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Tuba, Ariz., April 5th, 1908.

Mr. W. H. Code,  
Chief Engineer,  
Los Angeles, Cal.

Sir:

Concerning the work to be done at Tuba, I have to report as follows. Will discuss the matter under three heads: Work on the School lands, Work in Reservoir Canon, and work in the Moencopi wash.

S C H O O L .

The school has about 160 acres fenced about 40 acres of this being farmed now, the most valuable part being the orchards which represent a great amount of time and money in their development.

Water for school use is taken from spring "A" (on sketch). The overflow from "A" and the flow from "B" runs into reservoir 1, or reservoir 2 as desired. Reservoir 3 was thrown up to catch the seepage from the east bank of 2. Spring "C" runs into reservoir 4, and the overflow from 4 is now emptied into reservoir 5. This latter was originally built to impound the flood waters coming down the draw partly shown on the sketch.

The seepage from reservoir 4 has been of such amount as to ruin several acres of land directly in front of the reservoir by soaking the ground and bringing the alkaline salts in the soil to the top.

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The overflow from "A" and the run of "B" amount to .1 sec. ft. The run from "C" is .08 sec. ft. Measurements showed a loss of 10-18 % between the springs and the point where the water is emptied into the reservoirs.

Reservoir 1 is necessary to water the lands north of the school and west of the road. Unless the water is caught for a time in the reservoirs, then suddenly applied to the lands, by the seepage and evaporation in the distributaries enough water is lost to make irrigation very slow and almost impossible. Reservoir 1 has an area of about .2 acres and holds approximately .4 acre ft. This should be enlarged by raising the banks, and made to hold 1.6 acre ft., about a week's run of the spring. To do this would necessitate moving 900 yards of dirt and placing an impervious core in a fill about 260 ft. long and 8 ft. high.

Reservoir 2 has an area of 4.2 acres and a capacity of eight acre ft. Reservoir three holds about 2.5 acre ft. Reservoir 2 could be enlarged to hold about 40 acre ft. about the run of the springs "A", "B" and "C" for the five months when the water is not used for irrigation and must be allowed to go to waste for lack of sufficient storage capacity.

To do this would require moving about 14,000 yards of dirt and placing a core 1,400 ft. long in the fill.

Reservoir 4 could be abandoned, irrigating the field below by the run of the spring and a ditch from 2 which would reach the lower

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portion of this field.

The bank of reservoir 5 could be raised and this made to hold about 8 acre ft.

By doing this work all the water could be utilized, and by having enough storage capacity it would insure crops which are now partial failures for lack of water when the fruit is half grown, or the fields partly up.

This complete program involves the moving of 18,000 yards of dirt and placing 2,000 sq. yds. of a core, and protecting by rip rap and brush 2,500 sq. yds.

Bottle tests of the best available material for embankments showed from 80 to 90 % of very fine sand, and 20 to 10 % clay. This would be satisfactory for wide fills and flat slopes, but to stop excessive seepage some core or cut-off is required. Layers of fine sand are also found. There is the additional danger of gophers or other burrowing animals starting a leak in the banks, which, if not discovered and promptly stopped, would cause a serious break and might ruin the fields and orchards below. This danger is lessened by the core or cut-off.

The stone near here is a very soft sand stone and hardly deserves the name stone. In places this is capped by a thin layer of hard blue limestone. Lumber delivered at Flagstaff costs from \$25.00 to \$28.00 per M. but its cost here after hauling the 95 miles would be from \$60.00 to \$70.00 per M. Also, the time of its delivery would be

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uncertain as often several days are lost in crossing the Little Colorado river, and it is no unusual occurrence for horses and wagons to be lost in the river.

60 M. ft. B. M. at least would be required for the cut-off wall if lumber is used.

I have found no gravel in any quantity, so concrete work is almost impossible. The core might be built of cement plaster 4" thick laid on wire mesh, or expanded metal reinforcing. This would require 2,000 sq. yds. of reinforcing, and about 250 yds of mortar and about 450 bbls. of cement. Cement could hardly be delivered here for less than \$9.00 to \$10.00 per bbl.

The limestone in 4" to 6" layers can be had at \$7.00 per cord, or about \$1.50 per cu. yd. enough to pave 5 sq. yds. The cement would cost \$6.00 per cu. yd. stone laid, or cost stone and cement about \$1.50 per sq. yd. paved. It seems as if this would be the most feasible plan, stone grouted well in cement mortar.

Test pits along the toe of the lower banks of reservoir 2 showed from 2' to 3' of sandy soil and then a layer of quicksand mixed with a small percentage of sticky thin clay.

I suggest the plan for the core wall shown on the sketch. Start the core of stone and mortar below the present surface of the ground just above the quicksand, then drive or jet a row of short sheet piling as shown. I believe this would give an efficient cut-off. The sheet piling would last a long time being below the plane of moisture.

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To save all the water it would be necessary to use 4" spiral pipes from the springs to the reservoirs. By abandoning reservoir 4 and lowering the water in spring "C", its flow could be materially increased as at present there is about 11' of water and quicksand over the crevices in the rock from which this spring flows.

This is a most expensive proposition. I believe, however, it is highly necessary to have this system made as efficient as possible. Tuba is the only place where enough water is to be had to raise crops, forage, etc. on this western extension of the Navajo Reservation. Some farming is done by the Indians on a small scale at Navajo Springs about 60 miles north of Tuba.

Tuba is the natural base of operations, and it is important that the government have sufficient forage, etc. here to be able to make this the starting point and headquarters for conducting operations over the reservation.

For the school, I estimate as follows:

Dirt work	\$5000.00
Core	6000.00
Rip rap	<u>2500.00</u>
Total	\$13500.00

RESERVOIR CANON.

Reservoir Canon is situated about 2 miles east of Tuba, and runs in the general direction of North and South.

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Measurement of the combined flow of all the springs in the canon showed a flow of about .5 second feet.

In this canon there are three lakes or reservoirs. The lower one is about 15 acres in area, and here there is a dam about 350 ft. long and 5 ft. high. Through a head gate in this dam the lake can be lowered about 5 ft. Thus approximately 75 acre ft. are drawn off for use during the season. There is considerable seepage through this dam.

The middle reservoir has an area of about ten acres, and is about half a mile north, and, I should judge, 20' to 30' higher than the lower lake.

There appears to have been an old Mormon dam here. It might be possible to put in a low dam at this point, putting the head gates 4' or 5' lower than the present level of the water.

It is my intention to make a survey of this canon as soon as I can, and join same with a survey of the Moencopi wash and work done here to give a comprehensive map of the school, Reservoir Canon and Moencopi.

The prevailing winds are from the southwest, and in places along this canon are shifting wind formed sand hills. One of these sand hills is at the mouth of the middle lake, and another has almost closed the canon at the upper reservoir. This third reservoir has an area of about six acres, but the flow only measured .35 sec. ft. into this reservoir.

These moving sand hills complicate the problem, as the head gates must be placed so the hill cannot bury the inlet to the gates,

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and the dam must be placed so as to join a more impervious material on the ends.

The water is used by the Indians for farms lower down in the canon, and also in the Moencopi wash.

These latter lands cannot be easily watered from the Moencopi because a ditch taken out farther up the wash would involve a high dam in the stream channel and fluming the ditch around some bluffs, the stream flowing around the foot of these bluffs.

It would be quite feasible to enlarge these dams so as to store about 150 acre ft. (about five months' run) either in the lower, or the lower and middle one combined.

As now operated the gates at the lower lake are closed as soon as the season is over, but for about three months after filling this reservoir, the water runs over the spillway and is allowed to go to waste. To raise the lower dam looks to be the easiest plan, making the reservoir of sufficient capacity to hold 150 acre ft. It would be necessary to put some sort of cut-off in dam, and would use the same plan as described in the large reservoir on the school farm.

Would estimate about \$6000.00 for the dam in reservoir canon as I do not consider it nearly as difficult a problem as holding the water in the school reservoir.

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MOENCOP I WASH.

Mr. Janus has about 200 acres now under water in the Moencopi bottom. The run of the stream is about 2.5 acre ft. and this is only utilized during the day time, storing the water in the diversion during the night.

There are remains of an old ditch some 2 miles below the land mentioned above, and if the water were available, several hundred more acres could be put under ditch.

There is reported to be an excellent dam site about 20 miles from here. As the Moencopi has a large drainage basin, and during flood times a large amount of water comes down the wash, it appears that this water could be stored and utilized on lands not irrigated because of the paucity of the steady flow.

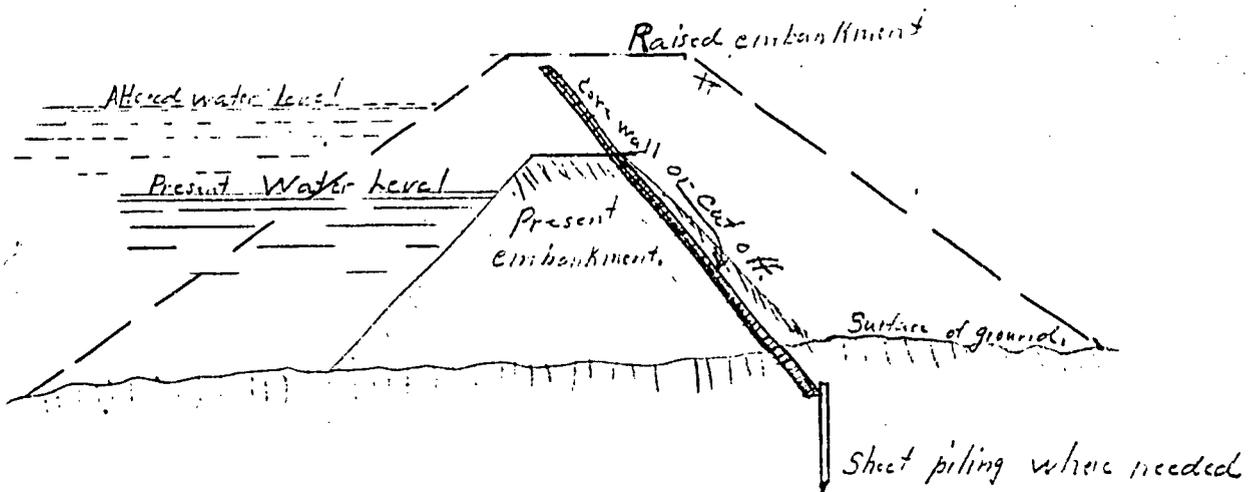
I would like authority to investigate and report on this, if such a proposition is favorably considered.

I will work on the temporary dam in the Moencopi, as outlined in my report of March 25th, then I would like to be informed as to the next move desired.

Reservoir 1 could be done first, using this to save the water while proceeding with reservoir 2, if anything is done with this project. Work should be deferred in reservoir canon until the lakes are emptied, as this would lessen the chances of accidents while doing the work.

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Sketch of proposed alterations  
in reservoirs



Front to be protected by rip rap & brush

H. F. Robinson Supt.

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