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June 24, 1988

Mr. T.C. Gardner, P.Eng.
Director of Engineering
District of Maple Ridge
11995 Haney Place
Maple Ridge, B.C.
V2X 6G2

Dear Mr. Gardner:

Re: Alouette River Studies

The Alouette River Studies conclude nearly three years of work, over which time our investigations were assisted by the BC Ministry of Environment and Parks, Water Management Branch 200 year floodplain mapping, and BC Hydro Alouette Lake dam hydrologic studies. With the District's assistance, we undertook additional hydrologic and river regime investigations to evaluate flood protection alternatives of lake storage, dyking, residential flood protection, diversion and dredging on the Alouette Rivers. We conclude that the 200 year protection costs for the preferred alternative, dyking would be expensive costing about $11 million, and would show a benefit/cost of less than 1. Lesser flood protection to 10 year frequency can, however, be achieved through dredging and at $100,000 per year its benefit/cost ratio exceeds 1.0. Accordingly, dredging is recommended for further evaluation by the District to determine scheduling, funding, costs and extent.

We have enjoyed the opportunity of participating with you in this interesting assignment.

Yours truly

DAYTON & KNIGHT LTD.

Agris Berzins, P.Eng.

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10. SCOUR MAINTENANCE IN SOUTH ALOUETTE RIVER

One of the flood control measures to be evaluated is channel dredging. To increase river capacity to 5 to 10 years protection, hydraulic analysis of the rivers showed that at least 0.6 m (2 ft) of bottom material must be removed. Test holes dug in the fall of 1987 indicate that 100 mm minus gravels are present to at least 2 m in 6 test holes dug between 216th and 232nd Streets. For the South Alouette River, from 216th Street to 128th Avenue and about 240th Street is the limit of the dredging reach examined.

Scour and deposition modelling and dredging effects were examined for the South Alouette for the following reasons:

1. The bed shows deep fluvial deposits (greater than 2 m).

2. The river once occupied larger bankfull flow (prior to 1925 dam) and it appears reasonable to recapture its capacity through dredging.

3. Use of the dam to provide controlled flood releases for scour maintenance in the river was of interest.

For examination of dredging and channel deposition, average monthly flows (varying from 1 to 7 cms (35-245 cfs)) were used to evaluate the effect of an assumed sediment supply and a bed load shift on channel filling. Two additional analyses were made to show effect of two actual hydrographs on bed load within the rivers. The hydrographs included a July 1972, 2-3 year return maximum day flow of 68 cms (2400 cfs) and a December 1980, 10 year return maximum day flow of 98 cms (3460 cs), (the December flood flow actually peaked to 128 cms and created a 20 year return flood. Examination of the hydrograph shows that the 128 cms is actually the sum of two floods. A 30 cms base when subtracted produces the 10 year flood of 98 cms). Figures 9, 10 and 11 show the three hydrographs.

Total dredging volume from 216th to 236th Streets was determined to be about 156,000 m^3 (250,000 tonnes) at the start of the modelling. Results of 1½ years of monthly average flows in Figure 9, after the river dredging, indicate little bed form change. River bed conditions after 1½ years show variations of scour and deposition to less than 0.3 m.

Examination of the effects of a peak flow on river channel bedforms is however much more significant. For the July 1972 hydrograph up to 40,000 tonnes/day in critical reaches were moved (at the maximum day). The model predicted a bedform lowering of between 0.15 to 0.35 m in reaches between 228th and 242nd Streets. Below 228th Street, depositions of 0.1 to 0.5 m occurred. The larger December 1980 storm predicted a greater bedform change and showed scour depths to 1 m in upper reaches and substantial deposition in lower reaches to 0.5 m. At peak flow up to 130,000 tonnes/day were predicted to be transported.

The scour studies showed that although initial dredging of about 0.6 m would improve channel capacity to allow passage of about a 10 year storm flow, materials transported into the dredged zones from upstream deposits would, with time, tend to fill the dredged areas. The movement is unpredictable and bedforms appear to be constantly changing. This is most evident when examining the effects of a large storm flow and although natural dredging effects through scour were predicted to occur in the upstream reaches, they were not consistent and bar formations through riffle-pool construction were observed. More importantly, lower reaches accumulated the bedload; these areas appear to be in the residential areas and floodplain where effects of flood would be worst. Use of controlled release is then concluded to be of limited value unless accompanied by dredging programs to remove material in the lower reaches. Annual dredging with or without selected releases is a probable requirement to ensure the river capacity (of about a 5 to 10 year flood) is maintained.

10.1 Trial Dredging Program

As a trial dredging program, assuming both the North and South Alouette Rivers would respond in similar fashion, a first stage dredging operation should consist of construction of a 1 to 2 m deep pocket just above 224th Street. Each excavation should remove about 15,000-20,000 m^3 of bottom deposits and occupy a reach of about 600 to 1000 m. Subsequently, stage two dredging of the channel below 224th Street to about 216th Street should be undertaken. Once the first stage of these operations are complete, the District should observe the river bed changes through use of 4 or 5 representative cross-sections along each river channel. The use of a scheduled dam release on the South Alouette to move channel deposits would also be a possibility as well to observe effects of flow increases on bedload transport.

11. ALTERNATIVES AND BENEFIT / COST

11.1 Alternatives

Flood control alternatives which lessen flooding occurrences in either the North or South Alouette River include combinations of storage, diversion and river channel improvements. Possibilities include:

1. Flood control on the South Alouette River by redefining the role of the Alouette Lake Dam as a flood control facility, (means loss of its role as a dedicated hydroelectric power facility and also partial reduction in use of lake's recreational value). Also required would be the construction of a second storage facility above 248th Street to create about 650 ha-m of additional storage.

2. Flood control in the North Alouette River by constructing flood control storage structures in the upper reaches of the North Alouette River watershed.

3. Flood control for both rivers by dyking river banks to 200 year flood line (as determined by the Water Management Branch).

4. Constructing diversions to connect the two rivers, and divert South Alouette River flood flows to the Fraser River adjacent to 232nd Street.

5. Flood control on both rivers by dredging to improve capacity in the North Alouette and to restore capacity in the South Alouette. (Dredging alone would not be sufficient to improve channel capacities beyond 1 in 5-10 year recurrence and would need to be used in conjunction with other alternatives if a 200 year protection were to be provided.)

6. Flood protection by requiring all buildings to be flood proofed and constructed above the high water mark, and all present construction to be raised where occupancy is threatened.

Costing includes a 35% allowance for administrative needs, engineering, financing and contingencies.

11.1.1 South Alouette Storage, Dyking and Dredging

By redefining control strategies of the dam to assure that flood flow releases do not exceed about 300 cms (as previously determined practical), floodproofing measures will still require dyking and annual channel dredging.

Approximately 17,200 m of dyke and about 150,000 m^3 of channel dredging will be needed initially. Annual dredging must be assured to maintain channel capacity. At $200-250/m for dyke work, allowing costs for dredging, floodbox structures, and engineering and contingencies, total cost is about $7.0 million. No costs are included for changes in the dam operation, but the 300 cms maximum release controls do not appear to significantly affect the present operation strategy.

Actual costs could be much higher. Little shoreline is available for much of the dyke work and vertical wall construction may be required.

11.1.2 South Alouette Dyking and Dredging

Without the advantage of additional Alouette Lake storage, floodproofing will be required to meet the 528 cms (18,640 cfs) Water Management Branch predictions. Dyking costs may be higher. If some dredging is included the cost at about $300/m is estimated at $8.0 million, (for dyking 17,200 m of riverbank and constructing flood relief structures at major creeks). As with the above, actual costs could be higher.

11.1.3 South Alouette Diversion

To divert flow from the South Alouette to the Fraser River, approximately 5 km of channel sufficient to convey about 300 cms would be needed. Over 25 m of excavation depth would be required; the cost would be excessive at over $100 million and this option is not examined further.

11.1.4 North Alouette Storage

As shown in Figure 1, the 74 km^2 of North Alouette River watershed is drained by two major channels. A lake system is present on the western channel, (Jacobs Creek). These lakes presently provide some runoff attenuation but affect less than 20% of the watershed. The lakes are also on the top of the watershed. Alone, their development would not be effective for flood control. A series of dams lower in the main North Alouette River channel are more appropriate and would provide flood control capability (possibly in conjunction with flood control improvements at the lakes). With the lakes providing 1 to 1.5 million m^3 of active storage, approximately 8 to 10, 25 m high dams would still be needed along the North Alouette River channel to provide the 9 to 10 million m^3 of total storage needed (to attenuate the 200 year flood flow down to present bankfull flow capabilities). The dams could be staged. Each represents about 1 million m^3 of storage. Three would be required to control the 10 year flood, five needed for the 25 year flood, and eight needed for the 100 year flood. Cost per dam and control structure is estimated at about $0.8 to $1.0 million. Total cost would be about $8 to $10 million. Impacts of Blaney Creek backwater in the lower floodplain are not accounted and dyke work may be needed in any event. Also, operation and control of the dams would be personnel dependent and the operations costs could be high.

11.1.5 North Alouette Dyking

About 8200 m of dyke would be needed on the North Alouette River. Total cost would be about $3.0-3.5 million for both banks. This would provide protection from Blaney Creek floodwaters as well.

11.1.6 Resident Flood Protection

To safeguard homes from the 2 m flood depths created by a 200 year flood of either river, homes would need to be raised or reconstructed. Costs of \$100-200/m^2 of flood area would be necessary for raising structures. (Table B-2, page B-4 "Physical and Economic Feasibility of Non-Structural Flood Plain Management Measures, U.S. Army Corps of Engineers"). For 400 homes of about 160 m^2 floor area, total cost would exceed \$12 million.

11.1.7 Dredging

River dredging would improve North Alouette River capacity and partially restore the South Alouette River capacity to provide a 5-10 year flood recurrence protection.

a)	North Alouette River 4000 m	127,000 m^3	\$340,000
b)	South Alouette River 5000 m (to rock outcrop from 216th Street)	156,000 m^3	420,000
	Total		\$760,000

Annual dredging to maintain the channel excavation must also be considered and an estimated annual cost of \$100,000 for both rivers is assumed to provide for the initial excavations and continuing channel maintenance.

11.2 Benefit / Cost

The benefit / cost ratio is generally determined for a 25 year period on a capitalized basis (as recommended by the Ministry of Environment, Water Management Branch). This does not give a fair comparison in all cases because many of the improvements such as dams and dykes will last much longer, and to provide equivalency, their capital costs should be discounted to this 25 year period. Nevertheless, the funding for these projects is based on a 25 year payback and benefit / costs are determined for this period. Loss of life is also not considered.

The benefit / costs for the flood control alternatives to provide protection for both rivers follow.

		Cost in $ (millions)		
		Benefits (25 yrs, 10%)	Capital	Benefit/Cost
1.	Dyking and dredging	200 yrs; $3.2	$ 11	0.29
2.	Storage on North Alouette and use of Alouette Lake Dam plus dyking	200 yrs; $3.2	$ 17	0.19
3.	Residential flood proofing	200 yrs; $3.2	$ 12	0.27
4.	South Alouette diversion	200 yrs; $3.2	$ 100	0.03
5.	Dredging only	5-10 yrs; $0.8-1.5	$ 0.97	0.8-1.55

The benefit / costs do not exceed 1.0 for any of the major corrective measures; however, lesser protection to a 5-10 year flood recurrence can provide a benefit / cost exceeding 1.0. The benefits / costs support at least a $100,000/yr dredging program. The dredging objective should be to obtain the 10 year capacity for both river channels.

12. CONCLUSIONS

12.1 Conclusions

The conclusions of this study also provide a summary of the study. These are as follows:

1. Fisheries services are not adverse to dredging providing it can be demonstrated to be feasible, will not harm the fisheries and will be done at an approved time of the year.

2. B.C. Hydro consider the Alouette Lake dam a single purpose structure for hydroelectric use only. Flood control is not a feature in its operation strategies.

3. The District of Maple Ridge is potentially subject to inundation of over 8.3 km^2 (3.2 mi^2) of floodplain presently occupied by rural homeowners and a farming community. Capitalized damage losses are estimated at $3.2 million (present worth, 10%, 25 yrs) for the 200 year flood and about $1.5 million for a 10 year flood.

4. Design flood flows (200 year recurrence) are determined by the Water Management Branch to be 539 cms (19,000 cfs) in the South Alouette River and 340 cms (12,000 cfs) in the North Alouette River. These appear to be conservative. The North Alouette River Water Rights records indicate a 200 year flood flow of about 200 cms (7060 cfs) at 232nd Street.

5. The Alouette Lake dam is capable of attenuating 200 year flood peaks and with a reassignment of operating criteria could attenuate flood flows to manageable river levels. Flood attentuation below 300 cms (10,600 cfs) is however, not practical because downstream flood flows reach this value. Present 200 year flood attenuation is predicted at 539 cms (19,000 cfs) (Water Management Branch).

6. South and North Alouette River capacity are limited to about an annual flood recurrence or less. The South Alouette River can pass about 85-95 cms (3000-3350 cfs); the North Alouette River can pass about 40-60 cms (1400-2120 cfs). A 0.6 m-0.75 m dredging of the South Alouette can improve its capacity to about 150-175 cms (5300-6200 cfs) or a 5-10 year flood. Similar dredging of the North Alouette could improve capacity to about 60-100 cms (2100-3500 cfs) or a 5 to 10 year flood recurrence.

7. The Alouette Lake dam has reduced flood peaks to the South Alouette River, but through reduction of annual flood flows appears to have promoted a sediment build-up and subsequent reduction in channel capacity in lower reaches of the channel, (below 248th Street). Conversely, loss of sediment supply has possibly promoted bed erosion below the dam in

reaches above the Correctional Institute, (above 248th Street).

8. Flood Control Alternatives can include diversions, dyking, dredging, lake storage and floodproofing and are compared as follows:

		Capital Cost	Protection	Benefit/Cost
a)	South and North Alouette River dyking and channel dredging	$ 11 M	200 yr	0.29
b)	North Alouette Lake storage and South Alouette Lake storage, dyking and dredging	$ 17 M	200 yr	0.19
c)	South Alouette River diversion (too expensive)	$100 M	200 yr	0.03
d)	Residential flood protection	$ 12 M	200 yr	0.27
e)	River dredging	$0.9 M	5-10 yr	0.8-1.55

9. The most appropriate 200 year protection is dyking or residential protection. Other alternatives are presently not practical. The low benefit/cost will likely postpone the 200 year protection. River dredging appears to be a practical and cost effective solution for protection from frequent flooding of 10 years and greater.

12.2 Recommendations

The District of Maple Ridge should explore opportunities for dredging the two rivers and establish a schedule for undertaking this option. This would first require meetings with Water Navigation, Fisheries, Water Management, property owners, contractors and other river users or regulatory agencies to determine constraints, costs and alternatives for undertaking the dredging program.

Once the dredging constaints are defined, a dredging program and allocations of funding should be set up. A cost of $100,000 per year was estimated in this study. Improved estimates should be made once these additional site investigations are undertaken and funding methods should then be studied.