TECHNICAL REPORT-A LIMNOLOGY STUDY

PREPARED BY: CATHERINE MACRAE, WILDLAND RECREATION STUDENT

PREPARED FOR: LEN DUNSFORD, WILDLAND RECREATION COORDINATOR

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SUMMARY

Conditions in the Seven Mile Dam Reservoir, on the Pend d'Oreille River, are much the same now as they were prior to construction of the Seven Mile Dam. Although access to the Salmo River spawning grounds has been made easier, oligitrophic conditions prevail and there is a lack of plankton, benthic organisms, and rooted aquatic vegetation. These are significant factors when considering the survival of any game fish, including rainbow trout, which are already present in the Salmo River, and have the potential for moving into the reservoir.

Another study or series of studies should be conducted during various other times of the year to determine whether the lake will retain its oligitrophic nature, or whether it will slowly improve.

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INTRODUCTION

The purpose of this report is to present the findings of a limnological study done at the confluence of the Salmo and Pend d'Oreille Rivers, which now make up part of the Seven Mile Dam Reservoir. A previous study was completed in the summer of 1974 in order to determine whether a game fishery existed, and, if it did, whether it would be harmed by the construction of the Seven Mile Dam.

The findings of the previous report indicated that the fish found in the river at that time were mostly coarse fish which would not be unduly affected if the dam were constructed.

Included in the conclusion of the 1974 report was a suggestion that the Seven Mile Dam Reservoir may improve the oligitrophic nature of the river, allowing a game fishery to prosper in the newly created lake.

The findings of the study which was done this year show that little has changed as a result of the construction of the dam. The reservoir is very oligitrophic and unless further studies indicate otherwise, no game fish will be able to survive in the lake.

LOCATION

The study area is located at the confluence of the Salmo and the Pend d'Oreille Rivers. This point is at the eastern end of the Pend d'Oreille Valley, approximately 18 km east of where the Pend d'Oreille River flows into the Columbia River.

The study area can be found on the 82F/W map sheet at the coordinates 49^0 02' and 117^0 23'.

The maps on the following pages show the location of the study area within the Kootenay Region.

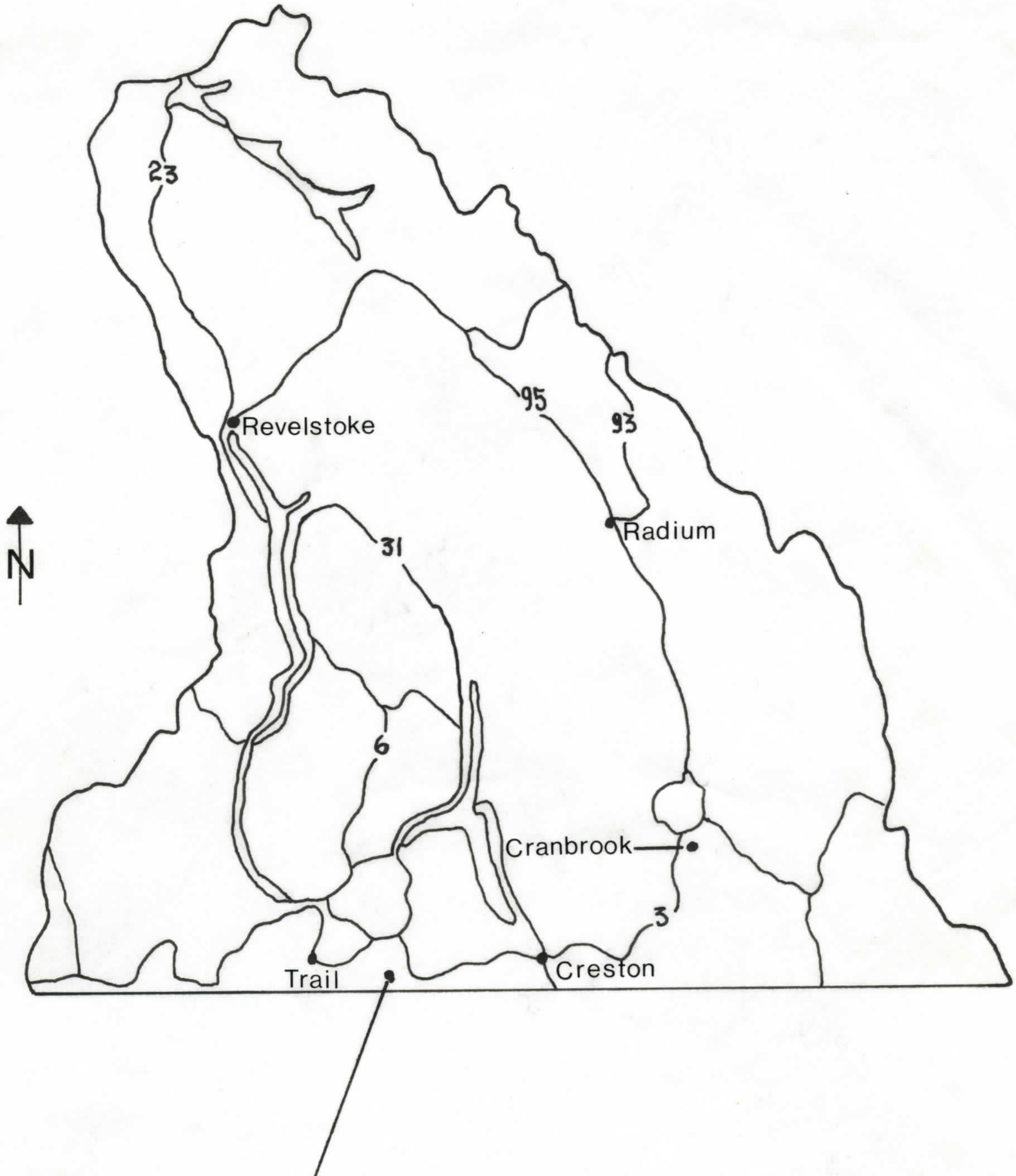
ACCESS

A 30 km secondary road runs through the Pend d'Oreille Valley, beginning at Nelway, and exiting on the Trail-Waneta Highway, approximately 18 km east of Trail.

Four-wheel drive vehicles may be needed to enter the area during winter and spring, but a two-wheel drive vehicle with high clearance should suffice at any other time of the year.

CLIMATE

The Pend d'Oreille Valley has a humid continental climate with warm summers and mild winters. July temperatures average 20^0C and winter temperatures average about -2^0C. The growing season begins around April 5 and continues until mid-October, and the number of frost free days averages 120. Annual rainfall averages 31 cm and annual snowfall averages 92 cm.



LOCATION OF STUDY AREA

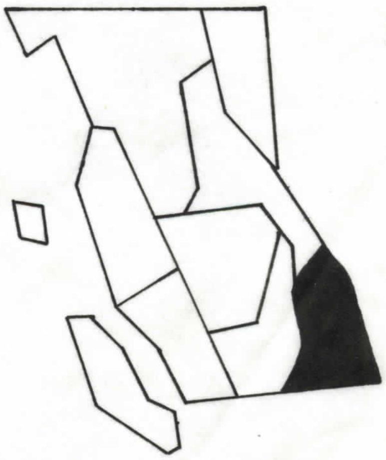


Figure 1

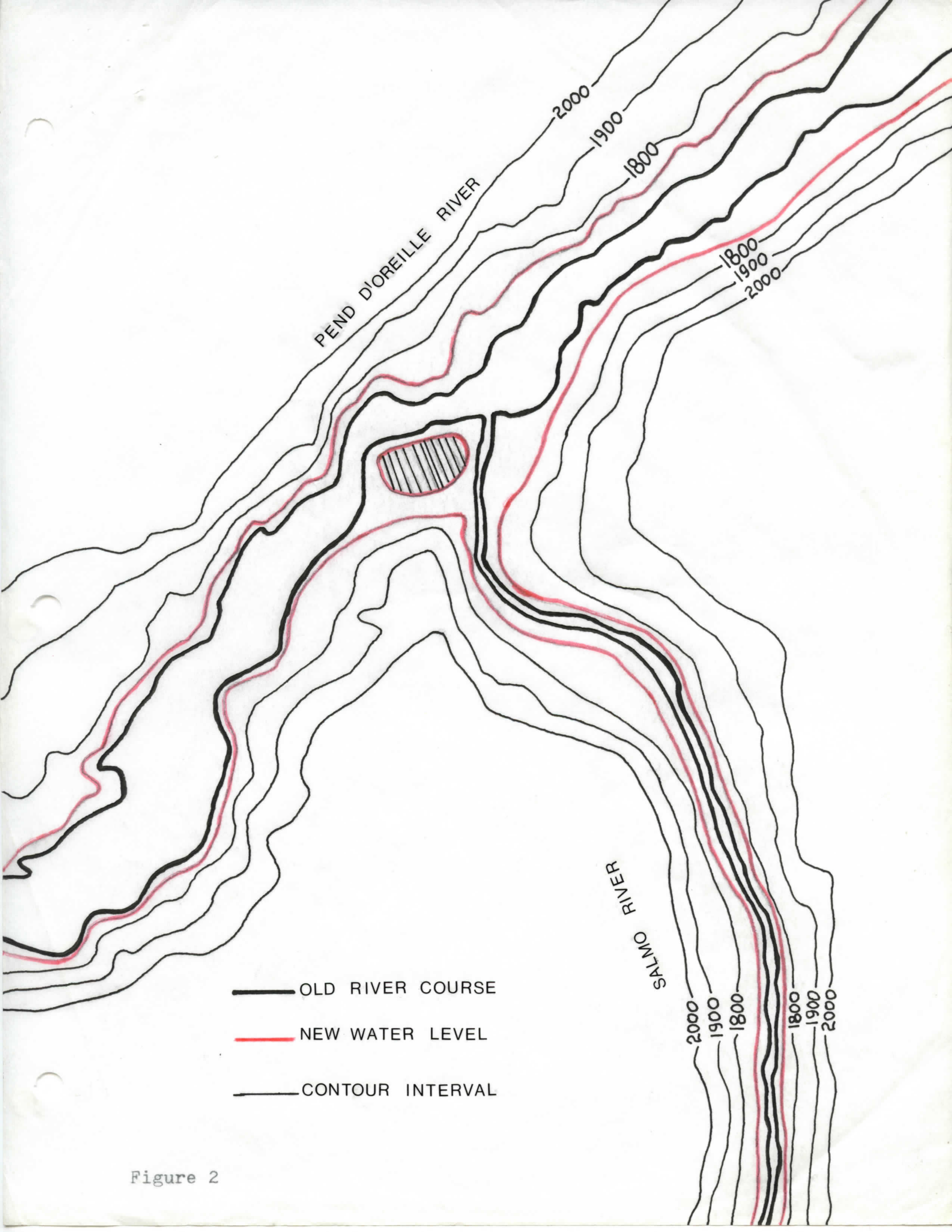

PEND D'OREILLE RIVER
2000
1900
1800
1800
1900
2000
SALMO RIVER
2000
1900
1800
1800
1900
2000
OLD RIVER COURSE
NEW WATER LEVEL
CONTOUR INTERVAL

Figure 2

VEGETATION

The area around the study site is in the Kootenay-Columbia moist southern interior Cedar-Hemlock (ICHaI) biogeoclimatic zone. Plant species which are found at the site are: Bunch Berry (Cornus conadensis), Lady Fern (Athyrium filix-femina), Bracken Fern (Pteridium aquilinum pubescens), Twin flower (Linnaea borealis), Prince's Pine (Chimaphila umbellata), Rattlesnake Plantain (Goodyera oblongifolia), Saskatoon Berry (Amelanchier spp.), Grouse Berry (Vaccinium scoparium), Black Mountain Huckleberry (Vaccinium membranaceum), Wax Berry (Symphoricarpos albus), Sitka Alder (Alnus sinuata), Cedar (Thuja plicata), Western Hemlock (Tsuga heterophylla), and Ponderosa Pine (Pinus ponderosa).

PREVIOUS STUDIES

Limnology studies were done during the summer of 1973-1974, prior to the construction of the Seven Mile Dam; in the Waneta Dam Reservoir, and in the lower portions of the Salmo River. These studies were performed to determine the extent of the fisheries in the Pend d'Oreille River and to determine whether they would be damaged or ruined by the construction of the Seven Mile Dam.

FINDINGS OF THESE PREVIOUS STUDIES

Waneta Dam Reservoir

It was found that the Waneta Dam Reservoir was very oligitrophic. The following table summarizes the ranges of values for various chemical constituents of the Waneta Dam Reservoir, for the summer of 1974.

Table 1 Ranges of values for chemical constituents-Waneta Reservoir [1]

Parameter	Range of Values
Total dissolved Solids	82-96 mg/l
Total suspended solids	31-67 mg/l
pH	7.7-7.9
Dissolved oxygen	8.2-8.3 ppm
Temperature	13.9^{0}C-16.1^{0}C
Conductivity	124-129 umhos/cm
CO_3	$<.5$ mg/l
HCO_3	57.8-60.8 mg/l
Cl^{-1}	1-12 ppm
SO_4^{-2}	5-6 ppm

Table 1 Ranges of values for chemical constituents-Waneta Reservoir

Parameter	Range of Values
Na^{+1}	1.9-2.6 ppm
Mg^{+2}	4.7-6.6 ppm
Ca^{+2}	18-23 ppm
K^{+1}	.9-1.1 ppm
Pb	$<$.05 ppm
Zn	$<$.05 ppm
Ag	$<$.05 ppm

The predominant anion was HCO_3, the water was slightly basic, and O_2 concentrations were near saturation.

The following plankton species were found and the percentage in which they were found is given behind them. Copepods (72.1), Rotifers (13.8), Cladocerans (12.8), and other (1.3). This is typical of oligitrophic river and lake systems in Canada.

The following benthic organisms were found: Oligochaetes (89.8%), Chironomids (4.0%), Nematodes (3.2%), and other (3.0%). Mayflies and dragonflies, which are important food species of Salmonids were absent.

The following fish species were found in the Waneta Dam Reservoir: Northern Squawfish (ptychocheilus oregonensis) -45.8%; redside shiners (Richardsonius balteatus)-40.9%; largescale suckers (Catostomus macrocheilus)-8.4%; peamouth chub (Mylocheilus caurinus)-2.8%; mountain whitefish (Prosopium wiliamsoni)-1.5%; longnose sucker (Catostomus catostomus)-0.3%; and rainbow trout (Salmo gairdneri)-0.3%. Approximately 1 game fish was found for every 25

1. Seven Mile Project For B.C. Hydro (january 1975)

coarse fish and the total number of fish counted was 216.

A silty layer was found along the bottom of the reservoir, which was caused by tailings from the old Remac Mine, located approximately 6.4 km west of Nelway.

The Lower Salmo River

The Salmo River used to flow through a narrow rock gorge which contained short rapids and deep pools, and during the summer there was a 6-foot waterfall at the mouth of the Salmo River. There were also many areas which were suitable for Salmonid spawning.

In 1974 the lower 10 miles of the Salmo River were observed by wet-suited divers and the number of fish were recorded with a hand tally-counter. The following fish were seen: Rainbow trout-74.5%; mountain whitefish-9.3%; largescale sucker-8.8% dolly varden char-4.6%; and northern squawfish -2.8%.

PREDICTIONS WHICH WERE MADE FOR THE SEVEN MILE DAM RESERVOIR

1. Water velocities in the Seven Mile Dam Reservoir will be similar to those found in the Waneta Dam Reservoir.
2. The water will be well mixed.
3. The silt load carried in the water will be less because operations at the Remac Mine and mill site are finished.
4. No significant changes in the water chemistry of the Pend d'Oreille River are expected following construction of the Dam.
5. A slight and short-term increase in nutrients may occur after flooding of the new reservoir, because of organic material leached from the newly flooded land. In the

Seven Mile Dam Reservoir, these nutrients could be flushed downstream relatively rapidly.

6. The oligitrophic nature of the Waneta Dam Reservoir will probably be duplicated in the Seven Mile Dam Reservoir.
7. The water in the new reservoir will be slightly alkaline with HCO_3 ions predominating.
8. O_2 concentrations in the new reservoir will remain high.
9. The N_2 gas in the reservoir may be high because of nitrogen entrapment in water spilling over the Boundary Dam.
10. It is unknown whether the abundance of plankton in the Seven Mile Dam Reservoir will differ appreciably from that in the Waneta Dam Reservoir.
11. The newly formed land on the bottom of the lake is not expected to have a layer of silt on it,because the Remac Mine is no longer in operation.
12. There may be a greater abundance of organisms such as damselflies, dragonflies, and caddisflies, and a relative decrease in the significance of oligochaetes, chironomids and nematodes relative to populations in the Waneta Dam Reservoir.
13. Coarse fish are expected to predominate although larger benthic populations could lead to slightly more trout and other benthic species.
14. Improved access to spawning areas in the Salmo River might facilitate the production of a sports fishery in the Seven Mile Dam Reservoir. Rainbow trout could spawn in the Salmo River and possibly spend a lake residence period in the Seven Mile Dam Reservoir.
15. Fish inhabiting the Salmo River may move into the reservoir,

providing an inhospitable reservoir environment does not prevail.

16. Sports fisheries are expected to be limited in the reservoir because there will probably not be large amounts of litoral feeding or nursery areas available.

17. The proposed reservoir will have few areas, if any, which will contain rooted aquatic vegetation.

In conclusion, conditions in the Waneta Dam Reservoir provide a favourable environment for several species of coarse fish, but not trout. A similar situation is anticipated in the Seven Mile Dam Reservoir, which will have many features that contribute to unproductive trout habitat.

HABITAT REQUIREMENTS FOR RAINBOW TROUT

All the following information was taken from the book Trout Streams, by Paul Robert Needham.

Rainbow trout love swift, turbulent waters, but will do well ineither lakes or rivers, making them the most adaptable of the trout. They prefer streams which are connected with oceans, large lakes or reservoirs.

Temperature tolerance of trout is dependent upon accompanying factors, such as the amounts of oxygen and other gases in solution, the chemical nature of the water, the presence or absence of pollutants, and the general condition of the fish. They can tolerate maximum summer temperatures of 28^0C if the oxygen content of the water remains high.

In general, high temperatures well within the limits of tolerance promote rapid development and growth, while low temperatures retard growth and inhibit development. This gives rise to mature, but stunted, emaciated fish.

The optimum amount of dissolved oxygen present in the water should be around saturation, but fish death does not take place until the oxygen supply has dropped below 3 ppm. Water in rapidly flowing, steep streams, where constant mixing with air is possible, seldom show oxygen depletion.

High carbon dioxide content is not usually harmful unless accompanied by low oxygen supplies. When oxygen is abundant, the carbon dioxide seems to have little effect on the fish. Carbon dioxide in excess of 22 ppm will effect the development of eggs and consequently they will not usually hatch.

Excess nitrogen (one litre of water at 18^{0}C will absorb about 18 ppm of nitrogen at a pressure of 760 mm) can cause gas disease in trout.

Rainbow trout spawn in smaller headwater streams. They prefer gravel beds at the lower ends of pools and above swift riffles, where considerable amounts of water must seep down through the gravel. This ensures that the eggs have a constant supply of oxygen during their development. They spawn in the spring from February until June, depending upon which locality they are in.

Caddisflies in their larval and pupal stages live submerged in cases they carry about with them, or in shelters attached to the stones. These insects form one of the most important parts of the trouts' diet. Other important foodstuffs are mayflies, two-winged flies, beetles, ants, bees, wasps, and stoneflies.

The following table shows the types and percentages of foods found in the stomachs of 80 rainbow trout. These trout ranged in length from 3" to 12", with an average of 6". Most of them were taken in May, June, and July, and all were taken from streams in New York State in the summer of 1959.

Table 2 Food Found in Rainbow Trout Stomachs[2]

Class of food	Number found in 80 Stomachs	Percent of Total
Mayflies	490	37.1

Table 2 Food Found in Rainbow Trout Stomachs

Class of Food	Number found in 80 Stomachs	Percent of Total
Caddisflies	247	18.7
2-winged Flies	234	17.8
Beetles	105	7.9
Ants, bees, and wasps	88	6.6
Stoneflies	44	3.3
Moth larvae	17	1.2
Snails	14	1.1
Leaf-hoppers	13	1.0
Crayfish and scuds	13	1.0
Alderfly larvae	11	.8
True bugs	11	.8
Grasshoppers	7	.5
Fish and Salamanders	6	.5
Miscellaneous	23	1.71
Total	1.323	

The following table shows some of the plants commonly found in healthy trout streams, and their productivity in various fish foods.

Table 3 Commonly Found Plants and their Productivity [3]

Name	Water Speed	Dominant Organism (%)	Pounds of Food/Acre
Stonewort	slow	Scuds, 61.4%	3,553
Watercress	slow	Scuds, 81.4%	1,229
Longleaved pondweed	slow	water-boat-men, 67.7%	566

Table 3 Commonly Found Plants and their Productivity

Name	Water Speed	Dominant Organism (%)	Pounds of Food/Acre
Curly pondweed	slow	Sow-Bugs and scuds, 57.9%	566
Water buttercup	slow	Midge larvae, 44.1%	336
Sage pondweed	slow	Water-boat-men, 75.9%	307
Algae & moss	swift	Midge larvae, 59.8%	403
Water moss	swift	Beetle larvae, 43.8%	297
Horned pondweed	swift	scuds, 60.6%	288

2. Trout Streams; Paul Robert Needham; (1960)
3. Trout Streams; Paul Robert Needham; (1960)

AN EXPLANATION OF THE PARAMETERS BEING CONSIDERED

All the following information was taken from the Forestry Handbook For British Columbia.

VEGETATION

Vegetation found beside streams, rivers, or lakes provides the shade needed to regulate water temperature control. The shadows cast over the water are used by the fish for hiding cover, and the roots help keep the banks stable. Insects live and breed among the vegetation and are an indirect source of food for the fish when they fall into the water. For these reasons, the taller the vegetation is, the greater its value will be.

Aquatic plants are necessary because they produce oxygen, which contributes to a high dissolved oxygen level. They provide living and hiding places for aquatic insects and fish, and are a food source for the herbivorous creatures.

TEMPERATURE

Temperature has a marked effect on the carrying capacity of dissolved oxygen in the water because the colder the water, the more dissolved oxygen it can carry. Aquatic plants and animals may be able to survive in cooler waters, but they grow faster and larger in waters which are warmer; providing the water is not so warm that it cannot hold a reasonable amount of dissolved oxygen.

OXYGEN

For cold water biota, it is desirable that dissolved oxygen concentrations be at or near saturation. This is expecially important in spawning areas where dissolved oxygen levels must not fall below 7 ppm at any time. For good growth and general well-being of trout, salmon, and their associated biota, dissolved oxygen concentrations should not be below 6 ppm.

CARBON DIOXIDE

The presence of carbon dioxide in the fishes' blood stream triggers the impulse to breathe oxygen, and is also an essential element in the process of photosynthesis for plant growth. The free carbon dioxide concentration should not exceed 25 ppm.

PHOSPHATES

Phosphorus is one of the nutrients of major importance to biological systems because it is most likely to be the main limiting or regulating element in productivity. Plants require inorganic phosphate, commonly found in the form of orthophosphate ions. The total phosphorous concentration of most uncontaminated surface waters are between 10 to 50 ppb.

pH

pH is the measurement of the hydrogen-ion concentration of a solution and should fall within the range of 6.5 to 8.5.

TOTAL DISSOLVED SOLIDS

If the concentration of dissolved materials exceeds 50 milliosmoles (equivalent to 1500 ppm NaCl) their harmfullness is due to osmotic effects. A high concentration of T.D.S. will also block light penetration and impede plant growth.

TURBIDITY

Turbidity limits light penetration into the water, which in turn reduces the growth of aquatic plants. Turbidity also effect many species of fish classed as sight feeders. In addition, suspended materials absorb solar heat, causing water temperatures to increase.

LAKE SURFACE ELEVATION

Elevation is critical in estimating the approximate number of snow and ice free days that may be expected during the year. The duration of the ice-free period also influences the amount of biological activity (fish growth for example) in the lake.

METHODS USED DURING THE STUDY

All the following studies and measurements were done at a station which was located in 17.37 meters of water, approximately half way across the channel. Depth to the bottom was measured with a weighted sounding line which had been previously calibrated into meters.

A temperature and dissolved oxygen profile were done for every meter from the top to the bottom, and several random samples were done at a depth of 10 meters in order to determine whether there was a marked difference between the chosen study point and other areas. Both the dissolved oxygen and the temperature were measured with a YSI model 57 oxygen meter, and depth was determined by tying together the dissolved oxygen meter's probe and the weighted sounding line.

Secchi disc visibility was measured at the station and at another randomly located point. Lake surface and atmospheric conditions were recorded at the time these measurements took place.

Five water samples were taken, using the Van Dorn bottle; from the surface, just under the thermocline, and just above the bottom. Nitrate, sulphate, nitrite, carbon dioxide, and orthophosphate ions, as well as the pH, were tested for using the respective small Hach kits, and the larger Hach kit.

Two 16 oz. jars were filled with water and taken back to Selkirk College for turbidity analysis and to find the amount of total dissolved solids. Turbidity analysis was done using the 420 mm and 660 mm wavelengths of the Baush and Lomb, Spectronic 20 photospectrometer. These wavelengths represent the blue-green and red light waves, which are the ones used in photosynthesis. The total dissolved solids were calculated using the following methods. First, nine beakers, three filters, and three filter papers were dryed and weighed. 1000 mls of water from the top, the middle, and the bottom, were filtered into the nine beakers. The beakers, filters, and filter paper were all put into the drying oven, and when the water had evaporated, they were all weighed again. The weights determined at the start of the experiment were subtracted from the weights at the end of the experiment. The difference in the weights of the beakers represented the total dissolved solids, and the difference in the weights of the filters and filter paper represented the total undissolved solids.

One ten meter long vertical plankton haul and one twenty-second horizontal plankton haul were done using a plankton haul net with an area of 113 cm^2, while rowing at a moderately fast speed. The resulting catch was put through a centrafuge in order to measure the volume of the plankton.

Two benthic samples were taken from the shallow water near shore, the material was seived and the names of any captured organisms were recorded. A visual description of the bottom was also given.

Fishing was done with a spin-cast rod and reel which had been baited with cheese and the fishing time was approximately two days.

RESULTS OF THE STUDY

The temperature of the water remained constant throughout, but the dissolved oxygen content increased slightly as the depth increased. The following table illustrates the temperature and dissolved oxygen profile.

Table 4 Temperature versus dissolved oxygen

Depth (meters)	Dissolved Oxygen (ppm)	Temperature (^{0}C.)
1	12.4	3
2	12.4	3
3	12.4	3
4	12.4	3
5	12.4	3
6	12.4	3
7	12.4	3
8	12.4	3
9	12.5	3
10	12.5	3
11	12.5	3
12	12.5	3
13	12.5	3
14	12.5	3
15	12.5	3
16	12.6	3
17	12.6	3

The temperature of the water at the randomly located points was also 3^{0}C and the dissolved oxygen content at these points was 12.4 ppm.

Secchi disc visibility averaged 5.79 meters. The sky was overcast with scattered sunny periods which caused slight reflections of bank vegetation to form on the waters surface.

The average pH at the surface was 6.5, but the middle and bottom both had a pH of 6.9. The average orthophosphate content of the surface, middle, and bottom waters was 4-6 ppm, the average nitrate content was 0-1 ppm, the amount of nitrite was 0 ppm, and the average CO_2 content was 10-15 ppm. The sulphate content of the surface and middle waters was 2-3 ppm, and at the bottom, it was 2-4 ppm.

The following table illustrates the relative turbidity of the water in terms of the percentage of light which was transmitted through a sample of water.

Table 5 Light Transmittance

Wavelength	Surface	Middle	Bottom
420	98.5%	96.5%	97.5%
660	97.5%	100%	100%

The total dissolved solids found at the surface were 44.5 mg/l; in the middle they were 45.8 mg/l; and in the bottom waters they were 46.2 mg/l. Total undissolved solids averaged 68.5 mg/l.

No plankton species were found in the nets after the plankton hauls were made, and the centrifuge yielded only a very miniscule amount of material (.1 ml).

Benthic samples found were very sparse. No living organisms were seen, but some sand particles, wood chips, and rocks, measuring approximately 2 mm in diameter, were seived. No aquatic plants were seen growing anywhere along the edges of the reservoir.

No fish were caught during this time.

DISSCUSSION OF THE RESULTS

(with reference to predictions made after the 1974 study)

1. The water velocity in the Seven Mile Dam Reservoir was not measured during this study.
2. The water is well mixed, with the dissolved oxygen content being very similar at all depths.
3. The water was virtually clear, but it was difficult to determine whether the silt load was less than before, because the study was not done in the mainstream of the Pend d'Oreille River, because of the swiftness of the current.
4. No significant changes in the water chemistry of the Pend d'Oreille River were found.
5. The orthophosphate level in the water was fairly high, indicating an increase in nutrients. It is unknown whether this level will remain high, or whether it will be short lived.
6. Based on the findings of this study, the oligitrophic nature of the Waneta Dam Reservoir has been duplicated in the Seven Mile Dam Reservoir.
7. Contrary to the predictions, the water in the reservoir is slightly acidic and carbon dioxide ions tend to predominate (among the ions which were tested).
8. Oxygen concentrations in the Seven Mile Dam Reservoir are higher than those found in the Waneta Dam Reservoir, but may tend to decrease to about the same level as spring and summer progress.

9. The nitrogen content of the water is almost zero, but this may be due to the time of year. Perhaps the N_2 content of the water will increase as the season of greatest productivity approaches.
10. No plankton was found in the reservoir, but that may be because of the time of year the study was conducted. The days are not long enough and the weather is still too cold for any plankton production to take place. The level will hopefully increase during the summer, as plankton is an important food source for fish and aquatic insects.
11. Although there was not a layer of silt on the newly formed land at the bottom of the reservoir, the material was soft and mucky.
12. No living organisms were found during this study, due to the time of year, and the lack of food species. The scarcity of benthic organisms is significant,as they also serve as a major foodstuff for the trout.
13. No fish were caught during this study, but it is expected that coarse fish will predominate over game fish because of the lack of favourable habitat found in the reservoir.
14. There are good areas for spawning in the Salmo River, and access has been made easier. Inhospitable conditions in the reservoir, however, make it unlikely that fish would spawn in the Salmo River and spend a period in the reservoir.
15. Trout inhabiting the Salmo River will probably not move into the reservoir because of the poor conditions which prevail.
16. The area surrounding the study point contains no rooted aquatic vegetation; consequently, there is nowhere for aquatic insects and fish to live and hide.

CONCLUSION

The Seven Mile Dam Reservoir is large and oligitrophic and at the present time could not support a population of rainbow trout or any other game fish.

This study was conducted during the winter season when most organisms are at their lowest ebb, so conditions may improve as the days lengthen and the temperature increases.

RECOMMENDATIONS

1. Another limnology study of the reservoir should be made during the summer in order to determine:
   a) The dissolved oxygen and nutrient content of water during the height of the period of productivity.
   b) If there are any living benthic organisms present during that time of year.
   c) If there is an increase in the number of plankton species.
   d) what type of fish are in the reservoir and in what percentage. If possible this should be ascertained by using a gill net instead of the method which was used in this study, as a better sampling of fish will be obtained.

2. Based on the results of this study, the lake should not be stocked with Rainbow Trout or any other type of fish.

BIBLIOGRAPHY

1. Environmental and Resource Management Studies, Seven Mile Project For B.C. Hydro; Pearse Bowden Economic Consultants Ltd.; Vancouver, B.C. January 1975.

2. A limnological Investigation of Orion Lake; Ross, David T. 1979.

3. Trout Streams; Needham, Paul Robert. 1960

4. Forestry Handbook of British Columbia; Forest Club, U.B.C. 3rd Edition, Vancouver, 1971.