ANALYSIS OF ALTERNATIVE WATER RELEASE OPERATIONS FOR PRIEST LAKE, IDAHO

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AUTHORIZATION TO PROCEED WITH THE FINAL DRAFT:

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OPERATIONS FOR PRIEST LAKE, IDAHO

ABSTRACT

by

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In this study several alternative water release operations of Priest Lake Outlet Dam are evaluated and compared with the present operation using guidelines established by National Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources." Functional purposes considered relevant to the plan are flood damage reduction, power, lake recreation, river recreation, land measures, regional income, and many classed under Environmental Quality and Social Well-Being objectives. A methodology, based on current information and a research of applicable literature, is developed for determining economic values for the National Economic Development and Regional Development objectives without actually testing any of the proposed alternatives. The Environmental Quality and Social Well-Being objectives are enumerated.

Problems associated with present lake regulation and resulting changes in river flow regime are discussed. The analysis of the alternative water release operations

is displayed in simple tabular form. The many environmental quality and social well-being objectives preclude any rigorous economic analysis to determine optimum operation. An approach to the selection of the optimum operation is suggested as well as improvements to the present method of operation. The operation selected as optimum from the seven alternatives investigated is the one which best satisfies the opposing concerns.

INTRODUCTION

Three major factors influenced the selection of the regulation of Priest Lake for study: (1) The development of a statewide water plan for Idaho has prompted studies of the major river systems in the state including Priest River. (2) Washington Water Power Company's Priest Lake Outlet Dam Operating Agreement with the state of Idaho is due for renewal in 1976, and a different system of operation may make revisions to the agreement necessary. (3) The Idaho Fish and Game Department has recently conducted studies on the Priest Lake and Priest River fisheries which show the present system of operation to be harmful to the fisheries, and the Department has recommended changes in the present system. The present system of operation results in abnormally low summer flows in Priest River in August and September and sudden abnormally high flows in the river when the stored water is released in October.

The purpose of this study is to assist state planners in defining the feasible alternatives and the problems involved in optimizing the regulation of Priest Lake. An attempt is made to identify all the possible functional purposes in the four account system of objectives developed in the Water Resources Council's "Principles and Standards" (1973) to provide a basis for comparison of the various alternative regulations examined. The objectives of this study are:

1. Determine the beneficial and adverse impacts of the present operation.

2. Develop feasible alternatives to the present operation.

3. Analyze and compare the feasible alternatives with the present operation.

4. Select an approach to the optimum system of operation based on the comparison of the alternatives examined.

The conclusions reached and recommendations offered in this study are the writer's own and do not necessarily reflect the thinking and opinions of the Idaho Department of Water Resources.

To meet the above objectives, this study outlines the background, uses, and ownership of Priest Lake and Priest River. Next, the changes in the natural river flow regime due to the present operation and the associated problems are developed in more detail. From this information and other limited data available on Priest Lake and Priest River, and a research of applicable literature, a methodology is developed to evaluate and compare the various alternatives. This methodology utilizes the format of the Water Resources Council's "Principles and Standards" which is explained in the section so titled. The existing data may be evaluated by some other methodology which would perhaps give different results. Following the display of the effects of each alternative in the Analysis section is a discussion of ways to physically control the outlet structure in conjunction with various alternatives.

The present operation and the alternatives studied are all pointed towards satisfying one or more of the three main concerns: lakefront residents and resorts, Lake Kokanee salmon, and river fisheries. The lakefront property owners and resort owners are the main proponents of the status quo while most of the other concerns are either enhanced or not affected by an earlier and more gradual drawdown of the lake. To assess the impact of lake level changes on lakefront property owners, a questionnaire was distributed around the lake in July of 1974. A summary of the responses is given in Appendix B.

The Idaho Department of Water Resources provided computer simulation runs of the various alternatives selected for study to simulate flows and lake levels over 43 years of record. Each alternative studied was chosen to enhance some particular benefit of lake regulation as suggested by the name of the alternative. Flows for each alternative are shown in Appendix D and lake elevations in Appendix E. The feasible alternatives for regulation of Priest Lake consider some modification of present operation in summer and fall months only.

Currently the Idaho Fish and Game Department is investigating losses of Kokanee spawn due to lake drawdown. The U.S. Forest Service is engaged in comprehensive data collection and public involvement in determining suitability of Priest River for inclusion in the National Wild and Scenic Rivers System. Also the University of Idaho Water Resources Research Institute has undertaken a study to assess public preferences toward use of Priest River and determine land values on lake and river. These on-going studies will perhaps answer some of the present unknowns associated with the various alternative operations.

This study concerns itself with the present situation only, and future developments will cause changes in the analysis. No attempt has been made to predict future lake and reservoir uses as the operation can be re-evaluated with new input at any time and appropriate changes made in lake regulation.

PRIEST LAKE/RIVER BACKGROUND

Upper Priest River originates a few miles north of the U.S.-Canadian border and flows into Upper Priest Lake which is connected to Priest Lake by a 2.6 mile narrow slack water channel called the Thorofare (see Fig. 1). Upper Priest Lake is approximately 3.4 miles long and 1 mile wide at its widest point. Priest Lake is approximately 19 miles long and 4.5 miles wide at its widest point with a surface area of approximately 36 square miles and a shoreline of approximately 52 miles (see Fig. 3). The drainage area at the Outlet Dam is approximately 600 square miles. At the U.S.G.S. gage on Priest River 2.7 miles north of the town of Priest River, the drainage area comprises about 900 square miles.

There are currently 5 campgrounds and one picnic ground around Priest Lake, 2 campgrounds on Upper Priest Lake, which are accessible by boat or trail only, and 6 campgrounds on Kalispell and Bartoo Islands in Priest Lake, which are accessible by boat only. There are two public boat ramps on the lake, one in Kalispell Bay and one at Coolin, a campground on Priest River a few miles below lake outlet and another campground at the mouth.

Public access to both the lake and river is somewhat limited as much of the easier access area is privately owned or leased.

The river frontage is approximately 30% U.S. Forest Service, 30% state, and 40% private with about 250 individual owners. The lake frontage is approximately 30% U.S. Forest Service, 37% state, and 33% private. There are about 1,000 private owners or lessees with lakefront lots (see Appendix A).

It is approximately 44 river miles from the Outlet Dam to the confluence of the river with the Pend Oreille River (see Fig. 4). There is a drop of about 380 ft in this distance. River gradients range from 28 ft/mile to 4 ft/mile with about 50% of the river at a gradient of near 4 ft/mile (U.S. Forest Service, 1974). Rapids, riffles, pools, swampy areas, and meanders are all present. Figure 2 shows Priest River at high spring flows.

Fishing, floating, and swimming occur in the river while fishing, boating, swimming, and water skiing take place on the lake. Bjornn (1957) found Kokanee to be the most abundant game fish in the lake while Leusink (1968) found it to be the most sought-after fish. Several commercial resorts have been established around the lake.

Under natural conditions high spring flows occurred around the first of June in Priest River and then decreased throughout the summer and fall until rains once again

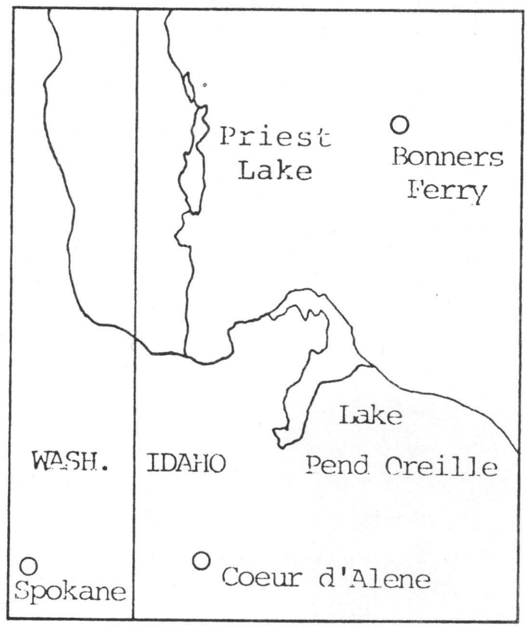

Fig. 1.--Priest Lake vicinity map

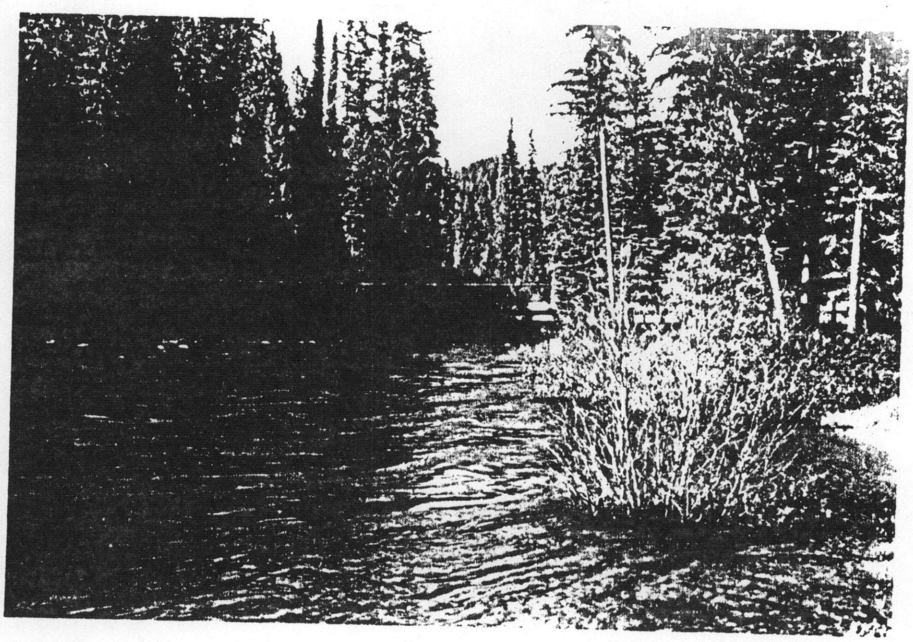

Fig. 2.--Priest River at U.S.G.S. Dickensheet gage

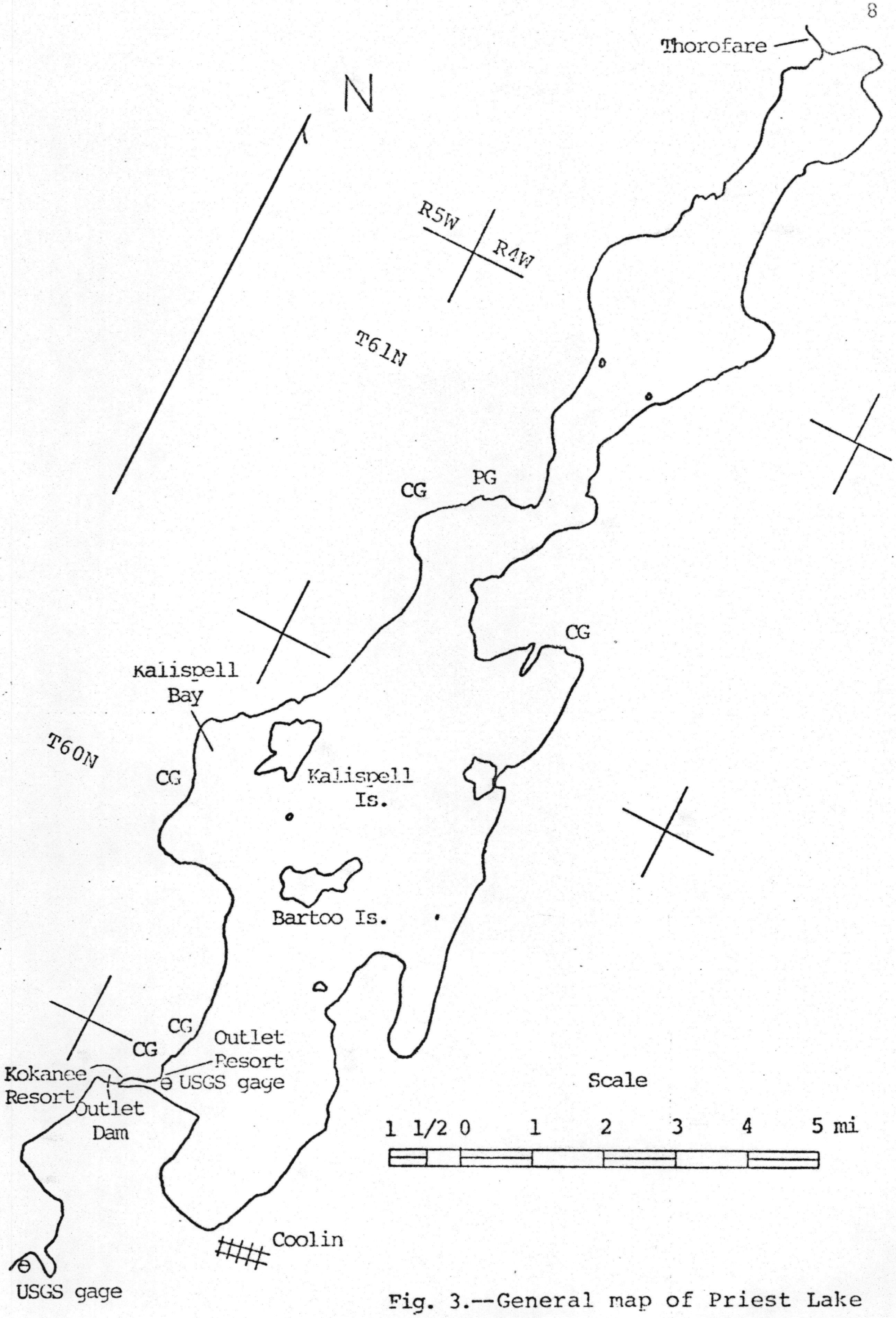

Fig. 3.--General map of Priest Lake

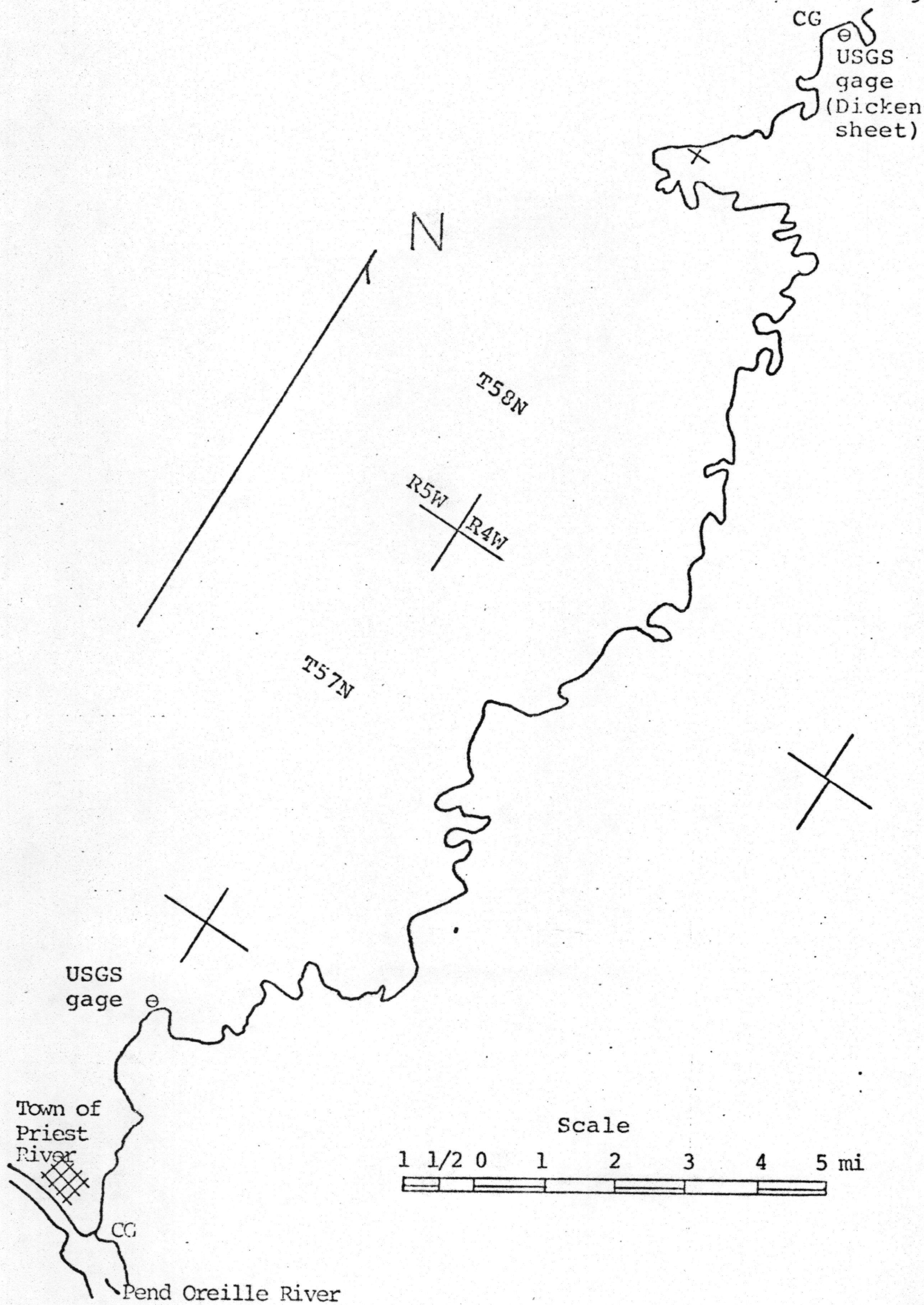

Fig. 4.--General map of Lower Priest River

increased flow. In the fall of 1950, the present outlet control structure was installed by Washington Water Power Company to provide a constant lake level during the recreation season, and then the stored water was released for power generation in the fall. Prior to 1950, logging operations in the outlet channel had resulted in some lake level regulation above normal.

Bjornn (1956) reports that lakefront property owners had mixed emotions about the stable lake level. Some had their beaches flooded while others were able to use their docks all summer. More cottage sites became accessible by boat, and the Thorofare was easier to navigate all summer. However, Cutthroat spawners going down the river in the spring were trapped in the river when the dam boards were installed as the lake level dropped.

PRESENT OPERATION AND PROBLEMS

The stoplogs are installed in the dam each year following spring runoff as gage height approaches 3.0 ft (gage height of 0.0 ft is the normal datum) and in recent years have been removed on successive weekends in late October. Figures 5 and 6 show the Outlet Dam. The gage height has varied from 2.9 to 3.4 ft during the summer, and occasionally the lake level has risen while river flow decreased probably due to the installation of additional stoplogs. Thus, the present operation meets neither the terms of the Operating Agreement (1956) between Washington Water Power Company and the state of Idaho nor Section 70-507 of the Idaho Code which states that the lake level will be maintained at the 3.0 level during the recreation season and not above this level.

Since the dam was put into operation, the flow regime in the river has changed substantially. Irizarry (1974) points out that prior to impoundment, the 39-year average minimum daily flows at the Dickensheet gage below the Outlet Dam were 372 cfs in August and 271 cfs in September. Average montly flows were 524 cfs in August and 344 cfs in September. In the 24 years since impoundment, minimum daily flows have averaged 165 cfs in August

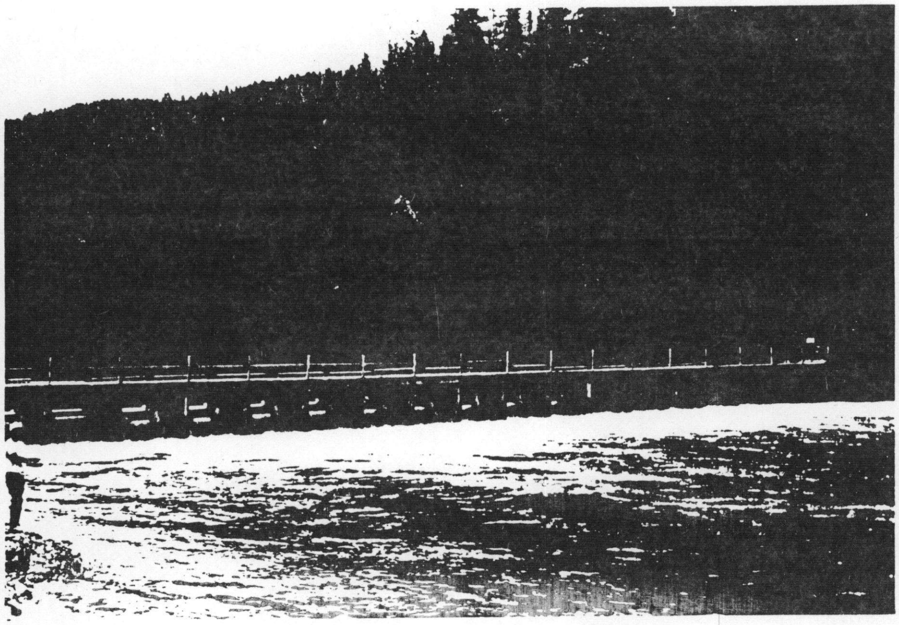

Fig. 5.--Downstream view of Priest Lake Outlet Dam

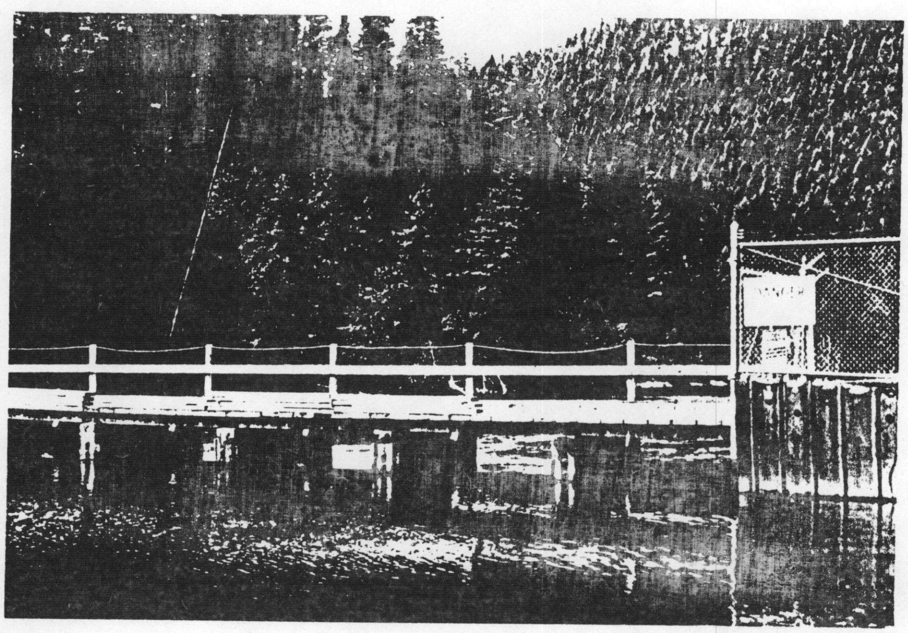

Fig. 6.--Upstream view of Priest Lake Outlet Dam

and 132 cfs in September. Average monthly flows have been 293 cfs in August and 261 cfs in September. Rainfall records for August and September at Priest River Experiment Station show similar averages for the periods prior to 1950 and after 1950. Several times minimum daily flows have dropped below 100 cfs in both August and September since 1950, while prior to 1950 flows never dropped below 200 cfs in August and never below 140 cfs in September. On occasion the average monthly flow in August has approached 100 cfs while dropping below 100 cfs several times in September since the dam was installed. In the fall when the stoplogs in the dam are pulled by local residents employed by Washington Water Power Company, the discharge at the Dickensheet gage increases to between 2,100 and 2,900 cfs within a day or two from flows as low as 200 cfs. This abnormally high discharge gradually decreases during November as the lake empties.

It is these below normal low summer flows and sudden large discharges in the fall with a corresponding drop in lake level which have prompted the Idaho Fish and Game Department to investigate the effects of the present operation on the lake and river fisheries. Irizarry (1974) has concluded that a minimum flow needs to be established before native fish stocks in the river can be increased or new species better suited to existing river conditions can be introduced. Also, to prevent Kokanee egg losses due to exposure during drawdown, at least two-thirds of the stored water should be released by the first of November.

However, as the lake level drops, some of the private shore stations become unusable. The accessibility of the docks at some of the commercial resorts becomes limited or impossible. The lakeshore owners have become accustomed to the present operation over the years and for the most part (from comments received on Property Owner Questionnaire) are satisfied with it.

Because of its disruption of the natural flow regime in Priest River, the present operation has an adverse impact on river recreation and several environmental considerations. These effects are considered in more detail later. It is important to note that the present operation itself could be made less damaging to the environment of the river by a more gradual release of the impounded water (see Appendix D).

WATER RESOURCES COUNCIL'S "PRINCIPLES AND STANDARDS"

The United States Water Resources Council, an executive agency of the government, was created by the Water Resources Planning Act of 1965 (Public Law 89-80). To provide for comprehensive planning, development, and use of the nation's water resources, the Council established "Principles and Standards for Planning Water and Related Land Resources." This document was published in the Federal Register of September 10, 1973.

The basis for the above mentioned method of evaluation of water resource development is a four account system consisting of (1) National Economic Development (NED) account, (2) Environmental Quality (EQ) account, (3) Regional Development (RD) account, and (4) Social Well-Being (SWB) account. This system attempts to encompass all the considerations involved in a water resource project. Beneficial and adverse effects in all accounts are assigned dollar values where possible. Environmental and social effects which cannot be evaluated monetarily are measured either in physical or ecological terms. For each alternative plan there is a "with" and "without-the-plan" analysis comparing all relevant objectives. This comparison indicates the tradeoffs among alternative plans and the appropriate plan can then be selected.

METHODOLOGY DEVELOPED TO ANALYZE NED AND RD OBJECTIVES

Using the procedures developed in the "Principles and Standards," it is possible to compare the present operation of Priest Lake with the various alternative operations. The functional purposes found to be relevant to Priest Lake and River include flood damage reduction, power, lake recreation, river recreation, and land measures in the NED account; a large number of functional purposes (developed in the following chapter) in the EQ and SWB accounts; and regional income in the RD account.

The present operation scheme is designated as the "without-the-plan" condition. Except for the known net benefit of the power functional purpose, all other net benefits for the NED and RD objectives for present operation are assigned values of zero for comparison of alternatives.

Economic values must be generated for the six NED and RD functional purposes considered relevant in this study. This is done below for each of the six functional purposes. A capacity table of gage height vs lake contents developed by the Idaho Department of Water Resources was used in this analysis. The U.S. Geological Survey capacity table differs slightly and would give slightly different values if used.

Figure 7 shows adverse scores for all lakefront residents due to changes in the normal lake levels. This table for the entire lake was developed from the responses given in Appendix B for 147 residents and multiplying by 6.0 since Appendix A shows there is a total of 877 residents around the lake (877/147 = 6.0).

Flood Damage Reduction

Discussion

Spring snowmelt generally causes lake levels to reach a peak around the first of June. The lake gage height usually drops below 4.0 ft by the middle of June. Assume that a gage height of 4.0 or greater at the end of June results in prolonged high water causing excessive beach erosion, shoreline damage, etc. Intentionally keeping lake levels at or near 4.0 following spring runoff is not a reasonable alternative because the benefits to be gained are far outweighed by the costs.

Procedure

1. Determine gage height at end of June to nearest half foot from Appendix E.
2. Find the adverse score for property value from Fig. 7 for a gage height of 4.0 ft or greater at the end of June.

3. Assume $100 in flood damage for each owner whose property value is slightly adversely affected (each point of the adverse score represents one owner whose property value is slightly adversely affected).

4. Multiply the adverse score for property value obtained from Fig. 7 by $100 to get the flood damage effect.

Power

Discussion

According to Glenn Nogle of Washington Water Power's Resources Division (10 July 1974), the critical period for power begins early in August and Priest Lake water has the same value if released any time within the critical period which ends when melting snow in spring replenishes stream flow. Ideally, the best use of Priest Lake water for power production may be made if water is released as soon as the critical period begins. Water has no value for power production if released outside the critical period. Storage draft from Pacific Northwest Power pools generally begins by 15 August and probably will never be any earlier than 1 August in the foreseeable future.

Therefore, water released between 15 August and April has the same value, water released between April and 1 August has no value, and water released between 1 August and 15 August may have some value for a particular year depending on the beginning of storage draft.

Pacific Northwest Coordination Agreement (1973-74 Contract Year) shows that Priest Lake's 71,000 acre feet (AF) of storage generates an average of 16.8 megawatts (MW) of usable energy each year with a $4,380 per MW limit payable for downstream use of storage. A storage volume of 71,000 AF is the 67,000 AF of storage from Priest Lake and approximately 4,000 AF of storage from Upper Priest Lake between gage heights 3.0 and 0.0. Value of storage released during the critical period between gage heights 3.0-0.0 is 16.8 MW x $4,380/MW = $73,600. Figure 8 shows gross power benefits for various mid-August lake gage heights. Gage height/3.0 x $73,600 was used to compute gross power benefits in Fig. 8.

Procedure

1. Determine gage height on 15 August from Appendix E.
2. Using this gage height, determine gross power benefits from Fig. 8.
3. Pacific Northwest Coordination Agreement (1973-74) shows WWP Company costs of $12,300 to operate Priest Lake for power, including $1,000 paid to the stateof Idaho.
4. Find additional costs by estimating additional manpower and wages needed for new operation.
5. Add additional costs to $12,300 to find total cost.
6. Net benefits = gross benefits - costs.

Level vs normal (3.0)	Property value	Boat dock	Beach
18" below	-786	-912	-684
12" below	-576	-642	-528
6" below	-288	-324	-234
6" above	- 96	- 60	-210
12" above	-432	-366	-522
18" above	-684	-540	-666

Fig. 7.--Adverse score for all lakefront residents due to changes in normal lake levels

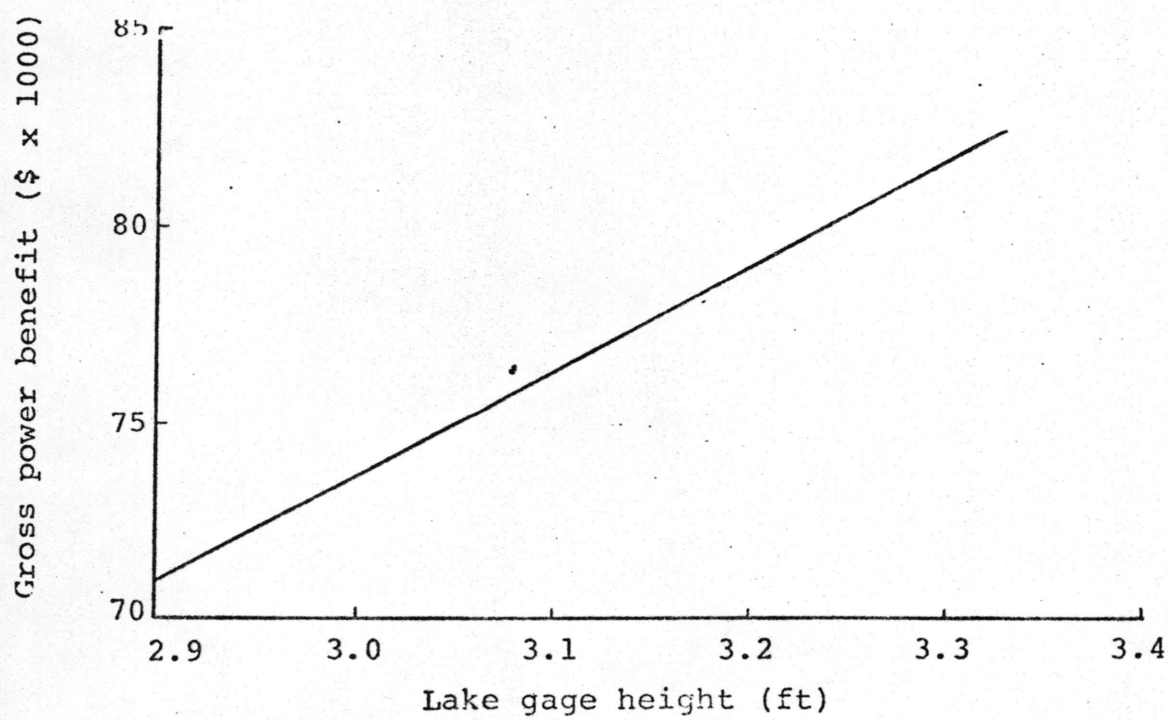

Fig. 8.--Gross power benefit vs mid-August lake gage height

Lake Recreation

Discussion

Public Recreation

The public boat ramp at Kalispell Bay becomes dangerous and unusable because of steep drop-off when the lake level drops. Amount of drop below gage height of 3.0 ft necessary to create this condition is unknown, but Irizarry (26 September 1974) estimates between 1 and 2 ft. At gage height of 1.9 ft, the ramp was still usable, but it appeared that with an additional 6 inch drop in level, it might become difficult to launch a boat.

Use of Priest Lake public boat ramps probably decreases considerably after Labor Day. Dowell (in Hammon et al., 1974) found that 90% of boat launchings on an Arkansas reservoir occurred on warm and relatively dry days. The problem of Thorofare passage at low water appears to be minor. Irizarry (1974) notes that use of Upper Priest Lake is low in the fall and the Thorofare can still be navigated slowly. Troxel, the Priest Lake Ranger District Recreation Specialist (31 October 1974), stated that most inboard/outboards can still pass even at gage height 0.0 and that recreation use of Priest Lake is much less after Labor Day. Appendix B reinforces this idea as Lakeshore Property Owners Survey showed only one resident who experienced difficulties in Thorofare after drawdown commenced last year.

It seems doubtful that lake drawdown would have much impact on public recreation if adequate access could be maintained. Morgan and King (1971) stated that 27 reservoirs studied over a 9-year period during the month of July showed no statistical relationship between water level and recreation attendance. Milligan and Warnick (1973) found that studies by other investigators show no relationship between water level fluctuations and recreation use.

Even with decreasing use of public boat ramp in September and October, there is probably enough use during these months to justify replacement of the present ramp with one suitable for use even at minimum lake stage. This would allow public access even into November and December which is not possible now. Rather than estimating the cost of boating opportunities foregone by an earlier drawdown, assume construction of a new boat ramp is the most likely alternative means of satisfying lost public recreation opportunity. Any proposed operation which drops lake level earlier than is presently done, therefore, has an added cost of installing a new year-round public boat ramp. This is the most likely means of satisfying public recreation opportunity lost due to earlier drawdown.

Private Recreation

From the comments received on the Lakefront Property Owners Questionnaire, most shorefront residents would not like to see present operation changed. Williams and Gilchrist (1973) found that property owners often react on an emotional rather than a rational level. It is interesting to note that Bjornn (1956) found that there were mixed emotions of property owners about the lake regulation; some people had their beaches flooded while others had improved summer-long accessibility to docks. More cottage sites became available because of boat access but recent survey of lakefront owners (Corbett, 1973) shows only 8% of sample felt that boat access only was preferred type of access.

Most people worry about what water level changes will do to their beach and docks. Burby (1971) indicates that the most important shoreline characteristics for property owners are suitability for swimming and erecting a boat dock. This same study indicated reservoir drawdown as one of the five problems most often perceived as very or fairly serious.

Lakefront Owners Questionnaire results indicate that although most people do not want any change in present lake operation, most would not be greatly affected by small fluctuations (6" or less), especially if levels increased (see Appendix B). Also only 61% of residents remain in September, 47% and 30% in November and December, respectively. Considering the above, it was decided to use the information provided by Appendix B in a month-by-month evaluation of swimming and boating opportunity lost by lakefront owners due to lake fluctuations different from present operation. The month of June was ignored because of normal high water and uncertainty of the weather.

Procedure

1. Estimate $20,000 capital cost for engineering and construction of public boat ramp. Use Water Resources Council's current discount rate of 5-7/8%.

2. Find capital recovery factor (CRF) for 20 year life, 5-7/8% discount rate, zero salvage value.

3. Annual cost = $20,000 x (CRF, 5-7/8, 20) = $20,000 x 0.08630 = $1,700 (cost of boat ramp).

4. For July through November, determine average level above or below normal (present operation) to nearest half foot (18" is max. diff.). (See Appendix E.)

5. From Fig. 7 find adverse scores for lake level changes on boat dock and beach.

6. Find fraction of residents on lake each month from Appendix B.

7. For each 2 points from Step 5, assume there is one owner adversely affected, and this owner loses all recreation days in the month (30 days).

8. Assign recreation values of $2.00/day for boating and $1.00/day for swimming. Assume swimming ends when September is over.

9. Multiply adverse scores from Step 5 by fraction remaining from Step 6 for each month to get seasonal totals for boating and swimming.

10. Multiply totals from Step 9 by 30 days x value of activity and divide by 2 (number of owners adversely affected) to get adverse effects on boating and beach use.

11. Total effects of boating and beach use.

12. Total effects of public ($1,700) and private recreation to get lake recreation effect.

River Recreation

Discussion

Very little information is available concerning actual recreational use of Priest River. The two main recreation values are fishing and floating.

Fishing

In June and July of 1973, Bowler (1974) indicates there were approximately 20 fisherman days/mile spent on a segment of the Coeur d'Alene River. On a heavily used short segment of the St. Joe River in July and August of 1973 Bjornn and Athearn (1974) indicate roughly 200 fisherman days/mile. Based on these findings, it is estimated that there could be 40 fisherman days/mile/year (1800 days/year) if substantial native game fish stock could be established in the river.

Gordon (1970) found that in northern Idaho, many more stream fishermen fish for trout than for non-game fish while by far the most preferred kind of stream fishing is trout fishing. For a good indication of Idaho fishermen habits and preferences, the reader is referred to both 1970 publications by Gordon. Furthermore, he shows that an angler spends approximately twice as much to stream fish for trout as to stream fish for other fish.

From the above information, it is estimated that only 50% of the fishermen who might fish Priest River if it had a native game fish now fish the river without a native game fish stock. Those that do fish it spend only half as much as a native trout fisherman would. If a native trout population could be established then full use of river fishing could be made.

Assume suitable trout stock could be established if minimum summer flows were above 200 cfs and maximum fall flows were below 1000 cfs. (Irizarry (1974) suggests 200 cfs minimum flow and 900 cfs maximum flow.) Use a value of $3.00/trout fisherman-day from "Principles and Standards."

Thus, at assumed optimum conditions (200 cfs < flow < 1000 cfs during summer and fall) value of river fishing would be 1800 x $3.00 = $5,400. Under present operation this value is $5,400 x 1/2 (number of anglers) x 1/2 (non-game anglers) = $1,350. This gives a range of $4,050/year ($5,400 - $1,350) over which improved stream flows may improve fishing benefits.

Floating

Irizarry (1974) has found that floating Priest River by raft is difficult at flows less than 500 cfs, some sections are slowly but easily floated at 200 cfs, while the entire river becomes unsuitable at flows less than 100 cfs. The writer found that canoeing the stretch just below the Outlet Dam was very difficult at a flow of 300 cfs.

Peckenfelder (1973), Peebles (1970), and Lewiston Morning Tribune (17 October 1973) have presented data that show there has been a boom in number of floaters on the Main Salmon River and the Middle Fork in recent years. Peckenfelder also found that on the Middle Fork, 80% of the floaters were in July, 16% in August, and 3% in September.

From the above information assume August is the only month floaters may be hindered on Priest River and that under ideal conditions (flow > 500 cfs), 10 floaters per day will be on the river. As the flow decreases, the number of floaters will also in the following manner: 8 at 400-500 cfs, 6 at 300-400 cfs, 4 at 200-300 cfs, 2 at 100-200 cfs, and 0 at flow < 100 cfs. Use value of $6.00/ floater-day from "Principles and Standards." Maximum value over 43 years is $6.00 x 10 x 30 x 43 = $77,400. The value computed for each alternative over the 43 years of simulations is then compared to the maximum value to determine the average annual value.

<u>Procedure</u>

1. Find number of times lake outflow exceeds 1000 cfs or falls below 200 cfs during August through November in simulated 43 years of operation.

2. Determine percent of the time flow is within optimum range (200-1000 cfs).

3. Multiply percent from Step 2 by $4,050 to find fishing value increase.

4. Find number of years average flows for August were more than 500 cfs, between 400-500 cfs, etc., and present in tabular form.

5. Find yearly value for flow ranges by multiplying number of floaters at $6.00/day by 30 days in August.

6. Multiply number of years from Step 4 by yearly value from Step 5 to get increment value.

7. Sum increment values from Step 6 to get total value.

8. Divide total value by $77,400 (maximum value) to get fraction of maximum.

9. Multiply fraction from Step 8 by $1,800 (maximum yearly value) to get average yearly value.

10. Subtract average yearly value determined for present operation ($800 by above procedure) from average yearly value found in Step 9 to get floating value.

11. Add fishing value from Step 3 to floating value from Step 10 to get river recreation value.

Land Measures

Appendix B shows that lake property owners fear a decrease in their property value if lake operation is changed, and Burby (1971) has pointed out importance of beach, boat dock, and drawdown in lake property owners' minds. However, Williams and Gilchrist (1973) have found that property owners often react on an emotional rather than a rational level. Klessig (1973) found that personal values far outweigh social or economic values in lake property ownership and use. Interestingly, Knetsch (1964) and David (1968) found no significant relationship between land values and degree of fluctuation in reservoirs.

It was decided to assume no property value changes due to any of the proposed operations for the following reasons: (1) the findings of David (1968) and Knetsch (1964); (2) the fact that all proposed operations maintain fairly constant lake levels through main summer season; (3) all the fluctuations are small; and (4) lake levels currently fluctuate between 2.9 and 3.4 ft during the summer. Furthermore, river property values might well rise if a more constant flow was established which would tend to balance any decline in lake property values.

Regional Income

Discussion

Commercial resort operations around the lake are geared to present lake regulation. An earlier drawdown of lake levels will hamper boat accessibility to resorts earlier than presently is the case. This will result in decreased resort business around the lake. Information relating lake levels to resort dock accessibility is virtually nonexistent. Irizarry (26 September 1974) feels some resorts such as Kokanee and Outlet Bay are seriously affected by lowered water levels. At gage level of 1.9 ft, the writer found access to Kokanee Resort docks severely limited, access to Outlet Resort docks still good, and no effect on either Hill's Resort or Priest Lake Marina. Troxel (31 October 1974) feels that dock access to all the other resorts on the west side of Priest Lake is better than that of Outlet Resort at low lake levels. All resorts on the west side with the exception of Kokanee and possibly with the exception of Outlet have some, if not most, of their docks accessible even at gage height 0.0. In view of lack of information, resort losses are estimated in the following manner.

Assume Kokanee Resort boat access is impossible at gage height 2.5 and Outlet Resort boat access impossible at gage height 1.5. Estimate 20 daily guests in September and October (only 2 months affected by proposed alternatives) and inaccessibility forces half (10) of the guests to depart. Each guest spends an average of $30/day of which 20% ($6.00) is profit for resort owners. The total lost by Kokanee and Outlet Resorts is doubled to account for the rest of the lake resorts.

Procedure

1. Find average gage height for September and October.
2. For Kokanee Resort, cost is $1,800 ($6 x 10 x 30) for each month average gage height is below 2.5.
3. For Outlet Resort cost is $1,800 for each month gage height is below 1.5.
4. Add total costs from Steps 2 and 3 for each resort.
5. Multiply cost from Step 4 by 2 to account for other resorts around lake.

DEVELOPMENT OF EQ AND SWB OBJECTIVES

Environmental Quality

Wild and Scenic River Classification

Wild and Scenic River Act calls for free-flowing river in its natural state. Flow records show unnatural flow regime in summer and fall since installation of dam. This has resulted in degradation of river habitat. A more gradual release of stored water from the lake might more nearly fit the characteristics desired for Wild and Scenic River classification.

Shoreline Management

Burby's 1971 study indicates the importance of shoreline characteristics such as beach, boat dock suitability, and drawdown. Property owners want stable lake level. Fluctuating shoreline may cause beach ownership and use problems.

Scenic Shoreline which is Visually Pleasing

Property owners want a constant lake level which adds to their recreational enjoyment--no unsightly drawdown or shoreline erosion with constant lake level.

Lake Fisheries

Dewatering of Kokanee eggs on drawdown is a major problem. Irizarry (1973, 1974) has found losses in both 1972 and 1973 and Leusink (1966, 1968) found potential losses in 1965 and 1967. Leusink (1966) and Irizarry (1974) have both found the peak of spawning to be in late November with the start of spawning around the first of November. Magnitude of egg losses is unknown. Irizarry (1973) and Bjornn (1957) both found that Kokanee is part of diet of Lake Mackinaw and Dolly Varden.

River Fish Habitat

Bjornn (1956) noted that cutthroat spawners going downriver in spring were trapped in the river when the dam boards were installed. Irizarry (1973, 1974) in both 1972 and 1973 found very few cutthroat trout, some whitefish, and many non-game fish in the river. Trout and whitefish are not suited to present operation while rough fish are. Hendrickson and Doonan (1972) report trout populations are generally higher where stream flow is relatively uniform and maximum water temperatures are not excessive.

Stocking of Rainbow Trout

Irizarry (1974) points out that several thousand hatchery Rainbow are stocked in Priest River each spring which satisfies angler demand. There is no permanent population expected. Gordon (1970) found in his study that in northern Idaho many respondents did not like the appearance of hatchery stocked trout and relatively few preferred to see native trout population supplemented with hatchery fish.

River Ecological System

Irizarry (1973) notes that reduced summer flows result in high stream temperatures, lower velocities, slower water turnover in pools, reduction in wetted stream area, and probably increased siltation. High fall flows adversely affect spawning gravels, food availability, fry emergence, and stream equilibrium.

Dissolved Oxygen and Temperature in River

Low summer flows generally mean less dissolved oxygen and higher temperatures at critical time for fisheries. Rosgen (1974) found a temperature increase and a dissolved oxygen decrease from mid-August to mid-September at the two U.S.G.S. gaging stations on the river.

Farm Animal Wastes in River

Irizarry (1974) found pollution from cattle wastes evident in the lower section of the river at low flows. He also found that he had trouble keeping his footing at all sections of the river investigated at flows greater than 300 cfs. Hence, it is reasonable to assume farm animals will enter the river more frequently at lower flows.

Sediment Pollution of River

Rosgen (in Irizarry, 1973) found that up to 4 to 6 inches of fine sand was deposited on stream bottom after high fall discharges. Hollingshead (1971), in a study of the Elbow River in Alberta, Canada, found virtually no bedload discharge up to 1,000 cfs and then dramatic increases through 4,000 cfs discharge. Yang (1972), in a study of the Niobrara River in Nebraska, found 50-fold increase in total sediment discharge when flow increased from 225 to 700 cfs. Love and Benedict (1948), in a study of the Boise River, found a dramatic increase in sediment discharge as flow increased and then an abrupt decrease as peak flow passed. During spring and summer of 1974, Rosgen (1974) found both bedload and suspended sediment in Priest River to increase tremendously as spring flows increased and then decline to very small amounts as flows decreased to 300 cfs. In a study by Hansen (1971), eroding bank sediments were of the same size as the bulk of the sediments deposited on spawning beds. For adverse effects on fisheries caused by sediment transport and deposition, the reader is referred to Gibbons and Salo (1973) and Gangmark and Bakkala (1970).

Social Well-Being

Recreational Opportunities

Clawson (1959, p. 15) suggests that "the whole outdoor recreation experience is, to a large extent, a package deal; it must be viewed as a whole, in terms of costs, satisfactions, and time, for all members of the family as a group." So the lake recreation opportunities must be balanced against river recreation opportunities. Hendrickson and Doonan (1972) found that a fast-flowing stream is more attractive to most people than is a sluggish stream. Also Opinion Research West's Survey (1973) found that in Idaho panhandle, 75% of those people questioned felt that Idaho should have a law which would allow the state to obtain minimum water flows for fish and wildlife, recreation, and water quality while only 13% were opposed.

Idaho Code

Section 70-507 states that Priest Lake waters must be maintained at 3.0 gage level, but not above, until the end of main recreation season. The end of the recreation season is to be determined by the Director of the Department of Water Administration. Many of the lakefront property owners will support the provisions of this section.

Section 67-4304 states that Priest Lake waters are appropriated by each succeeding governor of Idaho in trust for all the people of the state for scenic beauty, health, recreation, transportation, and commercial purposes. This section gives those people favoring no change in present operation a strong legal position.

Evaluation of Other Alternatives

Personal satisfaction may be gained from the knowledge of actually trying other alternatives of operation which appear to be an improvement over present operation. Present analysis is built upon assumptions and guesses and inaccurate social and economic feedback. If attempted operation proves harmful, then present operation can be resumed.

Other Unknown Effects

There may be other effects of alternative operations such as mosquito breeding, etc. which remain unknown.

ANALYSIS OF PRESENT AND ALTERNATIVE OPERATIONS

Each of the six alternatives studied is compared to the present operation in tables on the following pages. For a more detailed look at simulated flows and lake elevations during summer and fall months, see Appendixes D and E.

The first alternative is the Fish and Game alternative. It attempts to keep river flows high in summer and have lake drawdown completed by the end of October.

The second alternative is the Lake Recreation 1 alternative. It attempts to improve present river flows somewhat while still keeping relatively stable summer lake levels.

The third alternative is the Lake Recreation 2 alternative. It attempts to improve present summer flows while dropping summer lake levels only slightly.

The fourth alternative is the Kokanee alternative. It attempts to have most of the lake storage evacuated by the end of October.

The fifth alternative is the River Recreation alternative. It attempts to keep river flows very high through October.

The sixth alternative is the Combination alternative. It attempts to satisfy as many of the needs of the lake/river system as possible.

Appendix C shows computations used for NED and RD objectives for the Fish and Game alternative following the procedure developed in the Methodology section. Each of the other alternatives was evaluated in the same manner.

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES Fish and Game	Lake Rec. 1	Lake Rec. 2
National Economic Development					
	Flood Damage Reduction	$ 0	(43,200)	0	0
	Power	$60,200	62,300	66,900	61,400
	Lake Recreation	$ 0	(41,900)	(1,700)	(1,700)
	River Recreation	$ 0	4,000	2,200	3,000
Environmental Quality					
	Wild and Scenic River Classification	Hard to justify Wild and Scenic Rivers Classification. Unnaturally low flows in summer and sudden high discharge in fall.	Flows between 200-1000 cfs in summer and fall 88% of the time make classification easier	Flows between 200-1000 cfs in summer and fall 47% of the time make classification a little easier	Flows between 200-1000 cfs in summer and fall 63% of the time make classification easier.
	Shoreline Management	Constant shoreline during summer makes management easy.	(3.0 ft drop between June and end of September makes management difficult)	(0.4 ft drop between June and end of September makes management a little more difficult)	(0.6 ft drop between June and end of September makes management a little more difficult)

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES		
			Fish and Game	Lake Rec. 1	Lake Rec.2
Environmental Quality (continued)	Scenic shoreline which is visually pleasing	Constant shoreline is visually pleasing and increases recreational enjoyment.	(3.0 ft drop between June and end of September decreases beauty of shoreline).	(0.4 ft drop between June and end of September decreases beauty of shoreline slightly)	(0.6 ft drop between June and end of September decreases beauty of shoreline slightly)
	Lake fisheries	Many Kokanee eggs are dewatered on drawdown. 1.9 ft drop during spawning season.	No drop during spawning season resulting in no spawn loss	(2.0 ft drop during spawning season resulting in slightly more spawn loss)	(1.7 ft drop during spawning season resulting in slightly less spawn loss)
	River fish habitat	River quite inhospitable for game fish. Low summer flows and sudden high fall discharges	Flows between 200-1000 cfs in summer and fall 83% of the time improves habitat considerably	Flows between 200-1000 cfs in summer and fall 47% of the time improves habitat somewhat	Flows between 200-1000 cfs in summer and fall 63% of the time improves habitat
	Stocking of rainbow trout	Rainbow stocked in river each year. Native trout are preferred.	As above, making stocking unnecessary	As above, perhaps making stocking unnecessary.	As above, perhaps making stocking unnecessary.
	River ecological system	River ecological system is damaged due to unnatural flow regime.	As above, making flow regime ecologically sound	As above, making flow regime more ecologically sound	As above, making flow regime more ecologically sound.

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES Fish and Game	Lake Rec. 1	Lake Rec. 2
Environmental Quality (continued)	Dissolved oxygen and temperature in river	Reduced DO and high temperatures in river during critical low summer flows. Flows as low as 38 cfs and nearly always less than 200 cfs.	No flows below 200 cfs in 43 yr, resulting in higher DO and reduced temperature	20 flows less than 200 cfs and one flow less than 100 cfs in 43 yr, resulting in higher DO and reduced temperature in some years.	13 flows less than 200 cfs and no flows less than 100 cfs in 43 yr, resulting in higher DO and reduced temperature in some years.
	Farm animal wastes in river	Cattle wastes observed in lower section of river at low summer flows.	As above, increasing dilution and reducing likelihood of animals straying into river.	As above, increasing dilution and reducing likelihood of animals straying into river during some years.	As above, increasing dilution and reducing likelihood of animals straying into river during some years.
	Sediment pollution of river	Sudden high discharges in the fall result in erosion, sediment transport, and deposition making aquatic environment unstable. Flows between 2100-2900 cfs when stored water released.	10 flows above 1000 cfs in fall in 43 years with maximum of 2131 cfs results in decreased erosion.	25 flows above 1000 cfs in fall in 43 years with maximum of 2015 cfs results in decreased erosion.	19 flows above 1000 cfs in fall in 43 years with maximum of 1998 cfs results in decreased erosion.

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES		
			Fish and Game	Lake Rec. 1	Lake Rec. 2
Regional Development	Regional Income	$0	(10,800)	0	(3,600)
Social Well-Being	Recreational opportunities	Decreased river recreation opportunities, namely fishing and floating.	2 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.	5 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.	9 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.
	Idaho Code	Section 70-507 says water level will be kept at 3.0 all summer.	(Level drops from 4.2 in June to 1.2 at end of September, requiring change in Idaho Code)	(Level drops from 3.4 in June to 3.0 at the end of September, requiring change in Idaho Code)	(Level drops from 3.3 in June to 2.7 at the end of September, requiring change in Idaho Code)
	Evaluation of other alternatives	No opportunity to evaluate effects of alternate operations	No permanent harm done if this alternative tried and its effects can be evaluated	No permanent harm done if this alternative tried and its effects can be evaluated	No permanent harm done if this alternative tried and its effects can be evaluated
	Other unknown effects	Precludes the discovery of other unknown effects	Unknown	Unknown	Unknown

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

( ) indicates Adverse Effect

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	ALTERNATIVES Kokanee	River Rec.	Combination
National Economic Development	Flood Damage Reduction	$ 0	0	0	0
	Power	$ 60,200	60,500	58,000	64,400
	Lake Recreation	$ 0	(24,600)	(36,900)	(1,700)
	River Recreation	$ 0	2,500	4,600	4,300
Environmental Quality	Wild and Scenic River Classification	Hard to justify Wild and Scenic Rivers Classification! Unnaturally low flows in summer and sudden high discharge in fall.	Flows between 200-1000 cfs in summer and fall 64% of the time make classification easier.	Flows between 200-1000 cfs in summer and fall 90% of the time make classification easier.	Flows between 200-1000 cfs in summer and fall 100% of the time make classification easier.
	Shoreline Management	Constant shoreline during summer makes management easy.	(1.1 ft drop between June and the end of Sept. makes management more difficult)	(2.1 ft drop between June and the end of September makes management more difficult)	(0.4 ft drop between June and the end of September makes management a little more difficult)

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES		
			Kokanee	River Rec.	Combination
Environmental Quality (continued)	Scenic shoreline which is visually pleasing	Constant shoreline is visually pleasing and increases recreational enjoyment.	(1.1 ft drop between June and the end of September decreases beauty of shoreline)	(2.1 ft drop between June and the end of September decreases beauty of shoreline)	(0.4 ft drop between June and the end of September decreases beauty of shoreline slightly)
	Lake fisheries	Many Kokanee eggs are dewatered on drawdown. 1.9 ft drop during spawning season.	0.5 ft drop during spawning season results in little spawn loss.	0.3 ft drop during spawning season results in little spawn loss.	1.4 ft drop during spawning season results in less spawn loss.
	River fish habitat	River quite inhospitable for game fish. Low summer flows and sudden high fall discharges	Flows between 200-1000 cfs in summer and fall 64% of the time improves habitat.	Flows between 200-1000 cfs in summer and fall 90% of the time improves habitat considerably.	Flows between 200-1000 cfs in summer and fall 100% of the time improves habitat considerably.
	Stocking of rainbow trout	Rainbow stocked in river each year. Native trout are preferred.	As above, making stocking unnecessary.	As above, making stocking unnecessary.	As above, making stocking unnecessary.
	River ecological system	River ecological system is damaged due to unnatural flow regime.	As above, making flow regime more ecologically sound.	As above, making flow regime ecologically sound.	As above, making flow regime ecologically sound.

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES		
			Kokanee	River Rec.	Combination
Environ-mental Quality (Continued)	Dissolved oxygen and temperature in river	Reduced DO and high temperatures in river during critical low summer flows. Flows as low as 38 cfs and nearly always less than 200 cfs.	14 flows less than 200 cfs and 4 flows less than 100 cfs in 43 yrs results in higher DO and reduced temperature in some years.	No flows below 200 cfs in 43 yrs results in higher DO and reduced temperatures.	No flows below 200 cfs in 43 yrs results in higher DO and reduced temperatures.
	Farm animal wastes in river	Cattle wastes observed in lower section of river at low summer flows.	As above, increasing dilution and reducing likelihood of animals straying into river.	As above, increasing dilution and reducing likelihood of animals straying into river.	As above, increasing dilution and reducing likelihood of animals straying into river.
	Sediment pollution of river	Sudden high discharges in the fall result in erosion, sediment transport, and deposition making aquatic environment unstable. Flows between 2100 and 2900 cfs when stored water released.	17 flows above 1000 cfs in fall in 43 years with maximum of 2184 cfs resulting in decreased erosion.	9 flows above 1000 cfs in fall in 43 years with maximum of 2015 cfs resulting in decreased erosion.	No flows above 1000 cfs in fall in 43 years with maximum of 1000 cfs resulting in decreased erosion.

Four-Account Display of Plan Effects
Operation Alternatives for Priest Lake, Idaho

Accounts	Objectives	PRESENT OPERATION (w/o-the-plan conditions)	( ) indicates Adverse Effect ALTERNATIVES		
			Kokanee	River Rec.	Combination
Regional Development	Regional income	$ 0	(7,200)	(10,800)	(3,600)
Social Well-Being	Recreational opportunities	Decreased river recreation opportunities, namely fishing and floating	2 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.	39 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.	3 years of flows greater than 500 cfs in August in 43 years, providing more river recreation opportunities.
	Idaho Code	Section 70-507 says water level will be kept at 3.0 all summer.	(Level drops from 3.1 in June to 2.0 at the end of September, possibly requiring change in Code)	(Level drops from 3.4 in June to 1.3 at the end of September, requiring large change in Code)	(Level drops from 3.3 in June to 2.9 at the end of September, requiring change in Code)
	Evaluation of other alternatives	No opportunity to evaluate effects of alternate operations	No permanent harm done if this alternative tried and its effects can be evaluated.	No permanent harm done if this alternative tried and its effects can be evaluated.	No permanent harm done if this alternative tried and its effects can be evaluated.
	Other unknown effects	Precludes the discovery of other unknown effects	Unknown	Unknown	Unknown

DISCUSSION OF WAYS TO MANIPULATE OUTLET STRUCTURE

Description of Dam

Outlet Dam is a concrete and wooden structure consisting of 20 bays each approximately 7 feet wide. The bay on each end is kept closed at all times to prevent bank erosion. Each bay is a grooved pier into which the stoplogs are placed. The 3-inch thick stoplogs are approximately 1 x 8 feet, and the grooves are at an angle of roughly 30 degrees from vertical.

Present Method of Control

Each spring as lake level approaches 3.0 the stoplogs are inserted until 6 stoplogs are inserted in most or all of the bays which makes the dam about 5 feet high. Amount of water which then spills over the top depends on lake inflow. Until drawdown in late October there is very little additional control done. Occasionally boards are pulled if lake level rises too high or additional boards are installed if lake level falls too low. Upper boards can be pulled without the use of a mechanical hoist by 3 or 4 men using gaffs. Two or three men can install the stoplogs. The stoplogs which are under a greater head of water are much harder to remove and some type of mechanical hoist is required. Presently six men and a truck-mounted winch remove the stoplogs on successive weekends in late October. Half of the stoplogs (three) are removed from each bay the first weekend, and the remaining three boards the next weekend. To remove three boards from a bay with the truck-mounted winch takes about 10 minutes. The boards are left piled on the dam until installation the following summer.

Other Methods of Control

There are essentially two other ways to release the stored water. One is to build a gate or gates which would require considerable improvements to the existing dam and the other is to install a permanent hoist of some kind which could be moved from bay to bay to pull the stoplogs. Either of these techniques would reduce the number of men needed to remove the logs to only the gate or hoist operator and perhaps an assistant.

If no change in present operation is planned, then present system is suitable. If, however, a slower release of stored water in the fall is desired and more control in the summer envisioned, then it becomes necessary to analyze the different possibilities economically. The cost of additional men during the summer and fall and availability of a truck-mounted winch in the fall must be measured against the initial cost and maintenance of a more sophisticated system. This added cost of more manhours during summer and fall will depend on the alternative selected--the cost increasing as lake regulation increases. Appendix C shows computations for computing additional cost for added man-hours.

The average of five bids submitted to Georgetown Irrigation Company (1 November 1973) to install a 42 inch diameter slide gate was $900. From head versus discharge chart in Perkul Gates Catalogue 55 (1954), a 48" x 48" headgate would discharge 200 cfs under 5 feet of head. A sliding gate which could discharge 100-200 cfs could be installed in one of the existing bays for $2000-$3000 and eliminate $300-$400 in wages each summer. Fall releases would still require removal of boards. Gate operation would be more reliable because one man could make the necessary adjustments in flow releases.

Relationship between Board Removal and Flow

Flows corresponding to lake elevation and stoplogs in place (or gate position) need to be determined so that proper operation will result. This information should be permanently recorded so that anyone attempting to operate the dam to produce a desired discharge can readily do so. A set operating procedure which describes which stoplogs to remove or replace (or position of gate) for various lake levels to produce a given discharge would prevent undesired discharges. A more reliable system of discharges and lake levels would be the result.

SELECTION OF AN APPROACH TO THE OPTIMUM OPERATION

The optimum operation is that one which maximizes benefits and minimizes adverse impacts. All of the feasible alternatives retain storage in Priest Lake following spring runoff for use later in the year. On a closer look, however, it can be seen that most of the present problems associated with the present manner of regulation can be greatly reduced or eliminated by more monitoring and control of river flows and lake levels. Figures 9 and 10 on the following page show that there is a range of lake storage over which value is maximum and a range of river flows over which value is nearly maximum. These lake levels may vary slightly as may the flow ranges, but these figures are approximately correct considering both monetary and non-monetary effects.

It is apparent that the best operation is one which stores water a few inches above 3.0 gage height following spring runoff and slowly releases this "extra" storage during the summer to augment low summer flows. The other main concern is preventing loss of Kokanee spawn on drawdown by having the lake emptied by the first of November. This objective must be balanced, however, by the objective to reduce damage caused by unnaturally high fall flows.

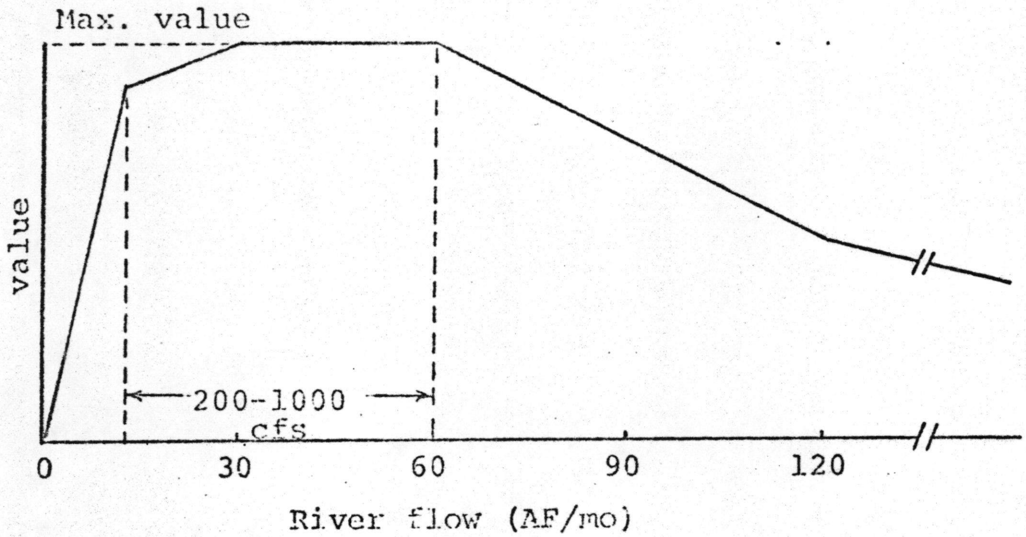

Fig. 9.--Relative value of August through November Priest Lake outflows

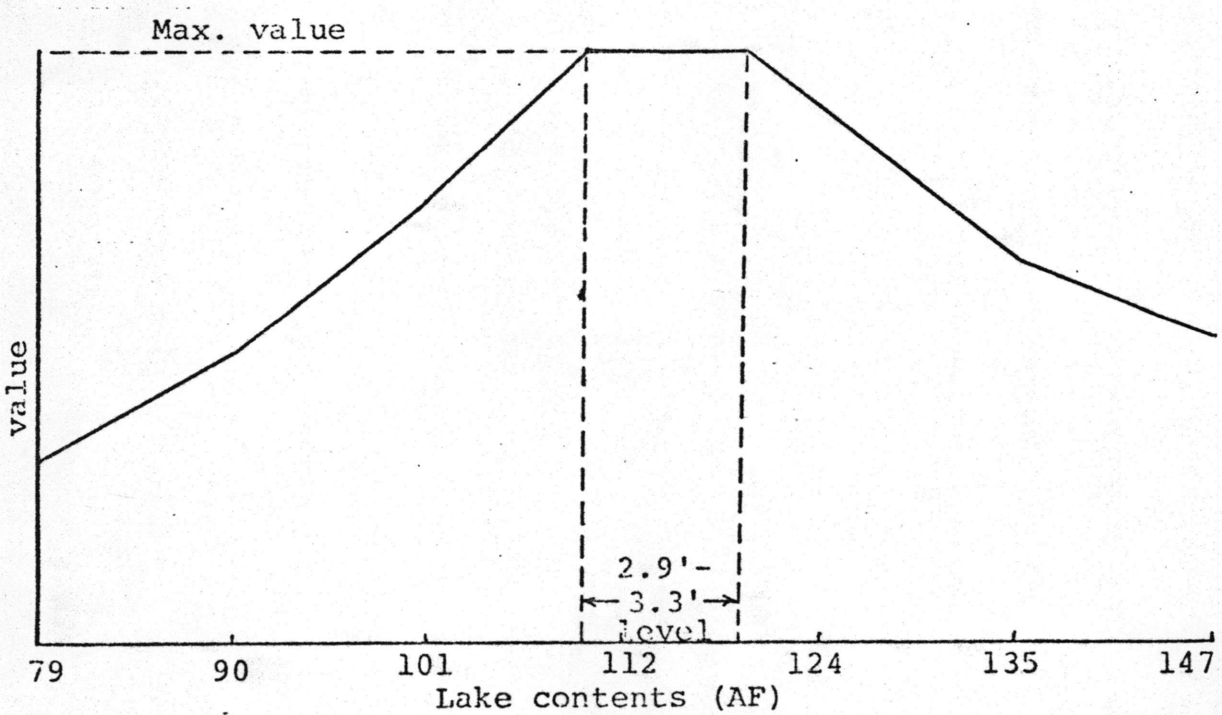

Fig. 10.--Relative value of end-of-June through September Priest Lake contents

It becomes a matter of releasing as much water as possible once recreation season ends without degrading river environment. The writer favors the end of September as the end of the recreation season because of weather changes and the fact that less than half of the lake residents remain after September.

Of the alternatives studied in this investigation, the Combination alternative is selected as the best as it most nearly satisfies the broad requirements of minimum and maximum river flows and suitable lake levels during recreation season. It leaves a little to be desired in completion of drawdown before Kokanee spawning, but the writer feels that this was the least critical of the trade-offs. The Combination alternative differs from present operation in that lake level is kept slightly higher following spring runoff, much more regulation is required during the summer to maintain 200 cfs minimum flow, drawdown begins on the first of October, and much more regulation is required during the fall to keep flows below 1000 cfs maximum. Some modification of this alternative, such as drawdown beginning in mid-September or allowing natural inflows to Priest Lake of greater than 1000 cfs in the fall to pass downstream, might be better still.

The basic concept of providing a few inches of additional lake storage following spring runoff to augment low summer flows and more control of fall releases has a significant beneficial impact on overall lake and river system. The only tangible drawback is the additional monitoring and control of the lake/river system which would cost $2000-$3000 annually for proper operation. This additional cost can be made up in the increased power value of the stored water alone.

The other major problem in regulating the lake above gage height 3.0 for even a short time is Section 50-507 of the Idaho Code which specifically states that lake levels will not be regulated above 3.0 feet. To legally regulate Priest Lake levels above 3.0 gage height would require changing the Idaho Code.

CONCLUSIONS

To satisfy most of the environmental concerns expressed in the analysis, some minimum flow greater than the present summer flows and some maximum fall flow less than the present maximum fall flows must be established. This range of flows needs to be selected in light of the recreation interests on the lake and the timing of the drawdown.

From the incomplete data presently available and using method of analysis developed herein, the best operating procedure of the seven alternatives investigated is the Combination alternative. There is probably some modification of this alternative which would be better still.

The present system of releasing all stored water in a great surge in the fall is unacceptable even if the present system of operation is kept. Much more refinement in removing the stoplogs is needed so that water is released gradually with less damaging effects. Alternative operations will require some removal and installation of a few stoplogs during summer months as well.

Lack of economic and social data precludes accurate assessment of various operations. A much sounder basis for selection of the optimum operation would be available if other feasible operations were tested and evaluated. Any of the proposed alternatives may be tested in actual operation and evaluated with no permanent commitment of the resources to the future. Likewise, any alternative may be retested in the future should changes warrant a different operation.

Additional data are needed on present and possible uses of the river if flow regime is altered, river water quality due to low summer and high fall flows, Kokanee losses due to drawdown, and how these losses affect overall fish population in the lake. A more detailed assessment of the effects of different lake levels on private residences and commercial resorts at different times of the year is needed.

Most of the lakefront property owners and resort owners would not be in favor of any change in the existing operation. Sections 50-507 and 67-4304 of the Idaho Code give their position legal backing. They are the only interests objecting to drawdown of the lake after mid-August and prior to mid-October.

The state of Idaho is not adequately compensated for the power generated by the Priest Lake storage released each fall.

RECOMMENDATIONS

More data on present and future uses of the river at various flow regimes, river water quality at high and low flows, Kokanee losses due to drawdown and the overall effect of these losses on lake fisheries, and more detailed assessment of lake levels on lakeshore residents and resorts should be obtained through questionnaires, hydraulic and water quality testing, site visits, interviews, etc.

The most promising alternative(s) should be tried and a close check kept on the effects.

A public information campaign informing Priest Lake area residents of all the factors involved in the regulation of Priest Lake should be undertaken.

A new public boat ramp which is safe to use at all lake levels should be built on the west side of the lake.

Depending on alternative selected, the possibility of using some type of movable winch or a gate for release of lake storage should be considered. Removal of stoplogs or gate position should be correlated to lake level and discharge, and this information kept on permanent record for future use.

State of Idaho should renegotiate terms of the Outlet Dam Operating Agreement with the Washington Water Power

Company to receive adequate compensation for the hydro-electric power generated by Priest Lake storage.

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APPENDIX A

SUMMARY OF PRIEST LAKE/RIVER FRONTAGE OWNERSHIP

SUMMARY OF PRIEST LAKE/RIVER FRONTAGE OWNERSHIP

Priest Lake Shoreline Ownership (miles)

Federal (U.S.F.S.)	15.5
State	19.4
Corporations	5.9
Private	11.3
Total	52.1

Private Lakeshore Ownership

Federal leased lots		137
State leased lots		355
State lots available	25	
Privately owned lots		478
Private lots available	21	
Privately owned lots with improvements		385

Total Lakeshore Lots with Dwellings

Federal	137
State	355
Private	385
Total	877

Data on state leases from Bandenberg (29 October 1972) and data on Federal leases from Troxel (31 October 1974). Remaining data from Roetheli (1974).

River Frontage Ownership (%)

Federal	30	
State	30	
Private	40	(approximately 250 owners)

River frontage ownership figures are a compromise between Roetheli (1974) and Forest Service (1974).

APPENDIX B

SUMMARY OF LAKEFRONT PROPERTY OWNER QUESTIONNAIRE

SUMMARY OF LAKEFRONT PROPERTY OWNER QUESTIONNAIRE

There were 147 questionnaires returned. Only one respondent mentioned any trouble navigating Thorofare after drawdown commenced last year.

The following table shows lakefront dwelling occupancy in the fall for the 147 respondents.

Month	No. of residents remaining	Percentage
Sep	90	61
Oct	69	47
Nov	44	30

To determine peoples' attitudes about changes in the present regulation of the lake, questions were asked about the effect of each of 6 different lake elevations (three above and three below current summer levels) on their boat docks, beaches, and the value of their property. The effects were labeled beneficial, slightly beneficial, no effect, slightly adverse, and adverse.

For lake level change effect adverse score was developed in the following manner:

Beneficial effect	+2
Slightly beneficial effect	+1
No effect or blank	0
Slightly adverse effect	-1
Adverse effect	-2

Lake Level Change Effects

Level vs normal (3.0)	Property value	Boat dock	Beach
18" below	-131	-152	-114
12" below	- 96	-107	- 88
6" below	- 48	- 54	- 39
6" above	- 16	- 10	- 35
12" above	- 72	- 61	- 87
18" above	-114	- 90	-111

APPENDIX C

EXAMPLE COMPUTATIONS FOR NED AND RD OBJECTIVES

EXAMPLE COMPUTATIONS FOR NED AND RD OBJECTIVES

Fish and Game Proposal

Flood Damage Reduction

1. Gage height 4.2 at end of June, 4.2 → 4.0
2. 4.0 is 12" above normal. Adverse score is 432
3. $100/owner slightly adversely affected
4. $100 x 432 = $43,200 adverse effect

Power

1. 15 August gage height = 3.1
2. $75,800 gross benefits
3. Costs of present operation = $12,300
4. Additional costs:

   September and October: 4 local men work
   1 hour every other day
   June, July, and August: 4 local men work
   1 hour every third day
   Wages are $5.00/hour
   $5.00 (4 x 1 x 30 + 4 x 1 x 30) = $1200

5. $1200 + $12,300 = $13,500 total costs
6. $75,800 - $13,500 = $62,300 net benefits

Lake Recreation

1. $20,000 capital cost
2. (CRF, 5-7/8, 20) = .08630
3. $20,000 x .08630 = $1700 annual cost
4. July -- 6" above
   Sept -- 12" below
   Oct -- 18" below
   Nov -- 18" below

5.

Level	Boat dock	Beach
6" above	60	210
12" below	642	528
18" below	912	684

6.

September	.61
October	.47
November	.30

7. Number of owners affected is adverse score/2

8. Boating value $2.00/day
Swimming value $1.00/day through September

9. Boating:

July	60 x 1.00 =	60.0
Aug	642 x 0.61 =	391.8
Sep	912 x 0.47 =	428.4
Oct	642 x 0.30 =	192.6
		1072.8

Beach:

July	210 x 1.00 =	210.0
Sep	528 x 0.61 =	322.2
		532.2

10. 1072.8/2 x 30 x $2.00 = $32,200

532.2/2 x 30 x $1.00 = $8,000

11. $32,200 + $8,000 = $40,200

12. $40,200 + $1,700 = $41,900 adverse effect

River Recreation

1. 10

2. $\frac{86 - 10}{10} = 0.88$

3. 0.88 x $4050 = $3600

4-7.

Flows	No. years	Yearly value	Increment value
> 500 cfs	2	1800	3,600
400 - 500	18	1440	25,920
300 - 400	13	1080	14,040
200 - 300	10	720	7,200
100 - 200	0	360	0
< 100 cfs	0	0	0
	43	Total	$50,760

8-9. $\frac{\$50,760}{\$77,400}$ x $1,800 = $1,200 average yearly value

10. $1,200 - $800 = $400 floating value

11. $400 + $3600 = $4000 beneficial effect

Regional Income

1. September 2.05
   October 0.6

2. Kokanee September $1,800
   October 1,800

3. Outlet October $1,800

4. Total $5,400

5. 2 x $5,400 = $10,800 adverse effect

APPENDIX D

AVERAGE AUGUST THROUGH NOVEMBER OUTFLOWS FROM PRIEST LAKE (cfs)

Present Operation

Water-year	August	September	flows > 1000 cfs October	flows > 1000 cfs November
30	147 cfs	72 cfs		
31	68	129		
32	255	156		
33	302	251		1226
34	141	62		1297
35	287	131		1299
36	79	152		
37	247	228		
38	188	136		1299
39	130	120		
40	87	231		
41	274	589		
42	405	237	1019	1729
43	375	144		
44	120	147		
45	198	213		
46	383	251		1004
47	310	317		
48	459	312	1572	1631
49	213	183		
50	459	251		1238
51	239	251		1849
52	182	117	1010	1403
53	405	197		
54	604	399		
55	459	316		1299
56	307	189		1485
57	230	124		
58	82	127		
59	256	623		
60	304	251	1144	1567
61	214	156		1139
62	247	251		
63	243	166		1299
64	343	251		1040
65	375	230		1085
66	180	134		
67	152	80		
68	395	399		1016
69	284	251		1808
70	126	171		
71	279	251		
72	405	251		
Average	266	221	817	1076

Fish and Game

Water-year	August	September	flows > 1000 cfs October	November
30	294 cfs	899 cfs	1331	
31	214	↓		
32	401			
33	400			
34	287		1083	
35	434			
36	226			
37	393			
38	335			
39	276			
40	234			
41	421			
42	299		1841	
43	473			
44	266			
45	344			
46	483			
47	456			
48	522			
49	359		2131	
50	499			
51	385		1465	
52	328		1505	
53	499			
54	604			
55	499		1002	
56	453		1419	
57	377			
58	229			
59	403			
60	450		1999	
61	361			
62	393			
63	390			
64	489			
65	499			
66	326			
67	299			
68	499			
69	382		1597	
70	273			
71	377			
72	499			
Average	391	899	867	547

Lake Rec. 1

Water-year	August	September	flows > 1000 cfs October	November
30	234 cfs	99 cfs		
31	152	157		
32	345	184		
33	343	342		
34	227	89	1002	1338
35	379	158		1542
36	163	180		
37	337	256		
38	276	163		1645
39	215	148		
40	172	259		
41	365	786		
42	505	221	1342	1598
43	419	172		1008
44	205	175		
45	286	241		
46	429	316		1141
47	402	412		1128
48	621	293	2015	1500
49	301	210		
50	525	178		1375
51	328	320	1481	1724
52	269	145	1460	1271
53	495	180		
54	707	397		
55	535	298		1441
56	399	217	1305	1471
57	320	152		
58	167	155		
59	347	820		1109
60	396	303	1471	1436
61	303	184		1276
62	337	296		
63	333	184		1475
64	436	332		1195
65	470	258		1222
66	268	162		1079
67	239	108		1160
68	490	552		1153
69	325	316	1279	1763
70	212	199		1128
71	320	306		
72	473	234		1062
Average	350	259	827	1136

Lake Rec. 2

Water-year	August	September	flows > 1000 cfs October	November
30	288 cfs	123 cfs		
31	205	180		
32	399	207		
33	397	365		1212
34	281	113		1187
35	433	182		1303
36	217	204		
37	391	279		
38	330	187		1303
39	269	172		
40	226	283		
41	419	815		
42	559	244	1327	1303
43	473	195		
44	259	199		
45	340	264		
46	483	340		
47	456	436		
48	675	316	1998	1303
49	355	234		
50	579	202		1224
51	382	343	1467	1370
52	323	168	1443	1120
53	549	204		
54	761	421		
55	589	322		1290
56	453	241	1288	1303
57	374	175		
58	221	178		
59	401	843		
60	446	327	1455	1285
61	357	207		1125
62	391	320		
63	387	217		1303
64	490	355		1044
65	524	281		1071
66	322	185		
67	293	131		1008
68	544	576		1002
69	379	340	1263	1409
70	266	222		
71	374	330		
72	525	258		
Average	404	283	811	1003

Kokanee

Water-year	August	September	flows > 1000 cfs October	November
30	136 cfs	460 cfs	1143	
31	54	517		
32	247	544		
33	246	702		
34	130	449	1170	
35	281	519		
36	66	540		
37	239	616		
38	178	524		1039
39	118	508		
40	74	620		
41	268	1146		
42	407	581	1510	
43	322	532		
44	108	535		
45	189	601		
46	332	677		
47	305	773		
48	524	653	2184	
49	204	571		
50	428	539		
51	231	680	1650	1118
52	172	505	1628	
53	397	540		
54	609	758		
55	438	658		
56	301	577	1473	
57	222	512		
58	69	515		
59	249	1180		
60	298	663	1640	
61	205	544	1071	
62	239	657	1061	
63	236	554	1086	
64	338	692		
65	372	618		
66	170	522		
67	141	468		
68	392	912	1015	
69	227	677	1448	1157
70	114	559	1024	
71	222	667		
72	375	594		
Average	253	620	1003	636

River Recreation

Water-year	August	September	flows > 1000 cfs October	November
30	540 cfs	460 cfs	1227	
31	458	517		
32	652	544		
33	650	702		
34	534	449	1002	
35	685	519		
36	470	540		
37	643	616		
38	582	524		
39	522	508		
40	478	620		
41	672	1146		
42	811	581	1342	
43	726	532		
44	512	535		
45	593	601		
46	736	677		
47	709	773		
48	928	653	2015	
49	608	571		
50	832	539		
51	635	680	1481	1034
52	576	505	1460	
53	801	540		
54	1013	756		
55	842	658		
56	705	577	1305	
57	626	512		
58	473	515		
59	653	1180		
60	702	663	1471	
61	609	544		
62	643	657		
63	640	554		
64	742	692		
65	776	618		
66	574	522		
67	545	468		
68	796	912		
69	631	677	1279	1072
70	519	559		
71	626	667		
72	779	594		
Average	657	620	842	559

Combination

Water-year	August	September	flows > 1000 cfs October	November
30	204 cfs	200 cfs		
31	200	200		
32	315	246		
33	313	404		
34	200	200		
35	348	221		
36	200	200		
37	306	318		
38	246	226		
39	200	200		
40	200	263		
41	335	848		
42	475	283		
43	389	234		
44	200	212		
45	256	303		
46	399	379		
47	372	475		
48	591	355		
49	271	273		
50	495	241		
51	298	382		
52	239	207		
53	465	242		
54	677	460		
55	505	360		
56	369	279		
57	290	214		
58	200	200		
59	316	882		
60	365	365		
61	273	246		
62	306	359		
63	303	256		
64	406	394		
65	439	320		
66	237	224		
67	209	200		
68	460	614		
69	295	379		
70	200	242		
71	290	369		
72	443	296		
Average	328	320	1000	842

APPENDIX E

AVERAGE JUNE THROUGH NOVEMBER END-OF-MONTH

LAKE GAGE ELEVATIONS AND GAGE

ELEVATION CAPACITY TABLE

Average End-of-Month Lake Elevation

Alternative	Jun	Jul	Aug	Sep	Oct	Nov
Present operation	3.1	3.0	2.9	2.9	1.9	0.6
Fish & Game	4.2	3.3	2.9	1.2	0.0	0.1
Lake Rec. 1	3.4	3.4	3.1	3.0	2.0	0.5
Lake Rec. 2	3.3	3.3	2.8	2.7	1.7	0.6
Kokanee	3.1	3.0	3.0	2.0	0.5	0.4
River Rec.	3.4	3.4	2.4	1.3	0.3	0.4
Combination	3.3	3.3	3.1	2.9	1.4	0.7

Capacity Table

Gage height (ft)	Capacity (AF)	Gage height (ft)	Capacity (AF)
3.6	126.4	1.7	83.2
3.5	124.0	1.6	81.0
3.4	121.6	1.5	78.7
3.3	119.3	1.4	76.4
3.2	116.9	1.3	74.2
3.1	114.5	1.2	71.9
3.0	112.1	1.1	69.7
2.9	109.9	1.0	67.4
2.8	107.7	0.9	65.2
2.7	105.5	0.8	62.9
2.6	103.3	0.7	60.7
2.5	101.1	0.6	58.4
2.4	98.8	0.5	56.2
2.3	96.6	0.4	54.0
2.2	94.4	0.3	51.7
2.1	92.2	0.2	49.5
2.0	90.0	0.1	47.2
1.9	87.7	0.0	45.0
1.8	85.5		