WATER CONSERVATION

IN THE CITY OF PASADENA

F. Sherman Hale

June 6, 1947

OBJECT

The object of this report will be to make a complete study of the water that is wasted in the storm drains of Pasadena and determine if there is any practical way of conserving this water.

The subject matter of this report has for a long time interested Pasadena's business men. They have made their interest known in many ways, some by writing in the paper, others by coming up to the city water office and talking of the plans. One real estate agent was so interested in this problem that he offered a thousand dollar prize to any one who could devise a method by which the water flowing away in the storm drains could be reclaimed and used by the city. The answers that he received were exceedingly interesting, but when they were turned over to the city water department they proved to be only an imaginary solution and not at all practical. Most of them would not work at all and those that would work were so expensive that they would be very impractical to use.

One of the best solutions was published in the Star News. This article treated the whole question so extensively that I have embodied it in my report and the following is an exact copy of the article just as it was published.

"Although the plan is one of interest, Samuel B. Morris, chief engineer-superintendent of the Municipal Water Department does not regard as practicable the scheme suggested by Ernon V. Oliver, Portland, Oregon, for the conservation of flood water in Pasadena.

"In a letter to The Star-News, Mr. Oliver, who is a former resident of Pasadena, suggests that the city conserve the storm water by having large storage pits dug throughout the city, filled with coarse sand and gravel, into which the water would percolate. By this means, he believes, the underground source of supply would be replenished.

"Mr. Morris, after reading Mr. Oliver's suggestion, admitted that it was unique and might have merit in some sections, but that the cost would make water almost prohibitive. Roundly, Mr. Morris estimates it would cost about $3000 per acre to carry out Mr. Oliver's plan.

"Mr. Oliver writes that he is interested in Pasadena's water problem, which he believes is, by all adds, causing more vexation and worry than any other that now confronts Southern Californis.

"Having pointed out the need of conserving every drop of rain water, Mr. Oliver tells how, in his opinion, this scheme could be carried out. He states that Pasadena possesses the legal right of eminent domain over all of the property within its city limits, and, therefore, can pass an ordinance requiring all property owners to save all the water that falls on their land.

"He would put unemployed men at work digging deep holes in every block, wells from seventy five to one hundred feet in depth, and from ten to fifteen feet in diameter, with tunnelled arms radiating outward and downward from the bottom of each pit for a distance of one hundred feet from the vertical shaft. Then he proposes that the holes be filled with sand and gravel and the tops of them used in summer time as sand playgrounds for children. The earth from the pits, Mr. Oliver would use in filling in low lands.

"'By Having enough of these pits", states Mr. Oliver, in closing, "every drop of rainfall could be conserved and none would reach the ocean. Your sub-soil would be full of water. Then great areas otherwise unoccupied could be planted to alfalfa, eucalyptus and fruit trees having long root systems. These would thrive on the underground supply, and a vegetable covering for your soil would be obtained that would keep your now parched air humid and tend to increase your rainfall, thus reversing the vicious circle that now obtains, wherein a lack of rainfall prevents vegetation from growing and a lack of vegetation tends noticeably to decrease the rainfall and speed up the runoff of what little does fall." "

Here, at least, is a plan that created a great deal of attention and appears practical until it has been studied a little farther into it.

First, however, I want to say a word or two about the water supply of the city and explain why there is such a great need for concern over the city's water supply. The city of Pasadena has two sources of water supply, one from the mountain streams in the mountains to the north of the city and the other source from two natural underground basins. These natural basins were formed by the faulting of the earth's crust and erosion of the earth's crust tipped downward towards the mountains on the north and upward to the south. If it had not been for the rapid erosion of the streams that kept filling in the depression with loose gravel and rocks from the mountains to the north, great lakes would have been formed, but instead of lakes, two underground basins were formed in which the water for past geological years has been stored. The edges of these blocks as they tipped prevented hard materials which have resisted erosion and they, due to the fact that they have not been washed away as fast as the surrounding soils, have formed hills which are plainly visible to anyone visiting Pasadena. The edge of the upper basin is not so plain but as you go north along Lincoln Avenue you find a place where the road is in a cut. This cut marks the intersection of Lincoln Avenue and the edge of the upper block. If you observe carefully you can follow the low ridge that lies in an east and west direction from there. The edge of the lower basin is more prominent, being marked very plainly by a ridge of low hills just south of Pasadena. Both the Raymond and the Huntington hotels are built on this ridge of hills. This ridge of hills extends from the Arroyo Seco on one side to the mountains on the other, thus forming a complete dam across the valley.

In developing her water supply the city of Pasadena has pumped water from this underground basin so fast that in late years the water level in it has been rapidly lowering and deeper and deeper wells have had to be dug. Even to a casual observer it is very plain that the surface area of basins formed in this way decreases very rapidly as the water lowers. This means that as the water is pumped from deeper and deeper wells the same volume of water will lower the level of the basin that much more. There is a limit beyond which it will not pay to pump the water and even if there were no limit to the depth to which water might be pumped, the supply of water for the underground basin does not equal the demand. Therefore, it is only a short time at best that the city of Pasadena can continue to draw water from these underground basins at the present rate.

Devils Gate Dam was built for two purposes--to control the floods from the Arroyo Seco and to increase this supply of water for these underground basins. Just above Devils Gate Dam the east side of the Arroyo Seco is porous and allows the water that is checked by the Devils Gate Dam to seep into it and replenish the underground basins. It has helped greatly, but it does not add enough water to the underground basin to prevent the water level from continuing to lower. Mr. Oliver proposes to supplement the underground supply by diggin pits and allowing the water to seep into the ground to these underground basins and thus increase the supply. It sound very feasible at first glance. What a natural solution! Here you have the water at the surface and an underground basin below it. Why not connect the two? That is, dig pits in which the water will collect and seep into the ground and be purified ready to be pumped out in pumps that are already operating and need the water.

It is with surprise that we read on and find that Mr. Morris estimates that the cost of saving the water by this method will be about three thousand dollars per acre, a figure that at once makes the plan impractical and almost valueless. Why should what appears to be such a simple process cost so much money? As we study into the details we will realize that what appeared to be such a simple solution is complicated by many details.

The first step in the study of this problem is to determine the quantity of water that is wasted in the storm drains in order to know how much to save. The runoff data obtainable is very limited as records of the runoff have only been kept since 1923, and 1927 records have not been compiled. Below are shown the tables as published by the state in their annual report of the San Gabriel drainage basin, Bulletin No. 5.

Monthly Runoff in Acre-feet   Upper Rubbion Wash

Season	Oct.	Nov.	Ded.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1923-1924	24.2	4.0	49.3	57.7	2.2	28.6	94.6			518
1924-1925	21.2	47.4	61.0	5.8	15.5	77.3	88.6	18.6	6.7	342
1925-1926	24.9	24.8	94.2	106	198	10.7	455			914
Averages for 3 yrs.	23.4	25.4	68.16	56.5	71.9	158.0	212.7	6.2	2.3	591.3

Monthly Runoff in Acre-feet   Upper Alhambra Wash

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1923-1924	14.9	2.0	28.9	23.2	4.8	134	43.8			252
1924-1925	21.2	41.0	37.7	5.4	15.7	61.3	111.	9.3	68.1	310
1925-1926	14.5	11.9	60.0	94.0	210	12.1	318			720
Averages yaearly	16.8	18.3								427.3

Total averages for both storm drains is 1018.6 acre feet per year.

The runoff from Pasadena is divided. The extreme east drain or the Upper Rubbion drains the east portion of Pasadena, an area of 10.66 square miles of city and 2.17 square miles of mountains northeast of Pasadena. The other, known in the State report as the Upper Alhambra, drains an area of 2.63 square miles of business district.

The average runoff for these three years from the Upper Rubbion Wash is 591.3 acre feet and the average from the Upper Alhambra is 427.3 acre feet, making a total average yearly runoff of 1018.6 acre feet of water wasted for the past three years.

The average yearly rainfall in Pasadena since 1884 has been 20.7 inches. The average for the years 1925 to 19[illegible] is only 14.1[illegible] inches. This would indicate that the average runoff would be about 1.4 times the average for these years. This means that instead of wasting only 1,000 acre feet Pasadena is losing about 1,00 time 1.4 or 1,400 acre feet per year.

In the pits the water would seep away very gradually and in some wet years more than the aberage rainfall falls in one month so the pits should have a capacity to store at least the average runoff for one year without figuring on any of it seeping away. Thus there would have to be a volume of 1,400 acre feet in pits. If loose gravel and sand are placed in the pits the volume must be increased in proportion or the pits should have a volume of about 2,00 acre foot. If we make the pits twenty five feet deep they would accupy eighty acres of land. The average value of land at convenient locations is about $5,000 per acre. At this rate it would cost $400,000 to buy the land alone. Compare this to the present selling price of water to customers of the city of Pasadena, namely, 13 cents per 100 cubit feet.

1,400 x 43,560 x $.0013 = $79,400 per year.

Capitalizing this yearly saving at 6% = $1,725,000.

These figures show that it would be profitable for the city of Pasadena to spend about thirteen hundred thousand dollars in order to save this water if there were no upkeep.

The cost of excavating and wasting the soil from the pit would be about $1,940,000 and to refill the pits with gravel would be about $2,910,000. These three items alone have already run the cost of construction about five times higher than the present value of water would justify and we have only begun to take care of the water, for in the operation of each pit there will be a large maintainence expense. The pit will fill up with debree and fine particles of sand and clay will clog the sand and make it so that the sand will have to be replaced after a short time or the water will not seep into the sands of the pits to theunderground basins. Thus, besides the original prohibitive cost, there is a cost of upkeep which is equally prohibitive. This plan must be regarded as absolutely impracticable.

Mr. Oliver's plan to use the army of the unemployed to dig the pits in smaller units is farther from a reasonable solution. Anyone who knows anything about excavation knows that excavating in large quantities from one place by steam shovel is very much cheaper than excavating an equal volume from a lot of places by hand even when labor is very cheap. To make these individual sand pits would only complicate the up-keep, fo instead of just one place to look after and keep cleaned a large number would have to be cleaned and cared for.

Another plan that at first sight appears to be practical is to construct a reservoir with capacity enough to hold the water for a few months and pump it up back of Devils Gate Dam in order to allow it to seep into the sub basins there. Since the drainage ditches are still there these basins would not have to be large enough to store all the water. A fair estimate of the capacity of such a reservoir is 300 acre feet. To construct such a reservoir, suppose we use 10 acres. The reservoir would have to be an average of 30 feet deep.

Estimate on construction or reservoir.

Average of thirty feet deep

$30 \times 43,560 \times 10 = 13,068,000$ cubic feet

$\frac{13,068,000}{27} = 483,000$ cubic yards
$.30 cost of excavating per yard
144,900.00 cost of earth work on reservoir

Concrete to cover 6" deep--

$\frac{10 \times 43,560}{2} \times \frac{5}{4} = 272,000$ cubic feet of concrete

Note: Factor $\frac{5}{4}$ to take account of side walls and partitions.

From Merriman's handbook reinforced concrete, six inches thick, is 50 to 80 cents per cubic feet. This type of concrete would be simple and it is a big job so that 50 cents per unit of volume is probably a very high figure.

$.50 x 272,000 = $136,000 cost of concrete.

Cost of constructing reservoir.--

Excavation	$144,900
Concrete	136,000
Total	280,900

280,900
x.05
$14,045.00

Cost of pumping in Pasadena--

It has been estimated as $7 to raise 1 acre foot 100 feet.

1,000 acre feet to be raised 550 feet.

$$1,000 \times \frac{550}{100} \times \$7 = \$38,500$$

14,045
$52,545

It will cost over $52,000 this year just to catch the water in a reservoir and raise it 550 feet. This shows that by the time that the additional expense of building additional storm drains, pipes and filtering of the water before pumping it would run the cost away up above the present valuation of the water and probably make the water saved in this way cost nearly doubly the present valuation.

Another and probably a more economical plan would be to divert as much of the water from the higher parts of Pasadena as will flow by gravity to Devils Gate Dam. Then in the present storm drains enlarge a certain section to allow for settling and storage of water so that it would be convenient to pump.

Estimate Of The Value of This Plan.

Water from Los Flores Canyon and Rubbion Canyon could be diverted and would flow by gravity to the reservoir. The area drained by these two streams is 1/5 that of all the rest.

The slopes are steeper and the ground is in a condition to aid runoff. This would mean that a great proportion of the rain goes into the runoff so that from 1/4 to 1/3 of total runoff in Rubbion is in the upper part.

Or about $\frac{600}{4} = 150$ acre feet.

The next thing is to discover the point at or below which it would be uneconomical to pump the water back up to this upper drain. The main expense of this is to build a small size reservoir and settling basin in which to collect the water before pumping. It certainly would not be economical to instal pumps large enough to pump all the water up as fast as it collected in the storms, for then the pumps would only work at capacity for very short time and the rest of the time these big pumps would be idle and out of service. If we place the pumps so that they will pump back the next third of the storm below this proposed storm drain, the selling price of this water will be $8,500 per year.

Capitalized value of this water equals $\frac{8,500}{.06} = \$140,000$

Estimated capacity of reservoir.

Maximum flow as recorded in past three years is $\frac{430}{3} = 133$ acre feet per month.

```
133 x 43,560 = 5,800,000 cubic feet volume of water
              -1,296,000 cubic feet removed by pumps
               4,504,000 cubic feet capacity of reservoir
```

To build such a reservoir it would take a pit covering five acres and twenty feet deep.

Cost of Reservoir--

Site	$5,000 x 5 =		$25,000
Excavation	$\frac{20 \times 5 \times 43,560 \times .60}{27}$ =		$48,500
Concrete	$\frac{5}{4} \times \frac{5 \times 43,560}{2} \times .50$ =		$68.450
Total cost of reservoir			$141,950

Cost of pumping--

150 x 2.5 x $7 =		$2.630	
Capitalizing at 6%			$4,290
Total estimate cost of putting water back into Devils Gate Dam			$146,240

The capitalized value of water is $140,000. Therefore, this plan is not as far from working as the other but the capitalized value of the water does not in any way represent the value of water delivered into Devils Gate Dam, for after the water has been allowed to seep into underground basin from Devils Gate Dam it must be again pumped to the surface and that would cost more money. This plan might be feasible if the value of the water was to double that at the present time.

Conclusion

The conclusion that I have reached in this study is that any attempt to cause the water to seep directly into the ground by digging large pits or small pits and filling them with gravel to aid in seepage is unpractical for several reasons. First, it is impractical due to the cost of making such pits and the expensive upkeep caused by the filling of the sand with clay particles. Second, an economic saving of part of the water may be accomplished by building a new storm drain so that water will flow in it by gravity to Devils Gate reservoir and yet drain the mountainous area now drained by the east drain and wasted into the Rubido Canyon. Third, it may be economical in later years to build reservoirs a little below this storm drain to catch the storm water for storage while it is being pumped up into Devils Gate Dam. This would not be worth doing until the selling price of water has doubled the present selling price.