SUSTAINABLE DREDGING PROGRAM ON THE LOWER FRASER RIVER

by

Włodzimierz Joseph Broś
B.Sc. (Civil Engineering), Queen's University, 1993

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF BUSINESS ADMINISTRATION

In the
Faculty of Business Administration
Executive MBA Program

SIMON FRASER UNIVERSITY

Summer 2007

APPROVAL

Name: **Włodzimierz Joseph Broś**

Degree: **Master of Business Administration**

Title of Thesis: **Sustainable Dredging Program on the Lower Fraser River**

Supervisory Committee:

Dr. Mark Selman
Senior Supervisor
Program Chair, Learning Strategies Group

Dr. Mark N. Wexler
Second Reader
Professor of Management and Organizational Studies

Date Approved: Aug. 7, 2007.

SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

STATEMENT OF ETHICS APPROVAL

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

(a) Human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

(b) Advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

(c) as a co-investigator, in a research project approved in advance,

or

(d) as a member of a course approved in advance for minimal risk human research, by the Office of Research Ethics.

A copy of the approval letter has been filed at the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Bennett Library
Simon Fraser University
Burnaby, BC, Canada

ABSTRACT

The Fraser River Port Authority dredges the Fraser River to maintain navigation in support of the port activities. Sales of the dredged river sand are the only source of revenue offsetting the cost of dredging. The Port Authority does not have the key success factors to compete in the sand market. The burden of dredging impedes the economic development of the Fraser River Port.

The Port Authority can change the status quo by extracting more value from the dredged river sand, implementing a user-pay system, reducing the scope of dredging, or obtaining government funding for dredging. The goals for the dredging program are efficient use of resources, equitable distribution of costs and benefits, no negative net impact on the environment, and acceptability to stakeholders. The analysis recommends that the Port Authority extract more value from the dredged material by utilizing it in land reclamation projects.

Keywords: Dredging, Fraser River, Strategy, Policy, User-Pay System, Government Funding, Land Reclamation.

Subject Terms: Dredging the Lower Fraser River

To my wife June

with thanks for all the support and love.

ACKNOWLEDGEMENTS

I would like to express my appreciation to the Fraser River Port Authority and my colleagues at the Port for support in my MBA studies. I acknowledge the following people for providing me with much insight into the dredging issue:

- Mark Adams
- Ted Carlson
- Tom Corsie
- Dave Hart
- Grant Hughes
- Tino Isola
- Ed Kargl
- Brian Naito

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Borrow Dredging	A process of mining sand from a river for the purpose of using it as a fill at another location.
Break-Bulk	A category of cargo that comes in dimensional packages, e.g. steel, lumber, pulp, and paper.
Capital Dredging	Dredging conducted to construct or improve a navigation channel or harbour. This is a one-time event to deepen, widen, or change shape of the channel or harbour. This infrastructure is then maintained through maintenance dredging.
Compensation area	An area with a designated purpose to increase productive capacity of existing habitat. Compensation is often required by regulatory agencies as a condition of site development.
Draft	Depth of water that is required to safely float a ship
Dredging	The removal of sediment from the bottom of a body of water through a use of mechanical equipment.
Fish habitat	"Spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." (Canada Fisheries Act, sec. 31.5)
Freshet	A seasonal increase in river discharged due to melting snows and/or heavy rains often bringing large volumes of sediment.
Highest and best land use	A reasonably probable land use that is legally permissible, physically possible, financially feasible, and maximally productive. Land is valued (assessed) based on the highest and best use at vacant and ready for development state.
Intertidal	Bound by the levels of high and low tide.
Maintenance dredging	Dredging required on seasonal basis to provide required navigation channel for marine transportation.

PANAMAX	A class of vessel that can pass through the Panama Canal. A vessel with a beam of less than 32m.
Preload	A technique used to mitigate differential settlement in compressible soils. A load of sand or gravel, equal in weight to the proposed structure, placed over the proposed building site for a period of 2 to 24 months.
Rip-rap	Large rock used to armour shorelines against water erosion
Riparian	Of, or growing on a bank of a river or other natural body of water
Road sub-base	A high strength aggregate layer below asphalt pavement and another thin aggregate layer called road base.
TEU	Twenty-foot equivalent unit. A unit of measuring containers, 20 ft length x 8 ft width x 8.5 ft height.
Till	An unsorted glacial sediment consisting of clay, silt, sand, gravel, and boulders.

LIST OF ACRONYMS AND ABREVIATIONS

CCG	Canada Coast Guard
CHS	Canadian Hydrographic Services. CHS acronym behind elevation refers to a chart datum established by Canadian Hydrographic Services. The chart datum is selected so water elevation seldom falls below it.
DFO	Fisheries and Oceans Canada
FREMP	Fraser River Estuary Management Program
FRPA	Fraser River Port Authority
FRPD	Fraser River Pile and Dredge
MFBM	1,000 board feet of lumber (FBM)
MMCD	Master Municipal Construction Document
TC	Transport Canada
TEU	Twenty-foot equivalent unit. A unit of measuring containers, 20 ft length x 8 ft width x 8.5 ft height.

1 INTRODUCTION

1.1 Project Objective

This paper is a strategic analysis of the dredging program on the Lower Fraser River. The Fraser River Port Authority currently dredges the river for navigation purposes. The average annual cost of this operation is $3.5 million. This cost is relatively large and, in the long term, it impedes the economic development of the Fraser River Port. Further, this cost puts FRPA at a disadvantage compared to other ports in Canada and the United States, which do not have to dredge or have dredging service provided at no cost to them.

The paper examines the potential for the Fraser River Port Authority to implement an economically sustainable alternative to the existing dredging program. It concentrates on the economic evaluation. The paper recognizes the importance of environmental and social issues. It proposes alternatives that appear to avoid a net negative impact on the environment and the community.

The dredging is analysed from the perspective of the Fraser River Port Authority, the government agency having jurisdiction over the Lower Fraser River. For this reason, the analysis concentrates on mitigating the negative economic impact of dredging on the Port's operation, and not on competing in the dredging market.

The views presented in this paper are the author's and not necessarily these of the Fraser River Port Authority. All figures presented in this paper are created by the author unless otherwise stated.

1.2 Background on Dredging and Navigation on the Lower Fraser River

The Lower Fraser River extends from the Georgia Straight upstream to the Kanaka Creek in Maple Ridge. The river is an important commercial waterway and a home to port facilities handling cargo that include construction aggregates, forestry products, steel, vehicles, and containers. This report concentrates on the South Arm of the Fraser River that is under the jurisdiction of the Fraser River Port Authority as this is where the regular maintenance dredging currently takes place.

The dredging program on the Fraser River dates back to the 1800's when a navigation channel was established on the river (Ferguson, 1991, p. 14). From the early 1900's to 1998, the Government of Canada, through Public Works Canada and Canadian Coast Guard, maintained a dredging program on the Fraser River that included a navigation channel for deep sea going vessels and a number of secondary channels for coastal shipping. In 1998, the Federal government introduced a new marine transportation sector policy and ceased the dredging program. The following year, the Fraser River Port Authority commenced its dredging program to maintain the port operation. FRPA scaled down the dredging program to the deep-sea navigation channel that exists between the Fraser Surrey Docks terminal in Surrey and the mouth of the river.

The Fraser River Port Authority adopted a policy not to dredge secondary channels unless the dredging cost was recoverable.

Since the 1980s, the navigation channel has been improved from depths that could provide for sailing of ships with a draft of approximately 6 meters during certain periods (Ferguson, 1991, p. 14) to depths that provide a daily navigation window for vessels up to 11.5 m draft. The channel is described in terms of a river draft that is the maximum draft of a vessel that can safely navigate the river every day of the year. The river draft is a combination of the fresh water depth and the ocean tide. For example, the navigation channel at Sand Heads is shallower than it is in New Westminster, but it benefits from a greater tidal influence, so the overall height of the water column meets the same vessel draft requirements. The existing deep-sea navigation channel is designed for daily use by vessels not exceeding 11.5 m draft, 245 m length, and 32.3 m beam (width). Vessels as large as 320 m in length and 45 m beam have sailed on the river in favourable conditions (FRPA, 2007b, p. 20).

1.3 Fraser River Port

The Fraser River Port is Canada's second largest port when measured by tonnage. The 2006 total throughput was 36 million tonnes of which 4 million were international cargo (FRPA, 2007d). Several terminals are located in the Fraser River Port. The largest three are Fraser Surrey Docks (FSD), WWL Vehicle Services Canada Ltd., and Fraser Wharves Ltd. FSD and WWL terminals are owned by the Port Authority and are leased to private terminal operators. Fraser Wharves is privately owned and operated. Fraser Surrey

Docks handles containers and break-bulk cargo. The current terminal container capacity is 415,000 TEUs (twenty foot equivalent units). Typical break-bulk cargo includes import steel, export lumber and pulp, export raw logs, and other cargo requiring specialized handling. WWL and Fraser Wharves handle approximately 450,000 vehicles that represent nearly all of the Asian made cars imported to Canada. Volume statistics for years 2002 to 2006 for major cargo are included in Appendix 1.

Fraser River Port is a local economic generator that provides a significant contribution to the local and national economies. In 2002, InterVISTAS Consulting estimated the total national economic impact of the Fraser River Port at $1.3 billion in wages, $2.1 billion in GDP, and $4.8 billion in economic output (InterVISTAS, 2002, p. vii). In 2006, FRPA issued an update on the economic impact of the Port. The 2006 statistics are $1.8 billion in wages, $2.8 billion in GDP, and $7.2 billion in economic output (FRPA, 2007e).

2 DREDGING ENVIRONMENT

2.1 Government Dredging Policy

The Canadian Government dredging policy is part of the overall marine transportation sector policy. It dates back to work undertaken by the Standing Committee on Transport, and the Standing Committee of Fisheries and Oceans in years 1995 to 1997. The two committees had a common objective to reduce the government subsidy of the marine sector. This resulted in a user-pay system. The Canadian Coast Guard withdrew from the dredging of harbours and channels and implemented Marine Services Fees for other services. Dredging became the responsibility of the newly created Canadian Port Authorities.

The Canadian Port Authorities were created as Federal Crown Agencies under Transport Canada. They were legislated by the Canada Marine Act of 1999. The Act authorized the port authorities to dredge, and to recover the cost of dredging through a user-pay system. The port authorities were given autonomy to implement their own dredging policies. At the same time, the port authorities were required to demonstrate self-sufficiency, which in turn made the dredging policy a business decision. In this environment, the users' willingness to pay determines the extent of dredging and the overall level of marine infrastructure (DFO, 1997).

Environment Canada (EC), which monitors the ocean disposal sites for dredged material, also adopted the user-pay policy. EC charges a $2,500 permit

application fee and collects an additional fee of 47¢ per cubic meter for disposed dredged material. The purpose of the fee is to cover environmental monitoring costs and to earn a fair return for the Canadian public for the exploitation of public resources (EC, 2006, pp. 1-3).

Similarly, the Government of British Columbia is seeking a fair return for the exploitation of provincial resources. BC is seeking a royalty for the sand removed from the provincial river bottom administered by the Fraser River Port Authority. FRPA has disputed the royalties claiming that maintenance of the navigation channel is a Federal right. The 2006 FRPA financial statements show $1.2 million contingent liability for sand royalties (FRPA, 2007c, note 10).

In the Lower Mainland, the Ministry of Transportation and the municipal governments' procurement policies indirectly affect the local dredging policy. These procurement policies regulate how the dredged sand is used on public infrastructure projects. Currently, both MOT and municipalities allow river sand as general fill and preload. However, until 2006, the Master Municipal Construction Document (MMCD) made it difficult to use river sand for civil works. MMCD specified sand gradation that sand from the Lower Fraser River could not meet. Further, MMCD required "special specification" [sic] by the project engineer for use of river sand (MMCD, 2000, § 02224 and 02226). Some engineers were reluctant to write this specification because of the additional effort required, and because of an increased professional liability risk resulting from deviating from the industry standards.

Finally, the dredging policy is influenced by the fish management policy. Fisheries and Ocean Canada has a guiding principle of no net loss of the productive capacity of fish habitats (DFO, 1986, p. 7). Canadian port authorities that are now responsible for dredging of harbours and channels have to meet this policy. All dredging programs, including FRPA's dredging of the Lower Fraser River, require DFO approval.

2.2 Dredging in the United States of America

The United States government recognizes ports as economic generators. It implemented a dredging policy that requires regulatory agencies to create an environment where dredging can be done in a timely and cost effective manner. Further, the American government recognized the value of the material dredged. The policy states that the dredged material be used for environmentally-sound beneficial uses such as wetland creation, beach nourishment, and development projects. The United States Government appointed US Corps of Engineers to administer the dredging program (US, 1994, chapter 4).

The US Government recovers the dredging cost through a Harbour Maintenance Tax (HMT). The US Congress enacted the HMT in 1986. Over the years, the tax has been modified. Today, the tax is 0.25% "ad valorem" (of value of cargo) on imports unloaded in deep water harbours. The HMT is deposited to the Harbour Maintenance Trust Fund. This is used to cover the US Corps of Engineers dredging cost. Over the years, the fund has grown a substantial surplus. This is now a source of public advocacy for increased investment in harbour infrastructure. The American Association of Port Authorities (AAPA)

estimated harbour maintenance cost for 2008 at $1.3 billion, whereas, the U.S. President proposed a budget of $750 million. The AAPA argues that the current funding is inadequate, and it advocates that all of the projected surplus of $4 billion be spent on the intended purpose (AAPA, 2007).

2.3 Stakeholders

2.3.1 Fraser River Port Authority

The Fraser River Port Authority is a federal government agency created under the Canada Marine Act in 1999. FRPA's jurisdiction begins at the mouth of the South Arm of the Fraser River and extends upstream to Kanaka Creek in Maple Ridge, and includes Pitt River (see Figure 2.1). Transport Canada authorized the port authorities to manage or engage in activities related to shipping, navigation, transportation of goods and people, and the handling and storing of goods. FRPA may engage in other activities that may be necessary to support port operations, though not as an agent of the Crown.

The Fraser River Port Authority's operational activities include administration of all port related activities on the river and the administration of crown properties placed within its jurisdiction. FRPA real estate holdings include the submerged river bottom and about 514 hectares (1269 acres) of land located mainly in Richmond, Surrey, and Delta (see Figure 2.1). All of the upland holdings and large parts of the river bottom are Federal Crown properties. The lower section of the river from Sand Heads to Upper Tilbury (80th St., Delta) is Provincial Crown property under a Head Lease to the Fraser River Port Authority.

FRPA leases out its land for port related purposes like deep sea or coastal terminals, warehousing and distribution, intermodal operations, and some manufacturing.

Figure 2.1 Fraser River Port Authority jurisdiction

Source: Fraser River Port Authority. Copyright. Used with permission.

2.3.2 Other Lower Mainland Port Authorities

Two other port authorities have an interest in the Lower Fraser River dredging program. These are the North Fraser Port Authority (NFPA) and Vancouver Port Authority (VPA). The North Fraser Port Authority has jurisdiction over the North and Middle Arms of the Fraser River. NFPA manages a shallow

draft waterway in support of industrial and commercial activities that remain on the rapidly gentrifying water banks. Currently, the North Arm has a draft of some 4.5 m, and the Middle Arm has a draft of 3.6 m (Chamber of Shipping, 2007). The North Fraser Port Authority does not have a maintenance dredging program. In 2006, the agency committed to dredge some high spots in the channel (Baydala, 2006).

Vancouver Port Authority has jurisdiction over the Burrard Inlet, Indian Arm, English Bay, and parts of Georgia Straight that includes Deltaport. Vancouver Port has no maintenance dredging requirements. However, it has an interest in dredging because of the proposed amalgamation of the Lower Mainland Ports. In 2006, The Federal Minister of Transport invited the three Lower Mainland Port Authorities to examine the feasibility of amalgamation (Port Amalgamation, 2007). The Minister's step is part of Canada's Asia-Pacific Gateway and Corridor Initiative (TC, 2007c), and is consistent with the Provincial government's BC Ports Strategy (BC, 2005, pp. 19-21).

2.3.3 Fraser River Estuary Management Program

Fraser River Estuary Management Program (FREMP) is an intergovernmental partnership of agencies having jurisdiction over some aspects of the river estuary. Geographically, FREMP extends from Georgia Straight upstream to Kanaka Creek and Pitt Lake, and it also includes Mud Bay, Roberts Banks, and Sturgeon Banks. The partner members of the Program are Environment Canada, Fisheries and Oceans Canada, BC Ministry of Environment, Fraser River Port Authority, North Fraser Port Authority, and

Greater Vancouver Regional District. The Program's objective is to provide integrated management of human and natural activities within the estuary. FREMP operates under a framework known as "A Living Working River" (FREMP, 2003, pp. 7-23). FREMP recognizes the need for dredging as it is required for navigation and flood protection. At the same time, FREMP partners recognize the need to minimize the environmental impact of dredging. In 2001, the agency developed Dredge Management Guidelines for the Fraser River dredging program.

2.3.4 Fisheries and Oceans Canada

Fisheries and Oceans Canada (DFO) is a federal government department mainly responsible for conservation and sustainable use of fisheries resources. Governing legislations for DFO activities are the Oceans Act, Fisheries Act, and Species at Risk Act. DFO is responsible to ensure compliance with environmental regulations and standards of new developments, and to conserve and protect aquatic ecosystems. The Canadian Coast Guard (CCG) is a department of DFO that has a mandate to provide safe water travel. Public Works and Government Services Canada (PWGSC) provides resources to CCG to perform hydrographic surveys of the Fraser River (DFO, 2007).

2.3.5 British Columbia Ministry of Environment

The BC Ministry of Environment (MOE) is responsible for sustainable management of the environment and resources of the province of British Columbia. The Ministry includes the Environmental Assessment Office (EAO),

which is responsible for the review and approval of development projects including dredging. Under the current government, the Ministry refocused its goals to better address government priorities and to provide responsive client service. This new directive has emphasis on collaborative approach to environmental management (MOE, 2007).

2.3.6 Environment Canada

Environment Canada (EC) is a federal equivalent of the MOE with similar responsibilities and powers. The bureau administers the Canadian Environmental Protection Act, the Species at Risk Act, and Canadian Environmental Assessment Act (CEAA). All projects including dredging have to meet CEAA requirements. CEAA review is included in the FREMP Dredge Management Guidelines. Environment Canada administers ocean disposal sites including one at Sand Heads where unsold dredged material from the Fraser River is disposed.

2.3.7 Transport Canada

Transport Canada's (TC) involvement in the Fraser River relates to the administration of the Canada Marine Act, Canada Shipping Act, Marine Transportation Security Act, Transportation of Dangerous Goods Act, and Navigable Water Protection Act. The Ministry leads the Asia Pacific Gateway and Corridor Initiative that advocates an expansion of the ports' capacities on the West Coast of Canada. Transport Canada includes the Navigable Water Protection Program that reviews dredging, filling, or any type of construction in,

over, or near a navigation channel. The Fraser River Port Authority reports directly to Transport Canada (TC, 2007)

2.3.8 Ministry of Transportation

The BC Ministry of Transportation (MOT) is involved in the dredging program on three levels. The Ministry leads the BC Ports Strategy that aims at increasing the annual ports contribution to the British Columbia economy by $4.7 billion by 2020 (BC, 2005, p. 2). MOT administers the Head Lease with the Fraser River Port Authority and the North Fraser River Port Authority. Finally, the Ministry administers the royalty program for extraction of sand and gravel from the Provincial Crown Land including the river bottom leased to the Fraser River Port Authority.

2.3.9 Municipalities

Most Lower Mainland municipalities have territory located within the floodplains of the Fraser River. These municipalities lobby the Federal government to ensure continuity of the dredging program as the program contributes to the overall flood risk management. The municipalities would also like the program extended to secondary channels as these would stimulate development of marinas and water related commercial activities. At this time, municipalities do not contribute financially to the dredging program.

2.4 Dredging Process

Dredging of the Lower Fraser River is seasonal. It starts towards the end of the freshet, approximately mid July to mid August, and it continues until early

March. The dredging activities on the river are generally not permitted between March 1st and July 15th to protect juvenile salmonids and eulachon (FREMP, 2005, p. 33). The start of the dredging season is tied to the water velocity and to the volume of water discharged at a control station in Hope. Generally, the river bottom is dynamic or fluid when the discharge is above 5000m^3 per second. Such a condition makes the dredging operation inefficient and it may endanger the dredging crew.

Figure 2.2 Dredging process

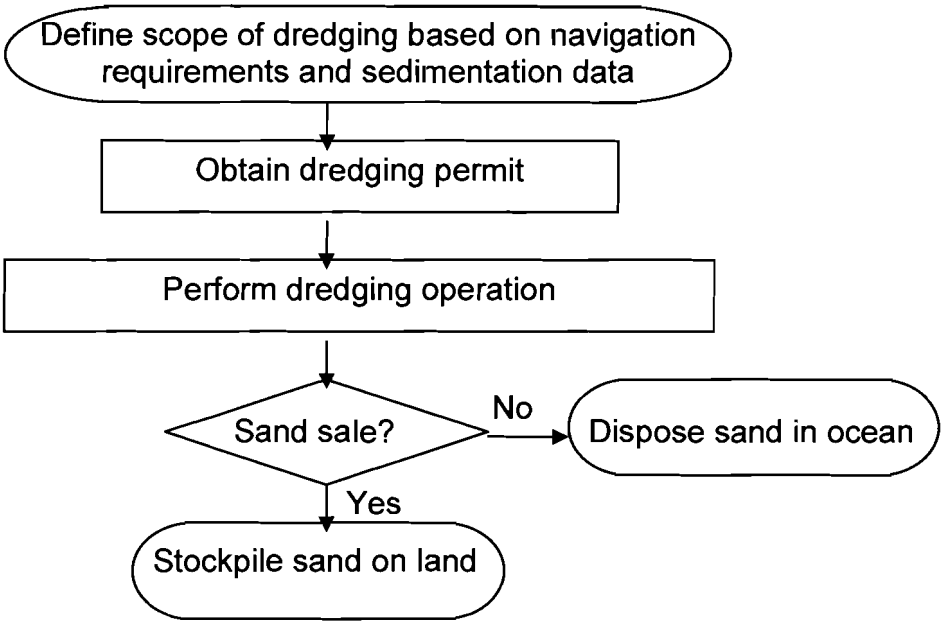


Figure 2.2 outlines the dredging process. The scope of dredging is triggered by navigation requirements. The navigation channel is defined in terms of width, grade elevation, and subgrade elevation. The grade elevation allows for safe passage of vessels. The subgrade elevation defines additional depth to allow for sedimentation that occurs mostly during the freshet. The subgrade

elevation is defined using historical data of the river sedimentation. The dredging operation removes the material contained between the actual surveyed elevation of the river bottom and the desirable subgrade elevation. Based on the above, the Fraser River Port Authority staff identifies the areas of the river that require dredging, and the volume of material that needs to be removed.

Once the dredging scope is defined, the Fraser River Port Authority then obtains a dredging permit from other authorities having jurisdiction over the river, and a separate permit for any material that requires ocean disposal. This process follows the FREMP Dredge Management Guidelines. The principle of these guidelines is that in the long run the volume of material removed from the river does not exceed the volume of sediment deposited at the river bottom. FREMP established a "Sediment Budget", which it uses to monitor the net change in the sediment stored in the estuary. Any material removed from the river comes out of this sediment budget. All dredging requires permits and is registered in the Sand Registry and counted in the Sediment Budget. (FREMP, 2005, pp. 15-19).

The physical dredging operation can begin only after the necessary permits are in place. FRPA contracts out dredging to the Fraser River Pile and Dredge Ltd (FRPD). FRPD carries out the dredging operation. It sells as much sand, within the capacity of the dredging equipment, as the market demands during the dredging season. Finally, it disposes of the unsold material in the ocean. Ocean disposal of dredged river sand is the least desirable option. It eliminates any chance to recover value from this material. However, the option is

used for disposing unsold sand as it is cheaper than stockpiling it on land. The Fraser River Port Authority receives monetary credits for the material sold and it pays for ocean disposal of the unsold material.

2.5 Scope of Dredging

Every year, the Fraser River Port Authority dredges approximately 2.6 million m^3 of sediment (mostly sand) from the Fraser River. This volume includes 2.3 million m^3 of navigation channel dredging and 0.3 million m^3 of dredging at Fraser Surrey Docks. The navigation channel dredging involves maintenance and capital dredging. On an annual basis, FRPA maintains the 11.5 m draft navigation channel that on average requires the removal of 2.1 million m^3 of sediment. Additionally, FRPA engages in capital dredging to improve or develop navigation channels or the approaches to upland facilities.

The difference between maintenance and capital dredging is not in the process but in the scope. The purpose of the maintenance dredging is to keep the navigation channel in equilibrium, whereas the goal of capital dredging is to make the channel deeper or wider. Between 2003 and 2006, the Port dredged 3.5 million m^3 of sediment to increase the draft of the navigation channel from 10.7 m to 11.5 m. It is possible to increase the channel draft to 12.5 m by removing an additional 4.4 million m^3 of sediment from the river bottom (Hay, 2005, p. 11). Deepening of the main navigation channel beyond the 12.5 m draft is unlikely, as it would involve removal or reconstruction of the George Massey Tunnel and some utility crossings.

The river environment is complex resulting in different dredging requirements in different parts of the river. Figure 2.3 and Table 2.1 identify the geographic location of dredging activities based on the volume of sediment removed. Seventy percent of dredging occurs at the mouth of the river, downstream from Steveston. Additionally, the quality of the material varies with each location. The material is finer in the lower section of the river.

Table 2.1 Maintenance dredging requirements

Reach	Km	Volume (m^3)	Volume (%)
Sand Heads Reach	-1 to 5	238,527	12%
Steveston Bend and Steveston Cut	5 to 12	1,212,326	59%
Woodward Reach	12 to 18	0	0%
Gravesend Reach	18 to 24	25,311	1%
Purefleet Point	24 to 27	74,336	4%
St. Mungo's Bend	27 to 30	112,726	5%
Annieville Channel	30 to 35	400,636	19%
Total Maintenance Dredging		2,063,862	100%

Source: Hay & Company (2005) Fraser River Dredging Study. Table 3.1. Purefleet Point's volume corrected by one digit in consultations with Jim Stronach of Hay & Company.

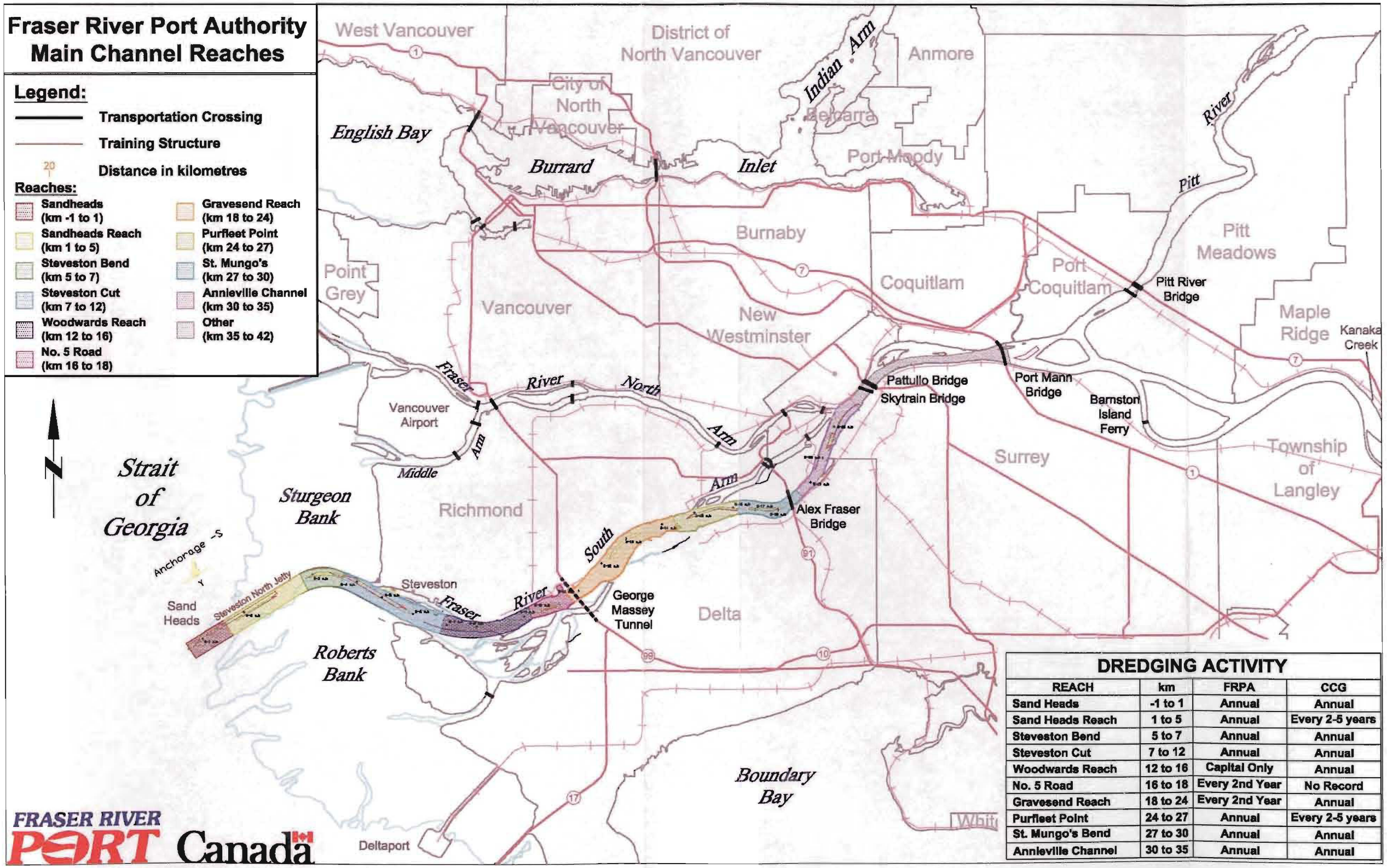
The Fraser River Port Authority evaluated the option of dredging the secondary channels that are shown in Figure 2.4. These channels have a proposed navigation draft of 4.6 m. They do not infill as much as the main channel, so the maintenance dredging would occur every few years. Table 2.2 shows estimated volumes and schedule for the secondary channels dredging. Dredging secondary channels would add approximately 250,000 m^3 per year to the scope of the dredging program.

Table 2.2 Secondary channels dredging, estimated volumes (thousand m^3) and schedule

Channel Name \ Year	1	2	3	4	5	6	7	8	9	10
Cannery Channel	46					45				45
Sea Reach		120						75		
Canoe Pass									10	
Ladner Harbour				120					-	
Ladner Reach									60	
Deas Slough					50		75			50
Tri-Mac									55	
Annacis Channel	43					40				
Gunderson Slough	23	15			15			15		
North Arm			20					20		
Poplar Channel								23		23
Sapperton Channel						65				
Queens Reach										2
Douglas North			50						50	
Douglas South		65	100	100				150		
Parsons Channel		65				65				65
Bishops Reach	150		100		175		150			
Derby Reach									19	
Chatham Reach										8
Fox Reach										
Total (m^3)	**262**	**265**	**270**	**220**	**240**	**215**	**225**	**283**	**194**	**193**

Source: Fraser River Port Authority. Dredging Program Proposal Secondary Channels. Table 5. Used with permission.

Figure 2.3 Maintenance dredging map

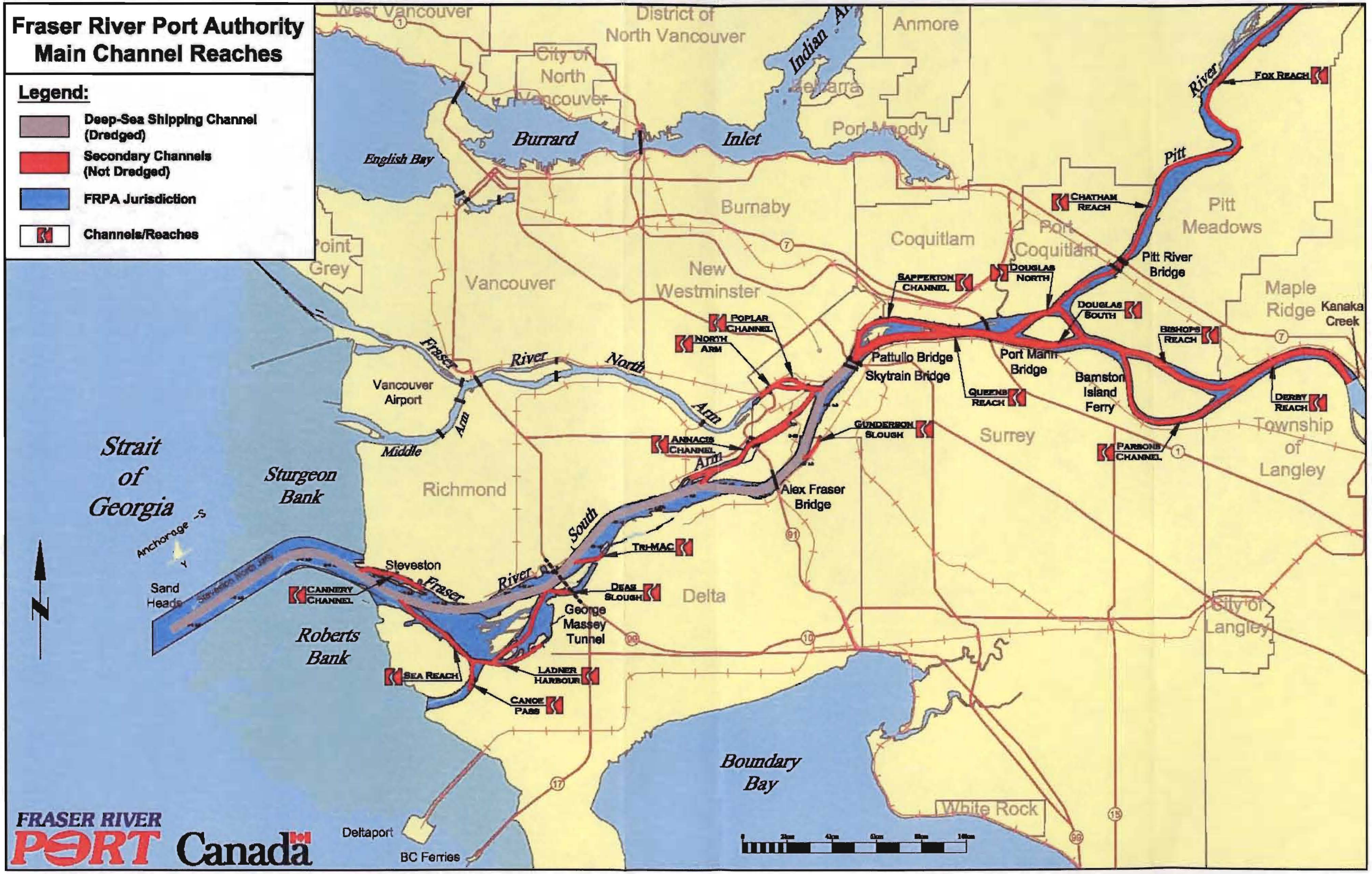


DREDGING ACTIVITY

REACH	km	FRPA	CCG
Sand Heads	-1 to 1	Annual	Annual
Sand Heads Reach	1 to 5	Annual	Every 2-5 years
Steveston Bend	5 to 7	Annual	Annual
Steveston Cut	7 to 12	Annual	Annual
Woodwards Reach	12 to 16	Capital Only	Annual
No. 5 Road	16 to 18	Every 2nd Year	No Record
Gravesend Reach	18 to 24	Every 2nd Year	Annual
Purfleet Point	24 to 27	Annual	Every 2-5 years
St. Mungo's Bend	27 to 30	Annual	Annual
Annieville Channel	30 to 35	Annual	Annual

Source: Fraser River Port Authority. Copyright. Used with permission.

Figure 2.4 Secondary channels map.



Source: Fraser River Port Authority. Copyright. Used with permission.

2.6 Sand, a By-Product of Dredging

The main product of dredging is the navigation channel itself. However, the dredged river sand is another product that has some value. In fact, in the past, sand was mined from the river in a process called borrow dredging. The practice of borrow dredging has ceased mostly because of environmental concerns. However, the sand from the Fraser River maintenance dredging is still widely used in land development.

River sand is a low value construction material used primarily for preload and general fill. The material is not suitable for road sub-base, concrete mix, or asphalt pavement applications because of its uniform gradation. Under a load, the grains of river sand close to the surface shift making it difficult to compact. Competing materials such as pit and quarry sands have a higher value because they can be used for road sub-base, concrete mix, and asphalt pavement in addition to the preload and general fill uses. River sand physical characteristics are identified in Table 2.3.

Table 2.3 Physical characteristics of river sand

Grain Size Range	0.074mm - 2.00mm
Classification	Fine to Coarse Sand
Bulk Density	1650 kg/m^3
Fines (<0.074mm grain size)	Less than 4%
Coefficient of Permeability	10^{-3} m/s

Source: Fraser River Port Authority web page (FRPA, 2007f). Bulk density value sourced from the Lower Mainland Aggregate Demand Study (Levelton, 1996, Table 1)

River sand has two advantages over pit sand. It can be hydraulically placed, and it is almost free of silt. These characteristics make river sand ideal

for preload and general fill. Hydraulic placement refers to a process of suspending river sand in water, pumping it via pipes, and spreading and draining the slurry at the desired location. The process results in 100% compaction and eliminates the need for expensive construction equipment to place the material. River sand can be pumped to sites within two kilometres from the river. For development sites further away from the river the material is hauled by trucks from half a dozen sand depots located along the river. River sand is nearly silt free because the dredging process removes the silt from the sediment. This makes the sand permeable and easy to use in any weather conditions.

2.7 Sand Sales

Sales of the dredged river sand are the only source of revenue that currently offset the cost of dredging. River sand is sold to sand vendors and directly to large project developers. The sand vendors include Mainland Sand & Gravel, Mathers E Bulldozing, and Mike's Contracting. All three vendors have their yards in south Richmond. Mainland also has two sand depots in Surrey: one near the Pattullo Bridge, and another one in Port Kells. Sand retailers have a capacity to receive approximately 700,000 m^3 of dredged sand from the Fraser River, and they sell an average of 924,000 m^3 per year. Table 2.4 lists sand depots, their capacities, turnover, and average sand sales. Additional sand is sold directly to large land development projects located near the river. In recent years, a large volume of sand was sold to the Big Bend development in south Burnaby. Such sales need to be at least near 200,000 m^3 to make the operation

feasible because of large set up costs. Between 1999 and 2007, sand sales to sand vendors and land developers averaged 1.5 million m^3.

Table 2.4 Sand depots' capacity and average annual sand sales to sand vendors

Existing Sand Depots	*Approximate Capacity (000 m^3)*	*Avg. Annual Sales (000 m^3)*	*Average Turnover*
MS&G Port Kells, Surrey	100	174	1.7
MS&G Timberland, Surrey	200	195	1.0
MS&G No. 5 Rd, Richmond	100	241	2.4
Mike's, No. 7 Rd, Richmond	200	101	0.5
Mathers, No. 7 Rd. Richmond	100	213	2.1
Total Sand Vendors	700	924	1.3

Source: Information on sand depots' capacity was obtained during an interview with Tino Isola of Fraser River Pile & Dredge. Average annual sand sales were sourced from FRPA records.

2.8 Sand Market

The Fraser River Port Authority competes for sand sales with construction aggregates from pits and quarries located mostly in Coquitlam, Abbotsford, and along the coast; and with material excavated for high-rise developments in downtown Vancouver, Brentwood, Lougheed, Metrotown, Guilford, and Whalley. BC Ministry of Energy and Mines records show that the construction aggregate production in the Lower Mainland fluctuated between 11 million and 29 million tonnes between 1980 and 2006.

Currently, FRPA sells an average of 1.5 million m^3 (2.5 million tonnes) of river sand per year, which represents 13% of the construction aggregate market in the Lower Mainland. Between 1979 and 1997, FRPA issued borrow dredging licences for extracting an average of 2.4 million m^3 (4.0 million tonnes) of river sand. Borrow dredging represented 19% of the construction aggregate market. In the same period, Public Works Canada placed ashore approximately 50% of

the sand dredged from the navigation channel. Some of that material was sold, and some was placed on the Port Authority's properties. Either way, the sand generated value and therefore it can be treated as sold. The total of borrow dredging and 50% of navigation dredging was 3.5 million m^3 (5.7 million tonnes), which represented 27% of the sand and gravel market. Therefore, the river sand share of the construction aggregate market is between 2.4 million m^3 and 3.5 million m^3. The market appears to be large enough to sell all of the 2.9 million m^3 of sand currently dredged from the river. Table 2.5 summarizes river sand sales and the Lower Mainland sand and gravel production. Detailed statistical information is provided in Appendix 2.

Table 2.5 Average annual supply of river sand (sales) in relation to the Lower Mainland construction aggregate production

Average Values for CCG and FRPA Dredging	Units	CCG 1979-1995	FRPA 1999-2006
Lower Mainland Construction Aggregate Production	'000 tonnes	21,283	20,343
Total River Sand Production	'000 tonnes	7,412	4,288
Total River Sand Production	**'000 m^3**	**4,492**	**2,599**
Total River Sand Sales	'000 tonnes	5,714	2,546
Total River Sand Sales	**'000 m^3**	**3,463**	**1,543**
River Sand Market Share	%	27%	13%
Borrow Dredging	'000 tonnes	4,017	
Borrow Dredging	**'000 m^3**	**2,434**	
Borrow Dredging Share of Construction Agg. Market	%	19%	

Source: 1979-1995 Lower Mainland construction aggregate construction sourced from BC Ministry of Energy (2007a). 1995 to 2006 Lower Mainland construction aggregate assumed as 50% of BC sand and gravel production as reported by BC Ministry of Energy (2007b). River sand quantities sourced from FRPA records. Information from years 1997/98 and 1998/99 was omitted as the dredging program was going through a transition period.

Figure 2.5 Dredged sand sales in relation to Lower Mainland construction aggregate production (1,000 tonnes)

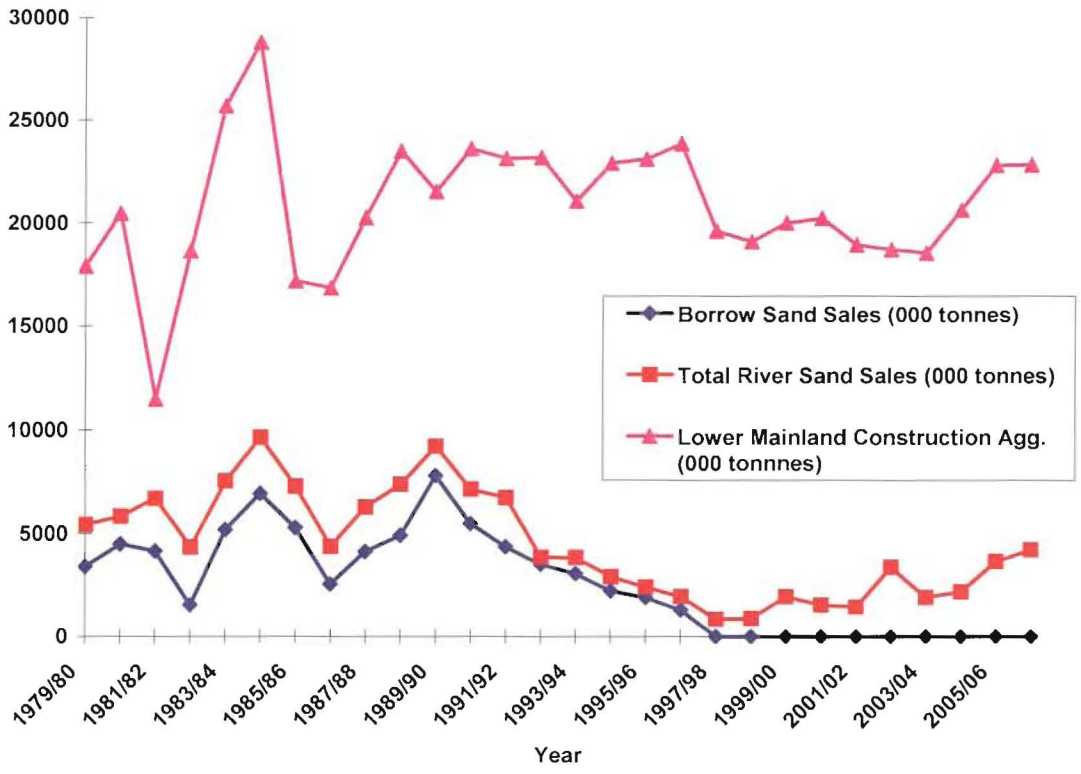


Table 2.5 and Figure 2.5 illustrate that the Lower Mainland construction market is mature with a steady consumption level of approximately 22 million tonnes per year. The consumption level is directly related to development activities in the region. The market peaked prior to Expo '86, and was in decline until the recent development boom. Major transportation projects such as the proposed Highway 1 widening and construction of South and North Fraser Perimeter Roads are likely to have a major impact on sand and gravel demand.

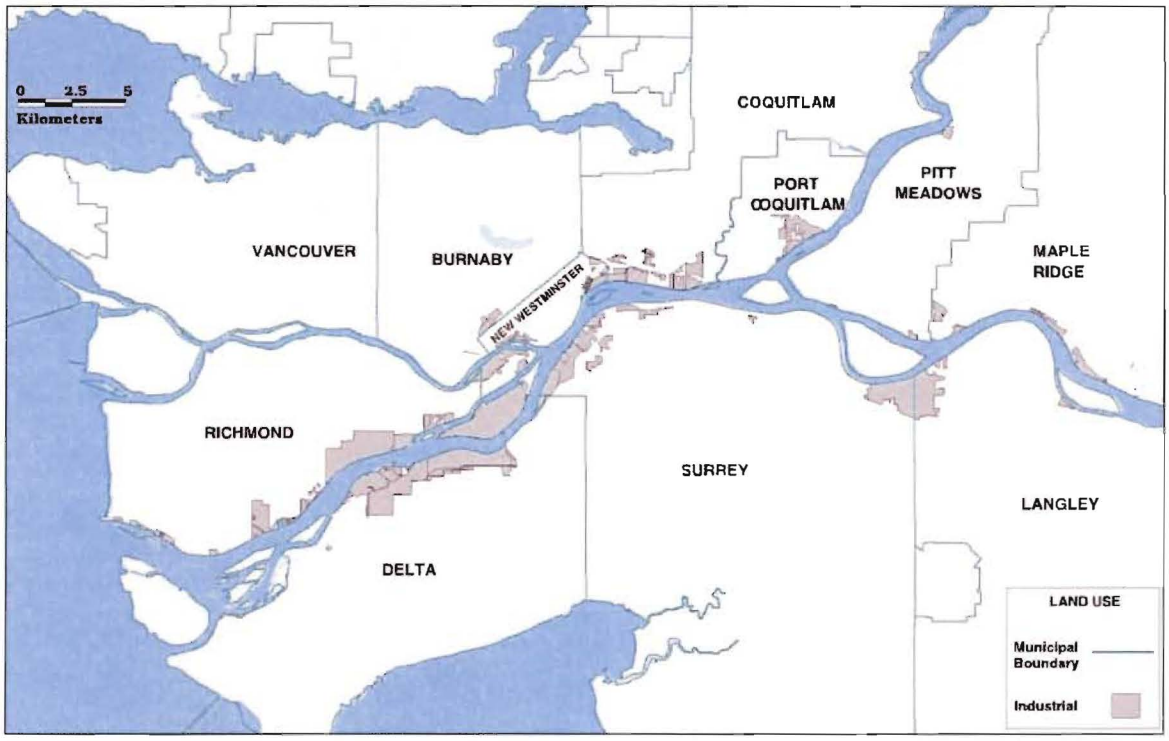
Table 2.6 identifies actual sales by region in comparison to sales projected by BC Research in 1984 and updated by Hay & Co. in 1995. BC Research based its projection on actual sand sales in the prior two decades and on proposed development projects. River sand sales declined in all parts of the

Lower Mainland with Delta and Burnaby showing the greatest decline. The table also identifies new upriver markets in Coquitlam, and Pitt Meadows. Table 2.6 shows that FRPA has the potential to sell more sand in areas such as Delta, Richmond, Surrey and Burnaby, and enter new geographic regions of Coquitlam, Pitt Meadows, and Maple Ridge. Figure 2.6 shows the location of industrial land in the Lower Mainland. Figure 2.7 shows the floodplain of the Lower Fraser River. The undeveloped industrial land in the floodplain of the Lower Fraser River creates opportunities for future river sand sales.

Table 2.6 Review of projected annual demand and sales for years 1999-2007

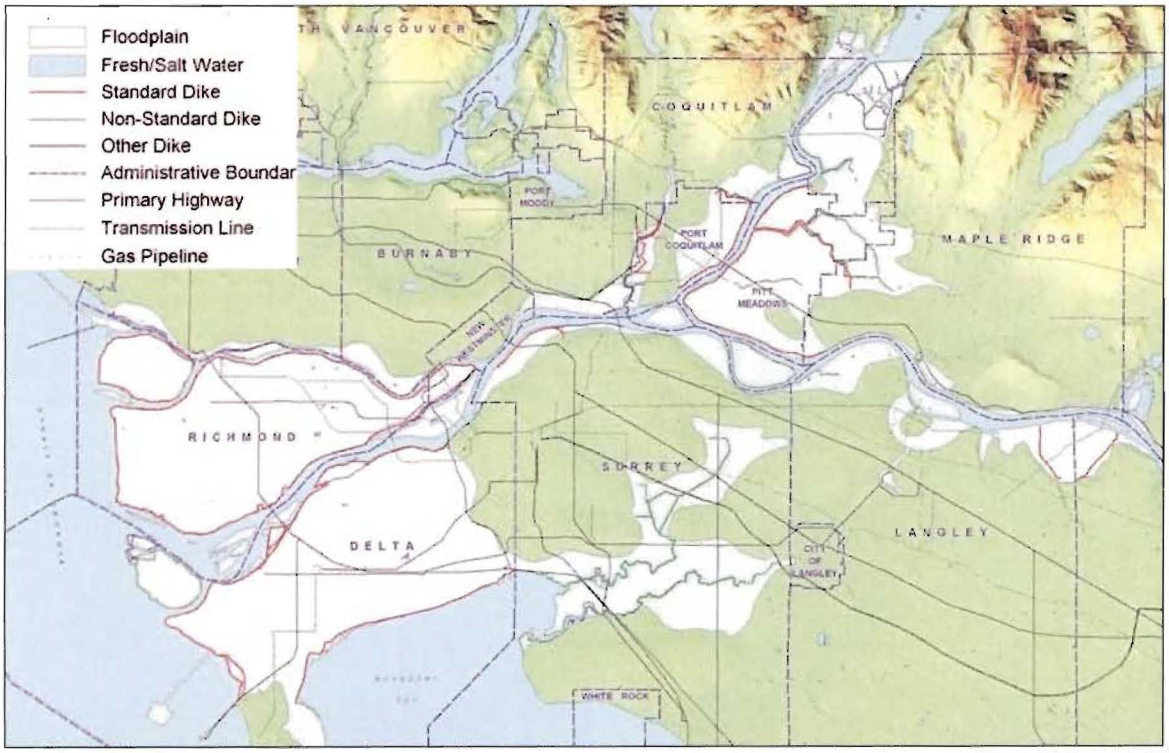
Location	Projected (m^3)	Actual (m^3)	Actual / Projected
Burnaby	550,000	55,965	10%
Coquitlam	-	41,280	N/A
Delta	500,000	53,531	11%
Pitt Meadows	-	96,211	N/A
Richmond	1,200,000	685,221	57%
Surrey	600,000	357,860	60%
Major Projects	1,000,000	240,176	24%
Total	**3,850,000**	**1,530,244**	40%
Projected = Average of Hay & Co. (1995, table 9.6) estimate			

Figure 2.6 Map of industrial land in the Lower Mainland



Source: Fraser River Port Authority. Copyright. Used with permission.

Figure 2.7 Floodplain of the Lower Fraser River

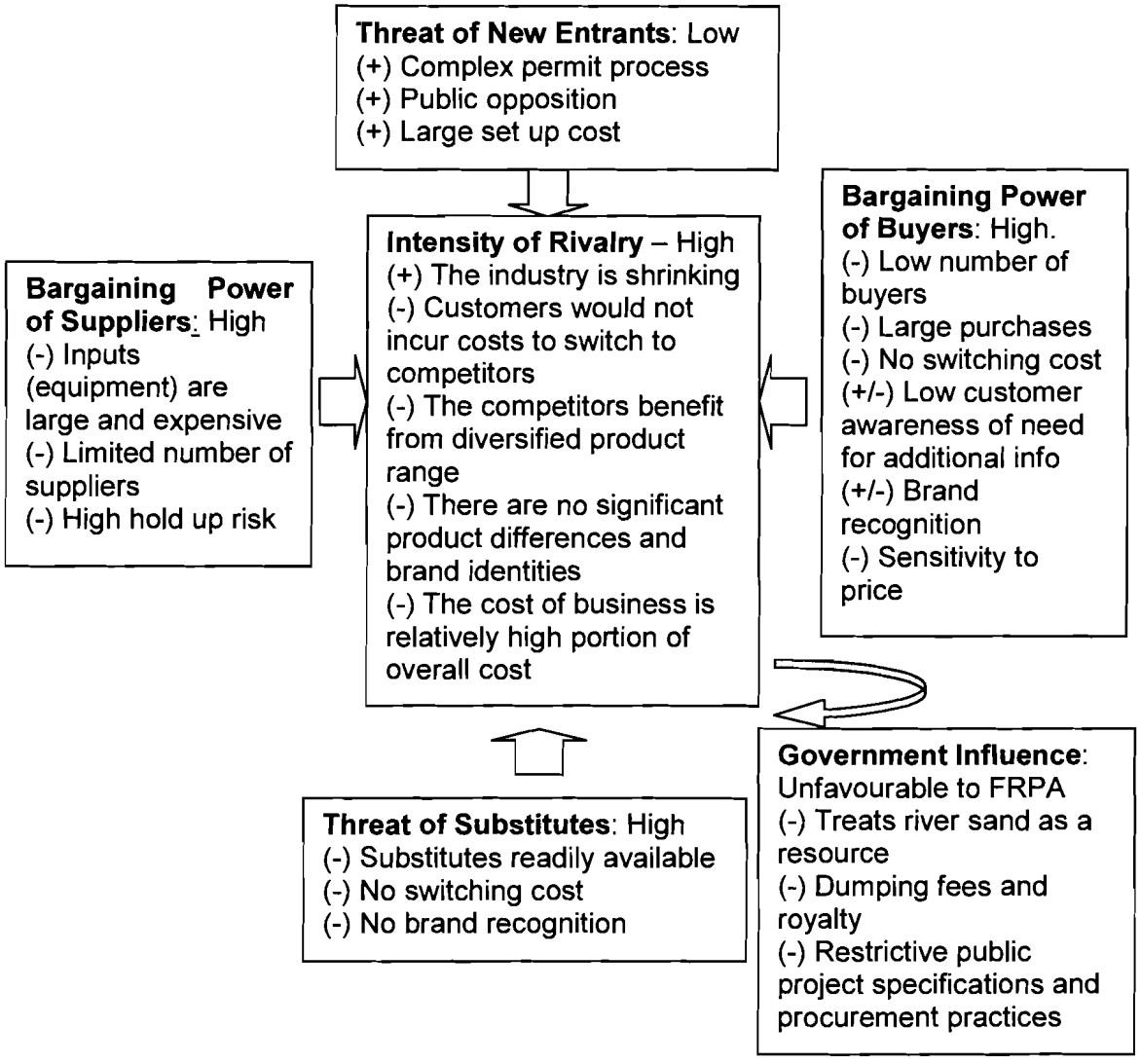


Source: Fraser River Port Authority. Copyright. Used with permission.

2.8.1 Five Forces Analysis

It appears that the Fraser River Port Authority is losing its share of the construction aggregate market. Porter's Five Forces model will be used to analyse the market situation. The goal of this analysis is to identify the key success factors that would enable the Port Authority to better position itself in the market.

Figure 2.8 Summary of Porter's five forces analysis and government influence



Adopted from Michael Porter's Competitive Strategy; Techniques for Analyzing Industries and Competitors (1998), pp. 1-33.

2.8.1.1 Threat of New Entrants

The construction aggregate market is saturated as deposits of sand and gravel are available in many parts of the Lower Mainland. Historically access to these deposits was easy; however, the situation has changed in recent years. New entrants are restricted from entering the market by a complex government permit process. Development of a new pit or quarry needs to address issues such as traffic, noise, dust, water quality, and ground remediation. The permit process for larger operations requires public consultation. Residents generally oppose new developments proposed in their neighbourhoods as such developments would likely negatively affect their quality of life. The conflict between industry and the general public increases as the Lower Mainland area becomes more populated.

The cost of starting a new pit or quarry operation is very high. First, there is the exploration cost to confirm the extent and quality of aggregate deposits. Second, there are the costs associated with the permit process. Third, there is the cost of heavy equipment and machinery. Finally, there is the start up cost. The development is usually located away from build up areas and it requires an access road. The sand, gravel, and rock deposits are usually covered by a layer of weathered material, organic mater, and vegetation. It typically takes months or years before the operation generates any revenues.

Access to sand deposits in the Fraser River are restricted by environmental regulations. Dredging operations have to meet the strict DFO's policy of no net loss of the productive capacity of fish habitats. The Fraser River

Port Authority has a permit and monopoly for dredging the navigation channel. Subject to meeting regulatory approval, the Port Authority permits owners of industrial facilities on the Fraser River to dredge their harbours. These operations can be neglected in the sand market analysis because of the small quantities and poor quality of the material removed.

The threat of new entrants into the construction aggregate market is low due to a restrictive permit process, public resistance, and high set up cost. Access to river sand is further restricted by government regulations effectively giving the Fraser River Port Authority a monopoly on dredging the Lower Fraser River. However, this monopoly is limited to dredging for navigation purposes. The key success factors are permitted access to raw material and low set up costs. Existing operation will enjoy a competitive advantage, as new entrants will face more stringent regulations and higher costs to meet these regulations.

2.8.1.2 Threat of Substitutes

Low value construction aggregates such as sand and gravel have many substitutes. This review will concentrate on substitutes for main river sand uses, i.e. general fill and preload. The main substitute for these uses is structural material excavated from construction projects. Highrise construction in Vancouver, Burnaby, Coquitlam, and Surrey generate large volumes of glacial till. This material is structural as it contains a large percentage of gravel and sand. Glacial till poses some challenges as it also contains clay and silt particles that make the material unworkable when oversaturated. In other words, the

material turns to mud in rain. The local climate restricts use of glacial till to short summer and early fall season.

Highrise developers have to dispose excavated material and are willing to pay for it. Landowners in low-lying parts of the Lower Mainland often set up landfill operations and import material excavated elsewhere. The purpose of these landfills is to improve soil conditions and to create a structural base for future land development. Landfill operators charge a small fee of about $20 per truck-load of dry material, and a higher fee over $100 per load of wet material. The premium fee for wet material is to allow for stockpiling, drying, and placement of the material during favourable weather conditions.

Excavated till is not available all the time and not in all areas of the Lower Mainland. Time is money, and this is especially true in real estate development. Land developers are willing to pay a premium for river sand or pit material to meet project deadlines. Developers often chose river sand over glacial till for preload because river sand gives the developer the flexibility to work with the material in any weather conditions and the cost of using river sand is not greater than the cost of using till. Developers pay for river sand up front and recover part of the cost from selling the sand at the end of the preload. When it comes to preloading with till, developers initially collect fees for receiving till but have to pay for its disposal at the end of the preload. After preloading with till an additional layer of material has to be removed and the area has to be dressed up with sand or gravel to prevent turning the land to mud.

The threat of substitutes in the construction aggregate market is high. This is especially true in the low end section on the market competing in the general fill and preload sector. Price and availability are the key success factors. Quality plays a factor in choosing material for preload.

2.8.1.3 Bargaining Power of Buyers

Land developers usually have a large selection of fill and preload material to choose from and have high bargaining power. They are very sensitive to price as this input does not visibly affect the end product. The material has to be able to support future development, but otherwise it is viewed just as a pile of dirt. Future users will only see a building, pavement, and landscaping. The material is a commodity with no brand recognition and no switching cost. Occasionally, availability of construction aggregate is restricted in certain areas of the Lower Mainland. In such conditions, the aggregate supplier has a bargaining advantage. This advantage is up to a point where transportation from other geographic regions becomes economically feasible.

The quality of construction aggregate is very important in highway and road construction. Public works project administrators have detailed specifications that restrict use of lower value materials. The Ministry of Transportation and municipalities are willing to pay a premium for higher quality material in order to extend the life expectancy of the pavement structure and to reduce its maintenance cost. On large projects, MOT and municipalities have high bargaining power because of the regulatory power that allows them to open project specific gravel pits

The bargaining power of buyers is high for the general fill and preload uses. Price is the key success factor. MOT and municipalities want quality, but they also have high bargaining power.

2.8.1.4 Bargaining Power of Suppliers

The Fraser River Port Authority outsources its dredging operation. The Port Authority has two possible dredging contractors to choose from, these being Fraser River Pile and Dredge, and JJM Construction. The scope of work is too small to engage both. One 2500 m^3 trailing suction hopper dredge is adequate to maintain the navigation channel. Using smaller equipment would be inefficient. Bigger equipment would also be inefficient as it would have unused capacity. In essence, the Lower Fraser River dredging is a natural monopoly.

In 1999, the Fraser River Port Authority tendered the dredging works, and awarded a 10-year contract to Fraser River Pile and Dredge. The contractor achieved high bargaining power for contract extension and for additional work through this exclusive long-term contract. In 2006, FRPA extended the dredging contract with FRPD until 2014 (FRPA, 2007c, note 11).

Operating cost of a dredge is high. The 1986 Don Doge study conducted for the Fraser River Harbour Commission estimated capital cost of acquiring a used cutter suction dredge at $4.3 to $5.4 million, and an annual operating cost $2.5 million. Given low sand prices and high operating cost, operational efficiency is a key success factor.

2.8.1.5 Intensity of Rivalry

The key players in the Lower Mainland construction aggregate supply are Lafarge, Lehigh, Jack Cewe Ltd, Allard, Mainland Sand & Gravel, Ministry of Transportation, and Fraser River Port Authority. Private companies specialize in producing higher value aggregate for concrete and asphalt production, and for road base. Sand and finer aggregates are often a byproduct of mining or quarry production. Coquitlam and Fraser Valley sources supply the western part of the Lower Mainland market, upstream of Pattullo Bridge. The aggregate can generally be delivered at a reasonable cost by truck for a distance of up to 40 km. The Ministry of Transportation reported that in 1999, cost of aggregate increased an average by 30% with haulage at a distance of eight kilometres, 50% at 19 km, and 70% at 30 km (Aggregate Advisory Panel, 2001, p. 9).

Sand for preload and fill in the eastern part of the Lower Mainland, downstream from Pattullo Bridge, generally comes from the Fraser River Port Authority. It doesn't mean that FRPA has a market monopoly in the area. Barging aggregate from the Valley or from coastal quarries could be conducted for as little as 3.8¢ per tonne-mile (2.5¢ per tonne-kilometre). This number shows how competitive the sand market is. For example, the Lehigh Cement's subsidiary Construction Aggregates Ltd. of Sechelt successfully competed with dredged sand for supply of aggregate for many construction projects in the Lower Mainland including Vancouver Airport expansion. The cost of barging sand from Sechelt, a distance of 40 miles, is $0.50 per tonne. The barged sand is sometimes bundled with other aggregate making it more difficult for FRPA to

compete. At the same time, FRPA was successful in supplying sand to project as far into the Fraser Valley as Mission Bridge.

The intensity of rivalry in the construction aggregate market is high. Transportation cost is a significant component of the overall cost. The market is divided into geographic regions based on source of material and transportation cost.

2.8.1.6 Government Influence

The government plays a significant role in the construction aggregate market. The government dredging policy is described in section 2.1. The policy has a direct impact on the sand market. For instance in 2005, the BC Ministry of Transportation (MOT) supplied fill and preload at no cost for Hwy 10, Hwy 15, and South Surrey Park & Ride projects from its sand pit in Langley. At the same time, the Government of BC charged a royalty on sand removed from the provincial section of the Fraser River. BC taxpayers might have benefited from the MOT supply of "free" sand to public works projects. However, the same taxpayers paid indirectly for dredging the Fraser River and disposing this dredged sand in the ocean. Additionally, the Federal government collect 47¢ per cubic meter of sand disposed in the ocean transferring funds from the region to Ottawa.

The three levels of government have created an unfavourable environment for the Fraser River Port Authority to operate a sustainable dredging program. FRPA may change the situation by actively lobbing the government to remove or lower the existing levies associated with river sand and to promote

use of the material on public infrastructure projects. Therefore, a key success factor is a lobbying expertise to achieve a supportive government policy.

FRPA would be better positioned to market and sell river sand if the material was recognized and pre-approved for a wide range of uses. The main agencies regulating the use of river sand in construction are the Ministry of Transportation and the Master Municipal Construction Documents Association. A key success factor is to have river sand pre-approved for construction uses in technical specifications issued by MOT and MMCD.

2.8.2 Key Success Factors and Industry Attractiveness

The key success factors for the sand market are

1. access to raw material / resource
2. low combination of material and transportation cost
3. operational efficiency
4. availability
5. pre-approved uses by MOT and MMCD
6. lobbying expertise to achieve supportive government policy

The construction aggregate market is very unattractive for the Fraser River Port Authority. First, it may appear that the permit process gives the Port Authority an advantage. This would be true if the river dredging operation was profitable. FRPA subsidizes the dredging operation and can only hope that the demand for river sand will increase with the depletion of sand and gravel deposits at existing pits and quarries. The renewable resource of river sand that is replenished every spring could be an asset; however, in unfavourable market conditions it is a curse.

Second, the Fraser River Port Authority cannot compete on price with the glacial till material excavated from construction projects throughout the Lower Mainland. River sand can successfully compete with pit and quarry material for supply of material to sites near the river where the material can be directly pumped ashore. Unfortunately, the potential for future sales decreases as these sites are developed. Undeveloped sites near the river have lately been subject to a waterfront gentrification policy driven by local governments. This policy further causes the potential sand market to shrink.

Third, the need for operational efficiency has created a monopoly for the dredging contractor. The contractor has a high bargaining power. FRPA is at a risk of a hold up, and it may find it difficult to obtain a competitive quote at the end of the existing dredging contract.

Fourth, FRPA is restricted from dredging the river from early March to August due to the salmon run and then freshet. This restricts availability of river sand.

Fifth, river sand is approved for use as general fill and preload by MOT and as of recently by MMCD. River sand reputation still suffers because prior to 2006 the MMCD technical specifications excluded river sand from uses in civil works.

Sixth, FRPA has been engaged in lobbying activities to improve the policy affecting dredging and sand sales; however, its lobbying efforts are limited by the Canada Marine Act that prohibits the organisation from making contributions to political parties or campaigns. The Port Authority can strengthen its lobbying

power by joining the Aggregate Producers Association of British Columbia and the Master Municipal Construction Documents Association. This would put the organization inside of the associations where it can monitor and influence changes to technical specifications regulating the industry. FRPA has qualified staff to engage in lobbying activities.

3 FRPA'S DREDGING CAPABILITY

3.1 Regulatory Power

The Fraser River Port Authority is well suited for dredging the Lower Fraser River at least from the functional aspect. The Port Authority manages the port that the dredging function supports. The organization is best positioned to decide what to dredge and how much. The Canada Marine Act gives the Port Authority the legal right to dredge, and to regulate other dredging activities within the Port's jurisdiction. In essence, the Fraser River Port Authority has a monopoly on dredging in the Lower Fraser River, and it also has monopoly on the river sand supply in the Lower Mainland.

3.2 Financial Resources

The Fraser River Port Authority commenced its current dredging program in 1999 with a $15 million dredging fund (InterVISTAS, 2005, p. 2). The dredging fund came from a settlement with the federal government when the Canadian Coast Guard stopped dredging the Fraser River. The settlement funded maintenance dredging until 2005 when the fund was exhausted. Currently, the Fraser River Port Authority funds the dredging program at an average annual cost of $3.5 million.

The dredging cost has a significant impact on the FRPA's bottom line. In 2006, FRPA had a net income of $1.1 million on $17.6 million operating revenue.

The dredging cost last year was $3.9 million. This represents 24% of operating expenses of $16.2 million. A year prior, FRPA reported $2 million net loss when dredging cost was $5.8 million (FRPA, 2007c). In 2007, Transport Canada committed $4 million over a two-year period for dredging of the Lower Fraser River to ensure dredging of the navigation channel and to manage the risk of flooding (TC, 2007b).

The Fraser River Port Authority is authorized under the Canada Marine Act to charge a fee for services such as dredging provided in respect of the port. The restriction being that the fee is fair and at a level that allows the Port to operate on a self sustainable financial basis (CMA, 1998, §49.1 and §49.3). FRPA does not charge a fee on vessels or cargo for the dredging service. The Port tariffs are set to position the Fraser River Port competitively within other ports on the West Coast that do not have the dredging expense.

FRPA has a legislated borrowing cap of $25 million (Canada Gazette, 1999, §9.3) that the organization is rapidly consuming to pay for the current land development. The borrowing cap and the financial position limit the organization's ability to invest in large scale projects or operations. The Port Authority is not allowed to pledge Crown properties as collateral, and the federal government is not allowed to grant moneys to port authorities with the exception of grants of general applicability (CMA, 1998, §8.(1)a, 25, and §30.(3)).

3.3 FRPA People Resources

The Fraser River Port Authority is a relatively small organization with approximately 40 staff of whom two are designated full time to administer the dredging program. These two staff members monitor the depth of the navigation channel, approaches to terminals, and berths. They define the scope of dredging, and priorities. They obtain regulatory approvals for dredging and ocean disposal. Finally, they verify the volumes dredged by the contractor and review invoices.

Between 1999 and 2007, the dredging team was successful in redesigning the navigation channel and redefining the dredging program to gain an additional 0.7 m draft and to increase the reliability of the navigation channel. An average transit window for 10.7m draft vessels was 3.8 hours prior to the channel redesign. Currently, this window is 16.6 hours, and the channel has an average 7.8 hour navigation window for 11.5 m draft vessels (FRPA, 2007b, p. 19). This was achieved by increasing the navigation channel dredging volumes by approximately 30%, from 2.0 million m^3 to 2.6 million m^3. .

FRPA has three staff dedicated to property development. From time to time FRPA utilizes some of the sand dredged from the river for its own property development. Over last three years, FRPA dredged over 1 million m^3 of sand onto its properties. The property, environment, and dredging staff commenced a study of land reclamation within the Lower Fraser River. The project is at an early concept stage.

The public relations staff of three also contributes to the dredging program. Their work centres on the public awareness of dredging and its contribution to flood protection. The staff has assisted the executive team and FRPA directors in their lobbying for funding for dredging from the Federal government.

3.4 Dredging Contract

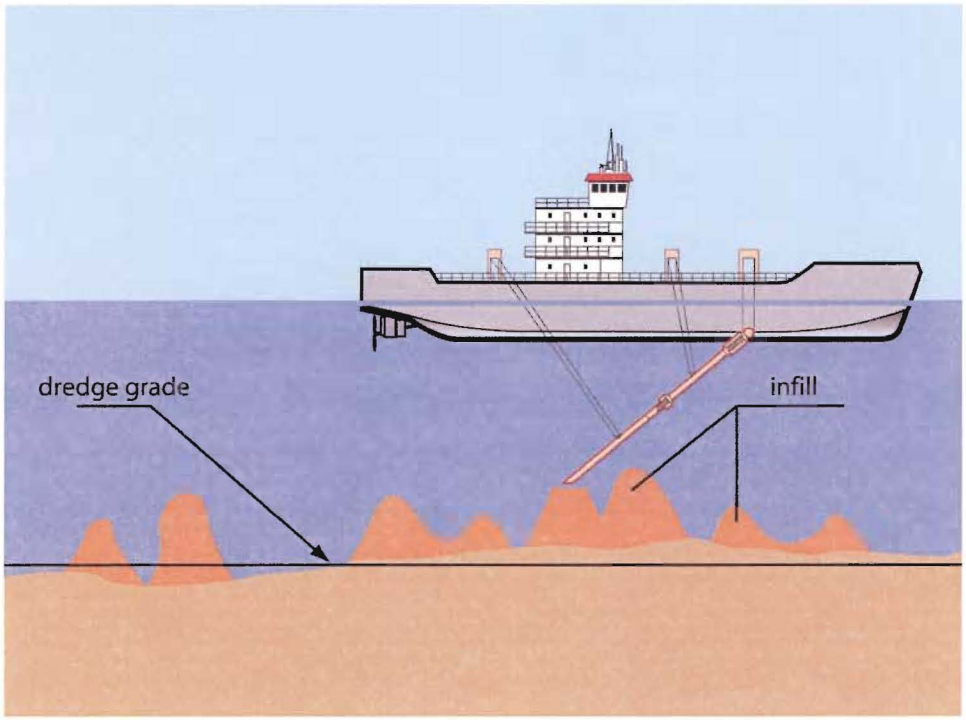
The Fraser River Port Authority has contracted out the dredging operation to Fraser River Pile and Dredge Ltd. (FRPD). The contract was awarded for a ten-year period after public tender in 1999. In 2006, the contract was extended until 2014 (FRPA, 2007c, note 11). FRPD dredges the majority of the river using a trailing-suction hopper dredge that vacuums sand off the bottom of the river and stores it in an onboard hopper – see Figure 3.1. The sand is disposed from the hopper through a gate at the bottom of the vessel. This hopper dredge can dispose the material only in the ocean or into an in-river transfer pit. FRPD uses a cutter section dredge to pump the dredged sand to an upland site – see Figure 3.2. In favourable conditions, a cutter suction dredge can dredge the sand directly from the navigation channel to an upland site. In most cases, the sand is handled twice, i.e. hopper dredge removes the sand from the navigation channel and places it into a transfer pit and then cutter suction dredge dredges it to an upland site.

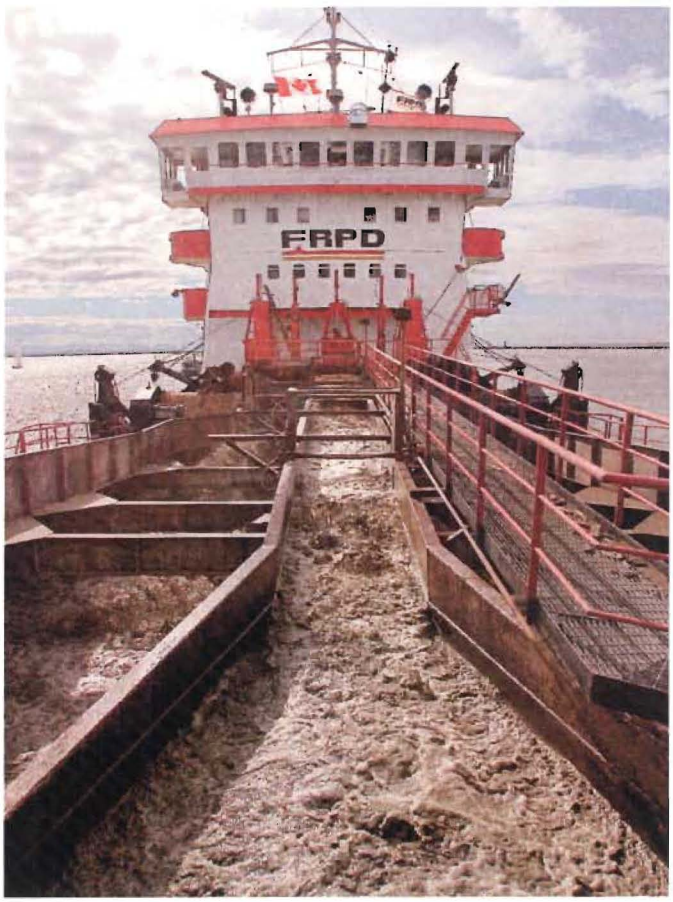
The Port Authority pays the contractor a fixed fee per cubic meter of sand removed by a hopper dredge or cutter suction dredge, and it pays a fuel surcharge cost. Dredging and ocean disposal is done by a hopper dredge and

therefore the Port pays only for this one piece of equipment. When the material is sold and placed on land, the hopper dredge moves the material to a transfer pit and the cutter suction dredge pumps the material ashore. In such cases, the Port pays two fees, one for each piece of equipment. This double handling cost is offset by sand sales credits; however, the credits are frequently not enough to recover the full cost of both machines. In favourable conditions when the disposal site is near the dredge site, the entire dredging can be done by the cutter suction dredge alone. Such operations are profitable for the Port Authority.

Fraser River Pile and Dredge sells and markets dredged sand on behalf of the Port Authority. FRPD has an incentive to sell sand rather than dispose it in the ocean. FRPD prices the sand based on the production cost and customer willingness to pay. The contract excludes the ocean disposal fee, which FRPA pays directly to Environment Canada.

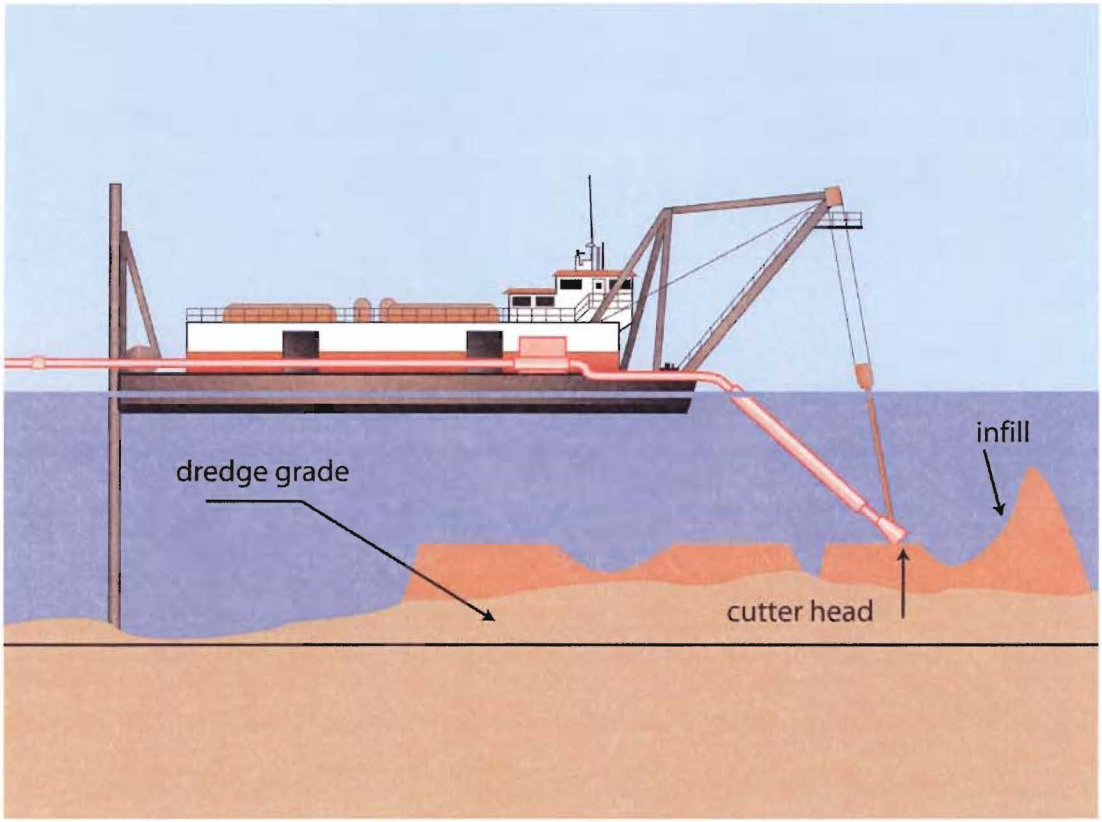
Figure 3.1 Trailing suction hopper dredge schematic and picture





Source: Fraser River Port Authority. Copyright. Used with permission.

Figure 3.2 Cutter suction dredge schematic and picture



Source: Fraser River Port Authority. Copyright. Used with permission.

4 FRPA CURRENT DREDGING STRATEGY

4.1 Corporate Strategy Overview

The Fraser River Port Authority recognizes dredging is vital to its business. The organization focuses on channel design and development in order to capitalize on business opportunities. FRPA has improved the channel draft from 10.7 m to 11.5 m and increased the duration of navigation windows on the Lower Fraser River. In 2005, FRPA engaged Hay & Company to evaluate the capital and maintenance dredging requirements for 12.5 m and 13.5 m draft channels.

FRPA's business strategy, which relies on deep navigation channel, is to capitalize on the growing container business. The Port identified 2.4 million TEU container capacity on the Fraser River at its properties in Surrey and Richmond (InterVISTAS, 2006, p. 6). Considering the draft requirements of existing and on-order container vessels, FRPA has to dredge the river to at least 12.5 m draft. Such capital dredging will require a one time removal of 4.4 million m^3 of sediment and then an annual increase of maintenance dredging of 1 million m^3 (Hay, 2005, pp. 11-12). Such capital dredging would cost $15.4 million at the current average cost of dredging. The Port Authority strategy goes beyond the 12.5 m draft navigation channel. FRPA identified 12.5m deep channel (equivalent to over 14.5m draft) as a strategic objective for the Pacific Gateway Strategy Action Plan. FRPA estimated the cost of constructing this channel at $175 million (InterVISTAS, 2006, p. 29).

Dredging is also linked to FRPA's land strategy. In 2007, FRPA announced the possibility of reclaiming land at Sapperton Sandbar. FRPA is also examining land reclamation near Tilbury Island. Land is required for the Port's growth, and it represents a key source of revenue for the Port Authority.

4.2 Advocacy for Public Funding for Dredging

The Fraser River Port Authority dredging strategy has been to obtain public funding, which will then enable the Port Authority to develop a sustainable dredging program. The Port Authority has never accepted responsibility for dredging. Between 1999 and 2007, the organization actively lobbied the Federal government to provide sustainable funding for the dredging program operated by the Port Authority. The Port Authority was lobbying for a $50 million one-time legacy fund to pay for maintenance dredging (FRPA, 2006). In 2002, FRPA made two submissions to the Canada Marine Act Review Panel recommending federal contribution to dredging for flood protection, and for access to government funding for dredging. In 2005, FRPA engaged InterVISTAS to prepare two reports supporting the efforts to secure public funding for dredging. That year, nine mayors signed a resolution supporting the Port Authority's advocacy for sustainable public dredging (FRPA, 2005 Sep.)

4.3 Commitment to Dredging

The Fraser River Port Authority has commercial commitments to the dredging contractor and to some of its tenants to continue the dredging program. FRPA guaranteed Fraser Surrey Docks to maintain a navigation channel in

support of Panamax size vessels (FRPA, 2004). The Panamax standard is identified in FRPA's Technical Specifications Handbook as 11.5 m draft.

The proposed amalgamation of the port authorities in the Lower Mainland is going to influence the dredging program. The Fraser River Port Authority believes that the new Port Authority will have sufficient financial resources to ensure continuity of the dredging program on the Fraser River. The dredging program will expand to include the North Arm of the Fraser River, which is currently under the jurisdiction of the North Fraser Port Authority. The amalgamated Port Authority may also expand the dredging program to secondary channels that used to be dredged prior to the national marine policy change in 1998.

4.4 Sand Management Strategy

The Fraser River Port Authority has outsourced not only the dredging operation but also marketing and sales of sand. Fraser River Pile and Dredge, the dredging contractor, prices the sand competitively in relationship to pit sand and substitutes. Neither FRPA nor FRPD engages in speculative stockpiling of sand. The sand is either sold or disposed in the ocean. The buyers have to be aware of the dredging season that runs from approximately August to March.

5 FINANCIAL ANALYSIS

The Fraser River Port Authority (2004b) reported $3.25 million average annual net dredging cost of the navigation channel for dredging seasons 1999/00 to 2003/04. This number is comprised of $7.10 million gross cost, $350,000 ocean disposal cost, and $4.2 million sand sales credit. Average unit rates for dredging can be calculated using the average annual volume dredged of 2.1 million m^3, and ocean disposal cost of $0.47 per m^3. Engineering cost was assumed to be negligible. The average cost of dredging was estimated at $3.44 per m^3, and the maximum average sand sale credit at $3.18 per m^3. The calculation suggests that the Port Authority subsidizes the sand sales approximately $0.26 per m^3. This means that the dredging program would operate at a $529,000 annual deficit even if all the dredged material was sold. Unit rates calculations are shown in Table 5.1.

Table 5.1 Estimate of dredging unit rates

	Cost ($)	Unit Rate ($/$m^3$)
Average annual dredging cost	7,100,000	3.44
Ocean disposal and engineering costs	350,000	0.47
Cost recovery	(4,200,000)	(3.18)
Average annual net cost	3,250,000	1.57
Cost recovery as % of average cost	59%	
Approximate subsidy		0.26
	Volumes (m^3)	
Average annual maintenance dredging volume	2,063,589	
Ocean disposed volume based on $350,000 cost	744,681	
Estimate of sand sales volumes	1,318,908	

Source: FRPA dredging brochure (FRPA, 2004b), and Hay & Co. (2005, p.11). Unit rates estimated by the author.

The average annual net dredging cost for seasons 1999/00 to 2006/07 is estimated in Table 5.2. This cost is approximately $4.1 million. The cost includes two components: the cost of dredging the navigation channel, and the cost of dredging berths and the approach to Fraser Surrey Docks. The average annual dredging cost of the navigation channel is approximately $3.5 million. The balance of the dredging cost is specific to FSD terminal and is approximately $0.5 million.

Table 5.2 Average annual dredging volumes and net costs

	Volume (m^3)	Estimated Net Cost ($)
Average annual channel dredging	2,257,000	3,543,490
Average annual dredging at FSD	342,000	536,940
Total average dredging	2,599,000	4,080,430

Source: Volume information provided by FRPA. Cost estimated by the author.

6 THE DREDGING CRISIS

Dredging of the Fraser River is a recognized necessity. Local municipalities want the dredging program to continue to manage the risk of flooding. Port users want the navigation channel at current or better conditions. Developers want continued access to river sand. Provincial and federal governments want to see the Pacific Gateway grow. It seems that everybody supports the dredging program, so what is the problem?

First, every year the Fraser River Port Authority disposes an average 841,000 m^3 of Fraser River sand in the ocean. This represents nearly one third of all ocean disposal in Canada. Any economic value of this material is lost once the material is dumped in the ocean. From an environmental point of view, the material is clean and therefore poses no risk when disposed in the ocean. However, the disposal creates no environmental benefit either. The disposal process creates a dead weight loss for the Port Authority and for Canada. Additionally, Environment Canada penalizes the Fraser River Port Authority for dredging the navigation channel by taxing the disposed material that goes beyond the environmental monitoring cost.

Second, the average annual consumption of river sand has declined from at least 2.4 million m^3 two decades ago to 1.5 million m^3 today. This decline is inconsistent with the related increase in population, development, and economic activities. Further, it is evident that river sand has lost market share to its

competitors The reason for this decline is likely related to the decrease of development near the river, customer preferences, purchasing policies for public infrastructure projects, and technical specifications for civil works.

Third, the price of river sand is inadequate to recover the cost of dredging and placement of sand on the upland. The only incentive to sell sand is to lower the overall dredging cost as ocean disposal is still a far more expensive option. BC Research (1984) and Grand Thornton (2002) found that the sand price is inelastic. River sand is priced competitively to material supplied from open pits and quarries. River sand competitors seem to push pit sand sales to effectively manage their operations and gain access to more valuable construction aggregate. FRPA does not have other construction aggregate for sale that could support lower sand price. The Port Authority seems to be in a position that the sand sales will have to continue be subsidized.

Fourth, the Canadian Government policy of a user-pay system is not implemented on the Fraser River, and it appears that the implementation of this policy would put the Fraser River Port at a disadvantage. FRPA established its tariffs competitively to other ports on the West Coast of North America that do not have a dredging expense. The user-pay policy would likely cause a shift of port activities to cheaper alternatives ultimately causing the decline of the Fraser River Port. Canadian ports on the West Coast do not currently have the capacity to absorb all deep sea cargo from the Fraser River Port. Transfer of this business to the United States would cause an economic loss to the Canadian economy.

Fifth, the cost of dredging is not equitably distributed among all beneficiaries. The dredging program benefits the flood risk management, fisheries, recreational boating, and navigation channel users who only pass through the Fraser River Port Authority jurisdiction. The benefiting parties include Fraser Wharves (a private deep-sea terminal), DFO, municipalities, and the Province of British Columbia. In effect, these parties are free riding.

Dredging poses a number of challenges for the Fraser River Port Authority that may be difficult to resolve. On the positive side, dredging provides the only means to conduct business for the Fraser River Port. This port business is currently growing at a double digit rate. The industry has the support of both the federal and provincial governments. The Asia Pacific Gateway and Corridor Initiative, and the BC Ports Strategy provide funding for major infrastructure projects in support of BC ports. The new business potentials and government support for the marine sector creates new opportunities for resolving the dredging problem on the Lower Fraser River.

7 DREDGING PROGRAM ALTERNATIVES

7.1 Continue Current Dredging Program

The Fraser River Port Authority funds the current dredging program and yet it remains profitable as an organization. The navigation channel is adequate for short to mid term port industry needs. The situation does not create a crisis that would require an immediate change. However, the dredging program is inefficient, and the distribution of costs and benefits is not equitable. In the long run, the program may not be able to deliver navigation channel improvements necessary to support future port needs. The Fraser River Port Authority has a number of alternatives and combinations of these to resolve the dredging problem.

7.2 Government Funding

The average annual funding deficit for dredging the navigation channel is $3.5 million. The Federal government committed $2 million per annum for dredging for years 2006 and 2007. The intent of this funding was flood prevention and safety of the navigation channel. The funding recognizes the contribution of dredging towards flood prevention, a service that is not a responsibility of port authorities. North West Hydraulics (2006, p. 50) estimated that the stoppage of dredging would cause the freshet floodwater elevations to rise by 0.42 m between Port Mann and Mission. Therefore, the stoppage of dredging would cause the need to raise all river dykes of the Fraser River and its

tributaries in the affected area. The cost of raising dykes would likely be in tens of millions of dollars.

FRPA's problem of funding the maintenance dredging of the navigation channel would be resolved if the Federal government recognized and provided a dredging contribution at $3.5 million per year; thus making the dredging cost neutral for the Fraser River Port Authority. This funding would require an escalation factor. A possible option would be to adjust the fund proportionally to changes in the BC or National Consumer Price Index.

7.3 No Dredging

The option not to dredge is feasible only in the long run as the Fraser River Port Authority has existing short to mid-term commercial commitments to its dredging contractor and to some of its tenants. The new port would have a natural river draft of 5.1 m (Hay, 2005, p. 7). This draft would be adequate for shipment of domestic cargo that currently represents 32 million tonnes out of 36 million tonnes total Fraser River Port throughput. Most of the domestic terminals and harbours are privately owned. These private owners dredge and maintain their harbours. This situation would continue in the future. The existing deep sea terminals would redevelop for a possibly higher and better use within the land use restrictions of the Canada Marine Act. Some of the international cargo would likely shift to the adjacent Port of Vancouver that has a natural deep harbour. The balance of the cargo would shift to US ports.

7.4 Reduce Dredging Scope

This alternative recognises the specific navigation draft threshold required to service two automobile terminals on the Fraser River: Fraser Wharves and WWL. The assumption is that the river would continue to be dredged to approximately 9.5 m to service these terminals. Fraser Surrey Docks, the third deep-sea terminal would likely redevelop and the cargo would shift to the adjacent Port of Vancouver. The alternative follows the findings of Hay and Company (2005, p. 12) that maintenance dredging of a shallower navigation channel is less than of a deeper one.

7.5 Implement a User-Pay Program

The user-pay program assumes equitable distribution of cost among river users. The users that require a navigation channel for deep-sea going vessels would pay fees proportional to the usage or benefit. The usage would be determined based on the number of vessel calls. Benefit would be determined based on cargo value.

The shippers of the domestic cargo would not be charged for dredging of the main navigation channel as the natural draft of this channel exceeds the industry needs. Domestic users would pay for secondary channels dredging if the Fraser River Port Authority expands the dredging program to include these channels. The fee would apply to all domestic cargo and it would be based on the cargo tonnage.

7.6 Increase Revenue from Sand Sales

This option assumes that sand sales can pay for the dredging program. The river sand market is estimated at 2.4 to 3.5 million m^3. This assumption goes back to market research conducted by Hay & Company in 1995 and BC Research in 1984. The lower market potential is based on the average borrow dredging below Pattullo Bridge that took place until 1997.

7.7 Use Sand for Land Reclamation

The land reclamation option creates a new market for river sand. The unsold sand would be used to create islands at approved locations within the Fraser River and Georgia Straight. These islands would be used for industrial development or for a compensation area for other industrial developments. The concept of compensation directly relates to the DFO policy of no net loss of fish productive habitat, and a practice of DFO accepting habitat compensation areas in exchange for the right to develop other land. The created compensation islands or areas would be sold to land developers at a rate that would pay for the dredging cost. The option assumes continuation of the current sand sales strategy. The land reclamation option would likely allow for an increase in sand prices that in turns would reduce or eliminate sand sales subsidies.

8 OVERARCHING DREDGING PROGRAM GOALS

The main objective of the proposed strategy is to achieve a sustainable dredging program on the Lower Fraser River in support of the economic activities and development of the Fraser River Port. The Oxford English Dictionary defines sustainable as "*Capable of being maintained at a certain rate or level*". The 1987 World Commission on Environment and Development described sustainable development as a "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The sustainable dredging program will therefore need to have economic, environmental, and social components. The following list summarizes the program goals.

- Efficient use of resources
- Equitable distribution of costs and benefits
- No negative net impact on the environment
- Acceptability to stakeholders

The resources related to the dredging program should be used efficiently. The main resource in question is the navigation channel. The dredging program creates opportunities for navigation on the Fraser River and for port development. An efficient navigation channel must be balanced with other infrastructure development such as terminals and manufacturing facilities relying on water transportation. The utilization rate of the navigation channel and terminal infrastructure defines the efficient use of these resources. The efficiency

review of the navigation channel needs to consider the current and future requirements.

The second resource to be evaluated for efficient use is dredged river sand. An efficient use of this resource means extracting the economic value from the material. Ideally, the sand extracted from the river would be valued to a point that it would cover the dredging cost. The efficiency evaluation needs to be broad enough to include the impact of river sand supply on other construction aggregates.

Equitable distribution of costs and benefits is a goal if the dredging operation cannot pay for itself through sand sales, which is the case today. Fairness requires that the users who currently benefit from the navigation channel contribute to the cost proportionally to the use and economic benefit they derive. Fairness to the Fraser River Port Authority, the port users, and Canadian taxpayers is a concern. Free riding must not be tolerated as it hurts these who pay for the dredging program, and it is against the principle of fairness.

The goal of the no negative net impact on the environment is based on the principle that the proposed dredging strategy does not have a negative impact on the environment in comparison to the current dredging program. The benchmark is the existing program and not an absolute measurement. For the dredging to have no impact at all on the environment, the Fraser River would have to be turned to its natural state. This is not feasible considering the existing inhabitation of the floodplain of the Fraser River. The impact measured needs to include both water and upland operations. An improvement or degradation of the

environment will be measured in terms of a net change to the environment in relationship to the status quo.

The dredging program on the Lower Fraser River has a large number of stakeholders as identified in chapter 2.3. The proposed dredging strategy needs to be acceptable to these stakeholders, as some of them have enough power to influence or even prevent the proposed change. Stakeholders are defined as individuals or organizations that are affected by the proposed strategy change, and/or can influence the outcome of the decision on the proposed change. The public at large needs to be considered in the proposed strategy change as well. The World Commission on Environment and Development (1987, §77) recommends that the public is consulted regarding use of public resources especially if this use affects the environment.

9 EVALUATION OF DREDGING PROGRAM ALTERNATIVES

The following analysis evaluates the proposed dredging alternatives identified in chapter 7 for satisfying the overarching dredging strategy goals identified in chapter 8. For this purpose, the paper uses the multi-goal analysis method. Impacts of the predicted outcomes for each of the seven options are described as high, medium, or low. The efficiency, equity, and no negative net impact on the environment goals utilize quantitative analyses to assist in the evaluation process. The utilization of sand is measured in cubic meters of sand disposed in the ocean, as well as, monetary value derived from sand sales. The utilization of the Port Authority's infrastructure is measured in predicted impact on cargo throughput and/or on rent. The distribution of costs and benefits analysis attempts to assign monetary value to the navigation channel users and beneficiaries. The environmental impact is evaluated in terms of the net impact on the environment as measured by the volumes of sand dumped in the ocean and the change in the area of productive fish habitat in the Fraser River estuary.

9.1 Continue Current Dredging Program

Efficient Use of Resources. The current dredging program results in an annual disposal of approximately 841,000 m^3 of dredged material in the ocean. Some of this material is silt and silty fine sand. The average annual volume of dredged material that has a market value is approximately 570,000 m^3. This

material has a value of $1.8 million based on the $3.18/m^3 average credit rate paid to the Port Authority by the dredging contractor as a share of revenue from sand sales. Likely, this sand has a higher value as the contractor does not credit the Port Authority the full sand value. The same sand could fetch $5.7 million in retail. The loss of sand value is not only to the Fraser River Port Authority but also to the BC and Canadian taxpayer. The sand disposed in the ocean is often replaced by sand mined from pits in the Lower Mainland. The dead weight loss to the taxpayers is evident on public works project where the taxpayers directly pay for the pit sand and gravel used for fill or preload, and indirectly pay for the disposal of suitable river sand in the ocean.

Table 9.1 Value of sand disposed in the ocean

Average annual volume of disposed material	m^3	841,250
Average annual volumes of silt and fine sand	m^3	270,389
Average annual volume of valuable material	m^3	570,861
Sand sales credit rate to FRPA	$/m^3$	3.18
Annual value of disposed material	$	**1,815,338**
River sand retail price 2006, FOB depot	$/m^3$	10.07
Retail value of disposed material	$	**5,748,570**

The Fraser River main navigation channel is fully utilized up to 9.5 m draft. This is the draft required for Ro-Ro and Pure Water Carrier vessels that deliver automobiles to Fraser Wharves and WWL terminals. These two terminals handle all of the Asian manufactured cars imported to Canada. The additional draft from 9.5 m to 11.5 m is required for break-bulk and container vessels calling at Fraser Surrey Docks. Within this range, there is another threshold of approximately 10.5 m for break-bulk vessels. Designated break-bulk berths 2, 3, and 4 at Fraser Surrey Docks have a depth restriction of 10.5 m. Few larger break-bulk

vessels call at FSD at the designated container berths 7, 8, and 9. However, this flexibility would not exist if the container berths were utilized for the intended container cargo. The final section of the navigation channel from 10.5 m to 11.5 m is almost exclusively utilized by container vessels.

In 2004, the Fraser River Port Authority, Fraser Surrey Docks, and IDC Distribution Services jointly committed to invest $190 million to expand the container business on the Fraser River. The team committed to increase the Port's container capacity to 415,000 TEUs by June 2005 and to open the Port to Panamax size vessels requiring a draft of 11.5 m. The second phase of improvements was to take the Port's capacity to 600,000 TEUs if the container business growth continued (FRPA, 2004). The plan initially worked and the container throughput reached 373,000 TEUs in 2005; however, a year later, the container throughput dropped to 95,000 TEUs. This drastic change was a result of a global consolidation of container shipping lines. In 2006, Hapag Lloyd acquired CP Ships, FSD's main container customer, and redeployed the CP's fleet to other geographic regions. Hapag Lloyd brought in larger vessels to the West Coast market that can no longer enter the Fraser River. The container terminal utilization rate is about 23% using the TEUs throughput as the measurement. Similarly, the navigation channel from 10.5 m to 11.5 m is utilized to only 23%.

Equitable Distribution of Costs and Benefits. The current dredging program has an average net cost of $3.5 million. The Fraser River Port Authority pays the entire net dredging cost and receives no direct benefit. The $17.6

million revenue in 2006 does not include a premium rent to cover the dredging cost. The Port Authority owns1269 acres of land, and it has invested $160 million in site improvements, marine infrastructure, and building. The net present value of this capital invested is $104 million. FRPA rents out approximately 50% of its properties. Table 9.2 shows a reasonable rent from FRPA properties based on the average industrial land value and an assumed cap rate of 8%. (The average land values are from January 1, 2004 assessment provided by the British Columbia Assessment Authority). The remaining rent can be attributed to the capital invested in property improvements. The return on the invested capital is approximately 4.9%. The rent analysis suggests that the navigation channel does not add to the property value, and that the Port users do not pay for dredging through an increased property rent.

Table 9.2 FRPA's rent analysis

Land holdings	Area (acre)	Utilization	Approx. Rented Area (acre)	Avg. 2004 Land Value ($/acre)	Expected Rent/ Acre ($/acre)	Estimated Rent ($)
Surrey	353	85%	300	218,881	17,510	5,254,020
Brownsville	28	95%	27	218,881	17,510	465,779
Annacis	145	95%	138	348,533	27,883	3,840,834
Richmond	694	20%	139	183,878	14,710	2,041,781
Delta	49	65%	32	232,157	18,573	591,536
Total land holdings	1,269	50%	635			12,193,949

Source: Land holdings and area from the FRPA Land Use Plan (FRPA, 2001, pp. 11-12). Average land value from GVRD 2006 Industrial Land Inventory, Table C1. Land utilization estimated by the author based on visual observation. Rent estimated by the author.

In 2002, InterVISTAS evaluated the federal government's tax revenue from the Fraser River Port at $126 million. The provincial government taxes were $60,000 million, and the municipal take was $3 million. It seems that the

federal and provincial governments benefit more from the Fraser River Port activities than does the Port Authority. The federal government additionally burdens the dredging operation by charging approximately $350,000 per year for ocean disposal of the dredged material. The Provincial government claimed approximately $1.2 million in royalties for sand removed from the provincial river bottom.

The Canadian taxpayer suffers a loss under the current state of affairs. As mentioned previously, $2.4 million worth of sand is dumped in the ocean, when other sand is mined from pits and quarries for public infrastructure projects. The taxpayer also suffers because it cannot benefit from the likely port development if the dredging money was otherwise available to the Port Authority.

No negative net impact on the environment. The environmental impact of the current management of dredging will become a benchmark for evaluating other alternatives. The key environmental measurables are 2.1 million m^3 of sediment removed from the river bottom; 570,000 m^3 of sand disposed in the ocean; and 570,000 m^3 of pit material substituting the use of river sand on the upland. Environment Canada approves the ocean disposal of dredged material because it views it as the best viable alternative assuming that no beneficial uses exist for all material dredged from the Fraser River. 12 million m^3 of material have been disposed at the Sand Heads ocean disposal site since the site opening in 1974. Most of the material was river sand (EC, 2007).

Acceptability to Stakeholders. The current dredging program is acceptable to stakeholders that have the decision making power. The Fraser

River Port Authority is not satisfied with the existing situation but does not have enough influence to change the status quo. Municipalities would like to see the dredging program expand to include secondary channels leading to commercial and recreational facilities. Municipalities are also concerned about FRPA reducing or terminating the dredging program as this would put an additional pressure on the local governments to upgrade river dykes for flood risk management. The public has little knowledge of the dredging program on the Lower Fraser River. It can be assumed that public finds the status quo acceptable.

9.2 Government Funding

The government funding option does not change the way the resources are used, and how the process affects the environment. The option redistributes the dredging costs and benefits. The government funding of the net dredging cost would make the dredging program cost neutral for the Fraser River Port Authority. This seems to be fair as the Port Authority does not benefit from the navigation channel and from dredging, whereas the national and provincial economies do. The option would better position the Fraser River Port Authority to compete with other ports on the West Coast.

In comparison, the US ports located on the Columbia River enjoy substantial financial contributions towards dredging from several sources including the federal government and the state governments of Washington and Oregon. The US Army Corps of Engineers dredge the Columbia River to 12.2 m depth and have plans to deepen the channel to 13.1 m to bring in larger "post-

Panamax" vessels. The cost of deepening the Columbia River channel is estimated at US$150.5 million (InterVISTAS, 2005b, p. 3). It is clear that the Canadian user-pay system places the Canadian ports at a disadvantage.

Stakeholders are likely to support the public funding for dredging option, as it would shift the financial commitment from an organization with limited resources to government. The Fraser River Port Authority will certainly welcome the change. The government funding option is consistent with FRPA's sustainable funding for dredging strategy. In the spring of 2007, Transport Canada recognized that the dredging situation on the Fraser River required government intervention and contributed $4 million to the program over the next two years. Transport Canada stated that the funding was provided to ensure the navigation channel is dredged and to manage the risk of flooding in the area. Taxpayers are likely to support the proposed change as they already consider the Port Authority an extension of the government.

9.3 No Dredging

Efficient Use of Resources. The no dredging option is a drastic shift in the way the river is managed, and it would have a major impact on the resource utilization. The Fraser River Port Authority would save $3.5 million on dredging. Land developers and public works project would pay a premium for pit sand or recycled blend in areas traditionally relying on river sand for fill and preload. The premium for recycled blend aggregate is approximately $4 per m^3. The premium for trucking pit material an extra 30 km from Coquitlam and the Fraser Valley to geographic areas traditionally supplied with river sand would also be near $4 per

m^3. The average annual industry loss would be $5.8 million based on average sand sales of 1.45 million m^3 per year. The construction industry would be better off to pay a premium for river sand up to $4 per m^3 to ensure continuity of the dredging program. This means that FRPD could raise the river sand prices approximately $2 per m^3 and still leave room for resellers to mark up the material price.

Hay and Company (2005, pp. 7-8) evaluated the impact of not dredging on the main navigation channel. It found that the navigation draft would be reduced to 10.0 m after one year, 9.2 m after 3 years, and 5.1 m after approximately 25 years when the river draft would reach the equilibrium. The implication of not dredging would be drastic on the deep sea going vessels; however, it would have no impact on coastal traffic. Fraser Surrey Docks would likely close within one year. The two auto terminals would close two years later. The domestic traffic would continue, as its draft requirement is less than 4.5 m. The channel utilization would drop by 12.5% when measured by cargo tonnage. In 2006, the Fraser River Port handled 4 million tonnes of international cargo and 32 million tonnes of domestic cargo.

InterVISTAS (2005, pp. 7-18) estimated the economic impact of the loss of automotive import business at 1526 FTEs, $106 million GDP, and $248 million economic output. The auto import business would likely be lost to US ports as there are no suitable facilities on the West Coast of Canada to accommodate this cargo. The economic impact of container and break-bulk business loss at Fraser Surrey Docks was estimated at 3194 FTEs, $222 million GDP, and $520

economic output. It is likely that the majority of the container and break-bulk cargo would be absorbed by other Canadian ports on the West Coast and therefore cause no impact on the national economy. The total direct and indirect exposure to the national economy is between 1526 and 4720 FTEs, $106 million and $238 million GDP, and $148 and $768 economic output.

The Fraser River Port Authority would initially suffer from the loss of the international cargo. However, the closure of the deep sea terminals may create major opportunities for the Port Authority to redevelop its land for higher and better uses within the restrictions of the Canada Marine Act. The rent the Port Authority charges terminal operators is on average less than rent on other industrial land in the Lower Mainland. The current rent from land and capital improvement was discussed in chapter 9.1. This lower rent at the Fraser River Port is similar to the Port of Vancouver lease rates. In 2007, the Property Assessment Appeal Board sided with Western Stevedoring's appeal of the assessed land value, and determined that the port land value should be based on the rent that the terminal operators pay. The reassessed value of Lynterm Terminal operated by Western Stevedoring was $25 million (Vancouver Sun, 2007, p. C3). Based on the above, the per acre land value of this 138-acre terminal is calculated at $181,159. This is way below other industrial land value in the area assessed at an average $714,410 per acre (GVRD, 2005, Table C 1). This confirms that from the financial point of view, the Fraser River Port Authority would be better off redeveloping its deep-sea terminals for other industrial uses, like warehousing.

Equitable Distribution of Costs and Benefits. This option proposes no dredging cost, so there is no issue of equitable distribution of costs. The option affects the distribution of benefits. The Fraser River Port Authority will suffer a short term setback from the loss of international cargo, but may benefit in the long run from property redevelopment. Municipalities will benefit from the higher property taxes because of the land use change. The federal and provincial governments will lose benefits derived from the two auto terminals and possibly some benefits from container and break-bulk business handled on the river. The change in redistribution of benefits proves that the main beneficiary of the dredging program is the national economy and not the Port Authority. Therefore, it would be fair for the Government of Canada to pay for the dredging cost.

The deep-sea terminals and shippers of international cargo would lose the benefit of having a free navigation channel. The auto terminals would likely relocate to U.S. ports. Cars shippers would have to pay the U.S. Harbour Maintenance Tax. Containers and break-bulk shippers would likely continue enjoying similar service and fees at other Canadian ports. The no dredging option would have no impact on the domestic cargo handlers. The taxpayers would suffer because of loss of jobs and likely loss of the auto business to the United States.

No negative net impact on the environment. The no dredging option would result in a new natural state of the Fraser River. This new state would be ideal for the marine environment. The air quality within the river basin would improve, as there would not be any emission from deep sea going vessels.

However, overall emission would increase due to a shift in cargo movement to ground modes of transportation. The economic and environmental costs of water based transportation is estimated to be about $1/10^{th}$ that of trucking and $1/5^{th}$ that of rail (InterVISTAS, 2002b, p. 18). On the upland, there would be some changes. Likely, some dykes would have to be raised to compensate for the changes to river hydraulics. Also, more material would have to be extracted from pits and quarries to compensate for the loss of river sand.

Acceptability to Stakeholders. It is certain that the option would not have support of the two senior governments, the river users, and the public. The federal and provincial governments would be unlikely to allow the loss of employment and economic output. The municipal governments will enjoy new taxes, but will be concerned about the flood risk management. The deep-sea channel users would likely ask the federal government to intervene as to continue enjoying current benefits of dredging. Taxpayers would likely oppose the change because of an the impact on their standard of living as defined by employment opportunities and protection from flooding. The option may appear feasible to the Fraser River Port Authority from the economic and environmental perspectives; however, it would likely cause a government intervention because of the negative impact on the national economy.

9.4 Reduce Dredging Scope

Efficient Use of Resources. This option suggests reducing the dredging scope to 9.5 m draft to support a reduced deep-sea navigation channel. Table 9.3 provides the rationale for selecting this draft restriction. The Fraser River

Port is predominately a domestic port with a niche import automobiles market. Two auto terminals are located in the Fraser River Port. Car manufacturers prefer fresh water ports for handling their cargo to reduce cars exposure to salty environment. Ship lines move automobiles using Pure Car Carrier and Ro-Ro vessels. Both vessel types have shallow draft requirements in this application. In 2004, the maximum recorded draft for these types of vessels was 9.5 m. The average draft and the industry trend is approximately 8.2 m.

Table 9.3 Vessel draft by cargo, 2004

	Maximum (m)	Average (m)
Containers	11.6	10.6
Pulp	11.4	9.3
Steel	11.4	8.7
Logs	11.5	8.0
Automobiles	9.5	8.2

Source: InterVISTAS (2005), Dredging the Lower Fraser River, Economic Analysis Table 4-1. Logs stats added by the author.

Fraser Surrey Dock is a general cargo terminal that handles other international cargo in the Fraser River Port. This cargo can be grouped into the following categories: containers, steel, pulp, lumber, and logs. The BC Government projected an annual growth rate of 6% to 8% in the container business over the next two decades. The business is trying to capitalize on the economies of scale. Current vessel size in the Vancouver area is 3,300 to 6,000 TEUs. New ships on order are typically 8,000 TEUs, and the potential is for 17,000 TEUs vessels (BC MOT, 2005, p. 26). Fraser Surrey Docks can handle only 11.5 m draft vessels that have a capacity of approximately 4,500 TEUs.

The BC Ministry of Transportation (2005, p. 8) projects no change in the break-bulk business over the next two decades. MOT estimated the existing and future demand at 4.9 million tonnes. The existing capacity in BC is 8.0 million tonnes: 3.0 million tonnes at the Fraser River Port, 4.0 million tonnes at the Port of Vancouver, and 1.0 million tonnes at the Port of Prince Rupert. The break-bulk business at Fraser Surrey Docks is stable with a downward trend. Five year cargo statistics for the Fraser River Port are included in Appendix 1. It appears that the Fraser River Port Authority will face many challenges to improve utilization of its Fraser Surrey Docks terminal and the related navigation channel draft.

Table 9.4 Dredging for Fraser Surrey Docks in relation to total dredging

	Total Dredging Volumes	FSD Dredging Volumes	Dredging Volumes Excluding FSD	FSD / Total
Year\Units	'000 m^3	'000 m^3	'000 m^3	%
1999/00	2,717	741	1,976	27
2000/01	1,815	380	1,435	21
2001/02	1,816	283	1,533	16
2002/03	2,873	393	2,480	14
2003/04	2,822	407	2,415	14
2004/05	2,506	176	2,330	7
2005/06	3,104	140	2,964	5
2006/07	3,137	218	2,919	7
Average	2,599	342	2,257	14
Minimum	1,815	140	1,435	5
Maximum	3,137	741	2,964	27
Note: 2003-07 volumes include channel deepening, approx. 4 million m^3				

Source: Data provided by the Fraser River Port Authority

The average annual dredging at berths and approaches to Fraser Surrey Docks is 342,000 m^3 representing 14% of the total average dredging volume (see Table 9.4). The material dredged at FSD is frequently disposed in the river

because it is of poor quality or because dredging is done in unfavourable river flow conditions for upland disposal. It is likely that some of this material settles to the river bottom and it has to be dredged again. The impact of FSD dredging on the overall dredging cost is approximately $1.2 million based on the $3.44/$m^3$ average dredging cost.

Reducing the navigation channel draft would lower the average annual dredging volume in the navigation channel. Hay & Company (2005, pp. 11, 12) estimated that annual maintenance of the 11.5 m draft channel requires dredging of approximately 2.1 million m^3. Hay & Co. also modelled a 12.5 m and 13.5 m draft channels. Annual maintenance dredging requirements for these options were 3.0 million m^3 and 4.1 million m^3 suggesting that maintenance dredging volume increases by approximately 1.0 million m^3 for each additional meter of lowered grade depth. It is unlikely that the formula works in reverse as the 9.5 m draft channel would reduce maintenance dredging requirements by 2.0 million m^3, i.e. to 0.1 million m^3. Hay & Co. did not model the 9.5 m channel, so there is not a reasonably certain maintenance dredging estimate for such a channel. However, Hay & Co. (2005b, p. 7) modelled the river infill if the dredging stopped. It found that river would reach equilibrium at 5.1 m draft. The linear interpolation of the results suggests that the likely maintenance dredging for the 9.5 m draft channel would be 1.4 million m^3. This volume is less than the average annual sand sales of 1.5 million m^3.

The maintenance of the 9.5 m draft channel could be self funded through sand sales. The price of sand would have to be adjusted to eliminate the current

subsidy. The reduced supply, marginally below demand, would allow FRPD to raise the price. It is uncertain if an adequate profit could be generated to cover the need to dispose approximately 270,000 m^3 of low quality material not suitable for sale. In the worst case, dredging and disposal of this material should not exceed $960,000 based on the average unit cost of dredging.

Equitable Distribution of Costs and Benefits. This option represents an improvement over the status quo. The dredging cost would be reduced to less than $1 million or possibly be eliminated. The reduction in cost would improve the perception of fairness, but would not eliminate inequity. FRPA's financial situation would improve to a point that the dredging would become a non-issue. The two auto terminals would continue to benefit from the dredging; whereas, the domestic cargo shippers would continue paying for dredging of their own harbours. Dredging for Fraser Surrey Docks, which represents the greatest inequity among river users, would be eliminated. FSD is the only terminal that the Port Authority dredges without adequate or any compensation.

In this option, the dredged river sand would be utilized 100% and only poor quality material would be disposed in the ocean. The reduced supply of sand to the construction market would likely eliminate the existing river sand subsidy. The option would completely eliminate waste. The option would likely result in a redistribution of the containerized and break-bulk cargo to other BC ports resulting in no impact on the national economy.

No negative net impact on the environment. The option reduces river sand supply to the construction market by approximately 7%. This material

would likely be substituted with recycled excavation material, pit sand, and fines from quarries. The net impact on the environment will be minimal. The impact would be positive if the substitutes were recycled materials, and negative if the materials came from pits or quarries.

The option has a positive impact on the river environment. The scope of dredging would be reduced to the level necessary to support economic activities dependant on the river environment. The area around Fraser Surrey Docks would be returned to its natural state. The extent of ocean dumping would be reduced from 841,000 m^3 to 270,000 m^3, or in other words by 68%.

Acceptability to Stakeholders. It is certain that Fraser Surrey Docks will oppose the proposed change. The change could not be implemented until the existing agreement with FSD expires, or until FSD willingly relocates to another facility. Auto terminals would likely oppose the change, as it would create an inconvenience for the few vessels with draft near 9.5 m. These vessels would have to time their sailing with high tides that occur twice a day. Other users would not be impacted by the change; therefore, they would likely stay neutral.

The federal and provincial governments would likely oppose the change as it may negatively influence the Pacific Gateway Initiative and BC Ports Strategy. The issue would likely be about perception and policy rather than economic impact. The taxpayers would benefit from this change, so they should not oppose it. The change eliminates waste and creates an improvement to the river environment.

9.5 Implement a User-Pay Program

The user-pay program has no impact on the efficiency and environment goals. Obtaining additional rent from the deep sea terminals to pay for dredging is considered a redistribution of costs and not a change in efficiency.

Equitable Distribution of Costs. A user-pay program is the goal of the Canada national marine policy. Transport Canada, the administrator of this policy, implemented the policy in 1999 when it authorized the Canadian Port Authorities to dredge and to recover the cost of this service through user fees. The Fraser River Port Authority needs to evaluate the component of the overall dredging cost that the users should pay. The total dredging cost includes maintenance dredging of the deep sea navigation channel, maintenance dredging of selected secondary channels, maintenance dredging of berths and the approach to Fraser Surrey Docks, and capital dredging. FRPA has a policy to not dredge secondary channels unless the cost is recoverable through sand sales, so this component is a non-issue for the user-pay system. The cost of dredging berths and the approach to Fraser Surrey Docks should be a direct cost to the terminal and should not be redistributed among other users. The widening of the navigation channel benefits all deep sea channel users, so this cost can be assigned proportionally to use. The channel deepening project mostly benefits FSD. Auto terminals benefit to some extent through an increased accessibility during low tide periods. This option assumes that the capital cost will be shared among all deep sea channel users.

The estimated average cost of maintaining and improving the navigation channel is $3.5 million per year – see Table 9.5. The cost of dredging berths and the approach to FSD is estimated two ways: using the net dredging unit rate and gross unit rate. Most of the material from FSD dredging is dumped in the river; however, occasionally the material is sold. Such a sale usually limits FRPA's ability to sell material from the navigation channel. Therefore, the cost to the Port Authority of dredging at FSD is based on the gross rate of $3.44 per m^3. If FSD dredged its berths and approach and sold some of the sand, then its cost would be a blend of the two costs. Table 9.6 shows the dredging cost allocation to the three deep-sea terminals based on the percent vessel transit.

Table 9.5 Breakdown of dredging costs

Dredging Program	Average Annual Volume (m^3)	Unit Rate ($/$m^3$)	Estimated Cost ($)
Navigation Channel	2,257,000	1.57	3,543,490
Berth and Approach, Net Option	342,000	1.57	536,940
Berth and Approach, Gross Option	342,000	3.44	1,176,480

Table 9.6 Allocation of dredging cost by percentage of vessel transit

Terminal	% Vessel Transit	Cost Allocation ($)		
		Shipping Channel	Berth & Approach	Total Cost
WWL Auto Terminal	23%	815,003	0	815,003
FW Auto Terminal	15%	531,524	0	531,524
FSD - Net Option	62%	2,196,964	536,940	2,733,904
FSD - Gross Option	62%	2,196,964	1,176,480	3,373,444

The Fraser River Port Authority charges harbour dues, berthage, and wharfage for use of its harbour, properties, and assets. The purpose of the harbour dues is to recover the cost of maintenance and administration of the navigation channel. The fee is levied against the users, i.e. vessels and their

owners. Berthage is a charge for use of the Port Authority's berths. It can be described as a short term property rent. Berthage is charged against vessels occupying the Port Authority's berths. Wharfage is a charge against cargo passing over the Port Authority's infrastructure. The purpose of wharfage is to recover the cost of construction and maintenance of wharves, which varies with the type of cargo handled.

Sections 49 and 50 of the Canada Marine Act authorize port authorities to fix fees in respect of ships, cargo, and service provided. The fees shall be at a level to permit port authorities to operate on a self-sustaining financial basis. The fees cannot unjustly discriminate among users or classes of users. However, the fees may differentiate among users or classes of users on the basis of volume, or value of goods shipped, or any other commercially accepted basis.

The Port Authority has no means of charging berthage and wharfage at privately owned terminals such as Fraser Wharves. The vessels calling at private terminals pay only harbour dues. The Fraser River Port Authority does not include the dredging cost in its harbour dues in order to keep the fee comparable to the harbour dues charged at the Port of Vancouver. Another reason for not charging for dredging is historical practices at the Port. Until 1999, the Government of Canada dredged the Fraser River at no cost to the Port.

This option suggests that the Port Authority raise fees charged for the channel use in order to capture additional rent to pay for dredging. This additional fee would apply equally to both the Port Authority and private terminals. The Port would have the flexibility to adjust wharfage and berthage,

which applies only to FRPA facilities, to keep its terminals competitive. Further, the option suggests that the channel usage fee is changed from the harbour dues to a cargo due, i.e. a levy against cargo and not a vessel. The proposed fee is commercially acceptable as a cargo type fee for the use of the navigation channel is currently charged by the North Fraser Port Authority

The proposed cargo due can be applied to deep sea going vessels only by specifying the minimum gross registered tonnage of vessels to which the fee would apply. Alternatively, the fee can be applied to all cargo. In the latter case, the fee would be distributed over 36 million tonnes of cargo verses 4 million tonnes of international cargo. The cargo fee on all cargo shipped through the Fraser River Port would be $0.10 per tonne. However, the domestic cargo shippers do not benefit from the dredging of the main navigation channel. The proposed expansion of the dredging program to secondary channels for the benefit of the domestic shippers would cost the Port Authority approximately $1.5 million per year. The cargo fee to recover this cost from the domestic cargo would be $0.05 per tonne.

The following is an estimate of the proposed cargo dues for the key types of international cargo handled at the Fraser River Port. The two auto terminals share of the dredging cost is $1,346,527 as per calculations in Table 9.6. The cargo due per automobile to recover the dredging cost would be $2.90 based on 2006 throughput of 465,092 cars (See Table 9.7). The Port Authority could recover the entire cost of dredging the navigation channel by charging $7.62 per car. In 2007, the Port Authority implemented a $4 per car wharfage fee at WWL

terminal without providing a new wharf or service. A $4 cargo due instead of wharfage would bring additional revenue from the private Fraser Wharves terminal, and it would level the playing field in the auto business in the Fraser River Port.

Table 9.7 Estimate of cargo due on automobiles to recover dredging cost

Allocation of dredging cost to WWL and FW – see Table 9.6	$ 1,346,526
Allocation of dredging cost to navigation channel – see Table 9.5	$ 3,543,490
Cars throughput 2006	465,092
Cargo due per car for WWL and FW share of dredging	$ 2.90
Cargo due per car for total channel dredging cost	$ 7.62

Containers represent approximately 50% of the Fraser Surrey Docks business when measured by dedication of the berth space. The net channel dredging cost allocated to FSD is $2.7 million. The cargo dues on containers would be $2.65 per TEU if the terminal reached its design capacity (see Table 9.8). The cargo due would have to be $11.61 per TEU if the container throughput continued at the 2006 level. Alternatively, a larger portion of the dredging cost could be allocated to break-bulk cargo. Currently, FRPA charges a wharfage fee of $10 per export TEU and $13 per import TEU. These fees have an escalation factor of $1 per TEU over the next three year period. The Port Authority is able to implement a cargo fee per container and reduce wharfage fees at its facilities without impacting competitiveness of its terminals. The cost of dredging berths and the approach at Fraser Surrey Docks is specific to this facility and therefore should not be allocated to overall cargo shipped through the port.

Table 9.8 Estimate of cargo due on containers to recover FSD dredging cost assuming 50/50 cost sharing between containers and break-bulk cargo

Containers = 50% of FSD Channel Net Cost Allocation – see Table 9.6	$ 1,098,482
FSD container throughput capacity (TEU)	415,000
2006 container throughput at FSD (TEU)	94,651
Dredging cost per TEU Capacity	$ 2.65
Dredging cost per TEU 2006 throughput	$ 11.61

The proposed cargo due on break-bulk is calculated in Table 9.9. The Port Authority would have to charge $0.24 per MFBM of dimensional lumber and $0.48 per tonne of other cargo to recover the break-bulk share of the net cost of dredging the navigation channel. FRPA currently charges wharfage fees of $1.10 per tonne of steel and $1.25 per MFBM of lumber. Similarly to the containers case, the Port Authority is able to implement a cargo fee on break-bulk and reduce wharfage fees at its facilities without impacting the competitiveness of its terminals. This move would allow the Port Authority to capture additional rent on cargo shipped through private terminals.

Table 9.9 Estimate of cargo due on break-bulk to recover FSD dredging cost assuming 50/50 cost sharing between containers and break-bulk cargo

Break-bulk =50% FSD Channel Cost Allocation – see Table 9.6	$ 1,098,482
2006 approx. break-bulk tonnage at FSD	2,300,000
Dredging cost per tonne	$ 0.48
Converted dredging cost per MFBM	$ 0.24

Acceptability to Stakeholders. Any user-pay program is difficult to implement because of the localized application of the tariff. Customers are likely to compare such a fee to an adjacent port and dispute it or just move their business. The Port Authority will also have difficulty implementing the program because of the business proximity to the clients. A tax like fee is more feasible to

implement at a national or provincial level. A parking tax proposed by Translink is an example of a local tax that failed, though there was a clear local benefit to result from the program. On the other hand, the unfavourable GST is paid without a dispute. A countrywide harbour fee like the US Harbour Maintenance Tax would be easier to implement than a local user-pay fee.

The proposed amalgamation of the three Lower Mainland port authorities would allow the new entity to apply a small fee to all cargo to recover the dredging cost. The fee could be specifically for the dredging operation, or the overall fees could be raised to cover the cost of dredging. Such a change would be supported by the senior government as it is in line with the national marine policy. The users will likely not object to the adjustment in fees because the change will be minimal.

9.6 Increase Revenue from Sand Sales

Efficient Use of Resources. The option assumes that the Port Authority and its contractor, Fraser River Pile and Dredge, can sell all of the dredged sand including additional sand that may be dredged from secondary channels. Sections 2.7and 2.8 describe the Lower Mainland sand market and sand sales. This option would utilize all of the dredged material with the exception of approximately 270,000 m^3 of silt and silty fine sand. The disposal of the poor quality material would still cost FRPA an average $930,000 per year. The Fraser River Port Authority would also pay approximately $600,000 in subsidies on the 2.3 million m^3 sand sales if the current average subsidy of $0.26 continues.

FRPD will likely have to lower the river sand price in order to increase sales, as price is the key success factor in the sand and gravel market. The subsidy would have to increase to \$0.76 per m^3 to lower the \$10.07 per m^3 retail price by 5%. The total annual subsidy would likely then be in the range of \$1.8 million assuming all of the good quality material is sold. Total cost of this program would be in the range of \$2.7 million. The program creates an opportunity to lower the total dredging cost by 34%. Table 9.10 shows the cost estimate of this option. Of course, there is a risk of the pit and quarry operators to retaliate and lower their cost of sand and gravel. This would negate FRPA's attempt to gain a market share, and it would increase the net dredging cost. FRPA's exposure is approximately \$770,000. If FRPA had an objective of increasing the sand sales within the existing dredging program budget, then it could subsidize sand sales by an average of \$1.35 per m^3 (\$1.09 price reduction) assuming that such a subsidy would guarantee 100% sand sales.

Table 9.10 Cost estimate of the increased sand sales option

	Unit	5% Retail Price Reduction	Max Subsidy, Current Budget
Average dredging volumes 1999-07	m^3	2,598,750	2,598,750
Average silt and silty fine sand	m^3	270,389	270,389
Proposed sand sales 100% of valuable material	m^3	2,328,361	2,328,361
Current average annual dredging cost	\$	4,080,038	4,080,038
Current average sand sale subsidy rate	**\$/m^3**	**0.26**	**0.26**
Proposed subsidy rate	**\$/m^3**	**0.76**	**1.35**
Max cost of the proposed subsidy	\$	1,769,554	3,149,900
Disposal cost of silt and silty fine sand	\$	930,138	930,138
Likely total cost of this option	\$	2,699,692	4,080,038
Likely savings	**\$**	**1,380,346**	**0**
Savings as % of total	%	34%	0%
Current average sand sales	m^3	1,542,930	1,542,930
Cost of increased subsidy on current sales	\$	771,465	1,686,176

The increased sand sales would require land for storing the additional volumes of sand. Sand depots may not be the highest and best use for industrial land, which currently reach prices over $1 million per acre as shown in Table 9.11. Sand depots are usually located on a low value land valued at about one third of the recent land transaction costs. A reasonable assumption for a sand depot property value would be $422,000 per acre, which is the GVRD medial land value from year 2004. A landowner would expect approximately $33,760 per acre rent for such a property. Table 9.12 calculates the required mark-up on sand sales to cover the land cost. This mark-up is approximately $1.53 per m^3, or 15% of sand retail price. The mark-up on sand to cover rent per $100,000 of property value is approximately $0.37 per m^3. Pit and quarry sand has an advantage over river sand, as it is available in retail at some pits and quarries eliminating the need for sand depots in urban locations.

Table 9.11 Recent land transactions (Fall 2006)

Parcel	Area (acres)	Price	Price/ Acre
10651 No. 6 Road, Richmond	13.5	$ 20,000,000	$ 1,481,481
8700-8790 Boundry Road, Burnaby	4	$ 7,800,000	$ 1,950,000
2633 Simpson Road, Richmond	6	$ 7,950,000	$ 1,325,000
Lougheed at Wren Street, Mission	33	$ 7,750,000	$ 234,848

Source: Avison Young (2006, Fall). Greater Vancouver Industrial Land Overview

Table 9.12 Impact of land value on the price of sand

Timberland depot size	acre	12	Mark-up on sand to cover rent per $100,000 of property value
Sand storage capacity @ Timberland	m^3/acre	16,667	
Annual turnover per acre	m^3/acre	21,997	
GVRD Median Land Value 2004	$/acre	422,000	100,000
Expected lease per acre	$	33,760	8,000
Mark-up on sand to cover rent	**$/$m^3$**	**1.53**	**0.36**
Retail sand price	$/$m^3$	10.07	10.07
Mark-up as % of retail price	%	15%	4%

Source of GVRD Medial Land Value: GVRD (2005) Industrial Land Inventory, Table C1

Should property rent become an issue for selling river sand in retail, the Port Authority should set aside some of its own land for sand depots. Industrial Crown land at the port is valued lower than the adjacent fee simple land. The value of sand sales for the port is approximately $2.13 per m^3 of total dredging volumes (the difference between the gross and net rate, and the ocean disposal fee). The $2.13 rate would pay for $47,000 per acre in property rent (or $587,000 purchase price) based on 22,000 m^3 per acre annual sand turnover. This suggests that FRPA is better off to provide land for sand depots than to dispose sand in the ocean. This is the worst case scenario as the property rent is still affordable for sand retailers as estimated in Table 9.12.

The increased sand sales option provides a nominal benefit to the Port Authority. FRPA can improve sand utilization; however, this would likely come at an increased subsidy rate of the price of sand or indirectly through land dedication for sand depots. The real benefit can be achieved by increasing availability of sand and keeping the current pricing structure constant. FRPA could achieve this by opening additional sand depots on undeveloped properties in Delta, Pitt Meadows, Maple Ridge, and Burnaby. This potential was discussed in sections 2.7 and 2.8.

Equitable Distribution of Costs and Benefits. The option does not achieve the goal of cost neutrality. The Fraser River Port Authority would continue to bear the cost, though reduced, of the dredging program. The minimum cost would be approximately $1.53 million based on the current price

structure and 100% sand sales. However, the net cost may increase if the Port has to increase the subsidy level, or the competitors retaliate.

The option has no impact on the navigation channel user or the government. However, it may negatively affect pit and quarry operators because of the proposed increased sand price subsidy. These parties may appeal to the government to end the perceived unfair business behaviour.

No negative net impact on the environment. The option increases sand utilization and therefore has a positive impact on both land and in the water. The maximized use of river sand in construction would reduce the use of non renewable resources from pits and quarries. The continuation of the dredging program would provide a continued contribution towards the flood risk management. The Sand Heads disposal site would benefit from the reduced volume of ocean dumped material.

Acceptability to Stakeholders. The option has no impact on the navigation channel stakeholders, so they are likely to support it. As mentioned above, pit and quarry operators would likely oppose the change because it directly affects the profitability of their operations. They may even challenge the proposed river sand subsidies in court. The public would likely support the option as it reduces waste and likely has a positive impact on the regional economy.

9.7 Use Sand for Land Reclamation

Efficient Use of Resources. This option utilizes all of the material dredged from the river including otherwise undesirable silt. The material would

be used for reclaiming land from the Fraser River and Georgia Straight. This land would be used for a mixture of industrial uses and environmental compensation. Figure 9.1 shows an example of a compensation area composing of riparian woodland, intertidal marsh, and intertidal mud. DFO allowed the Port Authority to develop and bank this compensation area in the late 1970's. Such a compensation area currently sells for approximately $90 per m^2, or $364,000 per acre.

Figure 9.1 Example of habitat compensation area. Timberland Basin, Surrey, BC.

Source: Fraser River Port Authority. Copyright. Used with permission.

Table 9.13 shows an order of magnitude estimate for an 82-acre land reclamation project in the Fraser River for environmental compensation purposes. This project is illustrated in Figure 9.2. The cost of dredging onto the

site was conservatively assumed at $5 per m^3, a value 1.5 times the average gross dredging cost. The sand would be placed onto the site using a cutter suction dredge. Some material would be dredged directly from Gravesend Reach and Purfleet Point, and most material would be transferred by a hopper dredge from Steveston and Sand Heads Reaches. The island's shorelines would be protected from erosion by 1.0 m thick layer of filter stone and 1.7 m thick layer of rip-rap. The embankment was assumed at a 2:1 slope. The growing medium was included in the fill volume. It would likely include silt, silty fine sand, and organics from dredging secondary channels and lower reaches of the river. The average cost per acre of this development would be $268,000, which is 27% less than the $364,000 previous sale price for similar land. It would take just over two years to develop this project utilizing material otherwise dumped in the ocean.

Table 9.13 Order of magnitude estimate of land reclamation in the Fraser River for environmental compensation use. Tilbury Area. Average depth 2.5 m CHS

82-acre Compensation Area	Area (m^2)	Volume (m^3)	Unit Rate	Cost ($)
Riparian woodlands - dredged fill	160,000	1,040,000	5	5,200,000
Tree planting	160,000		40	6,400,000
Intertidal marsh - dredged fill	170,000	850,000	5	4,250,000
Marsh plant planting	170,000		10	1,700,000
Rip-Rap 1.7m thick		49,415	60	2,964,884
Filter stone 1.0m thick		29,067	45	1,308,037
Total cost				21,822,921
Total volume of dredged material		1,890,000		
Cost per acre				**267,625**

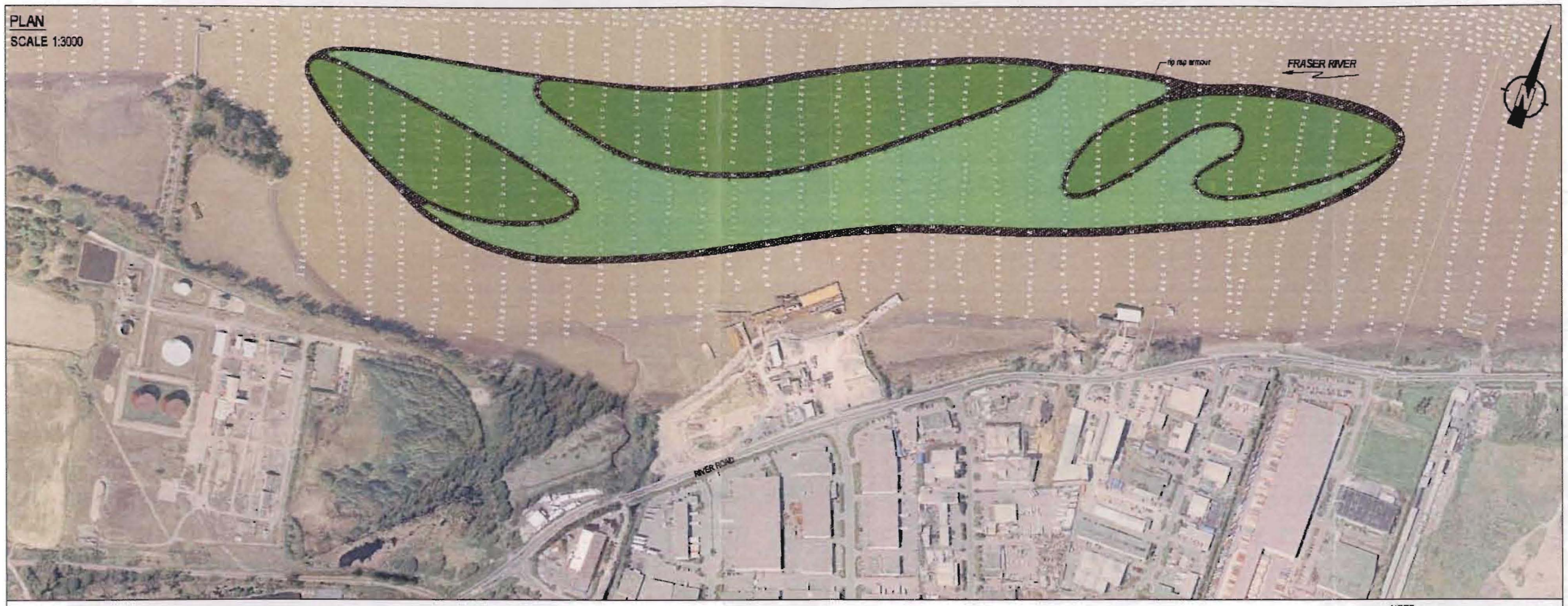
Figure 9.3 shows a concept for a 57-acre industrial land reclamation project in the same area of the river. The plan includes 38 acres of compensation area for this industrial development. The land is reclaimed in a similar fashion to the previous project. The industrial part of the land is built up to

5.0 m above the local low water, and then preloaded with 3 m of sand. The assumed settlement was 1.0 m. After the preload is complete, a 2.5 m thick layer of sand would be removed and sold. Cost of the access road and utilities was assumed at $2.25 million per kilometre, and the bridge was assumed to cost $5 million. The average cost of this development per acre of industrial area is about $556,000. Table 9.14 shows the details of this estimate. The cost of developing this industrial land is likely half of the price of comparable industrial land recently sold. Table 9.11 shows recent and comparable industrial land transactions in Richmond. Unfortunately, there were no recent land sales in the Tilbury area. It would take three and a half years to develop this project utilizing material otherwise dumped in the ocean.

Table 9.14 Order of magnitude estimate of land reclamation in the Fraser River for industrial uses. Tilbury, Delta. Average depth 2.5 m

57-acre Industrial Facility	Area (m2)	Volume (m^3)	Unit Rate	Cost ($)
Industrial area - dredged fill	230,000	1,725,000	5	8,625,000
Preload 3m high - river sand	230,000	690,000	5	3,450,000
Preload removal 2.5m	230,000	575,000	-5	(2,875,000)
Road and services 2 km				4,500,000
Bridge				5,000,000
Riparian woodlands - dredged fill	39,700	258,050	6	1,548,300
Tree planting	39,700		40	1,588,000
Intertidal marsh - dredged fill	115,000	575,000	6	3,450,000
Marsh plant planting	115,000		10	1,150,000
Rip-Rap 1.7m thick		53,353	60	3,201,192
Filter stone 1.0m thick		31,384	45	1,412,291
Total cost				31,049,783
Total volume of dredged material		2,673,050		
Cost per acre of industrial land				**546,334**

Figure 9.2 Plan of a potential 82-acre (33 ha) compensation area in the Fraser River near Tilbury, Delta. Average water depth 2.5 m CHS.



Source: Concept plan developed by ECL Envirowest Consultants for the Fraser River Port Authority. Copyright. Used with permission.

Figure 9.3 Plan of a potential 57-acre (23 ha) industrial development in the Fraser River near Tilbury, Delta. Average water depth 2.5 m CHS.

Source: Concept plan developed by ECL Envirowest Consultants for the Fraser River Port Authority. Copyright. Used with permission.

The proposed land reclamation would ensure profitability of the dredging program and a total utilization of the dredged material. The option would not affect the efficiency of the channel use or the existing terminals use. However, it would create an opportunity for a future terminal development and therefore a better utilization of the navigation channel. In addition, the option would create a new market for river sand that could justify future capital dredging projects and the expansion of the dredging program to secondary channels. From the two options presented above, the industrial land reclamation is preferable for three reasons: (1) it likely generates a better return on investment, (2) it is more likely to sell the reclaimed land, and (3) it utilizes more dredged material. The environmental compensation area may be cheaper to develop; however, it may take longer to sell. It took 15 years for the Fraser River Port Authority to sell the Timberland Basin compensation area. This suggests a 1 acre per year market absorption rate for compensation areas. However, a large industrial development like the announced Deltaport T2 expansion would create an immediate demand for the compensation area identified in this option.

The land reclamation program could not be sustained for long in the Fraser River because of the finite nature of the estuary. It would take only two to four years to develop projects presented in the examples above using the material otherwise dumped in the ocean. Equivalent projects in the Straight of Georgia will be more expensive because of high tides that are almost two meters above water levels registered near Tilbury in Delta. The cost of the environmental compensation project would be $326,000 per acre assuming the

same water depth (2.5 m). The development cost would increase to $488,000 per acre in 8 m deep waters. The industrial development potentials in the Straight of Georgia are only feasible on a large scale to justify the cost of constructing a bridge or causeway. Such projects are feasible as proved by the existing Deltaport terminal, its current 50-acre expansion, and the announced 200-acre T2 development.

Equitable Distribution of Costs and Benefits. The option is cost neutral and therefore does not cause inequity. The Fraser River Port Authority would have to invest $22 million to $31 million in up front capital before recovering the cost and likely turning a substantial profit. Both the Port Authority and the navigation channel users would benefit from the maintained navigation channel. The dredging program could expand to include secondary channels and therefore benefit domestic cargo shippers. The Port Authority would likely stop subsidizing sand sales allowing pit and quarry operators to charge a price closer to the market price. The option appears to be fair and desirable to all stakeholders.

No negative net impact on the environment. The option of reclaiming land and utilizing all of the dredged material is an improvement from the current situation. The proposed reclamation site is in essence an alternative disposal site to the current in-water disposal practice. The structural material would be utilized for the island base; and silts, fines, and organics would be used as a growing medium for marsh and woodland planting. In this option, no material would go to waste. The industrial land development could be perceived to have

a negative impact on the environment simply because of its environmental component. The land reclamation would have to be balanced with appropriate environmental compensation area.

Acceptability to Stakeholders. The location of the land reclamation site and the project design has to be approved by all authorities having jurisdiction. Reclamation for the environmental compensation uses will likely gain support of all government agencies and the public. The industrial island option will likely attract public opposition. This reaction will be similar to the public position on other industrial developments. It does not mean, however, that the Port Authority could not obtain the regulatory approval for this project.

The option is likely to gain DFO and other regulatory agencies support if the proposal creates a practical alternative to ocean disposal. The law and policy regulating ocean dumping prohibits such action unless it is environmentally preferable and no other practical alternatives exist (FREMP, 2003, p.44). The intent of the concept presented above is to create an environmentally preferable alternative to ocean dumping.

9.8 Evaluation Summary

The evaluation of all strategy alternatives is summarized in Table 9.15. The table states the policy goals and subdivides them into measurable impact categories. Analyses of strategy options presented include a quantitative evaluation of the economic efficiency goal. The summary table provides a qualitative evaluation of the proposed options against all four goals.

The land reclamation strategy provides the greatest improvement over the current dredging program. It achieves the highest efficiency of resources and it creates future development potentials. The option creates an environment where the dredging program pays for itself, and therefore it eliminates the need for the redistribution of costs and benefits. It creates an environment where the Port Authority can expand the dredging program to secondary channels, which in turn would improve the fairness of the dredging program to the domestic cargo shippers. The option eliminates ocean dumping and has a high potential to improve the overall environmental condition of the dredging program. Finally, the option is likely to gain regulatory approval.

It is clear that the no dredging option is the poorest choice and it is likely worse than the status quo. Although the option may generate more rent for the Port Authority in the long term, it would create a negative impact on the national economy in the short term. The loss of jobs and business could cause a government intervention other than providing the necessary funding for dredging the river.

Other options provide a varying degree of improvement over the status quo without pointing out a clear winner or loser. An attempt to rank these options would put too much weight on the analysis of their predicted performance. The weighting of each goal would also affect the outcome of the evaluation. The government funding option is strong on the equity and feasibility goals. The reduced dredging option provides a moderate improvement over the current situation in efficiency, equity, and environmental goals. The user-pay system

reveals a potential for recovering the proportional share of the dredging cost from the two auto terminals and ship lines calling at these terminals. The increased sand sales option generates a potential for lowering the overall dredging cost, but not without a risk.

Table 9.15 A Summary of dredging alternatives in terms of strategy goals

Goal	Impact Category	Dredging Alternatives, Part 1 of 2			
		Current Program	**Government Funding**	**No Dredging**	**Reduced Dredging**
Efficient Use of Resources	**Sand Utilization**	Poor – ocean disposal	Poor – no change	Poor – no value extracted	Very Good – near full utilization
	Channel Utilization	Moderate – not fully utilized	Moderate – no change	Poor – loss of value	Moderate – not fully utilized
	Terminal Infrastructure Utilization	Moderate – not fully utilized	Moderate – no change	Poor – loss of business	Good – improved utilization
Equitable Distribution of Costs and Benefits	**Cost Neutrality**	Poor - net loss	Poor - no change	Excellent - no cost	Good – 70% reduction
	Fairness to FRPA	Poor - large net cost, free riding	Good - no net cost to FRPA	Good- no dredging cost, higher rent from redeveloped terminals	Moderate – lower dredging cost, loss of international cargo
	Fairness to Channel Users	Poor - dredging for international cargo but no domestic cargo	Poor - no change	Poor - loss of access to international cargo shippers	Poor – dredging for auto terminals only
	Fairness to Taxpayers	Poor - net loss	Poor - no change	Poor - net loss	Excellent - no net loss
No negative net impact on the environment	**Impact of Upland Operation**	Moderate - glacial till utilized, pits open to supply sand	Moderate - no change	Excellent - return to natural state	Moderate – similar to the status quo
	Impact of Water Operation	Good - process resembles nature	Good - no change	Excellent - return to natural state	Very Good – minimum ocean disposal
Acceptability to Stakeholders	**Likelihood of Stakeholders Support**	High – program in place	High – blend of prior and existing programs	Low – loss of business, increased threat of flood	Moderate – government support, some users oppose
	Likelihood of Public Support	High – program in place	High - blend of prior and existing programs	Low – loss of jobs, increased threat of flood	High – no net loss

Goal	Impact Category	Dredging Alternatives, Part 2 of 2		
		User-Pay System	**Increased Sand Sales**	**Land Reclamation**
Efficient Use of Resources	**Sand Value**	Poor – no change	Moderate- utilization but high subsidy	Excellent – full utilization of river sand
	Channel Value	Moderate – no change	Moderate – no change	Moderate to High – possibility of self funded channel improvements
	Terminal Infrastructure	Moderate – no change	Moderate – no change	Moderate to High – improvement with deeper channel
Equitable Distribution of Costs and Benefits	**Cost Neutrality**	Poor – no change	Moderate – subsidy	Excellent – cost neutral
	Fairness to FRPA	Excellent - no cost	Poor to Moderate – % improvement	Good – no net cost, but upfront investment
	Fairness to Channel Users	Moderate – not perfect distribution	Poor – no change	Excellent – no cost, can dredge for domestic users
	Fairness to Taxpayers	Poor to Moderate – reduced loss, redistribution	Moderate – improvement but subsidy	Excellent – no net loss
No negative net impact on the environment	**Impact of Upland Operation**	Moderate – no change	Very Good – near full utilization of river sand	Moderate – no change
	Impact of Water Operation	Good – no change	Very Good – minimum to no ocean disposal	Excellent – no ocean dumping, beneficial use
Acceptability to Stakeholders	**Likelihood of Stakeholders Support**	Moderate – in line with government policy, resistance from users	Moderate – better utilization of sand, negative impact on pits and quarries	High – supported by current regulations, no impact on stakeholders
	Likelihood of Public Support	High – no impact	High – no impact	Moderate to High – improvement

10 RECOMMENDED DREDGING STRATEGY

The recommendation is that the Fraser River Port Authority adopts the highest ranked alternative: the land reclamation strategy. The additional recommendation is for the Port Authority to reclaim land for industrial uses, unless there is a guaranteed demand for an environmental compensation land, which then would make it the recommended option. The proposal is not a radical departure from the legacy of the Fraser River Port Authority. The proposed strategy builds on the past practice of reclaiming land for port facilities like the WWL and FSD terminals.

Goals. The proposed strategy has a redefined goal of achieving sustainable funding for dredging by extracting value from otherwise wasted material. Unlike the government funding option, this strategy gives the Port Authority more control over its destiny. FRPA should aim to obtain the regulatory approval, and to reclaim and lease out the first parcel of the reclaimed industrial land within five years. Since the land reclamation possibilities are limited, the recommendation is to increase sand sales and sand availability. A goal should be to open new sand depots in Delta, Burnaby, Pitt Meadows, and Maple Ridge. FRPA should also aim to increase sand sales to public infrastructure projects by lobbying the public policy makers and by bringing public awareness to the dredging issue. The aim should be to create a "green" label for river sand as a renewable resource. A stretch goal would be to have river sand identified as a

preferred material by the LEED program (Leadership in Energy and Environmental Design), and by procurement officers for public works. Finally, the recommendation is for the Port Authority to continue its efforts to eliminate royalties on sand dredged from the provincial river bottom.

Product Market Focus. The land reclamation projects should be the key focus for the Port Authority. At the same time, FRPA should continue with its market focus of selling sand for preload and general fill. The marketing efforts should expand to new geographic areas like Pitt Meadows, and Maple Ridge; and to re-establish river sand position in Delta and Burnaby.

Core Activities. FRPA should concentrate on developing the land reclamation project. This should include planning, regulatory approval, and marketing. To improve its position in the construction aggregate market, FRPA should participate in the industry associations, lobby local governments for an increase in use of river sand on public infrastructure projects, and bring public awareness to the river sand option as a renewable resource. To improve the availability of river sand the Port Authority should invest in stockpiling sand along the river and selling it through a concessionaire. FRPA should continue working with its contractor on selling sand to land developers and sand retailers.

Value Proposition. The new proposition should be based on the efficiency and environmental goals. The proposed land reclamation is an environmental improvement to ocean dumping. The reclaimed land creates an opportunity for economic development without affecting existing land base in the Lower Mainland. The program is self-funded and ensures continuity of dredging

on the Lower Fraser River that in turn benefits navigation and flood protection. The sand removed from the river is a renewable resource and should be promoted as a "green" option.

APPENDICES

Appendix 1 Fraser River Port cargo statistics for years 2002-2006

Domestic Cargo - Five Year Summary (tonnes)

Commodity \ Year	2002	2003	2004	2005	2006
Inbound					
Aggregate	2,463,057	3,204,170	3,756,505	3,623,025	3,374,623
General Cargo	1,984,983	2,066,877	2,200,540	2,299,266	2,431,300
Gypsum	148,952	98,627	122,171	168,958	175,011
Limestone	1,669,702	1,698,940	1,614,913	1,584,606	804,624
Logs	4,100,320	3,690,346	4,394,262	4,586,482	4,394,402
Lumber	15,400	6,700	0	70,500	136,500
Other	141,489	192,479	214,948	291,362	204,100
Paper	727,609	863,500	583,752	1,043,728	1,250,087
Pulp	130,500	217,700	342,800	121,933	19,000
Wood Chips	231,240	283,357	242,590	213,600	368,750
Total Inbound	**11,613,252**	**12,322,696**	**13,472,481**	**14,003,460**	**13,158,397**
Outbound					
Aggregate	246,621	651,563	371,293	318,500	484,500
Cement	228,910	266,302	304,045	273,352	271,606
General Cargo	10,115,050	10,995,410	10,037,080	11,801,559	11,693,850
Hog Fuel	576,970	463,809	630,856	703,522	771,953
Logs	2,693,300	2,239,230	3,116,368	3,340,136	2,614,063
Other	0	0	0	11,447	17,151
Sawdust	99,183	280,767	307,779	287,399	336,828
Steel	212,614	169,865	171,241	286,421	352,254
Wood Chips	2,242,646	2,329,084	2,564,662	2,189,561	2,191,594
Total Outbound	**16,415,294**	**17,396,030**	**17,503,324**	**19,211,897**	**18,733,799**
Total Domestic Shipping	**28,028,546**	**29,718,726**	**30,975,805**	**33,215,357**	**31,892,196**

International Cargo - Five Year Summary (tonnes)

Commodity	2002	2003	2004	2005	2006
Export					
Autos	4,660	816	259	292	94
Cement	710,853	667,149	727,829	662,611	448,315
General Cargo	375,713	558,753	563,887	639,314	332,463
Logs	1,208,570	1,137,914	870,018	1,087,550	1,002,983
Lumber	257,417	288,318	295,649	291,336	136,205
Other	52,457	151,612	207,879	171,615	131,471
Pulp	326,436	312,033	437,018	282,525	24,052
Wood Products	4,166	21,110	17,291	27,596	7,246
Total Export	**2,940,272**	**3,137,705**	**3,119,830**	**3,162,839**	**2,082,829**
Import					
Autos	434,500	444,985	436,931	452,326	465,092
General Cargo	430,334	890,657	1,036,074	1,094,233	410,320
Heavy Equipment	8,062	3,884	893	572	810
Lumber	4,113	1,675	4,399	5,035	13,590
Other	14,960	86,409	93,067	57,543	13,309
Pulp	4,765	4,991	-	614	4,500
Steel	703,595	713,734	860,620	793,346	992,319
Wood Products	8,107	28,206	34,547	36,682	22,601
Total Import	**1,608,436**	**2,174,541**	**2,466,531**	**2,440,351**	**1,922,541**
Total International Shipping	**4,548,708**	**5,312,246**	**5,586,361**	**5,603,190**	**4,005,370**
Containers (in TEUs)	**100,544**	**252,510**	**317,582**	**372,844**	**94,651**
Ship Arrivals	**753**	**774**	**730**	**692**	**598**

Source: Fraser River Port Authority's cargo stats (FRPA, 2007g)

Appendix 2 River sand sales in relationship to Lower Mainland aggregate production

	Year	Borrow Dredging (000 m^3)	Navigation dredging (000 m^3)	Total Dredging (000 m^3)	River Sand Production (000 tonnes)	Borrow Dredging Sand Sales (000 m^3)	Total River Sand Sales (000 m^3)	Borrow Sand Sales (000 tonnes)	Total River Sand Sales (000 tonnes)	Lower Mainland Construction Aggregate. (000 tonnnes)	Borrow Sand Sales as % of Construction Aggregate.	Total River Sand as % of Construction Aggregate
CCG Administration	1979/80	2,067	2,429	4,496	7,418	2,067	3,282	3,411	5,414	17,891	19%	30%
	1980/81	2,728	1,604	4,332	7,148	2,728	3,530	4,501	5,825	20,467	22%	28%
	1981/82	2,526	3,060	5,586	9,217	2,526	4,056	4,168	6,692	11,475	36%	58%
	1982/83	937	3,381	4,318	7,125	937	2,628	1,546	4,335	18,631	8%	23%
	1983/84	3,149	2,840	5,989	9,882	3,149	4,569	5,196	7,539	25,678	20%	29%
	1984/85	4,203	3,286	7,489	12,357	4,203	5,846	6,935	9,646	28,782	24%	34%
	1985/86	3,208	2,406	5,614	9,263	3,208	4,411	5,293	7,278	17,192	31%	42%
	1986/87	1,549	2,199	3,748	6,184	1,549	2,649	2,556	4,370	16,843	15%	26%
	1987/88	2,501	2,607	5,108	8,428	2,501	3,805	4,127	6,277	20,241	20%	31%
	1988/89	2,971	2,998	5,969	9,849	2,971	4,470	4,902	7,376	23,479	21%	31%
	1989/90	4,718	1,732	6,450	10,643	4,718	5,584	7,785	9,214	21,533	36%	43%
	1990/91	3,321	2,009	5,330	8,795	3,321	4,326	5,480	7,137	23,608	23%	30%
	1991/92	2,642	2,881	5,523	9,113	2,642	4,083	4,359	6,736	23,135	19%	29%
	1992/93	2,134	409	2,543	4,196	2,134	2,339	3,521	3,859	23,178	15%	17%
	1993/94	1,861	940	2,801	4,622	1,861	2,331	3,071	3,846	21,074	15%	18%
	1994/95	1,353	833	2,186	3,607	1,353	1,770	2,232	2,920	22,920	10%	13%
	1995/96	1,157	621	1,778	2,934	1,157	1,468	1,909	2,421	23,114	8%	10%
	1996/97	792	801	1,593	2,628	792	1,193	1,307	1,968	23,862	5%	8%
	1997/98	0	1,040	1,040	1,716	0	520	0	858	19,632	0%	4%
	1998/99	0	1,075	1,075	1,774	0	538	0	887	19,115	0%	5%
FRPA Administration	1999/00	0	2,717	2,717	4,483	0	1,192	0	1,966	20,028	0%	10%
	2000/01	0	1,815	1,815	2,995	0	948	0	1,564	20,254	0%	8%
	2001/02	0	1,816	1,816	2,996	0	885	0	1,461	18,945	0%	8%
	2002/03	0	2,873	2,873	4,740	0	2,047	0	3,378	18,713	0%	18%
	2003/04	0	2,822	2,822	4,656	0	1,166	0	1,925	18,541	0%	10%
	2004/05	0	2,506	2,506	4,135	0	1,328	0	2,192	20,635	0%	11%
	2005/06	0	3,104	3,104	5,122	0	2,218	0	3,660	22,798	0%	16%
	2006/07	0	3,137	3,137	5,176	0	2,559	0	4,222	22,829	0%	18%
Statistics	Average 79-97	2,434	2,058	4,492	7,412	2,434	3,463	4,017	5,714	21,283	19%	28%
	Min 79-97	792	409	1,593	2,628	792	1,193	1,307	1,968	11,475	5%	8%
	Max 79-97	4,718	3,381	7,489	12,357	4,718	5,846	7,785	9,646	28,782	36%	58%
	Average 99-07	-	2,599	2,599	4,288	1,543	1,543	-	2,546	20,343	0%	12%
	Min 99-07	-	1,815	1,815	2,995	885	885	-	1,461	18,541	0%	8%
	Max 99-07	-	3,137	3,137	5,176	2,559	2,559	-	4,222	22,829	0%	18%
	River sand conversion =1.65 tonnes/m^3											
	Total river sand sales for years 1979 to 1997 were calculated as borrow dredging plus 50% of navigation dredging											
	Statistical analyses exclude transition seasons 1997/98 and 1998/99											

Source: Lower Mainland construction aggregate total tonnage sourced from: BC Government statistics (BC, 2007), (Government, 2000). Dredging volumes from the Fraser River Port Authority records.

REFERENCE LIST

Aggregate Advisory Panel (2001, March). Managing Aggregate, Cornerstone of the Economy. Report of the Aggregate Advisory Panel. Victoria, BC

American Association of Port Authorities (2007, March). Corps of Engineers Works Program. AAPA Newsletter. Retrieved June 15, 2007 from http://www.aapa-ports.org/files/PDFs/corps.pdf

Avison Young (2006, Fall). Greater Vancouver Industrial Land Overview. Retrieved June 30, 2007 from http://www.avisonyoung.com/library/pdf/Van_Research/Avison_Young_-_Greater_Vancouver_Industrial_Overview_Fall_2006.pdf

BC Ministry of Energy, Mines, and Petroleum Resources (2007a). Pit and Quarry versus Dredged Production, Lower Mainland - 1980 to 2000 Retrieved June 15, 2007 from http://www.em.gov.bc.ca/Mining/MiningStats/51lwrmainconagg.htm

BC Ministry of Energy, Mines, and Petroleum Resources (2007b). Production and Values, Construction Aggregates 1992 – 2006. Retrieved June 15, 2007 from http://www.em.gov.bc.ca/Mining/MiningStats/51detailconagg.htm

BC Ministry of Transportation, BC Ministry of Small Business and Economic Development (2005, March) British Columbia Ports Strategy. Retrieved May 21, 2007 from http://www.gov.bc.ca/ecdev/down/bc_ports_strategy_sbed_mar_18_05.pdf

BC Research (1984, April). Market for Sand in the Lower Fraser Area. Prepared for Public Works Canada and Transport Canada. Vancouver, BC.

Baydala, Alan (2006, August). Dredging of CMA Grounds. Port North Fraser. Retrieved May 21, 2007 from http://www.nfpa.ca/06media/pdf/CMEGrounds.pdf

Bridges G.E. & Associates Inc. (2004, March 31). Coastal Aggregate Development Opportunities, Market Analysis prepared for the Ministry of Energy and Mines, Ministry of Sustainable Resource Management, and Ministry of Transportation, Victoria, BC.

Canada Gazette (1999, May 1). Fraser River Port Authority, Letters Patent. Supplement, Vol. 133, No. 18.

Chamber of Shipping (2007). Lower Mainland Ports. Retrieved May 21, 2007 from http://www.chamber-of-shipping.com/index/portssouth

Crossan, Mary M.; Fry, Joseph N.; Killing, Peter J (2005). Strategic Analysis and Action. Sixth Edition. Toronto, Ontario.

Dodge, Don (1986, July). Fraser Port Dredging Study. Report prepared for Fraser River Harbour Commission.

Environment Canada (2006, March). Discussion Paper on Disposal at Sea Permit Fees for Dredging and Excavation Operations. Environmental Assessment Division, Environmental Protection Operations Directorate, Environmental Sustainability Branch.

Environment Canada (2007). Fate of Dredged Fraser River Sediment. Changing Coastal Ecosystems. Retrieved June 26, 2007 from http://www.pyr.ec.gc.ca/disposal_at_sea/documents/SandHeadsslopepostererfinalvec.pdf

Environmental Protection Agency (1994, December). The National Dredging Policy, The Dredging Process in the United States; an Action Plan for Improvement. United States. Retrieved May 22, 2007 from http://www.epa.gov/owow/oceans/ndt/PDF/action1994_Ch4.pdf

House of Commons of Canada, The (1997, December). Canada Marine Act. Bill C-9.

Ferguson, Alan, Regional Consulting Ltd. (1991, January). Navigation, Dredging, and Environment in the Fraser River Estuary. *Fraser River Estuary Management Program, Navigation and Dredging Workgroup Report.*

Fisheries and Oceans Canada (1986). Policy for the Management of Fish Habitat. Ottawa, Ontario. Retrieved May 22, 2007 from http://www.dfo-mpo.gc.ca/Library/23654.pdf

Fisheries and Oceans Canada (1997, March 20). Federal Response to the Economic Impact Study of Major Marine Initiatives. Marine Sector Reform: Coast Guard Recovery and Other Initiatives. Retrieved May 27, 2007 from http://www.ccg-gcc.gc.ca/msf-dsm/archive/report/response/response_e.htm#top

Fisheries and Oceans Canada (2007). Fisheries and Oceans Canada, Vision and Mandate. Retrieved May 21, 2007 from http://www.dfo-mpo.gc.ca/dfo-mpo/vision_e.htm.

Fraser River Estuary Management Program (2003). A Living Working River.

Fraser River Estuary Management Program (2005). Dredge Management Guidelines.

Fraser River Port Authority (2001, April). Land Use Plan.

Fraser River Port Authority (2004, March 11). Fraser River Port Unveils $190 Million Project. Retrieved June 24, 2007 from http://www.fraserportauthority.com/news/news%20releases/031104.html

Fraser River Port Authority (2004b, April). *Dredging.* Retrieved May 18, 2007 from http://www.fraserportauthority.com/pdf/FRPA_DREDGING_Apr04.pdf

Fraser River Port Authority (2005, September). Fraser River Dredging. Update (FRPA newsletter).

Fraser River Port Authority (2006, May). Condensed Financial Statements December 31, 2005.

Fraser River Port Authority (2007, January 1). Schedule of Port Fees

Fraser River Port Authority (2007b). *Technical Specifications Handbook.* Retrieved May 18, 2007 from http://www.fraserportauthority.com/pdf/FRPA_TECHNICAL%20SPECIFICATIONS%20HANDBOOK.pdf

Fraser River Port Authority (2007c). Financial Statements, December 31, 2006, New Westminster, British Columbia.

Fraser River Port Authority (2007d). 5 Year Summaries of Domestic and International Cargo Statistics. Retrieved May 18, 2007 from http://www.fraserportauthority.com/facts/cargostats.html

Fraser River Port Authority (2007e, February). Economic Impact of the Fraser River Port Authority. Information Newsletter

Fraser River Port Authority (2007f). Sand. Retrieved July 6, 2007 from http://www.fraserportauthority.com/sand/index.html

Fraser River Port Authority (2007g). Cargo Stats. Retrieved July 6, 2007 from http://www.fraserportauthority.com/facts/cargostats.html

GVRD Policy and Planning Department (March 2006). Industrial Lands Inverntory for Greater Vancouver 2005. Final Draft Report.

Government of British Columbia, Ministry of Energy, Mines, and Petroleum Resources, (2000). Pit and Quarry versus Dredged Production, Lower Mainland – 1980 to 2000. Retrieved June 2, 2007 from http://www.em.gov.bc.ca/mining/miningstats/51lwrmainconagg.htm

Grant Thornton (2002, July 26). Market Elasticity of Sand in the Lower Mainland. Report prepared for the Fraser River Port Authority.

Hay & Company Consultants (2005 December). Lower Fraser River Sediment Analysis. Report Prepared for the Fraser River Port Authority.

Hay & Company Consultants (2005b, June 28). Fraser River Dredging Study. Report Prepared for the Fraser River Port Authority.

Hay & Company Consultants (1995, July). Channel Maintenance Management Study. Lower Fraser Study. Report Prepared for Canadian Coast Guard.

InterVISTAS Consulting Inc. (2002, May). The Economic Impact of Fraser Port. Prepared for Fraser River Port Authority. New Westminster, British Columbia.

InterVISTAS Consulting Inc (2002, November). Toward an Economic Vision for the Fraser River Estuary. Prepared for the Fraser River Estuary Management Program Economic Development Task Group. Burnaby, British Columbia.

InterVISTAS Consulting Inc. (2005, August 15). Dredging the Lower Fraser River: Economic Impact Analysis. Prepared for Fraser River Port Authority. New Westminster, British Columbia.

InterVISTAS Consulting Inc. (2005b, September 6). Dredging the Lower Fraser River: Multiple Accounts Evaluation Analysis. Prepared for Fraser River Port Authority. New Westminster, British Columbia.

InterVISTAS Consulting Inc. Colledge Transportation Consulting Inc. (2006, April). Pacific Gateway Strategy Action Plan. Report prepared for Industry Advisory Group. Retrieved June 10, 2007 from http://www.th.gov.bc.ca/PacificGateway/documents/PGS_Action_Plan_043006.pdf

Kirtchner, Matthias (2006, September). Container Vessels and Risk Aggregation. The Cargo's Underwriter View. AXA Corporate Solutions. Retrieved June 30, 2007 from http://www.cefor.no/news/IUMI/2006%20IUMI%20-%20FFC%20-%20Matthias%20Kirchner.ppt#256,2,Slide 2

Levelton Engineering Ltd. (1996). Lower Mainland Aggregate Demand Study. Volume I. Aggregate Supply and Consumption. Report prepared for BC Ministry of Employment and Investment. Victoria. British Columbia.

Master Municipal Construction Documents Association (2000). Master Municipal Construction Document, Volume II. Specifications.

Master Municipal Construction Documents Association (2007). Master Municipal Construction Document, Volume II. Approved Supplementaries (2). Retrieved May 31, 2007 from http://www.mmcd.net/downloads/ApprovedSupplementaries-06-02-2006.pdf

Melious, Jean O. (2006, September). Border Policy Brief. Focus: Governance of Canadian and American Ports. Border Policy Research Institute, Western Washington University. Volume 1, No. 5. Retrieved June 2, 2007 from http://www.ac.wwu.edu/~bpri/files/2006_Sep_Border_Brief.pdf

Ministry of Environment, British Columbia (2007). 2007/08-2009/10 Service Plan, Ministry of Environment Including Environmental Assessment Office. Retrieved May 21, 2007 from http://www.bcbudget.gov.bc.ca/2007/sp/env/

Northwest Hydraulic Consultants (2006, December). Lower Fraser River Hydraulic Model. Report prepared for Fraser Basin Council. Retrieved July 6, 2007 from http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/fraser_profile_report.pdf

Port Amalgamation (2007), Lower Mainland Port Amalgamation. Retrieved May, 21, 2007 from http://www.portamalgamation.com

Porter, Michael E. (1998). Competitive Strategy; Techniques for Analyzing Industries and Competitors. New York.

Transport Canada (1999). Letters Patent, Fraser River Port Authority.

Transport Canada (2007). Transport Canada, Marine Program. Retrieved May 21, 2007 from http://www.tc.gc.ca/marine/menu.htm

Transport Canada (2007b). Strategic Infrastructure. Asia-Pacific Gateway and Corridor Initiative. Retrieved June 2, 2007 from http://www.tc.gc.ca/majorissues/APGCI/infrastructure.htm

Transport Canada (2007c). Canada's Asia-Pacific Gateway and Corridor Initiative. Retrieved May 21, 2007 from http://www.tc.gc.ca/majorissues/APGCI/initiative.htm

Vancouver Sun, The (2007, January 25). Port taxes are way out of line.

World Commission on Environment and Development (1987). Our Common Future. Chapter 2, Towards Sustainable Development. Retrieved June 23, 2007 from http://www.eytv4scf.net/ocf-02.htm#III.7