Fish and Water Management Tool Project Assessments: Record of Management Strategy and Decisions for 2005

K.D. Hyatt and C. Bull

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, BC
V9T 6N7

2007

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2808

Fisheries and Oceans	Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques ques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits a l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2808

2007

FISH AND WATER MANAGEMENT TOOL PROJECT ASSESSMENTS: RECORD OF MANAGEMENT STRATEGY AND DECISIONS FOR 2005

by

K.D. Hyatt [1] and C. Bull [2]

[1] Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, BC V9T 6N7

[2] Glenfir Resources
465 Lower Bench Road
Penticton, BC V2A 8V4

© Her Majesty the Queen Right of Canada, 2007
Cat. No. Fs 97-4/2808E ISSN 0706-6473

Correct citation for this publication:

Hyatt, K.D. and Bull, C. 2007. Fish and Water Management Tool project assessments: Record of management strategy and decisions for 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2808: x + 37 p.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vii
RÉSUMÉ	ix
1.0 INTRODUCTION	1
1.1 Description of Water Management in the Okanagan Basin	2
1.2 Brief History of Water Management in the Okanagan Basin	4
1.21 Early Management Practices (1900-1950)	4
1.22 Development of an Operating Plan (1950-1999)	4
1.23 Development of the Fish and Water Management Tool (1999-2005)	6
2.0 METHODS	6
3.0 RESULTS	7
3.1 Pre-season Management Strategy	7
3.2 In-season Decisions	8
3.21 January 2005	8
3.22 February 2005	8
3.23 March 2005	10
3.24 April 2005	11
3.25 May 2005	13
3.26 June 2005	14
3.27 July 2005	14
3.3 Post-seasonal Analysis	15
3.31 Outcomes in Okanagan Lake	16
3.32 Outcomes in the Okanagan River and for sockeye at Oliver	16
4.0 DISCUSSION	20
5.0 RECOMMENDATIONS	21
6.0 GLOSSARY	24
7.0 LIST OF ACRONYMS	25
8.0 REFERENCES	25
9.0 APPENDIX 1. Abbreviated summary of “in-season” emails and teleconference calls during 2004-05.	29

LIST OF TABLES AND FIGURES

TABLES

Table 1	Preferred flows for sockeye salmon in the Okanagan River measured at Oliver.	4
Table 2	Members of the 2005 FWMTS Steering Committee and Operational Team.	8
Table 3	River Forecast Centre snow-water indices reported for the Okanagan-Kettle drainage in 2005.	15
Table 4	Record of discharge rates from Okanagan Lake Dam with decision rationale.	20
Table 5	Problems encountered in operational year 2005 and recommendations for avoiding similar problems in future.	21

FIGURES

Figure 1	Components of the Fish and Water Management Tools (FWMT) Decision Support System.	1
Figure 2	Map of the Okanagan basin.	3
Figure 3	Maximum, minimum, normal and current year snow-course water equivalents (mm of water) for the Okanagan-Kettle drainage.	12
Figure 4	Annotated figure of FWMTS performance indicators relative to seasonal changes to Okanagan Lake level.	17
Figure 5	Annotated figure of FWMTS performance indicators relative to seasonal changes to discharge at Penticton and Oliver.	18
Figure 6	All-year average estimate of water supply entering Okanagan Lake by week and the 2004-05 water year average by week.	19
Figure 7	Annotated figure of seasonal changes to discharge at Oliver.	19

ACKNOWLEDGEMENTS

This program was made possible by the dedication and hard work of many individuals:

- Richard Klinge first suggested a cooperative transboundary sockeye salmon restoration program that would marry the resources of Douglas County Public Utility District (DCPUD) with those of the Canadian Okanagan Basin Technical Working Group (COBTWG). COBTWG provided agency authority and expertise while DCPUD provided financial resources for the development of the Fish and Water Management Tools System (FWMTS). Rick and his supervisor, Bob Clubb, have encouraged and supported the program since its inception.
- Kim Hyatt suggested the concept of an interagency effort to build the FWMTS and has been the principal architect of its overall design, testing and operational deployment.
- Clint Alexander, of ESSA Technologies Ltd., was the main programmer for the FWMTS software and guided technical aspects of software development and support. Dave Marmorek and Calvin Peters of ESSA Technologies Ltd. also assisted in the early stages of sub-model design and development of the FWMTS software.
- Deana Machin, of the Okanagan Nation Alliance, ably administered the “umbrella” contract providing financial support to the program from DCPUD. We would also like to thank Pauline Terbasket for providing policy guidance on behalf of the ONA when required.
- Members of the FWMTS Steering Committee and Operational Team have been instrumental in developing and implementing the FWMTS. The members include (alphabetically):

    - Clint Alexander – ESSA Technologies Ltd. (ESSA)
    - Chris Bull – Glenfir Resources (Glenfir)
    - Cindy Harlow – Fisheries and Oceans Canada (DFO)
    - Gerri Huggins – BC Ministry of Environment (BC-MOE) Water Stewardship Division
    - Kim Hyatt – DFO, Science Branch
    - Ray Jubb – BC-MOE Water Stewardship Division
    - Deana Machin – Okanagan Nation Alliance (ONA)
    - Brian Symonds – BC-MOE Water Stewardship Division
    - Andrew Wilson – BC MOE-Fisheries Section
    - Howie Wright – ONA

- Dawn Machin ran simulations for the Retrospective Analysis which quantified potential benefits of the FWMTS.
- Brent Phillips and Brian Guy of Summit Environmental Services; and Kari Long, Howie Wright and Shayla Lawrence of the Okanagan Nation Alliance helped design and execute field surveys providing “real time” data feeds for operational application of FWMTS.

- Harvey Andrusak of Redfish Consultants assisted in development of the Okanagan Lake kokanee sub-model.
- Margot Stockwell ran simulations for the Retrospective Analysis, assisted Kim Hyatt with the FWMTS "Core Numbers and Traits" database development, temperature bias analyses, and numerous other tasks necessary to improve the model and support its application.
- Paul Rankin and Barry Hanslit helped design and then execute acoustics, trawl and lake survey work associated with assessing annual to seasonal production variations of juvenile sockeye salmon in the Okanagan River and Osoyoos Lake.
- Elmer Fast, Chair of the COBTWG facilitated meetings that lead to international acceptance of the model.
- Barry Rosenberger, DFO's Director of the B. C. Interior (BCI) Area encouraged his BCI fisheries habitat and management staff to share their time and experience with the FWMTS team.
- Members of the Wells Habitat Conservation Plan, Hatchery Committee provided the peer review required for the FWMTS to be accepted as a project capable of offsetting potential losses at Wells Dam. Members include:
    - Brian Cates – US Fish & Wildlife Service (US-FWS)
    - Rick Klinge – Douglas County Public Utility District (DCPUD)
    - Jerry Marco – Colville Confederated Tribes (CCT)
    - Kristine Petersen – National Oceanographic & Atmospheric Administration (NOAA)
    - Tom Scribner – Yakama Nation (YN)
    - Kirk Truscott – Washington Dept. of Fish & Wildlife (WDFW)

ABSTRACT

Hyatt, K.D. and Bull, C. 2007. Fish and Water Management Tool project assessments: Record of management strategy and decisions for 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2808: x + 37 p.

Annual freshet flows are stored in Okanagan Lake to reduce the risk of flooding, to reserve water for use in the dry summer months, and to provide suitable lake levels for kokanee and river flows for sockeye. To regulate the storage system, water managers predict the volume and timing of inflow well ahead of freshets and lower the lake to an appropriate level to accommodate incoming flows that pose a risk of flooding in spring. During the remainder of the year, water storage and release are carefully managed to meet a wide range of in-stream (e.g. fish production, ecosystem maintenance) and consumptive (e.g. irrigation) uses.

Estimating the storage requirement for any particular year, drawing down the lake in advance, governing outflows and trading off gains and losses among a wide range of interest groups requires intricate planning. An annual operating plan provides targets for lake levels and river flows at various times of the year but the volume of incoming water varies tremendously depending on snow-packs and climatic conditions which challenges both adherence to the annual plan and compliance with fisheries provisions of the Canada-BC Okanagan Basin Water Agreement (OBA). To help with the task, an operational team of fisheries and water management experts began testing the utility of a decision support system known as the Fish-and-Water Management Tools System (FWMTS). This report documents the use of FWMTS during its first year of operational deployment in 2004-05.

At the beginning of each month from January 2005 to June 2005, updated snow survey reports from the BC Ministry of Environment River Forecast Centre (RFC) were fed into the FWMTS. Snow reports included measurements of current snow-packs, recent climatic conditions and forecasts of what might be expected in terms of future runoff. FWMTS application facilitated integration of these data with real-time information on fish stocks and river and lake conditions to predict the impacts of a wide range of water storage and release scenarios on both fish and other water users. The most practical scenarios were reviewed by the Operational Team who then sought consensus on the best flow release pattern to satisfy multiple objectives.

Forecasting was difficult in 2005 because of erratic and unstable weather. The overall snow-pack for the basin was higher than normal entering the year but changed to well below normal as the season progressed. This temporal inconsistency was more than matched by spatial variations. Some watersheds within the Okanagan basin showed as little a 45% of their normal snow load while others were at 120%.

Temperatures remained anomalously high throughout the spring resulting in an extraordinarily early freshet. Inflows to Okanagan Lake between November and April

were 240% of normal. The large inflows simultaneously pushed Okanagan Lake elevations close to flood levels for riparian property owners and Okanagan River flows into the low end of the scour range for incubating salmon eggs and fry. The fact that minimal damages were incurred on both fronts is a tribute to the Tool and the team that used it.

By the end of the season both fisheries scientists and water managers expressed support for annual operational deployment of the FWMTS and the team approach to decision making. That said, there will always be room for improvement and this operational year provided a good opportunity to test the system and produce a list of recommendations to be considered for future years.

RÉSUMÉ

Hyatt, K.D. and Bull, C. 2007. Fish and Water Management Tool project assessments: Record of management strategy and decisions for 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2808: x + 37 p.

Les crues annuelles sont emmagasinées dans le lac Okanagan pour réduire le risque d'inondation, pour conserver l'eau et l'utiliser durant les mois d'été secs et pour assurer un niveau d'eau acceptable pour le kokani dans le lac ainsi qu'un débit fluvial adéquat pour le saumon rouge dans la rivière. Pour réguler le système de stockage, les gestionnaires des eaux prévoient le volume et le moment de l'apport d'eau bien avant les crues et ils font baisser le niveau du lac afin de réduire le risque d'inondation que suscite l'apport d'eau au printemps. Durant le reste de l'année, le stockage et l'apport d'eau sont gérés minutieusement pour satisfaire une vaste gamme de besoins sur place (p. ex. production de poissons et gestion des écosystèmes) et de besoins de consommation (p. ex. irrigation).

L'estimation des besoins de stockage pour une année donnée, la réduction du niveau du lac à l'avance, la régulation du débit sortant et l'établissement d'un compromis entre les gains et les pertes pour un vaste nombre de groupes d'intérêt nécessitent une planification complexe. Un plan annuel d'exploitation fournit des cibles de niveau d'eau et de débit fluvial pour diverses périodes durant l'année, mais le volume de l'apport d'eau varie considérablement en fonction des stocks nivaux et des conditions climatiques, ce qui met en doute le respect du plan annuel et la conformité aux dispositions sur les pêches de l'accord Okanagan Basin Water Agreement (OBA) conclut entre le Canada et la Colombie-Britannique. Afin de faciliter la préparation d'un plan, une équipe d'experts de la gestion des eaux et des pêches a commencé à étudier l'efficacité d'un système d'aide à la décision connu sous le nom de système d'outils de gestion des eaux et des poissons (Fish-and-Water Management Tools System - FWMTS). Le présent rapport porte sur l'utilisation du FWMTS durant la première année de son déploiement opérationnel en 2004-2005.

Au début de chaque mois, de janvier à juin 2005, des relevés nivo métriques mis à jour du Centre de prévisions des régimes fluviaux du ministère de l'Environnement de la C.-B. ont été enregistrés dans le FWMTS. Les relevés nivo métriques comprenaient des mesures récentes des stocks nivaux, les conditions climatiques récentes et des prévisions de l'écoulement futur. Le FWMTS a facilité le regroupement de ces données avec les données en temps réel sur les stocks de poissons et les conditions du lac et de la rivière afin de prévoir les effets d'une vaste gamme de scénarios de stockage et d'apport d'eau sur les poissons et d'autres utilisateurs de la ressource. L'équipe d'experts a examiné les scénarios les plus pratiques, et elle a ensuite cherché à obtenir un consensus sur le meilleur régime d'apport d'eau pour atteindre de multiples objectifs.

En 2005, l’établissement de prévisions a été difficile en raison des conditions météorologiques instables et erratiques. Le stock nival global pour le bassin de l’Okanagan était plus élevé que la normale au début de l’année, mais il a chuté au fil de la saison pour finalement atteindre une valeur bien inférieure à la normale. Cette variation dans le temps a été plus qu’égalée par les variations à l’échelle spatiale. Dans certains bassins hydrographiques du bassin de l’Okanagan, le stock nival était égal à seulement 45 % de la valeur normale, tandis que dans d’autres bassins, il atteignait 120 % de la normale.

La température est demeurée anormalement élevée durant tout le printemps, ce qui a donné lieu à une crue printanière très précoce. L’apport d’eau dans le lac Okanagan entre novembre et avril a été très supérieur à la normale (240 %). L’apport d’eau considérable a entraîné simultanément une augmentation du niveau du lac, ce qui a presque entraîné l’inondation de propriétés riveraines, et du débit de la rivière, ce qui a fait en sorte que la force d’affouillement du courant a été suffisamment élevée pour commencer à excaver les œufs de saumons en incubation et les alevins. Le minimum de dommages causés par l’augmentation de ces deux facteurs témoigne de l’efficacité du système et de la qualité du travail de l’équipe qui l’a utilisé.

Avant la fin de la saison, les spécialistes des pêches et les gestionnaires des eaux ont fait part de leur soutien à l’égard du déploiement opérationnel annuel du FWMTS et de l’approche d’équipe pour la prise de décisions. Cela dit, il y aura toujours place à amélioration, et cette année a constitué une bonne occasion de mettre le système à l’essai et de préparer une liste de recommandations à envisager au cours des prochaines années.

INTRODUCTION

Over the last century water management in the Okanagan has become increasingly difficult and complicated. Climatic conditions have become more erratic making water availability less predictable. Concurrently, rapid population growth and changing societal values have made water demands much harder to satisfy. To keep pace with these changes, the process for making water management decisions has had to change from a simplistic, one-person, “rule-of-thumb” method to a recently constructed decision support system known as the Fish-and-Water Management Tools System (FWMTS). Detailed descriptions of the design and functional properties of the FWMTS may be found in Alexander and Hyatt (2005) and Alexander et al. (2005) respectively. However, briefly the FWMTS consists of a set of quantitative, decision-support models and associated software designed to reduce uncertainties and improve the basis for water management decisions that influence annual production variations of fish. The FWMTS and associated software provide a multi-user, gaming environment based on a set of five, coupled, “state-of-the-science,” biophysical models (Figure 1). FWMTS software is accessed through standard web-browser technology from a common server at several locations by a consortium of natural resource managers representing private industry, First Nations, Fisheries and Oceans Canada and BC Ministry of Environment interests. The FWMTS operates in either retrospective mode on historical data sets or in operational mode on real time data to allow resource managers to identify optimal solutions to complex fish-and-water management decisions.

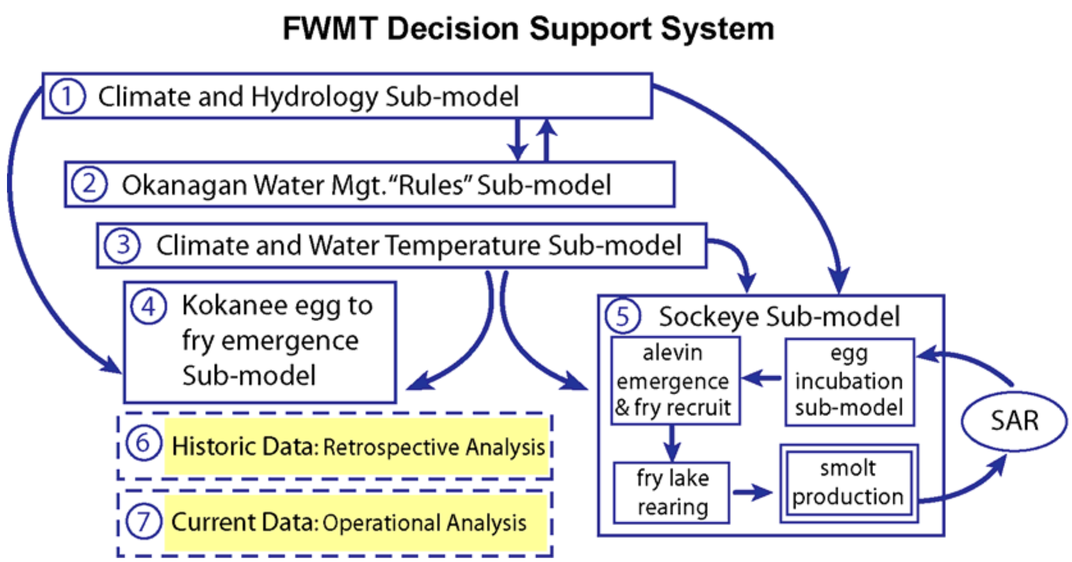

Figure 1. The FWMT System is a coupled set of 5 biophysical models of key relationships (among climate, water, fish and property) used to predict the consequences of water management decisions for fish and water users. FWMTS software allows system users to explore water management decision impacts in a “real-time”, operations-mode or in a retrospective-mode looking back on historic water supply, climate and fish years.

In the current report, we review the performance of the FWMTS during its first year of operational use in 2004-05. The report begins by reviewing the development of the water management strategy that the FWMTS is designed to assist and then documents the decisions made during the 2004-2005 water management year to fulfill that strategy.

DESCRIPTION OF WATER MANAGEMENT IN THE OKANAGAN BASIN

Most (about 80%) of the water entering the Okanagan Basin in Canada eventually flows through Okanagan Lake. A control dam at the lake outlet (Figure 2) near Penticton allows water to be stored during the spring runoff for release throughout the remainder of the year. Retention of freshet flows for later release can affect both the risk of flooding and the risk of water shortages in the summer and fall.

Making decisions on how much water to release and when is difficult because the volume of water entering the system varies from as little as 74 million cubic meters to as much as 1401 million cubic meters annually. Well ahead of freshet, water managers try to predict the amount of runoff based upon existing snow-packs and long term weather forecasts and bring down Okanagan Lake to accommodate predicted inflows. Failure to lower the lake sufficiently results in the flooding of lakeshore properties because Okanagan Lake Dam and the Okanagan River Channel are limited in size and often cannot release water fast enough to keep pace with spring-freshet inflows. Excessive drawdown, on the other hand, if coupled with limited inflows may result in the lake not reaching full pool and there not being enough water to meet irrigation, fisheries and recreation needs later in the summer.

Estimating the storage requirement, drawing the lake down to just the right level in advance, and trading off gains and losses among a wide range of interest groups is a complex task. The BC-MOE River Forecast Centre (RFC) in Victoria forecasts inflows while the Ministry's Engineering Section in Penticton decides the timing and quantities of water that must be released to adhere as closely as possible to the operating plan. Water managers are now assisted by fishery advisors from federal, provincial and First Nations fisheries authorities. The application of FWMTS and real-time data by an operations team are recent additions to a water management system that has been evolving over the last 100 years. A brief review of the last century of water management in the Okanagan provides a better appreciation of the progress that has been made.

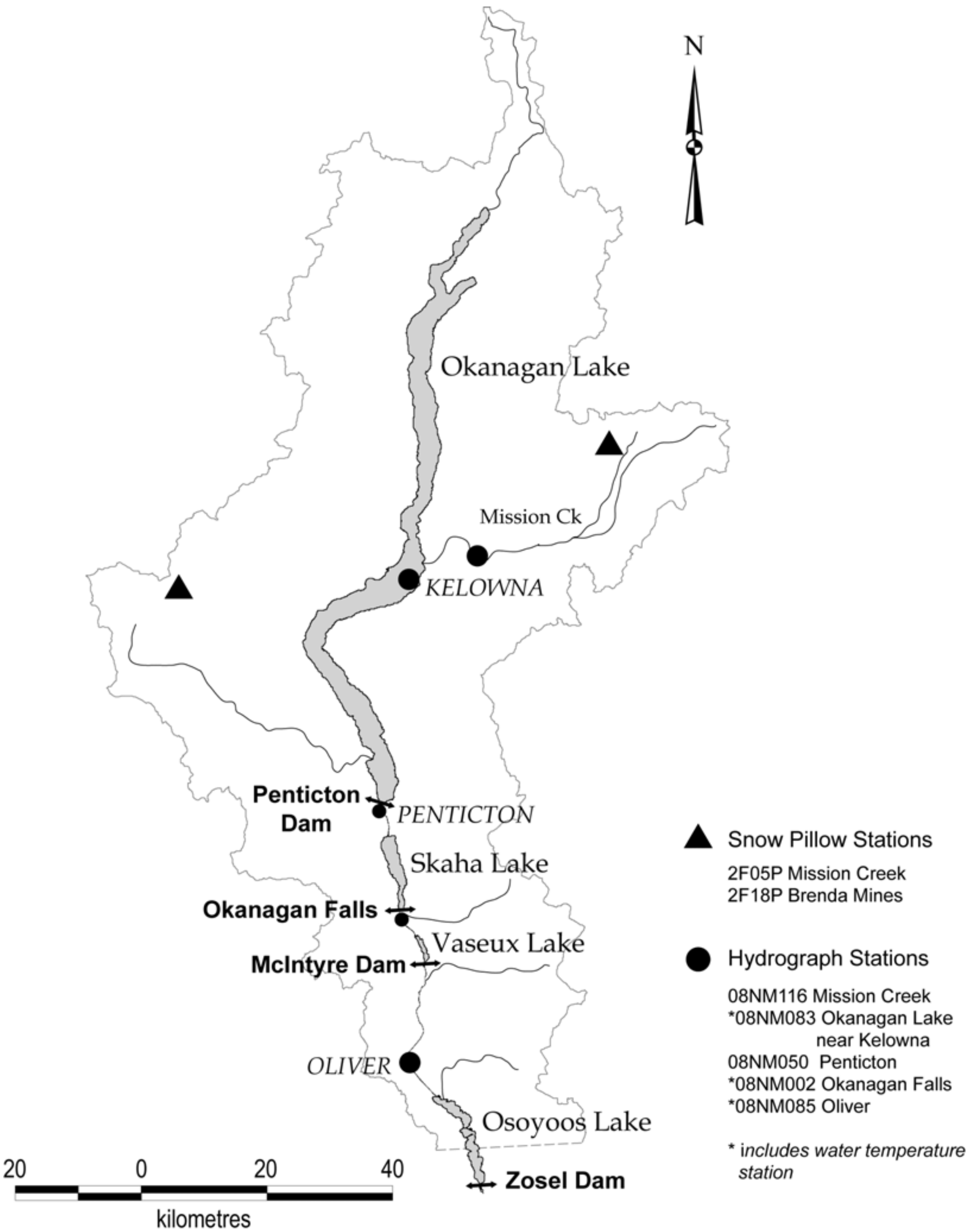

Figure 2. Map of major lakes, dam sites (Penticton, Okanagan Falls, McIntyre, Zosel), monitoring stations (snow-pack, water supply and temperature) and towns within British Columbia's Okanagan Basin (adapted from Hyatt et al. 2004)

BRIEF HISTORY OF WATER MANAGEMENT IN THE OKANAGAN BASIN

Early Management Practices (1900 – 1950)

Prior to 1950, water was managed strictly to promote economic development and population growth. Management strategies were limited to the control of floods and the supply of water for agriculture, domestic use and industry. Storage dams were constructed on a large number of lakes and tributaries to Okanagan Lake. Nearly all streams at lower elevations were channellized to allow for urban and agricultural development in the Okanagan Valley floodplain. Little, if any, consideration was given to fisheries, environmental or social needs.

Development of an Operating Plan (1950 – 1999)

The 1950's brought a general awareness of environmental needs and a departure from the belief that the only legitimate purpose of water was for out-of-stream uses that contributed to economic development (Hourston et al. 1954). The new paradigm led to the signing of the Canada – British Columbia Okanagan Basin Agreement (OBA) in 1969. This was "*a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth of the Okanagan Basin*" (O'Riordan, 1971). At the time, the Agreement was considered highly innovative, and for the first time it recognized the need to supply water for fish, wildlife, recreation and even aesthetics.

Many recommendations within the Agreement applied to fisheries. Some dealt with sockeye salmon and water management and these formalized "preferred" flows for fish in the Okanagan River (Table 1). Details may be found in Task 162 of the Canada/British Columbia Okanagan Basin Agreement (Anonymous 1973).

Table 1. Preferred flows for sockeye salmon in the Okanagan River at Oliver (Canada/British Columbia Report on the Okanagan Basin Agreement, 1973).

Sockeye Life History Stage	Dates	Preferred Range (m^3/sec)
Adult migration	August 1 - Sept. 15	8.5 - 12.7
Spawning	Sept. 16- Oct 31	9.9 - 15.6
Incubation	Nov. 1 - Feb 15	5.0 - 28.3 Incubation flows $\geq$ 50% spawning
Fry migration	Feb 16 - April 30	5.0 - 28.3

However, the OBA also added the qualifiers that:

- "*…water requirements for sockeye salmon in Okanagan River will be met in all years except consecutive drought years (years with inflows less than 247 million cubic metres).*" and
- "*After February 1, flood control requirements are given priority over fishery flows and it may, on occasion, be necessary to exceed the 28.3* m³/sec *upper limit*"

As part of the Okanagan Basin Study, Halsey and Lea (1973) discovered that 50% of the kokanee in Okanagan Lake spawned along the shore and they were genetically separate from creek spawners. This resulted in an additional recommendation: "…*to enhance spawning kokanee conditions over the fall and winter months, Okanagan Lake will be regulated such that, when possible, the lake level is not greater than 341.9 metres on October 15, subject to flow restrictions for sockeye salmon."* Subject to first meeting flow requirements for sockeye, this recommendation was later modified to limit lake drawdown to 15 cm between mid October (when Okanagan Lake kokanee spawning begins) and February 1 (when water levels are adjusted to accommodate spring inflows to Okanagan Lake). However, the recommendation anticipated that an additional 20 cm drop in Okanagan Lake levels would take place in February (O'Riordan et al.1997).

The operating plan devised during the Okanagan Basin Study was (and still is) considered reasonable and beneficial. It accommodates a wide range of interests and sets practical flows and lake levels for fish. Fishery losses have sometimes been substantial, but they have occurred not because the plan was inadequate but because it could not be followed. Water managers have had to try to control floods, meet rapidly rising demands for domestic and agricultural water, and also supply water for fisheries and recreation. In recent years, the task has been made even more challenging by extremes of climate that complicate forecasts of annual water yield and growth in human population, which has outstripped even the highest levels envisioned by the Okanagan Basin Study.

Low flows have occasionally destroyed sockeye, kokanee, mountain whitefish, rainbow trout and northern pikeminnow through desiccation and freezing (Hourston et al., 1954; Hansen, 1993; Peters et al., 1998; and Bruce Shepherd, DFO, Prince Rupert, pers. comm.). However, direct fishery losses from low flows are thought to have been rare, whereas losses due to high flows have been much more frequent and problematic. Bull (1999) reported that during the 15 year period 1982 to 1997 there was not a single year in which river flows were kept within the OBA recommended range. Furthermore in 10 of those 15 years maximum flows reached double the recommended level. Shepherd (1997) presented evidence that high flows (55 m³/sec) flushed 14% of the sockeye and kokanee fry out of the gravel prematurely and when flows reached 73 m³/sec, 43% of the fry were flushed prematurely.

<u>Development of the Fish and Water Management Tools System Program (1999 – 2005)</u>

Some deviations from the operating plan and recommended discharges under the OBA were unavoidable due to extremes of weather, but most of the time the plan could have been followed more closely if better field information had been available along with timely quantitative analysis to rapidly predict the consequences of a wide range of water release schedules for fish and other water users. This realization led to the development in 2001 to 2004 of the Fish-Water Management Tools Decision Support System.

The FWMTS program (Hyatt et al. 2001, Hyatt and Machin 2005) was developed by the COBTWG, which includes representatives from three parties (DFO, BC-MOE, ONA)) exercising authority over habitat and fisheries interests in the Okanagan. Financing was provided by Douglas County Public Utility District No.1 (DCPUD) the owner-operators of Wells Dam on the Columbia River near Pateros, Washington. DCPUD invested in the program to fulfill a requirement of their Federal Energy Regulatory Commission license to increase sockeye production by at least 100,000 smolts per annum (Rick Klinge, DCPUD, pers. comm.).

METHODS

The FWMTS was designed between 2001 and 2004 and by January, 2005 it was ready to be used on a routine basis (Hyatt and Machin 2005). A Steering Committee and Operational Team were formed, a user's manual was written (Alexander et al., 2005) and a decision making method and schedule were agreed to.

The "season" of concern spans the time period from mid-October of year n, when sockeye and kokanee spawn, to early November of year n+1 when salmon fry rearing is "complete". However, the FWMTS is particularly useful in assisting flow release decisions related to managing for flood risks between January and June of a given year.

Briefly, the method used to decide upon water releases and flows works as follows:

1. The BC-MOE-RFC conducts snow surveys at the beginning of each month from January through June with small additional surveys on May 15 and June 15. Within about 4 days of the survey a regional analysis is made of the snow-pack information to provide a prediction of the amount of water which will enter the system during subsequent months. Estimates are given for a low, average and high forecast. The information is generally available by the 4^{th} day of the month and may be entered into the FWMTS immediately. Without this information the FWMTS will not run.

2. By the 10^{th} day of the month, a member of the Operational Team enters the inflow forecasts into the FWMTS where it is combined with real-time field information (e.g. daily values for discharge and water temperature at various locations along the Okanagan River).

3. Between the 10^{th} and 15^{th} days of the month, individual Team members access the FWMTS through the internet and run a series of simulations or “scenarios” to predict the effects of various water release and storage patterns on fish (sockeye and kokanee salmon) or other water users. Scenarios that look useful are shared with the rest of the FWMTS Team via the internet (Alexander et al. 2005).

4. On the 15^{th} day of the month, Team members teleconference to discuss the scenario outcomes and come to a consensus on the preferred flow release plan for the next month.

5. In times of rapidly changing climatic conditions and inflow patterns, Team members run scenarios, confer and change release patterns whenever necessary – sometimes as often as every few days.

6. A “Post-season Analysis” is carried out to review the inflows that occurred, the forecasts that were predicted, the water release decisions that were made, and the results that were produced.

7. Finally the process is tracked and recorded in an annual report to provide a year-by-year record of the performance of both the FWMTS and associated management team.

RESULTS

PRE-SEASON MANAGEMENT STRATEGY (JANUARY 2005)

On January 20, 2005 a Steering Committee teleconference was held to discuss ways of putting the FWMTS into operation. The Ministry of Environment Water Management Section was not available, but other Committee members formed an Operational Team to use the tool in 2005 (Table 2). They also agreed upon the decision process steps outlined in the methods section of this report. The overall strategic objective for the year was to manage water storage and release decisions such that kokanee and sockeye salmon would be afforded protection (as per the OBA) from undue lake level or discharge variations without incurring significant increases of collateral damage to other “property interests” from flood or drought events.

Table 2. Members of the 2005 FWMTS Steering Committee and Operational Team

Agency	Steering Committee Representatives	Operational Team Representatives
BC Ministry of Environment Water Stewardship Division	• Brian Symonds • Gerri Huggins • Ray Jubb	• Brian Symonds
Fisheries and Oceans Canada	• Kim Hyatt • Cindy Harlow	• Kim Hyatt • Cindy Harlow
BC Ministry of Environment - Fisheries	• Andrew Wilson	• Andrew Wilson
Okanagan Nation Alliance	• Deana Machin • Howie Wright	• Howie Wright
ESSA Technologies Ltd.	• Clint Alexander (technical advisor)	• Clint Alexander (technical advisor)
Glenfir Resources	• Chris Bull (Project Coordinator)	• Chris Bull (Project Coordinator)

IN-SEASON DECISIONS

<u>January 2005</u>

The overall snow-water index provided by the RFC was 97% of normal for the Okanagan and Kettle drainage. Although this indicated a normal snow-pack, readings varied significantly between watersheds within the basin. Snow readings from the north and central Okanagan were normal or slightly above normal, whereas readings from the South Okanagan were significantly less than normal. Inflows to Okanagan Lake were far above normal during November and December, due to substantial precipitation and warmer than usual November-December temperatures.

Since conditions were nearly normal, snow-packs were still at an early stage of formation and runoff was not expected for some time, the FWMTS Team did not begin processing the data and running simulations. Instead they met through teleconference and devised the general strategy and decision making process outlined in the "Methods" and "Pre-season Management Strategy" sections above.

<u>February 2005</u>

Inflow forecasts made in early February were complicated by the erratic distribution of snow-packs. The overall Snow-water Index for the Okanagan basin was 90% of normal (Allan Chapman, BC-River Forecast Centre, pers. comm. 2005), but individual station readings varied from well below normal to well above normal. Stations at low elevations and stations on the south and west sides of the basin were showing dry conditions with snow-water values between 50% and 75% of normal. In the neighboring Similkameen basin, southwest of the Okanagan, snow-water-values were the lowest ever recorded. On the other hand, higher elevation stations and those situated along the north and east quadrants of the Okanagan exhibited higher readings than normal. Snow-water-levels at Silver Star Mountain were 100% of normal, and Mission Creek, the largest source of Okanagan inflow, was 133% of normal. To add to the confusion, climatic conditions were erratic. After a warm November and December, January was generally cooler. However, an intense Pacific frontal event in mid-January brought very warm temperatures and increased rainfall, resulting in low elevation snowmelt and above average seasonal runoffs.

Andrew Wilson obtained the RFC forecasts on February 11 and he and Dawn Machin ran several simulations on the FWMTS. Results of these FWMTS scenarios were shared over the internet and discussed by the Team during the February 15 teleconference. Water Management was not available but participating Team members agreed that RFC water yields were well within the range suggested to be readily manageable from an earlier FWMTS retrospective analysis (Hyatt and Alexander, 2005). Consequently, a release rate of 22 – 25 m^3/s was recommended as optimal for existing conditions until new forecast information was available or conditions changed significantly (Appendix 1.).

The Team decision was based upon:

- FWMTS simulations that showed benefits to sockeye salmon from staying below the threshold flows for scouring of salmon redds (30 m^3/s measured at the Oliver Station) in the absence of any imminent risk of flooding.
- Warnings from the RFC that the south and west Okanagan may experience low summer flows.
- Reports from Washington State climatologists (conveyed by Dr. Phil Mote at University of Washington) that dry conditions at lower elevations throughout the southeast Cascades would result in lower than normal inflows to low elevation lakes.

Water Management was not available for the February teleconference but were informed of the Team decision by email, telephone and individual conversations. Their decision, contrary to the advice of the FWMTS Team, was to increase release rates to 30 m^3/s based, according to Ray Jubb, on the following observations (Appendix 1):

- Okanagan Lake inflows were presently higher for this time of year than they had been since 1997, when a record water yield was experienced accompanied by extreme risk of flooding,
- Okanagan Lake levels were high,

- NE quadrant snow-packs were high,
- soils and aquifers in the watershed were assumed to be saturated from winter rain and early melting of low elevation snow-pack,
- Okanagan Lake Dam was not fully operational and this might hamper the ability to release more water later on when inflows increased,
- Water Management had been denied access to McIntyre Dam by the private landowner and were unable to control Vaseux Lake levels.

Fisheries representatives on the Team continued to believe that flows of 30 m^3/s were excessive because they:

- posed high risks of scouring sockeye eggs or alevins at Oliver,
- provided an unnecessarily high level of flood protection given RFC snow-pack data , FWMTS scenarios, and projections for sub-average snow-packs throughout much of the BC southern interior and Washington State;
- might not allow sufficient storage in the event of drought conditions to provide the water needed to minimize summer temperature and oxygen problems in Osoyoos Lake.

The FWMTS process promoted increased dialogue between Fisheries and Water Management representatives and the Team was determined to reach a mutually agreeable release rate. With further effort a consensus was reached that releases would be managed with the objective of maintaining flows of 30 m^3/s or less at Oliver. However all participants agreed that success in this would be weather dependent as very high runoff could result in inflows as high as 30 m^3/s solely from tributaries downstream of Okanagan Lake Dam.

By February 21 users of the FWMTS had detected a discrepancy between outflows used in the Tool and those shown on the Water Survey of Canada (WSC) website. WSC was alerted and found that their system had been vandalized by hackers and had not registered any changes since February 7. Thanks to quick detection and action by Team members (Andrew Wilson and Clint Alexander) and quick action by WSC staff (David Hutchison) the problem was fixed the same day it was reported. Clint Alexander informed Dr. Hutchison of the importance of alerting the Team should future WSC data system problems arise to affect FWMTS operational use.

March 2005

An intense Pacific frontal system, resulting in low elevation snow-pack melt and above average inflows to Okanagan Lake in mid-January, was followed by warm dry conditions through February. Further, the March 1 RFC forecasts showed snow levels in the Okanagan to be below normal and dwindling rapidly. Precipitation at Kelowna was only 27% of normal for February. By March 1 low elevations were dry and the south and west quadrants of the basin had snow values of 45-75% normal with little expectation of additional snow accumulation given the time of year.

Snow-water values at higher elevation and along the north and east side of the Okanagan basin were higher. Silver Star Mountain was 93% of normal, while Mission Creek was 114% of normal. Nevertheless, the overall Snow-water Index for the Okanagan was only 81% of normal and RFC was anticipating:

- an earlier than usual snow melt,
- an earlier than usual onset of low flow conditions,
- a decline in the high runoff that was experienced in January and February,
- unusually low summer flows in rivers unless precipitation over the remaining winter and spring period is at least normal.

Brian Symonds felt that runoff would be even earlier and lower than the RFC estimate.

The early and rapid runoff coupled with fall and winter rainfall meant inflows to Okanagan Lake were far above normal throughout the winter. Inflows during February were 31.3 $kdam^3$ (161% of normal), while inflows during the November – February period were 119.6 $kdam^3$ (217% of normal).

The Team decided that given low risk of flooding, Okanagan Lake should be held slightly higher than normal. This would protect incubating eggs or alevins of kokanee and provide more water to meet fisheries and other needs later in the summer. After running several FWMTS scenarios and discussions with the Team, Water Management reduced outflows to12.5 m^3/s on March 9. Inflows from unregulated streams located downstream from Okanagan Lake were causing flows affecting sockeye spawning grounds at Oliver to reach 17 m^3/s. In their March 15 teleconference the Team supported the flow cutbacks and agreed that if the dry conditions continued, Penticton Dam releases might have to be reduced to 6 - 7 m^3/s (resulting in flows of about 11 m^3/s at Oliver).

April 2005

March was slightly warmer and wetter than normal but precipitation approached seasonal norms. High temperatures in early March contributed further to snow melt and runoff remained high for the fourth consecutive month. Earlier than usual low flow conditions in the south and west quadrants of the basin prompted the RFC to predict that unless spring precipitation is at least normal, there is potential for unusually low summer season flow.

The overall Snow-water Index for the Okanagan-Kettle was 82% of normal (Figure 3), largely unchanged from March 1. Individual station readings varied but all except Mission Creek were below to well below normal. Snow-water values at low elevation and along south and west sides of the Okanagan were in the 45-75% of normal range.

Snow-water values at higher elevation and along the north and east side of the Okanagan basin were higher. Silver Star Mountain was 89% of normal, Greyback Reservoir 85%, and Graystoke Lake 86%. Despite the low snow-packs, inflows to Okanagan Lake during March were 237% of normal, while inflows during the 5-month November-March period were 272% of normal. By the time the RFC forecast data was received and reviewed, nights were cold and conditions were dry at lower elevations. Inflows were dropping but still coming in at high levels.

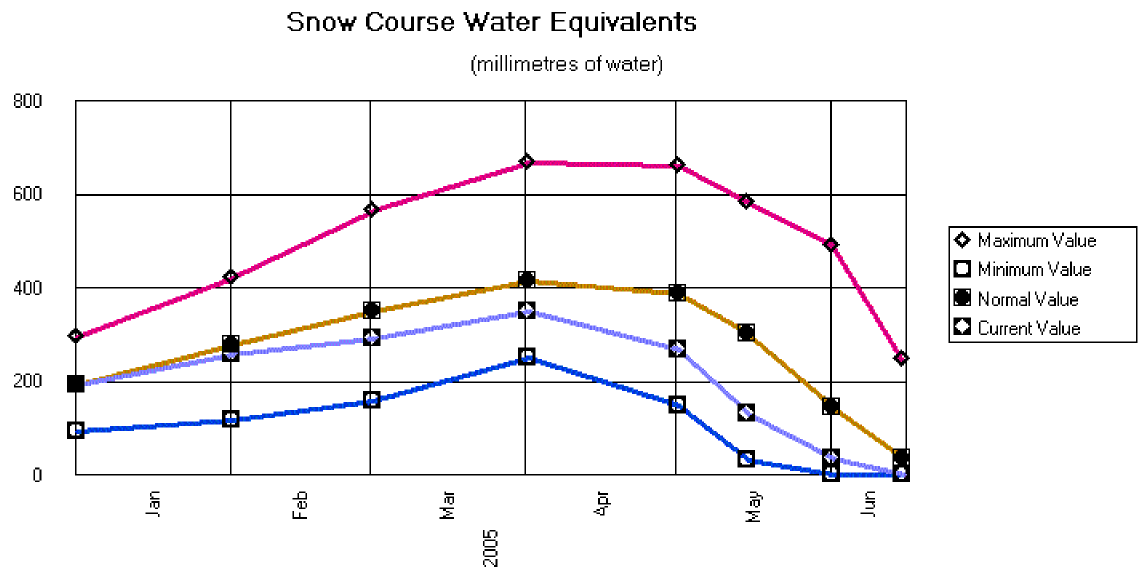

Figure 3. Maximum, minimum, normal and current year snow-course water equivalents (mm of water) for the Okanagan-Kettle drainage.

Water manager, Brian Symonds, entered average forecasts from RFC on April 6 and ran FWMTS scenarios. On April 12 he suggested release rates from Okanagan Lake dam of 20 – 25 m^3/s. Fisheries scientist Kim Hyatt posted a “fish-friendly” alternative scenario that retained releases from Penticton Dam at15 m^3/s until May 31 at which time releases would be increased to 30 m^3/s and held there through June and July. This he felt would keep flows below 30 m^3/s at Oliver and reduce the risk of scouring sockeye eggs without causing flooding. Water management agreed to try to meet the objective but warned that erratic weather could make this difficult to achieve.

The actual completion date of sockeye fry emergence was somewhat uncertain. The FWMTS predicted peak emergence between April 15 and April 30 but this was based on temperatures recorded at the Water Survey of Canada temperature recorder at Okanagan Falls. Careful review of WSC station temperature data versus independent observations from stand-alone data loggers deployed in spawning areas suggested a high bias in WSC winter observations (Stockwell and Hyatt, unpublished observations). Given that in-gravel incubation temperatures were 1-1.5

degrees lower over several winter months than the WSC values automatically fed into the FWMTS sockeye sub-model, Hyatt and Stockwell estimated that the actual 100% fry emergence would occur between May 11 and May 27 (i.e. some 2-3 weeks later than the FWMTS prediction). This information was shared with the FWMTS Team on April 16th as the basis for Hyatt's suggested "fish friendly amendment" to Symonds mid-April water release proposal. Hyatt also suggested using ongoing fyke-net sampling observations of migrating sockeye fry in the Okanagan River to verify the peak and end of the fry emergence period (see April 16-20th notes in Appendix 1.).

<u>May 2005</u>

Air temperatures were near seasonal averages during early April, but rose to well above normal in mid and late April causing high rates of snowmelt. Snow-water Indexes declined accordingly. Precipitation at Kelowna was only 40% of normal for April but because streams were in freshet 2-3 weeks earlier than usual, inflows to Okanagan Lake remained well above normal as they had since November. Inflows during the 6-month November - April period were 240% of normal.

The overall Snow-water Index for the Okanagan-Kettle was only 68% of normal, significantly reduced from its April 1 level of 82%. Individual station readings varied from below normal to well below normal and many snow-courses had no snow. For some courses, it was the earliest occurrence of zero snow on record. Snow-water values at higher elevation and along the north and east side of the Okanagan basin had the highest readings but they were still well below seasonal norms.

Drought seemed imminent and the International Osoyoos Lake Board of Control issued a formal drought declaration for Osoyoos Lake. The RFC issued a statement that unless spring and early summer precipitation is above normal, there could be unusually low summer season flows in rivers throughout the Okanagan.

<u>May 15, 2005</u>

Warm temperatures continued through early May causing the overall Snow-water Index for the Okanagan-Kettle to fall to 43% of normal (Figure 3) with most of the Okanagan snow free by May 15. Unregulated tributary streams experienced their largest peak flow of the snowmelt freshet period, at least 3 weeks earlier than usual. Further, ONA fyke-net sampling confirmed that sockeye fry emergence had begun, but that peak emergence was likely a week away in line with revised predictions provided in April to the FWMTS team by Hyatt. FWMTS predictions of flows expected at Oliver after mid-May, given various water regulation scenarios at Penticton Dam, were combined with unregulated tributary flow predictions to form the basis for decisions to avoid shoreline flooding at Okanagan Lake and river flows at Oliver that would damage sockeye alevins.

June 2005

Direct observations suggested that sockeye and kokanee fry emergence were virtually completed as of June 1st. Moreover, several lines of evidence suggested the possibility of a third year of drought developing in the Okanagan. By June 1 many tributaries to Okanagan Lake had already begun to recede into low flow conditions. Most of the Okanagan basin was snow free and the overall Snow-water Index for the Okanagan-Kettle had fallen to only 22% of normal (Figure 3). The RFC Outlook stated that "Unless spring and early summer precipitation is well above normal, there is a high potential for very low summer season flow in rivers throughout these areas". This suggestion focused attention of the FWMTS team on the possibility of a temperature-oxygen "squeeze" developing (Hyatt et al. 2005) with an attendant increase in sockeye fry mortality in the North Basin of Osoyoos Lake in late summer and fall. Consequently, FWMTS scenarios were developed under various water supply assumptions to identify whether sufficient water might be stored to provide a "flushing pulse" to Osoyoos Lake in late summer (see June 7-10th notes in Appendix 1).

June 15, 2005

The 2005 spring snowmelt was largely complete and snow-water indices for the Okanagan were at zero. The Okanagan basin was snow free with the exception of remnant patches of high elevation snow in the northeast portion. BC-RFC continued to warn that small and mid-sized rivers throughout the Okanagan were receding to well below normal levels for mid-June and although rainfall in mid-June eased the situation, potential water supply problems remained a concern.

July 2005

Above average, early summer precipitation and increased inflows brought Okanagan Lake to "full pool" in late June and supported adopting a water yield assumption closer to the all-year average (i.e. threat of drought had now receded). Given few remaining fish-and-water supply concerns, water managers increased water releases to 37 m^3/sec at the Penticton Dam on June 27th to reduce Okanagan Lake levels to a more acceptable level for property owners and recreational users. Water releases for the remainder of the summer were managed to accommodate precipitation events while moving towards the fall "benchmarks" for Okanagan Lake levels that are desirable for beach spawning kokanee. A new seasonal cycle of FWMTS deployment was initiated shortly after the 2005 brood year spawning by sockeye in the Okanagan River and kokanee in Okanagan Lake is complete.

POST -SEASON ANALYSIS

The FWMTS process promoted increased dialogue among the parties regarding fish-and-water management issues throughout 2004-05. FWMTS deployment allowed Team members to share common data sets, develop a common understanding of issues, and finally negotiate mutually agreeable water release rates during most of the year.

Determining the appropriate levels of water release through 2004-2005 was difficult since weather patterns were more erratic than usual and snow was irregularly distributed. Snow-packs on the south and west sides of the Okanagan Basin were low throughout the season while snow-packs along the north and east quadrants of the basin were larger than normal (Table 3). Warm wet weather in November and December was followed by generally cool weather in January. However, the intense Pacific frontal event in mid-January brought very warm temperatures, increased rainfall, low elevation snowmelt and an accelerated early runoff that signaled potential risk of flood.

These confusing and rapidly changing conditions underscored the need to use the FWMTS to consider a wide range of scenarios, communicate regularly, change tactics frequently, and make decisions based on input from all FWMTS Team members.

Table 3. River Forecast Centre snow-water indices reported for the Okanagan-Kettle Drainage in 2005.

Date (2005)	**Okanagan Kettle Drainage**	**Individual Watersheds in Okanagan Basin**
January 1	97 % of normal	n/a
February 1	90 % of normal	50 – 133 %
March 1	81 % of normal	45 – 114 %
April 1	82 % of normal	45 – 119 %
May 1	68 % of normal	No snow – 104 %
May 15	40 % of normal	No snow – 84 %
June 1	22 % of normal	No snow – 22 %
June 15	No snow	No snow

Outcomes in Okanagan Lake

Higher than average precipitation during fall 2004 resulted in Okanagan Lake levels that were several cm higher at 341.9 m than the preferred benchmark of 341.82 m (Figure 4) for kokanee beach spawning in Oct. As a consequence, water releases to draft Okanagan Lake to prepare for the usual spring freshet exceeded the 15 cm maximum drawdown (i.e. drawdown was 24 cm) recommended to avoid desiccation risk to kokanee eggs and fry. This condition was flagged as a cautionary interval on the FWMTS kokanee performance bar (Feb-March amber segment, Figure 4.). Inflow and water release decisions subsequent to early March provided outcomes that posed no risk to incubating kokanee and only a brief interval in the latter half of June when lake levels, given freshet inputs, posed any risk of foreshore flooding.

Outcomes in the Okanagan River and for Sockeye at Oliver

Seasonal discharges in the Okanagan River at Penticton and Okanagan Falls reflected water management decisions to maintain Okanagan Lake levels at seasonal benchmarks. Increased discharges at these locations in early Dec (Figure 5) were a result of increased spills from Okanagan Lake Dam to lower lake levels towards the late December benchmark (see Figure 4). Winter rains, low elevation snowmelt and above average inflows to Okanagan Lake (Figure 6, Jan-March interval) were accompanied by steady increases in Okanagan Dam water releases and discharge into mid to late February (see Figure 5).

Mid February flows triggered FWMTS hazard bar warnings of impending scour of sockeye eggs and alevins in the Okanagan River at Oliver (Figure 7). However, joint discussions of various FWMTS scenarios suggested scour inducing discharges could be avoided without incurring undue risk of lake or river channel flooding. The operational team advised lowering Okanagan Dam water releases to 22-25 cms (Table 4) to eliminate the threat of discharges greater than 30 cms which would scour sockeye eggs and fry at Oliver (see Figure 7).

Early snow-pack melt and freshet inflows to Okanagan Lake in late April and early May accelerated Okanagan Lake level increases. Accordingly, water managers increased water releases at the Okanagan Dam. This, in addition to unregulated tributary inputs between Penticton and Oliver (Figure 5 and 6), triggered FWMTS warnings again in late April of potential scour of pre-emergent sockeye alevins (Figure 7). FWMTS scenarios, supplemented with analyses outside of FWMTS indicating the likely late emergence of sockeye fry (April 16-20th communications of Hyatt to Operations Team and Symonds, Appendix 1), prompted the Operations Team to recommend lower releases. Water managers acted on this advice to keep flows below the scouring threshold until after sockeye fry had emerged at the end of May (Table 4 and see Figure 7).

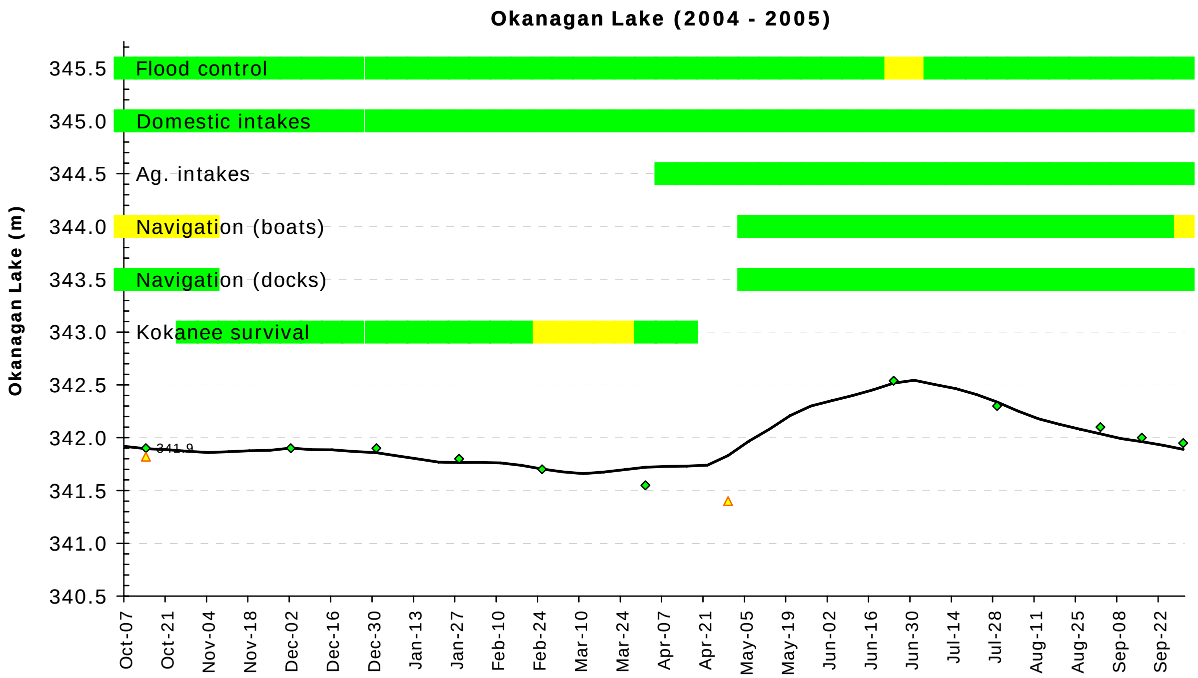

Figure 4. Seasonal changes to Okanagan Lake average daily level (solid line) relative to multi-year "benchmarks" (green diamonds) and hazard-bar performance indicators. Hazard bar indicators identify conditions that are safe (green), require caution (yellow) or actions to mediate unfavourable outcomes (red) if possible. Yellow triangles indicate preferred lake levels for kokanee spawning in October and the preferred lake-level target by the end of April in high snow-pack years posing elevated levels of flood risk.

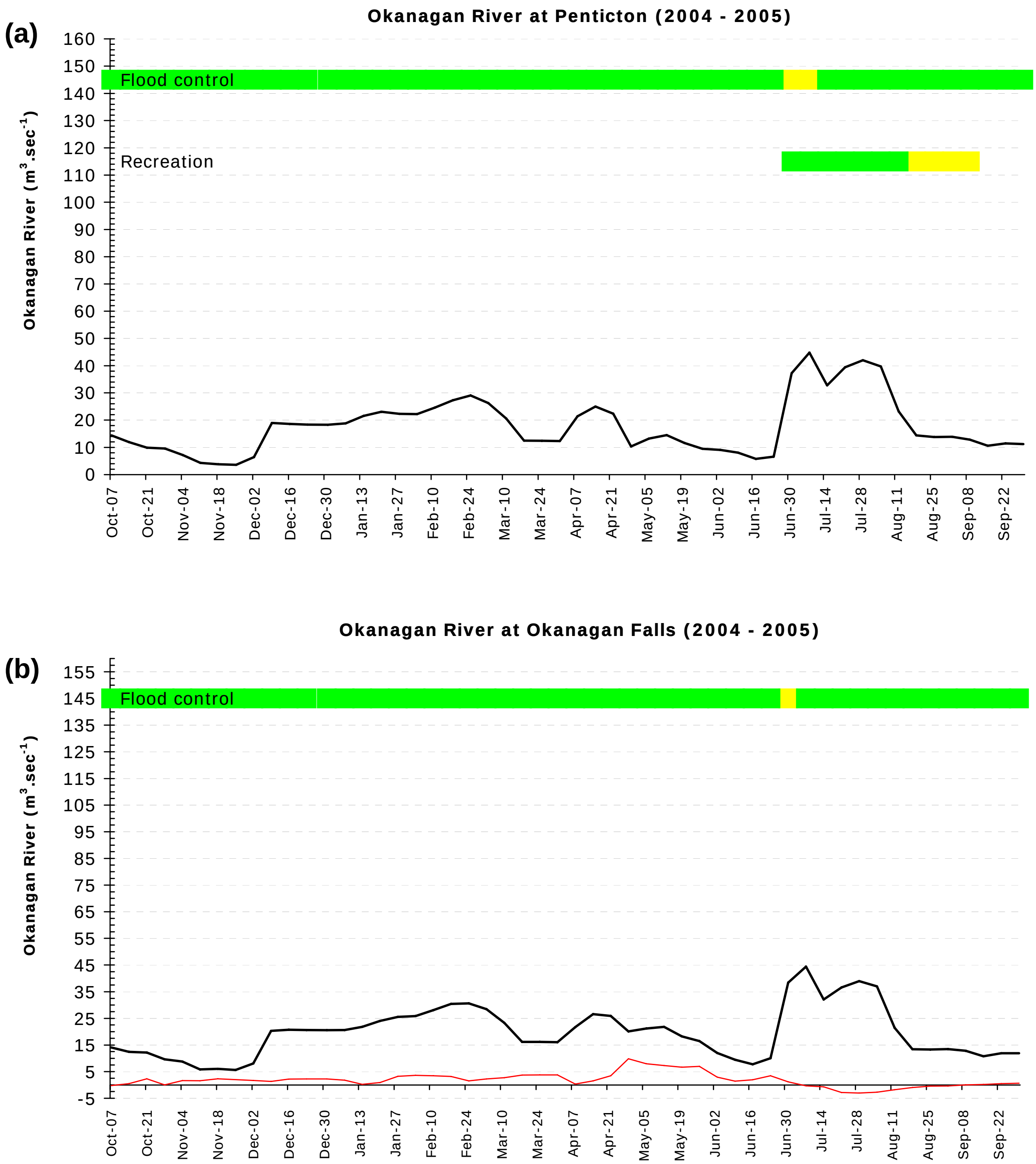

Figure 5. Seasonal change to Okanagan River average daily discharge (solid line) and unregulated tributary flow (red line) at (a) Penticton and (b) Okanagan Falls. Net inputs from tributary flows become negative in July due to the combination of irrigation withdrawals and evaporative water losses. Hazard bar indicators identify conditions that are safe (green), require caution (yellow) or actions to mediate unfavourable outcomes (red) if possible.

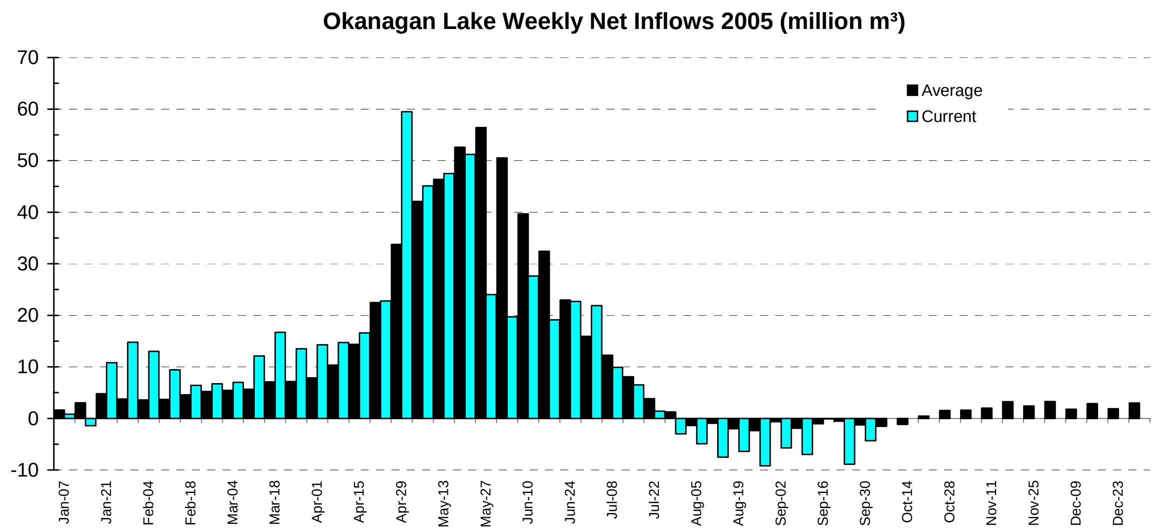

Figure 6. Weekly net inflows from all tributaries into Okanagan Lake for either the current year (blue bar) or the average across all years (black bar) from 1921 - 2003. Negative inflows in Aug-Sept result from water withdrawals for irrigation and evaporative losses from Okanagan Lake.

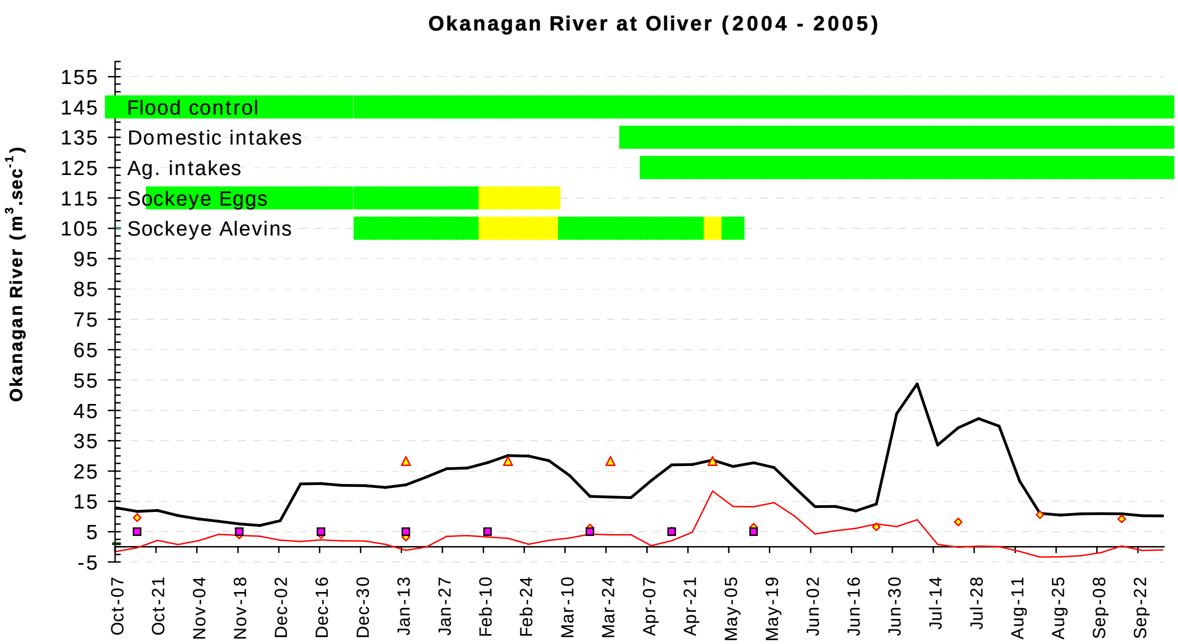

Figure 7. Seasonal change to Okanagan River average daily discharge (solid line) and unregulated tributary flow (red line) at Oliver. Hazard bar indicators identify conditions that are safe (green), require caution (yellow) or actions to mediate unfavourable outcomes (red) if possible. Yellow triangles indicate OBA targets to avoid scour of sockeye eggs/alevins. Purple squares indicate the egg/alevin threshold for desiccation. Small yellow diamonds are discretionary minimum flow targets recommended by the BC-Washington cooperative plan.

Table 4. Record of discharge rates from Okanagan Lake Dam with decision rationale.

Date (2005)	Discharge (m^3/s)	Decision Rationale
Dec 2 – Feb 15	22 - 25	Controlled water releases to maintain Okanagan L. at seasonally adjusted benchmarks.
Feb 15	22 – 25 (recommended)	Operational team recommended this discharge to reduce risk of scour without jeopardizing need for flood protection.
Feb 15	Increase to 30	Water management increased flows due to high runoff rates, high snow-packs in NE quadrant and a desire to reduce elevated lake levels to seasonal benchmarks (Figure 4.)
March 9	12.5	Discharge was lowered to maintain flows at Oliver < 30 m^3/s to prevent scour; retain lake levels for kokanee and provide a hedge against possible drought conditions
March 15	12.5	Team agreed with Water Management suggestion to maintain present flow levels
April 12	23.2	Water management suggested maintaining discharges of 20 -25 m^3/s to accommodate freshet inflows. Fisheries suggested holding back releases to ensure river flows at Oliver < 30m^3/s until after emergence (May 31).

DISCUSSION

From both fisheries and water management perspectives, the FWMTS worked well in 2005 (Brian Symonds, Kim Hyatt and Andrew Wilson – personal communication). In addition to producing a series of practical scenarios, the Tool provided a common base of understanding and a framework for communication under challenging conditions. Forecasting was very difficult because of erratic and unstable weather – perhaps a situation which will become increasingly common with global climate change. The overall snow-pack for the basin was higher than normal by early January 2005 due to heavy precipitation in November and December, but dropped off in mid-January as an abnormal and intense frontal system brought rain and unusually warm weather.

The distribution of snow throughout the basin was confusing with some watersheds showing as little as 45% of normal snow load while other watersheds were at 120% of normal on the same date. Temperatures remained high through March and April and inflows to Okanagan Lake were well above normal due to early freshet (see Figure 6). The extraordinary nature of prevailing conditions was borne out by the fact that the Similkameen River established a new high runoff record for February (350% of normal) despite having the lowest Snow-water Index ever recorded (47% of normal).

The Operational Team had to contend with uncertainties associated with rates of runoff that were 240% of normal during the 6-month November – April period. Such high rates of inflow could have resulted in extensive flooding or extensive scouring of sockeye redds; however, use of FWMTS facilitated careful planning and resulted in team recommendations and water management decisions that avoided major damage on both fronts. Lake elevations reached levels close to, but below the hazard level for flooding and river flows went up to but not far beyond the level for sockeye redd scour.

RECOMMENDATIONS

Year 2004-05, the initial operational year, provided an opportunity to look for ways to improve effective application of FWMTS and the performance of the operations team. Table 5 outlines problems encountered and suggests recommendations for solving them.

Table 5. Problems encountered in operational year 2005 and recommendations for avoiding similar problems in future.

Problem Encountered	Recommendations
Entry of RFC forecast values into FWMTS was occasionally delayed.	• Assign the task of retrieving forecasts and entering them into FWMTS to a specific Team member. • Assign an experienced alternate in case entry person is not available. • Investigate costs and methods of automatic retrieval and entry of RFC water predictions.

Problem Encountered	Recommendations
Water management was not available for the first two teleconferences. This resulted in a water release schedule that was not agreed to by other team members and the need to retrace the decision making steps.	• Match teleconference dates to availability of Water Manager. • Appoint FWMTS Team alternates for all members. • Set teleconference dates well ahead of time. • Provide e-mail reminders 1 week ahead of teleconference. • Document the reason for any discrepancies between actual releases and levels agreed to through Team consensus.
The level of risk aversion for both flooding and damage to fish production differed with the training and personal beliefs of individual Team members.	• Strive for Team decision and advisory standards and minimize personal biases. • Continue Team discussions of subject specific risk thresholds and record levels of agreement and disagreement.
Snow-pack varied tremendously in different quadrants of the basin, raising queries about the level of certainty in RFC water yield forecasts resulting from the pooled data.	• Review method of pooling snow indices and determine influence on reliability of RFC forecasts.
Changes to discharges (ramping rates) were sometimes made too quickly.	• Establish guidelines for the optimal and maximum permissible daily rate of change. • Consider adding guidelines to the Operational Plan.
Network "breach" and loss of real time data feeds at WSC and MOE impacted FWMTS.	• Investigate minimum security and maintenance standards for computer systems. • Flag need for continuous real time data from WSC to FWMTS and immediate notification of disruptions. Consider emergency, manual-import of discharge and temperature data to FWMTS if system is down for > 3-5 days. • Regularly check for questionable data.
Operational problems with Okanagan Dam and access problems at McIntyre Dam affected release decisions.	• Perform pre-season maintenance checks on dam gates by Nov. 1st.
No method was available for using novel information in water release decisions (e.g. in 2005 it was beneficial to consider reports from climatologists throughout the Cascade area that indicated water yields would be low and freshet would occur early).	• FWMTS Team to actively seek, fully consider and selectively implement additional data including informal reports of experienced water managers etc. • Formally record additional information used in decision making and give rationale for using it.

Problem Encountered	Recommendations
Temperatures recorded by WSC stations were warmer than in-gravel temperatures. WSC temperatures overestimate ATUs and predicted a sockeye fry emergence date that was too early.	• Provide an in-model correction factor for WSC station bias by using temperatures from in-gravel temperature loggers. • Maintain in-season quality assurance and quality control checks and correct incoming data when warranted.
For some FWMTS variables all year averages were sometimes used instead of real-time data.	• Revise model code to allow in-season updating of variables (e.g. ATUs). • Set dates; assign responsibilities for posting real time data (e.g. peak spawning date and number of spawners for subject salmon populations etc.). • Hold annual pre-season reviews of data being used in the model (by Nov. 30th).
The threshold of flows required to alleviate oxygen/temperature squeeze in Osoyoos Lake remained uncertain.	• Ensure that this subject is included in the IJC “plan of Studies” (deadline for inclusion Dec 2005). • Extend the FWMTS “season” to include late-season (Aug. to Sept.) flushing flows for Osoyoos L.
The Operating Plan for Okanagan River does not include guidelines for avoiding scour although OBA principles suggest these are required.	• Consider adding a guideline to the operating plan which would recognize the need, when possible, to limit flows on the spawning grounds to 30 m^3/s for the earliest of Oct 1 to May 31 or completion of fry emergence. • Continue to determine the accuracy of the 30 m^3/s guideline.
Some potential users were intimidated by complexity of the system.	• Clarify & simplify user manual wording. • Ensure all parties (DFO, MOE, ONA) are represented by experienced FWMTS users. • Provide training and support to new users.
Changes in discharge and the rationale for them were not adequately documented.	• Establish a standard digital log. • Link log directly to the FWMTS.
Need for a more thorough post-season review of FWMTS & management team performance.	• Schedule an annual, post-season performance review by the FWMTS Team. • Focus the meeting agenda on critical items.

GLOSSARY

Cumulative Precipitation: The total precipitation in a region since the previous November 1. Usually expressed as a percentage of normal.

Freshet: The substantial rise in water level of a stream or river caused by melting snow in the spring.

Fish and Water Management Tools Decision Support System: A computerized program for predicting the impacts of various water storage and release options on fish and property.

Hydrograph: A plot of the level or flow of a river over a period of time.

Normal: is the average value of a parameter over a fixed, usually 30-year period. At present the normal period is 1971-2000. Thus the normal water equivalent of a snow-course is the mean value for the 1971-2000 period, for that sampling date.

Regional Snow-pack Index: The sum of the snow-water equivalents at selected representative snow-courses in the region. Often expressed as a percentage of normal.

Snow-course: A marked location, free from encroachment, where snow depth and snow-water equivalent are measured on a regular basis with standard snow sampling tubes.

Snow-water Equivalent: The water content of a snow-pack at a point, expressed as the depth of water that would result from melting the snow.

Tool – see Fish Water Management Tools Decision Support System

Volume Forecast: A forecast of the volume of water expected to pass a given point on a river (or flow into a lake) in a set time period. This is based on current and antecedent conditions, but assumes normal weather patterns through the forecast period. Units are usually thousands of cubic decameters ($kdam^3$), which is the same as millions of cubic metres.

LIST OF ACRONYMS

ATU – Accumulated Temperature Units

BC-MOE – British Columbia Ministry of Environment

DCPUD – Douglas County Public Utility District #1

DFO – Fisheries and Oceans Canada

ESSA – ESSA Technologies Ltd.

FWMTS – Fish Water Management Tools System

Glenfir – Glenfir Resources Ltd.

IJC – International Joint Commission

Kdam^3 - thousands of cubic decametres = millions of cubic meters

m^3/s – cubic meters per second

ONA – Okanagan Nation Alliance

WSC – Water Survey of Canada

RFC – River Forecast Centre

REFERENCES

Alexander, C.A.D., Symonds, B., and Hyatt, K.D. (eds). 2005. The Okanagan Fish/Water Management Tool: Guidelines for Apprentice Water Managers (v.1.0.001). Prepared for the Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility District (DCPUD), Draft report submitted to COBTWG and DCPUD, Sept. 2005.

Alexander, C.A.D., and Hyatt, K.D. (eds.). 2005. The Okanagan Fish-and-Water Management Tool (Ok-FWMT) Record of Design (v. 1.0.001). Prepared for the Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility District No. 1 (DCPUD), Draft report submitted to COBTWG and DCPUD, Sept. 2005.

Anonymous. 1973. Canada/British Columbia Okanagan Basin Agreement, Task 162, 1973. Pacific Salmon population and habitat requirements. 44 p.

Bull, C. 1999. Fisheries habitat in the Okanagan River Phase 2: Investigation of selected options. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, Washington.

Halsey, T.G., and Lea, B.N. 1973. The shore spawning habit of kokanee in Okanagan Lake and the effect of lake level changes on reproductive success. British Columbia Fish and Wildlife Branch, Department of Recreation and Conservation.

Hansen, J. 1993. Upper Okanagan River sockeye salmon spawning ground survey – 1992. Colville Confederated Tribes, Fish and Wildlife Dept. Report to Douglas County PUD. 79 p.

Hourston, W.B., Clay, C.H., Burridge, E.W., Lucas, F.C., Johnson, D.R., Heg, H.T., McKinley, W.R., Barnaby, J.T., Fulton, L.A., and Gentry, A.A. 1954. The salmon problems associated with the proposed flood control project on the Okanagan River British Columbia, Canada. U. S. Fish and Wildlife Service, Washington State Dept. of Fisheries and Canada Dept. of Fisheries. 109 p.

Hyatt, K.D., Fast, E., Flynn, M., Machin, D., Matthews, S., and Symonds, B. 2001. Water management tools to increase production of Okanagan sockeye salmon. Fish-Water Management Proposal (June 21, 2001) submitted to Douglas County Public Utility District No. 1, East Wenatchee Washington. Canadian Okanagan Basin Technical Working Group Secretariat. 24 p.

Hyatt, K., Symonds, B., Wilson, A., Peters, C., Guy, B., Alexander, C., Wright, H., Phillips, B., Daniel, C., Andrusak, H., Machin, D., Bull, C., and Marmorek, D. 2004. The Okanagan Fish-Water Management (OKFWM) Tool: balancing water objectives in real time. Available at: http://www.essa.com/downloads/OKFWM%20news.pdf.

Hyatt, K.D., and Machin, D. 2005. Okanagan Fish and Water Management Tool (FWMT): Operational Deployment & Assessment of the FWMT System to Support 2005-06 Fish-and-Water Management Decisions: Year 1 of 8. Proposal (Sept. 2005) submitted to Douglas County Public Utility District No. 1, East Wenatchee Washington. Canadian Okanagan Basin Technical Working Group Secretariat. 34 p.

Hyatt, K.D., Peters, C., Alexander, C., Rankin, D.P., and Stockwell, M.M. 2005. The Sockeye Sub-model of the Okanagan Fish and Water Management Tool (FWMT). Chapter 6. *In* C. Alexander and K. Hyatt (eds.) The Okanagan Fish and Water Management Tool (Ok-FWMT): Record of Design. Submitted to Douglas County Public Utility District No. 1, Wenatchee Washington. ESSA Technologies Ltd and the Canadian Okanagan Basin Technical Working Group Secretariat. 161 p.

Hyatt, K.D., and Alexander, C.A.D. 2005. The Okanagan Fish-Water Management (OKFWM) Tool: Results of a 25 year retrospective analysis. Prepared for Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility District (DCPUD). Draft report submitted to COBTWG and DCPUD, July, 2005.

Okanagan Basin Implementation Board (Canada), 1973. Report on the Okanagan Basin Implementation Agreement.

O'Riordan, J. 1971. Comprehensive river basin planning with reference to the Okanagan Basin Study. Task 207A. Canada – British Columbia Okanagan Basin Study. 32p.

O'Riordan, J., Zackodnik, A.D., and Symonds, B. 1997. Decision Issue – Okanagan Flood Control System. Ministry of Environment, Lands and Parks Memo File 280-20 SIR-DI #97-02 February 5, 1997. 5 p.

Peters, C.N., Bernard, D.P., and Marmorek, D.R. 1998. Should sockeye be reintroduced to Okanagan Lake? – An exploration of potential benefits, impacts and uncertainties. ESSA Technologies Ltd. 50 p.

Shepherd, B.G., 1997. Okanagan River information package. B. C. Ministry of Environment, MS.

Left Blank on Purpose

Appendix 1. Abbreviated summary of “in-season” emails and teleconference calls during 2004-05.

The original wording has been paraphrased, extensively abbreviated and occasionally added to for brevity and clarity. The emails are generally tabulated in chronological order but exceptions are made where two or more emails should be linked because of a common subject. Acronyms are explained in List of Acronyms

Date Time	**From**	**To**	**Message**
Feb 7 10:11 AM	Wilson	Alexander Symonds Hyatt	• RFC forecasts not available on a timely basis. This is limiting the use of the tool. • Symonds is seldom available to enter forecasts.
Feb 7 10:01 AM	Alexander	Wilson Hyatt	• Model will not work without forecasts. • Need to decide who should enter forecasts.
Feb 7 11:37 AM	Alexander	Wilson Symonds Hyatt Bull	• Need more people to receive forecast since Symonds often absent. • Remind RFC to consider Okanagan forecasts high priority. • Automatic entering of forecasts is possible but would require forecasts to be web accessible and Tool capable of automatic retrieval. May be costly. Not recommended since present way of entering only takes about 30 sec.
Feb 11 8:36 AM	Wilson	Op Team	• Have entered forecast from Symonds • (535, 660 & 785 million m^3 for low, average and high forecasts).
Feb 15 10:11 AM	Bull	FWMTS Team	• Notes from Feb. 15 Teleconference: • Consensus on method (forecasts will be entered 10th of month; scenarios run 10th – 15th; consensus decisions by teleconference on 15th ; project coordinator to keep track of decisions). • RFC forecasts are well within the range (>280 but <860 million m3) of water yields that the FWMTS retrospective analysis suggests are manageable for maintenance of “fish friendly” flows. • Feb 2005 consensus decision (Water mgt not present) retain flows of 22 – 25 m^3/s from Feb 15 – Mar 15. Decision based on scenarios run by Andrew Wilson and Dawn Machin. Snow-pack 25% above normal but lower elevations are very dry.
Feb 19 12:47 PM	Hyatt	Op Team	• Must continue to record strategy decisions.
Feb 21 9:36 AM	Wright	Op Team	• WSC webpage shows flows raised to 30 m^3/s about Feb 8th contrary to FWMTS Team advice. • Just above scour level for sockeye.
Feb 21 9:42 AM	Wilson	Alexander	• Tool shows outflow Feb 21 at 22 m^3/s whereas WSC shows outflow for this date 28 m^3/s.

Feb 21 10:15 AM	Alexander	Wilson	• Seems to be a problem with WSC data.
Feb 21 10:22 AM	Hyatt	Op Team	• Should not set flow releases at Penticton that will result in scour inducing flows (>30 m^3/s) for sockeye at Oliver unless there is compelling evidence that flood risk is imminent.
Feb 21 10:25 AM	Alexander	Op Team	• Releases seem too high.
Feb 21 12:10 PM	Alexander	Op Team	• David Hutchison at Environment Canada reports hackers vandalized WSC website about Feb 7 – system still down. • WSC should notify us immediately if problems arise in future. • FWMTS analysis suggests snow-packs not high enough to justify present high outflows.
Feb 21 2:08 PM	Hutchison	Op Team	• Computer problem fixed – web service back on line.
Feb 21 12:32 PM	Alexander	Hutchison	• In future please notify us of any outages.
Feb 21 3:25 PM	Alexander	OP Team	Symond's explanation for setting outflows at 30 m^3/s: • Inflows and lake levels are both high. • Snow-packs are high in NE (low in SW). • Watershed is saturated from early snow melt. • Ok Dam gates are not fully operative (may not be able to release more water later on). • 30 m^3/s now may avoid higher flows later. • Further discussions suggested.
Feb 21 3:25 PM	Alexander	Op Team	• WSC website was repaired quickly because of early detection by Wilson and Wright and prompt reaction by Alexander. • Need more communication with Water Mgt and need their commitment to participate in teleconference calls. • Use of high side RFC predictions seem excessive. • Outflows (30 m^3/s) seem excessive. • There will be time to adjust even if high side forecasts are correct. • If low side RFC forecasts are correct Osoyoos Lake temp/oxygen squeeze could be a problem. • Water mgt has not commented on the guidebook nor Retrospective Analysis.
Feb 21 2:30 PM	Hyatt	Op Team	• More dialogue is required. • Need to rerun scenarios with updated WSC data.
Feb 22 4:58 PM	Klinge	Bull	• Notice flows jumped to 30 m^3/s on Feb 8. • What does model call for? • What will be the effect on sockeye?
Feb 23 11:54 AM	Bull	Klinge cc Op Team	• R. Klinge (DCPUD) asks about aberrant flows. • Bull provided Water Mgt's explanation and said we are

			communicating differences of opinion and seeking an OP Team consensus.
Feb 25 9:43 AM	Jubb	Op Team	• Water Mgt presently denied access to McIntyre Dam therefore storage on Vaseux Lake not controllable. This plus inflows from tributaries could result in flows at Oliver in excess of 30 m^3/s.
Feb 27 9:11 AM	Bull	Hyatt	• Recommend Teleconference to discuss flow release strategy & need for improved Op Team to Water Mgt communications.
March 7 8:58 AM	Wilson	Alexander	• FWMTS crashed due to lack of March forecast.
March 7 10:15 AM	Alexander	Wilson cc Op Team	• FWMTS cannot run without RFC forecast numbers.
March 7 4:38 PM	Wilson	Op Team	• Have updated tool with RFC numbers from Symonds (low 425, med 550, high 675).
March 8 9:50 AM	Wilson	Alexander	• FWMTS model predictions tab sets 100% emergence date for kokanee at April 5 but hazard bar under multi-objective assessment link says April 20.
March 8 10:10 AM	Alexander	Wilson	• Which is closer?
March 8 10:26 AM	Wilson	Alexander	• Think April 5 but need to confirm based on temperature logger.
	Alexander	Wilson	• Kokanee ATUS are based on WSC temperature recordings corrected for differences between measurement site and incubation site. Accumulated ATU have been used but a trial using raw daily temperature values provides a much earlier and more accurate emergence date. • Data from several years should be used to give the most accurate correction factor.
	Wilson	Alexander	• Use WSC temperature data until we have had a chance to review temperature data over a longer time period (3 or 4 more years). • Information from the NE Quadrant is preferable to data from the NW.
March 8	Hyatt	Symonds	• FWMTS scenarios and ongoing participation of Water Mgt in Ops Team discussions has been problematic on some occasions where Water Mgt authority for decisions has been delegated internally. • FWMTS scenarios suggest flood risk is low enough to avoid scour-inducing flows at Oliver.
March 9	Stockwell	Op Team	• FWMTS has peak spawn set at Oct 28 but it actually occurred much earlier.

2:12 PM			• My predictions for hatch and emergence times based on ATUs concurs with ONAs estimates based on hydraulic sampling. • Emergence could be 1-3 weeks earlier than predicted by FWMTS.
March 9 1:08 PM	Wright	Op Team	• Kokanee emergence date predicted by hydraulic sampling is April 4. • Sockeye 100% hatch occurred on Feb 24 (predicted date was March 27). Predicted date for peak emergence is May 1 with 100 % emergence predicted by May 7 (actual dates likely to be 1 week earlier this year).
March 9 3:05 PM	Symonds	Op Team	• Runoff now looks like it will likely be earlier and lower than RFC forecasts. • Inflows are returning to average levels. • The last month has been dry and this trend seems likely to continue. • Based on FWMTS scenario Water Mgt intends to reduce releases to 15 m^3/s starting tomorrow. • Further reductions may be needed later. • Important to get emergence dates as accurate as possible – had they been sorted out prior to February we may have been able to hold off on raising flows to levels that threatened fish.
March 9 2:31 PM	Alexander	Op Team	• It is valuable to use actual peak spawning dates rather than the default (Oct 28). • Need to choose the best possible ATU estimate (to predict egg hatch & fry emergence dates). • Ok Falls temperatures used due to past problems with the Oliver WSC recorder.
March 9 3:30 PM	Stockwell	Op Team	• Independent, spreadsheet estimates of kokanee hatch date concur with FWMTS predictions.
March 15 12:31 PM	Symonds	Op Team	• If dry trend continues might reduce flows to 11 m^3/s in Oliver (equates to about 6 m^3/s at Ok Dam). Present outflow about 12.5 m^3/s).
March 15 2:39 PM	Bull	Op Team	Notes from March 15 teleconference: • Conditions are dry (near record low snow-packs in south end; slightly below normal in Mission Creek which provides largest input to Ok Lake). • RFC forecasts indicate low risk of flooding. • Ok Lk level is slightly higher than normal (intentional - storage for kokanee). • Releases have been reduced from Feb levels of 30 m^3/s to 12.5 m^3/s – resulting in flows of 17 m^3/s at Oliver. • If dry trend continues may need to cut outflows to 6 or 7 m^3/s which would translate to a minimum of 11 m^3/s at Oliver. • ONA reports excessive ramping rates that may cause fish stranding in shallow sidechannels. Water Mgt agrees to reduce rate of ramping.

			• Last September's heavy rains kept the lake high increasing the risk of kokanee being affected by lake drawdown subsequent to beach spawning. • In future, year-specific, peak-spawning times and incubation temperatures should be entered in the model as soon as possible. This may require some alterations to the model coding. • Ops Team identifies need for (a) an early season meeting (November) to review and initialize "startup" values for the FWMTS model each year and (b) a post-season meeting (Aug-Nov) to review FWMTS and Ops Team performance.
March 16 6:02 PM	Hyatt	Op Team	• Have added to teleconference notes to supply enough information to capture logic behind release recommendations. • This important because we are trying to develop a "template" for an annual record of flow release strategies and outcomes.
April 6 2:00 PM	Symonds	Op Team	• Have entered the April 1 forecasts. • Have run scenario based on average forecast. • Welcome comments.
April 12 9:04 AM	Symonds	Op Team	• I modified the high and low forecasts for April 1 because the snow bulletins did not concur with the preliminary RFC numbers. The average forecast remains unchanged. • Have posted my proposed operating plan and comments are welcomed. May need to be modified in a couple of weeks depending on weather. • Would appreciate any field data on emergence. For now am assuming 100% emergence by end of the first week in May.
April 16 7:33 AM	Bull	Op Team	Notes from April 15 teleconference: • Flows were above average in Jan., Feb. & March but lower than average in April. • Cold nights and dry conditions at lower elevations are slowing runoff. • Inflows from the tributary streams south of Skaha Lake are lower than average but the tool assumes average flows. The tool sums the dam releases and the average tributary flows to calculate the flows at Oliver so it may be overestimating the redd scour problem.
April 16 8:52 PM	Hyatt	Op Team	• Daily temperature data for FWMTS predictions imported from WSC station at Okanagan Falls. Stockwell analysis of independent data logger observations suggests sub-gravel values are colder than WSC values so FWMTS emergence date predictions are biased by 2 weeks earlier than actual. Correction for this bias in WSC temps requires a change in FWMTS model code. • Given FWMTS bias 2005 emergence times to be calculated manually outside the model. Bias correction suggests peak emergence mid-May.

			• To reduce scouring Hyatt suggests a "fish friendly" amendment which retains flows at 15 m³/s (instead of Symonds April 12th scenario of 20-25 m³/s) until May 31. Subsequent releases to be increased to 30 m³/s through June and July. This reduces the risk to sockeye without causing flooding.
April 18 5:46 PM	Symonds	OP Team	• When will emergence be complete? • Do the predictions of emergence concur with the actual field observations carried out by ONA? • Will keep flows in Oliver below 30 m³/s until emergence is over. • Expect to just fill Okanagan Lake at end of June and then follow the OBIA lake level targets
April 20 9:09 PM	Hyatt	Symonds cc Op Team	• FWMTS predicts peak emergence between April 15 & April 30. • Temperature biases set date about 20 days early. • Peak emergence now predicted to be between May 4 & May 20. • 20 – 30% of fry will emerge during the weak after peak emergence. • 100% emergence is predicted between May 11 & May 27. • Suggest holding Penticton Dam releases below 15 m³/s (Oliver flows below 30 m³/s) until May 30 unless there is a risk of flooding or ONA's fyke netting shows emergence is complete.
April 25 11:23 AM	Alexander	Op Team	FWMTS simulations based on: • Nearest matching year (1998), revised RFC forecasts, and intuition based on field observations all support low end RFC forecasts of water yield. • Potential drought may pose a lake refill issue. • ONA sockeye netting results support Hyatt's advice to expect fry emergence into late May. Offer following recommendations: • Fix WSC station temp biases by calibrating field stations or by adding bias adjustment factor to FWMTS model code for 2005-06. • Consider recent release Scenario-254 emphasizing lake fill by holding outflows to 15 m³/s until June 3. This also protects sockeye against scour. There appears to be no flood risk.
April 25 12:18 PM	Hyatt	Op Team	• Alexander's Scenario-254 looks good. • Need to keep Oliver flows < 30 m³/s until fyke netting shows peak fry emergence is past. • Need to account for WSC temperature bias in FWMTS prior to using Tool in 2006.
April 25 1:12 PM	Symonds	Op Team	• Hot weather is causing rapid runoff and making regulation difficult. • On April 21 Oliver gauge was inoperable but manual readings showed Oliver flows reached 29.7m³/s. Penticton releases were reduced from 20.5 to 17 m³/s but Oliver flows continued to increase to 31.6 by April 23. Releases were dropped a further 3-4 m³/s which dropped

			Oliver flows to 26.5. By April 25 flows rebounded to 29 m³/s. Levels in Skaha and Vaseux Lakes were high and rising. On April 25 we cut back Penticton flows to 6 (i.e. well below the 18 m³/s called for by FWMTS only a few days ago). Weather may not allow us to keep Oliver flows below 30 m³/s. Comments welcome.
April 25 3:02 PM	Alexander	Symonds ccOP Team	• Congratulations on success managing system. • General concepts of Scenario-254 hold true (i.e. a fast melt requiring reduced releases in April with inflows slowing in May and June). • These extreme runoffs not expected to continue for long.
April 25 3:19 PM	Symonds	OP Team	• April 1 RFC forecasts are 330, 490 & 650 million m³. • The nearest matching year (1998) suggests that the mid-range forecast is most likely.
April 25 3:22 PM	Hyatt	Op Team	• Real time use of FWMTS and collaboration working well. • Need fyke netting results to confirm sockeye fry emergence status.
April 25 3:35 PM	Fast	Op Team	• FWMTS Team efforts in 2005 excellent example of inter-agency collaboration resulting in sensible decisions.
April 25 3:26 PM	Symonds	Alexander	• Scenario-254 looks good but rapid snowmelt may induce excessive inflows from tributaries between Penticton and Oliver (up to 35 m³/s). This complicates management of the system. • Will proceed with careful monitoring and adjustments to avoid scour inducing flows.
April 25 3:34 PM	Alexander	Symonds	• Suggest holding Penticton at 6 – 16 m³/s for 4-5 weeks through June 3 based on average forecast and considering need to fill Okanagan Lake in June and draw it down over the summer. • This scenario would need to be updated weekly using real time data.
April 25 3:50 PM	Symonds	Alexander	• Ability to keep Oliver flows below 30 will be weather dependent. • After sockeye fry emergence is complete, consider high flows in June – should be kept below 75 m³/s or if this is impossible, should not exceed that level for more than 2-3 days. • Need to also consider flows in Penticton. Ideally they should be kept above 5 m³/s. • Also trying to fill Okanagan L while keeping Skaha and Vaseux within acceptable ranges.
April 25 5:44 PM	Hyatt	Alexander	• Long distance accessibility of FWMTS is a tremendous benefit given current “duties” on east coast (i.e. Ops. Team members can remain “plugged in” from anywhere in the world). • Water mgt currently maintaining flows < 30 m³/s at Oliver but cooperation clearly depends on attitudes of the Water Mgr or their delegate.
April	Alexander	Op Team	• Have revised Scenario-254 to reflect low flows presently

27 6:07 PM			experienced in Penticton, need to readjust June/July releases and need to maintain lake levels and Oliver flows. • Revision is posted for review.
June 7 10:31 AM	Alexander	Op Team	• Inflows have slowed and Okanagan Lake is rising more slowly despite reductions in Penticton releases (i.e. flows ~9.5 m^3/s). • Low end of RFC forecasts seem appropriate. • Simulations show a “red” hazard for temperature/oxygen “squeeze” problems in Osoyoos Lake arising in July/August. • Might be an opportunity to pulse 128M m^3 into Osoyoos L in Jul-Aug to alleviate “squeeze”. • Revision of Scenario-254 to do this shows some possible impacts on Oliver water supply and a slightly below target Sept 30 lake elevation.
June 7 2:47 PM	Hyatt	Op Team	• Recommend storing water and then pulsing Osoyoos Lake in Jul-Aug unless we get an unusual amount of summer rain.
June 10 2:13 PM	Symonds	Alexander Hyatt	Have posted slightly different scenario which: • includes a pulse, • uses low inflow forecast, • accomplishes lake level targets for August, • provides more water for summer release. Lake is at 342.43 and rising in response to recent rain. Am expecting it to peak in about 10 days.
June 10 2:13 PM	Symonds	Alexander Cc Hyatt	• I ran a scenario based on low forecast which included an August pulse for Osoyoos but noticed a red hazard.
June 10 4:10 PM	Alexander	Symonds Cc Hyatt	• Your run releases 85 M m^3 for flushing Osoyoos but the sockeye model suggests 128 M m^3 is required. Running 128 gets rid of the red hazard bar. It would be valuable to know the lowest quantity of water that would result in a significant gain. • Are there any safety concerns for recreational floating down the channel? No upper limit is specified for modelling.
June 24 12:02 PM	Symonds	Op Team	• Ok Lk is at full pool so releases have been increased to avoid an additional rise. • Have prepared a new scenario based on releasing higher flows in August (Kim’s suggestion) – may or may not prevent “squeeze”). • Earlier scenarios were based on low forecasts but recent rains mean inflows will be close to the average forecast. • Average forecast predicts significant amount of inflow in July. This does not concur with my “gut” feeling. This may be a problem with FWMTS and may be related to the weekly distribution of the inflow forecast which does not fully account for the observed inflows.
June 27	Alexander	Op Team	• Previously FWMTS used the low forecast for May 1 – July 31 (220 M m^3). With rainy June it may be more

9:25 AM			appropriate to use average forecasts. Actual inputs from May 6 to June 24 were 220M m³. If conditions in July are average the total inflow for May 6 to July 29 would be 298 M m³. • The model does not continually replace RFC forecasts with real time inflows. This results in a noticeable discrepancy or "jump" when the corrections are made. • I ran a new scenario using inflows of 300 rather than the previous 370 M m³ and got a more realistic result. However, to lower lake levels and guard against flooding it may be wise to increase outflows to 20 – 26 m³/s now and check results in 2 weeks.
June 27 3:38 PM	Symonds	Op Team	• Its raining the lake is full and complaints are coming in. • We have increased outflows from 15 m³/s to 37 m³/s. (ramped as slowly and steadily as possible under the circumstances).
June 28 3:38 PM	Alexander	Op Team	• Phone calls to Symond reflecting property owners concerns reflected in model hazard bar caution (i.e. yellow flag) re: potential flooding. • A new Scenario-281 is posted with lower May 1 to July 31 inflows based on real-time measurements and Symond's estimates for the days remaining. Scenario-281 calls for 45 – 55 m³/s releases over the next few weeks to minimize flood damage and reduce lake levels. • Meeting the 128 M m³ water "threshold" to avoid a temperature-oxygen "squeeze" in Osoyoos Lake should not be a problem.
END	**END**	**END**	**END**