Executive Summary

The Clean Annapolis River Project (CARP) would like to develop preliminary designs for a preferred approach for restoration of the Moose River around the Clementsport Dam in Clementsport, Nova Scotia, the goals being to restore fish passage, ecological function, connectivity, diversity, and natural river processes and improve public safety. The structural integrity of the dam is deteriorating rapidly. A hole in the face of the dam was first observed in fall of 2008 by staff at CARP. The hole undermines the structure of the dam. CARP and the other project proponents, the National Oceanographic and Atmospheric Administration (NOAA) and Fisheries and Oceans Canada (DFO) believe the dam is at risk of failure. The PARISH team was contracted by CARP to develop a feasibility study (FS) to serve as a decision tool for the organization to address alternatives for stabilizing and restoring the site. The FS is intended to be a focused effort targeted toward the specific analyses and comparative evaluations necessary to allow CARP to have sufficient information to proceed to final design and implementation.

Summary of site assessment

The site assessment for the FS constituted a broad spectrum of work across many disciplines. It began with a review of historic documents related to the dam, the ownership of the dam, and previous and ongoing physical and biological studies. It also encompassed a review of aerial photos and topographic maps, which were partially ground-truthed by PARISH staff so the team could understand the role and impact of the dam on a watershed scale and so land-uses and cover types could be determined for hydrologic studies. Both a legal and a topographic survey were completed at the project site and both were incorporated into a base-map for the project. Photographs of the site are included in **Appendix A** and the surveyed base map is included in **Appendix B**. Estimates of stream flow frequency and steam flow duration characterized the volume and timing of floods at the dam site. A hydraulic model was then created to examine the flow characteristics as the floods passed through the site. The hydraulic model also allowed for the comparison of restoration alternatives and for insight as to how the alternatives might change the flow of water and sediment at the site.

At the onset of the project, CARP was uncertain if the Municipality of Annapolis, the Department of National Defense (DND), the Province of Nova Scotia or the Royal Canadian Legion (Clementsport Branch) owned the dam. To help resolve the issue a title search was conducted and legal counsel was consulted. Counsel determined that no party has clear title to the dam at the Clementsport site. He provided two recommendations based on his findings: Firstly, that a General Release and Quit Claim Deed be obtained from the Federal Government, the Municipality of Annapolis, the Royal Canadian Legion and the Province of Nova Scotia before any restoration work occurred on the site. Secondly, that an easement from the Province of Nova Scotia would be required to cover the location of the dam and concrete structure that is located within the waterway. In addition, the Kentville office of the Department of Environment was able to track down a Water Approval issued to the Clementsport Legion in 1989 for repair work on the dam. The approval is valid until 2019. According to the Department, it is uncertain if the open approval means the Legion has any residual responsibility.

The Special Places Protection Act (R.S., c. 438, s. 1.) of Nova Scotia provides for the protection and study of archaeological, historical, palaeontological and ecological resources in the Province. Under the Act, developments which may impact on known or potential archaeological resources require that an archaeological resource impact assessment be conducted by a qualified archaeologist. The initial investigation was completed as part of this work. The area was determined to be of low archaeological potential for historic period resources. However, the Moose River has been deemed of elevated archaeological potential for First Nations resources.

An assessment of fish habitat was completed by J. Cameron (DFO) in 1988 for the west branch of the Moose River. His findings concluded that the river below Clementsport Dam and the area upstream of the dam to the falls below Route 101 are suitable for Adult salmon spawning and rearing of juvenile salmon. Fish assemblage has been confirmed by a recent fyke net survey completed by CARP, and local experts, Reg Baird and Roy Bertaux. The net was placed downstream of the project site approximately 400 meters above the head of tide. Documented catches included Atlantic Salmon (Salmo salar) parr, Brook trout (Salvelinus fontinalis), and American eel (Anguilla rostrata). In June of 2010 a fyke net was installed in the same location for a period of 7 days; however, no fish were caught and the net was removed because of low water levels. In addition, a net was installed facing upstream for 28 days approximately 50 meters above the Clementsport Dam impoundment. Catches included White sucker (2), Minnow (1), Atlantic salmon parr (6), Brook trout (2), and Snapping turtle (2).

Three public meetings were held, on July 16, 2009, April 29, 2010, and July 29, 2010. All were held at the Legion Hall in Clementsport and hosted by CARP. The purpose of the meetings was to establish a level of transparency for the feasibility study; ensuring that community members could learn of the project, provide input, and ultimately affect the results of the study. The importance of identifying a proponent for each alternative under consideration was stressed at the meetings.

Summary of alternatives

Four alternatives were selected to cover the spectrum of restoration possibilities at the project site.

Alternative 1 – No Action. No action would be taken at the Clementsport Dam site, such that the structure would be left in place as it currently exists. No stream bank restoration and/or sediment excavation activities would be undertaken. This alternative poses significant risk as the condition of the dam continues to deteriorate quickly at the time this report is issued in late July of 2010.

Alternative 2 – Complete Rebuild of Dam. The existing structure would be reconstructed, and the fishway would be replaced. The dam would be replaced either by concrete gravity / headwall construction or by timber and rock construction. Some sediment removal adjacent to the dam may be required. Two different alternatives for construction of the dam were considered, primarily to assess the difference in cost between methods. The first was a

concrete headwall structure with a concrete fishway, the second being a timber crib and rock structure with a combination timber crib and rock and concrete fishway.

Alternative 3 – Partial Removal/Rebuild of Dam. The dam is partially dismantled and partially rebuilt to a lower elevation. A fishway, either a rock ramp or a concrete ladder, is rebuilt. This would reduce the size and depth of the impoundment. The portion of the structure removed would be taken offsite for disposal.

Alternative 4 – Complete Removal of Dam. The entire dam is removed, allowing the channel to return to a free-flowing condition. Floodplain surfaces and river features such as pools, steps and riffles would be constructed of natural materials to ensure fish passage and the biological/physical restoration of the site. The fine sediments in the impoundment area would either be secured (i.e. covered with soil, regarded and planted to construct floodplain surfaces) or allowed to migrate into downstream reaches. The new channel would be designed with the appropriate dimensions, planform pattern and profile to convey all flows up to bankfull discharge, and be integrated with floodplain surfaces to convey flood flows. All timber, metal and concrete would be hauled offsite for disposal.

Summary of the evaluation of alternatives

The goal of the FS is to compare each alternative in an unbiased way by incorporating biological, environmental, social, monetary and regulatory evaluation criteria. Each alternative was evaluated based on evaluation criteria and a discussion as to how each alternative could affect or be affected by the evaluation criteria is included in this report. Evaluation findings conclude:

Level of improvement to flooding and public safety. The risk of No Action at the site is great. The dam has deteriorated to the point that it could fail under high flows. Failure of the dam could lead to the destabilization of the streambed and banks upstream of the dam and the timber and wood debris could cause flooding downstream or create blockages at the Route 1 crossing.

If a controlled approach to removal was undertaken, the hydraulic model demonstrates that changes to the water surface elevation and to water velocity by restoration activities at the dam site are limited to a reach beginning about 10 meters below the dam to about 70 meters upstream of the dam. Within this area, the removal of the dam would decrease water surface elevations and increase water velocity. This is expected because the relative grade through the site increases when the dam is removed. Channel designs and bank treatments will need to take into account the change in energy through this reach. Upstream and downstream of this reach, flood water elevation and velocity would not be affected by changes at the Clementsport Dam site. In addition the concern that the loss of the dam would affect flood attenuation was quickly dismissed given that the volume of the impoundment is so small and that the attenuation would be insignificant at flood level discharges. It was also noted that dams present inherent risks to public safety. The project team found that any alternative which leaves or rebuilds a dam offers more risk to public safety than an alternative that proposes the removal of all structure from the river corridor.

Impact to community. The swimming hole created by the Clementsport Dam has been used by the community since before it was sold to the municipality in 1967. It is apparent from the public meetings that the swimming hole holds important personal, historical, and social value to many long time residents of Clementsport. It is also apparent that use of the swimming hole has diminished significantly in the last 10 years, and that maintenance and upkeep of the dam has not been a community priority. Three hundred or more mailings were mailed for the April 29, 2010 meeting. In addition, announcements were printed in local papers for all meetings. Turn out for all meetings were small, in the neighborhood of 10 to 20 attendees. At all meetings, there were two or three passionate and outspoken individuals interested in keeping the dam and frustrated with the Municipality of the County of Annapolis for not keeping up the dam and recreation area. It was noted that other participants seemed less interested in any specific remedy, but wanted to learn about the benefits of all the proposed alternatives. The project team considered the lack of public participation a level of indifference toward the project and to the recommendations and/or actions that may result. In summary, it is not possible based on the feedback from the community to suggest that they are more for or against any single restoration alternative.

Impact to cultural and heritage resources. The Clementsport Dam site is greatly altered from the pre-colonial or colonial condition during the construction of the dam and the park. The Western bank has also been altered by the construction, maintenance and protection of the Clementsport Road. It has also been demonstrated that changes to the configuration of the dam would not affect water levels or velocities outside of the project site. For these reasons, we believe that upon review of the project by provincial archeologists, the project will be found to have no impact to cultural heritage resources, and that no particular alternative will have greater affect than another.

Level of improvement to geomorphic stability. The Clementsport Dam is located in a short reach which is less steep than upstream and downstream reaches. The dam therefore likely exacerbates the deposition of material in a reach that likely provided some level of temporary and permanent sediment storage before the dam was constructed. This level of disruption to the natural flow of sediment through the site should be expected to continue for the No Action and Complete rebuild alternatives.

An assessment of sediment movement through the site was completed using the results of the hydraulic model and tenants of fluvial geomorphology; specifically, that bed material in stable alluvial channels is partially mobilized under bankfull conditions (here assumed 2-Year flow), and that typically, the critical particle size of the bankfull conditions corresponds with the D50 to D85 particle size observed in the more stable riffles of the natural channel. If the calculated critical particle size is much greater than observed, this would indicate that the channel will be unstable at this location. This understanding allows us to evaluate the likelihood that locations along the profile will remain stable if the dam is removed. The results of the analysis demonstrate that the removal or partial removal of the dam will destabilize the sediments in the impoundment area during bankfull flow conditions if no additional channel re-habilitation occurs. Cobble material in the bars and channel upstream of the impoundment would be easily mobilized under bankfull conditions with the removal of the dam without undertaking re-habilitation measures. Bed material downstream of the dam would remain stable under either scenario.

The destabilization of impoundment sediments could precipitate a failure that propagates far upstream of the impoundment. If impoundment sediments are moved out quickly, causing the base level of the stream to drop quickly, the lowered base level will migrate upstream, undermining bars and bed that might otherwise be stable. This is defined as a "head-cut" and would likely extend upstream to where the first bedrock outcropping would arrest its movement. Fortunately, bedrock in the bed of the channel was located upstream of the parking area located on the west side of the river.

A hydraulic model was constructed simulating rehabilitation measures including the modification of channel geometry and the inclusion of larger bed material. The model produced critical particle sizes more in line with material upstream and downstream of the dam and impoundment, which is the very material that would be used to construct the modification. This is a strong indicator that channel restoration/re-habilitation must be undertaken as part of a removal option and that the impoundment area could be stabilized using native material found locally upstream and downstream of the dam.

Level of improvement to fish habitat. Dams can block or delay upstream fish migration and thus contribute to the decline and even the eradication of species from a watershed that depend on longitudinal movements during certain phases of their life cycle. Anadromous and catadromous fish species are highly dependent upon the characteristics of the aquatic habitat which supports all their biological functions. The habitat immediately above the Clementsport dam is a small impoundment of slow moving water, at least during normal yearly and summer flow conditions. The impoundment may provide deep water cover for fish species utilizing the river above the dam; however there is limited in-stream cover around the perimeter of this impoundment. The stream bottom of the impoundment consists of silt and sand. By removing the dam, the impoundment area could be transformed into additional reproduction and foraging habitat for the species utilizing Moose River. The removal of the dam would likely cause an increase in the invertebrate populations as detritus material would be able to pass more freely through this reach. This in turn would increase the food source for fish species such as Atlantic salmon parr and brook trout.

Level of improvement to fish passage. Fish passage through the Clementsport Dam site is one of the primary goals of the Moose River Restoration Project. By most accounts, and by all observations made by the project team, the fish passage structure on the East bank of the dam is not functioning. All restoration alternatives which require the operation and maintenance of a structure must reinstate fish passage to the satisfaction of DFO and must demonstrate the passage of fish through performance monitoring.

It is beyond the scope of a feasibility study to design specific fish bypass structures for each alternative, but it is reasonable to assess fish passage at the site under the current conditions, and establish that it is technically possible and reasonable to achieve fish passage for each restoration alternative. The Complete Rebuild alternative will require a structural fish ladder. For the purposes of the FS, it is reasonable to state that the science of fish passage has progressed sufficiently that fish passage using conventional structures would be feasible. There are many case studies demonstrating the success of a baffled fishways on a low head dams similar to the Clementsport Dam.

There is little data available for the leaping height of different species of fish. In any case, it is instructive to understand what heights fish would have to leap to navigate over the dam. The results of the hydraulic model for average flows for each month of the year were reviewed to determine jump heights. The data indicates that fish must jump a minimum of 1.91 meters, which typically occurs in August, to navigate the dam. This precludes all jumping species with the exception of Adult Atlantic salmon, providing they have sufficient depth in the plunge pool to leap. The depth of the plunge pool at the base of the dam is relatively shallow at an approximately depth of 1.5 meters. However, it is noteworthy that 6 Atlantic Salmon parr were caught upstream of the dam in 2010, indicating that some spawning age salmon were able to navigate past the dam.

An assessment of velocity and depth as compared to published velocity envelopes and minimum depths was completed for each species of concern, namely Atlantic salmon, brook trout, and American eel. This assessment was completed for the existing conditions and for the Complete Removal alternative. The resolution needed for a true assessment of fish passage can only be complete at the final design phase when more detail about bed variation is understood. However, the conceptual model developed for the FS can be used to demonstrate how much bed variation is needed to achieve the desired hydraulic properties for fish passage, and if it is feasible to expect that passage can be achieved.

It is apparent from the existing conditions model that water velocities within the impoundment are not ideal for fish passage, and that there are several locations upstream and downstream of the dam where the depth of flow is less than desirable for larger species, like Atlantic salmon. The Complete Removal alternative trends toward higher velocities and shallower depths as compared to the existing conditions model; however, the velocity and depths are not so far from the published literature that they could not be reached by increasing the depth of pools and by refining the channel size and width/depth ratio during final design.

Impact on the terrestrial habitat. There have been several modifications to the natural landscape at the Clementsport Dam site that negatively affect terrestrial and riparian habitat. The first being the fill placed on the Eastern bank to elevate what is now the recreation park area above the dam. It is speculated, based on observation of the bank materials, that this fill material was excavated from the impoundment area, making it remnant alluvial material. The second major feature is the river-side levy that extends downstream of the dam on the eastern bank isolating what should be accessible floodplain from the West Moose River. If a No Action or a Complete Rebuild alternative is selected, we would not recommend excavation to lower the eastern floodplain, as this would increase the flood risk to these structures. The removal of the downstream levy could, however, be considered. It has been demonstrated that channel re-habilitation and restoration should be completed as part of any removal alternative. The restoration of channel geometry and grade will likely mean the reservoir will be filled with material and the elevation of the eastern floodplain lowered. From a construction standpoint, the pair are advantageous, providing both a cut and fill area. The new surfaces would be stabilized and would provide the surface into which the new channel, with the appropriate channel geometry and grade, would be cut. The removal of the earthen levy downstream of the dam would also open additional floodplain to the Moose River.

Impact on local groundwater. Given the age of the Clementsport Dam, groundwater elevations have adjusted to the river elevation as influenced by the dam. Changes to the configuration of the dam, or removal of the dam, will therefore likely have some effect on local groundwater tables in the immediate vicinity of the dam and impoundment. A groundwater study was not completed as part of this feasibility study; however, the project team does not believe that any alternative will have a significant effect on groundwater. No groundwater wells were located within the area that the dam could have influence over ground water levels.

Identification of a viable proponent. A critical path for the success of any restoration alternative is the identification of a viable proponent, a person, corporation or organization that has the means to bring the project to fruition, maintain the site and/or structure, and meet any regulatory and monitoring requirements. A primary purpose for the two public meetings, the first held on July 16, 2009 and the second on April 29, 2010 was to emphasize the importance to the recommendations of this FS of finding a viable proponent for each alternative. To date, the project team has not been made aware of such a proponent for the Partial Removal/Rebuild or the Complete Rebuild alternative, nor have we heard of a concerted effort to establish one. Several possible proponents have expressed interest and ability for the Complete Removal alternative. CARP is a possible proponents for this alternative. In addition, funding sources from NOAA and the Gulf of Maine Marine Council (GOMMC) have been identified possible contributors to the project.

Permits and regulatory requirements. All alternatives requiring physical work or alteration to the dam must be permitted by the Nova Scotia Department of Environment with a Water Approval Permit for Watercourse Alteration. In addition any work will require authorization through The Special Places Protection Act (R.S., c. 438, s. 1.) of Nova Scotia. From a permitting perspective, the project team did not identify advantages of one alternative over another.

Residual liability. The importance of a viable proponent is highlighted by understanding the residual liabilities that will accompany each alternative, particularly those alternatives which maintain a structure or dam within the waterway.

Dams in Nova Scotia are regulated by Nova Scotia Department of Environment through the Environment Act, but there is no specific dam legislation. In the absence of specific dam legislation, the Department often defaults to the Dam Safety Guidelines of the Canadian Dam Association (CDA) and cites compliance with the CDA Guidelines as a requirement for obtaining or renewing an operating license for a dam.

Section 22 of the Fisheries Act provides the Minister with the authority to regulate downstream water flows at an obstruction to provide for the safe and unimpeded descent of fish and for the free passage of both ascending and descending migratory fish during the period of construction. The powers of Section 22 are implemented through the issuance of a Section 22 order. A Section 22 order is discretionary and should only be issued where there is sufficient evidence to conclude that the free passage of fish is impeded due to insufficient water levels. To enforce Section 22, DFO can require ongoing monitoring or fish capture and count to prove that the dam continues to pass fish. This can be an ongoing requirement, with the frequency and duration of study being at the discretion of the Minister.

Constructability. The constructability, or the ability of the proposed alternative to be constructed using time tested methods and materials in a manner that does not cause excessive expense, take excessive time, or cause excessive damage to the environment, is an important consideration for the FS. Care has been taken to assure that all of the proposed alternatives have precedent in the dam construction, restoration or removal literature and case history. While each alternative may require different construction methods and construction times, none are unreasonable periods which cannot be mitigated with careful timing, site planning and dewatering and/or channel diversion practices. Differences in the construction between each alternative are best evaluated based on the capital and operating and maintenance costs.

Capital & operation and maintenance costs. Conceptual cost opinions to allow for comparison among the alternatives were prepared. Estimated costs were $458,000 to $461,000 for the Complete Rebuild alternative depending on the construction method used, $402,400 for the Partial Removal/Rebuild alternative, and $267,500 for the Complete Removal alternative. The No Action alternative had no cost. Since these opinions are based solely on concepts, there is a relatively high uncertainty in the accuracy of the opinions. That being said, they are based on our understanding of the project site and the cumulative experience of the project team and should provide a reasonable basis for comparisons.

Summary of the findings and recommended alternative

To limit subjectivity and bias from the determination of a selected alternative, the project team developed a decision matrix to guide decision making. The decision matrix applies a rating to each alternative and evaluation criteria pair. The ratings are then summed to give a total score for each alternative. Total scores were: No Action – 46, Complete Rebuild – 43, Partial Removal/Rebuild – 48, and Complete Removal – 67. The total score from the decision matrix provides one method for selecting the recommended alternative. Another is to consider which of the evaluation criteria pose critical paths to the success of the project; the criteria that are make-or-break for the alternative. The most obvious of these criteria is having a viable proponent for the selected alternative. To date, and to the knowledge of the project team at the time this report is written, only the Complete Removal option has a viable proponent. Should other proponents become available, the ratings in the decision matrix can be updated and the scores re-evaluated.

The Feasibility Study for the restoration of Moose River at the Clementsport Dam considered a broad range of evaluation criteria that were assessed only after a thorough legal, scientific, engineering, social and historical review of the project site. The project team believes that there is considerable risk to the No Action alternative as the dam is in poor structural condition and an uncontrolled catastrophic failure could lead to damage to downstream properties. Based on the findings of this Feasibility Study, we recommend that Complete Removal is the most favorable alternative for meeting the goals of the project and the restoration of the Moose River.