Background Summary Report:
CRIEMP II Cumulative Effects Assessment Scoping Workshop
Sept. 24-25, 2002

Prepared for:

Columbia River Integrated Environmental Monitoring Program

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1. Introduction and Purpose of Workshop

The Columbia River Integrated Environmental Monitoring Program (CRIEMP) was established to co-ordinate environmental monitoring in the Lower Columbia River, and to communicate the results of environmental monitoring programs to the public. The Committee is comprised of industrial and municipal representatives, as well as environmental scientists from the provincial and federal governments. Following a first phase of activity during the early 1990's (CRIEMP I), the CRIEMP II program was initiated in 2001 to identify and undertake a new program of monitoring focussed on priority environmental issues in the Lower Columbia River.

To assist CRIEMP determine its future focus and activities, a study was undertaken by G3 Consulting Ltd. during 2002 to review existing information covering aquatic environmental conditions in the lower Columbia River. Specifically, G3 was requested to undertake a critical review of existing environmental information from 1990 to 2002, identify data gaps, and propose a study design to:

- fill data gaps,
- address the state of ecological health of the river,
- define cumulative impacts of human activities,
- assign cause and effect relationships between human activities, and,
- optimize the integration of ongoing studies.

The two G3 reports were finalized during mid-2002. Subsequently, CRIEMP requested that MacDonald Environmental Sciences Ltd. (MESL) undertake an objective third party assessment and provide a brief critique of the G3 reports.

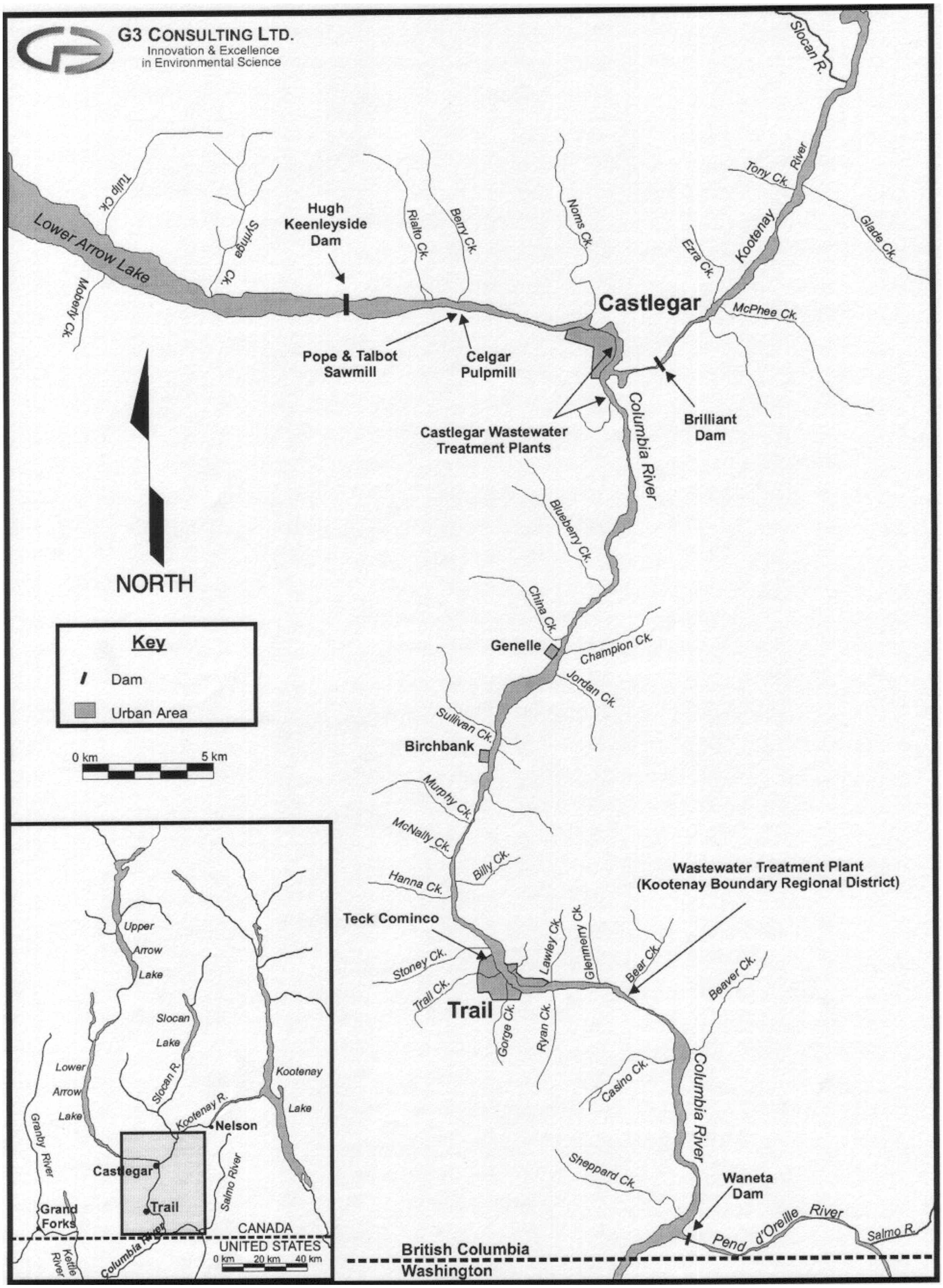
In a letter report on May 31, 2002, MESL recommended that CRIEMP:

- re-consider the G3 study design,
- conduct a 2002 field program in collaboration with the Celgar EEM program,
- articulate CRIEMP II priorities,
- determine 2003 field activities,
- convene a 2-day cumulative effects assessment scoping workshop later in 2002
- prepare a revised CRIEMP II study design, and,
- prepare a State-of-Environment report for the Lower Columbia River

The detailed MESL recommendations are shown in Appendix 1.

CRIEMP convened a meeting on June 17, 2002 to review the MESL recommendations. During this meeting, a CRIEMP draft "Vision Statement" was developed and the priority environmental issues in the lower Columbia River were identified. Consistent with the MESL recommendations, CRIEMP have convened a 2-day Cumulative Effects Assessment Scoping Workshop for Sept. 24-25, 2002. This workshop is being undertaken, in part, to assist CRIEMP II determine its priorities for the future.

FIGURE 1-1:
Lower Columbia River between Arrow Lakes and the Canada - USA Border, Showing Major Anthropogenic Influences



In advance of the workshop, this background report has been prepared for use by workshop participants. An agenda for the meeting is provided in Appendix 2. Two appendices (Appendix 3-4) have been prepared in support of the Sep. 24-25 workshop as a summary of environmental information contained within the G3 reports.

2. What is Cumulative Effects Assessment?

The Lower Columbia River from the High Keenleyside Dam to the Canada-United States boundary has been subject to substantial developmental pressure during the past century. Human activities include municipal development, infrastructure and linear developments (i.e. road, rail), pulp and paper manufacturing, metal smelting, timber harvesting, renewable energy development, flood control, and recreational endeavors. In combination, these human activities have the potential to greatly disrupt physical, chemical, and biological processes in the river basin.

Conventional environmental management in the Lower Columbia River has focused on the effects of single-issue development activities by means of environmental impact assessment (EIA) and environmental monitoring. However, the potential for interaction among human activities means that environmental managers need to evaluate cumulative effects, in addition to conducting traditional EIAs. Traditional approaches to environmental assessment do not usually consider the additive or interactive effects of multiple activities within an area.

CRIEMP II has identified a need to identify and evaluate the cumulative effects of human activities in the Lower Columbia River. In future, monitoring programs will be designed to address the adverse cumulative effects that are identified, so that their status can be tracked over time.

Cumulative effects can be defined as:

Those effects that result from the interactions of multiple human activities in time and space, each of which may be insignificant when viewed alone but which become cumulatively significant when seen in aggregate.

This definition reflects that change can accumulate in environmental systems in an additive or interactive manner on both temporal and spatial scales. Hence, cumulative environmental change may originate either from an individual activity that recurs over time (i.e., the time between events is insufficient for the system to fully recover) or from multiple activities with sufficient spatial and temporal linkages for accumulation to result. The process of systematically analyzing or evaluating cumulative environmental change is referred to as cumulative effects assessment (CEA). In its broadest context, CEA provides a basis for evaluating the social, economic, and environmental impacts of multiple human activities.

One approach to CEA is to consider the different stressors that influence species of public or managerial concern. For example, native fish species in the lower Columbia River may be subject to influence by all of the following variables:

Effects of hydro operations

- flow regime
- water velocity

- water depth
- temperature
- habitat
- total dissolved gas pressure
- nutrient cycling
- fluctuating water levels ⟷ stranding of fish and fish eggs
- fluctuating water levels ⟷ periphyton and benthic invertebrates

Effects of contaminants:
- pulpmill effluent from Celgar
- effluent from Teck Cominco
- municipal discharges
- effluent dilution

Effects of climate change:
- temperature distribution
- flow changes

Effects of introduced species:
- interactions with walleye
- mysid entrainment via Keenleyside discharges

Further, there can be interactions between all of these effects, e.g. hydro flow releases affect effluent dilution from point sources. All of these identified variables need to be considered within a CEA framework, with the goal of identifying cumulative effects (either additive or synergistic) from all of the existing stressors. Once cumulative effects are identified, then it should be possible to identify cumulative effects indicators which can be monitored over time.

The following integrated steps or activities, are commonly followed during CEA:

- identification of ecosystem goals and objectives;
- definition of the scope of the assessment;
- definition of the boundaries of the assessment;
- identification of the human activities that could affect the study area;
- identification of the types and probable locations of the environmental changes that could occur in response to the human activities;
- identification of the types and probable locations of receptors that could be affected by the environmental changes;
- identification of the types of ecosystem functions that could be altered by the environmental changes and the locations of such alterations;
- selection of cumulative effects indicators from the list of receptors and ecosystem functions that were identified previously;
- implementation of a retrospective or a predictive CEA, depending on the goals of the assessment;

- identification of data gaps and uncertainties in the CEA;
- preparation of a cumulative effects report, including maps, to communicate the results of the assessment;
- development and implementation of research programs to reduce data gaps and uncertainties to acceptable levels;
- refinement of the CEA based on the results of the research programs;
- design and implementation of an ongoing cumulative effects monitoring program; and,
- assessment of cumulative environmental effects based on the results of the ongoing monitoring program.

CEA in the lower Columbia River will require considerable time and effort on the part of all participants, and should be viewed as an ongoing, long-term process. The objective for the Sept. 24-25 CRIEMP workshop is to identify and prioritize future monitoring activities that are necessary to understand the status of cumulative effects in the lower Columbia River ecosystem.

Traditional environmental impact assessments (EIAs) are often preceded by carrying out an initial environmental evaluation (IEE). The IEE is a rapid overview analysis, frequently prepared in one month or less, and is used to guide the design and implementation of a longer duration (1-2 years) EIA process. The approach we are proposing to follow during the CEA scoping workshop on September 24-25 is analogous to an IEE approach, whereby we will undertake a rapid CEA overview analysis designed to support future CRIEMP activities.

Further information describing CEA can be found in a Canadian government publication, "Cumulative Effects Assessment Practitioners Guide" which is available over the internet at the following address: http://www.ceaa-acee.gc.ca/0011/0001/0004/index_e.htm

3. CRIEMP II Vision for the Lower Columbia River (draft)

A Vision Statement provides a useful frame of reference for the rationalization of program activities, budget allocations, and communications with the public. During the June 17 meeting, CRIEMP committee members developed the following text as a draft Vision Statement (re-printed as stated at the workshop):

> ***Our vision of the Columbia River encompasses/embodies a productive ecosystem with clean water that seeks to sustain and balance the following values: ecological, aquatic life, aesthetic, drinking water supply, fishing and spiritual values (social, cultural and economic). The vision recognizes existing constraints based on historical decisions/actions and strives to optimize biological production and economic benefits for the future while reducing negative consequences. The vision relies on a collaborative integrated monitoring approach to accurately understand and communicate the status and changes in the ecosystem, as a result of human activities. This is the role of CRIEMP.***

While this text still requires minor clarification by the CRIEMP Committee, the ideas expressed in the version above are sufficient to guide the activities during the Sept. 24-25 workshop.

4. Ecosystem Goals and Objectives (draft)

Implementation of an ecosystem-based management approach depends on developing ecosystem goals, ecosystem objectives, and cumulative effects indicators to help focus planning, research, and management activities.

Ecosystem goals are broad narrative statements that define the management priorities that are established for a specific ecosystem. Definition of management goals for the aquatic ecosystem is a fundamental step in support of a long-term vision and for developing strategies that will maximize the opportunities for achieving that vision.

Ecosystem goals that are developed for the lower Columbia River should reflect societal values and public concerns related to the ecosystem. As a starting point for future discussion by the CRIEMP Committee, the following five ***draft*** broadly-based ecosystem goals could be considered:

(i) Maintain the integrity of the lower Columbia River (the term 'ecosystem integrity' is defined as the physical, chemical, hydrological, and biological conditions necessary to maintain a productive and diverse aquatic ecosystem);

(ii) Preserve traditional culture and lifestyles;

(iii) Protect drinking water supplies;

(iv) Provide economic development opportunities that are consistent with the principles of responsible stewardship; and,

(v) Assure that no adverse cumulative effects occur as a result of multiple developments and land use activities.

To be useful for monitoring purposes, these ecosystem goals need to be further clarified and refined to establish ecosystem objectives that are linked more closely to measurable monitoring parameters. In turn, such ecosystem objectives can support the identification of cumulative effects indicators, which provide important information for evaluating the integrity of the ecosystem, as a whole.

The following statements have been articulated as ***draft*** ecosystem objectives for the lower Columbia River.

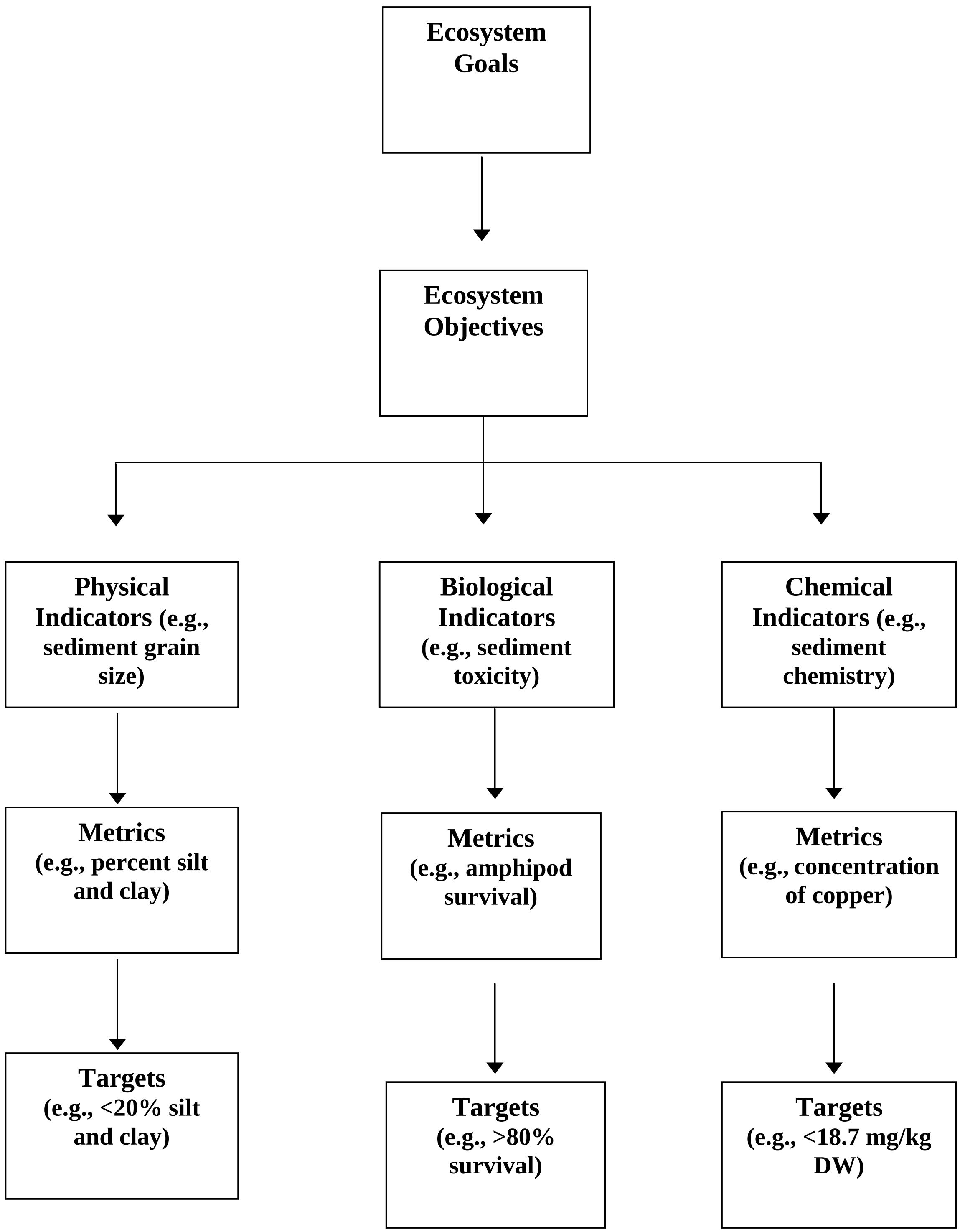
1. The aquatic, wetland, and riparian habitats within the lower Columbia River basin should be of sufficient quality and quantity to support communities of aquatic organisms and aquatic-dependent wildlife species that are productive, diverse, naturally reproducing, and self-sustaining.

2. Human impacts and inputs to the river should be managed so as to avoid interfering with potable water supplies, and to minimize interference with recreational and aesthetic uses that are derived from the ecosystem.

3.Human activities and decisions regarding the management of natural resources within the lower Columbia River should embrace environmental ethics, should demonstrate a commitment to responsible stewardship, and should assure that the potential for cumulative impacts is minimized.

A diagram which illustrates the relationship between ecosystem goals, objectives, indicators, metrics (measurable parameters) and targets is shown below.

Illustration of the relationship between ecosystem goals, objectives, indicators, metrics and targets:



5. Scoping of Issues

During the June 17 meeting, two break-out groups comprised of CRIEMP Committee members developed a list of priority environmental issues in the lower Columbia River. A number of issues were common between the two groups. Below are listed the primary issues that were identified, shown roughly in the order of priority determined by the meeting participants:

Aquatic pollution from contaminants and hazardous substances

- contributions from US sources (Pend d'Oreille R. and Kootenay R.)
- gaps in understanding concerning concentrations, fate, effects, sources

Cumulative environmental effects

- no agency is presently addressing these effects
- top predators (osprey, mink, otter) may be susceptible to cumulative effects

Total gas pressure (TGP)/Total dissolved gas (TDG) effects on fish/biota

- recognition of previous work carried out by BC Hydro and DFO

Water flow regulation by hydro operations

- effects on industrial operations/dilution of effluents

Historical legacy issues

- dam construction
- previous contamination

Temperature effects on biota

- temperature alterations due to local effects (i.e., flow regulation)
- temperature alterations due to global effects (i.e., global warming)

Communication gap between industries, government agencies, communities

- regulatory factors determine monitoring priorities (not ecological factors)

Nutrient and turbidity losses (from hydro construction and operations)

- inadequately addressed at present

Maintenance of native fisheries

Status of Columbia River sturgeon

Administrative and technical issues

- Geographic boundaries (artificial borders) versus watershed approach
- Appropriate measurements/end points that relate directly to issues of concern
- Budget and political (social) limitations that may preclude adequate protection, enforcement and monitoring of the river

This list is by no means an exhaustive list of relevant environmental issues in the lower Columbia River, and to some extent, reflects the opinions of CRIEMP committee members. However, the identified issues likely cover most of the present managerial concerns within the CRIEMP area.

One approach that can be adopted to analyse the present issues in the Lower Columbia River, is to group them into two categories (stressor groups or issue clusters):

Lower Columbia River stressors:

1. Impacts of aquatic contamination

2. Impacts of flow regulation
- Hydro construction (a legacy issue that could be addressed by retrospective CEA)
- Hydro operations/flow manipulation
- TGP effects on fish/biota

There are two additional stressors that MESL identified during workshop preparations, as important to include in a CEA, namely:

3. Impacts of climate change

4. Impacts of introduced species (e.g., walleye)

Lower Columbia River receptor groups:

The receptor groups (also called Valued Ecosystem Components[1]) which are affected by the stressors include:

Fish
Fisheries
Aquatic communities
Aquatic-dependent wildlife
Water quality
Public health
Recreation

During the workshop, it may prove strategic to break down the stressor groups into finer categories (e.g., fish into benthic fish and pelagic fish; invertebrates into benthic invertebrates and plantonic invertebrates; pelagic fish into individual species, etc.).

[1] Components of the ecosystem considered important by environmental managers and the interested public. VECs can include biological populations, species, and communities, as well as ecosystem attributes e.g. air quality conditions.

During the Sept. 24-25 scoping workshop, attention will focus on:

- establishing cause-and-effect relationships between the receptors and the stressors, and,
- determining the interactions within and between the stressors.

6. Linkage Diagrams

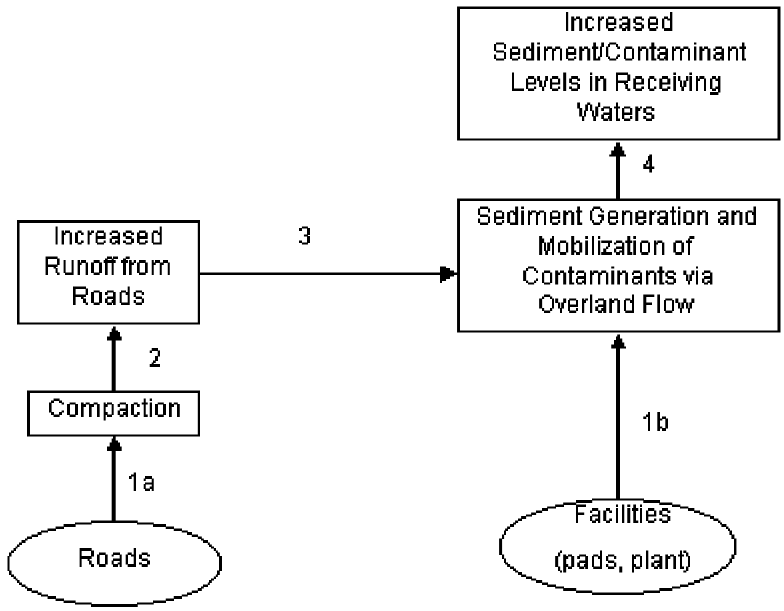
A linkage diagram, also called an impact hypothesis, is a box-and-arrow depiction of the relationships between stressors and receptors. These linkage diagrams depict what we know, or don't know, about ecosystem relationships.

The example below has been taken from the Cold Lake (Alberta) Oil Sands Project. The linkage diagram is one out of a total of 35 that were prepared for the EIA. The linkage diagram was developed to assess the effects of the Cold Lake Oil Sands Project on surface water quality.

The "Impact Statement" corresponding to the linkage diagram is the following:

Operation and maintenance of roads and facilities will result in the generation of sediment and transport of contaminants to receiving waters.

Linkage Diagram:



Linkage Statements:

1a. The operation and maintenance of roads will lead to compaction of the roadbed.

1b. Operation and maintenance of pads and plant facilities will result in the generation of sediment and mobilization of contaminants via overland flow from these facilities.

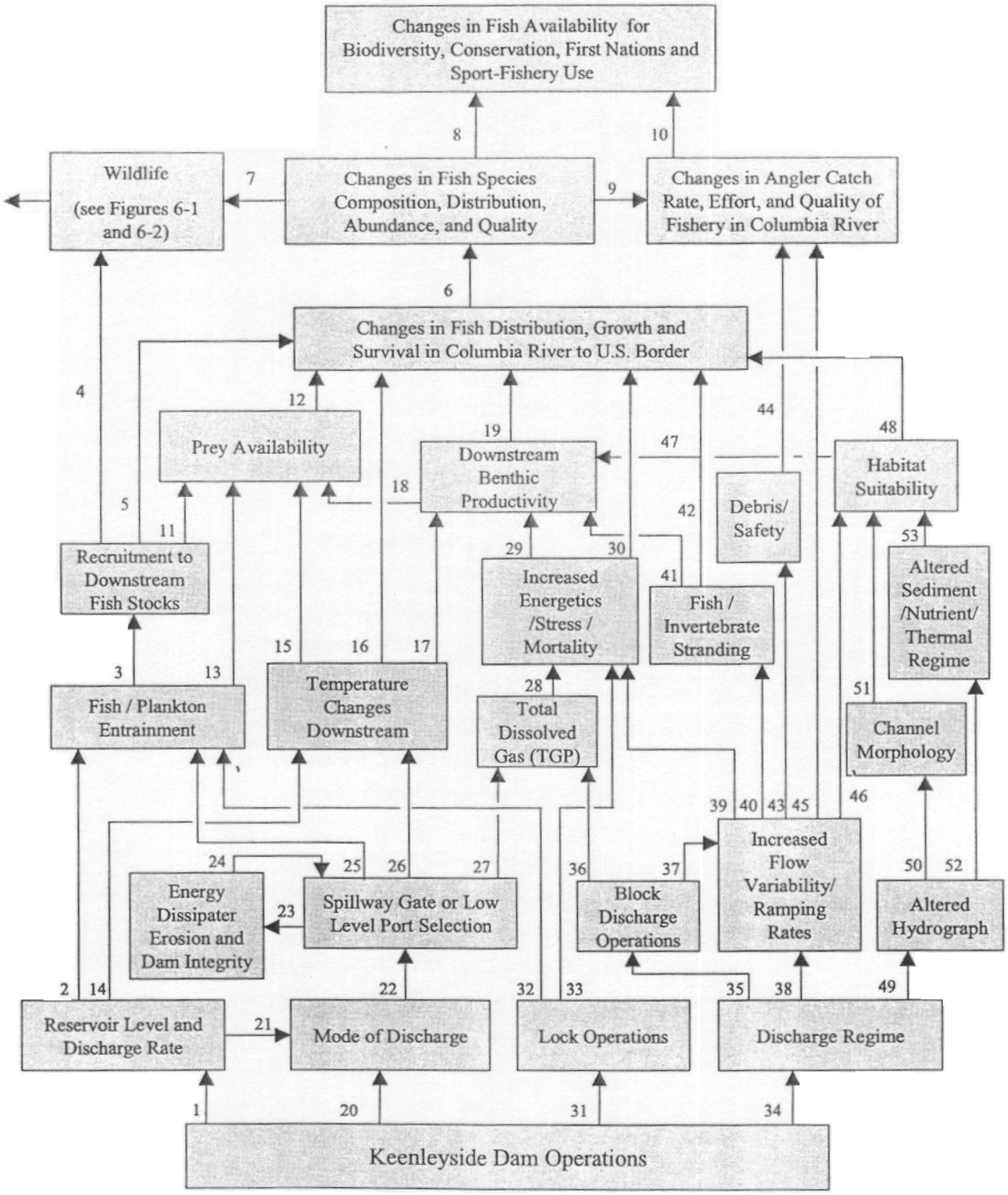
2. Compaction will cause an increase in surface runoff from the road.

3. Increased runoff from roads will result in erosion of exposed soils, resulting in an increase in sediment generation and transport. Soluble contaminants from the road and the road bed will be transported along with the sediment.

4. Increased sediment and contaminant transport will result in higher levels of these parameters in receiving waters, which will result in a decline in surface water quality.

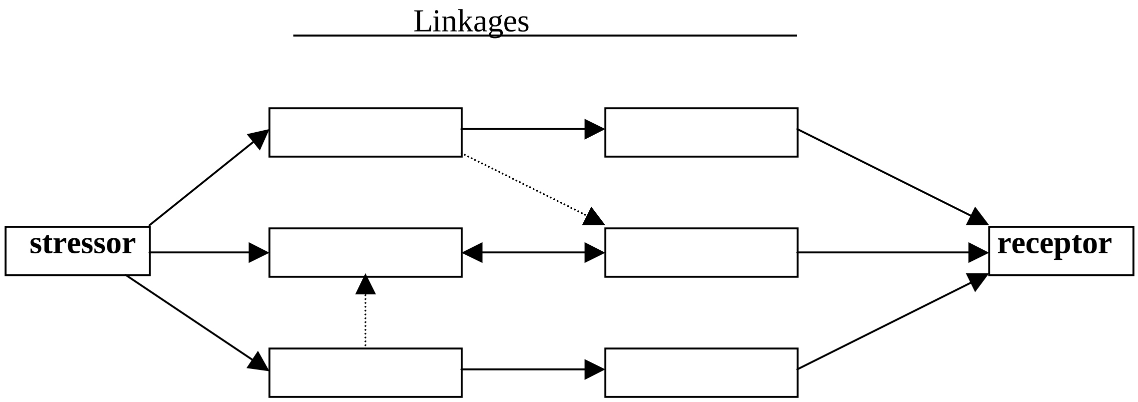
The main value in preparing linkage diagrams is to confirm what we presently understand, or don't understand, about the relationships between human activities (stressors) and the ecosystem under consideration (in our case, the Lower Columbia River).

Recently (March 2001), RL&L Environmental Services Ltd., on behalf of BC Hydro prepared the *Water Use Plan* (WUP) for the Keenleyside Project entitled "Environmental Information Review and Data Gap Analysis Volume 2: Lower Columbia Keenleyside Project". The WUP presents a detailed linkage diagram (shown below) which addresses the potential effects of hydro operations on fisheries resources and angling in the lower Columbia River.


Changes in Fish Availability for Biodiversity, Conservation, First Nations and Sport-Fishery Use
Wildlife (see Figures 6-1 and 6-2)
Changes in Fish Species Composition, Distribution, Abundance, and Quality
Changes in Angler Catch Rate, Effort, and Quality of Fishery in Columbia River
Changes in Fish Distribution, Growth and Survival in Columbia River to U.S. Border
Prey Availability
Downstream Benthic Productivity
Debris/ Safety
Habitat Suitability
Recruitment to Downstream Fish Stocks
Increased Energetics /Stress / Mortality
Fish / Invertebrate Stranding
Altered Sediment /Nutrient/ Thermal Regime
Fish / Plankton Entrainment
Temperature Changes Downstream
Total Dissolved Gas (TGP)
Channel Morphology
Energy Dissipater Erosion and Dam Integrity
Spillway Gate or Low Level Port Selection
Block Discharge Operations
Increased Flow Variability/ Ramping Rates
Altered Hydrograph
Reservoir Level and Discharge Rate
Mode of Discharge
Lock Operations
Discharge Regime
Keenleyside Dam Operations
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53

7. Development of linkages between stressors and receptors

During the workshop, the following convention will be adopted to generate linkage diagrams which depict relationships between stressors and receptors:



The different stressor groups to be considered during the workshop will include:

1. Effects of aquatic contaminants
2. Effects of hydro operations and flow regulation
3. Effects of climate change
4. Effects of introduced species

Specification of the important linkages will be undertaken in working groups. During these break-out sessions, participants will need to first define an appropriate receptor group. Next the linkages between the stressor and the receptors should be evaluated and depicted in terms of a linkage diagram. Upon completion, the group should evaluate:

- the appropriateness of the receptor group;
- the validity of the each of the linkages;
- the over-all validity of the linkage diagram;
- spatial and temporal (timing, duration, frequency) dimensions of relevant impacts, and,
- uncertain linkages where additional monitoring would be desirable

During the first day of the workshop (Sept. 24) participants will prepare individual linkage diagrams related to the four stressor groups. During the second day of the workshop (Sept. 25) we will consider the interactions between different stressors and evaluate cumulative effects.

8. Spatial and temporal dimensions

To be prepared during the workshop

9. Evaluation of cumulative effects
To be prepared during the workshop

	Contaminants	Flow regulation	Climate change	Introduced species
Contaminants	**************			
Flow regulation		************		
Climate change			************	
Intro'd species				************

10. Key elements for future monitoring of impacts using an indicator approach
To be prepared during the workshop

Appendix 1: MESL recommendations to CRIEMP provided on May 31, 2002

The CRIEMP Committee has established a number of objectives that need to be met to support the implementation of the CRIEMP II initiative. More specifically, the CRIEMP Committee has identified the need to:

- Conduct a critical review and assessment of existing environmental information from approximately 1990 to present;

- Identify data gaps;

- Develop a study design to fill those gaps, address the state of ecological health of the river, and define cumulative impacts of, and assign cause and effect relationships between, human activities on the river; and,

- Establish mechanisms and options for optimizing the implementation of the recommended studies, with other studies already planned for 2002/03 by other agencies or entities.

The reports that were prepared by G3 Consulting Ltd. provide a basis for achieving these objectives. However, the study design that was recommended by G3 should not be implemented directly at this time. Rather, the CRIEMP Committee should consider the following recommendations before moving toward implementation of the CRIEMP II Initiative:

- <u>Design and convene a cumulative effects assessment workshop</u>. Such a workshop should be designed to provide the overarching guidance that is required to inform the design of an integrated environmental monitoring program for evaluating ecosystem health and assessing cumulative environmental effects. Such a workshop should be designed to:

    1. Establish ecosystem goals and objectives;
    2. Establish linkages between stressors and receptors in the study area;
    3. Identify the types of environmental changes, and associated locations, that could occur in response to human activities;
    4. Identify the types of receptors and ecosystem functions, and associated locations, that are likely to be adversely affected by human activities;
    5. Identify the receptors and/or ecosystem functions that could be adversely affected by multiple human activities;
    6. Develop impact hypotheses based on defined linkages between stressors and receptors; and,
    7. Identify the cumulative effects indicators (and/or ecosystem maintenance indicators) and associated metrics that will provide a basis for assessing cumulative environmental effects and ecosystem health.

- <u>For 2002 field season, carry out a water quality and benthic program</u> that builds incrementally on the Celgar Cycle 3 EEM program. This activity is proposed to coincide with the field program that will be undertaken in August, 2002 by Celgar, and would be carried out as a co-operative program between Celgar and CRIEMP participants. The intention would be to expand the spatial coverage (benthic invertebrate sampling and sediment quality) and measurement parameters (water quality at the selected sampling sites) that are being addressed during the EEM Cycle 3 program. The importance of synoptic sampling of sediments for determination of whole sediment chemistry, sediment toxicity, and/or benthic invertebrate community structure cannot be overstated. The scope and spatial coverage of this program would reflect the available CRIEMP budget to be allocated to the program.

- Articulate CRIEMP II priorities. A preliminary indication of CRIEMP priorities can be obtained from the Questionnaire results reported in Appendix I of the G3 gap analysis report. The stated weaknesses of CRIEMP I identified by committee members included:

1. Some stakeholders had little or no involvement;
2. Possible weaknesses in details of sampling program identified;
3. Fuzzy goals, difficult to monitor the study and ensure appropriate results;
4. Did not continue or use lessons learned to improve process;
5. Difficult getting consensus on published results;
6. Concurrent sampling was lacking for some components, making it difficult to link measured contaminant levels to impacts; and,
7. Did not integrate impacts of flow regulation into overall impact assessments.

A number of new issues have arisen by Committee since CRIEMP I was completed, including:

1. Total gas pressure (TGP) and temperature, contaminants;
2. Endocrine disrupting compounds in waste treatment facility discharges;
3. Reports of excess algal growth (*Didymosphenia* mats);
4. Transboundary concerns (downstream movement of contaminants, TGP);
5. Spill procedures for industries;
6. White sturgeon status and recovery; and,
7. Ecological Risk Assessment, Trail Lead Task Force Assessment (Teck Cominco).

The hopes for CRIEMP II that were identified by committee members in the questionnaire included:

1. Develop integrated monitoring program to answer specific questions,identify cumulative effects, point and non-point sources of pollution, integrate data;

2. Eliminate permit-based piecemeal monitoring programs, supplement programs with broader based population wide monitoring activities unless a specific local need is identified;
3. Provide a broader picture of what is happening on the river;
4. Help identify and focus resources on environmental impacts;
5. Maintain communication and cooperation among agencies and corporations;
6. Use limited financial resources efficiently;
7. Create a template for other big river environmental impact assessments;
8. Demonstrate how stakeholders can join, address issues in timely economic manner; and,
9. Ultimately hope for ability to assess results and make changes to industrial processes, if necessary.

This input represents a starting point for articulating the CRIEMP II priorities for future implementation. A number of the points above fit together logically, and could be combined to guide future CRIEMP II activities. It should be possible to fairly rapidly reach consensus on the CRIEMP II priorities for implementation at a future CRIEMP meeting.

- <u>Determine CRIEMP field activities for 2003</u>. Following clear identification of priorities, the CRIEMP Committee can evaluate to what extent these issues are being addressed by ongoing activities. Where gaps are identified, this would provide an entry point for future CRIEMP activity. In determining future priorities, CRIEMP could ask a series of related questions:

1. What new information would be most valuable in improving the understanding of the Lower Columbia River ecosystem?
2. What new information would be most valuable in improving the basis for decision in the Lower Columbia River ecosystem?
3. What new information might be developed through research and monitoring?

- <u>Prepare a revised CRIEMP II Study Design</u>. This report should include the results of the CEA workshop, a refined data gap analysis, and the recommended study design for acquiring the data and information needed to evaluate ecosystem health, assess cumulative effects on the aquatic ecosystem, and identify the factors that are causing such effects. The report should also identify the schedule for preparing CEA reports and for re-evaluating the study design.

- <u>Prepare a "State of the Environment" (SOE) Report for the Lower Columbia River</u>. This report would be prepared to present a present-day snap shot, in simple nontechnical language, of the status of aquatic environmental resources in the area. As with other SOE reports, the format would be brief and concise, and would systematically evaluate defined components of the aquatic ecosystem. The information would be summarized to answer the following questions:

- Why is it important?
- What is its current status?

- How has its status changed over time?

The SOE would also include a general introduction summarizing the importance of the Lower Columbia River and describing the linkages between the ecosystem components. The chief benefits of this project would be to communicate the results of the numerous technical investigations on Lower Columbia River ecology to interested stakeholders and the general public. If this project is pursued, it is recommended that this be undertaken after the work to review cause-and-effect relationships and establish future monitoring/research priorities has been completed.

Appendix 2: Agenda for September 24-25,2002 CRIEMP II Workshop

September 24

08:30 – 09:00 Welcome & introductions, purpose of meeting, review agenda (JB)

09:00 – 09:15 Overview of Cumulative Effects Assessment (CEA), ecosystem goals and objectives, and relationship to environmental monitoring (MESL)

09:15 – 10:00 Review of CRIEMP vision statement, and proposed ecosystem goals and objectives for the lower Columbia River (All)

10:00 – 10:15 Coffee Break

10:15 – 10:30 Review of issue clusters, and linkage diagram example (All)

10:30 – 12:00 Prepare linkage diagrams for Issue #1 and Issue #2 (2 break-out groups)

12:00 – 13:00 Lunch Break

13:00 – 13:30 Break-out group reports and discussion

13:30 – 14:30 Prepare linkage diagrams for Issue #3 and Issue #4 (2 break-out groups)

14:30 – 14:45 Coffee Break

14:45– 16:30 Break-out group reports and discussion
Identification of spatial and temporal (timing, duration, frequency) dimensions of relevant impacts (i.e., individually for issues 1-4)

16:30 Adjourn

September 25

08:30 – 09:00 Review of Sept. 24 results and conclusions

09:00 – 10:00 Interactions between human activities in the Columbia River (i.e., Integrate results for Issues 1-4)

10:00 – 10:15 Coffee Break

10:15 - 11:30 Identify key elements of a CEA monitoring program for the Columbia River (2 break-out groups)

11:30 – 12:00 Break-out group reports

12:00 – 13:00 Lunch Break

13:00 – 14:30 Review of ongoing aquatic environmental monitoring activities in the Columbia River relative to the needs for CEA (BCH, MWLAP, Celgar, Cominco, etc.)

14:30 – 14:45 Coffee Break

14:45– 16:00 Future CRIEMP II priorities to address cumulative effects

16:00 End

Appendix 3: Summary of Information Related to Aquatic Contaminants in the Lower Columbia River:

Present (2002) Point sources:

TABLE 1-2:
Effluent Discharge Permits for the Lower Columbia River

Permit number	Entity	Details
PE 1272 PE 1273	Celgar Pulp Company Pope and Talbot Sawmill (treated sewage effluent discharged through Celgar's effluent treatment works)	treated process and sewage effluent, main diffuser, 3.3 km downstream of Hugh Keenleyside Dam (177,000 m^3/d industrial effluent, 70 m^3/d landfill leachate, 114 m^3/d domestic sewage)
PE 80, PE 4008	City of Castlegar (municipal wastewater discharge, primary and secondary treatment)	two discharges, north side of river 1 km d/s of railway bridge and south side of river 2 km d/s of Kootenay confluence (2,300 m^3/d total discharge)
PE 141	Selkirk College (Castlegar, Robson area)	small amounts of treated sewage
PE 7622	Lion's Head Neighbourhood Pub (Castlegar, Robson area)	small amounts of treated sewage
	City of Nelson (upstream on Kootenay River)	treated sewage goes into Kootenay R. just below Grohman Narrows
PE 2753	Teck Cominco Metals Ltd.	Combined Outfall IV enters at Stoney Cr. Combined Outfall III discharges upstream of New Bridge and Combined Outfall II discharges at New Bridge
PE 133 PE 71	Fruitvale Beaver Falls Montrose	small amounts of secondary treated sewage enter river via discharge to Beaver Cr.
No permit number found	Stralaeff's Mobile Home Park	small amounts of treated sewage
PE 2174	City of Trail (RDKB) (municipal wastewater discharge, primary treatment)	east bank, downstream of Bear Cr., ~ 10 km d/s Trail 7,300 to 11,000 m^3/d

Source: Butcher (1992), MacDonald Environmental Services (1997)

Non-point sources: stormwater run-off, other urban run-off, agricultural activities, forestry activities.

CRIEMP I results from the early 1990's:

Water Quality

Compounds traceable to Celgar (organochlorines, resin acids) were below prevailing provincial and federal water quality guidelines at all stations sampled.

Cadmium, chromium, mercury, lead, copper and zinc concentrations were higher than water quality guidelines at sites downstream of Teck Cominco in up to 40% of the water samples, although mean concentrations were frequently below guidelines.

Coliform levels, associated with municipal wastewater discharge, were below criteria established for drinking water and recreational use.

Sediment Quality

Resin acid concentrations were elevated immediately downstream of Celgar and at Waneta. Up to a 40-fold increase in trace metal concentrations in sediments at Beaver Creek, downstream of Teck Cominco. Differences in acid volatile sulfide (AVS) and total organic carbon (TOC) levels among sites may have accounted for some of the differences in contaminant levels. The lack of sediment quality guidelines at the time of CRIEMP I made it difficult to assess potential impacts of contaminants in sediment to aquatic life.

Biota

With respect to the influence of contaminants on biota, plant data collected during CRIEMP I were inconclusive. Three benthic invertebrate community types were identified in the Lower Columbia River: The first was from Hugh Keenleyside Dam to a point upstream of Celgar, where the river was slow and deep. The second was a faster flowing section between the Kootenay River confluence and Teck Cominco (Robson and Birchbank sites). The third was from Teck Cominco to the International Border (Ryan Cr. and Waneta sites), where lower invertebrate abundance and diversity was interpreted as effects from smelter discharges. Sediment bioassays using amphipods (*Hyalella azteca*) showed that survivals were reduced in sediments sampled downstream of both Celgar and Teck Cominco.

Major Environmental Improvements since CRIEMP I:

Since the early 1990's there have been significant environmental improvements in the Lower Columbia River associated with effluent treatment and process upgrades at both Celgar and Teck Cominco, the two largest point sources of liquid contaminants.

Celgar pulpmill undertook a major facility upgrade and expansion between 1990 and 1993, improved the effluent treatment system and switched from elemental chlorine to chlorine dioxide for pulp bleaching, which reduced discharge of dioxins and furans from the mill to below analytical detection limits.

Teck Cominco ceased discharging slag (a by-product of smelting) to the river and closed the phosphate fertilizer plant (1995), constructed a new KIVCET lead smelter with improved air and water treatment systems (between 1997 and 1999), and installed a seepage collection system in the Stoney Creek watershed (completed in 1999). Improvements at Teck Cominco were designed to reduce metal loads to the Columbia River and the air.

Environmental and engineering initiatives undertaken since CRIEMP I are listed below:

TABLE 2-1
Initiatives Undertaken Since CRIEMP I

Organization	Initiative	Year
Min. Water, Land and Air Protection	water quality objectives & monitoring program for sediment, fish and water, Birchbank to US border	2000
Environment Canada	Pulp and paper mill Environmental Effects Monitoring (EEM)	since 1992
	automated water quality monitoring at Waneta	
Fisheries & Oceans Canada	mountain whitefish health studies	1992 to 1996
	studies into effects of TGP on fish	2001
BC Hydro	*Water Use Plan*	2001
	maintain flows during rainbow trout spawning period, salvage of exposed eggs, fry, adults maintain flow during mountain whitefish incubation	since1992
	fish community assessment	begun 2001
Columbia Power Corp.	Arrow Lakes Generating Station	2002
	Brilliant Upgrade, proposed Brilliant Expansion Project	2002
Teck Cominco Metals Ltd.	closure of the phosphate fertilizer plant; construction of zinc electrolytic and smelting plants, zinc pressure leaching plant, cadmium plant, cessation of slag discharge	1995
	construction of KIVCET lead smelter	1997 to 1998
	construction of Stoney Cr. seepage collection system	1997 to 1999
	wide-area Ecological Risk Assessment	ongoing
	1995/1999 receiving environment study	2001
Celgar Pulp Company	upgrade and expansion completed (lime kiln, recausticizing plant, ClO_2 generator, effluent treatment system, pulp machine, evaporators, recovery boiler, Kamyr fibre line)	1993
	elemental Cl_2 for bleaching replaced with 100% ClO_2	1993
	Environmental Effects Monitoring, now into Cycle 3	since 1993
Multi-partner projects	habitat compensation projects	
	White Sturgeon Recover Plan	
	Transboundary Gas Group	since 1998
	Arrow Lake Fertilization and Monitoring Program	since 1998

Celgar contaminant impacts:

Since CRIEMP I, Celgar has undergone major process upgrades which are listed in the Table above. Most of these upgrades have been undertaken to reduce the contaminant impacts from the pulpmill.

The zone of 1% effluent concentration extends a maximum of 6 km downstream of the diffuser under minimum flow conditions. A fibre mat downstream of the diffuser, containing wood fibre, flyash and process chemicals (resin and fatty acids, dioxins and furans), has been decreasing in size since 1975. The fibre mat contains higher levels of compounds related to pulpmill effluent (resin acids, fatty acids, total organic carbon - TOC, chlorinated phenolics, dioxins and furans), than in a Reference Area. Near Field sediments, outside the historic fibre mat area, reflect a low impact of pulpmill effluent relative to downstream stations.

Many studies conducted for Celgar relate to Environmental Effects Monitoring (EEM) programs required by EC and regulated under the *Pulp and Paper Effluent Regulations* (PPER) of the federal *Fisheries Act*. Cycle 1 was conducted between 1994 and 1996, with field work undertaken in fall 1994. Cycle 2 was conducted between 1997 and 2000, with field work conducted in 1998 and 1999. A third cycle began in 2001, with field work presently underway during 2002.

EEM Cycle 1 monitoring results include effluent bioassays (no chronic toxicity reported for rainbow trout, *Ceriodaphnia dubia*, algae, *Daphnia magna*) and sediment bioassays (no toxicity for *Chironomus tentans*, *Hyalella azteca*). Water quality objectives were met, with the occasional exception of dissolved oxygen (high due to dam operations), pH and chlorinated resin acids. Sediment assessments showed elevated chlorinated resin and fatty acids, chlorinated phenolics, TOC, dioxins and furans near Celgar.

During EEM Cycle 2, sublethal effluent toxicity tests showed little or no impact of effluent and indicated potential zones of sublethal effects up to 121 m from the diffuser. Water testing showed no toxic or nutrient enrichment effects attributable to pulpmill effluent. A healthy and diverse benthic invertebrate community was reported for each site, with high numbers of *Hydra* sp. at the Reference Area. The Near Field Area had lower numbers of invertebrates than other areas, but higher diversity, equitability and richness indices. Mountain whitefish from the Near Field Area were in better condition than those from the Reference Area in terms of size, age and weight, suggesting enhanced growth in the Near Field.

During the Celgar EEM program, low levels of various dioxins and furans were measured at all stations, including the Reference Area. Mountain whitefish muscle tissue (n=5) tested for dioxins and furans in 1998 contained 0.28 to 0.60 pg/g TCDD TEQ/g wet weight, well below the water quality objective of 1 pg TCDD TEQ/g wet weight and lower than in 1994. Monitoring of mountain whitefish and rainbow trout muscle tissue undertaken by MWLAP in fall 2000 indicated that the dioxin/furan objective (<1 pg

TEQ/g wet weight) was met in samples from Genelle and Beaver Creek. Organochlorine concentrations are expected to decline further in future, as organochlorine levels in the fibre mat continue to decline.

Teck Cominco Metals Ltd.

Teck Cominco Metals Ltd. currently smelts zinc, lead, cadmium, silver, gold, copper and other products from ores mined in various regions of North and South America. Teck Cominco has undertaken major upgrades since CRIEMP I (listed in the Table above) designed to increase economic productivity and reduce environmental impacts on air and water quality.

As a result of the elimination of slag discharge and operation of the KIVCET lead smelter, metal levels in receiving waters dropped considerably between 1995 and 1999. In 1995, zinc, copper, lead, cadmium and thallium objectives were exceeded at the Old Bridge sampling station and zinc, copper and cadmium objectives were exceeded at Waneta. In addition, zinc and cadmium objectives were exceeded at the Stoney Cr. sampling site. Improvements were noted in 1999, with objectives met for copper, lead and arsenic at sites outside the effluent mixing zone. Zinc, cadmium and thallium concentrations exceeded water quality objectives by only small amounts.

MWLAP measured water quality at a number of stations in the Lower Columbia River during 2000. Physical conditions met water quality objectives (WQOs) at all sites and concentrations of most contaminants were below WQOs. However, at several sites cadmium concentrations exceeded the WQO. Several metals (cadmium, copper, lead, thallium, zinc) immediately adjacent to Teck Cominco were elevated during October, 2000. The elevated levels of contaminants were interpreted as the consequence of a smelter malfunction prior to water quality analysis.

Metal levels in bottom sediment were considerably higher at Waneta than Birchbank, the two main depositional areas in this region of the river, in both 1995 and 1999. However, metal contaminant levels at Waneta decreased substantially by 1999, likely reflecting cessation of slag discharge. Results from sediment analysis (MWLAP) showed that sediment contaminants (arsenic, cadmium, copper, mercury, lead and zinc) continued to decrease during 2000, although arsenic, copper, lead and zinc continued to exceed sediment quality objectives.

During toxicity studies, thallium was identified as a toxic component of effluent from Teck Cominco, and the company has developed processes for its removal and recycling.

Public health investigations regarding mercury contamination resulted in fish consumption advisories for walleye (limit of one or two servings per week) in 1989. This advisory was lifted in 1995, following major reductions in mercury emissions from Teck Cominco and in mercury levels measured in walleye. Metal levels in rainbow trout and mountain whitefish were either non-detectable or well below fish tissue objectives during 1999 and 2000.

Municipal discharges

Sewage discharges from Castlegar, Trail and Nelson are not believed to create water quality problems. Receiving water near Trail is periodically monitored for bacteria (fecal coliform, *Escheria coli*, and enterococci) and results are typically below water quality objectives. Understanding of water quality impacts from municipal discharges in the Lower Columbia River could be improved by more frequent contaminant monitoring.

Fish Consumption Advisories

Consumption advisories for sportfish, issued in 1989, were lifted in 1995 for mercury levels in walleye and in 1996 for organochlorine levels in mountain whitefish and lake whitefish, reflecting considerable improvement in contaminant levels in the river.

Appendix 4: Summary of Information Related to Water Regulation for Hydroelectric Power Generation and Water Storage

There are three dams within the study area:

Keenleyside: storage dam built 1967, 8 km upstream of Castlegar, formed of concrete and earth, 58m high and 869m long, built and operated by BC Hydro for hydropower generation (as of 2002) and downstream flood control

Brilliant: run-of-river dam built 1944 on Kootenay R., 3 km above confluence with Columbia R., 39m high and 190m long, facility upgrades in 1949, 1967, and 2002, built by Cominco and operated by Utilicorp

Waneta: run-of-river dam built 1954, on Pend d'Oreille R. 0.5 km above confluence with Columbia R., 76m high and 290m long, additional turbines added in 1963 and 1966, built by Cominco and operated by Utilicorp

Approximately 96% of the river flow at the Canada-US border is regulated, with about 39% of total annual flow at the border passing through Hugh Keenleyside Dam, 30% through Brilliant Dam and Kootenay R., and 27% through Waneta Dam and Pend d'Oreille R. The remaining 4% flows in through small tributaries.

The hydrologic regime in the Lower Columbia River has been altered primarily by Keenleyside water storage and releases. Brilliant and Waneta, designed as run-of-river dams, have minimal water storage and only minor influence on the downstream hydrograph.

Effects of flow regulation in the lower Columbia River include changes in:

- flow regime
- water velocity
- water depth
- temperature
- habitat
- total dissolved gas pressure
- nutrient cycling
- effluent dilution
- oligotrophication of Arrow Reservoir
- fluctuating water levels ⟷ stranding of fish and fish eggs
- fluctuating water levels ⟷ periphyton and benthic invertebrates

Since CRIEMP I, BC Hydro and Columbia Power Corp. have undertaken numerous large-scale habitat and fisheries assessments, and a number of annual monitoring programs at Hugh Keenleyside and Brilliant Dams. The preparation of a *Water Use Plan*, which summarized studies and initiatives to date (RL&L, 2001) involved consultation with various stakeholders to consider and balance competing water uses such as hydroelectric, industrial, recreational, community, flood management and fish habitat values. Columbia River environmental issues addressed by the *Water Use Plan* include oligotrophication of the Arrow Reservoir, elevated dissolved gas levels downstream of the Keenleyside Dam and altered habitat quality and availability (related to fluctuating water levels, dewatering of nearshore areas, stranding of fish, eggs and benthic invertebrates).

Elevated dissolved gas levels generated downstream of dams do not dissipate quickly, and tend to increase cumulatively downstream. High gas levels may affect fish populations, with greatest potential effects on survival and behaviour of fish in shallow waters. The Transboundary Gas Group was established in 1998 to further investigate total gas pressure issues and coordinate efforts in BC and Washington State; several members of the CRIEMP TGP (total gas pressure) subcommittee sit on the Transboundary committee.

Water quality guidelines have been established to protect fish from high TGP levels. The BC guideline is 110% TGP (110% total saturation at sea-level conditions) for water greater than 1 m depth and 103% TGP for water shallower than 1 m. Currently, the objective is met most of the year, but generally not in late summer, when flows are greatest. The effect of elevated TGP on fish is similar to the “bends” in human divers – most apparent when moving from deep to shallow water. Fish are most susceptible in shallow nearshore waters.

The most common effect of elevated gas pressure is gas bubble trauma (GBT), appearing as bubbles in the gills, vascular system, fins and eyes, and as overinflation of the swim bladder. GBT can produce both lethal or sublethal effects (disorientation, reduced feeding efficiency), depending on gas levels, species and life cycle stage, exposure time, water depth and temperature. The biological implications of GBT on fish populations downstream of the Keenleyside Dam are unclear (RL&L, 2001). During the 1990’s rainbow trout and mountain whitefish numbers downstream of the Keenlyside Dam were stable or increasing, suggesting that TGP has not dramatically reduced these fish populations in this portion of the river (RL&L, 2001).

Historically, TGP levels have been elevated downstream of Hugh Keenleyside Dam with levels greater than 140% TGP measured over extended periods during the summer. BC Hydro has conducted many TGP studies in the Columbia River under varying dam operations since the early 1990s, and has modified operations to reduce levels at sensitive times of year (RL&L, 2001). At Hugh Keenleyside Dam, use of spillways to discharge water result in the highest TGP levels, and use of low level ports result in lower TGP levels. However, the spillway facilities are used most consistently during the high flow period, July to October. Aspen Applied Sciences Ltd. developed and refined a computer model that recommends real-time operations to reduce TGP and indicates hazards in areas of the river that are extensively used by sportfish. However, decisions to modify discharge patterns must be balanced with structural safety issues of the dam, as well as the health of downstream aquatic communities.

TGP conditions in the lower Columbia River are also influenced by the inflow of water from the Kootenay and Pend d'Oreille Rivers, which also contribute TGP, mainly from May to late June, when tributary flows are maximal. TGP levels are elevated in the Arrow Reservoir itself, likely associated with upstream dam operations (Mica and Revelstoke dams), and increase downstream of the dam. Although maximum TGP levels have not changed over the years, the duration has decreased as a result of operational changes. BC Hydro and Columbia Power Corp. have adjusted operations to reduce TGP levels. A hydroelectric generating plant that is being installed at Hugh Keenleyside Dam and upgrades to the Brilliant Dam are predicted to reduce future generation of dissolved gas in the river.