STREAM AND LAKE SURVEYS

Introduction

The data from stream and lake surveys form a large portion of the basis for fishery management. Basically the survey is an inventory. It is obvious that Montana, with its limited fishery investigation personnel and large expanse of land and waters, cannot enjoy as complete a survey of its waters as has been made by many other states. The beginning of this survey finds Montana without even the most rudimentary knowledge of what waters it has. It is deemed advisable and necessary, therefore, that a complete file of the fishing waters of the state be made as quickly as possible with such pertinent information included as can be obtained with a minimum of effort. Following the completion of this survey, and even during the survey as opportunities present themselves, more detailed information will be obtained on the more important waters and on such others waters as the opportunity affords.

It is of the utmost importance that the investigator not lose sight of the primary objective of the survey: to determine what may be done to improve fishing. He has seen and examined the waters; he has been trained in his work; he is in a fine position to recommend management.

Methods

Details of methods will be considered under special headings of sections below, and only a general statement will be made here.

Since the purpose of the initial phase of the survey is to obtain a general inventory of the state's waters, a general coverage will be made first. This will be accomplished largely by airplane. Prior to making flights, the leader and his assistants should study carefully the mpas which are available for the area in which work is to be carried out. A scheduled flight pattern shall be outlined. During the flight, pertinent information shall be recorded on field maps or overlays and notes taken. After the flight, these shall be transcribed for permanent record and survey forms filled in to the degree of the information obtained. Questionable points will then be investigated by ground checks and further information obtained on the more important waters.

Each investigator should lay aside his individualistic tendencies. Remember that we are, in even contemplating a water survey, duplicating the work of many state and federal agencies. Many water surveys have been made by the State Water Conservation Board, by the Montana State Board of Health, by the U. S. Forest Service, by the Coast and Goedetic Survey, by the Bureau of Reclamation, by the Missouri River Basin Studies, by the U. S. Army Engineers, by the Soil Conservation Service, and by many other agencies.

The completion of our survey in a reasonable length of time will depend to a large extent upon the degree to which you use field observations made by these other agencies. One of the most productive uses of your time will be in going to the headquarters of these agencies, wherever they are in the state, in acquainting yourselves with what information they have, and in accumulating such information as they have about your waters.

As stated, there is no intention of completing every item on the blue stream and lake cards. From the airplane survey and work on maps and aerial surveys it should be possible to complete the information in the card heading and the following item numbers: 1, 2, 3, 4, 5 (for a good number of streams), 6, 7, 9 (at least partially completed), 10, 11, 13, 16 (at least partially completed), 21 (an estimate for the section of stream defined under item #3), and 24 (an estimate for the section of stream defined under item #3).

To complete the survey in the time desired, a good number of streams may not soon be visited on the ground. For those that are, besides expanding information on items listed above, an effort should be made to gather information on items 8, 12, and 14.

Most of the information on the back of the blue stream cards will not be obtained for most streams. This should not, however, be considered clearance to neglect gathering such data wherever there is an opportunity. Item 23, for example, will be especially easy.

On the lake card, the information in the heading should be completed and the following item numbers: 1, 2, 3, 4, (at least partially completed), 5, 7, 8, 10, 12, 13 (including maximum depth), 14, 15 (where water is clear enough), and 19.

As with streams, a goodly number of the lakes may not be visited on the ground for some time. For those that are, besides expanding information on the items listed above, an effort should be made to gather information on the following: 6, 9, 11, maximum depth of #13, 17, 18, and 22.

Item 25 on the lake card and 29 on the stream card will be completed as possible from creel census, net sets, shocking, etc.

Stream and Lake Survey Forms - General

Nine sets of stream and lake forms are available for use and file. They are provided in heavy and light weight paper. The heavy weight is for permanent file and the light weight paper is for use in recording field observations. The forms are as follows:

Name	Weight paper	Color
Stream Survey, Stream Summary	Heavy & Light	Blue
Lake Survey, Lake Summary	Heavy & Light	Blue
Stream Survey, Water Temperature	Heavy	Yellow
Lake Survey, Water Temperature	Heavy	Yellow
Lake & Stream Survey, Water Analysis	Heavy	Pink
Lake & Stream Survey, Fish Mortality	Heavy	Orange
Lake & Stream Survey, Notes & References	Heavy & Light	White
Lake & Stream, Management Record	Heavy	Green
Lake & Stream, Record of Addition to Lake & Stream Forms	Light	White

Each district biologist, as he gathers survey information, is to enter data on two copies of the appropriate form on heavy paper, file one at his headquarters, and send one to the Helena office for filing. Whenever changes or additions are to be made on a form sent in previously to the Helena office, these will be noted on the "Lake and Stream, Record of Addition to Lake and Stream Forms" which will, in turn, be sent to the Helena office so that corresponding changes may be made on forms filed there. If changes are quite radical or inclusive, the district biologist may fill out a new form and forward it with a note that it is to replace an outdated one in the file. The district biologist shall make no changes in his file without immediately notifying the Helena office so that the corresponding change may be made there. This procedure will insure at least one complete, up-to-date file remaining should one be destroyed, and it will facilitate the desimination of information by the Helena office.

Filing of the survey information shall be done by a standard system in all districts and in the Helena office so that a biologist being transferred from one district to another will find a familiar filing system.

The forms will be filed in a 6 x 9 inch steel filing case. The first breakdown in the file will be by drainage, each district using only those drainage breakdowns authorized by the Helena office. These drainages will be arranged in alphabetical order. Each drainage will be broken down further by streams and by lakes. The stream and lake forms will then be arranged alphabetically in their respective divisions. Each type of form

was made a different color so that the type could be easily identified. All forms will be filed in the same file under their respective stream or lake names.

Another file supplementary to the master file shall be made by using 3 x 5 inch cards. This file shall have two parts, the one designating streams and the other lakes. In these, all of the streams and lakes in the district (for the district files) or the state (for the Helena office file) shall be listed alphabetically irrespective of drainage. The name of the body of water shall be given at the top left-hand corner of the card. Under this, the drainage in which the stream or lake is found will be typed. After the drainage name, the number of streams or lakes with that name in that drainage will be noted, thus "Musselshell River Drainage - 3". Some streams or lakes such as Rock Creek and Loon Lake may be found in every drainage. In these cases every drainage will be listed.

This file shall, in addition, have listed on 3 x 5 inch cards in the same manner as above all names in use for any lake or stream, each name to be placed on a separate card in the upper left-hand corner. Under this name, then, state "See (give accepted stream or lake name) in (name the drainage)."

This file is helpful in finding information about a body of water when the exact location, even the drainage, is not known. It may seem that this file is not worthwhile to a man thoroughly familiar with his waters, but it is very helpful to a new man in the area.

More detailed information from surveys or special studies than can be recorded in the master file described above shall be reported on 8½ x 11 inch paper, a copy is to be sent ot the Helena office, and filed in the 8½ x 11 inch steel file cabinet. This file will be headed "Data and Reports". Arrangement of this file shall be the same as the master survey file; that is, there will be the drainage breakdown under which there will be a further stream and lake breakdown. The information will then be filed by lake or stream in an alphabetical arrangement.

Not only will the district biologists' data and detailed reports be filed in the "Data and Reports" file, but also all other information which is of sufficient value to constitute a permanent record. Herein shall be stowed all reports compiled by other agencies or individuals. These will include those of value made by the Missouri and Columbia River Basin Studies of the Fish and Wildlife Service, those made by the Refuge Branch of the Fish and Wildlife Service, those made by the Army Engineers, Bureau of Reclamation, State Water Conservation Board, State Board of Health, etc. Do not forget our own quarterly reports and bulletins.

Reports from other agencies, our own quarterly reports or bulletins should not be filed according to the drainage and stream-lake system described above, but should be filed under a "General" section of the "Data and Report" file, and should be arranged under the name of the organization concerned. Where a specific lake or stream is concerned, references will be made to that specific report or publication elsewhere (see section "Lake and Stream Survey, Notes and References").

Stream Survey, Stream Summary Form
(color blue)

Designating the waters: Because of the fact that some waters are still unnamed and because the same name is frequently given to a number of different streams in the same region, care must be taken in designating waters. If the stream is named, the accepted or most popular name shall be used at the top of the form. Where unnamed streams are found, they shall be designated by numbers on the maps and the number placed in the space provided for stream or name upon front of the stream form. The county or counties through which the stream or section of stream flows shall be noted in the appropriate blank. For further confirmation of stream location, a township, range, and section through which the steam flows and through which no other stream flows shall be located and recorded on the form. This should be taken from as near the mouth of the stream or bottom of the stream section as is possible. Other names of the stream than the one noted near the top of the form shall be listed after item #1, other names of stream.

Item #2, Tributary to: The stream or lake into which the stream studied flows shall be recorded, and further, the drainage shall be traced on down the system, ending with the name of the main drainage. For example, Cripple Creek is located in Lincoln County, it flows into Brimstone Creek. Item #2 for this creek would read: TRIBUTARY TO Brimstone Creek, Murphy Creek, Fortine Creek, Tobacco River. MAIN DRAINAGE Kootenai River.

Item #3, Stream Section: The river or stream is to be divided and worked in sections where warranted. The exact length of each section will depend upon the character of the stream, occurrence of ecological changes, variations in fishing pressure, changes in species composition, pollution, etc. In general, a stream section should be designated for every abrupt change in stream formation. A demarcation between sections should be made at the junction of large tributaries. The sections are to be numbered serially for each stream beginning with "No. 1" at the mouth and proceeding upstream to the source. The exact limits of the sections are to be described "from" and "to" working from the lower end to the upper end. The length of the section in miles are to be scaled with a map measure, preferably from aerial photographs, but from a map if photographs are not available. State the source of stream lengths. Most maps do not attempt to show stream meanders, therefore lengths from this source will be far in error. The length of the section is to represent the actual length of the stream channel with all its meanders. Remember that the number of the section should be in order, beginning at the mouth, and cannot be filled in until the whole stream is finished unless the survey begins at the mouth of the stream. The section number shall be entered in the proper blank at the center of the form near the top.

Item #4, Accessibility: Accessibility of stream determines in part the potential fishing load. State whether stream section is accessible by highway, truck trail, foot trail, county road, or railroad. Give the road name

or number. If access is by private road, secure the name of the owner. Do not specify merely that access is "good" or "bad".

Item #5, Elevation: Express in feet above mean sea level. These may be most easily obtained or estimated from data obtained from other agencies such as the Water Conservation Board, U. S. Forest Service, Bureau of Reclamation, and the Highway Department.

Item #6, Tributaries: List the names of tributaries entering the stream in the section under consideration in order from the lower end. In cases where stream sections may be rather long and tributaries numerous, it will suffice to give merely the number of tributaries in each flow category (item #7) entering the section.

Item #7, Water Supply: Information concerning the source of water is important in order to determine the probable continuity of stream flow and the type of fish which are suited to the stream. If the stream has no apparent source of water in the section being studied except for the normal stream flow entering the section, state that fact. Record evidence of extensive surface runoff at certain periods as indicated by erosions or destruction of vegetation. Seepage is water entering the stream through minute springs or feeders which are numerous but of insufficient flow to be measured by the ordinary field methods. Other sources of water will be drainage ditches, springs, runoff, lakes, swamps, and in occasional instances, sewage effluent or mine drainage.

"Normal flow" is an abstract term, and unless defined, there would be a great divergence of opinions and interpretations by the surveyors. For the purpose of this survey, "normal flow" will be average flow, apart from influences of man, which is the most characteristic of the stream. "Normal flow" will not be evaluated during periods of spring and early summer high waters nor during unusual winter conditions caused by ice jams and the like. It will not include periods during the year when streams are dewatered or lowered radically from irrigation use, from other man-made diversions, or from below normal spilling of water from storage reservoirs. These exceptions from consideration of "normal flow" are important but will be noted under their proper headings on the survey form.

One exception to the rule is: When a section of stream is dewatered regularly by the influence of man, the normal flow will be circled, and in addition number 7 will be circled. Then in the space after number 7, the reason for dewatering will be stated, such as from irrigation, power, storage, etc.

A second exception to the above should be made. Certain streams, such as the Missouri River below Holter Dam and Fort Peck Reservoir and the Madison River below Hebgen Lake and Ennis Lake are so completely controlled by man that a normal flow could not be obtained. There would be no choice but to take the man-made flow as normal flow.

The following flows will be represented by their corresponding numbers:

Type 1 - - Over 1500 c.f.s.
Type 2 - - 500 to 1500 c.f.s.
Type 3 - - 100 to 500 c.f.s.
Type 4 - - 20 to 100 c.f.s.
Type 5 - - Less than 20 c.f.s.
Type 6 - - Streams that go dry in dry years
Type 7 - - Streams that go dry every year

Each surveyor shall, from the records of the Montana State Water Conservation Board, Bureau of Reclamation, Army Engineers, Coast and Geodetic Survey and other agencies look up the flows of those streams for which records are available and rate them as to flow type. From these, then, the surveyor should have a good idea of ranges of flows for different sized streams and for streams with different velocities and should be able to place other streams into types by observations without measurements.

Since the types are broad and since there is a wide variation of flow in any one stream, the surveyor should be able, with some degree of confidence, to place border line cases in one type or the other. If it is definitely a border line case, the surveyor, instead of circling a number, may circle the space between two numbers, providing he draws an arrow to the right or left, indicating whether he feels it belonged in the higher or lower category.

The following figures for the Flathead River were taken from the records of the Water Conservation Board and cover a period of 32 years up

to 1938:

Month	c.f.s. Mean Flow	Month	c.f.s. Mean Flow
October	2,800	April	13,300
November	3,700	May	34,000
December	2,800	June	29,700
January	3,400	July	9,600
February	2,300	August	3,400
March	2,800	September	2,300

The flows for the months of April through July, while, very likely, representing the normal spring flows for the Flathead River, nevertheless tell nothing about the normal flow of that stream. What we are trying to get at is a normal stream size. A stream in western Montana may have a moderate spring runoff with sustained good flows through the rest of the year. Another stream in the east-central part of the state may have a terrific spring runoff with very low sustained flows through the balance of the year. If an average flow for the entire year were taken as the "normal flow", these two streams might show the same figure while one is "normally" much smaller, perhaps even to the point of drying up. Spring runoffs should be noted under "degree of flooding".

Therefore, for normal flows, the factors listed previously will be ignored. In the case of the Flathead River above, flows for the months of August through March will be averaged to obtain 2900 c.f.s. This is the "normal flow". It falls in Type #1.

Item #8, Pollution: Indicate the nature and extent of pollution.

Item #9, Dam: Locate all dams or obstructions as accurately as possible by a method such as township, range and section. The name of the owner or owners of dams is to be determined and recorded, as is the use to which the dam is given. Determine the type of dam; whether it is of earth, log, concrete, etc. "Head" refers to the elevation of the water in the pond above the water in the stream below the dam. "Effect on level" refers to the effects of the dam on the stream flows below the dam. Indicate whether or not the dam is passable to fish and whether or not there are fishways or other devices for transportation of fish over the structure. Many fishways are inefficient and others are completely inoperative. Some are kept permanently closed. Determine from observations and local contact if fish actually use fishway in quantities at any time of the year.

Item #10, Immediate Shore: Give the percent of the shoreline that is barren, that is vegetated, and that is marshy. For the type that is barren, give the average height of the banks and the degree of erosion. For the vegetated type, give the percent that is brushy (state density), the percent that is grassy, the percent that is herbs, and the percent that is trees (state type and density).

Item #11, Surrounding Country: For the drainage area of the section, state whether it is flat, rolling, hilly, mountainous, or marshy. Give the percent of each type of vegetative cover, wooded (type of trees), brushy, grass land, herbs or cultivated (type of crop).

Item #12, Fishing: The general reputation and history can be secured from landowners and fishermen. Do not take just one or two fishermen's words for it. State the source of your information. The summer and winter fishing intensity may be obtained from conversations with wardens, anglers, and landowners, but better still, from the surveyors observations of fishermen. Is public fishing allowed over private land or are the lands state or federally owned? Is the stream easily fished or is brush too dense, is water too fast, is the stream in an inacessible canyon, etc.

Item #13, Use of Water: State the use of the water, such as for industrial purposes (kind), recreational (fishing, pleasure boating, swimming), irrigation, power, etc.

Item #14, Spawning Grounds: It is highly important to make observations on the spawning grounds of all game fish. It will be possible in the early part of the survey to see the spawning activity of certain species. Give an estimate of the extent of suitable spawning grounds. If suitable spawning beds are lacking or inadequate, they can often be created by introduction of gravel or by speeding up water flow to remove muck. State whether the type of bottom is such that improvements could be made.

Item #15, Predators: List the predatory species of animals other than fish that are encountered or reported with an indication of their abundance.

Item #16, Beaver: Estimate the size of the beaver population in the section, that is, whether it is large, moderate, small, or whether there are none.

The number and age of beaver dams or houses and the degree and age of cuttings will give an indication. In like manner, estimate the number of dams together with their condition. Often dams are so abundant that the backwater from one reaches the dam above so that the whole stream bed is silty, leaving no open gravel for spawning. This should be noted. If shore cover has been significantly reduced by cutting, make careful note of the extent of damage. Give the value of the beaver to the ecology of the stream as it is related to fishlife.

Item #17, Remarks: Give other pertinent information not entered elsewhere. Items #18 through 29 refer to portions within the sections. If stream sections are very short, only one station need be established in the "middle" of the section. For sections a little longer, two stations may be made, one at the upper boundary of the lower third, and one at the upper boundary of the middle third. Three stations should be established in sections that are long, placing them about at the center of each of the thirds of the stream length.

Item #18, Station: Items #19 through 23 should be taken at stations definitely established. These stations should be typical of the conditions existing in the stream and should be located so as to be accessible by road or trail. Each station should be carefully defined so that it can be located by anyone at some time in the future. No report will be accepted which does not clearly indicate where the readings were taken.

Item #19. Average Width and Depth: Average width is to be determined by the average of three measurements in 50 to 100 feet of stream bed. Depth measurements should be made at each of the three locations of width measurements with three depth measurements in each series, these spaced equally across the stream, one at the center and one halfway between the center and the bank on each side. The nine measurements thus obtained shall be added together and the sum divided by nine to obtain the mean depth. The margins of the stream are thus not included in the average. It is normally considered that the very shallow margins do not provide the best trout habitat, except for small fish when cover is provided. Most streams have shallow margins which taper to zero depth. The purpose here is to determine the suitability of the water for trout from the standpoint of depth; therefore the stream margins will not be considered in the average depth. Shallow water for trout will be considered under item #26. If the station chosen has a stream bed such that the bulk of the flow is concentrated at one bank where the bank drops off abruptly and then tapers up gradually to the other side, one measurement shall be taken at or near the deep bank. Then, depending upon the width of the stream and the contour of the bottom, two or three measurements should be taken to give a representative picture of depth. If two are made, they shall be spaced 1/3 and 2/3 of the distance across the stream, and if three are taken, they shall be spaced 1/4, 1/2 and 3/4 of the distance across the stream.

Item #20, Volume: Volume is to be recorded in c.f.s. (cubic feet per second) where it is one or greater. Streams of less than one cubic foot per second should be described in gallons per minute. One cubic foot per second is equal to approximately 450 gallons per minute. Embody gives the following formula for determining the approximate flow of a stream:

$$R = \frac{W\ D\ a\ L}{T},$$

in which R is equal to the rate of flow in c.f.s.; W is average width; D is average depth in feet; L is the length of the section measured; a is a constant for correction of stream velocity; and T is the average time in seconds required for a float to traverse the distance, L.

If the bottom is rough and strewn with rocks and coarse gravel, "a" should be taken as 0.8; if the bottom is smooth (of mud, sand, hardpan, or bedrock), 0.9 is used as the constant.

A straight section of the stream is chosen where few obstructions to the current's flow are found. One hundred feet is measured off. The average width and depth are taken at each end of the section and at the middle. A handful of small floats are then dropped in at the upper end of the section, and the time for the first float to reach the lower end of the section is clocked. The average of three tests with the float is recorded as the time.

The average depth used in calculations for item #20 is not the one indicated in item #19. It shall be figured the same, except that division

of the summation of the measured depths shall be n + 1 instead of by n. This will allow for zero depth at each side.

Item #21, Velocity: Velocity as measured in item #20 may be recorded here in feet per second. Should no actual measurement be taken, velocity may be described as sluggish, rapid, or torrential. Where the current is very slight and the flow is less than 1/2 foot per second, the velocity is considered as sluggish. A rapid stream is considered as one in which the velocity is greater than 1/2 foot per second, and in which there is a regular succession of pools and riffles. Torrential streams are those which descend steep gradients and have few, if any pools in their course.

Item #22, Color and Turbidity: The color of the water is to be recorded, but it is not necessary to standardize it against color charts. Merely state whether the water is colorless (as is most water), light brown, or dark brown. Turbidity is expressed in the terms clear, murky, and muddy; clear if bottom is distinctly seen through 4 or more feet of water, murky if indistinct at from 1 to 4 feet and muddy if visible at less than 1 foot.

Item #23, Dissolved Solids: Dissolved solids will be measured from a sample of water by a conductivity cell (such as Nalacometer), measuring specific conductance. Results will be expressed in parts per million (p.p.m.).

Item #24, Pools: The following is quoted from Embody's outline, with slight modification, regarding pools:

"A good fish pool is generally deeper and wider than the average

for the stream, the current is appreciably slower and hiding places for fish are frequently more extensive.

"Not all pools, however, are equally attractive to fish. A type frequently occurring in narrow, deep gorges is scoured out during heary rains. It generally has a bottom of smooth bedrock or hardpan and the forage is scant. A shallow exposed pool, without shelter or food, is a detriment to any trout stream.

"There is not much information to guide us in evaluating pools and hence only a tentative outline of study can be suggested here.

"Near each station pace off about two hundred yards of stream length and study the size, type, and frequency of pools. Which of the following conditions prevail?

"Size:

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

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

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

"Type:

"1. Deep (2 feet 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 detrius, 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% relation of pools and riffle areas.

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

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

"If we let S refer to size, T to type, and R to frequency, then it is evident that a combination of $S_1 - T_1 - F_1$ would receive the highest ratings and $S_3 - T_3 - F_3$, the lowest. Likewise various other combinations may be roughly recorded as intermediate, although they are not necessarily of equal value. However, a more detailed evaluation would be too complicated to undertake in view of the purpose for which the outline is intended."

In case of heavily fished streams which are worked intensively, it is a good practice to make an actual count of the pools per mile of stream, classifying them as to size and type. Such a count may explain the high or low productivity of the stream and indicate definitely the amount of stream improvement needed.

State the factors responsible for pools at each station, i.e., whether caused by boulders, undercut banks, log jams, or whether simply open pools caused by the digging action of the current.

Item #25, Bottom Types: Describe pool and riffle bottom separately in the spaces provided. Record or estimate the percentages of:

Mud - Usually distinguished from silt and clay by its composition. It is compact in contrast to soft flocculent silt and is made up of a mixture of clay and other soils.

Silt - Flocculent, sedimentary material.

Sand - Loose, granular material resulting from the disintegration of rock.

Detritus - Bottom material composed of more or less finely-divided organic material such as bits of leaves, twigs, bark, remains of water plants, etc.

Hardpan - A cemented or compacted layer of soil.

Bedrock - Layer of solid rock.

Rubble - (large or small) Rough irregular stones ranging in size from an egg up to boulders about a foot in diameter.

Gravel, Coarse - Rock ranging from small rubble to particles about the size of a marble.

Gravel, Fine - Rock ranging from coarse gravel to coarse sand.

Type of bottom is particularly important from the standpoint of spawning, since many fish require gravel beds in which to deposit their spawn successfully, and from the standpoint of food production. Needham and later Pate have shown the following types of bottom productive in the order listed: Silt, small rubble, large rubble, coarse gravel, fine gravel, bedrock, hardpan, and sand.

Item #26, Shade - Cover: The stream should be described as densely shaded if over-hanging brush and trees render it practically unfishable, partly shaded if approximately half of the water is shaded, and open if no shade whatever exists. State cause of shade, i.e., size and kind of trees or kind of brush.

For cover, indicate the abundance of water plants, rocks, sunken logs, or whatever form of protection for fish is afforded, not only in pools, but along riffle areas as well. Electric census has shown cover in riffle areas provides one of the best apparent habitats for small trout.

Item #27, Aquatic Vegetation: Notes should be made of the types and abundance of water plants which are observed. This vegetation should be described as to the occurrence of (1) higher plants, (2) algae, and (3) mosses. If noticable upon practically every rock or if it margins the stream, it should be indicated as dense; if observed on approximately half of the rocks or patches here and there in the stream, it should be recorded as medium. If observed but seldom in a streach of stream, aquatic vegetation should be reported as sparse.

Item #28, Fish Foods: Dominant types of food observed are to be given. Abundance of natural foods are to be rated as (1) exceptional richness, (2) average richness, and (3) poor in food. A definition of these categories would entail quantitive bottom sampling, which, at the present time, is beyond the scope of this survey. Each biologist has seen various degrees of food conditions from exceptionally rich to poor. As he rates his streams, he should do so, not considering just his district, but the state as a whole. A rich stream in northwestern Montana might well be one of moderate richness in southwestern Montana; therefore the biologist must keep degrees of richness on a statewide basis in his mind.

Item #29, Game Fish: Species of fish present will be taken from all authentic sources. Use no information where there is a doubt of authenticity. List the species of fish known to be present in the extreme left column of the form, using common names from Special Publication No. 1 of the American Fisheries Society or using scientific names. In the next three columns give abundance, average (not dominant) size of fish in the catch, and growth rate. Use numeral designators for abundance, i.e., the most abundant species is 1, the next is 2, etc. Rate game and other fish together for abundance. After the numeral designator, place the letter "c" if abundance in the catch is indicated and the letter "p" of the abundance in the standing population is indicated. Give the average size in the catch in inches of total length. For growth rate, place a roman numeral to indicate in what

year of life the fish reach a length of seven inches. If seven inches is reached toward the end of a specific year of life, follow the roman numeral by a plus sign. The following is an example:

Rainbow trout	1c-2p-8.3 in.-II+
Brown trout	2c-1p-10.2 in.-II+
Rainbow & Cutthroat trout	3c-5p-9.1 in.-II
Cutthroat trout	6c-9p
Eastern brook trout	4c-6p-7.5 in.-II
Whitefish	5c-4p-8.6 in.
Sucker	3p
Carp	8p
Ling	7p
Cottus	Perhaps the most abundant of all

Item #30, Continuations: This is additional space for making entries where not enough room is provided under the proper headings.

Item #31, Prepared By and Date: Give name of one doing survey or name of party leader. Date is the single date or inclusive dates of the survey.

Lake Survey, Lake Summary Form
(color blue)

Since a complete point by point discussion was given the Stream Survey form, such a discussion here would be largely repetitious. The following points should, however, be noted:

Item #3, Outlet: Describe "size" as for normal flow on Stream Survey form.

Item #13, Area: Area should be determined by a planimeter. If an estimated area is given, say so, such as "135 acres est."

Item #13, Shore Development: Shore development equals the actual length of the shoreline divided by the circumference of a circle which would just inclose the area of the lake. To determine the circumference of a circle when the area (A) is known, solve the following formula:

$$C = 2\sqrt{\pi A}.$$

In general, the higher the value for shore development the greater the biological productivity of the body of water.

Item #13, Maximum Depth: Give the maximum depth in feet. Delete + sign.

Item #14, Area of Vegetation: Plant collections are not necessary. Give the area and types of emergent vegetation.

Lake Survey and Stream Survey, Water Termperature
(color yellow)

There will be very few instances when a complete series of temperatures will be available for any one body of water. There is excellent opportunity, however, to obtain one or even more temperatures from a body of water during a years time. As the biologist goes about his district, he can easily take a temperature of every stream or lake at which he stops. It may even be possible to obtain further temperatures from other sources such as from reliable and interested wardens and hatchery men. While individually these temperatures would mean little or nothing, collectively they could be very valuable and the only source of termperature available. Such records would eventually enable the biologist at least to group his waters into cold, moderate, and warm.

Each biologist should form the habit of taking a temperature at every opportunity and of recording these on the temperature record cards. He should also endeavor to develop other sources of water temperature information.

Lake and Stream Survey, Water Analysis
(color pink)

Similar to the water temperature data, water analysis data will not be taken in any one year in sufficient quantity for most bodies of water to be of great value. This card will provide a convenient record of all analyses for any one body of water. Methods of standard procedures provided with the chemical kits will be used in the analysis.

Lake and Stream Survey, Fish Mortality
(Color orange)

As with so much of the information gathered by the biologists, frequent notations of fish mortalities are made in the biologist's personal log and then forgotten. This form, as with the others noted, provides a means of notation where it can be found. A separate card should be completed to the degree possible for each significant mortality reported to or noted by the biologist. Note that, not only is provision made for entry of characteristics, cause, and extent of mortality, but also for the source of the information. This latter is very important, for it will make possible an evaluation of reliability now or at any future time.

The entries made on the back of the page should be from checks made by the biological staff. Of course, if such checks have been made by another person, there is no reason why they should not be entered on the card. In this event, however, an estimate of reliability should accompany the data.

Lake and Stream Survey, Notes and References
(color white)

This form is a sort of catch-all. Other bits of information gathered which do not fall into headings of other forms should be entered on this form. Perhaps two forms should have replaced this one, one for notes and one for references. Since this has not been done, the following procedure will be adopted:

"Notes" shall include any bits of information concerning a stream or lake which does not fall logically into headings on some other card. These shall be entered on a white card and the words "and references" in the upper right hand corner shall be deleted from that card. No "references" shall be entered on this card.

The file under consideration, where the forms being discussed will be stowed, shall include a record of all information available on each body of water. The "Data and Reports" file was mentioned under the section, "Stream and Lake Survey Forms - General". This file shall contain all data available which is too lengthy for entry on the Lake and Stream Survey Forms and all reports available. When a report or data is placed in the "Data and Reports" file, a reference to this shall be made on the "Notes and References" form. From this form the words "Notes and" shall be deleted from the upper right hand corner. In other words, notes and references shall not be entered on the same form.

Lake and Stream, Management Record
(Color green)

This form can be a most useful one for management purposes, but to be so, the biologist must be extra conscientious in efforts to keep this form up to date. Recommendations whether adopted or not adopted should be entered on the form. The biologist should, however, use discretion in making entries or the card will become so cluttered that it will be of little value. Every whim or desire of an individual or group that is presented in the form of a recommendation should not be entered on this form. Entry of those recommendations by individuals or groups should be limited to those that have merit or to those which, while lacking merit, are deep-rooted or serious. For every management measure entered, its disposition (whether adopted or rejected) should be noted also. If it were not adopted, the reason should be stated. If it were adopted and executed, where possible, the results -- not from unfounded opinion, however -- should be evaluated and recorded on the form.

Lake and Stream, Record of Addition to Lake and Stream Form
(color white)

This form is not to be placed in the file. It is to facilitate keeping the file up to date. Whenever a new entry or correction is to be made on a form already filed, that entry or correction is to be noted on the "Record of Addition, etc." form by the person making the entry or correction. If this person is the biologist in the field, he will then send this form to the Helena office where a corresponding addition or correction will be made on the form concerned. If the addition or correction was initiated by one in the Helena office, the "Addition" form will be sent to the biologist in the field so that he may make the corresponding addition or correction in his file.

Actually this could be done by letter just as well, but it was felt that by using a special form for recording additions or changes to be made, all needed information would be furnished and a minimum of errors would result.

MONTANA FISH AND GAME DEPARTMENT

STREAM AND LAKE SURVEYS

Introduction

The data from stream and lake surveys form a large portion of the basis for fishery management. Basically the survey is an inventory. It is obvious that Montana, with its limited fishery investigation personnel and large expanse of land and waters, cannot enjoy as complete a survey of its waters as has been made by many other states. The beginning of this survey finds Montana without even the most rudimentary knowledge of what waters it has. It is deemed advisable and necessary, therefore, that a complete file of the fishing waters of the state be made as quickly as possible with such pertinent information included as can be obtained with a minimum of effort. Following the completion of this survey, and even during the survey as opportunities present themselves, more detailed information will be obtained on the more important waters and on such others waters as the opportunity affords.

It is of the utmost importance that the investigator not lose sight of the primary objective of the survey: to determine what may be done to improve fishing. He has seen and examined the waters; he has been trained in his work; he is in a fine position to recommend management.

Methods

Details of methods will be considered under special headings of sections below, and only a general statement will be made here.

Since the purpose of the initial phase of the survey is to obtain a general inventory of the state's waters, a general coverage will be made first. This will be accomplished largely by airplane. Prior to making flights, the leader and his assistants should study carefully the mpas which are available for the area in which work is to be carried out. A scheduled flight pattern shall be outlined. During the flight, pertinent information shall be recorded on field maps or overlays and notes taken. After the flight, these shall be transcribed for permanent record and survey forms filled in to the degree of the information obtained. Questionable points will then be investigated by ground checks and further information obtained on the more important waters.

Each investigator should lay aside his individualistic tendencies. Remember that we are, in even contemplating a water survey, duplicating the work of many state and federal agencies. Many water surveys have been made by the State Water Conservation Board, by the Montana State Board of Health, by the U. S. Forest Service, by the Coast and Goedetic Survey, by the Bureau of Reclamation, by the Missouri River Basin Studies, by the U. S. Army Engineers, by the Soil Conservation Service, and by many other agencies.

The completion of our survey in a reasonable length of time will depend to a large extent upon the degree to which you use field observations made by these other agencies. One of the most productive uses of your time will be in going to the headquarters of these agencies, wherever they are in the state, in acquainting yourselves with what information they have, and in accumulating such information as they have about your waters.

As stated, there is no intention of completing every item on the blue stream and lake cards. From the airplane survey and work on maps and aerial surveys it should be possible to complete the information in the card heading and the following item numbers: 1, 2, 3, 4, 5 (for a good number of streams), 6, 7, 9 (at least partially completed), 10, 11, 13, 16 (at least partially completed), 21 (an estimate for the section of stream defined under item #3), and 24 (an estimate for the section of stream defined under item #3).

To complete the survey in the time desired, a good number of streams may not soon be visited on the ground. For those that are, besides expanding information on items listed above, an effort should be made to gather information on items 8, 12, and 14.

Most of the information on the back of the blue stream cards will not be obtained for most streams. This should not, however, be considered clearance to neglect gathering such data wherever there is an opportunity. Item 23, for example, will be especially easy.

On the lake card, the information in the heading should be completed and the following item numbers: 1, 2, 3, 4, (at least partially completed), 5, 7, 8, 10, 12, 13 (including maximum depth), 14, 15 (where water is clear enough), and 19.

As with streams, a goodly number of the lakes may not be visited on the ground for some time. For those that are, besides expanding information on the items listed above, an effort should be made to gather information on the following: 6, 9, 11, maximum depth of #13, 17, 18, and 22.

Item 25 on the lake card and 29 on the stream card will be completed as possible from creel census, net sets, shocking, etc.

Stream and Lake Survey Forms - General

Nine sets of stream and lake forms are available for use and file. They are provided in heavy and light weight paper. The heavy weight is for permanent file and the light weight paper is for use in recording field observations. The forms are as follows:

Name	Weight paper	Color
Stream Survey, Stream Summary	Heavy & Light	Blue
Lake Survey, Lake Summary	Heavy & Light	Blue
Stream Survey, Water Temperature	Heavy	Yellow
Lake Survey, Water Temperature	Heavy	Yellow
Lake & Stream Survey, Water Analysis	Heavy	Pink
Lake & Stream Survey, Fish Mortality	Heavy	Orange
Lake & Stream Survey, Notes & References	Heavy & Light	White
Lake & Stream, Management Record	Heavy	Green
Lake & Stream, Record of Addition to Lake & Stream Forms	Light	White

Each district biologist, as he gathers survey information, is to enter data on two copies of the appropriate form on heavy paper, file one at his headquarters, and send one to the Helena office for filing. Whenever changes or additions are to be made on a form sent in previously to the Helena office, these will be noted on the "Lake and Stream, Record of Addition to Lake and Stream Forms" which will, in turn, be sent to the Helena office so that corresponding changes may be made on forms filed there. If changes are quite radical or inclusive, the district biologist may fill out a new form and forward it with a note that it is to replace an outdated one in the file. The district biologist shall make no changes in his file without immediately notifying the Helena office so that the corresponding change may be made there. This procedure will insure at least one complete, up-to-date file remaining should one be destroyed, and it will facilitate the desimination of information by the Helena office.

Filing of the survey information shall be done by a standard system in all districts and in the Helena office so that a biologist being transferred from one district to another will find a familiar filing system.

The forms will be filed in a 6 x 9 inch steel filing case. The first breakdown in the file will be by drainage, each district using only those drainage breakdowns authorized by the Helena office. These drainages will be arranged in alphabetical order. Each drainage will be broken down further by streams and by lakes. The stream and lake forms will then be arranged alphabetically in their respective divisions. Each type of form

was made a different color so that the type could be easily identified. All forms will be filed in the same file under their respective stream or lake names.

Another file supplementary to the master file shall be made by using 3 x 5 inch cards. This file shall have two parts, the one designating streams and the other lakes. In these, all of the streams and lakes in the district (for the district files) or the state (for the Helena office file) shall be listed alphabetically irrespective of drainage. The name of the body of water shall be given at the top left-hand corner of the card. Under this, the drainage in which the stream or lake is found will be typed. After the drainage name, the number of streams or lakes with that name in that drainage will be noted, thus "Musselshell River Drainage - 3". Some streams or lakes such as Rock Creek and Loon Lake may be found in every drainage. In these cases every drainage will be listed.

This file shall, in addition, have listed on 3 x 5 inch cards in the same manner as above all names in use for any lake or stream, each name to be placed on a separate card in the upper left-hand corner. Under this name, then, state "See (give accepted stream or lake name) in (name the drainage)."

This file is helpful in finding information about a body of water when the exact location, even the drainage, is not known. It may seem that this file is not worthwhile to a man thoroughly familiar with his waters, but it is very helpful to a new man in the area.

Replaced by Computer Print-out of Lake & Stream name.

More detailed information from surveys or special studies than can be recorded in the master file described above shall be reported on 8½ x 11 inch paper, a copy is to be sent to the Helena office, and filed in the 8½ x 11 inch steel file cabinet. This file will be headed "Data and Reports". Arrangement of this file shall be the same as the master survey file; that is, there will be the drainage breakdown under which there will be a further stream and lake breakdown. The information will then be filed by lake or stream in an alphabetical arrangement.

Not only will the district biologists' data and detailed reports be filed in the "Data and Reports" file, but also all other information which is of sufficient value to constitute a permanent record. Herein shall be stowed all reports compiled by other agencies or individuals. These will include those of value made by the Missouri and Columbia River Basin Studies of the Fish and Wildlife Service, those made by the Refuge Branch of the Fish and Wildlife Service, those made by the Army Engineers, Bureau of Reclamation, State Water Conservation Board, State Board of Health, etc. Do not forget our own quarterly reports and bulletins.

Reports from other agencies, our own quarterly reports or bulletins should not be filed according to the drainage and stream-lake system described above, but should be filed under a "General" section of the "Data and Report" file, and should be arranged under the name of the organization concerned. Where a specific lake or stream is concerned, references will be made to that specific report or publication elsewhere (see section "Lake and Stream Survey, Notes and References").

Stream Survey, Stream Summary Form
(color blue)

Designating the waters: Because of the fact that some waters are still unnamed and because the same name is frequently given to a number of different streams in the same region, care must be taken in designating waters. If the stream is named, the accepted or most popular name shall be used at the top of the form. Where unnamed streams are found, they shall be designated by numbers on the maps and the number placed in the space provided for stream or name upon front of the stream form. The county or counties through which the stream or section of stream flows shall be noted in the appropriate blank. For further confirmation of stream location, a township, range, and section through which the steam flows and through which no other stream flows shall be located and recorded on the form. This should be taken from as near the mouth of the stream or bottom of the stream section as is possible. Other names of the stream than the one noted near the top of the form shall be listed after item #1, other names of stream.

Item #2, Tributary to: The stream or lake into which the stream studied flows shall be recorded, and further, the drainage shall be traced on down the system, ending with the name of the main drainage. For example, Cripple Creek is located in Lincoln County, it flows into Brimstone Creek. Item #2 for this creek would read: TRIBUTARY TO Brimstone Creek, Murphy Creek, Fortine Creek, Tobacco River. MAIN DRAINAGE Kootenai River.

Item #3, Stream Section: The river or stream is to be divided and worked in sections where warranted. The exact length of each section will depend upon the character of the stream, occurrence of ecological changes, variations in fishing pressure, changes in species composition, pollution, etc. In general, a stream section should be designated for every abrupt change in stream formation. A demarcation between sections should be made at the junction of large tributaries. The sections are to be numbered serially for each stream beginning with "No. 1" at the mouth and proceeding upstream to the source. The exact limits of the sections are to be described "from" and "to" working from the lower end to the upper end. The length of the section in miles are to be scaled with a map measure, preferably from aerial photographs, but from a map if photographs are not available. State the source of stream lengths. Most maps do not attempt to show stream meanders, therefore lengths from this source will be far in error. The length of the section is to represent the actual length of the stream channel with all its meanders. Remember that the number of the section should be in order, beginning at the mouth, and cannot be filled in until the whole stream is finished unless the survey begins at the mouth of the stream. The section number shall be entered in the proper blank at the center of the form near the top.

Item #4, Accessibility: Accessibility of stream determines in part the potential fishing load. State whether stream section is accessible by highway, truck trail, foot trail, county road, or railroad. Give the road name

or number. If access is by private road, secure the name of the owner. Do not specify merely that access is "good" or "bad".

Item #5, Elevation: Express in feet above mean sea level. These may be most easily obtained or estimated from data obtained from other agencies such as the Water Conservation Board, U. S. Forest Service, Bureau of Reclamation, and the Highway Department.

Item #6, Tributaries: List the names of tributaries entering the stream in the section under consideration in order from the lower end. In cases where stream sections may be rather long and tributaries numerous, it will suffice to give merely the number of tributaries in each flow category (item #7) entering the section.

Item #7, Water Supply: Information concerning the source of water is important in order to determine the probable continuity of stream flow and the type of fish which are suited to the stream. If the stream has no apparent source of water in the section being studied except for the normal stream flow entering the section, state that fact. Record evidence of extensive surface runoff at certain periods as indicated by erosions or destruction of vegetation. Seepage is water entering the stream through minute springs or feeders which are numerous but of insufficient flow to be measured by the ordinary field methods. Other sources of water will be drainage ditches, springs, runoff, lakes, swamps, and in occasional instances, sewage effluent or mine drainage.

"Normal flow" is an abstract term, and unless defined, there would be a great divergence of opinions and interpretations by the surveyors. For the purpose of this survey, "normal flow" will be average flow, apart from influences of man, which is the most characteristic of the stream. "Normal flow" will not be evaluated during periods of spring and early summer high waters nor during unusual winter conditions caused by ice jams and the like. It will not include periods during the year when streams are dewatered or lowered radically from irrigation use, from other man-made diversions, or from below normal spilling of water from storage reservoirs. These exceptions from consideration of "normal flow" are important but will be noted under their proper headings on the survey form.

One exception to the rule is: When a section of stream is dewatered regularly by the influence of man, the normal flow will be circled, and in addition number 7 will be circled. Then in the space after number 7, the reason for dewatering will be stated, such as from irrigation, power, storage, etc.

A second exception to the above should be made. Certain streams, such as the Missouri River below Holter Dam and Fort Peck Reservoir and the Madison River below Hebgen Lake and Ennis Lake are so completely controlled by man that a normal flow could not be obtained. There would be no choice but to take the man-made flow as normal flow.

The following flows will be represented by their corresponding numbers:

Type 1 - - Over 1500 c.f.s.
Type 2 - - 500 to 1500 c.f.s.
Type 3 - - 100 to 500 c.f.s.
Type 4 - - 20 to 100 c.f.s.
Type 5 - - Less than 20 c.f.s.
Type 6 - - Streams that go dry in dry years
Type 7 - - Streams that go dry every year

Each surveyor shall, from the records of the Montana State Water Conservation Board, Bureau of Reclamation, Army Engineers, Coast and Geodetic Survey and other agencies look up the flows of those streams for which records are available and rate them as to flow type. From these, then, the surveyor should have a good idea of ranges of flows for different sized streams and for streams with different velocities and should be able to place other streams into types by observations without measurements.

Since the types are broad and since there is a wide variation of flow in any one stream, the surveyor should be able, with some degree of confidence, to place border line cases in one type or the other. If it is definitely a border line case, the surveyor, instead of circling a number, may circle the space between two numbers, providing he draws an arrow to the right or left, indicating whether he feels it belonged in the higher or lower category.

The following figures for the Flathead River were taken from the records of the Water Conservation Board and cover a period of 32 years up

to 1938:

Month	c.f.s. Mean Flow	Month	c.f.s. Mean Flow
October	2,800	April	13,300
November	3,700	May	34,000
December	2,800	June	29,700
January	3,400	July	9,600
February	2,300	August	3,400
March	2,800	September	2,300

The flows for the months of April through July, while, very likely, representing the normal spring flows for the Flathead River, nevertheless tell nothing about the normal flow of that stream. What we are trying to get at is a normal stream size. A stream in western Montana may have a moderate spring runoff with sustained good flows through the rest of the year. Another stream in the east-central part of the state may have a terrific spring runoff with very low sustained flows through the balance of the year. If an average flow for the entire year were taken as the "normal flow", these two streams might show the same figure while one is "normally" much smaller, perhaps even to the point of drying up. Spring runoffs should be noted under "degree of flooding".

Therefore, for normal flows, the factors listed previously will be ignored. In the case of the Flathead River above, flows for the months of August through March will be averaged to obtain 2900 c.f.s. This is the "normal flow". It falls in Type #1.

Item #8, Pollution: Indicate the nature and extent of pollution.

Item #9, Dam: Locate all dams or obstructions as accurately as possible by a method such as township, range and section. The name of the owner or owners of dams is to be determined and recorded, as is the use to which the dam is given. Determine the type of dam; whether it is of earth, log, concrete, etc. "Head" refers to the elevation of the water in the pond above the water in the stream below the dam. "Effect on level" refers to the effects of the dam on the stream flows below the dam. Indicate whether or not the dam is passable to fish and whether or not there are fishways or other devices for transportation of fish over the structure. Many fishways are inefficient and others are completely inoperative. Some are kept permanently closed. Determine from observations and local contact if fish actually use fishway in quantities at any time of the year.

Item #10, Immediate Shore: Give the percent of the shoreline that is barren, that is vegetated, and that is marshy. For the type that is barren, give the average height of the banks and the degree of erosion. For the vegetated type, give the percent that is brushy (state density), the percent that is grassy, the percent that is herbs, and the percent that is trees (state type and density).

Item #11, Surrounding Country: For the drainage area of the section, state whether it is flat, rolling, hilly, mountainous, or marshy. Give the percent of each type of vegetative cover, wooded (type of trees), brushy, grass land, herbs or cultivated (type of crop).

Item #12, Fishing: The general reputation and history can be secured from landowners and fishermen. Do not take just one or two fishermen's words for it. State the source of your information. The summer and winter fishing intensity may be obtained from conversations with wardens, anglers, and landowners, but better still, from the surveyors observations of fishermen. Is public fishing allowed over private land or are the lands state or federally owned? Is the stream easily fished or is brush too dense, is water too fast, is the stream in an inacessible canyon, etc.

Item #13, Use of Water: State the use of the water, such as for industrial purposes (kind), recreational (fishing, pleasure boating, swimming), irrigation, power, etc.

Item #14, Spawning Grounds: It is highly important to make observations on the spawning grounds of all game fish. It will be possible in the early part of the survey to see the spawning activity of certain species. Give an estimate of the extent of suitable spawning grounds. If suitable spawning beds are lacking or inadequate, they can often be created by introduction of gravel or by speeding up water flow to remove muck. State whether the type of bottom is such that improvements could be made.

Item #15, Predators: List the predatory species of animals other than fish that are encountered or reported with an indication of their abundance.

Item #16, Beaver: Estimate the size of the beaver population in the section, that is, whether it is large, moderate, small, or whether there are none.

The number and age of beaver dams or houses and the degree and age of cuttings will give an indication. In like manner, estimate the number of dams together with their condition. Often dams are so abundant that the backwater from one reaches the dam above so that the whole stream bed is silty, leaving no open gravel for spawning. This should be noted. If shore cover has been significantly reduced by cutting, make careful note of the extent of damage. Give the value of the beaver to the ecology of the stream as it is related to fishlife.

Item #17, Remarks: Give other pertinent information not entered elsewhere. Items #18 through 29 refer to portions within the sections. If stream sections are very short, only one station need be established in the "middle" of the section. For sections a little longer, two stations may be made, one at the upper boundary of the lower third, and one at the upper boundary of the middle third. Three stations should be established in sections that are long, placing them about at the center of each of the thirds of the stream length.

Item #18, Station: Items #19 through 23 should be taken at stations definitely established. These stations should be typical of the conditions existing in the stream and should be located so as to be accessible by road or trail. Each station should be carefully defined so that it can be located by anyone at some time in the future. No report will be accepted which does not clearly indicate where the readings were taken.

Item #19, Average Width and Depth: Average width is to be determined by the average of three measurements in 50 to 100 feet of stream bed. Depth measurements should be made at each of the three locations of width measurements with three depth measurements in each series, these spaced equally across the stream, one at the center and one halfway between the center and the bank on each side. The nine measurements thus obtained shall be added together and the sum divided by nine to obtain the mean depth. The margins of the stream are thus not included in the average. It is normally considered that the very shallow margins do not provide the best trout habitat, except for small fish when cover is provided. Most streams have shallow margins which taper to zero depth. The purpose here is to determine the suitability of the water for trout from the standpoint of depth; therefore the stream margins will not be considered in the average depth. Shallow water for trout will be considered under item #26. If the station chosen has a stream bed such that the bulk of the flow is concentrated at one bank where the bank drops off abruptly and then tapers up gradually to the other side, one measurement shall be taken at or near the deep bank. Then, depending upon the width of the stream and the contour of the bottom, two or three measurements should be taken to give a representative picture of depth. If two are made, they shall be spaced 1/3 and 2/3 of the distance across the stream, and if three are taken, they shall be spaced 1/4, 1/2 and 3/4 of the distance across the stream.

Item #20, Volume: Volume is to be recorded in c.f.s. (cubic feet per second) where it is one or greater. Streams of less than one cubic foot per second should be described in gallons per minute. One cubic foot per second is equal to approximately 450 gallons per minute. Embody gives the following formula for determining the approximate flow of a stream:

$$R = \frac{W\ D\ a\ L}{T},$$

in which R is equal to the rate of flow in c.f.s.; W is average width; D is average depth in feet; L is the length of the section measured; a is a constant for correction of stream velocity; and T is the average time in seconds required for a float to traverse the distance, L.

If the bottom is rough and strewn with rocks and coarse gravel, "a" should be taken as 0.8; if the bottom is smooth (of mud, sand, hardpan, or bedrock), 0.9 is used as the constant.

A straight section of the stream is chosen where few obstructions to the current's flow are found. One hundred feet is measured off. The average width and depth are taken at each end of the section and at the middle. A handful of small floats are then dropped in at the upper end of the section, and the time for the first float to reach the lower end of the section is clocked. The average of three tests with the float is recorded as the time.

The average depth used in calculations for item #20 is not the one indicated in item #19. It shall be figured the same, except that division

of the summation of the measured depths shall be n + 1 instead of by n. This will allow for zero depth at each side.

Item #21, Velocity: Velocity as measured in item #20 may be recorded here in feet per second. Should no actual measurement be taken, velocity may be described as sluggish, rapid, or torrential. Where the current is very slight and the flow is less than 1/2 foot per second, the velocity is considered as sluggish. A rapid stream is considered as one in which the velocity is greater than 1/2 foot per second, and in which there is a regular succession of pools and riffles. Torrential streams are those which descend steep gradients and have few, if any pools in their course.

Item #22, Color and Turbidity: The color of the water is to be recorded, but it is not necessary to standardize it against color charts. Merely state whether the water is colorless (as is most water), light brown, or dark brown. Turbidity is expressed in the terms clear, murky, and muddy; clear if bottom is distinctly seen through 4 or more feet of water, murky if indistinct at from 1 to 4 feet and muddy if visible at less than 1 foot.

Item #23, Dissolved Solids: Dissolved solids will be measured from a sample of water by a conductivity cell (such as Nalacometer), measuring specific conductance. Results will be expressed in parts per million (p.p.m.).

Item #24, Pools: The following is quoted from Embody's outline, with slight modification, regarding pools:

"A good fish pool is generally deeper and wider than the average

for the stream, the current is appreciably slower and hiding places for fish are frequently more extensive.

"Not all pools, however, are equally attractive to fish. A type frequently occurring in narrow, deep gorges is scoured out during heary rains. It generally has a bottom of smooth bedrock or hardpan and the forage is scant. A shallow exposed pool, without shelter or food, is a detriment to any trout stream.

"There is not much information to guide us in evaluating pools and hence only a tentative outline of study can be suggested here.

"Near each station pace off about two hundred yards of stream length and study the size, type, and frequency of pools. Which of the following conditions prevail?

"Size:

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

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

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

"Type:

"1. Deep (2 feet 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 detrius, 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% relation of pools and riffle areas.

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

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

"If we let S refer to size, T to type, and R to frequency, then it is evident that a combination of $S_1 - T_1 - F_1$ would receive the highest ratings and $S_3 - T_3 - F_3$, the lowest. Likewise various other combinations may be roughly recorded as intermediate, although they are not necessarily of equal value. However, a more detailed evaluation would be too complicated to undertake in view of the purpose for which the outline is intended."

In case of heavily fished streams which are worked intensively, it is a good practice to make an actual count of the pools per mile of stream, classifying them as to size and type. Such a count may explain the high or low productivity of the stream and indicate definitely the amount of stream improvement needed.

State the factors responsible for pools at each station, i.e., whether caused by boulders, undercut banks, log jams, or whether simply open pools caused by the digging action of the current.

Item #25, Bottom Types: Describe pool and riffle bottom separately in the spaces provided. Record or estimate the percentages of:

Mud - Usually distinguished from silt and clay by its composition. It is compact in contrast to soft flocculent silt and is made up of a mixture of clay and other soils.

Silt - Flocculent, sedimentary material.

Sand - Loose, granular material resulting from the disintegration of rock.

Detritus - Bottom material composed of more or less finely-divided organic material such as bits of leaves, twigs, bark, remains of water plants, etc.

Hardpan - A cemented or compacted layer of soil.

Bedrock - Layer of solid rock.

Rubble - (large or small) Rough irregular stones ranging in size from an egg up to boulders about a foot in diameter.

Gravel, Coarse - Rock ranging from small rubble to particles about the size of a marble.

Gravel, Fine - Rock ranging from coarse gravel to coarse sand.

Type of bottom is particularly important from the standpoint of spawning, since many fish require gravel beds in which to deposit their spawn successfully, and from the standpoint of food production. Needham and later Pate have shown the following types of bottom productive in the order listed: Silt, small rubble, large rubble, coarse gravel, fine gravel, bedrock, hardpan, and sand.

Item #26, Shade - Cover: The stream should be described as densely shaded if over-hanging brush and trees render it practically unfishable, partly shaded if approximately half of the water is shaded, and open if no shade whatever exists. State cause of shade, i.e., size and kind of trees or kind of brush.

For cover, indicate the abundance of water plants, rocks, sunken logs, or whatever form of protection for fish is afforded, not only in pools, but along riffle areas as well. Electric census has shown cover in riffle areas provides one of the best apparent habitats for small trout.

Item #27, Aquatic Vegetation: Notes should be made of the types and abundance of water plants which are observed. This vegetation should be described as to the occurrence of (1) higher plants, (2) algae, and (3) mosses. If noticable upon practically every rock or if it margins the stream, it should be indicated as dense; if observed on approximately half of the rocks or patches here and there in the stream, it should be recorded as medium. If observed but seldom in a streach of stream, aquatic vegetation should be reported as sparse.

Item #28, Fish Foods: Dominant types of food observed are to be given. Abundance of natural foods are to be rated as (1) exceptional richness, (2) average richness, and (3) poor in food. A definition of these categories would entail quantitive bottom sampling, which, at the present time, is beyond the scope of this survey. Each biologist has seen various degrees of food conditions from exceptionally rich to poor. As he rates his streams, he should do so, not considering just his district, but the state as a whole. A rich stream in northwestern Montana might well be one of moderate richness in southwestern Montana; therefore the biologist must keep degrees of richness on a statewide basis in his mind.

Item #29, Game Fish: Species of fish present will be taken from all authentic sources. Use no information where there is a doubt of authenticity. List the species of fish known to be present in the extreme left column of the form, using common names from Special Publication No. 1 of the American Fisheries Society or using scientific names. In the next three columns give abundance, average (not dominant) size of fish in the catch, and growth rate. Use numeral designators for abundance, i.e., the most abundant species is 1, the next is 2, etc. Rate game and other fish together for abundance. After the numeral designator, place the letter "c" if abundance in the catch is indicated and the letter "p" of the abundance in the standing population is indicated. Give the average size in the catch in inches of total length. For growth rate, place a roman numeral to indicate in what

year of life the fish reach a length of seven inches. If seven inches is reached toward the end of a specific year of life, follow the roman numeral by a plus sign. The following is an example:

Rainbow trout	1c-2p-8.3 in.-II+
Brown trout	2c-1p-10.2 in.-II+
Rainbow & Cutthroat trout	3c-5p-9.1 in.-II
Cutthroat trout	6c-9p
Eastern brook trout	4c-6p-7.5 in.-II
Whitefish	5c-4p-8.6 in.
Sucker	3p
Carp	8p
Ling	7p
Cottus	Perhaps the most abundant of all

Item #30, Continuations: This is additional space for making entries where not enough room is provided under the proper headings.

Item #31, Prepared By and Date: Give name of one doing survey or name of party leader. Date is the single date or inclusive dates of the survey.

Lake Survey, Lake Summary Form
(color blue)

Since a complete point by point discussion was given the Stream Survey form, such a discussion here would be largely repetitious. The following points should, however, be noted:

Item #3, Outlet: Describe "size" as for normal flow on Stream Survey form.

Item #13, Area: Area should be determined by a planimeter. If an estimated area is given, say so, such as "135 acres est."

Item #13, Shore Development: Shore development equals the actual length of the shoreline divided by the circumference of a circle which would just inclose the area of the lake. To determine the circumference of a circle when the area (A) is known, solve the following formula:

$$C = 2\sqrt{\pi A}.$$

In general, the higher the value for shore development the greater the biological productivity of the body of water.

Item #13, Maximum Depth: Give the maximum depth in feet. Delete + sign.

Item #14, Area of Vegetation: Plant collections are not necessary. Give the area and types of emergent vegetation.

Lake Survey and Stream Survey, Water Termperature
(color yellow)

There will be very few instances when a complete series of temperatures will be available for any one body of water. There is excellent opportunity, however, to obtain one or even more temperatures from a body of water during a years time. As the biologist goes about his district, he can easily take a temperature of every stream or lake at which he stops. It may even be possible to obtain further temperatures from other sources such as from reliable and interested wardens and hatchery men. While individually these temperatures would mean little or nothing, collectively they could be very valuable and the only source of termperature available. Such records would eventually enable the biologist at least to group his waters into cold, moderate, and warm.

Each biologist should form the habit of taking a temperature at every opportunity and of recording these on the temperature record cards. He should also endeavor to develop other sources of water temperature information.

Lake and Stream Survey, Water Analysis
(color pink)

Similar to the water temperature data, water analysis data will not be taken in any one year in sufficient quantity for most bodies of water to be of great value. This card will provide a convenient record of all analyses for any one body of water. Methods of standard procedures provided with the chemical kits will be used in the analysis.

Lake and Stream Survey, Fish Mortality
(Color orange)

As with so much of the information gathered by the biologists, frequent notations of fish mortalities are made in the biologist's personal log and then forgotten. This form, as with the others noted, provides a means of notation where it can be found. A separate card should be completed to the degree possible for each significant mortality reported to or noted by the biologist. Note that, not only is provision made for entry of characteristics, cause, and extent of mortality, but also for the source of the information. This latter is very important, for it will make possible an evaluation of reliability now or at any future time.

The entries made on the back of the page should be from checks made by the biological staff. Of course, if such checks have been made by another person, there is no reason why they should not be entered on the card. In this event, however, an estimate of reliability should accompany the data.

Lake and Stream Survey, Notes and References
(color white)

This form is a sort of catch-all. Other bits of information gathered which do not fall into headings of other forms should be entered on this form. Perhaps two forms should have replaced this one, one for notes and one for references. Since this has not been done, the following procedure will be adopted:

"Notes" shall include any bits of information concerning a stream or lake which does not fall logically into headings on some other card. These shall be entered on a white card and the words "and references" in the upper right hand corner shall be deleted from that card. No "references" shall be entered on this card.

The file under consideration, where the forms being discussed will be stowed, shall include a record of all information available on each body of water. The "Data and Reports" file was mentioned under the section, "Stream and Lake Survey Forms - General". This file shall contain all data available which is too lengthy for entry on the Lake and Stream Survey Forms and all reports available. When a report or data is placed in the "Data and Reports" file, a reference to this shall be made on the "Notes and References" form. From this form the words "Notes and" shall be deleted from the upper right hand corner. In other words, notes and references shall not be entered on the same form.

Lake and Stream, Management Record
(Color green)

This form can be a most useful one for management purposes, but to be so, the biologist must be extra conscientious in efforts to keep this form up to date. Recommendations whether adopted or not adopted should be entered on the form. The biologist should, however, use discretion in making entries or the card will become so cluttered that it will be of little value. Every whim or desire of an individual or group that is presented in the form of a recommendation should not be entered on this form. Entry of those recommendations by individuals or groups should be limited to those that have merit or to those which, while lacking merit, are deep-rooted or serious. For every management measure entered, its disposition (whether adopted or rejected) should be noted also. If it were not adopted, the reason should be stated. If it were adopted and executed, where possible, the results -- not from unfounded opinion, however -- should be evaluated and recorded on the form.

Lake and Stream, Record of Addition to

Lake and Stream Form
(color white)

This form is not to be placed in the file. It is to facilitate keeping the file up to date. Whenever a new entry or correction is to be made on a form already filed, that entry or correction is to be noted on the "Record of Addition, etc." form by the person making the entry or correction. If this person is the biologist in the field, he will then send this form to the Helena office where a corresponding addition or correction will be made on the form concerned. If the addition or correction was initiated by one in the Helena office, the "Addition" form will be sent to the biologist in the field so that he may make the corresponding addition or correction in his file.

Actually this could be done by letter just as well, but it was felt that by using a special form for recording additions or changes to be made, all needed information would be furnished and a minimum of errors would result.

SEC. & RATE	TOTAL LGTH.	AVE. WIDTH Ave. of 3 Measu	AVE. DEPTH Ave. of 9 Measu ¼-½-3/4	LN. OF POOL Size 2 or 3	LN. OF RUNS	LN. OF RIFFLES	NO. OF POOLS IN SEC.	SIZE OF POOL 1-Larger 2-Equal 3-Smaller	TYPE OF POOL 1-Good 2-Fair 3-Poor	CAUSE OF POOLS 1-Boulders 2-Undercut 3-Debris 4-Digging Current	COVER-NON-POOL FORMING OBST. IN WATER 1-Boulders 2-Rocks 3-Debris 4-Undercut	SHADE-COVER-ABOVE SURFACE OF WATER 1-Dense 2-Med. 3-Light	COMMENTS
DT.													

Form devised by Jim Posewitz in 1961 for use on Prickley Pear Cr.
(L & C County)