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Mescalero, N.M., Dec.5, 1914.

Mr.H.F.Robinson,

Supt.of Irrigation,

Albuquerque, N.M.,

Dear Sir,

I have the honor to submit the following report on my investigations in regard to a diversion dam and ditch at Marsh Pass, Western Navajo Reservation, Arizona,

I left Tuba November 14, arriving at Marsh Pass the evening of November 16, and spent two and one half days there, arriving in Albuquerque November 27. While there, I spent a day and a half in looking over the project and looking up available material for construction, and one day in running a line of levels over the probable line of the ditch, taking profiles of the damsite, and measuring the flow in Laguna Creek, from which the water will be obtained.

A boarding school with a capacity of 60 children has just been established there, and opened this year for the first time with 25 children. The Indians in the vicinity seem to be very appreciative of any efforts made in their behalf, and are anxious to raise crops, as is seen from the way in which they take advantage of every small spring and seep, using every bit of water that they can develop to irrigate a small field or orchard. They have had very little contact with white men, and there are no returned students among them.

The school is 80 miles from Tuba, 150 miles from Gallup, and about 130 miles from Farmington. The elevation is

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around 6000 feet, and the annual rainfall is about 7 or 8 inches.

Irrigable Land There is from 100 to 150 acres of good land around in an old lake bed about one and one half miles west of the school, and just to the north and east of the school there is any amount of good land. The soil is an adobe, tho not very heavy, and some of that near the school is red sandy soil.

Laguna Creek. The water supply will be derived from Laguna Creek, which flows to the north of the school. The Creek rises about 15 miles above the damsite, and the upper portion of its watershed is very rocky, so that it rises to flood stage with almost every rain. Mr. Robertson, the school farmer informe me that during floods, which are very frequent during the summer, the water carries as much silt as the Moencopi Wash, and I have found up to 75-80 % of silt in the latter stream during floods. This amount of silt would prevent all a[illegible] [illegible] [illegible] [illegible] = to 30% + more

At the time that I visited the Creek, I made some rough measurements of the flow. In the middle of the morning the flow was about 4 second feet, and by noon it had increased to 6 second feet. This was probably due to the melting ice. Mr. Robertson states that this is about as low as the Creek ever gets. The water was of a reddish color, and I found about 5 % of silt in it. As there will be considerable ponded water above the diversion dam, this silt will in a large measure settle before entering the ditch, and what did enter would do no harm, with the possible exception of clogging up the reservoir of which I will speak of below. Not for long [illegible] [illegible] [illegible] work

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Diversion Damsite. The site for the diversion dam lies about three miles to the west of the school. At this point the banks of the Creek are lowered, and there id a ridge of sand rock which extends across the bed of the Creek. Above and below this site the Creek has cut thru the earth in a ravine ranging from 10 to 75 feet in depth, making this point about the only possible point of diversion. The Creek makes a right angled bend at this point, and the ditch would head on the inside of the curve, the dam being placed on the downstream side of the bend. Plate 1 gives a profile of the damsite.

Ditch Fr From the diversion dam the ditch will run on the right hand side, looking downstream, of the Creek for about a mile thru gently sloping ground. There will be about 700-900 feet of cutting thru sandstone, and several small gullies which may have to be flumed. At this point it will have to go thru a ridge about half a mile long from whence it will drop into the lake bed of which I spoke above.

Reservoir Site. This lake bed is baout 3500-4000 feet long, and not quite as widw. After a heavy rain Mr. Robertson says that there is a foot or so of water in it. Just beyond the lake bed there is a ridge 9 feet high, thru which a cut 1500 feet long could be made, and the water turned into a dry wash and taken out on the lands near the school. The soil in this lake bed is the same as the rest of the country, and if it were not used as a reservoir site, it would make good farming XX land, tho some provision would have to be made for carrying off the water which covers it after a storm.

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By placing a gate in the cut thru the ridge below the lake bed, with a depth of 7 or 8 feet it should store over 1000 acre feet of water, and there would still be from 80 to 100 acres of irrigable land above the water line. This land could be given to the Indians, and the school farm situated right at the school.

I do not know how many times the reservoir could be filled during the year, for the flood waters contain so much silt that they would not be available, and the evaporation from the large area of water surface would be considerable. However, as it would cost practically nothing to develop it for use as a reservoir, and there is plenty of good land near the school, I should consider it as being a good proposition.

Diversion Dam. Owing to the high cost of cement, due to the long haul from the railroad, and the lack of good material for aggregate, the most economical type of dam to install would be a crib dam, made of logs and filled with loose rock. From what measurements I could get of the high water marks, and slope of the stream, I should estimate that a flood flow of 7000 second feet would have to be taken care of. A dam with a crest length of 150 feet would pass this water with a depth of about 7 feet. A shorter crest length than this would make the abutments too high, and might cause considerable erosion of the downstream side, while it would not be practical to make the crest any longer, on account of the shape of the site, and probable increased cost.

The height of the diversion dam will depend on the depth of the cut thru the ridge mentioned above, the higher

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the dam the less the cut.Below are given some of the elevations which I took while at the damsite.

Location	Elevation
Bench Mark on top of bank at damsite	100.0
Bottom of Laguna Creek	84.8
Top of rock on south side of damsite	91.6
Top of rock on north side of damsite	89.4
High water mark about	95.0
Elevation of water surface 400' upstream	86.15
Elevation of water surface at damsite	85.21
Elevation of water surface 500' downstream	83.17
Ground surface-4200' from damsite-beginning of first ridge	92.6
Ground surface-5100' from damsite-top of first ridge	103.7
Edge of visible water line of old lake bed-9300' from damsite	90.7
Pottom of old lake bed	89.0
Top of second ridge-between old lake bed and dry wash-12900' from damsite	99.2
Probable end of ditch to bring water thru ridge into dry wash-13300' from damsite	

I have made estimates on two dams,with crest elevations of 97.0 and 101.0,heights 12' and 16' respectively, to show the relation between the height of dam and depth of cut thru the first ridge.I have assumed a log crib dam,12' in width,the back sheeted with 3"x 12" timber,and the top covered with the same.The crest length is to be 150',and the top of the abutments to be 8' higher than the crest.They are to trapezoidal in plan,12'thick with wing walls of 3"x 12"

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timber backed up with cribbihg,and an earth fill extending up the back to the hill,riprapped on the upstream side.Transverse logs are to be placed every 6'thru the length of the dam.A sluiceway 18' wide should be left in the top of the dam next the headgate,to keep the silt deposited during flood stages from filling up in front of the headgate.This floor of this sluiceway should be at the same elevation as the floor of the headgate,or lower if possible.

A ditch 3' on the bottom with 1½:1 side slopes and a grade of 0.0005 will carry about 6 second feet with a depth of water of 1 foot.This will about all the water that will come down the creek during its normal flow,and as I mentioned before,its flood flow has so much silt that it will be useless.

The top of the dam should slope up towards the downstream side,and there should be a water cushion of cribbihg 12' wide and half the height of the main dam on the downstream side.I do not think that the rock on the downstream side of the dam will cut away to any toany extent,as there is a small falls about 300'below the damsite where the water has cutthru the rock,and the Indians say that they have been in the same position for as long as they can remember.By the above arrangement,there will be two drops of from 6 to'8' on the downstream side of the dam,depending on the height of dam used.

The bottom logs in the cribbihg will be anchored to the bedrock by bolts let into the rock and fastened,coming up thru the logs and having a nut on their top.The rest of the logs will be fastened together with drift bolts.In estimating the number of logs required for the cribbing,I have

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assumedthat the logs are dapped so that they are 8"thick.

As from indications it would appear that the bed-rock is fairly level all the way across, the earthon the axis of the dam should be excavated qll of the way across both for the dam proper and the water cushion. This excavated earth can be placed in the embankment back of the abutments.

I will not submit a detailed plan of the dam, as it would have to be changed considerably when it was built, for I did not have time to make complete investigations, and it might be possible that with a little time given to it, a site obtained by moving the dam a short ways up or downstream would lessen the cost and at the same time make a stronger ~~XXXX~~ dam.

Headgate and Wasteway — The headgate will be placed just above the dam, so that the ditch is taken out at right angles t to the direction of the current. The front wall should be carried at least 8' above the crest of the dam. As the floor will, rest on earth it should have cutoff walls both in front and in back, and wing walls extending well into the banks.

Just below the headgate the ditch runs thru a ledge of sandstone, and a wasteway can be put in the ditch here with very little expense. It would be advisable to put this wasteway in, as it will considerably lessen the danger of the ditch washing out during high water when the headgates are not closed.

Material Labor etc. — There are a considerable number of cedar and pinon trees on the west of thedamsite, from which logs 12 feet in length and ranging from

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6"to 12" in thicknews can be obtained with an average haul of two and one half miles.To the south of the school on top of a mesa there are a large quantity of spruce timber,from which logs any length and any thickness can be obtained.They will hav have to be snaked down the side of the mountain by horses on a trail,and hauled to the damsite.Teams can make two trips a day from there,and the road is very good.I would suggest that the logs be cut and peeled in time to let them dry out well before they are hauled,as this will considerably lessen the cost of hauling.While the logs are drying work can be carried on building the ditch.

There is plenty of sandstone at the damsite,but as it would be alternately wet and dried,and there is considerable freezing westher in the winter,I do not think that it would be advisable to use it in the cribs.There is a ledge of very dense limestone or dolomite occuring in a dwaw about 2 miles fr from the dam,and this can be taken out in pieces running from 6"to 15"in thickness,and would make very good filling for the cribs.It is possible that there could be found a ledge nearer to the site with a little prospecting.

Sand can be found in most of the draws near the damsite.It is very fine,however,and contains about 5-8 % of dirt. Mr.Robertson informs me that good concrete gravel can be found in one of the canons of the Black Mesa,about 3 miles from the damsite.

Dimension lumber would have to be obtained either ~~fr~~ from the mills in Flagstaff,where it would cost about $ 85.00 per thousand,delivered,or possibly from the mills on the Fort

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Defiance Reservation,where the haul would not be so great.

Mr.Wetherill,the trader at Marsh Pass says that he pays the Indians $ 2.00 per cwt.for freighting from Gallup,and $ 1.75 per cwt.from Farmington.The school pays $ 2.50 per cwt. fro m Flagstaff,tho probably it could be done for less in large quantities.

The Indians in the vicinity have plenty of teams,but have practically no wagons or scrapers.They are very anxious to work for them on issue,and if it were possible,I think that they would willingly work for such things,or for picks,shovels or axes.Unless they were furnished these implements before the work commenced,The Government would have to furnish them to the Indians and them turn them over to the school after the work had been completed.Supt.Runke informed me that they were going to issue some implements to the Indians this year.

Mr.Robertson tells me that the Indians work for from $ 1.00 to $ 1.25 per day singlehanded and for $ 2.25 to $ 2.50 per day with teams,and that they are very good workmen,doing a full days work.

In the following estimate I have shown quantities and costs for two dams,one 12' and the other 16'in height.If the work on the dam proper is carried on during the time when there is no danger from floods,i.e.,between the middle of September and the middle of June,I think that the totals will come within the estimate.

It will be seen that the higher dam gives the lesser cost,due to the smaller amount of earth excavated from the

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ridge between the dam and the old lake bed.

Estimate of cost of construction.	12' dam		16' dam	
Description	Quantity	Cost	Quantity	Cost
Diversion dam				
Headgate-Lumber @ $ 95/M	2200	$ 209	2400	$ 228
Excavation, Gates, etc.,		35		45
Logs for cribs-@ .70 in place	700	490	900	630
Dimension lumber @ $ 95/M	14000	1330	16000	1520
Rock for cribs & riprap @ $ 8.00 per cord	205	1640	330	2640
Earth embankment at ends of dam @ .25 per C.Y.	600	150	1200	300
Total-Diversion dam		$ 3854		$ 5363
Wasteway		100		100
Ditch excavation				
Rock @ $ 1.00 per C.Y.	200	200	200	200
Earth @ .25 per C.Y.	22500	5625	13000	3250
Cutlet gate in Reservoir		100		100
Total for Ditch		$ 6025		$ 3650
Tools, equipments, etc		300		300
Total-Dam and Ditch		$10179		$ 9313
Engineering-Superintendence, 5 %		509		466
Contingincies-etc, 10 %		1018		931
Grand Total		$11806		$10710

From the above estimate it will be seem that there is a difference in the cost of the two dams, in the favor of the higher one, of about 10 %.

The above estimate does not take into consideration the placing of the water on the land, but this would be done by

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the school or Indians receiving the water.

Assumming that, by the aid of storage, there could be irrigated between 500 and 600 acres of land, this would bring the cost per acre about $ 20, which is very reasonable.

At present there is nothing in the way of a farmat the school. They pay from $ 45 to $ 70 per ton for Hay for the stock, and corresponding prices for grain. If 100-150 acres of land were put under cultivation for the school farm, it would be ample for some time to come, and the rest would be eagerly ta taken up by Indians. Most of these Indians have flocks of sheep or herds of cattle, and if they were given 10 or 15 acres of land apiece, under water, they could get along very well.

Respectfully yours,

Donald M. Baker.

Assistant Engineer.

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