PICI Annotated Bibliography

Created by Heather Wright, World Fisheries Trust

Some notes:

- 31 reports in total (13 of these are only available in hardcopy at WFT office)
- If you are reading through a report and come across something you think would be valuable to the project, please add it to the annotation for that report and include a page number.
- If you see a keyword missing please feel free to add it in.
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Neate, F. E. "Colquitz River an Appraisal and Plan," Corporation of the District of Saanich, 1967

Keywords: Colquitz, Swan lake, Beaver lake, Panama flats, Quicks bottom, history, restoration plans, sewage, groundwater, Cutthroat, Coho, flow, preservation plan, reach descriptions, land use, press clippings, reminiscences, map.

This report is an attempt to draw together information available in 1967 to permit a rational appraisal of the value of the Colquitz to the district of Saanich and outlines a plan by which this potential may be realized. The tributaries are not mentioned. Interesting historical information on pg 2. Description of the Colquitz starts on pg 3, on pg 6 it is noted that Coho, Steelhead, Dolly Varden char, catfish, sunfish, sticklebacks, crayfish and CTT. Pg 7 talks about "present" land use ranging from single family homes through corner stores and small nurseries to full-time dairy farming; the slow flow of water is noted and it is stated that any flow at the end of summer is made up of ground water seepage, sewage treatment plant effluent (serving 179 homes discharging at 15 gpm directly into the stream at Carey Road, 2 Municipal plants and one Plant serving a Provincial Institution flow into tributary ditches, and prior to 1967 a Winery discharged untreated effluent to Swan Lake Creek and waste discharges from a few individual homes; there was no release of stored water from Beaver Lake after 1963 or 64. Key considerations in the development of a preservation plan and tools to control the future of the stream are listed on pg 10. Noted on pg 11 that Panama Flats and Quick's Bottom have a very substantial influence on the rates of flow experience downstream and that a four to five-fold increase in cross-sectional area is required if the peak reducing basins disappear. Starting on pg 14 the Colquitz is divided into sections and good descriptions of each; figure 6 shows the land use of the area. Related press clippings start on pg 22 (some are cut off in the PDF). Fishing reminiscences from locals start on pg 29. On pg 33, paragraphs 3 and 4 talk about CTT and Coho; at the bottom of the page a list of steps for long term restoration plans starts. The very last page in this document is a map of the proposed Colquitz River conservation belt.

Waldichuck, M., Meikle, J. M., & Hyslop, W.F. "Victoria Harbour, the Gorge and Portage Inlet Physical and Chemical Oceanographic Data, 1965-1966," Fisheries Research Board of Canada Manuscript Report Series No. 938, 1968 *Paper copy only at this time

Keywords: Victoria Harbour, Gorge Waterway, Portage Inlet, pollution, seasonal changes, rate of flushing, coho, cutthroat, herring, sewage, nutrient levels, phytoplankton, Craigflower, Colquitz, estuaries.

This study was undertaken to examine the effects of pollution, to obtain a picture of seasonal oceanographic changes and to determine the rate of flushing of the system. It once had substantial numbers of oysters and still possesses small runs of coho, CTT and Pacific herring. Pollution in the upper end of the Gorge and in Portage Inlet was mainly domestic sewage, nutrient levels and phytoplankton densities in the water and their seasonal changes were determined (pg 1). A series of 13 sampling stations was established from Victoria Harbour to the upper end of Portage Inlet and into the Craigflower Creek and Colquitz River estuaries. Surveys were completed monthly, near the middle of the month, from Aug 65 to Oct 66 (pg 2). Sampling methodology is outlined from pg 2-3. Map on pg 10. Data tables from pg 11-114. No report of results given.

Glova, G. J. "Pattern and Mechanisms of Resource Partitioning Between Stream Populations of Juvenile Coho Salmon (*Oncorhunchus kisutch*) and Coastal Cutthroat Trout (*Salmo clarki clarki*)," A thesis submitted to the University of Victoria, 1972 *Paper Copy only at this time

Keywords: Coho, cutthroat, sculpins, juveniles, smolts, behaviour, spawning, habitat types/preferences, micro-habitats, diets.

Juveniles of anadromous populations of coho salmon and coastal CTT frequently occur sympatrically. Coho spawn in the fall and in early winter whereas CTT spawn in late winter and early spring. Coho emerge earlier and are of larger size at emergence than CTT. The young of both species normally reside in freshwater for one or more years before going out to sea but some coho populations see young fry moving seaward sooner (pg2). Small coastal streams are important nursery areas for juvenile coho and CTT where the two species compete for similar resources. Small stream environments provide three major flowing water habitat types – riffles, pools and glides, this study investigates pattern and mechanism of resource partitioning between juveniles of sympatric populations of coho and CTT by looking at microhabitat use and diets of these fish (pg 4). A laboratory model of a stream section consisting of riffle and pool habitats was used to observe fish microdistribution and social behaviour (where factors such as water level, flow rate, and food supply could be controlled) (pg 5) in addition to in stream monitoring during low flow periods (pg 8). Sculpins were given similar sampling effort due to their high biomass levels and considerable overlap in diet (pg 8). Creeks studied were Bush, Holland, Ayum, Bings, French and Shawnigan; a summary table is on pg 13. Fish population

estimates were determined by the removal method moving progressively in an upstream direction by blocking off sections with fine mesh minnow seines on down and upstream ends followed by a minimum of three successive runs (or until catches declined to near zero) with an electrofishing unit. At least 5 of each habitat in the mid-region of each system was sampled. Fish were anaesthetized in MS-222, fork length and species ID were recorded and scale samples were taken from age 0+ fish (pg 16-17). Biomass calculation given on pg 17. Coho made up 53.1 to 90.8% salmonid biomass in pools; in riffles CTT made up 63.4 to 88.0%; glides were areas of intermediate biomass for with coho ranging from 51.8 to 80.8% and CTT from 25 to 48.2%. Coho seem to prefer slower velocity habitats (pools and glides) while trout prefer higher velocity (riffles and glides) (pg 27). Graphs showing relative abundance (%) for coho, CTT and sculpins in pools, glides, and riffles for each creek on pg 25-26. Coho and CTT appeared to compete for space at the head of pools to attain priority in the exploitation of invertebrate drift (pg 29). Observations suggest that CTT are subdominant to coho and sculpins are subdominant to both (pg 31). Histograms of fork length frequency of sympatric populations by habitat type on pg 38. Diet analysis of under yearling coho and CTT on pg 41 shows that they eat a large percentage of Chironomid larvae/pupae and adult insects followed by trichopteran and dipteran larvae. Coho appear to be a more specialized feeder of drifting foods while CTT are a more generalized feeder of both benthic and drifting foods (pg 48). CTT consistently occupied a broader microhabitat niche than coho. CTT utilized faster velocity habitats, shallow waters of stream margins and small side channels (pg 49). The lack of coho and sculpins in allopatric populations of CTT resulted in a shift of habitat preference from riffles to pools suggesting interactive segregation occurs (pg 50). CTT in allopatric populations showed a tenfold higher biomass in some cases, based on these findings it is likely that interspecific interaction between coho, sculpins and CTT is a limiting factor for CTT populations (pg 51). Stream production of juvenile coho during summer was shown to be limited by food rather than space whereas riffle habitat taken up by coho in the summer when pool space is limited results in a loss of living space for CTT and could in part explain low biomass levels of trout in sympatric streams (pg 52). Laboratory studies starts on pg 55 (summer fish came from Craigflower Creek) and goes into more behavioural detail. Interesting information on threat display types and differences between coho and CTT on pg 94. Velocity and substrate-oriented instream engineering would would encourage segregation between coho and CTT simultaneously improving food supply and possibly enhancing production and smolt yield. Additional cover (large boulders and thick, low, overhanging shrubs at the stream bank) would increase winter carrying capacity (pg 122). Overwintering requirements of coho and age 1+ trout; coho utilize a variety of cover types in main and side channel habitats whereas trout remain mostly in main channel areas; sites common to both are deeper waters containing upturned or undercut root masses and log accumulations at meanders; trout but not coho are also found in close association with large boulders (pg 123). Since coho spawn in the fall and CTT spawn in the spring, partial or complete exclusion of coho by escapement control is feasible using temporary stream barriers (pg 125). Laboratory growth rates discussed starting on pg 126 with effects of temperature and photoperiod starting on pg 147.

Ptolemy, R. A. "Define Responses of a Coastal Sea-Run Cutthroat Trout (*Salmo Clarki Clarki*, Richardson) and Coho Salmon (*O. Kisutch*, Walbaum) Population to Habitat Development in Colquitz Creek, Vancouver Island," for the Fish Habitat Improvement Section Fish and Wildlife Branch, Ministry of Recreation and Conservation, 1977

Keywords: Colquitz, habitat improvement/complexity/surveys, fish biomass, smolt, Federal-Provincial Salmonid Enhancement, site description, juveniles, microhabitats, system problems, temperature, oxygen, flow, spawner, kelt, survivorship, angler exploitation, maps.

Colquitz Creek was selected for an experimental stream habitat improvement project aiming to determine if fish biomass is independent of habitat complexity; it was hoped that increasing habitat complexity would increase biomass loading and translation to smolt output. The joint Federal-Provincial Salmonid Enhancement Program (SEP) started in the fall of 1975 (pg 1). Site description (pg 1-2): third-order stream, watershed ~47.8km^2, drains four lakes, mainstem length of ~9km, salmonids using ~6km in 1976, low gradient of ~0.6%, variety of bottom types. Problems within the system are listed from pg 3-8; poor habitat complexity; (pg 4) low minimum flow 0.5cfs, elevated temps up to 25^{o}C, associated low oxygen saturation in sections with high BOD 200mg/L limited juvenile dispersion; anadromous salmonid juveniles in 3km (13.2%) of watercourse length; when minimum summer flows increased from 0.5cfs to 2.0cfs (sustained during the summer production periods) a wider distribution of juveniles occurred (25% watercourse length utilized); poor spawner/recruitment (out-migrating CTT ~700), 30% survivorship results in an estimated return 225 fish including 50 kelt with an adult run of ~170 fish assuming 75% are sexually mature; calculation for Spawner number requirement on pg 5; (pg 6) high angler exploitation of adult CCT resulted in ~200 killed between winter 75 and spring 76, closure of the fishery was suggested (pg 7); inadequate riparian land protection. Good section on Biomass Loading Principle pg 7 - 12. Extensive winter habitat surveys from 75-76 showed that in stream complexing characteristics were primary overwintering microhabitats (pg 16). Figures, maps and tables from pg 20-52.

Langford, R. W. "Colquitz - Craigflower Salmonid Enhancement Program," Aqua Science Consulting Ltd. for the Salmonid Enhancement Program, 1977 *Paper copy only at this time

Keywords: Colquitz, Craigflower, coho, cutthroat trout, migration patterns/timing/triggers, traps, removal method, electrofishing, scale samples,seining, anglers, fry, smolt, enhancement techniques, outmigration pattern/triggers, summer release.

Both Colquitz and Craigflower Creeks have low amounts of coho and CTT reduced from historic levels due to urbanization pressures. An increase in water volume in the Colquitz in 1976 resulted in a 40% increase in coho fry and an 83% increase in CTT (pg 1). A summary of CTT history (pg 17-22) includes adult migration patterns, timing, triggers and the location of the

Colquitz trap (situated at the upstream extent of salt water intrusion, 1 mile); juvenile habitat preference, timing movements and behavioural interaction between coho and CTT fry. Seber and LeCren (1967) removal method was used for population parameters using a shocking unit, scale samples were taken from fish exceeding a chosen length range. Neither shocking nor seining proved successful in deep pools with debris (pg 23-25). The Interpretation of data section (pg 32-51) goes over a number of problems that occurred and could be useful; movements, catch, angler catch and stream mortality of adult CTT and in some cases Coho is given; pattern and triggers of smolt outmigration, growth, and notes on artificially reared CTT are described. The Enhancement section (pg 54-61) suggests a blend of semi-artificial enhancement techniques (rearing smolts, 500 if available or 30%, in a saltwater pen in the Gorge - pg 59-60) with habitat enhancement techniques combined with full or partial fisheries closures for 2-3 years and gradual summer release from headwater storage is the best way to restore this fishery. Contains a number of data tables and diagrams that could be useful (pg 62-114).

Langford, R. W. "The Aquatic Environment, a Review for the Municipality of Saanich," for the Municipality of Saanich, 1977

Keywords: Colquitz, site inspections, restoration, water levels, DO, flow,, Swan Creek, Beaver lake, water licence, temperature, dams, spawning, water temperatures, substrate types, food production, insects, recommendations, sections, site descriptions, historical data tables, plankton abundance.

This report was compiled from site inspections and existing materials (pg 2). Historical pictures with descriptions from pg 3-9. The Colquitz river system needs to be looked and improved at as a whole if restoration is to be achieved (pg 11). The salmonids in this system required diverse habitats and water parameters to be successful (listed from pg 11-16). Gill membranes are unable to supply sufficient oxygen when DO falls below 1 ppm, below 4 ppm is sublethal but injurious; recordings in Swan creek dropped to 0.5 ppm Oct 1974; recordings have not been taken at adequate intervals in any part of the system (pg 12). Control of summer water levels throughout the system are minimal and at times reduced to zero; flow from Beaver lake is regulated by a small dam based on requirements for lake swimming, meaning outflow is often shut off causing the death of fish that get trapped in drying pools; reduced summer flows from tributary streams needs to be addressed; a water removal license at Interurban and Goward road means spawning and rearing areas below receives no water; no policing of conditions stipulated in licenses takes place nor is the water course examined for illegal water use (pg 13). High water temps in the summer can be attributed to a lack of covering foliage in the lower reaches; sublethal effects reduce the viability of the population; the absence of deep pools makes it impossible for fish to find lower water temps without moving up or down stream; dams on the lower section will not permit the movement of small fish upstream; the combined effect of the addition of cold spring water and heavy shading can maintain water temps; numerous small shaded pools are of greater value than shallow unshaded ponds (pg 14). Mud

and silt maintain low densities of food organisms compared to high densities in gravel and boulders; riffle areas are of greatest importance for food production; a major supply of food is produced in canopy with alder contributing the richest source of terrestrial insects that make up 66% if salmonid diets (pg 15-16). The major problems are siltation, flow reduction, scouring due to peak floods, unclear passage for mature fish to return to spawning grounds - recommendations to solve these conditions are in this report. Contains a good description of the Colquitz watershed broken down into sections: Beaver Lake to Hunt's Falls, Hunt's Flats to Quick's Bottom, Logan Park to Quick's Bottom, Quicks Bottom to Marigold, Swan Creek, Marigold to the Gorge, Portage Inlet and the Gorge. Detailed descriptions of Prospect Lake, Swan Lake, Beaver - Elk Lake and Maltby (pg 18-74). Has a comprehensive list of recommendations broken up by sections (pg 76-88). Contains a number of historical data tables used to generate this report, including Plankton abundance (pg 102-113).

Elliott, J. M. "Some Methods for the Statistical Analysis of samples of Benthic Invertebrates," Second Edition. Freshwater Biological Association Scientific Publication No. 25, 1977 *Paper copy only at this time

Keywords: statistical methods, bottom fauna, population.

The purpose of this guide is to give an elementary account of some suitable statistical methods that provide information on the spatial distribution of bottom fauna, enable estimates to be made of the total pop in an area of bottom and provide a sounds basis for judging the significance of quantitative differences between samples. All methods are described in detail and all data for the examples were collected from small streams. The tables of Pearson & Hartley (1966) are essential and must be obtained before some methods can be applied.

Burns, T. "The Present Status of Craigflower Creek and its Salmonids and Opportunities for Enhancement," for the British Columbia Fish and Wildlife Branch Ministry of the Environment, 1979 *Paper copy only at this time

Keywords: Craigflower, recommendations, management, wastewater, sediment, spawning, coho, cutthroat, historical data, counting fence, smolts, steelhead, chum, outmigration, habitat types, flow, water quality, Big Falls, maps.

The objective of this report is to summarize existing knowledge of Craigflower Creek, for which there has been substantial diagnostic analysis of the system, and provide recommendations for optimal management (pg1). Initial impacts from urbanization may have been serious but present impact is light aside from two concerns; the lower 1.6 km (~30% of utilizable habitat) is uninhabitable for fish due to wastewater from Fort Victoria; 1.2-1.6 km upstream is a large cleared area with two permanent to intermittent streams and one temporary stream

depositing large amounts of sediment (pg 3). Counting spawning salmonids is very difficult without some kind of migration control. Coho and CTT are very shy and like to spawn near cover; they retreat quickly at the slights disturbance, enter streams over prolonged periods of time and spawn at scattered locations. From 1975-1979 a counting fence at Helmecken falls was used to count spawners and was used from 1976-1978 to count downstream smolts. Data on historical coho population levels began in 1947 and a general decline of salmonids has been observed since that time(pg 6). Steelhead have not been recorded since 1959 (pg 8) and it has been many years since Chum have been spotted (pg 6) but this report suggests that Craigflower could have only supported small numbers of these fish (5-10 steelhead and 10-500 chum), reasons for this are listed on pg 7. Pg 8 has a salmonid escapement table for 1947-1979. Pg 9 has a smolt outmigration table for 1979-1978. Craigflower has good capability for CTT and coho production but low summer flows, overfishing and poor water quality have caused decline. Improving summer flows and the amount of utilizable habitat will allow for considerably more coho and CTT. CTT in upper reaches are progeny of lake residence (McKenzie, Prior & Pike = strong populations; Thetis, Fork & Fizzle = low to moderate populations (pg 13). Big Falls limits coho and sea-run CTT to ~25% of utilizable system (pg 14) therefore work to allow passage is necessary via permanent diversion of the creek around the falls through a flood channel and minor channel improvements (pg 15) It should also be possible to improve the falls itself by careful blasting of pools and wedged boulders (pg 15) as shown by diagrams on pg 16. Young coho have lesser habitat requirements than CTT and tend to dominate CTT relegating them to less favourable living spaces, for this reason, and because coho are maintaining themselves better, it is suggested to limit and design habitat above Big Falls specifically to CTT (pg 14). Annual precipitation over the watershed ranges from 30-45" (pg 10). Soil deficiency can begin ~ May 15th and lasts until ~ Oct 5th. The critical discharge period for stream dwelling salmonids is ~ 5 months (June-Oct), the period when Craigflower becomes dry with a few scattered pools and very low to no flow (pg 11). Habitat type maps and keys (pg 20-25). A number of opportunities to improve summer flows in the system are present and could increase utilizable habitat from 15% to 50%. There is a total of 717.2 acre-feet of potential storage at 24 different locations in the watershed that could provide 2.09 cfs of extra summer discharge for 5 months (pg 26), see table 3 pg 26-27. This would allow up to 2,400 coho and 400-600 sea run CTT to be produced in the system. Interesting stats on coho and CTT on pg 29. Pg 30 missing. Table of storage sites not strongly affected by evaporation pg 31-36. A minimum flow of 1 cfs would improve salmonid production greatly (pg 37). Min discharge characteristics from 1974-77 tables pg 37-39. Overall Craigflower provides a good balance of primary habitat features however there is a 0.8 km reach in lower Craigflower that is low gradient muck-detritus Type 1 habitat that could become usable with the addition of boulders and stones (pg 42). The next upstream reach is Type 2 habitat and would also benefit from an increase in complexity targeted toward CTT, riffles in this area are generally too shallow to hold trout. There is need for some larger pools to increase summer carrying capacity and was judged to be most feasible in Prior Creek, Pike Creek and McKenzie Creek, reaches described on pg 43. Summary of recommendations from pg 43-45.

Law, P. D. “Survival of Hatchery Cutthroat Trout in Colquitz/Gorge Waterway Between 1980 and 1983,” Ministry of Environment Lands and Parks *Paper copy only at this time

Keywords: Colquitz, cutthroat, hatchery, survival, catchability, health, Gorge Waterway, Portage Inlet, nursery, rearing, fish fence/modifications, smolts, trapping, adult migration, electrofishing, floy tags, leg bands, sites, stop nets, population estimate, removal method, creel survey, monitoring.

This report looks at the introduction of hatchery cutthroat trout to the Colquitz and compares their survival, catchability and health to wild cutthroat trout. Information on the creek and watershed is on Methodology pg 1. Fish fence located 1.7km upstream on the creek that can trap up or downstream migrants. The creek supports cutthroat trout, coho, pumpkinseed sunfish, brown bullhead, three spined stickleback, prickly sculpin and a small population of chum. The stream was closed to fishing during the time of this report. The Gorge provides nursery habitat for fish; Portage inlet supports eelgrass, herring, coho and sea run cutthroat trout in their early marine life; the outer harbour proves cutthroat trout an ideal summer rearing environment. No cutthroat trout have been reported caught outside of the Gorge. Information about fish fence and modification used for catching smolts on pg 2. Eggs for the hatchery smolt stocking program were obtained from Colquitz adults (wild and hatchery) held at Goldstream, Fulford Creek (one group of eggs in 1981), and Sandhill Creek (captive broodstock originated from fry captured in Colquitz in 1978). A total of 56,720 smolts were released over four years; 8 groups each with a unique mark. Pg 3 discusses downstream trapping methods. Adult migration methods, include dates, from pg 3-4; includes use of floy tags and monel-metal leg bands attached to the maxillary bones. Electofishing was used to estimate wild salmonid densities and hatchery smolt residuals in the first week of June each year; 10 sites 39m long were enclosed with stop nets; population was estimated using the removal method (Seber & Lecren, 1967) (pg 4). Creel survey methods from pg 4-6, includes catch effort calculation. Upstream Trapping pg 1; counted between November and March from 1979-1983; migration usually starts between January and February and is flow depended; it appears that the genetic variability of wild Colquitz CCT with respect to run timing may have been reduced because of the hatchery program; a total of 208 hatchery-marked CTT and 71 unmarked were counted and tagged at the upstream trap over 4 years. Pg 2; the introduction of hatchery smolts did not increase naturally spawning CCT populations in the Colquitz and may have actually reduced it; hatchery program put pressure on the natural population by encouraging fishing pressure (only 5% wild fish caught but this equaled 50% of the wild population). Biological characteristics of adults from pg 2-4. Wild vs. hatchery smolt survival pg 4-6. Summary pg 6-7. Creel Survey pg 1; overall catch per effort was 0.13 in 1980, 0.27 in 1981, and 0.19 in 1982; 201 interviews in 1980, 834 in 1981 and 1280 in 1982. Pg 2; proportion of the catch that was killed as opposed to released was higher for wild fish than for hatchery (87% vs. 77%); a 30 cm minimum size limit was introduced in 1982 and reduced the kill rate of hatchery fish to 61% but wild remained 90%. Pg 4; notes the differences between stocks; wild smolt contribution was 8.7%; hatchery fish were found to be 2.7 times more vulnerable to angling than wild. Pg 5 has age, length and weight of creeled fish; angler distribution in the Gorge; angler characteristics and results of the questionnaire (pg 5-7). Results section pg 1-5 discuss

physical stream monitoring, wild/hatchery smolt migration, age and size of downstream migrants, and factors affecting smolt survival.

Wightman, J. C. "Impacts of Flooding and Channelization Practices on Recreational Resources Associated with Small Streams – A case Example, Greater Victoria Area," for Fish Habitat Improvement Section Fish and Wildlife Branch Ministry of Environment, 1983 *Paper copy only at this time

Keywords: Colquitz, Craigflower, coho, cutthroat, flooding, channelization, dam, culvert, contamination, enhancement, stocked, flows, hydrographs, habitat diversity, bays, rubble substrate, restoration, anglers, maps.

The objective of this report is to review the impacts of flooding and channelization practices on recreational resources associated with small streams in the Greater Victoria, discuss alternatives to stream channelization for flood control, and outline an approach to restore stream channels that have been grossly modified from a natural state. Stream systems have been degraded by extensive channel modifications, dam and culvert installations, water withdrawals and contamination by various pollutants due to urbanization (pg 2). Colquitz Creek, once "called the most important trout stream in the area" has experienced intensive recreational development and has experienced a period of relative neglect (pg 3). The Municipality of Saanich recognized the need to acquire land along the Colquitz and in November 1981 the first phase of the 'Colquitz River Linear Park' was opened (pg 4). Colquitz Creek was the focus of several fisheries enhancement projects undertaken by the municipality and the provincial Ministry of Environment (Fish and Wildlife Branch). In 1977 provincial fisheries biologists manually placed large numbers of boulders and rootwads in one previously ditched section of the stream to evaluate the relationship and importance between artificial cover and abundance of juvenile coho and sea-run cutthroat trout (pg 5-6). Vancouver Island Anadromous Cutthroat Management Plan is Appendix 2, its goal was to create a highly successful urban sea-run CTT fishery with the introduction of CCT smolts to provide 7000 successful angler days on the Gorge annually by 1990. The fishery was closed at the time of this report. MOE got the CRD to agree to provide a minimum acceptable fisheries maintenance flow during the summer months of 0.057m^3/sec by regulating release from Elk/Beaver (pg 6). Salmonid populations in Craigflower are low but fishability remains good and it is rated as a high enhancement priority. Lakes in the Craigflower and Colquitz drainages are regularly stocked by the Ministry (pg 7). Map of fisheries resources of Greater Victoria on pg 8. Flows at the mouth of Colquitz Creek have ranged from summer lows of near 0 m^3/sec to estimated winter peaks of up to 8.5 m^3/sec (pg 10). Figure of typical flood hydrographs for various levels of urban land use on pg 11. Channelization commonly reduces overall stream length and can therefore result in a net loss of fish habitat, lacking habitat diversity and cover critical to the growth and survival of salmonids (pg 13). Bustard (1973) noted that both cutthroat and coho show a strong preference for bay areas offering overhanging bank cover as opposed to bays without cover, and for bays offering clean rubble substrate as opposed to silted rubble for

overwintering (pg 13). Ptolemy (1982) suggests the presence of stable cover is particularly important in preventing displacement and high mortality among overwintering populations of juvenile CTT and coho (pg 14). Figure of impacts of channelization on aquatic ecosystems on pg 15. Figure of direct and indirect effects of channelization on wildlife on pg 16. Pg 19 has two figures comparing hydrology of natural and channelized streams. Alternatives to channelization from pg 20 to 24. Stream restoration techniques from pg 24 to 27. Figure on pg 29 showing boulder grouping approach to habitat restoration. Appendices include fishing reminiscences from Victoria Fish and Game Protective association pertaining to the Colquitz; Priority ranking of Vancouver Island sea-run CCT enhancement opportunities; a summary of hatchery fish distributions in Greater Victoria lakes and streams; a map of human impacts on fish production and water quality in Victoria; and a summary table of site-specific flood loss reduction measures.

Drinnan, R. W., & Gordon, D. "Report: Annotated Bibliography of Environmental Reports for Victoria Harbour, the Gorge/Portage Inlet, Esquimalt Harbour and Esquimalt Lagoon," Aquatic Science Consultants Ltd. for Capital Regional District, 1991 *Paper copy only at this time

Keywords: Victoria Harbour, Gorge Waterway, Portage Inlet, Colquitz Craigflower, contamination, surveys, geomorphology, land use, management, sediment, water quality, tides, currents.

This report compiles numerous environmental studies conducted along the south coast of Victoria, by, and on behalf of, the CRD addressing environmental quality in the harbours, particularly with respect to contaminants in sediments and biological tissues. 113 reports and documents completed between 1961 and 1991 were reviewed. Topics covered for Victoria Harbour and the Gorge/Portage Inlet include biological contamination, biological/ecological surveys, geomorphology, land-based contaminants, land use and management, Marine sediment contaminants, physical/chemical oceanography (water quality), tides and currents. Colquitz and Craigflower are mentioned to similar but slightly less detail as the harbours. A large portion of this report, reference through to appendices, is missing.

Todd, Gary L. "A Lightweight , Inclined-Plane Trap For Sampling Salmon Smolts in Rivers." Alaska Fishery Research Bulletin 1, no. 2 (1994): 168–75

Keywords: Alaska, trap/design/plans, salmon, smolts.

The design and use of an inclined-plane trap is described for capturing salmon smolts in medium to large (5-60 $m^3.sec^{-1}$) rivers of Alaska. The trap was designed to minimize fish scale loss and mortality, be lightweight yet durable, minimize debris loading, be readily moved by 2

people and be easily transported by a small river boat. The tapered design allows traps to be stacked inside one another when being transported. This trap style has been used since the early 1980s in small clearwater streams and large glacial rivers of south central Alaska. Catch efficiencies from mark-and-recapture tests have exceeded 10% for a single trap. The highest daily catch to date for 1 trap occurred June 1994 when 96,979 sockeye salmon smolts were caught. Pg 170 has a list of materials used for construction with schematic diagrams on pg 171-172.

Brett, D., Carrow, G., & Stephen, M. "Colquitz Creek: a Study on Sources, Distribution and Implications of Suspended Solids on Salmonid Habitat," for Camosun College Environmental Technology Program, 1994 *Paper copy only at this time

Keywords: Colquitz, suspended sediment, channel erosion, sampling sites, map, turbidity, fry, rainbow trout, gills, Portage Inlet, Beaver Lake, storm drain, precipitation, data.

The objective of this study was to identify the sources, distribution and implications of suspended solids on salmonid habitat in Colquitz Creek. This was the first suspended sediment study done in Colquitz (pg 5). Suspended solids were measured at 10 locations along the Creek over a period of six days. Quicks Bottom removed suspended solids; Panama Flats contributed suspended solids (max 37 mg/L, pg 12); storm drains had a negligible influence; and channel erosion was the largest contributor. Sediment levels ranged between 7 and 101 mg/L, averaging 28 mg/L; turbidity ranged between 0.8 and 92.3 NTUs, and averaged 17.1 NTUs. Salmonids in the creek would not be significantly harmed by these sediment levels (pg 1). Turbidites of 25-70 NTUs reduces the ability of salmonids to find and capture food and after 5-10 days of exposure to 25 NTUs gill tissue can be damaged. Turbidity also negatively affects macroinvertebrates, the main food source of salmonids. Turbidity reduces light penetration which in turn harms primary productivity – in shallow streams 5 NTUs can lower production by 3-13% while 25 NTUS can lower production by 13-50% this affect is stronger in sections deeper than 0.5 m. Juvenile coho have been found to avoid water with turbidites over 70 NTUs and adult rainbow trout avoid water above 30 NTUs. At 100 mg/L coho fry diminish their feeding and stop altogether at 200 mg/L; rainbow trout exposed to concentration of 270-810 mg/L for 10 days can suffer gill structure damage and death; levels over 10 000 mg/L quickly kill salmonids (pg 3). Rainbow trout egg to fry emergence is closely related to suspended loading; 66% survival at constant 240 mg/L and 4% survival at 2,000 mg/L. The depth-integration method was used in this study where a bottle is lowered to the channel bottom and raised at a constant rate obtaining the average concentration in that column, filtering and weighing each sample was more effective than spectroscopy absorbance estimates (pg 4). Field and lab materials listed on pg 7. Sampling took place from Feb 26 – March 19; 10 sites were selected, based on accessibility, during a stream walk from the mouth at Portage Inlet to the Creek head at Beaver Lake. Sites listed on pg 8. Sampling methodology and storm drain locations from pg 9-10. Max sediment and turbidity data correlated with maximum recorded levels of precipitation. Beaver Lake, contributed max levels of 100 mg/L to the Colquitz with an average contribution of 47 mg/L with turbidity levels ranging from 6.7-62.9 NTUs (pg 11). Good tables and graphs from

pg 14-15. It is noted on pg 16 that observed NTU levels would have biological consequences and Beaver Lake sediment level results may have been altered due to additional weight from algae in the filtration process. Channel erosion is concluded to be the largest contributor of suspended solids to colquitz creek (pg 18), organic yard waste and natural debris were scattered along the bank and in some places altered flow and may contribute to erosion; many footpath crossings have completely deteriorated banks; 15 bridge sites also accelerate erosion (pg 19). A man-made salmon spawning bed was observed to be completely cemented by sediment and rendered useless, no reference given to location. NTU levels were of more ecological concern, prolonged exposure to peak levels could result in death to both salmon and trout. It is recommended that the creeks chemical components be tested and, if favorable, old salmonid spawning beds be cleaned and the creek stocked (pg 20). Map of sites on pg 22. Sampling data makes up the remainder or the appendices.

Roberts, J. M., and Harding, E. A. "The Craigflower Watershed Assessment," SHIP Environmental Consultants for the Capital Regional District, 1997 *Available in paper copy with full mapfolio

Keywords: Craigflower, coho, cutthroat trout, watershed management, assessment, flow, water quality, mapping, hydrology, risks, riparian zones, habitat, fish stocking, erosion.

This assessment of the Craigflower watershed was undertaken to provide background information for integrated watershed management planning and included mapping the aquatic features of the watershed, assessing the present condition of the watershed, identifying risks to the natural resources of the watershed, presenting options for addressing those risks. Main concerns within the Craigflower watershed were identified as erosion, flooding, low summer flows, effects of agriculture, water quality and fish/habitat (pg 5). Very good information about many aspects of the Craigflower watershed including history, hydrology, water control measures, and much more from pg 6-20. Pg 20 has a list of Protection of Riparian Zones by municipality. Fish and Fish Habitat information starts on pg 21 with fish observations by site number listed in table 6, fish stocking programs and fishing regulations on pg 25. Low summer flows discussed pg 26-27 and water quality from pg 28-32. Discussion of the watershed and impacts from human activities from pg 38-42; management options from pg 43-44. This report has lots of figures and maps that may be useful and has a very comprehensive appendices that include assessment tables.

Millar, J., Page, N., Farrell, M., Chilibeck, B., & Child, M. "Establishing Fisheries Management and Reserve Zones in Settlement Areas of Coastal British Columbia," Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2351, 1997 *Paper copy only at this time

Keywords: Cutthroat, fisheries management/reserve zones, setback distances, habitat features, methodology.

Rivers, streams lakes, wetlands, floodplains and their associated riparian areas provide a network of critical habitats for at least thirty species of fish, twelve species of amphibian, and many species of birds, mammals, insects and plants throughout coastal BC. Small streams in coastal BC sustain genetic and stock diversity for cutthroat trout, which is considered fundamental to species survival. Persistent increases in the rate of fish habitat loss in settlement areas strongly suggests that current urban land use and development practices area failing to adequately protect fisheries sensitive zones from serious impacts (pg 1). This document presents an approach to protecting riparian/aquatic fish habitat in urban and rural areas of coastal British Columbia that relies on the establishment of Fisheries Management and Reserve Zones (ix). The dimensions of the Fisheries Management Zones (watershed based high level planning boundary) and Fisheries Reserve Zones (immediate area adjacent to the aquatic feature required for water-land interactions) recommended in this document are based on distances required to protect various habitat features and functions (vi). The default management zone distances are as follows: actively fish bearing and potentially fish bearing permanent streams – 50 m on both sides of the stream channel from bankfull width; ephemeral and intermittent streams – 30 m on both sides of the stream channel from bankfull width; lakes and wetlands – 30m from the extent of seasonal inundation and/or hydrophilic plant community; contemporary floodplain (> 1 in 30 year recurrence interval) – any portion of the floodplain that is partially included in the Fisheries Management Zone should be completely encompassed within the FRZ; ravines, escarpments, or other steeply sloped areas – steep slopes (>30% slope) and any high relief features that are partially encompassed within 50 m of fish bearing permanent streams and 30 m of non-fish bearing permanent, ephemeral or intermittent streams should be wholly encompassed within the FRZ and additional setback at the crest of the slope may be required (as necessary) to ensure geotechnical and vegetation stability (pg ix). In many heavily urbanized watersheds, existing developments already occupy large portions of the FMZ, in these situations existing land uses and site alterations are considered in arriving at a feasible setback or habitat protection prescription (pg x). Section 2 (pg 4-26) summarizes information on specific fish habitat features provided by streams, floodplains, lakes and wetlands, hydrologic elements and riparian areas and includes a number of tables and diagrams that may be useful. Section 3 (pg 26-47) presents a methodology for establishing fisheries management and reserve zone boundaries in association with local government land use planning processes and includes some tables and a number of diagrams, including example site diagrams that show the result of the process step by step.

Roberts, J., Wark, R., & Harper, D. “Craigflower Watershed Management Plan,” for the Craigflower Watershed Management Forum, 1998

Keywords: Craigflower, management goals/plan, reaches, land use, runoff, coho, fry, smolts, fish fence, historical work, map.

List of management goals on pg i. The forum developed a Work Plan for meeting the goals (pg 18 onwards) with 17 objectives and 53 specific actions. Actions are categorized as Existing Actions (8), Program Amendments (12), New Actions (21) and Actions that Need a Lead Agency (12). List of top ten priority actions on pg ii. This management plan was based on an assessment of the Craigflower Watershed by Roberts and Harding 1997. The upper reaches of the watershed are still relatively undeveloped so groundwater recharge, flood regimes, and other ecological functions mostly reflect natural patterns but the watershed as a whole is facing strong urban growth pressures (pg 1). Controlling land use and runoff in ways that prevent damage to the stream and its ecosystem are important goals of watershed management. Pg 2-4 have a decent description of the watershed with a map on pg 2. List of benefits of good watershed management on pg 5. Good info on historical work along the creek starting in 1995 from pg 7-8, the release of 15,000 Coho fry annually in Pike and Prior Lakes is noted as is the counting of smolts at the Talcorr Road fish fence. Timeline tables from pg 43-46.

Vadocz, D., Anderson, R., Cummins, R., & Soberg, T. "The Cecelia Creek Project," for the Veins of Life Watershed Society, 1998 *Paper copy only at this time

Keywords: Cecelia creek, Gorge Waterway, sediment, sewage, wastewater management, federal fisheries act, stormwater quality, chemicals, Selkirk waterway, recommendations.

This report is a detailed assessment of the industrial presence within the Cecelia Creek drainage. The purpose was to identify non-point source polluters that are contributing to the degradation of the creek. The waters from Cecelia creek enter the second largest mudflat in the Gorge Waterway and is one of the most polluted creeks in the CRD draining 900 hectares of impervious substrate (pg i). Pg ii-v contains a list of detrimental practices broken down by industry. 101 businesses out of 119 (nearly 60% of these were part of the automotive industry (pg 10)) were rated based on interviews of their wastewater management practices; 27 were poor, 27 were suspect to satisfactory, 47 were negligible to good, and 18 were not interviewed. 42% never maintained their catch basins while 22% said they cleaned theirs once per year (pg v). Several of the practices witnessed infringe upon Municipal By-laws for storm water quality and the Federal Fisheries Act, neither of which are strongly enforced (pg vi). A historical description of the creek, and a current description, is on pg 2. The creek has sewage counts 75 ties the acceptable level for swimming and high sediment levels (pg2-3). Chemicals found in excess of Marine Sediment Quality Guidelines in Cecelia Creek are: Cadmium, Lead, Zinc, Copper, Mercury, Arsenic and Heavy and Light Polycyclic Aromatic Hydrocarbons (pg 3). Report is quite detailed and references drainage numbers and locations of storm drains and manholes often. Lots of information, graphs and tables on the various businesses and their practices from pg 8-33. The estuarine mudflat habitat of Cecelia Creek is significant for the preservation of marine habitat on the Gorge and Selkirk Waterway and should be a priority for remediation and could include modification of the creek to slow the more contaminated base flow, combined with addition of vegetation to partially treat the water and sediment. The addition of wet

detention ponds for Cecelia Ravine is also suggested (pg 35). A list of recommendations is on pg 38.

Nicholas, J. "The Oregon Plan for Salmon and Watersheds, Annual Report 1999," 1999

Keywords: report for the general public.

This is the second Annual Report of the Oregon Plan for Salmon and Watersheds, representing the Governor's Natural Resources office. Though this report was interesting I did not find much information that would serve to assist with the PICI project compared with the other reports. It is a good sample if we decide to create reports like this for the general public to take and read through at events.

Rosenfeld, J., Porter, M., & Parkinson, E. "Habitat Factors Affecting the Abundance and Distribution of Juvenile Cutthroat Trout (Oncorhynchus Clarki) and Coho Salmon (Oncorhynchus Kisutch)," British Columbia Ministry of Fisheries, Research and Development Section for the Canadian Journal of Fisheries and Aquatic Sciences, 57(4): 766-774, 2000

Keywords: Coho, cutthroat, distribution, abundance, habitat associations, bankfull channel width, parr, large woody debris, gravel-cobble streams.

The distribution, abundance, and habitat associations of juvenile anadromous coastal cutthroat trout (Oncorhynchus clarki) and Coho salmon (Oncorhynchus kisutch) were evaluated using survey data from 119 sites in coastal British Columbia. Both cutthroat and Coho occurred at their highest densities in very small streams (<5 m channel width), and bankfull channel width was the single best predictor of cutthroat presence ($p = 0.0001$) and density ($R2 = 0.55$). Within a channel, densities of Coho and larger (yearling and older) cutthroat parr were highest in pools, while densities of young-of-the-year cutthroat were significantly lower in pools and highest in shallower habitats. Abundance of larger cutthroat parr and pool habitat were positively correlated with large woody debris (LWD) within a subset of intermediate-gradient gravel-cobble streams, where pools appear to be limiting to larger cutthroat parr abundance. More than 50% of pools were formed by scour associated with LWD in streams ranging from 1.2 to 11 m channel width, and pools formed by LWD scour were on average 10% deeper than pools formed by other mechanisms. Disproportionate use of small streams by cutthroat indicates that protection of small stream habitat is important for long-term conservation of sea-run populations.

Archipelago Marine Research Ltd. “Subtidal Survey of Physical and Biological Features of Portage Inlet and the Gorge Waterway, Report & Map Folio,” for Victoria and Esquimalt Harbours Environmental Action Program, Capital Regional District, 2000 *Paper copy only at this time

Keywords: Gorge Waterway, Portage Inlet, Victoria Harbour, features inventory, maps, underwater video, eelgrass, sediment, algae, kelp.

This report contains subtidal physical and biological features inventory (conducted in spring and summer of 2000) information for the Gorge Waterway and Portage Inlet for incorporation into the overall Harbours Ecological Inventory and Rating (HEIR) project. Depths in the Gorge Waterway and Portage Inlet (encompass 110 hectares of subtidal areas) are generally less than 2m relative to chart datum, the seabed is relatively flat and formed of fine sediments. A towed, underwater video system was used to obtain extensive (50.3 km of vessel traclines and ~17 hrs of video), geo-positioned imagery of the seabed followed by SCUBA and snorkel observations. The survey was conducted on a 100m trackline grid but 5-10m spacing was used where important physical or biological features were anticipated. List of classified features on pg i. Portage Inlet (above Craigflower Bridge): shallow, med sediment except around shore margins; mostly depositional sediments; few man-made objects due to low use and depositional nature of sediments; eelgrass beds; foliose green algae (ulva); native oyster in subtidal mud sediments; herring spawn. Upper Gorge (Gorge Bridge to Craigflower Bridge): mix of depositional and current dominated sediments; man-made objects mostly associated with shoreline; extensive eelgrass beds; fringing filamentous red algae; shell/gravel bivalve beds; native oysters. Lower Gorge (Selkirk Trestle Bridge to the Gorge Bridge): primarily current dominated regime except in basins; gravel present in most sediments except Upper Selkirk Waters which appears to be a depositional environment; man-made objects are more common in the non-depositional, higher-current areas; kelps are the dominant vegetation in narrow sections of the Lower Gorge; ellgrass beds above Selkirk Waters Trestle Bridge; current dominated bryozoans/ascidian/sponge community. Gorge Narrows: current dominated; rock and cobble/boulder sediments; moderate to dense cover of filamentous red algae; native oysters, Japanese oysters, mussels and bryozoans/ascidian/sponge community (pg ii). Biophysical features are influence by a very protected tidal lagoon (Portage Inlet), restricted tidal exchange above the Gorge Narrows, and a channel (3.5km) dominated by tidal current. This combination of coastal physical features is unique within the CRD and is more characteristic of BCs Central Coast making this system a regionally significant area, particularly within an urban setting. ~80 hectares of eelgrass beds were mapped representing over 80% of the eelgrass beds in the Victoria and Esquimalt Harbours area, including Esquimalt Lagoon. Herring have historically spawned in Portage Inlet and the Upper Gorge in addition to coho and CTT spawning in Colquitz and Craigflower using this area as rearing habitat as juveniles (iii). Info on macrofauna from pg 15-18. Portage Inlet is noted as one of the most important herring spawning areas in the harbours region (pg 19). Lots of great tables throughout with various information on sediment, substrates, vegetation types/area, etc. Maps on pg 1 and 3, full map folio in appendices.

Olsen, E. M., & Vollestad, L. A. “An Evaluation of Visible Implant Elastomer for Marking Age-0 Brown An Evaluation of Visible Implant Elastomer for Marking Age-0 Brown Trout,” University of Oslo, Department of Biology, Division of Zoology for the North American Journal of Fisheries Management, no. 21 (2001)

Keywords: experiment, visible implant elastomer, age-0 brown trout, recapture

Injection of visible implant elastomer (VIE) was evaluated as a way to provide age-0 brown trout Salmo trutta with externally visible internal marks. We first tested this fluorescent elastomer material in a laboratory experiment using a single color and body position to batch-mark the fish (28.9-44.1 mm fork length). The experiment lasted for 77 days, with no mortality or tag loss and no significant (P = 0.44) effect on fish growth. Similar marks were then used to individually tag age-0 brown trout 926-70 mm) in small streams in the wild using four different colors and several body positions. The immediate mortality associated with the marking procedure was low (0.5%), and visual identification of VIE marks on recaptured individuals (169 out of 699 released; 39-83 d between release and recapture) was not difficult. We found no significant differences in mean fork length between tagged and untagged individuals captured on the same date at given sampling locations. This suggests that capture and marking had no major negative effect on fish growth (assuming that tagged and untagged individuals experienced similar condition between sampling occasions and otherwise had comparable histories).

Roni, P., & Quinn, T. P. “Density and Size of Juvenile Salmonids in Response to Placement of Large Woody Debris in Western Oregon and Washington Streams,” Canadian Journal of Fisheries and Aquatic Sciences, 58(2): 282-292, 2001

Keywords: coho, cutthroat, large woody debris, juvenile, age-1+, summer vs winter densities.

The addition of large woody debris can create pools, increase habitat complexity, reduce sediment transport, trap gravel needed for spawning, stabilize stream channels, provide food for aquatic invertebrates, and provide stream nutrients, increasing overall stream productivity. 30 streams in western Oregon and Washington were sampled to determine the response of juvenile salmonid populations to artificial large woody debris (LWD) placement. Total pool area, pool number, LWD loading and LWD forming pools were higher in treatment (LWD placement) than paired reference reaches during summer or winter. Juvenile coho densities were 1.8 and 3.2 times higher in treated reaches compared with reference reaches during summer and winter, respectively. The response (treatment minus reference) of coho density to LWD

placement was correlated with the number of pieces of LWD forming pools during summer and total pool area during winter. Densities of age-1+ cutthroat trout did not differ between treatment and reference reaches during summer but were 1.7 times higher in treatment reaches during winter. Trout fry densities did not differ between reaches, but the response of trout fry to treatment was negatively correlated with pool area during winter. This research indicates that LWD placement can lead to higher densities of juvenile coho during summer and winter and cutthroat trout during winter (pg 282). Materials and methods from pg 283-285; multiple-removal electrofishing was used to estimate fish abundance within each habitat type, night snorkel surveys were used in winter; difference in habitat, LWD, and fish abundance between treatment and reference reaches were compared using paired *t* tests with Bonferroni correction. Pg 285, table 1 shows physical characteristics of study streams measured during summer. Results discussed further from pg 285 to 290 and include a number of tables and graphs.

Tester, M. "Colquitz Creek Salmonid Enumeration Program 2001-2002," Coastal Enterprise and Resources Co-operative Association for the Urban Salmon Habitat Program, 2002 *Paper copy only at this time

Keywords:

TO BE ANNOTATED

CRD. "Thetis Lake , Francis / King , and Mill Hill Regional Parks Management Plan," for the Capital Regional District, 2004

Keywords: Thetis Lake, Craigflower, CRD management plan, regional parks, protection, water levels, flows, restoration, erosion, soil compaction, maps.

The CRD management plan for Thetis Lake, Francis King and Mill Hill regional parks focuses on the issues and policies that relate specifically to each of the three parks and sets out park management goals and objectives, and defines specific actions for achieving them. (pg 5) The three parks are in the center of a near continuous green/blue belt from Todd Inlet to Esquimalt Harbour, in the Coastal Douglas-fir biogeoclimatic zone, comprising of 1000 hectares between them. All three parks are designated as Regional Conservation Areas in the CRD Parks Master Plan, the highest level of protection provided by the CRD. (pg 20) Forested and wetland areas to the west of Thetis Lake are part of the Craigflower Creek watershed. The main stem of Craigflower Creek enters and exits Pike Lake along the eastern portion of the area while the western portion contains the upper part of the McKenzie Lake drainage into the Craigflower

watershed, much of these areas are found on private lands proposed for development. (pg 28) A large portion of Craigflower Creek, an important fish-bearing stream, flows through Thetis Lake Regional Park, all land managers within the watershed need to contribute to the protection and improvement of Craigflower Creek. Refers to The Craigflower Watershed Management Plan prepared by the CRD in 1998, in this plan the CRD's primary role is to maintain water control structures that help manage the water levels and stabilize water flows in the creek. Proposed actions to look after Craigflower Creek on pg 29. List of Thetis Lake park management priorities starts on pg 37. Pg 54 lists Phase 1 implementation priorities related to Craigflower; acquire land outside of the current park boundaries that complement the parks' natural features; conduct site restoration around Prior Lake and Thetis Lake where damage to lakeshore vegetation has caused areas to erode down to bare soil; clearly define trails in parks to minimize braiding and soil compaction; relocate trails away from riparian areas and water's edge in the floodplains. Map links not functioning.

Eastman, J., & Kasubuchi, T. "Vancouver Island Anadromous Cutthroat Trout Program Stock Status Report 2006," for the British Columbia Ministry of Environment & the British Columbia Conservation Foundation, 2006

Keywords: Colquitz, Craigflower, cutthroat, juvenile, habitat types, maps, flow, spawning gravel, vegetation, fry, channel over-widening, recommendations, electrofishing, snorkel survey.

This report compiles information gathered from 38 sites along 15 South Eastern Vancouver Island streams assessed in 2006 for juvenile CTT by BC Conservation Corps staff. Snorkel survey methods were used at Little Qualicum, Englishman and Oyster rivers while electrofishing was completed on the remaining sites (include Craigflower and Colquitz) that were approximately 100m^2 in area and broken down by habitat unit (riffle, glide or pool) (pg 4). Each site was closed using stop nets or natural breaks and mapped (included in document) using UTM coordinates, pictures, and sketches (pg 5). It was found that the Colquitz had ~150 fish/100m^2 and Craigflower had ~190 fish/100m^2 (pg 13-15). The Results section has graphs (pg 9, 10, 14, 15 show data for Colquitz/Craigflower) showing fish/100m^2, % of theoretical maximum FPU broken down by age categories, and average flow discharge (L/s) for each site, has good site descriptions and breakdown of results (pg 13-15). It is suggested that the addition of spawning gravel and vegetation along the banks of the Colquitz would improve overall habitat conditions and result in higher fry abundance (pg 14). Channel over widening and flow status are the main problems facing Craigflower sites (pg 15). Limited site selection likely prevented the most suitable or representable reaches of the streams from being sampled (pg 25). Fish results vary between all sites and systems, more complete data sets are needed; more sites sampled, more creeks within each watershed sampled, sampling over several years (pg 26).

Mitchell, B., & Richardson, J. "A Record of Fish Trapping in Creeks Flowing Through Royal Roads Property and into Esquimalt Lagoon," for the Esquimalt Lagoon Stewardship Initiative, 2007 *Paper copy only at this time

Keywords: Royal Roads, Esquimalt Lagoon, cutthroat, coho, fisheries potential, reintroduction of stock, gee traps, Bee creek, Colwood creek, pools, sand build-up, spawning grounds.

Esquimalt Lagoon, historically, was known to support sea run cutthroat and coho (pg 2). The purpose of this report was to determine the fisheries potential of the small streams and creeks that flow from the RRU property into Esquimalt Lagoon (pg 1) by first determining what, if any, fish species were present and secondly assess the lagoon as a site for reintroduction of stock by DFO (pg 2). Two creeks were selected for the initial trapping program based on recommendations from Tom Rutherford from DFO: Bee Creek and Colwood Creek. Gee traps (~50cm long, 23cm in diameter, with apertures of 2cm) were set up baited with smoked oysters (pg 1) in various reaches of the creeks. Traps were placed in water deep enough to cover the traps but calm enough to provide a safe environment to the trapped fish. Calm, deep backwater pools are perfect. Traps remained in the water for 24 hours, traps were not set on days with/when heavy rainfall was expected. Fish were retrieved from the traps and placed in a bucket of fresh stream water. Each fish was scooped individually into a ziplok bag with a small amount of water so measurements and observations could be made (pg 3). CTT were found in almost every trap ranging in size from 60mm to 155mm. Traps closest to the Lagoon often had sculpin, stickleback and occasionally perch which were identified and counted but not measured (pg 3). The presence of landlocked CTT above the road on RRU property is noted; Coho were present in Colwood Creek but not in any others; concern over increased sand build-up covering spawning grounds in Colwood Creek is noted (pg 4). Report includes all data tables.

Aqua-Tex Scientific Consulting Ltd. "Colquitz River Watershed Proper Functioning Condition Assessment," Aqua-Tex Scientific Consulting Ltd. for the District of Saanich, 2009

Keywords: Colquitz, tributaries, proper functioning condition assessment, recommendations, functional-at-risk, reaches, restoration, head cuts, invasive species, stormwater, integrated watershed management, physical characteristics, riparian species, flow controls, maps.

The purpose of this study was to determine the health and function of the creeks and other water bodies found within the Colquitz River Watershed, through a Proper Functioning Condition assessment (PFC), and provide recommendations as to how to maintain and improve these areas. In addition to the main channel the main tributaries (Durrell, Blenkinsop, Swan and Viaduct creeks) were also assessed. Has a good background section (pg vi) that includes info on the Colquitz River, Swan Lake/Creek, Blenkinsop Creek, Viaduct Creek and wetland, and Durrell Creek. Over 18 km of channel were assessed with ~37% non-functional, ~5% functional-at-risk with a downward trend, ~13% functional-at-risk with no apparent trend, ~1% functional-at-risk with an upward trend, and 45% was in PFC (pg x). The reaches that are functional at risk are the

highest priority for intervention and restoration and are listed in Table 1 (pg x) by priority. Recommendations are listed out starting on pg xii and include repair of headcuts, removal of invasive species, implement best management practices for stormwater and using an Integrated watershed management concept to enable a holistic and long-term approach to restoration and conservation. A list of focused recommendations starts on xiii and recommendations by reach (top 5 priorities) starting on xiv. Location maps and GPS location tables used for the PFC assessment start on pg 3 and are broken down by reach. List of water licenses starts on pg 13. Physical characteristics (climate, geomorphology, vegetation and fish habitat) pg 19-22. PFC assessment method outlined on pg 23. Findings outlined in Table 7-12, pg 25-29. Table 13, pg 30-33, is a master list of riparian species throughout the Colquitz River Watershed. List of flow controls on pg 34. Colquitz reach description summaries (from checklists), with pictures, from pg 35-62. Reach description for other assessed areas from pg 64-108. Recommendations by reach start from pg 115-127.

Ovaska, K., Sopuck, L., & Engelstoft, C. "Assessment of Impacts of the Craigflower Creek Fish Enhancement Project on Wildlife at Thetis Lake Regional Park," Biolinx Environmental Research Ltd. for the BC Conservation Foundation & CRD Regional Parks, 2010

Keywords: Craigflower, Thetis Lake, flow, enhancement, habitats, proposed water release, survey notes, maps.

The Craigflower Creek fish enhancement project (CFEP) aims to improve summer rearing habitat for salmonid fish, thereby enhancing fish productivity over the long term, by proposing water release from Thetis Lake to Craigflower Creek to maintain base flow through the summer and fall (pg 6). Great map images on pg 9 and 10 showing various aquatic habitats along Thetis Lake, info on these habitats from pg 7-8. Pg 25 (more comprehensive info from 11-23) has a table of predicted impacts of proposed water release on different wildlife groups including monitoring needs. Survey notes from page 31 to 33 with photos from 34 to 36.

Craigflower Creek Flow Enhancement Project. "Benefits to Downstream Fish and Fish Habitat of Summer / Fall 2011 Water Releases from Thetis Lake," for the BC Conservation Foundation, 2012

Keywords: Craigflower, Thetis Lake, storage release, flow, enhancement, hydrometric station, habitat, juvenile, dam, reach, parr, discharge.

During the summer and fall of 2011, a trial release of licensed storage from Thetis Lake occurred to enhance downstream aquatic habitat in McKenzie and Craigflower creeks; CRD used the dam valve adjacent to the spillway to release water. A maintenance Flow of 2 L/s was used most of the time but an Enhancement flow of 10 L/s was used through the driest period of

summer. Graph of Thetis Lake known historic levels and approved rule band for 2011 shown. (pg 1) BCCF monitored and documented downstream benefits of the trial release. Stream discharge was monitored at two primary locations through the summer, the Thetis Lake outlet recorded by CRD and BCCF and Craigflower Creek above Talcott Road using a permanent hydrometric station operated by EAA (range of 0.5 - 1,713 L/s) (pg 2). Craigflower Creek discharge was generally maintained between 5 and 10 L/s. As a result of a separate non-BCCF project looking at releasing water from Pike Lake, flows in upper Craigflower creek at Highland Road were observed Sept 8th at ~0.5-1.0 L/s, they would have otherwise been 0 (pg 3). Graph of discharge vs precipitation for Thetis and Craigflower on pg 4. Graph of Thetis levels relative to approved rule band on pg 5. Graph of effects of precipitation on Craigflower flows from 2010-2011 on pg 6. Photo documentation of Craigflower from pg 6 to 8. In 2011 stream connectivity was maintained throughout the nine reaches thanks to the continual release from Thetis, in 2010 when there were no releases from Thetis Reaches 2, 3, and 4 (1.58 km of stream length) dried out, BCCF documented the associated impacts to fish populations (pg 8). Differences in the quality of fish habitat through an augmented and normal season were identified by mesohabitat unit composition by reach through the entire stream length (following procedures in Johnson and Slaney 1996 Watershed Restoration Technical Circular No. 8) and applying unit-based estimates of loss to measured or observed, reach-based, wetted widths. Differences in habitat quality was measured in Reach 2 only using juvenile salmonid habitat suitability index curves developed by BC Hydro and flow transect data. Table of stream reaches on pg 9. Figure 5 on pg 10 is a pie chart showing overall mesohabitat composition between Thetis Lake and the mouth of Craigflower Creek. Habitat area gained with flow augmentation from 104 to 880m2 while the aggregate additional fish habitat totaled 3,525 m2. Figure 6 is a bar graph showing available rearing habitat by reach under augmented vs base flow. The quality of fish habitat available during flow augmentation improved dramatically (pg 11). Summer 2011 releases of 8-10 L/s could have supported ~ 3,166 Coho fry, 2,582 CTT fru and 558 CTT parr, diagram on pg 12 with a breakdown of density values and reasons for their use on pg 11.

Gaboury, M. “Fish Habitat Enhancement Designs for Colquitz River Watershed,” LGL Limited Environmental Research Associates for the Haig-Brown Fly Fishing Association, 2014

Keywords: Colquitz, salmon, trout, enhancement sites/designs, spawning platforms, gravel size, construction plans/window, eggs, alevins, maps.

The Haig-Brown Fly Fishing Association identified Colquitz River as a candidate for protection and enhancement of salmon and trout habitat. This report contains detailed instream enhancement designs for two short sections of Colquitz River (visited on October 20, 2014) proposing one LWD structure and several spawning platforms. It includes design sketches, materials summary, a work plan and schedule for the proposed enhancement (pg 1). Spawning gravel size should range between 0.5 and 10.0 cm for salmonids and ~32 m^3 would be required for five spawning platforms (locations shown via UTM in Table 1 and in Figures 1-2) (pg 2-4).

Great diagrams and construction plans throughout. Construction window, the period when there are no fish eggs or alevins present in the substrates, would fall between Aug 15 and Sept 15 as per the provincial environment ministry but will vary from year to year and actual permissible windows will be determined by federal and provincial regional staff (pg 10). An environmental monitor must be on site at all times during construction to mitigate potential fish impacts (sediment controlObs, fish salvage, etc) (pg 13). DFO Land Development Guidelines are included in the appendices. Appendices contain photos of each proposed site.

Clough, D. R. "Swan Creek Habitat Assessment Report," D.R. Clough Consulting for the Swan Creek Stewardship Society, 2014

Keywords: Swan creek, habitat assessment, restoration prescriptions, urban salmonid habitat program, mapping procedures, watershed description, data ranking, remediation.

The Friends of Swan Creek Society hired D.R. Clough Consulting to conduct a Fish Habitat Assessment in the spring of 2014 due to concerns over the degradation of Swan Creek (watershed code 920-0797000-24800) fish habitat by the 130 years of development on the watershed. It assesses the creek from Colquitz to the upstream outlet at Swan Lake and provides Habitat Restoration Prescriptions for future recovery programs. Contains a good description of the watershed with a bit of historical info (pg 6). Describes the reach segments, 1-6, assessed. Water quality parameters used are those laid out by The Pacific Streamkeepers Federation (Temp (^{o}C) 13-20, DO% 90-110, pH 6.5-8.0, Turbidity (cm) 65-160) and were measured daily with the exception of turbidity (pg 7). Figure 1, swan creek survey area, is missing from this document. Used Urban Salmonid Habitat Program procedure to conduct assessment and is outlined in the Vancouver Island Urban Salmonid Habitat Program Assessment and Mapping Procedures Manual, it was selected because of its wide use with other stewardship programs thus allowing for a comparative data base (pg 10). The method for analyzing fish habitat used is explained in Koning et al 1997. Fish populations were not sampled during this assessment. Data ranking was done in the USHP spreadsheet program which automatically extracts data for a number of habitat parameters and enters them into a summary table assigning them numeric values and rates them as good, fair or poor (pg 11). Includes summary tables of habitat data and ratings by reach and riparian assessment (pg 12-24). Swan Creek is in poor overall fish habitat condition and the report suggests that more riffle crests and spawning gravel should be added to the lower three reaches of Swan Creek to increase the summer carrying capacity and the areas where adult salmonids can spawn in the fall (pg 25-27). Includes descriptions of stream restoration techniques that apply to urbanized streams (pg 28-30). List of suggested order of priority for remediation on pg 31. Images and diagrams are missing from this document.

Daly, J. “Fish Presence and Distribution Survey Lindsay Road to 4654 West Saanich Road, Colquitz River, WSÁNÉC (Saanich) Territory, British Columbia,” Peninsula Streams Society, 2018

Keywords: Colquitz, coho, cutthroat, abundance, gee traps, data sheets, habitat, invasive flora and fauna.

A fish presence and distribution survey was conducted in the Colquitz Rivers mainstem between Casa Lida Drive and 4654 West Saanich Road to determine where native salmonid species are found within these reaches and their relative abundance from April 14 - June 13 2018. 2 Gee traps were deployed at each of the 11 sites within the upper reaches of the Colquitz Rivers main stem and baited with salmon roe (pg 2). Species found included Coho, CTT, Prickly sculpin, Signal crayfish, yellow perch and stickleback; no native salmonids were found upstream of the Wilkinson Road Bridge (pg 2). Includes full data sheets for upper and lower reaches (pg 3-6). The upper reaches of the Colquitz contain some good-quality salmonid habitat but no native salmonids were present, further investigation is required to determine the cause preventing salmonids from accessing this region. Control of invasive flora and perch is highlighted (pg 7). Appendix has a good site layout, including pictures.

“There has been a tendency to all too quickly forget about the little creeks… [by saying] “it’s only a few trout or salmon.”... We all too quickly forget that the whole of life equals the sum of its parts and, because of this forgetfulness, important threads of the life fabric are unwound.” Burns, 1979.

Habitat Acquisition Trust. “Colquitz River Enhancement Project”. January, 2006.

Keywords: Colquitz, riparian habitat, landowner contact, residential watershed issues, coho, outreach techniques

This is a summary report of the Colquitz Enhancement River Project (2006), which aimed to contact residents of the Colquitz river system, and inform them of conservation and stewardship considerations for the region. The report details methods of contact, results of the outreach activities, and lessons learned. HAT communicated many concepts to landowners such as the importance of riparian vegetation, the effects of invasive species and trampling on ecosystems, and the detrimental effects of the use of synthetic fertilizers and pesticides. Homeowners were also informed of the use of composting bins close to the river, and potential effects of leaching toxic, nutrient rich substances into the river. The report closes with an evaluation of the project, including lessons learned and future considerations. This report has some useful tips for contacting homeowners successfully (p.13).

PART 2 - focus on reports outside of PICI focus areas

Losee, J. P., Claiborne, A. M., Dionne, P. E., Faulkner, H. S., Seamons, T. R. "Size, age, growth, and site fidelity of anadromous cutthroat trout *Oncorhynchus clarkii clarkii* in the Salish Sea." 2018. Journal of Fish Biology.

Keywords: coastal cutthroat trout, nearshore, Puget Sound, site fidelity

Abstract: Pacific salmon *Oncorhynchus spp.* have been the focus of scientific research for over a century, but anadromous trout in this genus, in particular anadromous coastal cutthroat *Oncorhynchus clarkii clarkii*, have been neglected. *Oncorhynchus clarkii clarkii* occupy a diverse range of habitats including fresh water, brackish estuaries and marine water, but have a relatively small home range making them ideal for studies of behaviour and movements during ocean residency. In 2015, we sampled *O. c. clarkii* monthly along a small stretch of beach in Eld Inlet, south of Puget Sound, Washington using a beach seine. We collected tissue for genetic tagging and stock identification and scales for aging from 427 *O. c. clarkii,* ranging in size from 118 to 478 mm fork length. Additionally, we enumerated redds in natal streams of those fish tagged to describe inter-habitat movement patterns and investigate site fidelity of juvenile and adult *O. c. clarkii* in the marine environment. Consistent with other anadromous salmonids, *O. c. clarkii* captured at our study beach exhibited rapid growth rates, particularly in spring following dispersal into the marine environment (mean ± SD = 0.61 ± 0.29 mm^(2-d)). Genetic tag data revealed that while *O. c. clarkii* undergo inter-estuarine migrations, *O. c. clarkii* of all

life stages exhibited site fidelity in the marine environment. Twenty-one percent (64/305) of sampled *O. c. clarkii* were recaptures at least once during the course of the study while multiple fish (n=30) were recaptured up to five times. These results suggest that *O. c. clarkii* occupying south Puget Sound reside in or regularly return to a small geographic area in the nearshore environment for much of their life and therefore may be particularly vulnerable to anthropogenic disturbance (development, angling, *etc.*).