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Supporting Documents

1. April 2006 report from Golder Associates on Flood Risk and Habitat.
3. February 28, 2005 memo from DAID Hatzic Lake Level Select Committee - Request for Support and Input from Affected Parties - Seasonal Water Level Control for Hatzic Lake, Mission, B.C. To Improve Fish Access and Habitat and to Enhance Recreational Opportunities. .... See http://www.missionbc.com/DAID/ to retrieve document (21 pgs)
4. March 31, 2005 Memo from FVRD: Hatzic Lake Level Control Project
Application for Works in and Around a Dike

4) A person or a diking authority must NOT DO any of the following UNLESS it is done either with the prior written approval of the inspector or in accordance with the regulations made under section 8 (2):

   (c) construct, or cause or allow to be constructed, any works on or over a dike or dike right of way;

   (d) alter, or cause or allow to be altered, the foreshore or stream channel adjacent to a dike;

5) In granting an approval under subsection (4), the inspector must consider the appropriateness of a standard established by regulation under section 8 (2) in relation to the dike that is the subject of the request, in light of

   (a) the condition and location of the dike,

   (b) the surrounding land and bodies of water and stream channels that are in close proximity to the dike, and

   (c) the nature and condition of works related to the dike.
### PART 1. CONTACT INFORMATION

<table>
<thead>
<tr>
<th>Name of Applicant:</th>
<th>Dewdney Area Improvement District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Applicant Contact or Agent:</td>
<td>Steve Dimond, M.Sc., P.Eng.  Chairman, Lake Level Committee, Dewdney Area Improvement District</td>
</tr>
<tr>
<td>E-mail Address of Contact:</td>
<td><a href="mailto:steve@dimond.ca">steve@dimond.ca</a></td>
</tr>
<tr>
<td>Home Phone:</td>
<td>(604) 820 - 6700</td>
</tr>
<tr>
<td>Business Phone:</td>
<td>(604) 302 – 9900 cell</td>
</tr>
<tr>
<td>Fax Number:</td>
<td>(604) 820 – 6701</td>
</tr>
<tr>
<td>Mailing Address for Correspondence from MWLAP:</td>
<td>Steve Dimond, 12433 Cascade Court, Mission, B.C., V2V 7G9  Copy to: DAID, Box 3005, Mission, B.C.,</td>
</tr>
<tr>
<td>Date:</td>
<td>January 30, 2006</td>
</tr>
</tbody>
</table>

**NOTE:** The purpose of this form is to highlight this application’s major points to allow Ministry staff to both understand the key aspects of the project and to prioritize the application accordingly. For more information on the processing of this application, please read the preceding Approval Process.

### PART 2. EXISTING CONDITIONS

<table>
<thead>
<tr>
<th>Name of Dike and responsible Diking Authority (from Provincial Database at wlapwww.gov.bc.ca/wat/flood/pdfs_word/dikesriver.pdf)</th>
<th>Dewdney Area Improvement District</th>
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<tbody>
<tr>
<td>Exact Location of Proposed Works (Chainage specified on dyke maps at wlapwww.gov.bc.ca/wat/flood/maps.html#lmd_dikemaps or UTM Coordinates from srmapps.gov.bc.ca/apps/wlap_wrbc/):</td>
<td>UTM 556236 mE, 5443645mN</td>
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<tr>
<td>Adjacent Water Body(source of flooding):</td>
<td>HATZIC LAKE / FRASER RIVER</td>
</tr>
</tbody>
</table>

**PLEASE RETAIN A COPY OF THIS APPLICATION FOR YOUR RECORDS**

**FOR OFFICE USE ONLY**

<table>
<thead>
<tr>
<th>Date Ministry Received Application:</th>
<th>Diking Authority File Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority/Deadline:</td>
<td></td>
</tr>
</tbody>
</table>

Preliminary Review and the Initial Applicant Consultation Complete on: 

(date)

Comments:
**PART 3. PROPOSED WORKS**

Briefly describe your proposed works:

Two-Fold :

1. Approval of the concept of a permanent fishway installation, subject to engineering and design.

2. Installation of a temporary fishway in front of 1 of 4 outflow boxes to allow regulating summer lake levels up to September 15. Installation of weir-like improvements in 3 of 4 outflow boxes. Data to contribute to permanent installation.

Briefly describe your approach to ensure the integrity of existing flood protection system(s) is not compromised by the installation of the works:

Daily monitoring of levels. Single man changeover of retention improvements possible if/where lake levels rise. Existing facilities remain status quo with weir like installation in 3 of 4 outflow boxes.

Study on flood risks completed by Golder Associates, spring 2006

<table>
<thead>
<tr>
<th>Have you referred to the ‘Provincial Design and Construction Guide’ in your design?</th>
<th>Are there any exceptions to this guide? Yes or No (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

If yes, how and why have you deviated?

**PART 4. REQUIRED ATTACHMENTS**

Check off attachments to this application form:

- [ ] General Location Plan
- [ ] Detailed Site Plan
- [ ] Preliminary Design Drawings and Specifications
- [ ] Design Brief
- [ ] Previous correspondence regarding this site from the Ministry

If any required attachments are not included, please explain why.
Have you included attachments not listed above? Please list them below.

- Background paper soliciting support and financial assistance.
- Letter of support with qualifications from Fraser Valley Regional District
- Application to Fisheries & Oceans Canada
- Photos and mapping
- Study by Golder Associates on Flood Risk and Fish Habitat assessment

**Note:** Please forward a copy of this application to the appropriate Deputy Inspector of Dikes office as specified at [wlapwww.gov.bc.ca/wat/flood/dykeinsp.html](http://wlapwww.gov.bc.ca/wat/flood/dykeinsp.html)

**Surrey - John Pattle, Deputy Inspector of Dikes**

#10470 - 152 Street, Surrey, B.C., V3R 0Y3

(604) 582-5208

and to the Diking Authority responsible for the dike's operation and maintenance

(see database: [wlapwww.gov.bc.ca/wat/flood/pdfs_word/dikesauthority.pdf](http://wlapwww.gov.bc.ca/wat/flood/pdfs_word/dikesauthority.pdf) )

**Dewdney Area Improvement District**

Box 3005, 11010 Stave Lake Road

Ission, B.C., V2V 4J3

첩 Please confirm that a copy of this application has been forwarded to the Diking Authority
Fisheries and Oceans Canada

Lower Fraser Area

Project Review Information Requirements for Works Affecting Fish Habitat

The information Proponents provide on this form is the minimum necessary for Fisheries and Oceans Canada to evaluate compliance with the Federal Fisheries Act.

1. **Proponent:**
   - **DEWDNEY AREA IMPROVEMENT DISTRICT**
   - **Address:** BOX 3005
   - **City:** MISSION
   - **Postal code:** V2V 4J3
   - **Contact:** Steve Dimond, M.Sc., P.Eng.
   - **Telephone:** 604-820-6700
   - **Fax:** 604-820-6701
   - **E-mail:** steve @ dimond . ca

2. **Project title:**
   - Fishway Installation at Hatzic Dike for Test Lake Level Control

3. **Location of works:**
   - **Regional district/ land use authority:** Dewdney Area Improvement District
   - **City/ municipality:** Fraser Valley Regional District
   - **Street address of pertinent property:** Hyde Buker Road, Hatzic Pumphouse
   - **Complete legal description of all lands affected by changes:** Part Statutory Right of Way Plan 12605, New Westminster District
   - **Watercourse name:** Hatzic Slough, Hatzic Lake, Fraser River
   - **Location on watercourse:** at Hatzic dike
   - **What watercourse/ waterbody does it flow into?** Fraser River

4. **Agent(s) name:** Steve Dimond
   - **Address:** 12433 Cascade Court
   - **City:** MISSION
   - **Postal code:** V2V 7G9
   - **Contact:** Steve Dimond, M.Sc., P.Eng.
   - **Telephone:** 604-820-6700
   - **Fax:** 604-820-6701
   - **E-mail:** steve @ dimond . ca

5. **Environmental Monitor:** Golder Associates
   - **Address:** #200 - 2790 Gladwin Road
   - **City:** Abbotsford BC
   - **Postal code:** V2T 4S8
   - **Contact:** Jay Hammond, MSc., B.Sc., R.P.Bio
   - **Telephone:** 604-850-8786, 604-296-4230
   - **Fax:** 604-850-8756, 604-298-5253
   - **E-mail:** PMorgan@golder.com, JHammond@golder.com
6. **Proposed timing:**
   - **Start** (day/month/year): ASAP 2006 - pre freshet - temporary installation
   - **Finish** (day/month/year): September 15 annually. Permanent installation to have further engineering and approvals. Approval of concept requested.

7. **Notification to Ministry of Water Land and Air Protection (MWLAP)**
   - Has MWLAP been notified of the proposed works?  **X** Yes  □ No
   - □ Other Ministry (specify) ____________________________
   - John Pattle, Deputy Inspector of Dikes

8. **Tenure to land:**  **X** Registered owner  □ Lessee
   - □ Other (specify) ____________________________________

9. **Restrictive covenant on property?**  □ Yes  **X** No

The following information should be prepared by qualified professionals and must be attached for review of the project:

10. **Written justification for the proposed works, including:**
   - ✔ Confirmation that no alternatives to the proposed work exist.
   - ✔ Confirmation that the works are permitted under local by-laws, zoning, etc.

11. **Description of proposed activities, including:**
   - ✔ Detailed description of proposed works including how works are to be carried out and what machinery will be used.
   - ✔ Clearly marked and detailed drawings of the proposed works (to scale).
   - ✔ Detailed description of all materials to be used. Note the placement of materials and/or structures in and around watercourses must be consistent with DFO and MWLAP regulations, standards, policies and guidelines.

12. **Description of existing fish and fish habitat, including:**
   - ✔ Fish presence and distribution
   - ✔ Fish habitat assessment (instream and riparian)
   - ✔ Hydrological information

13. **Fish habitat impact assessment, including:**
   - ✔ Potential impacts to fish and fish habitat
   - ✔ Identification of the nature, magnitude, duration (permanent and temporary) and location of impacts

14. **Mitigation proposed, including:**
   - ✔ A description of all actions, including contingency plan(s), that will be taken to avoid, reduce or eliminate the impacts outlined above.
   - n/a Sediment, runoff and erosion control plans, which emphasize minimizing disturbances and source control.
   - n/a Vegetation disturbance replacement/ remediation plan.
15. Habitat compensation plans (if the project is likely to cause the harmful alteration, disruption or
destruction (HADD) of fish habitat)
   Fish habitat compensation plan must be consistent with iThe Department of Fisheries and
   Oceans Policy for the Management of Fish Habitatf, 1986.
   n/a Written approval from all affected landowners.
   Area based habitat balance
   Itemized cost of compensation (construction, planting and monitoring (during construction and
   post construction))

16. Maps
   ☑ Small scale overview location map (approx. 1:20,000)
     Detailed large scale map(s) of the site (1:500 or larger) indicating:
     ☑ Location of proposed works in relation to all watercourses within the property.
     ☑ Location of any designated parks, environmentally sensitive areas, wildlife refuges,
     ☑ Restrictive covenants, etc.
     n/a Location of major streets.
     ☑ Delineation of vegetation removal.

17. Photographs
   Detailed photographs of the site, taken from a variety of perspectives, appropriately marked
   to clearly display:
   ☑ The proposed works area including any vegetation to be disturbed.
   n/a The proposed area of compensation for habitat losses associated with the proposed
   works.

It is understood that the completion of this form does not constitute approval or authorization
under the Federal Fisheries Act.

Signed: [Signature] Date: April 10, 2006
(Proponent/ Agent)

Note: All maps and/or drawings must be submitted folded.
Please complete each section. All incomplete submissions will be returned
unprocessed.

Policy and guideline documents are available on line at:
http://www-heb.pac.dfo-mpo.gc.ca/publications/publications_e.htm

Project Review Information Requirements should be submitted to:
Fisheries and Oceans Canada
Habitat and Enhancement Branch
100 Annacis Parkway, Unit 3
Delta, BC, V3M 6A2

For further information, call 604-696-1152
Design Brief Accompanying Application by Dewdney Area Improvement District

We first provide some background on remedial and emergency actions taken by DAID since 2000 and provide background data on Hatzic Lake.

Background
In the fall of 2002, Hatzic Lake water levels were so low that fish passage through to the spawning areas was not possible for many. Dead salmon were seen in the shallow water in the channel on a number of occasions.

Early in September 2003, after months of heat, evaporation, and lack of rain, an urgent request was made by a Hatzic prairie farmer who had irrigation water licences on Hatzic Lake. The lake levels were so low that irrigation was becoming difficult and could soon be impossible. 5,000,000 plants in the nursery were at risk and several hundred jobs were at stake. At the same time, reports of dead fish were becoming more numerous as water levels subsided and temperatures climbed.

DAID, in consultation with DFO (Mission) and with the area provincial MLA, installed panels at the dike. This proved successful in bringing up the lake water levels by 32 cm. On the 10th day, a DFO officer attended the dike at low low tide, whereupon the water velocities through the panel and the water drop over the weir were too high to support fish passage and removal orders were made. If the visit was at high tide, the flow would actually have been reversed – flowing into the lake. It was then that the idea of a fishway was conceived in order to allow control of the lake water levels and permit continuous fish passage, acceptable to Fisheries and Oceans Canada.

In October 2003, rainfall reached record levels with a 200 year storm event. This caused widespread and prolonged flooding (weeks) in the Hatzic Valley. In 2004, the lake levels in Hatzic Lake rose to ‘normal’ summer levels only on June 12, long after normal, and began to fall on July 20th, only 38 days later. It was evident that the lake levels were destined for very low levels, as is the case in many watercourses throughout the province during the 2004 summer. In November 2004, another rain event caused flooding in Hatzic Valley with a further event happening in January 2005. PEP funds were expended in with these flood events to assist with flood control and for assistance for affected residents.

The start and End of Hatzic Lake summer water levels of 2.50m or greater:

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<th>2005</th>
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<td>May 23</td>
<td>Jun 04</td>
<td>May 24</td>
<td>May 13</td>
</tr>
<tr>
<td>End</td>
<td>Aug 13</td>
<td>Aug 09</td>
<td>Aug 02</td>
<td>Jul 19</td>
<td>Jul 10</td>
<td>Jul 25</td>
</tr>
<tr>
<td>Days</td>
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<td>65</td>
<td>71</td>
<td>45</td>
<td>47</td>
<td>73</td>
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</table>
Research by DAID – Hatzic Watershed

When the Fraser River levels lower, Hatzic Lake drains. As well, members of the Dewdney Area Improvement District’s Lake Level Committee have suspicions that the Fraser River contributes inflow water during winter storm events. In reviewing the issues related to the water levels of Hatzic Lake, the committee installed measurement gauges, set to datum, to monitor lake levels. Some key determinations from those readings are:

1. The west side of the lake is cut off during the year from the east by sandbars. Elevations were found to be at least 30cm difference during testing of Aug/Sep 2003.
2. Hatzic Lake water levels bear little on the water elevation in Legace Creek at the Dale Road bridge. (Preliminary findings, 2005)
3. Hatzic Lake water levels at the Lougheed Bridge can be significantly different than at the pumphouse and up to 0.85m higher during a heavy storm event.
4. The inadequate size of three CPR culverts are contributing to high Hatzic Lake water levels and flooding in winter periods.
5. A study by Golder Associates is under way. The study is reviewing the risk of flooding during the months of August and September.

Further information which needs to be learned:

1. More detail on the water levels in Legace Creek compared with changes in levels of Hatzic Lake. We have data from a UBC PhD applicant in the Institute for Resources, Environment and Sustainability. This data recorded creek elevations every 15 minutes during 2003-2005. This is valuable data and we hope to expand on it.
2. Impact of Hatzic Lake on water tables in Hatzic Valley – proxied by ditch water elevation.
3. Further analysis of CPR culvert impacts
4. Review and analysis of the effectiveness of the Flap Gates at the dike. Floodbox inflow velocities and volume estimations are required under tidal and storm conditions.
5. Detailed review of annual tidal elevations and the effectiveness of a year-round fishway and establishment of minimum Hatzic Lake water levels.
6. Fish populations in Hatzic Lake – Study of fishway habitat passage.
7. Lake elevations – DAID has recently (March 2006) installed electronic level gauges at 2 points in the lake and at the Dale Rd bridge on Legace Creek. These instruments will provide levels data every 15 minutes and will be instrumental in adding to the data available.

DAID Approvals

Following receipt of agency approvals, the Board of Directors of the Dewdney Area Improvement District will meet to discuss and provide final approvals for installation, subject to engineering and insurance issues.
Project Overview

The project was envisioned to further evaluate the water levels in Hatzic Lake and their effects on upstream farm field conditions, fish habitat and transport corridors, and the effectiveness of control water levels. A further desired effect is that sustained water levels will address a decades long problem of extremely poor recreational use of Hatzic Lake during mid to late summer. Low levels are also problematic for fish, both for passage and for higher, and deadly, water temperatures. As well, water for fire fighting is available with higher water levels.

The DAID Lake Level Committee (DAIDLLC) is proposing to install systems at the dike to accommodate fish access during varying Fraser River levels using standard fish weir techniques and principals in order to control the lake elevation for short terms. This will allow control of lake level without blockage to fish passage. The installation would provide the equivalent lake levels as did naturally occur in 1999.

The application is asking for the approvals for the concept of installing a permanent fish ladder at the Hatzic dike. In addition, approvals are requested for a temporary installation proposed to accomplish this and to allow the further gathering of data towards an approved permanent installation.

The costs of a permanent installation would be significant, likely in the $100,000’s of dollars and we feel having an interim temporary installation will result in knowledge not now available and will assist in the ultimate design of a permanent installation. Approvals for a permanent installation may well include requirements for review of further engineering and design information – something the temporary installation will assist with.

A key consideration for this project is that the approvals requested are twofold:

1. For a temporary installation to provide the means and incentive for further data collection and a greater understanding of the conditions on Hatzic Lake.
2. For a permanent installation with engineering and detailed design to follow after receiving approvals herewith for the concept. A requirement that further approvals of the permanent design is anticipated.

It is expected that a more detailed analysis and environmental review may be required prior to a permanent installation. The data collected and experience from the temporary installation is essential prior to moving towards a permanent solution.

Temporary Fishway

A length of 7.4 metres of open top pre-cast concrete box culvert would be installed covering the exit of one of the outflow boxes at the dike. The culvert will be a modified version with support struts across the top for structural integrity. A series of wooden
baffles, sequentially reducing in height, will result in reduced head pressures and consequent outflow velocities between panels permitting fish passage. The baffles will be hinged for easy, one man, removal (lay down). The three remaining outflow boxes would have weir like panels – with the possibility of having only one of the three operation (see section on Weir and Pool Fishway - Calculations). Each of the outlets would be to a height of 2.2 m with openings for fish passage. With daily tidal conditions, each opening will meet design criteria for fish passage at some point in the day. The box culvert is designed to allow fish passage at all times of the day.

This will not provide a precedent in terms of lake levels in September. In 1999, levels in Hatzic Lake were maintained at 2.6 m through to the second week of September by natural forces – the Fraser River levels remained high due to a record snow pack and low spring/summer temperatures, thereby extending the freshet period. This project would allow control of lake levels through to mid September.

The temporary project will be in place during the spring/summer months and up to September 15 only. The operational effects of the installation will only result once the Fraser River levels decline. This has commenced between July 10 and August 13 in the last 6 years.

The temporary installation will greatly assist the design and engineering of a permanent installation, which may well draw on the experience and expertise of Fisheries and Oceans personnel. The approvals requested for this project will allow for data collection and compilation. A detailed design would be required with more efficient operating conditions and controls for a permanent installation. With a limited budget, the temporary installation will require hands on observations that will draw on the volunteer efforts of many.

Given the daily tidal variations and the hi & low elevation range in the Fraser River throughout the year, this type of installation could be a permanent, year-round improvement operating for all but the spring freshet high Fraser River levels. Water passage through the Hatzic Slough and dike is variable due to tides and due to the configuration of the flap gates used at the dike. When levels of the lake are near those of the Fraser River the outflow is minimal and the flap gates would be closed for all but the smallest of fish. During low low tides, outflow can be at high velocity and during high high tides and low lake levels, the flap gates close, thereby eliminating any ability for fish passage. With a permanent installation, combined with flood closure protection, fish passage could be at all times except during the spring and early summer freshet period. The temporary project will provide a data set and experience towards a worthwhile goal of a permanent installation.

A study of the pumps at Hatzic Lake conducted for the Fraser Valley Regional District in conjunction with DAID and DFO, and paid for by DFO, was completed in July 2003. A recommendation to DFO in that study was:

Fish passage needs to be evaluated and applied in a step-wise manner that will allow investigators and fishery managers to make application decisions using
data and information from rigorous scientific assessments. As funding sources
for any upgrades at Hatzic are likely to come from the public sector, which itself
has funding limitations at present, it is important that a rigorous evaluation be
undertaken prior to implementation.

The DAIDLLC believes there is an advantage to having year-round minimum lake levels.
Whereas we do not propose that with this project, the data collected will be helpful to
investigating this option further.

**Fisheries and Oceans Canada**

The General Requirements for Approvals under the Dike Maintenance Act indicate the
applicant is responsible for obtaining any required approvals under the *Fisheries Act,*
*Water Act,* and other legislation and bylaws.

Fisheries and Oceans Canada (know previously as DFO) staff review project proposals to
determine whether the project is likely to cause a harmful alteration, disruption or
destruction (HADD) of fish habitat. Both the temporary and permanent installation will
improve the fish habitat in Hatzic Lake. Further engineering is required for a permanent
installation. However, with the requisite approvals to expend public funds towards that
goal, DAID can proceed with the knowledge that the system has merit and will receive
further approvals with appropriate engineering design.

Access to the lake is highly dependent on tidal conditions. The flap gates at the Hatzic
dike create obstructions to passage when water outlet speeds are too high (low tides) or
too low (high tides). A fishway will provide consistent access to the lake.

The DFO Land Development Guidelines book shows the swimming speeds of various
fish populations. The proposed flow speeds through the fishway are within the guidelines
set out by DFO and are estimated at 1.54 m/s

Low water levels have numerous negative effects:

a) **Potential to trap fish** in ponds created as levels subside.
b) **Warming of water temperature in the shallow areas of the lake.** 22°C is lethal to salmon. We found water temperatures up to 27°C in the lake. Dead fish were reported throughout the late summer and fall periods.
c) **Passageway restriction for spawning salmon and rearing sturgeon.** In the fall of 2001 and 2002 Hatzic Lake water levels were so low that fish passage through to the spawning areas was not possible for many. Dead salmon were widely observed in the 3 to 6 inches of water in the channel on a number of occasions. As well, juvenile sturgeon require 0.5m water depth to survive which is much more than the 0.23m required for salmon.d) **Increased weed growth** – milfoil. Warm and dry summers have resulted in extremely low lake levels and increased water temperatures.
levels have been at ‘normal’ summer levels for less than 40 days each summer in 2003 and 2004. Weed growth in the lake is reported to be the worst it has ever been.

e) **Increased potential for bacterial growth and coliform** from, in part, exposed and ‘baked’ bird droppings and elevated water temperatures.

f) **Elimination of pumping ability for irrigation of farmlands.** The installed works in 2003 came about in part because a lakeside nursery with 5,000,000 plants could not irrigate from the lake. 250 jobs were at risk and the 10 day installation assisted in keeping the operation functioning.

g) **Elimination of water pumping for fire suppression.** We all recall the Okanagan fires of 2003 and there should be water available in the lake for this purpose.

h) **Reduction and elimination of recreational opportunities.** (canoes, boating, fishing, swimming)

i) **Visually unsightly** mud bottom exposed.

**Golder Associates – 2006 review of Flood Risks and Fish Habitat**

In April, 2006, Golder Associates completed a review of the risks of flooding in August and September, together with comments regarding the proposed installation. In part, they commented: (full report attached)

“The drop in lake level has the following adverse impacts on fish and fish habitat (Golder 2002):

• Increase in water temperatures which increase risk of disease, promotes algal and weed growth, and favours non-native fish species while excluding native species;
• Physical reduction in the extent of the littoral region of the lake where most of a lake’s production occurs; and,
• Relocation of recreational activities to deeper parts of the lake thereby concentrating activities in a smaller area and the stressing of fish during their passage through or residency in the lake.

Focusing strictly on the biological aspects of this approach, higher lake levels would:

• Serve to moderate temperature increases presently seen as water levels drop;
• Maintain migration corridors for salmon moving to upstream spawning sites;
• Maintain a functioning littoral zone in the lake; and,
• Distribute the recreational activities over a larger area. “

**Increasing Lake Levels would improve the fish habitat.**
Design Brief Accompanying Application by

Dewdney Area Improvement District

We first provide some background on remedial and emergency actions taken by DAID since 2000 and provide background data on Hatzic Lake.

Background

In the fall of 2002, Hatzic Lake water levels were so low that fish passage through to the spawning areas was not possible for many. Dead salmon were seen in the shallow water in the channel on a number of occasions.

Early in September 2003, after months of heat, evaporation, and lack of rain, an urgent request was made by a Hatzic prairie farmer who had irrigation water licences on Hatzic Lake. The lake levels were so low that irrigation was becoming difficult and could soon be impossible. 5,000,000 plants in the nursery were at risk and several hundred jobs were at stake. At the same time, reports of dead fish were becoming more numerous as water levels subsided and temperatures climbed.

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In October 2003, rainfall reached record levels and, as we understand it, a 200 year storm event occurred. This caused widespread and prolonged flooding (weeks) in the Hatzic Valley.

In 2004, the lake levels in Hatzic Lake rose to ‘normal’ summer levels only on June 12, long after normal, and began to fall on July 20th, only 38 days later. It was evident that the lake levels were destined for very low levels, as is the case in many watercourses throughout the province during the 2004 summer.

In November 2004, another rain event caused flooding in Hatzic Valley with a further event happening in January 2005. PEP funds were expended in with these flood events to assist with flood control and for assistance for affected residents.
The start and End of **Hatzic Lake summer water levels of 2.50m or greater:**

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>May 26</td>
<td>Jun 05</td>
<td>May 23</td>
<td>Jun 04</td>
<td>May 24</td>
<td>May 13</td>
</tr>
<tr>
<td>End</td>
<td>Aug 13</td>
<td>Aug 09</td>
<td>Aug 02</td>
<td>Jul 19</td>
<td>Jul 10</td>
<td>Jul 25</td>
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<tr>
<td>Days</td>
<td>79</td>
<td>65</td>
<td>71</td>
<td>45</td>
<td>47</td>
<td>73</td>
</tr>
</tbody>
</table>

Research by DAID – Hatzic Watershed

When the Fraser River levels lower, Hatzic Lake drains. As well, members of the Dewdney Area Improvement District’s Lake Level Committee have suspicions that the Fraser River contributes inflow water during winter storm events. In reviewing the issues related to the water levels of Hatzic Lake, the committee installed measurement gauges, set to datum, to monitor lake levels. Some key determinations from those readings are:

1. The west side of the lake is cut off during the year from the east by sandbars. Elevations were found to be at least 30cm difference during testing of Aug/Sep 2003.
2. Hatzic Lake water levels bear little on the water elevation in Legace Creek at the Dale Road bridge. (Preliminary findings, 2005)
3. Hatzic Lake water levels at the Lougheed Bridge can be significantly different than at the pumphouse and up to 0.85m higher during a heavy storm event.
4. The inadequate size of three CPR culverts are contributing to high Hatzic Lake water levels and flooding in winter periods.
5. A study by Golder Associates is under way. The study is reviewing the risk of flooding during the months of August and September.

Further information which needs to be learned:

1. More detail on the water levels in Legace Creek compared with changes in levels of Hatzic Lake. We have data from a UBC PhD applicant in the Institute for Resources, Environment and Sustainability. This data recorded creek elevations every 15 minutes during 2003-2005. This is valuable data and we hope to expand on it.
2. Impact of Hatzic Lake on water tables in Hatzic Valley – proxied by ditch water elevation.
3. Further analysis of CPR culvert impacts
4. Review and analysis of the effectiveness of the Flap Gates at the dike. Floodbox inflow velocities and volume estimations are required under tidal and storm conditions.
5. Detailed review of annual tidal elevations and the effectiveness of a year-round fishway and establishment of minimum Hatzic Lake water levels.
6. Fish populations in Hatzic Lake – Study of fishway habitat passage.
**Project Overview**

The project was envisioned to further evaluate the water levels in Hatzic Lake and their effects on upstream farm field conditions, fish habitat and transport corridors, and the effectiveness of control water levels. A further desired effect is that sustained water levels will address a decades long problem of extremely poor recreational use of Hatzic Lake during mid to late summer. Low levels are also problematic for fish, both for passage and for higher, and deadly, water temperatures. As well, water for fire fighting is available with higher water levels.

The DAID Lake Level Committee (DAIDLLC) is proposing to install systems at the dike to accommodate fish access during varying Fraser River levels using standard fish weir techniques and principals in order to control the lake elevation for a short term. This will allow control of lake level without blockage to fish passage. The installation would provide the equivalent lake levels as did naturally occur in 1999.

A length of 7.4 metres of open top pre-cast concrete box culvert would be installed covering the exit of one of the outflow boxes at the dike. The culvert will be a modified version with support struts across the top for structural integrity. A series of wooden baffles, sequentially reducing in height, will result in reduced head pressures and consequent outflow velocities between panels permitting fish passage. The baffles will be hinged for easy, one man, removal (lay down). The three remaining outflow boxes would have weir like panels. Each of the outlets would be to a height of 2.2 m with openings for fish passage. With daily tidal conditions, each opening will meet design criteria for fish passage at some point in the day. The box culvert is designed to allow fish passage at all times of the day.

This will not provide a precedent in terms of lake levels in September. In 1999, levels in Hatzic Lake were maintained at 2.6 m through to the second week of September by natural forces – the Fraser River levels remained high due to a record snow pack and low spring/summer temperatures, thereby extending the freshet period. This project would allow control of lake levels through to mid September.

This project will be in place during the spring/summer months and up to September 15, 2006 only, should we have the required approvals. The operational effects of the installation will only result once the Fraser River levels decline. This has commenced between July 10 and August 13 in the last 6 years.

This project is also only a test towards a permanent installation. The approvals requested for this project are for 2006 to allow for data collection and compilation. A detailed design would be required with more efficient operating conditions and controls for a permanent installation. With a limited budget, this installation will require hands on observations that will draw on the volunteer efforts of many.

Given the daily tidal variations and the hi & low elevation range in the Fraser River throughout the year, this type of installation could be a permanent, year-round improvement operating for all but the spring freshet high Fraser River levels. Water passage through the Hatzic Slough and dike is variable with tides and due to the configuration of the flap gates used at the dike.
levels of the lake are near those of the Fraser River the outflow is minimal and the flap gates would be closed for all but the smallest of fish. During low low tides, outflow can be at high velocity and during high high tides and low lake levels, the flap gates close, thereby eliminating any ability for fish passage. With a permanent installation, combined with flood closure protection, fish passage could be at all times except during the spring and early summer freshet period. This project will provide a data set and experience towards the worthwhile goal of a permanent installation.

A study of the pumps at Hatzic Lake conducted for the Fraser Valley Regional District in conjunction with DAID and DFO, and paid for by DFO, was completed in July 2003. A recommendation to DFO in that study was:

Fish passage needs to be evaluated and applied in a step-wise manner that will allow investigators and fishery managers to make application decisions using data and information from rigorous scientific assessments. As funding sources for any upgrades at Hatzic are likely to come from the public sector, which itself has funding limitations at present, it is important that a rigorous evaluation be undertaken prior to implementation.

The DAID LLC believes there is an advantage to having year-round minimum lake levels. Whereas we do not propose that with this project, the data collected will be helpful to investigating this option further.
Fishway Considerations

Gauley (1967) tested the preference of chinook, sockeye and steelhead for submerged fishway entrances with head differentials of 1.0, 2.0, and 3.0 feet. Theoretical velocities through the orifices were 8.0, 11.3, and 13.9 feet per second (fps), respectively. The study was conducted by comparing the preference of fish between pairs of entrances, not the absolute attraction to each of them. The majority of fish of all three species chose entrances that had 2.0 and 3.0 foot of head when compared to the 1.0 foot entrance head. An increasing number of fish failed to enter any entrance, however, when the head was increased to 2.0 and 3.0 feet. The fact that these fish chose to remain in the tailwater pool rather than pass through the experimental or control entrances, suggests that they were attracted to the greater flow from the experimental entrance, but would not pass through it. The entrance head of about 1.0 foot is therefore preferred.

Other sources suggest, for Pacific salmon and steelhead, an entrance head of about 1.2 feet is preferred for streaming flow conditions. A range of 1.0 to 1.5 feet is a normal operating range.

We have designed the fishway with panel elevation differences of 0.30 m (1 foot). Our calculations (flow speeds through an opening above) that a head differential of 1 foot or 0.30 m yields flow speeds of 1.56 m/s. We note that these speeds will be maximums given the geometry of the panels in the box culvert. During periods of high tide, which may rise to 2.2 m during August and September, the flows could well be reversed and flowing into Hatzic Lake.

Fish Behavior

Quoted from references:

“Fish behavior and swimming abilities affect design concepts and details of fish ladder design. Fish move through fishways in different patterns. Early-chinook tend to use orifices and late-chinook and sockeye prefer weirs. The movement of early and late-steelhead is the reverse of this. Shad use weirs exclusively and are wall-oriented. They follow the walls and can be trapped in corners where there is no exit. (Squawfish, suckers, and carp use orifices.)”

“A practical fishway entrance shape is a rectangular port with a width to height ratio from 0.6 to 1.25.”

“Attraction velocity should be 4 to 8 fps, preferably in the 8 fps (2.43 m/s) range.”
Fisheries and Oceans Canada

The General Requirements for Approvals under the Dike Maintenance Act indicate the applicant is responsible for obtaining any required approvals under the *Fisheries Act*, *Water Act*, and other legislation and bylaws.

Fisheries and Oceans Canada (know previously as DFO) staff review project proposals to determine whether the project is likely to cause a harmful alteration, disruption or destruction (HADD) of fish habitat. This project will improve the fish habitat in Hatzic Lake. An application for review is included.

Access to the lake is highly dependent on tidal conditions. The flap gates at the Hatzic dike create obstructions to passage when water outlet speeds are too high (low tides) or too low (high tides). The fishway will provide consistent access to the lake.

The DFO Land Development Guidelines book shows the swimming speeds of various fish populations. The proposed flow speeds through the fishway are within the guidelines set out by DFO and are estimated at 1.54 m/s

Low water levels have numerous negative effects:

a) **Potential to trap fish** in ponds created as levels subside.

b) **Warming of water temperature in the shallow areas of the lake.** 22°C is lethal to salmon. We found water temperatures up to 27°C in the lake. Dead fish were reported throughout the late summer and fall periods.

c) **Passageway restriction for spawning salmon and rearing sturgeon.** In the fall of 2001 and 2002 Hatzic Lake water levels were so low that fish passage through to the spawning areas was not possible for many. Dead salmon were widely observed in the 3 to 6 inches of water in the channel on a number of occasions. As well, juvenile sturgeon require 0.5m water depth to survive which is much more than the 0.23m required for salmon.

d) **Increased weed growth** – milfoil. Warm and dry summers have resulted in extremely low lake levels and increased water temperatures. Water levels have been at ‘normal’ summer levels for less than 40 days each summer in 2003 and 2004. Weed growth in the lake is reported to be the worst it has ever been.

e) **Increased potential for bacterial growth and coliform** from, in part, exposed and ‘baked’ bird droppings and elevated water temperatures.

f) **Elimination of pumping ability for irrigation of farmlands.** The installed works in 2003 came about in part because a lakeside nursery with 5,000,000 plants could not irrigate from the lake. 250 jobs were at risk and the 10 day installation assisted in keeping the operation functioning.

g) **Elimination of water pumping for fire suppression.** We all recall the Okanagan fires of 2003 and there should be water available in the lake for this purpose.

h) **Reduction and elimination of recreational opportunities.** (canoes, boating, fishing, swimming)
i) Visually unsightly mud bottom exposed.

A key consideration for this project is that the approvals are for a test installation to provide the means and incentive for further data collection and a greater understanding of the conditions on Hatzic Lake.

It is expected that a more detailed analysis and environmental review may be required prior to a permanent installation. The data collected and experience from this test installation is essential prior to moving towards a permanent solution.
Engineering Considerations

Hydrology

Associated Engineering reviewed lake level controls in their 1992 study due to the long standing desire for changes from the public. The report noted:

“For the design of the lake control structure, a 2 day, 10 year return value of **40 mm/day** was used. Using this value, the runoff without using lake storage is estimated to be 12.9 m³/s for AMC II conditions and 5.0 m³/s for AMC I condition. In addition, considering the precipitation records for the month of August only from a combination of Pitt Polder, Mission West Abbey and Stave Lake Stations as well as Pitt Polder station on its own, the 2 day - 10 year return value is computed to be **28 mm/day** and the runoff is estimated at 7.6 m³/s for AMC II and less than 5 m³/s for AMC I conditions.

Considering the above if the control structure can accommodate an outflow of say 7.0 m³/s acting as a weir or by utilizing the available pumping facilities at the dyke, the upstream land owners concerns can, for the most part, be addressed.

Based on records from Atmospheric Environment Service (AES) the average total rainfall in August over the last 23 years (to 1992) has been **65 mm per August**.”

Golder Associates will complete a risk assessment for flooding in August and September in early 2006. The results of this analysis should confirm that the system is capable of handling any storm event during August or to the 15th of September. Results of this analysis will be forwarded upon completion.

Lake Inflows – Empirical and Estimated

Extensive research was undertaken to design the proposed installation. A number of factors need to be considered for a fishway, with the predominant issues being head differential across pools in a fishway and the resulting water flow speeds.

For fish passage, analysis of these factors was completed and compared with data and information from a variety of sources. Chiefly, the pressure drops across weir baffles will dictate the flow velocities over the weir and, in our case, through the orifices in each weir.

We first estimate the flow volumes through the flood boxes in August and September. During periods of higher flows, weir panels will be removed and pumping systems are available as a further back-up.

In September 2003 net water inflow was calculated as follows. A test installation had set weirs at the dike. It can be estimated that the water inflow to the lake was between 1 and 2 m³ per second, although this was a particularly dry period with low flows.

- (84.4 Ha (east side of lake, plus Chilqua and Hatzic Slough) x 10,000 m²/Ha
x 0.3m rise = 253,200 m³ net water inflow over
4 days x 24 hour/day x 3600 s/hr
= 0.73 m³ per second inflow)

• Outflow over the weirs and through the orifice in the weir panels add to the total
flow. With tidal effects, this quantity is difficult to estimate. We would expect this to
be a similar amount to that from lake level storage.

Total estimated flows are 1 – 1.75 m³ under dry conditions. This project includes for more
advanced measurement including stream cross-sections and, hopefully, velocity profiles. With
this, an accurate assessment of lake inflows can be made – heretofore not available.

**Tidal Effects**

The chart below has Water Survey of Canada data from the Mission Gauge (near real time with
high/low tides) and the daily physical survey at the Hatzic dike, roughly 4 km east on the Fraser
River. Since the DAID measurements are taken at alternative times in the day, apparent single
day anomalies are found – these are only reflective of varying tidal levels.

The chart shows the tidal range in September 2005 — from a low of roughly
0.4m to a high of 1.8m in a single day. The flows out of the lake will vary dramatically with
time of day – with tide levels. A pool and weir fishway will limit the velocity and volumetric
flow changes as tides drop to lows and head differentials increase.

Due to the variations in tides, flow volumes and velocities will vary from the flood boxes.
Attraction flows for fish at the entrances to the flood boxes is important – fish will generally be
attracted to faster streams, although successful passage rates do fall off as speeds increase above
2.0 m/s. The weir overflows for each floodboxes will be roughly equal. The orifices (square
openings) in the weir panels are calculated to allow greater flows through the fishway than over
and through the alternative floodbox. This will result in greater attraction velocities for fish at
the exit from the fishway. Fortunately, any conditions which are not ideal will correct itself
within hours due to tidal changes.
Another source of level data was developed by a Mr. Jamie Ross, a PhD Candidate at the Institute for Resources, Environment and Sustainability, UBC. He collected creek level data and water temperature using data loggers – records every 15 minutes during 2003-2005. This data is valuable as it allows a comparison with measurements taken at the dike. We also see temperatures up to 23°C in the creek with low levels. Lake temperatures have been recorded to 28°C under low level conditions. Higher water levels would reduce these temperatures in the heat of August. We propose to further augment this dataset with level data at the dike and at other locations on the lake.

The data also indicates that water level effects in Legace Creek do not occur until approximately a 2.2m lake level. Again, with this project, the dataset on the Hatzic watershed will be expanded.

Tide variations shown in plot of Mission Gauge data (http://scitech.pyr.ec.gc.ca/waterweb/formNav.asp) with DAID dike data overlain:
Weir and Pool Fishway - Calculations

With a flow rate of 2.25 m³/s through the dike, the fishway orifice is designed to accommodate 0.5 m³/s, and weir overflow was calculated at 1.75 m³/s. The weir overflow height is then 0.259m yielding a lake level of 2.2 + 0.259 or 2.459m. At expected lower inflow/outflow rates, the lake level would be in the range of 2.3 m.

### Flow Speeds Through an Opening

**Torricelli's Theorem**

Velocity of water from an orifice

\[ Q = A \times V \times C_v \times C_c \]

\[ V = \sqrt{2gH} \]

\[ C_v = 0.99 \]

\[ C_c = 0.65 \]

\[ g = \text{gravitational constant} - 9.808 \, \text{m/s}^2 \]

\[ H = \text{water differential head} \]

**Width:Height Ratio**

\[ \text{Width:Height Ratio} = 0.75 \]

\[ (0.6-1.2) \]

\[ \text{m}^3/\text{s} \]

\[ \text{Inflow} = 0.50 \]

### Flow over WEIRS

**EQ'N**

\[ Q = C_w L H^{1.5} \]

**Area Required**

- \[ Q = 3.3 \times L \times H^{1.5} \]
- \[ Q = 1.84 \times L \times H^{1.5} \]

<table>
<thead>
<tr>
<th>HEIGHT</th>
<th>VELOCITY</th>
<th>Width</th>
<th>Height</th>
</tr>
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<tr>
<td>m</td>
<td>ft</td>
<td>m/s</td>
<td>ft/s</td>
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<tr>
<td>0.10</td>
<td>0.33</td>
<td>3.9</td>
<td>0.90</td>
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<td>0.20</td>
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<td>1.27</td>
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<td>0.25</td>
<td>0.82</td>
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<td>1.64</td>
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<td>1.80</td>
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<td>0.60</td>
<td>1.97</td>
<td>23.6</td>
<td>2.21</td>
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</table>

<table>
<thead>
<tr>
<th>Inflow</th>
<th>0.50</th>
</tr>
</thead>
</table>

**Flow Rates**

25% Water Height above weir

<table>
<thead>
<tr>
<th>Q m³/s</th>
<th>Q ft³/s of total</th>
<th>Q m</th>
<th>Q ft</th>
<th>H metre</th>
<th>H feet</th>
<th>H inches</th>
<th>speed m/s</th>
<th>speed ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>8.83</td>
<td>2.21</td>
<td>0.071</td>
<td>0.234</td>
<td>2.8 in</td>
<td>0.490</td>
<td>1.607</td>
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</tr>
<tr>
<td>0.50</td>
<td>17.66</td>
<td>4.41</td>
<td>0.113</td>
<td>0.372</td>
<td>4.5 in</td>
<td>0.617</td>
<td>2.025</td>
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</tr>
<tr>
<td>0.75</td>
<td>26.49</td>
<td>6.62</td>
<td>0.147</td>
<td>0.487</td>
<td>5.8 in</td>
<td>0.707</td>
<td>2.318</td>
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<tr>
<td>1.00</td>
<td>35.32</td>
<td>8.83</td>
<td>0.179</td>
<td>0.590</td>
<td>7.1 in</td>
<td>0.778</td>
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<tr>
<td>1.25</td>
<td>44.14</td>
<td>11.04</td>
<td>0.207</td>
<td>0.684</td>
<td>8.2 in</td>
<td>0.838</td>
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<tr>
<td>1.50</td>
<td>52.97</td>
<td>13.24</td>
<td>0.234</td>
<td>0.773</td>
<td>9.3 in</td>
<td>0.890</td>
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<tr>
<td>1.75</td>
<td>61.80</td>
<td>15.45</td>
<td>0.259</td>
<td>0.857</td>
<td>10.3 in</td>
<td>0.937</td>
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<td>2.00</td>
<td>70.63</td>
<td>17.66</td>
<td>0.284</td>
<td>0.936</td>
<td>11.2 in</td>
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<td>3.00</td>
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<td>14.7 in</td>
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<td>3.679</td>
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<tr>
<td>4.00</td>
<td>141.26</td>
<td>35.32</td>
<td>0.450</td>
<td>1.486</td>
<td>17.8 in</td>
<td>1.234</td>
<td>4.050</td>
<td></td>
</tr>
</tbody>
</table>
Golder (2003) wrote “Passage of fish during periods of low flow can be greatly improved by changing the way the gates operate at the flood box. A short-term solution is to force the base flow into a single box rather than distribute the flows across all four boxes. This box should have its gate fully open and baffles placed within the box. The remainder of the gates should be closed unless required for flood discharges. …… A more permanent solution for fall fish passage and winter flooding would be the addition of a weir controlled floodbox(s).”

The above note is in reference to attraction flows at the outlet. There may be an opportunity to close some of the flood boxes completely depending on the water inflows to the lake. If summer conditions are dry enough, and total flows ebb to 1 m³/s, then one flood box – the fishway – could handle the flows out of the lake with a resulting lake level of 2.48m. The installation team will observe flows with the intention of reaching this goal. Flood boxes can be easily closed with the flap gates. Reversal of the closure can be effected quickly by one man.
Fish Populations

“White Sturgeon are known to exist in the Hatzic watershed with high numbers of juveniles found in the lower Hatzic Slough downstream of the pump station. (Lane and Rosenau, 1994) Local adult sturgeon usually reside in the Fraser River while juveniles move back and forth from the Fraser River into shallow water sloughs, such as Hatzic Slough.”

Fish Found in Hatzic Lake  (reported by Golder, 2003)

<table>
<thead>
<tr>
<th>Common Name (resident and anadromous)</th>
<th>Scientific Name</th>
<th>Native/Non native.</th>
<th>BC Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black crappie</td>
<td>(Pomoxis nigromaculatus)</td>
<td>non-native</td>
<td>Introduced</td>
</tr>
<tr>
<td>Brook stickleback</td>
<td>(Culaea inconstans)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Brown bullhead</td>
<td>(Ameiurus nebulosus)</td>
<td>non-native</td>
<td>Introduced</td>
</tr>
<tr>
<td>Carp</td>
<td>(Cyprinus carpio)</td>
<td>non-native</td>
<td>Introduced</td>
</tr>
<tr>
<td>Catfish (general)</td>
<td>(Ameiurus sp.)</td>
<td>non-native</td>
<td>Introduced</td>
</tr>
<tr>
<td>Chinook salmon</td>
<td>(Oncorhynchus)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Chum salmon</td>
<td>(O. kela)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Coho salmon</td>
<td>(O. kisulch)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Cutthroat trout</td>
<td>(O. clarki clarki)</td>
<td>native</td>
<td>Blue</td>
</tr>
<tr>
<td>Dolly Varden</td>
<td>(Salvelinus malma)</td>
<td>native</td>
<td>Blue</td>
</tr>
<tr>
<td>Lamprey (general)</td>
<td>(Lampela sp.)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Large scale sucker</td>
<td>(Calosalomus macrocheilus)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Northern pikeminnow</td>
<td>(Ptychocheilus oregonensis)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Feamouth chub</td>
<td>(Mylocheilus caurinus)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Pink salmon</td>
<td>(O. gorbusha)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Prickly sculpin</td>
<td>(COillus asper)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rainbow trout and Steelhead</td>
<td>(O. mykiss)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>Sculpin (general)</td>
<td>(COIUS sp.)</td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Sucker (general)</td>
<td>(Calosalomus sp.)</td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Threespine stickleback</td>
<td>(Gaslerosleus aculealus)</td>
<td>native</td>
<td>Yellow</td>
</tr>
<tr>
<td>White sturgeon</td>
<td>(Acipenser transmonlanus)</td>
<td></td>
<td>Red</td>
</tr>
</tbody>
</table>

Bass which have been caught in Hatzic Lake and sturgeon sightings are common.
Selected References


Introduction to Fishway Design, Chris Katopodis, P.Eng., Freshwater Institute, Central and Arctic Region, Department of Fisheries and Oceans, 501 University Crescent, Winnipeg, Manitoba, Canada, R3T 2N6, Ph:(204) 983-5181, FAX:(204) 984-2402, January 1992, http://eem.wra.gov.tw/upload/20031028094203617.pdf


Report on Hatzic Pump Station Upgrade – Strategic Plan, Golder Associates, July 16, 2003 for Fraser Valley Regional District, with funding provided by Fisheries and Oceans Canada.


REPORT ON

HYDROLOGIC ANALYSIS
LATE SUMMER LAKE LEVEL ASSESSMENT
HATZIC LAKE, MISSION, B.C.

Submitted to:

Dewdney Area Improvement District
Box 3005
Mission, B.C.
V2V 4J1

DISTRIBUTION:

2 Copies - Dewdney Area Improvement District
2 Copies - Golder Associates Ltd.

April 6, 2006

051-450121
April 6, 2006

Dewdney Area Improvement District
Box 3005
Mission, B.C.
V2V 4J1

Attention: Carl von Einsiedel

RE: HYDROLOGIC ANALYSIS
LATE SUMMER LAKE LEVEL ASSESSMENT
HATZIC LAKE, MISSION, B.C.

Dear Sir:

Golder Associates Ltd. (Golder) was engaged to carry out a hydrologic review of late summer lake levels on Hatzic Lake. The purpose of this assignment is to provide Dewdney Area Improvement District (DAID) with a review of the potential risk of flooding in the lake, if late summer lake levels are altered. It is understood that DAID may consider raising the operating levels in late summer, if the risk to properties from flooding is acceptable.

The scope of our work is limited to the hydrologic aspects of the project only, and does not include any specific provisions for geotechnical assessments, the investigation, testing or assessment of the potential presence or impact of soil or groundwater contamination at the site, or provision for bioscience services. Golder has the capability and will be pleased to provide such specialist environmental engineering services, if requested.

This report should be read in conjunction with the “Important Information and Limitations of this Report” which is appended following the text of the report. The reader’s attention is specifically drawn to this information as it is essential that it be followed for the proper use and interpretation of this report.
1.0 SCOPE OF WORK

As detailed in our letter proposal dated June 23, 2005, our proposed scope of work is as follows:

1) Review of available hydrological reports, as well as interpretation of available recent lake operating levels and Fraser River levels;

2) Assessment of the potential increase in risk of flooding to the farmland in Hatzic Prairie north of Hatzic Lake, should the lake’s operating level be raised to 2.1 to 2.3 m GSC, to enable boating from approximately July 1st to September 15th;

3) Assessment of potential extension of a flood, if one occurs when the lake is held at 2.1 to 2.3 m GSC; and,

4) Preparation of a letter report summarizing our analysis and recommended concepts of mitigative works.

2.0 DATA COMPILATION

2.1 River and Lake Level Data

Various agencies (MOE, DAID) have compiled a detailed list of daily lake levels, daily Fraser River levels, and pump operation periods which extend back to 1949. Records from 1949 to 1966, and from 1968 to 2005, were provided.

2.2 Meteorological Data

Canadian climate normals were obtained for Station No. 1105190 from Environment Canada. These data are included in Table 1 and salient points include:

- Daily average temperatures range from a high of 18 °C in August to a low of 2.5 °C in January; and,
- Monthly average rainfall ranges from a high of 242.9 mm in December to 63.6 mm in July.
Table 1
Canadian Climate Normals, Mission, BC, Station ID 1105190

<table>
<thead>
<tr>
<th></th>
<th>Average Daily Temperature (°C)</th>
<th>Average Rainfall (mm)</th>
<th>Average Snowfall (mm)</th>
<th>Average Precipitation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>2.5</td>
<td>197.3</td>
<td>19.7</td>
<td>217.0</td>
</tr>
<tr>
<td>Feb</td>
<td>4.7</td>
<td>178.8</td>
<td>11.9</td>
<td>190.7</td>
</tr>
<tr>
<td>Mar</td>
<td>6.8</td>
<td>151.2</td>
<td>3.4</td>
<td>154.6</td>
</tr>
<tr>
<td>Apr</td>
<td>9.7</td>
<td>129.5</td>
<td>0.2</td>
<td>129.7</td>
</tr>
<tr>
<td>May</td>
<td>12.6</td>
<td>102.5</td>
<td>0.0</td>
<td>102.5</td>
</tr>
<tr>
<td>Jun</td>
<td>15.1</td>
<td>100.6</td>
<td>0.0</td>
<td>100.6</td>
</tr>
<tr>
<td>Jul</td>
<td>17.9</td>
<td>63.6</td>
<td>0.0</td>
<td>63.6</td>
</tr>
<tr>
<td>Aug</td>
<td>18.0</td>
<td>74.0</td>
<td>0.0</td>
<td>74.0</td>
</tr>
<tr>
<td>Sep</td>
<td>15.6</td>
<td>77.9</td>
<td>0.0</td>
<td>77.9</td>
</tr>
<tr>
<td>Oct</td>
<td>10.9</td>
<td>141.1</td>
<td>0.1</td>
<td>141.2</td>
</tr>
<tr>
<td>Nov</td>
<td>6.1</td>
<td>249.1</td>
<td>3.6</td>
<td>252.7</td>
</tr>
<tr>
<td>Dec</td>
<td>3.5</td>
<td>242.9</td>
<td>27.1</td>
<td>260.1</td>
</tr>
</tbody>
</table>

2.3 Lake Volume Storage Data

Associated Engineering (AE, 1992) presented a relationship between lake level and storage volume in the lake. The incremental storage volume available, with respect to elevation, is as follows:

Table 2
Storage Volume wrt Elevation in Lake

<table>
<thead>
<tr>
<th>Elevation (m, GSC)</th>
<th>Storage Volume (10^6 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.506</td>
</tr>
<tr>
<td>1.5</td>
<td>6.155</td>
</tr>
<tr>
<td>2</td>
<td>8.462</td>
</tr>
<tr>
<td>2.2</td>
<td>9.570</td>
</tr>
<tr>
<td>2.5</td>
<td>11.430</td>
</tr>
<tr>
<td>3</td>
<td>15.056</td>
</tr>
<tr>
<td>3.5</td>
<td>19.342</td>
</tr>
</tbody>
</table>
2.4 Potential Evapo-transpiration

A preliminary estimate of potential evapo-transpiration was estimated for Hatzic Lake assuming a 3 km$^2$ surface area. Evapo-transpiration was estimated using the Thornethwaite equation. Table 3 summarizes the results.

<table>
<thead>
<tr>
<th>Month</th>
<th>$m^3$</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>21,476</td>
<td>7.2</td>
</tr>
<tr>
<td>Feb</td>
<td>45,673</td>
<td>18.2</td>
</tr>
<tr>
<td>Mar</td>
<td>89,942</td>
<td>30.0</td>
</tr>
<tr>
<td>April</td>
<td>150,441</td>
<td>50.1</td>
</tr>
<tr>
<td>May</td>
<td>232,628</td>
<td>77.5</td>
</tr>
<tr>
<td>June</td>
<td>291,105</td>
<td>97.0</td>
</tr>
<tr>
<td>July</td>
<td>355,257</td>
<td>118.4</td>
</tr>
<tr>
<td>Aug</td>
<td>326,732</td>
<td>103.9</td>
</tr>
<tr>
<td>Sept</td>
<td>236,816</td>
<td>78.9</td>
</tr>
<tr>
<td>Oct</td>
<td>138,274</td>
<td>46.1</td>
</tr>
<tr>
<td>Nov</td>
<td>59,807</td>
<td>19.9</td>
</tr>
<tr>
<td>Dec</td>
<td>29,708</td>
<td>9.9</td>
</tr>
<tr>
<td>Annual</td>
<td>1,977,860</td>
<td>659.3</td>
</tr>
</tbody>
</table>

2.5 Flood Boxes

Gravity flow out of Hatzic Lake into the Fraser River is conveyed through flood boxes which are located on the north side of the existing pump station. The boxes cross under the nine (9) metre high dike which separates the Fraser River from Hatzic Lake. The boxes cross at a right angle to the axis of the dike and consist of four- (4) 1800 mm x 1800-mm rectangular concrete boxes approximately 70 meters long.

Each box has a pair of vertical stop log guides on the upstream inlet. The stop logs allow a box to be isolated for servicing. The stop logs may also be used to regulate the upstream level of the lake and flow into the boxes. However, the stop logs have the adverse effect of reducing the efficiency of the boxes at passing flood flows. Therefore, the stop logs would have to be manually pulled out for flood conditions. This can be a large operational problem since storm flows occur at all hours. The stop logs can also act
as a fish barrier depending on the flow and water level differential between Hatzic Lake and the Fraser River. Stop logs have an additional disadvantage for both level and flow control in that they come in fixed increments.

The outlet end of the flood boxes has a top hinged flap gate. The flap gate functions as a check valve allowing water to flow through it in one direction only. It prevents backflow from the Fraser River into Hatzic lake from high tides or river floods. The gates are not perfectly water tight but reduce the flow back into the lake to such a small amount that even over extended periods of time there is no appreciable increase in the lake depth. The flap gate consists of a flat plate fabricated from steel supports with a timber face. It is hinged at the top of the outlet where it is fastened to the concrete deck.

The plate falls into a near vertical position over the outlet of the individual flood box to close it. A positive head differential against the downstream face due to water rising in the Fraser River above the level of water in Hatzic Lake will force the flap against the face of the flood box to seal it. A positive head against the upstream face due to water level higher in the lake than the river will force the gate open to release water into the river.

The invert of the flood boxes is at El. 0.0. A preliminary review of the capacity of the flood boxes was undertaken assuming orifice flow in an enclosed pipe. The flow capacity of the pipes will depend upon the differential head from the upstream to downstream end, however, a typical flow rate, assuming full pipe flow and a differential head of about 1 m, is about 35 m$^3$/s.

2.6 CPR Culverts

3 culverts extend through the CPR track, upstream of the flood boxes and downstream of the bridge over Lougheed Highway that drains flow from Hatzic Lake. 2 culverts are 3.05 m diameter, one is 2.44 m diameter. The invert of the 2 larger culverts is at El. -0.969, the invert of the smaller culvert is El. 0.43.

3.0 POTENTIAL INCREASE IN RISK

3.1 Analysis

In order to characterize the effect of raising the water levels in the lake, it is first necessary to consider the present regime of operating levels during the summer time window of interest. For the analysis, it was assumed that the target elevation would be El. 2.2. The water level data (refer to Section 2.1) were reviewed and organized to
extract all years with complete water level records for the lake and the river throughout the summer season, from July 1 to September 15. The years included in the analysis were the following:


For the years of analysis, there were a total of 2157 days where water levels were recorded from July 1 to September 15. A frequency histogram of these data was prepared. These data were then reviewed and those days where the water level was less than El. 2.2, were adjusted manually and the frequency histogram revised. The frequency histogram of water levels is detailed in Table 4 below. The number of adjusted days ranged from 0 for 1976, for which the Fraser River level itself did not drop below El. 2.68, and 67 days for 1993. The annual average number of days was 31, with a standard deviation of 17, meaning that 67% of the observations are between 14 and 48 days.

The table illustrates some interesting results:

- The actual historic lake levels vary from El. 0.6 m up to El. 4.0 m for the 28 years of record, however, 38% of the time, the lake level was between El. 2.4 and 2.6 m.
- 44.5% of the time, the lake level was at or below El. 2.2, which is the proposed operating threshold. Thus, adjustment of the lake level to hold it at El. 2.2 will alter the lake operating level for almost 50% of the time from what it would have been naturally.

Table 4
Histogram of Lake Levels, Raw Data from July 1 to September 15, as well as adjusted water levels

<table>
<thead>
<tr>
<th>Water Surface Elevation</th>
<th>Frequency</th>
<th>Frequency %</th>
<th>Cumulative Frequency</th>
<th>Frequency</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>8</td>
<td>0.4%</td>
<td>0.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>33</td>
<td>1.5%</td>
<td>1.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>68</td>
<td>3.2%</td>
<td>5.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>129</td>
<td>6.0%</td>
<td>11.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>120</td>
<td>5.6%</td>
<td>16.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>118</td>
<td>5.5%</td>
<td>22.1%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>1.8</td>
<td>174</td>
<td>8.1%</td>
<td>30.1%</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Adjustment of the lake level to El. 2.2 m essentially results in the loss of potential storage, should a storm occur. For example, the water can flow out through the flood boxes and also fill in the lake, providing some storage before upstream flood levels are affected.

Typical implications of considering the storage volumes (refer to Section 2.3 above) are as follows:

- holding the lake at El. 2.2 results in the loss of potential storage of about $5.06 \times 10^6 \text{ m}^3$, a volume equivalent to a flow rate of 59 m$^3$/s for 24 hrs, if the lake has a starting El. of 1.0;
- if the lake has a starting El. of 1.5, there is a loss of potential storage of about $3.42 \times 10^6 \text{ m}^3$, a volume equivalent to a flow rate of about 40 m$^3$/s for 24 hrs.

The peak pumping rate is 6.06 m$^3$/s through the pump station (Golder, 2002).

It is understood that the critical elevation in the lake, whereby upstream flooding starts to become a problem, is approximately El. 2.5. Golder (2002) reported that, for a starting water level of 2.5 m, about 2.5 km of Lagace Creek, between the intersection of Stave Lake Road and Farms Road, and about 500 m downstream of Dale Road Bridge, would be prone to flooding during a 10 year, 2 day event, using an estimated inflow rate of about 36 m$^3$/s. This would correspond to approximately $6.22 \times 10^6 \text{ m}^3$ of runoff over the 2 day period. If one considers a starting water level of El. 2.2, only about 1/3 of this runoff volume could be stored in the lake before there is a noticeable effect on the upstream water levels.

<table>
<thead>
<tr>
<th>Water Surface Elevation</th>
<th>Frequency</th>
<th>Frequency %</th>
<th>Cumulative Frequency</th>
<th>Frequency</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>158</td>
<td>7.3%</td>
<td>37.5%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>2.2</td>
<td>152</td>
<td>7.0%</td>
<td>44.5%</td>
<td>960</td>
<td>44.5%</td>
</tr>
<tr>
<td>2.4</td>
<td>234</td>
<td>10.8%</td>
<td>55.4%</td>
<td>234</td>
<td>10.8%</td>
</tr>
<tr>
<td>2.6</td>
<td>837</td>
<td>38.8%</td>
<td>94.2%</td>
<td>837</td>
<td>38.8%</td>
</tr>
<tr>
<td>2.8</td>
<td>59</td>
<td>2.7%</td>
<td>96.9%</td>
<td>59</td>
<td>2.7%</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>0.7%</td>
<td>97.6%</td>
<td>15</td>
<td>0.7%</td>
</tr>
<tr>
<td>3.2</td>
<td>11</td>
<td>0.5%</td>
<td>98.1%</td>
<td>11</td>
<td>0.5%</td>
</tr>
<tr>
<td>3.4</td>
<td>12</td>
<td>0.6%</td>
<td>98.7%</td>
<td>12</td>
<td>0.6%</td>
</tr>
<tr>
<td>3.6</td>
<td>11</td>
<td>0.5%</td>
<td>99.2%</td>
<td>11</td>
<td>0.5%</td>
</tr>
<tr>
<td>3.8</td>
<td>5</td>
<td>0.2%</td>
<td>99.4%</td>
<td>5</td>
<td>0.2%</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>0.6%</td>
<td>100.0%</td>
<td>13</td>
<td>0.6%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>2157</strong></td>
<td><strong>100%</strong></td>
<td><strong>2157</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
The average daily loss (in m of head, for each year) of potential storage was estimated considering only the days in each year where the lake level was held at El. 2.2 (i.e. the revised water level) and comparing the Fraser River level on those days. This number is variable, ranging from a maximum of 1.35 m in 1998 to 0.27 in 1991. These numbers correspond to storage volumes of $5.43 \times 10^6$ m$^3$, and $1.47 \times 10^6$ m$^3$, respectively (i.e. the potential storage volumes between El. 2.2 and 0.85, and El. 2.2 and 1.93).

Golder (2002) reviewed the flows corresponding to various return period events for summer and winter conditions. Flows for 10 year, 20 year and 200 year summer events were estimated for several durations ranging from 1 day up to 30 days. Flow data for Norrish Creek and Kanaka Creek were areally adjusted and used for the analysis. Table 5 below summarizes some relevant events for comparison.

### Table 5
Flow Rates and Total Volumes for Various Return Period Events for Hatzic Lake

<table>
<thead>
<tr>
<th>Duration (days)</th>
<th>10 year Total Volume of Water (m$^3$)</th>
<th>20 year Total Volume of Water (m$^3$)</th>
<th>100 year Total Volume of Water (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43.7 3,775,680</td>
<td>54.7 4,726,080</td>
<td>79.2 6,842,880</td>
</tr>
<tr>
<td>3</td>
<td>31.7 8,216,640</td>
<td>40 10,368,000</td>
<td>61.8 16,018,560</td>
</tr>
<tr>
<td>5</td>
<td>26.8 11,577,600</td>
<td>33.5 14,472,000</td>
<td>51.8 22,377,600</td>
</tr>
<tr>
<td>10</td>
<td>20.5 17,712,000</td>
<td>25.3 21,859,200</td>
<td>37.6 32,486,400</td>
</tr>
</tbody>
</table>

If the lake level is held at El. 2.2, there is at most, about $2.58 \times 10^6$ m$^3$ of storage before the lake levels rise above El. 2.44 and about $6.59 \times 10^6$ m$^3$ before the lake levels rise above El. 3.0 m. It is understood that pumping commences at El. 2.44 m (S. Dimond, pers.comm). Thus, considering Table 5 above, it can be seen that, for the 10-year, 24 hour event, there is about $1.28 \times 10^6$ m$^3$ of excess water that will have to be either pumped or managed. For the 20-year, 24 hour event, there will be about $2.14 \times 10^6$ m$^3$ of excess water.

The drop in Fraser River water levels in the late summer must also be considered, as this will allow water to drain out of the lake through the flood boxes. A preliminary review of flood box flow rates was undertaken, assuming a lake operating level of El. 2.2 and Fraser River levels ranging from 0.0 to 2.0. The potential flows through the flood boxes range from about 5 m$^3$/s (for the river at El. 2.0) to about 35 m$^3$/s, for the river at El. 0.0.
By holding the lake at El. 2.2, considering the loss of storage, ranging from a maximum of 1.35 m in 1998 to a minimum of 0.27 in 1991, and comparing this to the total runoff volume for a 10-year, 24 hour event, enough storage to potentially detain all of the water has been lost by the change in operating procedure. If the maximum loss of storage (1.35 m) has occurred though, this results in a larger differential head between the lake level and river level, thereby allowing more water to be released through the flood boxes to make better use of their capacity. Assuming that a maximum of about 35 m$^3$/s can be released through the flood boxes, and turning on the pump at El 2.2 instead of El. 2.44, about 41 m$^3$/s can be released. With an inflow rate of about 43.7 m$^3$/s (refer to Table 5), there is about 320,000 m$^3$ of extra water, which results in a lake level rise of about 0.11 m, which remains below the El. 2.5 m threshold for upstream effects.

On average, the lake will lose about 0.11 m per month in July, August and September due to evaporation (refer to Section 2.4 above). This works out to be about 3 mm per day, which does not contribute significantly to additional storage.

For a longer term, longer duration storm, such as a 10-year, 10 day event, releases through the flood boxes are more than able to keep up with the estimated inflow rate of 20.5 m$^3$/s.

However, for longer term, short duration events, the loss of storage will result in a rise in water levels potentially longer than what would have been observed. For a 20-year, 1 day event, the peak inflow rate of 54.7 m$^3$/s results in a total volume into the lake of about 4,726,080 m$^3$. Assuming a maximum potential release of 41 m$^3$/s, a potential extra volume of 1,270,080 m$^3$ results, rising the water level to about El. 2.5, which is the trigger for upstream flooding. Thus, by holding the water level higher, the potential for upstream flooding has increased, albeit only for longer return period, short duration (i.e. 24 hour events). For those events where the potential release rate through the flood boxes and by pumping is less than the inflow rate, and where the potential storage volume has been lost by raising the water level, the potential for upstream flooding has been increased.

For the 20-year, longer duration events, the inflow flow rate is lower than the potential release rates, thus the loss of storage has less impact.

In those years where the Fraser river doesn’t drop very far, essentially holding the water level at El. 2.2 does not affect flooding in a meaningful way, because the loss of storage is minimal and the potential release through the flood boxes will be lower, due to the smaller gradient through the flood boxes.
It is understood (S. Dimond, pers. comm., 2006), that infilling to the lake since 1992 has occurred due to sediment delivery from Pattison (Legace) Creek. Any infilling will decrease the potential storage, thus the potential effect of holding water at a higher level will actually be less, as there is less storage to be lost.

4.0 POTENTIAL INCREASE IN FLOOD DURATION

The potential increase in flood duration is small. For the 20-year, 24 hour event, the potential additional volume of 1,270,080 m$^3$ requires an extra 8 to 10 hours to pass the flow, assuming a rate of 41 m$^3$/s can be maintained. If the difference in elevation between the lake and the river is less than 1.35 m, then the outflow rate will be lower and the high level period in the lake will be longer.

5.0 EFFECT OF LAKE LEVELS ON FISH HABITAT

Normal operating level in the lake generally varies from 2.2 to 2.4 m geodetic. However, during the summer months, lake levels can drop quite low due to higher potential evaporation compared to rainfall, as shown in Tables 1 & 3.

The drop in lake level has the following adverse impacts on fish and fish habitat (Golder 2002):

- Increase in water temperatures which increase risk of disease, promotes algal and weed growth, and favours non-native fish species while excluding native species;
- Physical reduction in the extent of the littoral region of the lake where most of a lake’s production occurs; and,
- Relocation of recreational activities to deeper parts of the lake thereby concentrating activities in a smaller area and the stressing of fish during their passage through or residency in the lake.

Focusing strictly on the biological aspects of this approach, higher lake levels would:

- Serve to moderate temperature increases presently seen as water levels drop;
- Maintain migration corridors for salmon moving to upstream spawning sites;
- Maintain a functioning littoral zone in the lake; and,
- Distribute the recreational activities over a larger area.
6.0 SUMMARY

Based upon the available data, there is a marginal increase in the potential risk of flooding for longer term, short duration rainfall events, due to the loss of potential storage in the lake in years where the Fraser has dropped rapidly in the late summer. For those events where the potential release rate through the flood boxes and by pumping is less than the inflow rate, and where potential storage in the lake has been lost by raising the water level, the potential for upstream flooding has been increased, as the effect of elevated water levels in the Fraser has been artificially set.

For those years where the Fraser River has not dropped significantly, resulting in small differences between the lake and the river level, the effect of holding the lake at El. 2.2 will be minimal.

7.0 CLOSURE

We trust that this report addresses your current requirements. Please do not hesitate to contact us if you have any questions regarding the above.

Yours very truly,

GOLDER ASSOCIATES LTD.

[Signature]
Peter Morgan, P. Eng.
Associate and Senior Water Resources Engineer

PWM/tk
051-450121
8.0 REFERENCES


Golder Associates Ltd. (Golder), 2002. Hatzic Pump Station Upgrade Strategic Plan for Fraser Valley Regional District, Chilliwack, B.C.
IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

**Standard of Care:** Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

**Basis and Use of the Report:** This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

**Soil, Rock and Groundwater Conditions:** Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.
Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.
Lifting Apparatus
4 x Panels

3 @ 2.44 m Section length
Open Culvert
2.356 m height from floor.

Safety mesh over entire box.
Gangway over top.

Plan View
Hatzic Pumphouse
Steel cable through panels
to winch - easy open
4 x 1.8 m x 1.8 m
Outflow Boxes

View to Outflow Boxes
5 x hinged Panels
1 x Outflow Boxes Weir
Pivot Rod at base of each panel.
3 x Controlled Outflow Boxes
Alternate: 2 boxes closed on river side
Fish passageways approx.:
≈ 0.6 m x 0.4 m

Dewdney Area Improvement District - Lake Level Committee
Designed by SHD  Date: Dec. 2005  Scale: shown

PANEL LAYOUTS
HATZIC DIKE
Single Movable Winch Support on gangway above for panel removal from each of 4 floodboxes.

(Steel structure)

Cable secured thru hinged Panel Doors. Secured to winch on Manway above. Hinge rods placed through concrete.

Cable connects all hinged panels

Superstructure/Catwalk above allows walking and structural support for culvert. Cross struts for further support.

Panel Detail - Typical

2x2" Interior Frame
3/4" Steel Rod Pivot through culvert walls secured to frame
3" galv. screws to secure plywood to frame
3/4" pipe section for cable to pass
2 @ 1" Plywood sandwich

Clearance on inside panel to rotate panel down

Fishway

Hoist Detail

Dewdney Area Improvement District - Lake Level Committee

Support Cables & Panels
HATZIC DIKE

Designed by      SHD      Date: Dec. 2005      Scale : shown

Sheet P-03
FOR DAID PROJECT, OPEN TOP BOX CULVERT TO BE USED.

FOR DIMENSIONAL REFERENCE ONLY

(Note by DAID)

Dimension marked by "***" changes with the wall thickness

"A" is same width as the wall thickness for each size

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Notes:
1. Box is manufactured to ASTM C1433/M-01 specifications or as vertical chamber.
2. Standard section length is 2.44 meters. Other lengths/heights are available upon request.
3. Vertical chamber sections are supplied with rungs.
4. Cores, bends, or other special requirements are available upon request.
5. Sections are supplied with lifting devices.
Hatzic Lake Pumphouse

Fishway location
Low Lake levels trap fish and reduce habitat zones

September 2003 photo of Hatzic “Lake”
Hatzic Lake – as it should be
Sylvester Road Photo
2005 - spawning

SALMON SPAWNING AREAS
Coho Salmon: Scattered
       Heavy
Chum Salmon: Scattered
       Heavy

Nth North Arm of Chiqua Creek considered a
significant producer of chum salmon in Lower
Fraser Region.

Diatom Survey. ORC Stream Information Summary

HATZIC PRAIRIE
STUDY AREA
Hello Christy, Jay et al.

To summarize conversations of today between Steve Dimond, Dewdney Area Improvement District and Christy Wright and later between Steve and Jay Hammond,

A request was made by a Hatzic prairie farmer to have lake levels increased to permit irrigation pumping for 2 water licences which now exist and which service 5 million plants and provide for 400 jobs. Mr. Randy Hawes, MLA, was instrumental in coordinating a quick review and the Dewdney Area Improvement District has approved the changing of the Lake, with the further advice and direction of DFO.

Under the letters patent for the DAID and from the Water Act, DAID is able to retard or confine water and is able to place obstructions in streams or the bed of streams. The spillway at the dyke is designed to accommodate stop logs or similar on the lake side to facilitate this effort.

Mr. Steve Dimond has been given the direction from the Chairman of the Dewdney Area Improvement District, Mr. Craig Appleby, to effect these changes in Lake Levels.

We discussed the following: (Please advise ASAP to any corrections or additions .... )

* No quantitative (empirical) estimates are readily available for Hatzic Lake temperatures at differing water depths.
* Existing channels run up the east side of the lake to the north end where they traverse westerly to the Legace Creek outfall
* Deeper water would be cooler than shallower water
* Water temperatures above the sand bars, where water will cover with elevated levels, may increase.
* Native fish will likely travel the water path of least temperature
* Native fish will likely travel within the deeper existing channel due to cooler water temperatures
* ie ... elevated temperatures in waters upon sand bars would cause native fish to divert to the cooler, deeper, channel
* Increased lake levels would be better from a habitat perspective than shallower waters for the fish.
* Evidence of dead catfish now found in the lake might suggest elevated temperatures, especially since catfish are a warm water, non-native fish (personal observations to Steve Dimond relayed by resident at Lake Level meeting of August 24)
* Temperature conditions in the Lake require monitoring at key areas
* Changing the lake level should be a closely monitored project with temperature records at key locations
* A trial and error approach should be taken with interim monitoring of temperatures and upstream effects
* Temperatures above 20 deg C are not good for native fish populations
* Try increasing lake levels where temperatures approach high limits
* Test water temperatures at new elevations.
* Initial intentions are to raise the lake 2 to 3 feet.
* Further increases may be warranted based on sand bar coverage and resulting temperatures.
* DFO has indicated an allowance for fish passage should be maintained at the Lake outfall.

* Feedback and suggestions are welcome.

For your further information:

* A meeting of interested parties on August 24, 2003 at Everglades Hall had about 150 attendees from the island and north of the lake. A "petition for change" was signed by nearly 500 people. This was for changes to Lake levels through late september only for recreational use.

* http://www.missionbc.com/lakelevel/ currently has historical data on lake and river levels which will be augmented with the results and data from this project.

Steve Dimond (604) 820-6700 and David Scott (604) 814-2192 will be co-ordinating elevation surveys before, during, and after increasing lake levels at key areas including pumphouse, CPR culverts, Mid lake, Legace Creek outfall, Farms Road bridge, Dale Road Bridge, and other points deemed worthy. Temperatures will also be checked with potential for further upstream measures to ensure base case conditions are understood. Short periods of full blockage may be required to effect level changes (< 24 hours each) due to low inflows to lake.

Upstream effects of raising the lake levels are to be specifically reviewed in order to provide further data for analysis for a pilot project in 2004, being coordinated and proposed by a select committee of the Dewdney Area Improvement District chaired by Steve Dimond with members including David Scott, Robert Dale, Glenn Towns, Cathy Cloutier, and John Connor.

Will advise further as we progress.

Cheers
sd

cc: Golder Associates Ltd staff
     DFO Staff
     DAID and committee

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steve@dimond.ca
MEMORANDUM

To: Hugh Sloan, Director of Planning
From: Graham Daneluz, Planner I – Long Range
Date: March 31, 2005
Subject: Dewdney Area Improvement District – Hatzic Lake Level Control Project
File No.: 9600-24-001

RECOMMENDATION

THAT Electoral Area Directors support Dewdney Area Improvement District’s initiative to test temporary water level controls on Hatzic Lake subject to:

1. a commitment from DAID that the works will be removed prior to and throughout the duration of any in-stream works undertaken by Fraser Valley Regional District so that water levels in the Lagace Creek-Hatzic Slough main stem above Hatzic Lake return to the levels that would occur under pre-existing conditions; OR certification by a hydraulic engineer that the proposed works will not influence water levels above Hatzic Lake; and,
2. determination by a hydraulic engineer of any increase in the risk of flooding associated with the works;
3. DAID holding a public information meeting to discuss risks and benefits associated with the works prior to implementation;
4. supervision of the project by a responsible professional; and,
5. authorization from Fisheries & Oceans Canada.

ISSUE

Dewdney Area Improvement District proposes to install a temporary flow control device at the Hatzic Pump Station to maintain higher water levels in Hatzic Lake over the summer. There are potential implications for flood risks and FVRD’s plans for flood mitigation works in Hatzic Prairie.

BACKGROUND

During the late summer, particularly in recent years, low water level in Hatzic Lake has greatly impeded its recreational use. Deposition of sediment, drier than average summers, and possibly withdraws of water for irrigation, all contribute to low lake levels. Dewdney Area Improvement District proposes to install a temporary flow control device at the Hatzic Pump Station to maintain higher water levels in Hatzic Lake during the summer.

The Hatzic Pump Station consists of floodboxes and pumps. When the Fraser River water level is low, the floodboxes remain open to allow water from the Hatzic system to drain out by gravity. When the Fraser rises, the floodboxes close to prevent Fraser River water from flooding into the Hatzic system. When the floodboxes are closed water draining from Hatzic is pumped away to the Fraser.

During August and September, Fraser River levels are typically low and the floodboxes remain open. DAID proposes to temporarily modify the floodboxes during August and September to restrict water from flowing out of the Hatzic system and thereby raise the water level in Hatzic Lake. Specific details about how this would be accomplished are not provided, except that a fish weir would be included to maintain, even improve, fish access.
The purpose of the test installation is to improve summer recreational use, test the effectiveness of the designed floodbox modifications, assess impacts on a variety of related values, and to collect data to increase understanding of lake hydraulics. Higher lake levels may have a variety of ancillary benefits such as improving conditions for fish, increasing lakeshore habitat and reducing aquatic weed growth.

A memo from the Dewdney Area Improvement District outlining the proposed lake level control project is attached as Schedule 1.

**DISCUSSION**

There are long-standing concerns relating to the Hatzic Pump Station:
- it has insufficient pumping capacity to prevent flooding during moderate to heavy rain storms;
- it doesn’t provide means for controlling lake levels during the summer; and,
- it kills fish when the pumps are operating.

In 2003, the Regional District, in partnership with DAID, DFO and others, commissioned Golder Associates to develop a strategic plan for pump upgrades to solve these problems. Unfortunately, the price tag for the needed infrastructure upgrades is in excess of $6 million. Accordingly, the Improvement District is looking for a low-cost way to temporarily modify their infrastructure to allow control over summer lake levels. The proposed works don’t address concerns with fish mortality or pump capacity.

There is strong support among Hatzic Island residents for raising summer lake levels to improve recreational values. Of those who responded to a community planning survey in 2004, 60% identified low summer lake levels as the most important issue facing the community. There may be considerably less support among Hatzic Prairie farmers who have traditionally perceived there to be an increased and unacceptable flood risk associated with maintaining higher lake levels.

**Flood Risk**

High water levels in the Hatzic system are most likely to occur: 1) May to July when the Fraser is in freshet and drainage is dependent on pumping; and, 2) November to December when the greatest amount of rainfall occurs and the chances of extreme rain events are greatest. High water levels are least likely to occur January to March.

DAID records of pump operations indicate that the pumps often operate in August and occasionally in September. Again, the pumps operate when higher Fraser River levels cause the floodboxes at the outlet of the Hatzic system to close. Drainage from Hatzic is dependent on pumping at these times and the risk of flooding rises. A regional-scale rainstorm which causes water levels in both the Fraser and Hatzic to rise could cause flooding during August and September. While the risk of flooding in the late summer is lower than during other times of the year, there clearly is some risk. Maintaining higher water levels during this period will exacerbate any flood event that might occur by reducing storage capacity in the lake.

It may be that flood risks associated with the proposed works are low and acceptable. However, the risk should be assessed by a hydraulic engineer and presented to the community for discussion before any works are undertaken. Ultimately, the community must be able to understand any increase in risk and decide whether it is acceptable. Staff recommend that FVRD’s support for this project be contingent on a hydraulic engineering assessment of flood risk and the holding of a public meeting to discuss flood risks and other aspects of the works. Staff further recommend that the overall project be supervised by a responsible professional and that the works be designed so that any structures can be quickly and safely removed, even under high flow conditions, if a heavy rain storm occurs and flooding is immanent.

**Impact on Hatzic Prairie Sediment Control Works**

Frequent and widespread flooding occurs in Hatzic Prairie during moderate to heavy rainfalls when water levels in Hatzic Lake are moderate and the floodboxes are open. This flooding is largely independent from Hatzic Lake levels; it is caused by sediment build-up in the Lagace Creek – Hatzic Slough main stem which prevents water in tributary streams from draining away.

It is not clear whether raised lake levels would increase the risk of Hatzic Prairie flooding caused by stream bed aggradation. However, higher water levels would likely interfere with the program of in-stream sediment removal planned to alleviate Hatzic Prairie flooding.
FVRD has applied for funding from the Provincial Emergency Program to excavate sediment from the Lagace Creek-Hatzic Slough main stem this summer. Under provincial and federal regulation, in-stream works such as the removal of sediment may only occur during the ‘fisheries window’ - mid August to mid September - when impacts to fish are minimized. The ‘fisheries window’ coincides with the period when DAID wishes to maintain higher lake levels. Low water level in Hatzic Prairie streams is a critical operational requirement for this in-stream work. Higher water levels would likely increase project costs and increase the complexity of sediment removal efforts.

Staff recommend that FVRD seek assurances from DAID that any lake level control works will be removed prior to and through-out the duration of any in-stream works undertaken by Fraser Valley Regional District so that water levels in the Lagace Creek-Hatzic Slough main stem above Hatzic Lake return to the level that would occur under pre-existing conditions. Coordination between DAID and FVRD will be required to avoid conflicts.

Community Plan Policies

Low water levels in Hatzic Lake have been a concern for recreational users for at least two decades. The current Official Community Plan for the Dewdney-Hatzic Lake area, adopted in 1988, recognizes this problem and assures Regional District assistance in resolving it while acknowledging that DAID is the responsible authority. Relevant OCP policies are:

6.1 The Regional Board recognizes that recreational opportunities on Hatzic Lake are curtailed during the summer months because of inadequate water levels. The Regional Board also recognizes the inadequate capacity of outlet facilities on Hatzic Slough as well as the need to manage stream drainage in the Hatzic Basin.

6.2 The Regional Board will continue to liaise with the Dewdney Area Improvement District and will provide assistance when called upon to help resolve the problem of drainage management and lake level control on Hatzic Lake. However, the Regional Board also recognizes that the Dewdney Area Improvement District is the responsible authority for drainage management in the plan area.

Conclusion

The solution to problems with the Hatzic Pump station is infrastructure upgrades to significantly increase pumping capacity, improve fish access and enable greater control of lake levels without unacceptably increasing flood risks. However, the costs for such work, estimated at more than $6 million, are well beyond the means of the local community and no external sources of funds have been identified.

Therefore, staff suggest that EA Directors support DAID’s initiative as an interim measure towards addressing lake level concerns subject to:

- a commitment from DAID that the works will be removed prior to and through out the duration of any in-stream works undertaken by Fraser Valley Regional District so that water levels in the Lagace Creek-Hatzic Slough main stem above Hatzic Lake return to the level that would occur under pre-existing conditions - OR - certification by a hydraulic engineer that the proposed works will not influence water levels above Hatzic Lake;
- determination by a hydraulic engineer of any increase in the risk of flooding associated with the works;
- supervision of the project by a responsible professional;
- DAID holding a public information meeting to discuss risks and benefits associated with the works prior to implementation; and,
- authorization from Fisheries & Oceans Canada.

COMMENT BY DIRECTOR OF PLANNING

COMMENT BY ADMINISTRATOR

Graham Daneluz, Planner I - Long Range
Dear Trustees of the Dewdney Area Improvement District:

RE: Seasonal Water Controls, Hatzic Lake

I am writing in response to the February 28, 2005 communication from the Dewdney Area Improvement District Lake Level Select Committee regarding seasonal water level controls for Hatzic Lake.

Thank you for the opportunity to provide comments. The matter was considered at the April 12, 2005 meeting of Fraser Valley Regional District’s Electoral Areas Services Committee (EASC). The EASC resolved:

THAT Electoral Area Directors support Dewdney Area Improvement District’s initiative to test temporary water level controls on Hatzic Lake subject to:

1. a commitment from DAID that the works will be removed prior to and through out the duration of any in-stream works undertaken by Fraser Valley Regional District so that water levels in the Lagace Creek-Hatzic Slough main stem above Hatzic Lake return to the levels that would occur under pre-existing conditions; OR certification by a hydraulic engineer that the proposed works will not influence water levels above Hatzic Lake; and,

2. determination by a hydraulic engineer of any increase in the risk of flooding associated with the works;

3. DAID holding a public information meeting to discuss risks and benefits associated with the works prior to implementation;

4. supervision of the project by a responsible professional; and,

5. authorization from Fisheries & Oceans Canada.

The staff report accompanying the DAID communication on the EASC agenda is enclosed herein for your information.

Clearly there is a strong need to coordinate activities in this watershed. Elevated water levels in the Hatzic system would negatively affect flood reduction projects FVRD has planned for the August-September fisheries window this year. Accordingly, our support for the lake level control initiative is contingent on a written commitment from DAID that lake level control works will be removed prior to and through out the duration of any in-stream works undertaken by FVRD so that water levels in the Lagace Creek-Hatzic Slough main stem above Hatzic Lake return to the levels that would occur under pre-existing conditions. Alternately, you could provide certification by a hydraulic engineer that the proposed works will not influence water levels above Hatzic Lake. I look forward to your response.

I will ensure that DAID is informed of all activities planned by FVRD in the Hatzic area. Please inform FVRD of any activities planned by the Improvement District.
We wish you success in your endeavour.
If you have any questions or comments, please contact me at 1-800-528-0061 or by email at gdaneluz@fvrd.bc.ca.

Yours truly,

Graham Daneluz
Planner I – Long Range

cc: Lloyd McKimmon, Director, Electoral Area “G”
    Richard Bogstie, Director, Electoral Area “F”
Steve,

This is following up on your proposed project to control seasonal water levels in Hatzic Lake. Firstly, I apologize for the delay in responding to your recent call out for feedback, but I was on vacation last month. Anyway, based on your proposal to install works to regulate flows at the Hatzic floodbox, please be advised that the changes/alterations to the Hatzic Lake floodbox require Dike Maintenance Act (DMA) approval. Attached is a DMA application form and some background information on the requirements in this regard. (Note: this application form isn't yet on our website, but the site has other information on dikes, etc that you may find useful -- follow the link in my signature block below).

With your DMA application, you should submit plans of the proposal and any supporting info that may be relevant to it's construction, operations and maintenance.

In the preparation of your DMA application, some issues that you should be aware of include:
* The DIAD would become responsible for the operations & maintenance of new works.
* The proposed works & alterations to the floodbox must be designed by, and constructed under the supervision of, a suitably qualified Professional Engineer.
* The proposed works must be designed to function in a manner that would not increase the risk to public safety. In this regard the design should consider a fail-safe mechanism to ensure it can be removed in the event of an emergency.
* A water-level operations manual with rule curves that include specific lake level operating criteria would be required as a condition of approval.
* For our records "As built" drawings and an Operations Manual (as noted above) will be required to be submitted to this office at the completion of the works.

I hope this helps, and if you have further questions please don't hesitate to call.
Regards, John

Flood Safety Officer / Deputy Inspector of Dikes
Flood Hazard Management Section (Surrey)
Ministry of Water, Land and Air Protection
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