Irrigation Canals and Reservoirs.

C. E. Rice. Class of '97.

Outline.

Reservoirs.
- Water Supply.
- Situation.
- Building.
  - Materials for construction.
  - Methods of building.
- Earthen and Masonry reservoirs.
- Examples of Reservoirs.

Canals.
- Water Supply.
- Route of Canal
- Construction.
  - Shape.
  - Grades.
  - Flumes.
  - Headworks
    - Head gates,
    - Waste gates
    - Sandgates.
  - Laterals.
- Loss of Water
  - Evaporation + Seepage.
- Cost of Canals.
- Examples.

The all important question to the modern farmer is that of water supply. In the eastern and southern States the annual rainfall is sufficient for all agricultural purposes and sometimes necessitates drainage, but in the more arid regions of the west the rainfall is not sufficient and the farmer must help nature in the struggle with drouth. By skillful use of the rainfall, the arid deserts of Utah have become luxurious gardens, the valleys of Colorado have become as productive as her mines, the endless stretch of buffalo grass in southwestern Kansas has changed to a green sea of alfalfa, and throughout the whole arid west the course of the canal is marked by prosperous homes.

The subject of irrigation is too extensive for one person to thoroughly put forth in so limited an article, so only one phase of it will be discussed; irrigation canal and reservoirs.

The water supply comes from several distinct sources, namely: natural lakes and reservoirs, rivers, artesian wells and underflow waters, and surface waters. Of these, the surface waters are most commonly stored in reservoirs.

The irrigator who has a reservoir has the equivilent to a gold mine. He has a supply of water always on hand and need not be in fear of drouth. The water of a wet year can be stored for a dry one. A very small percent of the annual rainfall, if properly stored, would be sufficient to water all arid America.

Reservoirs, by storing the storm waters, considerably lessen the danger of floods which every year do so much damage. If a sufficient number of large reservoirs should be built the country would recieve a twofold benefit, floods would be lessened and thousands of square miles of land, now useless, would become productive. The also increase the moisture of the atmosphere making a cooler climate and increasing the rainfall.

In building a reservoir the first step is in selecting the site. This must be chosen in consideration of the area and character of the land to be irrigated, distance from the land, area of the watershed from which the water is to be obtained, the drainage which will fill the reservoir, and the maximum and minimum rainfall of the water shed. It is always advisable to build it of such capacity as to hold more than the minimum rainfall, to provide in a wet year for a dry one. It is always best to select as economic a basin as possible. Often it is possible to make a good reservoir with very little work by improving a small lake or pond.

Reservoirs should always be in a position out of danger of floods. If in a place where water will flow in several directions, so much the better, as more land can be irrigated at less expense

After choosing the site, comes laying out and constructing. The bottom of reservoir should not be more than three feet below the surface of the ground, for all below is useless. Much care should be taken in calculating the pressure and in the shape of the dam. The pressure on the dam is not greater when the flow of water is large than when it is small. It is the height of the body of water that counts. High dams are therefore dangerous and should be avoided.

In building an earthen embankment, first make arrangements for removing water. For this purpose iron pipes are most useful, though wooden culverts are often used. The pipes should have a good safe bearing beneath and should be packed in cement or clay to prevent leaks. The surface upon which this rests should be plowed and freed of all roots. Water should be used freely in the construction, the materials being well sprinkled when put on. Another important thing is the sorting of materials. The fine impervious material should be placed next to the water and the coarser outside. The inner slope of the dam should be gentler than the outer one and should be riprapped to prevent erosion. The base of the embankment should be three times its height.

The cost of a typical earthen reservoir is about twenty cents a cubic yard. Taking it to be 1283 ft. long, 640 ft wide and 20 ft high, holding 23,50000 cubic feet of water, which is an average reservoir, the cost would be $37.617. This would irrigate two hundred and thirty five acres at $11.25 for all time to come.

Earthen reservoir often reach an enormous size. The one known as Lake Yosemite, Merced County, Cal. is very large. It is fed by the Merced River. To removed danger of floods it is situated in a gap in the foot hills, nine mile away and is connected with the river by a canal one hundred feet wide and ten feet deep. The embankment is four thousand feet long, two hundred-fifty feet wide at the base and twenty at the top and is sixty feet high. The inner slope is riprapped to prevent erosion.

For masonry reservoirs no definite rule can be given. The chief failure is in the construction of dams. A masonry dam should have a foundation of concrete laid on solid rock over piles driven close together. The stones should be cemented together by a very strong cement. At the top should be a waste channel to carry off flood waters. The ends of the dam should be carried up as high as possible to prevent the water from cutting out around. In construction of a very large dam, safety should be secured in every direction, regardless of expense. The best way to show the construction of masonry reservoirs would perhaps be by giving a few examples.

The Bear Valley dam in Southern California is a typical masonry reservoir. It is built into the solid rocks of the gorge. It is in the form of an arch curving inward, forming the arc of a circle 335 ft in diameter. The base is 17 ft thick and the top 8 ft thick, the highest point is 60 ft above the creek bed. The dam is built of huge blocks of granite and portland cement. It took 3304 cubic yds of rock and 1350 barrels of cement. At the bottom is a stone culvert 21 x 24 inches which discharges 8000 inches of water into a weir which measure the discharge. There is a spillway on one side, four feet from the top, to remove overflow water.

The Sweetwater Reservoir is another example. It is the largest piece of engineering work of its character in the world. It is built of granite and portland cement. Is 90 ft high, 76 ft long at base and 396 ft at top, 46 ft thick at base and 12 ft at top. The reservoir covers 700 acres and stores six billion gallons of water. It gathers water from 186 sq miles of territory and holds two years supply for ten thousand acres

Canals.

The constructor of irrigating canals meets many difficulties. The principal question is to get the most water at the least expense. The source of the water for a canal is a river, lake or artificial reservoir. In choosing the route must select as direct a one as possible. Curves should be avoided as much as possible and when necessary should be as gentle as possible. A sharp curve checks the flow of water and erodes easily.

To get the greatest velocity, the canal should be in the shape of a half pipe.

Grades are important. For short distances, the grade should be steep. In main ditches the grade is from $1\frac{1}{2}$ to $2\frac{1}{2}$ ft per mile. When the grade becomes too steep it is lowered by means of a drop or reduction box. It is useful where the supply of water is lessened by customers up the line. By keeping up the grade a larger area can be watered.

The construction of flumes should be avoided if possible as they are very expensive and apt to leak.

Silt is an important factor. It settles in the bottom of the canal and causes much expense in removing. By proper construction of head works the water may be made comparatively free. A dam causes the silt to settle to the bottom where it can be let out at waste gates.

In the construction of a canal the best effort should be on the head works. The head gate should be a few hundred feet from the intake at the river, with a bay of moderate grade intervening. It should be at a point convenient to discharge water back into the river through the waste and sand gates. Wings of piling or masonry should extend for fifty feet on each side to protect against floods.

Sand gates are also important. By means of them, silt and sand is caught and drawn off with out entering the canal.

Waste gates are the saftey valves of a canal. By them the flood waters, which would otherwise damage the canal, are caught and carried off.

The outlets into the laterals should be set before the canal is built. The size is governed by the amount of water delivered. The gate should be at the inner end of the outlet. The construction is simple, a tight slide over the end of the outlet box being all that is necessary.

The banks of the laterals should be made so that the bottom is above the surface to be irrigated. The may be constructed in loose soil and remade every time the water is applied, thus preventing the ground from baking. The best things for making laterals are a common plow and scraper. The ditch bottom should be as wide as a scraper and the plowing about three times as wide to break up the ground.

The loss of water by seapage and evaporation is great. The loss by evaporation in the summer is from 3-4 inches per day or 4 or 5 ft a year.

The loss by seepage will depend on the character of the soil and the care in building the banks. In a canal 15 miles long with good grade the loss will be 58% before the point of delivery is reached.

It may be prevented by cementing the sides and bottom with a layer of cement 3/4" thick. When the soil is sandy this becomes absolutely necessary. It may be done cheapest and best by putting on the thin coat of cement without using stone.

The average cost of main canal less than 5 ft wide is $481 per mile, 5 to 10 ft wide, $628, over ten ft wide $3603 per mile. This includes headworks, flumes, etc.

Some canals have been constructed on an immense scale. The Edgemont canal in South Dakota starts from the Cheyenne River, fourteen miles from Edgemont. It is twenty-six feet wide and four feet deep. At Edgemont it falls thirty feet and runs several large factories. After this, ten thousand acres can be irrigated from it.

The Sonora Canal in Mexico is 35 ft wide, 30 miles long and will irrigate 315,000 acres of land.

The End