UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

**Living Breakwaters: Archival Project and Aerial Photography Study**

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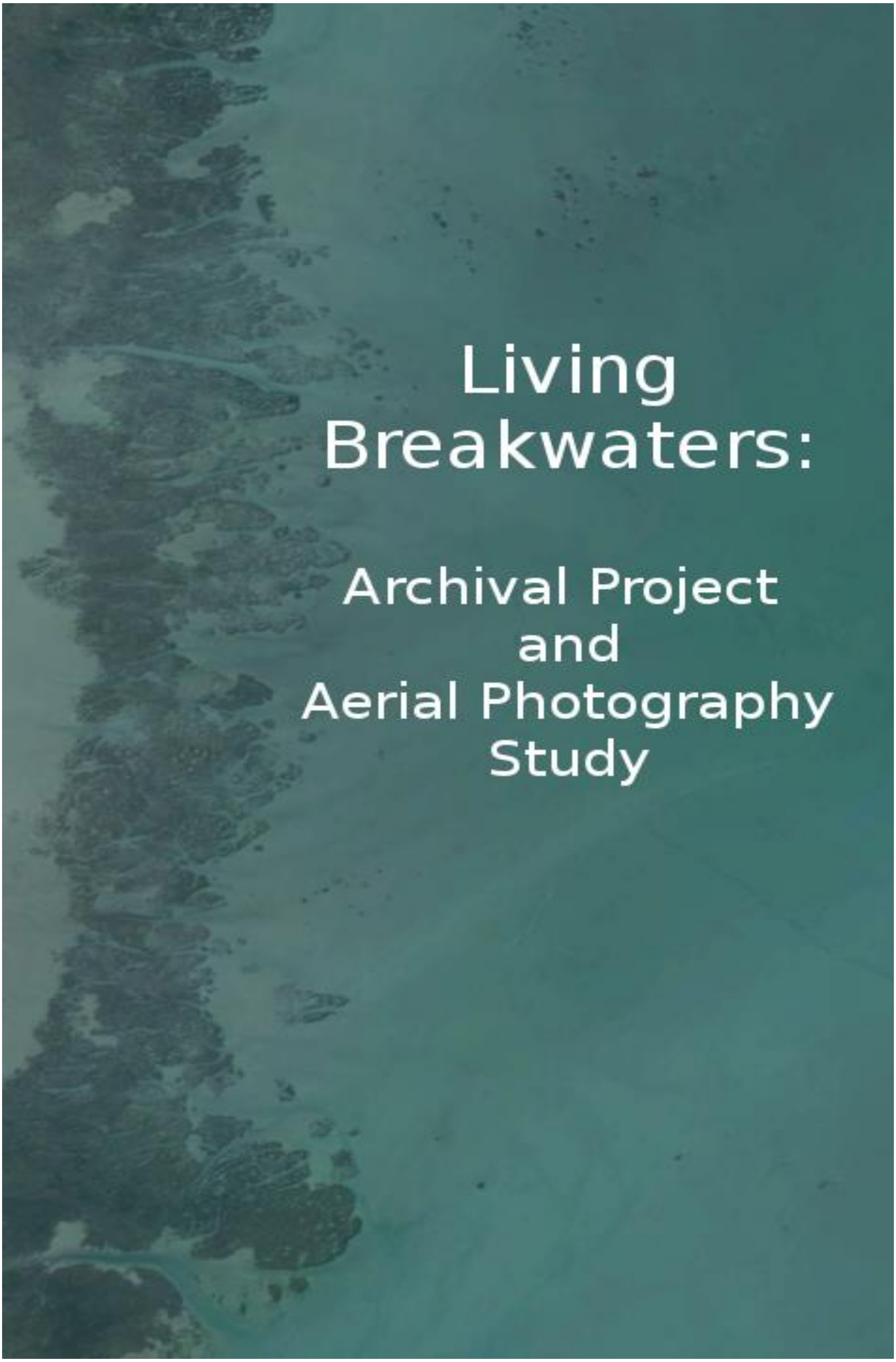
**VOL 400**

**Themes: Climate, Land, Water**

**December 19, 2018**


Living
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and
Aerial Photography
Study

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Acknowledgments

This research was conducted under the guidance of the University Alliance for Sustainability and under the framework of the UBC SEEDS program.
Key project partners involved in this research were Tugce Conger, Assistant project manager of the Living Breakwaters Resilience Project and Ph.D. candidate at the UBC Institute for Resources, Environment, and Sustainability, who acted as principal advisor. Doug Doyle, Associate Manager at UBC's Municipal Engineering, David Gill, SEEDS Project Coordinator, and Kees Lokman, Project Manager of the Living Breakwaters Resilience Project and assistant professor at UBC School of Architecture and Landscape Architecture, each provided technical expertise and resources and reviewed this paper.

Table of Contents

# 1. Executive Summary

The Archival Project and Aerial Photography Study is a subproject (SP1) of the Living Breakwaters Resilience Project (LBRP).

## 1.1. Introduction

While conventional, hard infrastructure solutions are commonly associated with disadvantages that range from disrupting ecosystems to being very costly and maintenance intensive, the LBRP aims at exploring natural-based solutions that provide an efficient option with co-benefits, while still offering a cost-effective and appropriate protection against sea level rise and further coastal erosion.
Under the framework of the LBRP, the Archival Project and Aerial Photography Study aims at researching, gathering and systematizing accounts on the history of coastline interventions in the Lower Mainland region.
Recognizing the transdisciplinary, multi-year scope of the umbrella project, the presented research must not be understood as a definite, concluded study. It is intended to provide a comprehensive overview and baseline that can be accessed for, and further expanded by, future work relating to the project.

## 1.2. Objectives

The objective of this archival and aerial photography study is to compile and systematize graphical data that helps to visualize key transformative processes in the Greater Vancouver region. This is achieved by researching the available historical visual files and comparing them against nowadays conditions.

## 1.3. Methodology

The process of gathering material relied just as much on reviewing literature and research as on the careful inspection of the available graphical data. For many historical textual reports, there is little to none complementary photographic documentation available, which makes the scanning and reviewing of studies a requirement to fill in the gaps and learn about events that are not recorded visually. Given the multitude of studies discussing topics relevant for this overview, this archival work focused initially on reports previously reviewed and

discussed in the expert literature provided by the umbrella project and expanded to linked research from there on.
To have a spectrum of visual display available in this report, it was decided beforehand to rely on cartographic and photographic material as well as aerial and orthographic imagery as the main modes of presentation.
Different timelines are included in this research to provide a better overview of certain sections. For developing the timelines, the approach was thorough online research of the photographic collections of the Vancouver Archives, the BC Archives, as well as the UBC Archives. Alongside, literature available via the UBC Library was reviewed to get a sense of the different interventions and processes in the Lower Mainland. Given a large amount of data, this report focuses on the most relevant developments and does not include every event or intervention in the region. In addition, this research is also restricted to the timeframe of the colonial settlement. This was done to compile and discuss a list of important key events while maintaining manageable size and practicability. Furthermore, a special focus was put on four Focus Areas that were defined with the help of the project group. The research will be sectioned into an Overview Timeline, which lists general events and interventions relating to the history of Greater Vancouver, as well as events relating to the Focus Areas. This timeline includes a separate category that assigns each listed event a significance (administrative, economic, ecological and social), to provide a finding aid for future more specific, in-depth research.
Afterward, a section will discuss general historical events and transformations of Greater Vancouver, divided up in 20-year intervals. The subsequent section is dedicated to the Focus Areas. Each area is discussed individually and includes a timeline.
Concluding, this paper will consider the limitations of this study and make suggestions for further research.

## 1.4. Findings

The highly diverse Focus Areas are each subject to particular and largely different sets of human impact, which will be discussed more closely in their respective sections.
As well, with the exception of False Creek, all Focus Areas lie in the midst of sensitive and threatened ecosystems as identified by the Sensitive Ecosystem Report (see Fig. 42).

## 2. Necessary Explanations

According to Hales (2000), there is no evidence First Nations trained or altered the coastal and river environment on a larger scale, hence the pre-colonial period will be mostly excluded from this study.

As will be indicated in the Area Overview (see Fig. 3), a color code will be employed throughout the entire study, to act as a visual aid both for discussing and displaying the respective areas, as well as serving as an overview and finding aid when revising both Timeline and Focus Areas. The Focus Areas are as follows:

> False Creek and the False Creek Flats were identified as interest area mainly because this heavily urbanized site underwent a lot of different, mostly industry-related, interventions. In addition, sea level rise and climate change projections identify the space as severely threatened by flooding should no further preventive measures be implemented in the future. The UBC Cliffs were identified an area of interest since their bare sand cliffs are especially prone to storm surge and wave energy caused erosion of the cliff foot, that has - and will continue to cause - instability of the slopes. Iona Island was decided upon as a key region of interest because of its jetties and the Iona causeway - jetties significantly alter fresh-water and sediment transport and are hence of great relevance. Lastly, the coastline of Steveston was deemed important because of its risk of flooding, as well as because of the jetties that are constructed on the southwest tip of the island.

The “Significance” section of the Overview Timeline (see Table 1) that might facilitate complementary, more targeted work is comprised of four tags. The label *administrative* refers to any legislation or administration related topics and might be linked to any organization or body. Events tagged *economic* refer to economic or financial subjects, while *ecological* marks the implications of an event in terms of its environmental significance. *Social* is assigned to events associated with socio-historic interventions in the region, events that relate to urbanization, or events that are relevant on a wider societal scale.

Furthermore, it seems reasonable to comment on the different jetties discussed in this study. Their names might differ from other designations encountered in research, but the names given here do correspond with how the jetties are labeled most frequently.

North Arm Jetty (a):
Located at the mouth of the northern Fraser River arm. This jetty is an extension of Iona Island and stretches towards the north-west into the Sturgeon Bank, parallel to the coast of Vancouver and the University Endowment Lands. It is 7,5 km long and consists of rock rubble ("North Arm Jetty" 2014).

Iona South Jetty (b):
Sometimes referred to as *Iona Jetty* or *South Jetty,* this structure is likewise an extension of Iona Island. It stretches south-west into the Sturgeon bank and is approximately 4 km long, consisting of a sewage pipe, concrete, and gravel (“Marine-Iona Group”).

Steveston (North) Jetty (c):
Alternatively labeled *South Arm Jetty*. This Jetty is located at the northern channel of the south - or main arm - of the Fraser River. This bent construction extends from Garry Point to the south-west and acts as clear-cut confinement of the Sturgeon Bank. Nearly 9 km long, it consists mainly of rock rubble ("Steveston North Jetty" 2014).

Steveston South Jetty (d):
Steveston South Jetty can either refer to *Jetty No.1* or *Jetty No.2* (see p. 96). Today’s jetty (No.2) is located offshore and extends westwards from Reifel Island, elongating the Albion Training Wall. Constructed out of rock rubble, this structure is 3,5 km long ("Steveston South Jetty No. 2" 2014).

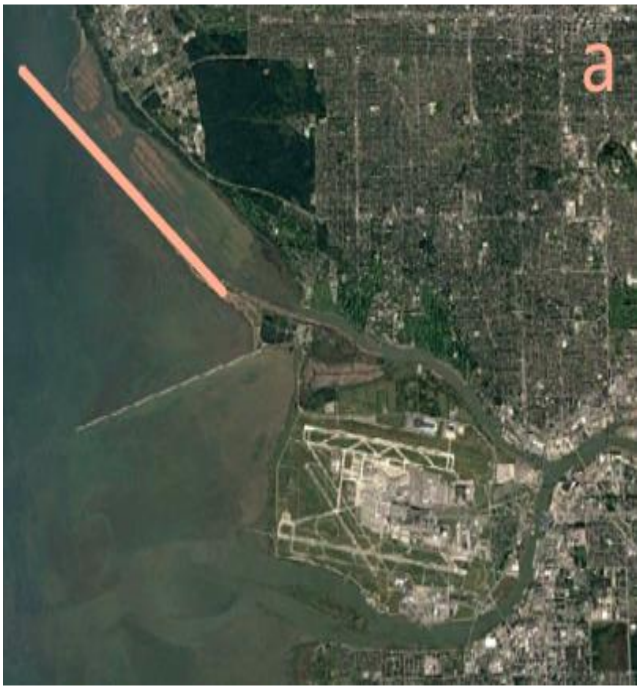


Fig. 1a. North Arm Jetty

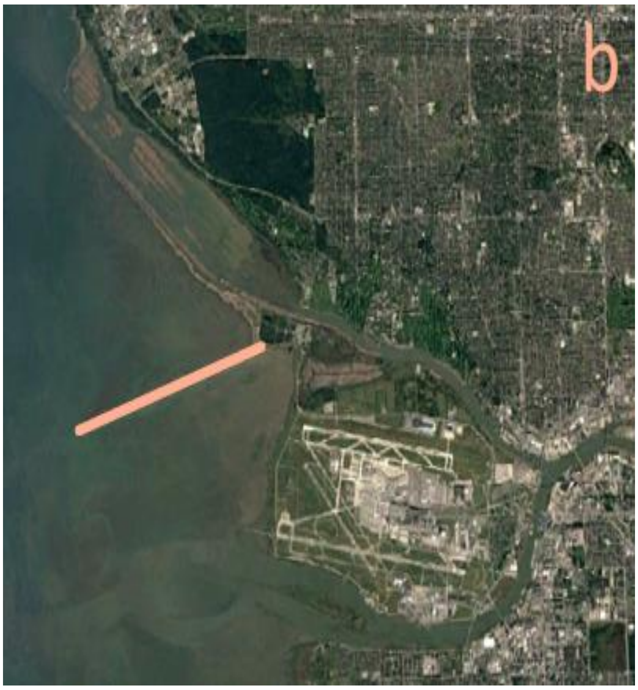


Fig. 1b. Iona South Jetty

Fig. 1c. Steveston (North) Jetty

Fig. 1d. Steveston South Jetty

## 2.1. Area Overview

- The False Creek Focus Area is located on the southern tip of Downtown Vancouver. The creek itself is located at the western and middle section of the area, whereas the Flats pertain to the creek at its eastern end.
- The UBC area is located on the western tip of Greater Vancouver and encompasses the entire shoreline of the University Endowment Lands.
- Iona Island and its jetties are located right below the UBC focus area, they also form the north-western tip of Sea Island.
- The Steveston Focus Area and the adjacent jetties form the southwestern tip of Lulu Island.


Fig. 2. Color Code Focus Areas


Fig. 3. Area Overview

## 3. Archival Research

### 3.1. Overview Timeline

| Focus Area Event | Year | Regular Event | Significance |
|---|---|---|---|
| | 8000 years ago | Native Settlement in the region | social |
| | 1800 - present | Dredging of the Fraser began | economic; ecological |
| | 1863/64 | Beginning of Colonalization | social |
| | 1864 | Dykes on Lulu Island | economic; social |
| | 1873 | Drainage, Dyking, Irrigation Act | administrative |
| River Training Attempts | 1880 | | economic; ecological |
| | 1894 | Fraser River Flood, largest flood | social |
| | 1906 | Extension of Dyking System | economic; social |
| False Creek Fill In | 1910 | | economic; social |
| Steveston Jetty construction | 1911/1912 | | economic; ecological |
| UBC logging | pre-1914 | | economic |
| North Arm Jetty Construction | 1916 | | economic; ecological |
| Granville Island Extension | 1916 | | economic; social |
| | 1918 | Fraser River dredged | economic; ecological |
| Seawall Construction began | 1918 | | social |
| | 1921 | Geological Surveys | economic |
| | 1923 | Draining of Sumas Lake | ecological; social |
| Landslides at UBC | 1935 | | ecological |
| | 1948 | Fraser River Flood, 2nd largest | social |
| | 1948 | Fraser Valley Dyking Board est. | administrative |
| | 1949 | Town Planning Act | administrative |
| North Arm Jetty Extension | 1951 | | economic; ecological |
| South Steveston Jetty Construction | 1951 | | economic; ecological |
| Sewage Water Plan | 1953 | | ecological |
| Iona Island Treatment Plant and Fill In | 1961/63 | | economic; ecological |
| | 1968 | Agreement on Flood Control Plan | administrative; social |
| | 1972 | Fraser River Flood, 3rd largest | economic; social |
| | 1973 | Trifurcation works | economic; ecological |
| Steveston Jetty reconstruction | 1978 | | ecological |
| UBC Cliff Erosion Task Force | 1979 | | ecological; social |
| Seawall completed | 1980 | | social |
| Iona South Jetty extended | 1988 | | ecological |
| Damage to the Cliffs | 1989 | | ecological |
| Stormwater-Runoff destroyes property | 1990s | | economic |
| | 1996 | Dike Maintenance Act | administrative |
| | 1998 | Canada Marine Act | administrative; ecological |
| Seabed Slope Study: Instability | 1998 | | social |
| | 2010 | Wetland Loss Study | ecological |
| Sensitive Ecosystem Study - Technical Report | 2010 | | ecological |
| Study concludes UBC Cliffs unstable | 2016 | | ecological; social |
| Tidal Marsh Project for Marsh Creation | 2017 | | ecological |
| False Creek Flats Plan | 2017 | | ecological; social |
| False Creek Pollution | 2018 | | ecological |
| | 2018 | Coastal Restoration Fund | administrative; ecological |

Table 1. Overview Timeline

### 3.2. General History of Metro Vancouver

The settlement of the Lower Mainland region can be traced back long before the arrival of the first Europeans. Many coastal First Nations resided in British Columbia, with mainly the Musqueam and the Squamish inhabiting what is today Metro Vancouver. The Vancouver territory was confirmed to be settled by the Musqueam people for at least 3,000 years, with other sites in the Greater Vancouver area reportedly being inhabited for an estimated 8,000 years. The first contacts with Europeans and their introduced diseases in the late 1800s were fatal to most members of the aboriginal nations, but it was not until the beginning of large-scale colonization that what remained of the First Nations was driven off their traditional lands to make room for European development desires (McDonald 1992 10-13).

Fig. 4. Native Settlement prior to Colonial Period


This map (see Fig. 4) shows different locations of native settlement in the Lower Mainland. Smaller markings indicate temporary settlements, bigger markings indicate villages.

Today, with 75% of the population located in the southwest corner of the province, Metro Vancouver is the most densely populated area of British Columbia (Lemmen et al. 2016). Situated in glacial lowland (Robinson 2007) that is streaked and defined by the Fraser River, and westwards enclosed by its estuary and the coastline, the general vulnerability of the area to extreme weather events is evident and severely characterizes the history of the region.

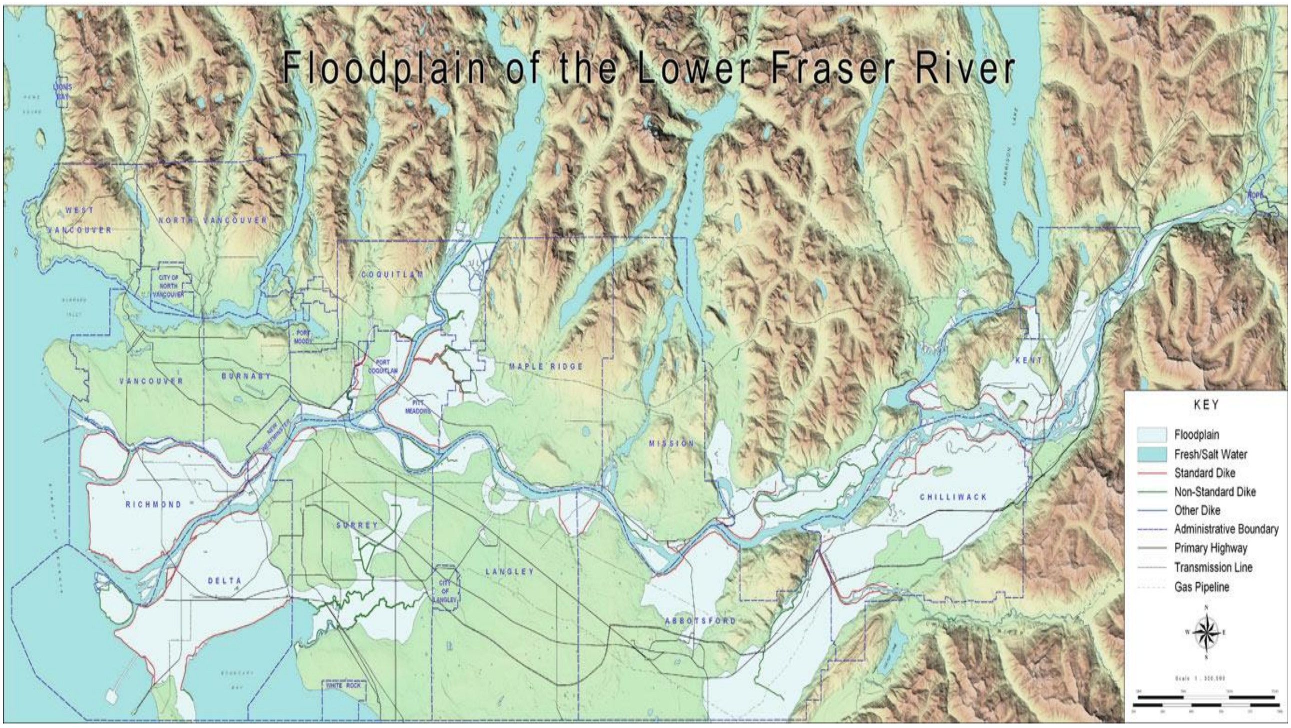
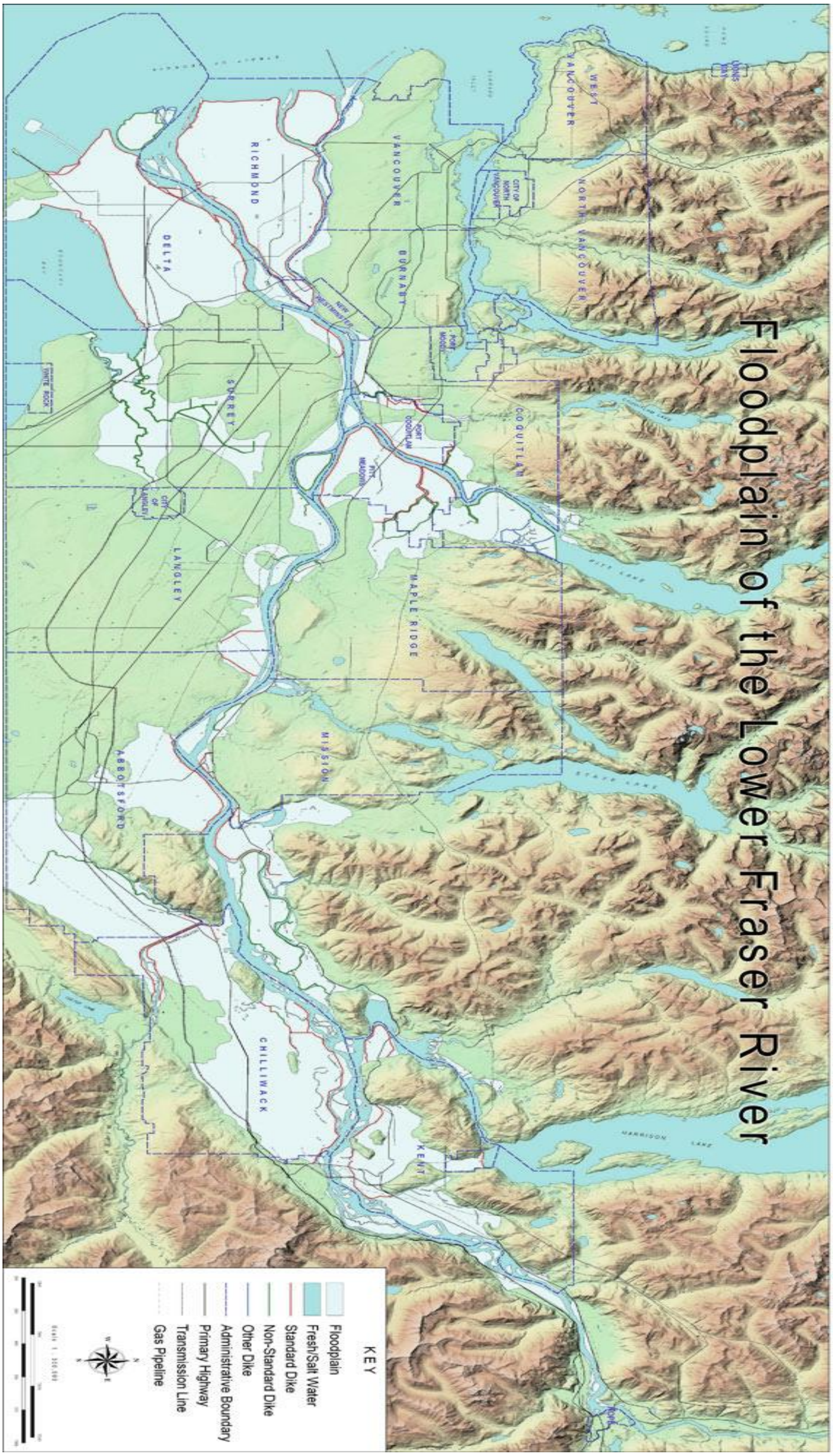



Fig. 5. Floodplain of the Lower Fraser

This map (see Fig. 5) shows which areas are most prone to flooding due to their low elevation above mean sea level, highlighted in light blue; it also shows dike location throughout the Lower Mainland.

Fig. 5. Floodplain of the Lower Fraser



### 3.2.1. 1860-1880

The defining development for this period of time is the starting of a large-scale European settlement. Settlers were drawn into the region because of the abundance of natural resources, of which especially wood and gold were of initial interest. Both industries - mining as well as wood-processing - followed by fish-processing in Greater Vancouver (McDonald 14-17), and in later years agriculture along with import and export, set the frame for the total dependence on and heavy usage of the waterways and harbors in the area.

With the Fraser being crucial to all those industries, and to facilitate the better management of the river and the river delta, the first dredging efforts even precede this time-period and date as far back as the beginning of the 19th century (Hales 29).

This map (see Fig. 6) from 1860 is one of the earliest available maps of the region, noting that caution had to be used when accessing the channels by ship, and with notes and necessary information on how to navigate them. It also displays the locations of the first mills on the north and south shore of the Burrard Inlet, as well as indicating areas of land that are floodplain throughout the summer (Pitt Meadows).

Also within this time period is the ratification of the first act linked to flood protection, which also directly relates to better facilitation and management of proper settlement and subsistence economy - ***1873's Drainage, Dyking, and Irrigation Act***. While not laying the foundation for governmental involvement, this administrative novum regulated the formation of diking districts ("Administrative Historical Study" 25-28).

Fig. 6. Fraser River and Burrard Inlet Map (1860)

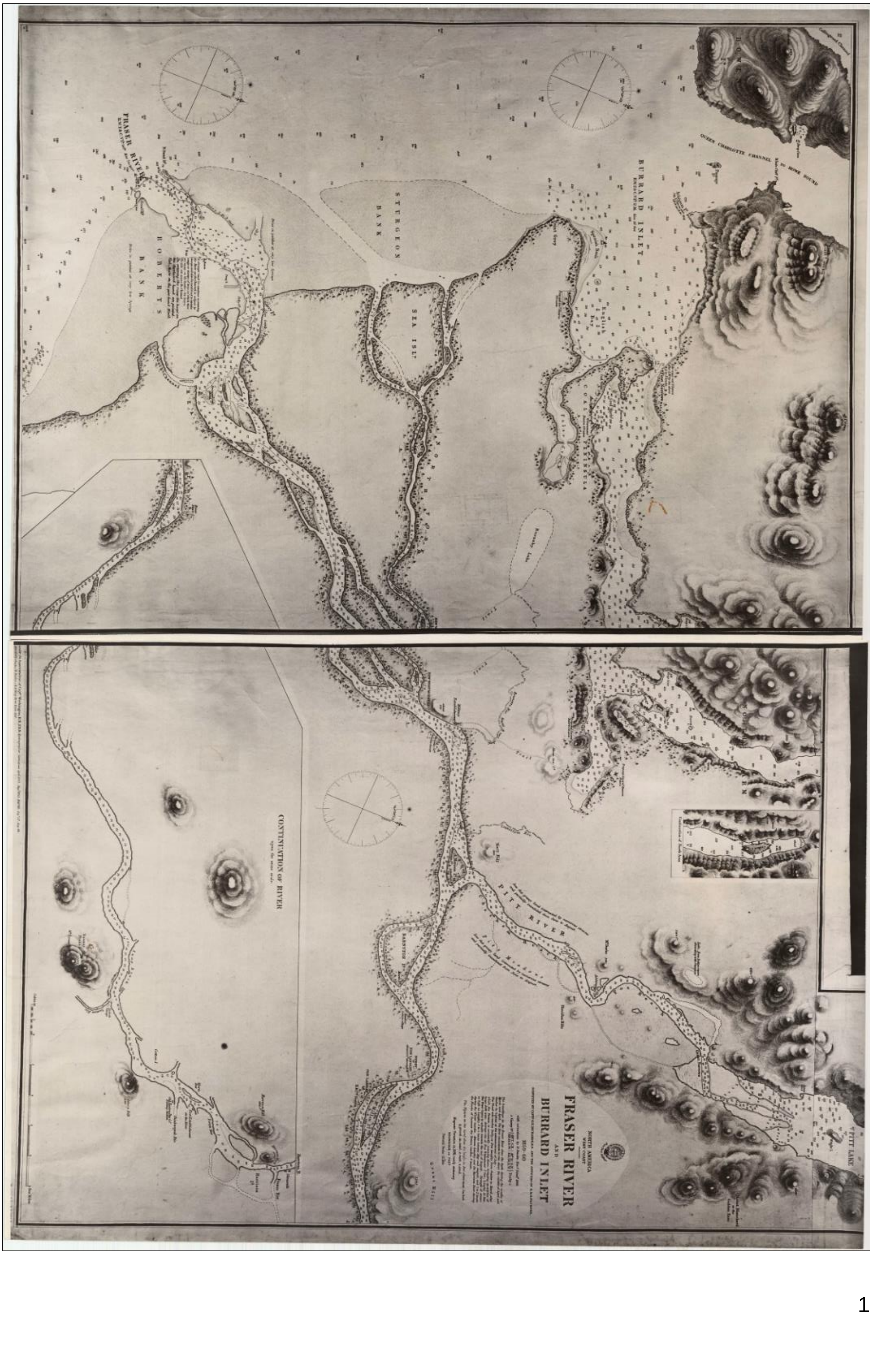


Fig. 7. Dredging Ditches on Lulu Island

Prior to this legislation, erecting dikes to secure one's own property was largely a private affair, but soon it was gradually better coordinated and regulated in order to create and maintain areas of dry, farmable land. After 1880 the municipal government became increasingly involved and first enterprises that were tasked with drainage and diking emerged (Hynek 1-3).

This picture from 1891 (see Fig. 7) shows a heavy machinery dredging float that digs ditches as a measure of floodproofing.

### 3.2.2. 1880-1900

Of special interest in this time-frame is the Fraser River Flood of 1894. With some evidence that unusually high levels of snowfall in the preceding winter might be a contribution to the largest flood event to date in the region - with an estimated watermark of almost 7,85m at Mission, and an estimated discharge of 17,000m³ per second - this event today serves as a model to design and simulate extreme flood scenarios (Northwest Hydraulic Consultants 10-11).

Due to sparse settlement in the Fraser Lowland at that time, the economic and infrastructural losses were not as high as those caused by the second highest flood event, the flood of 1948 (Burton 2006).

The Alexandra Suspension bridge located few kilometers north of Spuzzum can serve as visualizing aid for the flood extent. Erected in 1863, the suspension bridge spanned 23m above normal water levels in the Fraser Canyon and was washed away and destroyed by the flood (Northwest Hydraulic Consultants 8).

Fig. 8. Alexandra Suspension Bridge (1868)

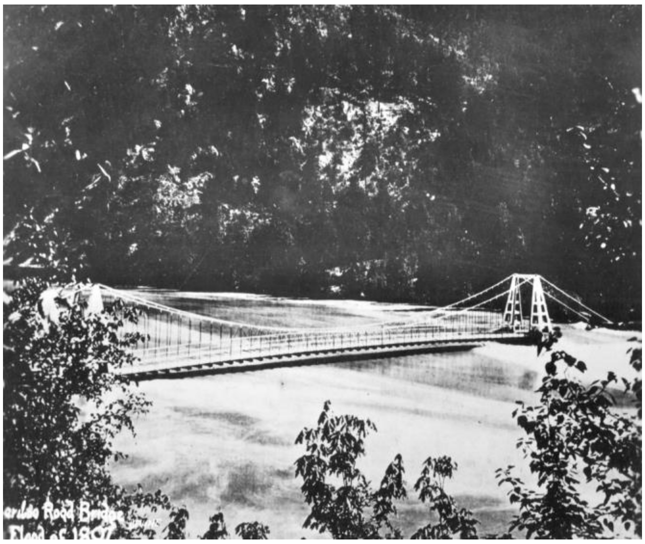


Fig. 9. Bridge during the 1894 flood

While more specific descriptions of the flood extent in the Lowland are hard to find, reports do describe that the Fraser section between the Harrison River and Richmond was flooded. ("Flood and the Fraser"), and Annacis Island was reportedly completely submerged (Hughes et al. 2018).

For comparison, this aerial shows the conditions at Poplar Island during the second largest flood event, 1948.

Fig. 10. Aerial view of Poplar Island during 1948 flood (upstream)

Poplar Island is the island well visible in the forefront. Located behind Poplar Island is the upstream tip of Queensborough, and after that, with difficult visibility in the distance, Annacis Island, that was completely submerged during the 1894 flood (see Fig. 10 for upstream and Fig. 11 for downstream part).

Two more aerials from 1955 (see Fig. 12) and 1959 (see Fig. 13) show the upstream tip of Annacis, that could already be observed in the Poplar Island photographs.

The full dimensions of Annacis, and its relative size compared to Queensborough and Poplar Island, are displayed afterwards (see Fig. 14).

Fig. 11. Aerial view of Poplar Island during 1948 flood (downstream)

Fig. 12. Annacis Island upstream tip close-up (1955)

Fig. 13. Annacis Island upstream tip (1959)

Fig. 14. Annacis Island today

3.2.3. 1900-1920

Combating the yearly spring floods, and as an aftermath of the 1948 record flood, the diking system on Lulu Island was further extended (Northwest Hydraulic Consultants & Triton Consultants Ltd. 4-7). Reliable protection against flooding was an existential requirement for further development of the area since Richmond and Delta are situated on low elevations and constantly threatened by both river and sea flooding.

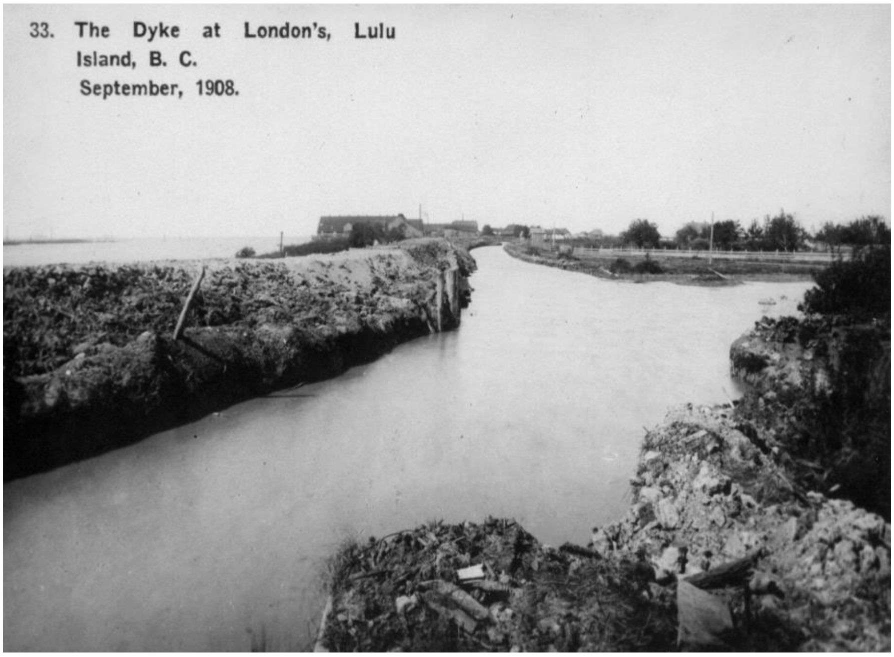


Fig. 15. Dike on Lulu Island (1908)

This photograph from 1908 shows the early diking systems on Lulu Island. Design standards that were not able to provide reliable protection were not yet implemented. Gradual upgrades and improvements in the decades to come were therefore indispensable.

Another important intervention of this period is a historical account ("The North Arm of the Fraser – Industry in 1918" 2018) on dredging of the Fraser: dredging started as soon as the early 19th century and continues to this day. Aside from borrow dredging that refers to the extracting of sand and gravel material to use elsewhere, it contributes as well to flood control since it lowers and stabilizes water levels (Northwest Hydraulic Consultants & Triton Consultants Ltd. 19-20). In 1918, however, dredging was an economic necessity in terms of facilitating the navigability of the lower Fraser river for deeper, larger vessels ("The North Arm of the Fraser – Industry in 1918" 2018).

Today, dredging efforts have declined, not only because of the detrimental effects on the fluvial ecosystems but also on account of possible negative effects due to altered sedimentation patterns. The changes in sedimentation might contribute to the erosion of the off-coast sandbanks and are under observation (Atkins et al. 793). Moreover, McLean et al. (403) discuss that while it is difficult to assess the single effects of dredging in the highly trained and altered river environment of the nowadays Fraser, the beneficial effects of the measure must be generally disputed.

### 3.2.4. 1920-1940

In 1921 important geological surveys were published that examined the sedimentation patterns and geological features of the Fraser River delta.

The differences in material, size, and weight of the sediments result in different deposit patterns throughout the delta. In combination with differences in depth profile and channel width of the Fraser arms, which results in locally variant streaming velocities, the aggregation and erosion patterns of deposits are highly variable and subject to constant change (Johnston 1921 3-15).

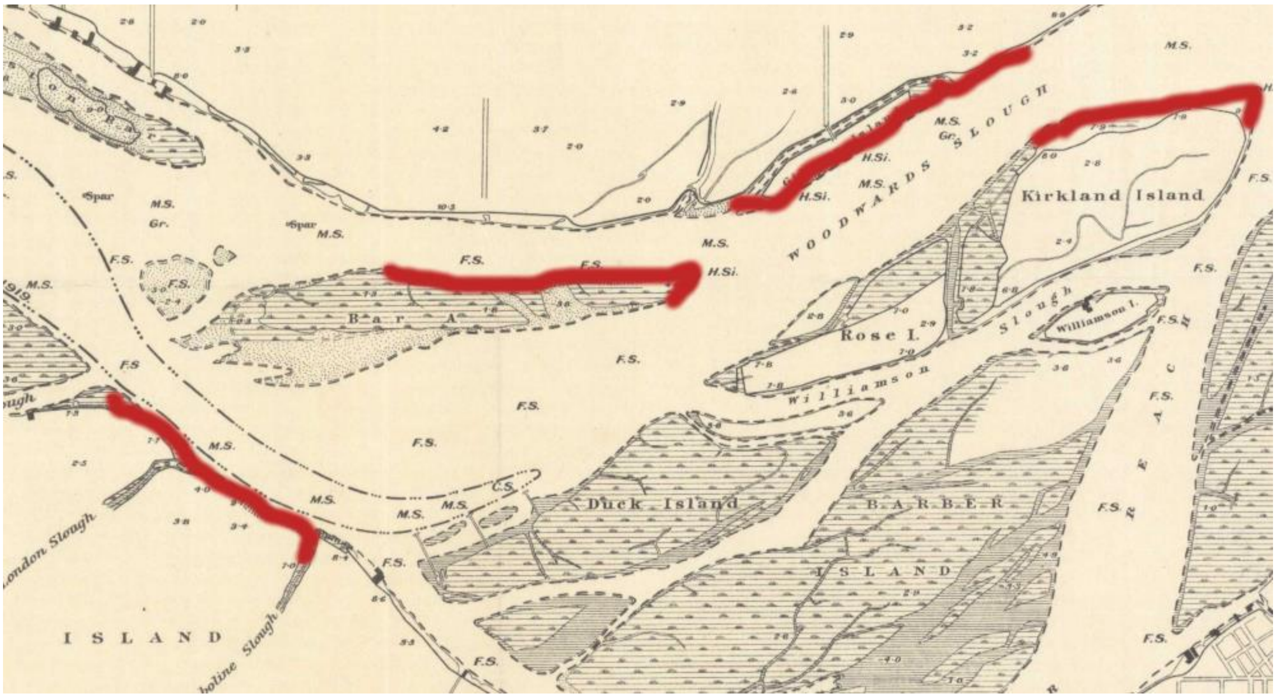



Fig. 16. Riverbank sections affected by erosion

This close-up (see Fig. 16) of a map in the ***Sedimentation of the Fraser River*** geological survey depicts the in-river banks most prone to erosion in the area of Woodwards Landing, here highlighted in red. The entire map is displayed afterwards (see Fig. 17).

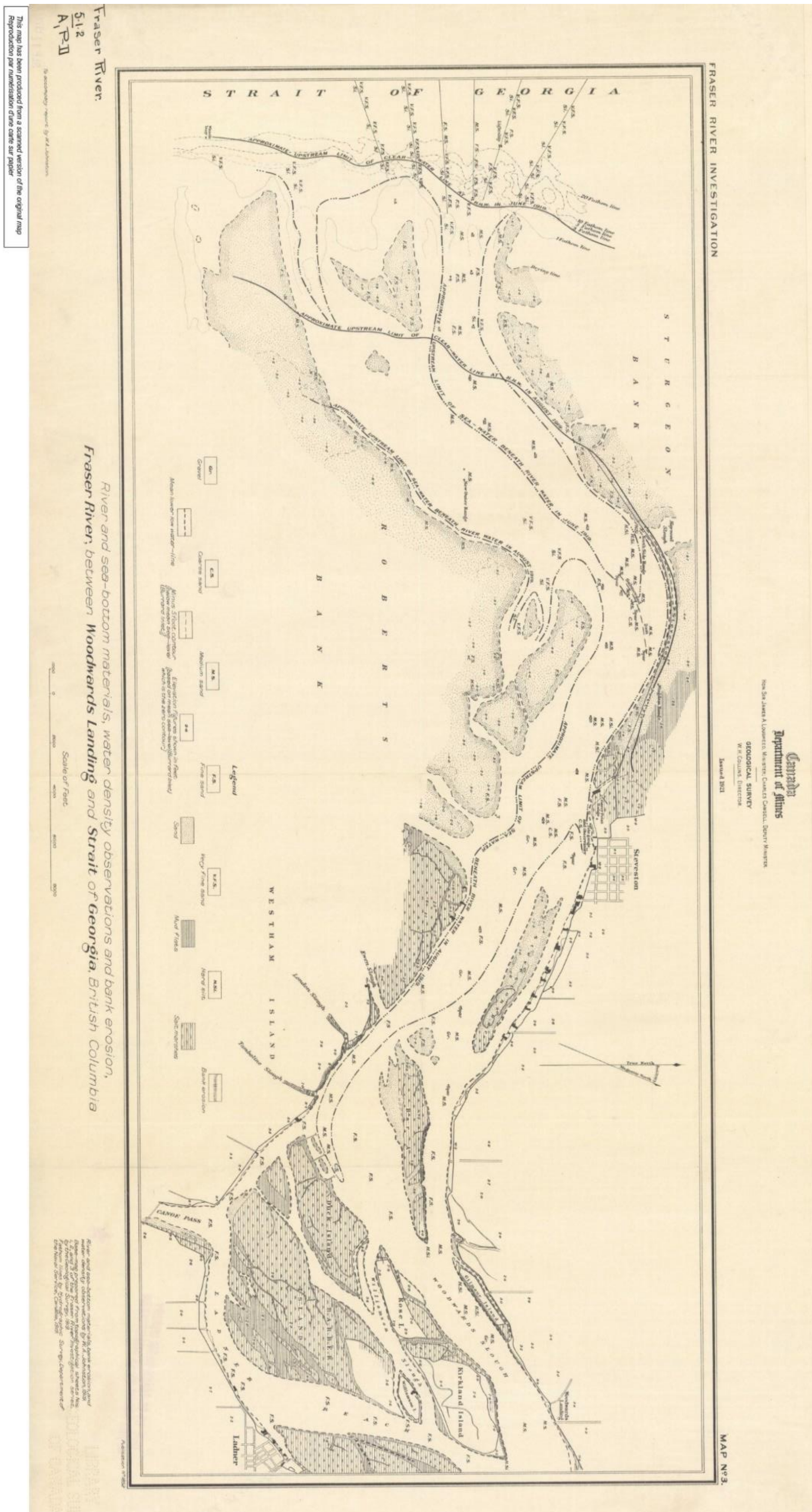



Fig. 17. Erosion map of the Area between Woodwards Landing and the Strait of Georgia

The high dynamics of the changing landscapes in the delta are well illustrated with the case of the Westham Island environment.

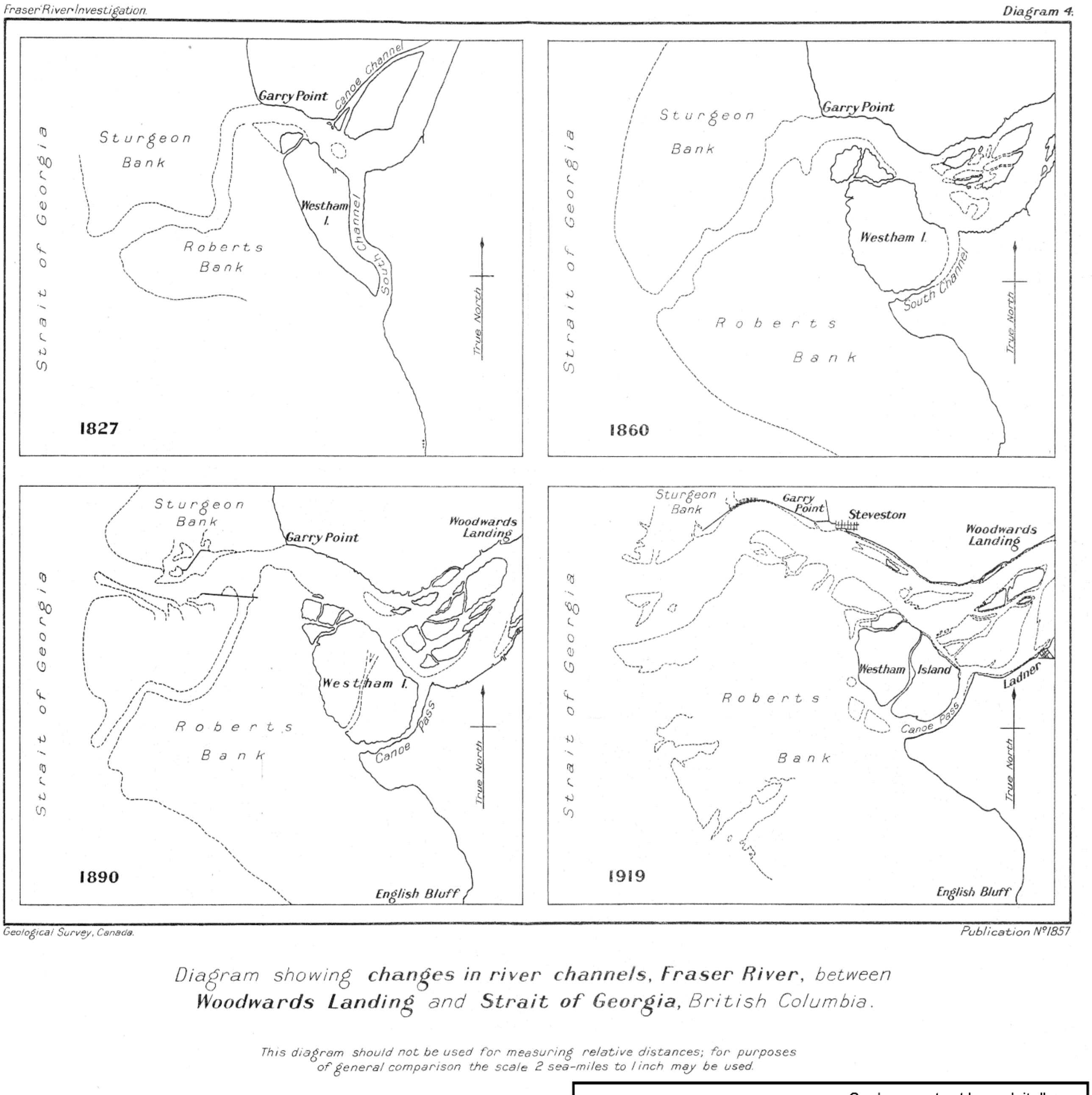



Fig. 18. Study of changes in the Westham Island area

For comparison, Westham Island as of 2018. Management and diking of the delta have maintained the island in comparably similar condition as of 1919.


Fig. 19. Westham Island today

Another large-scale intervention of the 1920-1940 period is the draining of Sumas Lake. The Lake was located between Abbotsford and Chilliwack, south of the Sumas Mountain. The region surrounding Sumas Lake was the traditional territory of the Sumas band and other First Nations and has been inhabited long before European colonialization started (Archer).

Photographs from 1922 show the dimensions of the lake,
that was surrounded by extensive wetland and swamp areas
(see Fig. 20 and 21).

Fig. 20. Sumas Lake before the reclamation (1922)

Fig. 21. Wetlands at Sumas Lake (1922)

In the early years of the 1920s, plans were developed to drain the lake, mostly in order to convert the inundated area and the extensive wetlands it into dry, fertile, and farmable land that could fit European needs. Previous attempts to settle and farm the area had been frustrated by the difficult on-site conditions and recurring flooding events.

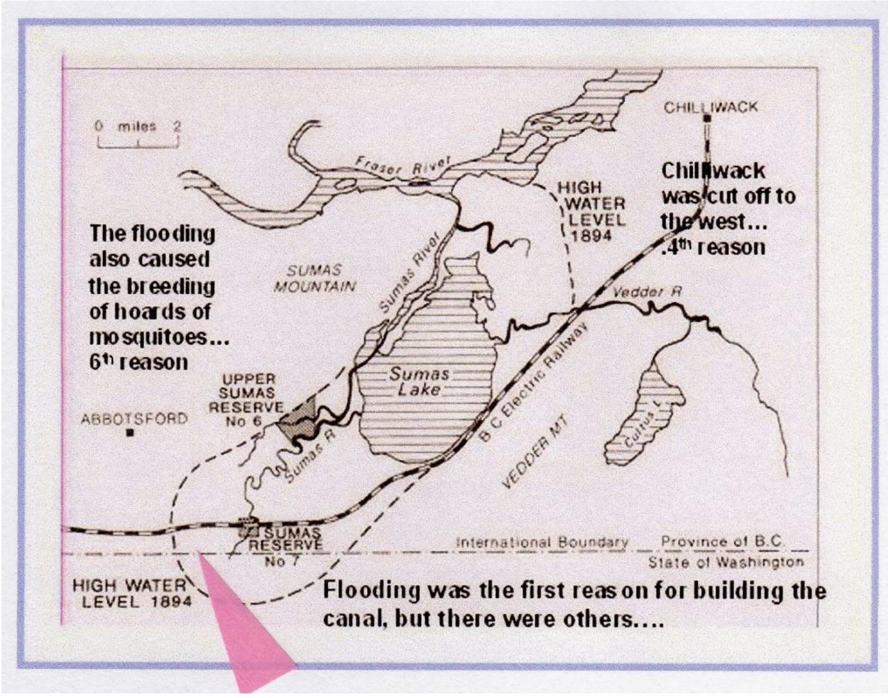



Fig. 22. Sumas Lake with 1894 flood outline

The Sumas Lake area, located between the Sumas mountain to the northwest and the Vedder Mountain to the southeast (see Fig. 22), was affected by yearly extensive spring flooding.

After the area was drained, the space was converted into farmland (see Fig. 23).

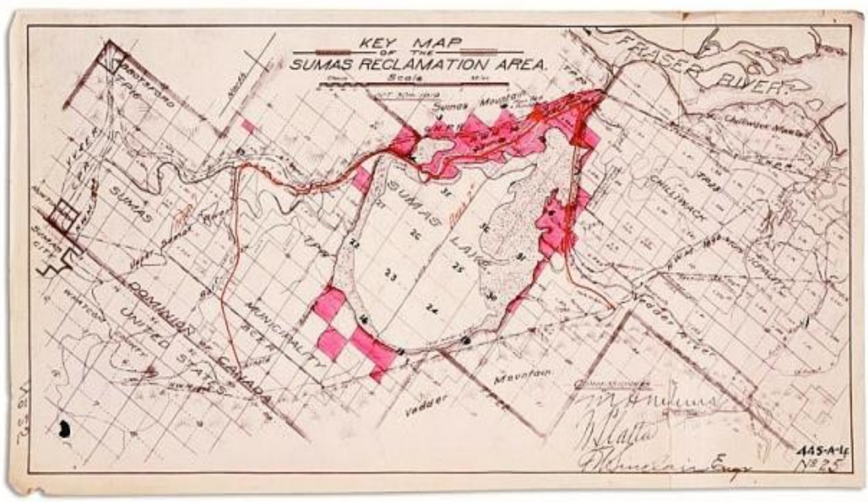



Fig. 23. Map of the Sumas reclamation area

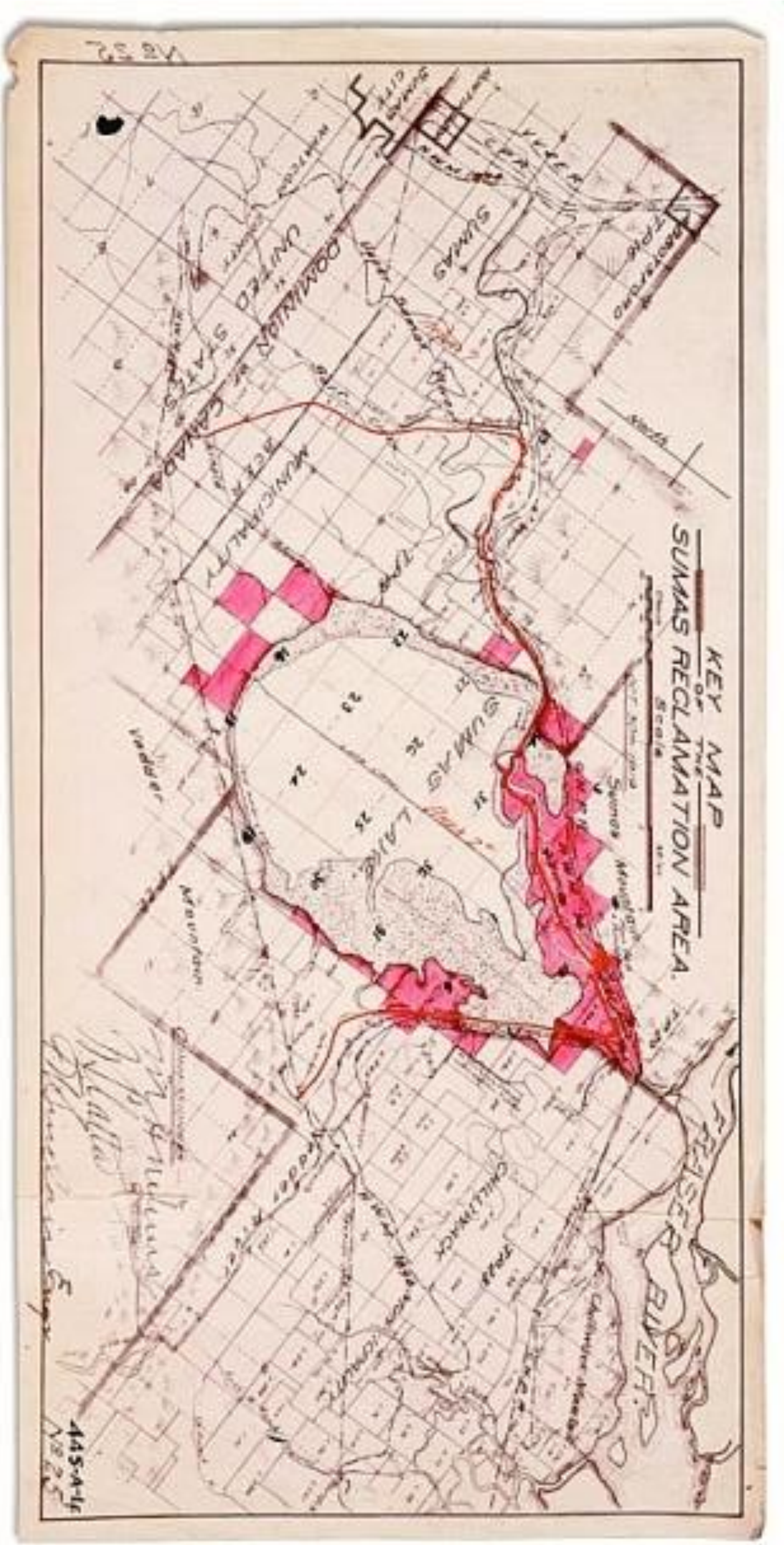



Fig. 23. Map of the Sumas reclamation area

In 1923 the plans were put into practice and, the lake was drained into the Fraser River by utilizing a canal and pump system. The newly gained 134 km² of land was sold to farmers. The reclamation of Sumas Lake deprived the local First Nations of their traditional hunting and settlement territory and erased the origin of many resources crucial to their traditional aboriginal lifestyle (Smith & Verstraten 2013).

Today the Sumas, struggling with the complete disregard of their cultural and historical claims of the territory in the 1920s, are negotiating to have their losses compensated.

Fig. 24. Sumas Prairie with Sumas Mountain Fig. 25. Sumas drainage canal


Fig. 26. Sumas Prairie today

3.2.5. 1940-1960

With high levels of snowfall and late, but rapid thawing in May 1948 due to sudden weather change and above normal temperatures (Northwest Hydraulic Consultants 10-11), more than 50 years after the largest flood event ever documented in the region, a second extreme flood event took place. With a watermark of 7,5m at Mission, the flood of 1948 did not exceed the record flood in terms of its extent but in regard to the social and economic loss. The region was in the meantime much more densely populated and infrastructurally developed (Burton 2006).

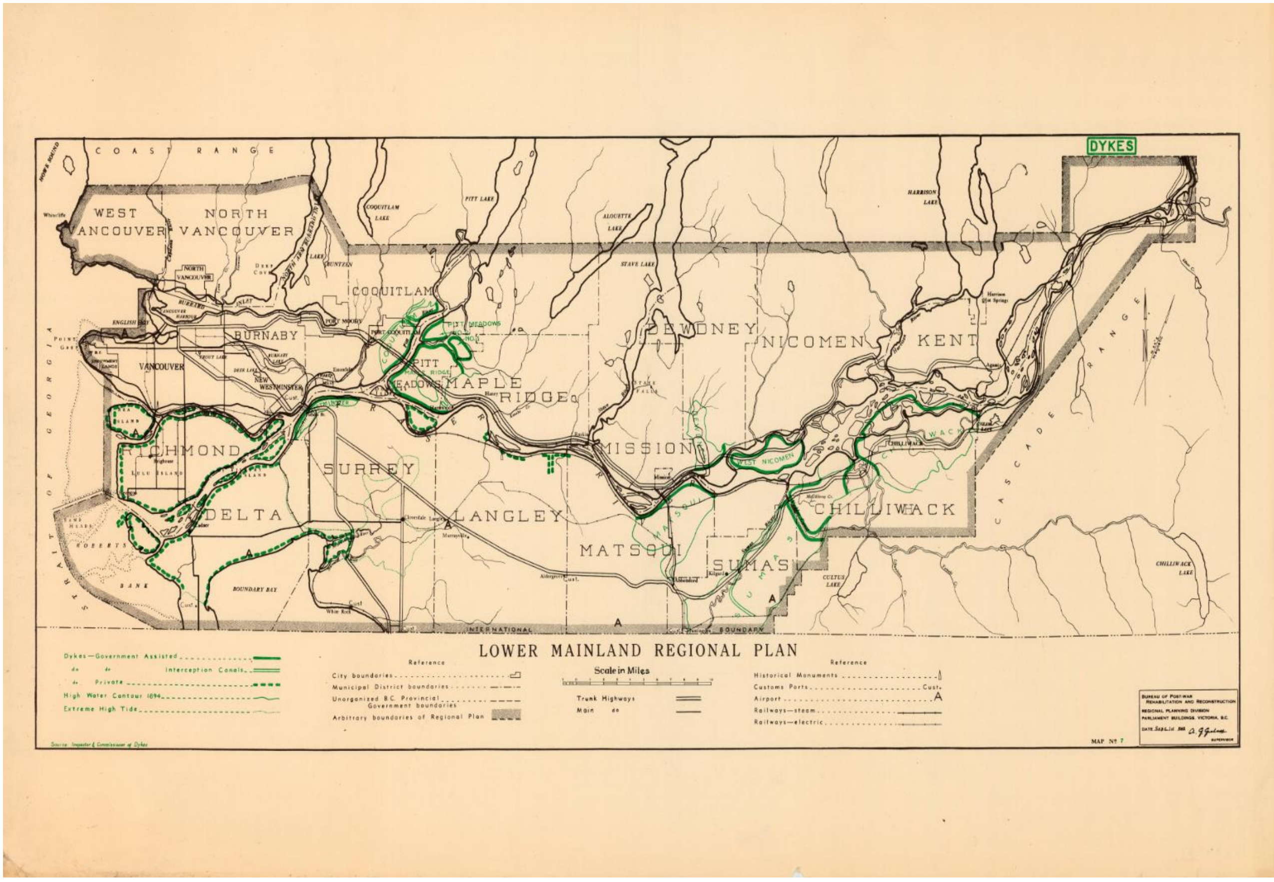


Fig. 27. Lower Mainland diking system (1945)

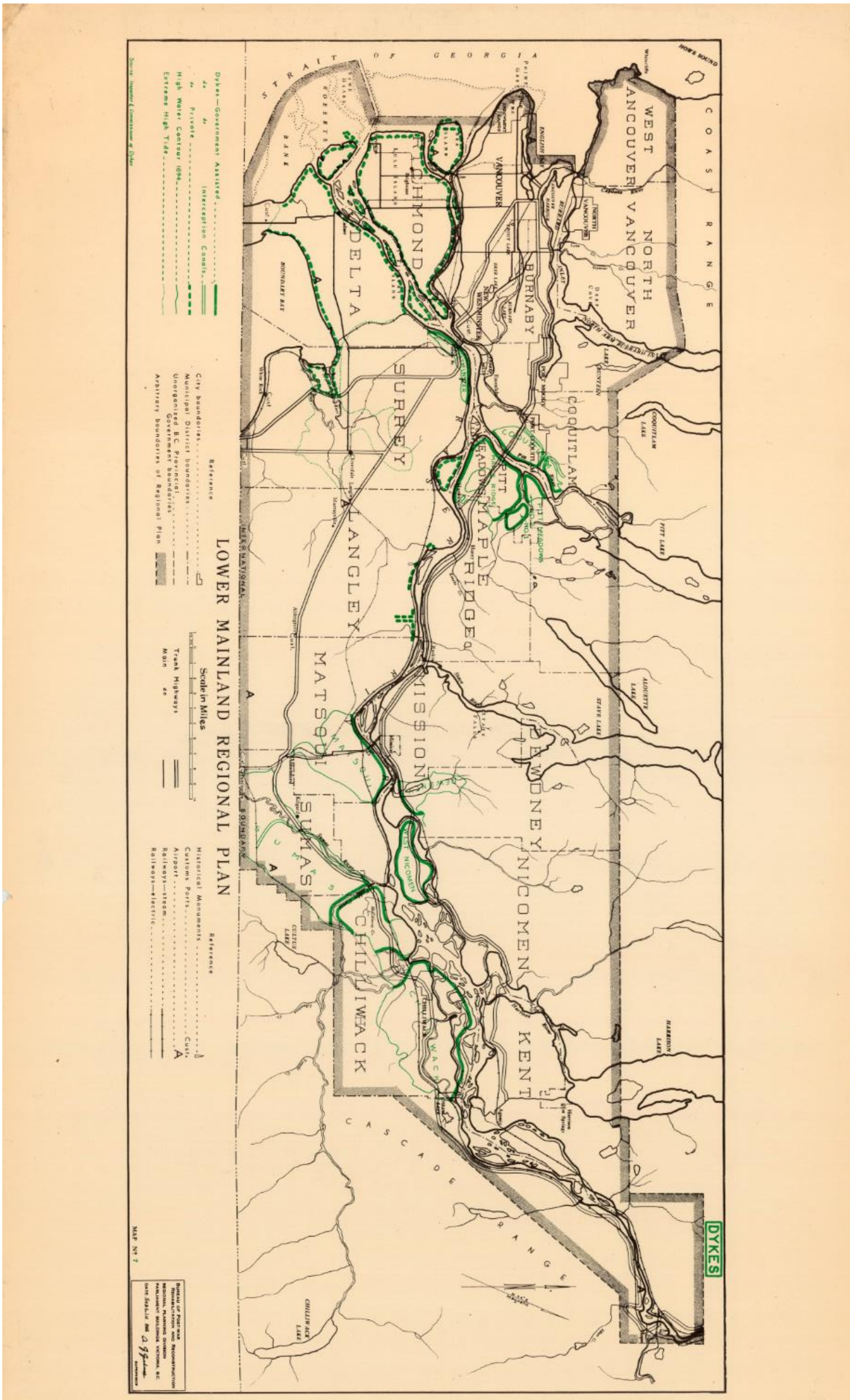



Fig. 27. Lower Mainland Diking system (1945)

This map (see Fig. 27) from 1945 provides an overview of the to that date established diking system, which could not provide sound protection against the flooding. Dikes breached on several locations throughout the Lowlands, with the heaviest flooding occurring in the area of Hatzic and Mission City. In the Greater Vancouver Regional District flooding occurred in the Langley area as well as near the Coquitlam River and at the tip of New Westminster.

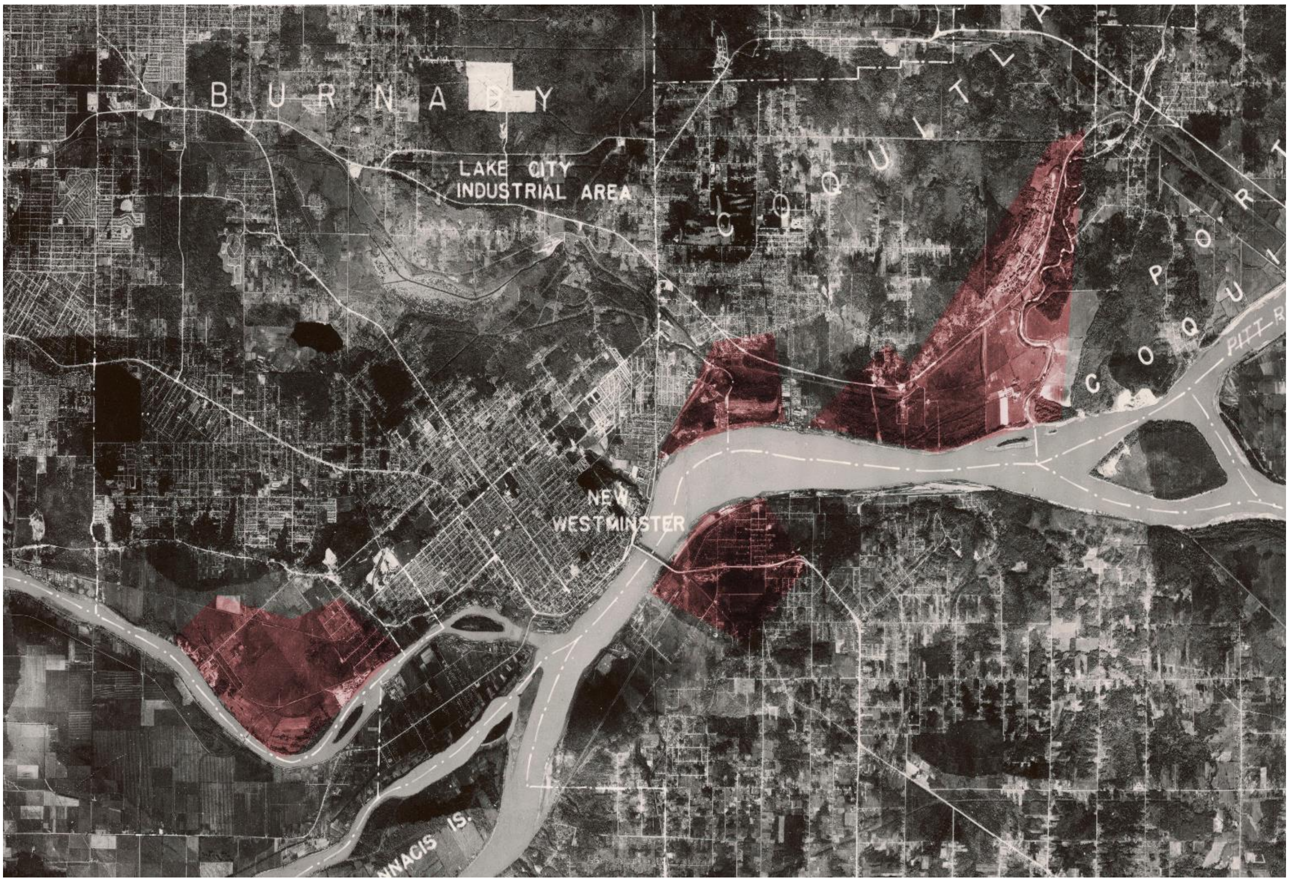


Fig. 28. Floodplain of 1948 on aerial of 1952

For illustration purposes, the flooded area of 1948 from Richmond up to the Coquitlam River, mapped onto an aerial of the 50s (see Fig. 28). Considerable parts of the tip of New Westminster and large areas adjacent to the Coquitlam River would be inundated. Today, the area of the 1948 floodplain is with exception of larger areas around the Coquitlam River mouth completely covered by infrastructure.

Mapping the floodplain on a current aerial visualizes how extensively developed the floodplain area is (see Fig. 29)

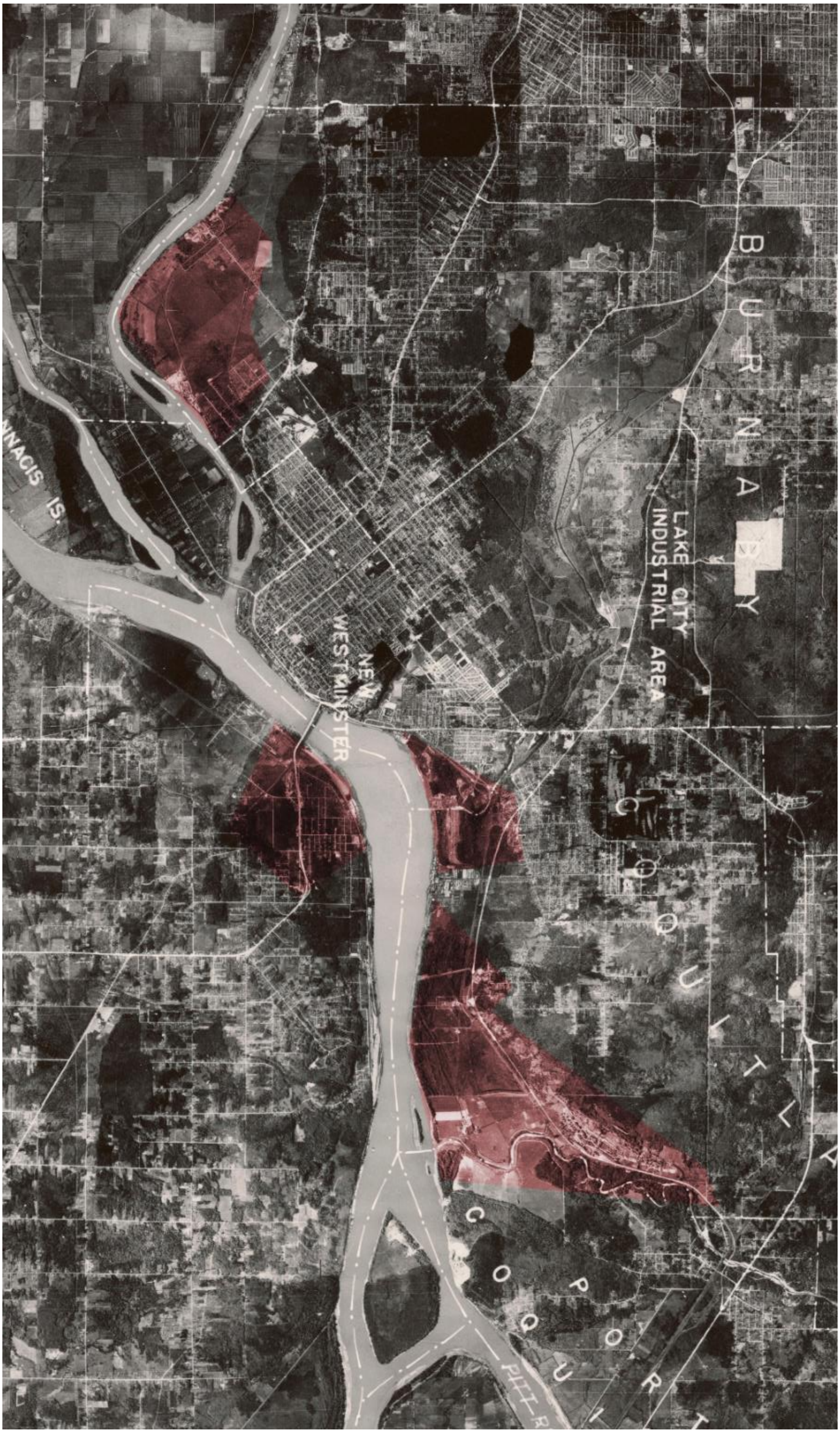



Fig. 28. Floodplain of 1948 on aerial of 1952

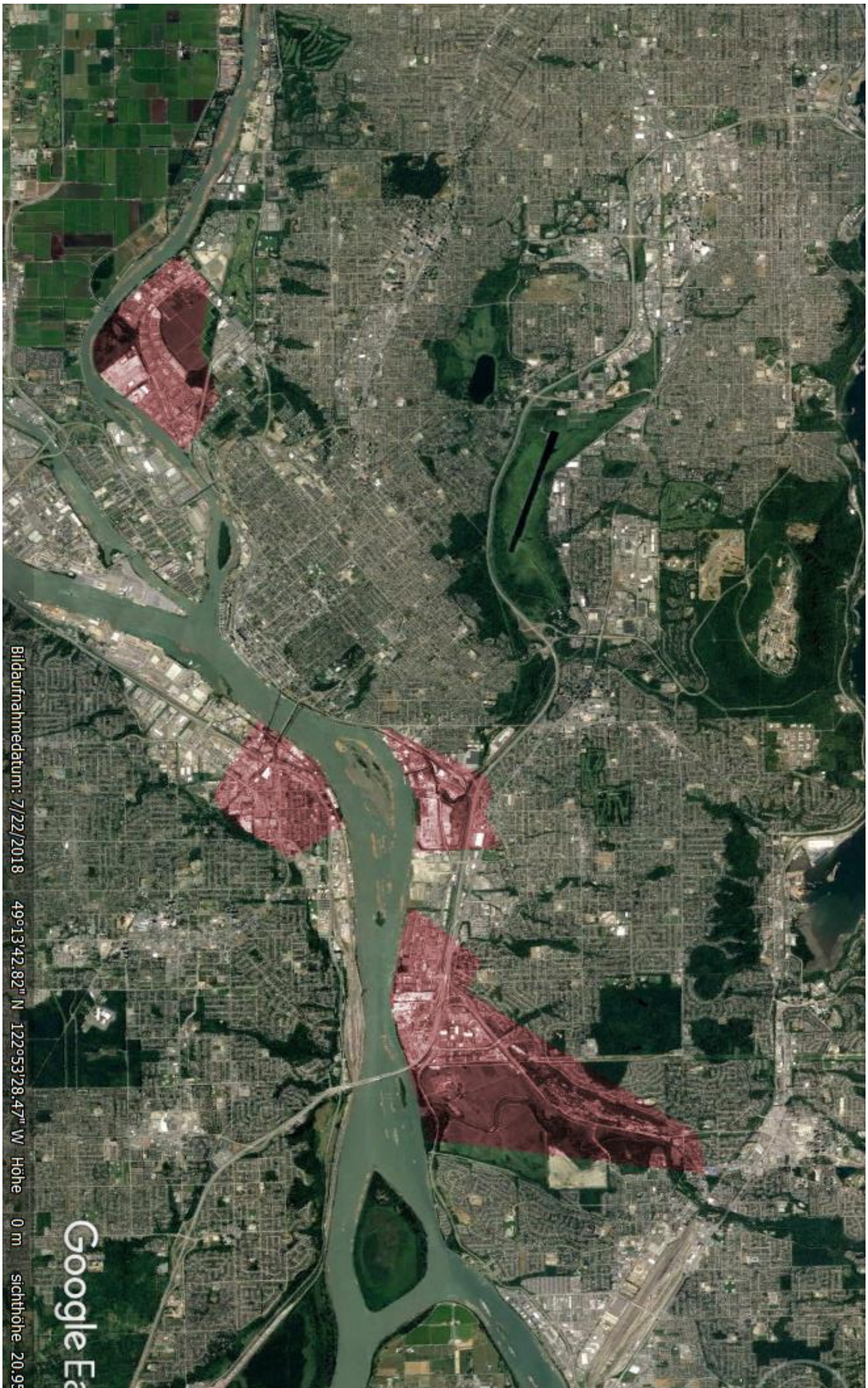


Fig. 29. Floodplain of 1948 on aerial of today

Legislative-wise important aftermath of the flood were amendments to the ***Town Planning Act*** in 1948, which with its ratification a few years later gave way to the flood zoning of the Lowlands, restricting the extensive development of areas that lie within the floodplain (Simmons et al. 14).

In addition, the Government of Canada and British Columbia established the ***Fraser Valley Diking Board***, tasked with the construction, repair, and remodeling of dikes. The Board set dike design standards, implementing to have the general crest height exceed the highest known water levels by over half a meter. The board ceded action in 1950 after significant improvements were made (5).

The ***Dominion-Provincial Board***, likewise founded in 1948 for the Fraser River Basin, had other equally important contributions to make. The basic accumulation of data as well as first attempts to develop multi-purpose solutions can be attributed to this institution. The board evaluated the general dike condition to be in severe need of improvement, and strongly recommended the general upgrade of flood protection (5).

### 3.2.6. 1960-1980

The final report of the ***Fraser River Diking Board*** led to the agreement upon a cooperative flood control plan in 1968 between the federal and provincial governments, acknowledging that further flood protection needs to be established (5). The flood event of 1972, which is the third highest flood event in the colonial period, put the diking system to test. Although flooding upstream occurred, the established flood protection generally prevented larger damage, especially in Metro Vancouver (Burton 2006).

Subsequently, containing the Fraser River was further advanced. The trifurcation works on Annacis Island in that period can be chosen as an exemplification of the heavy river training efforts in place.

The island is located at the trifurcation where the north arm and the Annacis channel branch off of the main channel. The island was rigged with dike works in the early 70s that led to severe alteration of flow patterns and bathymetry of the north arm, the Annacis channel, and the main channel. With building a V-shaped structure that is located partially submerged on the north-east tip of Annacis Island, about 15% of the main arm flow was redirected away from the main stream into the two channels. This provides a steady flow pattern for all canals, and, by installing further river narrowing structures, facilitates the three river channels to dig themselves out deep enough to provide better navigability, while at the same time reducing maintenance dredging ("Trifurcation Phase II Training Wall" 2014).

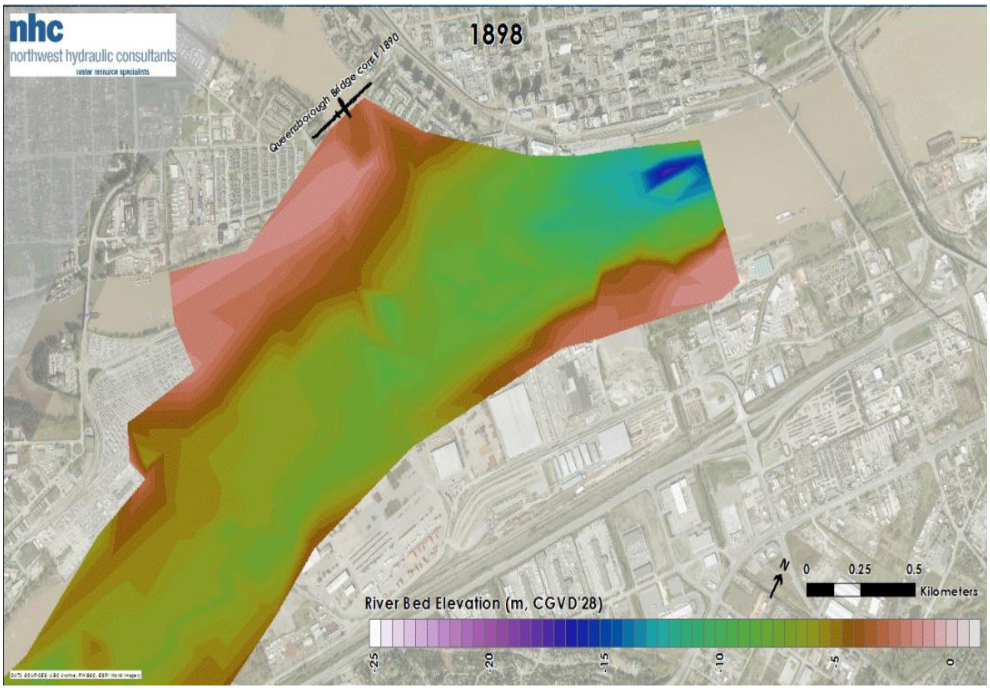


Fig. 30. 1898 channel depth Annacis Island

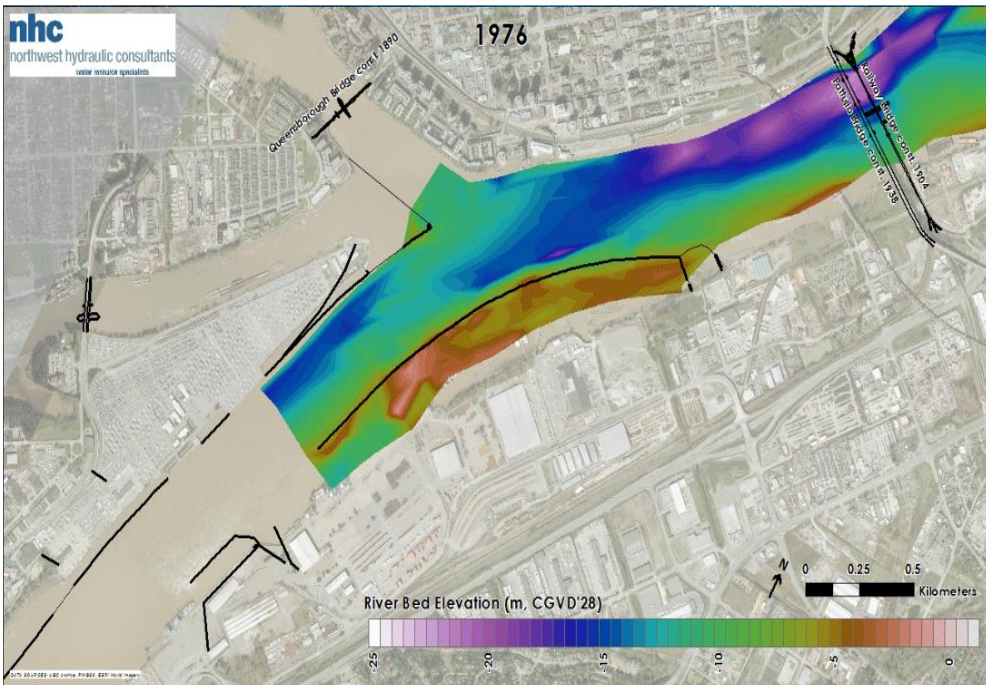


Fig. 31. 1976 channel depth Annacis Island

These publications by NHC (Northwest Hydraulic Consultants) visualize well, how the channel has transformed from a -2,5m to -12,5m range to a depth that well exceeds -12,5m in most places.

This aerial overview by Port Metro Vancouver of the trifurcation area from 1972, with (from up to down) the north arm, the Annacis channel, and the main channel on the left side of the image. Below the same area from another angle.

Fig. 32. Aerial overview of Annacis Island (1972)

Fig. 33. Aerial overview of Annacis Island (2017)

3.2.7. 1980-2000

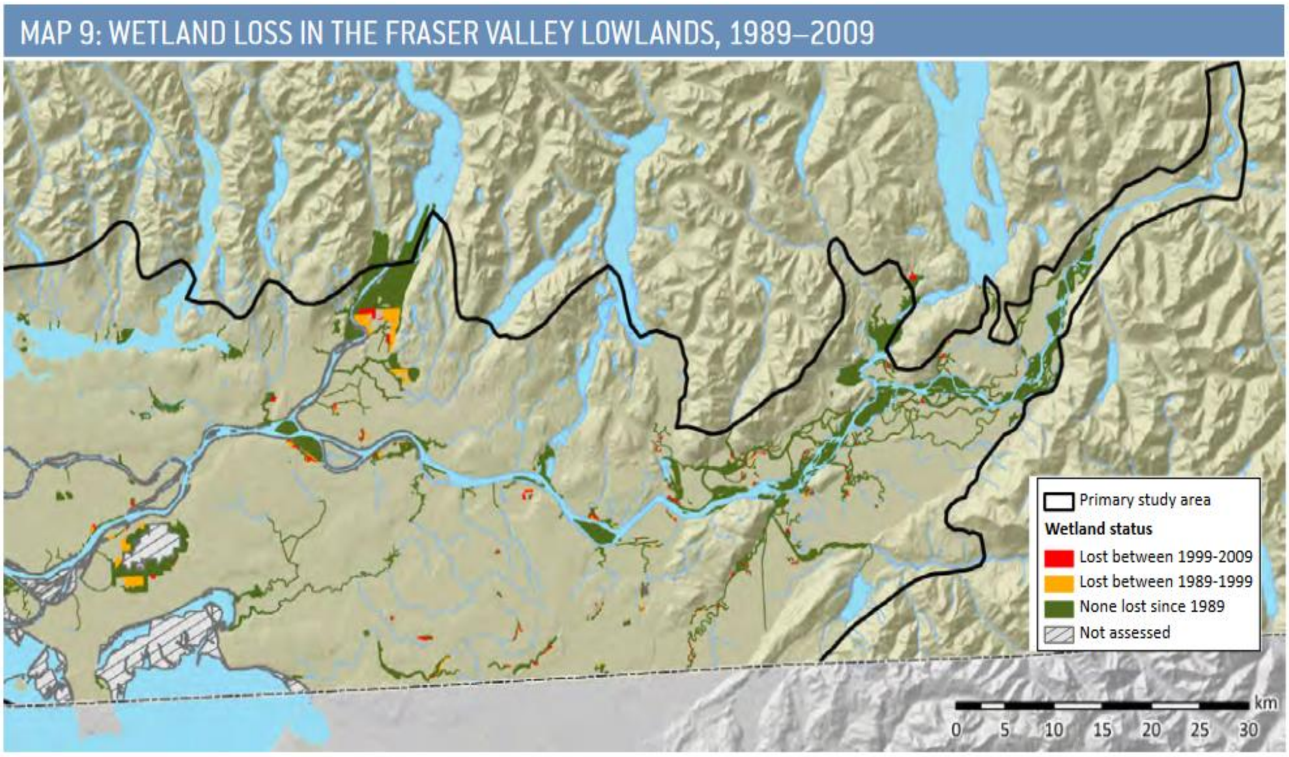


Fig. 34. Wetland Loss map

In terms of loss of productive ecosystems in the Fraser lowlands, especially the fast progressing conversion of large shares of wetlands in the Lower Mainland, mainly in the Metro Vancouver region, is problematic. In the timeframe 1989-99, an estimated 1,046ha of wetland was converted, for the most part for agricultural purpose or to create golf courses (Wilson 47-49).

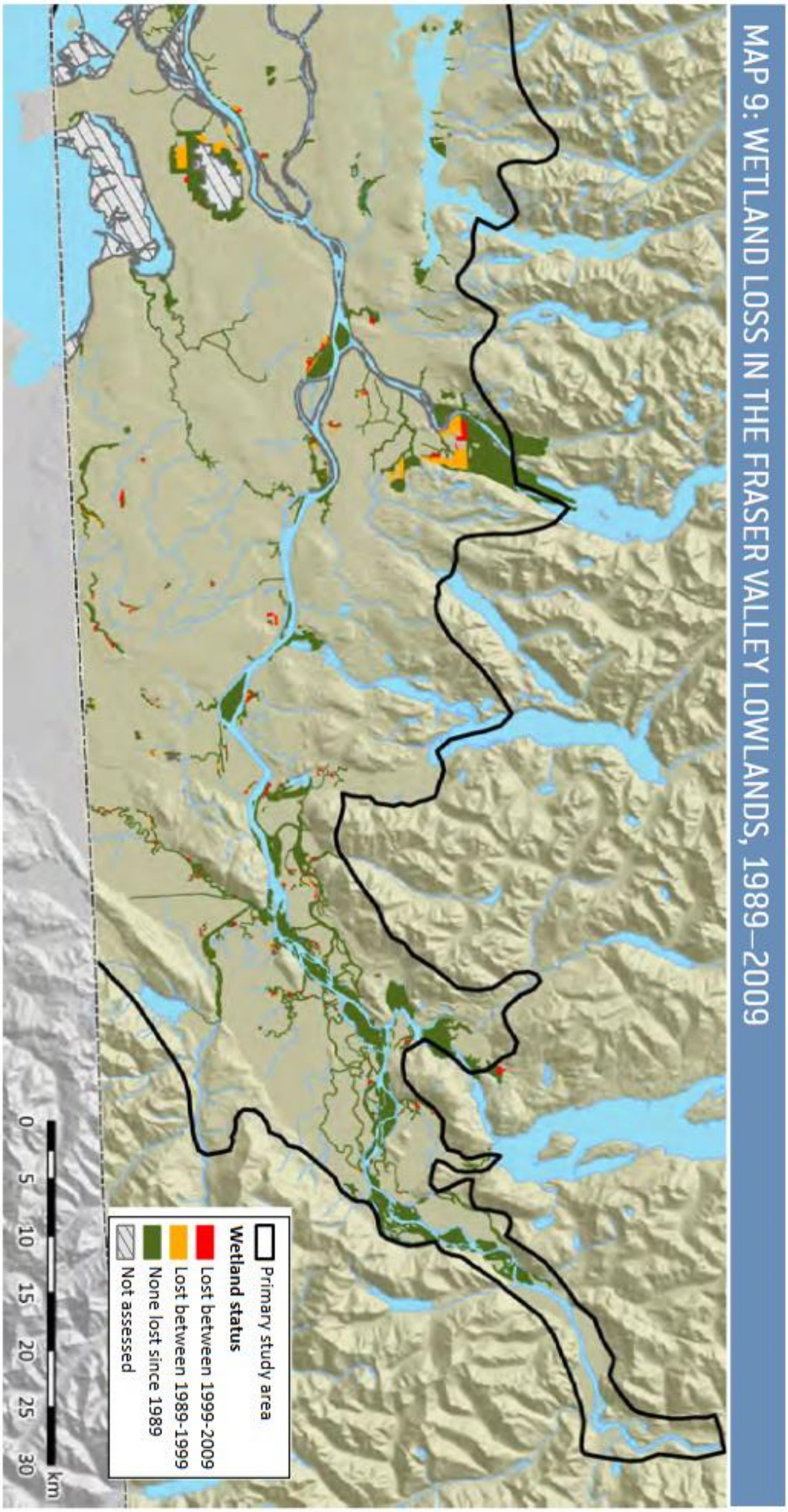



Fig. 34. Wetland Loss map

A close-up aerial of the south-west section of the map, of land close to the main channel and Annacis Island (the island in the upper middle), visualizes the change in wetland composition. Conditions 1985:


Fig. 35. Wetland Loss area I (1985)

The transformation and conversion processes are well visible when compared to other aerials (see Fig. 36)

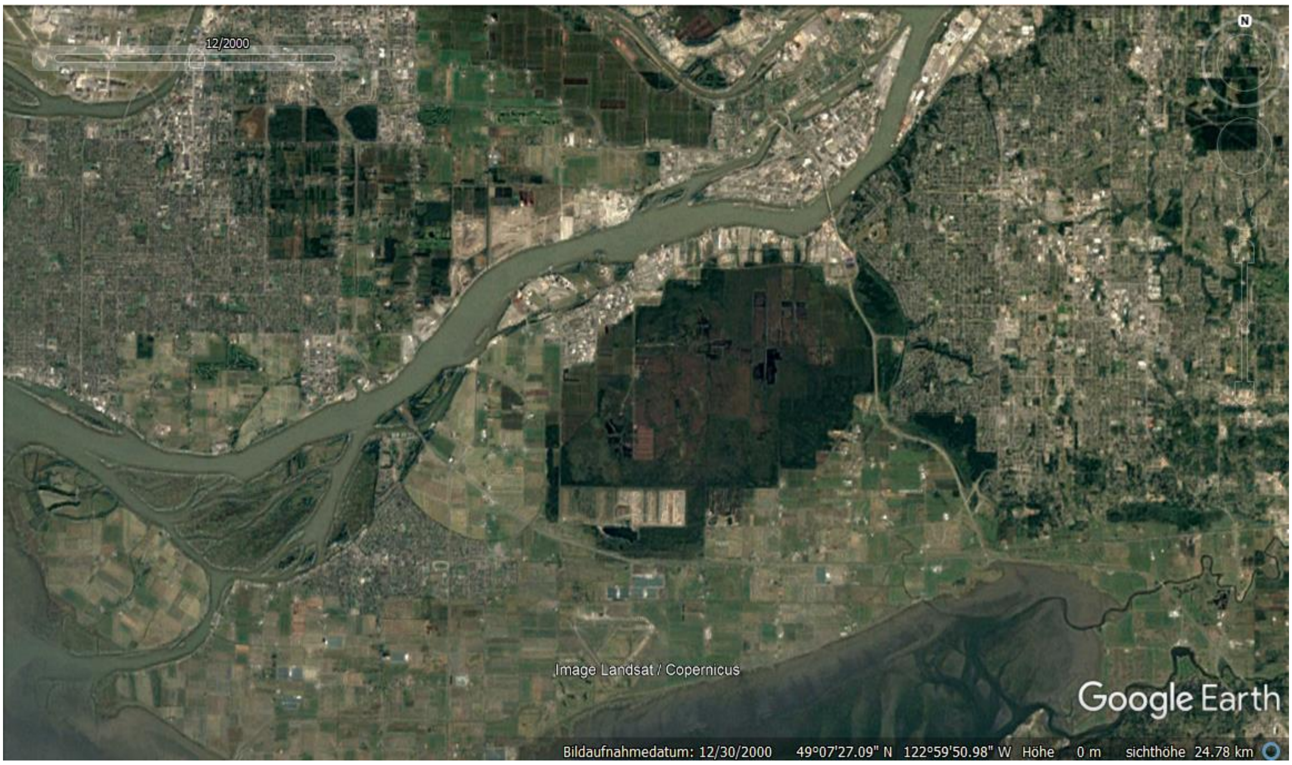


Fig. 36. Wetland Loss area I (2000)

The same area in 2000, as indicated by the Wetland Loss map. Land conversion is especially well visible in the areas highlighted below.

Fig. 37. Wetland Loss area I, highlighted


Fig. 37. Wetland Loss area I, highlighted

Less well visible changes occur in the region between Coquitlam and Maple Ridge. The conditions in 1986:


Fig. 38. Wetland Loss area II (1986)

In comparison the same area in 2001:

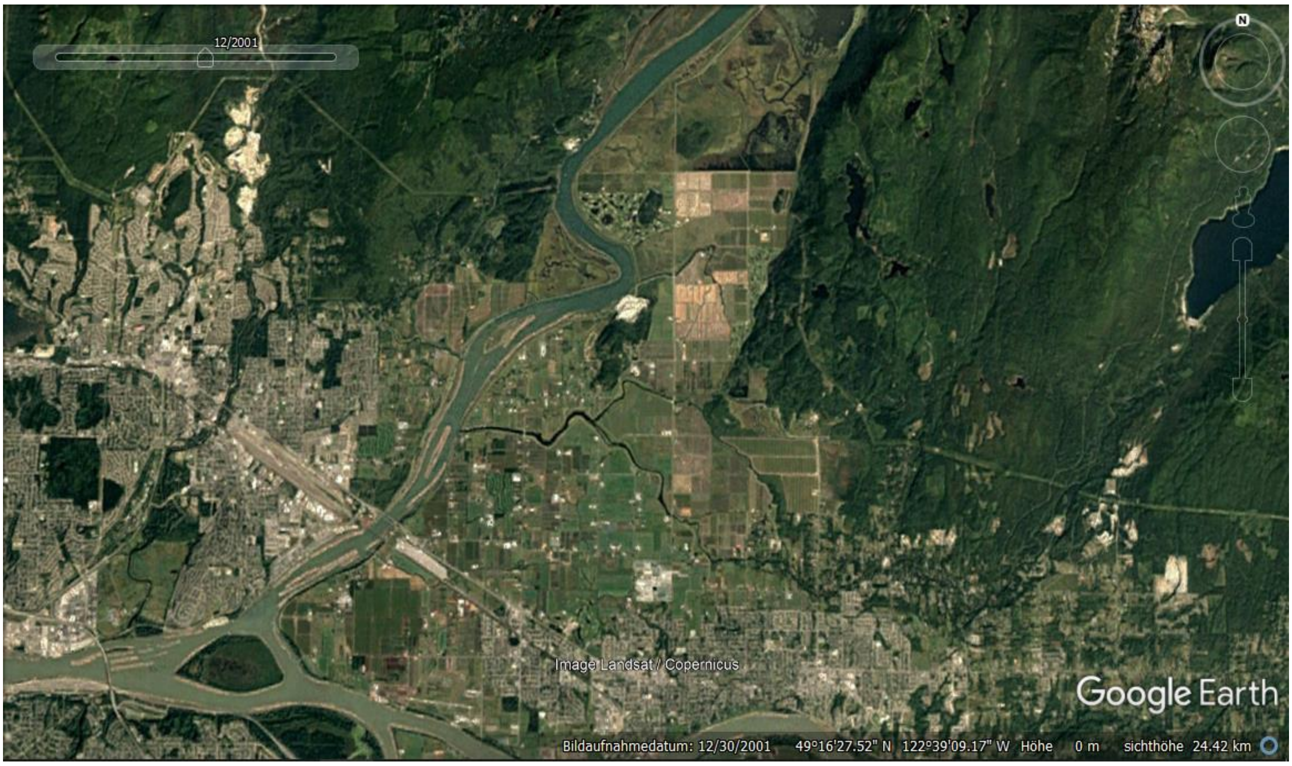



Fig. 39. Wetland Loss area II (2001)

The areas subject to change, highlighted:

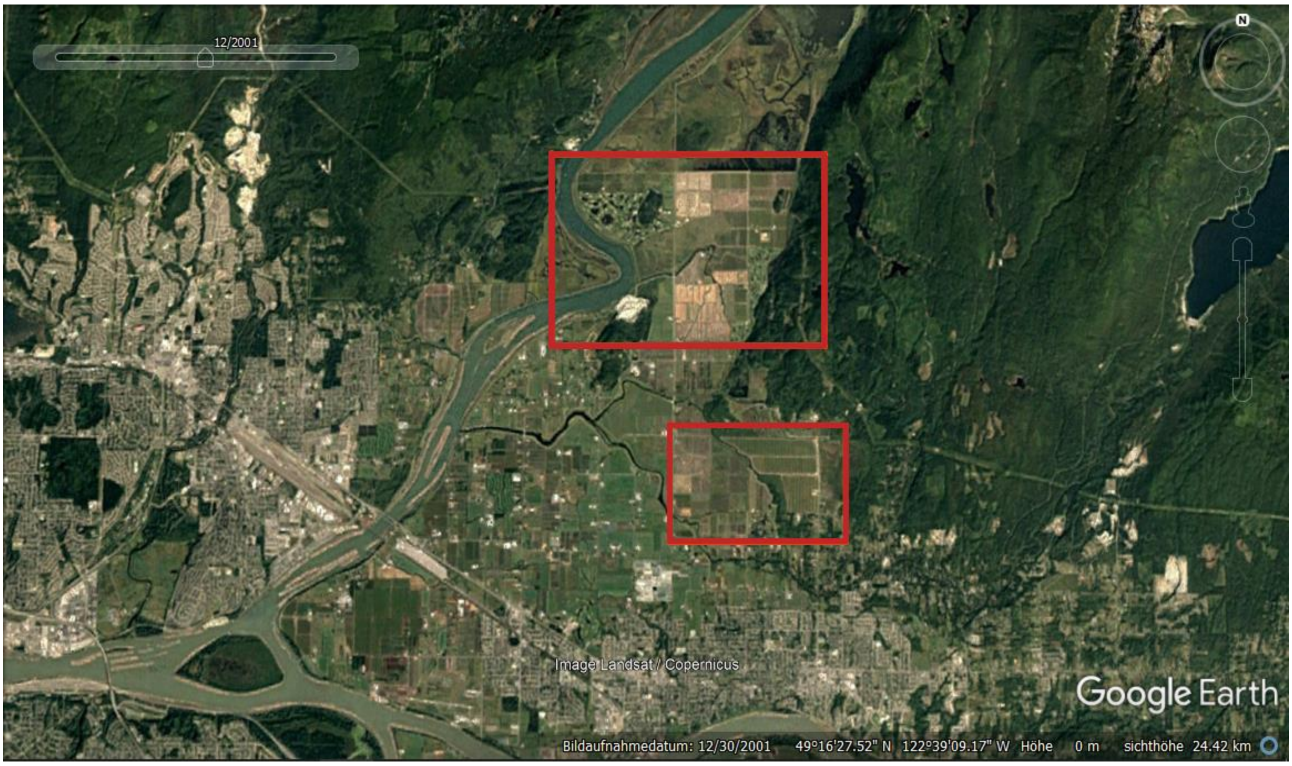



Fig. 40. Wetland Loss area II, highlighted

Wetlands offer a wide range of ecological contributions, of which the most important ones are aiding climate regulation, contaminant filtration and treatment, as well as water supply (Wilson 42-49). With the expansion of farmland close to the Fraser River and its tributaries, further stress was put on the fluvial and river adjacent ecosystems, since heavy machinery pollutants from large scale farming, along with fertilizers and pesticides contaminate rivers, soil, and groundwater (Pynn 2014).

However, an important legislative foundation for closely regulating, timing and reducing dredging was established by the ***Canada Marine Act***, in 1998 (Fraser River Estuary Management Program 1). This results in benefits for the fluvial habitat for salmonids, and the overall ecosystem. The heavily trimmed and altered Fraser channels and river tributaries (Hales 27-39), in combination with the transforming environments of the marshlands and sandbanks in the delta, put a strain on fish habitats and nursing grounds. Further protection measures need to be implemented to maintain a stable population.


Fig. 40. Wetland Loss area II, highlighted

### 3.2.8. 2000-2020:

The ***Dike Maintenance Act*** of 1996 serves as the main legislation governing the overseeing and improvement of structural flood-protection employed in British Columbia (The Arlington Group 22). However, today it is widely acknowledged that the approach to rely on structural measures only cannot completely reduce the risk of flood threats, which is why the range of adaptation and avoiding strategies needs to be broadened (Simmons et al. 4, 10-12).

Regarding hazard mapping and land zoning, this possibly includes retreat away from flood-plain lands and avoiding their development despite progressing urbanization and population density. In addition, climate change and sea level rise projections - mostly outlining scenarios that predict an approximate 1m SLR by 2100 for the Lower Mainland - visualize the pressure on the GVRD to further advance and implement solutions that meet the requirements in the years to come (“Sea Level Rise” 2014). In simplified projection, where SLR is uniform, the high-risk areas include the area surrounding Sea Island and Iona Island, the entire eastern part of Richmond and vast areas in Surrey – the largest adjacent to Boundary Bay.

Fig. 41. Aerial with high flood risk areas

This Aerial (see Fig. 41) of 2015 shows the areas severely threatened by flood risk. The areas were identified via www.seeing.climatecentral.org; Projection for 1m sea level rise.

While alike projections do include some uncertainties, they still provide a useful visualization of risk posed by hazards like storm surges and floods. Because any further future installation of protection measures would be based on assumptions, most models work with the protection system in place today, and map scenarios for extreme weather events.

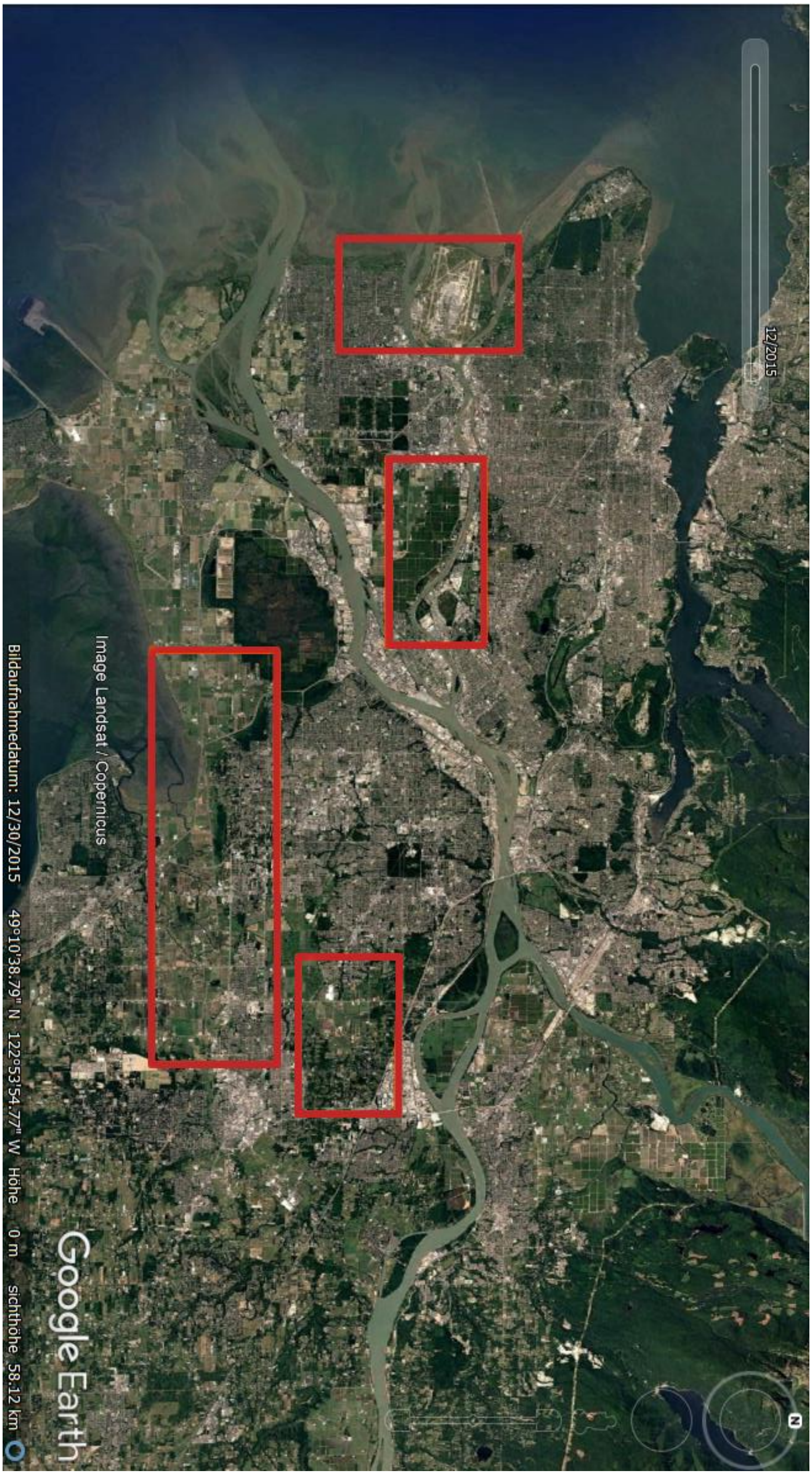


Fig. 41. Aerial with high flood risk threat

As an important measure to prioritize the future stability and nature conservation of sensitive ecosystems such as the intertidal flats, the (salt) marshes and the Fraser channels, as outlined in the ***Sensitive Ecosystem Inventory Technical Report 2010-2012*** (Meidinger et al. 2014), the ***Coastal Restoration Fund*** (Government of Canada 2018) was created by Fisheries and Oceans Canada to help protect and restore endangered aquatic habitat.

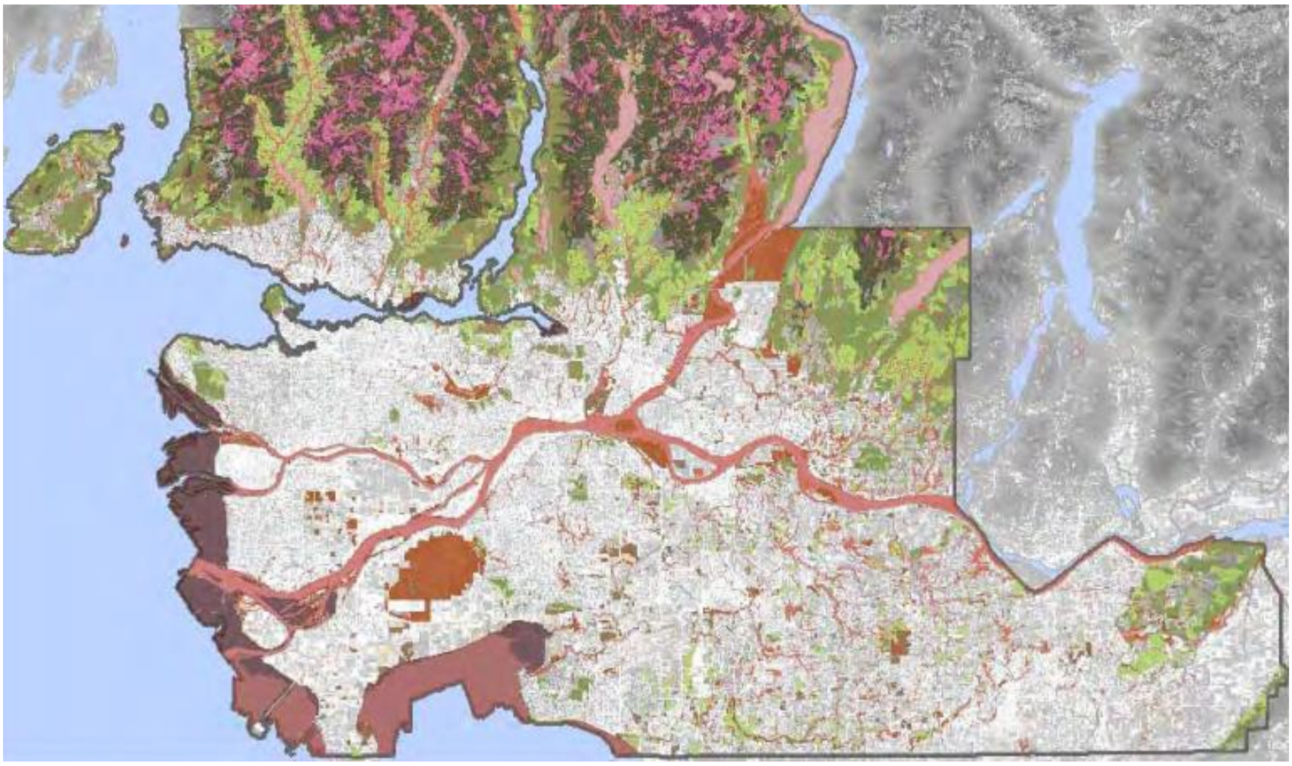


Fig. 42. Sensitive Ecosystem map

The areas marked in different colors differentiate various, sensitive habitats throughout Greater Vancouver. Of special interest for this study, and identified as sensitive to environmental influences, is the entire coastline of BC and the closer coastline environment, the wetland areas, and all river environments.

Three of four Focus Areas lie in midst of sensitive habitats (see Fig. 3).

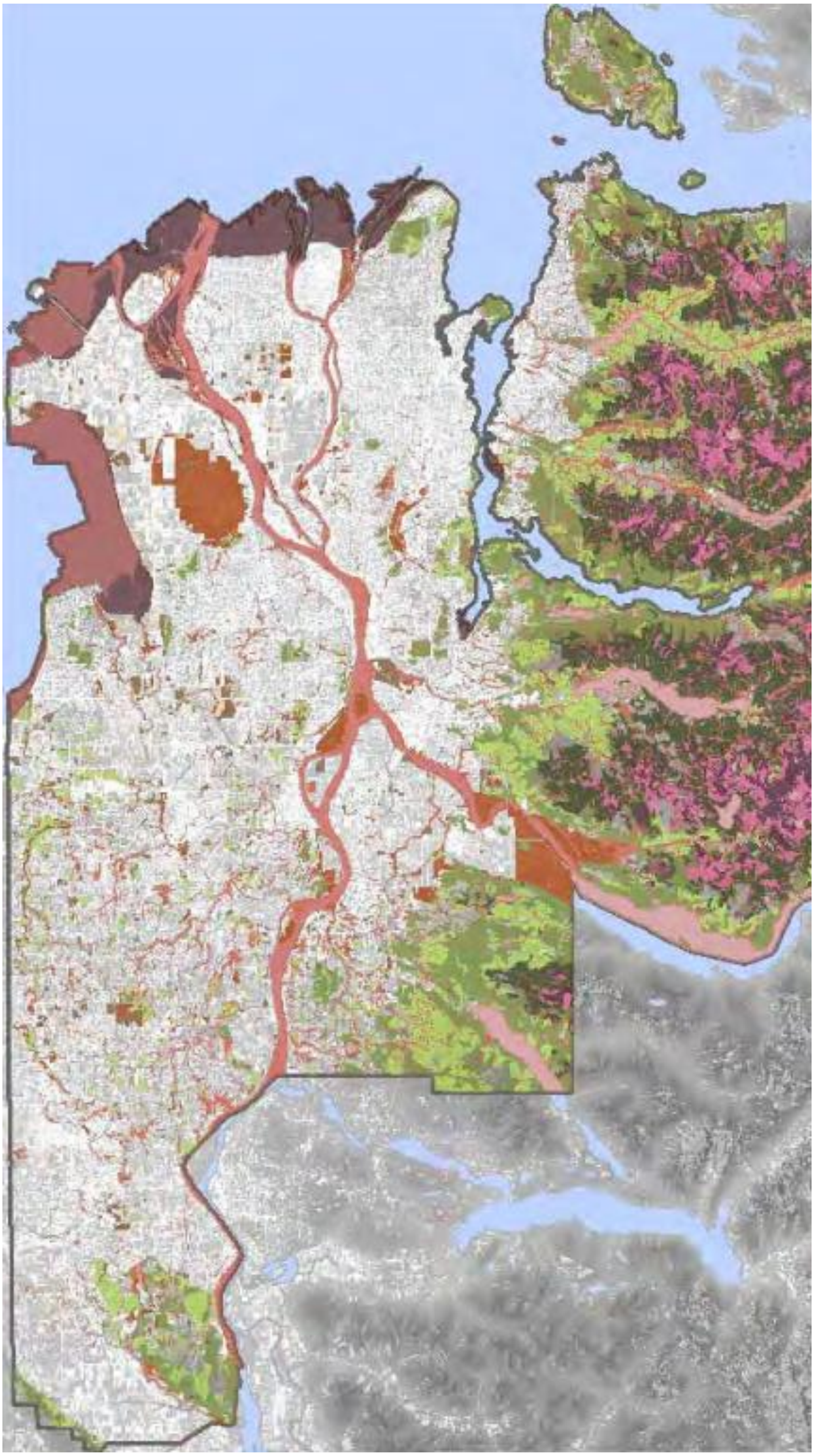


Fig. 42. Sensitive Ecosystem map

3.3. Focus Areas

3.3.1. False Creek

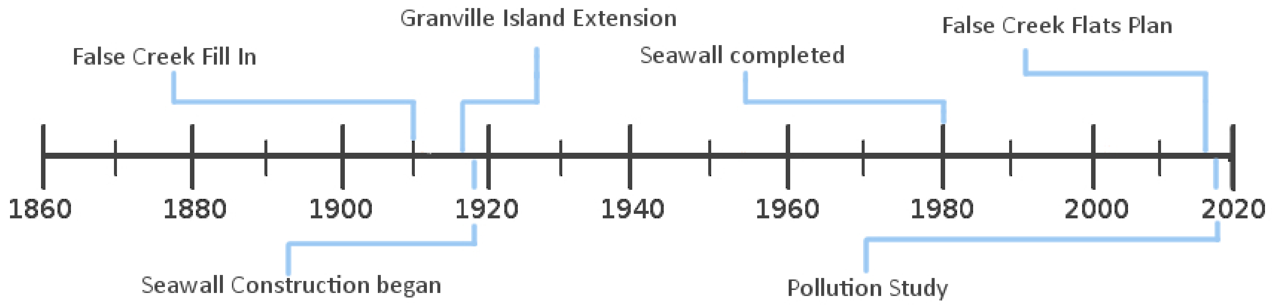



Fig. 42. False Creek Focus Area Timeline

Due to the location in the immediate urban center of Vancouver, the False Creek Focus Area is mainly subject to urbanization and industrialization processes. The first severe transformation of the space in the colonial period was the Fill-In of a large portion of its eastern marshland with logging scraps and waste material in 1910 (“The Flats. Area Profile: An Overview of Your False Creek Flats”).

The photographs below show the conditions before the space was transformed.

Fig. 44. False Creek original shoreline I

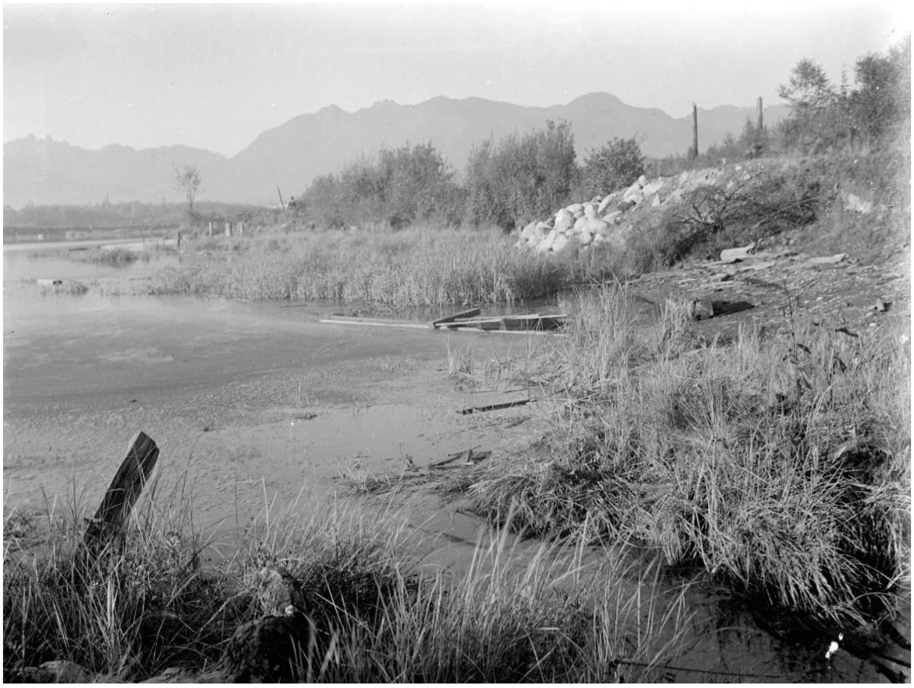


Fig. 45. False Creek original shoreline II

These early photographs (see Fig. 44 and 45) show the original conditions in the tidal mud and marsh flats at the eastern-most portions of the creek. Complimentary maps from that time visualize the original dimension of False Creek, which would extend eastwards up to Clark Drive prior to the fill in. The exact dimensions are well displayed on this early map, which outlines the original conditions (1893).

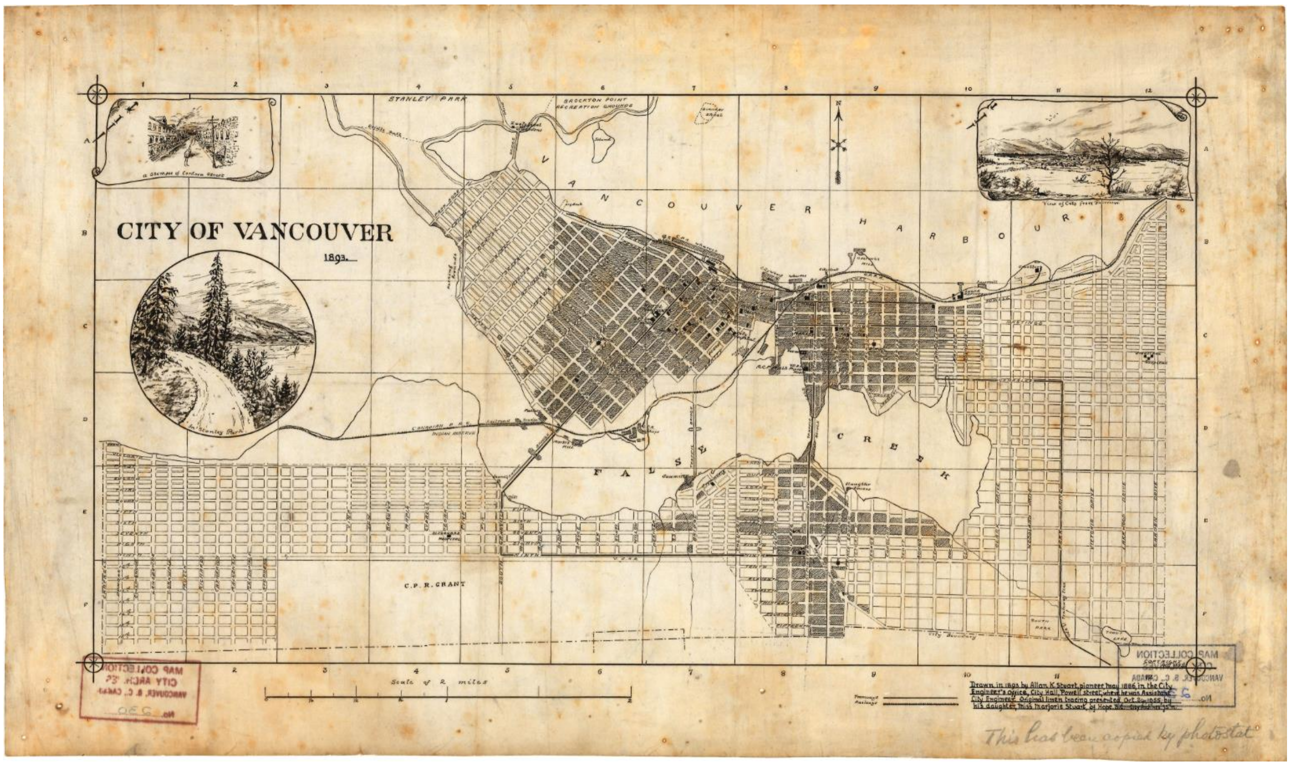



Fig. 46. Map with original False Creek dimensions (1893)

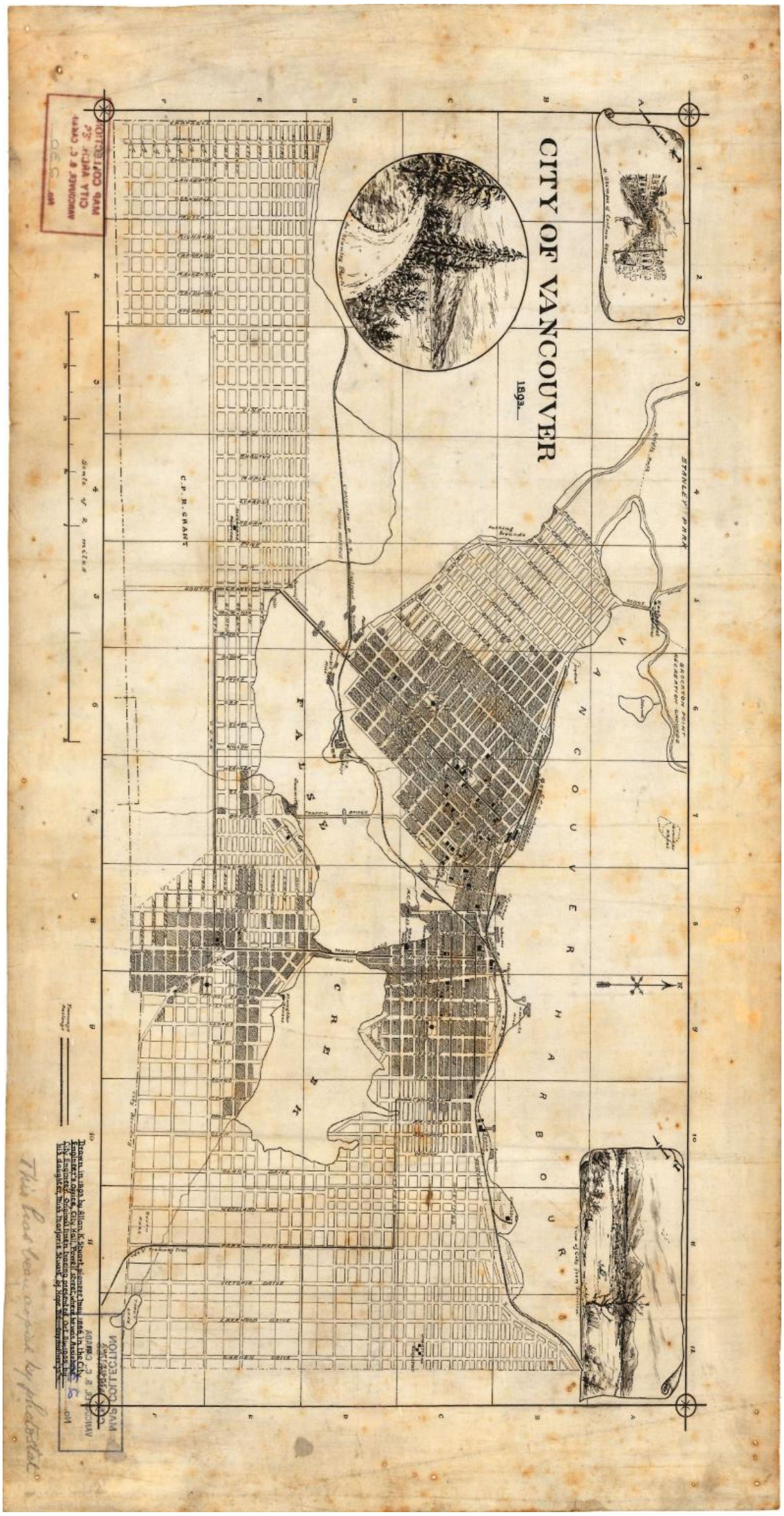



Fig. 46. Map with original False Creek dimensions (1893)

To allow the construction of the CPR rail lot, the approximately 2km² spanning site was laid dry to advance and further develop the industrialization of the city.


Fig. 47. Construction CPR rail lot

These photographs (see Fig. 47 and 48) show the rail lot in its construction phase. The space was drained in 1910, after that the construction works commenced.

Fig. 48. Workers on CPR rail lot


Similar transformation processes hold true for the Granville Island area. Converted to properly accommodate industry, the former tidal flat was drained and extended with dredged material, thereby transformed into the peninsula that it is today ("It Started with a Mud Flat"). This detail (see Fig. 49) from an 1893 nautical map shows the marsh and mudflat conditions both for the flats and Granville Island.

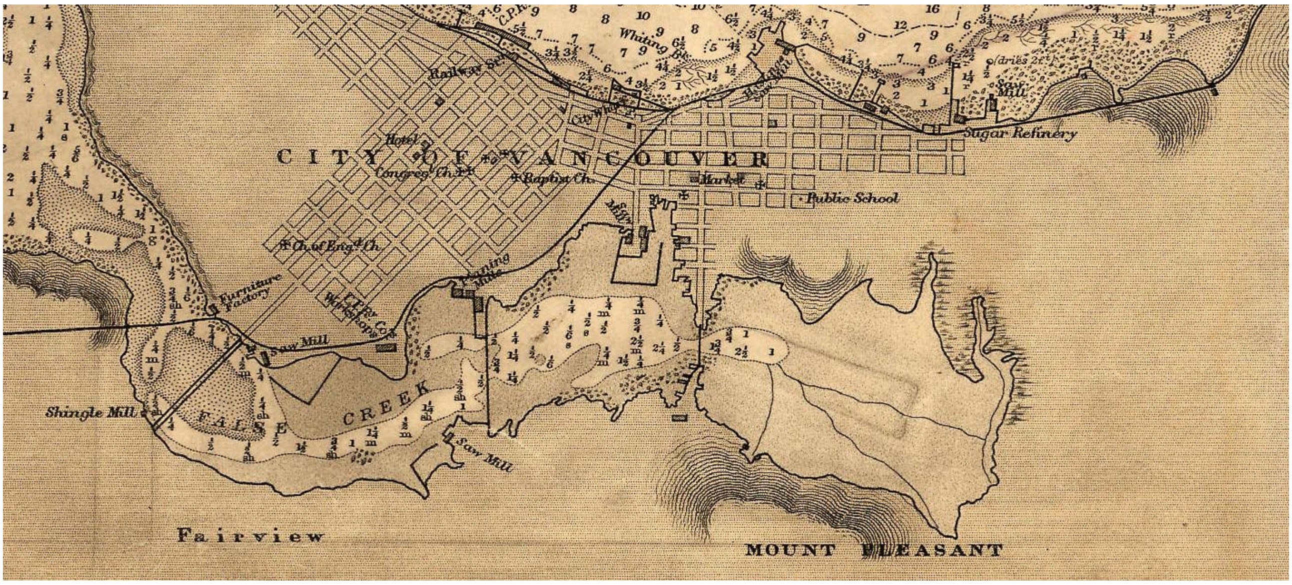


Fig. 49. Nautical map close-up


Fig. 50. Nautical Map of Burrard Inlet (1893)

Fig. 51. East Granville before the extension (1916)


Fig. 52. West Granville before the extension (1916)


Fig. 53. Early aerial of Granville

Fig. 54. Aerial of Granville (1956)

Fig. 51 and 52 show Granville Island before it was drained an extended to accommodate industry.

Fig. 53 is an aerial photograph taken in the 1930s. The center of the image shows the already extensively developed Granville Island.

Fig. 54 is a section from a composite aerial from the 1950s. Again, Granville Island is clearly discernible, so are the industrial sites of the space.

With the seawall construction starting as early as 1917 and being completed in 1980, the construction of the False Creek portion of the structure would not start until 1974. The whole shoreline of the area is circumscribed with the wall, Vancouver’s landmark hard infrastructure to fend off the threats of flooding. The pictures below show the seawall in its early construction stages in 1974.

Fig. 55. Construction of the Seawall I

Fig. 56. Construction of the Seawall II

Although in general environmentally disrupting, research suggests that seawalls can be redesigned and augmented to create and enhance ecological benefits (Dyson and Yocom 202). In addition to that, while changing the composition of the local fauna and flora, studies show that some species, like salmonids, can adapt to the disruption by a change of dietary habits (Munsch et al. 2015).

Fig. 57. The False Creek Flats

Up to this day, the False Creek and its Flats are much rather defined by its industrial heritage than by its ecological qualities. Plans are in place to further develop the Flat area ("False Creek Flats Plan"), that is characterized by its mixed-use zoning for industry and employment.

A picture of the Flats from sometime between the 60s and 80s shows the brownfield space.


Fig. 58. Seawall circumscribing False Creek today

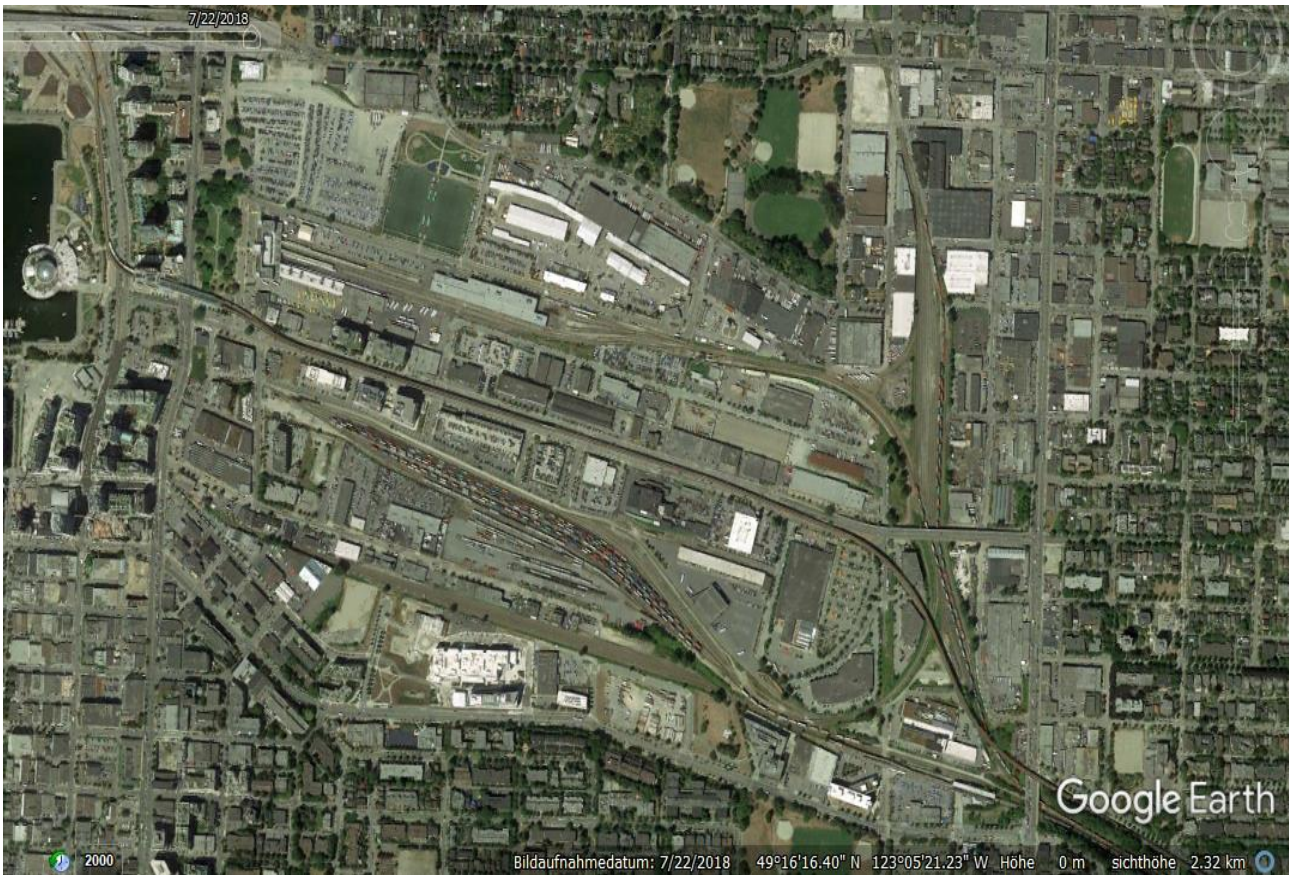


Fig. 59. Aerial of the False Creek Flats today

Specifically disallowing residential development in the area, the plans mainly focus on advancing the site's better integration into the city environment, alongside with making the area more sustainable and top up its social benefit. Yet, despite the efforts to establish a less polluted False Creek and Flats neighborhood, the current situation still proves problematic. A 2018 newspaper article discusses the high pollution figures of False Creek and its bacterial contamination, which is above 4 times the level safe for swimmers (Lazaruk 2018). The goal to make the creek available for recreation and swimming and to lower the water pollution to unharmful levels has to be suspended until water condition and performance is more closely studied, and until the causes for the contamination can be better assessed. Discussed possible contributors to the unclean waters are the marine industries - which pump sewage directly into the creek - along with possible sewage water inflows from surrounding residential and commercial areas after heavy rains.

The False Creek and the False Creek Flats area are therefore a site that is heavily affected by its urbanization and the ensuing pollution. Future redesign and updates in sewage systems and wastewater management can contribute to keeping the pollution levels in check in the future.

### 3.3.2. UBC

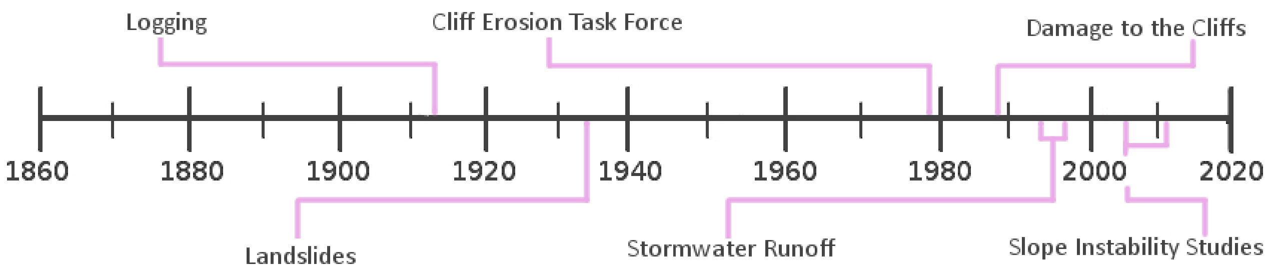



Fig. 60. UBC Focus Area Timeline

Old logging trails (Birmingham et al. 16) hint that the area of the University Endowment lands was utilized and logged even before the space was slowly developed to accommodate the UBC faculties in the early 20th century. The clear-cutting of land left for the most parts only small stretches of tree stocks intact, which ring the UBC site and are located within immediate proximity to the Quadra sand cliffs.

Fig. 61. UBC aerial (1927)

Some of the earliest available aerials from 1927 show the conditions in the early stages of UBC's construction phase (see Fig. 61) while an aerial from the 50s well visualizes the in places complete lack of vegetation on top the exposed cliffs (see Fig.62).

The bare cliffs were also photographed and published in a geological survey in 1923 (see Fig. 63).


Fig. 62. UBC aerial with bare cliffs (1943)

B. Pleistocene deposits in sea-cliff on the northwest side of point Grey, Vancouver, B.C. The lower, darker-coloured beds are plant-bearing, interglacial beds. The cliff is about 200 feet high. (Page 43.)

Fig. 63. Bare cliff photograph (1923)


Fig. 64. Point Grey Cliffs (1925)

This photograph from 1925 shows only few clearings where the white cliffs peak through. The other flank of the cliff, however, has a large sparsely vegetated space on the seaward cliff side where larger trees and shrubs have difficulties sustaining themselves due to the loose and instable soil conditions. For another perspective compare to Fig. 62.

Fig. 65. UBC aerial (1956)

This aerial from 1956 shows a much more advanced university complex. Fig. 65 and 66 visualize well how the site expands in close proximity to the cliffs.


Fig. 66. UBC aerial (1956)

With the land getting more developed throughout the following decades, the cut back of vegetation along with the urbanization of the area can be regarded as a contributing factor to substantial erosion (UBC/Pacific Spirit Park Cliff Erosion Management Planning 22-25). One of such events was a landslide that took place in close proximity to Green College in 1935. Caused by an extreme storm, extensive water runoff cut a large ravine into the ground behind the buildings, in its dimension large enough to partly destroy and washout infrastructure like streets (see Fig. 67 and 68).


Fig. 67. Graham's Ravine

Fig. 68. Graham's Ravine washed out street

The approximate location of the ravine, highlighted in red:


Fig. 69. Approximate location Graham's Ravine

The subject matter of vegetation, more precisely the deciding importance of stabilizing the territory that has its soil mostly composed of sand, small gravel, and slit, was of crucial interest to the UBC ***Cliff Erosion Task Force***, which was established in 1979. Aiming at developing solutions to prevent or slow down the further erosion of the cliffs adjacent to the campus. The Task Force made an important contribution to preserve the foreshore environment, while at the same time addressing the danger of collapse regarding some UBC facilities, should the cliff retreat further continue

Fig. 70. Museum of Anthropology

The Museum of Anthropology is located in close proximity to cliffs with considerable slope instability.

The Task Force resorted to extensive protection measures (UBC/Pacific Spirit Park Cliff Erosion Management Planning 12), like preventing base erosion of the cliffs by putting riprap structures in place (see Fig. 75), as well as planting vegetation on the bare cliffs (see Fig. 76 and 77).

Fig. 71 and 72 show the conditions of the UBC cliffs before the Cliff Erosion Task Force initiated a large-scale replanting in order to stabilize the slopes.

Fig. 73 and 74 show the planted, transformed cliffs.


Fig. 71. Bare UBC cliffs I

Fig. 72. Bare UBC cliffs II


Fig. 73. Planted UBC cliffs I

Fig. 74. Planted UBC cliffs II

Fig. 75. Armoring the shoreline

Fig. 76. Planting the cliffs

Fig. 77. Woman planting the cliffs

UBC's cliff management, however, was not always undisputed. In 1989 a newspaper article records the public discussion and criticism regarding pruning of vegetation on the Wreck beach area (Moya 1989), a foreshore section that is one of the few beaches in Vancouver which to this day remain in a relatively natural state. In addition, approximately 6m of the cliff edge was torn down since, according to UBC, it was at risk to fail because of extensive undercut, thereby posing a threat that had to be eliminated. Vegetation with longer roots to facilitate a stronger cohesion of the uppermost soil layers was planted afterward.

In 1994 and 97, another strong storm event once more posed a threat to UBC buildings (UBC/Pacific Spirit Park Cliff Erosion Management Planning 19), again eroding the same area as in 1935, and thereby causing damage to Cecil Green House and the Coach House on Green Campus. It was criticized that the hydrology studies recommended by the Cliff Erosion Task Force almost a decade earlier had not been conducted, and no adequate measures were implemented to facilitate better drainage of the area.

In 2016 a study assessed the current state of the UBC cliffs and came to the conclusion that the slopes between Trail 3 and 4 (see Fig. 78) have stability problems and were subject to a moderate-high probability to fail if not stabilized (Lee et al. Appendix C), other studies evaluated similarly (Aecom 11-13).

Fig. 78. Area with slope instabilities

As noted in the studies, the area identified as possibly threatened by future by slope failure encompasses the Museum of Anthropology (the south-western portion of infrastructure in highlighted area in above visual), as well as the entire Green Campus (north-eastern infrastructure in the highlighted area, above visual).

It was furthermore concluded that the recession of the cliff would further advance, more precisely about 7m every 100 years (Lee et al. 10).

The present-day conflict of interest relating to the UBC Focus Area is to what extent natural processes, like erosion, can be allowed as opposed to closely managing the area in order to conserve the current status quo.

### 3.3.3. Iona Island

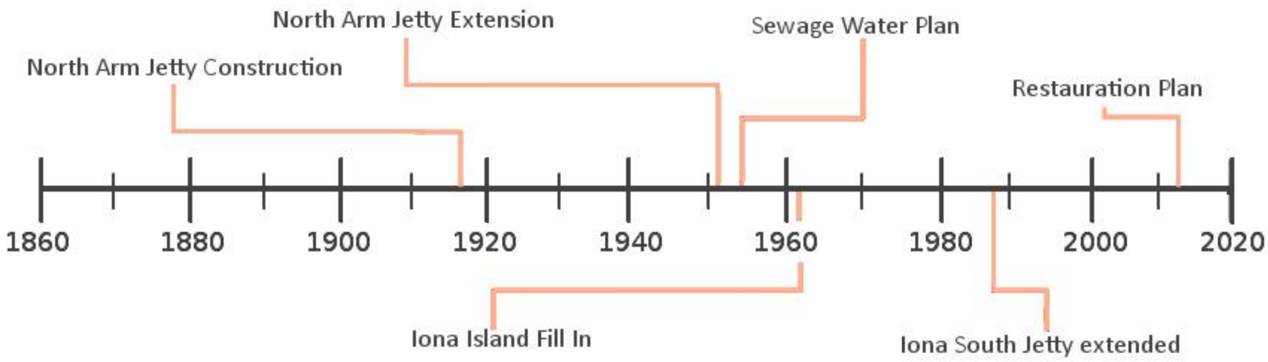



Fig. 79. Iona Island Focus Area Timeline

Before the North Arm Jetty was constructed around 1916 (“The North Arm of the Fraser – Industry in 1918” 2018) on Iona, the north-west tip of the island (see Fig. 80) had already been the site for earlier attempts to erect river training structures in order to confine the north arm. Putting the Jetty in place, the foundation was laid to train the north channel well enough to facilitate log storage and the better navigability for ships, as well as providing a harbor for small vessels during storm events with rough seas in the Georgia Strait (“North Arm Jetty” 2014).

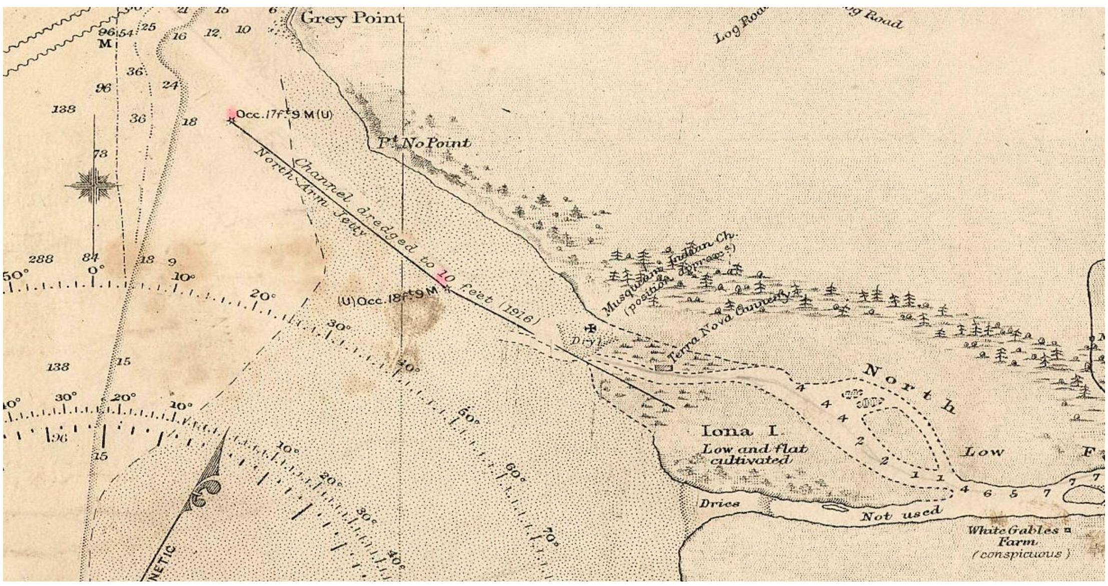



Fig. 80. Close-up of map with dredging date (1923)

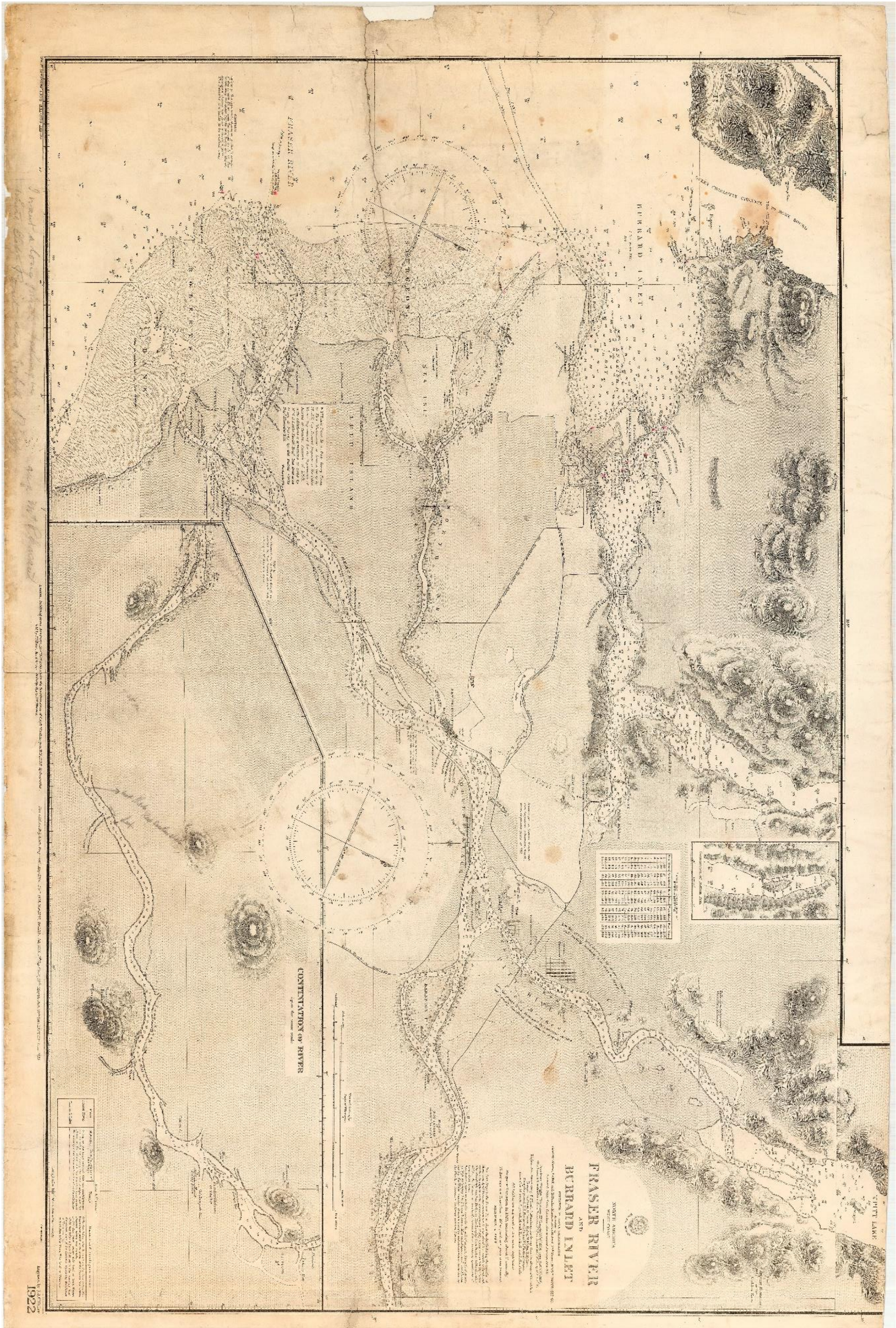


Fig. 81. Map of Fraser River and Burrard Inlet (1923)

The extension constructions stopped in 1951, and a close-up of an early Metro Vancouver aerial from 1952 shows the full dimension of the North Arm Jetty for the first time, without the Iona South Jetty being in place yet.

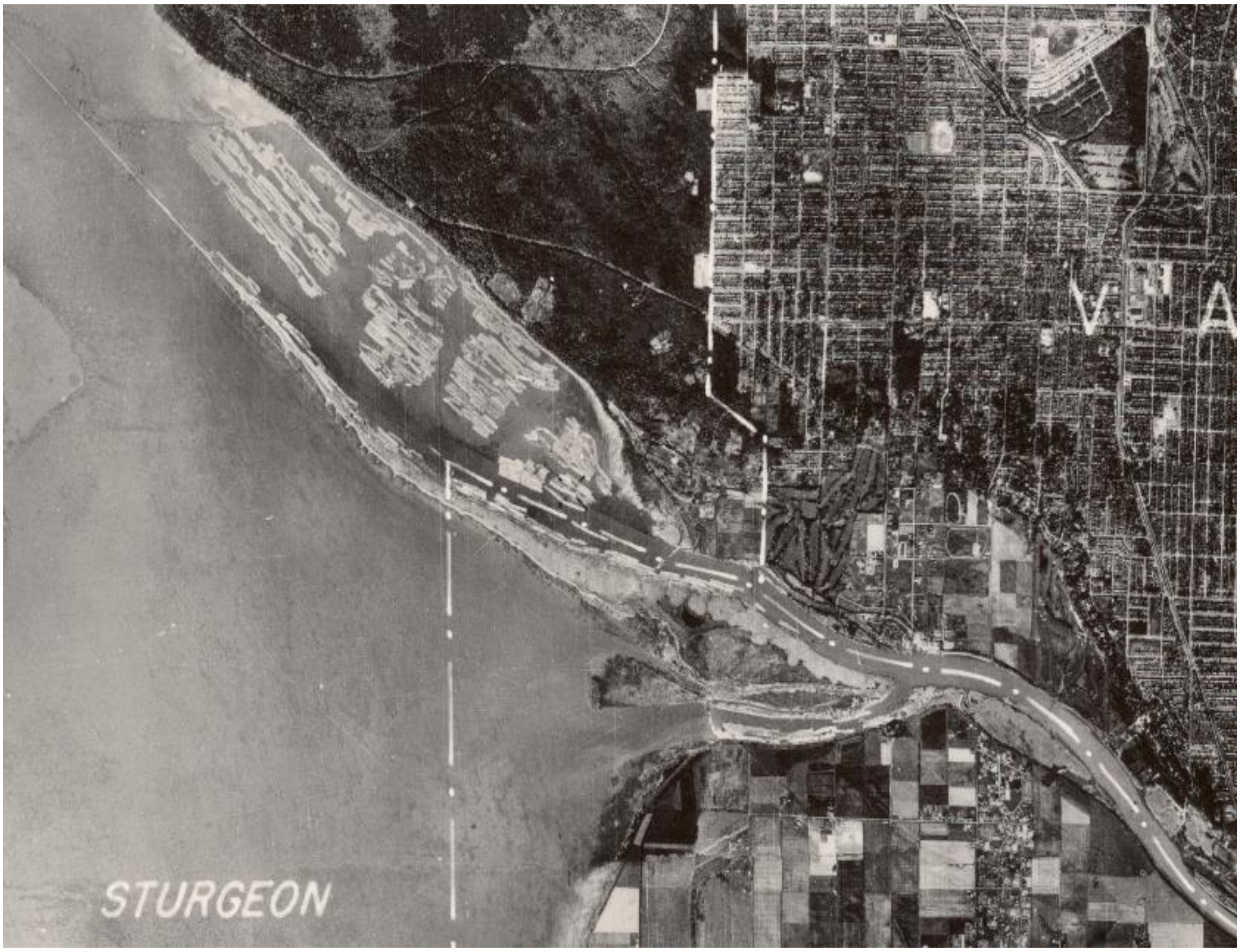


Fig.82. Iona full extension North Arm Jetty (1952)

In 1953 the Iona Island Water Treatment plant was constructed. The Iona South Jetty, a sewage pipe, would conveniently allow draining the treated water directly into the Sturgeon bank, away from recreational beaches (Jones 5-7).

Fig. 83. Iona aerial (1930)

Fig. 84. Close-up of aerial mosaic of Richmond (1935)

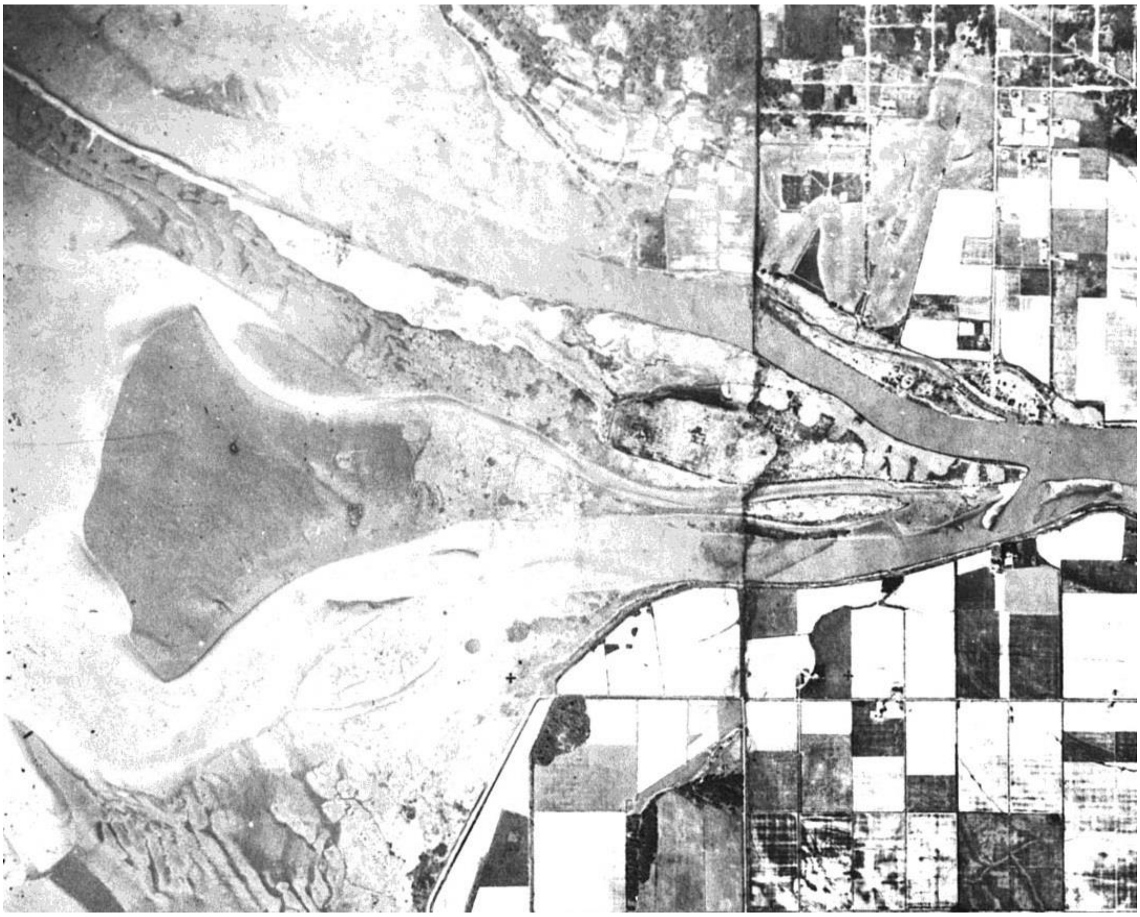


Fig. 85. Iona aerial (1948)

Fig. 83 and 84 show Iona Island in its early state with the North Arm Jetty already in place. Aside from that the island is not developed, and the southern channel is not yet filled in.

Fig. 85 shows Iona from a greater distance. The North Arm Jetty in its relative position to the mainland shoreline is well visible.

Fig. 86. Iona aerial (1956)

This high-resolution close-up of Iona Island from 1956 shows the conditions before the island was filled in. The North Arm Jetty stretches away from the island in the upper left corner of the image.

Fig. 87. Iona Island Treatment Plant

The treatment plant (see Fig. 87) and the connected jetty would resume work in the early 60s, and alongside with the erection of the plant, the Iona causeway was constructed. Therefor the Island was filled in so that now its southern part connects to the north-west side of Sea Island. With the two jetty structures and the Iona peninsula in place, former water flow patterns and sedimentation, along with freshwater inflow into the site and into adjacent Sturgeon Bank remain severely transformed. (Jones 5-7).

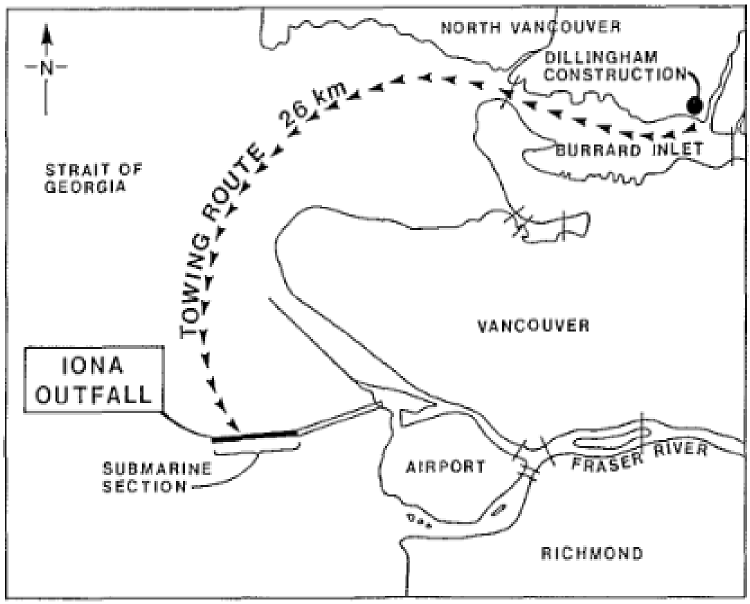



Fig. 88. Iona Outfall submarine section

The to this day most current, large intervention pertains to further extension of the outfall pipe, the Iona South Jetty (see Fig. 88). Recognizing the detrimental effects of the wastewater for Sturgeon bank, a further extension into the ocean and away from the sensitive habitat was administered, with the final stretch of the pipe being entirely submerged (Lively et al. 1).

The effects of the transformation, and to what extent the area is negatively affected or threatened in an ecological sense is intensively studied (Nishimura et al. 1996). A well visible and observable effect of today's conditions is the land gain in the jetty region, that can mainly be attributed to the change in sedimentation conditions and the calmer waters (Hales 129-132).

Aerial images of the Iona Jetty environment visualize well where sediment aggregates. Below are two images of the area taken in 2003, where the left aerial shows the area between the northern and the southern jetty, while the second aerial shows the conditions from the south jetty downwards.

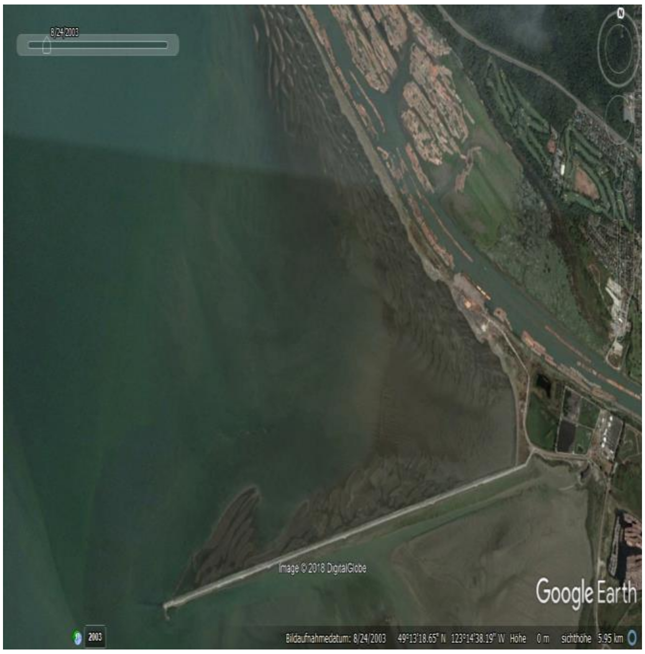



Fig. 89. North Arm Jetty (2003)

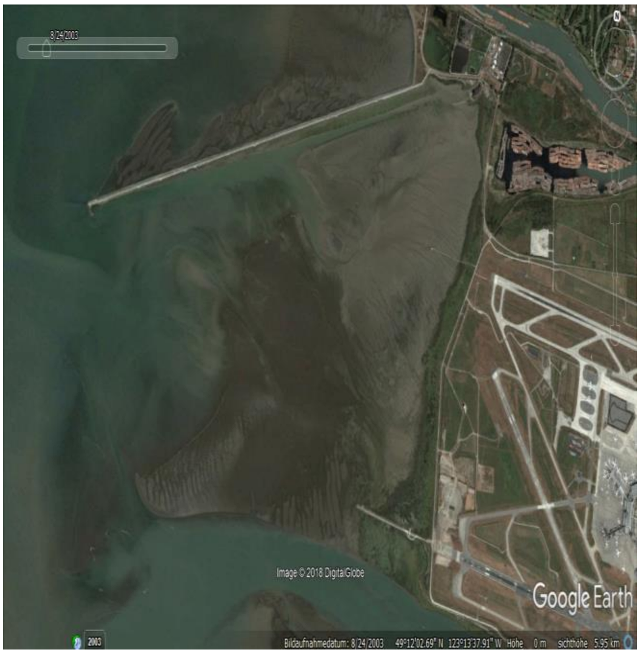
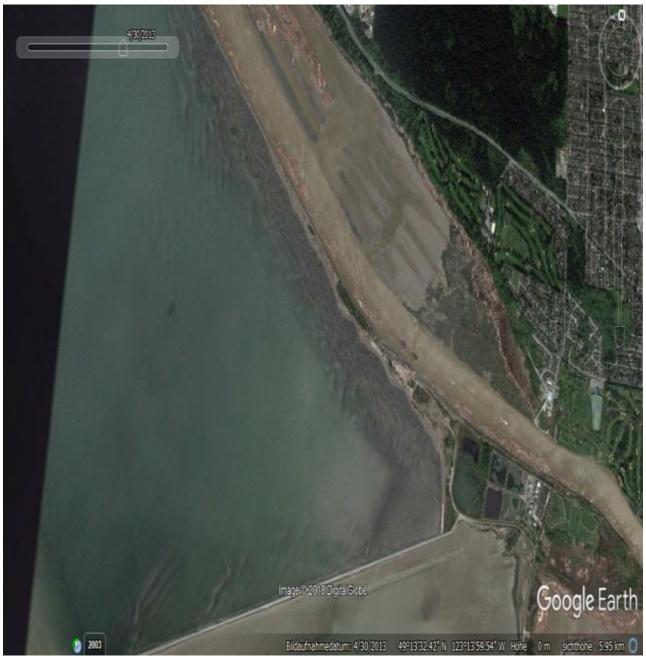



Fig. 90. Iona South Jetty (2003)

Followed by another set taken in 2013, again - the left aerial shows the area between the northern and the southern jetty, while the second aerial shows the conditions from the south jetty downwards.



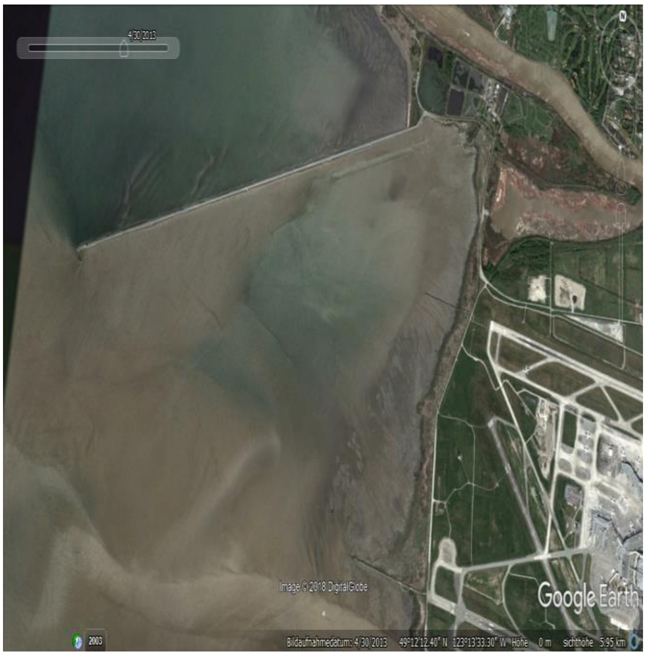




Fig. 91. North Arm Jetty (2013)

Fig. 92. Iona South Jetty (2013)

Studies identify gradual sediment aggregation in the Jetty environment. The aggregating areas are demonstrated below, highlighted in red.

Fig. 93. Sediment aggregation North Arm Jetty environment

Fig. 94. Sediment aggregation Iona South Jetty environment

Iona Beach, today, is a regional park (IBRP). Its ecological and wildlife status are studied and under observation. The ***Sensitive Ecosystem Report*** includes Iona as sensitive and threatened ecosystem, and the ***Technical Report & Restoration Plan for Iona Beach Regional Park*** identified a variety of environmental stress factors to the area (Newberry 25-26).

Some of the stressors – like airplane traffic, human presence, climate change, and noise pollution – are unlikely to be adequately managed in the short, medium or long term. The IBRP will, therefore, continue to be negatively affected by human impact.

### 3.3.4. Steveston

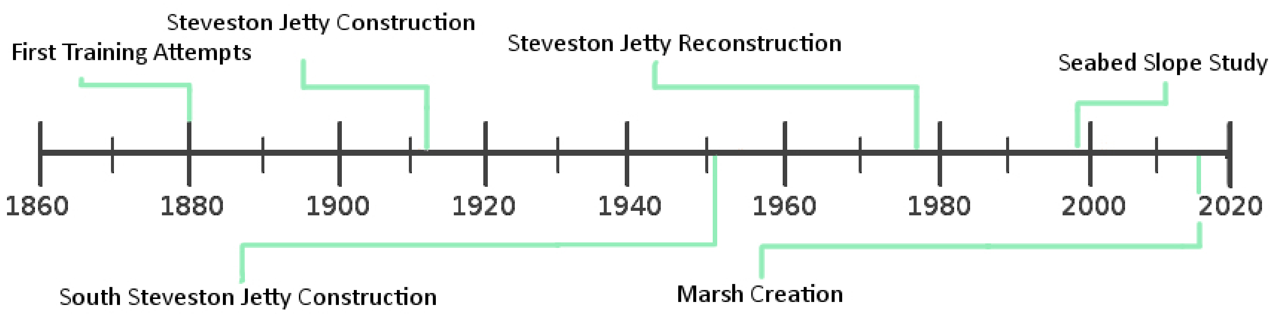



Fig. 95. Steveston Focus Area Timeline

According to NHC, attempts to train the main channel date back to the early stages of colonial settlement in the 1880s. Structures put in place intended to confine the channel, but they failed eventually when being overtopped by the 1894 flood (Northwest Hydraulic Consultants and Triton Consultants Ltd. 4).

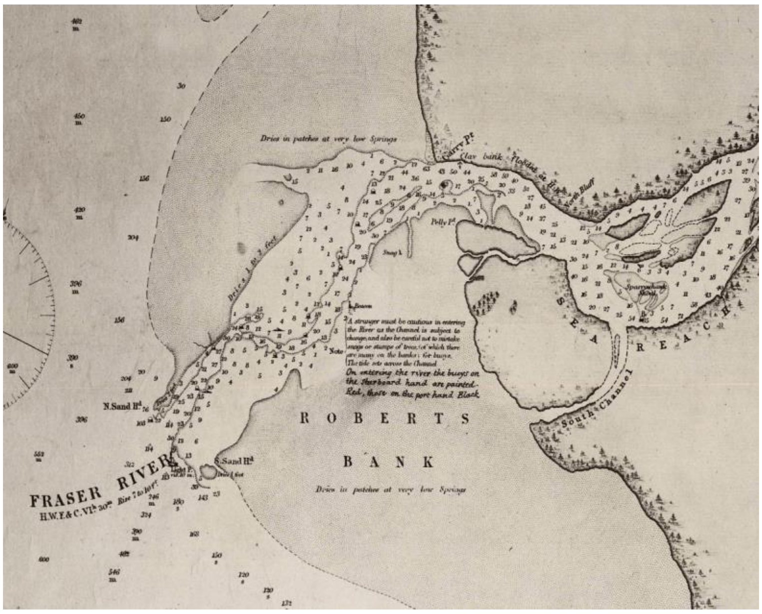
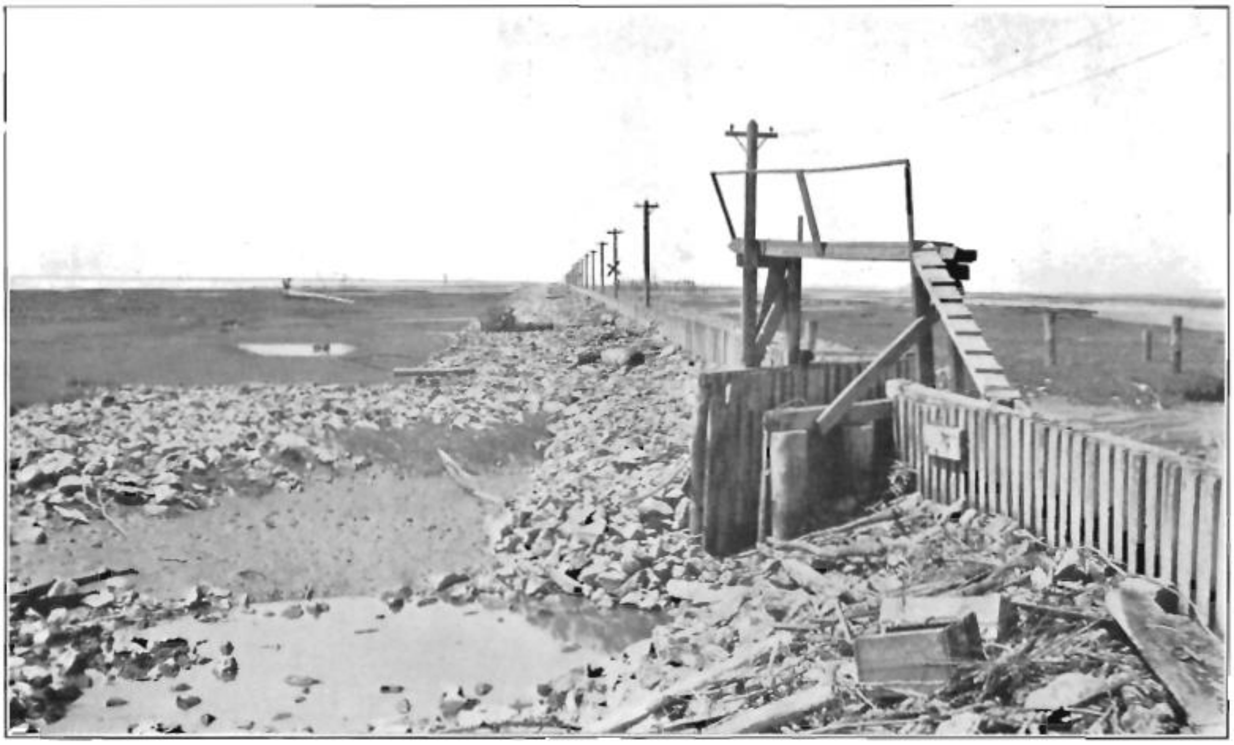


Fig. 96. Garry Point environment before the jetty

The Steveston Jetty construction followed as early as 1911. It is not only the longest structure discussed in this study, but its construction date is also the earliest of the jetties still in place today, with further construction and expansion continuing up until the 30s ("Steveston North Jetty" 2014).

Early maps that outline the shore and bank conditions in detail (see Fig. 96; for the entire map see Fig. 6) suggest that the characteristic bent construction of the jetty might in part follow the natural on-site conditions, thereby lining and confining the Sturgeon Bank. This would correspond to the purpose of the structure, which is not solely to train the river, but as well to prevent sediment inflow up the main channel during flood tide.

PLATE II



Steveston jetty and tidal flats at the mouth of Fraser river, B.C. View seaward from near inner end of jetty. (Page 6.)

Fig. 97. Steveston jetty and the tidal flats (1923)

This photograph from 1923 was published in a survey that examined the ***Geology of the Fraser River Delta.*** The viewpoint is located on Lulu Island and overlooks the jetty structure seawards.

The photograph was taken at low tide. Tidal flats are visible on the left and right side of the jetty.

Fig. 98. Aerial mosaic of Richmond

This aerial mosaic of Richmond from 1935 shows the already extensive development on the coastal islands and the relative position of important islands discussed in this study.

Relevant islands from top to bottom (Annacis not included):

- Iona Island (close to Sea Island) in the upper left corner (see also Fig. 86)
- Lulu Island with Steveston on its southwestern tip (see also Fig. 101)
- Shady Island, elongated structure located close to the Steveston shoreline (see also Fig. 102)
- Reifel Island, located across Steveston at the northwest tip of Westham Island (see Fig. 106).
- Westham Island, located below Reifel Island (see also Fig. 19).

Fig. 99. Aerial of Garry Point (1953)

Fig. 100. Marshland Steveston (1950)


Fig. 101. Aerial of Shady Island and Steveston (1959)

Fig. 102. Aerial of Shady Island and the jetties (1960)

While the Steveston South Jetty No.1 was also constructed in the 30s, it did not stand the test of time and had to be replaced with another, more sturdy structure - the Jetty No.2. (“Steveston South Jetty No. 2” 2014). The second jetty was put in place in the early 50s and constructed as an elongation of the Albion Training wall, which stretches towards the Strait of Georgia from Reifel Island.

Fig. 103. Shady Island (1976)

This aerial shows Shady Island, likewise looking seawards, in 1967. Together with Fig.101 and Fig. 102 it is well displayed how the island, although left relatively untouched, was armored with different structures on its south-, up- and downstream side to provide calm and sheltered conditions for the Steveston waterfront.


Fig. 104. Lower Fraser River today

This aerial (Fig. 104) shows Garry Point and the jetty environment at the mouth of the Fraser River south arm in its current state. The Steveston jetty extends from Garry Point on the bottom left part of the image. Sediment and marsh conditions are well visible.

Fig. 100 shows a photograph of the marshland in Steveston. The photograph was taken at the end of Steveston highway looking west.

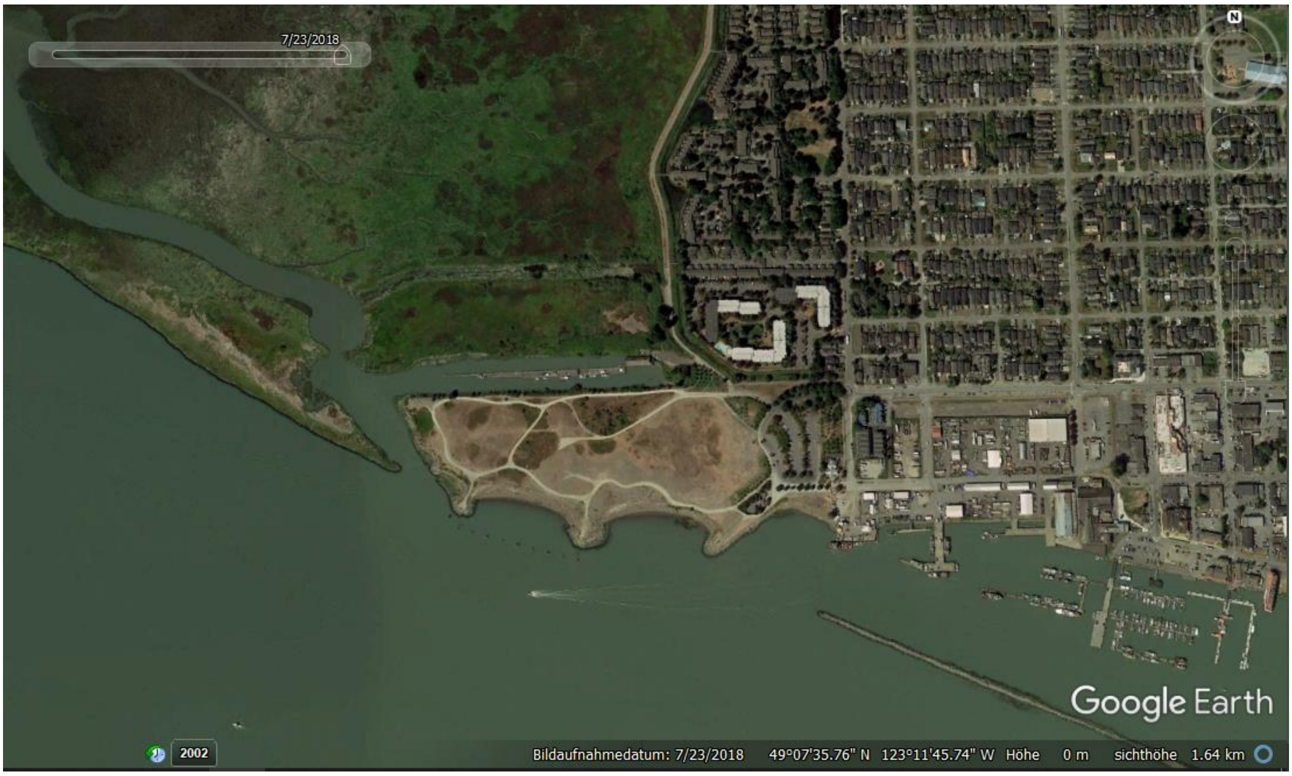



Fig. 105. Garry Point today, with the jetty to the west and Steveston to the east

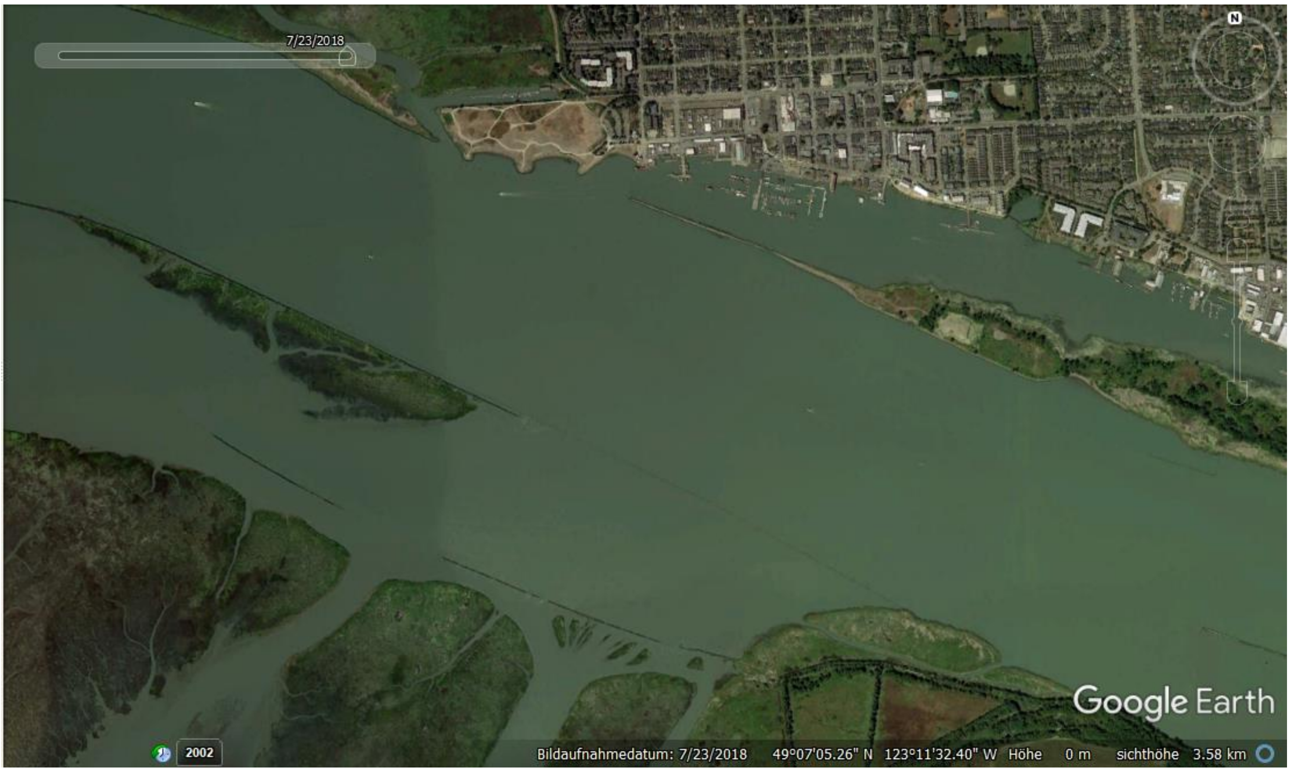



Fig. 106. Steveston and part of Reifel Island on the bottom right

Placed amid the crucial off-coast areas Sturgeon and Roberts Bank, the northern jetty - recognizing the immense environmental impact of alike transformations - was in later years subject to reconstruction. Several sections of the structure were replaced with meshed steel wire, to allow free movement of sea life (“Steveston North Jetty” 2014). In addition, sediment disposal on the northern side of the jetty favored marsh development alongside the structure.

A project plan from 2017, still in its design and development stages, proposes the further extension of the marshland (South Arm Jetty Tidal Marsh 2017), see Fig. 107 and 108.

Fig. 107. Marsh along the jetty, current state

Fig. 108. Proposed new marshland

The pictures above show the site discussed. The first picture displays the current condition of the marshland while the second picture (simulated) shows the development goal of the project - further 43ha of sandflat converted into a highly productive marsh.

Fig. 109. Tidal Marsh area (2003)

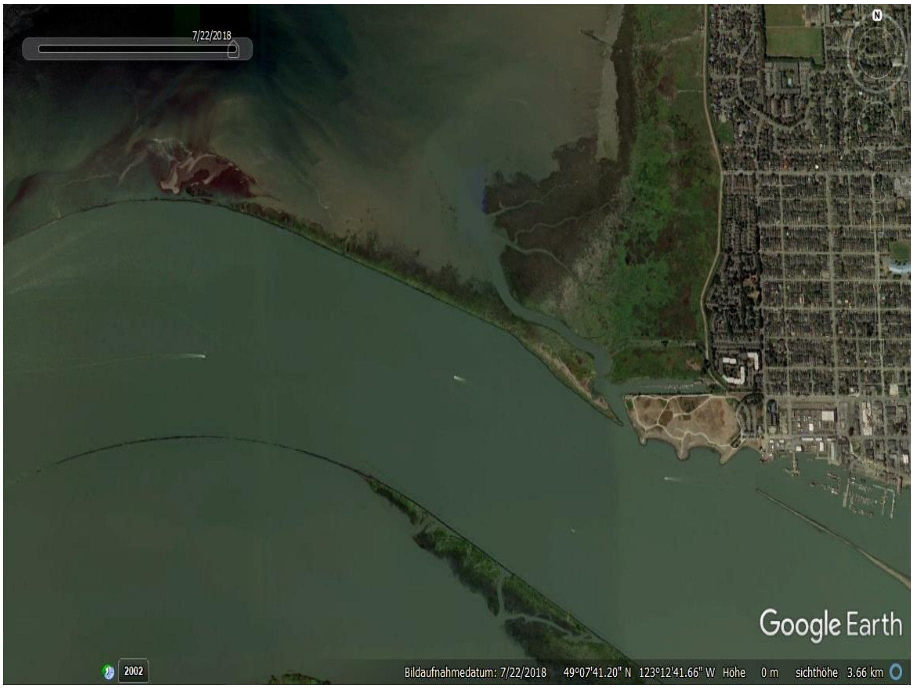


Fig. 110. Tidal Marsh area (2018)

The aerial of the area from 2003 (see Fig. 109) is a further visualization of the site conditions. The bent jetty structure aggregates sediment on its northern side, an area that is adjacent to the Sturgeon bank. The 2018 conditions (see Fig. 110) show a considerable marsh area on the northern jetty side. That area can possibly be further extended in the future by the ***South Arm Jetty Tidal Marsh*** Project.

While changed sedimentation patterns through the river training did lead to the extension of marshland, thereby having beneficial properties for the environment, the altered sedimentation patterns can also pose a significant threat, as a study from the 1998 finds (Christian et al. 1989).
The research is concerned about the submarine slope environment of the Roberts Bank and investigates the risk of potential slope failure than can result in a tsunami (228), see Fig. 110 and 111.

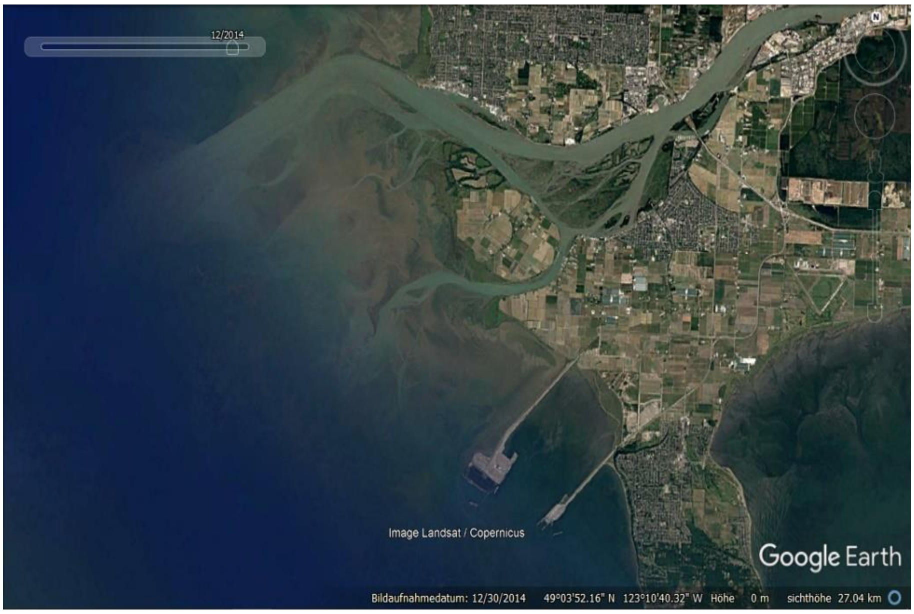


Fig. 111. Aerial of Roberts Bank environment

Fig. 112. Aerial of possible seabed slope instability area

Important recent interventions in the Steveston Focus Area can be labeled as an attempt to mitigate negative environmental impacts. Redesigning the jetty as well as creating a highly beneficial marsh landscape are two important measures that can at least partially offset the ecological stressor of increased future ship traffic.

### 3.4. Limitations and Suggestions for Further Research

Reviewing literature and other resources for this study proved to be challenging considering the four layers of government and their overlapping, at times changing responsibilities, as well as the multitude of different bodies and organizations at work. This can potentially result in overlooked or omitted data.

Another impeding factor is the scarcity and occasional impreciseness of material - especially concerning earlier historical periods (e.g. the fragmented history of diking in the 1800s, differing date specifications for events that complicate targeted research, estimated publication years for maps), which might make correcting some of the given dates with help of further research a necessity. Present-day accounts, on the contrary, prove to be complex since there's a variety of research with at times contrasting research conclusions (e.g. debates concerning the state of the sandbanks).

Therefore, some strong suggestions for further research can be made, which would help to better chronologize the transformations and interventions and get an extended understanding of the actors at play.

Most importantly - the state of the marshes and sandbanks has to be reviewed more closely. Their diverse and rapidly shifting character makes a definite statement on whether, at what rate, and on which location they are eroding within the scope of this research a difficulty. Here, follow-up studies, as well as further review and systematization of research and in-field expertise is recommended. In addition, a study targeting the legal and administrative framework would be beneficial to learn which current legal framework exists and is relevant for the umbrella project and its subprojects, as well as get a more in-depth sense of the historical legal situation. For similar reasons, a study of the history and transformation of relevant bodies and organizations would be beneficial.

### 3.5. Final Remarks

The list of interventions and transformative processes in the Lower Mainland is long - and extendable far beyond this archival study. However, the report already reflects well how close the heavily urbanized Greater Vancouver area is intertwined with, and dependent on, its marine and river environment.

Exploring both lasting and environmentally sustainable solutions under the framework of the LBRP to face the challenges posed by climate change cannot be labeled any differently than being an urging necessity, which will discipline today's delays and negligences with loss in the future, both economically and environmentally.

That being said, the significances assigned in the overview timeline already imply in how far especially economic and environmental aspects are at play historically, and they will gain importance considering the further development and urbanization of the study area, that will expose an even greater number of the population to a changing coastal and river delta environment.

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**Fig. 91.** North Arm Jetty (2013). From: Google Earth
**Fig. 92.** Iona South Jetty (2013). From: Google Earth
**Fig. 93.** Sediment aggregation North Arm Jetty environment. Base Image: Google Earth
**Fig. 94.** Sediment aggregation Iona South Jetty environment. Base Image: Google Earth
**Fig. 95.** Steveston Focus Area Timeline
**Fig. 96.** Garry Point environment before the jetty. Base Image: Vancouver Archives, *Fraser River and Burrard Inlet,* 1860.
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5. Appendix - Email Correspondence Additional Resources

A.

"RICHMOND BATTLES THE SEA"

by

Barbara Hynek

Early settlers who were attracted to the islands at the mouth of the Fraser River soon found themselves faced with many arduous tasks. Along with clearing and cultivating their fields, farmers were forced to deal with problems of flooding which required the installation of draining and dyking systems.

The first dyke dates back to 1862 when Hugh McRoberts dyked in a field on his Sea Island homestead. A few years later, in 1863-64, William McNeely dyked in the first acreage on Lulu Island. During the early years of Richmond's history there was no such thing as public works. Most of the dykes were constructed by individuals with occasional joint efforts undertaken by farmers who had adjoining fields.

Even after the fields were dyked, winter flooding was common. Farmers did not seem to mind as long as their crops were secure during the planting, growing and harvesting seasons. After incorporation, petitions from land owners asking for ditches to drain their property poured into Council and during the next few years, contracts for ditch digging were awarded. During the 1880's, the Municipal Council became seriously concerned about improving dyking and drainage facilities. Council pleaded with the Provincial Government for assistance in drainage problems.

Fearing the Orientals would dominate the labour force, Council attempted to pass a resolution prohibiting the letting of contracts or the employment of Chinese in any municipal projects. The motion was defeated since some of the council members did not want to eliminate totally their source of cheap labour. However, a resolution was later passed which stated that "no more contracts be let to Chinamen, or anyone employing them, unless it could be shown that white men could not be obtained to do the work for a price that would not exceed twenty-five percent of the lowest tender from Chinamen".

Inadequate drainage not only posed problems for crops but frequent flooding made life in general unpleasant. Most of the year settlers had to wear gum boots and row boats were often the easiest method of transportation.

Every few years, the river would overcome the narrow handmade dykes and flood the islands. Farmers often suffered heavy property damage and livestock frequently drowned while scrambling to reach the highest point of ground. In 1906 a floating dredge dug a canal which provided building material for a more efficient dyke on Lulu Island.

During the early 1900's, the Municipality was broken down into several dyking districts. Each had their own system of tax levies and commissioners who experimented with different methods of dyking and drainage.

Before the introduction of automatic electric pumps, flood-boxes were used to pass water from the drainage ditches into the river. These flood-boxes contain gates which are balanced to operate according to water pressure. When the river pressure is less than the water pressure in the ditches, the gate opens and allows the water in the ditch to drain into the river. When water pressure is reversed the gate closes, preventing the river water from entering the ditches and canals.

During the 1930's, pumps began to replace flood-boxes. In 1933, the New Slough Dyking District installed a pump with a capacity of 16,000 gallons per minute. The Lulu Island West Dyking District soon followed with the installation of two pumps capable of pumping 20,000 gallons per minute. These automatic electrical pumps were manufactured and installed by Pumps and Power Limited of Vancouver. Over the years, they proved to be much more efficient and economical than the old style pumps requiring an operating staff which were being used in other municipalities.

Today some 39 pumps with a capacity of 10,000 to 40,000 gallons per minute along with nine pumps of lesser capacity operate within Richmond.

As dyking and drainage systems became more complex and costly, it was decided that the responsibility for drainage and flood control should be amalgamated. Under the provisions of the provincial Dyking and Drainage Act, municipalities were allowed to petition the government for the formation of a commission to accept the responsibility of maintaining dykes and drainage systems. Richmond's dyking schemes were amalgamated and placed under the control of Municipal Council in 1937.

Many residents may recall some of the tragic events which occurred in the drainage ditches which crisscrossed the community. Mothers once lived in constant fear that their children would slip and drown in the ditch. With the advent of residential subdivisions, most of the ditches have been culverted but one occasionally notices automobiles which have failed to negotiate narrow planked driveways and nosedived in the ditch.

Richmond could not have developed into a thriving industrial and residential community if substantial dyking and drainage systems had not been developed. However, no community is totally immune to the whims of "Old Man River". This fact was painfully brought to mind during the spring of 1948 when heavy snows coupled with a prolonged spell of warm weather resulted in a raging flood which destroyed dykes all the way from Hope to the mouth of the Fraser. The valley was declared a national disaster area. Along with the armed forces, residents banded together in an attempt to raise and repair the dykes through the use of millions of sandbags.

We've come a long way since the days of Hugh McRoberts when each individual was responsible for protecting his property against Mother Nature. Today Richmond is almost completely surrounded by substantial dykes, some of which provide us with pleasant walking areas and scenic drives. However, it would be foolish to believe that we have conquered "The Mighty Fraser".

Much of the material for this article has been derived from an unpublished manuscript on dyking and drainage prepared by Archie Blair. The Richmond '79 Centennial Society is grateful to Mr. Blair for his efforts to document our community's history.

## Appendix 1:
## Administrative Historical Study, Lulu Island West Dyking District

Immediately after incorporation, the Municipality of Richmond had no systematic means to finance public dyking and drainage projects. Early dyking activities were primarily the private enterprises of early settlers. From the late 1880's, the Municipal government became increasingly involved in dyking and drainage projects.

The Municipality of Richmond was divided into two dyking districts - the Lulu Island West Dyking District and the New Lulu Island Slough Dyking District. The LIWDD was bordered by the Fraser River to the south and the North Arm of the Fraser River to the north and from No. 3 Road on the east to the tidal flats on the west until Francis Road, at which point, from No. 4 Road on the east to the tidal flats on the west. The district included Steveston, Terra Nova, Sturgeon Banks, and the central business area of present day Richmond, excluding Sam Brighouse's property. Each dyking district was administered by a Commission.

Facing the threat of annual flooding along the Fraser River, private individuals owning or occupying land in the West area of Lulu Island came together to form the LIWDD Commission in 1905. The Drainage, Dyking and Irrigation Act of 1873 provided for the appointment of Commissioners to a district for the work of reclaiming land by means of drainage, dyking and irrigation and established the authority of the Commissioners to request men, teams, tools and materials to build and repair dykes and to assess landowners for any expenses incurred in the building and repairing of dykes. The Commissioners were appointed by two-thirds of landowners within a district upon approval of the Lieutenant-Governor.

The LIWDD Commission functioned to render productive the lands within the district. To this end, the Commissioners had the "power to construct, build, dig, make, operate, and maintain dykes, dams, weirs, flood-gates, breakwaters, drains, ditches, pumping machinery, flumes, erections or improvements as they may deem necessary for draining, dyking and irrigating the lands" (B.C.S. 1894, c.12, s.16). Furthermore, the Commissioners had the power to require proprietors to furnish men, teams, tools and material and to make, levy and collect assessments for any expenses incurred in the construction and maintenance of such works. In carrying out these duties, the Commissioners had the right to appoint a clerk, a collector, an engineer, and one or more overseers, to borrow money from any willing lender upon security of the fines, rates and assessments, and to issue bonds or debentures in respect of borrowed money.

Amendment to the statute in 1913 served to establish the

Commission as a corporate body. An amendment of 1924 served to change the selection and terms of election. Commissioners were elected annually during a general ratepayer's meeting. One commissioner was elected for one year, a second was elected for two years, and a third was elected for three years.

Each commission functioned as an independent body, however an administrative link was established between the LIWDD and NLISDD Commissions in 1919, when the Municipal Clerk began to serve as Clerk of the Dyking Commission. Moreover, as the dyking of Richmond increased, the functions of the Municipality, the LIWDD Commission and the NLISDD Commission began to overlap considerably. Under the Richmond Dyking and Drainage Act of 1936, the LIWDD and NLISDD Commissions were amalgamated into one Municipal body, the Richmond Dyking Commission. Town Council became responsible for dyking and collecting of assessments under the Municipality's tax roll. The LIWDD Commission still existed but its sphere of activities was limited to collecting taxes to pay off outstanding debts. Furthermore, under this statute, only members of the Municipal Council were eligible to serve as Commissioners.

In 1959, an amendment to the Municipalities Enabling and Validating Act provided for the transfer of all assets of the Lulu Island West Dyking District and the New Lulu Island Slough Dyking District to the Richmond Municipal Council. Stripped of all powers and assess the LIWDD Commission became a defunct body.

## Appendix 2:
## Administrative Historical Study, New Lulu Island Slough Dyking District

Immediately after incorporation, the Municipality of Richmond had no systematic means to finance public dyking and drainage projects. Early dyking activities were primarily the private enterprises of early settlers. From the late 1880's, the Municipal government became increasingly involved in dyking and drainage projects.

The Municipality of Richmond was divided into two dyking districts - the Lulu Island West Dyking District and the New Lulu Island Slough Dyking District. The NLISDD was bordered by the Fraser River to the south and by the north arm of the Fraser River to the north, and by No. 3 Road on the west and No. 6 Road on the east. Each dyking district was administered by a commission.

In response to continual flooding problems, the residents of Richmond established the first dyking and drainage district, the Lulu Island Slough Dyking District, in 1900. This district soon evolved into the New Lulu Island Slough Dyking District. The Drainage, Dyking and Irrigation Act of 1873 provided for the appointment of Commissioners to a district for the work of reclaiming land by means of drainage, dyking and irrigation and established the authority of the Commissioners to request men, teams, tools and materials to build or repair dykes and to assess landowners for any expenses incurred in the building and repairing of dykes. The Commissioners were appointed by two-thirds of landowners within a district and a clerk was appointed by the Lieutenant-Governor.

The NLISDD Commission functioned to render productive the lands within the district. To this end, the Commissioners had the "power to construct, build, dig, make, operate, and maintain such dykes, dams, weirs, flood-gates, breakwaters, drains, ditches, pumping machinery, flumes, erections or improvements as they may deem necessary for draining, dyking or irrigating the lands" (B.C.S. 1894, c.12, s.16). Furthermore, the Commissioners had the power to require proprietors to furnish men, teams, tools and material and to make, levy and collect assessments for any expenses incurred in the construction and maintenance of such works. In carrying out these duties, the Commissioners had the right to appoint a clerk, a collector, an engineer, and one or more overseers, to borrow money from any willing lender upon security of the fines, rates and assessments, and to issue bonds or debentures in respect of borrowed money.

Amendment to the statute in 1913 served to establish the Commission as a corporate body. An amendment of 1924 served to change the selection and terms of election. Commissioners were elected annually during a general ratepayers' meeting. One commissioner was elected for one year, a second was elected for two years, and a third was elected for three years.

Each commission functioned as a independent body, however an administrative link was established between the NLISDD and LIWDD the Commissions in 1919, when the Municipal Clerk began to serve as Clerk of the Dyking Commissions. Moreover, as the dyking of Richmond increased, the functions of the Municipality, the NLISDD Commission and the LIWDD Commission began to overlap considerably. Under the Richmond Dyking and Drainage Act of 1936, the NLISDD and LIWDD Commissions were amalgamated into one municipal body, the Richmond Dyking Commission. Town Council became responsible for dyking and collecting of assessments under the municipality's tax roll. The NLISDD Commission still existed but its sphere of activities was limited to collecting taxes to pay off outstanding debts. Furthermore under this statute, only members of the Municipal Council were eligible to serve as Commissioners.

In 1959, an amendment to the Municipalities and Validating Act provided for the transfer of all assets of the New Lulu Island Slough Dyking District and the Lulu Island West Dyking District to the Richmond Municipal Council. Stripped of all powers and assets the NLISDD became a defunct body.