Island 32 Erosion

prepared for
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

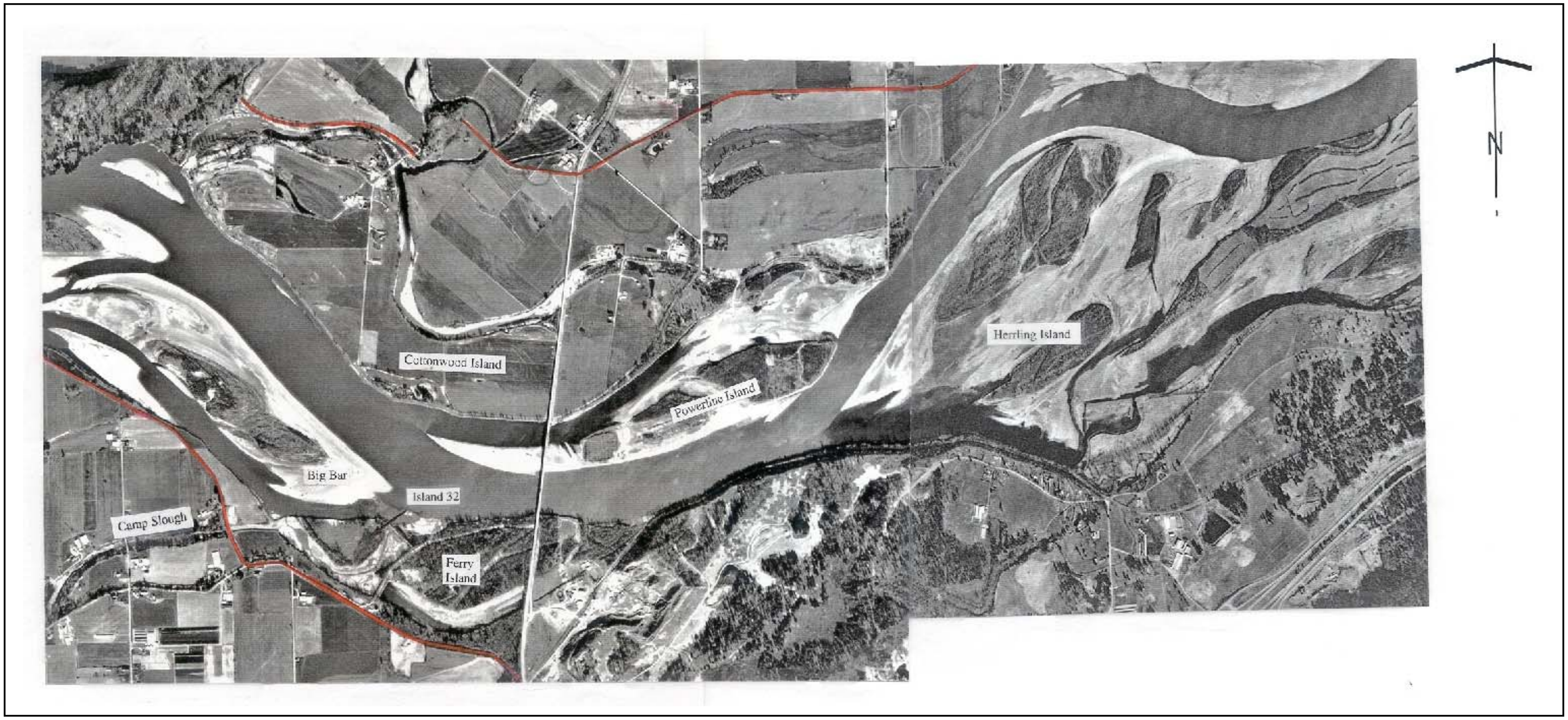
Purpose and organization of this report

In recent years, the left bank of Fraser River downstream from the Agassiz-Rosedale Bridge has been subject to erosion. The affected shore includes the north side of Ferry Island and, in particular, the next island immediately downstream, Island 32 (Figure 1). Unlike Ferry Island, the north bank of Island 32 has never been armoured with rip-rap and there is concern that continued erosion could threaten the floodplain dike during a large flood. Contemporary management objectives for the river are focused on the need to prevent flooding outside the channel zone of the river, and to discourage erosion beyond the active channel zone.

The Ministry of Environment, Lands and Park (MELP) has requested a report that documents channel changes in this reach during the past century and potential future developments. The basis of this analysis is an ongoing study of the sediment budget (volumetric channel changes derived from channel surveys), and changes in channel morphology of Fraser River between Laidlaw and Mission. This recent work updates a previous study of similar scope conducted between 1982 and 1987 (cf. McLean and Mannerstrom, 1984; McLean and Church, 1999).

The report is organized as follows. The next section provides a brief summary of previous studies in the immediate area. The following section describes the recent history of the river in the vicinity of Ferry Island and Island 32. The final section comments on possible future developments along the reach.

Figure 1 Island 32 and vicinity, March 20, 1999; Mission flow 699 m^3/s. Airphoto 15BCB99001-19; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks. Scale is approximately 1:20,000. To facilitate comparisons, a similar scale is maintained for Figures 2 through 8.



Previous Studies

In the past few years, there have been several reports that pertain to the study reach. Most of these are related to the removal of gravel at Powerline Island (Figure 1). In the winter of 1996, about 200,000 m^3 of gravel was removed from the entrance to the secondary channel which flows behind Powerline Island. Gravel removal was recommended from the entrance in a report by Northwest Hydraulic Consultants Ltd. (NHC) to the Cheam Indian Band (NHC, 1996). The report indicated that, by increasing channel volume in the side channel (as the result of gravel removal), water flow velocities would be reduced, flow diversion toward the channel banks (around the bar deposits) would be lessened, and the erosion of the channel banks along both the main and side channel would be reduced. Material was again removed during the winter of 1998 after an exceptionally high freshet in 1997 that left notable gravel accumulations at a number of places along the river. NHC (1998) estimated that the 1997 deposition was about 150 000 m^3 and recommended removal of up to 83 000 m^3, plus some additional material to shape the excavation for adequate drainage and subsequent channel flows.

The removal of this gravel from the channel was of concern to Habitat Protection officers of Fisheries and Oceans Canada (DFO) because of potential local and downstream effects upon aquatic habitat in the river. Consequently, they asked Dr. Church of the Geography Department, University of British Columbia (1998) to comment on the probable impacts of gravel removal at Powerline Island on the aquatic habitat. In his report, Dr. Church describes the recent history of the river channel in the vicinity of Powerline Island. Much of this commentary is repeated in the next section since the changes at Powerline Island have direct relevance to Island 32 due to their close proximity (Figure 1).

More recently, the Cheam Indian Band commissioned NHC to investigate the cause of erosion on the left bank downstream of the Agassiz-Rosedale Bridge and to provide conceptual short-term options for the protection of the bank against erosion (NHC, April 10th 1999). NHC attributed the erosion primarily to the development of a gravel point bar in the middle of the river under the bridge, which has shifted the thalweg[1] to the left (south) bank. To reduce velocities along Ferry Island and Island 32, NHC recommended excavation of the large point bar. Starting from the downstream end of Powerline Island, it was recommended that the excavation extend 2 to 3 m below low water level. Gravel extraction was also recommended from the upper end of Big Bar (Figure 1) to further reduce velocities along Island 32. Further to these recommendations, the large point bar was excavated during April, 1999. DFO has estimated this removal at 200 000 m^3. It is apparent that the upper end of Big Bar also influences flow along the shore of Island 32, but material was not removed from Big Bar, since that would have required moving gravel by barge.

At about the same time, NHC also completed a report for the District of Chilliwack that examined the entrance to Camp Slough, located at the downstream end of Island 32 (NHC, May 3rd 1999). The District of Chilliwack was concerned that continued erosion of Island 32 could cause problems at the slough entrance, which is protected by a rock spur. If the bank of Island 32 was to erode sufficiently, a portion of the main channel flow would be caught behind the spur causing a reverse eddy to develop. In turn, this would result in bank erosion at the slough

[1] The deepest portion of the channel.

entrance. NHC recommended relocating the spur further into the back channel behind Island 32 so that any impinging flows would be guided back into the main channel. This work was completed prior to the 1999 freshet, which peaked in early July.

Historical changes in the vicinity of Ferry Island and Island 32

The channel zone immediately upstream of Island 32 is relatively narrow and stable. That presumably is why the ferry crossing was established there early this century and why the bridge was subsequently built there. The reason for the relatively stable channel here is the presence of high ground on the left (south) bank of the river upstream of the bridge, extending to the downstream end of the Herrling Island complex (Figure 1). Farther upstream, topographic confinement constrains the river to flow in a southwesterly direction toward the high ground. Further movement of the channel to the south would entail the erosion of relatively large volumes of well consolidated sediments, and so would occur slowly. A main railway line has been built on the river bank around the outside of this high ground, so the bank has been heavily rip-rapped and actively repaired throughout this century (Figure 1). The river is here pinned against an effectively stable bank. Downstream of the bridge, however, the banks consist of erodible floodplain and alluvial sediments. As such, the banks of Ferry Island have been heavily rip-rapped to discourage the river from moving further south. Island 32 has a similar stratigraphy but its banks have not been armoured.

The right (north) side of the river, including Powerline and Cottonwood Islands, also consists of floodplain deposits (Figure 1). Due to the present alignment of the channel, erosion is not currently a problem. Nonetheless the south bank of Cottonwood Island has been riprapped to protect agricultural land and the northern bridge approach. Cottonwood Island has been present since the time of the first land survey near the end of the 19th century. Neither Ferry Island, Powerline Island nor Island 32 are noted in that survey, but that may mean they were inaccessibly low rather than absent. All were well established by 1928 (Figure 2), although occupied by notably immature woodland, and have persisted since. Secondary channels behind Powerline and Ferry Islands were by that date relatively large.

The result of the local channel stability is that, whilst substantial bed material transport occurs through this reach, sediment deposition and erosion are relatively limited. But in the reach immediately upstream, adjacent to Herrling Island, there has been substantial instability (Figure 1). Major sediment deposition and island construction toward the left bank and erosion on the right bank as far downstream as Powerline Island have persisted for many decades. It is probable that persistent aggradation occurs here because the relatively narrow channel at the bridge constricts the river at high stage, causing a backwater and slackening of current upstream. Although removed by about 4 km, these processes have influenced channel changes in the vicinity of Island 32.

Air photography of December 5, 1943 (Figure 3) reveals a major bar spanning the channel between the upstream end of Powerline Island and the downstream end of the Herrling Island complex. The channel occupied a tortuous bend around this deposit, which brought the main flow against the south side of Powerline Island and confined the majority of flow to the right side of the channel. This flow configuration enabled a significant gravel bar to develop at the upstream end of Ferry Island, protecting the banks of Island 32 and Ferry Island. The high stage of the 1928 photography makes it impossible to determine whether this sediment accumulation was already present at the time.

The 1943 photography also reveals a chute across the back of the bar past the entrance to the Powerline Island secondary channel. By 1949, realignment of the main channel along the chute was accomplished (Figure 4). Consequently, flow was directed straight onto the left bank high ground and the Powerline Island backchannel was bypassed. The realignment of the main channel at the Agassiz-Rosedale Bridge back to the left side also had the effect of moving the navigable channel away from the main navigation span built over the north side of the channel. Substantial gravel deposition occurred off the lower end of Powerline Island, along Ferry Island, and on the right bank downstream of Island 32. The Ferry Island back channel appears to have been relatively active and the large bar that developed prior to 1943 is in the initial stages of break-up.

Between 1949 and 1962 (Figure 5), the river continued to shift to the right opposite lower Herrling Island, causing erosion that trimmed the shore along upper Powerline Island. The main channel continued to be confined to the left side and the large bar off Ferry Island had moved downstream and appears to have been considerably reduced (although flow stage in the successive airphotos makes strict comparison difficult). The remains of the bar were located off the downstream end of Island 32, as shown on Figure 5. In addition, the entrance to the Ferry Island back channel had begun to silt up.

By 1971, the Ferry Island backchannel was largely inactive and had a much reduced conveyance capacity (Figure 6). This increased the high stage constriction of flow in the main channel. Bar growth continued at the downstream end of both Powerline Island and Island 32, beginning the development of Big Bar. A small upstream portion of Island 32 was also eroded during this period indicating that high flows were spilling through the channel between Ferry Island and Island 32.

During the 1970’s, the main channel upstream of Powerline Island began to become more sinuous and erosion commenced on the left bank at Herrling Island. Sediment eroded along the upstream banks appears largely to have been incorporated into the continuously developing bars at Powerline Island and Island 32. By 1979, Big Bar was practically connected to Island 32. The deposition near Island 32 promoted erosion on the opposite (right) bank near Hopyard Hill beginning in the late 1950’s as flows were directed toward the northwest. By 1983, much of this island complex had been eroded (Figure 7). Minor vegetation of the central portions of Big Bar is evident on the 1983 airphotos, marking the onset of island development. Although the high stage of the 1983 air photography is not useful for tracking bar development, it does illustrate the relatively large secondary channel behind Big Bar. The prominence of this channel is related to the continued growth of the bar downstream of Powerline Island, which confines the majority of flow to the left side and directs a significant portion of the flow behind Big Bar, directly past the front of Island 32.

Figure 2 Island 32 and vicinity, July 15, 1928; Hope flow 5,780 m^3/s. Airphotos A288-75, 77, 78, 79, 81 and A296-64, 66, 69, 71; source National Air Photo Library, Canada Department of Natural Resources.

Figure 3 Island 32 and vicinity, December 4, 1943; Hope flow 533 m^3/s. Airphotos A7077-7, 9, 11, 13; source National Air Photo Library, Canada Department of Natural Resources.

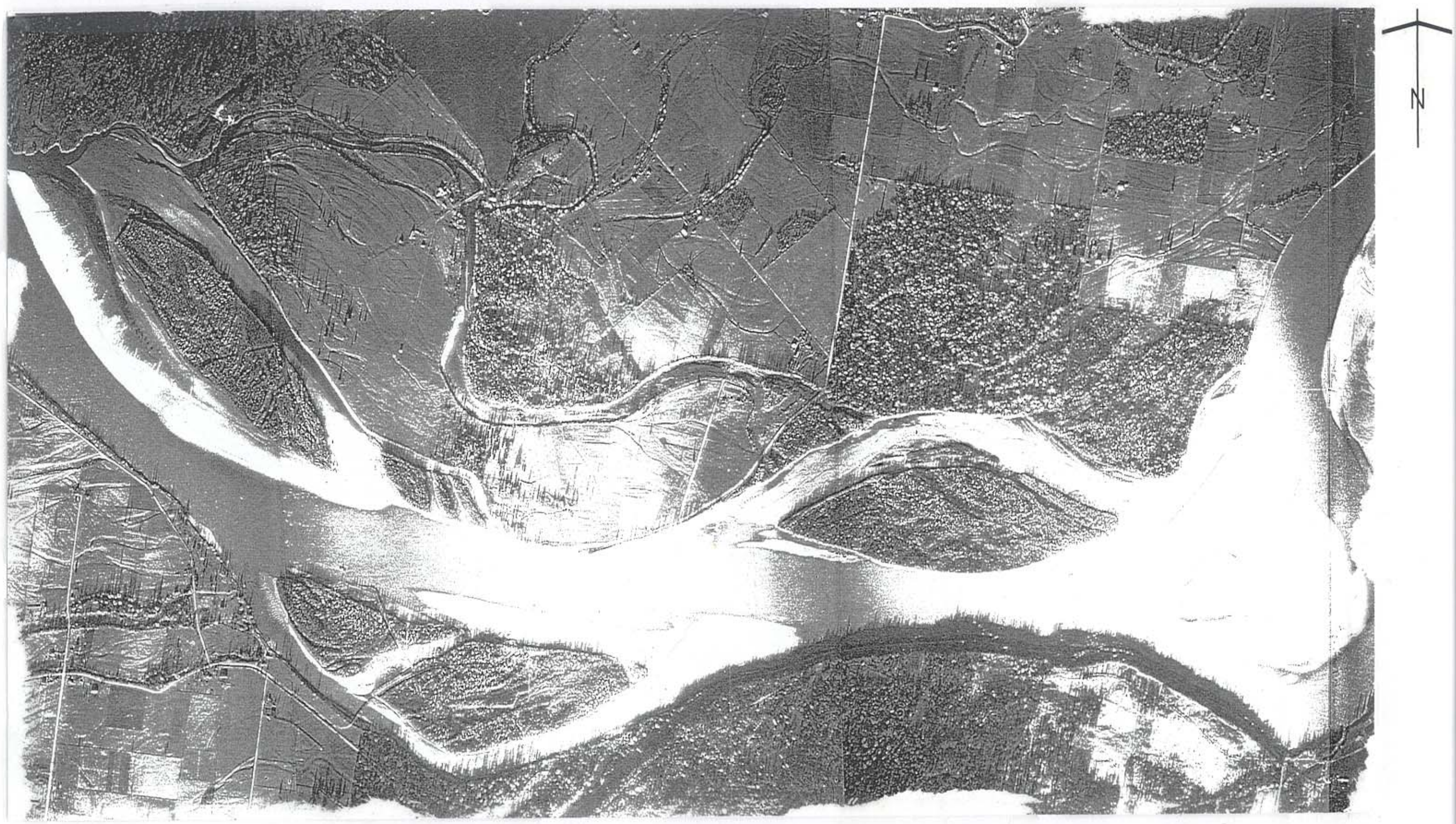


Figure 4 Island 32 and vicinity, March 23, 1949; Hope flow 733 m^3/s. Airphotos BC719-23, 24, 114, 116, 118 and BC730-90, 92, 94; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks.

Figure 5 Island 32 and vicinity, May 7, 1962; Hope flow 2,940 m^3/s. Airphotos BC5042-100, 101; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks.

Figure 6 Island 32 and vicinity, March 19, 1971; Hope flow 799 m^3/s. Airphotos BC5046-150; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks.

Figure 7 Island 32 and vicinity, July 22, 1983; Hope flow 5,380 m^3/s. Airphotos 30BC83012-17, 19; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks.

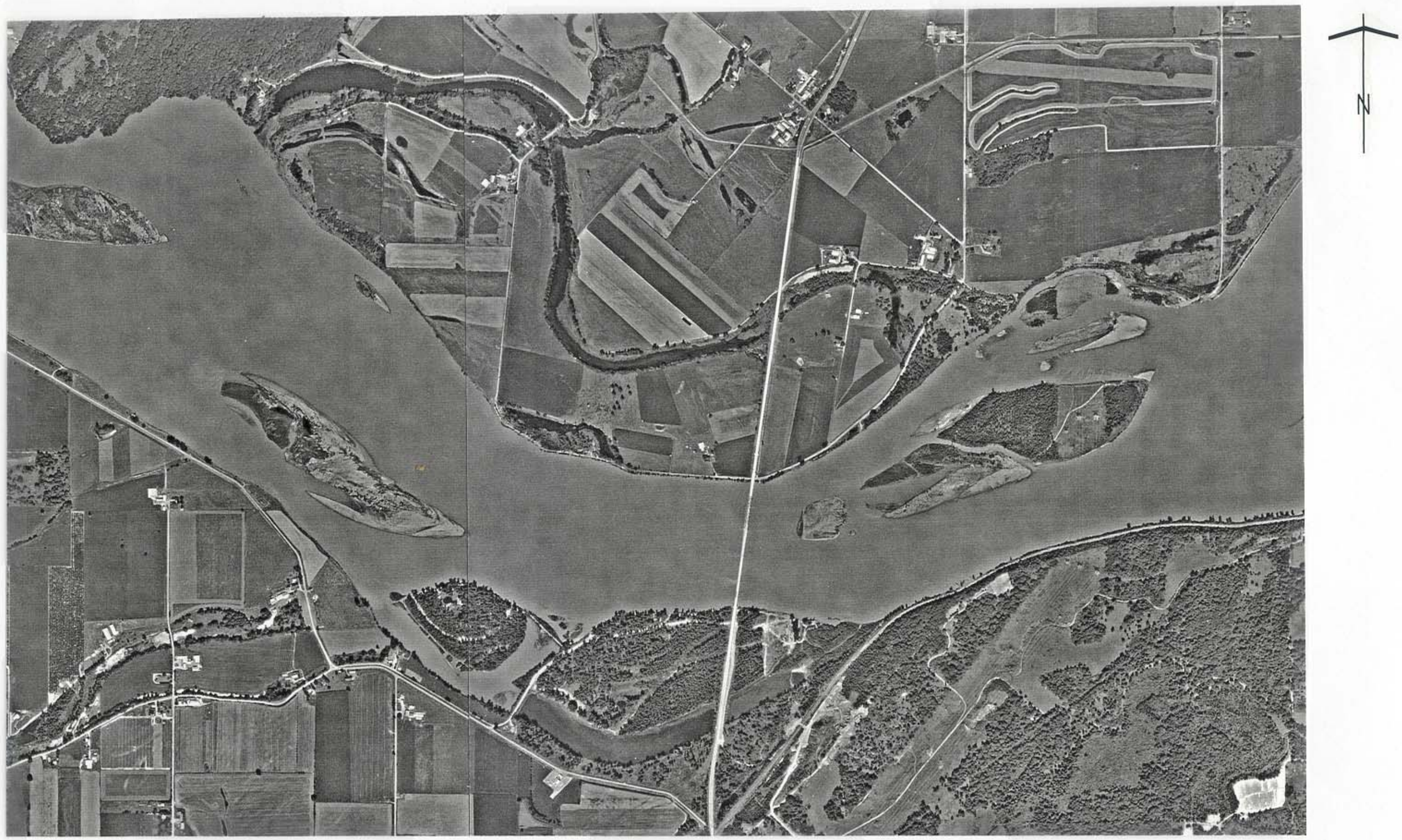


Figure 8 Island 32 and vicinity, September 5, 1991; Hope flow 4,410 m^3/s. Airphotos 15BCB91079-66; source Resource Surveys and Mapping Branch, British Columbia Ministry of Environment, Lands and Parks.

The same general alignment of the channel continued through the 1980's, with erosion along lower Herrling Island and minor bar growth at the downstream end of Powerline Island. Progradation of this bar past the bridge in the 1980's contributed to the eventual decision to abandon a gauging station that had been established there in the 1960's. For the most part, however, the channel morphology remained stable between 1983 and 1991 (Figure 8). The only changes of note in this period are continued vegetation of Big Bar and minor erosion at the downstream end of Island 32. Presumably the latter is related to the continued development of the flow diversion behind Big Bar.

The 1999 photography (Figure 1) was taken at extremely low flows and illustrates the areal extent of Big Bar and the bar at the tail end of Powerline Island. Erosion continued to occur along the north bank of Island 32 during the 1990's, trimming the bank so that is parallel with the bank of Ferry Island.

The changes described above can be assessed quantitatively by using historic channel maps of channel bar, island and bankline positions. By digitizing airphotos for the gravel reach of Fraser River, channel maps for 1949, 1962, 1983, 1991 and 1999 have been created at the Geography Department of University of British Columbia. Bankline positions from these years for Island 32 have been plotted on Figures 9a to 9d (Figure 9). Erosion of the north bank of Island 32 between these dates is as follows:

Table 1. Historic erosion of Island 32.

Period	Erosion (m^2)	per year (m^2)
1949 – 1962	3,200	250
1962 – 1983	41,100	1,950
1983 – 1991	10,600	1,325
1991 – 1999	19,400	2,425

The more active erosion following 1962 is a product of the main flow becoming increasingly confined to the left side. Some erosion has also occurred along the bank of Ferry Island within this time period, but extensive armouring of the banks has limited loss of land. The most active period has occurred within the past eight years.

Since the early 1970's, the general configuration of the river is for flow to move through the bar and island complex on the lower end of Herrling Island which forms a long diagonal riffle across the channel and reaches the left bank of Powerline Island. The channel below the Herrling Island complex represents the chute into which the riffle flows escape. The chute and the bend here sustain a secondary circulation, which directs the nearbed flow and sediment transport to the right, toward Powerline Island. In turn, this has allowed considerable gravel to be deposited on the bar tail downstream from Powerline Island and in the entrance to the Powerline Island back channel. The end result is that flows have become increasingly confined to the left side of the channel.

Figure 9 Bankline position of Island 32 study reach: a) 1949 to 1962, b) 1962 to 1983, c) 1983 to 1991, and d) 1991 to 1999.

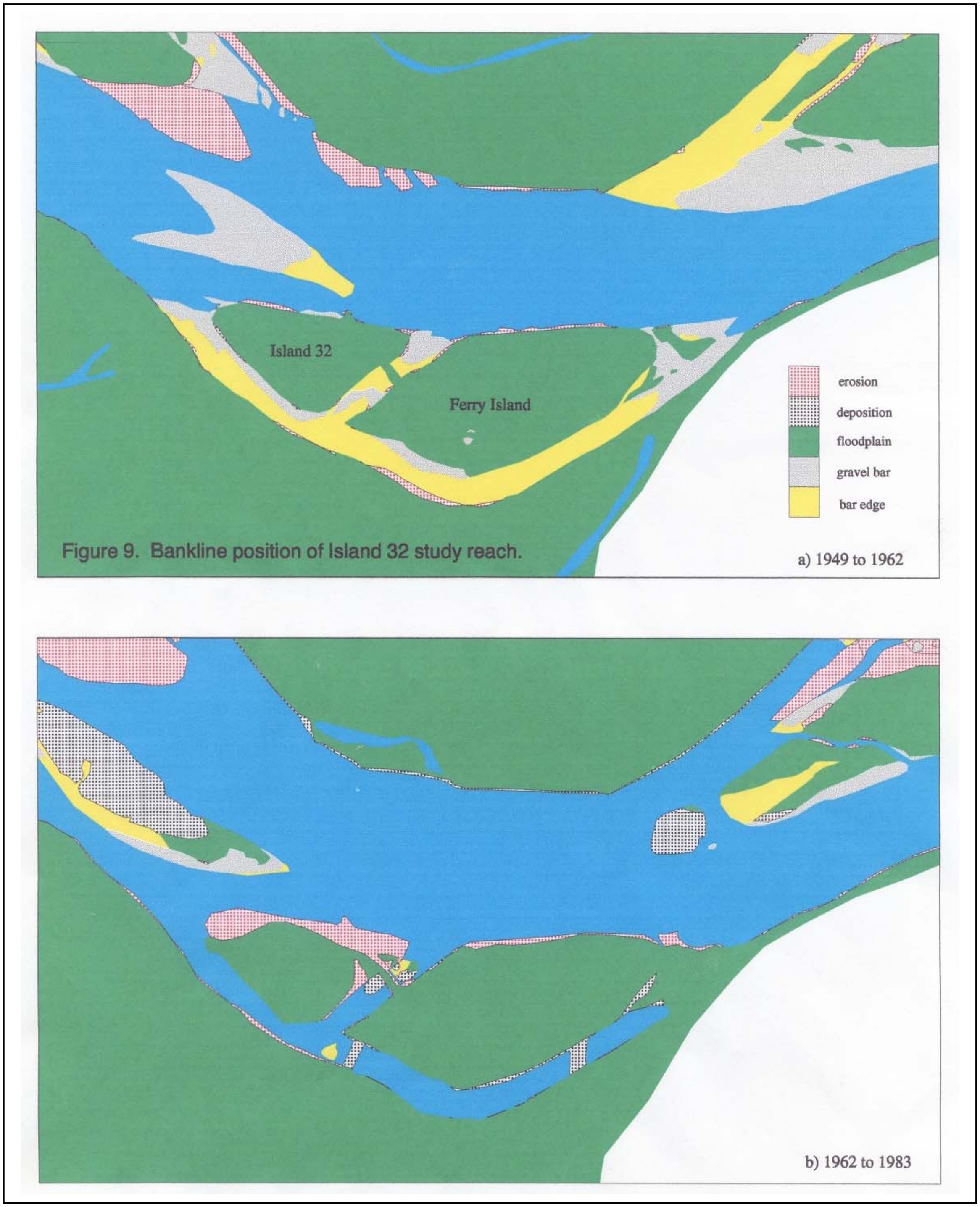
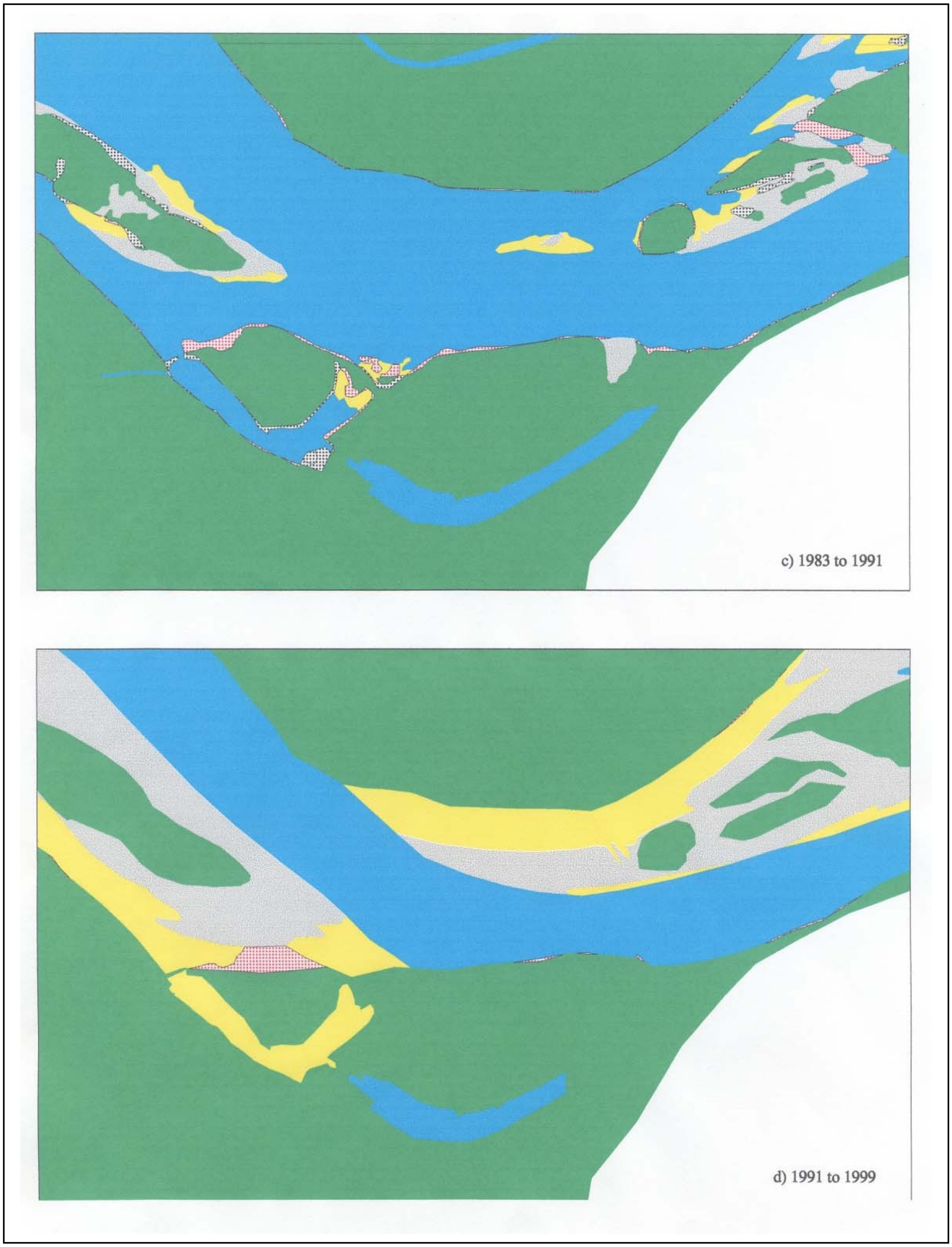


Figure 9 cont'



The progressive shift of the channel to the left is illustrated by comparing bathymetric surveys of the channel, which were completed in 1952, 1984, and 1999. Seven cross-sections through the study area (Figure 10) have been constructed from these bathymetric surveys and are shown in Figure 11. Since 1952, there have been few changes in the channel geometry at Powerline Island (cross-sections 6 and 7). Further downstream, however, there is an abrupt shift in the thalweg from the right to the left between 1952 and 1984 (cross-sections 3 and 4), and progressive deepening of the channel to the present. These changes are associated with the migration of the "Ferry Island bar" downstream into Big Bar, development of the Powerline Island bar, and the consequent channel realignment. Furthermore, the entrance to the Ferry Island back channel silted up in the 1970's and gravel deposition occurred in the Powerline Island back channel. Reduced flow conveyance in these backchannels has increased the high stage constriction of flow in the main channel. At cross-sections 1 and 2, off Island 32, the thalweg continues to be on the right bank but, following the construction of Big Bar after 1950, the channel remains divided, and there is significant degradation in the left hand channel, which flows between Big Bar and the left bank.

Figure 10 1999 bathymetry of study reach and cross-section locations.

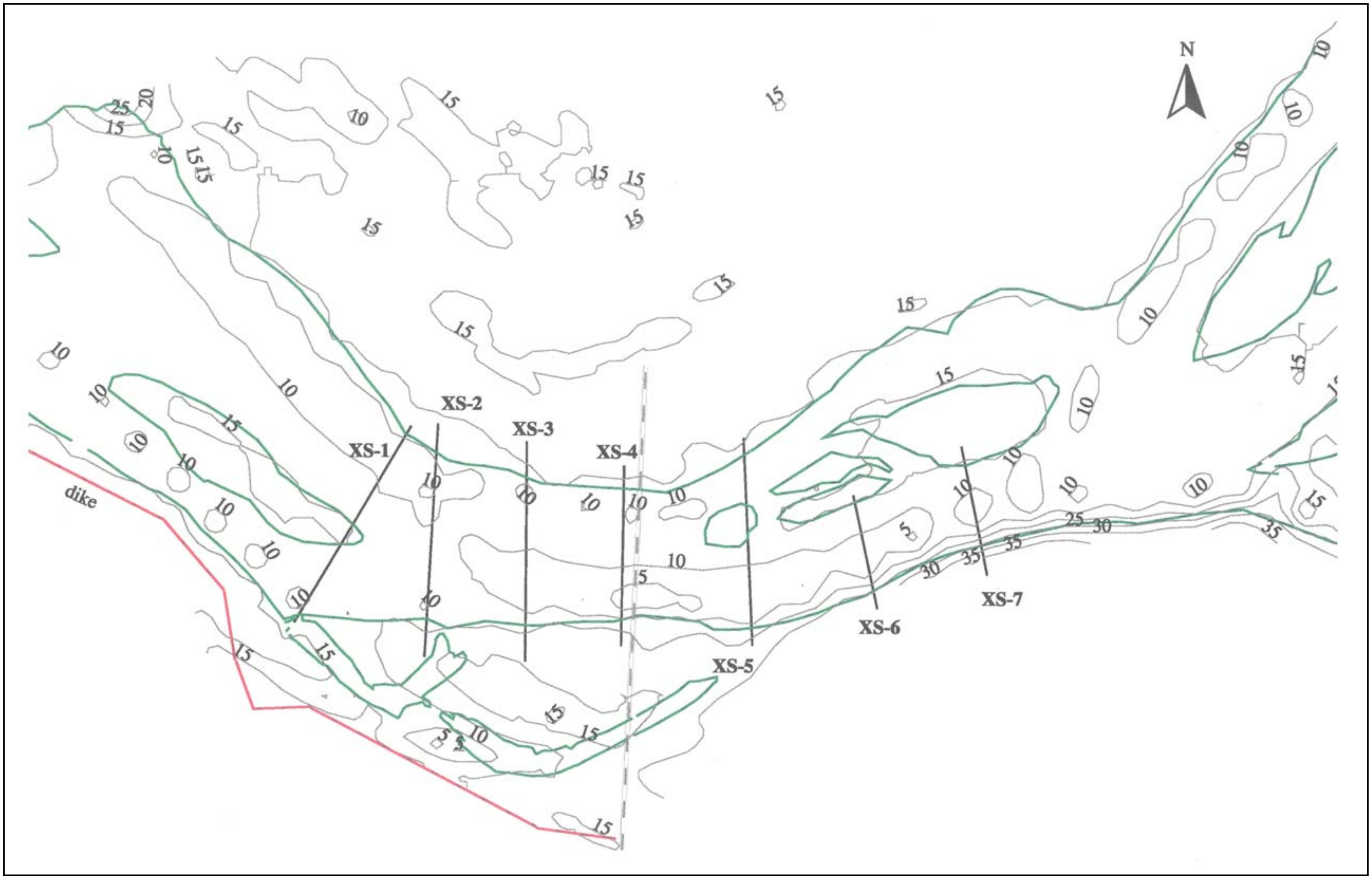
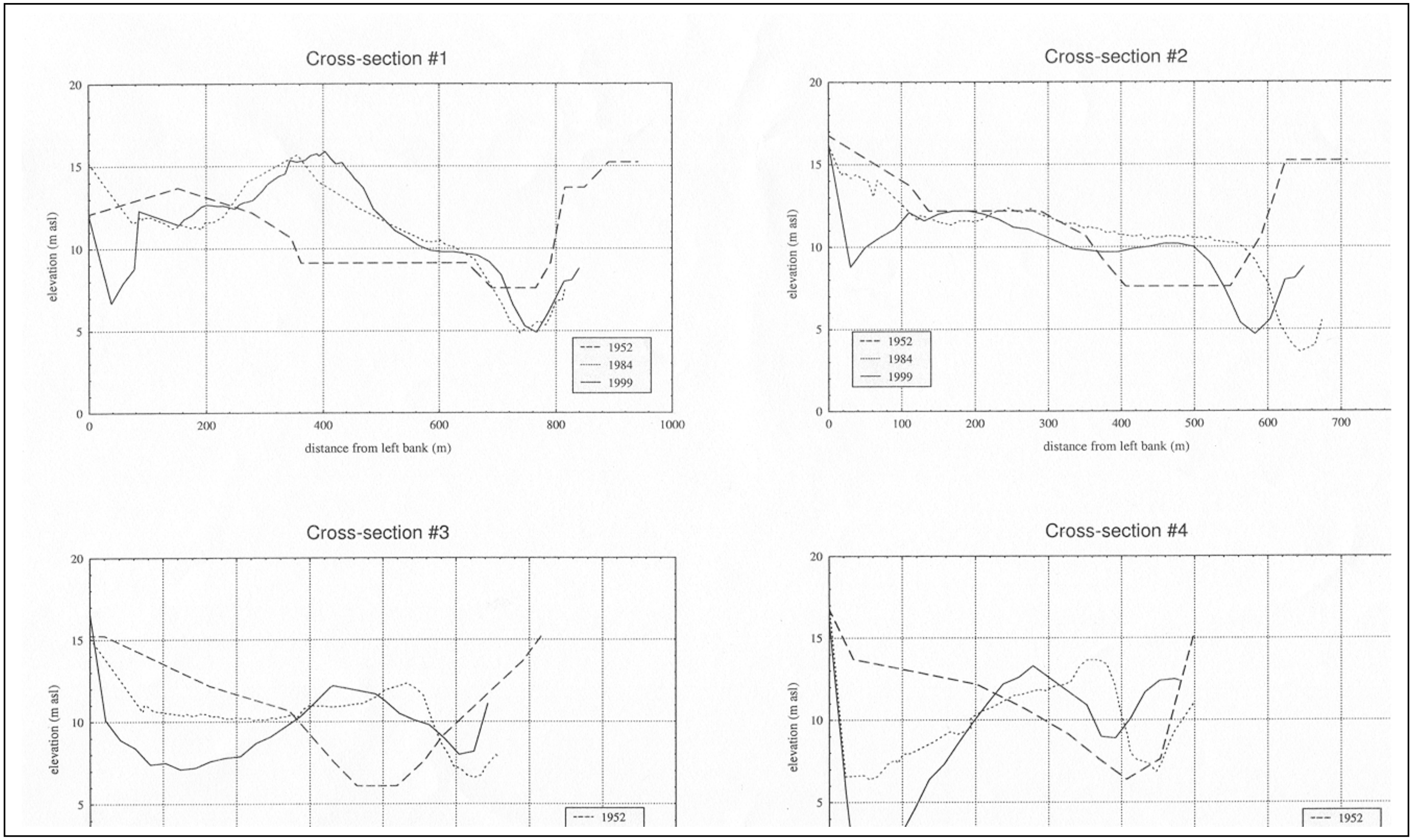


Figure 11 Cross-sections through Island 32 study reach.



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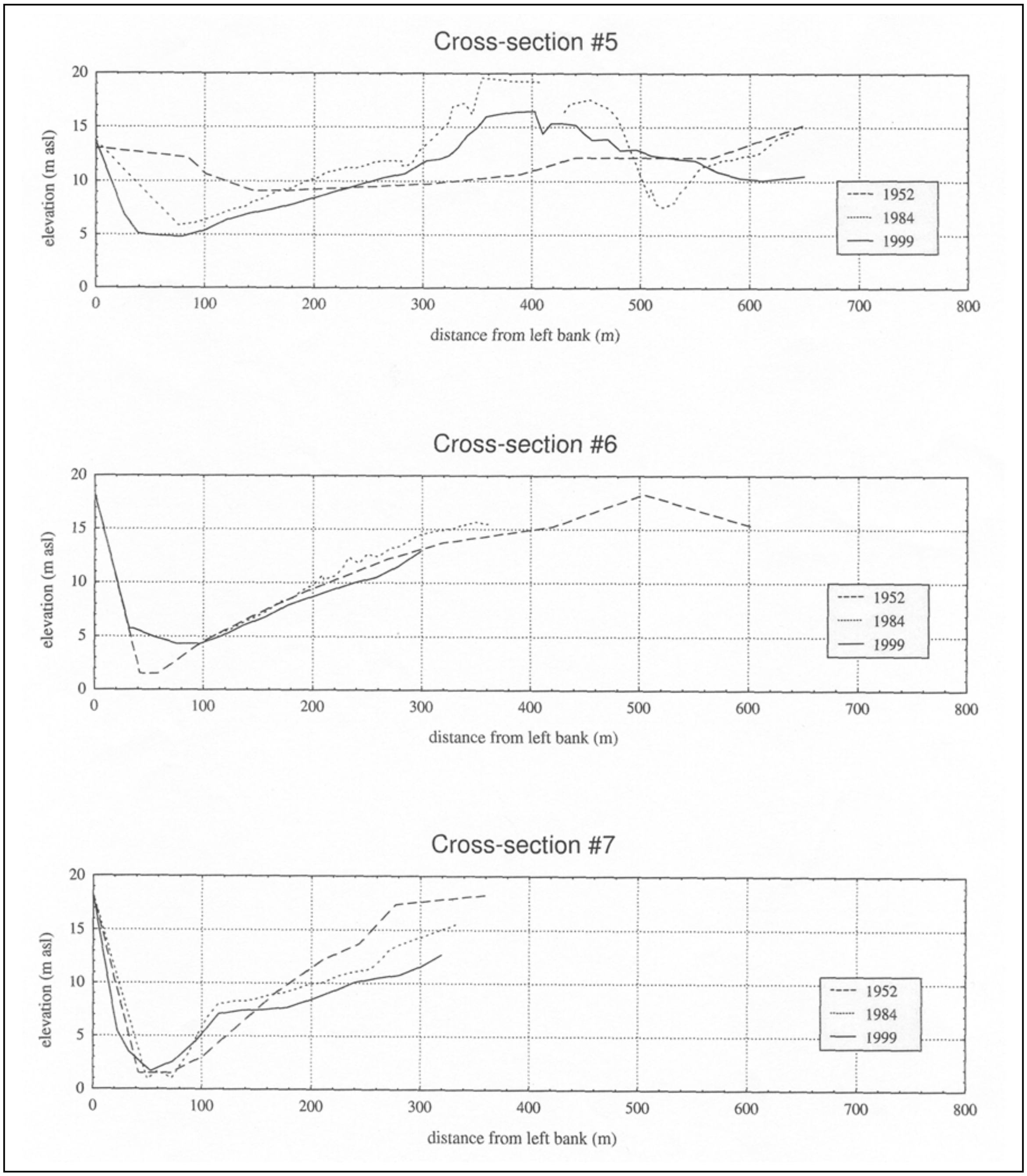

Possible future developments at Island 32

The pattern of recent erosion at Island 32 and concomitant sedimentation at the head end of Big Bar suggest that the channel which passes between Big Bar and Island 32 is moving left and increasing in depth. It consequently is abstracting an increased volume of water from the present main channel, which is set directly toward this channel entrance. The March, 1999, photography (Figure 1) indicates that there remained a sill across the entrance to this channel which is not recorded in the August, 1999, bathymetry (Figure 10), so that this channel may be enlarging quite rapidly now. At the same time, the main channel crossover zone, between the tail end of the Powerline Bar and the head end of Big Bar, remains relatively shallow at ca. 10 m elevation although the right bank channel beyond the crossover is deep.

One possible development, in this circumstance, is for the left bank channel to continue to develop, gradually abstracting more and more of the flow, so that it eventually becomes a large -- possibly dominant -- channel. Two factors indicate the plausibility of this suggestion:

- the deeply-scoured channel upstream is set directly toward the left hand channel;
- in comparison with often observed configurations, the overall configuration of the right-hand bend here suggests that, eventually, a chute will develop at the upstream end of Big Bar, with the majority of the flow moving through the chute and into the left-hand channel (see Figure 12(a and b)).

In this case, additional sedimentation will occur on the left-hand side of Big Bar and strong flow forces will impinge on the left bank of Fraser River downstream from the corner where Camp Slough takes off. The river would quickly move left and threaten the existing bank revetment (the bank was armoured in the early 1970s). Maximum depths offshore could increase to as much as 15 m below floodplain level. If the bank protection were to become undermined by direct attack, the floodplain might then erode relatively quickly, bringing the river against the main dyke within a few years. The entrance to Camp Slough might also come under attack. However, this is unlikely to lead to uncontrolled flows into the slough, since a gate located at the main dyke controls flows into the slough.

An alternative scenario would see the main channel of the river continue to cross over to the right bank past Big Bar, with little or no additional sedimentation in the crossover zone. In this case, it is even possible that Big Bar might eventually suture itself to Island 32, although it is not clear where the volumes of sediment required for this might come from (see below). The right-hand bend past Big Bar is not tight, and the river is only slightly narrow through this crossover (425 m between terrestrial vegetation lines, against a desirable width for the full channel of 500 m, the difference being represented by the left-hand channel). A configuration in which the lesser of two channels is on the outside of the bend (as at present) is not unusual along Fraser River (see Figure 12a).

To discriminate between these possibilities, it is helpful to ask how bed material transport and deposition appear to be proceeding through the reach between Powerline Island and Big Bar at present. In recent years the tail of Powerline Island has grown relatively quickly, whilst there appears to have been only limited deposition around the head of Big Bar. The river as it moves into this reach from the downstream end of Herrling Island sets up a counterclockwise spiral which directs bottom flow from the left bank toward the right bank. The result should be scour along the left bank of Ferry Island, and sediment deposition on the right bank (in this case, the bar downstream from Powerline Island), as observed. Although some sedimentation occurs in the old channel entrance between Ferry Island and Island 32, the gravel platform here is composed of old, tightly locked material, and there has been fresh accumulation in recent years only of sand at the channel margin. Bed material in transport is being directed away from the left-hand channel toward the right bank and the channel crossover.

It appears that there is a good chance the erosive tendency will persist on the left bank for some time, and that there is some possibility that the left-hand channel will open up. It is worth noting that, in general, the configuration that could then develop, with a co-dominant or dominant channel on the left bank, is the configuration that existed at this site before 1950 (Figure 2, Figure 3), before Big Bar began to grow.

Figure 12a Current (simplified) configuration of channel in vicinity of Island 32 and Big Bar , with the secondary channel on outside of the bend. The potential configuration - secondary channel inside the bend – is overlain in color.

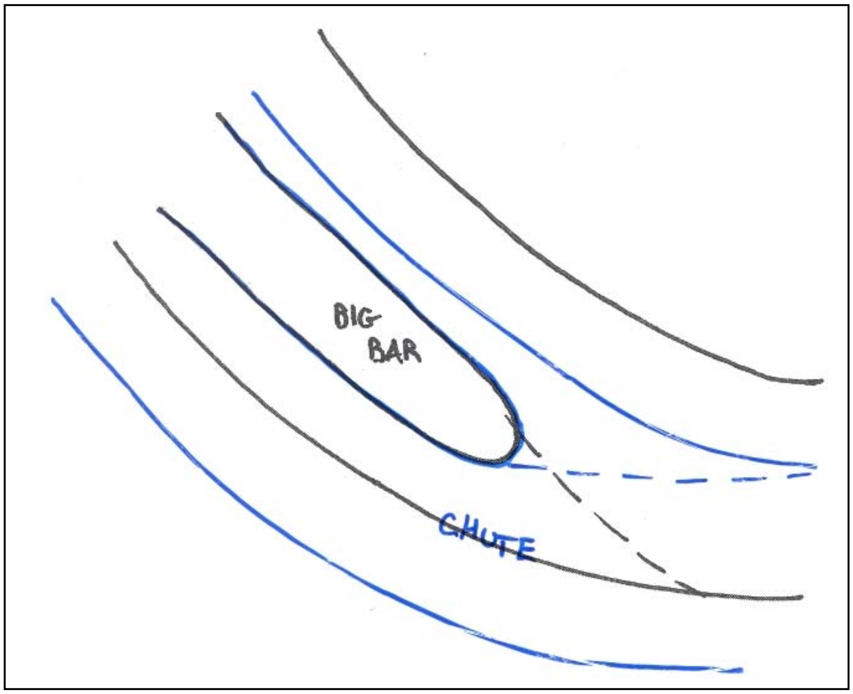

Figure 12 b