**Instream Flow Modeling Studies During FERC Relicensing;
Common Issues and A Case History**

Preface

There are a number of ways to get 'snookered'. Some of them can occur during the technical phase of a Federal Energy Regulatory Commission (FERC) relicensing process. We all generally realize that the very nature of the FERC (an energy regulator) 'relicensing' sets the resource agencies up for an acceptance of current conditions (the dam and power generation), and that resource concessions will be made. In no way should it be construed by the following expose′ that consultants or power companies are dishonest – in fact, you should assume that they are doing as you are and would – looking out for their organization's best interest. But shenanigans will occur – you should expect them. Recognizing what is going on is the first step; what we hope to avoid is any resource agency naiveties in the study design, data collection, and analysis phases of the FERC process which effectively tilt the playing field any further. Politics and economics (very often just different words for the same thing) are a reality. Ideally, we want to keep politics and science discreet, at least as much as possible and particularly in the objectives, data collection and analysis phases.

The Instream Flow Group out of Fort Collins provided information and caveats for many of these same issues, though more likely in a more neutral, 'scientific' tone. There is also a S.P.E.C. (Study Plan Evaluation and Checklist) Report available that covers most of the conceivable issues you are likely to see.

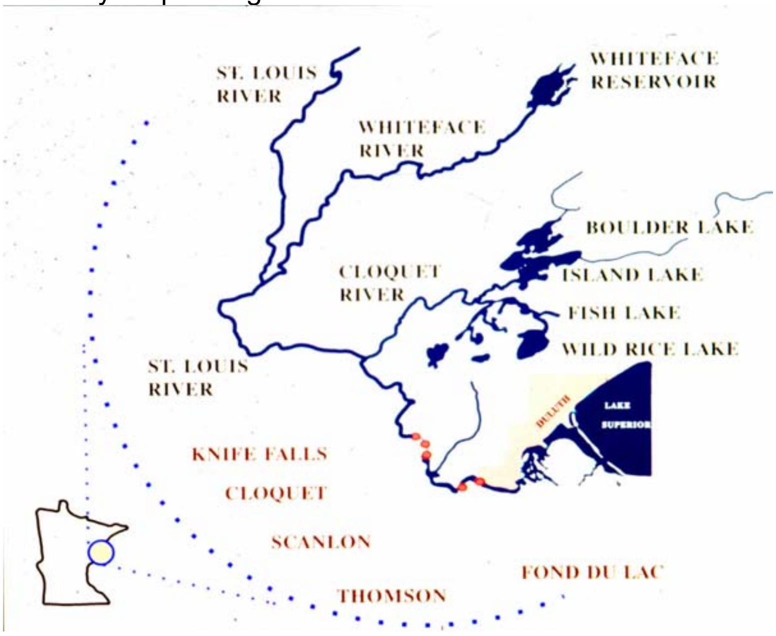
What follows is a presentation of some MN experiences with PHABSIM studies conducted by power company staff and consultants. I have created headers or categories for the strategies being used: I'm sure there are variations on these general themes and perhaps other ways to group them. The Minnesota experience is obviously not unique, and is offered as an example of what to look for and one way to respond. Through dumb luck and a healthy dose of contrariness, we were able to negotiate the relicensing process and accomplish positive change for the resource. However, the political context the FERC operates in cannot be ignored; today there is no guarantee of your results, regardless of the veracity of your science. At the very least though, you will be aware of what is being done to the generations and resource(s) you represent.

Background for the St. Louis River Project

1) The project is operated under a FERC license, re-issued in 1995.

2) The St. Louis River relicensing constituted a large (150 miles of river with 5 hydropower projects affected), hydrologically complex project (see attached figure, below).

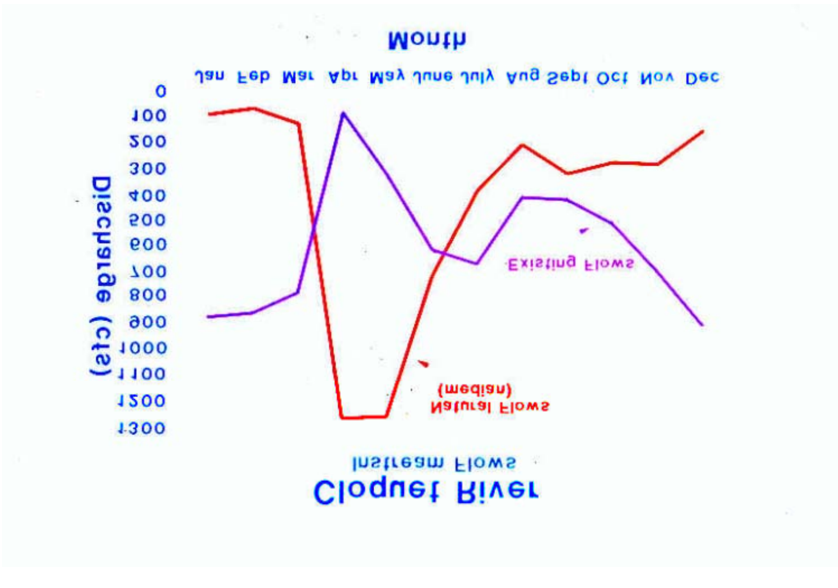
Covering approximately 8280 acres at full pool, Island Lake Reservoir was created during the years 1914-1920, for power production. In a sense, the reservoir exists today largely because of its utility for power generation.



3) The St. Louis Project represents the largest hydropower project in Minnesota –power is an existing and economically important use. At the same time, the environmental impact of dams and hydropower on river systems is widely known and recognized as real and significant. As a result, the FERC, in balancing between power production and the restoration and enhancement of fish, wildlife and recreation, forced concessions to these other uses and values of the river. The Final EIS document specified that the concessions MP made on their FERC relicensing, which included the change in maximum drawdown rate on Island Reservoir and establishment of seasonal flow releases, cost 1.8 million dollars annually (change in levelized net annual power benefits).

4) The FERC process took more than five years and involved stream habitat, hydrologic and reservoir modeling

5) Past operations focused on power generation only (see figure below)



Introduction

During the relicensing of the St. Louis River project, the Minnesota Dept. of Natural Resources staff were exposed to a series of technical and philosophical issues, centered around the use of the IFIM. At the time our familiarity with this collection of models and procedures was, at best, 'dangerous'. We were at the stage where we were very familiar with certain aspects (data collection, PHABSIM modeling, summary, etc.), but were almost completely unaware of how the fundamental assumptions, study design and specialized interpretation of the study results could be used unscrupulously. Eight of the main issues we encountered are presented below:

Derivation of Instream Flow Recommendations

1) Your 'management goal';
2) Species selection and phenology;
3) Transect weighting;
4) Transect Placement;
5) Hydrology and Simulated Flow Range;
6) Derivation of Fisheries 'Minimum' Flows;
7) Reservoir Operations Modeling;
8) Habitat Time Series Analysis.

Under each of these items are presented: 1) an issue definition, 2) what's at stake, 3) a general response *(advice)*, and, 4) a specific response (one used in the FERC process for the St. Louis River relicensing).

1) Your 'Management Goal'.
Issue Definition. Stating your management goal clearly and concisely is, of course, an important first step in any instream flow study (see book 2). Everyone needs to know what the target is, before we start aiming (modeling). The PHABSIM will produce endless reams of output, therefore results can only be judged relative to stated goals and objectives.

What's at stake. What you should be aware of is the other edge to this sword in a FERC process. You will be held to whatever you come up with – for good or ill. Perhaps, the stream in question is known to be degraded and has not been actively managed for years. Coming up with a management plan at your first meeting with the consultants and power company, one that satisfies the entire Fisheries Division and will stand the test through a 5 or ten year FERC process may be a daunting task. Or maybe, if you had time and thought to ask the local Fisheries Manager, she gave you a response from her perspective that is really more of a products objective, for example: "We manage the reservoir for trophy smallmouth bass."

General response Be very careful with this question and do not answer it in terms of management *objective(s)*. While increasing the number of (or habitat for) trophy size smallmouth bass is a very understandable, specific, and straightforward objective, it is also exactly the type of answer for a management goal that a 'gaming' consultant needs to direct the science to his clients desired ends. If you are not explicit about the need for juvenile, fry and spawning habitat, as well as habitat for prey items (for each smallmouth bass life stage), the flows that form this habitat that such trophy fish and organisms that they need in their food cycle, you may end up trying to explain why more water is needed than that predicted just by the adult bass habitat output. My advice: adopt a goal that speaks to a broader, ecosystem perspective. Say and write it down early, consistently, and often. Adopting an ecosystem perspective and goal clearly opens the door to the IFC's five component approach.

The criteria that we developed and prepared for developing recommendations from the integrated instream flow and reservoir modeling reflected a system approach to the overall problem. They were:

- no 'no flow' conditions
- reservoir refill (June 1) – drawdown – and refill
- fisheries flows, recreation flows and aesthetic flows
- summer growing season (May through September) emphasis
- mimic natural regime, as much as possible (sediment transport, channel maintenance, habitat maintenance).

<u>Specific response</u>   For the St. Louis River Relicensing the overall management goal for the involved rivers was: "To protect and enhance the fisheries on a community level."
"The Leonard and Orth approach to PHABSIM habitat analysis was selected because it represents, to our knowledge, the best means to develop flow recommendations for warmwater/coolwater species assemblages. The point of conducting an IFIM study is to identify flows needed for fish and other instream uses; implicit is that these flows will be the "minimum" necessary for a given management objective so that offstream uses can also be developed. Research has shown that microhabitat availability for riffle-dependent species is most limited at low flows while micro-habitat availability for pool-dependent species is most limited at high flows (Orth and Leonard 1990).
Key elements of the approach include the following:

- Selection of appropriate fish species and life stages on which to base analyses of instream flow needs is a critical step in determining flow regimes necessary to support fish populations (Orth 1987).

- Species selection is extremely important because flow dependent habitat characteristics of a stream (e.g., depth, velocity, substrate, cover) influence community structure and stability (Gorman and Karr 1978, Schlosser 1982, Moyle and Vondracek 1985). Changes in habitat characteristics may cause shifts in species composition (Bain, et al. 1988).

- Selected species should have, among them, a wide range of habitat needs (Leonard and Orth 1988).

- Because warmwater streams are characterized by high species richness (Orth 1987), direct analysis of habitat requirements for all species is not possible. The guild approach was used to simplify the species selection process.

- A guild is defined as “a group of species that explicit the same class of environmental resources in a similar way” (Root 1967).

- Food and habitat are the most important resource axes identified in previous resource-partitioning studies of stream fishes (Ross 1986).

- Species using similar resources should be affected similarly by the alteration of those resources (Roberts and O’Neil 1985).

- Consequently, recommendations for instream flow must represent a compromise among the needs of all species (Leonard and Orth 1988).”

- When in doubt, any compromise will be guided by the natural flow regime. (*Mimicking the natural flow regime to the extent possible* ***is*** *often the best overall goal for a biologist to adopt; just be sure you know what the natural hydrology is that you are mimicking*.)

2. *Species Selection and Phenology*

Issue Definition

Selecting the species and life stages for modeling is a fundamental aspect of PHABSIM analysis and extremely important. While it follows that the more complex stream fish assemblages demand explicit and careful consideration and selection of species to ensure all habitat types are modeled, it is erroneous to think that ‘simpler’ stream ecosystems (simpler in terms of # of fish species) can be approached lackadaisically. Particular attention must also be paid to the timing of modeled life stages, to ensure maximum coincidence with temperature cues and flow regime requirements.

What’s At Stake?

Certain life stages typically require more water (e.g., spawning), and others less (e.g., fry). Whenever there are storage reservoirs as part of the project operations, you can expect potential ‘gaming’ especially coinciding to key hydrology/operation months. For example, in Minnesota, peak flows typically occur in spring (April/May), precisely when the power company’s operators seek to minimize outflows to refill the storage reservoirs. Conversely, November is naturally a lower flow month in Minnesota, but begins the drawdown cycle and so results in higher flows in downstream rivers. Inattention to these operation and hydrologic details can result in ‘shifts’ (large and small) in timing of desired flows for targeted species and life stages.

General Response

Know the basic biology of your organisms and insist on seasonal time frames that match what is occurring in nature. This area is the natural purview of the resource agencies and should not be abrogated under any circumstances. Cueing operation changes on hydrologic and temperature changes is best when possible, avoiding a rigid date-driven change which may be appropriate some years and wholly off during others. Be aware of the power company’s desired operation schedule and protocols and how it matches with specific proposals relative to species life stages being modeled and the seasons they recognize.

Specific Response

"As we have discussed on several occasions with BEAK and MP representatives, we agree that walleye fry do occur in the St. Louis River as early as mid-May. We do not agree that it is appropriate to consider their habitat requirements during May. Walleye fry are planktonic during early development, they have no paired fins, are incapable of swimming horizontally, and are consequently not able to seek preferred habitat (Becker 1983). Several studies suggest that fry drift downstream into lakes during the early fry stage (Priegel 1970; Robert Strand, MDNR Regional Fisheries Supervisor, personal communications). Priegel (1970) found that if flows were insufficient to carry the fry into these downstream lakes within 3-5 days they would not survive. Walleye fry continue to live a pelagic existence until they are at least 25 mm long (Eschmeyer 1950; Morsell 1970). Walleye fry would not reach this size in May.

Reference is made by BEAK to the MDNR classification of walleye young-of-the-year (y-o-y) as walleyes up to 150 mm in length. Although we consider walleyes of this size to be y-o-y, we do not consider 150 mm walleyes to be fry. MDNR has not developed suitability criteria for walleye y-o-y; if we had done so, we would have partitioned the first year into fry and fingerling stages as we did with smallmouth bass. The suitability criteria used by BEAK were in fact for walleye fry (post-sac fry <50 mm) (Larry W. Kallemeyn, personal communications), not for y-o-y up to 150 mm as stated by BEAK. Therefore, we hold firm to our original position of considering walleye fry in June and July only.

We do not agree with MP that it is appropriate to include smallmouth bass spawning in May. During the spring of 1988 and 1989, two of the warmest years on record, we made observations of over 150 bass nests in the Zumbro River, which is 200 miles south of the St. Louis River. The earliest nest construction observed was May 19. A male bass may construct several nests before settling on one for spawning (Mraz 1964) and each nest may take as long as two days to coincide with the onset of spawning. Because it is 200 miles further north and fed by shaded cool and coldwater streams, the St. Louis River should warm much more slowly than the Zumbro. Furthermore, average May flows under natural conditions are invariably higher than June flows in Minnesota streams. Smallmouth bass have adapted to these declining flows during the onset of spawning. These higher early flows may cause smallmouth bass to find slackwater areas that are less susceptible to fluctuating flows. Fluctuating and increasing flows during nesting have been shown to be detrimental to smallmouth bass spawning success (Simonson and Swenson 1990).

When defining the seasonal classes we attempted to identify time frames and associated species life-stage assemblages in a normal year. We do not imply that certain species-life stages will not appear outside of these time-frames in abnormal years. Rather, we feel that the seasons we have identified are the most important for the suggested species-life stages."

3. *Transect Weighting*

Issue Definition

An important aspect of any modeling effort is to represent as much of the universe as possible. For PHABSIM studies, habitat mapping has been proposed as a way to represent or expand the sampled habitat to as much of the river as possible. Transect weighted is the means of transferring the transect data to the mapped river reach(es). The data from each transect are expanded to match the proportion of that habitat type in the mapped reach(es).

What's At Stake?
Although this seems straightforward and even desirable, there are problems with this approach. The underlying assumption of this approach is that the amount of habitat (area) is the key. One could argue that this is the basic assumption of PHABSIM itself (that habitat area is the key to population size), however, habitat is further 'qualified' by its degree of suitability in the PHABSIM model.

The effect of weighting transect data based on habitat mapping is to emphasize abundant habitat and discount rare habitat. In many streams, pool habitat is most abundant, and riffles are rare. Riffles are also typically more sensitive to flow changes (below bankfull) than pools; if we minimize their importance we minimize this impact.

General Response
Make it clear from the beginning and throughout the coordination process that rare or important habitat will not be weighted by area. Riffles are "biological hotspots" in river systems. As noted above, they are also the hydraulic control points in river segments, and are most sensitive to flow changes; if you protect riffles you tend to protect the rest of habitat. Of course there are exceptions to this (e.g., backwater habitat at stages above bankfull). Therefore, any and all habitat(s) should be evaluated for flow sensitivity; you may be surprised by the results.

Specific Response
"MDNR has considerable concern regarding the weighting of transects and the application of species modeled in each transect. Specifically, MDNR is concerned with the dissection and weighting of the mainstem St. Louis and the upper and lower Cloquet study sites.

Weighting transects can be an extremely important determinant of IFIM results on two levels, if not done properly: 1) it may directly negate important but limited habitat, and 2) it can distort the habitat versus flow relationships for some species-life stages.

The National Ecology Research Center (NERC) recommends at least 5 to 7 transects be used to evaluate habitat availability. The MP/BEAK flow analysis and recommendations are based on only two transects on the Upper Cloquet and Mainstem St. Louis study locations. The transects used in this analysis are classified as shallow pool/slow run. It is well documented that pools are the least susceptible type of habitat to low flow conditions. By using only pool transects, available habitat in riffles, runs and transition zones is misrepresented in the analysis and the resulting flow recommendations are invalid.

In the Upper Cloquet site, BEAK placed a 50% weighting factor on transects 8 and 9, and negated the faster water areas (transects 1-7), the Upper Cloquet Island site. Transects 8 and 9 have water depths ranging between 3 and 5 feet and velocities generally less than 0.8 feet per second; they are pools. Subsequent application of riffle species in the pool transects (8 & 9) results in habitat for riffle species generally peaking at near zero discharges (for example, see Instream Flow Study Report, Figure D-11) and in a determination of "optimum" conditions to be at near-zero discharge. Similar results would be expected if BEAK re-ran all transects and used the 5% total weighting factor for transects 1 through 7. These transects are primarily composed of riffle and fast run habitat and must be considered a critical habitat type in this section of river. Since riffles are a major source of biomass production, and are in short supply in this section of the river, a weighting of five percent is not an accurate representation of their value to the ecosystem. This points out the necessity of applying appropriate species to appropriate habitat types (i.e., riffle species to riffles and pool species to pools) if the transects are separated, either directly or through weighting factors.

The lower Cloquet site is a high gradient river section. BEAK's inclusion of pool-dwelling, velocity-avoiding species into this study location is inappropriate. The resulting habitat analysis indicated that flows levels are not acceptable to these species until velocity is very low (i.e., little or no flow). The inclusion of two low-gradient run transects is also inappropriate, based on the habitat mapping conducted by BEAK. The habitat mapping indicates that no low-gradient run habitat is available in the reach, yet these two transects received a weighting of 30 percent in the lower Cloquet instream flow model (see Vol. VI, App. E-7, pp. 23 and 41). Inclusion of low gradient transects at the lower Cloquet site, if we are to be consistent with the MP/BEAK stance on the Upper Cloquet, is a gross over-representation of low velocity habitat in a high velocity site.

BEAK divided the St. Louis study location into two parts based on slope and habitat characteristics (high gradient: transects 1-6, riffles and fast runs; low gradient; transects 7 & 8, slow runs). All species were examined at both locations. This division of study locations into fast water and slow water and the placing all species, regardless of habitat preference, into each subdivision of a study site is inappropriate. Weighting factors of fifty percent were given to transects 7 and 8 at the lower gradient site. These transects contained water depths between 5 and 10 feet and velocities below 1 foot per second (0.6 fps). Applying riffle species to these transects results in very small amounts of actual habitat, which is masked by the normalization step, critical to the Leonard and Orth (1988) approach.

In summary, re-evaluation of weighting and representative analysis is essential to ensure accurate study results. The existing work by MP/BEAK is unacceptable to the MDNR. The following discussion is provided in further support of our position on these issues."

RIFFLES AS CRITICAL HABITAT

A discussion of our view of riffles as critical habitat was contained in a letter dated March 29, 1990 providing the Department's comments on the Final Study Plan (January 1990). We feel that negating riffle and any other habitats through weighting factors is totally inappropriate. The following review is presented in support of the Department's view of riffles as "critical habitat", particularly when they are scarce, as in the case of the Upper Cloquet Study Reach.

a) Definition of critical or unique reaches

A definition of critical reaches, which we accept, is as follows:

> "Critical reaches are portions of rivers containing a particular type of microhabitat that is absolutely essential for the completion of one or more life stages of a species and

absent or in very short supply in the representative reaches. Critical reaches are often associated with migration, spawning and incubation, and development of newly emerged young-of-the-year fish." (Bovee 1982).

b) The Importance of Riffles

- Food Production. Velocity is a predominant characteristic of riffles and controls the occurrence and abundance, and hence the whole structure, of the animal community (Hynes 1970). Productive riffle areas are particularly affected by changes in flow, through flooding or drying (Briggs 1948; Neel 1963; Abbott and Morgan 1975). Riffles contain the majority of a river's benthic invertebrates (Goldman and Horne 1983) and are consequently vital food production areas for fishes. Schlosser (1987) found densities of benthic insects to be 6.2-7.9 times higher in riffles than in pools. For mayflies and caddisflies, which were the most frequently found invertebrates in smallmouth bass stomachs (Aadland et al. 1991), Schlosser found densities to be 53.5 times higher in riffles than in pools. Riffles also contain the highest densities of fish in many streams (Schlosser 1982, Lobb and Orth 1991, Aadland et al. 1991). In the Cloquet River, Hassinger (1967) had high fish catches in pools below rapids but caught few or no fish in long straight sections of river channel.

- Fish reproduction. During the past four years, we have made habitat observations of nearly 40,000 fish of 70 different species in nine river systems, including the St. Louis River. For these 70 species, riffles are the most important habitat type for spawning. Of the obligate riverine species (those found almost exclusively in rivers), 80% are riffle spawners. Most of the pool spawners are facultative riverine species, which can carry out their entire life cycle in lakes. These species are consequently less dependent on appropriate flows than the obligate riverine fishes. Of the fish sampled by Hassinger (1967) in the Cloquet River, 75% of the individuals were riffle spawning species. This is probably an underestimate since Hassinger sampled with a boat electroshocker, which is not effective for sampling riffles. **The rarity of riffles in a river segment does not mean they are not important, but conversely, that they are critical**. For example, lake sturgeon spawning habitat in Dead Man's Rapids on the Little Fork River covers about as much area as an average living room. Radio tagged sturgeon migrated from as far as Lake of the Woods to this small area to spawn, traveling a distance of more than 100 miles.

- Sensitivity to flow. Under the low flow condition, riffle and raceway habitat is most constricted while moderately deep and deep pools are relatively unaffected Figures 4 & 5, Attachment 6) (Curtis 1959, Kraft 1972). When flows approach zero, pools appear as a series of discontinuous ponds in the river channel. The channel between these pools is riffle or raceway habitat at normal flows that quickly diminishes as flows drop."

4. *Transect Placement*

Issue Definition

As I first heard many years ago from Ken Bovee on these matters: 'garbage in equals garbage out.' Data collection is all about objectives. Placement determines the data that will be collected. The key is representation, that is, how well do the data represent the channel? In other words, how representative is the transect location of the rest of the channel (not being measured)?

What's At Stake?
As a resource agency, your objective when sampling habitat is most likely to represent as much of the channel as possible. However, you should not assume that is the same objective as the consultant actually doing the field work. It may be that they want the transect data to reflect a limited and special situation (e.g., a hydraulic chute) and still be assumed to represent an entire stream reach. If successful, the effect then is to extrapolate an area of limited habitat value to an entire reach.

General Response
Make sure you personally are there (or a trusted representative) when transect headstakes are established, especially for bypassed reaches. Even if you are there for a general scoping meeting, but miss the specific headstake placement phase, you risk getting snookered (as we were on the Thomson bypassed reach).

Specific Response
"MP has stated that the channel is much smaller in the diverted sections (Thomson and Fond du Lac) than the undiverted reaches of the river and therefore the flows examined in the models are adequate. MP also contends that the amount of habitat available at optimum flows is a small percentage of the total area available at that flow. Based on this information, MP assumes that the fishery is of limited value in this segment.

In examining topographic maps of the study site location within the diverted segment below the Thomson dam, it appears the study location is within a confined channel segment and is not representative of a large proportion of the bypassed river segment. Transect profiles and a visual examination of the study site also indicate that this segment is a fairly deep bedrock channel. BEAK's habitat analysis of the study area shows habitat is best at low flows. MDNR contends that the study site is located in a section that is not truly representative of the diverted section. High flows in the river segment in which the study site is located produce extremely high velocities and depths that are not typically suitable for the species examined. Topographic maps show that a substantial proportion of the bypassed river channel is wider and shallower than the site selected for the habitat analysis. It is quite possible that available habitat in these wider, shallower sections is greater at higher flows.

Transect placement on the diverted reach of the natural channel at the Fond du Lac site was also a concern to us. The transects do not appear to be adequately representing the significant riffle and shallow run habitat that exists directly downstream of the dam.

In summary, use of the model results may be skewed due to the limited range of flows modeled for certain months of the year and transect placement may have resulted in predicting conditions which are not representative of actual available habitat. MDNR recommendations should be viewed as representative of minimum conditions due to the limitations of the modeling and transect placement."

5. Simulated Flow Range

Issue Definition
The PHABSIM models can only address flows within a range (0.4 times the lowest measured flow and 2.5 times the highest measured flow). Outside of this range you have no basis for drawing conclusions or making recommendations. Some experienced practitioners view the 0.4 to 2.5 times the measured flows as an expectation limit and use other quality control indicators to de3termine how far they can actually extrapolate. These include: VAFs, limits on state relationships and velocity indicators.

What's At Stake?
If the measured flows cover only the very lowest flows, your recommendations will be limited to minimum values as well. Watch for this issue, especially in bypassed reaches, where dedicated flows cut directly into power generation (the degree dependent on the upstream storage and operation plan) and dam regulation and power production can limit the flow you see.

General Response
Insist that the measured flows will cover the natural range of flows this channel experienced previously, even if you realize there is no way, politically, that you will see them implemented. You will firmly establish what it is you (the public) are losing – at the very least, an effective basis for other concessions.

Specific Response
"The highest flows simulated did not reflect natural, normal spring flow conditions in the Thomson and Fond du Lac diversions. Based on the hydrologic assessment performed by MDNR, the flow levels are less than the 80 percent exceedence flows for the spring spawning season at Thomson (April-June). At Fond Du Lac, the highest flows simulated did not attain the 80 percent exceedence flow for April or May. This is significant in that instream habitat continued to increase throughout the range simulated for these sites, and never reached a maximum level. Because high discharges, typical of spring flows, were not modeled, interpretation of results must be guarded. The shape of the habitat/ discharge relationship is unknown at the higher discharges and peak habitat may occur well beyond the flow ranges that were modeled. Thus, when WUA/discharge curves are normalized, species which peak beyond the modeled range will show a peak occurring at flows lower than normal. Therefore, any evaluation based on the simulated flows will not take into consideration the total amount of habitat available during normal spring spawning.

The BEAK instream flow study indicates that available habitat is very limited in both diversion sections. We believe this is due, at least in part, to the flow range simulated in the model. The range of flows examined in the assessment reflects extremely low levels of naturally occurring flow for the St. Louis River. The BEAK community-based habitat optimization study analyzed habitat based on low flow conditions, rather than normal, natural historical flows. This limitation has necessitated making our preliminary flow recommendations based on incomplete data.

In summary, MP should revise its instream flow model to address a more realistic range of spring flows in the St. Louis River for the sites downstream of the Thomson Reservoir. MDNR should be involved in addressing this potentially significant gap in the analysis."

6) Derivation of Fisheries 'Minimum' Flows

<u>Issue Definition</u>

Because the output of habitat flow relationships for many species life stages are often 'bell-shaped', that is, they increase to an optimum and then decrease again, they present an opportunity to play games with flow recommendations. The most common game is to use the graphical output to draw lines from higher flow and habitat values to 'equivalent' habitat levels at lower flows.

<u>What's at Stake?</u>

Habitat and habitat diversity. Recall that PHABSIM models what we know about these systems. What we don't know eclipses this information – just because the model results indicate things are okay – does this really make sense? Does it match the natural hydrology of the system that the organisms have evolved to? Unless there are extremely few fish and complete understanding of the stream's ecology play as few of these games as possible with the results. There is no free lunch.

<u>General Response</u>

Don't agree to anything the first time you hear it. Do this as a matter of protocol. Say you require time to discuss it with other agency experts and will get back to them by *such and such a* date. Discuss it in-house or with other biologists you respect and trust. Special approaches to select or develop flow recommendations should be openly and explicitly discussed between the resource agencies and the power company and their representatives and agreed to or shelved. If this type of thing is 'sprung' on you with short notice (no time for review), be suspicious. Typically, resource agencies can assume that special approaches being offered by the power company or their consultants will result in recommendations that favor power production.

<u>Specific Response</u>

"BEAK used a "flow window" procedure for deriving lower discharge values by equilibrating habitat levels to the mean monthly flows (Minnesota Power Instream Flow Study, Figure 4.1-1). We do not agree that this approach is suitable and believe it represents a deviation from the intended use of the approach outlined by Leonard and Orth (1988). The "flow window" approach used by BEAK was proposed by the National Ecology Research Center (NERC) to develop habitat-based flow recommendations for a single target species or species life stage. It assumes that similar habitat quantities at different flows will have the same effect on the species in question. However, a broader, community-level perspective is needed to protect stream resource values in warmwater streams (Orth 1987; Miller, et al. 1988). The Leonard and Orth method was developed to deal with multiple species in highly diverse warmwater streams. It attempts to simplify the species selection and optimization process and is not a true composite, but rather a plot of all relevant species-life stage normalized WUA vs. discharge relationships.

The Leonard and Orth method was chosen by MDNR because it is a community-based approach driven by those species-life stages, which suffer the greatest loss of habitat over a specified alteration in flow. The suggested flows obtained by this method are a compromise among the WUA vs. discharge relationships for all species life stages, which are most habitat limited relative to their optimal flow. The window method used by BEAK was never agreed to by MDNR as a valid approach for use with the Leonard and Orth method. The assumption made by BEAK that its minimum flows provide the same habitat as the higher average monthly flows is not correct. Therefore, it is incorrect to imply that habitat for all species at 738 cfs (natural flow) is equivalent to habitat for these species at 22 cfs (BEAK "equivalent"), as BEAK has done for the Upper Cloquet site during June and July. In fact, the BEAK method would result in an almost complete loss of walleye spawning habitat (90-100% loss of habitat available under natural flows; 95-100% loss from MDNR recommended flows) in the Cloquet River. If habitat comparisons are to be made between natural flows and some "alternate" flow, the habitat of all relevant species-life stages must be examined-not only two or three as BEAK has done."

7. *Integration of Reservoir Needs* (i.e., *Reservoir Operations Modeling)*
Issue Definition

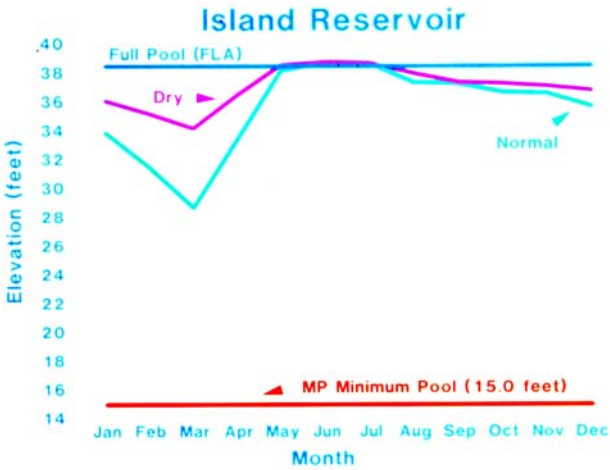
As the state's fish and wildlife agency, MNDR sought to:

a) restore and protect fish and wildlife resources on entire system (used habitat guild approach and also modeled for catfish, walleye, smallmouth bass): reservoirs, rivers and bypassed reaches
b) restore and protect recreational opportunities on entire system (operation-related changes focused on canoeing in Cloquet River)
c) as part of this process, we have been responsive to reservoir impacts; have limited drawdown substantially over previous license conditions (see figure below), established refill dates, prescribed dry year rule curves (rejected by the FERC) and allowed for secondary outflows (i.e., inflow) when dry conditions occur.

Reservoirs and hydropower dams, and associated resources are part of a river system, and changes on one part will affect the rest. To address impacts, the DNR's objectives were to:

a) return to natural flow regime as much as possible:
    a. no "no-flow" conditions below reservoirs
    b. establish reservoir rule curves and drawdown limits, establish inter-annual (seasonal) and intra-annual (wet, normal, dry water years) flow regimes for outflows (see figure below),
    c. designate ramping rates when moving between flow seasons to mimic natural changes as much as possible and avoid negative environmental impacts
b) manage the reservoirs and rivers as a system, not focus on one component over another.

What's At Stake?
If there are storage reservoirs in the project you are reviewing, their operation will determine when you get water and how much. While it is true that except for evaporation loss, the reservoir will not change the total volume of water received in downstream channel(s) in an annual sense, they can and often do change when it is received. And in biology, timing is everything. In the northern half of the world, snowmelt and spring runoff dominate the hydrograph. Operation of storage reservoirs for power production can drastically change the shape of the hydrograph (see Figure 2 above), and hydrology drives these ecosystems.



General Response

Insist on a networked reservoir model as part of the analysis and final recommendation phase. Participate in the development of the reservoir model to ensure that the hydrologic (inflows) and hydraulic (stage/volume) data is as accurate and representative as possible.

Specific Response

"**General Procedures and Criteria**

On the tributary rivers, the Cloquet and Whiteface, our recommendations are two-fold, providing for reservoir elevations and providing for downstream river flows on a monthly basis. (*editors note: there were no gage data >> all hydrologic information had to be synthesized*) We furnish monthly reservoir elevation rule curves for both 'normal' and 'dry' inflows and matching outflows for the rivers. Our intention is to have MP operate the reservoirs within the bounds of these constraints, with actual outflows in any month determined by precipitation forecasts and reservoir elevations.

For the Thomson and Fond Du Lac bypassed reaches, we will be providing minimum flow regimes, derived to meet a variety of resource objectives. Our procedures and criteria were coordinated with MP and their consultant through the process of reconstructing the IFIM studies. The need to redo much of the consultant's work is in large part due to a lack or coordination between the original data collection and report stages of this IFIM study. Instream flows and associated reservoir elevations for 'normal' and 'dry' inflows (defined below under procedure 2.) were initially presented as a MNDNR handout at the February 19, 1992 workshop meeting with MP and their consultants. The general procedure for developing final MNDNR recommendations for the tributaries was:

1. Instream flows for fisheries were established using the habitat guild approach outlined by Leonard and Orth (1988) and recommended for Minnesota instream flow recommendations by Aadland et al. (1989, 1991), Aadland (1993). In this approach,

habitat discharge relationships for appropriate species life-stages in each season are modeled and the results are normalized, such that all habitat/discharge curves peak at a weighted useable area of one (1). To determine a specific flow recommendation, appropriate species life stages are plotted together, including habitat guild representatives and gamefish. As seen from the output in Appendix A2, different life stages need different flow levels. For some species life stages, habitat peaks at higher flows, and for others their habitat peaks at lower flows. The flow recommendation must represent a *compromise* between the needs of the most flow sensitive species. By adopting that flow where the high flow limited species intersects with the low flow limited species, we maximize the diversity of habitats available and optimize protection for the entire community. Keep in mind that as the raceway representative, adult shorthead redhorse, represent all species life stages preferring raceway habitat, not a single species life stage. The guild representatives and their associated habitat chosen for this study were: log perch adults, fast riffle; longnose dace adults, slow riffle; bluntnose minnow young-of-year, shallow pool; emerald shiner young-of-year, shallow pool; channel catfish juveniles, medium pool; shorthead redhorse adults, raceway.

2. Modeling of inflows, reservoir elevations, and outflows was undertaken using the model developed by Owen Caddy of the MNDNR. This networked reservoir model was an integral part of our flow recommendation process, particularly with regard to the storage reservoirs. The modeling process was incremental and iterative; outflows had to be changed to ensure reservoir refill under different inflow conditions and ensure maintenance of a recreational pool during summer. 'Normal' reservoir inflow conditions were modeled using the 50% exceedence flows developed from the MNDNR hydrologic data. 'Dry' reservoir inflow conditions were modeled using the 80% exceedence flows developed from the same data set. A run was considered successful when the criteria was met (e.g., refill by June 1) for two consecutive years under the model inflows (e.g., two consecutive and complete years of 80% exceedence flows for inflow to the reservoir). Precedence for defining 'dry' hydrologic conditions as we have done can be found in the IF201Manual for 'Problem Solving with IFIM', prepared by the National Ecology Research Center, Fort Collins, Colorado. To our knowledge, there have been no objections to using these conventions; . . . . "

. . . .

"As stated in the Results section, MNDNR developed a reservoir model that networked the St. Louis River hydro system together and, using the simulated hydrology and the IFIM-derived fisheries recommendations as input, developed final recommendations that bracketed hydrologic possibilities and still met resource concerns. A more detailed discussion of the MNDNR procedure and criteria used to guide our recommendation process can be found in the METHODS section, pages 3 through 5. MNDNR directly considered different inflow levels and their effects on reservoir elevations and subsequent dam outflows for the rivers.

MP took a different tack in modeling reservoirs and instream flow requirements. According to MP, specific instream flow needs for habitat were derived in three steps. <u>First</u> mean monthly flows, under natural conditions, were estimated for each study site. <u>Second</u>, the composited habitat-discharge relationships for each study site were used to determine the monthly habitat levels that would be available under the natural, unregulated river flow conditions. Third, the composited habitat-discharge relationships were used to find the lowest flow in each month that would provide the same or more habitat as available under natural, unregulated flow conditions. MP considered these resultant flows as the instream flow needs for habitat, but additionally, evaluated them at each site relative to the effects or constraints on MP operations.

It is obvious that the differences in approach outlined above, can lead to different final recommendations, in fact, it would be surprising if they did not. We contend that it is duplicitous to assess instream flow needs while simultaneously factoring in off-stream (reservoir storage, power production) demands. Competing uses of water should be factored separately, to allow full consideration and appreciation of the values to be lost or gained on both sides of the equation. "

SEE APPENDIX A FOR A MORE COMPLETE GRAPHICAL SUMMARY OF RESERVOIR OPERATION RECOMMENDATIONS

8. *Habitat Time Series*

Issue Definition

Identifying the amount of habitat, over time, afforded by one proposal versus other proposals is considered the culmination of the PHABSIM modeling process. Greater amounts of fish habitat for your proposed regime is evidence that your operation proposal protects or restores fish and wildlife values, one of the basic charges of the FERC and roles of the state agencies in the FERC process.

Also, because it is a driver for the amount of habitat, the hydrology used for this analysis is critical. Understanding the hydrologic data set being used in terms of its relation to natural, historic, and proposed flows (*see issue 5 above*) is a key component of successful interpretation and negotiation of the results.

What's At Stake?

You must go into this part of the process with your eyes wide open. Time series modeling is about comparing one scenario to others; be very careful that you actually compare what you intend or think you are comparing. For example, hydro-plant operations that increase water flows during the fall and winter months may be hydraulically increasing habitat on an annual basis but during a time that is biologically meaningless. For long-lasting species life stages (e.g., adult smallmouth bass), with habitat suitability criteria collected and developed during the open water season (15-20 °C), it is not appropriate to use this HSC for winter conditions (1-5 °C).

The differences between natural and historic baseline conditions should be thoroughly understood (mathematically and conceptually). Natural hydrologic baseline represents those flow conditions without any regulation; historic hydrologic baseline may or may not be the same as natural conditions and often represents the regulated condition over the past license period or a specific segment of it.

General Response

To the extent possible, make sure that the years selected as input are continuous (no cherry-picking), of sufficient length in terms of number of years (10 or more), and representative as far as low, medium, and high water flows. Regardless of the water years used, be aware of the degree of departure from the natural hydrology. Whenever possible, run a least three time series: natural, your proposal, and the power company's preferred alternative. Including the natural hydrology in your analysis provides you with two things: the degree of departure you are already granting to power production (assuming you are not simply recommending natural flows), and the amount extra that the applicant is recommending be dedicated to power production. It will also elucidate areas of potential agreement, if there are any. Be prepared to discuss the relationship of your proposal's results to that proposed by the hydropower company, as well as their relationship to the natural condition and historic condition(s).

Specific Response

Based on its habitat time series results, MP stated in its last submittal that flow regimes resulting from proposed MP operations will increase available habitat over historic operation. For the Upper Cloquet, the MP operations will increase average annual habitat for 16 of 21 species-life stages, and 12 of 21 species-life stages at the Lower Cloquet IFIM site. We believe that this is inaccurate. Obviously, the amount of water that passes through a project eventually will have to be passed downstream regardless of the operation scheme.

As per our discussion of MP's habitat modeling above, it is the timing of different flow levels that is most important and timing is masked by average annual habitat statistics. Our approach was to look at the April through September growing season period, applying species-life stages for appropriate months during that period. We did not complete analysis on the Lower Cloquet site for this submittal, but will during the drafting of the EIS. Based on the MP results from the Upper and Lower sites, we expect even more disparity between MP and MDNR operating regimes and resulting habitat.

Our time-series comparisons of habitat for the Upper Cloquet site of the MDNR and MP proposals (using 20 foot maximum drawdown elevation scheme at Island Lake) showed that the MDNR operating schemes for the Cloquet River reservoirs provided more average monthly habitat for all life stages of channel catfish, adult and juvenile smallmouth bass, adult, juvenile and young-of-year brown trout, spawning walleye, and log perch adults, during all months compared (Appendix B, Figures 1-6). Additionally, the MDNR proposals favored spawning bass in July, shorthead redhorse in April May, June and August, longnose dace adults in June through September, emerald shiner y-o-y during June through September, and bluntnose minnow y-o-y in July and September. In short, the only species-life stages that were not better off at some time during the growing season under the MDNR proposals were adult, juvenile, and y-o-y walleye and y-o-y smallmouth bass.

The situation was repeated in a comparison of MDNR and MP proposals using MP's 25 foot maximum drawdown elevation scheme at Island Lake (Appendix B, Figures 7-12). A reversal occurred in walleye adults during May and juveniles during July, where the MDNR operating scheme produced slightly more habitat over the time series. For the rest of the output, the same species and life stages were favored by the MDNR operating scheme, during the same periods; the only change was the amount of difference in habitat. In all cases, the disparity in habitat produced by the two scenarios was decreased, but the general shape of the curve defining habitat over time for each species remained. Clearly, this indicates that the MDNR operating scheme for Cloquet River reservoirs provides more habitat, and a greater diversity of habitats, during a critical part of the year.

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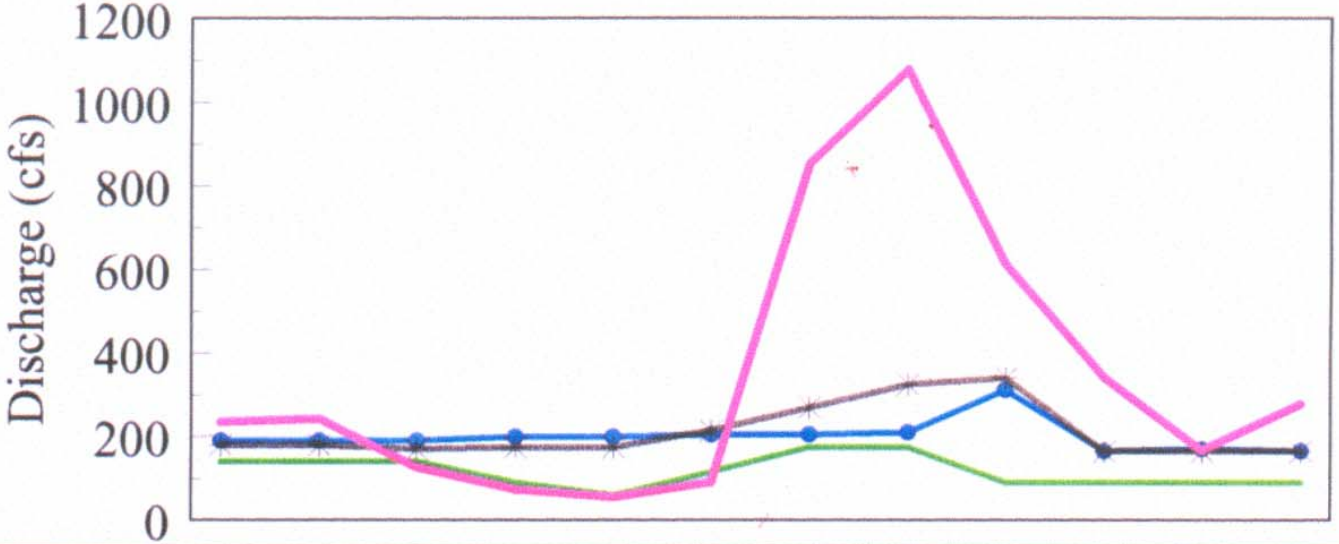
Appendix A
Summary of Reservoir Operation Recommendations
St. Louis River (MN) Projects



1969-1979	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old MDNR Minimum	190	190	190	200	200	205	205	210	312	165	170	165
New MP Minimum	140	140	140	90	60	115	175	175	90	90	90	90
New MDNR Minimum	180	180	170	175	175	215	270	325	340	165	165	165
Natural Flows (Median)	233	242	126	73	54	90	852	1,077	612	341	167	277

Figure 1. Recommended minimum outflows for Island Lake Reservoir proposed by Minnesota Power (MP) and the Minnesota Department of Natural Resources (MDNR). Median flows are presented to show the relationship (timing, magnitude) of each proposal to natural conditions. Median flows were developed by the MDNR, Division of Waters and represent natural flows without the effect of the reservoirs.

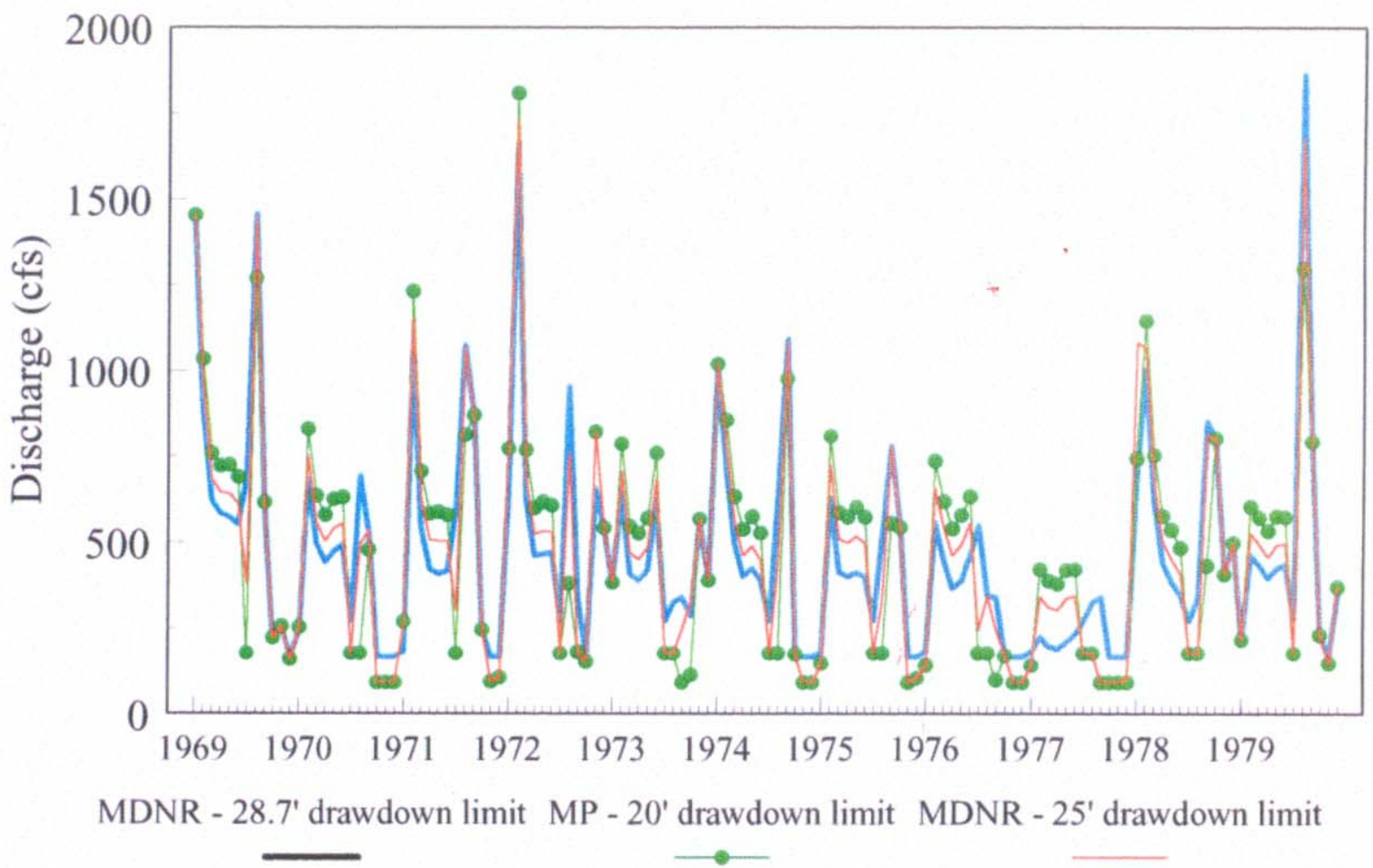


Figure 2. Comparison of outflows from Island Lake Reservoir operated under drawdown and minimum outflow proposals by MP and MDNR. Results are produced from the reservoir model developed by BEAK using hydrologic inflow data for water years 1969 through 1979. MP proposes operating Island Lake with drawdowns to 20 or 25 feet elevation. For testing, we assumed continuous operation under each drawdown limit. Results are displayed by water year, that starts with October and ends in the September of the named year.

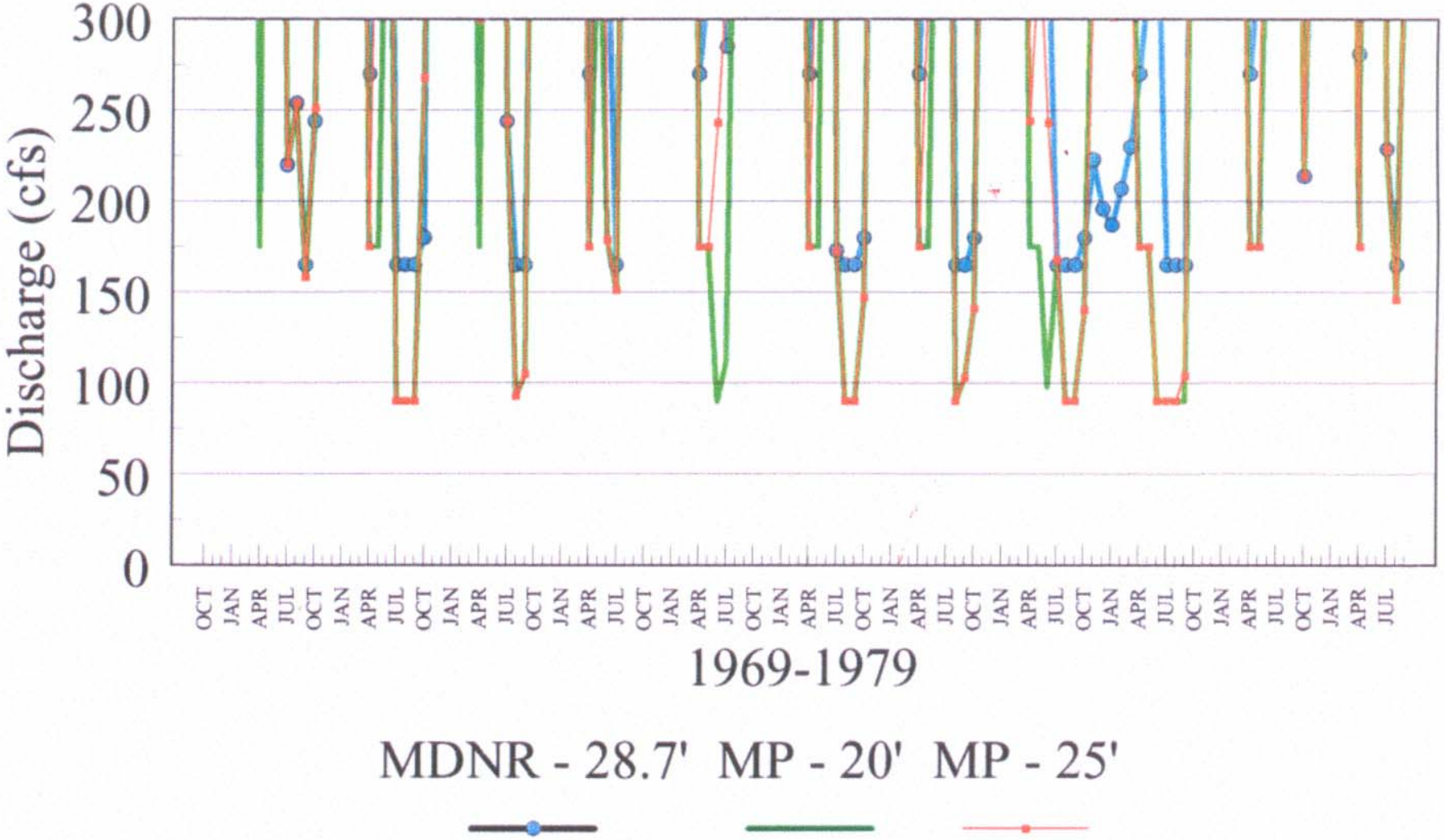


Figure 3. Close-up of outflows from Island Lake Reservoir using a smaller scale to show the timimg and magnitude of minimum flows for proposals by MP and MDNR, 1969 to 1979.

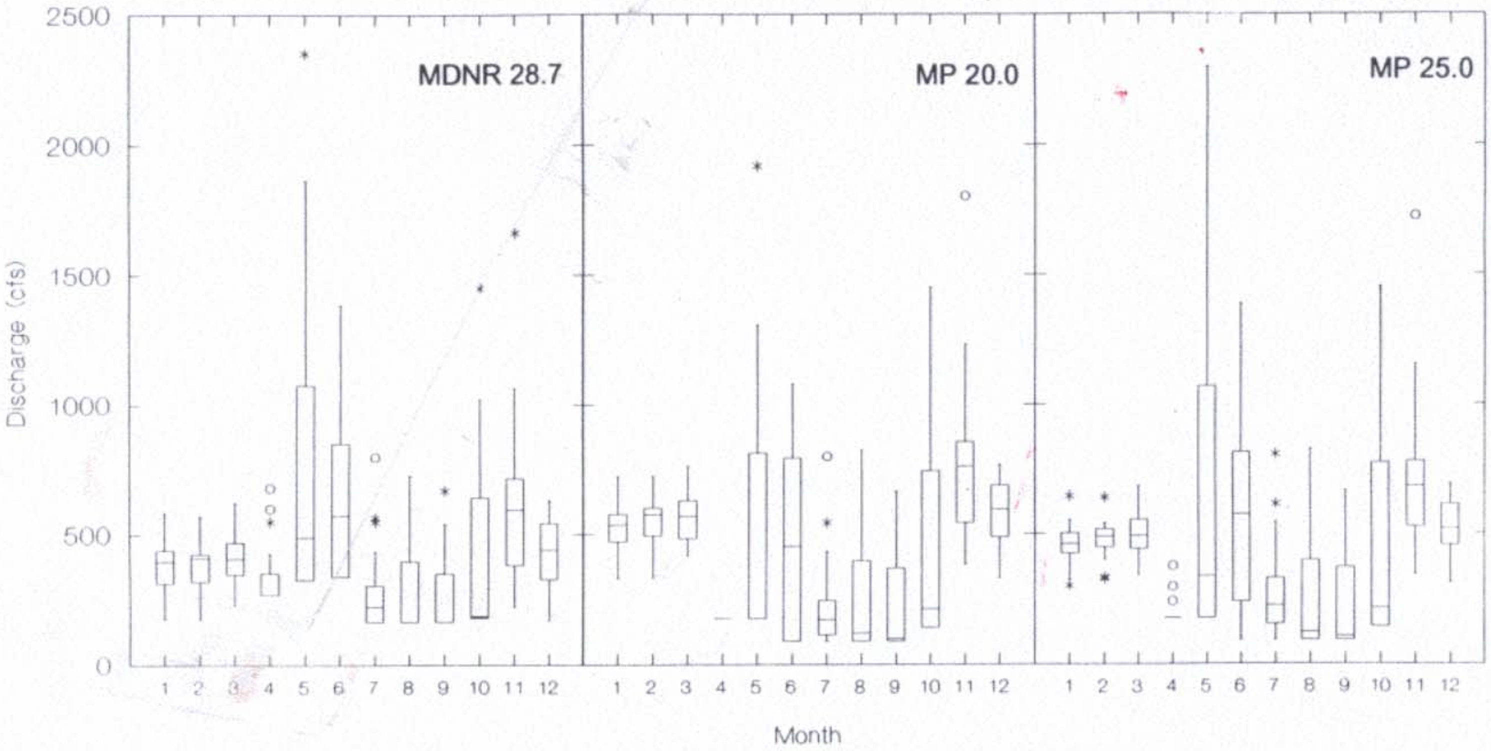
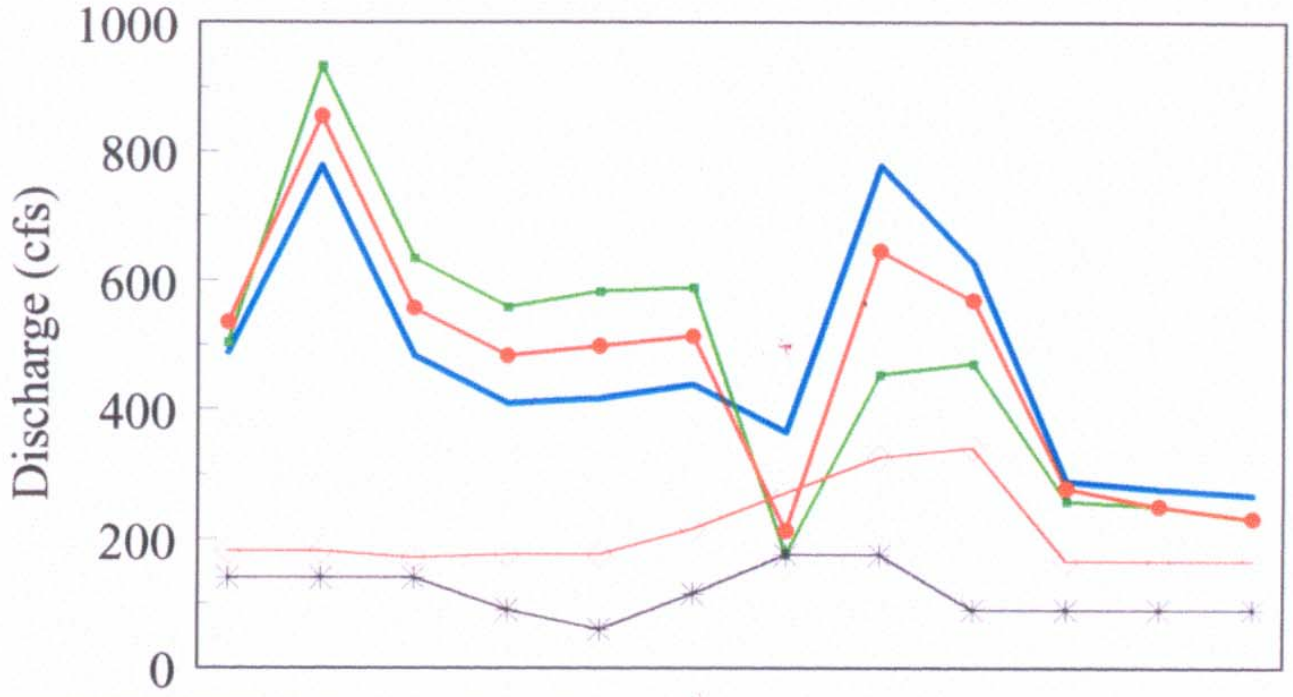


Figure 4. Box - whisker plots of monthly outflows from Island Lake reservoir under operating schemes proposed by MP and MDNR. Outflows are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevation of each proposal (MP - 20 and 25 feet, MDNR - 28.7feet), and the hydrologic inflow data for water years 1969 though 1979.



1969-1979	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR - 28.7' drawdown limit	488	777	482	408	416	438	364	777	627	288	276	267
MP - 20' drawdown limit	503	932	633	558	582	588	175	453	470	257	249	229
MP - 25' drawdown limit	534	853	556	482	497	512	211	644	568	277	249	230
MDNR - minimum flows	180	180	170	175	175	215	270	325	340	165	165	165
MP - minimum flows	140	140	140	90	60	115	175	175	90	90	90	90

Figure 5. Average monthly outflows and recommended minimum flows from Island Lake Reservoir for operating schemes proposed by MP and MDNR. Average outflow results are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevations of each proposal (MP - 20 & 25 feet, MDNR - 28.7 feet), and the hydrologic inflow data for water years 1969 through 1979. MP proposes operating Island Lake with drawdowns to 20 or 25 feet elevation. For testing, we assumed continuous operation under each drawdown limit.

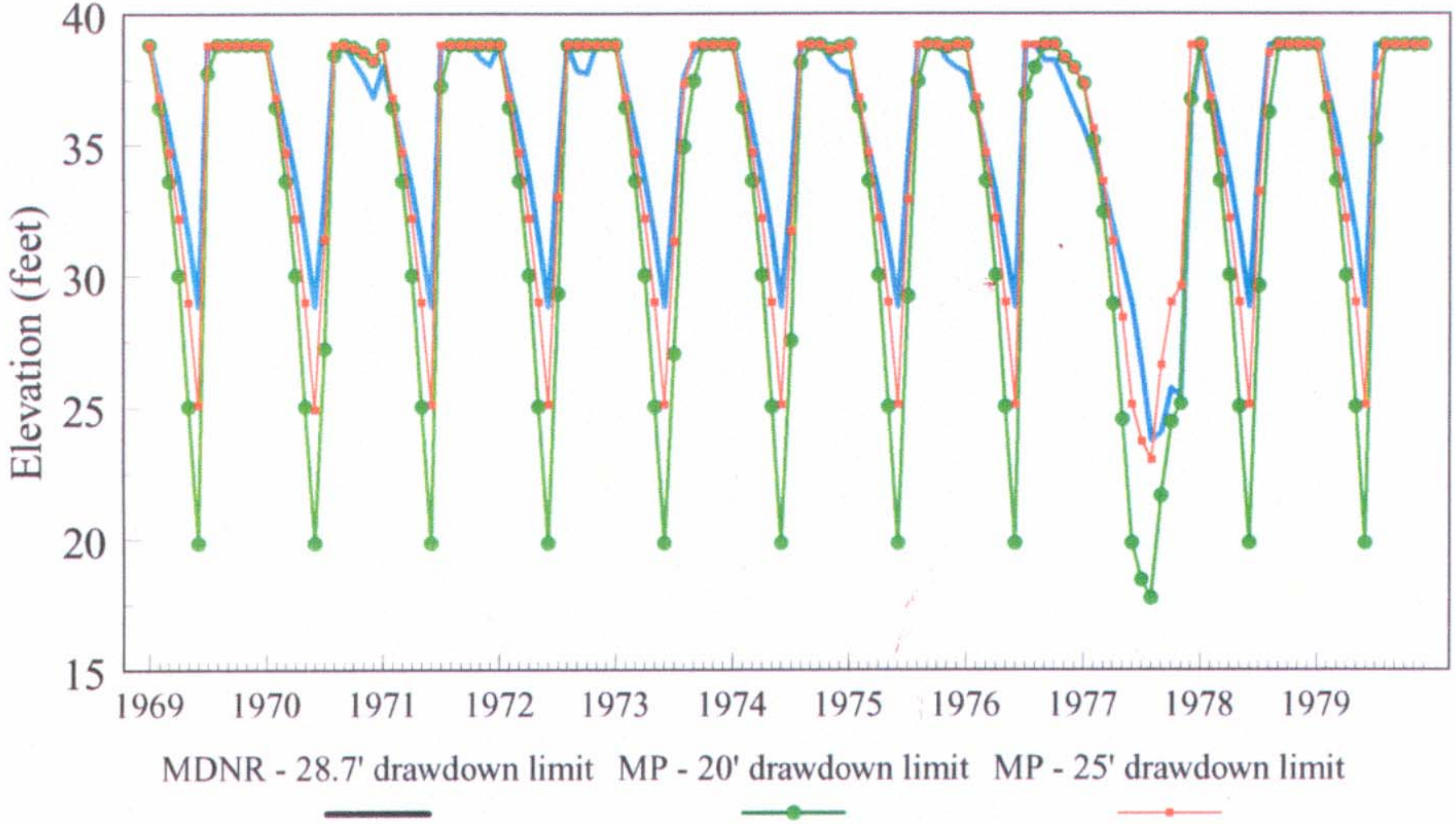
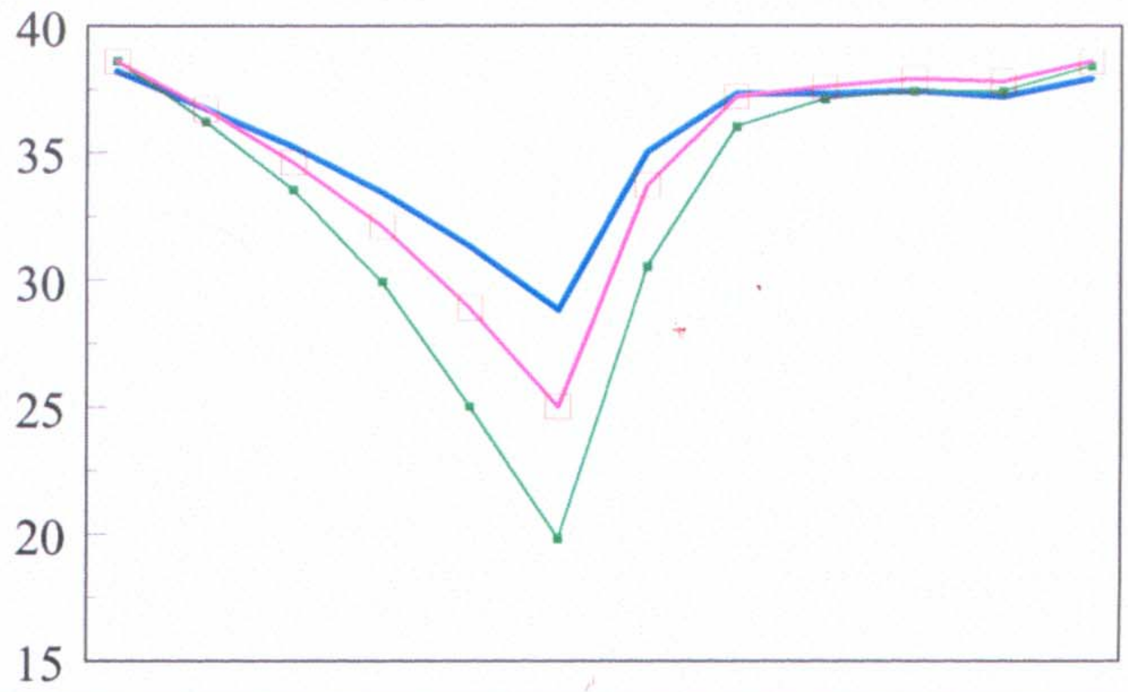
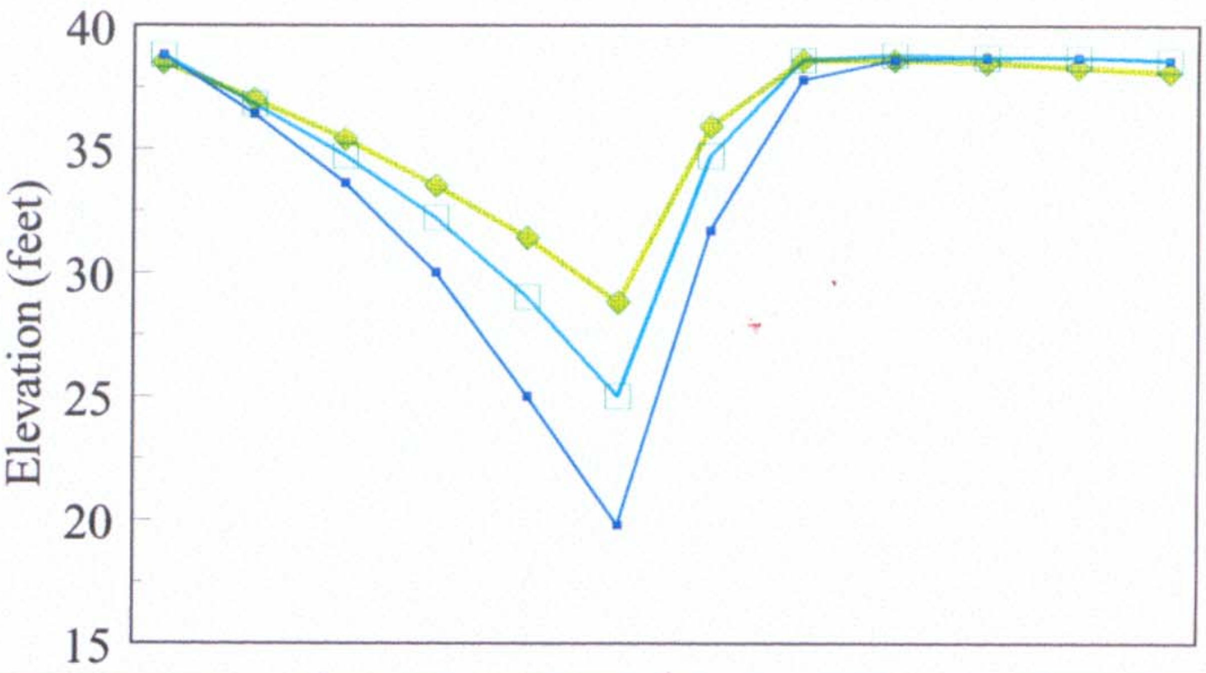


Figure 6. Comparison of Island Lake reservoir elevations resulting from operating schemes proposed by MP and MDNR. Results are produced from reservoir model developed by BEAK using hydrologic inflow data for water years 1969 through 1979. MP proposes operating Island Lake with drawdowns to 20 or 25 feet elevation. For testing, we assumed continuous operation under each drawdown limit. Results are displayed by water year, that starts with October and ends in the September of the named year.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR - 28.7' drawdown limit	38.2	36.7	35.2	33.4	31.3	28.8	35.0	37.3	37.3	37.4	37.2	37.9
MP - 20' drawdown limit	38.6	36.2	33.5	29.9	25.0	19.8	30.5	36.0	37.1	37.4	37.4	38.4
MP - 25' drawdown limit	38.6	36.7	34.6	32.1	28.9	25.0	33.7	37.2	37.6	37.9	37.8	38.6

Figure 7. Average monthly elevations of Island Lake Reservoir for operating schemes proposed by MP and MDNR. Results are produced from the reservoir model developed by BEAK using hydrologic inflow data for water years 1969 through 1979. MP proposes operating Island Lake with drawdowns to 20 or 25 feet elevation. For testing, we assumed continuous operation under each drawdown limit.



1969-1979, no 1977	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR - 28.7' drawdown limit	38.5	37.0	35.4	33.5	31.4	28.8	35.9	38.6	38.6	38.5	38.3	38.1
MP - 20' drawdown limit	38.8	36.4	33.6	30.0	25.0	19.8	31.7	37.8	38.6	38.7	38.7	38.6
MP - 25' drawdown limit	38.8	36.8	34.7	32.2	29.0	25.0	34.7	38.6	38.8	38.7	38.7	38.6

Figure 8. Average monthly elevations of Island Lake Reservoir for operating schemes proposed by MP and MDNR. Results are produced from the reservoir model developed by BEAK using hydrologic inflow data for water years 1969 through 1979, without the 1977 drought year. Water year 1977 was not included in the calculation of average monthly elevations to produce numbers typical of normal operations.

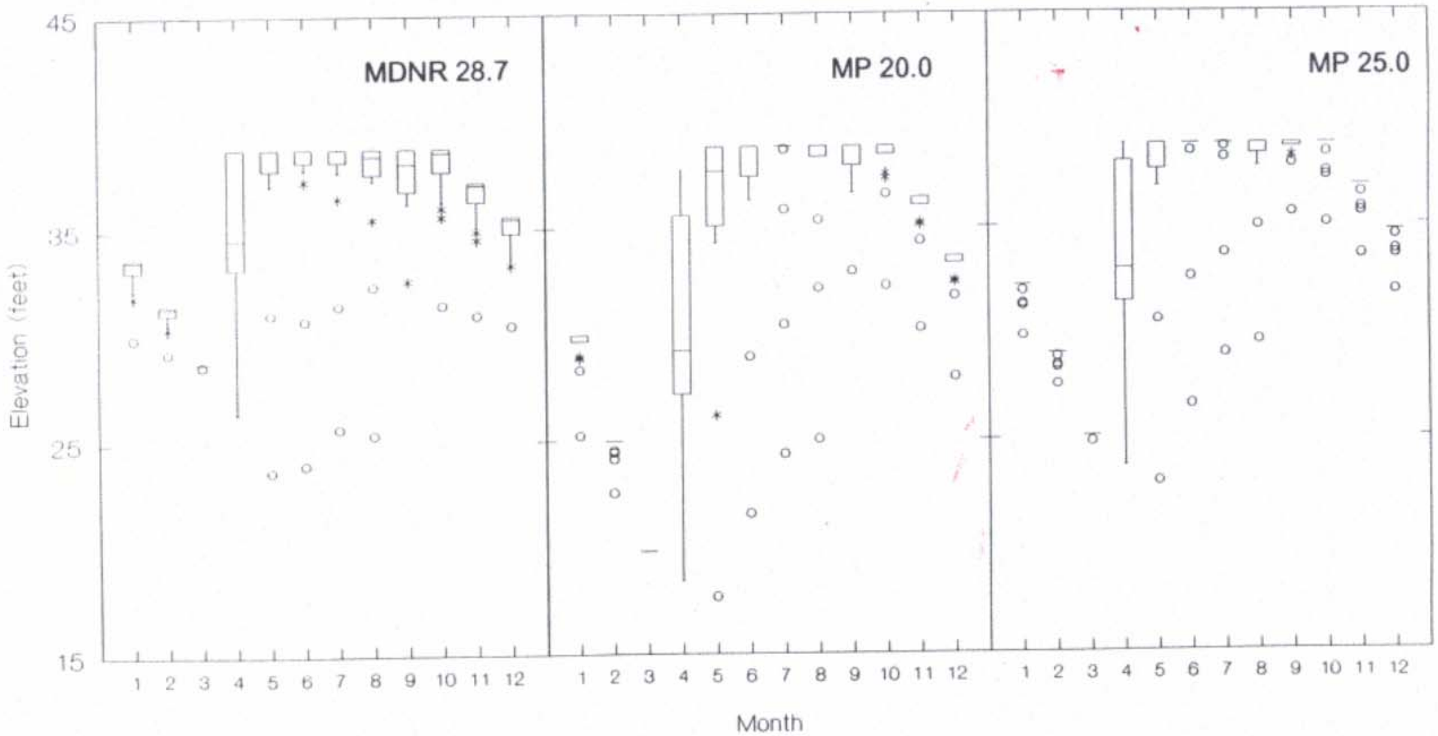


Figure 9. Box-whisker plots of monthly elevations from Island Lake Reservoir under operating schemes proposed by MP and MDNR. Outflows are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevations of each proposal (MP - 20, 25 feet, MDNR - 28.7 feet), and the hydrologic inflow data for water years 1969 through 1979.

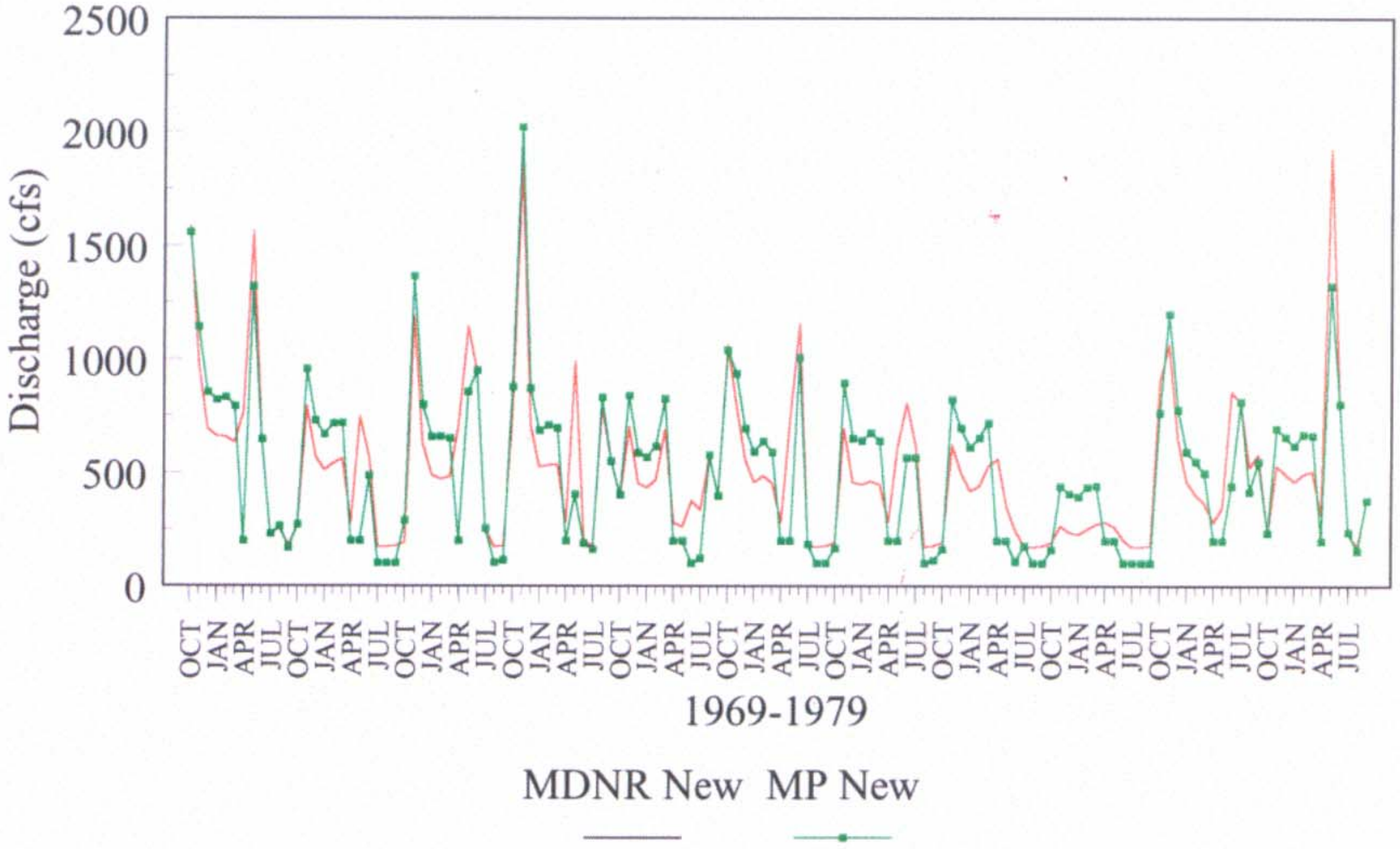


Figure 22. Comparison of Cloquet River flows resulting from operating schemes proposed by MP and MDNR for the reservoirs. Outflows are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations for each reservoir, maximum drawdown elevations of each proposal, and the hydrologic inflow data for water years 1969 through 1979. Results are displayed by water year, that starts with October and ends in the September of the named year.

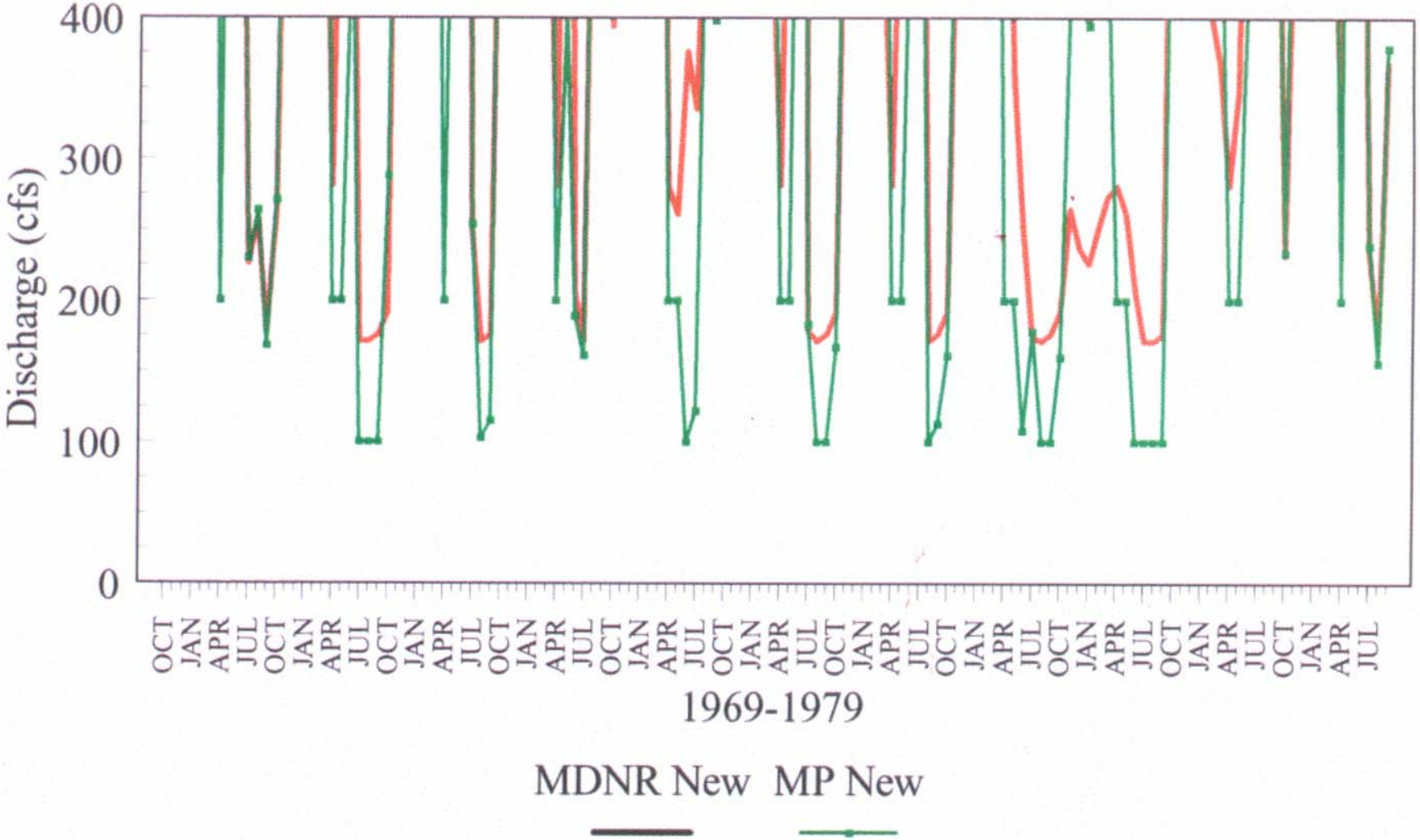
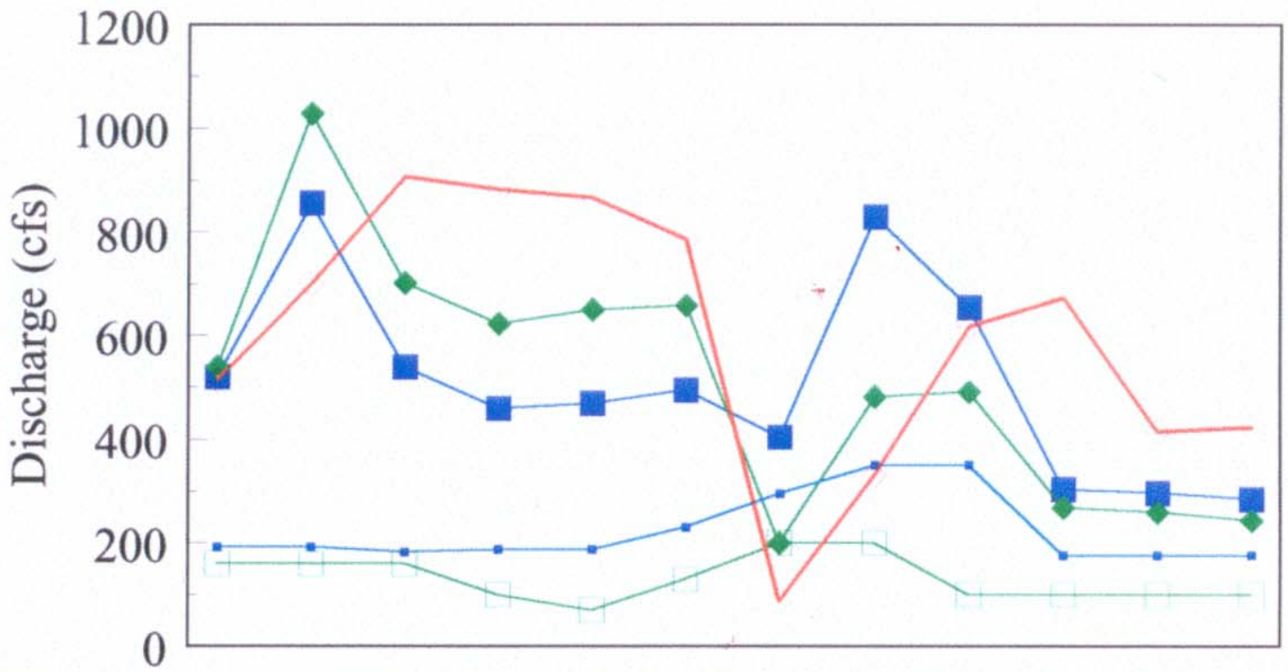


Figure 23. Close-up of flows in the Cloquet River using a smaller scale to show the timimg and magnitude of minimum flows for proposals by MP and MDNR, 1969 to 1979.



1969-1979	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Flows under MDNR scheme	520	855	539	459	469	495	404	829	654	303	296	284
Flows under MP scheme	539	1,028	702	623	650	658	200	482	491	268	259	243
MDNR minimums	192	192	182	187	187	230	295	350	350	175	175	176
MP minimums	160	160	160	100	70	130	200	200	100	100	100	100
Existing Flows (1978-1988)	514	700	906	881	865	786	88	331	618	673	415	423

Figure 24. Average monthly flows, existing conditions, and the recommended minimum flows for the Cloquet River produced by the operating schemes proposed by MP and MDNR. Average outflow results are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations for each reservoir, maximum drawdown elevations of each proposal, and the hydrologic inflow data for water years 1969 through 1979. Existing conditions were determined from 1978 to 1988 flow release records provided by Minnesota Power.

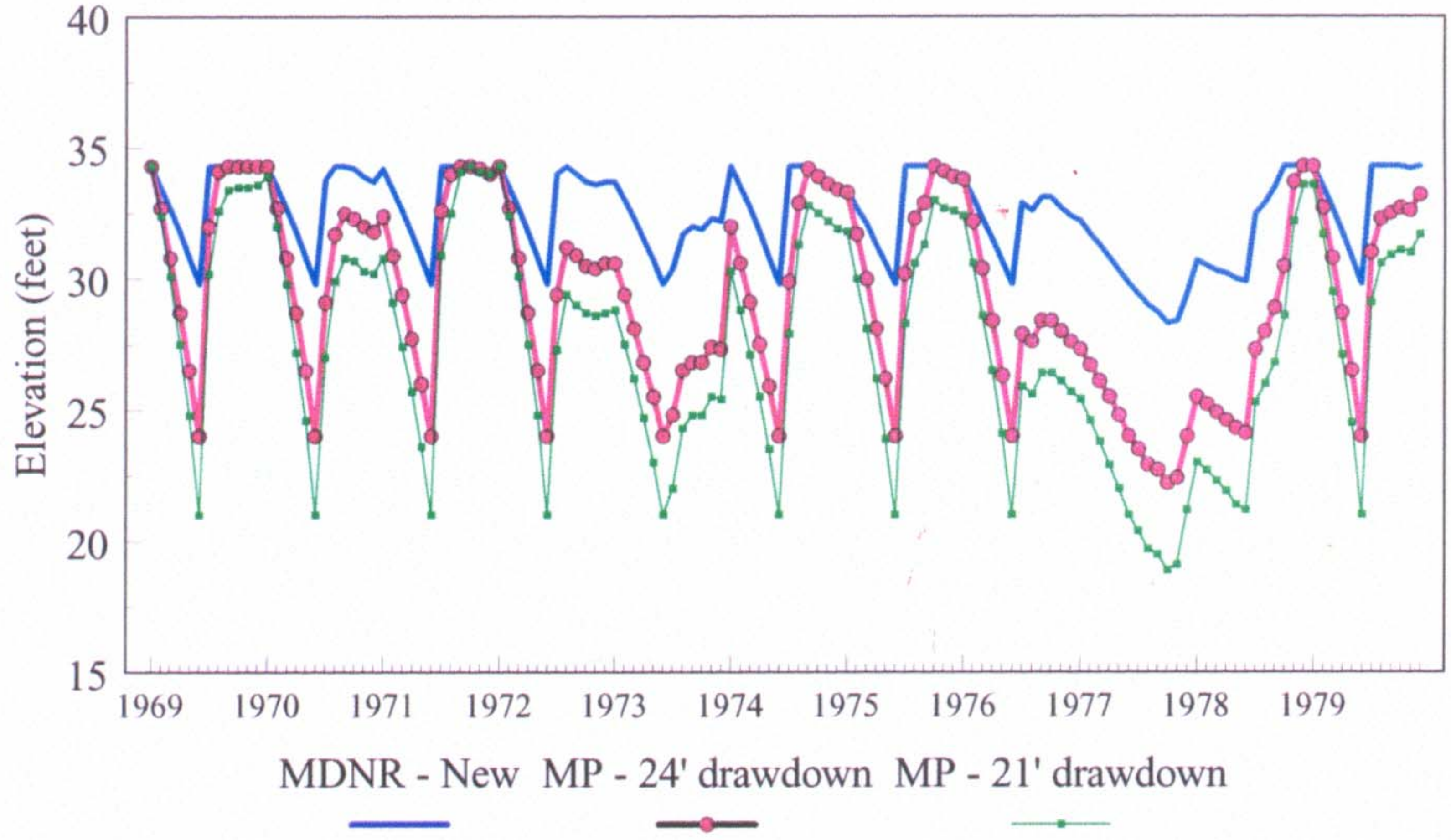
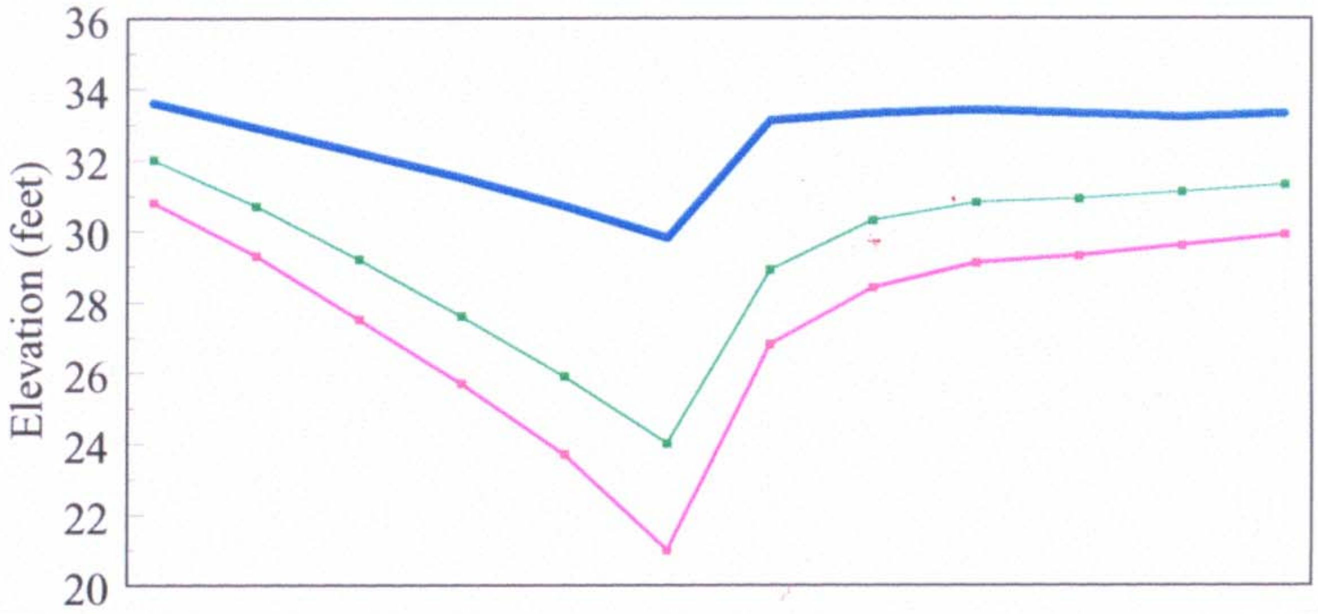


Figure 25. Comparison of Whiteface Reservoir elevations resulting from operating schemes proposed by MP and MDNR. Elevations are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevations of each proposal (MP - 21, 24 feet, MDNR - 29.8 feet), and the hydrologic inflow data for water years 1969 through 1979. Results are displayed by water year, that starts with October and ends in the September of the named year.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MNDR - 29.8'	33.6	32.9	32.2	31.5	30.7	29.8	33.1	33.3	33.4	33.3	33.2	33.3
MP - 21'	30.8	29.3	27.5	25.7	23.7	21.0	26.8	28.4	29.1	29.3	29.6	29.9
MP - 24'	32.0	30.7	29.2	27.6	25.9	24.0	28.9	30.3	30.8	30.9	31.1	31.3

Figure 26. Average monthly elevations of Whiteface Reservoir for operating schemes proposed by MP and MDNR. Elevations are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevations of each proposal (MP - 21, 24 feet, MDNR - 29.8 feet), and the hydrologic inflow data for water years 1969 through 1979.

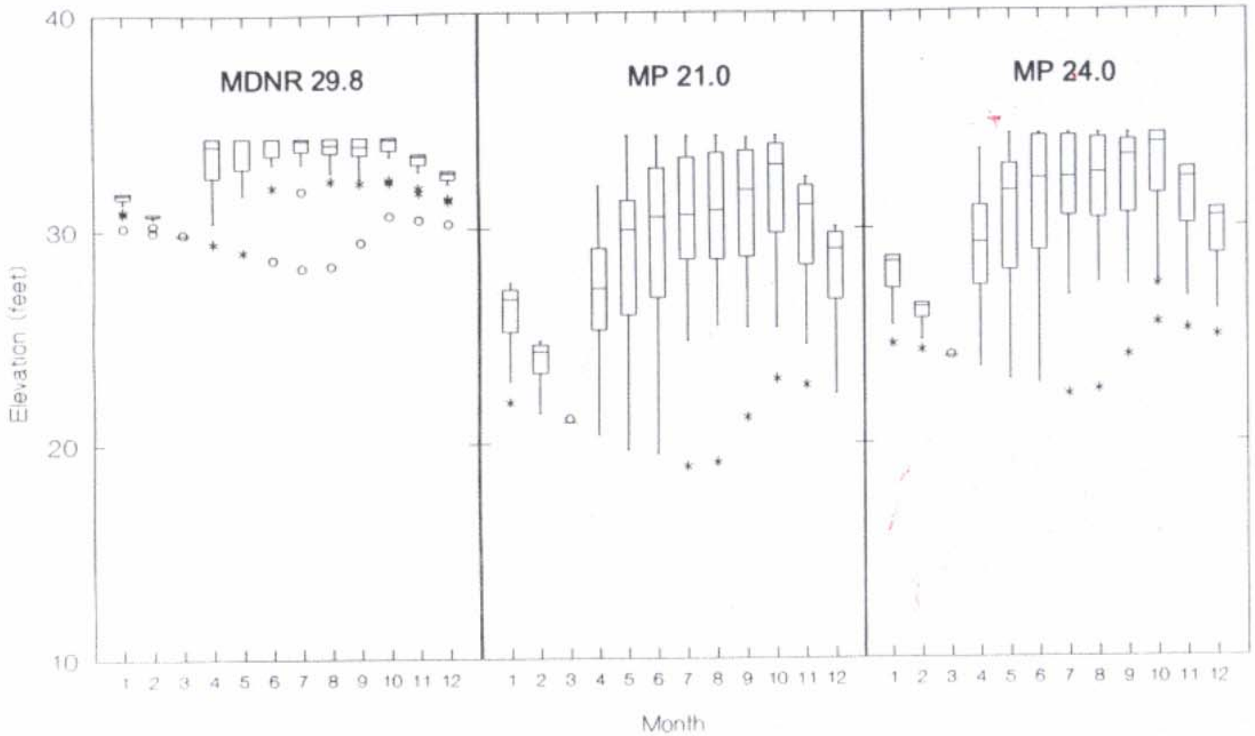
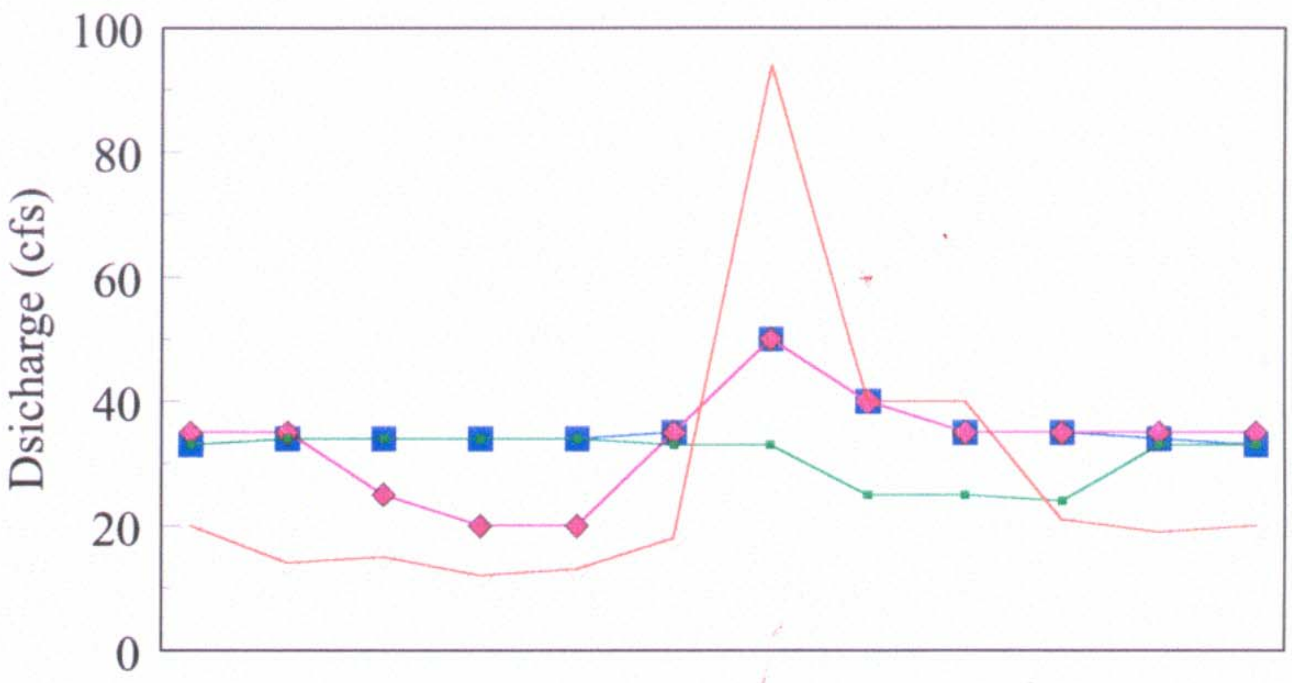
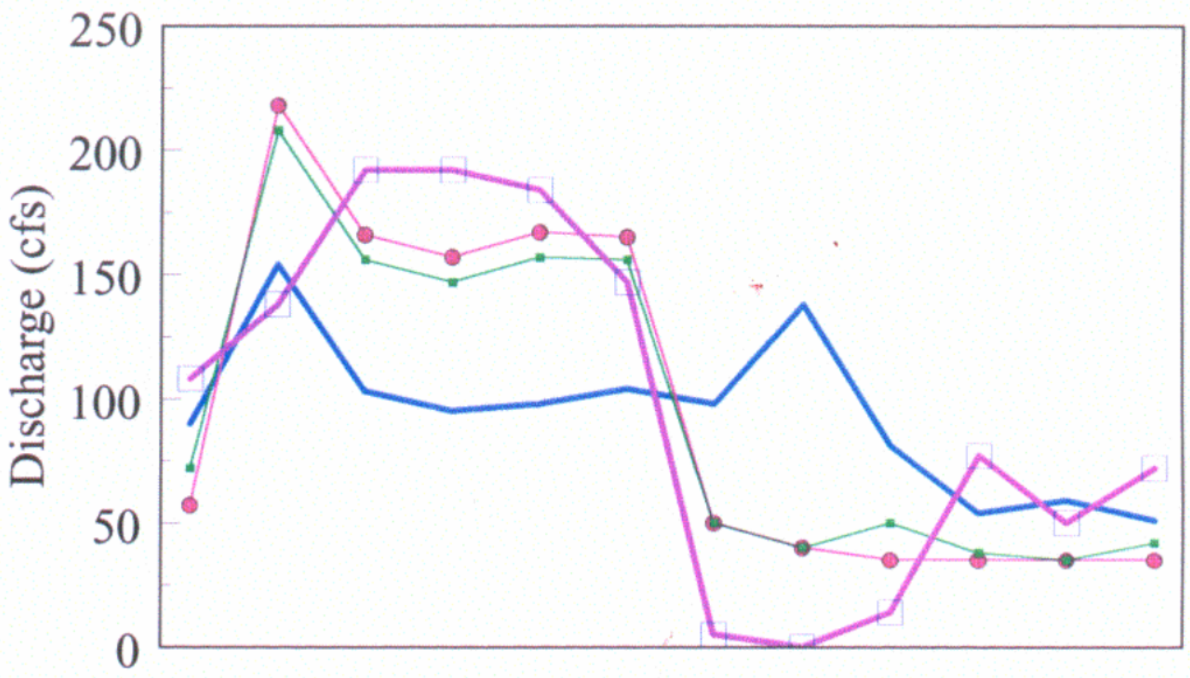


Figure 27. Box - whisker plots of monthly elevations of Whiteface reservoir under operating schemes proposed by MP and MDNR. Elevations are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevation of each proposal (MP - 21 and 24 feet, MDNR - 29.8 feet), and the hydrologic inflow data for water years 1969 though 1979.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR - New	33	34	34	34	34	35	50	40	35	35	34	33
MP - New	35	35	25	20	20	35	50	40	35	35	35	35
MDNR - Old	33	34	34	34	34	33	33	25	25	24	33	33
90% exceedence flows	20	14	15	12	13	18	94	40	40	21	19	20

Figure 28. Recommended minimum outflows proposed by MP and the MDNR for Whiteface Reservoir and 90% exceedence flows (low flows). Low flows are presented to show the relationship (timing, magnitude) of each proposal to natural conditions.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR - 29.8' drawdown limit	90	154	103	95	98	104	98	138	81	54	59	51
MP - 21' drawdown limit	57	218	166	157	167	165	50	40	35	35	35	35
MP - 24' drawdown limit	72	208	156	147	157	156	50	40	50	38	35	42
Existing Flows (1978-1988)	108	138	192	192	184	147	5	0	14	77	50	72

Figure 29. Average monthly outflows from Whiteface Reservoir for operating schemes proposed by MP and MDNR and existing flow conditions in the river. Average outflow results are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevations of each proposal (MP - 21, 24 feet, MDNR - 29.8 feet), and the hydrologic inflow data for water years 1969 through 1979. Existing conditions were determined from 1978 to 1988 flow release records provided by Minnesota Power.

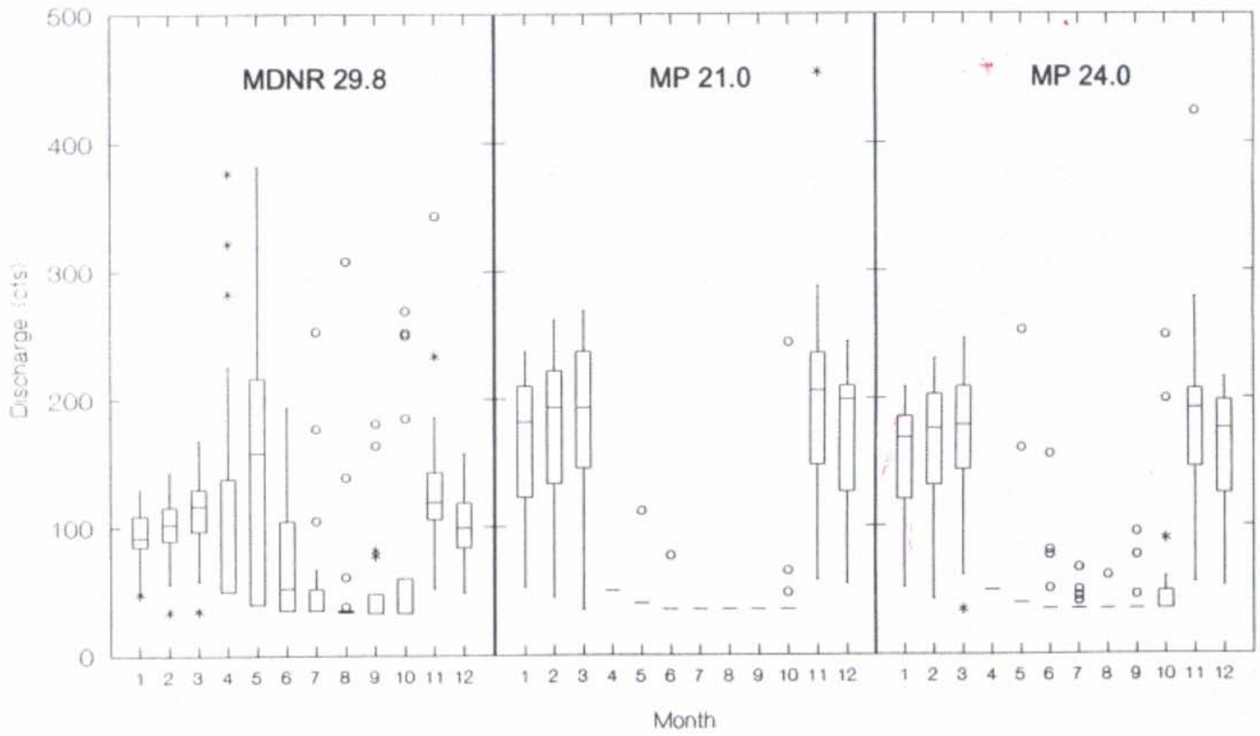
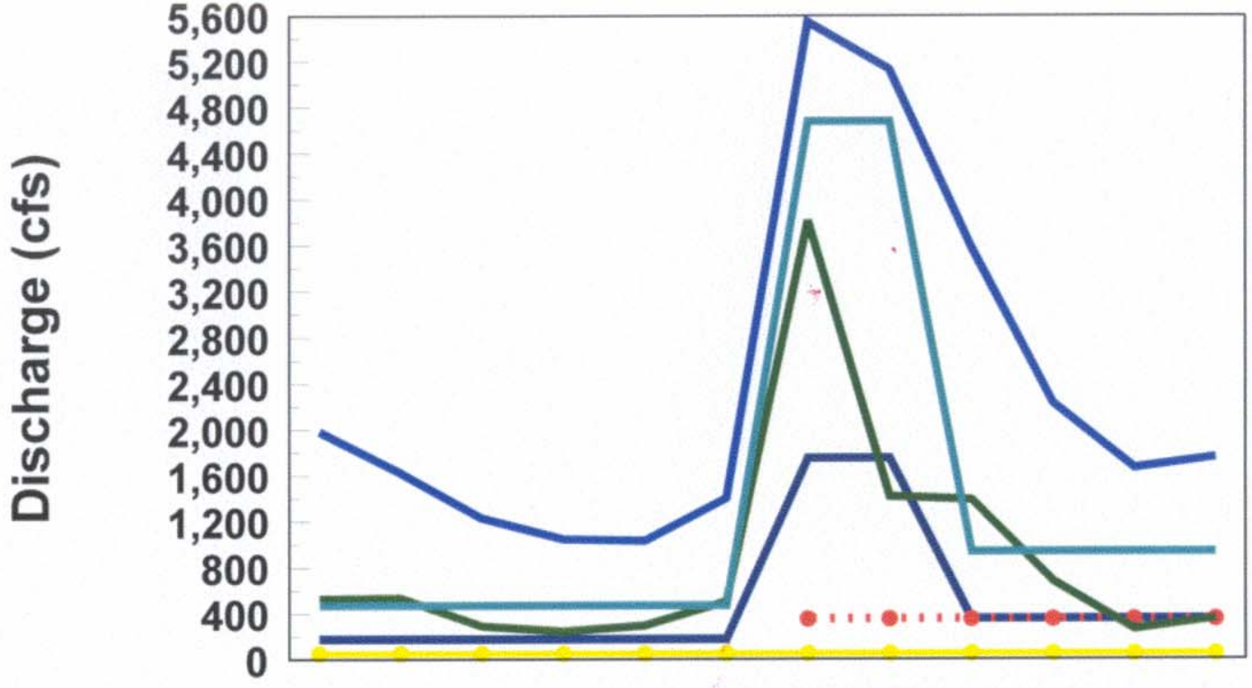
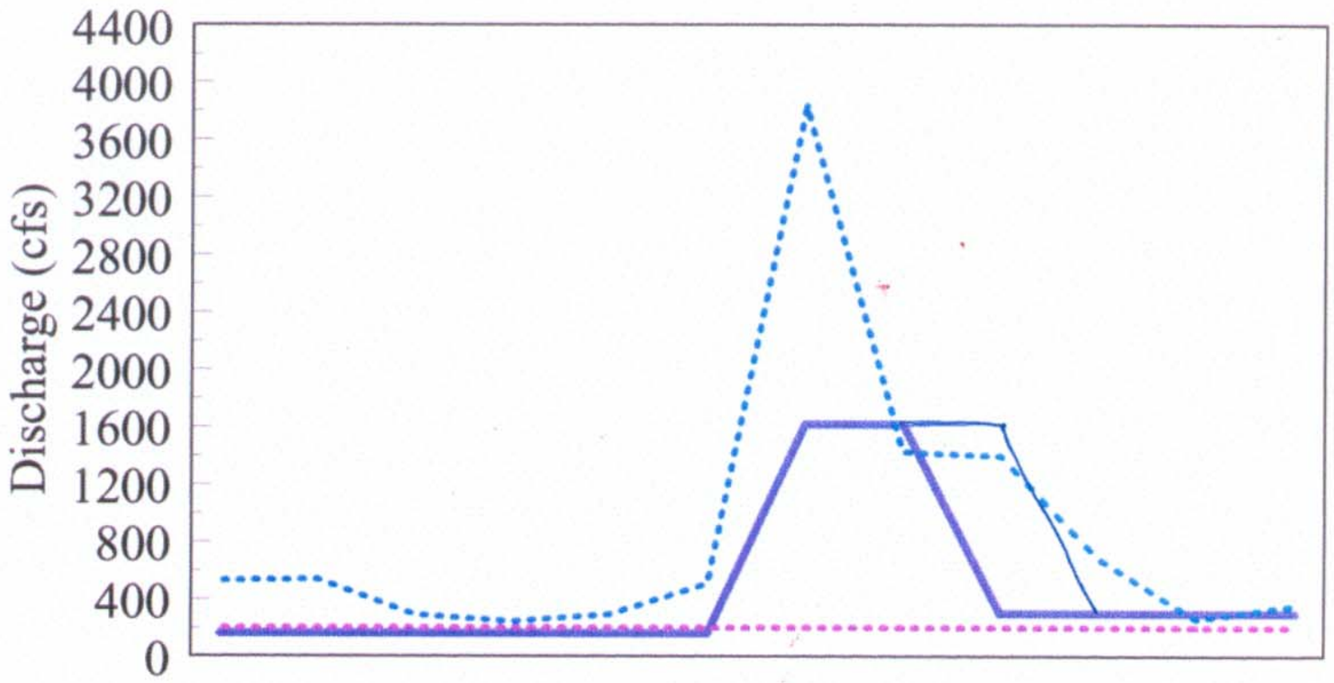


Figure 30. Box - whisker plots of monthly outflows from Whiteface reservoir under operating schemes proposed by MP and MDNR. Outflows are produced from the reservoir model developed by BEAK, and use the minimum outflow recommendations, maximum drawdown elevation of each proposal (MP - 21 and 24 feet, MDNR - 29.8feet), and the hydrologic inflow data for water years 1969 though 1979.



Month >>>	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
MDNR	175	175	175	175	175	175	1,750	1,750	350	350	350	350
MP Aesthetics							350	350	350	350	350	350
MP Base Flows	50	50	50	50	50	50	50	50	50	50	50	50
90% Exceedence Flows	526	533	289	244	295	504	3,813	1,416	1,390	677	261	355
Tennant Flows (mean=2338 cfs)	468	468	468	468	468	468	4,676	4,676	935	935	935	935
Mean Flow (at Scanlon)	1,982	1,625	1,231	1,047	1,033	1,402	5,543	5,131	3,580	2,229	1,666	1,760

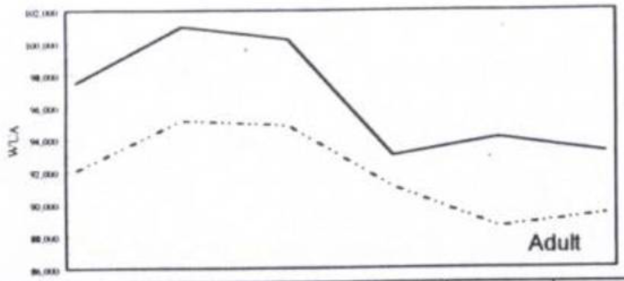
Figure 31. Recommended minimum outflows proposed by MDNR and MP for the bypassed reach below Thomson Reservoir, 90% exceedence flows (low flows), Tennant-derived flow recommendations, and mean monthly flows. Mean and low flows are presented to show the relationship (timing, magnitude) of each proposal to natural conditions. MP proposes a base flow of 50 cfs, and 350 cfs on weekends and holidays, during daylight hours, from Memorial Day to Labor Day. MP will also provide water that cannot be used by the turbines (>3060 cfs). Tennant flows are presented for comparison and are calculated from mean annual flows (2338 cfs).



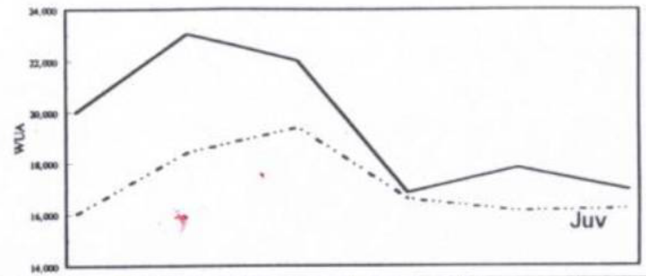
Month	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MDNR	160	160	160	160	160	160	1,615	1,615	~~300~~ 1615	300	300	300
MP	200	200	200	200	200	200	200	200	200	200	200	200
90% exceedence flows	529	536	290	245	297	508	3,834	1,423	1,398	681	262	357

Figure 32. Recommended minimum outflows proposed by MP and the MDNR for the bypassed reach below Fond Du Lac Reservoir and 90% exceedence flows (low flows). Low flows are presented to show the relationship (timing, magnitude) of each proposal to natural conditions. MP will also provide water that cannot be used by the turbines (>2000 cfs).

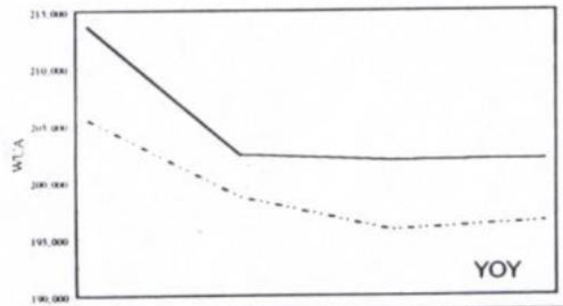
Appendix B
Times series Analysis of Habitat for Reservoir Operation Recommendations
St. Louis River (MN) Projects



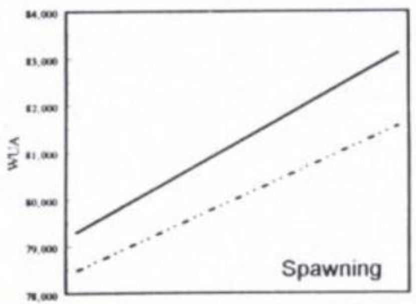
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	97,524	100,996	100,211	92,966	94,095	93,172
MP (20') - ·	92,075	95,161	94,851	91,032	88,539	89,313



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	19,985	23,037	21,990	16,845	17,822	16,941
MP (20') - ·	16,009	18,408	19,366	16,592	16,138	16,200

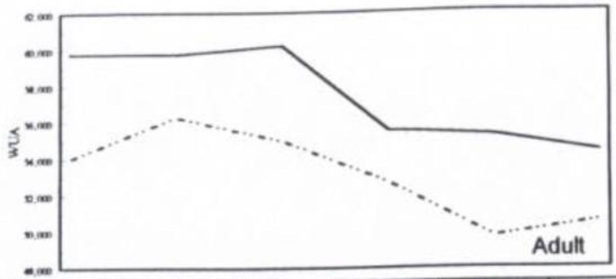


	Jun	Jul	Aug	Sep
MNDNR —	213,656	202,379	201,873	201,982
MP (20') - ·	205,445	198,666	195,738	196,509

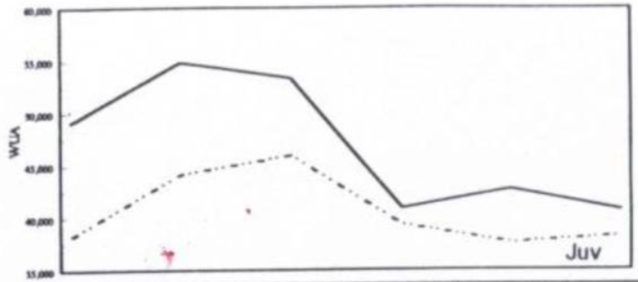


	Jun	Jul
MNDNR —	79,301	83,114
MP (20') - ·	78,487	81,557

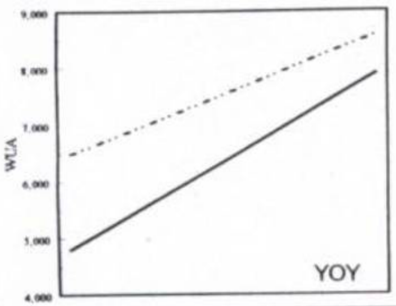
Figure 1: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning channel catfish using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



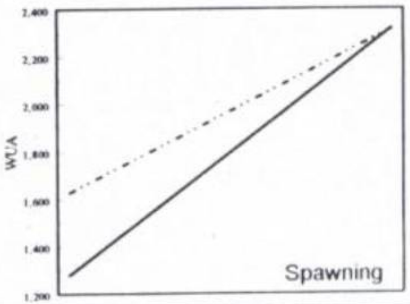
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	59,754	59,737	60,202	55,508	55,236	54,300
MP (20') - ·	54,014	56,266	54,963	52,663	49,704	50,534



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	49,110	54,746	53,255	40,805	42,614	40,675
MP (20') - ·	38,213	44,101	45,902	39,274	37,594	38,225

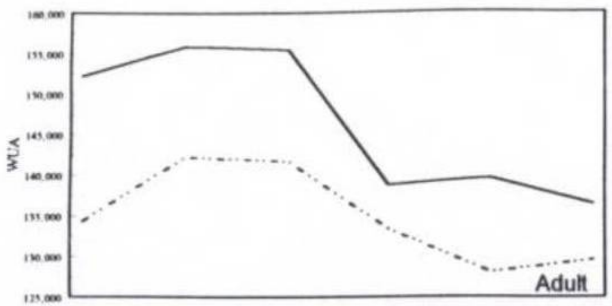


	Jun	Jul
MNDNR —	4,796	7,894
MP (20') - ·	6,472	8,574

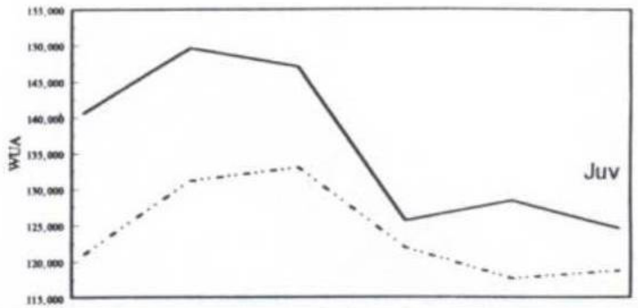


	Jun	Jul
MNDNR —	1,280	2,318
MP (20') - ·	1,626	2,317

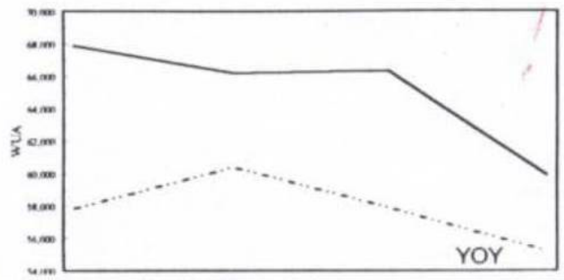
Figure 2: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning smallmouth bass using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	152,158	155,905	155,448	138,657	139,626	136,418
MP (20') ···	134,189	142,236	141,733	133,323	128,091	129,568

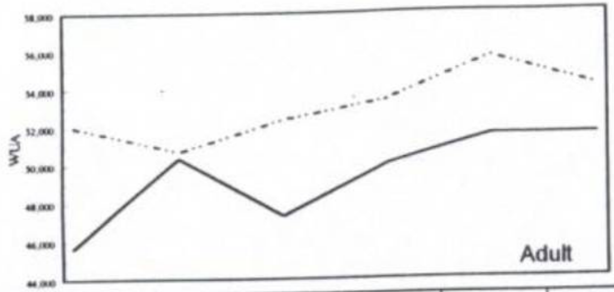


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	140,577	149,583	147,024	125,652	128,413	124,597
MP (20') ···	120,961	131,132	132,954	121,857	117,618	118,728

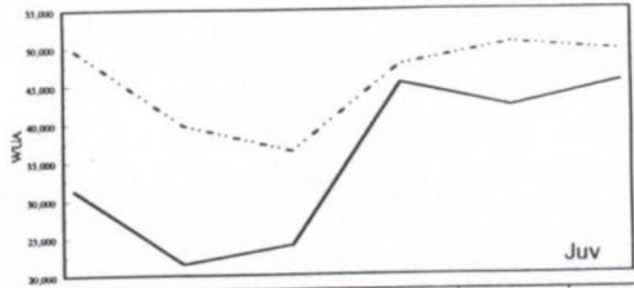


	Apr	May	Jun	Jul
MNDNR —	67,887	66,217	66,355	59,860
MP (20') ···	57,803	60,412	57,887	55,203

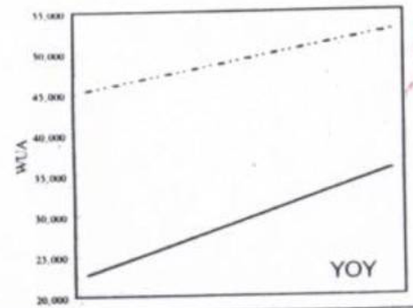
Figure 3: Comparisons of weighted usable area (WUA) for adult, juvenile and young-of-year brown trout using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



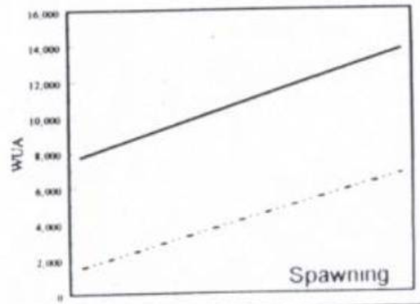
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	45,652	50,377	47,323	50,003	51,537	51,514
MP (20') -··	52,007	50,714	52,383	53,395	55,567	54,062



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	31,312	21,538	23,987	45,246	42,165	45,361
MP (20') -··	49,702	39,723	36,373	47,716	50,555	49,410

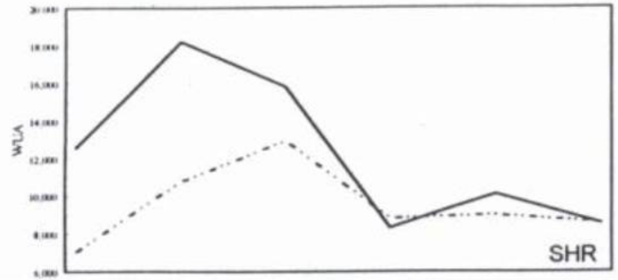


	Jun	Jul
MNDNR —	22,736	35,562
MP (20') -··	45,374	52,637

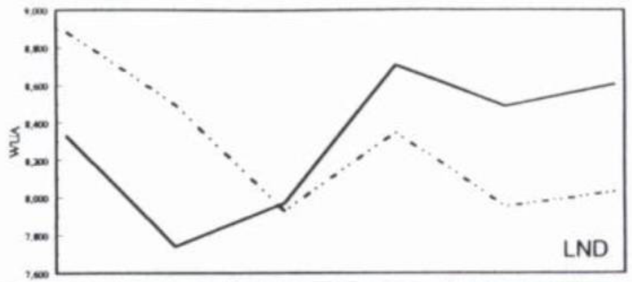


	Apr	May
MNDNR —	7,728	13,719
MP (20') -··	1,499	6,697

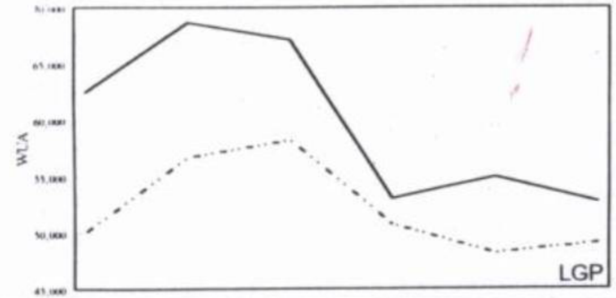
Figure 4: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning walleye using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	12,551	18,217	15,833	8,287	10,114	8,547
MP (20') - -	7,035	10,751	12,928	8,829	8,981	8,592

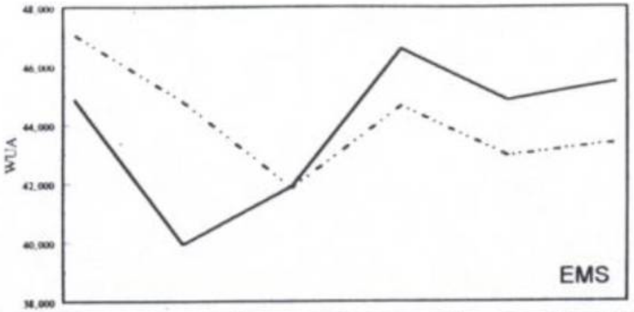


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	8,331	7,742	7,972	8,707	8,485	8,602
MP (20') - -	8,882	8,497	7,930	8,348	7,952	8,031

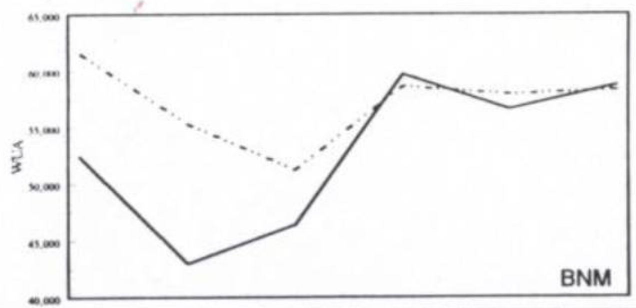


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	62,516	68,687	67,161	53,002	54,926	52,728
MP (20') - -	50,088	56,698	58,234	50,744	48,180	49,055

Figure 5: Comparisons of weighted usable area (WUA) for adult shorthead redhorse, adult longnose dace and adult logperch using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.

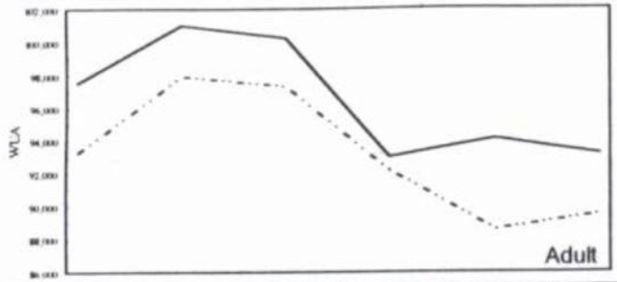


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	44,858	39,950	41,896	46,578	44,826	45,438
MP (20') - -	47,056	44,783	41,856	44,633	42,947	43,394

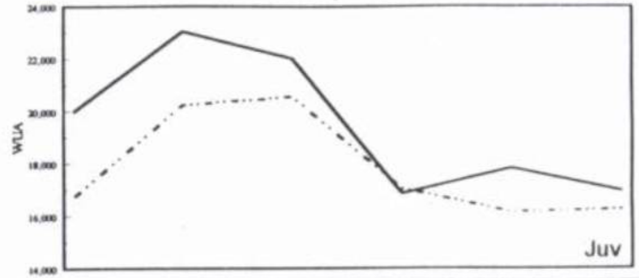


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	52,427	42,982	46,364	59,699	56,579	58,672
MP (20') - -	61,525	55,311	51,186	58,604	57,931	58,225

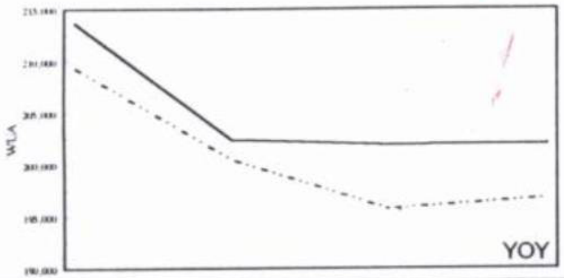
Figure 6: Comparisons of weighted usable area (WUA) for young-of-year emerald shiner and young-of-year bluntnose minnow using MNDNR and MP (20') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



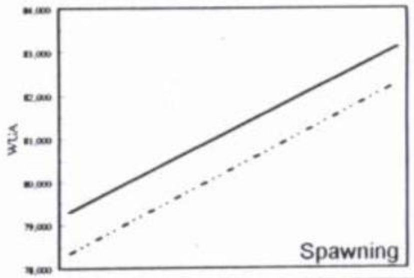
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	97,524	100,996	100,211	92,966	94,095	93,172
MP (25') --	93,229	97,916	97,286	92,135	88,539	89,517



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	19,985	23,037	21,990	16,845	17,822	16,941
MP (25') --	16,714	20,232	20,550	17,041	16,138	16,234

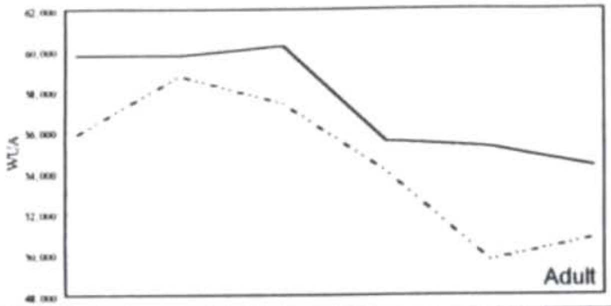


	Jun	Jul	Aug	Sep
MNDNR —	213,656	202,379	201,873	201,982
MP (25') --	209,299	200,461	195,738	196,749

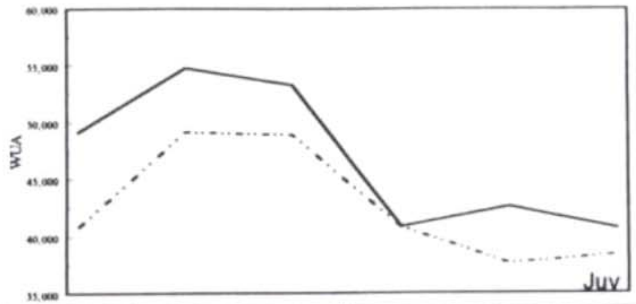


	Jun	Jul
MNDNR —	79,301	83,114
MP (25') --	78,333	82,261

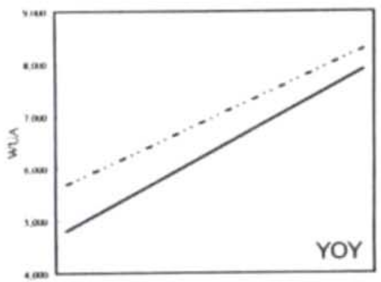
Figure 7: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning channel catfish using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



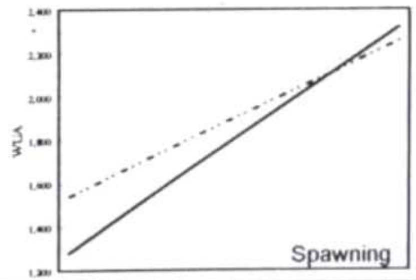
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	59,754	59,737	60,202	55,508	55,236	54,300
MP (25') - ·	55,840	58,711	57,359	54,025	49,704	50,756



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	49,110	54,746	53,255	40,805	42,614	40,675
MP (25') - ·	40,741	49,104	48,865	40,802	37,594	38,370

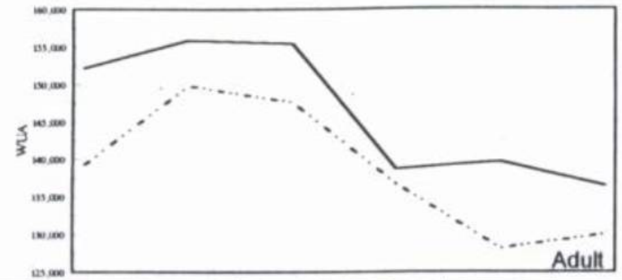


	Jun	Jul
MNDNR —	4,796	7,894
MP (25') - ·	5,689	8,281

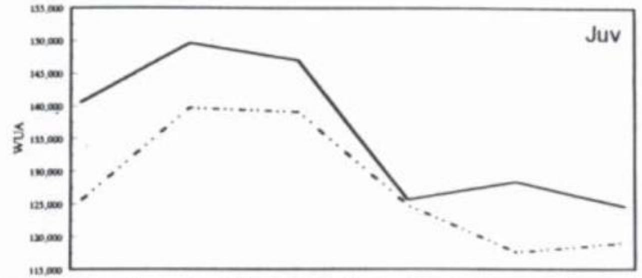


	Jun	Jul
MNDNR —	1,280	2,318
MP (25') - ·	1,539	2,254

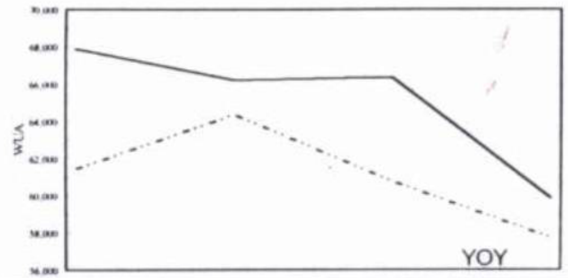
Figure 8: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning smallmouth bass using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	152,158	155,905	155,448	138,657	139,626	136,418
MP (25') -·	139,153	149,814	147,624	136,666	128,091	129,955

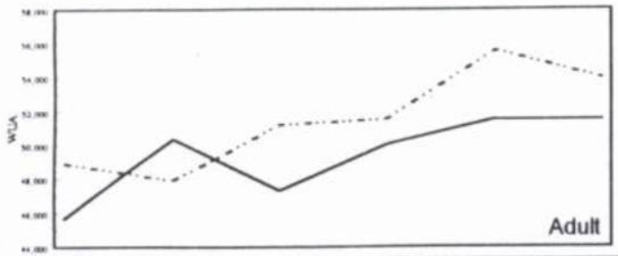


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	140,577	149,583	147,024	125,652	128,413	124,597
MP (25') -·	125,536	139,760	139,086	124,831	117,618	119,073

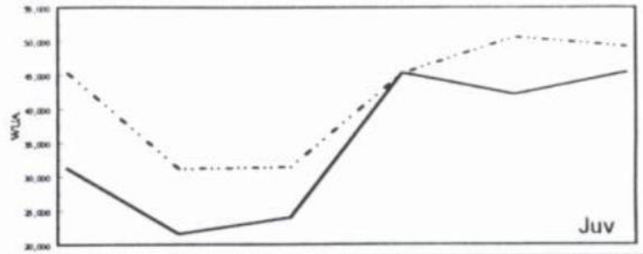


	Apr	May	Jun	Jul
MNDNR —	67,887	66,217	66,355	59,860
MP (25') -·	61,405	64,366	60,756	57,737

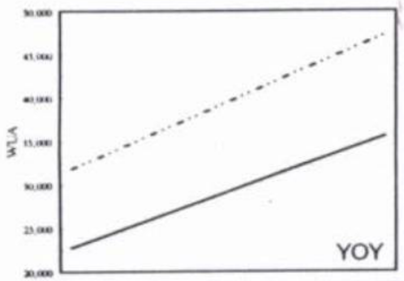
Figure 9: Comparisons of weighted usable area (WUA) for adult, juvenile and young-of-year brown trout using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



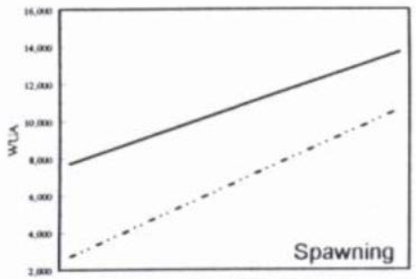
	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	45,652	50,377	47,323	50,003	51,537	51,514
MP (25') -··	48,926	47,900	51,204	51,484	55,567	53,949



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	31,312	21,538	23,987	45,246	42,165	45,361
MP (25') -··	45,489	31,096	31,396	45,157	50,555	49,195

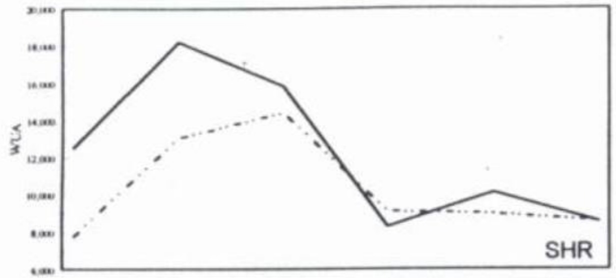


	Jun	Jul
MNDNR —	22,736	35,562
MP (25') -··	31,799	47,240

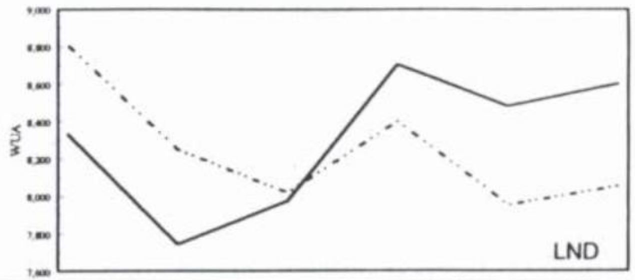


	Apr	May
MNDNR —	7,728	13,719
MP (25') -··	2,675	10,637

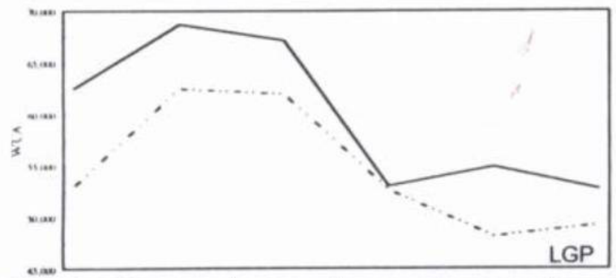
Figure 10: Comparisons of weighted usable area (WUA) for adult, juvenile, young-of-year and spawning walleye using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	12,551	18,217	15,833	8,287	10,114	8,547
MP (25') -·	7,693	13,099	14,425	9,099	8,981	8,602

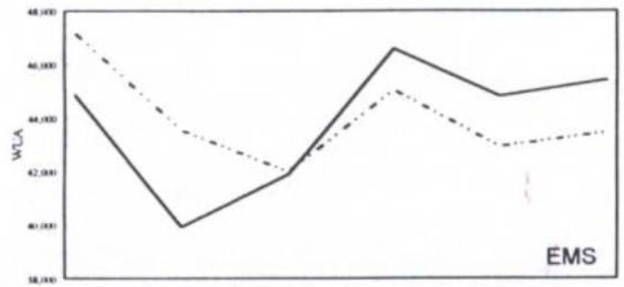


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	8,331	7,742	7,972	8,707	8,485	8,602
MP (25') -·	8,810	8,247	8,019	8,401	7,952	8,051

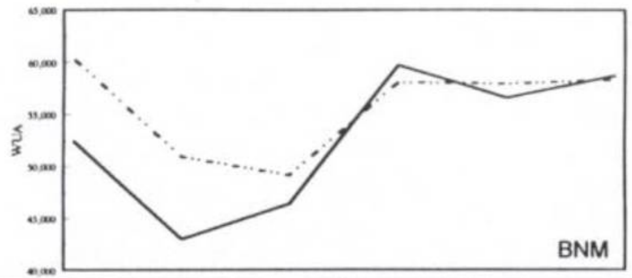


	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	62,516	68,687	67,161	53,002	54,926	52,728
MP (25') -·	52,992	62,447	61,949	52,636	48,180	49,255

Figure 11: Comparisons of weighted usable area (WUA) for adult shorthead redhorse, adult longnose dace and adult logperch using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	44,858	39,950	41,896	46,578	44,826	45,438
MP (25') - -	47,183	43,568	42,015	45,043	42,947	43,468



	Apr	May	Jun	Jul	Aug	Sep
MNDNR —	52,427	42,982	46,364	59,699	56,579	58,672
MP (25') - -	60,292	50,932	49,165	58,017	57,931	58,303

Figure 12: Comparisons of weighted usable area (WUA) for young-of-year emerald shiner and young-of-year bluntnose minnow using MNDNR and MP (25') scenarios. Comparisons are monthly averages for the Upper Cloquet site from 1969 to 1979.