A Summary of Water Quality Monitoring in the Somenos Basin 2003-2005

Prepared For

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EXECUTIVE SUMMARY

Urban and agricultural developments within the lowlands surrounding Somenos Lake contribute significant nutrient loads to the Somenos Basin, resulting in degraded salmon habitats. Exacerbating the problems in the basin are low summer flows and low gradients in Somenos Creek, Somenos Lake and the lower reaches of inlet tributaries, which are anoxic from spring until fall, and often into early winter. Another issue of concern in the basin is flooding of agricultural fields in spring and fall, which can cause late crop seeding or complete loss of harvest for many farmers.

In 2003, extensive water quality monitoring, followed by a water level monitoring program in 2004, were implemented in the Somenos Basin to investigate these issues and determine actions that might mitigate the problems. Objectives of the overall study were to:

1. Conduct a hydrological flow and water quality study in the Somenos Basin to establish the base-line water quality, water level, and fish use conditions prior to drainage management activities (beaver dam and aquatic vegetation removal);
2. Evaluate and report on the impact/benefit of aquatic vegetation removal on water quality in Somenos Creek;
3. Evaluate the potential benefits to the fisheries and agricultural resource from a minimum flow release from Crofton Lake in Richards Creek and Somenos Lake;
4. Develop recommendations for habitat restoration prescriptions to improve water quality and fish access into the watershed.

Results of the hydraulic flow study are reported in a separate document titled "*Somenos Lake Hydraulic Modelling"*, Northwest Hydraulic Consultants Ltd., 2005.

From the results of this study, the following conclusions and recommendations have been made:

1. Historical fish distribution data and recent minnow trapping results (2004/05) indicate very low densities of rearing coho fry in the Somenos watershed except in the higher reaches of the inlet tributaries. It is likely that Somenos Creek and Somenos Lake are used solely as migration corridors during periods of adequate water quality for adults to access spawning habitat in the upper reaches of tributaries and for seaward migration of pre-smolts.
2. Coho juveniles likely would avoid over-wintering in Somenos Creek, because it does not usually exhibit acceptable oxygen levels until after late fall/early winter. This is too late for coho juveniles which normally establish over-wintering areas during the on-set of fall rains and declining water temperatures.
3. Chinook fry were recorded on only one survey in very small numbers. Their complete absence during minnow trapping in 2005 was surprising in spite of their peak numbers in the Cowichan and the suitable conditions in Somenos at the time

of survey, since they are often attracted to warmer productive waters to attain biomass before their seaward migration.

4. Increasing fish use in Somenos Creek would require maintenance of cooler water temperatures below 20 degrees and oxygen levels above 5 mg/l. This could be achieved to some degree by improvements in drainage combined with the maintenance or establishment of taller vegetation on the southern-side of the creek and reductions in nitrogen and phosphorus inputs.
5. With only one year of water quality data available post treatment, the vegetation and beaver dam removal in Somenos Creek in 2004 did not result in significant improvements in water quality. A long-term water quality monitoring program may identify further improvements in future.
6. Based on the amount of storage available in Crofton Lake, an average flow of 28.3 L/s or 1 cfs could be released from July 1st until the end of September to augment summer base flows in Richards Creek. This represents an increase from 1% MAD to 7% MAD, thus increasing fish production from 12% to 70% of optimum (with optimum juvenile fish production at 10-20% of MAD). While most of the benefit would be observed in the higher gradient reaches of Richards Creek, improvements in fish production in the low gradient section would likely be less significant due to the high biochemical oxygen demand (BOD). A test release should be conducted during the summer months to evaluate potential improvements in water quality in the lower slough-like section of Richards Creek.
7. Somenos Lake would not be a good candidate for lake aeration because of its shallow depth, thick layer of anoxic bottom sediment and sub-lethal temperature profile throughout the water column in the summer.
8. On the other hand, the addition of aeration in Somenos Creek and some sections of the inlet tributaries could potentially increase fish utilization in areas where summer water temperatures are suitable. It is recommended to further evaluate the use of aeration as a means of improving water quality by conducting a short-term trial using compressed oxygen and fine pore tubing in a small section of Somenos and/or Richards Creeks.
9. Lastly, the implementation of Beneficial Management Practices (BMPs) among the agricultural community and streamside protection initiatives targeted at urban landowners will play a significant role in improving conditions for fish production and for farmers in the long-run.

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Funding for this project was provided by the Pacific Salmon Commission - Southern Boundary Restoration and Enhancement Fund, the District of North Cowichan, and Fisheries and Oceans Canada. We would also like to thank J. Smith for the extensive time series of general water quality data collected at Lakes Rd. footbridge, as well as Doug Poole, Margaret Wright, Wayne Haddow and David Tattam for assisting with field data collection. Much appreciation is also extended to the Cowichan Tribes and the many other private landowners for permitting access to water quality monitoring stations, and Dr. Ken Ashley for taking time to accompany us on a tour of the Somenos Watershed, and providing valuable comments and advice on lake aeration technology and applications for this system.

1.0 INTRODUCTION

The Somenos Basin is recognized as a key area for coho production in the Cowichan River watershed. Bings, Averill, and Richards Creeks, tributaries in the Somenos Basin, provide quality year round rearing and spawning habitat for salmonids. Somenos Lake and Somenos Creek also support salmon during higher flows in the spring and winter but poor habitat during the summer and fall. This eutrophic system experiences lethal temperature and oxygen levels during this period.

Urban and, more importantly, agricultural development around the Somenos Creek watershed has intensified interaction between agriculture and fish habitat concerns. Farmers, fisheries biologists and hydraulic engineers have been reviewing the physical and biological conditions of the watershed and all strongly suspect that a combination of agricultural practices, low stream gradient, poor flow conveyance and backwatering effects from Cowichan River have a negative effect on both agriculture and fish habitat. A detailed survey of the Somenos Creek drainage area from Somenos Lake to the Cowichan River confluence conducted in the early 1980s determined that the overall water elevation drop over the 3 km distance was only 0.6 meters. Most of the drop occurred over two beaver dams near the confluence to Cowichan River. When Cowichan River is in flood, water level can rise up to 2 meters and backwater Richards Creek, a tributary that flows into the head of Somenos Lake. Under these conditions, several farms are flooded and seeding and harvesting during the spring and fall months are problematic or impossible. It is very likely that flooding problems increased in the Somenos watershed when the Cowichan River was diverted in 1956 into a relic channel, which received outflow from Somenos Creek (Department of Agriculture, 1958).

Through the Federal / Provincial Agricultural Rural Development Subsidiary Agreement and with support from the District of North Cowichan (DNC), Somenos and Richards Creeks were excavated in 1983. Following this activity Somenos Lake flood levels were reduced by approximately 0.8 m but resulted in only short-term improvements (Hay & Co., 1998). Provincial and federal biologists observed slightly improved water quality in Somenos Creek as well, likely due to suspected increases in groundwater upwelling flow exposed during the dredging. It is reported that the improved conditions sustained coho summer rearing for several years (Burns, 1999).

The objectives of this study will be to document the current fish habitat conditions in the watershed, identify limiting factors and recommend restoration activities to increase the productive capacity of salmon and correspondingly improve agricultural production. The work is being coordinated through the Somenos Basin Technical Committee (SBTC), which is the technical support group for the Somenos Basin Steering Committee. The SBTC has representatives from the Cowichan Agricultural Society, Ducks Unlimited Canada, Ministry of Agriculture, Food and Fisheries, Fisheries and Oceans Canada (DFO), Cowichan First Nation and the DNC.

This report will summarize the results from the following field studies and activities:

1. A water quality study that will:
   - determine the effect of aquatic vegetation on water quality in the Somenos Basin;
   - determine if aquatic vegetation and beaver dam removal is beneficial to maintaining water quality for;
   - determine if a minimum discharge of 28.3 L/s (1 cfs) from Crofton Lake will improve fish habitat and water quality in Richards Creek;

2. Consultation with experts in the field of limnology and lake aeration to determine the feasibility of creating cold water refuge habitat in Somenos Lake.

3. A literature search and field study will be conducted to determine the degree of coho juvenile utilization and the presence of 0+ chinook juveniles in Somenos Creek. This type of habitat has been documented as prime rearing habitat for Chinook juveniles in similar watersheds.

2.0 STUDY AREA

The Somenos Basin is located on east Vancouver Island near the city of Duncan (Figure 1). It is a tributary of the Cowichan River and is comprised of a series of lowland lake and wetland complexes and associated riparian habitats (Somenos Lake), a headwater reservoir (Crofton Lake), and three inlet streams (Averill, Bings and Richards creeks). Somenos Lake discharges to the Cowichan River via a 3 km outlet stream (Somenos Creek). The total drainage area of the Somenos Basin is 63.7 km^2. Activities specific to this study were focused mainly in lower Richards Creek to the Cowichan River confluence.

3.0 METHODS

3.1 Water Quality Monitoring

In 2003 six WQ sampling sites were selected in Richards Creek, between Crofton Lake and Herd Road (Figure 1). In 2004, six additional sites from Somenos Lake to the Somenos Creek outlet and one site in the Cowichan River were included in the WQ monitoring program. Dissolved oxygen (DO) and temperature measurements were collected bi-weekly during the summer and monthly during spring and fall, using an OxyGuard® oxygen meter. In addition, continuous temperature data was collected at 6 of the sites using either Tidbit® temperature data loggers or Solinst Inc. water level data loggers. The latter instruments were installed at 4 locations in the Somenos Basin to collect water level data for the development of a hydraulic model for Somenos Lake.

Additional water quality data included in this report was collected by a local Streamkeeper volunteer at Lakes Rd. Footbridge. Temperature was measured using a glass stem pocket thermometer and dissolved oxygen was measured using a Hach dissolved oxygen kit.

Precipitation records were obtained from DNC supplemented with on-line data from a nearby Meteorological Service of Canada climate station (Duncan 1012573) for August – September 2005.

3.2 Juvenile rearing assessment

Utilization of lower Somenos Creek by juvenile salmonids was assessed using baited minnow traps and electrofishing methods. The creek was assessed using minnow traps on May 6, 2004, and March 31, April 28, and May 12, 2005 using cylindrical wire mesh (8 mm and 0.32 mm diagonal) minnow traps measuring 41.5 cm x 22.5 cm with 2 cm openings in each inverted funnel. The traps were baited with equal amounts (<50 ml) of borax-preserved salmon roe and set in similar macrohabitat types in the creek with trap openings aligned with direction of flow. At each site, both a large mesh and small mesh trap were set. They fished for a minimum of 3 hours on one day and 24 hours for the other 2 days. Thirty traps were set on the first two trapping events and 23 on the third event.

Minnow trap-caught fish were identified to species when possible using a combination of external morphological characteristics according to Pollard *et al.* (1997), or to family. Water temperature and dissolved oxygen was measured from the Lakes Rd. footbridge during each event.

On May 25th, 2005, the reach of Somenos Creek from below Tzouhalem Rd to the Lakes Road footbridge was electorfished by boat (approximately 1 km).

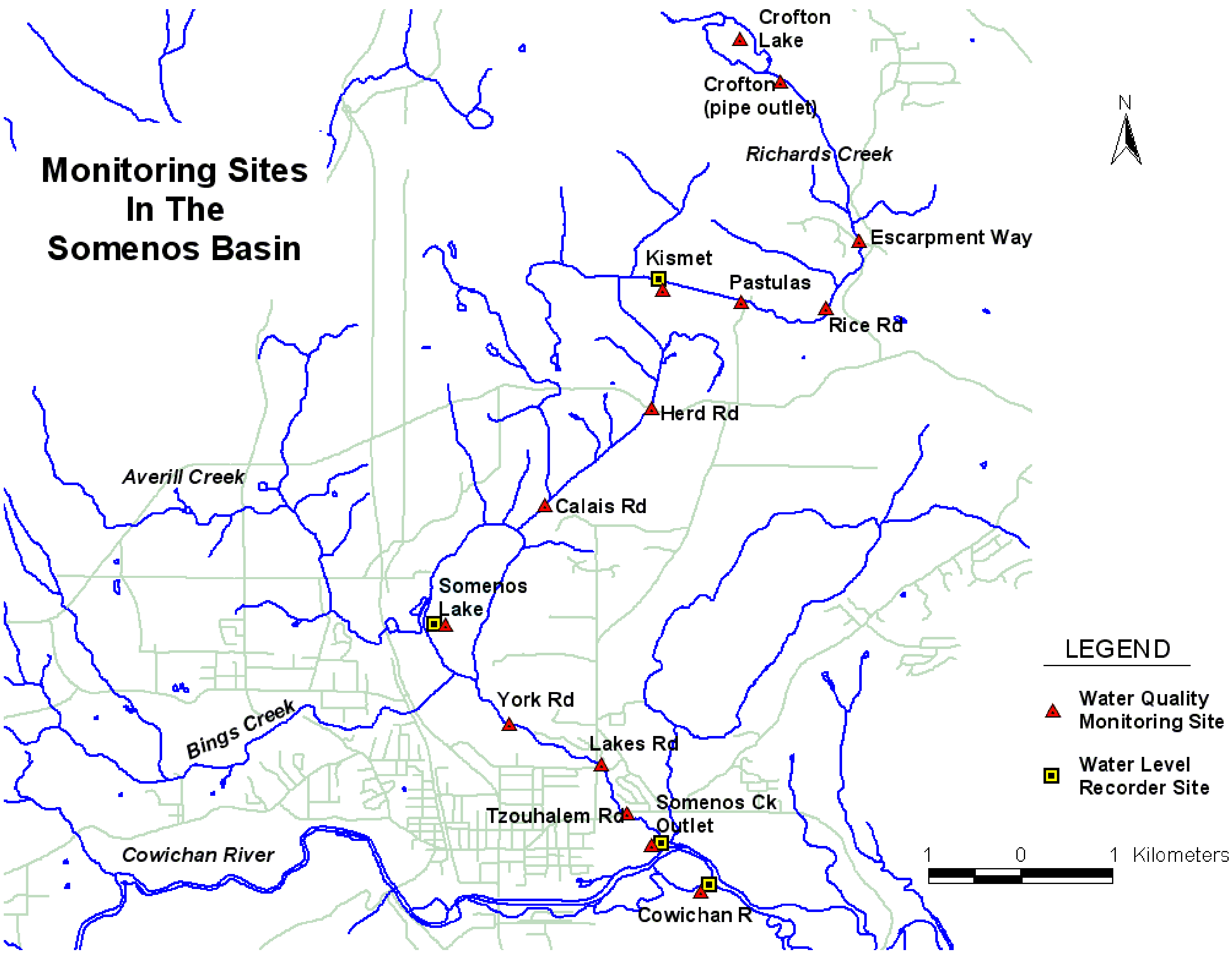


Figure 1. Overview of the Somenos Lake watershed showing locations of water quality and water level recording sites monitored between 2003 – 2005.

4.0 RESULTS AND DISCUSSION

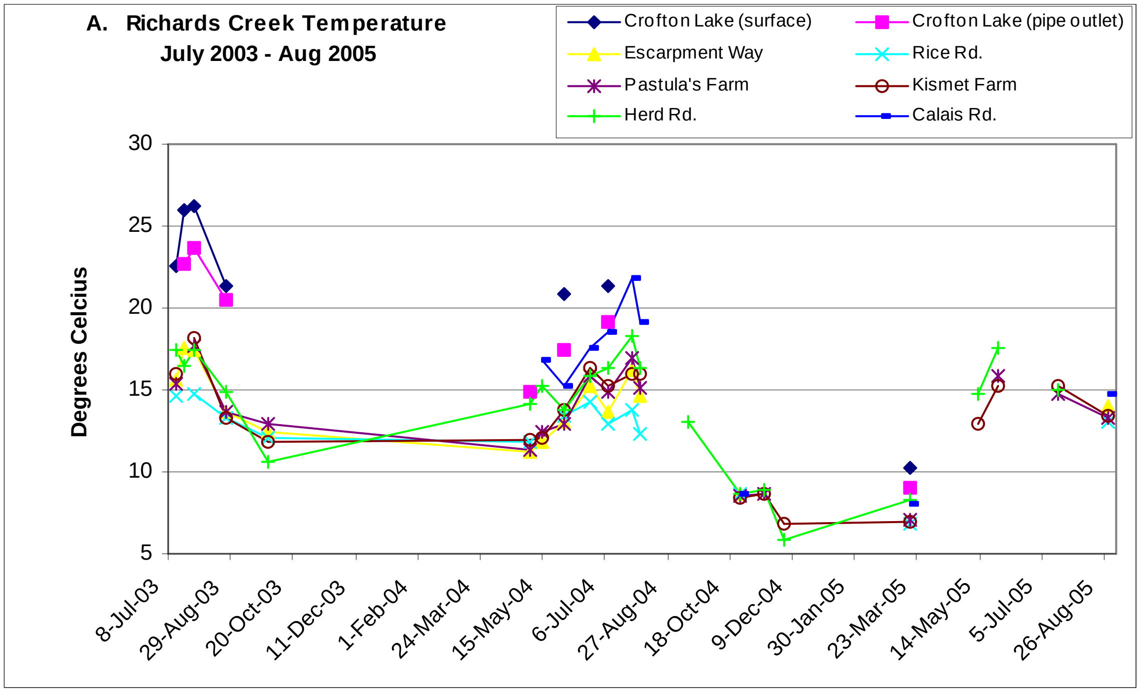
4.1 Water Quality in Richards Creek

Richards Creek flows southeasterly from Crofton Lake to Richards Trail Road, then south westerly, emptying into the northeast end of Somenos Lake (Figure 1). The DNC regulates flow from the Crofton Lake reservoir into Upper Richards Creek through a 5 cm valve/pipe, which discharges 60 m below Crofton Lake outlet. The intake is located 4.16 m (13.65 ft) below spillway crest, approximately 15 m (50 ft) from shore. An impassable barrier restricts anadromous fish distribution to the lower 6.5 km of Richards Creek upstream of Somenos Lake.

Water quality was collected at 6 sites in Richards Creek from Crofton Lake to Herd Road beginning in July 2003 (Figure 1). A seventh site was added in 2004 at Calais Road, just upstream of the confluence of Richards Creek and Somenos Lake. Water temperature results are displayed in Figure 2 Chart A and corresponding dissolved oxygen results are in Chart B.

The data indicates that during summer months (July and August), elevated temperatures (greater than 20 ^{o}C) are released from the lake into upper Richards Creek. However, numerous groundwater springs located downstream, reported in Burns, 1999, augment the minimum flow regulated from the lake resulting in cooler temperatures and higher dissolved oxygen at sites monitored downstream (Figure 2A). This is evident in Figure 3, which displays continuous temperature measurements collected at three of the monitoring sites using Tidbit water temperature data recorders (Crofton Lk Outlet and Calais Rd.) or a Solinst Water Levelogger (Kismet Farm). Daily mean temperatures are plotted except at the latter site, which plots temperature collected at 30-minute intervals.

Once flows are within the low gradient channelized section of Richards Creek, (approximately 5.2 km downstream of Crofton Lake) summer temperatures increase only slightly (Figure 2A; Appendix A, Photo 1). At Herd Rd for example, temperatures in summer were on average only 1-3 degrees warmer than Pastula Farm located 3 km upstream (Appendix A, Photo 2). This may be attributed to shading from riparian shrubs along extensive sections of the creek, which limits solar heating. Temperatures increase more rapidly from Herd Rd to Calais Rd., 1.5 km downstream where the channel is more open to solar radiation, and at times temperature exceeds 20^{o}C which is less favorable for salmon and trout species (Figures 2 & 3).



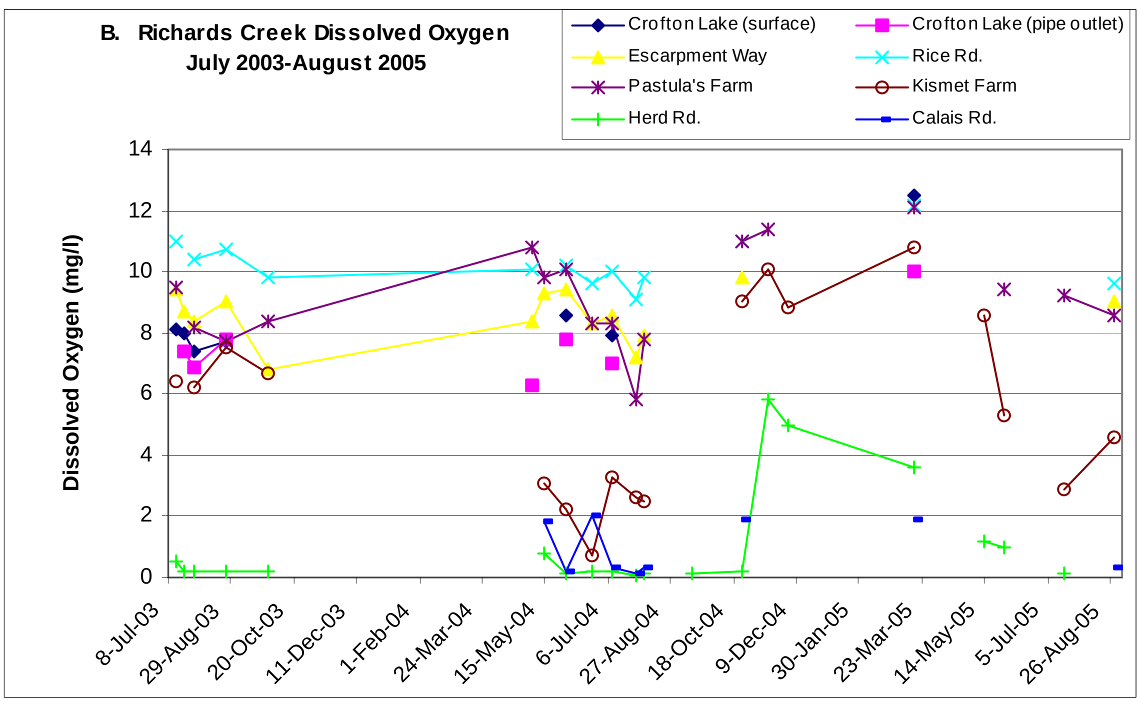


Figure 2. Water temperature (Chart A) and corresponding dissolved oxygen (Chart B) measured in Richards Creek from July 2003 to August 2005.

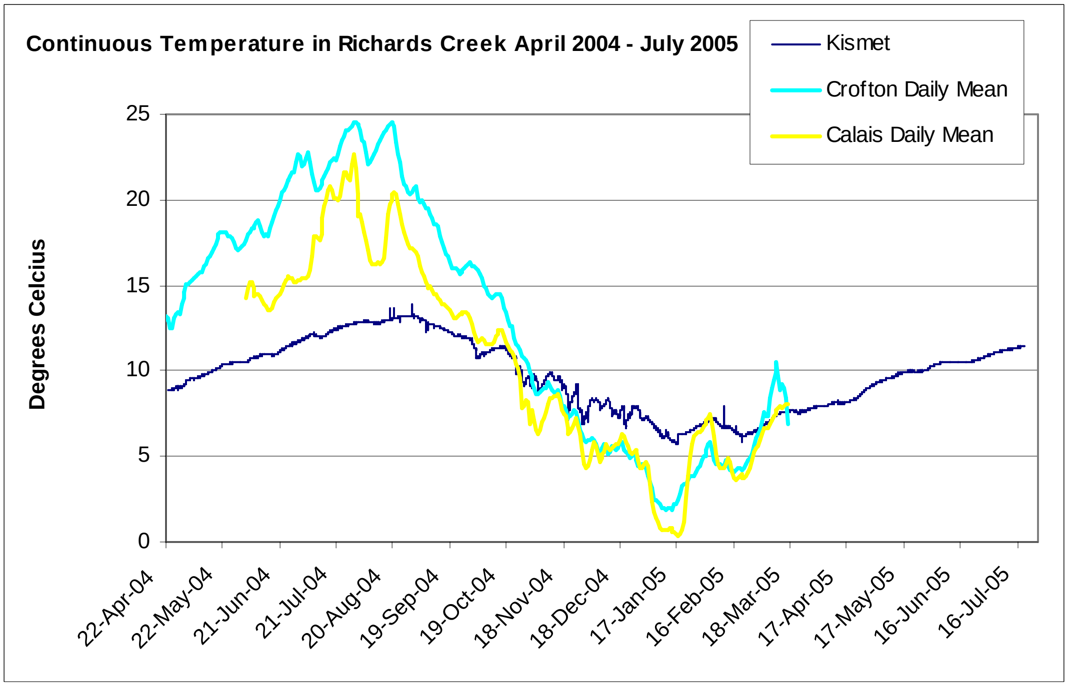


Figure 3. Continuous temperature measured at three sites in Richards Creek from the headwaters (Crofton Lake) to the outlet (Calais Rd.) between April 2004 and July 2005.

Conversely, dissolved oxygen levels depleted rapidly within the low gradient "slough-like" section of Richards Creek. On July 9, 2004, a dissolved oxygen profile was measured in Richards Creek from Pastula's Farm to Kismet Farm, to determine how rapidly water quality deteriorated between these sites (Table 1). Discharge measured at Rice Rd. upstream of Site 4 was 0.0026 m^3/s (41 gal/m). Although temperature increased marginally from 14.9 ^oC to 15.2 ^oC, dissolved oxygen rapidly decreased from 8.3 mg/l to 4 mg/l, 350 m downstream. Habitat condition for salmonids is considered "stressed" at a dissolved oxygen level of 4 mg/l, after which time growth rates of juvenile coho severely declines (Herrmann et al., 1962).

Table 1. Temperature and Dissolved Oxygen profile from Pastula Farm to Kismet Farm July 9, 2004.

Distance downstream (m)	Temp (^oC)	DO (mg/l)	% Saturation
0 (Pastula)	14.9	8.3	83
40	14.6	8	81
128	14.3	7.2	71
209	14.8	5.1	49
350	15	4	39
800	15.1	3.2	32
1000 (Kismet)	15.2	3.3	33

4.2 Water Quality in Somenos Creek

Water quality was collected at 5 sites in Somenos Creek from Somenos Lake to the outlet and one site in Cowichan River from May 2004 to August 2005 (Figure 1). Water temperature results are displayed in Figures 4 (Chart A) and corresponding dissolved oxygen results are in Chart B.

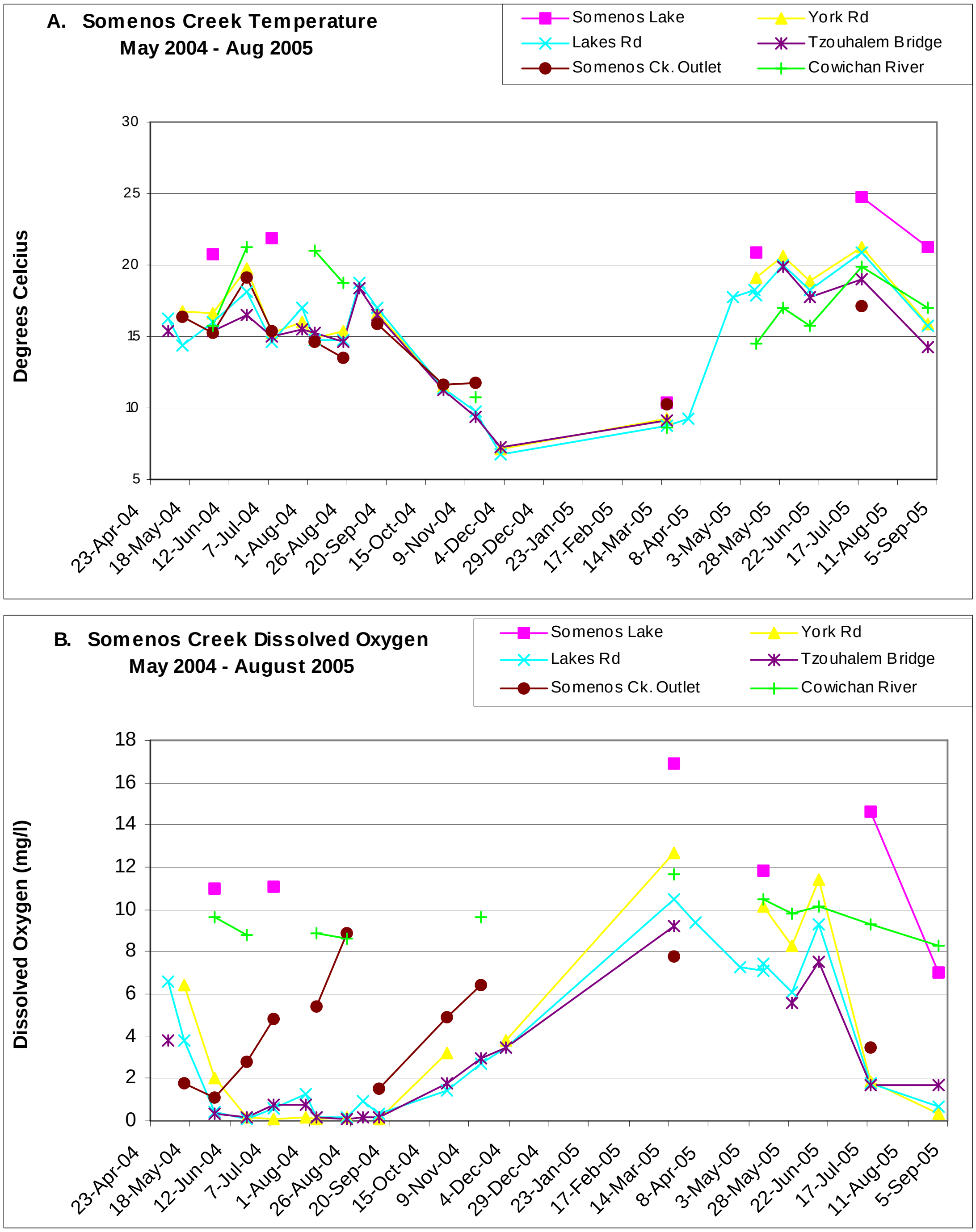


Figure 4. Water temperature (Chart A) and corresponding dissolved oxygen (Chart B) measured in Somenos Creek and Cowichan River from May 2004 to August 2005.

At four of the sites continuous temperature measurements were also collected using Tidbit water temperature data recorders (York Road and Somenos Creek Outlet) or Solinst Water Leveloggers (Somenos Lake and Cowichan River; Figure 5). Daily mean temperatures are plotted except at the latter 2 sites, which plot temperature collected at 30-minute intervals.

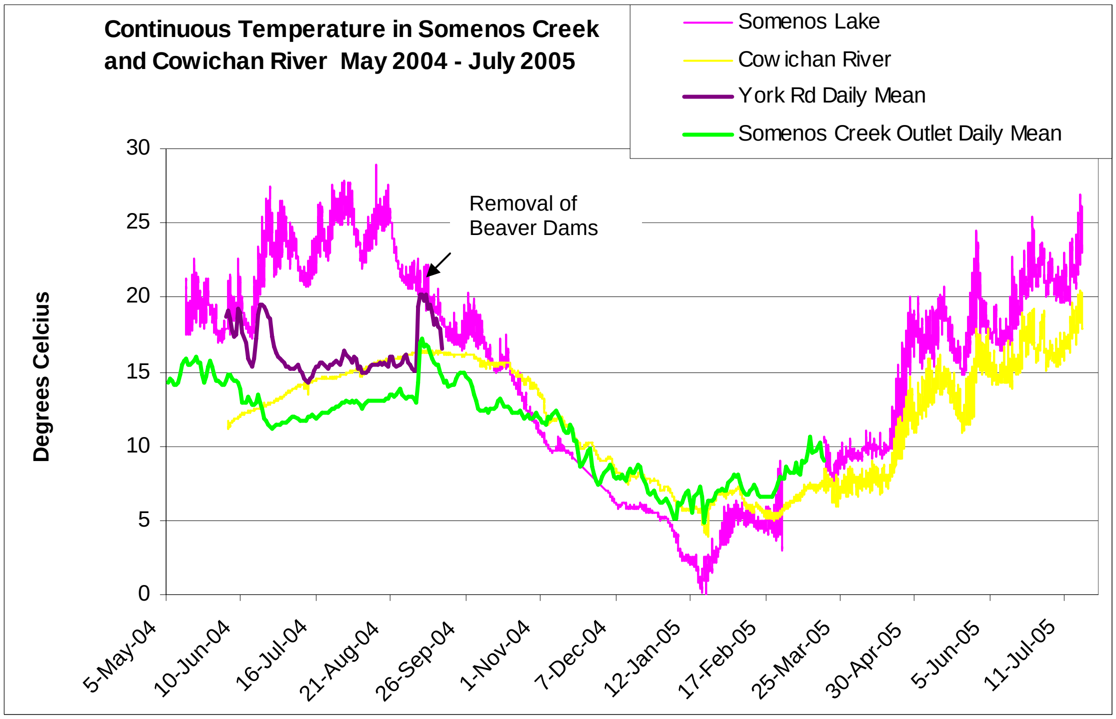


Figure 5. Continuous temperature measured at three sites in Somenos Creek from Somenos Lake to the outlet and one site in Cowichan River between May 2004 and July 2005.

Channel maintenance activities were completed in Somenos Creek in September 2004. This included removal of two beaver dams in lower Somenos Creek on September 2 and 3, and excavation of vegetation from the channel from the lake outlet to Tzouhalem Road by the District of North Cowichan during the week of September 15-22. Water quality conditions at three sites in Somenos Creek (York Rd, Lakes Rd. Footbridge and Tzouhalem Rd.) before and after these activities are displayed in Figure 6, Charts A, B and C respectively. Despite beaver dam and vegetation removal from the Somenos Creek channel, dissolved oxygen levels declined to “stressed” or anoxic conditions (≤4 mg/l) and temperatures increased to lethal levels (>20 ^{o}C) for salmonids during the summer low flow period in 2005.

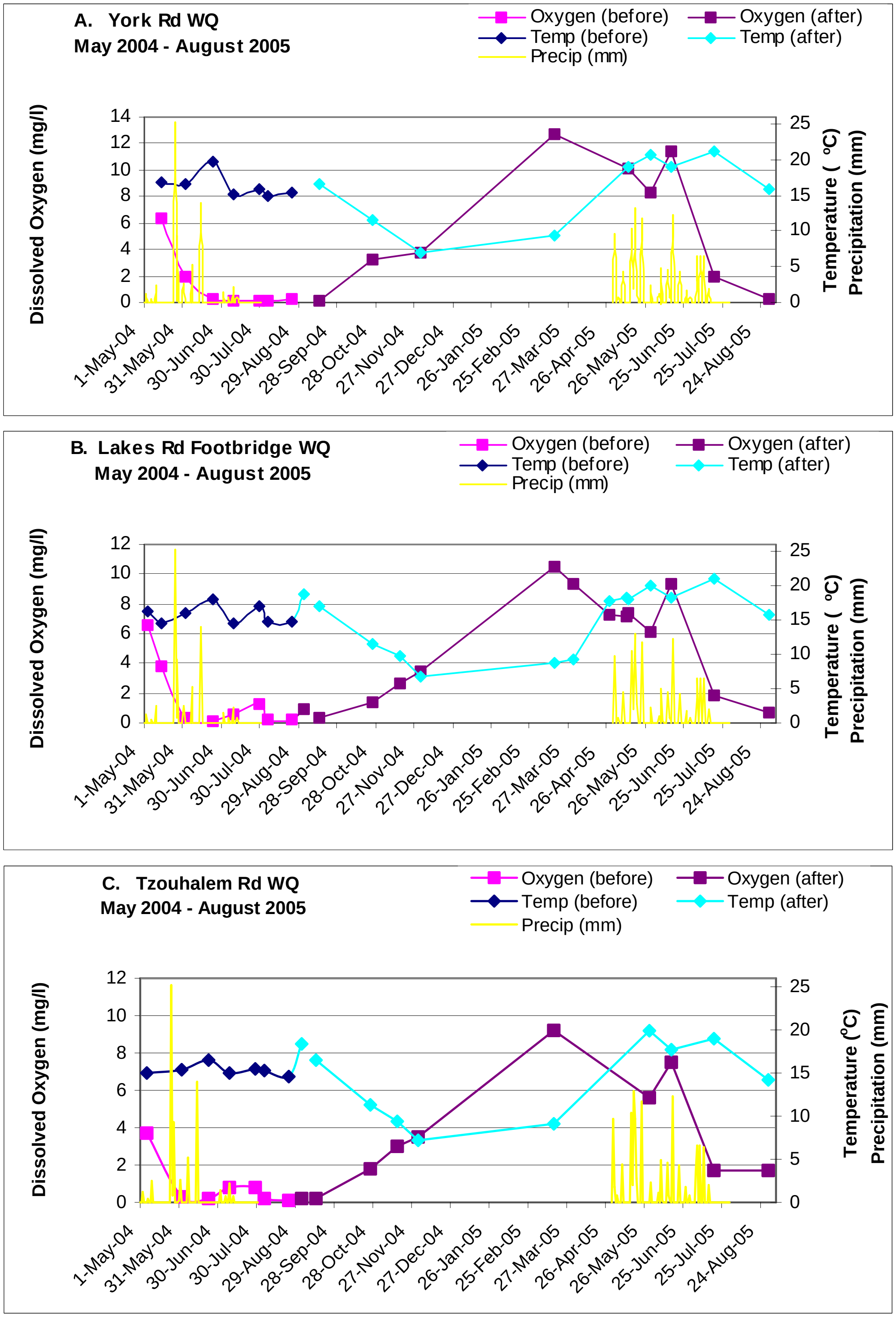


Figure 6. Water quality at three sites in Somenos Creek from May 2004 to August 2005 to show conditions before and after channel maintenance activities in September 2004 (Chart A – York Rd, Chart B – Lakes Rd and Chart C – Tzouhalem Rd.)

The removal of the to beaver dams immediately resulted in a drop in water level (Appendix A, Photo 4) which was recorded by continuous water level loggers in Somenos Lake and Somenos Creek (refer to the attached Somenos Lake Hydraulic Modelling Report; nhc, 2005). There was also an increase in temperature recorded at York Rd and Somenos Ck outlet immediately following this work (Figure 5). Prior to this work water temperature was around 13 – 15 °C at these two sites, despite Somenos Lake surface temperatures hovering around 25 °C. The cooler temperatures downstream are likely due to groundwater upwelling as observed in the York Rd. area and cooler inflows from Rotary side-channel which discharges just upstream of the Somenos Creek outlet. Although temperatures were cooler, dissolved oxygen levels in Somenos Creek were low due to high BOD. Immediately following the beaver dam removal, there is a sharp increase in temperature at both of these sites in Somenos Creek as Somenos Lake begins to quickly drain. Water temperature at York Rd. approximates lake surface temperatures for the remainder of the logging period (Figure 5).

Water quality at Lakes Rd. Footbridge has been measured weekly since 1998 by a local Streamkeeper volunteer (Figure 7; Appendix A, Photo 3). This data has been included to show trends in temperature and dissolved oxygen at this site before and one year following channel maintenance activities. This longer time series of water quality data collection at one site in Somenos Creek illustrates how temperature and dissolved oxygen conditions in the creek follows a similar pattern each year although with minor fluctuations in min and max DO and temperature and duration of summertime stressed/anoxic habitat conditions. These variations are likely more a factor of inflows and backwatering effects from Cowichan River than from improvements in drainage.

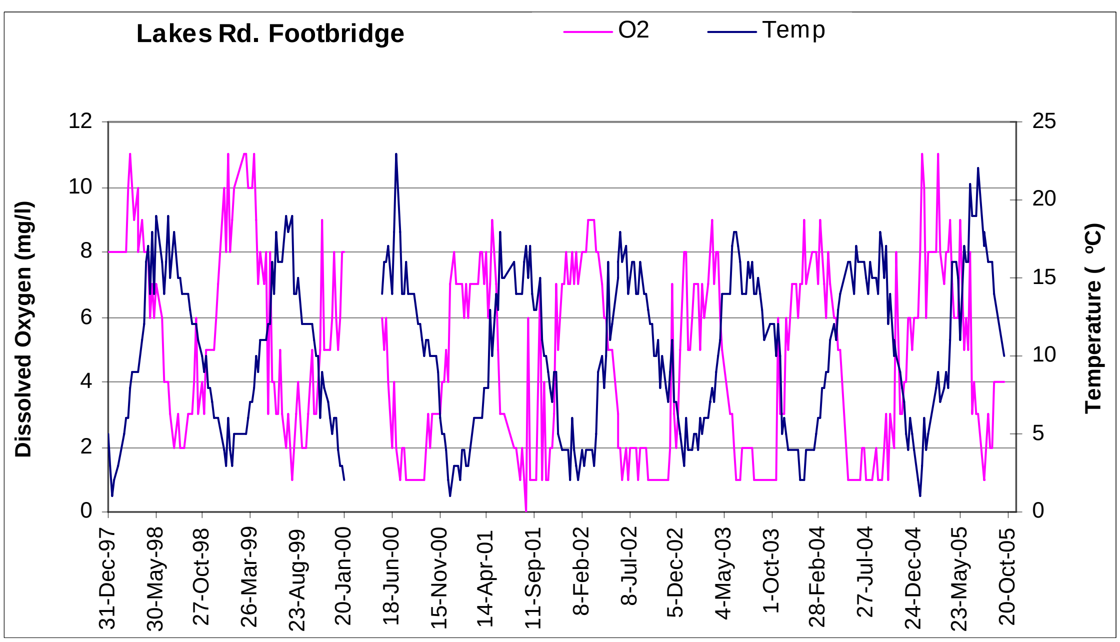
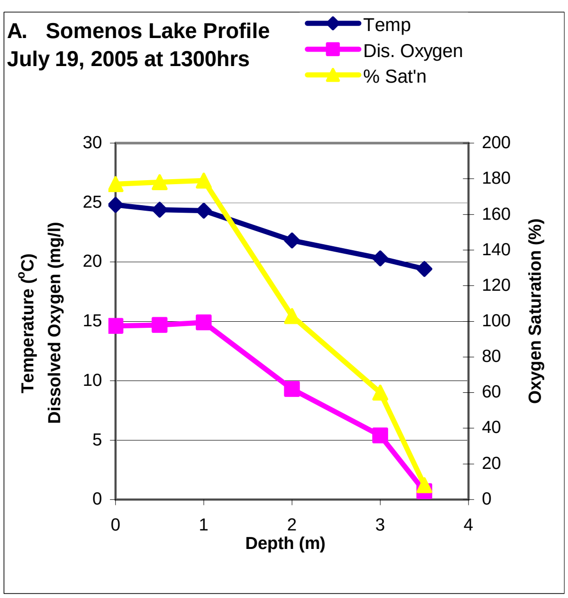


Figure 7. A comparison of water quality trends at Lakes Rd. Footbridge for the years 1998 - 2005 taken from weekly measurements by a local Streamkeeper volunteer.

Water quality data collected in Somenos Creek supports previous reports that conditions in the creek are normally very poor for fish production during the summer 'low flow' period, but good during late fall and into early spring. The data does not provide evidence that channel maintenance activities significantly improved water quality conditions in Somenos Creek for salmonids, at least not in the short term. Continuation of the monitoring program in Somenos Creek may determine potential longer term changes in water quality.

4.3 Water Quality in Somenos Lake

Somenos Lake is a small (100 ha) shallow lake (mean depth 4.2 m; max depth 6.5m). Temperature and oxygen profiles were collected several times during the 2 year monitoring program. Temperature and dissolved oxygen profiles for summer and early fall 2005 are displayed in Figure 8, Chart A and B. Chart A illustrates that during summer months, temperatures can become almost lethal for rearing salmonids at the lake surface and the shallow depth provides little thermal refuge. In addition, algal blooms observed during the summer create supersaturated conditions in the upper layers during the day (180 %) as indicated in Chart A. Though there is a slight descending temperature gradient from the surface to the lake bottom, the lake does not display a true thermocline, typical of deeper lake systems where there is a transition layer between the warmer mixed layer at the surface (epilimnion) and the cooler deep water layer (hypolimnion). However, the deeper layers are oxygen deficient likely due to the high biochemical oxygen demand (BOD) of bottom sediments. By October, temperature and dissolved oxygen conditions are more uniform in the water column, except near the lake bottom (Chart B).



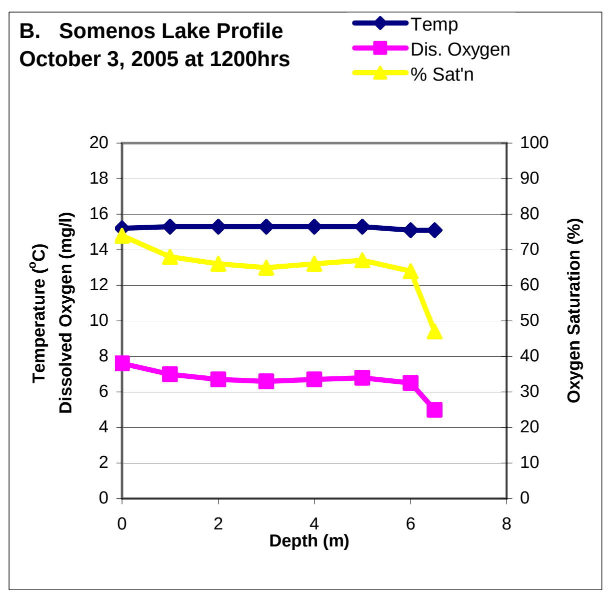


Figure 8. Temperature, dissolved oxygen and oxygen saturation profiles for Somenos Lake in July (Chart A) and October 2005 (Chart B).

4.4 Fish Distribution

Fish production in the Somenos Basin originates from two sources: 1) progeny from adults that spawn in tributary creeks (Bings, Averill and Richards), and 2) salmonids that migrate in from other areas of the Cowichan system to overwinter.

A literature search was conducted on the utilization of the Somenos Basin by coho and chinook juveniles. Much of the information is available as unpublished data sheets and reconnaissance reports. From surveys conducted in 1982 (Wightman et al.), 1989-1990 and 1997 (DFO Stock Assessment), utilization of Somenos Lake, Somenos Creek and lower Richards Creek is mainly limited to coho and trout. On only one sampling event in Somenos Lake (May 1997) 8 chinook juveniles were identified in fyke net captures. Higher densities of coho and trout were present in Richards Creek, particularly upstream of the slough/glide habitat (upstream of Pastulas). Estimates from DFO Stock Assessment sampling ranged from 7.0-9.4 coho/sq.m. in middle to upper Richards compared to 0.014 coho/sq.m in lower Richards at Herd Rd. (Appendix B). In Somenos Lake and Somenos Creek, densities and/or catches from minnow traps were usually very low.

Results of juvenile fish sampling in Somenos Creek in 2004/2005 are presented in Table 3. Densities of coho were very low in March/April but captures of both coho fry (0+) and smolts (1+) were higher in May, possibly due to increases in temperature and photoperiod. Increasing water temperatures and photoperiod are cited as likely triggers for smoltification and outmigration observed in previous juvenile salmonid assessments in Somenos-Richards Creeks (Wightman et al. 1982). Results from electrofishing lower Somenos Creek on May 25, 2005 over a 1 kilometre distance yielded very few salmonids (less than ten).

Salmon utilization of Somenos lake is likely restricted to emergent fry use in early spring until July when temperatures become sub-lethal, and pre-smolt rearing in late fall after lake turnover and re-oxygenation. Coho smolts captured in May 2005 and by DFO Stock Assessment in May of previous years indicate that smolt size is large (>100mm). Juveniles likely attain part of this growth in Somenos Lake, which is common in productive lake systems.

Table 2. Summary of minnow trapping results in lower Somenos Creek (Lakes Rd. Footbridge to downstream of Tzouhalem Rd.) in 2004 and 2005.

				Total No. Captured			Catch/Trap	
Date	No. Traps Set	Set Duration	Temperature (^oC)	Coho 0+	Coho 1+	non-salmonids	salmonids	non-salmonids
6-May-04	16	3 hrs	15.4	13	-	392	0.81	24.5
31-Mar-05	30	3 hrs	9.3	-	-	7	0	0.23
28-Apr-05	23	24 hrs	17.7	-	1	30	0.04	1.3
13-May-05	23	24 hrs	17.9	29	19	288	2.1	12.5

5.0 DISCUSSION

5.1 Juvenile Rearing Habitat in Somenos Creek

The year 1997 was the only record that could be found that verified Chinook fry presence in the system. From March to May 2005, a period when Chinook fry emerge and seek rearing habitat, minnow trapping and electroshocking in lower Somenos creek failed to capture any fry. This was unexpected in view of peak chinook fry captures at the Downstream Enumeration Rotary Screw Trap on the Cowichan River (Figure 9). During this period, temperatures and oxygen levels in Somenos Creek were suitable for rearing and should have attracted Cowichan Chinook fry. The water temperature was warmer than the mainstem Cowichan (Figures 4 & 5). Chinook fry are usually attracted to warmer slough-like areas for feeding. These areas are usually highly productive and allow Chinook fry to quickly attain biomass and reach a smolt threshold size before migrating to the estuary in May/June. The availability of food sources was not assessed and may have been a factor limiting their use of the creek.

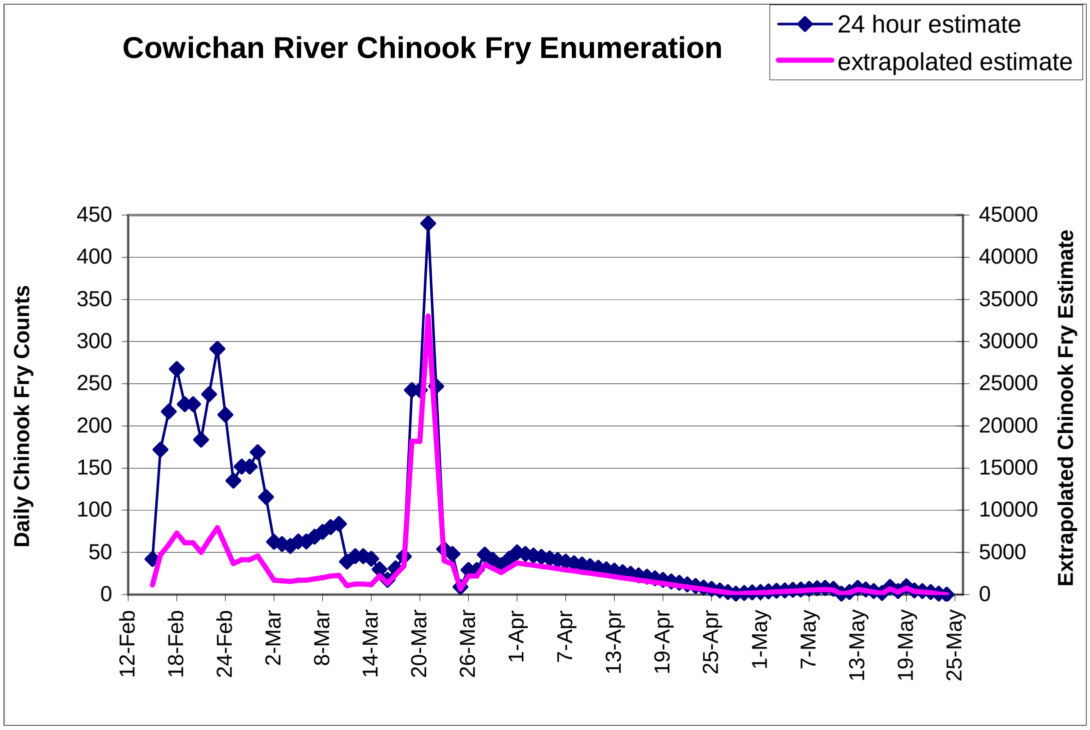


Figure 9. Daily chinook fry counts and extrapolated estimates in the Cowichan River, captured between Feb 15 and May 24, 2005.

Based on minnow trapping results in March, April and May 2005, coho rearing densities appear to be very low. A peak count of only 29 coho fry and 19 smolts were captured in 23 traps in a one kilometer section of lower Somenos Creek. Although water temperature and oxygen levels were good during this period, oxygen was poor in the summer and fall months prior and during the on-set of the dropping water temperatures and fall rains, which is when coho juveniles establish over-wintering areas. During this period, coho tend to develop a high fidelity to over-wintering sites with good cover, low flows and high oxygen. Typically the juveniles would reside at these sites until the following spring (Atagi et al., 1999). Coho juveniles would avoid over-wintering in Somenos Creek, which does not exhibit acceptable oxygen levels until after late fall/early winter. This was recently demonstrated in a similar low gradient wetland with similar temporal oxygen problems in the District of Kent, B.C. (Slaney and Northcote, 2003).

Increasing fish use in Somenos Creek would require maintenance of cooler water temperatures below 20 degrees and oxygen levels above 5 mg/l. Establishing taller vegetation on the southern-side of the creek would help maintain lower water temperatures, however, oxygen depletion would remain a factor unless water exchange could be increased and nitrogen and phosphorus inputs could be reduced. In a study completed at the District of Kent, (Slaney and Northcote, 2003) removal of instream vegetation from the centre of the stream reduced BOD and increased oxygen levels especially during night respiration. By concentrating vegetation removal in the thalwag and not disturbing bank vegetation, there was no increase in nutrient loading associated with the dredging or run off from the fields. The same dredging technique was used in Somenos Creek in September 2004. Although night oxygen levels were not monitored, it is suspected that vegetation removal may have had a similar effect on oxygen levels.

The addition of aeration in the creek could potentially increase fish utilization in areas where summer water temperatures are suitable. Aeration trials were conducted in the summer of 1999 and 2000 by the Cowichan Watershed Council on three areas in the Somenos Basin: a) a section of Bings Creek b) Chesterfield Park pond, and c) Somenos Ck upstream of Lakes Rd. bridge. In the first two trials, dissolved oxygen levels were elevated to support coho fry in these areas. In the latter trial, DO was only increased to 3.5 ppm (from 0.25 ppm) due to the high BOD in this reach (Groves, 2001). All 3 trials used compressed air and a fine bubble grid or line aeration system. Based on the above results, it was suggested by Dr. Ken Ashley, senior limnologist and environmental engineer with the BC Ministry of Environment and an expert in the field of lake aeration, that a similar trial be conducted using compressed oxygen instead of air. This trial would be restricted to the section between York Rd. and Lakes Rd. Footbridge of Somenos Creek and in Richards Creek from Pastula's to a distance downstream within 1 km below Kismet Farms. Dr. Ashley recommended a trial using compressed oxygen and fine pore tubing. This may increase overall performance of oxygenation. Portable compressed oxygen bottles and regulators commonly used for acetylene gas welding and 50-100 meters of irrigation weeping hose found in hardware stores could be used for the experimental set-up. A trial run over a 2-4 hour period would determine if the performance of the system was adequate. A unit cost could then be calculated to determine if this would be cost effective.

A review of multi-pass electroshocking field data in the tributaries of the Somenos Watershed from 1990 to 2004 was provided by DFO Stock Assessment. High densities of coho juveniles were consistently measured in Upper Richards, Bings and to a lesser degree Averill Creek. Somenos Creek, Lower Richards Creek and Somenos Lake had low salmonid juvenile densities and appear to be used primarily as migration corridors to access the higher gradient sections of Somenos watershed tributaries where water temperatures and oxygen levels are good most times of the year. Providing good oxygenation in the migration corridors during adult migration in Nov/Dec and smolt migration in April/May will maximize salmonid use in the Somenos tributaries. Based on the water quality data collected in 2004/05 from Crofton Lake to the Cowichan River, and weekly measurements at Lakes Rd. Footbridge from 1997 to 2005, oxygen levels appear acceptable most years during these periods. However, occasionally, re-oxygenation in the late-fall/early-winter can be delayed depending on rainfall storm events and backwatering from Cowichan River. Inflow from Cowichan River has a significant effect on oxygenation in Somenos Creek. DFO staff observed inflow velocities of approximately 0.5 m/sec during minnow trapping surveys in April/May 2005. Cowichan water is fully saturated with oxygen and can potentially increase oxygenation in Somenos Creek rapidly. At a minimum discharge of 70 m^3/s in the Cowichan River, oxygen saturated water is delivered from the river into Somenos Lake. Storm events and high wind action can also increase the rate of oxygenation in the lake.

5.2 Crofton Lake Flow Release for Summer Rearing Juveniles

Crofton Lake dam was originally constructed in the 1940s and rebuilt in the 1950s. The reservoir was the source of domestic water supply for the town of Crofton until recently. The DNC currently regulates a minimum flow of 3.8 L/s (50 gal/min or 0.13 cfs) from the lake into Richards Creek during the summer to satisfy downstream water licences for irrigation. Discharge in Richards Creek measured at Rice Road ranged from 5.8 L/s - 0.8 L/s (76 - 10 gal/min or 0.2 – 0.03 cfs) during June – August 2004.

A proposal to utilize this reserve in Crofton Lake to potentially augment water quality downstream in Richards Creek during summer months was identified several years ago. Concerns regarding the potential impact of an increased flow on flooding adjacent agricultural land may have prohibited further evaluation of this option.

The theoretical storage capacity of Crofton Lake is approximately 513 acre-feet. However, not all of this storage is available to improve fish habitat downstream since the reservoir is still used by DNC as a back-up water supply for the town of Crofton. This amount is calculated at approximately 150,000 gallons/day. Therefore, taking into account this back-up requirement, the amount of storage available to release for fisheries flows is between 22.2 and 34.3 L/s (0.8 and 1.2 cfs) with a mean of 28.3 L/s or 1 cfs, from July 1st until the end of September. Based on a catchment area of 13.3 km^2 and a unit runoff of 30 L/s per km^2 (using Bings Creek), the mean annual discharge (MAD) for Richards Creek is about 399 L/s or 14 cfs. A meta-analysis of low summer flow requirements for salmonids in North American streams (Hatfield and Bruce, 2000) clearly demonstrates optimum juvenile fish production at 10-20% of MAD. Therefore a baseflow increment from 3.8 L/s or 50 gal/min to 28.3 L/s or 1 cfs represents an increase from 1% MAD to up to 7% MAD. Salmon productivity is expected to increase significantly at 7% of MAD. Based on the meta-analysis model, fish production would increase from 12% to 70% of optimum (Figure 10). This is a substantial change and one that is expected to have significant ecological benefits to coho and trout, particularly in upper Richards Creek, which has a

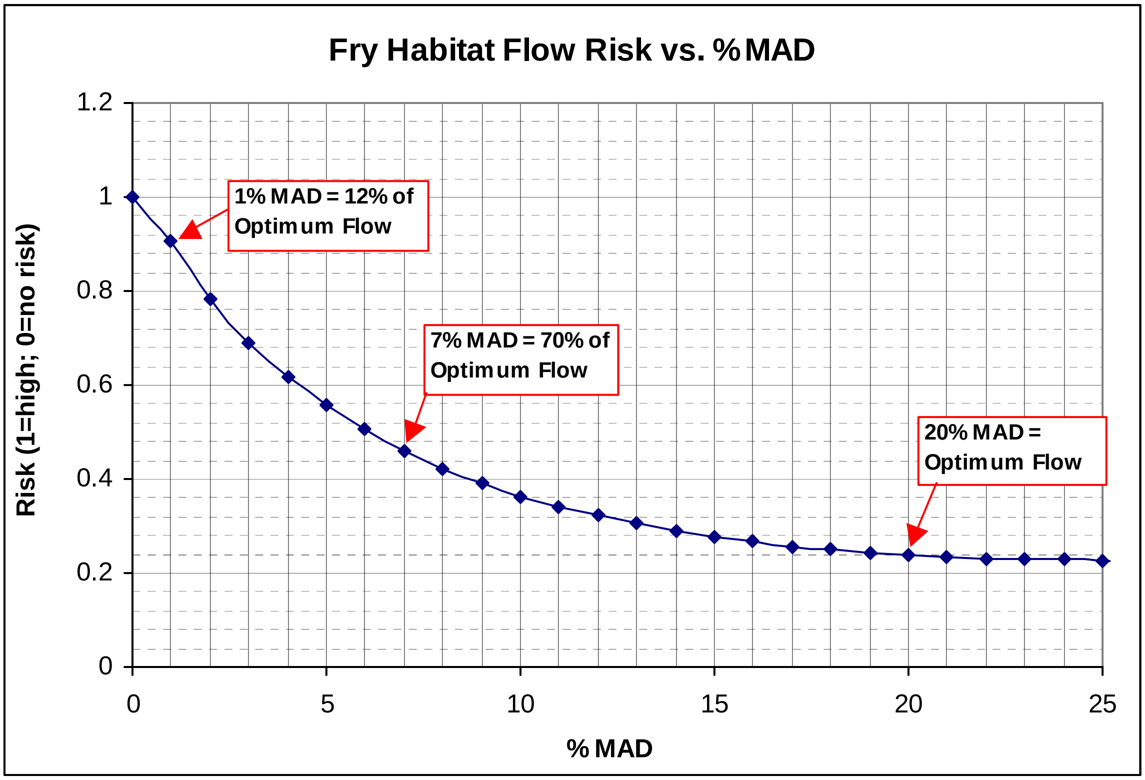


Figure 10. Relationship between percent of mean annual discharge (% MAD) and risk for salmonid fry habitat. Text boxes indicate % optimum flow for fry rearing as discussed in the Somenos Water Quality study (T. Hatfield, pers. comm).

higher gradient and more riffle habitat (R. Ptolemy, pers. comm.). Based on measurements of oxygen depletion between Pastula and Kismet Farm, a low gradient section of Richards Creek, (Table 1), from 8.3 to 4 ppm, oxygen levels are expected to decline rapidly downstream of Kismet. It is suspected that only 1-2 kilometers of Richards Creek downstream of the Pastula Farm Site (Richards Trail Road crossing) would maintain acceptable oxygen levels during the summer.

The results of the Somenos Lake Hydraulic Modelling demonstrate that a flow release from Crofton Lake of 40 L/s will have an immeasurable impact on the flood capacity of the Richards Creek channel (NHC, 2005). This flow was modeled in consideration of potential beaver activity in the area, and as such assumed a beaver dam was present on Richards Creek. The additional flow increased water elevations in the channel by only 5 cm.

Taking into account these results, a test flow release from Crofton Lake should be monitored to determine the benefits to fish habitat in Richards Creek. A release of 28.3 L/s could be monitored for a short duration between July and August at several locations in the low gradient as well as higher gradient reaches of the creek.

5.3 Crofton Lake Flow Release for Fall Adult Migration

There has also been an interest in using the available storage in Crofton Lake to improve oxygenation of Richards and Somenos Creek in the fall (Oct – Nov) for attracting and facilitating adult salmon migration from Cowichan River to spawning habitat in the upper reaches of the Somenos tributaries.

Flow data collected during this study provides limited insight on the benefit of an increased fall flow. The only comparisons are based on uncontrolled discharge measurements taken at different times of the year (Table 2). Summer discharges ranging from 0.8 to 5.8 L/s resulted in oxygen levels peaking at 3.5 mg/l at Kismet Farm. Discharges of 26.1 L/s in October and 32.9 L/s in March produced oxygen levels of 9 and 10.8 mg/l at Kismet. However, the downstream depletion of the oxygen level was not closely monitored. The nearest monitoring station downstream was Herd Road which is 2 km downstream and oxygen readings were only recorded above 4mg/l on two sampling events (Nov and Dec 2004). Flows on these dates were 189 and 103 L/s respectively. Oxygen depletion was measured upstream from Pastula to Kismet Farm at a discharge of 2.6 L/s. Oxygen dropped from 8.3 to 4 mg/l over a length of 1 km. Based on this finding, a fall release would not likely have any benefit on oxygenation 1-2 kms downstream of Kismet Farm. Furthermore, there is likely limited storage potential in Crofton Lake for providing a pulse or fall release of a flow sufficient to increase water exchange and oxygenation. At 103 L/s, the available storage would be used up within 28 days. Results were similar in Somenos Creek. The top meter of the water column of Somenos Lake drains into Somenos Creek generally fully saturated. By the time it reaches York Rd. oxygen is generally below 2 mg/l during the summer and below 4 mg/l in Sept and Oct when flows are generally higher.

Table 3. Comparison of water quality measured in lower Richards Creek at Kismet and Pastula Farms and Herd Rd. under a range of flows, June 2004 – August 2005.

		Pastula			Kismet			Herd		
Date	Flow (L/s)	Temp (^oC)	Oxygen (mg/l)	Sat'n (%)	Temp (^oC)	Oxygen (mg/l)	Sat'n (%)	Temp (^oC)	Oxygen (mg/l)	Sat'n (%)
2-Jun-04	5.8	12.9	10.1	97	13.8	2.2	22	13.8	0.1	1
23-Jun-04	2.9	15.8	8.3	84	16.4	0.7	7	15.8	0.2	2
9-Jul-04	2.6	14.9	8.3	83	15.2	3.3	33	16.3	0.2	2
29-Jul-04	2.9	16.9	5.8	60	16	2.59	26	18.3	0.07	0.6
5-Aug-04	0.8	15.1	7.8	77	16	2.5	26	16.4	0.1	1
26-Oct-04	**26.1**	**8.5**	**11**	**92**	**8.4**	**9**	**76**	**8.6**	**0.2**	**2**
16-Nov-04	188.9	8.7	11.4	101	8.7	10.1	90	8.9	5.8	45
2-Dec-04	103.3	-	-	-	6.8	8.8	74	5.9	5	40
17-Mar-05	32.9	7.1	12.1	101	6.9	10.8	88	8.3	3.6	30
30-Aug-05	2.9	13.3	8.6	81	13.4	4.6	43	-	-	-

Notes: Bold font represents a discharge approximating that which could be released from Crofton Lake during the summer months (28.3 L/s).

5.4 Lake Aeration

Urban and agricultural development within the lowlands surrounding Somenos Lake contributes significant nutrient loads to the system. Combined with low summer flows and low gradients, Somenos Creek, Somenos Lake and the lower reaches of inlet tributaries are anoxic from spring until fall, and often into early winter. Anoxic conditions also result in the production of noxious ammonia and hydrogen sulfide gases causing further deterioration to fish production.

Lake aeration is a restoration procedure that has successfully been applied in North America and Western Europe to remediate against the effects of eutrophication and hypolimnetic anoxia (Ashley and Hall, 1990). Several technologies have been developed to achieve this and they can be grouped into 3 different categories: artificial destratification, hypolimnetic aeration and and hypolimnetic oxygenation (Beutel, 2002).

Destratification systems use compressed air, which is injected into the hypolinnion through perforated pipes or other diffusers. The rising air bubbles cause cooler water from the hypolimnion to rise to the lake surface and induces vertical mixing. Oxygenated water at the surface (through contact with the atmosphere and photosynthetically produced) circulates throughout the water column. While this method increases hypolimnetic DO, it results in a water body with no thermal stratification (i.e. temperature is similar from top to bottom).

Hypolimnetic aeration is similar to destratification whereby compressed air is injected into the hypolimnion but the technology used maintains thermal stratification of the water body. This aeration technique is also referred to as the air-lift method of circulation. As air bubbles are injected into the bottom of an ‘intake’ tube, oxygen is transferred to the water column as the bubbles rise up the tube. This oxygenated water is then returned down a second ‘exit’ tube to the hypolimnion. This technology was used effectively on St. Mary’s Lake on Saltspring Island, B.C. to improve water quality for domestic use while supporting a “two-story” recreational fishery (Ashley and Nordin, 1999).

Hypolimnetic oxygenation is similar to hypolimnetic aeration in that thermal stratification is preserved. However, instead of using compressed air, pure oxygen is used which has a higher solubility (Beutel, 2002). Oxygen bubbles produced from a fine-pore diffuser dissolve in a surrounding plume of rising water. The smaller the bubble produced, the faster it will dissolve before reaching the epilimnion (to protect thermal stratification) or the lake surface (K. Ashley, pers. comm.). The choice of oxygen to use in this type of application is based on supply, level of isolation of site, volume required, and cost. Listed from most to least expensive, the options include high-pressure gas cylinders, portable liquid oxygen cylinder, bulk storage of liquid oxygen, and on-site oxygen generators.

DFO sought the advice of Dr. Ken Ashley, during an on-site reconnaissance of the Somenos Basin in October 2005. These technologies were discussed with respect to their potential application in the Somenos Basin to improve water quality. Based on observations made during a tour of Somenos Lake and Somenos Creek, and results of the water quality sampling program provided in this report, it is evident that Somenos Lake is highly eutrophic and appears to receive extremely high levels of nutrients throughout the year (K. Ashley, pers com.). This has contributed to the formation of a deep layer of anoxic bottom sediment in Somenos Lake, which is also a net source of phosphorus. Oxygen/temperature profiles of Somenos Lake taken throughout the summer demonstrated a loss of thermal stratification mid-summer which is common for lakes less than 10 meters deep. Water temperatures are sub-lethal throughout the water column during the summer months and would be inhabitable for salmonids even if areas of oxygenated refuge could be created. Consequently, hypolimnetic aeration would be ineffective under these conditions. The oxygen demand of this system would require such a large investment in capital and operating costs to purchase, set-up and manage the equipment, that the excessive costs would simply make a lake aeration project unfeasible.

6.0 SUMMARY

A properly designed drainage management program in Somenos and Richards Creeks coupled with reductions in nutrient loading in the watershed will likely have long term benefits to both fish productivity and the farming community. Although the recent water quality monitoring program did not collect water samples for nutrient analysis, it should be stressed that in order to improve fish production in the long term, the nutrient loading problem needs to be more effectively addressed. Identifying and reducing point and non-point sources of nutrients should form part of a larger educational program directed at the surrounding community (urban and agricultural). This may include: i) encouraging every farm to complete an Environmental Farm Plan (EFP) and implement Beneficial Management Practices (BMPs) that addresses Riparian Area Management (such as providing off-stream water for livestock, buffer establishment, fencing, improved stream crossings), Improved Manure Storage and Handling, Farmyard Runoff Control, Erosion Control Structures (Riparian and Non Riparian), and Enhancing Wildlife and Biodiversity; ii) maintaining drainage systems to allow timely crop management and harvesting in order to remove nutrients from the floodplain, iii) encouraging residents to use responsible fertility practices on their lawns and gardens as excess nutrients tend to migrate to the low lands (W. Haddow, pers. comm.).

With only one year of water quality data available post treatment (i.e. vegetation and beaver dam removal), it is difficult to identify significant improvements in water quality. Over time however, improvements may become clearer. For example increasing the drainage capacity of Somenos Creek could potentially improve oxygen levels in the tributaries, and/or as a minimum increase the rate of oxygen re-saturation in the lake during the spring and fall months. “Soft” removal of 20% of the in-stream vegetation in the channel thalwag can increase drainage by 90% (Slaney and Northcote, 2003). Maintaining bank stability and riparian cover during this practice will reduce the amount of bank sloughing when material is excavated out of the channel and help maintain a deeper channel, which will inhibit re-colonization of aquatic vegetation. The bio-filtering capacity of an established riparian zone will reduce the amount of nutrients draining into the creeks from field runoff. Introduction of trees on the southern-side of the creeks will provide solar shading, increase fish habitat and improve invertebrate food production. Lake aeration may one day play an important role in improving the quality of fish habitat in the Somenos Basin, but only as part of an integrated plan that will one day lead to high quality fish, wildlife, agriculture and even recreational values.

7.0 RECOMMENDATIONS

1. A test flow of 28.3 – 56 L/s (1-2 cfs) should be released in the summer for a week and oxygen levels should be monitored daily at 500 m intervals to determine the effectiveness of a minimum summer flow in the lower gradient reach of Richards Creek. Habitat flow improvements should also be measured in the higher gradient reaches of Richards Creek and oxygen readings should be monitored in Somenos Creek to determine if there is any affect further downstream. This test would have negligible impact on adjacent farms during the summer (NHC, 2005).

2. Conduct an aeration trial in a section of Somenos Creek between York Rd. and Lakes Rd. Footbridge or Richards Creek from Pastula's to a distance downstream within 1 km below Kismet Farms using liquid oxygen and fine pore tubing. Portable compressed oxygen bottles and regulators commonly used for acetylene gas welding and 50-100 meters of irrigation weeping hose found in hardware stores could be used for the experimental set-up. A trial run over a 2-4 hour period would determine if the performance of the system was adequate. Results could then be used to calculate a unit cost to determine if it would be feasible on a larger scale.

3. Develop a water quality monitoring program to identify point and non-point sources of nutrient inputs in the inlet tributaries of Somenos Lake, as part of a larger nutrient input management plan for the Somenos Basin.

4. Continue to monitor beaver activity in Somenos Creek and implement a drainage management plan on a more frequent basis such that longer-term benefits to salmonid rearing habitats can be identified.

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APPENDIX A: Photos

Photo 1. Pastula Farm WQ monitoring site in Richards Creek looking downstream, May 4, 2004. Note: remaining riffle habitat in low gradient reach.

Photo 2. Herd Road WQ monitoring site in Richards Creek looking upstream, June 11, 2005.

Photo 3. Somenos Creek looking upstream from Lakes Road, upstream of WQ monitoring site at Footbridge, May 4, 2004 (before vegetation removal).

Photo 4. Somenos Creek looking downstream from Tzouhalem Road, June 11, 2005 (no vegetation removal in this section).

Photo 5. Beaver dam removed from lower Somenos Creek September 2, 2004. Height of beaver dam can be determined from remaining debris on right of photo.

Appendix B. Summary of raw fish data from DFO Stock Assessment 1990-1997

Date	Location	Method	Density	Comments
May 1/97	Somenos Lake	Fyke		112 coho captured mean length of approx 125 mm; 8 chinook mean length 108 cm
Jul 9/90	Bings		7.35 coho/sq.m.	discharge .067 cu.m./sec
Jul 9/90	Richards Trail middle		7.53 coho/sq.m.	discharge .008 cu.m./sec
Jul 10/90	Richards Trail upper		7.65 coho/sq.m.	discharge .018 cu.m./sec
Jul 11/90	Fish Gut Alley		5.64 coho/sq.m.	discharge .0721 cu.m./sec
Jul 11/90	Rotary upper		8.76 coho/sq.m.	
Jul 11/90	Rotary Pond-east		1.78 coho/sq.m.	
Jul 12/90	Rotary Pond-west		3.93 coho/sq.m.	
Jul 19/90	Lower Bings		10.5 coho/sq.m.	
May 15/90	Richards Creek		9.4 coho/sq.m.	discharge .068 cu.m./sec
May 17/90	Richards Creek upper site		7.0 coho/sq.m.	discharge .067 cu.m./sec
May 18/90	Bings		10.4 coho/sq.m.	discharge .106 cu.m./sec
May 23/90	Fish Gut Alley lower site		11.5 coho/sq.m.	discharge .145 cu.m./sec
May 24/90	Fish Gut Alley u/s pond		3.66 coho/sq.m.	discharge .244 cu.m./sec
May 24/90	Somenos Creek		0.19 coho/sq.m.	discharge .398 cu.m./sec
May 25/90	Rotary Pool east site		0.46 coho/sq.m.	
May 25/90	Rotary Pool west site		0.714 coho/sq.m.	
May 25/90	Richards Creek lower		0.014 coho/sq.m.	
Jun 6/90	Somenos Lake -NE Beach		1.82 coho/sq.m.	
Jun 6/90	Somenos Lake -Boat Ramp		1.04 coho/sq.m.	
Jun 7/90	Bings near Somenos Lake		0.12 coho/sq.m.	
Oct 26/90	Bings lower			low water level 9.5 degrees moderate coho densities
Oct 26/90	Somenos Lake NE Beach	Seine		12 degrees low coho density
Oct 15/90	Richards -upper			moderate densities 8.5 degrees
Oct 16/90	Richard -middle			moderate densities 7.0 degrees
Oct 17/90	Fish Gut Alley upper			moderate densities 17.0 degrees
Oct 18/90	Fish Gut Alley lower site			moderate densities 15.8 degrees
Oct 15/90	Bings at Mary Rd.			high densities 8.5 degrees
Oct 17/90	Rotary Pond ds end	Seine		very low densities 15 degrees
Oct 17/90	Rotary Pond us site	Seine		low densities
Nov 30/89	Somenos Creek	Minnow Trap		set 46 traps captured 30 coho 6.7 degrees
Jan 10/90	Richard Creek	Minnow Trap		set 44 traps captured 25 coho mean 91.5 mm/8.55 grams
Jan 10/90	Somenos Lake	Minnow Trap		set 46 traps captured 3 coho 82-94 mm
Jan 10/90	Somenos Creek	Minnow Trap		set 30 traps captured 3 coho
Feb 14/90	Richard Creek			3 coho 85-103 mm
Feb 14/90	Somenos Lake			1 coho 88mm
Feb 14/90	Somenos Creek			7 coho 86-106 mm