NAVAJO SERVICE

LAND MANAGEMENT UNIT NO. 3

ENGINEERING REPORT

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T. C. 2174

I N D E X

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Boundary

Land Management Unit Number 3 is located in the extreme western portion of the Navajo Reservation and includes the Hopi village of Moencopi. Roughly, it includes the Reservation west of the 111° of longitude. Several changes have been made in the location of boundary. However, this report covers only that area which will be enclosed by the final boundary line.

The boundary of Unit Number 3 is as follows: Starting at Black Falls on the Little Colorado River the boundary follows the river approximately ten miles north to the beginning of the fenced portion of the Reservation boundary. The boundary of the Unit then follows the fenced Reservation boundary to the west and south for about twenty-five miles, then runs roughly north for thirty miles where it again meets the Little Colorado River. It follows down this river for two miles to its junction with the Colorado River. The boundary then continues to follow the Reservation boundary up the Colorado River to a point about six miles above the Navajo Bridge. From here the boundary of Unit Number 3 does not follow the Reservation boundary but runs southward along the Echo Cliffs to a point two miles north of the Gap Trading Post. Here it goes slightly north of east along Crooked Ridge for seventeen miles, then southeast to Little White Mesa. It then goes south for seven miles to the Moencopi Wash, at the 111° of longitude.

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The boundary then goes east up the Moencopi Wash for thirteen miles, then south for twelve miles to the Denibito Wash. It follows this Wash southwest, goes around the south end of Ward Terrace, then continues on southwest back to Black Falls on the Little Colorado River, the point of origin.

The boundary as outlined above encloses an area of 1,750,800 acres. Included in this are the following areas, which are interesting due to the fact that little or no work is recommended on them:

Moa Nave Demonstration Area . . . . . 10,500 acres
Barren
Inaccessible 156,801
Waste land
Bad Lands 125,263

Mountainous . . . . . .

Very Sandy (Low Runoff) . . . . . .

Topography and Soils

Elevation in Unit Number 3 averages about 4,500 feet. Approximate elevations are given below:

Lees' Ferry . . . . . 3,200 feet

Cameron . . . . . 4,200 feet

Tuba City . . . . . 4,500 feet

Moencopi Plateau . . . . . 5,500 feet

Red Mesa . . . . . 6,500 feet

Grey Mountain . . . . . 7,000 feet

The topography of Unit Number 3 consists mostly of plateaus. In the southern part of this area these plateaus are generally level with a few rather large drainages which flow toward the Little Colorado River. Howell Mesa and Coal Mine Mesa are both cut by a canyon 500 to 800 feet deep. In the western portion of the Unit between the Little Colorado River, the Colorado River, and Echo Cliffs is a section of rolling country bounded on the south and west by deep canyons. The slope is generally to the east and drainages are shallow due to the type of soil and to rock outcrops. The central portion of the Unit is classed mostly as bad lands. The northeastern and eastern portion consists of rolling land which has been wind modified. There is very little runoff from this area and few drainages of any kind. The only mountainous section is Grey Mountain in the southwest corner of the Unit.

Of the soils of Unit Number 3, most important from an engineering point of view are those derived from Moenkopi and Chinli Shales, indicated on the soils map by symbols 42, 46 and 60. These soils are usually heavy in texture, have a relatively high alkali content, and are often dispersed. Whether residual or alluvial, these soils can usually be recognized in the field by a reddish brown or maroon color. Heavy textured soils of these series, indicated on the map by the texture symbols 13 and 16, have a relatively low absorbtive capacity.

If highly dispersed, the rate of water penetration is almost nil. Further, because of the high clay and alkali content, these soils are usually unadapted to agricultural development.

Other important soils mapped in this Unit are the Todilto in the eastern and northeastern, and the Springerville and Kiabab in the southwestern part of the Unit. These soils have a friable or loose, permeable surface soil, and a fairly deep heavier textured subsoil. They are well adapted to range use, but are unadapted to agricultural development. With the exception of extremely sandy textures and occasional small areas which are highly impregnated with alkali, these soils can be approved for structural purposes. A typical alkali area on the Todilto series can be observed immediately east of Tuba City.

Drainage

The largest drainage in Unit Number 3 is the Marble Canyon section of the Colorado River. This river forms the northwestern boundary and flows generally south. The second largest drainage is the Little Colorado River, which flows northwest through the southern part of the Unit. Two-thirds of the area drains into this river. The third largest drainage is the Moencopi Wash, which flows southwest and enters the Little Colorado River at Cameron.

The Colorado River is definitely confined to its channel within the Unit, as it runs through a canyon varying from 600 feet deep at Lees' Ferry to an estimated 3,000 feet at the junction with the Little Colorado. The Little Colorado has a sandy river bed above Cameron. The bed itself averages 600 feet wide with a valley a mile or more in width. During floods the river will be one-half mile in width at places. There is very little gully erosion in the stream channel or in the side drainages. Below Cameron the river is confined to a canhon which rapidly increases in depth as it approaches the Colorado River. The Moencopi Wash flows through a valley generally 2,000 feet or more in width. The wash is confined in a cut bank gully varying in depth from 15 to 60 feet and 100 to 300 feet wide.

Within the boundary of the Unit no use can be made of the permanent flow of the Colorado River. Deep canyon walls prevent the use of the water on any of the surrounding country.

Very little use can be made of the semi-permanent flow in the Little Colorado River. It is entirely possible that some farm land could be located on sand bars a few feet above the river. Sub-irrigation should be sufficient to produce a good crop. However, a crop could not be expected every year nor could subjugation be attempted due to the danger of flooding. Due to the size of the river, any diversion structures would necessarily be large. Such a structure would require the subjugation

of at least 1,000 acres of land, and no such area was found in the vicinity of the river.

Although the Moencopi Wash has a semi-permanent flow and a relatively wide valley, little additional use can be made of this water. The soil is of a poor type for farm land and also during the months of June and July the entire flow of the wash is hardly sufficient for the land already developed. There are two diversion dams located on the Wash. However, they will be described under "Projects". Both of these projects could be greatly improved if a storage of at least 500 acre foot capacity could be found on one of the larger drainages of the Moencopi. An attempt to find a location for a reservoir was made in Coal Mine Canyon but weather conditions prevented a survey except in a small portion of the canyon.

In numbering these drainages the following system was used:

Colorado River . . . . . #1.0

Little Colorado River . . #2.0

Moencopi Wash . . . . . #3.0

Side drainages of these are given the whole number of the main drainage and a decimal which indicates which side of the wash it enters from. Facing upstream on the Moencopi Wash the first side drainage to enter from the left would be #3.1 and the second #3.3 etc. Those entering from the right would be given consecutive even decimals.

Climate

The following rainfall and temperature records of Tuba City, compiled from a 29 year incomplete record, are representative of most of the Unit:

Normal Monthly, Seasonal, and Annual
Temperature and Precipitation at
Tuba City, Arizona (Elevation 4500 feet)

	Temperature			Precipitation			
Month	Mean	Absolute Maximum	Absolute Minimum	Mean	Total amount for the driest year (1924)	Total amount for wettest year (1906)	Snow Average Depth
December	32.3	70	-13	.58	.82	2.23	3.5
January	32.0	68	-15	.55	.16	.53	2.7
February	39.2	73	- 3	.54	.00	.34	2.3
Winter	-	-	-	1.67	.98	3.10	8.5
March	45.9	85	12	.54	.12	1.59	1.1
April	53.8	88	14	.43	.09	.19	.5
May	61.7	99	22	.53	.02	.34	.1
Spring	-	-	-	1.50	.23	2.22	1.7
June	71.1	104	34	.19	.00	.00	0
July	76.8	105	40	.34	.00	1.73	0
August	77.8	108	44	.93	.10	1.26	0
Summer	-	-	-	1.46	.10	2.99	0
September	67.6	100	28	.84	.14	1.37	T
October	55.7	95	18	.68	.13	.27	.1
November	43.4	88	8	.78	.00	2.92	1.9
Fall	-	-	-	2.30	.27	4.56	2.0
Year	54.8	108	-15	6.92	1.58	12.57	12.2

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Runoff Data

Runoff data on Unit Number 3 has been calculated only at the places where such information will be useful in designing structures or in the development of farm lands. Due to lack of runoff data, such factors may be somewhat in error. However, they have been based on field studies of the entire drainages, rainfall records, studies of the factors applied on other similar areas of the Reservation, and in a few cases, observation during floods.

The runoff factors as used in this report, multiplied by the drainage area in acres, gives the total runoff expected in second feet. The maximum flood expectancy needs no further computation. The annual expectancy of the wash is assumed to be equal to the estimated flow in second feet, lasting for a period of four hours. Therefore, in order to reduce the annual expectancy to acre feet, the product of the drainage area in acres and the annual expectancy factor must be divided by four.

There is one stream gauge in Unit Number 3. It is located at the bridge on the Moencopi Wash about five miles southwest of Tuba City. Records are available on this wash for the period July 1, 1926 to September 30, 1936. The drainage area of the wash is 1,453,000 acres. From these records the annual expectancy at the bridge is 16,000 acre feet, which gives us an annual expectancy factor of 0.044.

The maximum flood recorded by the gauging station is 15,100 second feet, recorded on August 4, 1929. Assuming that a maximum flood would not flow over 19,000 second feet, we get a maximum flood expectancy factor of 0.013. The minimum annual runoff recorded was 4,510 acre feet in the year ending Sept. 30, 1928, while the maximum was 46,000 acre feet in the year ending Sept.30,1930.

The following shows a list of runoff factors applied to drainages in Unit Number 3. It also shows the amount of runoff expected at important points and the amount which can be used on some irrigation projects. The reduction on the amount available on irrigation projects is due to estimated seepage and evaporation losses and the limited openi in the intake of diversion structures, usually 30 second feet.

		ANNUAL EXPECTANCY		FLOOD EXPECTANCY	
Location	Drainage area in acres	Factor	Amount in A/Ft.	Factor	Amount in Sec/Ft.
Stream Gauge on Moencopi Wash	1,453,000	0.044	16,000	0.013	19,000
Lower Moencopi Diversion Dam			3,850		19,000
Upper Moencopi Diversion Dam			4,250		19,000
Cedar Ridge Farm Area. Quad #83 Farm #1.1	1,500	0.3	110	0.5	750
Quad 35 Farm #1.2	2,400	0.26	155	0.4	960
Quad #85 Farm #1.3	2,500	0.26	160	0.4	1000

More will be said about the amount of runoff expected in the description of each project.

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AGRICULTURAL PROJECTS

The following agricultural areas are the ones which are the most important and which need some immediate work on them. These projects have not been listed as to importance or necessity of immediate attention but rather as they can, in the near future, affect the income of the population.

Any project mentioned in this report can be found on the 1937 Agronomy-Engineering map of Unit Number 3.

Upper Moencopi

The upper Moencopi diversion project is located about two miles south of the Tuba City. The U.S.I.I.S. has constructed a permanent diversion dam for the project. A ditch system has been constructed which provides water to all the land that can be subjugated. Leveling and bordering of the land has been completed and crops are being raised at present. The capacity of the diversion structure is 30 second feet, which is sufficient to take care of the 780 acres of present farm land. This farm land is divided between the following owners:

Government owned. . . . . 340 acres

Navajo owned . . . . . 358 acres

Hopi owned . . . . . 82 acres

The project can be handled as a unit instead of dividing it by ownership.

There is a gauging station located about four miles down the Moencopi from the diversion structure. From a study of the runoff records of this station and the amount of water used on the farm land, the following estimates can be made as to the quantity of water available to the project:

1. An excess amount of water will be available from the middle of July to the last of March.

2. Sufficient water can be expected in April, with an average yearly expectancy of 115 acre feet.

3. The yearly expectancy for May is 100 acre feet.

4. Very little irrigation can be done during the month of June and the first part of July, as the annual expectancy is only 25 acre feet.

The biggest problem on this project is to provide a method for handling flood water from the side drainages coming in from the north. These floods wash out portions of the crop and also deposit soil of an inferior nature on the fields. It is suggested that this water be handled by the construction of three drainage ditches across the farm land and emptying directly into the Moencopi. The total length of these ditches will be about 4,000 feet and it will require about four acres of land for their location. A drop, probably of the corrugated culvert type, will be needed at the lower end of each ditch.

There are a few small active gullies on this farm land which need some control work. Most of this will be at the lower end of the project

just above the Moencopi bridge. Gully control is necessary on the farm land on both sides of the wash. This will be largely small dykes leading excess irrigation and some flood water into the wash.

One ditch change is necessitated on the main canal just below the diversion dam, where the Moencopi is slowly cutting its channel toward a short section of the ditch. It will be cheaper to relocate about 300 feet of ditch than to stabilize the wash.

Pasture Canyon Project

The Pasture Canyon project includes Pasture Canyon, one mile east of Tuba City, and about 100 acres of farm land along the Moencopi Wash above the diversion structure. Water is supplied from a permanent spring in the head of the Canyon. The water is allowed to flow down the canyon floor for three miles, where it is caught in the Hopi Reservoir. The permanent flow is used on some farm and pasture land above the reservoir. Below the reservoir the water is led by ditches to land which has been leveled and bordered.

Ownership of the 235 acres is divided as follows:

Hopi owned	196 acres
Government owned	25 acres
Navajo owned	14 acres

The 25 acres of Government owned land lies at the head of the canyon and at present is in meadow. The superintendent at Tuba City has made plans for some of the boys from the school to develop this into

farm land. It is planned to first drain the land with a system of ditches to carry off the spring flow. Some leveling would be necessary and a few irrigation ditches would be needed to supplement sub-irrigation. It is suggested that this land be left to the agency to develop.

Between the Government land and the Hopi Reservoir is about 15 acres of farm land. The spring flow is allowed to spread over this land and much water is lost from evaporation and over-irrigation. A drainage ditch should be provided through these farms, with supplementary irrigation ditches where needed. A drainage ditch could probably be made large enough with a lister by making three or four trips. Directly above the Hopi Reservoir a sand dune has developed completely across the canyon. A ditch about five feet deep carries the spring water to the reservoir. This ditch, however, is not very successful as it has to be cleaned quite often. This trouble can be eliminated by laying a 12 inch corrugated steel pipe through the sand dune. This would require 550 linear feet of pipe and the construction of a silt basin and trash rack at the upper end.

The Hopi Reservoir has a capacity of approximately ~~300~~ 220 acre feet. It evidently never reaches the capacity, as no spillway is provided. It is recommended that an additional three feet be added to the dam and that a spillway be provided at the western end.

Below the Hopi Reservoir the water is allowed to flow down the stream bed for about one mile. Here it is picked up in ditches and led to the farm land. Much evaporation and seepage loss could be eliminated by the construction of a ditch with checks and drops along this section. The farm land itself needs no subjugation, as it is already leveled and bordered.

Although there is no potential farm land below the Hopi Reservoir, the work outlined above should provide more water for the present farms. The ditch system will greatly reduce the amount of seepage and evaporation losses. Such additional water as can be provided is needed on the farm land as the present supply is less than is necessary for a first class irrigation project.

Moa Nave Demonstration Area

The Moa Nave Demonstration Area lies about five miles west of Tuba City. The flow from several small springs has been united and stored in several small reservoirs. The water is led from these reservoirs by ditches to land which has been leveled and terraced. The present farm land totals 107 acres. No work will be needed on this other than the regular maintenance which is necessary on a highly developed piece of farm land.

There are two locations where excess water from the completed project can be stored for use on additional farm land. There are also two new

locations which may prove feasible for developments. Two other storages were found. However, is it doubtful if they will prove to be economically feasible. These sites have been indicated on the map by the letters A, B, C, D, E, and F.

Projects A and B are somewhat similar. Both are located away from the steep bluffs, where the problem of subjugation of the land and flood control is greatly lessened. Each project will need about 500 feet of ditch to lead a small spring flow to the storage reservoir, and about 300 feet of ditch from this to the farm land. The storage reservoirs are located in heavy soil, from which samples should be taken to determine the soil texture, dispersion and alkali content. The capacity of each of these reservoirs will be from 4 to 6 acre feet and with the permanent flow of the springs will supply enough water to subjugate about five acres of land. Cost estimates on the storage reservoirs were not made. However, the dams will be relatively small and the projects appear to be entirely feasible and desirable.

Project C, located above the Vanzee Ranch house, will store the excess water from the existing project at this location. A storage reservoir located here will tie in with the existing ditches and supplement the present storage. The capacity of any new reservoir should be at least 15 acre feet in order to conserve the waste water. This additional storage will allow the subjugation of 5 to 7 acres of additional land. This potential land is

located below that which is already subjugated and additional irrigation ditches will tie in with those already constructed. Leveling of this land will be rather easy as it lies on a 1% grade and has been farmed several years. A cost estimate of the reservoir sits will be necessary as none could be made in this survey. The soil is rather sandy and it may be necessary to line the reservoir with heavy material. The site is not exceptionally good. However, it seems to be the best location possible to find inthe locality.

Sites located at D, E, and F are near old Moa Mave and close to the present Day School. The purpose of additional storage is to save the winter runoff from the developed springs in this area for use on additional land. The runoff amounts to approximately ¼ second foot.

The sites marked D and E will probably not be feasible due to high cost per acre foot of storage. They may be worth considering at a future date when the need arises for more storage capacity.

No cost estimate has been made at the site marked F but storage at this location appears to be economically feasible. Enough storage could be provided for an additional 10 or 15 acres of land. The land will have to depend entirely oh the storage of winter runoff as all of the stream flow is needed on that already under subjugation. Subjugation costs will be low as the land has previously been farmed. If the cost of providing the necessary storage capacity of at least 25 acre feet is not excessive the project will be economically feasible and provide good farm land for several Navajo or Hopi families.

Lower Moencopi Diversion Project.

The Lower Moencopi Diversion Project is located four and one-half miles below the Moencopi Bridge south of Tuba City. The U.S.I.I.S. has constructed a diversion dam which is capable of diverting about 30 second feet of water. They have also constructed a ditch system including checks, drops and wasteways. To date, however, no subjugation or farming of any kind has been done.

The head walls at each end of this dam should be raised. There has been a flow already which went about six inches over these walls. It is suggested that they be raised three feet. This will require about 20 cubic yards of reinforced concrete retaining wall.

As this project lies directly below the gauging station on the Moencopi, we have an accurate record as to the amount of water available for flood irrigation purposes. The following graph and table show the amount that we can annually expect to be diverted by the Diversion Dam. This does not show the total runoff as it is assumed that any flow over 500 second feet will carry too much silt for irrigation purposes and also that the maximum amount diverted at any time is 30 second feet, which is the capacity of the head gate. In making these tables it is assumed that the water can be used twenty-four hours a day if necessary.

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1926												
1927	301	375	369	400	328	289	4	0	105*	234	635	740
1928	117	500	443	566	265	338	30	154	6	234	860	256
1929	600	716	424	210	121	169	143	0	0	600	1160	550
1930	370	321	298	405	268	137	89	22	2	840	700	480
1931	300	294	250	353	385	155	60	145	2	540	480	425
1932	500	361	309	331	970	194	33	44	14	180	400	240
1933	480	263	238	229	412	237	105	38	0	770	580	440
1934	845	440	325	339	240	69	215	200	38	370	580	186
1935	206	278	339	600	333	289	66	28	0	150	1175	500
Avg.	413	394	333	381	369	208	83	70	8	435	730	424

Total 3848

Flow that can be diverted at the Lower Moencopi Diversion Dam

*This figure not used in computing average flow for June.

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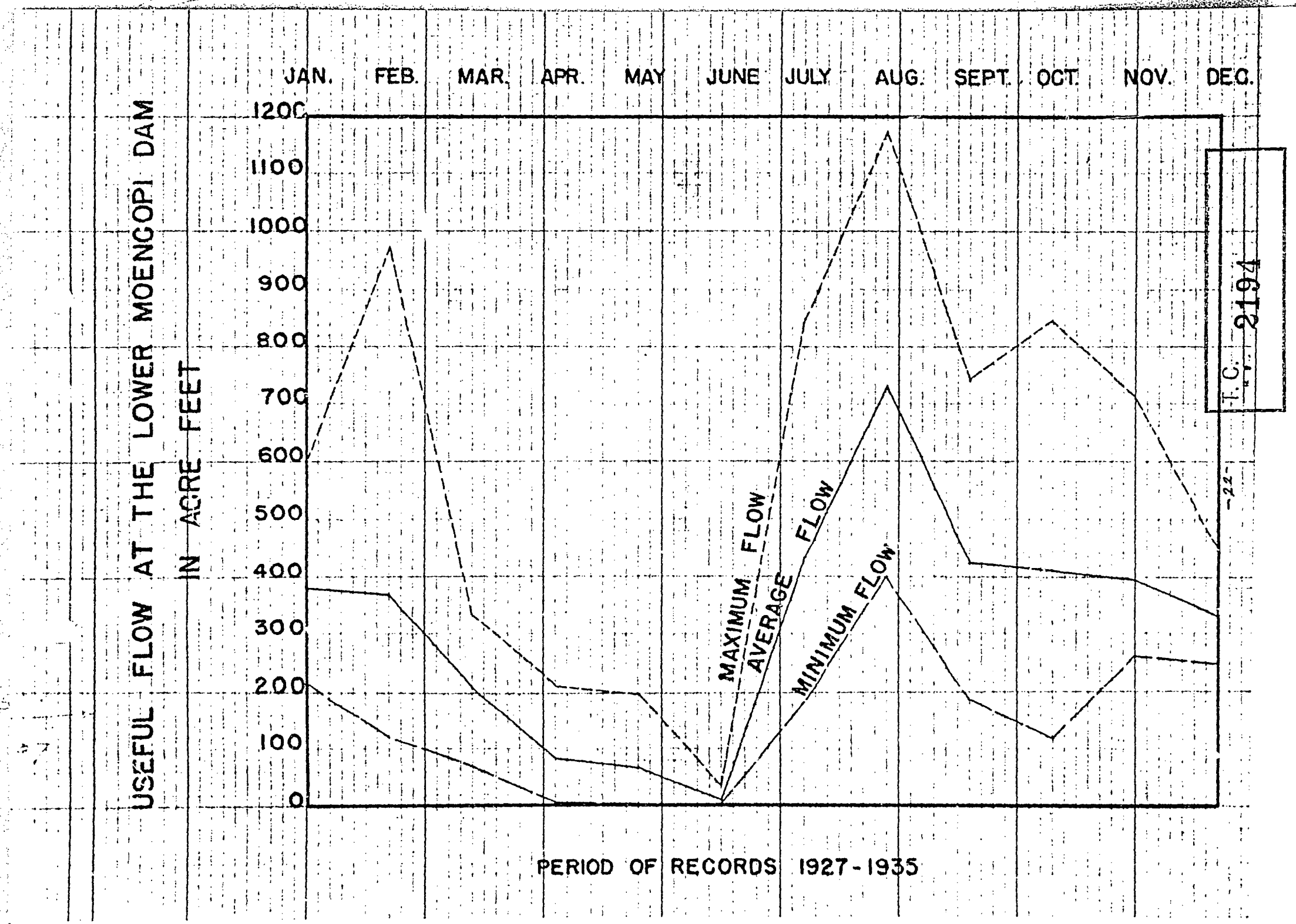

From a study of the above table and graph and from the daily records of flow on the Moencopi Wash, the following conclusions can be drawn:

1. Practically no irrigation water can be expected during the month of June.

2. Insufficient irrigation water can be expected once in five years for the period from May 1 to July 15.

3. Insufficient irrigation water can be expected in the month of April once in ten years.

4. An excess amount of water can be expected during the rest of the year.

5. It will be necessary to grow crops which will stand a certain amount of drought.

6. The land must be flooded during February and March in order to store soil moisture before the dry season.

There are 400 acres of land that can be irrigated from this diversion dam. As the main ditch line, including the necessary drops and checks, has been constructed, the only work necessary to finish the project is to rough level the land and construct borders. Leveling will consist chiefly of smoothing off the small hummocks. Rough leveling and bordering only is recommended on this project. Finish leveling and maintenance of borders should be required by the farmers as the land is allotted to them.

Due to the lack of water in the months of May and June it is suggested that only a limited amount of the land be subjugated. The type of crop will naturally affect the amount to be subjugated. It is suggested that about fifty acres be subjugated at once, however, this might be increased somewhat by the use of drought resisting crops. Recommended crops for this area can be found in the 1937 Agronomy report of this Unit.

Willow Springs and Vicinity.

This project lies directly northwest of the Mon Wave Demonstration Area and consists of several small farms. Most of the farms receive some irrigation water from the small springs at the base of the cliffs. The Indians have leveled most of the land and provided borders. They have also built a few small reservoirs and have dug small irrigation ditches. No work is suggested on the land itself as it is already in fairly good shape and is being maintained by the farmers. There are a few farms which need protection from storm water and also several locations where small storage reservoirs could be provided. A more detailed description of the work suggested will follow.

All of these farms are located on Quad. 110° 15' - 36° 15'. The farm numbers referred to in this report can be located on the Agronomy and Engineering map for this Unit.

Farm No. 8. Additional storage can be provided for this farm by increasing the size of the lower storage reservoir. The only work suggested is to raise the dam about three feet. This will allow the

three more acres of land.

Farm No. [illegible] A small amount of flood control is needed to divert the water away from the terraced land. Suggested treatment - 300 lineal feet of three foot dyke.

Farm No. 17.1 Flood control is also needed on this farm. It will require 500 lineal feet of 3.5 foot dyke to divert the water.

[illegible] stabilizers of about 5 cubic yards each are needed to check erosion in a small gully.

Farm No. [illegible] A storage reservoir of about 3 acre foot capacity can be [illegible] lineal feet of 8 foot dam. A head gate and [illegible] should be provided. A soil analysis should be run to determine the possibility of [illegible] the reservoir.

Farm [illegible] There is a small storage site on this farm. It is not recommended that this be increased, due to an excessive cost. The farmer should provide more storage for the permanent spring flow. The [illegible] is suggested for this farm:

200 lineal feet of 4' dyke

[illegible] fire sausages 5 cubic yards each

[illegible] provide 50 feet of 4 inch pipe to allow the flow from the spring be put under the above dyke.

An estimate of the cost of the above projects can be found in the [illegible]nd Management Construction" cards which

Cedar Ridge Farm Area

This area lies along the wash just north of Cedar Ridge. Although some use is made of flood water for irrigation purposes, more of this could be done. At the upper end of this project floods are not excessive and it is suggested that large borders be constructed across the entire valley to hold up and spread the water. At the lower end there is little that can be done to provide water for the farms. For the treatment of individual farms see the 1937 Agronomy report of Unit Number 3.

Navajo Spring

At present there is no farm land in this area. There is some possibility that about ten acres of irrigated land could be developed. A good location for a storage reservoir was found near the base of the cliffs. From here the water could be led to fairly level land by constructing about 2,000 lineal feet of lined ditch. The present flow from the spring is not sufficient to justify the project. However, residents state that the flow can be greatly increased with a little maintenance. No work should be done on this project until it is definitely found that there is sufficient water available. If at all feasible this land should be developed, as there are no farms of any kind in this section of Unit Number 3.

Water Spreading

There are very few possibilities for water spreading on this Unit. A large portion of the area is very sandy, allowing such a small amount of runoff that no defined drainages have developed. Much of the remaining area is either bad lands or is so rocky that little effective work can be done. The projects which were found to be feasible and desirable are listed below:

Quad. 111° 15' - 36° 00'. Water Spreading Area No. 1. This will be a rather small project lying two miles north of Cameron on the east side of Highway 89. A dyke about 300 feet long will be required to spread the water from a small gully on to 200 acres of sandy clay loam range land. The land lies on a 1% to 2% slope and few spreaders will be needed to control the water.

Quad. 111° 15' - 36° 15'. Water Spreading Area No. 15. This water spreading area will consist of several small spreading structures on the numerous small gullies. Some benefit will also be derived from erosion control as these gullies are causing head cutting along the west side of the Moencopi Wash. The soil is rather sandy in the spreading area and the general slope is 1%.

Erosion Control

There are only a few erosion control projects located on Unit 3. Cost estimates and location of these can be found in the Resource Inventory and Land Management Construction cards accompanying this report.

Most of these are small jobs and should be worked by a reservoir maintenance of conservation crew when such crews are in the vicinity of the projects. Sending a special crew in to do these jobs will add considerable to the cost. A crew can be sent to work both E-C #1 Quad 111°30' - 35°45' and E.C.#1 Quad 111°30' - 36°00 at the same time. The erosion control work recommended above on the Upper Moencopi farms can also be worked by a special crew.

Roads

The entire area of Unit Number 3 is accessible to cars. Most of the roads or car trails are passable except under the worst weather conditions. United States Highway #89 is surfaced from Cameron south to the Reservation boundary. North of Cameron the road bed is completed and a gravel surface is provided. At Cameron the Arizona State Highway has drawn plans for a new bridge across the Little Colorado River. I understand that this is to be built in the near future.

There is also a paved highway from Cameron west through Unit Number 3 to Grand Canyon.

The U.S.I.S. has made plans for improving the road from Highway #89 to Tuba City. There are three locations for this road through the Upper Moencopi Farms. Two of these go directly through the farm land. The third will roughly follow the present road. It is

recommended by the survey party that this third route be used. Very little, if any, farm land would have to be used at this location and it is evident that no farm land in the entire Unit should be used for any purpose other than farming. Due to the diversion dam on the Moencopi Wash this is probably the most valuable piece of land in this section of the Navajo Reservation.

The road east from Tuba City toward Red Lake (Tonalea) has been improved by the Indian Service Roads Department. The sub-grade is completed for a distance of about 15 miles from Tuba City. A gravel surface is provided on the first ten miles of this. Plans are made for the completion of this road as soon as funds are made available.

The Roads Department has also completed 16 miles of gravel road from Tuba City to the Coal Mine on the Tuba City-Kotevilla road. The completion of this road on over to Kotevilla is included in the work plans of this department. They also have plans for a bridge on the road across the Moencopi Wash at Moencopi. This bridge is very important to the management of the entire southeastern section of Unit Number 3 and it is suggested that this be completed as soon as possible.

There is also an ECW truck trail across Grey Mountain. No immediate work is required other than a small amount described above in this report. No improvements other than regular maintenance are needed on this road.

With the present roads and the completion of the above all-weather roads, all of this Unit will be accessible from any point on the Reservation, even in poor weather conditions. The completion of these

roads will also reduce the driving distance from Tuba City to the main offices of the Navajo Service.

Priority List of Projects.

Projects recommended for immediate work.

1. Work on Upper Moencopi Farm Land.
2. Pasture Canyon Project.
3. Lower Moencopi Farm Project.
4. Bridge across the Moencopi at the Moencopi Village crossing.
5. Cedar Ridge
6. Moa Nave - Reservoirs at potential farms Nos. 6, 16, 17.
7. Willow Springs Farm No. 11.
8. Completion of the Tuba City-Red Lake (Tonalea) and the Tuba-City-Hotevilla Roads.

All other projects described in this report are considered to be of a secondary nature. If it is desired to work any of these other projects, while a more detailed plan is being worked out for the immediate work projects, this will be favorable to the study group.

It is the opinion of the study group that the following projects are so obviously economically feasible and desirable that work can be started on them at once without extensive cost estimates being made. In other words, only a few days engineering work will be required to stake out the final plans for the structures and provide accurate yardage and cost

estimates. This list does not consider the requirements of the land or of the people but is only those projects which can be easily and quickly started.

1. Pacture Canyon Project.
2. W.S. #1 Quad 111° 15' - 36° 00'
3. W.S. #15 Quad 111° 15' - 36° 15'
4. E.C.#1 Quad 111° 30' - 35° 45' and E.C.#1 Quad 111° 30' - 36° 00'
5. Mon Have Demonstration Area proposed reservoirs A, B, and F.

Estimating Procedure

No accurate yardage estimates were possible in this survey. Any estimates which were made are merely from optical inspection of the location and therefore can be expected to be somewhat in error. They will, however, serve somewhat as a guide as to the size and feasibility of the project. The following unit costs were used in making these estimates:

Earth (Heavy Equipment)	15¢ per cubic yard
Earth (Team Work)	.30¢ per cubic yard
Spreader Fences (Wire)	9¢ per lineal foot
Rock Sausages (Wire and Rock). .	$3.45 per cubic yard

Future Plans

There will be projects developing from time to time which have not been covered by this report. Some places will have been missed on this survey and others will develop at a later date. Maintenance will be one of these big items. The following work can be expected to develop in the future:

1. Maintenance on all roads.
2. Maintenance of all irrigation projects.
3. New work on any erosion projects which have been missed on this survey or should develop at a later date.
4. Development of stock water according to range management plans.
5. A possible large storage site above the Moencopi farm projects.
6. More efficient use of the water on irrigation projects.

QUAD 110° 45' - 36° 00'

Job	Type of Work	PRIORITY Primary	PRIORITY Secondary	ACREAGE EFFECTED Cultivated	ACREAGE EFFECTED Range	Estimated Cost
E.C.#1	Frosion Control		x	10	750	$740.00
		QUAD 110° 45' - 36° 15'				
Farm #3	Farm Development		x	20		110.00
		QUAD 111° 00' - 36° 15'				
Pasture Canyon	Drainage and Irrigation Ditches	x		235		850.00
	550 Ft. of Pipe	x		235		710.00
	Raise Reservoir and provide spillway	x		235		640.00
		QUAD 111° 15' - 36° 00'				
#1	Water Spreading		x	200		200.00

QUAD 111° 15' - 36° 15'

Job	Type of Work	PRIORITY		ACREAGE AFFECTED		Estimated Cost
		Primary	Secondary	Cultivated	Range	
# 15	Water Spreading		x		800	400.00
Lower Moenkopi Dam	Diversion	x		400		500.00
	Subjugation	x		50- 400		15.00 per Acre
Upper Moenkopi Dam	Ditch Change	x		730		150.00
	Erosion Control	x		730		2400.00
	Flood Control	x		780		100.00
Moa Kave Dam. Area						
Location A	Farm Development	x		10		1150.00
	Subjugation	x		10		180.00
Location B	Farm Development	x		5		250.00
	Subjugation	x		5		75.00
Location C	Farm Development	(No estimate made - look into feasibility)				
Location D	Farm Development	"	"	"	"	"
Location E	Farm Development	"	"	"	"	"
Location F	Farm Development	(No estimate made - probably feasible)				

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QUAD 111° 15' - 36° 15' (Continued)

Job	Type of Work	PRIORITY		ACREAGE EFFECTED		Estimated Cost
		Primary	Secondary	Cultivated	Range	
Mon Nave Dem. Area (Continued)						
Farm #8	Farm Development	x				$ 90.00
Farm #9	Flood Control	x				110.00
Farm #10.1	Flood Control	x				350.00
Farm #11	Storage	x				450.00
Farm #12	Erosion Control	x				200.00
	QUAD 111° 30' - 35° 45'					
E.C.#1	Erosion Control		x		800	270.00
	QUAD 111° 30' - 36° 00'					
E.C.#1	Erosion Control along; Road	x				150.00

QUAD 111° 30' - 36° 30'

Job	Type of Work	PRIORITY Primary	Secondary	ACREAGE EFFECTED Cultivated	Range	Estimated Cost
Cedar Ridge Farms #1 to #1.3	Subjugation	x		45		$1125.00

QUAD 111° 30' - 37° 00'

Havajo Spring Farm #1	No estimate was made on this project, as it is necessary to develop the spring to see if there is enough water to make the project feasible.