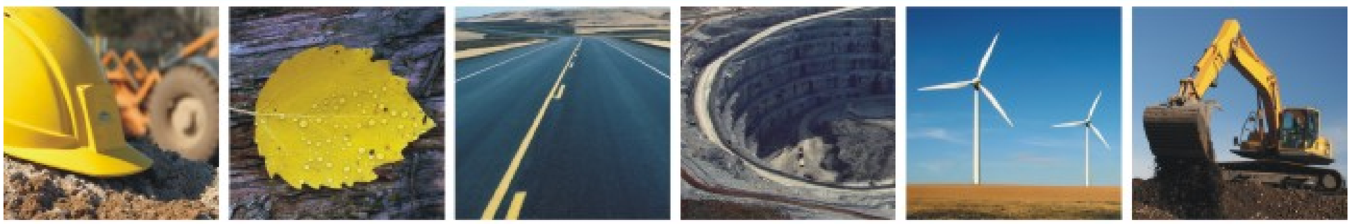
CITY OF CHILLIWACK

VEDDER RIVER MANAGEMENT AREA PLAN UPDATE
DATA GATHERING PHASE REPORT



REPORT

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1.0 INTRODUCTION

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) is pleased to submit this report as a component of the Vedder River Management Area (VRMA) Plan Update report.

The main objective of this report is to identify and collect all available information that will contribute to development of the VRMA Plan Update. Five subject areas are addressed in this study.

- Gravel Management
- Erosion
- Habitat
- Recreation
- Heritage Sites and First Nations Interests.

The report includes a list of all the data gathered by the project team to date and a discussion on data availability, gaps, and potential applications. Brief summaries of each reference source are provided, where possible. If a report has a bearing on more than one subject area, it appears more than once, with different emphases in the synopsis.

Fieldwork for this assignment is not yet complete and it is intended to supplement the information gathered to date with that obtained in the field over the course of this study in the final version of this report.

2.0 GRAVEL MANAGEMENT

The Vedder River and Vedder Canal gravel management program was initiated by the Vedder River Management Area Committee (VRMAC) in the early 1980s to retain the floodway capacity. Prior to 1980, gravel was removed from the Vedder River, but not as part of a formal gravel management program. Information on timing and quantities of gravel removed prior to 1980 is therefore limited. A number of reports and maps have documented the gravel management activities since the establishment of the VRMAC. This section provides a summary of available documentation and its application to the VRMA Plan Update.

2.1 Gravel Transport and Removal Activities

The Vedder River Gravel Management Plan (1996) lists the quantities of gravel excavated from the Vedder River from 1980 to 1995. This information is supplemented by the volumes removed in subsequent years in Table 2.1. Since 1980 a total quantity of 1.9 million cubic metres has been removed, which is equivalent to an average of about 61,300 cubic metres per year. Gravel removal has been on a two-year cycle since 1998. Gravel removals also occurred prior to 1980, including a quantity of 534,000 cubic metres that was removed for construction of the Vedder setback dykes.

Table 2.1: Gravel Quantities Removed from the Vedder River and Canal

Year	Quantity (m^3)	Year	Quantity (m^3)
1980	27,400	1995	52,600
1981	18,000	1996	217,000
1982	51,940	1997	52,530
1983	23,000	1998	156,100
1984-89	0	2000	80,100
1990	158,600	2002	65,400
1991	187,500	2004	128,620
1992	64,050	2006	212,710
1993	33,000	2008	105,930
1994	167,800	2010	99,630

Brief summaries of some recent reports on gravel management follow.

Bland Engineering Ltd., 2000, 2002, 2004, 2005 and 2008. Vedder River Hydraulic Profile Updates

Bland conducted five Vedder River hydraulic profile update studies between 2000 and 2008. These studies include calculations of the Vedder River and Vedder Canal 200-year flood profiles using the corresponding channel surveys. Natural deposition volumes in the Vedder River and Vedder Canal were calculated using the difference in the channel storage area in consecutive survey years. The studies propose future gravel removal options and evaluate their benefit in terms of flood level reduction. The long term deposition rate was updated in each study. It served as the basis for future gravel removal activities to maintain the floodway capacity.

Hay & Company, a Division of EBA Engineering Consultants Ltd., 2010. Vedder River Hydraulic Profile Update 2010

This study updates the Vedder River and Vedder Canal 200-year flood profiles using the February 2010 survey data. The 2008-2010 natural deposition quantities were calculated and added to the historical data series to determine the long term average deposition rate. The effectiveness of proposed gravel removal was assessed in terms of flood protection and erosion control.

Nova Pacific Environmental, 2010. 2008 Vedder River Gravel Excavation – Habitat Changes and Environmental Impacts

The report describes the impacts related to the sediment removal program of 2008, when a total volume of 106,000 cubic metres of gravel was removed from nine gravel bars. For each site, habitat outcome was rated in terms of flood risk reduction, refilling of pits, and erosion.

Nova Pacific Environmental, 2010. 2010 Vedder River Sediment Removal Environmental Monitor's Report

The report documents the implementation of the 2010 gravel removal program. A total quantity of 99,630 cubic m of gravel was removed from eight sites in 2010, which was 72% of the target volume proposed by the Vedder River Management Area Committee. Recommendations and conclusions which arose from the work conducted are presented.

Ferguson, Bloomer and Church, 2011. Evolution of an Advancing Gravel Front: Observations from Vedder Canal, BC

This research paper documents studies of the bed composition and sediment transport along the Vedder Canal and lower Vedder River reaches. Approximately 90% of the sediment budget passing Vedder Crossing was deposited along the study reaches. Morphological development of the Canal and lower Vedder River are discussed in terms of gravel bar formation and sediment size distribution.

Martin and Church, 1995. Bed-Material Transport Estimated from Channel Surveys: Vedder River, BC

The study used a morphological approach to analyze bed material transfer in the Vedder River. The mean annual gravel transport rate for the period of 1981-1990 was estimated to be 36,600±5,600 m^3/y using surveyed bed volume changes and dredged material volumes along the 8 km Vedder River reach. The sediment transport regime was evaluated in relation to sediment texture, peak flood flows and erosion.

McLean, 1980. Flood Control and Sediment Transport Study of the Vedder River

McLean studied the sediment transport process using the bedload data collected on the Vedder River by Water Survey of Canada. Analysis of bedload size distribution showed that for discharges under 226 m^3/s, the sediment load was composed predominately of sand. Above this discharge, bedload size increased sharply to gravel sizes. McLean identified a reasonably consistent relationship between bedload transport rate and discharge. By testing various sediment transport empirical formulae, McLean concluded that the Einstein equation gives the closest agreement to the field measurements in the Vedder River.

AMEC Earth and Environmental Ltd., 2004 and 2006. Sieve Analysis Report

Sediment gradation (sieve size vs. percent passing) analyses were conducted on sediment samples that were excavated from selected gravel bars at the surface, 1.5 m or 3.0 m depths. Maps of the 2004 and 2006 Vedder River and Vedder Canal gravel removal sites were provided.

Steelhead Aggregates Ltd., 2000. 2000 Vedder River Gravel Extraction Gradation Report

The 2000 Vedder River gravel extraction occurred in August and September. During this time, sieve analyses were performed at each extraction site. Dry samples weighting 70 kg were analyzed at random locations and depths following standard procedures. Sample locations, screen sizes and the corresponding percent passing were provided for Greendale, Yarrow, Bergman, and Peach Creek Bars.

Ministry of Environment, 2011. Vedder River and Vedder Canal Dike Map

This map was prepared by Ms. Sandra Jensen of the Ministry of Forests, Lands and Natural Resource Operations in July 2011. Key features include orthophotos taken in October and November 2008, the boundary of Vedder River Management Area, historical cross section locations, floodplain areas, setback dikes, gravel bars, hydraulic structures, etc.

River Surveys

The Vedder River was surveyed in 1981, 1996, 2000, 2002, 2004, 2005, 2007, 2008 and 2010. The Vedder Canal was surveyed in 1979, 1991, 2002, 2004, 2005, 2008 and 2010. The surveyed cross sections were provided by Mr. Karl F. Bornemann in .xls format. The next survey of the Vedder River and Vedder Canal system is expected to take place in February or March 2012.

Hydrometric Data

Daily and maximum flow records were obtained from the Chilliwack River at Vedder Crossing hydrometric station (08MH001) operated by the Water Survey of Canada (WSC). Representative peak flow hydrographs will be used to simulate sediment transport in the Vedder River and Vedder Canal.

Data Application

Vedder River and Vedder Canal natural sedimentation rates within each management cycle will be compiled and related to the historical flood events. The relationship will be calibrated using a sediment transport model with appropriate survey data and flood hydrographs obtained from the Chilliwack River at Vedder Crossing hydrometric station.

A relationship between gravel removal volume and flood level reduction will be developed from the previous hydraulic profile update studies. The result will provide guidance to the long term gravel management planning.

3.0 EROSION

Data regarded as useful background information for evaluating erosion protection includes: Reports about gravel extraction and associated impacts on habitat and environment, reports on the condition of river bank protection and flood damage, studies published on channel morphology, in-channel sediment composition and movement, sequential air photos, cross-section surveys, historical hydrometric records from the gauging station at Vedder Crossing and maps of the surficial geology of the study area.

3.1 Reports

Tara Friesen and Joe Koczkur, 2011. Summary of March 1, 2011 Vedder River Bank Inspection. Summary; Photos from March 2011 Inspection, City of Chilliwack.

The summary lists seven erosion sites on both sides of the river channel. Three sites are recommended to be monitored to assess the rate of erosion and condition of the affected bank. Four sites require action:

(1) Lost toe material immediately downstream of Vedder Crossing on the right bank should be replaced.

(2) About one kilometer further downstream, erosion occurred on the right bank around rock placed two years prior. As erosion has removed material to within 10 feet of the Rotary Trail, new bank protection is required to protect the bank from further loss of material.

(3) At Peach Road, some toe material has been eroded on the right bank and should be replaced.

(4) New erosion just downstream of the parking lot at Lickman Road suggests that bank protection should be upgraded at this location. All the locations of erosion mentioned in the summary will be taken into consideration during the field assessment, and their current state will be compared to their condition described in March 2011.

Northwest Hydraulic Consultants, 2010. Inspection of River Bank Protection 2010. Final Report, City of Chilliwack.

Several high velocity flows passed through the Vedder River system within a few years up to 2009, which made it necessary to inspect and assess the condition of protective works along the left and right banks of the river. Data collected during field inspection between May and August 2009 reveals several sites along both channel banks that have been affected by erosion. Recommendations for protective measures are site dependent and range from monitoring to upgrading of rock protection works.

Northwest Hydraulic Consultants, 2009. City of Chilliwack, Vedder River. Bank Erosion at Cross Section #44 after the January 8, 2009 Flow. Issued January 22, 2009, City of Chilliwack.

On January 8, 2009, a sudden surge of flow estimated at 400 to 500 m^3/s passed through the Vedder River system and resulted in selective erosion on the right bank of the river near cross-section #44. Following this event, riprap was placed along the affected site to protect the river bank from further erosion in the short term. Recent sediment deposition within the river channel redirected the main flow into the right channel bank, which is expected to result in more erosion occurring upstream and downstream of the eroded site. The report recommends continued monitoring of the site and developing a long term plan in order to deal with future erosion along this section of the right river bank. The report found another short section of the right river bank near Peach Road (cross-section #46) affected by local scour as a gravel bar had recently started to develop in close proximity to the bank. This issue was resolved by placing rock protection along the bank.

Northwest Hydraulic Consultants, November 23, 2006. Vedder River Assessment of November 2006 Flood Damage, Memorandum prepared for City of Chilliwack, November 23, 2006.

The primary objective of the report was to assess damage caused by high flows on November 5/6, 2006 along the Vedder River. Inspections of the entire right river bank and isolated sections of the left river bank were carried out on November 8 and 16, 2006, shortly after the flood. As discharge was receding but still relatively high, it was not possible to inspect the lower slopes and toes of the banks and therefore the report recommended conducting a second inspection when water levels receded further. Eight sites were identified that showed evidence of varying degrees of erosional damage caused by the flood, five of which were located on the right bank of the river channel while three were located on the left bank. In summary, no large failures of banks and bank protection were observed, but overtopping of the river channel resulted in local erosion of trails and access roads, development of local scour holes and head cutting behind freshly accumulated debris. Suggested short-term solutions to maintain the present channel alignment include repair and placement of riprap to reinforce river banks, and repair of damaged sections of access roads and paths.

Northwest Hydraulic Consultants, November 2004. Inspection of River Bank Protection – 2004, Vedder River. Final Report, City of Chilliwack.

The purpose of this report was to assess the condition of bank protection along the inner dike of the Vedder River, following a series of floods with high velocities during the previous year. The report identifies several sites of active erosion and recommends repairing the bank protection where required. It is suggested to establish an annual monitoring program to assess the condition of bank protection works as the risk of bank erosion and failure of bank protection varies considerably along the river system, both spatially and over time. Furthermore, the authors advise continuing to maintain the area between the inner dikes and setback dikes as a "floodway – erosion zone" to buffer lateral movement of the river channel and contain floods below the 200 year return period.

3.2 Studies on Vedder Canal, Vedder River and Chilliwack River (Published Articles)

There have been numerous publications on the Vedder and Chilliwack River system over the years, which will provide the necessary information for the geology and hydrology section of the final report. This information will serve as background information for the assessment of erosion issues along the Vedder River. A more complete list of published articles is included at the end of this report.

Ferguson R.I., Church M. and Weatherly H, 2001. Fluvial Aggradation in Vedder River: Testing a One-dimensional Sedimentation Model. Published in Water Resources Research. Vol. 37 No.12, pp. 3331 – 3347. December 2001.

Sediment routing models simulate the coevolution of the river long profile and bed grain size distributions. They have been used to investigate various disequilibrium situations in rivers - like downstream fining - over a range of timescales. The authors of this study have extended one of these one-dimensional models to include both bedload components, gravel and sand (as opposed to gravel only in one-dimensional numerical models), and tested the model's ability to simulate patterns and rates of aggradation as well as fining trends in Vedder River. The study found that the varying sensitivity of the model to different boundary conditions and parameters indicates that testability and accuracy of predicting sedimentation are limited.

Ferguson R.I., Bloomer D.J. and Church M., 2011. Evolution of an Advancing Gravel Front: Observations from Vedder Canal, British Columbia. Published in Earth Surface Processes and Landforms. Vol. 36 Issue 9, pp. 1172 – 1182. July 2011.

The article addresses how an abrupt gravel-sand transition (GST), or gravel front, evolved in Vedder Canal since it was built. Vedder Canal is a perfect study site as the transition from gravel to sand bed is abrupt and was artificially created when the channel was built in 1922. Observed changes in bed character are probably related to size-selective transport and deposition. Although aggradation occurred within the canal over years, channel morphology has remained largely stable. Based on air photo evidence, visible gravel deposition on bars progressed downstream consistently over the years, but in particular within the flood-rich decade starting in 1998. By 2008, gravel covered the surfaces of all but a few attenuated bars to the mouth of the Canal. The study also found that general grain size of bed-material decreased downstream from gravel-dominated at the entrance of the Canal to sand-dominated at the mouth of the Canal.

Ham D. and Church M., 2000. Bed-Material Transport Estimated from Channel Morphodynamics: Chilliwack River, British Columbia. Published in Earth Surface Processes and Landforms. Vol. 25 Issue 10, pp. 1123 – 1142. September 2000.

The purpose of this study was to investigate the relation between channel changes and bed material transport along Chilliwack River, upstream of Vedder Crossing. Channel features between 1952 and 1991 were mapped in detail from sequential aerial photographs, and then data was imported into a Geographical Information System (GIS) to analyze morphologic changes over time. Based on this data, the authors estimated volumes of erosion and deposition along the river. Using a sediment budget approach, they were able to relate morphologic changes to bed-material transport rates, with the highest rate of transport estimated at 55,000 ± 10,000 m^3 annually between 1983 and 1991. The authors state that significant morphologic changes occur approximately every 5 years, when flows are sufficiently large to erode and transport large volumes of bed material, while transport rates decline and vegetation begins to establish as long as large floods are absent.

Martin Y. and Church M., 1995. Bed-Material Transport Estimated from Channel Surveys. Vedder River, British Columbia. Published in Earth Surface Processes and Landforms. Vol. 20, pp. 347 – 361.

As commonly employed sediment transport formulae are based on idealized hydraulic principles, they fail to predict sediment transport accurately. This study assumes a direct relation between changes in channel morphology and sediment transport, which can be used to evaluate sediment transport with greater accuracy. Therefore, data from repeated cross-sectional surveys were used to estimate volume changes along Vedder River between Vedder Crossing and the entrance to Vedder Canal. The study reveals that transport and deposition of bed material in the Vedder River is complex and rates of bed-material transport show significant variations spatially and temporally, with a mean annual transport rate of bed material averaging 36,600 ± 5,600 m^3 per year.

Millard, Tom, 2010. Review of the Chilliwack River Watershed and Forest Practices. Ministry of Forests and Range, Internal Report, June 2, 2010.

Based on published literature and the author's knowledge of the study area, this report evaluates the effects of past and future forest operations on flooding and channel stability of the Chilliwack River and summarizes the landslide hazards present in lower parts of the valley. It concludes that historical forest operations (which are not allowed today) resulted in an increase in landslides, which affected the stability of the river considerably and probably resulted in extensive bank erosion. Although landslides associated with forest operations have declined since the mid-1980s, the rate is still elevated in comparison to natural landslide rates. Overall, the amount of sediment introduced into the river is largely derived from bank erosion, which exceeds sediment input from landslides by far.

Tunnicliffe J.F. and Church M, 2011. Scale Variation of Post-Glacial Sediment Yield in Chilliwack Valley, British Columbia. Published in Earth Surface Processes and Landforms. V. 36 Issue 2, pp. 229 - 243. February 2011.

The goal of this study was to estimate the Holocene volumetric sediment budget for coarse textured sediments in formerly glaciated Chilliwack River Valley. Data was collected to establish the drainage network and calculate erosion, deposition and transfer of sediment within the valley during the Holocene period, including information extracted from aerial photographs and Digital Elevation Models (DEMs). Several types of sediment source areas were identified, i.e. major gullies, incised fans and valley fills. The study concludes that, during the Holocene period, debris flows have transported a large amount of material down the valley slopes and accumulated it along footslopes where fluvial processes entrain the material and transport it further down valley.

3.3 Air Photos

See Table 3.1 for a list of air photos flown between 1963 and 2002. Flight lines with frame numbers were obtained from the online base map at the Integrated Land Management Bureau - Crown Registry and Geographic Base Branch (http://openmaps.gov.bc.ca/imfows13/imf.jsp?site=idt&request=airphoto). Air photos flown before 1963 and after 2003 are not listed in the online map, but will be included in the request for air photos from the Geographic Information Centre at UBC. In order to assess erosion and deposition within the river channel between two dates, it is necessary that air photos are flown during low flow or bars will be submerged below the water surface. Therefore, the table also gives the discharge recorded for Chilliwack/Vedder River at Vedder Crossing (Station 08MH001) on the day of each flight. Caution must be exercised in using flow estimates of less than approximately 150 m^3/s at Vedder Crossing, as the gauge is not considered to be accurate for very low flows. The final selection of air photos to be used is subject to availability from the air photo library at UBC.

Table 3.1: Air photo Coverage Vedder River 1963 – 2002

Roll No.	Frame No.	BW/ Color	Date	Scale (Nominal)	Discharge* (m^3/s)
30BCC02026	9-13	Color	12/08/2002	1:15,000	45
30BCB02025	204, 205	Color	12/08/2002	1:15,000	45
30BCB95122	1-10	BW	10/02/1995	1:10,000	94
15BCB95045	66-68	BW	28/06/1995	1:50,000	87
15BCB94002	96-98, 125-132	BW	25/03/1994	1:10,000	51
30BCB93026	122, 123, 166-171	BW	01/08/1993	1:15,000	58
15BCB91157	172-174	BW	09/09/1991	1:40,000	47
15BCB90115	83-88	BW	10/09/1990	1:4,000	24
15BC89083	31-42, 46-49	BW	30/11/1989	1:10,000	57
30BCC451	162-163, 180-181	Color	03/08/1986	1:10,000	44
15BC84001	76-84	BW	05/02/1984	1:12,000	58
30BC83010	16-21	BW	18/07/1983	1:15,000	145
15BC82037	49-58	BW	17/08/1982	1:10,000	(48)
15BC80065	212-216	BW	21/07/1980	1:50,000	67
15BC78101	104-105	BW	07/07/1978	1:40,000	98
15BC77005	184-191	BW	20/04/1977	1:12,000	37
15BC5704	3-7, 11-15	BW	11/03/1976	1:12,000	31
15BC5697	23-24, 79, 105-111, 196-198, 199-211	BW	04/12/1975	1:6,000	345
15BC5698	20, 39-48, 106, 117	BW	04/12/1975	1:6,000	345
15BC5584	41-48	BW	31/05/1974	1:12,000	116
30BCC88	35-38	Color	04/09/1973	1:12,000	19
15BC5318	133-140	BW	11/03/1969	1:12,000	21

Table 3.1: Air photo Coverage Vedder River 1963 – 2002

Roll No.	Frame No.	BW/ Color	Date	Scale (Nominal)	Discharge* (m^3/s)
30BC7057	154-161, 198-199	BW	18/05/1968	1:15,840	(120)
15BC5236	192-193	BW	04/06/1967	1:32,000	221
14BC5097	149-151	BW	22/06/1964	1:31,680	135
15BC5065	192-201	BW	04/05/1963	1:12,000	40

Source: http://openmaps.gov.bc.ca/imfows13/imf.jsp?site=idt&request=airphoto (available from website of Integrated Land Management Bureau - Crown Registry and Geographic Base Branch in Victoria).

* Discharge data obtained from station 08MH001 Chilliwack River at Vedder Crossing, and rounded to nearest 1 m^3/s. http://www.wateroffice.ec.gc.ca/graph/graph_e.html?stn=08MH001.

4.0 HABITAT

4.1 General

The following pages list and provide a brief summary of the documents and reference sources that will form the background for the habitat components of the work. These include numerous monitoring and assessment reports completed by Nova Pacific Environmental Ltd. that provide a substantial data set to be analyzed to assess the effectiveness of past sediment extraction strategies for avoiding habitat impacts. The more recent assessment reports also include an extensive computer map based data set and these will be analyzed to help evaluate excavation strategies and to identify possible longer term effects of the sediment removal program.

Most of the remaining research papers and information sources are focused on identifying means to validate and/or improve approaches to sediment removal, other aspects of floodway management, and the assessment thereof. In addition, these should help improve the understanding of the interrelationships between fluvial geomorphology and habitat value.

4.2 January 2012 Site Visit

On January 10, 2012 Bruce Wright of Nova Pacific Environmental led a field trip for the study team to provide an opportunity for an early interdisciplinary dialogue. The purpose of this trip was to:

- improve the background familiarity of the study team members with the Vedder River Management Area Lands;
- share past experience with sediment removals while observing sites in the Upper, Middle and Lower reaches;
- help ensure that future sediment removal planning incorporates an understanding of the important habitat aspects within the active floodway; and
- identify potential interactions between the groundwater and off channel habitat resources and floodway management and other activities within the Vedder Lands.

4.3 Preliminary Overview of Previous Analyses

River discharge during aerial photography is a key factor in facilitating comparability between years. Photographs taken at flows ranging from 15 m^3/s to 72 m^3/s have been used in the analyses between 1994 and the present (Table 4.1). These flow estimates are from WSC gauge Chilliwack River at Vedder Crossing. Caution must be exercised in using these flow estimates as the gauge is not considered to be accurate for very low flows.

Table 4.1: Hydrometric Data during Aerial Photography (Water Survey of Canada 2011)

Year	Date of Flight	Hydrometric Data from Vedder Crossing	
		Flow (m^3/s)	Water Level (m)
1994	Sept. 21, 1994	19	
1995	Jan. 15, 1995	38	2.36
1996	Feb. 12, 1996	72	2.74
1997	Sept.19, 1997	46	2.24
1998	Sept. 1998	data not available	
1999	Oct.18, 1999	37	
2000	Sept.19, 2000	35	
2001	Mar.7, 2001	17	
2002	Sept.23, 2002	20	
2003	Sept.3, 2003	15	2.11
	Oct.9, 2003	26	2.27
2004	Sept. 29, 2004	38	
2005	Sept. 17, 2005	16	
2006	Nov 1, 2006	20	1.89
2007	Sept. 28, 2007	24	
2008	Sept. 29, 2008	26	
2010	Oct. 5, 2010	35	1.78
	Oct. 7, 2010	29	1.68
2011	Sept. 24, 2011	31	0.90

A study looking at variations in flow only in 2003 compared results at flows of 15 and 26 m^3/s (water levels of 2.11 m and 2.27 m, Sept 3 and Oct 9, respectively) and found that variations in habitat area were similar in magnitude to those observed by using 2002 and 2003 photos to assess the changes caused by excavation in 2002. Thus, when comparing data from different years it is important that the water levels be as close as possible, (therefore similar flows at the WSC gauge should be compared) since the areas of habitat types will vary significantly as a result of differences in water levels alone.

While there has been considerable variation in flow rates during assessments, several years have had photos at similar flows to 1994, the original record of the river prior to initiation of the project. These include 2001, 2002, 2003 and 2006 (15–20 m^3/s range) so there is a good record for detecting any long-term changes. A second set of photos was taken at similar flows, and these were from 1995, 1999, 2000, 2004 and 2010 when flows ranged from 35- 38 m^3/s (Table 4.1). A third set of photos from 2003, 2007, 2008, 2009, 2010 and 2011 was taken at flows that ranged from 23 – 29 m^3/s. While discharge data from other years are inconsistent or lacking, the available information provides extensive data for determining long term changes in river morphology.

Each year, data sets were used in conjunction with field checks, in part due to the logistic challenges of obtaining aerial photography and ground-truthing information under varying weather and flow conditions.

The requirement for select water levels for comparative purposes prevents utilization of ortho-photography. Instead, photos are taken with a conventional camera, from a plane flown at a consistent altitude. Photos are cropped such that only the centre of the image is used. These are fitted together using persistent features, such as roads and dykes, as a guide. Mapping accuracy is assessed by comparing the total area per study section from year to year. For example, if the total habitat area indicated between cross-section X and cross-section Y is 123,456 m^2 in 2008, and 123,789 m^2 in 2009, then we calculate the overall accuracy of mapping to be (123,456-123,789)/123,456 = ±0.3%.

Table 4.2 summarizes the available data and shows differences in data collection and processing over the life of the project.

Table 4.2: Summary of Available Data from 1994 – 2011

Year	Photography	Photos Corrected to Base Map	Computer Mapping	Spawning Maps	Habitat Ranking	Habitat Area Measured	Comments
1994	Overhead. Lower and Middle Reaches only.			X			
1995	Overhead. Complete. Heavy shadow over Upper Reach.			X	X		Photos are prior to 1995 summer excavations
1996	Overhead. Complete. Some shadow.			X	X		Photos are prior to 1996 summer excavations
1997	Overhead. Complete. Some shadow.			X	X	X	Quantification of excavation area only.
1998	Overhead. Complete.		X	X	X	X	
1999	Overhead. Complete.	X	X	X	X	X	No excavations.
2000	Overhead. Good photomosaic.	X	X	X		X	
2001	Overhead. Complete, very high altitude.		X	X		X	No excavations. Orthocorrect photoset from BC government.
2002	Oblique. Complete. Bright reflected sunlight.	X	X	X		X	

Table 4.2: Summary of Available Data from 1994 – 2011

Year	Photography	Photos Corrected to Base Map	Computer Mapping	Spawning Maps	Habitat Ranking	Habitat Area Measured	Comments
2003	Sept 3. Oblique. Complete.	X	X	X		X	A study was conducted, to evaluate the impact of water level on habitat classification.
	Oct. 9. Oblique. Complete. Some out of focus.	X	X			X	
2004	Oblique. Incomplete. Poor focus.					X*	No mapping completed in 2004.
2005	Complete	X	X	X	X	X	
2006	Complete. Good Quality.	X	X	X	X	X	
2007	Complete. Good Quality.	X	X	X	X	X	
2008	Complete.	X	X	X	X	X	
2009	Complete. Oblique.	X	X	X	X	X	
2010	Complete. Oblique.	X	X	X	X	X	
2011	Oblique. Complete.	X	X	X	X	X	

* 2004 spawner distribution mapped on 2005 base maps.

4.4 Review of Relevant Literature

Nova Pacific Environment (Formerly New Pacific Ventures) Vedder River reports from 1994-2011:

Wright, B.F. and M. Robinson, 1994. Environmental Monitors Report Vedder River Gravel Removal Project 1994. Prepared for Ministry of the Environment and Vedder River Management Committee. 16 p.

The report provides a brief documentation of events relating to environmental issues that occurred during excavations of sand and gravel from the Vedder River in late summer of 1994.

Wright, B.F. and M. Robinson, 1995. Assessment of the Environmental Impacts from 1994 Vedder River Gravel Bar Excavations. Prepared for Ministry of Environment Lands and Parks, District of Chilliwack, City of Abbotsford. 13 p.

The report describes the changes to the river following these excavations. Five examinations of the excavations and surrounding river were conducted during the spawning season and monthly at other times from September 1994 until July 1995. Three fishery-related objectives were identified for the assessment: impacts on fish populations, particularly chum spawners, habitat which was either directly or indirectly destroyed by the excavations, and new habitat that was created by the excavations. Northwest Hydraulic Consultant's observation report is included as Appendix 1.

Recommendations focused on optimizing pit design and location to reduce impacts on spawning habitat in the future. The excavations for the most part, contributed to the amount and diversity of habitat in the affected sections of the Vedder River, but some resource losses were incurred as a result of the loss of spawned eggs in the pits and the loss of flow to some secondary channel habitats.

Wright, B.F. and M. Robinson, 1995. Vedder River Gravel Removal Environmental Monitor's Report 1995. Prepared for Ministry of Environment Lands and Parks, District of Chilliwack, City of Abbotsford. 14 p.

The report describes environmental monitoring of gravel excavation conducted on the Vedder River during the summer of 1995. The primary purpose of excavation was to reduce flood risk. The main objectives were to contribute to the Vedder River fishery values through habitat creation and to avoid salmon spawn losses associated with substrate instability.

Wright, B.F., 1997. Evaluation of Habitat Changes and Environmental Impacts Following the 1995 Gravel Excavations. Prepared for B.C. Ministry of Environment Lands and Parks. 24p.

The report describes the environmental assessment that followed gravel removal in the Vedder River in the summer of 1995 to reduce the risk of flooding. The study area covered the Vedder River from Lickman Road downstream to its confluence with the Sumas River. Most of the effort was focused in the vicinity of the four excavation sites located above the Vedder Canal, named informally Brown Road (95-30L), Relief Bar (95-22R), Yarrow (95-14L), and Lower Channel (95-10R) however, two additional excavations were completed downstream of this area by the City of Abbotsford. These were identified as Pipeline Bar and Sumas Bar.

Two main purposes were identified for the post excavation environmental assessment. First, pink and chum salmon spawning were observed in order to evaluate the impact of the excavations on spawning and to help prevent such impacts in future excavations. This was particularly important for pink salmon which had not been previously studied in this river for this purpose. Second, changes to the river arising from the effect of high flows on the excavation sites were evaluated for their impacts on fish or fish habitat.

Significant high flow events caused localized shifting of gravel, which resulted in the loss of Chum and Pink redds at two of the excavation sites. The Lower Channel site provided new pink and chum spawning habitat. Habitat complexity for the most part increased among all excavation sites, primarily through the creation of temporary channels, microchannels, backwater areas, and shallows. A distinct pattern of Pink salmon spawning at the downstream end of glides just above riffles and of Chum salmon below riffles was observed. This correlates, respectively, to areas where one would expect flows into and out of the gravel.

New Pacific Ventures, 1999. Habitat Changes and Environmental Impacts Following 1996 Gravel Excavations on the Vedder River. Prepared for The Vedder River Management Committee. 22 p.

Gravel was removed from the Vedder River at three locations during the summer of 1996: immediately upstream of Peach Road on the right bank, immediately downstream on the left bank towards Giesbrecht Road, and further downstream on a mid-channel bar near Wilson Road in Yarrow. The report describes the rationale, implementation, and post-excavation assessment of habitat changes for each excavation. Habitat types for each area before and one year after the excavations were mapped and compared.

The habitat mapping showed an increase in habitat values; however, short term channel changes from the long length affected by the excavations at Peach and Giesbrecht appear to have been primarily detrimental.

The Peach Road excavation showed significant habitat value increases as determined using the habitat polygon approach. Areas of shallows, riffles, and microchannels increased. As well, moderate levels of Pink and Chum spawning were observed in the assessment year, compared to no evidence of spawning pre-excavation. The Giesbrecht site experienced short-lived improvements in microchannel and overall Chum spawning habitat as a result of flow diversion into the pits. The Yarrow site showed no net change in habitat, maintaining the structure of habitat alterations from the 1994 excavations.

Pits located in areas that have not been recently excavated were noted to create more habitat benefits than those in areas which have been recently excavated. Eight recommendations focused on improving future strategies for gravel removal are provided.

New Pacific Ventures, 1999. Habitat Changes and Environmental Impacts Following the 1997 Gravel Excavations on the Vedder River. Prepared for The Vedder River Management Committee. 9 p.

This report is the sixth in a series addressing fish habitat impacts associated with excavation of gravel bars in the Vedder River. Only one gravel bar, located near the upstream end of the braided reach approximately 100 m below Vedder Crossing, was excavated in 1997. This site was further upstream than any previous deep pit excavation. The 1997 site was formally identified as 97-45Mid. The habitat mapping protocol previously developed for use on the Vedder showed habitat values for the area that were similar before and after the excavation.

Mapped post excavation changes included a slight decrease in wetted habitat and an increase in unvegetated gravel bar. This negative change was offset by an increase in complexity, primarily pool habitat in the pit area. The excavated pattern was persistent in the years following the excavation and it was recommended to consider removing the top third of a bar where gravel trapping is the main purpose. The cross-berms were found to be a technically feasible approach to containing silt-laden water during excavations of bars with large head drops but required leaving a lot of material behind that increased gravel movement downstream as they were eroded.

Scholz, P.S., Wright, B.F., M.C. Robinson, and V. Galay, 2001. Habitat Changes and Environmental Impacts Following 1998 Gravel Excavations on the Vedder River. Prepared for The Vedder River Management Area Committee. 45 p.

This report describes the effects of eight gravel bars excavated in 1998 in the Vedder River on fish habitat, spawning patterns, and distributions of rearing juvenile salmonids. Seven were deep-pit type excavations, while one, near Lickman Road, was scalped.

A brief study of the spatial distribution of juvenile salmonids was undertaken to assess the use of remnant excavation pools by rearing salmonids. Low catch per unit effort limited the conclusions of the study, but the pits are likely used less than the main channel, while side-channel and microchannel features are more important for rearing.

Detailed mapping of habitat types showed that most excavations had higher habitat ratings one year following the excavations than they had at the time of the excavation. The methods of habitat mapping and before-and-after comparisons that were initiated in earlier monitoring reports for the Vedder have been augmented with this report. The report recommends continuing to use fish habitat criteria as key tactical drivers in formulating the sediment removal program elements.

Wright, B.F., 1999. Gravel Removal Constraints, Guidelines, and Planning Procedures for the Protection of Fish Habitat: The Vedder River Floodway Protection Program 1994 to 1998 Working Document. Prepared for The Vedder River Management Area Committee. 48 p.

The working document summarizes the five-year practical learning from the monitoring program between 1994 and 1998 and provides a basis for a consistent approach to planning future excavations. Detailed evaluation of the constraints and guidelines that have been used to date and a brief summary of the outcome for each of the pits for the years 1994 through 1997 are presented in this report. Most of the guidelines were found to be valid under appropriate circumstances.

The report provides a six-step process for planning future excavations and recommends continuing to use 16 of 18 constraints and guidelines as the basis for planning gravel excavations from the river.

Wright, B.F. and P.S. Scholz, 2003. Habitat Changes and Environmental Impacts Following 2000 Gravel Excavations on the Vedder River. Prepared for The Vedder River Management Area Committee. 35 p.

This report describes the results of follow-up assessments that took place in the two years following four gravel excavations in the Vedder River in August and September of 2000 as part of an ongoing program to maintain floodway capacity. Sites near Yarrow, downstream on the Greendale side of the river and upstream at the mouth of Peach Creek and at Bergman Bar yielded a total of 71,000 cubic metres of gravel.

Unlike other years, the Peach and Bergman excavations were designed to capture much of the flow and change into a stable configuration quickly after the end of the excavation. This approach proved unsuccessful and is not recommended for future excavations. Existing guidelines provide a good basis for gravel removal, specifically for this example that no pit should bypass more than one riffle section.

The lack of a significant freshet resulted in many of the pits not filling in, and this likely led to the loss of pink salmon redds at the Yarrow site as spawned areas shifted in year 2. The small magnitude of the loss and low probability of recurrence meant that a change to the guidelines was not recommended. Greendale also did not refill until the second year but with no apparent detrimental effects.

Key recommendations include preservation of the spawning areas around Lickman Bar as a key part of the gravel removal strategy, less frequent excavation of Yarrow bar to allow return to a more natural central bar with habitat channels on the edges, and careful excavation design of Greendale in order to reduce the risk of causing a shift of the thalweg to the right.

Scholz, P.S. and B.F. Wright, 2003. Environmental Monitors Report on 2002 Excavations of Gravel Bars on the Vedder River. Prepared for The Vedder River Management Area Committee. 72 p.

The report describes the planning and implementation of the 2002 excavations from the environmental monitoring perspective. Five gravel bars were excavated in 2002: Bergman A Bar (02-24L), Bergman B Bar (02-28L), Boundary (Left Side Abbotsford Canal) (02-23canalL), Keith Wilson Bar (02-26canalR), and Chadsey (Right Side Chilliwack Canal) (02-19canalR) Bar. The report provides a brief discussion on each site and addresses the rationale and plan as well as the issues and changes that arose during the excavations. A collection of photos for each of the excavations, a synthesis of the monitors' daily logs, habitat maps and a brief interpretation, based on aerial photos from September 2003 are included in the report as appendices.

Patton, T., Scholz, P.S. and B.F. Wright, 2005. Habitat Changes and Environmental Impacts Following 2002 Gravel Excavations on the Vedder River. Prepared for The Vedder River Management Area Committee. 33 p.

The report describes the results of follow-up assessments for five Vedder River gravel bars that were excavated in August and September of 2002. Two bars were located in the Vedder River near Bergman Road and three were located in the Vedder Canal between the Highway 1 Bridge and the Keith Wilson Bridge. The five excavation sites yielded a total of 65,400 cubic metres of gravel.

Habitat mapping was used to quantify and compare changes in habitat units pre and post excavation and to examine the extent to which changes were caused by excavations. In general, dry habitat areas remained relatively unchanged from 2002 to 2003. Shallows, riffles and habitat edge area decreased significantly during the same period while backwater, microchannel and pool habitat increased.

Lickman and Campground spawning areas were heavily used in 2002, but by 2003 Campground had been cut off from the main river due to natural changes and the Lickman area was mainly dry, significantly decreasing the number of spawning salmon identified within this segment of the Vedder River.

Carl, C., Wright, B.F. and T. Patton, 2005. 2004 Vedder River Gravel Excavations Environmental Monitor's Report. Prepared for The Vedder River Management Area Committee. 21 p.

In 2004, nine gravel bars were excavated. They were Community A Bar, Community B Bar, Salad Bar, Yarrow A Bar, Yarrow B Bar, Greendale Bar, Peach Creek Bar, Powerline Bar, and Railway Bar. A total of 128,624 cubic metres of gravel was removed comprising approximately 82% of the proposed removal volumes. The report describes the planning, rationale and implementation of the 2004 excavations.

Murray, R. and B.F. Wright, 2007. Assessment of Fish Habitat Changes in the Vedder River Following Gravel Excavations in 2004 and a Review of the Assessment Methodology. Prepared for The Vedder River Management Area Committee. 35 p.

The report provides an assessment of the impacts of gravel extractions completed in 2004 and a review of the assessment methods used for the Vedder River from 1994 to 2007. A list of recommendations for refinement of methods employed on the Vedder River is also included.

The assessment of impacts of excavations is based on field observations, aerial photography, and detailed habitat mapping. Results of habitat mapping show that dry habitats decreased by 3.54% while wet habitats increased by 4.92% following the excavations. Key recommendations include using smaller gravel trap style excavations particularly around Yarrow, Relief, Bergman and Peach Bars. The objective would be to have these refill without changing local geomorphology. Habitat excavation recommendations include: deepening the entries to the microchannels located at Community Bars A and B, increasing the size of the habitat excavation at Greendale to provide backwater habitat, and maintaining the habitat channel at Salad Bar to prevent periodic drying.

Coe, K., Wright, B.F. and R. Murray, 2007. 2006 Vedder River Gravel Excavations Environmental Monitors Report. Prepared for The Vedder River Management Area Committee. 29 p.

Twelve gravel bars were excavated in 2006. A total of 212,700 cubic metres of material was removed, comprising 105% of the proposed removal volumes. The report describes the planning, rationale and implementation of the 2006 excavations.

Nova Pacific Environmental, 2008. Post Excavation Assessment of 2006 Vedder River Gravel Excavations. Prepared for The Vedder River Management Area Committee. 57 p.

The report provides an assessment of changes to the river in the areas affected by the excavations. About 212,700 cubic metres of gravel was removed from twelve gravel bars, which was approximately 5% more than the amount proposed. A habitat assessment was conducted based on aerial photos, ground-truthing, and professional interpretation in an effort to understand fish habitat impacts following the excavations.

The freshet following these excavations produced the largest instantaneous flow on record. Significant changes to river geomorphology made it difficult to determine the effect of the excavation on surrounding conditions.

Pre and post excavation mapping based on aerial photos was completed in an effort to understand fish habitat impacts following the excavations. Habitat values remained relatively constant despite higher water levels in 2007. However, complexity appeared to have decreased, likely due in part to the freshet of late November 2006. Of the twelve excavation sites, two showed a positive net gain in habitat value, five showed a negative net change, and the remainder where neutral or unchanged.

Excavator operator error resulted in greater than permitted gravel removal and over-steepening of the upper edge of some pits. This likely contributed to head cutting and consequent erosion of important habitat features. Strict adherence to excavation designs would likely have prevented some of the negative impacts associated with the excavations.

Nova Pacific Environmental, 2008. 2008 Vedder River Gravel Excavations Environmental Monitors Report. Prepared for The Vedder River Management Area Committee.

Twelve gravel bars were scheduled for excavation in 2008; however, due to high water levels and changes during the spring 2008 freshet, only nine bars were excavated. The total volume for the nine excavations was 105,931 cubic metres of bed material, which was 69% of the proposed removal volume. The report describes the planning, rationale and implementation of the 2008 excavations.

Wright, B.F., P.S. Scholz and K. DeBoer. Nova Pacific Environmental, 2010. 2008 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts. Prepared for The Vedder River Management Area Committee.

This report describes the results of an environmental assessment undertaken to determine fish habitat changes and other impacts related to nine individual sites providing a total removal of 106,000 cubic metres. A habitat assessment was undertaken at the time of the excavations and one year later to determine if the excavations altered habitat types in their vicinity.

The mapping assessment showed that habitat ratings increased for six locations, decreased for two, and remained relatively unchanged for one. When considering other factors such as limitations in mapping accuracy, poor refilling of pits, site instability, erosion, fish trapping, or impacts to spawning, four of the nine sites were found to be positive from the habitat perspective, three were found to be neutral, and two were found to be negative. The data supports the hypothesis that there has been no net loss of habitat arising from the excavations in 2008.

Negative consequences attributed to the pattern of refilling at several excavations have led to three key recommendations: ensure that the gravel berm separating the excavated area from the adjacent channel is as narrow as possible to ensure functional inflow and outflow; place the inflow opening at the most upstream extent of the site to ensure continuous flow and even distribution of material throughout excavation; and scalp immediately upstream of excavation inflow to encourage flow and redistribution of material. The negative consequences observed and hence the recommendations apply in particular to sites in the upper reach where the coarser substrate tended to hold its shape during the freshet.

DeBoer, K. and B.F. Wright, 2010. 2010 Environmental Monitors Report. Prepared for The Vedder River Management Area Committee. 48 p.

Eight sediment removal sites were proposed for implementation in the summer of 2010. The total volume which was planned to be removed was 138,400 cubic metres. Following completion of the work the volume of material removed was determined to be 99,630 cubic metres, or 72% of the intended volume. The report describes the implementation of the sediment removal project at each of the designated sites. The planning and rationale for each site layout are discussed. A description of the work at each site is presented, as well as photos documenting the condition of the site before, during, and after the work. Recommendations and conclusions that arose from the work conducted in 2010 are presented and discussed.

Wright, B.F., Kozlova, T. and P.S. Scholz, 2012. 2010 Vedder River Gravel Excavation – Habitat Changes and Environmental Impacts. Prepared for The Vedder River Management Area Committee. Draft.

This report describes the results of the assessment undertaken to determine fish habitat changes and other impacts related to the sediment removal program of 2010. Gravel removal amounting to 99,630 cubic metres was achieved from seven removal sites.

Habitat mapping based on aerial photos was completed in an effort to understand fish habitat impacts following the excavations. Most sites experienced an increase in habitat rating (3.7% - 39%) with the exception of Greendale Bar (-7.8%). When direct impacts on fish or spawning were included, four of the seven sites experienced an overall positive effect on habitat while two sites experienced an overall negative effect (Community, Greendale) and one a neutral effect (Railway).

With respect to the future implementation and assessment of similar sediment removal projects on the Vedder River, the following key recommendations were provided: reduce excavation in the middle reach where freeboard is not limited allowing more gravel to migrate into the lower reach, resulting in more gravel refilling and improved spawning habitat; design shallower excavations with contouring mimicking natural conditions to prevent further erosion of banks and dykes in erosion prone areas; and continue to determine sediment size distribution at each excavation prior to sediment removal and annually at all locations that have been subject to excavation within the previous four year period.

4.5 Literature from Other Sources

This includes various articles on-hand, references sourced from key reports and selected results from online journal searches.

Lister, D.B., Beniston, R.J., Kellerhals, R. and M.Miles, 1995. Rock Size Affects Juvenile Salmonid Use of Streambank Riprap. In: River, Coastal and Shoreline Protection: Erosion Control Using Riprap and Armourstone. Edited by Thorne, C.R., Abt, S.R., Barends, F.B.J., Maynord, S.T. and K.W. Pilarczyk. Copyright 1995 John Wiley and Sons Ltd.

The paper describes the results of studies that examined salmonid fish rearing along essentially unvegetated banks of riprap and natural cobble-boulder material. The riprap consisted of blasted, angular granite. While the focus is on the influence of rock size, factors such as stream depth and velocity are also considered.

Bergman, L.A., 1996. Report on Vedder River Gravel Management Plan. Prepared for Ministry of Environment, Lands and Parks, BC Environment.

The report describes the procedure and necessary approvals needed in order to remove gravel from the floodway area. The purpose of the report is, firstly, to document the need to remove gravel from the Vedder River in order to maintain the integrity of the floodway for the protection of a large agricultural area, and secondly, to describe the current requirements for gravel removal from the river.

Church, M., 2001. River Science and Fraser River: Who Controls the River? In: Gravel-Bed Rivers V. New Zealand Hydrologic Society, Wellington.

The purposes of the paper are to attempt to clarify the real authority and responsibility of technical river managers – engineers and ecologists- and the river scientists who advise them.

Church, M., 2010. Sediment Management in Lower Fraser River – Criteria for a Sustainable Long-Term Plan for the Gravel-Bed Reach. Prepared for Emergency Management BC, Flood Protection Program, Ministry of Public Safety and Solicitor General.

The objective of this report is to contribute towards the development of a sustainable long-term sediment management plan for Lower Fraser River. The specific objectives discussed are as follows: to examine the current status of the sediment budget, to review the effect of sediment removals to date, to appraise what may be efficient measures of the effectiveness of a sediment removal program to mitigate the flood hazard, to propose an effective program for ecological monitoring based on experience to date, and to recommend candidate sites, volumes and methods for gravel removal in a long-term program.

Ferguson, R.I., Bloomer, D.J. and M. Church, 2011. Evolution of an Advancing Gravel Front: Observations from Vedder Canal, British Columbia. Article first published online: March 1, 2011, DOI: 10.1002/esp.2142.

Channelization of the lowermost part of Vedder River in 1992 initiated a natural experiment relevant to the unresolved question of how abrupt gravel-sand transitions develop along rivers. Changes in morphology and sedimentology as gravel advanced into and along the Canal are documented using air photos, historical surveys, and fieldwork. Calculations show that even though the gravel bed at the head of the Canal is almost unimodal, size-selective transport during floods can account for the strong bimodality farther downstream.

Rempel, L.L. and M. Church, 2009. Physical and Ecological Response to Disturbance by Gravel Mining in a Large Alluvial River. Can. J. Fish. Aquat. Sci. 66, p. 52-71.

The effects of a single, experimental gravel removal on the physical habitat and invertebrate and fish communities in the lower Fraser River were examined, and sampling requirements for effect detection in a large river system was evaluated. Results suggest that physical changes due to this mining operation fell within the range to which local aquatic populations are accustomed during flooding, because the ecological response was modest and short-lived.

4.6 Other Related Articles

Burke, J.L., Jones, K.K., Dambacher, J.M., 2001. HabRate: A Stream Habitat Evaluation Methodology for Assessing Potential Production of Salmon and Steelhead in the Middle Deschutes River Basin. Aquatic Inventories Project. Oregon Department of Fish and Wildlife.

Abstract: HabRate represents a simple spreadsheet model that rates the potential quality of stream habitat for the early life stage of salmon and steelhead based on common survey data. The model was developed for a specific application to the middle Deschutes River basin in Oregon, but was intended for general application to the Pacific Northwest Basins. We summarized available literature on salmonid habitat requirements. Habitat requirements for discrete early life history stages (i.e. spawning, egg survival, emergence, summer rearing, and winter rearing) were summarized and used to rate the quality of reaches as poor, fair, or good, based on attributes relating to stream substrate, habitat unit type, cover, gradient, temperature, and flow. Reach level summaries of stream habitat were entered into a computer spreadsheet, and interpreted by logical statements to provide a crude limiting factor assessment of potential egg-to-fry and fry-to-parr [juvenile fish] survival for each reach. The model is a decision making tool that is intended only to provide a qualitative assessment of the habitat potential of stream reaches within a basin context. Design criteria for the model were simplicity and flexibility. While HabRate was based on our interpretations of the published literature, specific criteria for habitat quality were structured to be easily adjusted where interpretations differ from ours. Information not common to standard stream survey designs, such as seasonal flow or temperature extremes are included as input from professional judgment. A graphic summary of the rating results was presented as an example of the potential interpretation.

National Marine Fisheries Service, 2004. Sediment Removal from Freshwater Salmonid Habitat. Available from http://swr.nmfs.noaa.gov/hcd/policies/April 19-2004.pdf.

Summary: Effects on Riffle Habitats: An undesirable effect of most forms of commercial and flood control sediment removal is reduced channel complexity and surface topography, either directly or through time due to diminishing sediment sorting processes that result in a more uniform stream bed. The bed material may become finer or coarser, depending on the rate of sediment removal and antecedent conditions of the bed and banks. Reduced complexity, diminished sediment sorting and armour layer development, and reduced topography result in fewer or less defined riffles and pools. Reduced bed complexity also results in a less stable channel, which increases the potential for injury to salmonid embryos in areas of streambed disturbance. The movement of water does not cease at the interface between the river and its substrate. Water moves through pore spaces in the riverbed, particularly where the bed has topographic relief. Predictable zones of inflow and outflow (downwelling and upwelling) are found on the riverbed.

The more complex the channel pattern and surface topography, the more strongly developed are downwelling and upwelling hyporheic zones (Brunke and Gonser 1997) characteristic of salmonid spawning habitat (Stanford et al. 1996). Zones of downwelling flow are located at the heads of riffles, where the bed topography is sloped slightly upstream and where there is an increasing hydraulic gradient (Thibodeaux and Boyle 1987). Salmonids select this environment for digging redds and laying their eggs (Groot and Margolis 1991). Sediment removal practices can adversely affect proper functioning riffle habitats by exacerbating sedimentation of the substrates, changing hyporheic flow patterns, causing barriers to adult migration, and reducing benthic invertebrate production.

Fish and Wildlife Services, National Marine Fisheries Services, US Army Corps of Engineers, & the Environmental Protection Agency, 2006. Sediment Removal from Active Stream Channels in Oregon. Available from http://www.fws.gov/oregonfwo/ExternalAffairs/Topics/Documents/GravelMining-SedimentRemovalFromActiveStreamChannels.pdf

Summary: Sediment removal from streams can result in bed degradation, bank erosion, channel and habitat simplification, reduced geomorphic processes such as pool maintenance, sediment sorting, and sediment intrusion, reduction in large woody debris, direct or indirect loss of riparian zones, and lowering of the shallow aquifer/hyporheic zone. Adverse biologic effects may include reduced primary productivity and macroinvertebrate populations, reduced ability for fish to avoid predators, reduced fish growth and success, reduced riparian vegetation and all associated aquatic and terrestrial benefits, reduced water quality, and direct mortality of fish.

Brown, A.V., Lyttle, M.M., and Brown, K.B, 1998. Impacts of Gravel Mining on Gravel Bed Streams. Transactions of the American Fisheries Society 127(6): 979-994.

Abstract: The impacts of gravel mining on physical habitat, fine-sediment dynamics, biofilm, invertebrates, and fish were studied in three Ozark Plateaus gravel bed streams. Intense studies were performed upstream, on site, and downstream from one large mine on each stream. Invertebrates and fish were also sampled in disturbed and reference riffles at 10 small mines. Gravel mining significantly altered the geomorphology, fine-particle dynamics, turbidity, and biotic communities. Stream channel form was altered by increased bank-full widths, lengthened pools, and decreased riffles in affected reaches. Fine particulate organic matter transported from riffles to pools was decreased. Biofilm organic content was decreased on flats and increased on remaining riffles. Density and biomass of large invertebrates and density of small invertebrates were reduced at the small, more frequently mined sites. Total densities of fish in pools and game fish in pools and riffles were reduced by the large mines. Silt-sensitive species of fish were less numerous downstream from mines. Attempts to mitigate or restore streams impacted by gravel mining may be ineffective because the disturbance results from changes in physical structure of the streambed over distances of kilometers upstream and downstream of mining sites. Stream morphology was changed by lack of gravel bedload, not by how bedload was removed. Mining gravel from stream channels results in irreconcilable multiple-use conflicts.

Payne, B. A., 1997. Channel Morphology and Lateral Stability: Effects on Distribution of Spawning and Rearing Habitat for Atlantic Salmon in a Wandering Cobble-bed River. Canadian Journal of Fisheries and Aquatic Sciences 54(11): 2627 - 2636.

Abstract: Pronounced downstream variations in channel morphology in the wandering, gravel-cobble Nouvelle River, Quebec, provided an opportunity to assess certain effects of channel planform and stability on rearing and spawning habitat for Atlantic salmon (Salmo salar). At summer low flows, weighted useable area per unit channel length differed significantly among five reaches of contrasting morphology with identical discharge regimes. A braid-like reach, dominated by a wide, dissected midstream bar, offered three to five times more potential habitat for juveniles (21 m usable width for fry, 12 m for parr) than two sharply curved reaches with minor backchannels (4 m for both fry and parr) and two to three times more potential habitat than two moderately curved reaches. Fining of potential spawning riffles downstream from eroding cutbanks was not detected, in five unstable river reaches even where erosion rates reached 10 m/year, and the percentage sand content of eroding banks was five times that of instream gravels. This finding challenges the assumption that large local inputs of sand necessarily cause fining of instream spawning gravels, and suggests that hydraulic forces in a moderately powerful river can be quite efficient in preventing the buildup of excess fines in mid-channel riffle habitat.

Kondolf, G.M., 1998. Geomorphic and Environmental Effects of Instream Gravel Mining. Landscape and Urban Planning 28(2): 225 – 243.

Abstract: Instream gravel mining involves the mechanical removal of gravel and sand directly from the active channel of rivers and streams. Active channel deposits are desirable as construction aggregate because they are typically durable (weak materials having been eliminated in river transport), well-sorted, and frequently located near markets or on transportation routes. Instream gravel mining commonly causes incision of the channel bed, which can propagate upstream and downstream for kilometers. As a result, bridges and other structures may be undermined, spawning gravels lost and alluvial water tables lowered. In analyzing the effects of instream gravel mining, a sediment budget analysis sheds light on the relative magnitude of gravel supply, transport and extraction. Computer models of sediment transport are simplifications of complex natural processes; they can be useful components of a sediment budget analysis but should not be relied upon alone. A historical analysis of channel change and sediment supply is needed to understand the underlying processes responsible for present conditions. While instream gravel mining can be a useful tool in flood control and river stabilization in aggrading rivers, most rivers in the developed world (certainly the vast majority below reservoirs) are not aggrading and are more prone to incision-related effects of instream gravel mining.

Couloumbe-Pontbriand, M. and Lapointe, M., 2004a. Geomorphic Controls, Riffle Substrate Quality, and Spawning Site Selection in Two Semi-Alluvial Salmon Rivers in the Gaspe Peninsula, Canada. River Research and Applications 20(5): 577 – 590.

Abstract: The relationship between valley and channel morphology, spawning substrate quality (content of fine sediment <2 mm) and the selection of spawning sites by Atlantic salmon (Salmo salar) were investigated along 45 km of two semi-alluvial, valley-confined rivers in the Gaspé Peninsula, Canada. Linear and logistic regressions confirm that Atlantic salmon prefer spawning at riffles providing good rather than mediocre or poor spawning substrate, as defined by the percentage sand and the Sand Index of Peterson and Metcalfe. However, exceptionally large concentrations of redds were observed on the few riffles located at island heads, with sub-optimal substrate quality. This observation suggests that, in addition to content of fine material in the substrate, the morphology of spawning reaches may be a significant factor controlling the intensity of inter-gravel flow through redds and the consequent selection of spawning sites. In the study systems, the quality of spawning substrate was controlled by 'large-scale' geomorphic attributes at the scale of valley segments (1-6 km here): segments located within a wide valley were actively meandering, had higher sinuosity and bank erosion rates, generally lower shear stresses and presented somewhat higher sand content than segments confined by a narrow valley.

Although sand contents were significantly higher, laterally unstable segments in wide valleys still harboured good to excellent spawning substrate overall. The study data do not allow the roles of variations in levels of riffle-zone shear stress to be distinguished from those of cut bank fines input, to explain the observed inter-segment association between valley width and riffle fines content.

Buffington, J.M., Montgomery, D.R. and Greenberg, H.M., 2004. Basin-scale Availability of Salmonid Spawning Gravel as Influenced by Channel Type and Hydraulic Roughness in Mountain Catchments. Canadian Journal of Fisheries and Aquatic Sciences 61(11): 2085 – 2096.

Abstract: A general framework is presented for examining the effects of channel type and associated hydraulic roughness on salmonid spawning-gravel availability in mountain catchments. Digital elevation models are coupled with grain-size predictions to provide basin-scale assessments of the potential extent and spatial pattern of spawning gravels. To demonstrate both the model and the significance of hydraulic roughness, we present a scenario for optimizing the spatial extent of spawning gravels as a function of channel type in Pacific Northwest catchments. Predictions indicate that hydraulic roughness could control more than 65% of the potential available spawning habitat at our study sites. Results further indicate that bar roughness can be important for maintaining spawning gravels in lower mainstem reaches, while wood roughness may be required for spawning-gravel maintenance in steeper, upper mainstem channels. Our analysis indicates that wood loss and consequent textural coarsening could deplete up to one third of the potentially usable spawning area at our study sites.

Moir, H.J., Gibbins, C.N., Buffington, J.M., Webb, J.H., Soulsby, C., and Brewer, M.J., 2009. A New Method to Identify the Fluvial Regimes Used by Spawning Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 66(9): 1404 – 1408.

Abstract: Basin physiography and fluvial processes structure the availability of salmonid spawning habitat in river networks. However, methods that allow us to explicitly link hydrologic and geomorphic processes to spatial patterns of spawning at scales relevant to management are limited. Here we present a method that can be used to link the abundance of spawning salmonids to fluvial processes at the mesoscale. We show that the frequency of spawning activity at individual morphological units (riffles, pools, runs) is quantitatively related to a number of fluvial parameters. Of these, bankfull excess shear stress was the best predictor of spawning frequency. Results suggest that this can be used to represent the fluvial regimes that spawning salmon are responsive to as well as to assess the likely impacts of altered flow regimes.

Heino, J., Mykra, H., Hamalainen, H., Aroviita, J. and Muotka, T., 2007. Responses of Taxonomic Distinctness and Species Diversity Indices to Anthropogenic Impacts and Natural Environmental Gradients Instream Macroinvertebrates. Freshwater Biology 52(9): 1846 –1861.

Summary: Many studies have shown traditional species diversity indices to perform poorly in discriminating anthropogenic influences on biodiversity. By contrast, in marine systems, taxonomic distinctness indices that take into account the taxonomic relatedness of species have been shown to discriminate anthropogenic effects. However, few studies have examined the performance of taxonomic distinctness indices in freshwater systems.

We studied the performance of four species diversity indices and four taxonomic distinctness indices for detecting anthropogenic effects on stream macroinvertebrate assemblages. Further, we examined the effects of catchment type and area, as well as two variables (pH and total phosphorus) potentially describing anthropogenic perturbation on biodiversity.

Although neither species diversity nor taxonomic distinctness indices revealed anthropogenic degradation of macroinvertebrate assemblages in this study, the traditional species diversity and taxonomic distinctness indices were very weakly correlated. Therefore, we urge that biodiversity assessment and conservation planning should utilize a number of different indices, as they may provide complementary information about biotic assemblages.

5.0 RESOURCES FOR RECREATIONAL COMPONENT

5.1 Recreation Information Sources

Vedder River Management Area Plan, Vedder River Management Committee (Sept., 1983)

The 1983 management plan covers 325 ha of active river channel and floodplain downstream of Vedder Crossing. The public recreation objective of the plan is to provide public recreation facilities in the form of hiking and riding trails, river access points, an overnight campground, a multi-purpose playing field, outdoor amphitheater, horse staging area and a public information program.

Although some of the material in this document is outdated, the goal of the plan "to ensure the integrity of the Vedder River floodway while maintaining and enhancing natural resources of the area and incorporating where compatible and desirable, recognized historical uses and educational programs for the benefit of the people of British Columbia" is still relevant and will provide some guidance for the updated management plan.

One of the six management objectives is to provide public recreation facilities. The public recreation objective is still valid and should be considered within the management plan area. The specifics of the recreation activities that are taking place within the Vedder River Management Area should be updated.

Furthermore, protecting the great blue heron nesting grounds and maintaining and enhancing the spawning and rearing capabilities in the main river tributaries and side channels are two of the six management objectives with the primary objective being retaining the 200-year floodway capacity.

An appendix to the plan includes a 1981 recreation study of the Vedder River between Vedder Crossing and the Vedder Canal. The eight page study, including two map pages, is both dated and rudimentary. The introduction notes the primary purpose of flood control "also presents the possibility of other compatible uses, including recreation". Key recreational features identified are the campground and the Yarrow Community Hall area, both on the left or south bank of the Vedder River. Other activity nodes are the horse staging area and sportsfield, also on the left bank. The management plan identifies 6 access points, Lickman Road and Railway Road on the right bank and First Road (now Community Street), Wilson Road, Browne Road and Ford Road (now Giesbrecht Road) on the left bank.

An additional appendix included a survey of the Great Blue Heron colony. The survey indicated between 96 and 110 nests from 1977 to 1980, of which over 90% were typically occupied.

The City reports essentially all the 1982 recreational development plans have been implemented.

2008 Vedder River Gravel Extraction - Habitat Changes and Environmental Impacts. Nova Pacific Environmental for the Vedder River Management Area Committee (May 2010)

The report describes the results of an environmental assessment undertaken to determine fish habitat changes and other impacts related to the sediment removal program. Recreational issues are not addressed but are indirectly involved in relation to sediment removal areas, access routes to remove sediment, and proximity of trails to fish habitat.

Experience the Fraser River – Lower Fraser River Corridor Project: Concept Plan (Sept., 2011)

Concept plan developed as a collaboration between the Province of BC, the Fraser Valley Regional District and Metro Vancouver. Experience the Fraser (ETF) is a recreational, cultural and heritage project that extends 160 km along the Lower Fraser River Corridor connecting Hope to the Salish Sea and includes the Vedder Canal to the Keith Wilson Bridge. The ETF Concept Plan expresses the Project's Vision and Goals and presents a framework for the long-term development of inter-regional trails and facilities to showcase the Fraser River and its rich natural and cultural heritage. It presents Trail and Blueway routes which form the signature backbone of the project, and which link communities and Fraser River themed features, amenities and experiences.

The four goals of the ETF Concept Plan are to:

- Connect Hope to the Salish Sea along the Fraser River by means of a network of over 550 kilometres of trail, 43% of which is already in place;
- Inspire and link experiences along the Fraser River such as parks and trails that provide river access, and fishing spots and that interpret the river's ecological importance to salmon, raptors, and bird migrations;
- Develop enduring and committed partnerships among different levels of government, First Nations, other agencies, the private sector, non-profit organizations and citizens; and
- Build and deepen physical, emotional, and spiritual connections to the Fraser River.

Initial funding of $2,000,000 for the plan came from the Province of B.C. in April 2009. It was followed up with an additional $500,000 to help build two demonstration projects in Mission and the Township of Langley intended to form the first segments of the inter-regional trail network. Although the contributing parties have agreed to the content of the plan, no commitment has been made to implement the plan.

Vedder River Flood Response Plan (2011)

This plan provides details as to how the recreational areas in the Vedder River Floodplain will be affected and identifies the most vulnerable areas and strategies to protect them. Graphics of a dyke breach over time for a 1 in 200 year flood are provided. Closure of the most vulnerable recreation areas is included in Phase I of the response.

Minutes of the Sumas Prairie Diking, Drainage and Irrigation Committee, City of Abbotsford. (October 19, 2006).

These minutes provide a discussion of some of the management problems associated with recreational use along the Vedder River and suggests some solutions, including designation of the area as a park to give the City more control over the usage.

A Sto:lo-Coast Salish Historical Atlas (2001)

The historical atlas produced by the Sto:lo Nation provides rich documentation of the First Nations history including the oral history, legends, spiritually significant areas, pre-contact archaeological sites such as pit house settlements, contact era settlements, river trade routes, migrations, family relationships, seasonal availability of resources, demographic changes, establishment of Indian reservations, draining of Sumas Lake in 1924 and its transformation into farmland, diversion of the Chilliwack River and creation of the Vedder Canal, closure of the aboriginal fishery in 1926 and the replacement by a non-aboriginal sports fishery, establishment of parks and protected areas, and the exploitation of upland forest and other resources.

Chilliwack Official Community Plan, City of Chilliwack (1998)

Key recreational objectives are to:

- Provide parks and recreation areas, facilities and services which meet a cross-section of community needs. Provide a range of parks and recreation facilities and services that address all age group and income needs.
- Designate and develop a system of parks which meets existing and future resident needs. Provide for cross-section of park types, including natural parks, and active and passive parks.
- To improve access to parks and recreation facilities. Achieve an effective distribution of parks by acquiring lands for future parks throughout the City, particularly for under-represented areas or those increasing significantly in density, such as the downtown and adjacent residential areas.

To examine innovative ways of designating and developing new parks and recreation facilities. Continue to form partnerships with groups and organizations with complementary goals in order to identify and manage new park opportunities. Key policies include the following:

- Continue to develop a multi-purpose trails network throughout the community, incorporating walking, cycling, and equestrian paths. Attempts should be made to maximize the use of natural areas and non-vehicular routes that establish links between community and neighbourhood parks; recreation, school and civic facilities; and residential subdivisions. Where appropriate and beneficial to its residents, the City should integrate its parks and trails network with regional, provincial and national systems such as the Trans Canada Trail.
- Encourage and coordinate development and operation of Parks and Recreation amenities by private, non-profit and community groups and service clubs with the land use and policies of this Plan.
- Develop a comprehensive Parks and Recreation Master Plan to address, guide and prioritize our parks and recreational needs (including a detailed analysis of adequate amounts, locations, types, definitions and standards for recreation in Chilliwack).

The OCP identifies the Vedder River as a gravel resource in addition to the area's recreational value. The OCP designates the Vedder River floodplain as the Vedder River Management Area. No potential trailways are identified on the OCP in the Vedder River Management Area although a potential new or expanded community park is indicated at the south end of Sumas Prairie Road. The OCP also contains discussion and objectives with respect to flood hazard management in the form of dykes.

Chilliwack Strategic Plan for Parks and Recreation Services, Professional Recreation Environmental Consultants for the City of Chilliwack (31 December, 2003)

The strategic plan documented 32 km of trails and pathways or 1 km per 2,200 residents. A community survey identified trails and walkways as the type of new or improved services that is most needed in the City of Chilliwack (64%).

The strategic plan recommended that the City maintain its current support within the OCP for adding to the public trails and linear corridors within Chilliwack on a case by case basis in order to meet the utilitarian and recreational needs of the citizens. No specific standard was recommended as the need for neighbourhood trails varies with the topography and site conditions. The strategic plan does not specifically mention the Vedder River Management Plan area.

City of Abbotsford Parks and Recreation Master Plan, Catherine Berris Associates for the City of Abbotsford (2005)

The City of Abbotsford has approximately 83 km of off-road trails including a portion of the Trans-Canada Trail. Trail standards are quite variable ranging from 1 to 4 metres in width and with surfaces from rough dirt tracks to granular surface or pavement. Some trails are barrier free and some include steps. While most trails support pedestrian usage, others are used by recreational cyclists. Trails for expert cyclists are located on Sumas Mountain. Several areas such as the Matsqui Trail and on Sumas Mountain see significant equestrian use.

The greatest shortages were perceived to be cycling trails and walking and jogging trails. Future park opportunities included expansion of Sumas Mountain Regional Park, acquisition of a park on Vedder Mountain to provide trails and acquisition of a regional trail along the Fraser River to complement the Fraser River Greenway.

Only a small portion of the Vedder River Management Area is administered by the City of Abbotsford but the master plan recognizes the opportunity to tie in to Chilliwack's main trail along the Vedder River and Vedder Canal and the possibility of adding cycling paths.

The Master Plan map shows the existing west bank dyke trail along the Vedder Canal with a proposed trail extension (long-term vision) extending southwest between the base of Sumas Mountain and Highway 1. Future cycle trails are also shown south and west of the Keith Wilson Bridge over the Vedder River Canal. Long-range connectively is addressed in the Abbotsford Trail Development Strategy as noted below.

Abbotsford Trail Development Strategy. Lees and Associates Landscape Architects for the City of Abbotsford Parks and Recreation (undated but 2004 indicated)

The trail development strategy consists of specific components of a trail concept plan and fundraising strategy. The project goals are to:

- determine the economic benefits of a community trail system,
- develop a greenway vision for the City of Abbotsford,
- develop a blueway vision for the Fraser, Sumas and Vedder Rivers,
- develop a trail concept plan for a segment of the trail system, and
- develop a fundraising strategy for a segment of the trail system.

Three major trail alignments were selected as the primary framework of a community trail network plus the Fraser River waterway. Although not selected for initial development, the Sumas Trail was the one trail with connections to the Vedder River and Vedder Canal. This 30 km rural recreation trail goes from Sumas Prairie, Old Yale and Yarrow along the northwestern flank of Vedder Mountain north to the Vedder Canal, follows the left dyke trail along the Vedder River to Highway 1, the shoreline dyke of the Sumas River at the base of Sumas Mountain past Barrowtown and continues southwest across Highway 1 back to Sumas Prairie. The northern portion of the trail exists as a segment of the Trans Canada Trail while the southern portion will require an extension of the Old Yale Trail route through to Yarrow. The possibility of a connection over Vedder Mountain to Cultus Lake Provincial Park is raised. This strategy also discusses the significant natural features that are attractions to the community including the Vedder Canal as a popular fishing spot.

The Trail Concept Plan includes the following eight criteria:

- paved universal access trail as the project standard;
- anchor the trail with significant community destinations as nodes;
- develop trail network connections along greenway corridors;
- provide a loop opportunity for in-line skating distance training;
- create a lively atmosphere at trail nodes to encourage use;
- plan a specific section of trail to serve as a demonstration project;
- develop strategic alliance to ensure the success of the project; and
- develop a promotional brochure to solicit community support.

The standard trail section consists of a three metre wide paved trail section within a five metre clear zone. The plan includes cross-sections for rural and urban trails, boardwalks, bridge crossings and cross slope trails. Also included is an extensive section on a fundraising strategy including goals, precedents, guidelines, corporate, service club and community involvement, special events, volunteer activities, marketing strategy and campaign strategy.

5.2 Present Recreational Usage

Vedder Greenway Recreational Usage, Parks Division, City of Chilliwack (2011)

In 2011, Chilliwack Parks provided documentation on the Vedder Greenway. It noted that essentially all the recreational development plans in the 1983 Vedder River Management Plan have been implemented. Documentation on the following was provided:

Vedder River Campground – contains 270 campsites and has operated with full occupancy during much of the summer since before the management plan was developed. The campground area includes a sports field, gazebo and outdoor day-use picnic area.

Great Blue Heron Nature Reserve – has an area of 130 ha that serves to protect over 100 nesting pairs as well as provide an educational function. The reserve includes a large interpretative centre, self-guided interpretive trails, a viewing tower and viewing blinds. Visits to the reserve have increased steadily since the opening in 2002. Annual recorded visitors in 2010 were 19,000. In addition the reserve hosted 80 school visits by 26 different schools in 2010.

Vedder River Rotary Trail – initially consisted of a walking trail along the right river bank from a parking lot at Vedder Crossing to a parking lot at Hopedale Road. The trail was later extended to 7.3 km by passing under the railway bridge and onto the gravel pit area at the east end of the Great Blue Heron Reserve. The loop back to the Great Blue Heron Reserve was completed in 2011 with a connector trail. The Vedder River Rotary Trail is now Chilliwack's most popular trail as well as its most widely used recreational facility with over 120,000 annual visits. The trail is now 7.5 km long and was resurfaced in 2011. New kilometre markers were installed and an audio guide is provided at www.trailtalker.ca.

Vedder River North Dyke Trail – occupies the right dyke from Webster Road to the Keith Wilson Bridge. It provides links to the Vedder Canal, the Fraser River Dyke and the Trans Canada Trail.

Peach Creek Trail – was constructed by the Department of Fisheries and Oceans to provide maintenance to the Peach Creek spawning channel. The narrow dirt trail provides an alternative to the wider and more heavily used trail along the Vedder River.

Vedder River South Trail – runs parallel to the left bank from the Vedder River Campground at Geisbrecht Road to the near the railway bridge. This trail interconnects at three points with the Vedder River South Dyke Trail.

Vedder River South Dyke Trail – occupies the left dyke from the Vedder River Campground to its junction with the Trans Canada Trail to Abbotsford.

The report concludes by identifying proposed expansion of the Vedder River South Trail in the Upper Reach to enable a loop trail to the Vedder River Bridge, park development of Vedder Park on part of the former CFB Chilliwack, Peach Road Park and new loop trails in the Great Blue Heron Reserve.

5.3 Stakeholders

Chilliwack Vedder River Clean-up Society – formed in the Spring of 2002, the founders were anglers, birdwatchers, conservationists, biologists and concerned local residents. It unites a group of individuals who are concerned about the increasing amount of garbage being left along the Chilliwack/Vedder River. The Society has two major objectives. One is to coordinate major clean-up activities three times annually, in cooperation with the City of Chilliwack and Fraser Valley Regional District. Since 2002, over 70 tonnes of garbage has been collected along the Chilliwack Vedder River riparian areas. The second objective is to educate the public on the value of the river and the need to keep it clean. www.cleanrivers.ca

Great Blue Heron Nature Reserve Society – The Great Blue Heron Nature Reserve Society is a non-profit organization whose mandate is to operate a nature interpretive centre within the Great Blue Heron Nature Reserve on the right bank of the Vedder River. The centre's programs are designed to broaden the community's awareness and appreciation of the natural and historical values of the Reserve through research, exhibits, tours and educational programs for the benefit of the Chilliwack and area community.

The Great Blue Heron Nature Reserve is a 130-hectare site (325 acre) located on the floodplain of the Vedder River. Managed by the Great Blue Heron Nature Reserve Society, the site is known for the breeding colony of Great Blue Herons as well as a wide variety of wildlife and vegetation.

The Rotary Interpretive Centre was funded and constructed by Rotary Club of Chilliwack and is managed by the Great Blue Heron Nature Reserve Society. Volunteers operate the interpretive centre year round. Experienced volunteer staff provide interpretive programs for school groups and other interested parties. www.chilliwackblueheron.com.

Crime Prevention Support Unit & Operational Support Unit, Chilliwack RCMP

Engineering Division, Southern Railway of British Columbia

Parks Services, City of Abbotsford

Canada Lands Company.

6.0 HERITAGE AND FIRST NATIONS ISSUES

The study team includes representation from the staff of the Stó:lō Research & Resource Management Centre (SRRMC). The data gathering phase involved a review of previously recorded site location maps, topographic maps, aerial maps or photos, development plans, and literature generally applicable to the study area and immediate vicinity. Sources for this information include local museums and archives, including those housed at the SRRMC. The Stó:lō Archives include interviews with Stó:lō elders and others knowledgeable on the history and traditional use of the subject Management Area. The study area was also assessed within the framework of the Stó:lō Heritage Management Plan spatial databases (GIS), housed at the SRRMC.

Data review includes review of published and unpublished documents, transcripts, maps and photographs. Transcripts are documented interviews from Stó:lō community members who are knowledgeable about historic and current land use and sites in proximity to the study area, and of persons who are knowledgeable about Stó:lō traditions.

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Photos are included in the Archaeological Overview Assessment of Vedder River Management Area Report, by the Stó:lō Research and Resource Management Centre, 2012), an appendix to the accompanying Management Phase Report (EBA, 2012).

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City of Chilliwack, the Ministry of Forests, Lands and Natural Resources Operations (MFLNRO) and their agents. EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company, does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City of Chilliwack or MFLNRO, or for any Project other than the subject assignment. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix A of this report.

8.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Sincerely,
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APPENDIX A

EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

DESIGN REPORT

This Design Report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than EBA's Client, unless authorized in writing by EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

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2.0 ALTERNATIVE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, EBA's client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by EBA's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon EBA's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.