DESIGN AND COST OF FISH PONDS ON THE MICHIGAN STATE COLLEGE RIVER FARM

Thesis for the Degree of B. S.

MICHIGAN STATE COLLEGE

Wayne E. Lesher

1948

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Design and Cost of Fish Ponds on
The Michigan State College
River Farm

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

By

Wayne E. Lesher

Candidate for the Degree of

Bachelor of Science

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INTRODUCTION

In my planning of fish ponds on the Michigan State College River Farm, I have attempted to make use of some land, that now stands idle, at a reasonable price as possible. The department of Zoology would find this project invaluable as the ponds can be used for research and for student study. I have planned the ponds to be of different sizes mainly for experimental possibilities.

The fish ponds are small artificial lakes with dirt bottoms and sides. They range in size from approximeatly one acre to one ninth of an acre in surface area. For good pond management and fish production a fish pond should probably be not larger than one acre nor less than one tenth of an acre in surface area.

Fish ponds are built for various species of fish. The ponds here are for warm water fish-Primarily Bass and Bluegills. It is estimated that a one acre pond will produce from 150 to 450 pounds of pan-sized fish each year. It depends of course upon the type of management the pond is given. The cost of producing fish will run only a few cents a pound excluding the initial cost of building the pond. Bluegills should not be planted alone, but a ratio of 1,000 bluegills to 100 bass has proven to be most satisfactory. If the pond is overstocked or over-populated, the results will be stunted fishes. If the pond is not harvested of fish either all at once or little by little, the results may bring about an over-population. It is important also to keep the correct balance between the bass and the bluegills or the production again will be cut down. If all sizes of bluegills are to be found and there is an evident gradation from the smaller to the larger sizes, the pond is in a healthy condition. However if certain sizes are missing or if all the fish are of about the same size, it is an indication that the population is out of balance.

The large mouth black bass is cannibalistic and is found very desirable to mix with bluegills. They eat the young fish and keep the pond from becomming over-populated. Usually they do not exceed seven pounds.

The bluegill is an excellent food fish and is very hardy. It grows to be a pound or a pound and a half in weight. In a years time it will grow four or five ounces. It attains a length of twelve to fourteen inches.

I have planned these ponds with an assumption that the proposed dam across the creek fed by springs and drainage water, will be built.

POND LOCATION

In finding the location for the ponds there was not much choice in the area in which they could be built. There is no natural location for them outside of the large pond that would be formed from the backwater of the proposed dam. The ponds in this writing are in addition to this backwater.

I ran a topographical survey of the area and plotted the map. From this I picked the location for the ponds.

There are several factors that are essential for the location of an ideal pond. The most essential things are: A water supply that can be diverted into the ponds in the amount required, a pond bottom which will hold water, a location where the ponds can be built economically (Including satisfactory and sufficient materials nearby), a location that is not subject to flooding, and in such a location that the ponds can be drained. With all these requirements in mind a location was picked out which satisfied these to some degree.

It was clear that the pond embankments must be built up to some extent and also the pond would have to be dug out somewhat. Therefore both excavation and fill would be necessary. The ideal case is to have the amount of earth excavated equal to the amount of fill required. In most cases this will give the most economical cost. I have done this to about as close as I could plan, having 91 cu. yards of excavation greater than that of fill.

I did not run soil borings test but borings have been taken in the immediate area (where the proposed dam is) and it was found that till clay is prevailent from one to five feet below the surface of the ground. Of course this is not a satisfactory test for the area in which the ponds are located and soil test borings should be run about every 50 feet or so to determine accurately just where the clay is. If the borings that were made are indicative of what is in the entire area there will be an ample amount of clay soil available for the sealing of the pond sides and bottom.

With somewhat of a limited supply of impervious soil available it would be advisable to construct the dikes or sides of the pond by puddling the water side and not by attempting to make the dike out of the mixture of the soil. This would be all right if the soil were of an impervious, homogenious mass, but it isn't.

In order to be able to drain the ponds a drainage system must be worked out. With the pond locations next to the river this presents no problem. However there is a limit to the height of the water in the pond and in order to make the ponds of minimum depth it is necessary to sacrifice some of the drainage qualities in order to have depth to the pond. From the bottom of the ponds to the river there is only a drop of one and one-half feet. During high water it would be impossible to drain the ponds by gravity, but if necessary, they could be pumped. There is no way in getting around this handicap using the water supply from the reservoir. There are two capped artesian wells in an old foundation just a short distance from the ponds and what I recommend before any definite plans are decided upon, is that tests be taken on these wells to find there potentialities as a water supply. It has been reported that the flow on the wells is several hundred gallons of water per minute and if this water supply were adequite it would offer a more desirable water system than the reservoir. The water head would be several feet higher than the reservoirs, and would allow a better drainage of the ponds and also deeper ponds if so desired. It would be necessary to raise the height of two of the dikes two or three feet higher but this could be done with no harm to the present layout and with very little additional work. It would require less piping and would in general be more convenient and more economical. Whichever water supply is chosen the plans of the ponds here will work in either case.

In order to build the ponds in this particular spot quite a lot of land has to be cleared of trees and brush as the pond sites lie in a wooded area. The woods are not thick but it does require an additional cost to clear the land.

From the contour map it can be seen that a dike or strip of land jets out from near the old foundation. By utilizing this strip as dikes for two large ponds it helps cut the expense. It stands at a sufficient elevation so that no work need be done on it at all.

WATER SUPPLY

The water supply has been mentioned previously to a small extent. There are three sources of water; springs, streams, and surface runoff. Ponds built just below spring heads are usually considered best. The flowing well has been mentioned with its possibilities and will not be elaborated upon any more.

In the construction of ponds it is the water supply that has more to do with where and how the ponds will be built than perhaps any other single item.

Flowing water is not essential for pond fishes. The most successful ponds, in general, are those which receive only enough water to maintain a constant level. An excess of water and too little water are both undesirable. The pond should just be kept full with no water running out. The water should be clear and not contain any silt. These qualities are found in the water supply in this problem.

There is a small creek that is located three hundred feet west of the old foundation. This creek is fed by drainage and by many small springs. It runs through a wooded section and flows into the Red Cedar. There is a high bank on either side of the creek. An earthen dam has been proposed to be built near the outlet of the creek. This dam will cause the creek to back up to an elevation of 840.0 feet above sea level over approximately an acre and a half of land. There is enough flow in the stream to take care of evaporation and to keep the water level constant. It would be possible to raise the water level to 841.0 feet without any harm and would add about three fourths of an acre to the flooded area. I would recommend doing this in order to give more elevation with which to work with in the water system of the ponds. I have planned the ponds, however, assuming the proposed elevation of 840.0 feet for the backwater of the dam. The supply pipe for the ponds will tap the reservoir twenty-five feet up from the dam and shall be three feet below the water surfaces.

One of the most important conditions to study in the building of ponds is that of flood possibilities. In every locality the flood characteristics are different so it is rather hard to obtain accurate information unless observed directly in that particular place. I feel my results of this particular area are the latest and most accurate found as to date. I have used two methods; one by direct observation and the other by calculation.

The danger of flood comes from the Red Cedar River with a watershed area of some 355 square miles. The United States Geological Survey records of flow of the Red Cedar River goes back to 1930. From that time to the present (May 1948), the maximum flow was in the springs of 1947. The measuring gage is located under the Farm Lane Bridge. Previously it had been located just a short distance upstream from the present location before the new bridge was put in.

I found the elevation of the river at the M.S.C. River Farm and during the same day obtained the gage reading at the Farm Lane Bridge. Since the elevation of the river was at the top of the ice and the gage reading was at the free water, I shall add .3 of a foot, to allow for the ice, to the gage reading of 3.50 feet giving 3.8 feet. The elevation of the river (top of ice) at the bridge was therefore the datum of the gage (824.39 feet) plus the gage reading of 3.8 feet or 828.2 feet above sea level. Since the elevation of the river at the M.S.C. River Farm at the same time was 832.6 feet there is a difference in the elevations of 4.4 feet. The gage reading during maximum flood in the 1947 was 11.58 feet or an elevation of 825.97 feet. Adding the difference of elevations of the two localities gives a maximum flood height of 840.4 feet at the M.S.C. River Farm. It must be remembered that the two points on the river are located some approximate five miles apart by river and that there can be a great difference in the flood characteristics due to obstructions in the river such as dams (a small one at Okemos), bridges, and natural obstructions which act to differentiate in the behavior of the river.

In 1921 a gage reading of 14.5 feet was recorded, the datum of the gage being 824.96 feet. There is great doubt as to the authenticity of this report. It appears in a publication of the U. S. Geological Survey and the facts leading to the information are questionable. Supposing however, that this questionable information is considered. The height of the flood would have been at an elevation of 839.5 feet at East Lansing or at a height of 843.9 feet at the M.S.C. River Farm. Therefore by this method of calculating the maximum flood level, an elevation of 844.0 feet in building the dikes would be sufficient to hold back any floods that might occur.

During the spring flood (1948) I took actual measurments at the pond locations. The water level at the time was 839.5 feet. The maximum flood level (1948) was 1.7 feet higher than this or an elevation of 841.2 feet at maximum height. The maximum gage reading in 1947 was 11.58 feet and in the spring of 1948 (up to May) was 10.46 feet or a difference of 1.12 feet. Therefore the maximum flood level by this method was 839.5 feet plus 1.7 feet, plus 1.1 feet or 842.3 feet above sea level.

By building the dikes at an elevation of 844.0 feet, they should keep back any flood as bad as what has been encountered before.

CONSTRUCTION

As the ponds are permanent structures which cost considerable to build, it is important that they be built properly. The construction is divided into clearing, excavation, dikes, inlet, and outlet.

CLEARING AND GRUBING:

Most of the land where the ponds will be located is wooded. There is approximately 95,000 square feet of land which must be cleared. The land is not thickly wooded and there is not much underbrush. The trees run up to about twenty-one inches in diameter. This land must also be grubbed. All tree roots and undergrowth must be removed, including, leaves, dead branches, and all vegetation.

EXCAVATION:

In order to have a pond of minimum depth of six feet it is necessary to excavate. Since it is also necessary to build dikes I have tried to balance the amount of excavation and the amount of fill which of course helps to minimize the cost of construction. This had to be done by trial and error -- changing the size of the ponds and their location, until the desired results were obtained.

I have made the ponds with the area of the six foot depth (maxmum depth) equal to approximately one-quarter of the surface area of that particular pond. This allows for an ample area of depth which is required in the winter months and also for the larger fish in the summer months. From this six foot depth I have maintained a uniform slope up to the top of the water. I have not made the slope the same all the way around the pond because of the more possibilities it would present to experimental purposes with varying slopes.

In order that the ponds can be drained it is necessary that the six foot depth be sloped slightly toward the outlet. The slope need be just enough to keep the water flowing. It is better to have the water drain slowly from the six foot depth area in order to keep small fish from being caught on the drained area. To show how the pond sides slope I have drawn pond contours on the topographical map.

The pond contours are the finished slopes. Actually the excavation is carried to a depth six inches to eight inches greater than the contours shown. If the bottom is of good clay material (impervious) a six inch back fill of top soil should be added to make the bottom and sides of the pond fertile. If the soil is found to be of pervious material a two inch layer of clay soil should be put on and then six inches of top soil added to that. Any extra clay that is excavated should be kept separated from the other soil in case the clay is needed to line the pond for imperviousness. If enough soil borings are run this could be determined beforehand.

There will be about 100 cu. yards of excavation that will not be used for fill. This can be disposed of easily in the immediate area surrounding the ponds.

DIKES:

In this case the dikes are used to hold the pond water in and the flood water out. It is necessary to build the dikes to a elevation of 844.0 feet in order to keep out this flood water. Where the dikes separate two ponds it is sufficient to build the dikes two feet higher than the pond water elevation. This would give an elevation necessary for the dikes of 842.0 feet between ponds.

There is a dike at elevation 845.0 feet which runs out from the old foundation almost to the river, as can be seen on the contour map. I have utilized this by letting it act as a dike for both pond #1 and pond #2.

The first and most important consideration in earth dam or dike construction is that they be made as nearly impervious to the action of water as possible. Seeping water is destructive in several ways: The saturation of the dikes imparts an effect of buoyancy which lessens the effect of gravity upon which in a large measure the stability of the dikes depend. The cohesion of the soil particles in the dike is destroyed by this seeping water. Water acts as a lubricant upon which the soil particles will slide.

Since on every dike the dike is subject to water pressure on both sides (either the flood water or the pond water), I have planned the sides fora slope of three to one on both sides. This will also cut down seepage of water through the dikes and it virtually eliminates the possibility of the dikes slipping and caving. In order to allow room for automobile and truck traffic and also to allow room for tractor equipment in the building of the dike, I have planned a ten foot wide top to the dikes. This of course with a three to one side slope demands more earth than a dike of narrower width and steeper slopes. However the ponds have to be excavated to some extent anyway, and the earth might just as well be utilized as wasted and for very slight extra cost get a good wall put around the ponds. In other words it is economically desirable to build a ten foot wide top and slopes of three to one on the dikes. A three to one slope also will not settle like a steeper slope.

There are many causes of failure of earthen dams or dikes. Some

Some of the major causes are:

Inadequate spillway -

Here spillways are not needed at all since the amount of incomming water is controllable.

Foundation leakage -

It is necessary to be sure there is a good bond between the dike and the ground. It is important that the entire side area be impervious or excess percolation of water through the foundation will cause a failure. The danger of this is lessened by using side slopes of three to one.

Seepage along outlet and inlet conduits -

Concrete collars or cutoff walls are built around the conduits thus keeping water from seeping along the conduit and gradually enlarging the space until a failure results.

Unsuitable soil material -

It is a good idea to run a mechanical analysis of the soil to determine the suitability of the soil for imperviousness. A thin layer of clay (which is found in the excavation) should be placed on the slopes. Again a three to one slope cuts down the possibility of a failure due to a pervious soil.

Inadequate compaction -

The dikes must be compacted thoroughly. Best results can be obtained when the soil is at its optimum moisture content.

There should be a good bond between the ground and the dikes. To obtain this (after the land has been cleared and grubbed) the top soil should be removed. This is approximately a one foot excavation. Where the center of the dike comes, a trench two feet deep by five feet wide should be dug. The ground should be scarified and loosened along the bottom of the dike. The dirt for the dikes should be put on in twelve inch layers and each layer compacted, preferably with a sheepsfoot roller. By compacting this way it helps to make the dike watertight and also there will be very little settlement. The dikes should be seeded or sodded with vegetation to protect the sides from erosion. The side of the dikes toward the ponds should be sodded down to the water line or the side will wash due to wave action.

The pond side of the dike should have a two inch layer of clay covered with a six inch layer of good top soil. The object of the top soil on the pond sides and bottom is for the growth of aquatic plants, upon which fish food depends.

Earthwork for dikes was computed by the end area method. That is the proposed dike was layed off in stations depending upon the contours and the end area of each station computed. The end areas of two successive stations were averaged and the results multiplied by the distance between stations.

It may be necessary to put rip rap on the north side of ponds numbers 1, 2, and 4, to keep the dikes from washing during floods. This can be found only by trial. However, if a good growth of vegetation is on the slopes, that may be sufficient to keep the sides from washing.

POND EARTHWORK:

The earth-work of each pond includes the excavation and the building of the dikes, both of which has been discussed. The following are the quantities of cut and fill required for each pond. I have allowed 15% extra for earth in the building of the dikes to allow for compaction, loss, and shrinkage of the earth.

POND #1

Surface Area ------------	17,612 sq. ft.
Area of 6ft. depth ------	4,198 sq. ft.

Pond Bottom;

Total Excavation --------	740 cu. yds.
Total fill --------------	180 cu. yds.

Pond Dikes:

Fill --------------------	3,606 cu. yds.
+ 15% ----------------	541 cu. yds.
Total fill --------------	4,147 cu. yds.

Pond Totals:

Cut ---------------------	740 cu. yds.
Fill --------------------	4,327 cu. yds.

POND #2

Surface Area ------------	43,460 sq. ft.
Area of 6ft. depth ------	10,480 sq. ft.

Pond Bottom:

Total Excavation --------	4,695 cu. yds.
Total fill --------------	0 cu. yds.

Pond Dikes:

Fill --------------------	1,425 cu. yds.
+ 15% -----------------	214 cu. yds.
Total fill --------------	1,639 cu. yds.

Pond Totals:

Cut ---------------------	4,695 cu. yds.
Fill --------------------	1,639 cu. yds.

POND #3

Surface Area ------------	12,576 sq. ft.
Area of 6ft. depth ------	2,976 sq. ft.

Pond Bottom:

Total Excavation --------	2,072 cu. yds.
Total fill --------------	0 cu. yds.

Pond Dikes:

Fill --------------------	1,301 cu. yds.
+ 15% ------------------	195 cu yds.
Total fill --------------	1,496 cu. yds.

Pond Totals:

Cut ---------------------	2,072 cu. yds.
Fill --------------------	1,496 cu. yds.

POND #4

Surface Area ------------	4,944 sq. ft.
Area of 6ft. depth ------	1,216 sq. ft.

Pond Bottom:

Total Excavation --------	931 cu. yds.
Total fill --------------	0 cu. yds.

Pond Dikes:

Fill --------------------	770 cu. yds.
+ 15% ------------------	115 cu. yds.
Total fill --------------	885 cu. yds.

Pond Totals:

Cut ---------------------	931 cu. yds.
Fill --------------------	885 cu. yds.

PONDS #1, #2, #3, #4:

Grand Total:

Cut ------------- 8,438 cu yds.

Fill ------------ 8,347 cu. yds.

INLETS:

The inlets are arranged so each pond has its separate inlet pipe with a gate valve, allowing for complete control of the incoming water in each pond. The valve controls are located on the edges of the dikes to give easier access to controlability.

The inlet pipes branch off from the main supply pipe. Each opening of the inlet pipe should be on a fairly flat slope so the incoming water will not flow to rapidly and wash a gully in the pond bottom. Stone or rip rap of some type should be put directly below the opening of the pipe to keep the bottom from washing from the falling water. It is a good idea to have at the end of the pipe, a one-quarter Bend (or 90°) section of pipe to shoot the water upward instead of outward. Care should be taken to see that the top elevation of the one quarter Bend piece below enough to keep a high enough head so water will flow rapidly through the pipe. A three foot head or an elevation of 837.0 feet would work out all right.

As the water reaches the top of the inlet pipe outlet, the head will decrease and the water will flow more slowly until it will barely be flowing as the water level nears 840.0 feet.

A six inch cast iron pipe is used on the inlet pipes as on the main supply pipe. The valves are also six inch. The cost of a six inch valve hardly warrants for putting in a four inch valve with the very little money that it would save. The largest pond (the one acre one) can be completely filled in less than three days with a six inch pipe with an elevation of outlet at 837.0 feet. The cost of pipe above six inch diameter increases rather rapidly.

The inlet pipe to pond #4 is 233 feet from the main pipe. The inlet piping for this one pond will cost about $700 at present day prices. By connecting a pipe between pond #3 and pond #4 through the common dike, the cost would be about $100, a savings of $600. A valve could be placed in this pipe and it would allow fairly good control of water in pond #4, but not as an extensive control as the way as shown on the map. I have planned it with the use of the separate pipe system but with a slight alteration of plans the less costly system could be used. It depends upon the extent of water control desired in pond #4 and the financial resources available as to which plan is desired.

Cut off walls should be placed along the inlet pipe to prevent seepage of water along the line of contact between the soil and the pipe. They should be placed about ten feet apart. These walls consist of square collars built around the pipe and are made of thin slabs of concrete six inches thick and from a one foot to two feet wider than the pipe. Two collars per pipe should be sufficient on ponds #1, #2, and #3. On pond #4 three collars should be used.

The outlet of the pipes should be covered with a fine screen to keep fish out. The screen should be welded to the pipe or the pressure of the water when filling will force the screen off.

If there is seepage in any pond the intake valve can be left open to maintain the water level. The main supply pipe is 560 feet long, and the connectors to the ponds are as follows:

Pond #1 ---------- 50 ft.

Pond #2 ---------- 57 ft.

Pond #3 ---------- 39 ft.

Pond #4 ---------- 233 Ft.

PIPING:

The piping consists of the main supply pipe, the inlet pipes,and the outlet pipes. The main and inlet pipes are six inch, cast iron pipe. The outlet pipes are ten inch vitrified clay pipe.

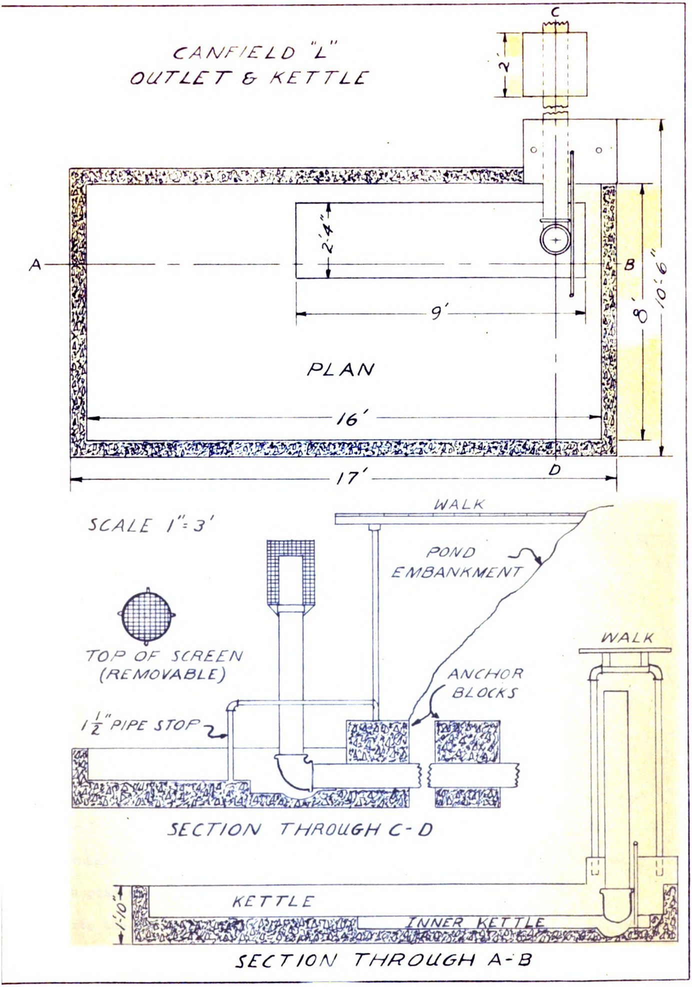
The main pipe starts in the dammed up creek twenty-five feet above the dam. The top of the inlet is 3 feet below the surface of the water or a elevation of 837.0 feet. The inlet must be covered with a fine screen in order to keep fish and debris from entering the pipe.

The main and inlet pipes do not have to follow the hydraulic grade line, but should stay below it. Otherwise the pipes would have to act as syphons and trouble could result. It is necessary that the pipe be layed below the frost line. The maximum depth of trench necessary is 15 feet for about 25 feet distance. The average cut for trench is around 7 feet to 8 feet. The outlet and inlet pipes should be layed before the dikes are built to save excavating the trench through the dikes.

OUTLETS:

The outlet consist of that portion of piping and materials that have to do with the draining of the ponds. They are located at the sides of the ponds nearest the river. The outlet from the ponds are as shown in detail in the accompanying drawing.

This type of outlet allows the pond to be lowered to any elevation desired and also to maintain a constant water elevation even if water is entering the pond from the inlet pipe. The base of the stand pipe is


CANFIELD "L"
OUTLET & KETTLE
C
2'
2'4"
A
B
9'
8'
10'6"
PLAN
16'
D
17'
SCALE 1" = 3'
WALK
POND
EMBANKMENT
TOP OF SCREEN
(REMOVABLE)
ANCHOR
BLOCKS
1 1/2" PIPE STOP
SECTION THROUGH C-D
WALK
KETTLE
INNER KETTLE
1'10"
SECTION THROUGH A-B

attached to the drain pipe by a loosely threaded elbow. Graphite can be used on the threads. By swinging the upright pipe at an angle and holding it in place by a chain attachment to the stanchion, the height of the water in the pond can be regulated. The height of the stand pipe should be so that its maximum elevation will reach 844 feet in order to keep flood waters from backing up into the pond. A fine screen must cover the top of the standpipe to keep fish from draining out with the water. A walk has to be built out to the pipe in order to make the pipe accessible for control.

The kettle should be placed so it is slightly lower than the bottom of the pond. This will give complete drainage of the pond. It is advisable to have shallow channels six inches deep by fifteen inches wide, extending radially outwards from the kettle. The fish have a tendency to follow these channels and can be seined out more readily when draining the pond.

The drain pipe is ten inch vitrified clay sewer tile. It has a long life and is economical. It will break easily if there is a settlement of the ground but in this case the drain is below the dikes so there is no danger of breaking due to settlement.

Concrete collars should be placed every ten feet around the outlet pipe. They are like the ones for the inlet pipe. Since on pond #3 the outlet pipe runs below #4, it is a good idea to put the collars all along the pipe at intervals of twenty feet except for two ten inch interval collars to begin with. On pond #1, two ten foot interval collars and one twenty foot interval collar is sufficient. Pond #2 and #4 drain into the outlet of pond #3 and two fifteen foot interval collars on pond #2 will work all right. The outlet of the drainage pipe is into the Red Cedar River at an elevation of 832.5 feet. During periods of high water the ponds will not be able to be drained completely. With the river normal there is no trouble in completely draining the ponds if so desired. A concrete collar should be built around the pipe where it comes out of the bank of the river.

The length of the outlet pipes for the various ponds are as follows:

Pond #1 --------	78 ft.
Pond #2 --------	45 ft.
Pond #3 --------	162 ft.
Pond #4 --------	10 ft.

The maximum excavation for pipe laying would be eight feet or an average of about six feet.

The ponds will drain under a pressure head varying from 7.5 feet to 0 feet. The pipe has to follow the hydraulic grade line or below in order to completely drain the pond. By setting the bottom of the kettle at an elevation of 833.0 feet and the bottom of the outlet pipe at 832.5 feet the slope is .64% and by Kutter's formula for pipes flowing full, using N as .015, the quantity of flow (with no pressure head) is equal to 1.3 cu. feet per second, and the velocity of flow is 2.5 feet per second. This flow is sufficient.

For pond #2 the bottom of the kettle can be set at an elevation of 833.3 feet. This pond is dependent upon pond #3 and has the same flow characteristics.

For pond #3 the elevation of the bottom of the kettle is 833.5 ft. and the elevation of the bottom of the pipe outlet in the river is 832.5 feet giving a slope of .62%. By Kutter's formula for a ten inch diameter pipe using N as .015 the velocity is 2.45 per second, and the quantity of flow is 1.3 cu. feet per second.

For pond #4 the flow is the same as pond #3 since it is dependent upon pond #3's outlet. The bottom of the kettle can be set at an elevation of 833.1 feet.

COST OF CONSTRUCTION

(Estimation of prices as of May 1948)

Items	Quantity	Unit Cost	Total
Clearing & Grubbing	2.18 acres	$300.00	$654.00
Excavation Fill	8,438 cu. yds. 8,347 cu. yds.	.50¢ ——	$4,219.00 ——
Labor	600 hrs.	$1.00	$600,00
6" C.I. pipe	939 ft.	$3.00	$2,817.00
10" V.C. S.S. pipe	295 ft.	$2.50	$737.50
6" C.I. Gate Valve & Box	4	$70.00	$280.00
Canfield "L" Outlet & Kettle	4	$100.00	$400.00
		Total Cost	$9,707.50

As can be seen there is no charge for the fill. The excavation (since that is the most) is what is paid for. This price also includes seeding the dikes when finished. It is necessary to have hand labor to fix the corners, help direct machinery, etc,.

[redacted]

[redacted]

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