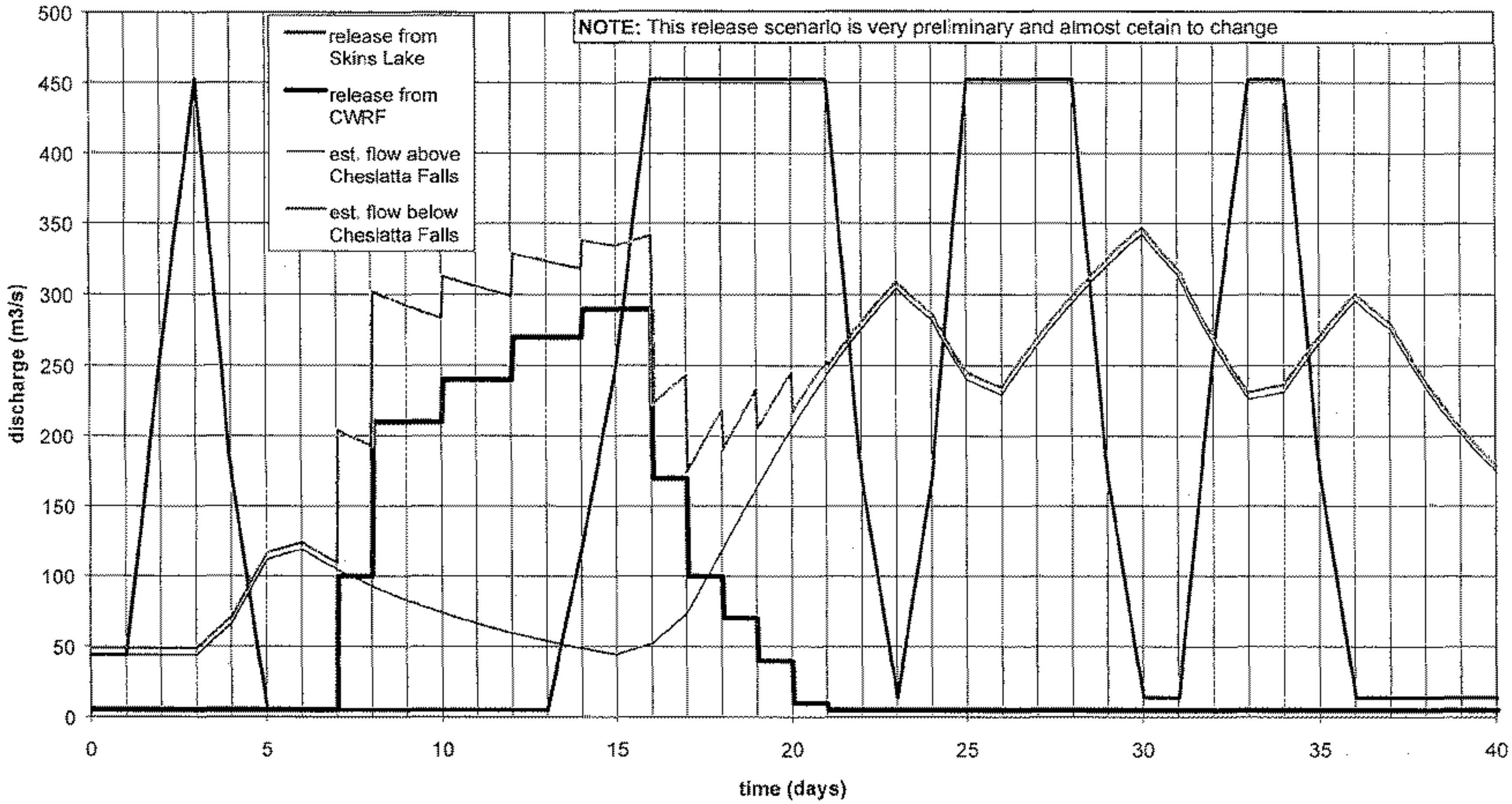

Figure 5.2.2-2 Assumed magnitude and duration of third Commissioning Pulse

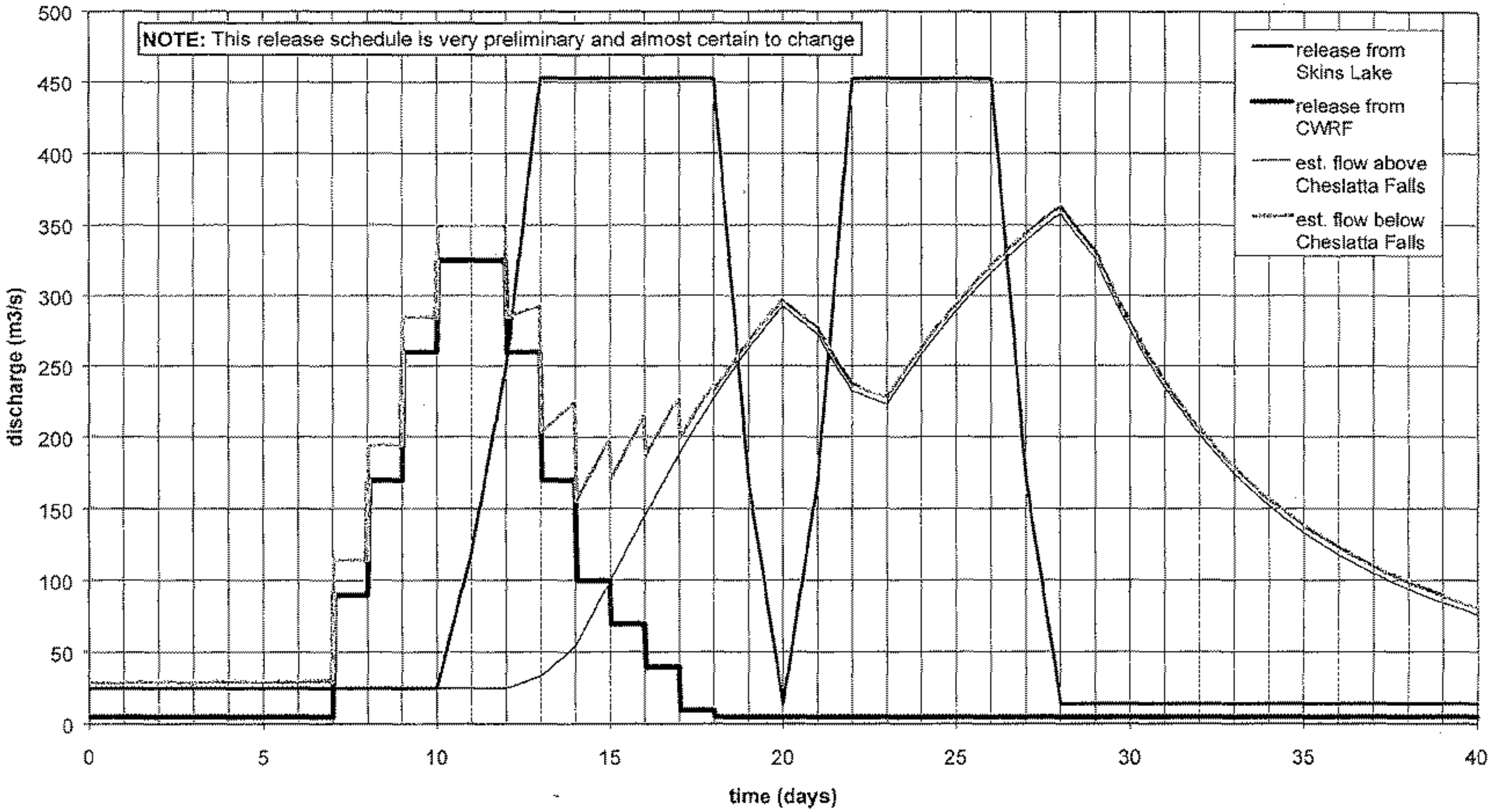

Figure 5.2.2-3 Assumed magnitude and duration of fourth commissioning pulse

In the scenario represented by the above table, the second and third pulses would require the largest total volumes of water. The fourth pulse would require the highest peak discharge, but a lesser flushing requirement is anticipated afterward, as the suspended sediment concentrations are expected to be much less than those created by the earlier pulses

5.3 Monitoring Program

5.3.1 Collection of Baseline Data

The objective of baseline monitoring is to provide a set of data against which future measurements can be compared to determine impacts of a change. In this case, the main concern is the effect of the sediment transported through the reach on fish habitat. It is recommended that the following baseline parameters be measured in advance of the reactivation flows:

- sands and fines content in the upper gravel layers at precisely known locations on several prime spawning beds along the Nechako River below Cheslatta Falls;
- suspended sediment concentrations throughout the June 1 through August 20 time window at several locations along the Nechako River and major tributaries where the concurrent discharge can be determined;
- cross sections of the existing channel at a several representative locations in the canyon where erosion induced changes are expected, and at about 12 locations on the Cheslatta Fan;
- grain size distributions for soils along the existing channel across Cheslatta Fan at locations that are likely to erode, to provide the approximate composition of the material that will be transported off the fan; and
- numbers, species, size and age of fish using the existing channel habitat in the canyon and on the fan in two different seasons of the year.

5.3.2 During and After Initial Set of Commissioning Flows

Intensive monitoring is recommended during the initial pulse of flow through the canyon and fan and during the passage of flushing flows from the Skins Lake spillway. The key parameters that should be monitored include the following:

- suspended sediment concentration at the downstream end of the fan above Cheslatta Falls (continuous), at a point below Cheslatta Falls where the flows from the canyon and the Cheslatta River are thoroughly mixed, at key downstream spawning areas on the Nechako River, at all the gauges on the Nechako River, and at the Nechako River Mouth at Prince George; and
- the water level at several locations on the fan including Scour Hole Lake (continuous).

After the initial set of releases have passed, the following measurements should be made and compared to the baseline data:

- sands and fines content in the upper gravel layers at precisely known locations on several prime spawning beds along the Nechako River below Cheslatta Falls;
- cross sections of the existing channel at several representative locations in the canyon where change due to erosion is expected, and at about 12 locations on the Cheslatta Fan;

- numbers, species, size and age of fish using the existing channel habitat in the canyon and on the fan in two different seasons of the year; and
- usage of spawning areas by fish at the same areas where the sand and fines content in the gravel layer are measured.

It will be necessary to be able to measure the suspended sediment concentration relatively quickly at the downstream end of the fan in order to effectively use the information to influence the magnitude of the releases from the CWRF. The standard method of sampling and analysis by filtering the sample, then drying and weighing the filters may be too slow to be effective, as the changes in sediment concentration are expected to occur rapidly, and a rapid response system is warranted.

An alternative approach might be to correlate turbidity to suspended sediment concentration, and to use a turbidity meter to provide immediate and continuous measurements. This relationship would have to be estimated in advance, then frequently verified, because as the flushing proceeds, the fine organic sediment is probably the first to be mobilized and the first to be depleted, possibly changing the relationship between turbidity and suspended sediment concentration. Also, larger flows will entrain increasingly larger sized particles, and this would also likely affect that relationship.

5.3.3 Subsequent Commissioning Flows

The experience gained during the initial pulse will almost certainly affect the future monitoring program, as this aspect should be adaptively developed as well as the flow releases schedule. At this time, only the same set of parameters recommended in the preceding section were identified for monitoring in subsequent years, namely the following:

- suspended sediment concentration at the downstream end of the fan above Cheslatta Falls (continuous), at a point below Cheslatta Falls where the flows from the canyon and the Cheslatta River are thoroughly mixed, at key downstream spawning areas on the Nechako River, at all the gauges on the Nechako River, and at the Nechako River mouth at Prince George.
- bed load movement at the downstream end of the fan above Cheslatta Falls
- the water level at several locations on the fan including Scour Hole Lake (continuous).

After each subsequent set of releases have passed, the following measurements should be made and compared to the earlier sets of data, including baseline:

- sands and fines content in the upper gravel layers at precisely known locations on several prime spawning beds along the Nechako River below Cheslatta Falls
- cross sections of the existing channel at a several representative locations in the canyon where erosion induced changes are expected, and at about 12 locations on the Cheslatta Fan
- numbers, species, size and age of fish using the existing channel habitat in the canyon and on the fan in two different seasons of the year
- usage of spawning areas by fish at the same areas where the sand and fines content in the gravel layer are measured.

6.0 CONCLUSIONS

6.1 Hydrology and Channel Morphology

1. The construction and operation of Kenney Dam has significantly altered the flow and sediment regime of Nechako River. Average and peak flows have been reduced, the seasonal distribution of flow has been altered and the sediment loads from the upper river have been eliminated.

2. Significant quantities of sediment were transported through Nechako Canyon prior to the construction of Kenney Dam. Large, mobile gravel bars were present upstream and downstream of the Cheslatta confluence.

3. Post regulation sediment accumulations in the Nechako Canyon consist of:
   - materials derived from a spoil pile situated on the left bank of the river, approximately 0.4 km downstream of Kenney Dam;
   - natural deposits on the former river bottom and material thought to have originated from the fill placed during the early phases of dam construction;
   - fine textured, organic rich sediments that have been deposited in small ponds in the upper part of the canyon; and
   - small fans that have developed at the outlets of two small streams.

4. Aerial photograph analysis and site inspections indicate that the location and volume of potentially mobile sediment has not changed significantly since Triton's previous study in 1991. Their volume estimate of 28,000 m^3 (comprised on unconsolidated clay, silt, sand and pond materials) could be somewhat high, but appears reasonable for planning purposes.

5. Hydraulic and sediment transport calculations confirm that the deposited sediments would be mobilized and transported out of the canyon by relatively small flows during the earlier stages of canyon flushing, likely creating high suspended sediment concentrations and turbidity.

6.2 Vegetation

6. Although not quantified by field sampling, observations and ground photographs in September 2002 indicated that there is not a large amount of woody material available for downstream transport if the Nechako Canyon were to be rewatered. This observation lessens the concern about how to handle vegetation debris expressed in the Triton (1991) report.

7. At present it is not possible to quantify the volume or biomass of woody material that would be flushed from Nechako Canyon into Scour Hole Lake. However, September 2002 field observations did confirm that much of the flushed woody material would be small pieces, much of it from small trees under 5 m tall.

8. Plant material subject to removal would be biomass accumulated since dewatering of the canyon in the 1950's. There were no large trees within Nechako Canyon at elevations potentially susceptible to removal during rewatering of the canyon. The trees found in the canyon are generally less than 22 cm in diameter and shorter than 15 m in height. These sizes, in relation to

the width of the channel, are not expected to create massive accumulations of woody debris that could suddenly break and release. The presence of mobile vegetation, large or small, is not expected to have significant adverse impacts on the aquatic ecosystem.

9. The greatest potential for large trees to be removed by reactivation of Nechako River flows is on the southeastern flank of the Cheslatta Fan where an 'island' of relatively old trees survived the depositions of alluvial fan material in 1961. Air photos since 1950 indicate that there are less than 50 large trees at this location.

10. Cottonwoods occur naturally on the Cheslatta Fan and the downstream section of the Nechako River. Their presence will assist in implementing guidelines to encourage a broadleaf deciduous component of the forest as called for in the Nechako Canyon Resource Management Zone and the Upper Nechako River Resource Management Zone.

11. At present, there are no obvious concerns for rare or endangered plant species in the area that would be rewatered. Most of the area that would be flooded is occupied by vegetation that has established in the canyon since the early 1950s. Plant species with the ability to establish on habitats newly exposed by dewatering 50 years ago do not fit the concept of rare or endangered species.

6.3 Fish and Wildlife

12. Field observations in September 2002 and the hydraulic modeling studies indicate that:
    - Beavers will be displaced from the canyon and remnant river channel as flushing flows will wash out the existing dams and the maintenance flows will prevent new dams from being constructed.
    - Larger forms of wildlife such as moose will no longer be able to use the canyon as a migration corridor, except possibly when discharges from the CWRF are very low.
    - Water velocities during periods of high discharge may create velocity barriers, particularly for juvenile fish. It is difficult to assess how significant this is, as the flow regime of the CWRF is not yet known and the micro-habitat conditions in a complex environment such as the canyon are difficult to predict.

13. The potential impacts on fish and wildlife will result in a localized change in distribution and habitat use. These impacts are not considered to be significant as none of the species affected are red or blue listed, habitat in the canyon and near the fan is not "critical" and there is abundant habitat in downstream areas. Following commissioning of the CWRF, flow conditions would be more similar to pre-impoundment conditions. Furthermore, the benefits that the CWRF would have for the long-term management of the Nechako River would offset the localized impacts in the canyon or the remnant river channel around the fan.

6.4 The Cheslatta Fan Channel

14. The Cheslatta Fan appears to have developed over the period between 1961 when the Cheslatta River shifted course and the mid 1970's when a saddle dam was constructed to force the river back into its original course. This avulsion resulted in the:
    - partially impoundment of the upstream scour hole (Scour Hole Lake) and raising the water level;
    - confinement of the Nechako River to a 30 to 40 m wide remnant channel along the right bank valley wall; and
    - infilling of a pre-existing scour hole located upstream of the Cheslatta confluence.

15. The remnant channel around the Cheslatta Fan is well defined at both the upper end near Scour Hole Lake and in the lower portion near the "Neck." The central portion of the channel is poorly defined and heavily influenced by beavers. The remnant channel carried a substantial portion of the Cheslatta River discharge at times during the formation of the fan.

16. Of the 14 options reviewed in the NEEFMC report by Hayco, *Options for Passing Flows through the Cheslatta Fan*, our study team concurred with the elimination of 12 of them, leaving only the Meandering Pilot Channel (Option 12) and the River-cut Channel (Option 13) for more detailed assessment.

17. The proposed Meandering Pilot Channel is likely to shift into the existing channel when discharges exceed the limited capacity of the pilot channel. A continuous armoured dyke between the pilot channel and the existing channel would be required to prevent this avulsion due to the lower elevation of the existing channel.

18. We did not concur with Hayco's relative ranking of the impacts of their Meandering Pilot Channel and River-cut Channel options, in which they perceived substantially worse sediment generation consequences from the River-cut Channel option. In our view, considering the potential for the pilot channel to shift back into the existing channel across the fan, both concepts would result in very similar sediment mobilization scenarios and downstream impacts. Also, we differ with Hayco's conclusion that the River-cut Channel option would result in a braided channel across the fan.

19. The cost of the Meandering Pilot Channel was re-estimated at $1.41 million. This estimate did not include the costs of water with which to commission the channels, bioengineering for bank protection, environmental studies, permits, approvals, and monitoring.

20. Three new options were evaluated for the present study:
    - Option A, named the Reactivated Natural Channel Option, was similar to Hayco's River-cut Channel Option except that it includes careful channel commissioning using an adaptive management approach, and bioengineering to stabilize the riparian areas adjacent to the proposed channel.
    - Option B, is the same as Option A except for the addition of a short pilot side channel, two berms and a short revetment.

- Option C, calls for construction of a large concrete slot structure on the Nechako River downstream of Cheslatta Falls.

21. The costs of Options A, B and C are estimated to be zero, $0.7 million, and $2.3 million, respectively. These cost estimates exclude the costs of water with which to commission the channels, bioengineering for bank protection, environmental studies, permits, approvals, and monitoring. The water used for commissioning flows in a low or average water year, would have to be taken from water normally allocated for power production, hence there would an additional cost associated with commissioning Option A or B. In a high water year commissioning could be carried out with surplus water that would have to be spilled from the reservoir, thus the cost would be negligible.

22. The evaluation of the Meandering Pilot Channel Option and Options A, B and C, using Hayco's evaluation matrix, indicates Option A is the best choice, with Option B a close second. Each of the four independent additional elements of Option B (the pilot side channel, the two berms and the revetment) offers a modest environmental benefit at a modest cost. If required, one or more of these additional features could be added to Option A.

23. Option C is clearly the poorest choice, and is not deemed feasible.

24. Although the Meandering Pilot Channel Option, proposed by Hayco (2000), is considered feasible, it ranks below Options A and B.

25. The issue of constructability of the main channel across the fan in Options A or B is addressed by the commissioning strategy, as the channels would be formed by flowing water.

26. The pilot side channel, berms and revetment of Option B are deemed constructable. Although the need for dewatering the pilot side channel excavation and the possibility of weak foundations in the locations where the berms and side channel are proposed would pose construction challenges, these would be neither insurmountable nor prohibitively expensive to deal with.

27. It appears feasible to flush the accumulated sediment out of the Nechako Canyon and to enlarge a reactivated channel across Cheslatta Fan using only flows from the CWRF. The negative impacts of increased sediment loads on the downstream aquatic environment can be managed. However, to do so will require a departure from traditional regulatory suspended sediment criteria, because there is no way to remove the fine sediment from Nechako Canyon, nor to create a natural self-enlarging channel across Cheslatta Fan, without exceeding these criteria by a large margin.

28. It is not possible to calculate or otherwise predict the rates of sediment transport along the bed of the river or the concentrations of suspended sediment that would occur as a result of the initial stages of the commissioning process. It appears likely that instantaneous sediment concentrations could reach 10 g/L at the canyon mouth and on the fan prior to dilution at Cheslatta Falls; however, these concentrations would not be sustained for long due to the limited volume of fine material to be flushed out.

29. Research by Newcombe and others has shown that juvenile and adult salmonids can tolerate short-term exposures to suspended sediment concentrations that are much higher than some of the commonly employed regulatory criteria without suffering mortality. The exposure-effect relationship developed by Newcombe (e.g., Newcombe and Jensen 1996, Newcombe 2003) can be used to guide the adaptive management process (see below) used to flush fine sediments from the canyon and form a channel around the fan.

30. The volume of water required to commission the Option A or B channels cannot be estimated with any certainty in advance, since the volume required would partly depend on the concentrations of suspended sediment generated, and on the rules for flow releases at Kenney Dam that would be developed during the adaptive management process. A series of assumed flow release scenarios that would occur over four separate years suggest that net additional water volumes ranging from 7% to 12% of the total average annual inflow to the Nechako Reservoir in each of these four years may be adequate to fully commission the channel. This 4-year total is 2.4 billion m^3 of water, or about 3 m of depth in the reservoir.

31. It must be recognized that implementing any of the self-enlarging channel options will involve some risk of higher sediment loads, unexpected sediment deposition patterns downstream, and/or greater water volume requirements than anticipated in studies prior to commissioning. However, it is the unanimous opinion of our study team that the risks of the short-term negative environmental impacts associated with rewatering the Nechako Canyon and allowing the creation of a self-enlarging natural channel across the Cheslatta Fan would be significantly outweighed by the substantial long term environmental benefits. More natural annual flow patterns on the Nechako River and restoration of the Cheslatta River can only be achieved by building the CWRF.

7.0 RECOMMENDATIONS

7.1 General

1. Sufficient information now exists to determine whether the proposed flushing flows are an acceptable method of removing sediment from the Nechako Canyon and commissioning the proposed channel across Cheslatta fan. To expedite enhancement of the Nechako and Cheslatta systems and the sturgeon recovery efforts, we would encourage the Nechako Enhancement Society to make this decision as soon as possible.

7.2 Nechako Canyon

2. The study team recommends that the sediments deposited in the Nechako Canyon be flushed out of the canyon using flows from the CWRF. If required, sediment loads could be reduced by protecting the toe of the spoil pile near the dam from erosion and by possibly pre-excavating beaver dam or fluvial materials from the vicinity of the two fans. It would not be technically or economically feasible to remove all other sediment deposits.

3. It is recommended that the small trees that have grown in Nechako Canyon since it was dewatered be removed by canyon flushing without advance cutting, piling, and burning of the trees.

4. A detailed field inventory for a better estimate of the volume of woody material potentially flushable from the canyon is not recommended at this time.

7.3 Cheslatta Fan

5. We recommend forwarding Option A to the next stage of study and evaluation, subject to a clear indication from all the regulatory agencies involved that they will be willing accept alternative suspended sediment concentration-duration criteria for the purpose of evaluating this project. If this willingness is not forthcoming, then there is no point in proceeding with this project.

6. If the pilot side channel or berms proposed for Option B are to be included in the final plan, then additional survey, test pits, drilling and geotechnical investigations should be included in future studies.

7.4 Commissioning Flows

7. We recommend a series of progressively larger releases from the CWRF to flush sediment from the Nechako Canyon and to commission the proposed channel across Cheslatta Fan. These flows would be manipulated to ensure that water turbidity or suspended sediment concentrations and durations did not cause mortality to fish in the lower Nechako River by applying new criteria that would be based on research by the BC Government (see Newcombe and Jensen 1996, Newcombe 2003).

8. The CWRF releases should be increased in stages over time to control the quantity of sediment mobilized by the flow at any one time. The primary means of protecting the downstream habitat should be an adaptive management technique that would ultimately control the rate of flow being released through the Nechako Canyon and Cheslatta Fan on the basis of continuously monitored suspended sediment concentrations and/or turbidity levels.

9. As part of the adaptive management strategy, intensive monitoring of sand and finer material in prime spawning areas in the Nechako River should be conducted before and after each set of releases. This would allow the next set of releases to be adjusted if necessary to prevent the entrainment of unacceptable quantities of fine materials.

10. The commissioning flows should be released during the period from May 15 to August 20, and preferably in the early part of that period when the pre Kenney Dam flows would have been high and turbid. The first set of commissioning flows should involve only small discharges (to a maximum of 60 m^3/s) and should be used as an intensively monitored test case to provide data for planning subsequent releases. After these commissioning flows have peaked, they should be reduced in steps to determine the maximum discharge from Kenney Dam that does not entrain significant amounts of fine sediment. This should allow the CWRF to become at least partially operational immediately after the initial set of commissioning flows.

11. Once each set of releases through the canyon and fan has ended, or is reduced to such a low flow such that the mobilization of new sediment effectively stops, the pulse of sediment laden water released downstream should be diluted and flushed all the way to the confluence of the Nechako and Fraser Rivers at Prince George. To ensure the lower river has been cleared of suspended sediment, the flushing flows from the Cheslatta River should not be substantially reduced for at least five days after the cessation of turbid flushing releases from the canyon and fan.

12. To flush sand and fines from the gravel portions of the riverbed, the peak discharge of the flushing flows downstream of Cheslatta Falls should, at some time after cessation of releases through the canyon and fan, equal or exceed the peak discharge downstream of Cheslatta Falls during the releases through the canyon and fan. It would be desirable that this peak flow be great enough to mobilize the surface armour layer in most gravel spawning areas.

13. The flushing discharges from the Cheslatta system should not be constant, but fluctuate as much as possible to provide a series of rising and falling flows to winnow sand and fines from the channel bed and redeposit this material on the channel margins.

14. The combined flows from the CWRF, from Skins Lake spillway and from local inflow should not exceed levels that would cause flood damages in developments in riparian areas along the Nechako River.

8.0 REFERENCES

Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region, Parts 1 and 2. BC Ministry of Forests, Victoria, BC Land Management Handbook No. 26. 2 volumes.

Beaudry, P.G., D.L. Hogan, and J.W. Schwab. 1990. Hydrologic and geomorphic considerations for silvicultural investments on the lower Skeena River floodplain. Forestry Canada and BC Ministry of Forests, Victoria, BC. FRDA Report 122. 41 p.

Bradley, K.M. and N.M. Peterson. 2002. Nechako River cold water facility bibliography. Prepared by Environmental Dynamics Inc., Prince George, BC and Western Ecological Services, Victoria, BC for the Nechako Enhancement Society, Victoria, BC. 67 p.

Brink, V.C. 1954. Survival of plants under flood in the lower Fraser River valley, British Columbia. Ecology 35:94-95.

Cadden, D. Fish and Wildlife Section Head, Ministry of Water, Land and Air Protection, Prince George, BC, personal communication.

Cadden, V. 2000. Review of historical white sturgeon distribution within the Nechako River watershed. Prepared by Norcan Consulting Ltd Prince George, BC for BC Ministry of Environment, Lands and Parks, Omineca Sub-Region, Prince George, BC. 21 p. + 3 appendices.

Caine, Nel. 1980. The rainfall intensity-duration control of shallow landslides and debris flows. *Geografiska Annaler*, v. 62A. pp. 23-27.

Cotic, I., J. Van Barneveld and P.N Sprout. 1976. Soils of the Nechako-Francois Lake Area - Interim Report. Soils Branch, Department of Agriculture, Kelowna, British Columbia.

Dhaliwal, D. Alcan, Kittimat, BC. personal communication.

Diakow, L.J., I.C.L. Webster, T.A. Richards and H.W. Tipper. 1997. Geology of the Fawnie and Nechako Ranges, Southern Nechako Plateau, British Columbia. *In*: Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies. Geological Survey of Canada, Open File 3448. pp.1-30.

Envirocon Limited. 1984a. Environmental studies associated with the proposed Kemano completion hydroelectric development. Volume 9. Vegetation resources baseline information. Prepared for Aluminum Company of Canada, Ltd., Vancouver, BC. 127 p.

Envirocon. 1984b. Environmental studies associated with the proposed Kemano Completion Hydroelectric Development. Volume 5. Fish resources of the Nechako River system: Baseline Information. Prepared by: Envirocon Ltd., Vancouver, BC. for the Aluminum Company of Canada Ltd., Vancouver, BC. 415 p.

Fisheries Information Summary System (FISS). 2000. BC Ministry of Environment, Lands, and Parks, Victoria, BC. Website (http://www.bcfisheries.gov.bc.ca/fishinv/fiss.html), searched January 14, 2003.

Fyles, J.W. and M.A.M. Bell. 1986. Vegetation colonizing river gravel bars in the Rocky Mountains of southeastern British Columbia. Northwest Science 60:8-14.

Gottesfeld, A.S. and L.M.J. Gottesfeld. 1990. Floodplain dynamics of a wandering river, dendrochronology of the Morice River, British Columbia, Canada. Geomorphology 3:159-179.

Government of British Columbia. 1997. Vanderhoof land and resource management plan. Prepared by the BC Ministry of Forests, Ministry of Employment and Investment, and Environment, Lands, and Parks, Victoria, BC.

Hay and Company Consultants Inc. (Hayco). 2000. Options for passing flows through the Cheslatta Fan. Prepared by Hay and Company Consultants Inc., Vancouver, BC and Aquatic Resources Ltd., Vancouver, BC for the Nechako Environmental Enhancement Fund Management Committee. 33 p. + figures.

Hazel, J.E. Jr., M. Kaplinski, R. Parnell, M. Manone and A. Dale. 1999. Topographic and bathymetric changes at thirty-three long-term study sites. In: The Controlled Flood in Grand Canyon, Geophysical Monograph 110. American Geophysical Union, Washington, DC. pp. 161-183.

Huang, S. 1994. Ecologically based individual tree volume estimation for major Alberta tree species. Report #5 – Ecologically based individual tree volume tables for white spruce (*Picea glauca* (Moench) Voss). Alberta Environmental Protection, Land and Forest Services, Edmonton, Alberta. Publication T/294. 99 p.

Huang, S., S.J. Titus, and T.W. Lakusta. 1994. Ecologically based site index curves and tables for major Alberta tree species. Alberta Environmental Protection, Land and Forest Services, Edmonton, Alberta. Publication T/307. 112 p.

Journeay, J.M., S.P. Williams and J.O. Wheeler, 2000. Tectonic assemblage map, Prince George, British Columbia. Geological Survey of Canada, Open File 2948e, scale 1:1,000,000.

Julien, P.Y. 1995. Erosion and sedimentation. Cambridge University Press, Cambridge, UK.

Kellerhals, Rolf, 1967, Stable channels with gravel-paved beds. Journal of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineering, Vol. 93, no WW1, pp 63 - 84.

Kellerhals, R., and D.I. Bray. 1971. Sampling procedures for coarse fluvial sediments. ASCE Proceedings, Vol. 97 No. HY8.

Kellerhals, R., M. Church, and L.B. Davies. 1979. Morphological effects of interbasin river diversions. Canadian Journal of Civil Engineering 6: 18-31.

Klohn Leonoff Consulting Engineers. 1989. Kemano Completion Project – Summary of information for the Technical Committee Nechako Fisheries Compensation Program, Cheslatta Fan Improvements, Preliminary Design Development. Prepared by Klohn Leonoff Consulting Engineers, Vancouver, BC for the Aluminum Company of Canada Ltd., Vancouver, BC. 7 p + appendices.

Klohn Leonoff Consulting Engineers. 1991a. Kenney Dam Release Facility Flood Operation Study. Report to Alcan Smelters and Chemicals Ltd. January.

Klohn Leonoff Consulting Engineers. 1991b. Kemano Completion Project – Cheslatta Channels Design Report. Prepared by Klohn Leonoff Consulting Engineers, Vancouver, BC for the Aluminum Company of Canada Ltd., Vancouver, BC. 61 p + appendices.

Klohn Crippen. 2001. Water Release Facility at Kenney Dam. Updated Conceptual Layout and Cost Estimate. Report No? KC-155(PP1229) prepared for Nechako Environmental Enhancement Fund Management Committee.

Klohn Leonoff. 1991a. Kenney Dam Release Facility Flood Operation Study. Report to Alcan Smelters and Chemicals Ltd. January.

Klohn Leonoff. 1991b. Kemano Completion Project - Cheslatta Channels Design Report. Report to Alcan Smelters and Chemical Ltd. March.

Klohn Leonoff and Triton Environmental Consultants. 1991. Kemano Completion Project - Kenney Dam Release Facility Summary Report. Report to Alcan Smelters and Chemicals Ltd., March.

Korman, J. and C. Walters. 2001. Nechako River White Sturgeon recovery planning: summary of stock assessment and Oct. 2-3, 2000 Workshop. Prepared by Ecometric Research Inc., Vancouver, BC and Fisheries Center, University of British Columbia, Vancouver, BC for BC Fisheries, Victoria, BC. 26 p.

Krasny, M.E., J.C. Zasada, and K.A. Vogt. 1988a. Adventitious rooting of four Salicaceae species in response to a flooding event. Canadian Journal of Botany 66:2597-2598.

Krasny, M.E., K.A. Vogt, and J.C. Zasada. 1988b. Establishment of four Salicaceae species on river bars in interior Alaska. Holarctic Ecology 11:210-219.

Larsen, L., Floodplain Technician, Ministry of Water, Land, and Air Protection, Prince George, BC, personal communication.

Lowe, C., V.M. Levson, L.C. Struik, A. Plouffe, R.G. Anderson, and D. Mate. 2001. Shaded-relief digital elevation model, Nechako River map area, British Columbia: an aid to geoscience studies. Geological Survey of Canada, Open File 4027, scale 1:250,000.

McLennan, D.S. 1991. Black cottonwood: ecological site quality and growth in British Columbia. Forestry Canada and B. C. Ministry of Forests, Victoria, BC, FRDA Memo 183. 8 p.

McLennan, D.S. and T. Johnson. 1999. Assessment and restoration of ecological functions of riparian ecosystems in British Columbia: ecological principles and practical applications. *In* B. Egan, editor. Helping the Land Heal, Ecological Restoration in British Columbia, Conference Proceedings, November 5-8, 1998, Victoria, BC, BC Environmental Network Educational Foundation, Vancouver, BC. pp. 138-145.

McLennan, D.S. and A.-M. Mamias. 1992. Cottonwoods in British Columbia: problem analysis. Forestry Canada and BC Ministry of Forests, Victoria, BC. FRDA Report. 195. 50 p.

Massie, M.R.C., E.B. Peterson, N.M. Peterson, and K.A. Enns. 1994. An assessment of the strategic importance of the hardwood resource in British Columbia. Forestry Canada and BC Ministry of Forests, Victoria, BC. FRDA Report 221. 206 p.

Meidinger, D., J. Pojar, and W.L. Harper. 1991. Sub-Boreal Spruce Zone. *In* D. Meidinger and J. Pojar, editors. Ecosystems of British Columbia. BC Ministry of Forests, Victoria, BC. Special Report Series 6. pp. 209-221.

Nanson, G.C. and H.F. Beach. 1977. Forest succession and sedimentation on a meandering-river floodplain, northeast British Columbia, Canada. Journal of Biogeography 4:229-251.

Nechako Watershed Council (NWC). 2002. Proposed work plan for the cold water release facility at Kenney Dam. Prepared for Minister of Competition, Science and Enterprise, Victoria, BC. 32 p. + appendices.

Nechako Environmental Enhancement Fund (NEEF). 2001. Report of the Nechako Environmental Enhancement Fund Management Committee. 34 p.

Newcombe, C. 2003. Impact assessment model for clear water fishes exposed to excessively cloudy water. Journal of the American Water Resources Association. In press.

Newcombe, C. 2002. Impact assessment model for clear water fishes exposed to conditions of reduced visual clarity. Habitat Branch, Ministry of Environment, Lands and Parks. 16 p.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16: 693-727.

northwest hydraulic consultants ltd (nhc). 2002a. Nechako River geomorphology Assessment phase 1: Historical analysis of lower Nechako River. Draft Report submitted to BC Ministry of Water, Land and Air Protection.

northwest hydraulic consultants ltd (nhc). 2002b. Nechako River substrate quality and composition project: Comparison of 1992 and 2000 freeze-core sample results. Nechako Fisheries Conservation Program Technical Committee. 16 pages + appendices.

Obedkoff, W. 2001. Streamflow in the Skeena Region. Report prepared by the Water Inventory Section, BC Ministry of Environment Lands and Parks.

Peterson, E.B., N.M. Peterson, and D.S. McLennan. 1996. Black cottonwood and balsam poplar managers' handbook for British Columbia. Forestry Canada and BC Ministry of Forests, Victoria, BC. FRDA Report 250. 116 p.

Plouffe, A and S.P. Williams. 2001. Quaternary geology data: Manson River (93N), Fort Fraser (93K) and Nechako River (93F), central British Columbia. Geological Survey of Canada Open File D2270. CDRom.

Porter, G.L. 1990. Willow species of disturbed sites in the Sub-Boreal Spruce Zone in north-central British Columbia. Forestry Canada and BC Ministry of Forests, Victoria, BC, FRDA Handbook 6. 67 p.

Read, D. and D. Rogers. 2003. Nechako Cold Water Release Facility long-term communication plan. Prepared by Aspen Communication Ltd., Prince George, BC and Denis & Muntener Advertising Ltd., Prince George, BC for the the Nechako Enhancement Society, Victoria. In prep.

Reksten, D. 1994. Study 287 Nechako Reservoir Peak Flow. Unpublished letter report to C.H. Coulson (File 43250-30/KCPS2211-05) by Surface Water Section, Water Management Branch, BC Ministry of Env., Lands and Parks. 2 p.

Rescan Environmental Services Ltd. 1999. Nechako River: summary of existing data. Prepared by Rescan Environmental Services Ltd., Vancouver, BC, for the Nechako Environment Enhancement Fund. 46 p. + appendices.

Robinson, G. 2003. Multiple accounts framework for assessing the effects of the Nechako River Cold Water Release Facility. Prepared by Robinson Consulting and Associates Ltd., Victoria, BC for the Nechako Enhancement Society, Victoria, BC. In prep.

Rood, K.M. and C.R. Neill. 1987. A study of some aspects of the geomorphology of the Nechako River. Prepared by Reid Crowther & Partners Ltd., North Vancouver, BC and Northwest Hydraulics Consultants Limited, Edmonton, AB for Fisheries and Oceans Canada, Vancouver, BC. 87 p.

Rood, K.M. 1998a. Nechako River sand mapping. Nechako Fisheries Conservation Program Technical Report RM90.8-1. K. Rood and Associates. 6 p.

Rood, K.M. 1998b. Nechako River secondary channel geomorphology studies phase II River. Nechako Fisheries Conservation Program Technical Report RM88-1. K. Rood and Associates. 1 volume.

Rood, K.M. 1998c. Nechako River substrate quality and composition. Nechako Fisheries Conservation Program Technical Report M89-7. K. Rood and Associates. 24 p.

Rood, K.M. 1999. Identification and ranking of sources contributing sediment to the upper Nechako River. Nechako Fisheries Conservation Program Technical Report RM89-7. Nechako Fisheries Conservation Program. 22 p.

Simard, S. and A. Vyse. 1992. Ecology and management of paper birch and black cottonwood in southern British Columbia. BC Ministry of Forests, Victoria, BC Land Management Report 75.

Tipper, H.W. 1963. Nechako River Map Area, British Columbia. Map to accompany Geological Survey of Canada, Memoir 324, scale 1:253,440.

Thrower, J.S., A.F. Nussbaum, and C.M. Di Lucca. 1994. Site index curves and tables for British Columbia: interior species. 2nd. ed. BC Ministry of Forests, Victoria, BC Land Management Handbook Field Guide Insert 6. 1 volume.

Triton Environmental Consultants Ltd. 1991. Investigation of the flushing of accumulated sediments from the Nechako Canyon. Prepared by Triton Environmental Consultants Ltd., Richmond, BC for Alcan Smelters and Chemicals Ltd., Kemano Completion Project, Vancouver, BC. 47 p + appendices.

Triton Environmental Consultants Ltd. 2000. Kenney Dam Water Release Facility: Additional numerical modeling to evaluate the effect of alternate operating protocols on cooling water requirements and Nechako River temperatures. Report prepared for Nechako Environmental Enhancement Fund, c/o Ministry of Environment, Lands and Parks.

Triton Environmental Consultants Ltd. and Klohn Leonoff Ltd. January 1991. Reconnaissance of Fish Habitat and Surficial Deposits of Nechako Canyon. Prepared for Alcan Smelters and Chemicals Ltd., Richmond, BC.

US Army Corps of Engineers (USACE) Hydrologic Engineering Centre. 1998. HEC-RAS River Analysis System Hydraulic Reference Manual, Version 2.2. Davis, CA

Van Schubert, R.M. and A. Compton. 2001. Nechako and Stuart Rivers chinook spawner enumeration: 1998. Prepared by EDI Environmental Dynamics Inc., Prince George, BC for the Nechako Fisheries Conservation Program, Vancouver, BC. in prep.

Webb, R.H., J.C. Schmidt, G.R. Marzolf and R.A. Valdez [eds.]. 1999. The controlled flood in Grand Canyon. American Geophysical Union Monograph 110. 367 p.

Williams, S.P. 1997. Geological compilation of the Nechako River (93F) map area, British Columbia. Geological Survey of Canada, Open File 34G29, scale 1:250,000.

Wu, F-C. 2000. Modeling embryo survival affected by sediment deposition into salmonids gravels: application to flushing flow prescriptions. Water Resources Research 36(6): 1595-1603.

APPENDIX 1

PHOTOMOSAIC OF NECHAKO CANYON AND CHESLATTA FAN 2000

30BCC00015 #50			September 6, 2000 Air Photo			APPROXIMATE SCALE: 1:5,000	M. MILES AND ASSOCIATES LTD. 645 ISLAND ROAD, VICTORIA, BC, V8S 2T7 Phone: 250-595-0653 Fax: 250-595-7367 email: mmaa@coastnet.com
						DATE: August 28, 2002	
REFERENCED DRAWING NO.			REFERENCED DRAWING DESCRIPTION			DRAWN: S. Gibbins	
A	Aug. 28, 2002	Issued For Discussion	SG	MM		DESIGNED: S. Gibbins	
B	Jan. 23, 2002	Issued For Report				CHECKED: M. Miles	CLIENT: NECHAKO ENHANCEMENT SOCIETY
						APPROVED: M. Miles	

PROJECT: NECHAKO RIVER COLD WATER RELEASE FACILITY

TITLE: 1:5,000 AIR PHOTO MOSAIC SHOWING CONDITIONS IN 2000

FIGURE 1

PROJECT NO. 219 | REV: A

Km NO. 0 to 1.5

30BCC00020 #40		September 22, 2000 Air Photo				APPROXIMATE SCALE:	1:5,000
						DATE:	August 28, 2002
REFERENCED DRAWING NO.		REFERENCED DRAWING DESCRIPTION				DRAWN:	S. Gibbins
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CLIENT:
NECHAKO ENHANCEMENT SOCIETY

PROJECT:
NECHAKO RIVER COLD WATER RELEASE FACILITY

TITLE:
NECHAKO RIVER AIR PHOTO MOSAIC SHOWING CONDITIONS IN SEPTEMBER 2000

FIGURE 2

PROJECT NO.	219	REV: A
Km NO.	1.5 to 3	