here. Flood-control structures to stabilize valuable farm land are being considered at Red Lake, and a structure to increase the storage facilities at Cow Springs is contemplated. However, justifiable cost based on increased returns from improved agricultural land will limit the extent of these operations.

Specific adaptations of the soils for construction purposes is discussed under Soil Groups.

SOILS*

The soils of this Unit have been systematically classified according to origin, profile characteristics and surface texture. They have been further classified according to land use, slope, erosion and potential adaptability to proper range and agricultural practices. The soils have been separated into 14 series and 30 types, exclusive of rough broken and rough stony lands, and riverwash and gravels.

The majority of the soils of the Unit originate directly or indirectly from sandstone and are highly susceptible to wind erosion when the vegetative cover has been partially or wholly destroyed.

*All soil series names contained in this report are tentative, pending correlation by the Interbureau Correlation Committee.

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"Practically all the district is included in the Kaibito Plateau physiographic sub-province. The geological formations present are confined entirely to the Jurassic and Cretaceous eras, and include the Navajo sandstone, Carmel, Entrada and Morrison formations of the Jurassic age, and the Dakota, Mancos and Mesaverde formations of the Cretaceous age. The dominant formation is the Navajo sandstone, which covers as much area as all other formations in the Unit."*

The soils in the western half of the Unit are derived from the grayish white Navajo sandstone, from the dark red Carmel formation in the north, in the east from the red Entrada formation, and in the south and east from scattered areas of the brown to buff Dakota sandstone and the dark bluish gray Mancos shale. A better developed soil, Buell clay loam, less affected by wind, is derived from the Carmel sandstone. Soil developed from Mancos shale on Black Mountain is heavier-textured and more severely affected by water erosion.

Residual soils occupy the greater portion of the area and constitute the better classes of grazing land. The Floy, Todilto, Buell and Kaibito series are the most important of the six residual soil series mapped. Of the eight series of alluvial soils mapped, the light, medium-textured types of the Ives, Oraibi, Dinnehotso and Concho series are the only ones cultivated.

GRAZING LAND CLASSIFICATION OF SOILS

In the following discussion the soils have been classified into

*Geological Report, Land Management Unit #1 - T.L.Meeks, 1937.

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five groups on the basis of range adaptation. Their location is shown on the maps accompanying this report.

Soil moisture is undoubtedly the most important factor limiting the density and growth of native vegetation in the Unit. Soils vary greatly in their capacity to absorb and hold moisture for plant growth. Factors influencing soil moisture and plant growth are slope, erosion, permeability and water-holding capacity of the surface soil and subsoil, and the concentration of water-soluble salts.

A large portion of the soils of the Unit are coarse-textured and readily permeable, making maximum use of rainfall in the production of native vegetation if the soil profile is not permeable to too great a depth; however, low annual rainfall and the loose structure reduce their range value because of susceptibility to wind erosion.

Erosion will materially reduce the productive capacity of some soil types, but will not materially damage others; therefore, several soil-erosion classes may occur within the same group. For example, Kayenta loamy sand, a deep permeable soil, allows water to percolate below normal grass-root systems; consequently, native vegetation consists of a sparse browse of relatively poor quality and conducive to a higher degree of wind erosion. However, because of its uniform profile, it will not be damaged to the same degree as would a shallower soil or one with an impervious subsoil, and recovery will be relatively rapid.

GROUP A SOILS

Group A includes soils which are regarded as excellent from the

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standpoint of their potential range capacity and which will under a good range-management program most rapidly and completely control erosion.

In Unit 1, Group A soils have the following limitations:

Slope - 0-3%.

Erosion - Class 1 or 2 sheet erosion, P wind removals, K accumulations.

Alkali - Less than .2 of 1%.

Drainage - Good.

Soil - Permeable surface soil, good water-holding capacity.

Portions of the following soil types comprise the A Group range soils:

Residual	Alluvial
Floy loamy sand	Kayenta sandy loam
Buell sandy loam	Kayenta clay loam
	Bonito sandy loam

Moisture Penetration (No data available)

Field observations indicate that these soils have a high rate of moisture penetration. Water penetration on the Floy loamy sand and Kayenta sandy loam is limited largely by the available moisture.

Water-holding Capacity

With the exception of the Floy loamy sand, with a relatively low water-holding capacity, all Group A soils have a medium high water-holding capacity.

Vegetative Adaptation

The present vegetative cover consists of blue grama, galleta, spiny muhly, and browses including sand sage, chamise and Mormon tea. Native vegetation at present is sufficient to protect from erosion the light sandy soils upon which it grows.

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Value of Soils for Construction Purposes

Field observations indicate that the medium to moderately light soils of the sandy loam and clay loam types are very good for construction purposes. The loamy sands can be used only if proper precautions, such as lining and cut-off walls, are taken.

Erosion

Erosion is slight on Group A soils. Buell sandy loam is not so susceptible to wind erosion as Floy loamy sand. Both have at present an excellent vegetative cover and a good range-management program will fully protect them from wind and water erosion.

Low annual rainfall on the highly permeable soils of this group results in a low percentage of runoff; consequently, sheet and gully erosion are negligible.

Improvement Program Feasible from a Soils Standpoint

A few isolated gullies may warrant mechanical treatment. (See erosion map.)

Group A soils are readily adapted to water spreading. Kayenta sandy loam, Kayenta clay loam and Bonito sandy loam in the Red Lake-Cow Springs area are especially adapted to such treatment. Insufficient water will limit the usable acreage.

Destruction of native vegetation under present grazing practices is rendering these soils unstable. Proper stocking, proper seasonal use and rodent control will protect these soils and their cover.

GROUP B SOILS

Group B grazing land soils have the following limitations:

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Slope - 3% - 10%.

Erosion - Class 3 sheet, occasional small gullies, P to S wind removal, depending upon the soil depth, L accumulation.

Alkali - .2 to .3 of 1% slight carbonates.

Drainage - Relatively good, high water table harmful if alkali present.

Soils - Moderately permeable; moderate water-holding capacity.

Portions of the following soil types are included:

Residual	Alluvial
Todilto loamy sand	Dinnehotso sandy loam
Todilto sandy loam	Hunt sandy loam
Floy loamy sand	Hunt clay loam
Buell loamy sand	Bonito loamy sand
Buell sandy loam	Tolani loamy sand
Kaibito loamy sand	Kayenta clay

Moisture Penetration (No data available)

The majority of the soils in Group B are coarse-textured and moisture penetration is limited by the depth to parent material and the available moisture supply. Hunt clay loam has a moderately permeable surface soil. Kayenta clay has a shallow, permeable granular mulch-like surface soil and is slowly permeable. Other portions of Kayenta clay show evidence of being dispersed. Even the hummocks are more or less impervious.

Water-holding Capacity (No data available.

Deep uniform profiles of the sandy types have a relatively low water-holding capacity. Low annual precipitation and a high rate of evaporation contribute to a low moisture content of these soils. Kayenta clay has a good water-holding capacity, but has a relatively high water table in the vicinity of Red Lake.

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Vegetative Adaptation

Good stands of blue grama, spiny muhly and needle-and-thread grasses occur on sandy soils in Group B. Mormon tea partially stabilizes hummocky areas. Sand sage is common to the wind-modified Floy loamy sands of this group. Galleta and yellow brush predominate on the heavier Hunt soils. All types on the steeper slopes support a growth of mixed grasses.

Value of Soils for Construction Purposes

In general, Group B soils have the same value for construction purposes as those of Group A. Kayenta Clay, with a high clay content, high alkali concentrations and dispersed physical structure, is unsuited for construction purposes. It should be used only if extraordinary precautions are taken to prevent structural failures.

Erosion

Over-utilization, light soils and strong southwest winds combine to make the greater soil area of Group B susceptible to damaging erosion.

Head erosion is prevalent on portions of the group, particularly on Hunt clay loam and Kayenta clay. Control measures have been attempted with some success on Kayenta clay near Red Lake.

The density of heavier alluvial soils has in itself partially stabilized gullies.

Improvement Program Feasible from a Soils Standpoint

Areas of Group B soils showing no appreciable accelerated erosion at present are seriously menaced by the increase in rodent concentrations. Critical areas warrant immediate treatment to prevent accelerated runoff and consequent increase of erosion resulting from depletion of the natural cover.

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A sound range-management program and rodent control will solve the erosion problem on the greater part of this group; however, portions of Hunt clay loam east of Kaibito require mechanical treatment to control active gully heads.

Kayenta sandy loam occurs on alluvial deposits in the southeast portion of the Unit. Kayenta sandy loam and Bonito sandy loam are well adapted to agriculture. The possibility of flood irrigation of these types from short drainages off Black Mountain should be examined more thoroughly.

Precautions

Floy and Todilto loamy sands are subject to wind erosion; consequently, a maximum vegetative cover should be maintained. Gully heads on Hunt clay loam should be controlled to protect forage resources and soils of good range land.

GROUP C SOILS

Limiting factors established for Group C soils are:

Slope - 10-20%.

Erosion - 3 sheet erosion, occasional deep gully, S wind erosion depending upon depth, N accumulations.

Alkali - .3 to .5 of 1%.

Drainage - Fair, high water table with moderate alkali.

Soil - Fair permeability, fair water-holding capacity, susceptible to wind erosion.

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Soil types included in Group C are:

Residual	Alluvial
Todilto loamy sand	Concho loamy sand
Floy loamy sand	Concho sandy loam
Floy sandy loam	Concho clay
Buell sandy loam	Dinnehotso clay
Kaibito loamy sand	Hunt sandy loam
Kaibito sandy loam	Hunt clay
Moenkopi sandy loam	Ives clay loam
	Kayenta loamy sand
	Kayenta sandy loam
	Rough broken and Rough stony areas of the Floy series.

Moisture Penetration

Water penetration is slow in Hunt and Dinnehotso clays. Coarse-textured soils readily absorb all moisture. Kayenta loamy sand is rapidly permeable throughout and the only factor limiting depth of penetration is the amount of water penetrating the surface. Subsoils of the Moenkopi and Buell sandy loams are either impervious or slowly permeable, due to clay content or geologic parent material. Scattered soil remnants within rough broken or rough stony areas are fairly permeable; however, their subsoils are generally impervious, due to geologic parent materials present.

Water-holding Capacity

The water-holding capacity of the sandy types in Group C is low. Ives clay loam has a low water-holding capacity because of free subdrainage to a large gully. That of Dinnehotso and Hunt clays is relatively high. A shallow profile limits the moisture-holding capacity of Moenkopi sandy loam. Water-holding capacity of the soil remnants within rough broken and rough stony land is only fair, due to free subdrainage.

Vegetative Adaptations

Vegetation is similar to that of Group B soils with the exception

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of the heavy alluvial soils and the severely overutilized Moenkopi sandy loam. Yellow brush is dominant on the overutilized areas of Moenkopi sandy loam, and greasewood and salt bush predominate on the Concho clay. Properly utilized areas of Hunt clay and clay loam in the northeast portion of the Unit support adequate protective stands of blue grama and galleta, with some snakeweed and yellow brush. Severely grazed Dinnehotso clay north of Red Lake sustains a greasewood and Russian thistle cover which affords little protection for the soil. A variety of vegetative types occurs within rough broken or rough stony areas and includes spiney muhly, sand sage and blue grama, with woodland types most common.

Value of Soils for Construction Purposes

The heavier clay soils are generally unsuited for construction purposes. A high colloidal clay content, a dispersed soil condition, or a high alkali content reduces their value for such purposes. In light materials such as sands, dispersed clay will gradually leach out, thus all sealing clay is lost and increased filtration occurs. This should be especially watched in stock tank construction.

Erosion

The normal erosional feature of the sandy soils is a hummocky surface topography partially stabilized by Mormon tea. The area lying west of Kaibito and portions of the Unit in the south have small active sand dunes and drift sand over extensive areas.

Sheet and gully erosion are prevalent on the steep slopes of Black Mountain. Combined water and wind erosion have materially reduced the value of Group C alluvial soils, especially in the vicinity of Red

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Lake and Cow Springs.

Improvement Program Feasible from a Soils Standpoint

The coarse-textured soils of this group will readily respond to a range-management program insofar as low annual rainfall will permit, but the re-establishment of a normal soil and vegetative cover will be especially slow on the severely wind-modified areas.

Extensive areas on Black Mountain are beyond the possibility of any practical control program. A shallow intermittent soil cover and natural geologic processes definitely limit any improvement program.

Critically eroded areas of Todilto loamy sand and Kaibito loamy sand warrant a deferred grazing program to rehabilitate the already severely depleted natural cover and to stabilize the easily blown soil.

Conservation on specific localities of the Hunt series should consist of restricted grazing and mechanical treatment of gully heads.

Precautions

Alkali areas with accompanying dispersed soil conditions should be avoided in treatment unless extreme precaution is taken in construction work. An intensive alkali investigation of areas south of Red Lake should be made before attempting to re-seed or develop these soils for agricultural purposes.

GROUP D SOILS

Limiting factors established for Group D soils are:

Slope - 20% - 40%.

Erosion - 4 sheet, 8 type deep gullies, S wind removal, N accumulations.

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Alkali - Greater than .5 of 1% neutral.

Drainage - Permanent water table 6" or less from surface, low forage value of vegetation. Not a limiting factor.

Soil - Low permeability, low fertility or low water-holding capacity.

Soil types included in Group D are:

Residual	Alluvial
Todilto loamy sand	Oraibi loamy sand
St. John's clay	Oraibi sandy loam
Floy sandy loam	Tolani loamy sand
Moenkopi sandy loam	Kayenta loamy sand
	Rough broken and rough stony land with intermittent cover of Todilto, Floy and Moenkopi sandy loam, etc.

Moisture Penetration (No data available)

Areas within this group having deep accumulations of sandy material such as Todilto loamy sand and Floy sandy loam are readily permeable. St. John's clay, with a severely eroded surface soil and consequent exposure of the subsoil, is slowly permeable with a high degree of runoff.

Water-holding Capacity

Exposed impervious subsoils result in a low water-holding capacity for the greater part of Group D soils.

Vegetative Adaptation

The vegetative cover on these soils is sparse. On Moenkopi sandy loam in the north portion of the Unit it consists mainly of black brush with widely scattered areas of blue grama. Moenkopi sandy loam in the south and central portions supports a moderately heavy stand of yellow brush, indicative of a severely overgrazed and eroded condition.

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Value of Soils for Construction Purposes

The construction value of these soils is very low. Exposed dense subsoils, alkali concentrations and relatively high dispersion ratios definitely limit the structural possibilities. Sites for stock-water tanks should be selected with special consideration of the limiting factors.

Erosion

All phases of erosion are relatively high due to a combination of steep slopes, barren geologic material and improper range practices.

Improvement Program Feasible from a Soils Standpoint

Because Group D grazing lands represent the more severely eroded soils of the Unit and the steep slopes are partially denuded of protective cover, these soils, with the exception of some severely wind-eroded areas, will not readily respond to any improved range-management program. Portions of Todilto loamy sand and Moenkopi sandy loam would respond to a restricted grazing program. Mechanical treatment would be practical only where it is possible to protect better soils below these critical areas.

Precautions

Same as for Group C soils.

GROUP E SOILS

Areas consisting mainly of exposed geologic materials classified as rough stony or rough broken land are included in this group. They have the following limitations:

Slope - Greater than 40% (barren because of slope).

Erosion - Geologic.

Alkali - Greater than 1% of neutral salts or more than .2 of 1% carbonates.

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Drainage - Ephemeral Lakes (none mapped on this area).

Soil - Very droughty or otherwise unfavorable to any type of plant growth.

Moisture Penetration and Water-holding Capacity

The nature of the material and lack of a soil profile prevent moisture penetration and consequently makes the water-holding capacity negligible.

Vegetative Adaptation

Scattered growths of trees and shrubs are found on the small intermittent bodies of soil. There is practically no natural reseeding and artificial reseeding would be impractical due to a scarcity of soil cover.

Value of Soil for Construction Purposes

This group has no value for construction purposes other than the availability of rock for masonry work.

Erosion

Severe natural geologic erosion is prevalent on the greater portion of this group.

Improvement Program Feasible from a Soils Standpoint

Steep slopes and exposure of geologic material without sufficient soil cover to support other than a meager growth of vegetation definitely limit any improvement program.

AGRICULTURAL SOILS

Ives Clay loam	Dinnehotso sandy loam
Dinnehotso clay	Concho sandy loam
Concho loamy sand	Oraibi loamy sand
Oraibi sandy loam	Hunt clay
Hunt sandy loam	Kayenta sandy loam
Tolani loamy sand	

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Agricultural soils under cultivation occupy 0.7 of 1% of the Unit, an exceptionally small portion of the total area. Grazing is of primary importance.

No attempt is made to discuss agricultural soil groups in this report; however, the adaptability of each agricultural type to irrigation is briefly given.

Agricultural soils thus discussed are limited to those distributed on gully fans and in the valleys. Dry farming has been attempted but environmental features are such that this activity has been almost completely abandoned.

Insufficient water for irrigation definitely limits agricultural possibilities in this Unit.

Soil types more or less adapted to agriculture appear in the Ives, Dinnehotso, Concho, Oraibi, Hunt, Kayenta and Tolani series. They are classified as A, excellent; B, good; C, fair to poor; D, non-irrigable.

The Ives clay loam as mapped has a friable topsoil over a medium- to heavy-textured subsoil. Water penetration is good in the surface soil and adequate in the subsoil, except in the extremely heavy and compact subsoils. This type is well adapted to agriculture under approved irrigation practices, the water supply being the only limiting factor in subjugation.

The Dinnehotso series includes some of the most important agricultural soils in this Unit. It embraces a large portion of the present cultivated land. The surface soil ranges from friable to moderately compact, and the subsoil is moderately compact and highly calcareous.

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Ordinarily this series has a low alkali content. Local areas are sometimes highly dispersed and have a high alkali content and should be avoided. The series in general has a moderately high water-holding capacity. Where the subdrainage is adequate this soil is rated as Class B agricultural land. Areas of clay of high alkali concentrations and of dispersed soils should be avoided in all subjugations.

The Tolani loamy sand is a recent overwash soil. It is light in texture, has a friable and open surface and subsoil with a low alkali content. However, its light texture makes it susceptible to severe wind erosion and high percolation losses, both of which lower its agricultural value. It is rated as Class C agricultural land.

The Hunt soils commonly have a heavy, compact subsoil fairly impervious, resulting in poor subdrainage and high alkali concentrations. However, some types, especially the Hunt sandy loam, have an open surface and subsoil with good water penetration and a moderate water-holding capacity. Hunt sandy loam is rated as B agricultural land.

The Concho soils are generally fine-textured and slowly permeable. A significant portion of this series is impregnated with alkali and characterized by "slick spots" and the presence of alkali-tolerant vegetation. Restricted areas, however, are more suited to irrigation. These include Concho sandy loam and clay loam. Alkali concentrations and high clay content are limiting factors in this series. Because of impervious subsoils and high alkali content, Concho soils are usually classed as C or D agricultural land.

Oraibi loamy sand is another recent overwash soil. It has a

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friable, calcareous surface and a deep variable-textured subsoil low in organic matter. It absorbs water rapidly but the prevailing coarse-textured subsoil makes it somewhat droughty. It is adapted to Navajo farming methods and occupies many of the small valleys. The loose, porous nature of this type makes it susceptible to wind and head erosion, which further reduce its agricultural rating to B or C.

Actually, all Kayenta soils are nonirrigable in the Unit, due to site, but from a soils standpoint alone medium-textured Kayenta soils are well adapted to farming when the slopes are not prohibitive. Kayenta sand is much too light for irrigation purposes. The clay type, while being somewhat difficult to handle and slowly permeable, may be classed as Group C soil, and Kayenta sandy loam as Group A or B, depending on the relative amount of coarse materials in it.

Bonito sandy loam is a Group A soil as far as productivity under irrigation is concerned. Lighter droughty types, however, should not be subjugated.

Grouping Soils for Irrigation

Limiting factors:

A Group

Slope - 3% or less.

Erosion - 1 or 2 class, slight wind erosion, few gullies.

Alkali - Less than .2 of 1%. No carbonates.

Drainage - Good.

Soil - Readily permeable with a high water-holding capacity.

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B Group

Slope - 3 to 5%.

Erosion - 3 class, moderate wind erosion, 7 type shallow gullies.

Alkali - .3 of 1%. Slight carbonates or bicarbonates.

Drainage - Water below 6 feet.

Soil - Moderately permeable and of moderate water-holding capacity.

C Group

Slope - 5% or less.

Erosion - 4 class, severe wind, 8 type shallow gullies, 7 type B or C deep gullies.

Alkali - .4 of 1% less than .1 of 1% carbonates.

Drainage - Water table below 5 feet.

Soils - Fair permeability and fair water-holding capacity.

D Group (Nonirrigable)

Slope - Greater than 5%.

Erosion - 5 class, very severe wind, 7 or 8 type deep gullies.

Alkali - Greater than .4 of 1% white alkali and greater than .1 of 1% black alkali.

Drainage - Water table above 5 feet.

Soil - Low permeability, low water-holding capacity.

ALKALI

A limited portion of the Unit contains alkali or soluble salts in such concentration as to be injurious or prohibitive to plant growth. The fine-textured soils of the Concho and Binnehotso series, in the vicinity of Red Lake, are affected to some extent by concentrations of alkali.

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These areas are recognized by "slick spots," "piping holes," and by the presence of alkali-tolerant vegetation. No detailed investigation was made of this area to determine the amount of alkali present, as tolerance of plants to alkali varies with conditions. Tolerance is influenced by such conditions as the nature of the salt present, soil type, moisture, etc. Alkali is not a problem when considering the Unit as a whole. The greater portion of the soils are permeable and well drained and distribution of the salt through the soil profiles is such that there are no appreciable concentrations of alkali.

Normal precautions should be observed, however, in the selection of vegetative species for any proposed artificial revegetation.

Specific mention of alkali is made in the discussion of each soil group.

SUMMARY OF RECOMMENDATIONS

1. Range and rodent-control programs to protect the natural cover on easily eroded soils.

2. Gully head control in designated valleys to protect valuable range and agricultural soils. (See Erosion map.)

3. Careful investigation of alkali-impregnated areas before attempting reseeding, building erosion-control structures, etc.

4. Stock water development and better distribution of livestock for improvement in native vegetative cover and stabilization of the soils.

5. Wind and water erosion control on agricultural land to protect crop lands and reduce the advance of wind-blown materials upon surrounding areas.

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Table VI

Characteristics of Soils Included in Grazing Land Soil Groups

Soil Series	Texture Type	Nos. on Map	Erosion: Water: Sheet	Erosion: Water: Gully	Erosion: Wind: Removals	Erosion: Wind: Accum.	% Slope	Permeability: Surf.	Permeability: Subsoil	Water-holding Capacity: Surf.	Water-holding Capacity: Subsoil
Group A Range Soils											
Floy	Loamy sand	26-1	0-1	0	P	0-6"	0-3	Good	Good	Low	Low
Buell	Sandy loam	38-7	0	0	P	0-6"	0-3	Good	Low	Med.	Good
Kayenta	Sandy loam	80-7						Good	Good	Med.	Med.
	Clay loam-	80-13	2	7-7	P	0-12"	0-3	Good	Med.	Med.	Med.
Bonito	Sandy loam	75-7	2	7	P	0-6"	0-3	Good	Good	Med.	Med.
Group B Range Soils											
Todilto	Loamy sand	21-1						High	High	Low	Low
	Sandy loam	21-7	0-2	0-7	0-R	0-12"	0-10	High	High	Med.	Med.
Floy	Loamy sand	26-1	0	0	P-R	0-36"	0-10-	High	High	Low	Low
Buell	Loamy sand	38-1						Good	Good	Med.	Med.
	Sandy loam	38-7	0	0	P-S	0-12"	0-3	Med.	Low	Med.	Med.
Kaibito	Loamy sand	44-1	0	0	P	0-6"	0-3	High	High	Low	Low
Dinnehotso	Sandy loam	57-7	0-2	0-7	P	0-6"	0-3	Good	Good	Low	Low
Hunt	Sandy loam	60-7						Good	Good	Med.	Med.
	Clay loam	60-13	0-2	0	P	0-6"	0-3	Med.	Med.	Good	Good

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Table VI (Continued)

Group B Soils (Continued)

Soil Series	Texture Type	Nos. on Map	Erosion: Water: Sheet	Erosion: Water: Gully	Erosion: Wind: Removals	Erosion: Wind: Accum.	% Slope	Permeability: Surf.	Permeability: Subsoil	Water-holding Capacity: Surf.	Water-holding Capacity: Subsoil
Tolani	Loamy sand	68-1	Recent alluvium				0-3	High	High	Low	Low
Bonito	Loamy sand	75-1	2	7	P	0-6"	0-3	High	High	Low	Low
Kayenta	Clay	80-16	2	7	P	6-12"	0-3	Low	Low	Good	Good

Group C Range Soils

Soil Series	Texture Type	Nos. on Map	Erosion: Water: Sheet	Erosion: Water: Gully	Erosion: Wind: Removals	Erosion: Wind: Accum.	% Slope	Permeability: Surf.	Permeability: Subsoil	Water-holding Capacity: Surf.	Water-holding Capacity: Subsoil
Todilto	Loamy sand	21-1	2	7-7	P-S	0-72"	0-20	High	High	Low	Low
Floy	Loamy sand	26-1						High	High	Low	Low
	Sandy loam	26-7	0-2	0-7	P-R	6-72"	0-10	Good	Good	Med.	Med.
Buell	Sandy loam	38-7	0	0	S	36-82"	0-3	Med.	Low	Med.	Med.
Kaibito	Loamy sand	44-1						High	High	Low	Med.
	Sandy loam	44-7	2	7	P-S	0-72"	0-10	Good	Good	Med.	Med.
Moenkopi	Sandy loam	46-7	0-3	0	R-S	6-72"	3-10	Med.	Low	Med.	Med.
Concho	Loamy sand	55-1						Med.	Low	Med.	Med.
	Sandy loam	55-7-16	2-3	7-7	R-S	6-36"	0-3	Med.	Low	Med.	Med.
Hunt	Sandy loam	60-7						Med.	Low	Med.	Med.
	Clay	60-16	2	7	P	0-6"	0-3	Low	Low	Good	Good
Ives	Clay loam	66-13	2	7	P	0-6"	0-3	Med.	Med.	Low	Low
Dinnehotso	Clay	57-16	2	7			0-3	Low	Low	High	High
Kayenta	Loamy sand	80-1						Good	Good	Low	Med.
	Sandy loam	80-7	0-2	0-7	R-S	6-72"	0-10	Good	Good	Med.	Med.

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Table VI (Continued)

Group D Range Soils

Soil Series	Texture Type	Nos. on Map	Erosion: Water: Sheet	Erosion: Water: Gully	Erosion: Wind: Removals	Erosion: Wind: Accum.	% Slope	Permeability: Surf.	Permeability: Subsoil	Water-holding Capacity: Surf.	Water-holding Capacity: Subsoil
Todilto	Loamy sand	21-1	0-4	0-7	R-S	12-36	3-20	High	High	Low	Low
St. Johns	Clay	29-16	4	7			10-20	Low	Low	Low	Low
Floy	Sandy loam	26-7	0	0	S	12-36	3-10	Good	Good	Med.	Med.
Moenkopi	Sandy loam	46-7	2	0-S	P-S	6-72"	0-20	Good	Good	Low	Med.
Oraibi	Loamy sand	65-1						High	High	Low	Med.
	Sandy loam	65-7	Recent				0-3	Good	Good	Low	Med.
Tolani	Loamy sand	68-1	Recent				0-3	High	High	Low	Med.
Kayenta	Loamy sand	80-1	0	0	S	12-36	3-10	High	High	Low	Med.

Group E Range Soils

Rough stony land	19S	Geologic	0-40	Impermeable	Low	Low		
Rough broken land	19B							

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Table VII — Laboratory Analyses of Soil Samples

Lab. No.	Field No.	TS**	$NaCO_3$	Sand	Silt	Clay	% Disp***	$CaCO_3$	O.M.*	Water Holding Cap'y	Depth	Soil type
4071	S11-01-01	.02-	0	92.2	1.5	6.3	17.0	0	0.24	27.5	0-19"	Kayenta sand
4072	S11-01-02	.02-	0	93.3	1.5	5.2	32.8	0	0.60	25.5	19-44"	Kayenta sand
4073	S11-01-03	.02-	0	85.8	3.6	10.6	7.8	0	0.38	29.3	0-19½"	Buell sandy loam
4074	S11-01-04	.02-	0	74.8	3.9	21.3	15.1	0	0.59	34.7	0-5"	Buell clay loam
4075	S11-01-05	.03	0	84.9	2.9	12.2	15.0	2.55	1.05	29.1	5-14"	Buell clay loam
4076	S11-01-06	.11	0	47.6	19.6	32.8	10.2	5.2	.60	42.7	0-5"	Oraibi clay (light)
4077	S11-01-07	.13	0	45.4	20.5	34.1	4.5	4.4	1.02	42.2	5-16"	Oraibi clay (light)

* O.M. = Organic matter
** T.S. = Total salts
*** % Dispersion represents percent clay fraction of soil dispersed in quiet water.

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Table VIII

Acreage of Soil Types in Grazing Land Soil Groups by Sub-Units
Land Management Unit 1. (Preliminary planimeter data)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit I				
38-7	Buell sandy loam	5,920		1,562			7,482
26-7	Floy sandy loam	1,280					1,280
26-1 (19S)	(Floy sandy loam and) (undifferentiated) (Rough stony land)		21,067	4,608			25,675
46-13	Moenkopi clay loam		8,448				8,448
60-13	Hunt clay loam		96				96
68-1	Tolani sand				282		282
26-1	Floy loamy sand		4,160	5,855			10,015
44-7	Kaibito sandy loam			2,106			2,106
46-7	Moenkopi sandy loam			11,776	11,411		23,187
19B (Other)	(Rough broken land and) (undifferentiated soil) (remnants)			2,682	15,013		17,695
19S (Other)	(Rough stony land and) (undifferentiated) (soil remnants)				25,299		25,299
38-1	Buell loamy sand		435				435
26-7 (19B)	(Floy sandy loam and) (undifferentiated) (rough broken land)				16,397		16,397
	Undifferentiated Areas					62,113	62,113
TOTALS		7,200	34,206	28,589	68,402	62,113	200,510

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Table VIII (Continued)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit II				
26-1	Floy loamy sand	1,254	73,119	14,656			89,029
26-7	Floy sandy loam	1,658					1,658
26-1(19S)	Floy loamy sand in rough broken areas		49,455				49,455
19S(21-1)	Rough stony land with Todilto loamy sand		20,852		2,874		23,726
19S(26-1)	Rough stony land with Floy loamy sand		1,754	4,916			6,670
21-7	Todilto sandy loam		5,760				5,760
44-7	Kaibito sandy loam			3,418			3,418
21-1	Todilto loamy sand				896		896
26-7	Floy sandy loam			4,980			4,980
19S	Rough stony land				9,030		9,030
26-1(19S)	Undifferentiated Floy loamy sand and rough stony land			42,909	608		42,517
	Undifferentiated areas					10,826	10,826
TOTALS		2,912	150,940	69,879	13,408	10,826	247,965

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NN00626

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Table VIII (Continued)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit III				
26-1(19S)	Floy loamy sand and rough stony land		10,688				10,688
38-1	Buell loamy sand		3,642				3,642
44-1	Kaibito loamy sand		1,571	6,874			8,445
46-7	Moenkopi loamy sand		2,630				2,630
60-13	Hunt clay loam		442				442
28-7	Buell sandy loam		230				230
26-1	Floy loamy sand		640	294			934
80-1	Kayenta loamy sand			44,461			44,461
80-13	Kayenta clay loam			422			422
26-7	Floy sandy loam			3,840	4,403		8,243
26-7 (19B)	Floy sandy loam in rough broken land				17,338		17,338
65-1	Oraibi loamy sand				186		186
19B	Rough broken land				1,536		1,536
19S	Rough stony land				1,383		1,383
	Undifferentiated areas					10,761	10,761
TOTALS			19,843	55,891	24,846	10,761	111,341

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NN005755

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T.C. 16172

Table VIII (Continued)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit IV				
38-1	Buell loamy sand		11,917				11,917
38-7	Buell sandy loam		22,535				22,535
44-1	Kaibito loamy sand		3,725	11,540			15,265
60-13	Hunt clay loam		6,343				6,343
60-7	Hunt sandy loam		269				269
26-1	Floy loamy sand			628			628
80-1	Kayenta loamy sand			3,245	2,823		6,068
46-7	Moenkopi sandy loam			6,835			6,835
60-7	Hunt sandy loam			448			448
60-16	Hunt clay			199			199
44-7	Kaibito sandy loam			9,056			9,056
19B-19S	Rough stony and broken land				24,117		24,117
19B	Rough broken land				3,571		3,571
65-1	Oraibi loamy sand				3,335		3,335
65-7	Oraibi sandy loam				429		429
19B(16-7)	Rough broken land with Floy sandy loam				6,119		6,119
19B(80-1)	Rough broken land with Kayenta loamy sand				1,856		1,856
	Undifferentiated Areas					12,127	12,127
TOTALS			44,789	31,951	42,250	12,127	131,117

NN005756

T.C. 16173

Table VIII (Continued)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit V				
80-7	Kayenta sandy loam	4,883					4,883
21-1	Todilto loamy sand	1,363	53,888	38,074	5,504		98,829
75-7	Bonito sandy loam	653					653
21-7	Todilto sandy loam	986	14,880				15,866
80-13	Kayenta clay loam	205					205
26-7	Floy sandy loam	1,457	2,291	4,589			8,337
26-1	Floy loamy sand	154	33,184				33,338
60-13	Hunt clay loam		64				64
80-1	Kayenta loamy sand		9,610		1,573		11,183
80-13	Kayenta clay loam		928				928
57-7	Dinnehotso sandy loam		1,024	3,814			4,838
68-1	Tolani loamy sand		589				589
75-1	Bonito loamy sand		397				397
38-7	Buell sandy loam		973				973
46-7	Moenkopi sandy loam		2,003				2,003
19B	Rough broken land			7,027			7,027
55-7	Concho sandy loam			4,992			4,992
55-1	Concho loamy sand			122			122
55-16	Concho clay			1,280			1,280
19B-19S	Rough broken and rough stony land			21,133			21,133
26-7	Floy sandy loam and rough broken land			24,371			24,371
19B(21-1)	Rough broken land and Todilto loamy sand			2,944			2,944

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Table VIII (Continued)

Field No.	Soil Type	A	B	C	D	E	Totals
			Sub-Unit V (Continued)				
66-13	Ives clay loam			902			902
19S	Rough stony land			1,850	3,802		5,652
80-7	Kayenta sandy loam			128	147		275
57-16	Dinnehotso clay			1,280			1,280
65-7	Ives sandy loam				96		96
26-1(19S)	Floy loamy sand and rough stony land				5,274		5,274
29-16	St. John's clay				2,927		2,927
Undifferentiated areas						66,895	66,895
	TOTALS	9,701	119,831	112,506	19,323	66,895	328,256
			Buck Pasture				
26-1	Floy loamy sand		9,805				9,805
21-1	Todilto loamy sand		538				538
38-7	Buell sandy loam		166				166
26-1(19S)	Floy loamy sand and rough stony land			3,040			3,040
19S	Rough stony land				2,240		2,240
	Geologic exposures					562	562
	TOTALS		10,509	3,040	2,240	562	16,351
	GRAND TOTALS	19,813	380,118	301,856	170,469	163,284	1,035,540

NN005758

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T.C. 16175

Table IX

Agricultural Land Soil Groups
Land Management Unit #1

Field No.	Soil Type	A	B	C	D	Totals
57.7(16)	Dinnehotso sandy loam and clay loam undifferentiated		617.6			617.6
80.7	Kayenta sandy loam		348.8		224	572.8
80.1	Kayenta loamy sand			1,228.8	1,312	2,540.8
75.7	Bonito sandy loam		617.6			617.6
68.1	Tolani loamy sand			960	262.2	1,222.2
				275.2		275.2
57.7	Dinnehotso sandy loam		563.2			563.2
			192			192.0
57.[illegible]	Dinnehotso clay				1,191.1	1,191.1
80.13	Kayenta clay loam				857.6	857.6
55.7 (16)	Concho sandy loam and clay loam undifferentiated			2,419.2		2,419.2
60.7	Hunt sandy loam		576			576.0
65.1	Oraibi loamy sand			678.1		678.1
66.13	Ives clay loam		554.4			554.4
	TOTALS		3,469.6	5,561.3	3,846.9	12,877.8

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