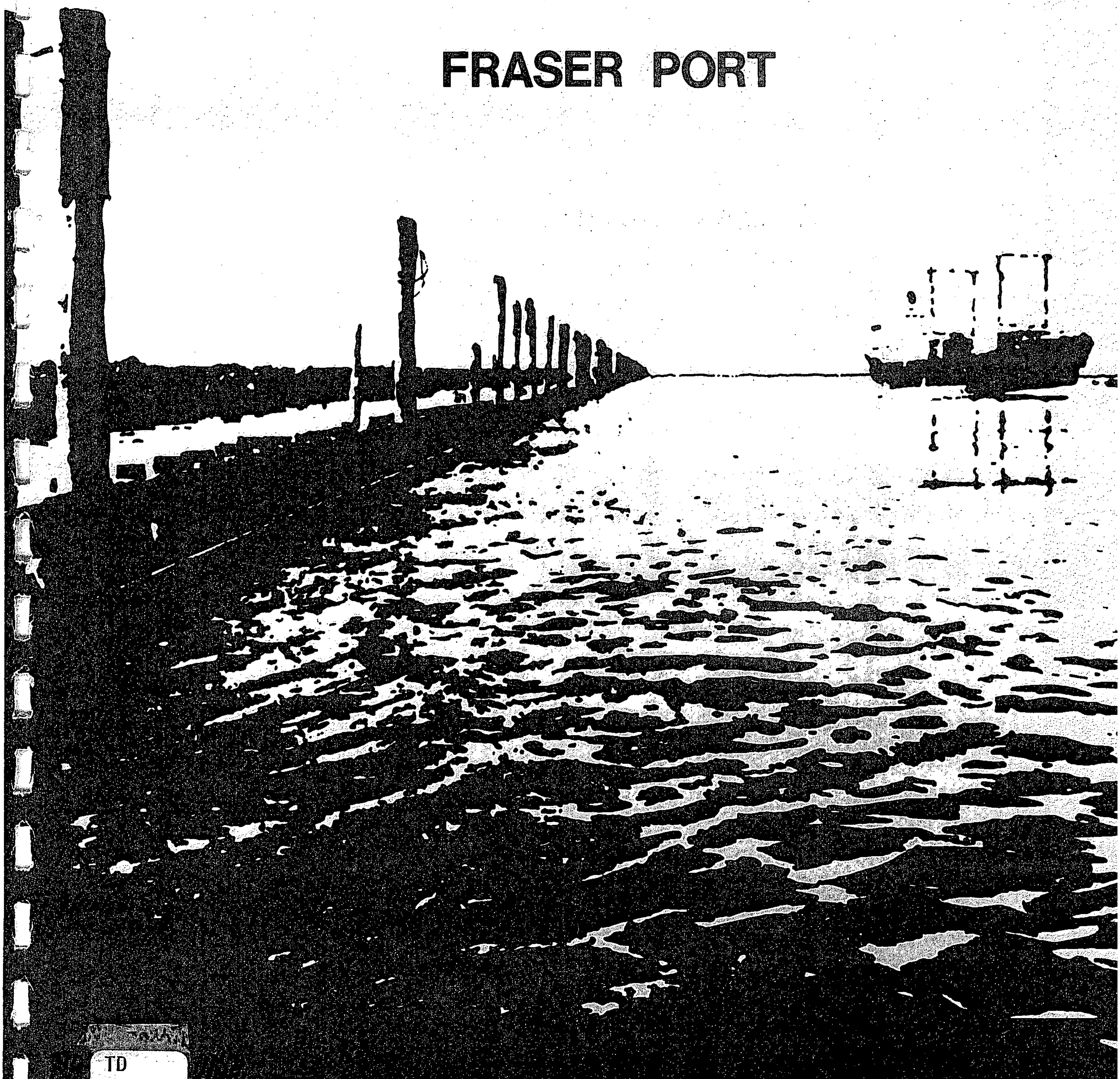
SPILL RESPONSE MANAGEMENT MANUAL

FRASER PORT



Environment Canada
Environmental Protection

Fraser River
Harbour Commission

ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION
PACIFIC AND YUKON REGION

FRASER RIVER HARBOUR COMMISSION

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FRASER PORT

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FOREWORD

This manual was prepared under the direction of Environment Canada and the Fraser River Harbour Commission to facilitate response to oil and chemical spills in Fraser Port. It is intended to supplement government agency and facility-specific contingency plans concerned with mitigating the effects of accidental discharges of hydrocarbons and other floating contaminants in the lower Fraser River. To this end, the manual generally examines the ecosystem and amenities potentially at risk. It also reviews the selection and implementation of countermeasures as well as local resources which might be applied to deal with spills that have escaped at-source confinement.

Unlike other more expansive sections of coastline, the lower Fraser River supports a continuum of resources of high and sometimes contrasting value. The estuary has biological and related recreational significance throughout its entirety; fish, waterfowl and marsh figure prominently in this regard. Industries and port facilities also rely on locations bordering the lower river reaches. Designating and ranking priority sites requiring spill protection is therefore an arbitrary, if not difficult, task.

The manual does address spills in terms of both ecological factors and facilities. Sites enumerated by the Department of Fisheries and Oceans (DFO) as part of that agency's inventory of habitat have been specifically identified, as have larger areas of intertidal marsh. Amenities are noted pertaining either to possible impacts from spills or as sources of materials, equipment and other forms of assistance for response operations. This in no way is intended to discount a concern for other entities in the estuary.

Response options also consider the complex hydrodynamics of the lower river system, albeit at a cursory level. Tide, current, runoff and wind combine to produce surface flow that is in a constant state of flux, changing in velocity and direction. This essentially eliminates utilizing a fixed set of spill control sites. It will often negate the effectiveness of currently available, conventional response methods and hardware. Alternative approaches must be considered.

In summary, this manual should be regarded as an overview of practical spill control considerations for Fraser Port providing direction for the management of spill response.

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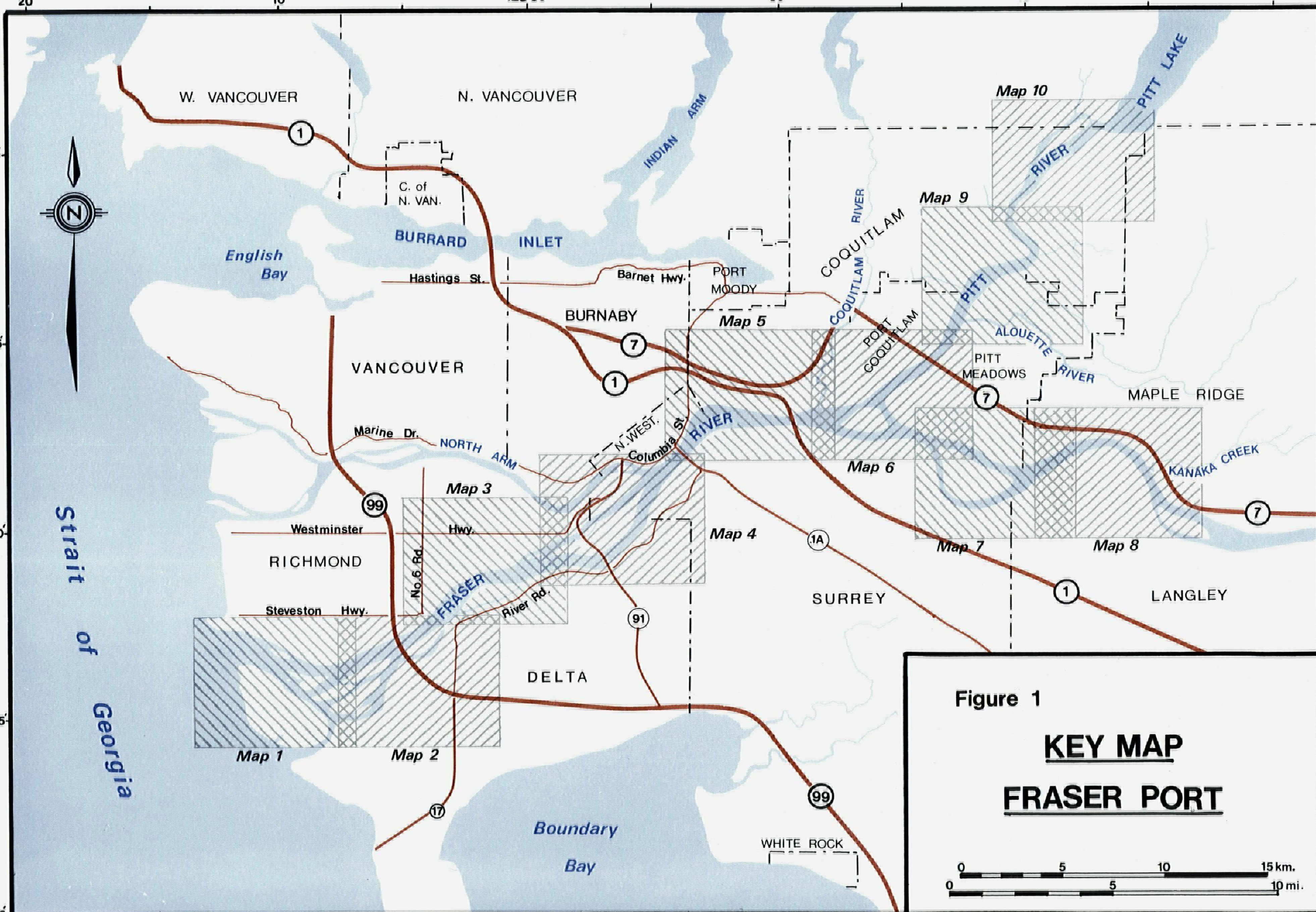


Figure 1

KEY MAP

FRASER PORT

PART I: BACKGROUND INFORMATION

1.0 INTRODUCTION

1.1 Setting

Fraser Port extends from Garry Point at the mouth of the mainstem of the Fraser River east to Kanaka Creek. It also includes the Pitt River to Grant Narrows at the entrance to Pitt Lake and takes in a portion of the North Arm east of the inlet bounding the east side of Tree Island. Canoe Passage to Brunswick Point also lies within its jurisdictional limits. Spill response is considered for all waters within Fraser Port according to ten sectors as indicated in Figure 1 Key Map. Spills are of no less concern in the approaches to the Fraser River and their cleanup there is addressed in Environment Canada's Shoreline Protection and Clean-up Manual for the Port of Vancouver.

1.2 Format of the Manual

This manual has been organized according to two sections, namely Part I Background Information and Part II Operational Data.

Part I gives an overview of resources, factors affecting the fate of spills, and generalized response options for Fraser Port:

Chapter 1.0 Introduction

Chapter 2.0 summarizes the vulnerabilty to spills of fish, birds, mammals, marsh, and human-related amenities.

Chapter 3.0 discusses physical features which influence spill behaviour and response such as current, tide and wind.

Chapter 4.0 reviews countermeasures alternatives that might generally be applied to control spills in the river. The cleanup phases of containment, deflection, dispersion, recovery, storage, transfer and disposal are discussed.

Part II comprises the working component of the manual and presents site-specific data for Fraser Port:

Chapter 5.0 introduces information shown on ten operational maps to expedite their use. Complementary data sources are suggested.

Chapter 6.0 features ten maps depicting primary spill concerns and cleanup resources. Accompanying tables and text summarize environmental considerations and response strategies.

Appendices present selected information sources pertinent to spill cleanup in the Fraser River as well as a cross-reference for the DFO enumerated sites correlating the numbering system used in this manual to DFO desginations. Spill response arsenals in the Lower Mainland Area are also listed.

2.0 RESOURCES OF FRASER PORT

A noteworthy feature of the Fraser estuary is the interdependence of its fish, wildlife and vegetation which co-exist with a large urban centre and port. Countermeasures strategies cannot look upon any one of these aspects in isolation from the others but must consider the safety of people and the preservation of property inclusive of port facilities, industries and amenities--all in conjunction with an interrelated biological community.

The various resources of Fraser Port and their interdependence are reviewed from the perspective of spill management concerns.

2.1 Fish

2.1.1 Species

The most prized species of the commercial and recreational fishery in the lower Fraser River are salmonids--sockeye, pink, chum, coho and chinook salmon, and cutthroat and steelhead trout. Of the shellfish, Dungeness crab are the most valuable although crayfish are also caught. The vulnerability to spills of both salmonids and shellfish generally extends year-round. The crab fishery is located outside of the river and could be at risk should contaminant enter mudflats near the river mouth.

A smaller portion of the Fraser River fishery also collectively posing year-round concern as regards spills is comprised of:

Dolly Varden
mountain whitefish
white sturgeon
eulachon
surf smelt
carp

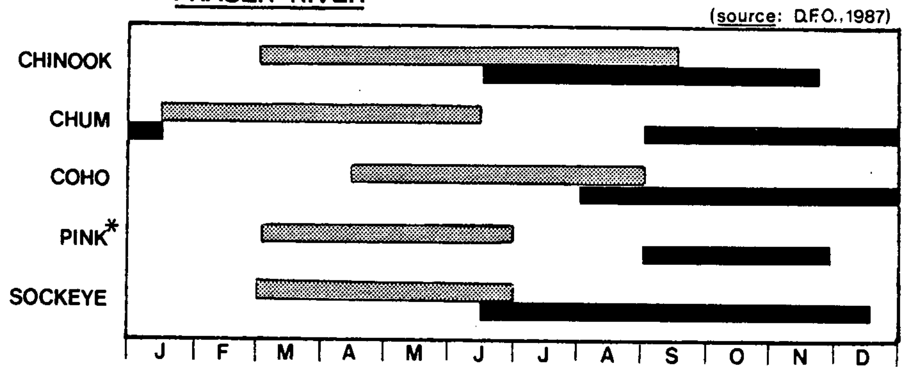
Spill implications to salmon are considered in greater detail because of their high relative value. Although not reviewed further, the significance of other fish species to the estuary should also be borne in mind.

2.1.2 Timing

Both salmon and trout spawn in the Fraser River system. The passage of adults through the lower river towards upstream spawning grounds extends throughout the year (see Figure 2). The primary runs, and the greatest number of adult, are present from June to December, starting with the early Stuart run of sockeye three years out of every four. The duration of the migration in the lower mainstem is variable, depending upon water temperature, discharge, tidal cycles and the timetable of specific runs. Certain salmon are known to pause briefly in the estuary before continuing upstream, which also adds to the uncertainity of the exact timing of runs.

Figure 2 SALMON MIGRATION AND REARING IN THE LOWER FRASER RIVER

(source: D.F.O., 1987)



* Pink adult migrations occur odd years only. Pink juvenile migrations occur even years only

KEY
juvenile migration & rearing
adult migration

2.1.3 Location

Adult salmon use all vertical and lateral sectors of the mainstem. Under certain conditions, adult salmon prefer surface and mid-water depths. Subsequent downstream migration of juvenile salmon through the lower river can start in early January with the emergence of the first chum salmon fry. Peak numbers occur from April through mid-May, or at least one month prior to peak freshet, with the bulk of the migration finishing by the end of May. Chinook and Harrison sockeye juveniles are unique in this regard and tend to linger longer in the estuary.

During migration, juvenile salmonids tend to swim within the top 1 1/2 metres although sampling has indicated some fish at depths of up to 5-6 metres. All lateral segments of the river are used during out-migrations with greater numbers generally concentrated in the high velocity segments of the river. Rearing and feeding take place in the more quiet waters of intertidal marsh habitat.

2.1.4 Sensitivity to Spills

Both adult and juvenile salmonids would be potentially at risk and therefore vulnerable to spills should these result in toxic concentrations in the upper portion (several metres) of the water column. Under the conditions when adults prefer surface migratory routing, they could be affected by floating substances. Higher current velocity regimes occurring in mid-channel would tend to transport pollutants out of the river to minimize such impacts, except in the case of a spill originating in a backwater area.

Slower moving water, often associated with marsh habitat, could be the recipient of higher concentrations of contaminant following a spill. Juvenile fishes engaged in rearing and feeding activities might then be at greatest risk. The ability of fish to avoid pollutants is questionable and it is therefore not known whether they would seek deeper water and/or retreat from marshes should a spill occur. Both short-term effects from spills, including outright mortalities, and longer-term consequences are possible. This suggests that discharged materials should be deflected away from marshes into the main channel, particularly on ebb tides.

Salmon account for part of the difficulty in designating priority protection zones because they utilize much of the lower river. Since each species, however, displays different usage patterns in the lower mainstem during its juvenile stage, it is helpful to examine their vulnerability to spills separately in this regard (see also Figure 2):

Pink Salmon

Peak concentrations of pink salmon fry occur in the lower Fraser River during the spring of even-numbered years. Their passage is believed to be rapid and mainly confined to the mainstem with very limited occurrence and likely no rearing in marsh habitat. The probability of impact by a spill is therefore somewhat limited except for late April on alternate years.

Chum Salmon

Chum fry move into the lower Fraser River as early as January and are believed to out-migrate in relatively quick, successive waves primarily from March to late May. They are abundant in the mainstem as well as in marsh habitat. There is more likelihood of chum encountering a pollutant versus pink from the viewpoints of both timing and location. However, the shorter-term utilization by chum of the lower river reduces the overall probability of spill impacts while increasing the effect on any one run encountering significant concentrations of a pollutant.

Chinook

Migrations of chinook salmon fry peak in the lower Fraser River March through May. They continue to rear in marsh habitat in the river throughout the summer in gradually declining numbers. Some may persist during winter months. Juvenile chinook are therefore at a greater risk from spills than other salmonids due to both temporal and spatial usage patterns.

Sockeye Salmon

Sockeye smolts migrate through the lower reaches of the Fraser River in maximum numbers in April and May after rearing during their first year in upstream lakes. Their passage is relatively quick and is primarily confined to high velocity, mid-channel sectors of the river. Fry account for a small proportion from May onwards. Sockeye juveniles generally would have less probability of encountering a spill, with their preference for higher currents further reducing the potential severity of impacts. Harrison sockeye stock are an exception and rear as fry in river marshes for longer periods, possibly during winter, thus increasing their chance of exposure to spilled contaminants.

Coho Salmon

The least numerous species of Pacific salmon in the lower Fraser River system is coho. Fry tend to rear upstream for one year or more prior to the quick passage of smolts through downstream reaches. Potential vulnerability of coho to spills is therefore relatively low vis-a-vis other salmon.

2.1.5 Dipteran Insects

Two-winged (dipterous) insects called chironomids comprise a major food source for juvenile salmonids and are believed to reproduce in slow-flowing backwater channels. If chironomid production is depressed as the result of a spill, a secondary threat could be imposed on juvenile salmon populations.

2.2 Birds

The Fraser estuary is the most important area of waterfowl habitat on the British Columbia coast supporting more than 200 resident and migratory species including the largest number of wintering wildfowl in Canada. Numbers vary seasonally with peak periods generally occurring in February and towards October, and lowest utilization taking place during July and August.

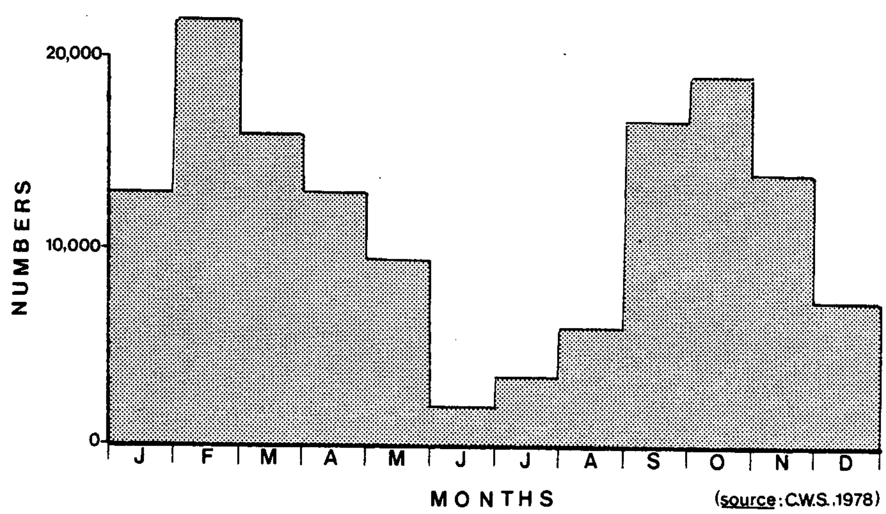


Figure 3 AVERAGE TOTAL NUMBER OF WATERBIRDS PER COUNT DURING EACH MONTH, LOWER FRASER RIVER, 1976-77

There is some variability in this regard among groups of species and their relative abundance. For example, based on a one-year survey conducted of the lower Fraser River in 1976-77 the ten most abundant species in descending order and comprising 75% of all birds counted were:

glaucous-winged gull
mew gull
American wigeon
mallard
herring gull
dunlin
California gull
green-winged teal
pintail
Bonaparte's gull

The most abundant species groupings were:

gulls 71.5%
dabbling ducks 15.0%
shorebirds 4.6%
passerines 3.1%
diving ducks 1.9%
other individual groups <1%

Waterfowl are at greatest risk from spills through direct contact of slicks, loss of the insulating value of feathers and the ingestion of toxicants when feeding and/or preening. Waterfowl include dabbling ducks (mallard, American wigeon, pintail and green-winged teal), diving ducks (scoters, goldeneye, scaup and mergansers), divers (loons, grebes and cormorants), and geese (Canada goose, snow goose and brant). They generally appear in the estuary in greatest numbers from January through April.

Gulls peak in number September through November but utilize the river in great abundance year-round. They are prone to similar adverse effects from spills as are waterfowl.

Although present in the estuary in significant numbers, passerines (songbirds) would not be directly exposed to spilled substances because of the location of their habitat in backshore areas somewhat removed from the river.

Shallow-water waders such as herons and bitterns favour sloughs and marshes while smaller shorebirds, such as sandpipers and plovers tend to feed in the intertidal zone, following the waterline as the tide recedes. Both groups could be affected by spills throughout the year either through direct contact or because of the ingestion of contaminated food organisms. They have not been observed, however, as victims of spill incidents in the numbers that waterfowl have been.

Raptors, which include falcons, hawks, eagles and owls, are at less immediate risk from spills. Generally, they are present at more remotely located foreshore and backshore areas, particularly during the summer months. Any impact on raptors is more likely to originate from human activities on river bank and not from direct contact with contaminant. A waterside response operation to clean shoreline would reduce the severity of such impacts.

Birds are widely distributed throughout Fraser Port with several of the more important concentrations in the marshes of Woodward, Duck and Barber Islands, and Sea Reach, Ladner marsh, Ladner Reach, Canoe Cove, Cannery Channel and Albion Island. Numerous gulls can often be seen in Gravesend Reach. Many additional significant habitat are reviewed in conjunction with each of the operational maps. The extent of the potential risk to birds from spills relates to effects not only on large local populations but also to impacts to a much broader-based ecosystem.

2.3 Mammals

Marine mammals that could be affected by a spill include harbour seals, killer whales and sea lions. Of these, harbour seals are by far the most abundant and would be present in greatest numbers at times coinciding with salmon runs. Sea lions and killer whales remain in deeper water, off Sturgeon Bank, and are more likely to be in the area when salmon are preparing to enter the Fraser River to spawn.

Contact and ingestion of contaminants is more probable by seals than by sea lions or whales due to their wider, more numerous distribution throughout Fraser Port.

Muskrat and beaver inhabit the freshwater marshes along the river banks, especially those of the Pitt River. Generally, these mammals would be at less risk from a spill because of the lower probability of a contaminant entering the areas which they frequent. River otter should also be of less concern for similar reasons. However, should a spill affect their habitat, the mitigation of potential impacts should include minimizing shoreline-related cleanup activities disruptive to them.

2.4 Marshes

Tidal marshes serve many ecological functions vital to the interdependence and, ultimately, the survival of fish, birds, mammals and invertebrates in the Fraser estuary. They provide sources of food for many organisms and are life-long and seasonal habitat offering an adaptive and protective environment for others. Commercially significant fish, waterfowl and many other members of the food webb rely upon the waters and land associated with marshes for one or more life stages. Sensitivity to spills is year-round, although the March-to-October period is particularly critical to both the growth of vegetation and the development of other biological species.

The concern with spills thus centres not only around the immediate and direct contact of vegetation and sediments but also on the secondary impacts to marsh-dependent lifeforms including juvenile salmon, dabbling and diving ducks, geese and waders. Both short- and long-term effects are possible. These inherent sensitivities mean that the cleanup of marshes must be carefully undertaken with a minimum of damage and disruption. Preventing the intrusion of pollutants into such areas in the first instance would be the ideal countermeasure strategy to pursue since the protection of various species would be simultaneously achieved.

There are large regions of marsh in the lower reaches of the mainstem covering most of Woodward, Duck and Barber Islands plus adjacent low-lying areas. Other significant marshes occur along Canoe Pass, near Albion Island, beside Cannery Channel, at Surrey Bend and along the Pitt River. Many other smaller pocket marshes are also scattered throughout the lower river. The Department of Fisheries and Oceans has conducted an inventory of many sites which could be used as either the recipient of transplants or as the source of donor plants. Such habitat management planning is consistent with training efforts by Public Works Canada to enhance flow regimes and scouring in sections of the river. This has led to the stabilization of river bank and the growth of marshes, although the processes of erosion and accretion have not been entirely subdued and continue to affect marsh distribution.

2.5 Amenities

Port facilities, various industries, water intakes, float homes, parks, beaches, marinas and fishing bars are all located in Fraser estuary. Many of these are depicted on the operational maps, although the industries shown are primarily restricted to those with facilities such as launches, barge ramps and marine railways of potential use to spill cleanup operations.

In brief, larger terminals include Fraser-Surrey Docks, Annacis Auto Terminal, Fraser Wharves, B.C. Packers and B.C. Ferries Corp. Industries range from saw-, shook and paper mills to cement, chemical, steel, and fish packing plants. Towing companies, shipworks, marinas and pipelines have also been located in the region. The George C. Reifel Migratory Bird Sanctuary, Ladner Harbour Park, Mayfair Park, Derby Reach Regional Park and Kanaka Creek Regional Park are examples of an expanding number of recreational areas along the lower river.

A significant use made of the Fraser River system is log transportation and storage. Dolphins to which log booms are secured are generally located upriver from Tilbury Island and New Westminster, and into the Pitt River. Because of the transitory nature of such activities, these are not illustrated on the maps.

Each amenity would have to be considered separately in the event of a spill to ascertain ecological/environmental sensitivities and response requirements, and minimize cleanup and other costs.

3.0 FACTORS AFFECTING SPILL BEHAVIOUR & RESPONSE

3.1 River Current and Discharge Volume

Surface current velocities in the lower Fraser River exceed critical values for spill control at many locations in Fraser Port on both flood and ebb tides throughout the year. During the freshet period between May and July, unidirectional surface flow is highest and occurs coincident with augmented discharge.

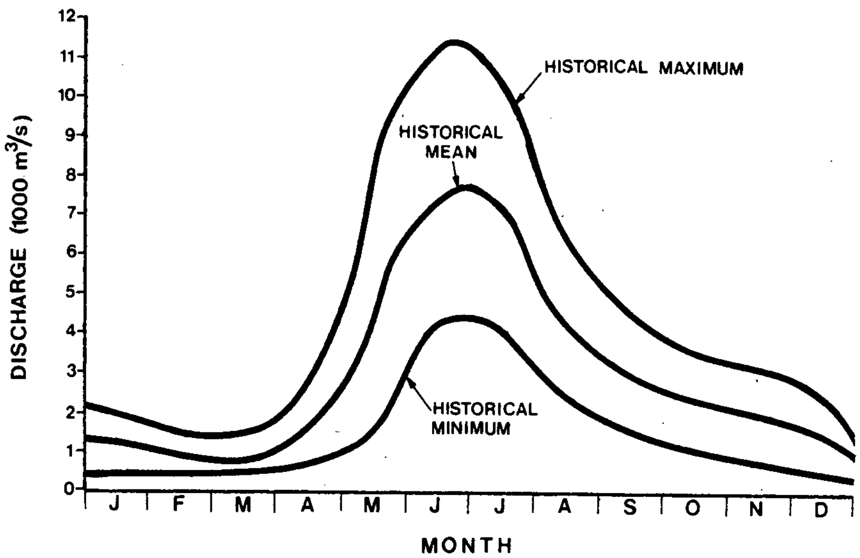


Figure 4 ANNUAL DISCHARGE FOR THE FRASER RIVER

High currents occur in both the main and side channels and are highest at constrictions in the river. Specifically, it will not be feasible to set out booms to deflect slicks if velocities exceed about 1 1/2 knots (0.8 m/s) while at 3/4 to 1 knot (0.4-0.5 m/s) containment becomes ineffective.

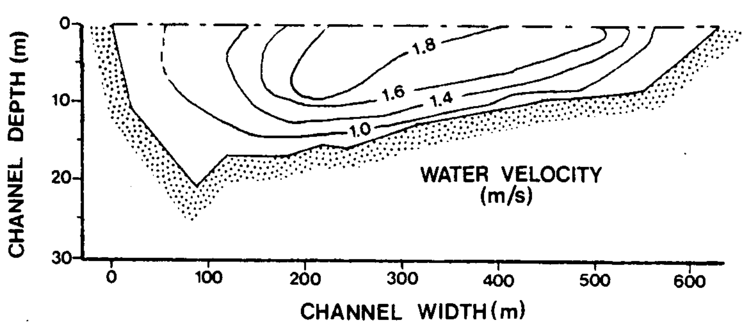


Figure 5 TYPICAL DISTRIBUTION OF MAIN CHANNEL VELOCITIES (DEAS ISLAND-June 1978)

Slower current velocities tend to occur close to banks, in shallow water, and downstream from obstructions and side channels. Sloughs which are not hydraulically well-connected to the main channel would have lowest velocities. Cleanup in these sectors is more plausible.

The outflowing river water tends to flow over incoming salt water so that during the low flow conditions of mid-winter, a salt water wedge tends to move upriver to establish an equilibrium position in the vicinity of Deas Island. It then moves up- and downriver from that point on successive tidal cycles. During the freshet period, the wedge intrudes into the river only as far as Steveston Bend. Should a contaminant be dispersed at depth, it could move with the wedge and be broadly distributed in the more environmentally sensitive lower estuary, particularly December through March. This might not be apparent by looking at surface flow. The option of dispersion therefore remains questionable, pending the availability of more specific data.

Eddy currents will also affect spill control operations; they can be detected if oil or other material is present. Their pattern is likely to change over the course of any tidal cycle and each situation must be individually assessed. Eddy currents might occur in proximity to pronounced land forms and inlets or, more generally, at mixing boundaries between fast and slow moving water. They tend to become more fully developed at ebb tide when velocities are highest. Eddies will sometimes hinder attempts to deflect free-floating substances but might also, on the other hand, be effectively utilized to enhance oil containment and concentration in backwater areas, sloughs and embayments. Advice during spill cleanup operations should be sought from operational personnel familiar with this aspect of the Fraser River.

Flow distribution is another important factor characterizing the river. It is often expressed as an approximation for specific locations. At trifurcation, for example, about 15% of the flow is attributed to the North Arm, 10% to Annacis Channel and 75% to Annieville Channel. On outgoing tides, Ladner Reach accounts for about 15% of the flow which then divides equally between Sea Reach and Canoe Passage.

The primary implication for spill response is that the higher discharge volumes of the main channel of the mainstem, especially during the May-to-July period, offer the most significant potential for the eventual dilution and dispersion of floating contaminants. The prevention of spill intrusions into other river channels should be prevented because of possible high concentrations, longer residence times and related environmental concerns.

3.2 Tide

River stage changes primarily due to the diurnal ocean tidal cycle influencing the Fraser. Tide tables should be examined during a spill to determine when and to what extent changes in water level will occur. It is most important to note that:

Daily minimum stages are influenced more by river discharge than are daily maximum stages. This is more critical during the freshet period (May to July).

Daily maximum levels are more or less independent of river discharge.

Tides are more important overall in influencing water levels than is river discharge.

For operational purposes, time of day is more important than time of year in predicting water levels.

The effect of tide on water level fluctuation decreases upriver.

The most extensive intertidal areas are located downstream from Deas Island. All river bank within Fraser Port will undergo intertidal exposures and must be assessed individually according to its width and steepness to determine the extent of tidal influence.

Daily flood tides cause temporary flow reversals (i.e. upriver flow) throughout the year with the exception of about mid-May to the end of July. In current reversal situations, the time taken for boom deployment might not leave significant operational time before repositioning must be undertaken, thus rendering the approach unfeasible.

Flow reversal also significantly influences the residence time of a contaminant in the lower Fraser River. During periods of relatively low discharge (September through April), a release in the vicinity of the Port Mann bridge might persist in the mainstem 30-40 hours, moving up- and downriver prior to finally leaving the estuary. During the peak flows of May, June and July, residence time would be more than halved. Should contaminant enter Canoe Passage, especially during low flow, residence time could be doubled to two to three days.

Insofar as cleanup is concerned, the freshet period will likely see a significant portion of a spilled floating substance quickly move through the lower Fraser River, exit into the Strait of Georgia and generally produce lower concentrations in the water column. Spill control will not likely be possible. Discrete pockets of contamination might result which would be amenable to physical recovery; shoreline impacts should be minimal.

During periods of lower flow, more time will be available to implement cleanup. Flow reversal will also probably result in broader distribution of contaminants, especially at slack tide, and possibly more affected river bank, depending upon the physical and chemical properties of the spilled material.

3.3 Wind

Easterly winds occur with the greatest frequency in the Fraser River area, blowing 27-42% of the time, based on monthly data. Velocity is generally between 10 and 15 k/h which would tend to move slicks toward the north shore of the mainstem downriver from Annacis Island; the effect of surface and tidal currents would still remain the dominant factors influencing spill movement.

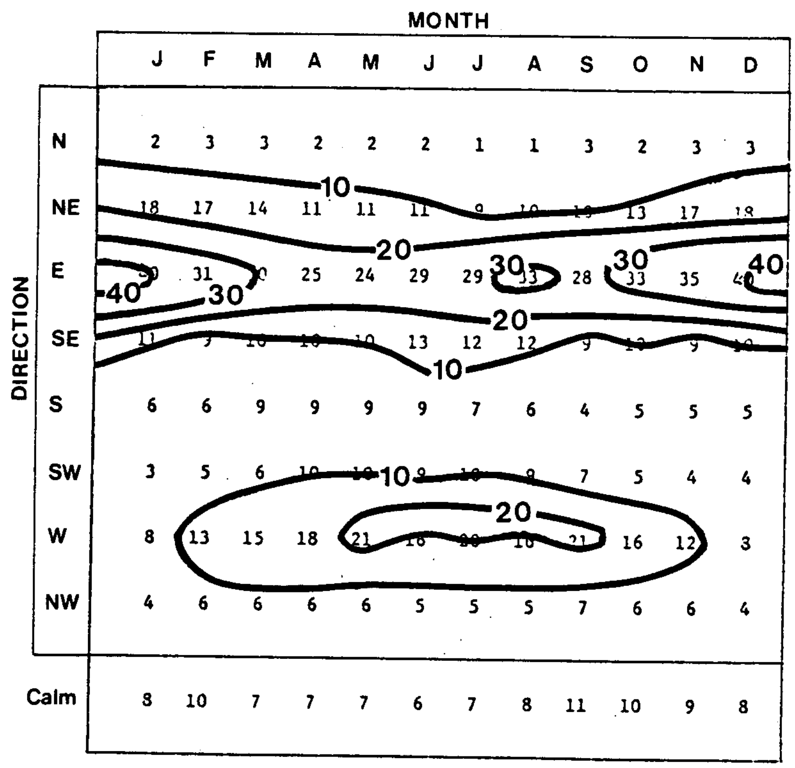
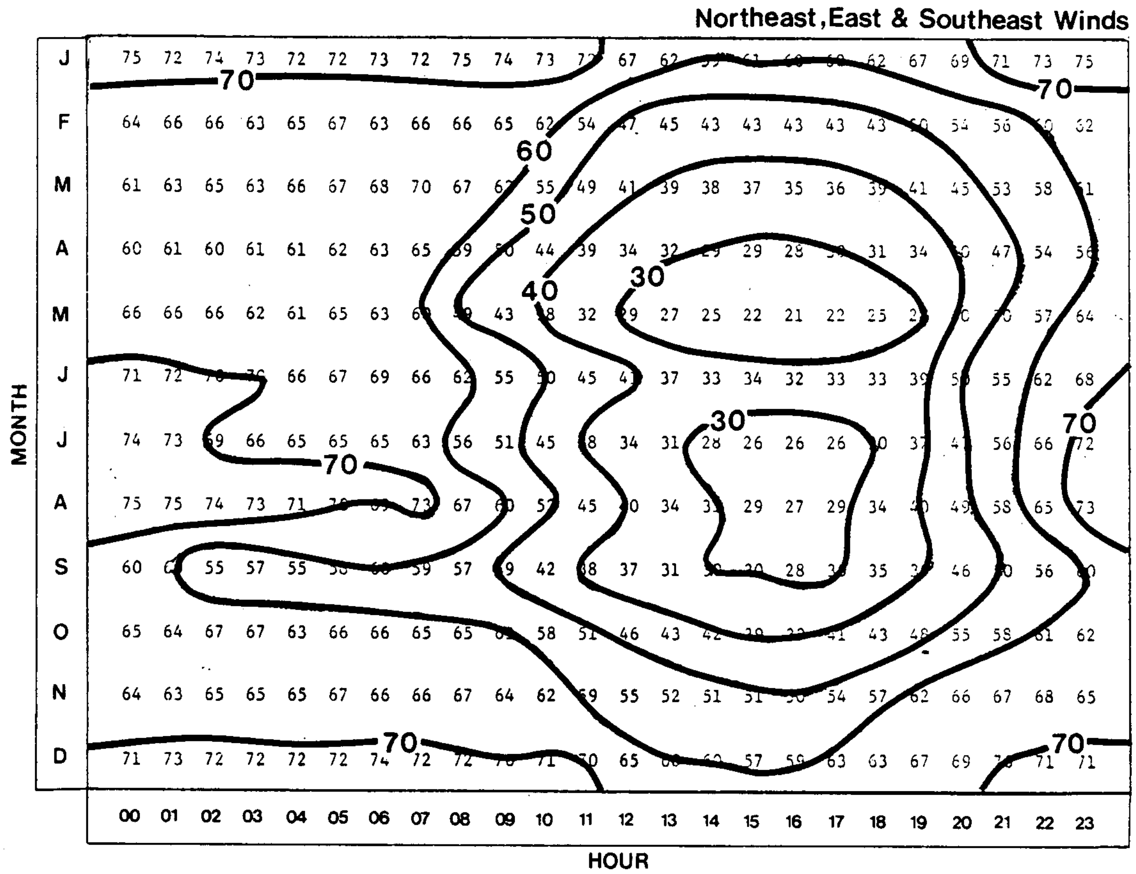


Figure 6 PERCENT FREQUENCY WIND DIRECTION

It is also important to point out that west winds tend to blow from about 1000 hrs to 1900 hrs between March and October which would push materials toward the south shore. Of all winds, westerlies blow at the highest velocity throughout the year and generally will exceed 20 k/h during all months of the year except for July and August. This has implications for spill impacts since the more sensitive biological resources of the lower Fraser River are generally located along the south shore.

There may be significant variability in wind speed and direction at different locations along the river, particularly at New Westminster and upriver. Local channeling of wind may occur. Wind direction and speed would have to be determined at the time of an incident with due attention paid to localized conditions and/or abrupt changes associated with storm fronts.



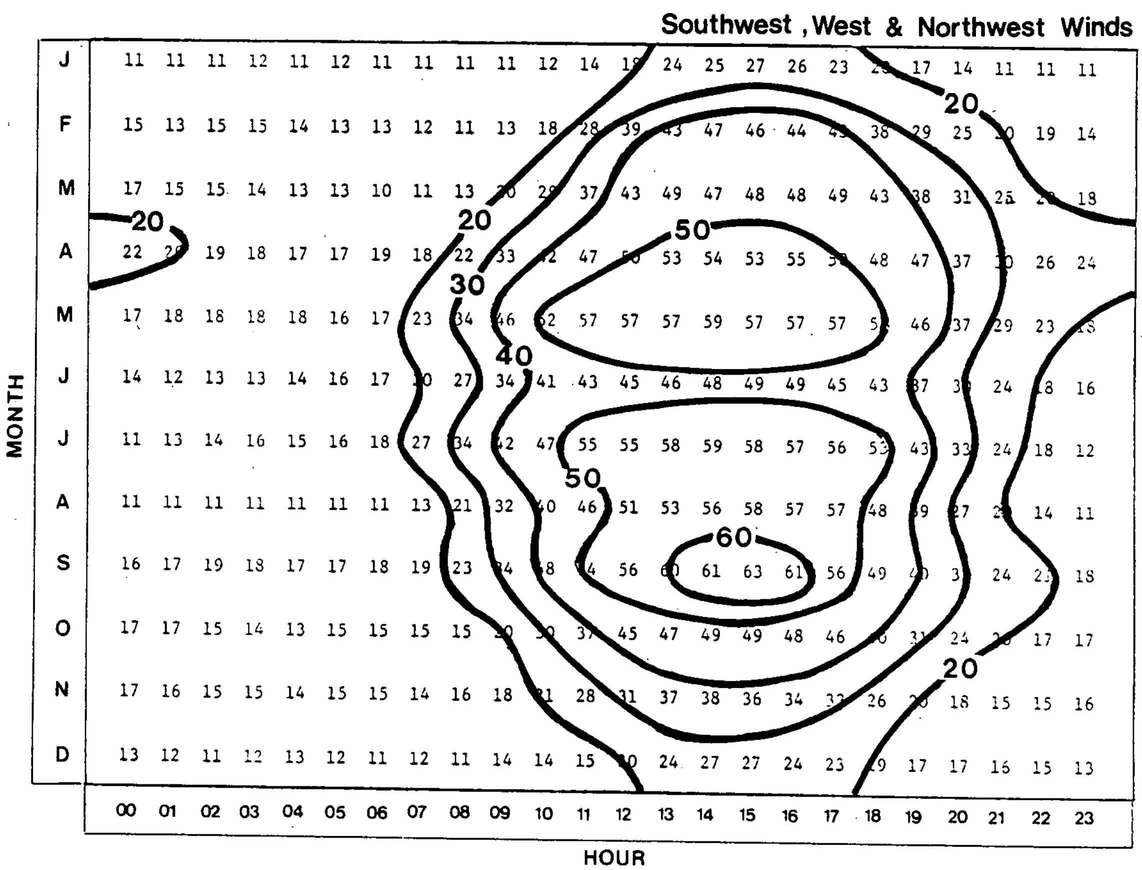


Figure 7 DIURNAL ANALYSIS – PERCENT FREQUENCY WIND DIRECTION

In order to calculate the rate at which a surface contaminant is advected by wind, multiple the wind velocity by 3%. Vectoral addition to surface current can then be applied to predict the probable movement of floating contaminants. In the Fraser River, wind is most likely to significantly influence the fate and behaviour of slicks at slack tide throughout the year or, on infrequent occasions, when velocities of 30-40 k/h are reached or exceeded.

4.0 COUNTERMEASURES

4.1 General Strategies

A basic element of strategy for any spill is that, failing its prevention in the first instance, the spilled substance should be contained at the original point of release when this is reasonable and safe to do so.

In the case of unconfined discharges entering the Fraser River, hydrocarbon distillates (e.g. diesel and kerosene-based fuels), fresh crude oil, and similar low-viscosity floating substances can be expected to quickly spread. Slicks will then move longitudinally under the influence of surface currents, and laterally at slack tide and by winds and eddies. Depending upon the volume discharged, slicks might then diffuse to thicknesses and concentrations not amenable to physical recovery. Some impact of shoreline is possible.

More highly viscous substances, such as Bunker C, are less likely to spread and will follow flow patterns associated with the main channel. Some deposition of such materials might occur on river banks, particularly at slack tide. Their partial submergence as they are transported is also possible. Monitoring their movement --and control and cleanup--might therefore be a difficult task.

Spill response should include attempts to deflect slicks away from biologically sensitive areas and recreational and other amenities. High current velocities, broad slick fronts, wide river reaches and channels, inadequate response time, hours of darkness, and flow reversal can be expected to interfere with such operations. Removing materials released directly into and/or accumulating in sloughs and backwater areas will also have to be addressed; higher potential for success is anticipated in controlling such spillages. Response might also entail cleaning contaminated shoreline. Such efforts should be undertaken so that minimal disruption to vegetation, fish and wildlife results. Water-based cleanup is foreseen for many situations year-round.

It is unlikely that response strategies will include the containment and recovery of slicks moving in the river or their interception using mobile skimming systems. Dispersion should not be pursued in the lower river even if containment/removal appears to be impractical since broader distribution of contaminant might result due to salt water intrusions at depth. Dealing with logs and other large debris forms that are either stranded or free-floating is an additional spill cleanup concern.

Spill response in the Fraser necessitates the examination of several different factors. Tide tables must be used to predict the direction of river flow. The amount and duration of ebb and flood tides will dictate the possible points of impact and choice of control sites and methods for each tidal cycle.

Surface current velocity is a second aspect that must be considered. Generally, when surface current exceeds about 1 1/2 knots (0.8 m/s), deflection of floating contaminants will not be practical using conventional oil spill containment barriers even when placed at an angle of less than 90^{o} to the direction of flow. If boom is deployed perpendicular to the current, significant losses will occur at velocities of between 3/4 and 1 knot (0.4-0.5 m/s). Log booms would be similarly restricted in application. Velocity can be readily determined by timing a floating block of wood over a known distance from a fixed position based on, for example, the average time of three trials.

A third factor to be taken into account when planning response, is the physical characteristics of the affected river reach. Channel width or the distance across a critical opening must be estimated. If a significant percentage of a contaminant cannot be prevented from entering a critical area or deflected for other purposes, countermeasures operations will not be feasible. Water depth must also be sufficient to permit the passage of vessels needed for such work. These concerns particularly apply to the more expansive marshes towards Ladner.

Since intercepting slicks will rarely be possible in the Fraser River, an element of spill response strategy should be to attempt to encourage contaminant to follow the main channel of the mainstem into the Strait of Georgia so that a greater degree of natural dispersion and dilution ultimately results. Generally, contaminant should be prevented from entering more sensitive river reaches and sloughs. At trifurcation, efforts should be made to direct slicks away from the North Arm and Annacis Channel and into Annieville Channel. Other protection priority areas include Cannery Channel and the triangular region bounded by Ladner Reach, Sea Reach and Woodward Reach (Canoe Pass would also be protected). High current velocity, wide channels, opposing winds and inadequate response time might still impede efforts to divert slicks to the main channel.

This manual assumes that personnel knowledgeable of the river along with its tidal cycles, eddies and various sensitivities will be called upon to participate in spill cleanup. Ideally, resources should be utilized originating at locations central to the lower river and and immediately available for transport along the water to the cleanup site. Movement of materials, hardware and personnel by land is only foreseen in the event of a large spill incident resulting in significant shoreline contamination and/or large accumulations at accessible locations when time allows for mounting this type of response.

Bird-scaring systems are not reviewed in this document but might, when their use is recommended by the appropriate authorities, comprise a necessary component of a countermeasures strategy in view of the abundance and importance of migratory and resident species.

4.2 Containment and Deflection

Booming techniques should be used for deflecting slicks in currents of less than 1 1/2 knots (0.8 m/s). Deployment in higher current speeds can be tried if some diversion is reasonable to expect in conjunction with training walls and other structures.

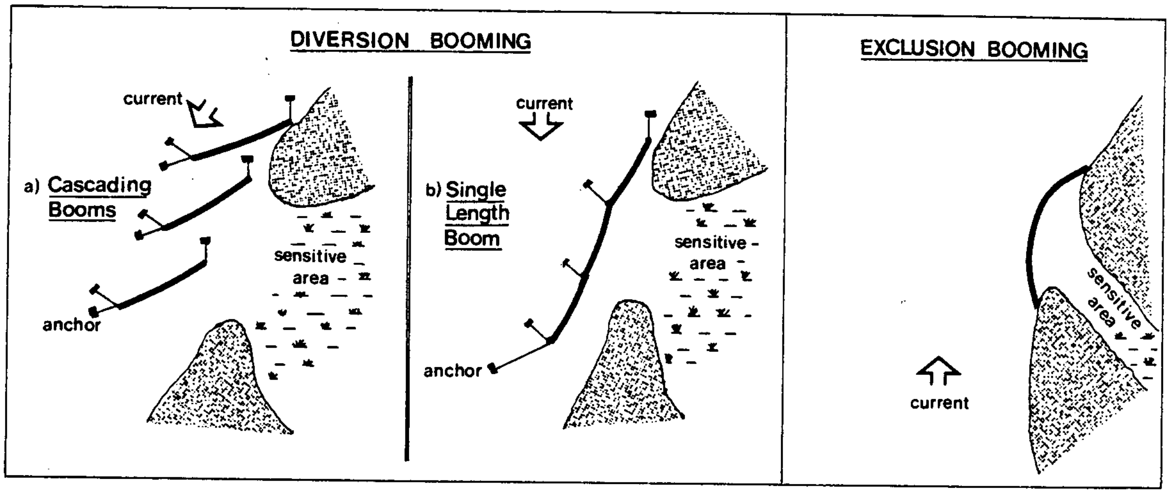


Figure 8 TYPICAL BOOM DEPLOYMENT

Conventional river boom should be considered for use either in slower, less exposed waters or for shorter-term applications. It should primarily be deployed to exclude the entry of slicks into sloughs, embayments, marinas and other sensitive areas or be used to confine and concentrate stationary accumulations for subsequent recovery. The length of boom used should not exceed 100 to 150 metres per site so that its entire length can be properly managed.

Basic features of the containment boom should include robust fabric (22-28 oz material) reinforced at the connectors, top and bottom tension members, high reserve buoyancy (>3), and overall maximum height of about 45 cm (18-in.). Repeated contact with logs and other debris should be prevented since damage to the fabric will occur. The boom should be readied in a quick-deployment configuration as part of a spill cleanup package.

Alternatives are permanent harbour boom for use in non-moving water where its heavier construction would be more durable, or a quick deploying/retrieving lightweight boom for shorter usages.

Log booms (i.e. collections of log sticks) could also be tried in more exposed locations for longer-term deflection operations. Although they are capable of withstanding impacts from debris, their effectiveness and cost must still be determined. Individual log sticks joined together could be used to block off sloughs and other quiet water areas to substitute for commercial spill booms.

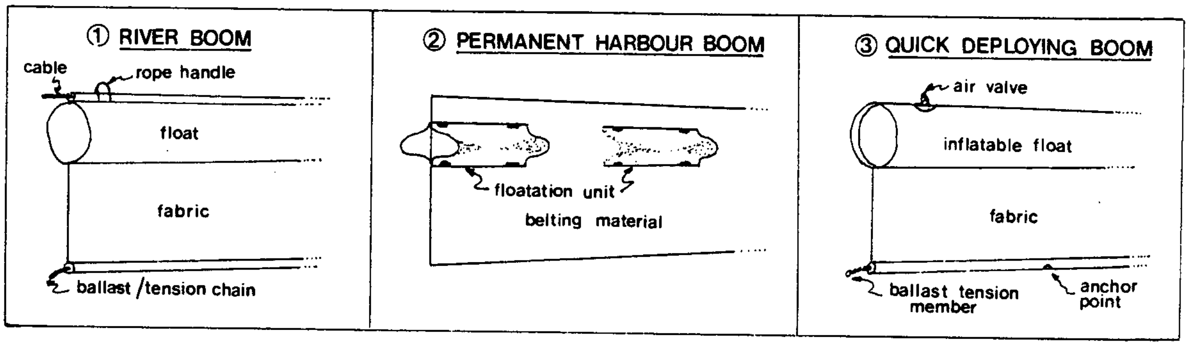


Figure 9 TYPICAL CONTAINMENT BARRIERS

Another method that is proposed for the deflection of surface slicks is the use of tug boat wash. A tug would nose up to a bridge abutment or other structure and push against it to create a wake thus diverting floating materials. A tug boat can be quickly deployed to the selected site and does not need a lengthy time for setup vis-a-vis booms. Nor is the wake affected by debris moving through it. The main disadvantages are that water depth and the lack of appropriate structures or river bank might not always permit implementation of the technique. Moreover, it must still be proven, particularly in fast currents.

A fourth technique that has been used to divert slicks (primarily toward mobile skimmers) is the coherent plunging water jet.

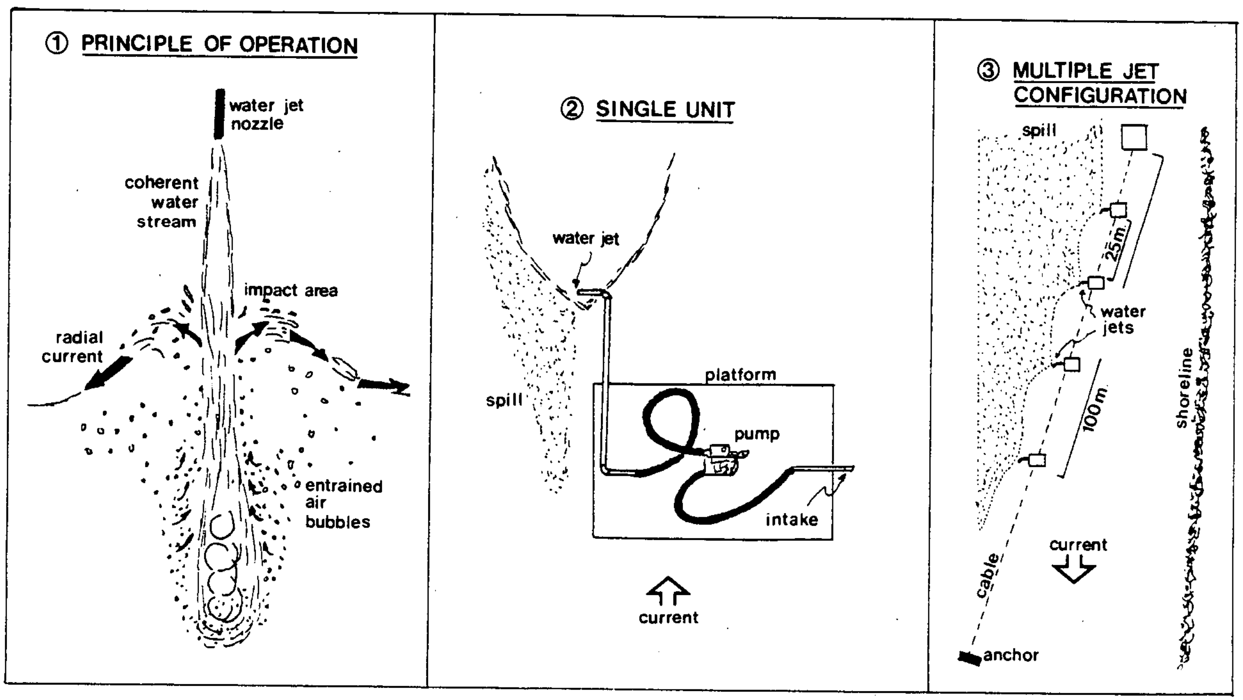


Figure 10 COHERENT PLUNGING WATER JET

A simple cone nozzle is used to direct a stream of water vertically downward to result in the movement of slicks to either side of it. Waves, debris and other potential interferring factors do not affect the operation of the jet. Standard off-the-shelf pumps, hoses, nozzles and ancillary hardware comprise the system and can be readily procured. However, a practical, total package has yet to be designed for quick deployment over an extended distance. Limited testing of the basic concept has been conducted in the Fraser River.

High water pressure barrier systems (as investigated by Environment Canada) do not yet exist in a format which allows their fast positioning and trouble-free, efficient use in a large river. Improvements to this type of equipment might eventually result in a more practical device.

Other techniques could be devised in the field, depending upon the availability of equipment and the situation, to deal with smaller volumes of pollutants in more confined locations. Propellor wash or an outboard motor affixed to a dock might be effectively used to direct and concentrate slicks at a boom for mechanical recovery. A simple water hose, spray, air blower or other device could be similarly applied to move floating slicks from under pilings or other structures so that subsequent collection was facilitated.

4.3 Dispersion

Since containment and deflection of slicks will often be impractical in the higher flow velocity regimes of the Fraser River, dispersion might be considered. There are, however, drawbacks to both mechanical and chemical methods. The former approach might not produce droplets small enough to remain in the water column while the latter technique is believed to be less efficient in low-wave environments. Moreover, if dispersion does work to inhibit the recoalesence of droplets, resultant environmental effects must still be assessed in terms of the broader distribution of contaminant in the estuary including possible deeper penetration into sediments.

Nevertheless, dispersion remains attractive because it is not restricted by surface current velocity nor by debris. The problem is one of selecting methods, times and locations that would enhance natural mixing energies and the innocuous dispersal of a contaminant while protecting sensitive areas. The possibility exists of using mechanical devices in combination with chemical agents capable of generating small droplets, dispersed at depth and subject to the mixing action of the Strait of Georgia.

4.4 Recovery

The stationary skimming of lighter oils will likely be the main type of physical recovery operation conducted in the Fraser River, usually at docks or in embayments and sloughs.

A disc skimmer could be effectively used for recovery operations in the free-floating mode. At docks, self-levelling weirs could be used but might plug occasionally with debris. Should medium viscosity products be involved, a rope mop device could be tried.

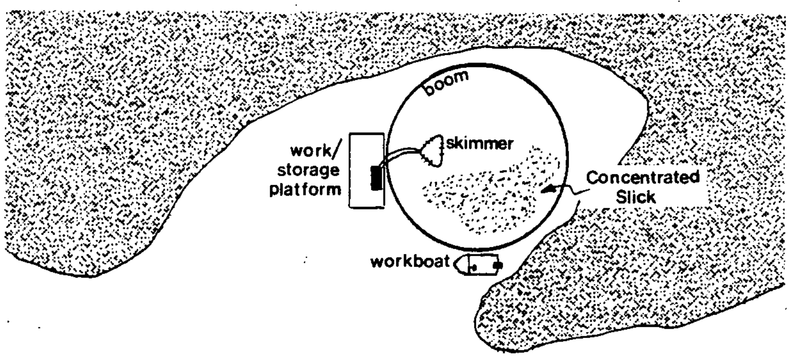


Figure 11 TYPICAL STATIONARY COLLECTION OPERATION

For heavy oils and, generally, more viscous substances contained in quiescent waters, an Archimedian screw skimmer could be used to process the oil plus virtually any form of debris. Belt skimmers could also be brought in for longer-term cleanup and should be manually assisted in the recovery operation.

Vacuum and air conveyor units should be used to remove slicks where road access permits the stationing of vehicles immediately adjacent to the substance being collected.

At locations where current is less than 1/2 knot (0.3 m/s), channel width is relatively narrow, and time allows for set-up, two sections of boom could be deployed in a V-configuration to direct slicks back to an adjustable weir skimmer for recovery.

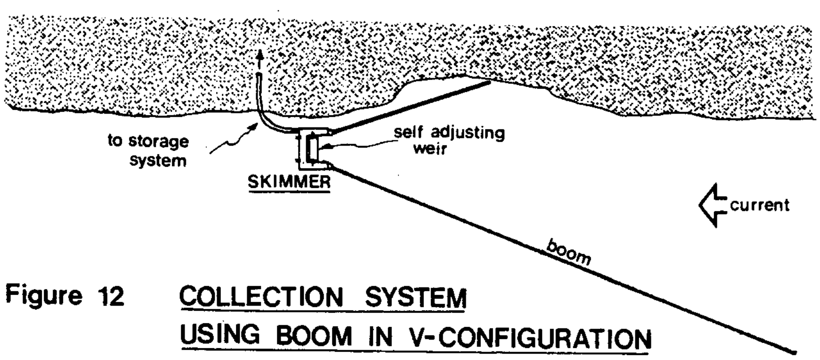


Figure 12 COLLECTION SYSTEM USING BOOM IN V-CONFIGURATION WITH SKIMMER

This type of operation will not be feasible in the mainstem and is generally seen to have restricted use in side channels but might, under some circumstances, be considered as an option. Interference from debris, flow reversal, and deployment difficulties are anticipated to be its main drawbacks.

4.5 Shoreline Cleanup

Much of the Fraser River is bordered by man-made materials in the form of riprap or armoured dyke that may or may not be covered to some extent with vegetation. The intertidal area does not generally consist of expansive mudflats but is significant in width in some locations. Sandy beaches occur sporadically.

When minimal disruption to vegetation would result, i.e. riprap and rock walls have been contaminated, hydroblasting (or hydrolasing) can be used to remove contaminant toward the high tide line. Containment and skimming of released materials should be prearranged if this is feasible to consider. In the case of coating by lighter products, the high pressure stream of water would probably reduce resultant volumes of contaminant on the water surface to thicknessess not amenable to physical recovery. At locations exposed to high current velocities, no cleanup action is an alternative if natural forces will remove contaminant on subsequent tidal cycles.

Steam cleaning would have the same effect and should be undertaken so that recontamination is prevented. This approach is seen to be less practical for logistical and mechanical reasons.

Where vegetation becomes coated, particularly in intertidal areas having a gentle slope and characterized by dense growth of grasses and sedges, generally no action should be initiated during low tide (at or toward the end of ebb tide). If at high tide, a waterside operation can be conducted using low water pressure flushing to remove contamination, then this should be tried. Subsequent containment and removal of materials should proceed as possible. Neither pedestrian nor vehicular traffic should be allowed on foreshore areas adjacent to significant pockets of marsh since such activities are likely to cause more damage to plants and organisms than the contaminant.

When sandy beaches are coated with pollutants, heavy machinery will sometimes provide effective cleanup. A minimal amount of beach materials should be removed. Front-end loaders, backhoes, elevating scrapers and bulldozers can all be used for such operations, depending upon available access and the amount and size of debris. Manual methods (i.e. rakes and shovels) might also be used, particularly on narrow beaches with uneven foreshore, occasional inlets or other interruptions in sandy stretches as well as large debris forms. Such latter beach types are more common along the lower Fraser River.

Generally, beaches with finer sediments will not undergo deep penetration of most hydrocarbons although very low viscosity substances might enter several centimetres or more into some beach materials. Coarser grain beaches comprised of gravel will be much more difficult and often impractical to clean because of deeper penetration by contaminants.

Minimum use should be made of sorbents to remove floating pollutants adjacent to shoreline. They are likely to recover a small amount of material and they are better applied to spills on land where their utilization is much more efficient and can be more readily controlled. Their use is not recommended for the final so-called "polishing" stages of spill cleanup in the river since efficiencies of use particularly diminish in very thin slick thicknesses and recontamination with flow reversals and tidal cycles is likely to occur.

4.6 Storage

For water-based operations, smaller barges available on the river should be used to store collected materials on an interim basis. This would consolidate the capabilities of a working (skimming) platform and expedite the cleanup process. Transfer to tank trucks and dump trunks can then be arranged using the barge ramps denoted on the operational maps. Where possible, direct transfer from removal operations to vehicles on land should be prearranged to facilitate cleanup. This would avoid delays if storage capacity is limited.

For on-shore storage, options include heavy duty plastic bags and open top drums for minor amounts of materials, waste bins (which can be easily removed by truck), and portable tanks (which can be quickly moved into position). Temporary storage pits are unlikely to be an alternative along the Fraser River.

4.7 Transfer

The movement of liquids and solids can be readily accomplished using available equipment. Standard centrifugal pumps should be capable of moving most collected liquids although progressing cavity units might be required to transfer more viscous liquids. Solids-handling equipment will also have to be used to deal with debris. Dump trucks, flat beds and other such units will have to be designated for use to carry collected materials to disposal sites.

4.8 Disposal

The Waste Management Branch of the B.C. Ministry of the Environment should be contacted with regard to disposal options Ofor any spill. Alternatives include combustion at the spill site, incineration, land cultivation, secure landfill and disposal at a refinery or other facility.

PART II OPERATIONAL DATA

5.0 UTILIZATION OF MAP SET

5.1 Introduction

Ten operational maps are included in Chapter 6.0 reproduced at a scale of 1:25,000 and generally aligned east to west to cover all sectors of Fraser Port. These have been colour-coded so that black and grey features pertain to land (shoreline type and access routes), green denotes environmental concerns, blue items are water-related, and red highlights resources of potential use in spill cleanup operations. A legend of all symbols according to colour and category is given on each map. Figure 1 Key Map preceding page 1 is not repeated and should be referenced to determine the relative location of any particular sector.

Accompanying each map is an outline of environmental considerations tabularized by location. Primary concerns only have been noted. Countermeasures are subsequently described, similarly organized by location. All information presented is based on data contained in the Part I overview.

5.2 Physical Data

The operational maps can be utilized to locate land forms within and adjacent to the river, identify reaches, generally define the main channel, estimate channel width, and obtain an indication of shoreline type. In this latter regard, riprap refers to any man-made materials comprising shoreline including armoured dyke. It is the most extensive type of river bank on the Fraser although vegetation has established itself over the armour at many locations. Other classifications are vegetated, eroding, beach and marsh. Field reconnaissance is recommended to verify shoreline type at specific sites.

5.3 Amenities and Other Features

The maps show main overland access routes. Training structures within the river are also included as are municipal boundaries and water intakes. Several of the major industries have been noted and, in particular, those with resources of possible use during a spill. Launches and floats are also depicted that are not associated with companies. Marinas will sometimes be regarded as potential suppliers of equipment, fuel, and miscellaneous items and at other times as facilities to be protected from slick intrusions.

5.4 Environmental and Related Considerations

Entities having high recreational or other value that could be affected by spills are shown on the maps in green. These include parks, beaches, popular locations for bar or sport fishing, small moorages, Indian reserves, float homes and the DFO enumerated sites. In addition to habitat areas specifically noted for each map under Environmental Considerations, the above items generally comprise protection priorities.

5.5 Countermeasures Options

Countermeasures strategies are discussed for each of the ten sectors as options or alternatives that might be considered during the course of a spill response operation. The approaches reviewed often include the application of equipment and methods that would <u>ideally</u> provide protection and/or cleanup capability. Practical considerations in the field will form the basis for formulating control techniques actually used to combat a spill.

Spills would usually be expected to follow the main channel on both flood and ebb tides in most reaches of the lower river. Their diversion and deflection would only then be attempted for any specific location subsequently discussed when this is deemed to be necessary and possible. At slack tide, broader distribution of slicks might require the examination of one or more operational maps to assist in the determination of protection priorities and cleanup sites. Discharges into sloughs and other backwater areas are likely to result in more confined slicks and more localized response activities.

5.6 Additional Information Requirements

This manual assumes that more precise data would be gathered in conjunction with any given spill event, training exercise or facility-specific contingency plan. Examples of such information include fish, animal and plant species actually present and at risk at a particular location or time, and weather, wind, river flow and tide fluctuations. Development work in countermeasures should also be monitored that might lead to improved methods.

When planning or responding to a spill incident on the river, the following documentation should be consulted, as applicable:

hydrographic charts 3490 (Fraser River)
3060 (Pitt River)

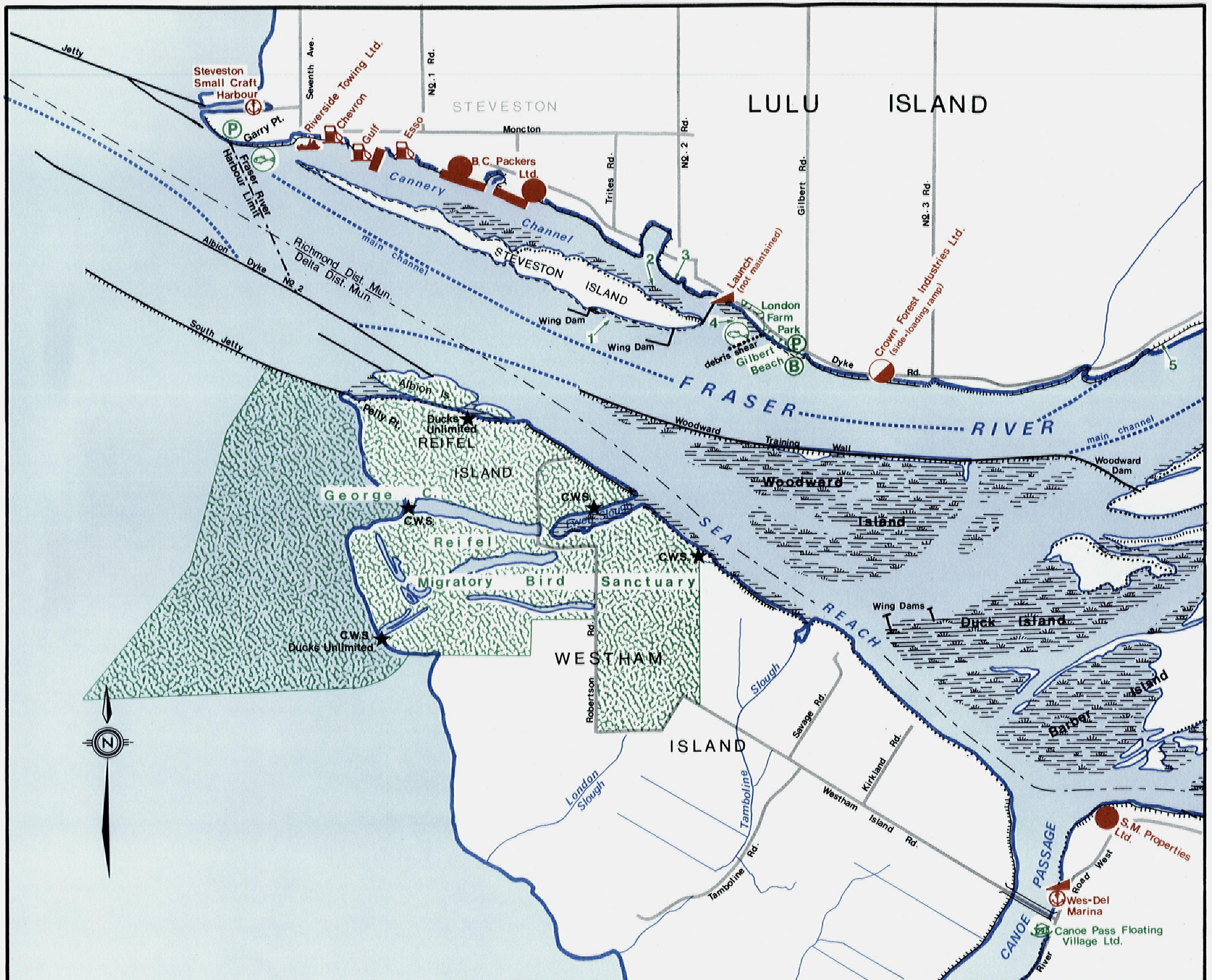
Public Works Canada bathymetric blueprints

tide tables

contingency plans for specific facilities; agencies

These items are critical to ensuring a prompt, safe and effective response through the accurate determination of water depth, proper notification and alerting procedures, current sources of assistance and other information. The Fraser River Harbour Commission also maintains a current set of aerial photographs of Fraser Port which could be used to study a specific location.

6.0 OPERATIONAL MAPS



Map No. 1

FRASER RIVER
Garry Point to Woodward Dam

LEGEND

Shoreline Type
- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities
- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources
- industry / with barge ramp
- towing company / with barge ramp
- marine railway
- fuelling depot
- floatplane base / with launch
- marina / with launch
- launch
- wharf
- crane

Other
- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 500 1000 metres

0 1000 2000 3000 4000 feet

MAP NO.1
FRASER RIVER: GARRY POINT TO WOODWARD DAM

Environmental Considerations

Highlights

This entire sector is very productive and sensitive to spills throughout the year. The natural productivity is a result of the estuarine, conditions i.e. interaction of the Fraser River fresh water and marine waters from the Strait of Georgia. Large expanses of intertidal and associated mudflats, e.g. Woodward, Duck, Barber and Westham Islands, provide critical habitats for juvenile salmonids, waterfowl and marsh birds, and several species of wildlife. Their importance as inner marsh rearing and physiological transition zones for juvenile salmonids and as wintering, resting, and feeding areas for waterbirds can not be over-stated. The George C. Reifel Migratory Bird Sanctuary on Westham Island reflects the importance of the area. Steveston Island has been designated a vegetation study area. Steveston provides a logistical centre for commercial fishing operations. Recreational canoe and kayak routes exist in the vicinity of Steveston and Woodward-Duck-Barber Islands.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Woodward, Duck & Barber Islands	- intertidal marsh - juvenile salmon - waterfowl & marsh birds	Mar - Oct Mar - Oct year round
George C. Reifel M.Bird Sanctuary	- waterfowl & shorebirds	year round
Canoe Passage	- intertidal marsh	Mar - Oct
Steveston Island	- intertidal marsh - juvenile salmonids	Mar - Oct Mar - Oct
Gilmour Slough	- intertidal marsh	Mar - Oct
Bar fishing sites	- chinook, coho, steelhead	year round
DFO sites	- intertidal marsh	Mar - Oct
Steveston Is., Garry Point Park Gilbert Beach	- sandy beach	year round

Countermeasures

Garry Point

Riprap can be cleaned with high pressure water flushing to remove contaminant. Released materials should be retained by booms and physically removed using water-based operation. Shoreline might change as development of this area into parkland proceeds. Sand beaches might then be amenable to mechanical cleanup methods, depending upon the configuration and extent of beach.

Cannery Channel

Ideally, on the flood tide, use conventional boom at Garry Point opposite "hole-in-the-wall" in the Steveston Jetty to prevent slicks from entering Cannery Channel from the west and to deflect these into the main channel. Navigational aids generally align diagonally from west to east starting with the marker on the Garry Point side and moving east to the western tip of Steveston Island. These provide a good indication of the desired angle. Problems might be encountered in securing the boom end at Garry Point, dealing with high currents, impeding marine traffic through the channel, and deploying the length of boom needed to effect the deflection. This area also has relatively high exposure to wind which either might produce interferring wave conditions or result in deflected slicks impinging upon Steveston Island, assuming intial diversion has been achieved.

On ebb tide, deflect slicks at the eastern entrance to Cannery Channel by placing conventional boom or, preferably, log boom immediately adjacent to the debris shear which extends diagonally from the north shore. A log string should already be in place as part of the debris shear. In addition to problems of sealing the boom at the shore end and the distance over which deflection is desired, excessive current speeds can be expected to result in significant losses due to entrainment and underflow. Debris could also damage fabric boom at this location. Note nearby navigational hazard.

Protection booming of vessels in Cannery Channel is possible if sufficient quantity of containment boom is obtained in time to deploy parallel to the river current at the outer perimeter of docks and boats. Shorter, manageable sections (100 m) should be utilized to protect individual facilities. Time constraints and a total distance of 2-3 kilometres could limit the effectiveness of this approach.

Steveston Island

The south shore of Steveston Island might be impacted following a spill. Where vegetation exists, particularly between the two wing dams, low pressure water flushing should be employed to remove contamination. A water-side cleanup operation could then remove released materials. In the sandy areas toward the western end of the island, mechanical removal should be tried with collected items taken away by barge. Should the north side of the island receive contamination, waterside low pressure flushing, containment and removal is suggested for this more sensitive shore.

Sea Reach

Ideally, on flood tide, prevent slicks from entering Sea Reach by setting up a deflection device either along Albion Dyke No.2 toward Albion Island or extended from the eastern end of Harlock Island. Navigational aids can be used which align from west to east to indicate the desired angle. Problems in attempting this approach include the long distance over which the diversion of slicks would have to take place and excessive current. Main channel flow should generally result in slicks bypassing this area although slack tide combined with a west-northwest wind could drive contaminant into the area.

Gilbert Beach, London Farm Park, North Shore to No.3 Rd

Slicks which impact the shoreline in significant volume could be retained for subsequent removal using conventional booms. A land-based recovery operation could be set up where road access permits. Mechanical removal of contaminant from the sandy sediments of Gilbert Beach should be possible using heavy equipment. Arrange for direct transfer of materials with dump trucks and other vehicles as possible and appropriate. Manual cleanup methods will have to be used along some sections of this river bank.

Woodward Island

A possible point of slick impact on either tidal cycle is the northern face of Woodward Island. Since this area is one of high energy, low viscosity substances would very likely be removed by river flow, assuming adherence of any significant quantity in the first instance. Cleanup of more viscous materials is unlikely in view of the exposure of the riprap to relatively high currents.

Woodward Dam

On ebb tide, verify if main flow directs material away from Duck Island (and Sea Reach). Supplement with log boom to facilitate deflection when and if needed.

Intertidal Marsh Habitat

See also Deas Island, Map No.2.

Extensive sensitive areas noted in the summary table of environmental considerations for this sector should be cleaned using water-side operations so that minimal disruption to vegetation and sediment results. Low water pressure flushing should be used so that contaminant is directed to containment booms where mechanical skimming would recover significant concentrations.

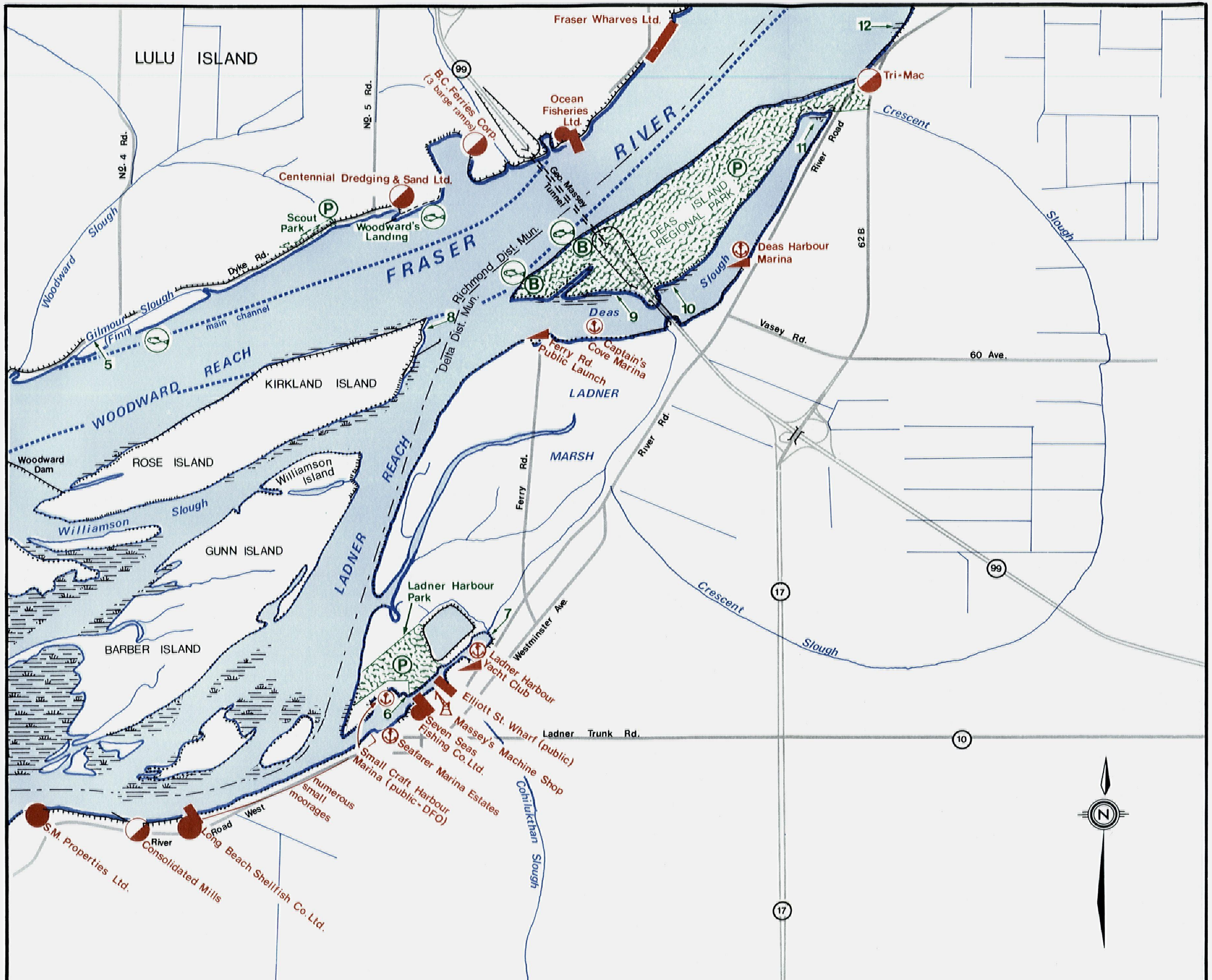
Such operations are foreseen to be usually conducted at or toward the peak of high tide and at the beginning of the ebb tide. Access to many areas will still be restricted by shallow water. If it is reasonable to conduct flushing and collection at low tide when initial, limited contamination occurs, then such actions should be pursued.

Gilmour (Finn) Slough/Island

Use conventional boom at either entrance to prevent entry of slicks into the slough--the western opening on the flood and the eastern entrance on the ebb. Interconnected log sticks will also readily block the slough entrance and could be used if available.

Map No. 2

FRASER RIVER Woodward Dam to Deas Island



LEGEND

Shoreline Type
- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities
- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources
- industry, with barge ramp
- towing company, with barge ramp
- marine railway
- fuelling depot
- floatplane base, with launch
- marina, with launch
- launch
- wharf
- crane

Other
- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 500 1000 metres
0 1000 2000 3000 4000 feet

MAP NO.2
FRASER RIVER: WOODWARD DAM TO DEAS ISLAND

Environmental Considerations

Highlights

Ladner Reach and Kirkland-Rose-Gunn-Barber Islands provide productive intertidal habitats for juvenile salmonids and waterfowl, and are sensitive to contaminant spills year round. Ladner reach has been designated a vegetation area. Ladner and Deas Sloughs provide sheltered habitats for juvenile salmon and other resident fish, and are used by wintering waterfowl. Intertidal fringe marshes provide important rearing and food producing areas for juvenile salmonids and other fish species. Numerous bar sport fishing areas occur within the map area.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Ladner Reach	- intertidal marsh	Mar - Oct
Kirkland-Rose-Gunn-Barber Is.	- intertidal marsh	Mar - Oct
	- juvenile salmonids	Mar - Sep
	- waterfowl & marsh birds	year round
Deas Slough	- intertidal marsh	Mar - Oct
	- juvenile salmon	Mar - Sep
	- waterfowl	Aug - Apr
Ladner Slough	- juvenile salmonids	Aug - Sep
DFO sites	- intertidal marsh	Mar - Oct
Bar fishing sites	- chinook, coho & steelhead	year round

Countermeasures

Deas Island

On ebb tide, deploy boom toward south end of Deas Island to prevent entry of contaminant into Ladner Reach. Secure upriver end to shore immediately downriver from the navigation light. Use about 100 metres of conventional boom, log boom or try tug wash. This location would also suit the utilization of a plunging water jet type of system since deflection of less than 100 metres would achieve the desired effect of diverting slicks to main channel flow and out into the Strait of Georgia.

On the flood tide, minor impacts could occur toward the lower end of the island. Small pocket beaches would have to be cleaned using manual methods. The vegetated riprap could be restored using low water pressure flushing, as necessary.

A waterside collection operation might be necessary at the point where the north end of Deas Island joins the mainland. North winds might tend to drive materials toward Tri Mac Concrete on the ebb tide. Conventional boom, skimming capability and suitable working platform would be required for this type of approach.

Kirkland, Rose, Gunn, Barber Islands

Should contaminant enter Ladner Reach on the ebb tide, marsh habitat associated with this inner group of islands might be at risk. Low pressure water flushing, booming and skimming methods would then have to be implemented from a water-based platform. Restricted access might impede this type of approach although, generally, the outer marsh fringes should be primarily affected and flushing should be possible.

Kirkland Island

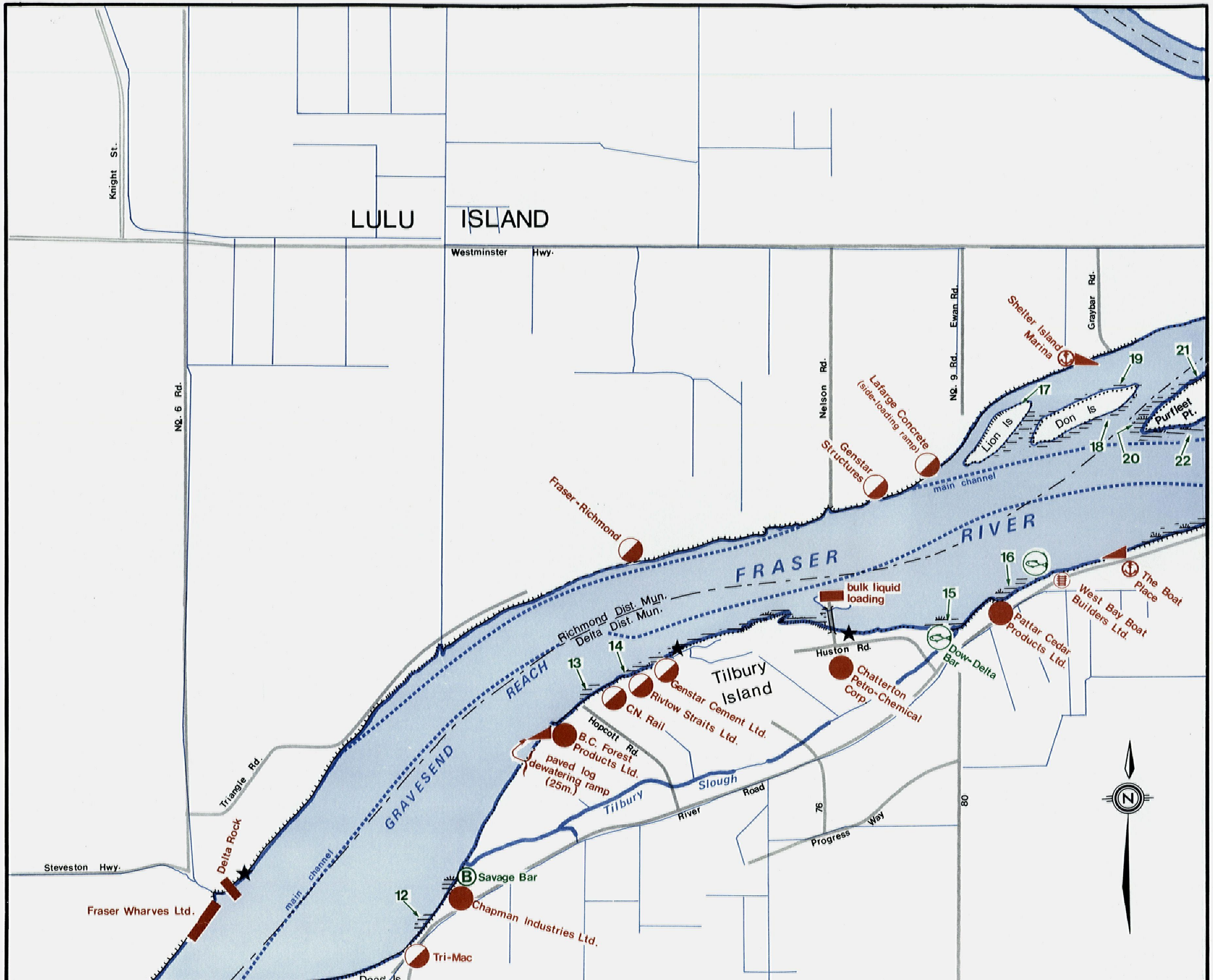
Some materials might tend to deposit on the northern shore of Kirkland Island on either the flood or ebb tide. Low water pressure flushing should be tried and traffic at shoreline contacting marsh and grasses discouraged. Containment of materials for subsequent recovery might be impractical at this location because of the proximity of the influence of the main channel flow. The riprap toward either end of Kirkland is less sensitive and could be cleaned using high pressure water streams.

B.C. Ferry Basin

On ebb or flood tide, use joined log sticks at entrance to basin to prevent slicks from entering. Strong easterly winds might result in slicks being driven toward this area. Remove accumulations, should these result, with a water-based boom/skimmer/barge system.

Woodward's Landing

Shoreline cleanup might be necessary at Woodward's Landing if material deposition occurs, largely as the result of winds driving slicks ashore. There could be some tendency for eddy effects in this area at the peak of ebb tide to also result in impacts on shore. Manual methods could be tried at selected, less sensitive locations to remove materials. Low pressure water flushing of intertidal area should also be pursued in vegetated zones. The utilization of mechanical equipment is a less likely alternative. Adjacent riprap would have relatively low sensitivity and could be cleaned using high pressure water streams as necessary and appropriate. The containment and removal of released contaminant should be preplanned.



Map No. 3

FRASER RIVER

Deas Island to Purfleet Point

LEGEND

Shoreline Type

- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities

- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources

- industry / with barge ramp
- towing company / with barge ramp
- marine railway
- fuelling depot
- floatplane base / with launch
- marina / with launch
- launch
- wharf
- crane

Other

- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 — 500 — 1000 metres

0 — 1000 — 2000 — 3000 — 4000 feet

MAP NO.3
FRASER RIVER:DEAS ISLAND TO PURFLEET POINT

Environmental Considerations

Highlights

Tilbury Slough has been enhanced to provide higher quality rearing habitats for juvenile salmonids and resident fish, and is also used by wintering waterfowl. Extensive intertidal marshes exist along the Tilbury Island Fraser shoreline and around Lion and Don Islands providing habitats for fish and aquatic organisms. Several bars are used for sport fishing. Large numbers of gulls utilize this reach of the river.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Tilbury Slough	- intertidal marsh	Mar - Oct
	- juvenile salmon	Mar - Sep
	- waterfowl	Aug - Sep
Tilbury Island shoreline	- intertidal marsh	Mar - Oct
Don & Lion Is.	- intertidal marsh	Mar - Oct
DFO sites	- intertidal marsh	Mar - Oct
Bar fishing sites	- chinook, coho & steelhead	year round

Countermeasures

Tilbury Island--Tilbury Slough, Savage Bar

On flood tide, there is the possibility of impacts to the southern tip of Tilbury Island toward or at Savage Bar and the entrance to Tilbury Slough. A log stick can be positioned to block off the entrance to the slough. A waterside cleanup using containment boom and working platform with stationary skimmer might then be applied to deal with resultant accumulations of contaminant. Mechanical removal of materials from the sandy beach should be possible using heavy equipment.

Tilbury Island--Dow-Delta Bar

On ebb tide, some floating contaminant might leave the flow in the main channel under the influence of west-northwest winds and be deposited in the Dow-Delta area. A waterside cleanup is anticipated for this area using commercial containment boom and skimmer. The possibility exists that contamination could be relatively widespread in this sector of the river and not amenable to containment even if flow velocities are somewhat lower. Accumulations in the embayment to the east of the Chatterton dock should be confined and removed using mechanical methods.

Nelson Road and No.6 Rd. Areas

On either the flood or ebb tides, and during periods of strong east winds, deposition of slicks could occur in the vicinity of Nelson Road and upriver from No.6 Rd. Low pressure water flushing of this shoreline, which is mainly characterized by riprap overgrown with vegetation, should be possible with some containment and skimming also possible to deal with released materials. The proximity of main channel flow to this shore might result in the dispersion of low viscosity contaminants which could be specifically planned for during ebb tide.

Annacis Channel

<u>Ideally</u>, prevent entry of floating substances into Annacis Channel on flood tide by deploying log booms. One should be placed diagonally out from shore at the Canada Lafarge dock so that it blocks the side channel between the north shore and Lion Island. Similarly, slick deflection could be attempted between Lion and Don Islands. The extensive distance between Don Is. and Purfleet Point all but eliminates the technique from being tried there. If entry of a large volume of contaminant into Annacis Channel cannot be prevented, then other means to deal with materials in the Channel should be considered.

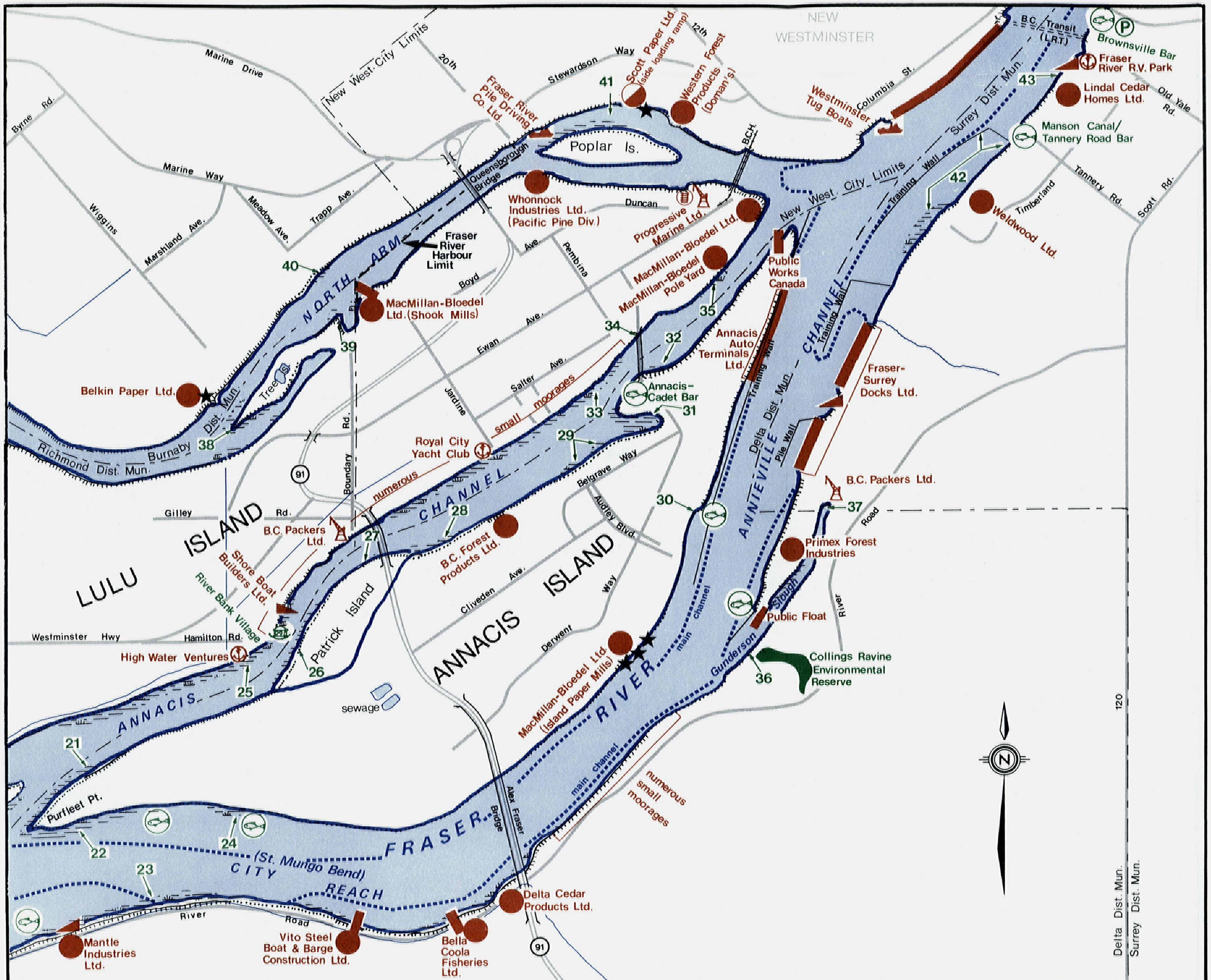
Alternatively, and also <u>ideally</u>, slick diversion at the Lafarge dock would be desirable if surface flow could be influenced to direct materials out into the main channel. Tug boat wash, coherent plunging water jets or other means should be tried.

Lion, Don Islands

Flood or ebb tides could result in the deposition of contaminants on Lion and/or Don Islands. Associated intertidal marsh should be cleaned using water flushing methods so that minimal damage to vegetation occurs. Work should be conducted on the ebb tide so that the probability is reduced for materials (re-)entering Annacis Channel; containment of dislodged substances, however, should be possible for sites on the islands removed from the mainstem.

Annacis Island

The southern shore of Annacis Island from Purfleet Point and extending some distance upriver could receive contamination on the flood tide. Low pressure water flushing would then have to be conducted to remove materials from marsh habitat with free-floating substances contained as possible and physically removed. Sandy beaches along this shore would have to be cleaned using manual methods.



Map No. 4

FRASER RIVER Purfleet Point to L.R.T. Bridge

NORTH ARM – Tree Is. to Trifurcation

LEGEND

Shoreline Type

- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities

- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources

- industry / with barge ramp
- towing company / with barge ramp
- marine railway
- fuelling depot
- floatplane base / with launch
- marina / with launch
- launch
- wharf
- crane

Other

- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 500 1000 metres

0 1000 2000 3000 4000 feet

MAP NO.4
FRASER RIVER: PURFLEET POINT TO LRT BRIDGE
NORTH ARM: TREE ISLAND TO TRIFURCATION

Environmental Considerations

Highlights

Intertidal marshes occur at Popular and Tree Islands in the North Arm, along much of the shoreline of Annacis Channel, and at scattered locations along Annieville Channel. Extensive marsh areas exist on south Annacis Island and on the adjacent Delta shoreline. Gunderson Slough is also utilized by juvenile fish for rearing. Smaller numbers of waterfowl may rest in protected bays during the winter. Numerous bar fishing sites exist within this sector.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
DFO sites	- intertidal marshes	Mar - Oct
Gunderson Slough	- intertidal marshes	Mar - Oct
	- juvenile salmonids	Mar - Aug
Bar fishing sites	- chinook, coho & steelhead	year round

Countermeasures

Gunderson Slough

On the flood tide, log sticks placed at the entrance to the slough should result in the prevention of entry of materials into it. Should cleanup be required in the slough, a total package of working platform, boom and skimmer would be required with extra lengths of boom used to confine/protect areas and facilities that have not been impacted by slicks.

Annacis Channel

Should slicks gain entry into Annacis Channel, it will be impractical to attempt to set up either protection or exclusion booming for many sectors. Specific entities could be protected using conventional boom or log sticks if sufficient forewarning is available to implement such measures. This might not be possible, however, because of the central location of the channel and its proximity to potential release sources.

Cleanup will likely entail the use of a waterside self-contained package of boom/skimmer/platform with minimal or no contact made of equipment or pedestrian traffic with the sensitive sections of the shoreline. An example of this type of operation would be the use of boom in the vicinity of the Annacis Cadet Bar to first surround floating slicks and then skim using a disc skimmer from a barge which could also be utilized to store collected liquids.

Ideally, boom deployed in a V-configuration leading to a skimmer could be tried when this is practical to do so. Deployment problems might impede such efforts and are anticipated in this sector of the river.

Tree Island

At the inlet and slough in the vicinity of the MacMillan-Bloedel Ltd. shook mill (Tree Island), log sticks or booms should be used to guard the entrances against the intrusion of slicks. Any cleanup would have to be approached from the waterside using a self-contained countermeasures package. Exposed riprap in the area could be flushed with high pressure water streams.

Poplar Island

Because Poplar Island remains largely in its natural state, cleanup of shoreline, if required, must proceed with care. Both its eroding southern banks and the marsh of its northern shore should be cleaned from the waterside using low water pressure flushing with attempts made to contain and recover dislodged materials, when this is practical to do so. High current velocities could impede containment operations.

Trifurcation

Ideally, it should be of some benefit to deflect slicks moving downriver on the ebb tide to the main channel. The intention is to prevent the entry of contaminant into both the slower moving Annacis Channel and into the North Arm. Both of these latter water courses offer considerably diminished dilution and dispersion potential to contaminants entering them.

To accomplish the desired deflection, it is proposed that the Annacis training wall be effectively extended at its northern end through the use of log boom. Losses can be expected to occur through the entrainment of floating slicks; however, some diversion of contaminant should result. To supplement the effect of the logs, tug boat wash might be tried from the New Westminster shore just upriver from a point opposite the north end of the "extended" Annacis training structure. Since the deflection effect from the wash might be relatively short-lived, correctly positioning the tug would be critical to achieving the intended slick deflection.

At present, this is an unproven approach that requires further investigation. The supporting dock structure on the New Westminster side (in front of the townhouse development) is not substantial enough to withstand a tug pushing up against it and would have to be reinforced, if possible.

Other means should also be tried to control slicks at this critical juncture in the river. Coherent plunging water jets or other system might be utilized if configured to provide slick deflection over a distance of about 100 metres and at a point strategic to diverting materials.

Fraser-Surrey Docks

Training walls create an area of low current velocity adjacent to Fraser-Surrey Docks. Conventional boom for short-term usages or logs for longer durations could be considered to both supplement the effects of the training structures and contain slicks for subsequent physical removal. If practical, a land-based operation might be planned so that the dock is used as a platform from which collection takes place using vacuum trucks or smaller skimming heads and tank trucks.

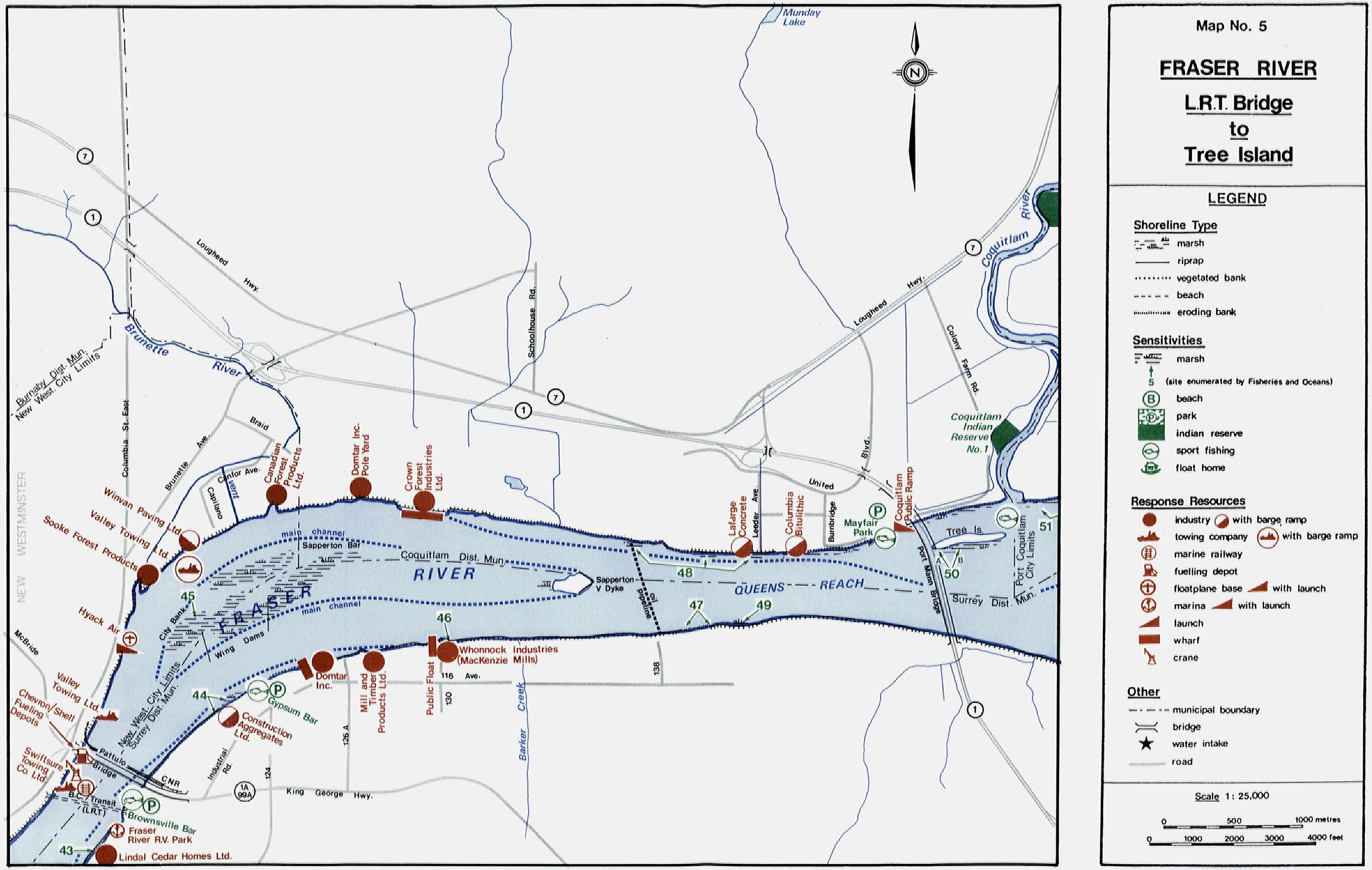
Annacis Island

On flood tides that result in surface flow upriver, contaminant might enter behind the Annacis training wall in the vicinity of the DFO enumerated site No.30. Containment of slicks should be possible using conventional boom, with removal attempted using smaller skimmers. Any action should only proceed if it has been determined that significant accumulations of pollutant are present and that a recovery operation is feasible to undertake.

Alex Fraser Bridge, South Shore

Accumulations of contaminant might result on either flood or ebb tide along the south river bank downstream from the Alex Fraser Bridge between Bella Coola Fisheries Ltd. and Vito Steel Boat & Barge Construction Ltd. Shoreline type varies at this point from vegetated bank to riprap, with some interdispersed marsh. Debris can be expected to be deposited in this area.

Cleanup should address the removal of materials at the shore, with due care taken to minimize disruption to marshy sections. Occasional access from the land-side exists which might be utilized as a transfer point to remove collected materials. Otherwise, a waterside containment and collection operation is foreseen in close proximity to the shore using working platform, section of boom and skimmer. Slicks moving on this reach of the river further from shore will likely be transported quickly in main channel currents and will not be amenable to interception using either fabric or log booms.



Map No. 5
FRASER RIVER
L.R.T. Bridge
to
Tree Island
LEGEND
Shoreline Type
marsh
riprap
vegetated bank
beach
eroding bank
Sensitivities
marsh
5 (site enumerated by Fisheries and Oceans)
beach
park
indian reserve
sport fishing
float home
Response Resources
industry
with barge ramp
towing company
with barge ramp
marine railway
fuelling depot
floatplane base
with launch
marina
with launch
launch
wharf
crane
Other
municipal boundary
bridge
water intake
road
Scale 1: 25,000
0 500 1000 metres
0 1000 2000 3000 4000 feet
Munday Lake
Lougheed Hwy.
Burnaby Dist. Mun.
New West. City Limits
Brunette River
Columbia St. East
Brunette Ave.
Braid
Canfor Ave.
Capilano
vent
Canadian Forest Products Ltd.
Domtar Inc. Pole Yard
Crown Forest Industries Ltd.
Schoolhouse Rd.
Winvan Paving Ltd.
Valley Towing Ltd.
Sooke Forest Products
Hyack Air
McBride
NEW WESTMINSTER
main channel
Sapperton Bar
Coquitlam Dist. Mun.
RIVER
FRASER
City Bank
Wing Dams
Sapperton V Dyke
oil pipeline
QUEENS REACH
45
46
47
48
49
50
51
44
43
Lafarge Concrete
Leeder Ave.
Columbia Bitulithic
Burnbridge
United Blvd.
Mayfair Park
Coquitlam Public Ramp
Colony Farm Rd.
Coquitlam Indian Reserve No. 1
Coquitlam River
Tree Is.
Port Mann Bridge
Port Coquitlam City Limits
Surrey Dist. Mun.
Whonnock Industries (MacKenzie Mills)
116 Ave.
130
Public Float
Mill and Timber Products Ltd.
Domtar Inc.
Barker Creek
138
126 A
Gypsum Bar
Construction Aggregates Ltd.
New West. City Limits
Surrey Dist. Mun.
Industrial Rd.
124
King George Hwy.
Pattullo Bridge
CNR
B.C. Transit (L.R.T.)
Valley Towing Ltd.
Chevron/Shell Fueling Depots
Swiftsure Towing Co. Ltd.
Brownsville Bar
Fraser River R.V. Park
Lindal Cedar Homes Ltd.

MAP NO.5
FRASER RIVER: LRT BRIDGE TO TREE ISLAND

Environmental Considerations

Highlights

The Brunette and Coquitlam Rivers, which flow into the Fraser River in this sector, are active sites for salmon enhancement activities. Scattered intertidal marsh and riparian vegetation exist, especially at Sapperton Bar and east of the mouth of the Coquitlam River: most extensive marsh development is at DFO sites 49, 50 and 51. Sport fishing is enjoyed at several river bar and shoreline sites.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
DFO sites	- intertidal marshes	Mar - Oct
Coquitlam River mouth & Tree Is.	- intertidal marsh	Mar - Oct
	- juvenile salmonids	Mar - Aug
	- waterfowl	Aug - Apr
Bar fishing sites	- chinook, coho & steelhead	year round

Countermeasures

Overall Sector

The deflection and collection of slicks will not generally be feasible in this reach of the river. At slack tide, broad distribution of slicks could occur in the river toward Sapperton Bar. Isolated waterside cleanup operations are envisaged at predesignated points of relatively higher sensitivity including the DFO sites (44-50), Brownsville and Gypsum Bars and the marsh near Sapperton Bar.

High surface current velocities can be expected to develop toward both the Patullo Bridge and downstream from the Port Mann Bridge which will negate defelection and containment operations at these points.

Coquitlam River

Habitat bordering the mouth of the Coquitlam River might require cleanup. This should be conducted from the waterside using low pressure water flushing techniques, as possible. Traffic on the shore should be avoided. Containment of dislodged materials should be planned.

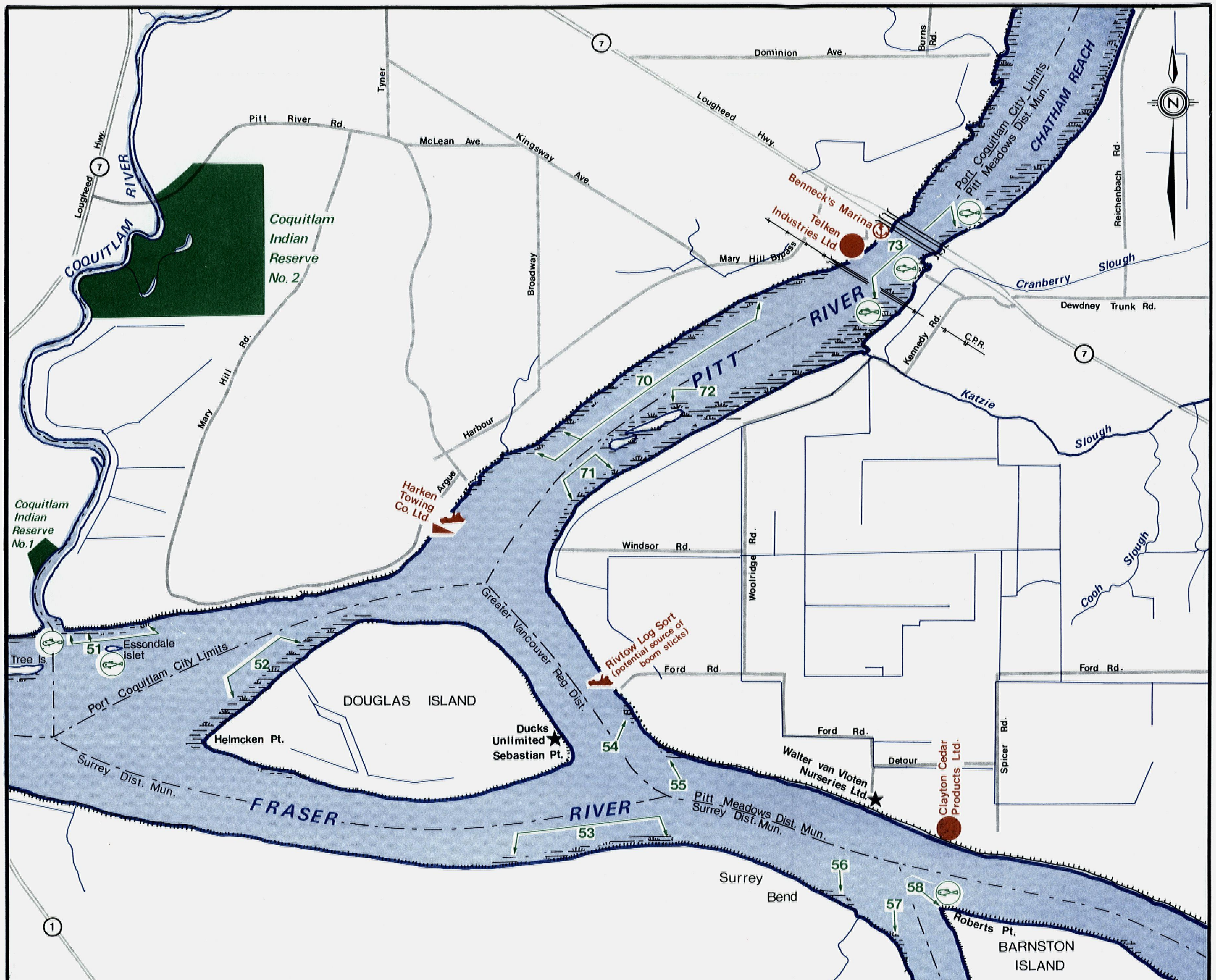
Tree Island

Water flushing techniques should be similarly applied to remove materials deposited on Tree Island. Attempts to contain dislodged contaminant might prove to be impractical for many river stages.

Map No. 6

FRASER RIVER – Tree Island to Roberts Point

PITT RIVER – Douglas Island to Chatham Reach



LEGEND

Shoreline Type

- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities

- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources

- industry; with barge ramp
- towing company; with barge ramp
- marine railway
- fuelling depot
- floatplane base; with launch
- marina; with launch
- launch
- wharf
- crane

Other

- municipal boundary
- bridge
- water intake
- road

Scale 1 : 25,000

0 – 500 – 1000 metres

0 – 1000 – 2000 – 3000 – 4000 feet

MAP NO.6
FRASER RIVER: TREE ISLAND TO ROBERT POINT
PITT RIVER: DOUGLAS ISLAND TO CHATHAM REACH

Environmental Considerations

Highlights

The Pitt River provides productive habitat for anadromous and resident fish, waterfowl and other waterbirds, and several species of wildlife (e.g. river otter, beaver and muskrat). Surrey Bend is one of the largest undyked areas of floodplain on the Fraser River and provides flood relief during freshet. Important habitats include bog forest, flooded meadows, marshes and small creeks. The diverse and unique habitats support large numbers of birds and wildlife. Douglas Island, largely undeveloped, provides flooded riparian habitat along the eastern shoreline for waterfowl, and an extensive intertidal marsh zone to the west. These areas have year-round sensitivity to spills. Several river bars are popular sport fishing sites (e.g. Edgewater Bar and along Pitt River). Cutthroat trout, Dolly Varden char and coho salmon are the main fish species taken.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Pitt River	- intertidal marshes	Mar - Oct
	- anadromous salmon & trout; resident fishes	year round
	- waterfowl and waterbirds	year round
Surrey Bend	- floodplain habitats	May - Jul
	- waterfowl & waterbirds	year round
	- juvenile salmonids	Mar - Jul
Douglas Island	- floodplain habitats	May - Jul
	- intertidal marsh	Mar - Oct
	- juvenile salmonids	Mar - Jul
DFO sites	- intertidal marshes	Mar - Oct
Bar fishing sites	- coho & steelhead	year round

Countermeasures

Coquitlam River, Tree Island

As noted for Map No.5, low pressure water flushing should be tried to remove materials deposited on Tree Island or toward the mouth of the Coquitlam River. Traffic on shorelines should be minimized. It will unlikely be possible to contain dislodged materials at Tree Island unless cleanup is attempted at slack tide.

Douglas Island

On flood tides with upriver surface flow, DFO site 52 north of Helmcken Point could the recipient of slicks. Low pressure water flushing of contaminant should be tried along with the containment of materials using conventional boom. Traffic at the shore should be avoided so that water-borne activities only are mounted.

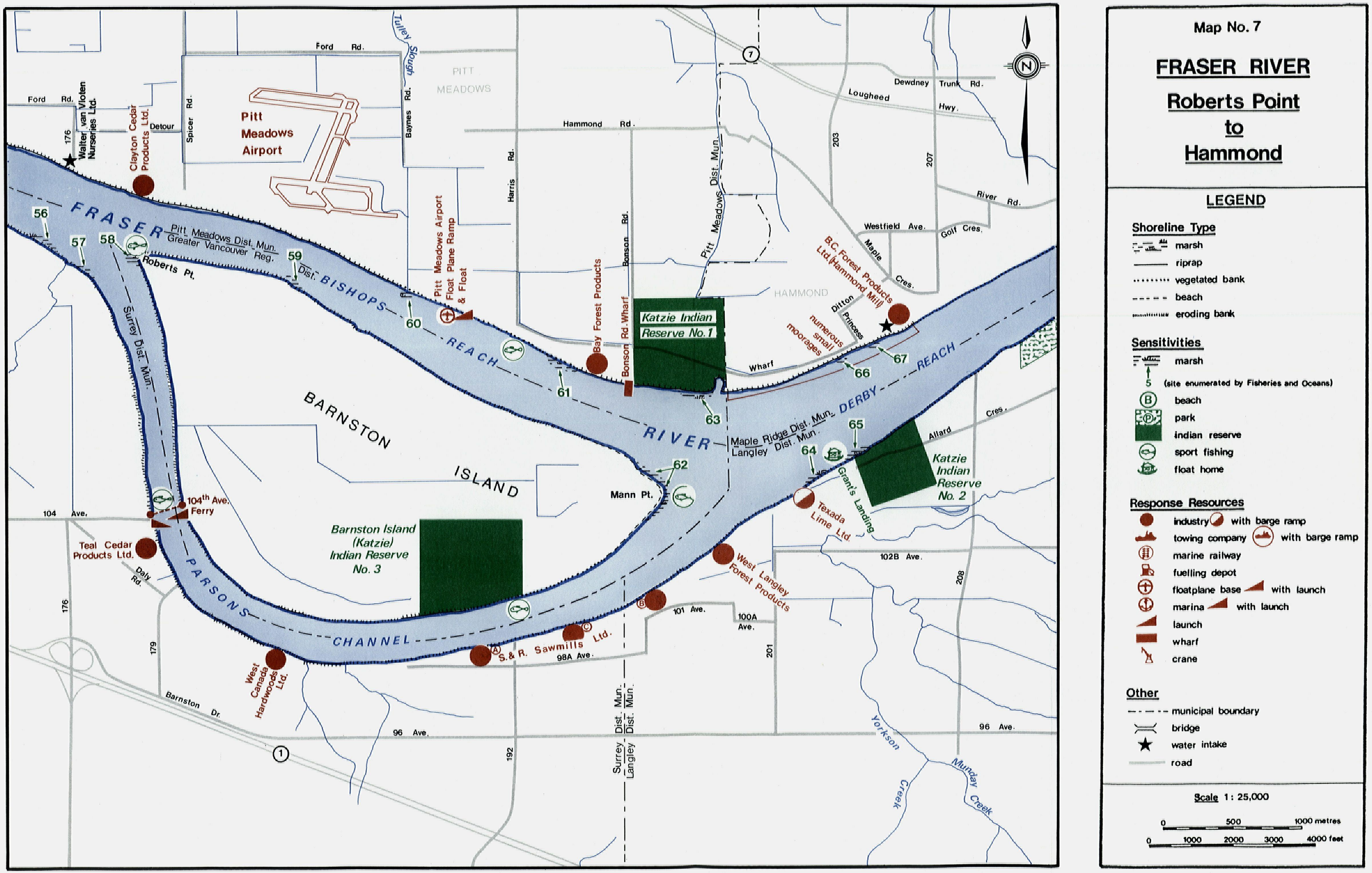
On the ebb tide, some deposition of contaminant might occur on the shore immediately to the west of Sebastian Point. This is less sensitive and cleanup of stranded pollutant could be attempted using manual methods.

Surrey Bend

DFO site 53 could receive slicks particularly on the flood tide and should be attended to employing waterside cleanup techniques as described above. This site is known for its wetlands and any traffic at the shore should be restricted to water-only operations at the outer perimeter of marsh habitat, as necessary and possible. DFO sites 56 and 57 should receive similar attention. Flooding during the freshet period could hamper such cleanup activities.

Pitt River

Generally, the Pitt Meadows/Maple Ridge shore of the Pitt River has more extensive intertidal area in this reach and therefore impacts from slicks could be more significant there. The vegetated bank necessitates that low or no traffic occur on the shore. Water-based cleanup is recommended for this sector. Note also that the Port Coquitlam shore of the Pitt River towards the confluence with the Fraser River has also been enumerated by DFO and also has relatively high sensitivity. Similar precautions should be taken to eliminate on-shore activities. Low water pressure flushing and subsequent containment of materials should be tried at or toward high tide. Current velocities are highest toward the Lougheed Highway crossing and cleanup there might not be feasible.



Map No. 7
FRASER RIVER
Roberts Point
to
Hammond
LEGEND
Shoreline Type
marsh
riprap
vegetated bank
beach
eroding bank
Sensitivities
marsh
5 (site enumerated by Fisheries and Oceans)
beach
park
indian reserve
sport fishing
float home
Response Resources
industry
with barge ramp
towing company
with barge ramp
marine railway
fuelling depot
floatplane base
with launch
marina
with launch
launch
wharf
crane
Other
municipal boundary
bridge
water intake
road
Scale 1: 25,000
0 500 1000 metres
0 1000 2000 3000 4000 feet
FRASER
RIVER
BISHOPS REACH
DERBY REACH
PARSONS CHANNEL
BARNSTON ISLAND
Barnston Island (Katzie) Indian Reserve No. 3
Katzie Indian Reserve No. 1
Katzie Indian Reserve No. 2
Pitt Meadows Airport
PITT MEADOWS
HAMMOND
Pitt Meadows Dist. Mun.
Greater Vancouver Reg. Dist.
Surrey Dist. Mun.
Maple Ridge Dist. Mun.
Langley Dist. Mun.
Surrey Dist. Mun.
Langley Dist. Mun.
Pitt Meadows Dist. Mun.
Walter van Vloten Nurseries Ltd.
Clayton Cedar Products Ltd.
Pitt Meadows Airport Float Plane Ramp & Float
Bay Forest Products
Bonson Rd. Wharf
B.C. Forest Products Ltd.(Hammond Mill)
numerous small moorages
Texada Lime Ltd
Grant's Landing
West Langley Forest Products
S.& R. Sawmills Ltd.
West Canada Hardwoods Ltd.
Teal Cedar Products Ltd.
104th Ave. Ferry
Roberts Pt.
Mann Pt.
Wharf
56
57
58
59
60
61
62
63
64
65
66
67
Ford Rd.
Detour
Spicer Rd.
Baynes Rd.
Harris Rd.
Hammond Rd.
Bonson Rd.
Lougheed Hwy.
Dewdney Trunk Rd.
River Rd.
Westfield Ave.
Golf Cres.
Maple Cres.
Ditton
Princess
Allard Cres.
102B Ave.
101 Ave.
100A Ave.
98A Ave.
96 Ave.
104 Ave.
Daly Rd.
Barnston Dr.
Tulley Slough
Yorkson Creek
Munday Creek
176
179
192
201
203
207
208
7
1

MAP NO.7
FRASER RIVER: ROBERTS POINT TO HAMMOND

Environmental Considerations

Highlights

Floodplain forest, bog forest and intertidal marshes exist at Surrey Bend. Scattered intertidal marshes and stretches of riparian vegetation occur throughout the sector. Sport fishing bars are distributed along the Fraser River. A recreational canoe route is located around Barnston Island, and a sandy beach is situated at Mann Point. Shoreline habitats are used by juvenile salmonids during their downstream migration during the late spring and summer. Waterfowl may also make use of protected areas during the winter.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Surrey Bend	- floodplain forest	May - Jul
	- waterfowl & waterbirds	year round
	- juvenile salmonids	Mar - Aug
	- intertidal marshes	Mar - Oct
DFO sites	- intertidal mashes	Mar - Oct
Bar fishing sites	- salmon & trout	year round

Countermeasures

Surrey Bend

Waterside cleanup methods are reviewed for Surrey Bend in conjunction with Map No.6 and are aimed at minimizing damage to marsh habitat bordering the shore. Note difficulties associated with flooding during the freshet period. See also Parsons Channel/Bishops Reach below.

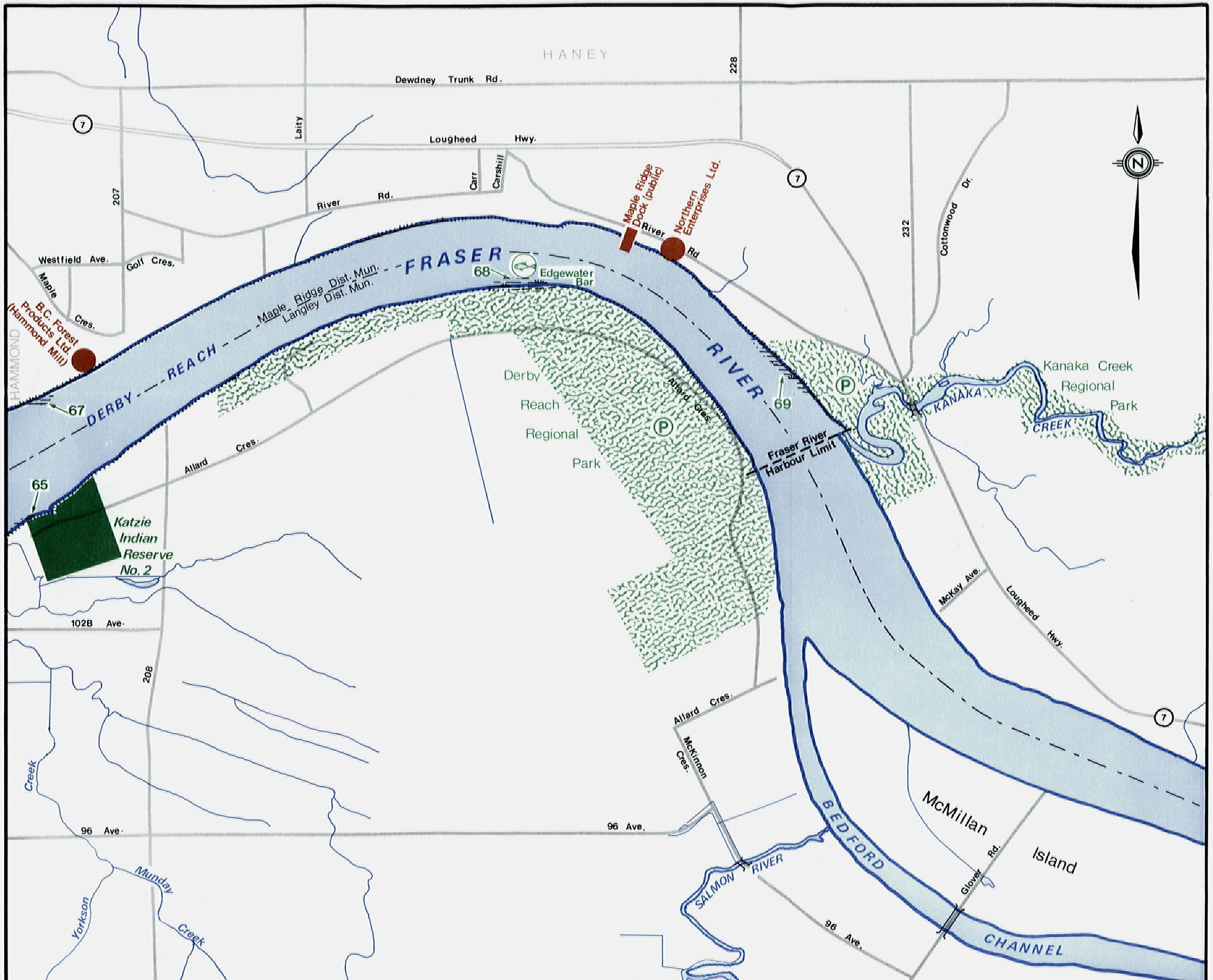
Barnston Island

Eroding banks predominate on Barnston Island and must be cleaned with care if contaminant is deposited toward the high tide mark. Low water flushing is then recommended with nearshore recovery of dislodged materials. At the western tip of the island (Mann Point), the sandy beach might be amenable to restoration during high water tides using manual methods to remove material, when accumulations of pollutant warrant this attention. Roberts Point at the eastern end of the island consists of an eroding bank and should not be subjected to high pedestrian traffic at the shore during cleanup. Some deposition of materials might occur on ebb tide toward DFO site No.59.

Parsons Channel/Bishops Reach

Current velocity is generally higher in Parsons Channel than in the mainstem and, within Parsons Channel, higher along the Surrey/Langley shore than along the Barnston Island river bank. Parsons Channel is also generally less environmentally sensitive than Bishops Reach although the shore toward Surrey Bend is an exception. Flooding of this latter area during freshet would impede cleanup operations as would strong currents in this reach throughout the year. The deflection of slicks is not likely to be possible.

Response efforts should concentrate on removing pollutant where and when this is feasible to do so. Cleanup should be directed at river bank in the vicinity of Surrey Bend and at the DFO sites along the mainstem using waterside techniques, i.e. water flushing of vegetated shore. Stationary collection of accumulations might also be possible at some stages of the tide using a working platform/boom/skimmer combination. Exclusion booming might be required to protect specific amenities, including the foreshore areas of the Katzie Reserves, although it is difficult to predict probable patterns of contaminant transport in this sector of the river.



Map No. 8

FRASER RIVER

Hammond to Kanaka Creek

LEGEND

Shoreline Type

- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities

- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources

- industry — with barge ramp
- towing company — with barge ramp
- marine railway
- fuelling depot
- floatplane base — with launch
- marina — with launch
- launch
- wharf
- crane

Other

- municipal boundary
- bridge
- water intake
- road

Scale 1 : 25,000

0 500 1000 metres

0 1000 2000 3000 4000 feet

MAP NO.8
FRASER RIVER: HAMMOND TO KANAKA CREEK

Environmental Considerations

Highlights

A substantial freshwater marsh occurs at the mouth of Kanaka Creek. At Edgewater Bar, downstream of Kanaka Creek, a shoreline park exists for "overnight" fishermen. Some small stretches of intertidal marsh and riparian vegetation exist along the banks of the Fraser River. A bog forest occurs south of Edgewater Bar, which supports over a dozen heron nests and numerous other wildlife species.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Kanaka Creek mouth	- intertidal marsh	Mar - Oct
	- juvenile salmonids	Mar - Jul
DFO sites	- intertidal marsh	Mar - Oct
Edgewater Bar	- sport fishing & camping	year round

Countermeasures

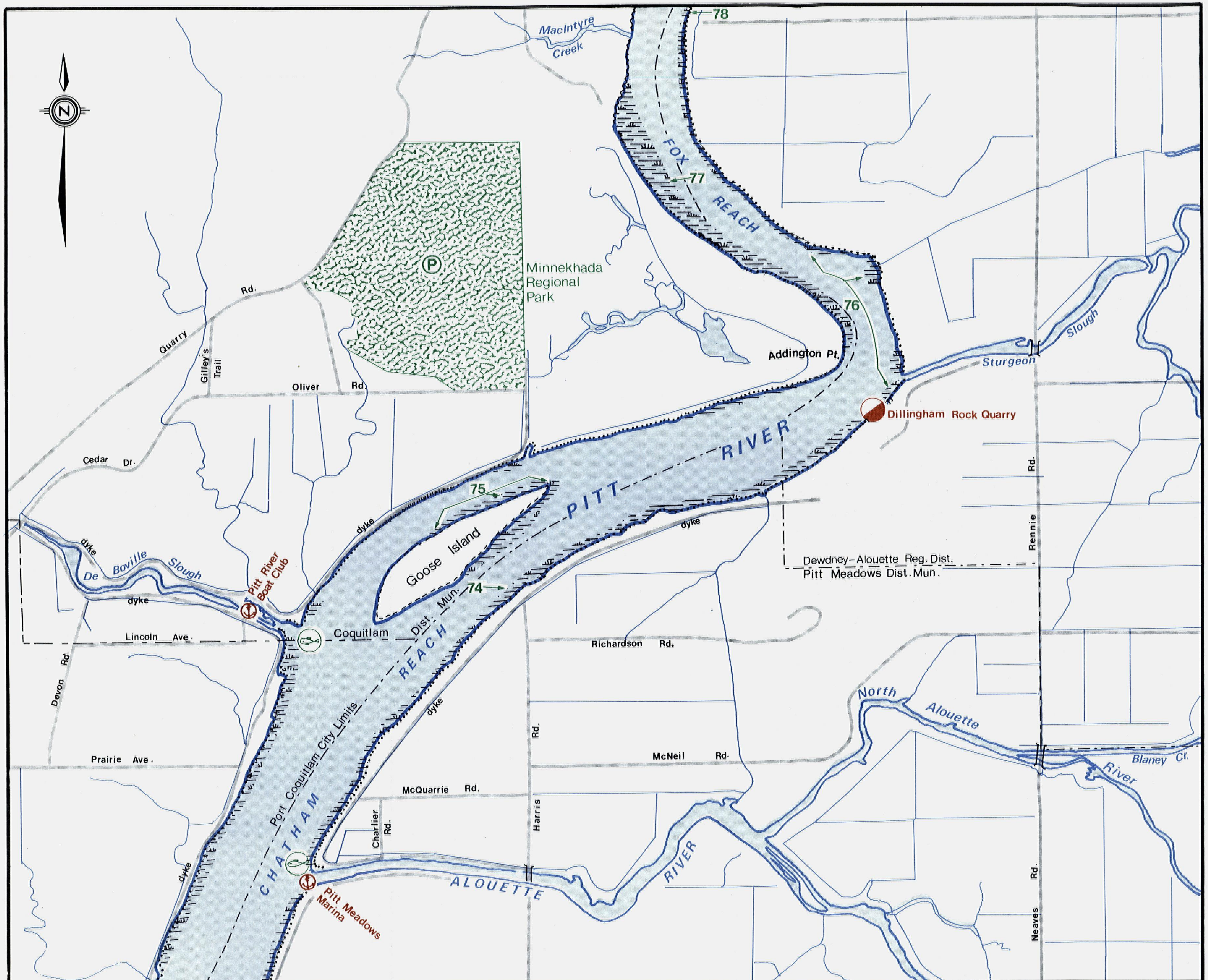
Overall Sector

Derby Reach and Kanaka Creek Regional Parks dominate this reach of the river as environmentally sensitive zones requiring water-based cleanup methods should shoreline impacts of pollutants occur. Because of its location at the bend in the river, the shoreline in the vicinity of the Maple Ridge public dock also warrants similar consideration should contaminant be transported to this reach of the river. Ideally, diversion and collection of slicks at that point might be considered if current velocities are sufficiently low enough to allow the deployment of conventional booms so that these function to deflect slicks. Over the short term, it might be feasible to plan such an operation using fabic booms; however, for longer durations, a log boom might have to be deployed if contact with debris is anticipated. High current velocities can be expected to develop for some river stages at this relatively narrow reach which might eliminate the utility of this approach.

Exclusion booming might also be considered to protect moorages which are located along the north shore of the river. This latter operation has a higher probability of success--if commercial spill barriers can be positioned in time to prevent slicks from contacting vessels.

Kanaka Creek

Waterside cleanup of slicks is the preferred response method if spills impinge upon vegetated shore or marsh habitat in the vicinity of Kanaka Creek. Low pressure water flushing, subsequent containment, and no traffic at the shore would be primary strategies of such activities.



Map No. 9

PITT RIVER

Chatham Reach to MacIntyre Creek

LEGEND

Shoreline Type
- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities
- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources
- industry / with barge ramp
- towing company / with barge ramp
- marine railway
- fuelling depot
- floatplane base / with launch
- marina / with launch
- launch
- wharf
- crane

Other
- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 500 1000 metres

0 1000 2000 3000 4000 feet

MAP NO.9
PITT RIVER: CHATHAM REACH TO MACINTYRE CREEK

Environmental Considerations

Highlights

Extensive fringe marshes are situated in the Pitt River, and provide important habitats for fish and waterfowl. Wildlife management areas, such as Addington marsh, increase the sensitivity of the sector to spills. The tributaries (e.g. Alouette River, DeBoville Slough and Sturgeon Slough) support steelhead and cutthroat trout, coho salmon and Dolly Varden char. Sport fishing is popular throughout the sector, and recreational canoeing is common on the Pitt and Alouette River. Furbearing animals (e.g. river otter, muskrat and beaver) inhabit the Pitt River drainage and may colonize riverine areas.

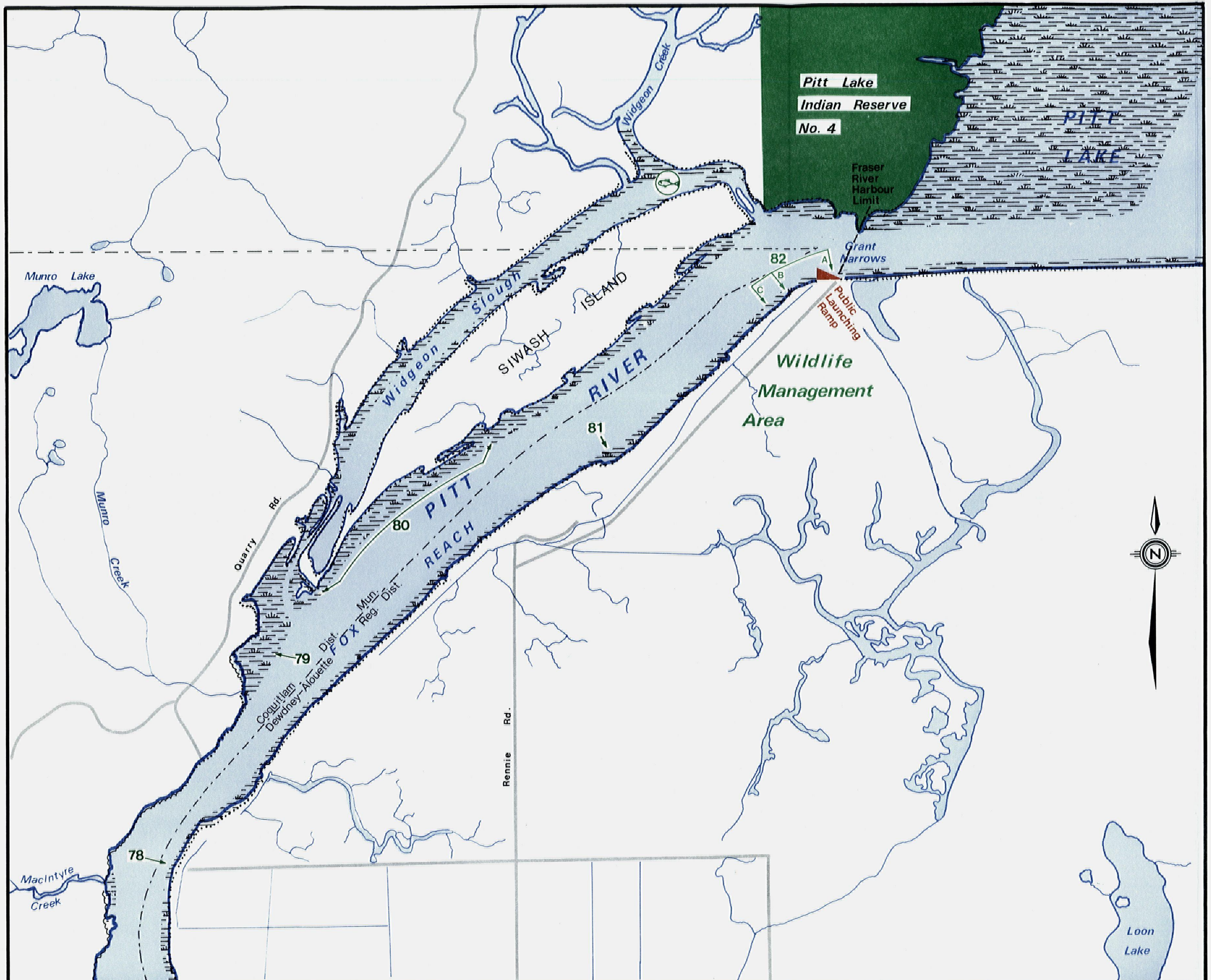
Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Pitt River	- intertidal marsh	Mar - Oct
Addington marsh	- intertidal marsh	Mar - Oct
	- waterfowl & waterbirds	year round
Goose Island	- intertidal marsh	Mar - Oct
	- waterfowl & waterbirds	year round
	- salmon & trout; resident fishes	year round
Alouette River, DeBoville & Sturgeon Slough	- coho, cutthroat & steelhead	year round
bar fishing sites	- salmon & trout	year round

Countermeasures

Overall Sector

The entry of contaminant into the Pitt River is unlikely in this reach. DFO sites are identified which would have cleanup priority; however, the whole area is generally sensitive and bordered by vegetated shoreline. Water-based methods would be used, if required, to remove contaminant from shoreline. Low water pressure flushing followed by the containment and removal of pollutant could be tried. More significant deposition of materials would be expected to occur in the vicinty of Goose Island towards either side of its upriver end. Generally, cleanup would be pursued at high tide.



Map No. 10

PITT RIVER

MacIntyre Creek to Grant Narrows

LEGEND

Shoreline Type

- marsh
- riprap
- vegetated bank
- beach
- eroding bank

Sensitivities

- marsh
- 5 (site enumerated by Fisheries and Oceans)
- beach
- park
- indian reserve
- sport fishing
- float home

Response Resources

- industry; with barge ramp
- towing company; with barge ramp
- marine railway
- fuelling depot
- floatplane base; with launch
- marina; with launch
- launch
- wharf
- crane

Other

- municipal boundary
- bridge
- water intake
- road

Scale 1: 25,000

0 500 1000 metres

0 1000 2000 3000 4000 feet

MAP NO.10
PITT RIVER: MACINTYRE CREEK TO GRANT NARROWS

Environmental Considerations

Highlights

A provincial Wildlife Management Area exists on the east side of the Pitt River. The Siwash Island and Widgeon Creek area has also been proposed as a management area but most of it is currently privately-held land. The sector is highly valued for waterfowl and waterbirds, anadromous and resident fish, and wildlife such as river otter, muskrat and beaver. Sport fishing and recreational canoeing is popular in Widgeon Creek. The sector has year-round sensitivity to spills.

Summary (Note: Marsh has year-round sensitivity; spill risk to plants is higher during Mar-Oct active growth phase.)

Location	Resource	Temporal Sensitivity
Pitt River	- intertidal marshes	Mar - Oct
	- salmon & trout; resident fishes	year round
	- waterfowl & waterbirds	year round
Widgeon Creek	- intertidal marshes	Mar - Oct
	- salmon and trout	year round
	- waterfowl & waterbirds	year round
	- salmon & trout sport fishing	year round

Countermeasures

Overall Sector

As was noted for Map No.9, it is unlikely that spills would intrude into this sector of the river. The relatively high environmental sensitivity of vegetated river bank and extensive marsh habitat associated with Siwash Island necessitate that minimal or, preferably, no disruption to shoreline take place. Water-based cleanup methods would be used to deal with stationary accumulations of contaminant as has been indicated for other river reaches.

APPENDIX A

SELECTED REFERENCES

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APPENDIX B

CROSS-REFERENCE FOR FISHERIES AND OCEANS ENUMERATED SITES

Numbers assigned to the DFO enumerated sites on the operational maps are listed under Manual while corresponding DFO designations are listed under DFO. This latter number should be quoted when contacting the Department of Fisheries and Oceans for further information.

Manual	DFO
1	6:9,24:i4
2	6:9,24:i11
3	6:9,24:9
4	6:9,24:7
5	6:10,5:5
6	6:10,18:3
7	6:10,2:1
8	6:8,9:i2
9	7:9,24:i18
10	7:8,17:i16
11	7:8,16:14
12	7:9,27:12
13	7:9,27:10
14	7:10,5:8
15	7:10,11:6
16	7:9,6:4
17	7:9,6:i3
18	7:9,6:i2
19	7:9,6:i1
20	8:8,30:i21b
21	8:8,30:i21a
22	8:8,30:i12
23	8:8,31:10
24	8:8,30:i8
25	8:8,31:19
26	8:8,30:i17
27	8;8,30:i15
28	8:8,30:i13
29	8:8,30:i11a,b
30	8:8,30:i4
31	8:8,30:i9
32	8:8,30:i5
33	8:8,31:7
34	8:8,31:3
35	8:8,31:1
36	8:8,31:6
37	8:8,31:2
38	4:9,18:i4a,b
39	4:9,18:2
40	4:9,7:3
41	4:9,18:i1
42	9:8,23:14
43	9:8,23:12
44	9:8,23:10
45	9:8,14:i5
46	9:8,23:8
47	9:8,8:6
48	9:8,22:3
49	9:8,23:4
50	9:8,22,23:i2a,b
51	9:8,22:1
52	10:8,8,22:i15
53	10:8,28:8a,b,c
54	10:8,22:13
55	10:8,22:11
56	10:8,28:6
57	10:8,28:4
58	10:8,10,22:i2
59	10:8,22:i9
60	10:8,22:7
61	10:8,29:5
62	10:8,29:i3
63	10:8,29:1a,b
64	11:8,29:6
65	11:8,29:4
66	11:8,29:5
67	11:8,29:3
68	11.8,29:2
69	11:8,29:1
70	12:8,20:5
71	12:8,30:6
72	12:8,21:i3
73	12:8,30:4
74	12:8,21:2
75	12:8,30:i1
76	13:8,30:4
77	13:8,20:5
78	13:8,21,30:2e
79	13:8,20:3
80	13:8,30:i1
81	13:8,21,30:2d
82	13:8,21,30:2a,b,c

APPENDIX C

SPILL EQUIPMENT DEPOTS

CANADIAN COAST GUARD BASE:SEA ISLAND, MIDDLE ARM

BOOMS

1830 m Bennett boom (0.9 m)
1 Vikoma Sea Pack - CCG base Kitsilano
1 308 m Versatech disposable boom (0.5 m)

SORBENTS/DISPERSANTS

80 cartons of Oil Snare
10 cartons of Conwed
17 rolls of 3M
10 drums Oilsperse 43 (204 litres each)
2 dispersant back packs (22.7 litres each)
2 sets of vessel-mounted dispersant spray equipment c/w pump & concentrate adapter
1 inshore dispersant spray pump

BOATS/SPECIAL VEHICLES

1-29 m cutter - CCG base Kitsilano "Rider"
1 S.R.N. 5 + 1- S.R.N. 6 Hovercraft - Sea Island (273-238 S.A.R.)
1-4x4 c/w radio telephone (call channel N410291) and marine VHF radio (channels VHF RAY 55)
1 utility trailer 3.05 x 1.8 m
5 boom trailers (0.9 m Bennett boom each)
1-11.4 m sea truck c/w crane, 1000 kg, VHF radio 25 W
1-6.4 m Boston whaler
1-3/4 ton truck c/w VHF radio RAY 55
1-3 ton flat deck truck w/hydraulic crane, c/w VHF radio
1-13.7 m Equipment/trailer
1-6.77 x 2.46 m Utility trailer
1-7.6 m O.S.C. Communications trailer

CANADIAN COAST GUARD (Continued)

SKIMMERS/PUMPS/TANKS

1 slicklicker - vessel mounted
3 spate pumps
2 Komara Mini-Skimmers
2 back packs
10-4545 litre Port-A-Tank
1 Oil Mop (semi-portable)
2-115 V gasoline/dispersent pumps
5 Transtech containers capacity 2.6 m3 each
1 Oil Mop
1 MI30 Skimmer
1 Destroil screw pump

GENERATORS/LIGHTS

1-2kW portable generator - 110V AC
2 floodlight assemblies
3 portable floodlight assembly with gas engine

COMMUNICATION EQUIPMENT

9-3 W Transceiver VHF Ch. 6, 11, 12, 16, 18A, 81A
5-3 W Transceiver VHF Ch. 6, 12, 16, 81A
1-25 W Repeater - Ch. 81A
1-25 W Portable unit

SAFETY EOUIPMENT/SPECIAL CLOTHING

100 pr. rubber boots
100 pr. each socks and insoles
100 suits rain gear
15 "Floater" coats

OTHER EOUIPMENT

100 rakes
1 steam cleaner (portable)
local resources

BURRARD CLEAN OIL SPILL CO-OPERATIVE:BURRARD INLET

BOOMS

2000'-24" harbour boom
2000'-36" harbour boom
1800'-36" compactible boom
500'-12" gundry bilmac type

BOATS

1-27' work boat w/outboard motor
2-18' work boat w/outboard motor

SKIMMERS/PUMPS/FITTINGS

Burrard Cleaner #1 - 48' self propelled vessel
Burrard Cleaner #2 - 50' self propelled vessel
2 Morris M1-2 skimmers
1 Komara skimmer
1 Oil Mop (Mark II-9 DP)
1 Scavenger

PUMPS/HOSES/TANKS

1-1600 gallon PVC tank
1-1000 gallon PVC tank
2-Homelite gas-powered pumps
sundry hoses