STREAM IMPROVEMENT TECHNIQUES

Wildland Recreation

No. 271

To: R. Loftus
D. Davis

Date: May 3, 1980

From: G. Edmondson

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FIGURE | PAGE

STREAM IMPROVEMENT TECHNIQUES

INTRODUCTION

The following report is an attempt to simplify and bring together some of the varied information concerning the field of stream improvement work. It is not a steadfast manual of stream improvement. It does not contain explanations of how to use the sophisticated equipment developed for stream analysis. Its purpose is to provide some guidelines in the stream improvement field which may be used by the average person, instead of the average stream biologist.

It has become evident that much of the improvement of the streams in this province is attempted by outdoor clubs and organizations, and not by biologists and the Fish and Wildlife Branch. This is because of the fact that little money or time is available to these government agencies for this purpose. Therefore, groups get the idea to improve their favourite trout stream and often end up wasting their time and money and possibly even damaging the stream in the process, because they do not know what they are doing. It is toward these people, therefore, that this paper is directed.

The following paper explains some of the most common and effective improvement devices used; derived from various sources which are not usually available to the average person. Also included, is an example of a small stream improvement project conducted on a local stream to illustrate what one person can do with no funds and few materials.

WHAT STREAM IMPROVEMENT IS

Stream improvement is a broad term. It includes all aspects of improving a stream, from picking up a tin can from a stream bank, to the most elaborate and extensive improvement programs. Regardless of what action is taken, the term means: to physically improve the habitat and productive quality of a stream to aid the growth of the organisms inhabiting it.

Stream improvement had its beginnings in England near the turn of the century. Before that time and for many years afterward, most of the streams of England were owned by wealthy land owners. The streams were fished only by the wealthy and were the pride of their owners. It was on these private streams that improvement work first developed, in an attempt to provide even better fishing. From England, the idea slowly established itself in the United States, and in the 1930's was practiced by the U.S. Bureau of Fisheries. From that time it has become widely used all over the United States and has become established in Canada.

Some of the early improvement techniques are still used today, while some of them have proven ineffective or even damaging. New techniques and designs are being developed still, as the whole concept gains wider acceptance.

WHY IMPROVEMENT IS DONE

A stream which is productive (able to support fish and a myriad of other aquatic life), is comprised of pools, riffles, slack water, shady and sunny spots, deep, shallow and covered areas. A stream with all of this in its composition, in the correct proportions, is the "ideal" fish habitat. However, sometimes these conditions are lacking in a stream, and this results in fewer fish, smaller fish or no fish. This happens either from human interference or by natural occurrences. It is when this is the case, that stream improvement is of value.

The Productive Stream

The productivity of a stream can be described as a stream's ability to produce fish, plus the food to feed those fish. This means that a stream that is productive supports a large variety and quantity of organisms. The stream's ability to do this however, depends upon certain physical conditions present there. These conditions are the quality of water, the quantity of water, and the physical characteristics of the stream which provide desirable sites for the feeding, resting and reproduction of the organisms living there. If one or more of these conditions are not present, or are minimal, then the productivity of the stream is lessened or even destroyed.

Water quality refers to the cleanliness of the water itself. Pollutants and siltation are detrimental to water quality. And this factor alone can cause a stream to be totally barren of life. Water suitable to support a viable stream must also be of the correct temperature. On a hot summer day, the temperature of a stream must be between 9.9° C and 23.9° C. If it is warmer than this for any prolonged length of time, then the trout and many of the insects living there will die. While too warm of water can harm a stream ; water which is too cold can also be damaging. Cold temperatures retard the growth and development of trout and other organisms. This can occur in the summer as well as the winter, but in the summer, it is perhaps more damaging, since it is the time of year during which reproduction and rapid growth takes place; whereas winter is a time of slowed metabolism.

Water temperatures can be changed through stream improvement. The addition of trees and shade along stream banks can cool water. Conversely, the removal of shade, can warm the water. Pollutants can be combated by the removal or control of their source. Siltation can be stopped through bank plantings and bank reinforcement, to reduce the erosion which causes the problem.

Water quantity is perhaps the most important of the stream conditions. If a stream dries up or is dried up (by man) for part of the year, then there is little sense in improving it. Conversely, large amounts of water during floods can be most damaging to a stream. Spawning areas, feeding grounds, resting pools, cover, and food organisms can all be destroyed by high water. This can also strike a devastating blow to the work of the stream improver. However, some structures can be built which will survive such punishment and have a slowing effect on flood water.

The physical character of a stream can be very important to a healthy trout population. A stream is not simply a long stretch of running water; it is comprised of pools, riffles, eddies, channels, turns, kinks and rapids. Without this varied habitat, a fish population cannot thrive.

The life of a trout is not spent entirely in one place. Riffles (shallow rocky areas with a rapid current) are good food producers. A great number of insects live among the rocks, and trout go to these places to feed. After the trout have fed they usually return to slower moving water. Often deep pools and areas with cover (undercut banks, overhanging brush, large rocks, aquatic plants) harbour large fish. It is in these areas trout often feed also, however they only respond to food passing by, and usually do not actively search for it, as they do in the riffles. These slow moving areas are where trout rest and find protection from their enemies (birds, other fish, animals, and man).

Often small fish are found in slow areas, but more often, they find protection in areas where the larger fish cannot go. Feeder streams, backwater areas, shallows and brushy spots provide good protection for these small fish.

Another area necessary for a trout population, is spawning gravel. Trout require fine to coarse gravel in which to build their nests. It must be loose enough so the fish can work it over, and it must be free of silt and sand which can smother the eggs. A rapid current which percolates through the gravel is also necessary to successful spawning.

All ot these conditions must be present to provide the healthy living requirements for trout. If these places are not provided for by nature, there are ways of making them artificially through stream improvement.

Man Caused Damage

Sometimes the conditions favourable to a healthy stream are altered or destroyed either by natural phenomena or more often by human influences.

Logging usually has disastrous effects upon a stream. Log jams which obstruct fish migrations, the removal of trees and cover resulting in heated water, and siltation from eroding exposed banks are often the results of logging operations. Destructive flooding is also common after logging because the removal of trees allows rain water to pour into streams instead of being trapped by living vegetation.

Photo 1 Erosion of stream banks because of the removal of trees.

Another human activity harmful to streams, is the practice of dredging and channelization to reduce flood danger and to provide more farm land. This practice causes the loss of much stream length because of channel straightening.

Photo 2 Dredging equipment. Note the wide stream channel and barren banks.

The equipment used for channelling, digs a smooth stream bed without riffles, boulders, ledges and pools. Many years are required before the stream again develops the natural undulation of a stream course.

Photo 3 A channelized river beginning to redevelop its once sinuous course.

Pollution, of course, can cause untold damage to streams, and can totally destroy a stream ecosystem. Unfortunately, little can be done to reverse the results of a polluted stream except for the removal of the pollution source, and eventually, attempts to promote stream life after the pollution is flushed from the system.

Overall, much can be done to restore and improve the physical habitat of fish and other organisms in streams; whether the necessity of such action be the result of natural or man caused factors. It is this improvement and how it is done which is to be described in the following pages.

STREAM IMPROVEMENT ALTERNATIVES

There are many and varied techniques by which a stream may be improved. Different structures, materials and ways of building have been dreamed up since the idea first came to the minds of men. However, these ideas often involve complicated structures, expensive and often unsightly materials such as concrete. It is the object of the next section of this paper to show some of the simpler, cheaper and more attractive devices.

Safety

Perhaps before the structures are described, a word about safety should be included. Some of the work involved in stream improvement can be quite dangerous if not done correctly. When one or more people are manoeuvring a very large boulder or log into place for a structure, it often happens that fingers or feet end up in very painful positions.

Rocks have a tendency to move in strange directions when they are rolling over other rocks, and the rushing water can distort the image of what a boulder is heading toward. It is under these conditions~~,~~ that painful injuries can result. A shovel, or other tool, can save injuries ~~a lot of~~ to fingers, hands and feet. Back strain is another danger in this type of work. A shovel or better yet a P steel bar or pick can be used for leverage to move large objects. Tools of any kind should, of course, be handled carefully, especially in the midst of a group of people.

Dams and Deflectors

Improvement devices can be divided into two main categories: dams and deflectors. Differing materials and techniques and variations from the basic designs result in the various structures used in this field of work.

Dams in General

A dam is, of course, an obstruction to ~~the~~ a flow of water. It is used to slow, ~~to~~ deepen, ~~to~~ widen and ~~to~~ increase the length of pools, and to create pools where none existed before. But when considering a dam or any structure, correct placement of it should be thought of.

Dams, to increase the size of pools, are usually placed at the tail of the pool. It is usually preferable to position the structure so that any large well-anchored boulders can be used in the construction ~~or~~ as structural supports. Also when placing a dam, some consideration should be paid to where the backed up water will go.

It could end up going over low banks, down old creek beds or over desired food producing riffles.

Building materials should also be decided upon; streams with large boulders provide their own construction materials, as do those with fallen trees along their banks. Any device made of wood should be built, if possible, so that the wood is submerged at all times. This is because wood exposed to the air will rot much more quickly than wood under water.

Another consideration is the form the dam will take. Dams are usually built directly across a stream; the water flowing over top would then progress straight down the channel. Often a small gap is left in a dam, usually in the center. The purpose of this gap or "spillway" is to provide a main opening for passing water. The plunge basin formed below the spillway creates a good taking off point for migrating fish leaping over the dam. Another advantage to a spillway, is that more water will be flowing down the desired channel below than would be over the top of the dam. If low dams (.75 meter or less) are constructed, spillways are not really necessary.

Some sort of reinforcement of the banks at each end of the dam should be provided, especially if the banks are made of soft materials, to guard against any erosion.

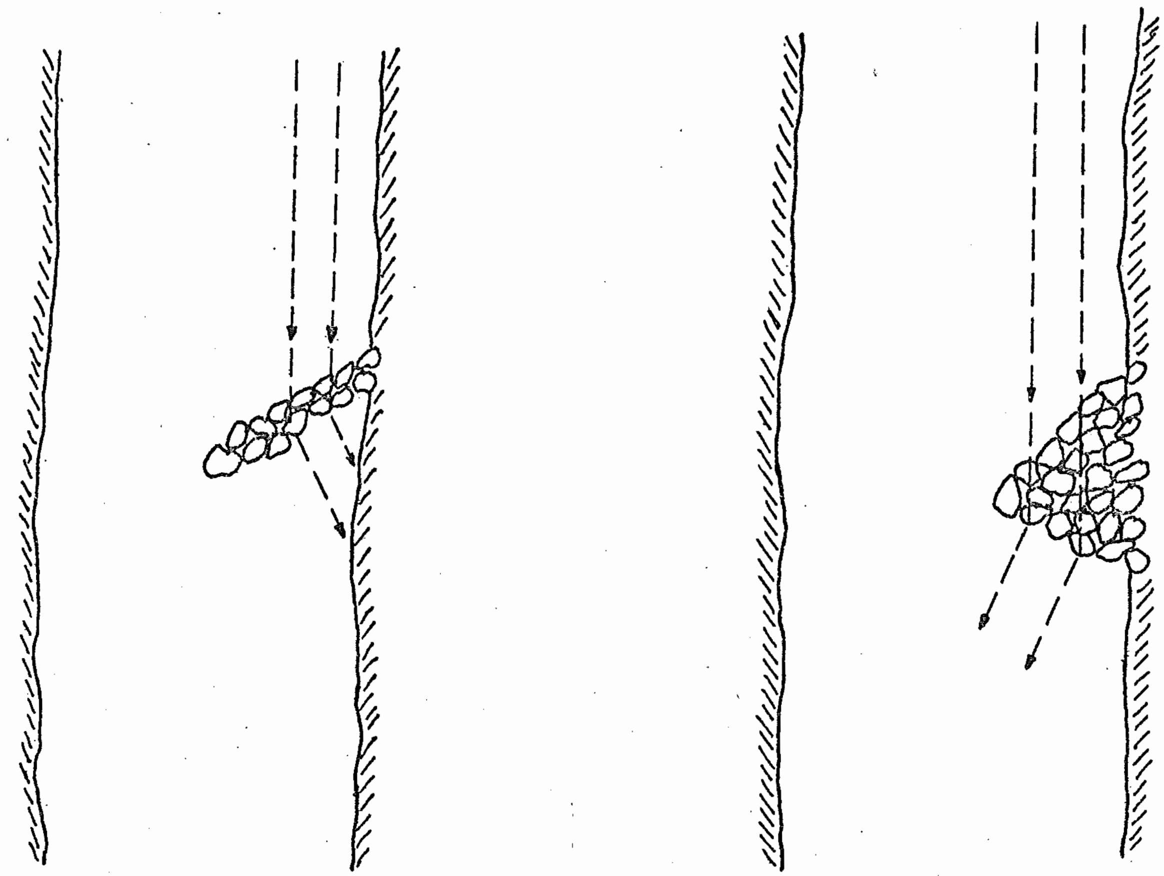
Deflectors in General

The deflector is a structure built in a stream to direct the flow of water in a desired direction to obtain a desired effect. Deflectors can push water down a channel instead of along the shore, they can aid in causing eddies to dig fish holding holes, or they can add some kinks and curves to a long unbeneficial shallow stretch of water.

The building materials can vary, but as in the case of the dams, the materials at hand give these structures a more natural look than materials brought in.

The size of deflectors varies with the application, but they should not stretch all the way across the stream. Their length varies with the stream velocity and the amount of current redirection desired. Deflector angle also varies with the application. Some stream improvement manuals state 45° is the correct angle, however there is no "correct angle." When designing deflectors, two principles should be observed: (1) They should guide the current rather than dam it, and (2) They should have no protrusions on which drifting debris may accumulate.[1]

Originally, deflectors were designed in a peninsular shape such as that achieved by a single log. It was found however, that during flood conditions, the water flowed over these devices, and caused erosion of the bank adjacent to them. The reason for this was the fact that water runs over objects at right angles to the last surface touched. For this reason, deflectors took on a triangular shape. This principle can be seen in Figure 1. With a triangular shape, the water flowing over the device will be directed back toward the center of the stream instead of toward the bank.



Peninsular

Triangular

Fig. 1
FLOODS OVER DEFLECTORS

Improvement Approaches

In the following section, descriptions of various improvement devices and stream management considerations are given. These descriptions are of a general nature and since streams and their physical characteristics and needs vary, the final implication of any of the improvement procedures to be described must also vary accordingly.

Structural Approaches

The Boulder Dam

The boulder dam should be constructed in streams where there is a good supply of large boulders. It is desirable to choose a site where embedded boulders exist, so that the other boulders jammed against them will be anchored somewhat. Boulders as large as can be handled by the crew should be moved toward the site. Incidentally, boulders are easier to move downstream than up.

When most or all of the boulders are moved, their placement based on their size and shape can be decided upon. This should be done so that they fit tightly together. Digging depressions to embed the boulders in the stream bottom increases their resistance to movement by the water. Also, when placing the boulders; if the rounder, smooth sides are kept upstream, there will be less resitance to the water.

Boulder dams are usually built directly across the stream, since any curvature would increase the size of the structure along with the possibilities of water damage. Spillways are easily included with this type of dam; however it is a good idea to place the spillway between deeply embedded boulders so undercutting is minimized. More boulders should be laid at each end on the upstream side of the dam along the bank to stop any erosion.

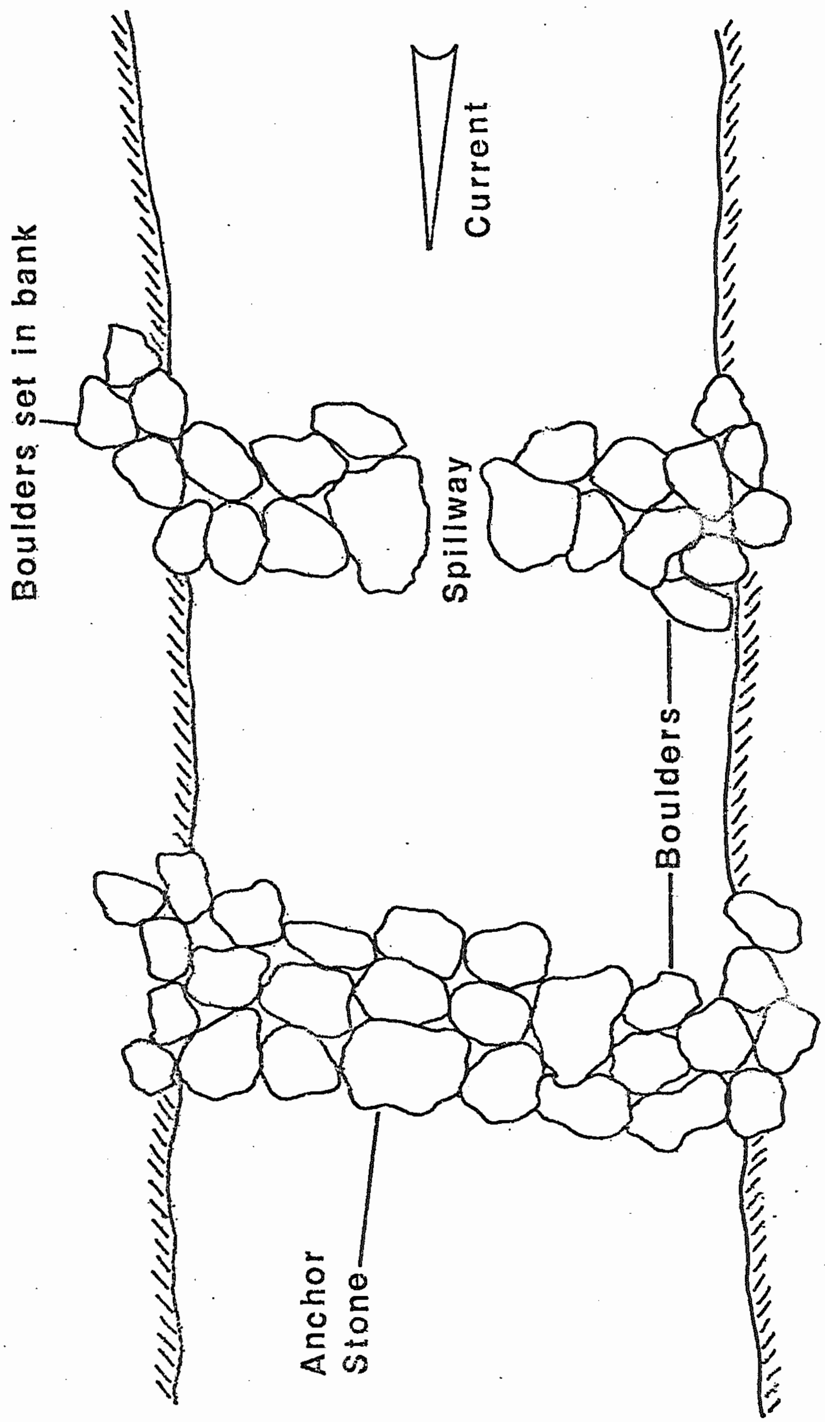


Fig. 2
BOULDER DAM

Improved Boulder Dam

A way of improving a boulder dam so that it will further resist damage by floods, is the addition of wire fencing in the construction. The following design was developed by Mr. John G. Lynde[2] of Beaver Falls and it is with his permission that it is included here.

Galvanized reinforcing wire with a 5-centimeter mesh is used. This wire is laid on the stream bed before any boulders are placed. The upstream edge of the wire is directly along the line where the dam will be built with the remainder of the wire laid downstream. Then the boulders are laid on the wire as described in the building of a boulder dam. Then when the boulders are in place, the remainder of the wire is brought up and over the dam and the end placed on the upstream side. This end is then covered with more boulders to hold it down. With this construction, the harder the flood waters force against the dam the tighter the wire is held in place. To add even more strength, the whole dam should be embedded in the stream bottom.

If a spillway is included, then the wire should be in two sections, and the open ends wired closed. The amount of wire needed to go over the dam will vary with the structure's size, but it can be guessed at, based on the size of the boulders to be used. If the boulders are large, it may be necessary to cut lengths of the fencing and lay them side by side and wire them together. The wire at the banks should be set under the protecting boulders to hold it in place. Aesthetically, the wire may not be as pleasing to the eye as boulders only, but it will reduce dam damage and maintenance considerably.

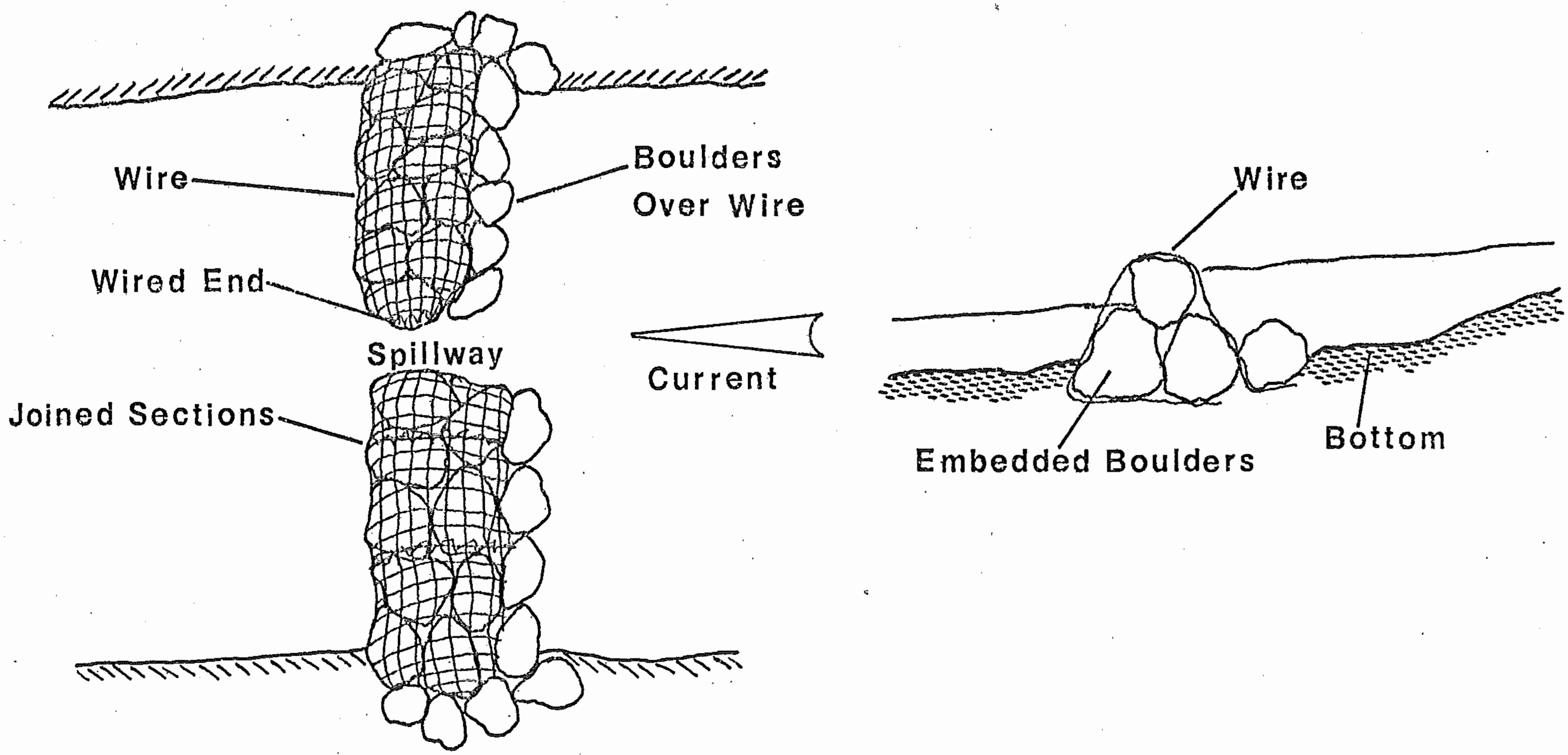


Fig. 3
IMPROVED BOULDER DAM

Log And Brush Dam

This dam is made of logs and brush and can be used on various sizes of streams and under various conditions of bottom type. The size, number and length of the logs and brush will depend on the size of the stream and how high the dam is to be.

To construct the dam, a trench is dug across the stream and if possible, is extended into the bank from 0.5 to 2 meters. The trench should be deep enough to take about half of the log diameter to be used. The trench should extend upstream to a distance equalling that of the brush length. Slope the trench so that it is deeper on the upstream side than down. The log is then laid in the trench, and a layer of brush is then laid on it, with the tops upstream, and if desired, the butts nailed to the log with spikes of sufficient length (7-15 centimeters). Cover the brush well with flat boulders, gravel, rubble or sand. The next log is placed on top, a little upstream of the first. It is covered with brush and fill as before. This is continued until the desired height is reached. The face of the dam and the banks are then protected with boulders fit closely together.

One problem with these dams, is the constructing of a spillway, However, with the water falling over the top of the dam, a deep plunge basin will be formed below, to harbour fish.

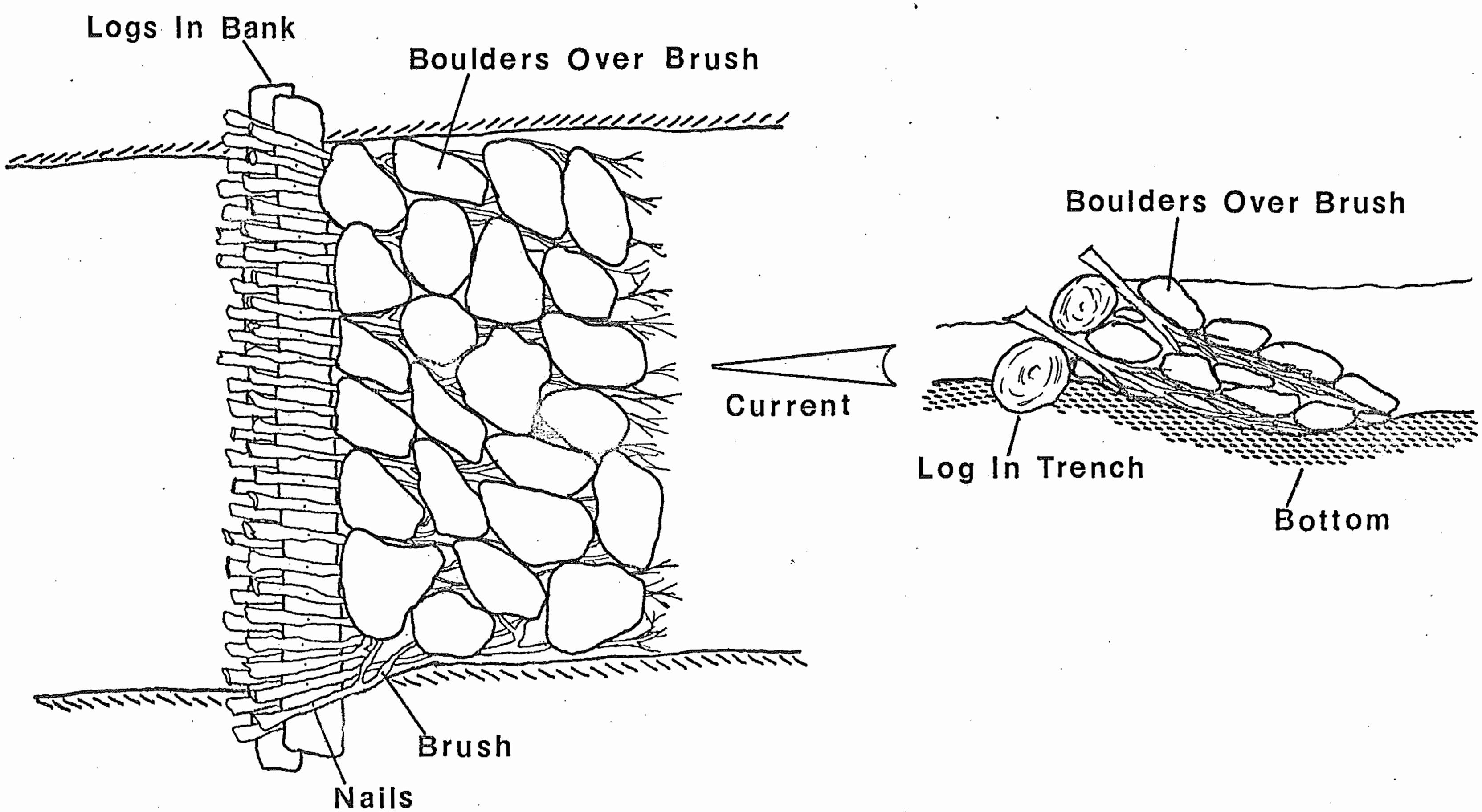


Fig. 4

LOG AND BRUSH DAM

Plank Dam

This dam was taken from Edward R. Hewitt's book,[3] and is much the same as the "log and brush" dam. It can be built on any type of bottom and nearly any size stream.

The dam, according to Hewitt, should have an angle of one vertical to four horizontal units. The reason for this low angle, is so that the weight of the water pushing down on top of the dam will be greater than the pressure of the water pushing downstream, so the dam would be held in place.

To construct, several small logs approximately 15 centimeters in diameter are layed up to 1 meter apart pointing upstream on the bottom with the large end at the point where the dam is to be built. A cross log, at least 30 centimeters in size is then set into each bank and layed across the smaller logs at the large ends of them and spiked in place. Another smaller diameter log is then nailed across the small logs about half way up their length. Notching the small logs to receive the cross logs would help. Then rough cut planks at least 2.5 centimeters thick (the thicker the better) are layed along the dam from the top of the log upstream into a shallow trench dug in the stream bed and mailed down. The upstream ends of the planks are then covered with rocks and gravel to keep them in place. The lengths of the cribbing logs and the planks depends on the intended height of the dam in correspondence with the angle ratio.

If a higher dam is desired, two sets of cribbing logs can be spiked on top of each other topped by the planks. At each end of the dam, the cross logs are set into the bank and the bank reinforced with rocks to stop the current from cutting around the ends.

One advantage of this dam is the fact that after high water, the cribbing under the dam should be filled in with stones and gravel from the water. Also, when the water falls over the dam, it may undercut the structure, however with this construction it will not cause any collapse, in fact it should provide cover for fish. Since the surface of the dam is smooth, logs and brush should not get caught as they move over the structure. A notch in the planks can also be cut to allow the passage of fish even in low water conditions.

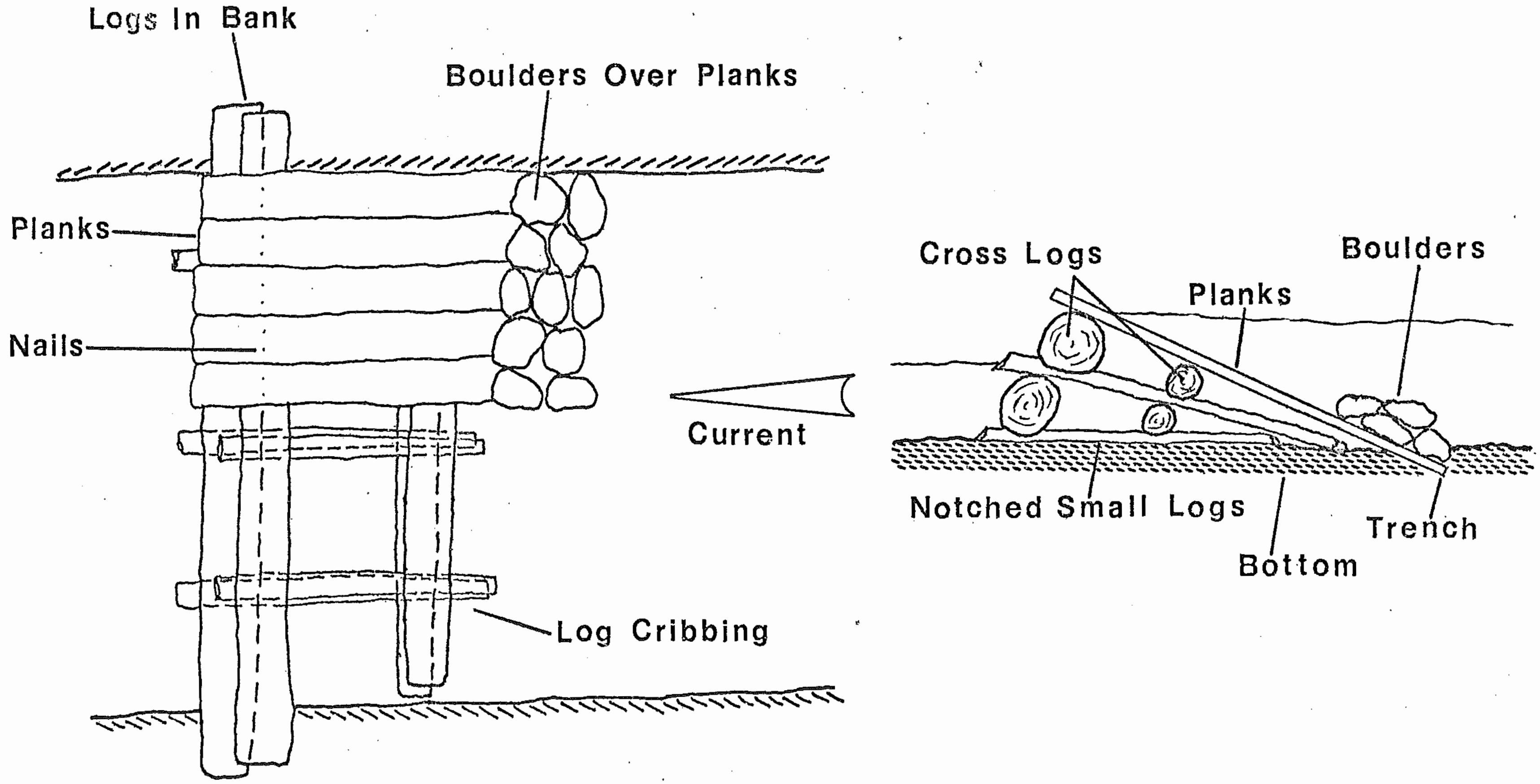


Fig. 5
PLANK DAM

Boulder Deflector

The boulder deflector can be constructed on nearly any type of stream bottom, as long as there is a supply of boulders at hand. The shape of the deflector is roughly triangular out from the bank. The reason for this, (as described earlier), is to cause any flood water running over the structure to flow back toward the center of the stream from the downstream side of the deflector.

Boulders as large as can be handled should be used for the construction. The largest of these should be fit tightly together along the upstream and downstream edges as well as at the point, since these are the areas most susceptible to boulder dislodgement. Embedding these boulders will increase the deflector's durability. The center of the structure can be filled with boulders of varying sizes since the center is held together by the edge boulders. Embedding of the center boulders also, will increase stability. As described in the general section on deflectores, there is no correct angle out from the bank. However, the device must not be too abrupt, as it will tend to stop the current instead of direct it. The angle can be judged quite easily. Care should be taken so that the deflected current does not erode the opposite bank because of the deflector being too long.

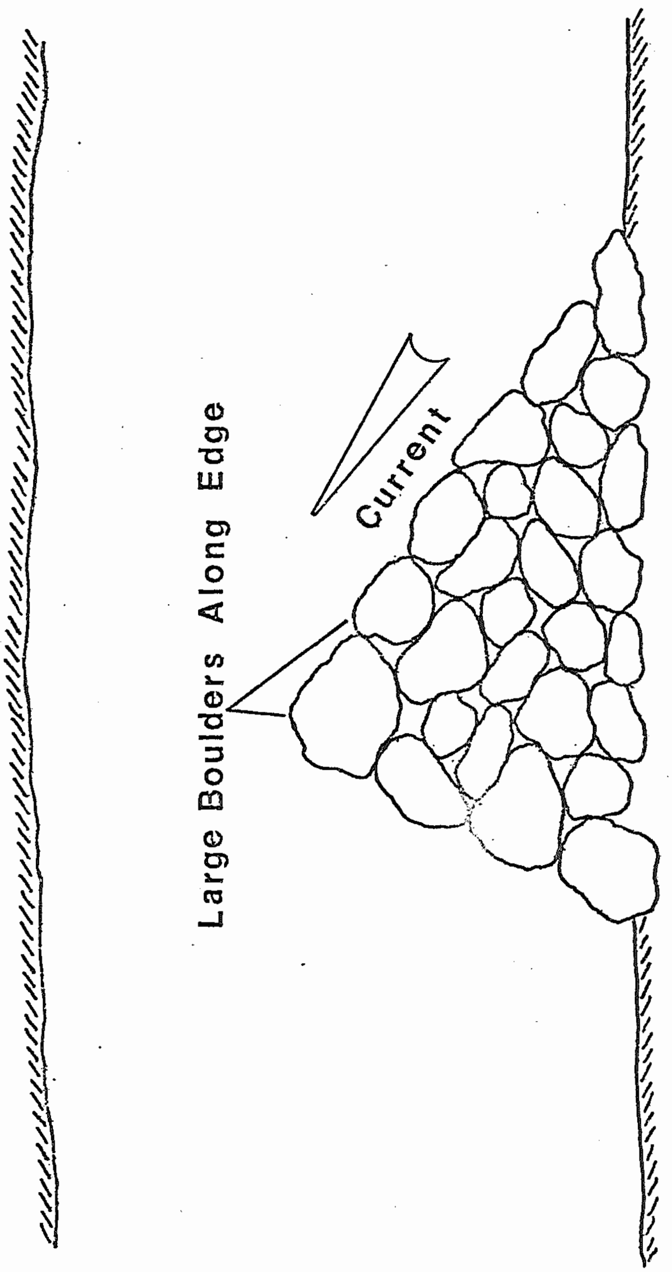


Fig. 6
BOULDER DEFLECTOR

Bank Cover Deflector

This is from a design in, "Guidelines for Management of Trout Stream Habitat in Wisconsin"[4] and combines a deflector with bank cover. It is designed mainly for use on fairly deep streams (1 meter plus) with low grassy banks, such as streams with little cover flowing through meadows. Usually they are constructed on the outsides of curves where the stream sweeps along the bank.

To construct, dig into the bank, where the cover is to be placed, a trench deep enough to be 25 to 35 centimeters below water level, 1 to 2 meters long and about 25 to 30 centimeters wide. Directly out from this, two posts 12 to 15 centimeters in diameter are driven at least 0.5 meters deep in the bottom, in line with the trench. Their tops should be a few centimeters higher than the trench bottom. The distance between the posts, and between them and the bank will depend on the width of the device wanted. In the bottom of the trench a layer of rocks about 10 to 15 centimeters in size should be placed. On this a board at least 2.5 centimeters thick (the thicker the better) and 10 to 15 centimeters wide should be laid. It should be long enough to lay the length of the trench and out to just past the two posts. This is nailed to the tops of the posts; and boulders are placed on it in the trench. Nailing may be aided by using a short steel bar and a hammer. Further along the bank the same process is repeated at distances of 1 to 1.5 meters until the length of the cover desired is reached. Then more boards of the same thickness and of the lengths required are nailed joining the first boards. Then boulders are placed on top of all the boards to a point above the water level, and almost up to ground level. It must be remembered that all of the wood must be under water or it will rot quickly. On these boulders sod should be placed from the surrounding area vegetation, to grow and give the device a natural appearance. The sod covering the trench should end up level with the bank sod. If cutting the sod is not desired, then soil can be placed on top of the device and seeded with desired plants.

The device and the boulders help to deflect the current, protect the bank, and give shelter to fish. Small fish can benefit also if tree branches are secured under the cover during construction.

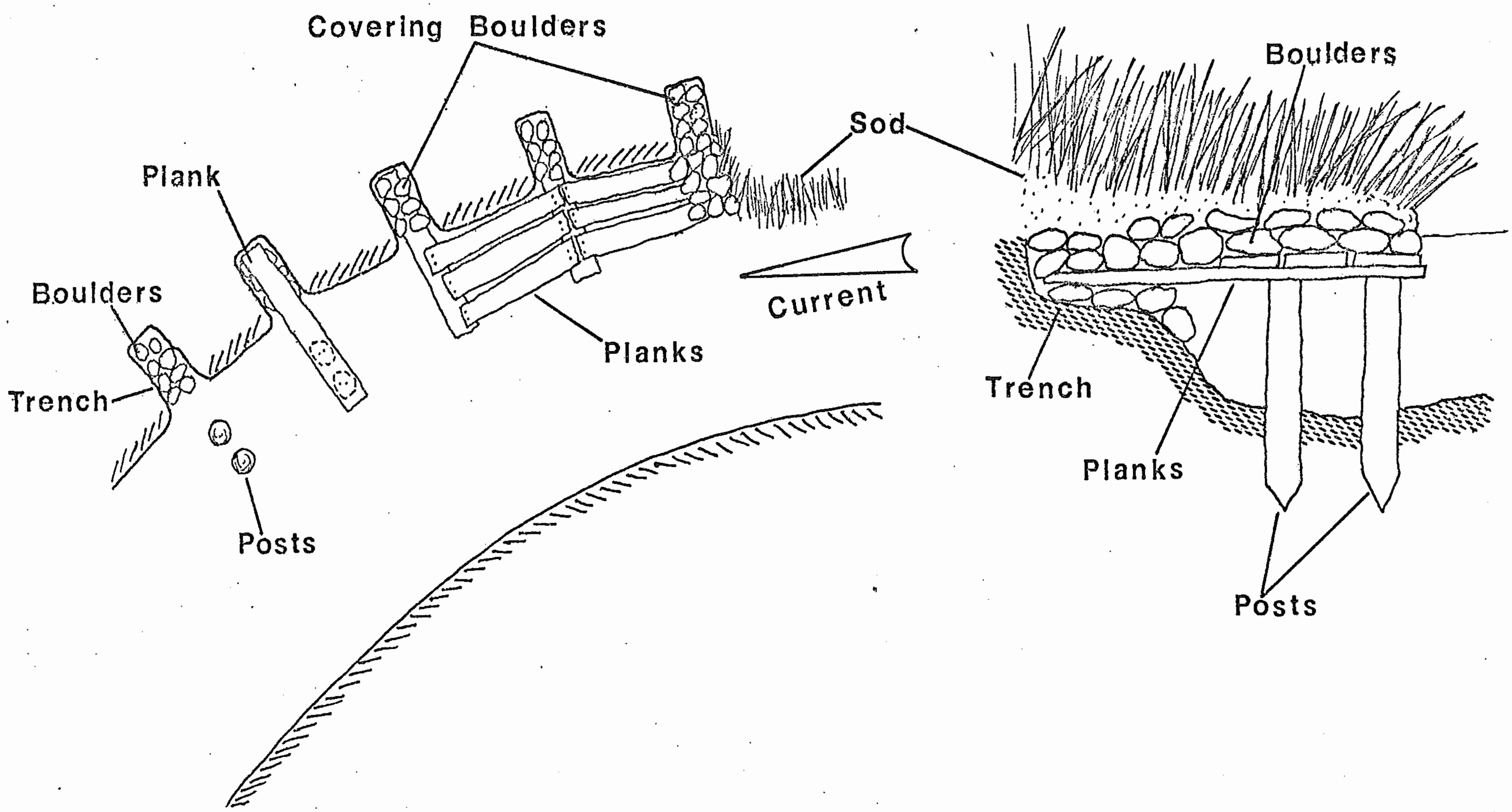


Fig. 7
BANK COVER DEFLECTOR

Rip-rap

Rip-rap or rock revetment is a way of protecting stream banks from erosion. It can affect the trout habitat by deepening the stream at bend pools, and can increase the hiding places for trout.

Rip-rap is the placement of boulders along a stream bank; and should not look like a masoned rock wall, but instead a jumbled mass of boulders. This has a more natural appearance and the jumbled boulders themselves provide trout with hiding places. Boulders as large as can be moved should be used for the revetment, because since the boulders are in a jumbled mass and not fit closely together, there is more possibility of movement by flood waters. Ideally, the upper portions of the rip-rap above the water level will become covered with turf.

Materials other than rock should not be used for bank protection. Logs, boards and cement used for barriers are not as effective, as permanent or as natural looking. Wood rots quickly when exposed to the air, and flood waters invariably scour between the barrier and the bank. Also, such structures give the stream an artificial appearance.

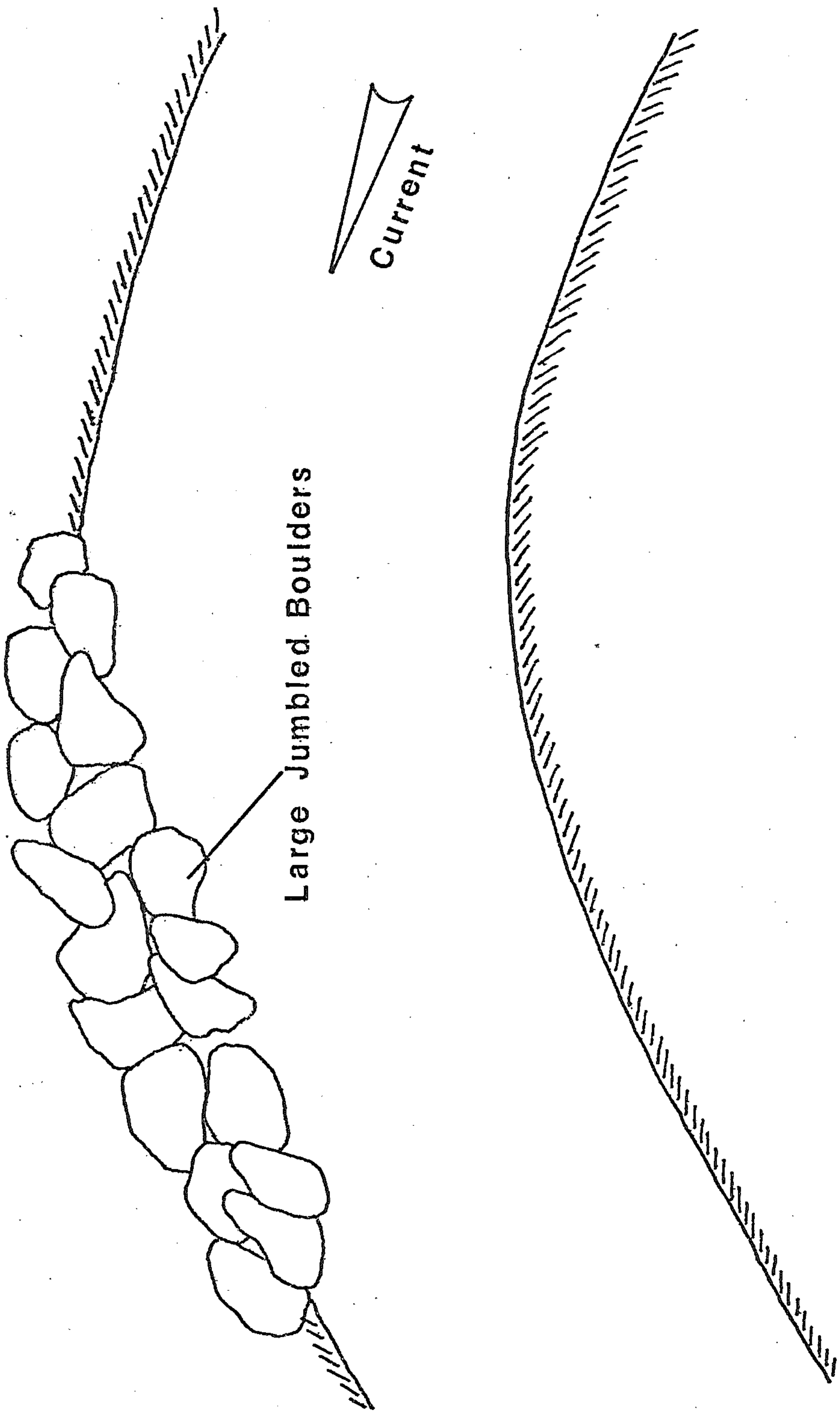


Fig. 8
RIP–RAP

Submerged Shelters

Brush submerged in a stream along a bank provides excellent cover for fish. Large trout as well as fingerlings can find a maze of hiding places in a tangle of brush. Submerged brush hides trout from their enemies, aerial, terrestrial and aquatic, and can protect small fish from cannibalism.

Brush can be cut from along the banks and it should be secured, butt end upstream, to bank anchors (posts, rocks, stumps and trees), by a short cable to allow the brush to move with fluctuating water levels. The butt end should be secured just above the shoreline, so debris does not get caught on it. It should also be placed so it is streamlined and does not block the flow. In larger streams, whole trees can be used.

Submerged logs can provide shelter for larger trout. The logs should be secured to the bank and should be aligned with the flow of water, so the flow is not dammed. Large boulders in a stream can provide hiding places for trout also. The current going around them tends to dig holes on the downstream side, which trout often use. Placement of the boulders should be random and scattered, to give a natural appearance, and should not dam the stream flow.

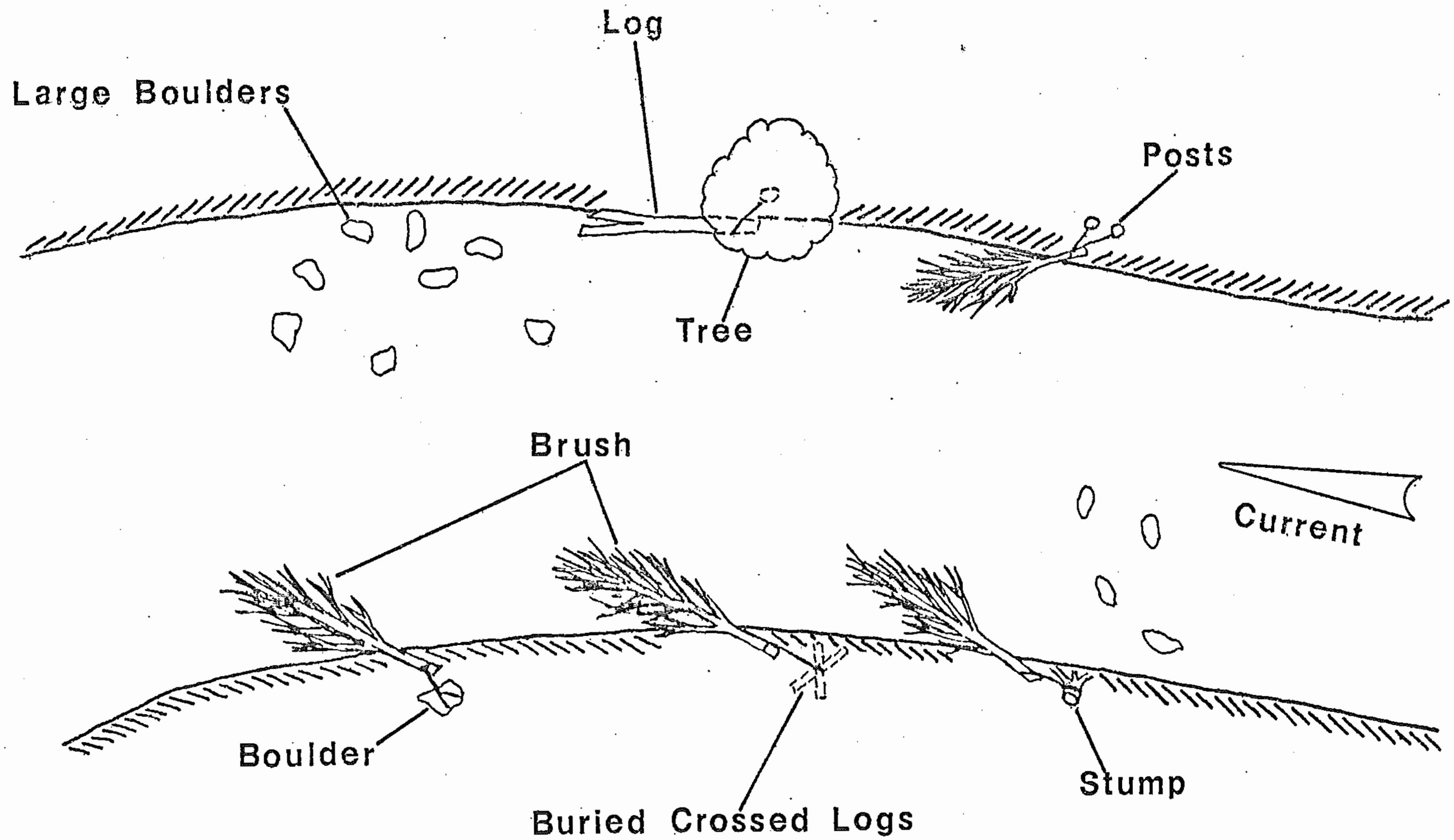


Fig. 9
SUBMERGED SHELTERS

Managerial Approaches

Vegetation

Along some streams, erosion, lack of trout cover, excess shade and other problems are very detrimental to fish populations. Management of the vegetation along these streams could help alleviate these problems.

Erosion can be lessened, as mentioned, with the installation of rip-rap along the eroding banks. However in some streams, there are not enough boulders to install rip-rap. Also, above the rip-rap boulders, rains and runoff would still partially erode the banks. In these instances, the planting of vegetation can be of benefit. Trout cover can be increased along stream banks much more cheaply through plantings than by building cover devices.

Grasses, such as reed canary grass (Phalaris arundinacea), or other grasses native to the area can be used for plantings. The root systems of grasses capable of living on stream banks bind the soil together, and their tops hang over the water and into it to provide excellent trout cover. Willows (Salix spp.), are also very useful as bank protectors. Their extensive root systems hold the banks together even under bad flood conditions, and the roots themselves form many ledges and grooves under water which trout use for cover.

Willows do require some maintenance, needing basal pruning about once every three years. This maintains a dense growth of saplings. If pruning is not done, the saplings will grow into larger trees. These trees will eventually grow large enough to shade the area so much that very little will grow there, and the erosion problem will return.

Shade is a problem with many streams, there can be too much or too little of it. Too much shade (from tall trees), can result not only in a lack of bank and instream growth, but it can cause excessive cooling of the stream, resulting in temperatures intolerable to trout. Too little shade can result in growth of cover along the banks; however some streams become too warm in summer without shade. Therefore, streams must be examined to see if such extremes exist, and shade removed or added depending upon the situation.

The technical bulletin, "Guidelines For Management of Trout Stream Habitat in Wisconsin," states that in streams less than 4.5 meters wide, grasses only should be encouraged as bank cover. On streams from 4.5 meters to 9 meters, very low bushes can be included for bank cover and protection, however alders should not be present because they grow so high that excessive shading is often the result.[5] Naturally, bank vegetation and cover varies from stream to stream, and any particular stream should be examined closely before any decisions are made concerning plant management.

Livestock

Cattle and other livestock can be very damaging to streams and stream bank vegetation. Livestock can destroy desired stream bank vegetation because many of the plants which grow along streams are wild and often cannot withstand grazing. Livestock not only eat the vegetation, but they trample it in the process. Often they cave in fish protecting overhangs, and their activities along and through streams can cause a great deal of siltation downstream.

While it is true that many streams are adversely affected by livestock, in most cases it would take more than that fact to convince livestock owners to improve their fencing without some sort of aid. At the present time no such incentives are apparently available to property owners. It is only when new fences are being built, that the owners could be asked to co-operate. Possibly volunteer help in construction would make them consider suggestions.

Fencing is often absent or in the wrong place, allowing plant damage. Fences should be built well back from the bank (3 to 6 meters), preferably above the flood plain so that the posts do not catch debris and become damaged during floods. Also, by keeping the fences well back, the bank plants will have a chance to grow; keeping in mind the fact that a cow can stretch her head almost a meter through a fence. Another advantage in keeping fences back, especially on the outside of stream bends, is to protect them from being undermined by the stream.

Naturally, decisions concerning fencing materials are up to the land owner. However, aesthetically to blend into the area, wood is the most appealing to the eye. Steel posts can be made a little less unattractive by painting them green or brown. Cattle watering areas should be enclosed, and made so that they can be moved out of the way during floods. Crossings can be comprised of a few strands of wire strung across the stream. These require little to replace after flood damage. Machinery crossings should be built high enough so that debris during floods will not get caught on them. These few aspects concerning livestock and fencing will benefit streams greatly.

Food

The food available to trout, as indicated, is comprised of aquatic, terrestrial and airborne organisms. Sometimes, for various reasons, this supply of food is reduced or even obliterated. Sometimes there is just not enough food produced to keep a larger trout population even though there is room for more fish. The causes for these conditions could be pollution, bad floods or a poor stream configuration. If the problem is pollution, then stopping it would hopefully cause the food supply to build up again over time. Floods could be controlled somewhat by the introduction of deflectors and low dams along the stream to slow down the flow.

One way of providing more food, is that described in the article, "Living Gold," in "the Flyfisher" magazine,[6] where certain food organisms are taken from the receding waters of a larger high producing river and transplanted to the stream in question. This however is expensive and time consuming, and could result in transplanted diseases, if the insects are from different watersheds. A more natural and less uncertain way, is simply to provide conditions in the stream which are favourable to the growth of food organisms.

To promote food growth, adequate light should reach the stream and its banks. Excessive shade can stunt and stop plant growth both in the stream and along its banks. Plants in the stream harbour many more insects than a bottom of rocks do. Also, low overhanging plants (grasses, shrubs) contain more terrestrial insects than do high shrubs and trees. Riffles should be preserved and can be produced, (if there are very few of them), by speeding up slow shallow water with deflectors.

An important consideration to keep in mind when aiding the growth of aquatic plants, is the amount of nutrients entering the stream from sewage outlets. The chemicals present in sewage are beneficial to plant growth; like a liquid fertilizer. However, the amounts of this sewage must be low enough to avoid what is called "stream eutrophication." This is a condition in which there are so many plant organisms (including algae) living in the stream, that at night the stream's oxygen level is depleted below levels tolerable to fish and food organisms. After dark, plants use oxygen through respiration, while during the day, they produce it through photosynthesis. It is not meant here, that sewage should be deliberately dumped in a stream to aid plant growth. Sewage may be benficial to plants, but it is not very beneficial to the fish in the same stream. An examination of the stream's condition will aid in food improvement plans.

Spawning Areas

The artificial improvement or construction of spawning areas in streams is very complicated, and work in this area is only in the developmental stages. At the present time, the only sound management practices concerning spawning grounds, is simply to preserve gravel beds and to restore those covered by water from dams and log jams.

Trout require rapid riffles with a gravel bottom and no silt, in which to spawn. Ways to improve and preserve existing spawning areas would be to build deflectors to help the water scour silts and sediments from covered gravel. Remove dams and obstructions which cause water flowing over spawning beds to slow and cause siltation. Hiding cover at the edges of spawning areas is advantageous. Since spawning takes place in exposed shallow water, fish often prefer to take cover at times when spawning. Aquatic plants can give protective cover for fingerlings after hatching, and should be promoted near spawning areas.

<u>Discussion</u>

After work has been completed on a stream, periodic inspections should be conducted to determine damaged areas followed by any repairs necessary. Vegetation plantings should also be inspected to see how they are doing, followed by any maintenance required. A whole program of improvements could be a waste of time, effort and money if the work done is not maintained.

Inspections should take place after the spring floods have passed; and at the end of the fishing season (check for damage by anglers). Planted vegetation should be tended, to aid it in establishment, and to control undesired species. Pollution, illegal fishing and any damage to the stream by any means can be determined during inspections, and followed by the necessary actions. If a stream is worth improving once, it is worth keeping it that way.

THE EXAMPLE OF BEAVER CREEK

Introduction

As stated earlier, a small section of Beaver Creek was improved, to illustrate some of the stream improvement methods described; as well as to show what can be accomplished by one person, no funds and little equipment. It is the intent of this small amount of work, to help the reader to realize that elaborate equipment and expense is not necessary to improve a stream, it requires only the will and energy to do it.

Much of the literature concerned with stream improvement (if it can be acquired) is directed toward the biologist or government employee. Many of the instructions contained within these documents deal with various pieces of survey, and analytical equipment. These things are often not available to the average person or outdoor group. However, much of the same work can be accomplished by using easily acquired articles.

Usually, outdoor groups rarely lack manpower for their projects. However, funds for equipment is often a determining factor. It is because of this that the example of Beaver Creek was included. The structures described earlier, and the methods illustrated in the following sections are for the purpose of aid to the would-be stream improver.

Location

The section of Beaver Creek in which the improvements were made is approximately 250 meters long. It is approximately 0.4 kilometers above the Beaver Creek Falls, which is about 4.4 kilometers from the stream's mouth. The location of Beaver Creek and the improvement section may be found on Figure 10. Also, the stream location may be found on the Department of Energy, Mines and Resources Maps: Rossland-Trail 82 F/4 and Salmo 82 F/3, with a 1:50.000 scale. The military grid reference for the improvement area is 586374.

Access To Creek

Access to the improvement section may be achieved by travelling along road 3B toward Salmo from Trail. After reaching Beaver Falls, travel for 1.4 kilometers and turn right down a secondary road (see Figure 10), and park at its end. From here it is a relatively short walk along a trail through private property (Mr. and Mrs. Langergraber - by permission) to a Burlington Northern Railway trestle above the falls. From here a trail leads to the creek. After donning waders, comes a walk of approximately 200 meters up the creek to the improvement section.

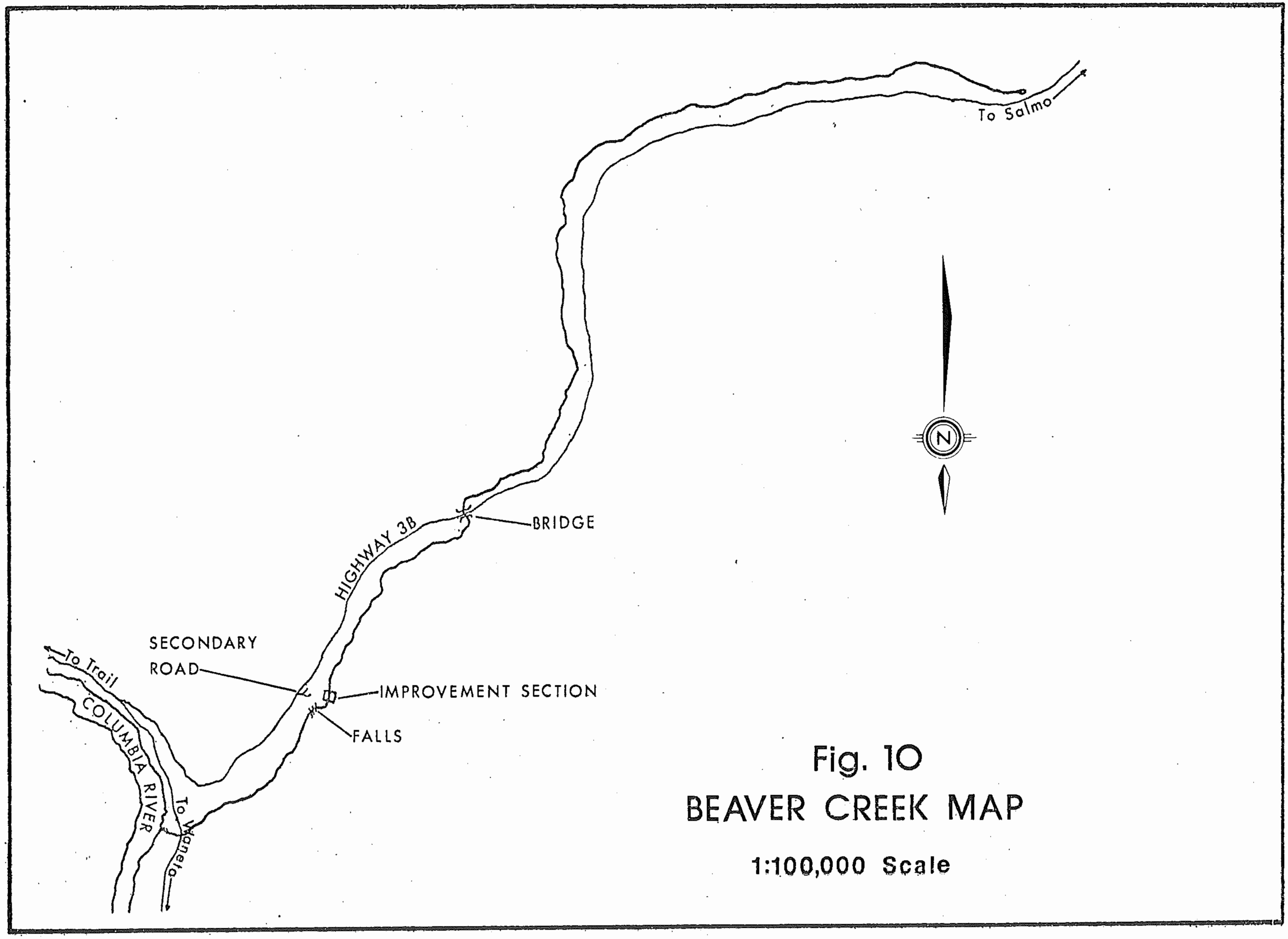


Fig. 10
BEAVER CREEK MAP

1:100,000 Scale

Description Of Creek

Beaver Creek finds its beginning in a marshy area near Erie Lake, at approximately 716 meters elevation. From that point it travels 28.8 kilometers to its mouth at the Columbia River, approximately 7 kilometers east-south-east of Trail. From beginning to end, it drops approximately 300 meters to an elevation of 411 meters. The stream forms a spectacular 24 meter waterfall located approximately 4.4 kilometers from the stream mouth.

From the falls down, brook trout (Salvelinus fontinalis) and rainbow trout (Salmo gairdneri) live. Above the falls, brook trout are the main inhabitants, with very few rainbow trout present there. Much of the stream is quickly flowing. The stream bed varies greatly, ranging from sand and mud to large boulders; and the average boulder size is approximately 15-20 centimeters.

Sewage effluent is put into the streams at two points. One of these is the sewage treatment lagoons in Fruitvale, and the other is from the sewage treatment facility located in Montrose. It appears that little damage has resulted from these two facilities, as they have been in operation for several years, and the stream still supports an active fishery.

Vegetation

The vegetation along both sides of the improvement section of the stream consists mainly of sparse forest intermixed with grassy areas. There were several places where the vegetation overhung the stream, however it was mainly comprised of high bushes and trees (see Figure 12) thereby not affording hiding cover for the fish. The following is a list of the main species found in the area:

Table 1

i)	Mountain Alder - Alnus tenuifolia
ii)	Red Osier Dogwood - Cornus stolonifera
iii)	Rose - Rosa spp.
iv)	Willow - Salix spp.
v)	Black Cottonwood - Populus trichocarpa
vi)	Great Mullein - Verbascum thapsus
vii)	Grasses

There was no vegetation in the stream to speak of, except for a few patches of algae on rocks along the edges of the water.

Insects

A small investigation of the types of insects in the stream was made. The insects were gathered by turning over boulders upstream of a fine meshed screen. The following is a list of some of the insects present:

Table 2

i) Caddis Fly Nymph - Glossosoma
ii) Caddis Fly Nymph - Hesperophylax
iii) Caddis Fly Nymph - Mystacides
iv) Mayfly Nymph - Thraulus
v) Mayfly Nymph - Epeorus
vi) Stonefly Nymph - Chloroperla
vii) Dragonfly Nymph - Aeschna
viii) Aquatic Larvae - Hydropsyche
ix) Fly Larvae - Tabanus
x) Fly Larvae - Chironomus
xi) Fly Larvae -- Psychoda

Improvement Procedures

Naturally, the first step in stream improvement is to decide upon the stream to improve. Beaver Creek was decided upon because of its close proximity to my residence, and of course because there were areas in need of improvement. However if a stream to improve must be found, then various possibilities must be considered. After various possible streams are thought of, each one must be considered for its need to be improved, as well as the possibilities for success. Obviously, if a stream is heavily stocked, and heavily fished, then improvement would do little to aid a healthy fish population. Also if a stream is badly polluted, no amount of improvement structures would help very much. If there is some doubt concerning whether or not a stream is suitable, advice from a local fisheries biologist or the Fish and Wildlife Branch could be helpful. Often these people have water analysis data and fish population estimates which could help in deciding if a stream is to be improved or rejected.

Of course there has to be a need for improvement. If a stream is diverse and varied and fits into the "ideal" stream described earlier, then it is a waste of time to attempt to improve it. In fact, by tampering with an already healthy stream in the name of improvement; damage can actually result. The reason is that improvements making pools and riffles etc., can cause these features to be too frequent and too close together, and this can be as distasteful to the trout as if the stream were channelized. Under natural conditions pools and riffles are normally repeated every five to seven channel widths. Therefore by making these features closer together through improvements, the stream may take on the characteristics of a deep, quiet river, which is better suited to coarse fish.

After the stream or area is decided upon, the areas in need of improvement should be found, and possible improvements discussed. A good way to start in an improvement plan, is to obtain a map of the improvement section. With Beaver Creek, and most streams, the topographical maps available are of too small a scale to be of much use. Therefore a workable map must be drawn up.

A relatively accurate map can be obtained by using the planetable survey method. The stream map Figure 12 was drawn in this way.

Planetable Survey

The following is a list of the materials needed to make a planetable surveyed map:

Table 3

- 1 piece plywood 61cm. x 79cm. x 1cm.
- 1 tripod (surveyor's or photographic) capable of rising to chest level
- an apparatus to attach board flat to top of tripod
- 1 compass (hand-held type)
- paper to cover top of board
- 1 3 sided ruler (30cm. long)
- 2 long straight pins (5cm.+)
- several shorter straight pins
- 1 roll coloured surveyor's tape
- 4 wooden stakes (at least this many)
- 1 protractor
- 1 roll masking tape
- pencils and eraser

First of all is the setting up of the equipment. The board is attached to the top of the tripod. For this survey, a steel plate was screwed to the bottom side of the board, and the camera bolt from the tripod was screwed into a threaded hole in the plate.

Photo 4 Tripod and planetable. Note steel plate on bottom of board.

The paper was taped to the board. Next the two long pins were secured to the three sided ruler with tape (see Photo 5). Two grooves were filed in the ruler to help keep the pins in place.

The reader's understanding of the following survey method will be aided with reference to Figure 11. Using the compass, a bearing was taken which generally corresponded to the bearing of the stream, in this instance it was N 12°E. A straight line was then drawn up the middle of the paper. This line was to be the bearing N 12° E. Next the scale of the map was decided upon. It was made so the width of the stream (approximately 6 meters) was 2 centimeters on the map. This 2 centimeters was the length of the "baseline" on the map. The baseline is a line directly across the stream perpendicular to the flow. A distance of 6 meters was then measured along this theoretical baseline, from shore to shore. Often the stream was not exactly 6 meters wide, so for simplicity, the same distance was left from each end of the 6 meters to the shore, and this distance was indicated on the map. At each end of the 6 meters a stake was driven in the stream bottom. One stake was "A" and the other was "B."

The tripod was set up over stake A, levelled, and the long line on the paper was lined up using the compass along bearing N 12° E. Then using the compass, a bearing to stake B was read from A, in this case N 76° E. The difference between 76° and 12° was 64°, so a line was drawn on the paper at 64° from the bearing line. Since this was the beginning of the map, this line crossed the bearing line. Along that line, a 2 centimeter segment was measured; one end corresponding to stake A and the other to stake B.

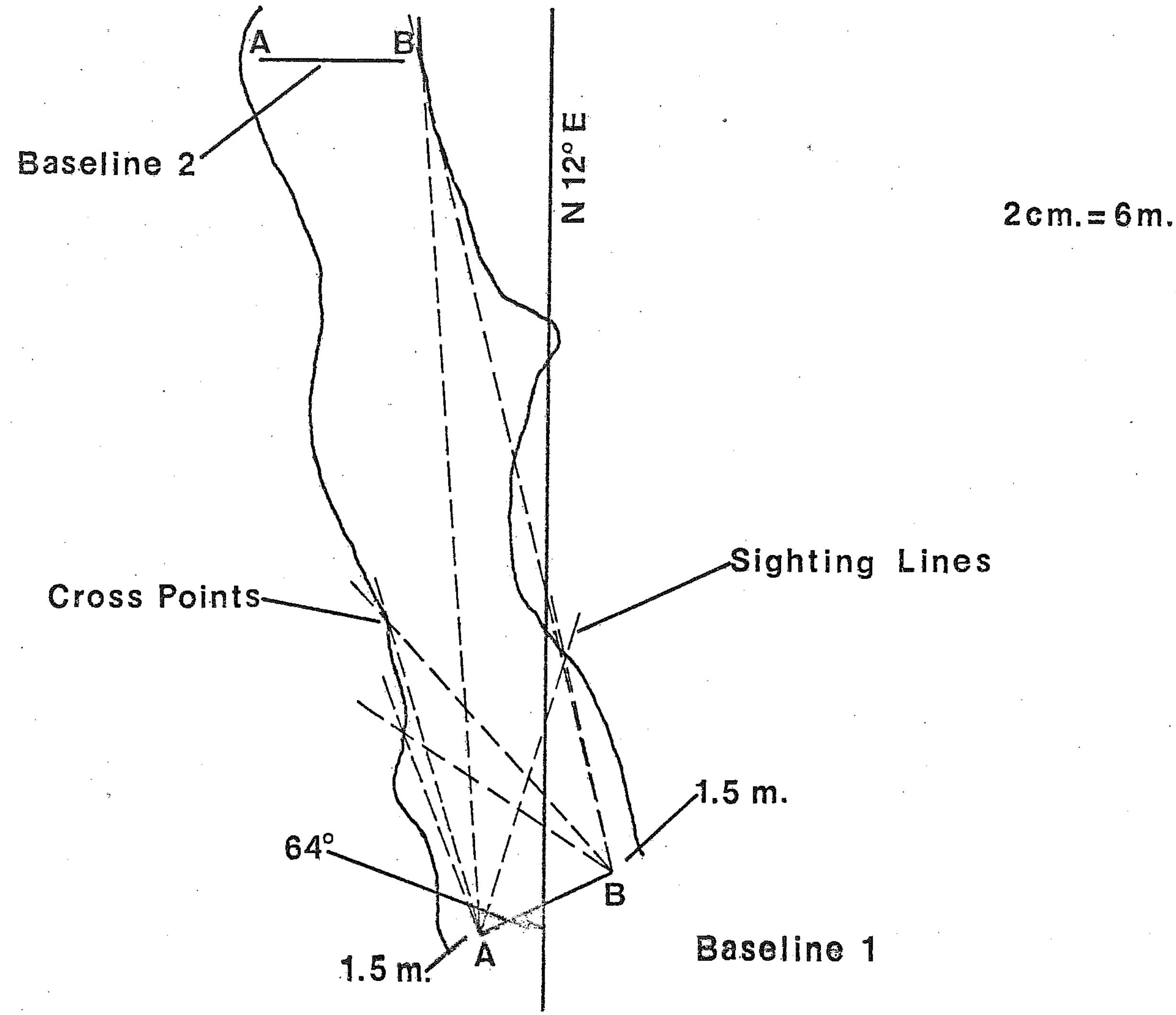


Fig. 11
PLANETABLE MAP

Various points along each shore of the stream were spotted and remembered (stumps, trees, rocks, roots, etc.), surveyor's tape tied to these aided in identification. Then one edge of the ruler with the pins in an upright position was put on point A on the paper. The two pins were aligned and sighted in on the first point on the shore. It was easier to keep the edge on point A by sticking a pin in the paper at that point.

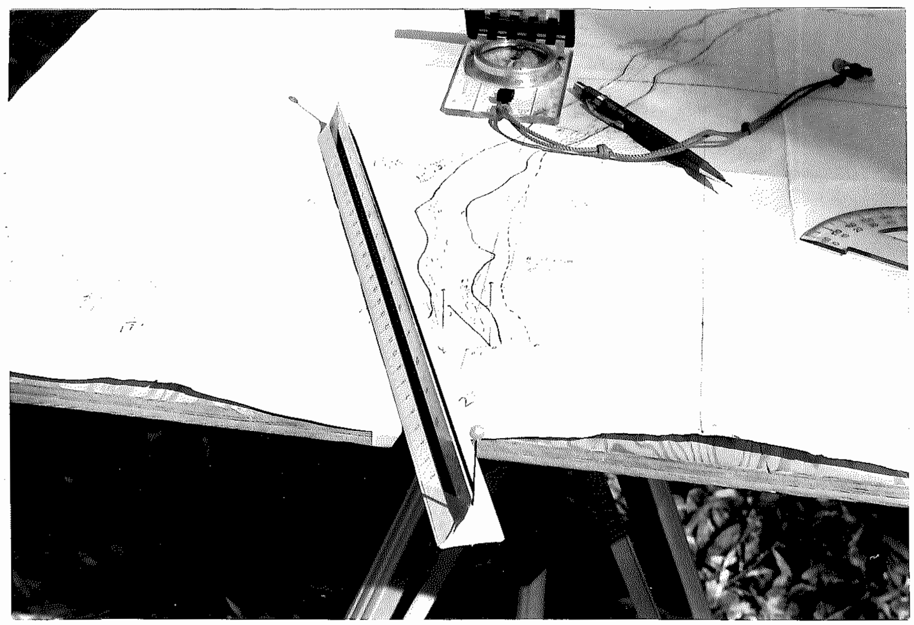


Photo 5 Ruler with pins attached, against point A and lined up with the point on shore. Note pins at each end of the baseline to help keep the ruler in place.

When the pins and the point were aligned, a line was drawn along the ruler edge from point A. The line length was at least as long as the ruler. This was continued until lines were drawn aligned with each of the points (always using the same edge of the ruler).

After that was done, the tripod was moved over stake B. The bearing line was aligned again as before, and baseline AB was lined up with stake A using the compass as a check. When this was set up, a pin was driven into point B. Then using the same edge of the ruler as before, the same points were aligned with the pins, and lines drawn. Where the lines crossed was the corresponding point on the map of the point on the ground. These points when joined yielded quite an accurate map.

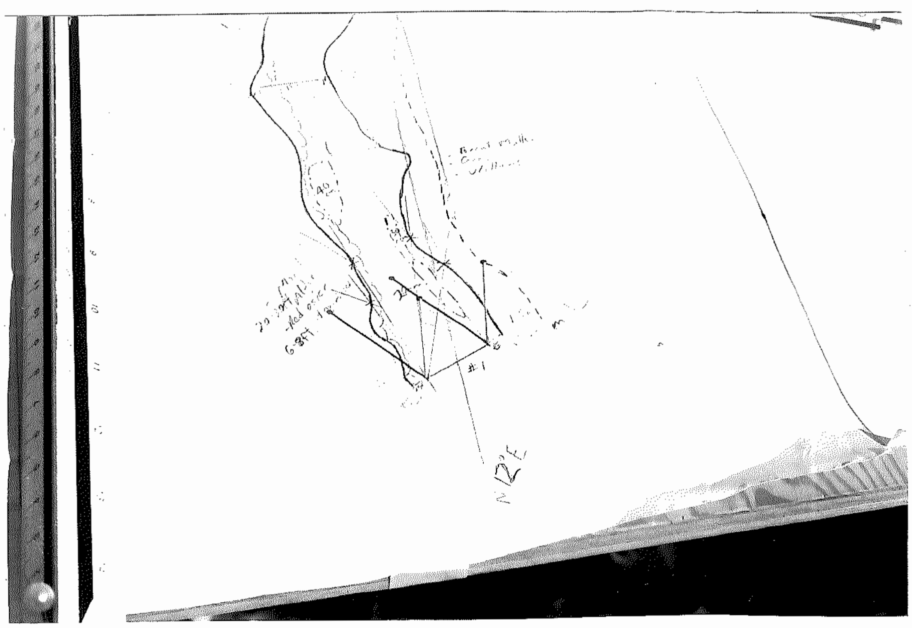


Photo 6 Crossed lines from points A and B. Note the crossed line points joined to show stream shores.

After the first area was finished, a new baseline of equal length was set up further up the stream. The distance on the ground from the center of baseline 1 to the center of the stream at the furthest point or points surveyed from that baseline was measured. Using the map scale, this distance was determined on the map. That spot measured from baseline 1 became baseline number 2.

At baseline 2, the tripod was set up over stake A, a new baseline bearing read from A to B and this new baseline was drawn on the map as before, at the distance determined above. Points were then identified and the whole process repeated.

The resulting map was quite accurate, checks were made from the baseline stakes to the various points along the shores, and these distances compared very well to those shown on the map. This is the most accurate map which can be drawn without becoming involved with expensive equipment.

After the map was drawn, other features such as overhanging bushes, islands, falls, rapids, etc. were measured and drawn in.

Maps such as these, are beneficial in the planning of an improvement program. It is advisable to identify areas to be improved and types of improvements to give an overall impression of the work to come. Before the improvement work is begun, permission should be aquired from the Fish and Wildlife Branch to allow work to take place. It is for this also, that a map is beneficial, to give the Conservation Officer a good idea of what is intended, and to allow him to make clear suggestions.

Stream Analysis

After the improvement locations are decided upon, it is often a good idea to do some analysis of the areas before beginning work to give further information on them which could aid in final decisions concerning improvement work. Some of the readings should also be repeated after the work to give some idea of changes resulting from the improvements. These readings will be explained further on.

Where the readings are taken depends upon the type of structure to be placed in the stream. A low dam affects the stream above it; whereas a deflector affects the stream below it. Therefore the exact place where before and after readings are taken from should change accordingly.

In Beaver Creek, the procedures for the readings were from a book entitled, "Freshwater Fishery Biology" by Karl F. Lagler.[7]

Width And Depth

Width was simply determined by using a tape to measure from shore to shore at the point where the readings were to be taken from.

Depth was measured using a graduated stick, halfway between one shore and the middle of the stream, at the middle and halfway between the middle and the other shore. The average depth was determined by the following formula:

$$\frac{\text{READINGS ADDED (cm.)}}{\text{NUMBER OF READINGS +1}} = \text{AVERAGE DEPTH (cm.)}$$

Adding one to the number of readings was to allow for the zero depth at each shore. These procedures were repeated again after the structure was made to determine how much effect the device had on the stream.

Velocity

Velocity of the stream was measured by attaching a small piece of wood (a small fisherman's float may be used) to 3 meters of limp monofilament line. The line should be less than 0.025 centimeters in diameter to reduce drag. Two pound test line was used for these readings with a diameter of 0.015 centimeters. The wood was then dropped onto the surface of the stream at each of the points used for depth readings and the time required for the wood to travel the 3 meters was determined by stopwatch. Each of these three times were put into the following formula:

$$\frac{\text{LENGTH (m.)}}{\dfrac{\text{TIMES ADDED (sec.)}}{\text{NUMBER OF POINTS}}} = \text{VELOCITY (m./sec.)}$$

The resulting velocity was recorded and the same procedure was repeated after the improvement structure was made, to determine how much effect the structure had on the stream.

Certainly width, depth and velocity readings depend upon the condition of the stream at the time of recording, and will vary throughout the year. However, if the readings are taken just prior to actual improvement work, then in the time taken to improve that spot and to do the readings again, the stream should not have changed very much.

Pools And Shelter

The evaluation of particular pools or a section of stream can be of benefit when trying to determine what types of structures should be used for improvement purposes. Pools are judged subjectively with regard to size, type and frequency, and there is little specific information which can aid in the evaluation of pools.

In Lagler's book, one system of pool evaluation is suggested:

Size

1. Pools having an average width or length much greater than the average width of the stream.

2. Pools having a width or length equal to the average width of the stream.

3. Pools much narrower or shorter than the average stream width.

Type

1. Deep (0.6 meters or more) exposed pools containing a great luxuriance of aquatic plants harbouring a rich fauna; or deep pools with abundant shelter (overhanging banks, logs, roots, boulders) much drift or detritus, and shaded by forest cover or shrubs.

2. Pools intermediate in depth, shelter, plant abundance, etc.

3. Shallow exposed pools without shelter and without plants; scouring basins.

Frequency

1. More or less continuous pools - about 75% to 25% ratio of pools to riffles.

2. Rather close succession of pools and rapids - approximately 50% to 50% relation.

3. Pools infrequent with long stretches of swift, shallow water between - pools making up 25% or less of the total stream area.[8]

If a pool or section of stream is number 1 in all of these categories, it would have the highest rating. If it is number 3, it would have the lowest rating. Other combinations would roughly be considered as being intermediate. It was with the aid of this classification, that the improvement sites were considered.

Shade

The determination of the amount and type of shade along a stream can help in deciding if shade or cover should be changed in the improvement program. Shade was subjectively described by Lagler as:

> Dense - if overhanging brush and trees render the stream unfishable.
>
> Partly Shaded - if approximately half of the water is shaded.
>
> Open - if little or no shade exists.[9]

The size and type of shade, brush or trees is often recorded to help in deciding what to provide or remove, if observation shows shade management is warranted.

Bottom

The size and type of material making up the stream bed should be considered to determine if conditions for natural spawning are available, and to decide what type of structure if any should be built. If the bottom contains large boulders for instance, then a boulder dam or boulder deflector would give the area a very natural appearance.

Another reason that bottom type is an important consideration, is for the evaluation of productivity. Eagler showed the following types of bottoms are productive in decreasing amounts as listed: silt, small rubble, coarse gravel, fine gravel and sand. It seems that the silt and rubble produce large varieties of water plants. Therefore these types of bottom produce large amounts of fish food, because most of the food organisms are dependent on the plants for food and shelter.

The bottom types for the example area were recorded for the improvement areas only and were expressed in percentages of the differing types.

Food Richness

The food organisms available to a population of fish should be considered when deciding whether or not to improve a stream. Also this knowledge can have a bearing on what types of improvements are to be made, as described in the Managerial Approaches section under "Food." The amount of food can be determined fairly easily.

Estimates of the bottom food are often based on square foot samples made with a net. Where the sample improvements were made, two samples of fish food were taken, one in the middle of the stream and one between the middle and a shore.

The sampler was simply nylon window screen, stapled to two pieces of wood, with a loose mesh cloth funnel sewn to a hole in the screen cut 10 centimeters up from the bottom. The funnel is not absolutely necessary, but it is easier to collect the organisms from the bottom of a funnel than from across a large screen. Another piece of wood was bolted to the tops of the other two pieces to hold the screen open.

Photo 7 Sampler screen, Note cloth funnel sewn around hole in screen. Note also the piece of wood across the top to hold screen out.

Since I was alone, forked sticks held the sampler upright in the stream, otherwise for two or more people, one person could simply hold the screen in place. The screen was set up and directly upstream of the funnel, a square foot was measured on the bottom. Then all of the stones and sticks within that square were turned over and washed off in front of the net and into it, and then moved out of the measured square. After that, the bottom within the square was stirred up to dislodge the deeper lying organisms. After the bottom debris was replaced in the sample square, the contents of the screen and funnel were washed and placed in a pan. The sticks and debris were removed and the insects were taken out (while being counted) and placed in another container. This was when some of the various species were observed.

The evaluation of food richness does not depend upon numbers alone; although large numbers do increase the possibilities of fish utilization. Volume is also an important factor. A large number of small organisms can have a smaller volume than a few very large organisms. The latter however, could presumably produce more fish and would require less energy in obtaining it. However, a sample of large organisms could only feed a few fish, since fish do not share their meals. Therefore volume and numbers are important.

To obtain volume (as described by Lagler), the organisms were placed on a folded sheet of paper to drain. The caddis fly nymphs were removed from their cases and only the nymphs were put on the paper. After the organisms drained, they were to be put in a graduated centrifuge tube with a known amount of water. But since one could not be obtained, a large graduated syringe without the plunger and needle and a plug in the small end was used. This was obtained from the waste-basket of a local clinic. The difference between the known amount of water and the amount after the insects were added was the volume of the insects in the sample.

The volumes of the two samples taken at each site were averaged by adding the volumes and dividing by 2. The quantities of the samples were also averaged in the same way. These became the final results of the sites.

Again from Lagler is a list of the standards of richness:

Food Grade 1 - (Exceptional richness) volume greater than 2 cc., number greater than 50.

Food Grade 2 - (Average richness) volume from 1 to 2 cc., more than 50 organisms.

Food Grade 3 - (Poor in food) volume less than 1 cc., and (or) fewer than 50 organisms.[10]

To qualify, both the numerical and volumetric standards must be met for any one grade. For example, a sample containing 30 insects with a volume of 2.5 cc. would be graded 3. Similarly, a sample containing 200 insects with a volume of 0.9 cc. would be graded 3.

Creek Improvements

Along the sample section of Beaver Creek, four different improvement sites were decided upon. However, of these, only the first two were actually improved (see Figure 12). One weekend it was found that the third site was the new location of a large beaver dam, and the fourth site, upstream of that, was covered with backed up water from the dam.

Photo 8 Site number 3. Beavers got to it first.

No readings had been taken at either site since work had not begun there yet. There was only one picture taken and that was of site number 4, before it was covered with water.

Photo 9 "Before" shot of site number 4.

Unfortunately, it was too late in the year to try to extend the improvement section since a new map would have to have been produced for inclusion in this paper. Before Fall, three beaver dams in all were built in the improvement section. Luckily, the first two improvement sites were not affected.

The stream analysis procedures were conducted on the improvement sites before the work was done. However, after the improvements, only those features which changed as a result of them were analysed again. The following is a section on the results before the improvements, followed by the improvements themselves and followed again by the results of the analysis after the improvement work.

Stream Analysis Results Before Improvements

Width And Depth

The widths of the stream at the two improvement sites where readings were taken were:

Site 1 - 3.5 m.

Site 2 - 8.3 m.

The average depth of the two sites were:

Site 1 -

$$\frac{17\text{cm.} + 34\text{cm.} + 30\text{cm.}}{4} = 20.25\text{cm.}$$

Site 2 -

$$\frac{26\text{cm.} + 30\text{cm.} + 21\text{cm.}}{4} = 19.25\text{cm.}$$

Velocity

The velocities at the improvement sites were found to be the following:

Site 1 -

$$\frac{3\text{ m.}}{\dfrac{8\text{sec.} + 6\text{sec.} + 6.5\text{sec.}}{3}} = 0.439\text{ m/sec.}$$

Site 2 -

$$\frac{3 \text{ m.}}{\dfrac{7.2\text{sec.} + 4.9\text{sec.} + 14.6\text{sec.}}{3}} = 0.337 \text{ m/sec.}$$

Pools And Shelter

The pools and shelter at each improvement site were evaluated as the following:

Site 1 - Size - 2
- Type - 2
- Frequency - 2

Site 2 - Size - 2
- Type - 3
- Frequency - 3

As can be seen, at both sites, the quality of the pools and shelter were not the highest. This was one of the main reasons the sites were chosen for this example.

Shade

The shade which existed along the stream in the improvement areas was rated as follows:

Site 1 - Partly shaded.
- Shade was along the west shore only and was composed of 5-9 meter Mountain Alder (Alnus tenuifolia) and 2-3 meter Red Osier Dogwood (Cornus stolonifera).

Site 2 - Open
- The bush and trees grew to within one meter of the water, however because of

their size and the manner in which they grew, there was very few overhanging branches affording shade. The species which grew there were 2-3 meter Red Osier Dogwood (Cornus stolonifera), 6 meter Mountain Alder (Alnus tenuifolia) and 2 meter Rose bushes (Rosa spp.).

The shade described at Site 1 and Site 2, was quite high, 2-3 meters was the lowest of the species. In veiw of this and the fact that fish often rest and hide under the branches of vegetation growing over the water; low growing vegetation such as grasses and willows could have been of benefit here.

Bottom

The bottom types in each area as mentioned before, were expressed in percentages as follows:

Site 1 - Pool (most of site) - 50% boulders 20cm.+
- 40% rocks 5-19.9 cm.
- Riffle (small part of site) - 10% coarse gravel <5cm.

Site 2 - Riffle - 40% boulders 20cm.+
- 50% rocks 5-19.9cm.
- 10% coarse gravel <5cm.

The types of bottom described here had a bearing on the types of improvements used for the stream example, in that the large numbers of boulders were used for building materials.

Food Richness

Food richness samples were taken at each of the improvement sites and the results were as follows:

Site 1

First sample (stream center) - 1.2 cc. with 68 organisms.
Second sample-- 1 cc. with 59 organisms.

Average - 1.1 cc. with 64 organisms.

Site 2

First sample (stream center) - 1.4 cc. with 74 organisms.
Second sample - 1.3 cc. with 70 organisms.

Average - 1.35 cc. with 72 organisms.

These results indicate an average richness of food in this section of the stream. As previously indicated, silt and small rubble produce the most in the way of organisms; however these two sites have boulder bottoms. Little plant life grew among these boulders, however they afford excellent hiding areas for the organisms, and trap plant detritus between them to provide food for the insects, and are therefore relatively productive.

Stream Improvement Sites

As mentioned before not all of the improvement work planned for the stream section became a reality. However, the work that was accomplished will be examined here.

Site 1

As seen on Figure 12, this spot was fairly narrow, and was located just downstream of a slight rapid.

Photo 10 Section of stream a Site 1.

Notice in Photo 10 the channel on the left, and the water trickling through the rocks on the right. It was the channel that I wanted to deepen, and it was that water trickling through the rocks and into the channel that was going to help.

The plan was to build a low dam at the bottom of the channel, and a deflector in the shallow water to direct more water into the channel. The deflector was of the triangular type.

Photo 11 Site 1 with deflector and part of dam. Note the direction of water along the deflector and into the channel, compared to Photo 10.

The upstream edge of the deflector was approximately 5 meters long. The largest boulders in the immediate area were used for the upstream edge, and the point, as they were to receive the most water pressure. Large boulders were also used for the lower edge and in the center to help hold the structure together.

After the deflector was built, the dam was constructed. The largest boulders in the immediate area were used for this and were carefully fit together to help strengthen the dam.

Photo 12 The finished dam. Notice the water being directed into the channel by the deflector, the deflector point is at the upper right in the photo.

Built into the dam was a spillway, (seen at bottom center of Photo 12), to help direct the water down the center of the stream below the dam. The action of which, over time will produce another channel. The dam was built so that two of the largest boulders were on each side of the spillway to overcome the fact that the spillway is a weak point.

From looking at the photos, it may become apparent that the dam did not stretch the full width of the stream. It did in fact only go from one shore to a very large boulder 2/3 of the way across. There were several reasons for this. One, was the fact that from the large boulder to the next shore, was a wide section of smooth bedrock. To place boulders on this would be a waste of time as the next flood would prove. To build a structure that would stay there was beyond my resources, though it can be done. To have placed the dam upstream or down would not have taken advantage of the deflected water fully, and it would also have meant losing out on some important anchor points. Also, the device added some interesting and advantageous kinks and curves to the stream. One of the benefits, was the fact that migrating fish could go around the dam instead of over it. Also, water of varying speeds was provided within a small area. This was beneficial to aquatic life of different species, which prefer various living conditions.

Site 2

The second improvement site was a wide, shallow area with very little shade or cover for fish. A few ideas were considered for this spot. Deflectors to bounce the current back and forth along the section to add diversity were considered, but with the low banks, erosion could have been a problem. A dam was thought of and rejected because of the wide expanse to go across the stream and because of the low banks at that point.

Photo 13 Site 2 before improvements.

Finally, a double deflector was decided upon, which is simply two deflectors built at the same site. The reason for a double deflector was because of the action which could be expected from such a structure. The problem with the section of stream was its width and shallowness, and a lack of a main channel. A deflector built out from each bank just stopping short of each other, would cause the water to be forced toward the center of the stream thus being sped up because of the funnelling action. This water would over a relatively short time, dig a channel down the center of the stream below the structure. This channel would then afford desirable quarters for fish to feed and rest.

As with Site 1, the deflectors were of the triangular type, and were constructed with the largest boulders in the immediate area.

Photo 14 Deflectors in place. Notice large boulders at points of deflectors.

Photo 15 Another angle looking at deflectors.

Photo 16 Closer look at deflectors. Notice how water is funnelled between the structures and down the center of the stream.

As can be seen in the photos, the two deflectors are not too close together so as the almost dam the water. There is no measurement as to how close they should be, it simply takes judgement.

Stream Analysis After Improvements

After the previously described improvements were completed, some analysis of the stream was again conducted at the same points as previously done. The measurements taken were width, depth and velocity since these stream characteristics changed as a direct result of the improvements.

Width And Depth

The following were the widths of the stream at the improvement sites after improvement:

Site 1 - 3.9 m.

Site 2 - 8.3 m.

The average depths of the stream at the improvement sites were as follows:

Site 1 -

$$\frac{22\text{cm.} + 43\text{cm.} + 24\text{cm.}}{4} = 22.25\text{cm.}$$

Site 2 -

$$\frac{30\text{cm.} + 45\text{cm.} + 28\text{cm.}}{4} = 25.75\text{cm.}$$

If the results from before and after the improvements are compared, an increase in the depths of both sections of stream will become apparent. This increase in depths was because of the fact that the water was being obstructed by an object (the structure) causing it to deepen. The width at Site 1 only increased however. This was because of the type of structure. Being a dam it held back the water more than the double deflectors, which because of their design actually forced the water past them.

Velocity

The following are the velocity calculations based on readings taken from the stream at the improvement sites:

Site 1 -

$$\frac{3\text{ m.}}{\frac{8.5\text{sec.} + 5.5\text{sec.} + 16\text{sec.}}{3}} = 0.3\text{ m/sec.}$$

Site 2 -

$$\frac{3 \text{ m.}}{\frac{5.9\text{sec.} + 4\text{sec.} + 11.4\text{sec.}}{3}} = 0.423 \text{ m/sec.}$$

When comparing the velocities at each site before and after improvements, differences are obvious. Site 1 shows quite a large drop in velocity after the improvements, from 0.439 m/sec. to 0.3 m/sec. This was the aim of the Site 1 construction, to slow down the current speed. Site 2 shows an opposite trend, from 0.337 m/sec. to 0.423 m/sec. after improvements. This increase in velocity was created by the construction of the device, in an attempt to create a deeper stream channel.

Overview

The improvement work done on this section of Beaver Creek produced the effects wanted, which, hopefully were of benefit to the stream. However, to prove whether or not the improvements were very beneficial to the stream would require several years of observation and analysis, both of which are too involved to be included here.

Though it is true that the work accomplished on

Beaver Créek did not meet the original expectations; the work and analysis which was done provided a good example for this paper. As stated before, it was the intent of this paper to illustrate some of the stream improvement techniques known, and to provide an improvement example to show what can be done by one person. In this respect the example work done proved successful.

CONCLUSION

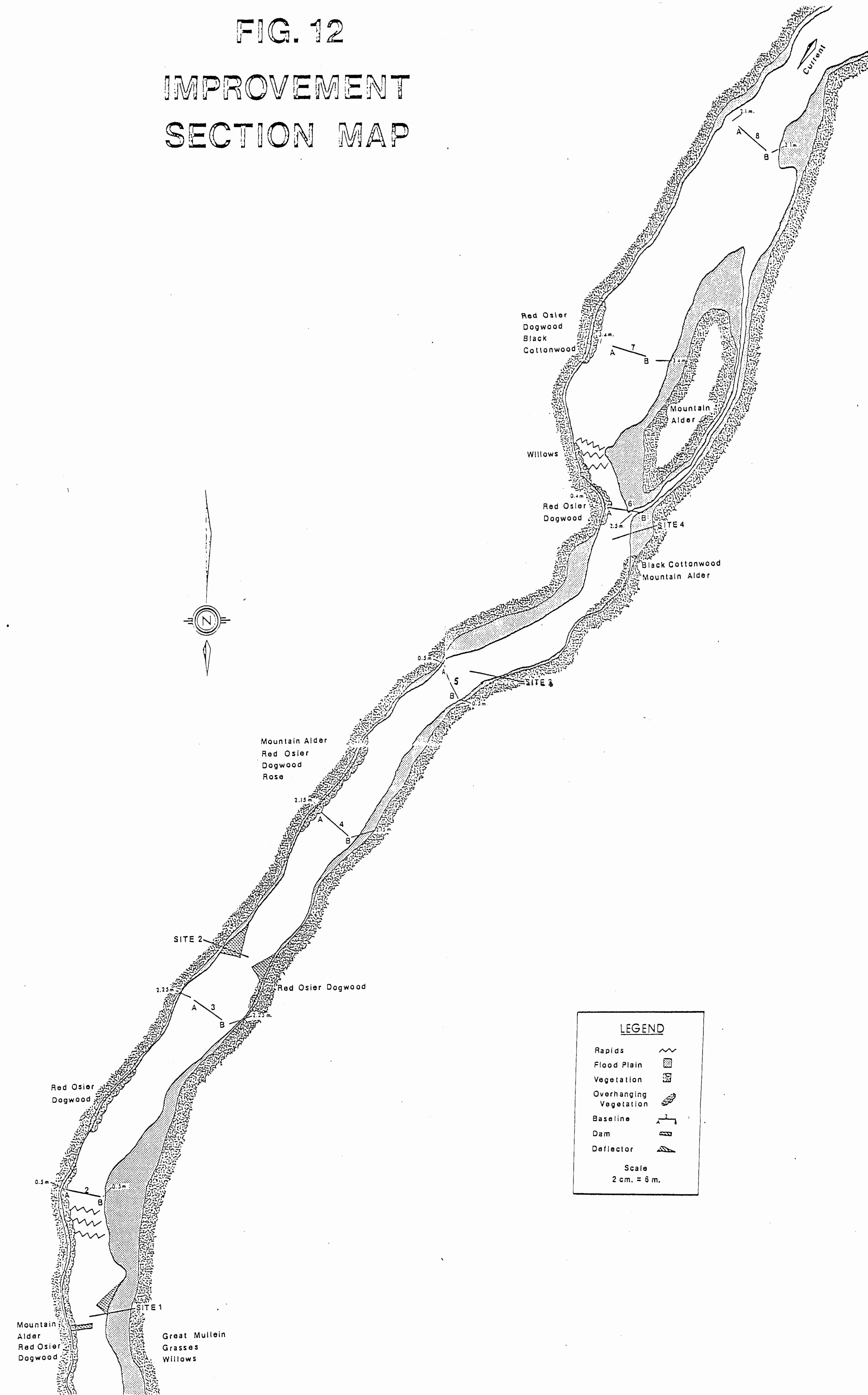
The characteristics of a stream are many and varied. The life which exists in it depends on the stream's productivity, water quality and quantity to live. Sometimes however, these characteristics are altered or are not present. Man's, as well as nature's activities often damage streams to the point where the life in them is in jeopardy. It is when these conditions exist, that stream improvement is so important. The repairs and enhancement afforded by correct stream improvement techniques are the life-savers of many streams across the country in need of their application. And it is often outdoor groups who come to the aid of these streams.

Improvement techniques are described in this paper to provide some form of aid to those who enjoy the beauty of a healthy stream. The procedures examined are relatively simple and inexpensive to implement and include improvement techniques as well as analytical procedures to determine just what type of work in warranted as well as to analyse that which is done. An example of an actual improvement project was included to illustrate just what can be accomplished in this field of work. From the information described, it is hoped that more improvement of our streams will result.

IMPROVEMENT SECTION

MAP

FIG. 12
IMPROVEMENT SECTION MAP



ENDNOTES

1. Ray J. White and Oscar M. Brynildson, Guidelines For Management of Trout Stream Habitat in Wisconsin (Madison, Wisconsin, 1967), Technical Bulletin No. 39, p. 21.

2. John G. Lynde, Box 355, Montrose, B.C.

3. Edward R. Hewitt, Hewitt's Handbook of Stream Improvement (New York, 1934), pp. 27-30.

4. Ray J. White and Oscar M. Brynildson, Guidelines For Management of Trout Stream Habitat in Wisconsin (Madison, Wisconsin, 1967), Technical Bulletin No. 39, p. 23.

5. Ibid, p. 14

6. Dwight R. Schuh, "Living Gold," the Flyfisher (No. 2, 1973), 6:6-8.

7. Karl F. Lagler, Freshwater Fishery Biology (Dubuque, Iowa, 1972), pp. 297-305.

8. Ibid, pp. 300-301.

9. Ibid, p. 302.

10. Ibid, p. 305.

BIBLIOGRAPHY

1. Biette, R. M. Better Streams For More Trout. Ontario: Ministry of Natural Resources, Fisheries Branch, 1978.

2. Brinker, Russell C. and Paul R. Wolf. Elementary Surveying. New York: IEP-A Dun-Donnelley Publisher, 1977.

3. Brumitt, Clint. "Helping Fish Help Themselves," the Flyfisher (No. 1, 1975), VIII:1,32.

4. Dalzell, Bonnie. "French Creek Has A Friend," the Flyfisher (No. 1, 1978), XI:28-31.

5. Hayes, Jim. "Miracle of Whites Creek," Outdoor Life (November, 1964), pp. 24-27, 92-95.

6. Hewitt, Edward R. Better Trout Streams. New York, London: Charles Scribner's Sons, 1931.

7. Hewitt, Edward R. Hewitt's Handbook of Stream Improvement. New York: The Marchbanks Press, 1934.

8. Lagler, Karl F. Freshwater Fishery Biology. Dubuque, Iowa: William C. Brown Co. Publishers, 1972.

9. Lyons, C. P. Trees, Shrubs and Flowers. Toronto, Vancouver: J. M. Dent & Sons Ltd., 1976.

10. Marcuson, Pat. "Silt Pollution Kills Trout," Montana Outdoors (July, 1970), Vol. V, No. 7.

11. Migel, J. Micheal, ed., The Stream Conservation Handbook. New York: Crown Publishers, Inc., 1974.

12. Moyle, Peter B. "Some Effects of Channelization on the Fishes and Vertebrates of Rush Creek, Modoc County, California," California Fish and Game (No. 3, 1976), 62:179-186.

13. Needham, James G. and Paul R. Needham. Fresh-Water Biology. San Francisco: Holden-Day, Inc., 1975.

14. Needham, Paul R. Trout Streams. San Francisco: Holden-Day, Inc., 1969.

15. Otis, Maurice. Guide to Stream Improvement. New York: New York State Conservation Department, Division of Conservation Education, n.d.

16. Peterson, Norm. "What Makes A Stream Good Fishing?" Montana Outdoors (July/August, 1974), No. 4, 5:35-38.

17. Platts, W. Carter. Trout Streams. London: The Field Press Ltd., circa, 1930.

18. Platts, W. Carter. Trout Streams & Salmon Rivers - their management and improvement. London: The Field Press Ltd., 1930.

19. Pryce-Tannatt, T. E. Fish Passes. London: Edward Arnold & Co., 1938.

20. Schuh, Dwight R. "Living Gold," the Flyfisher (No. 2, 1973), VI:6-8.

21. U.S. Bureau of Fisheries. Methods For the Improvement of Streams. Washington: 1935.

22. White, Ray J. and Oscar M. Brynildson. Guidelines For Management of Trout Stream Habitat in Wisconsin. Madison, Wisconsin: Department of Natural Resources, Division of Conservation, Technical Bulletin, Number 39, 1967.