City of Richmond

Report to Committee

To:	General Purposes Committee	**Date:**	February 22, 2021
From:	Milton Chan, P.Eng. Director, Engineering	**File:**	10-6060-01/2021-Vol 01
Re:	**Review of Land Raising Initiative in the City's Flood Protection Management Strategy**		

Staff Recommendation

That the staff report titled "Review of Land Raising Initiative in the City's Flood Protection Management Strategy", dated February 22, 2021 from the Director, Engineering be received for information.

Milton Chan, P.Eng.
Director, Engineering
(604-276-4377)

Att. 1

REPORT CONCURRENCE		
ROUTED TO:	**CONCURRENCE**	**CONCURRENCE OF GENERAL MANAGER**
Policy Planning	☑	
Sewerage & Drainage	☑	
Fleet & Environmental Programs	☑	
Bylaws	☑	
SENIOR STAFF REPORT REVIEW	**INITIALS:**	**APPROVED BY CAO**

Staff Report

Origin

At the January 27, 2020 Regular Council meeting, the following referral motion was made:

"That staff review the City's Flood Protection Management Strategy 2019, as referenced in the staff memorandum titled "Non-Farm Use Soil Deposit Proposal for the Property Located at 21700 River Road" dated January 13, 2020, and provide comments with regard to the raising of land, specifically as it relates to agricultural land and agricultural viability."

This report responds to the referral and supports the following strategies within Council's Strategic Plan 2018-2022:

Strategy #1 A Safe and Resilient City:

> *Enhance and protect the safety and well-being of Richmond.*
>
> *1.2 Future-proof and maintain city infrastructure to keep the community safe.*

Strategy #2 A Sustainable and Environmentally Conscious City

> *Environmentally conscious decision-making that demonstrates leadership in implementing innovative, sustainable practices and supports the City's unique biodiversity and island ecology.*
>
> *2.1 Continued leadership in addressing climate change and promoting circular economic principles.*

Analysis

The land raising objective within the Flood Protection Management Strategy is expected to accrue flood protection benefits over the long term (100-year horizon) and would be realized as the agricultural community fulfills their farming objectives by addressing the impacts of climate change. The intent of the Flood Protection Management Strategy is to identify that any raising of land for agricultural purposes would be consistent and supportive of the City's flood protection objectives. Land raising, whether for agriculture or in urban areas of the City, is an overall benefit to the City from a flood protection perspective. Land raising does not need to be comprehensive in order to meet the objectives of the Flood Protection Management Strategy, and any raising should be consistent with all the City's land use strategic objectives.

As detailed in the City's Flood Protection Management Strategy, Richmond is situated approximately 1.0 m above sea level and flood protection is integral to protecting the health, safety, and economic viability of the City. The Flood Protection Management Strategy identifies raising land within all areas of the City as a key overall long-term objective, whereby the City will strategically encourage land to be raised where such raising is proposed to meet City objectives, such as agricultural viability.

Agriculture is a critical, protected land use in Richmond and approximately 39% of the municipality is within BC's Agricultural Land Reserve (ALR). Maintaining agricultural viability is a high priority for Richmond. This has been demonstrated through a number of council referrals, including:

- At the February 8, 2021 Regular Council meeting, Council endorsed that staff be directed to consult with the Food Security and Agricultural Advisory Committee on the Draft New Soil Deposit and Removal Bylaw, dated January 11, 2021, from the General Manager, Community Safety, and report back to Council with a proposed bylaw for adoption.

- At the February 8, 2021 Regular Council meeting, Council endorsed the Farming First Strategy.

The City retained a consultant, which included Professional Agrologists, to perform a review of land raising, specifically as it relates to agricultural land and agricultural viability. Their final report is included as Attachment 1 and a summary is outlined in the sections that follow.

Staff are not recommending any changes to the City's Flood Protection Management Strategy or any further actions at this time.

Historic Geomorphology

Richmond's agricultural land is underlain by sediment deposited from the Fraser River. In recent centuries, the seasonal flooding of the Fraser River deposited sediment throughout the island. The installation of dikes eliminated the natural sediment deposition process. Without dikes, the annual cycles of sediment deposition that formed Lulu Island would have continued and created a quasi-stable equilibrium resulting in a long-term trend of negligible land subsidence or rising instead of the approximately 2 mm per year of subsidence that is currently observed. Without diking, the average elevation of undeveloped areas of the island would be slightly higher than it is currently.

Climate Change

Climate change and sea level rise are expected to have broad impacts to Richmond's agricultural land. This includes an extended growing season with warmer drier summers, warmer wetter winters and fewer frost days. It also includes an increased chance of extreme weather events that have the potential to be problematic to crop production. Current climate change science estimates that sea level will rise approximately 1.0 m by the year 2100 and 0.2 m of land subsidence is forecasted over the same time period.

Richmond's groundwater table varies with the tide and the Fraser River water levels. Since most of the City's agricultural land is at or below daily high tide, the groundwater level is close to the surface in these areas. Climate change induced sea level rise is expected to worsen this issue by raising the groundwater table, which would cause the root zone to be saturated longer. These conditions are expected to reduce root growth, crop yield and plant resilience.

Land raising is expected to keep crops out of the rising groundwater table without the need for active groundwater pumping. This will subsequently increase the number of growing days annually and will enhance the parcel's Land Capability Classification for Agriculture in BC. In exchange, there may be an increased irrigation requirement caused by a drier root zone.

Saltwater Intrusion

Richmond's agricultural land is susceptible to saltwater intrusion. Saltwater intrusion occurs when saltwater from the ocean (and from the wedge of saltwater that travels up the Fraser River during high tide) seeps into the fresh groundwater inland. Saltwater intrusion is expected to increase and move further inland with climate change induced sea level rise and subsidence, further altering soil chemistry and negatively impacting crop viability. Crops that are sensitive to soil salinity include berry crops like strawberries, raspberries and blueberries.

Raising land reduces the impacts of saltwater intrusion movement landward by lifting the rooting zone above any saline groundwater, and by potentially raising the groundwater level inside the dike enough to push back against saltwater intrusion.

Drainage

Land raising is expected to facilitate drainage as there will be an increase in unsaturated soil, allowing more rainfall to infiltrate into the ground. This would reduce the peak runoff that enters the City's drainage system, as rainfall travels slower through the ground than it does over land.

Raising land on one parcel also has the potential to impact lower adjacent land; however, this can be mitigated with a City-reviewed and approved drainage plan and assessment completed by a Qualified Professional, as currently required through the City's soil deposit application.

Over the long term, an increase to the land elevation will also increase watercourse capacity and storage potential, reducing the risk of flooding.

Next Steps

When the City's Flood Protection Management Strategy was developed, the Agricultural Advisory Committee (now known as the Food Security and Agricultural Advisory Committee) was a key stakeholder. Staff will be bringing the content of this report to a future FSAAC meeting for discussion and will advise Council of any required actions arising from this discussion.

Financial Impact

None.

Conclusion

Land raising over the long-term is an effective way to mitigate the effect of climate change and sea level rise when undertaken using best practices. Land raising replaces the natural sediment deposition process that offset the subsidence of Lulu Island prior to the construction of dikes and to protect the City from flooding. Properly done, land raising maintains or improves agricultural viability in the low-lying areas of Richmond, thereby increasing food security over the long-term. Staff are not recommending any changes to the City's Flood Protection Management Strategy at this time.

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JH:ch

Att. 1: Land Raising Review (Flood Protection Management Strategy) Final Report by KWL

Attachment 1

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Flood Protection Management Strategy

Land Raising Review

Final Report
November 30, 2020
KWL Project No. 651.161-300

Prepared for:

Richmond

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Executive Summary

The City of Richmond (Richmond) has initiated an investigation into the benefits and challenges of widespread raising of agricultural land, as recommended in their 2019 Flood Protection Management Strategy (FPMS). The majority of Richmond's municipal land lies on Lulu Island, with approximately 4,993 ha, or 39% of the municipality, within BC's Agricultural Land Reserve (ALR). Richmond has policies in place to preserve and protect agricultural land in Richmond, including the Agricultural Viability Strategy (AVS) and the overarching policies in the Agricultural Land Commission (ALC). These policies guide any land raising that is to occur in the ALR.

Climate change and sea level rise (SLR) is expected to have broad impacts to Richmond with positive and negative implications for agricultural production. Climate change is expected to extend the growing season with warmer drier summers, warmer wetter winters, and fewer frost days, while increased chances of extreme weather events will be problematic to crop production. Sea levels are estimated to rise by 1 m by the year 2100 and the land in Richmond is expected to subside approximately 0.2 m by the same time. SLR combined with land subsidence will cause increased groundwater tables and saline intrusion into soil zones with crop root systems, leading to decreased crop viability. Land raising is estimated to reduce flood risk by reinforcing existing dikes (if the land being raised is adjacent to an existing dike) and by creating more land above flood levels. Using land raising as a flood mitigation strategy is recommended in other jurisdictions around the world but there seems to be a lack of applied documentation of its outcomes, aside from the *'Poldar'* system in the Netherlands.

Currently, agricultural land raising in Richmond is enabled under ALC policies and City bylaws, which require a landowner in the ALR to have an assessment completed by a qualified professional (QP) prior to importing soil. This process is similar to policies set in other jurisdictions in the lower mainland of BC and the world, however there are few examples where widespread land raising has been put into practice.

Research in this study found that the potential benefits to land raising in Richmond include:

- Offsetting subsidence and sediment replenishment that would naturally occur without the dikes;
- Mitigating the effects of SLR on groundwater, salinification, and flood risk;
- Reducing flood risk from river, ocean and stormwater drainage;
- Increasing growing days; and
- Improving agricultural viability on lands that currently experience high groundwater tables.

The most prominent challenges identified with agricultural land raising are:

- Changing drainage patterns around raised land and neighbouring low land;
- Obtaining quality soils that are suitable for agriculture in Richmond;
- Mitigating the potential introduction of invasive species; and
- Temporary loss of agricultural production during and soon after raising.

If done under a standardized set of best practices, agricultural land raising presents a flood management strategy that supports existing flood management infrastructure, reduces flood risk on agricultural lands, and improves crop viability particularly in areas with existing high groundwater tables. Lastly, if land raising is undertaken with the best practices, it is considered to be an effective way to mitigate the effect of SLR by restoring the quasi-stable natural process which kept Richmond's' agricultural lands above sea level prior to the construction of dikes, protect raised lands from ocean and Fraser River flooding and maintain or improve agricultural viability in the lowest-lying areas of Richmond, thus improving food security.

1. Introduction

Richmond's FPMS identifies land raising as an important strategy for flood management across Lulu Island. Lulu Island faces increasing risk of flooding due to a combination of land subsidence (sinking) relative to rising sea levels which are exacerbated by climate change and an increased magnitude of spring freshet. Land raising is one of many flood management initiatives posed in the FPMS to be implemented over the next 20 years and beyond.

1.1 Purpose & Objectives

The purpose of the study is to consider how land raising initiatives identified in Richmond's FPMS could impact agricultural lands and viability. The study is based on a review of literature and documentation regarding land raising and the experiences and outcomes of land raising on agriculture in other jurisdictions. This report provides a summary of the history of land raising in Richmond and summarizes the benefits and challenges that land raising has on agriculture and gives brief high-level recommendations to overcome or mitigate some challenges. This report does not cover the economic, social, or logistical benefits and challenges regarding agricultural land raising.

1.2 Scope

This study considers the relationship between land raising and agriculture through the following topics:

- Agricultural history and current practices in Richmond;
- Impacts of diking;
- Historical Fraser River delta formation, and theoretical delta development in the absence of any form of diking;
- Net impact of land subsidence and SLR on agriculture and groundwater; and
- Impacts of soil placement on water table, drainage, agricultural uses, productivity and soil quality.

1.3 Team

The team involved in this study includes:

- Colin Kristiansen, P.Eng. – Project Manager and Flood Protection Planner;
- Dwayne Meredith, P.Ag. – Senior Agrologist and Technical Reviewer;
- Bryce Whitehouse, B.Sc., P.Ag. – Agrologist; and
- Robin Hawker, MCIP, RPP – Climate Change Adaptation.

2. Background

Agriculture is an important land use in the municipality of Richmond that is vulnerable to impacts from climate change and flooding. The Richmond FPMS outlines land raising as one strategy to preserve and protect agricultural land from river and coastal flood events.

2.1 Agriculture Land Reserve

According to Richmond's agricultural fact sheet, approximately 4,993 ha of Richmond's land base, or 39% of the municipality, is within BC's Agricultural Land Reserve (ALR). Approximately 2,000 ha of this has active farms (City of Richmond, 2018). Over time, the ALR land has slowly been converted to other land uses but regulations created by the Agricultural Land Commission in the 1970's have curbed the transition of ALR to other land uses.

Agricultural land in Richmond is underlain by sediment deposited from the Fraser River. Atop the Fraser River deposits lie rich organic surficial soils from prolonged plant growth that developed from a variety of crops and livestock (Diamond Head, 2014). Cranberries, blueberries, and hays / grasses make up approximately 79% of the active farmland in Richmond (AECOM, 2013). Maintaining the soils and environmental conditions that ensure the viability of these and other crops is a high priority for Richmond.

Currently, Richmond has strategies in place to preserve and protect agricultural land in Richmond, including the Agricultural Viability Strategy (AVS) and the ALC has numerous policies that seek to maintain not only the ALR but that quality of that land; like Policy L-23 *Placement of Fill for Soil Bound Agricultural Activities* that is specific to land raising practices.

2.2 Climate Change

As declared by the governments around the world and by the City of Richmond, there is a climate emergency. Climate change is expected to have broad impacts across Metro Vancouver, with positive and negative implications for agricultural production in Richmond. Rising annual temperatures are expected to extend the growing season with warmer drier summers, warmer wetter winters, and fewer frost days. However, other climate change impacts such as heavy rainfall events, drought, and extreme weather could affect the health of crop and livestock and damage agricultural infrastructure (Metro Vancouver, 2016).

Richmond is also particularly vulnerable to SLR, in which gradual increases in mean ocean water levels can inundate low lying areas and exacerbate flooding during storm events. Water levels in the Fraser River delta are projected to rise by approximately 10 mm annually resulting in a 1.0 m rise by the year 2100 (Ausenco Sandwell, 2011). Agricultural land in Richmond is particularly vulnerable to flooding, with most agricultural land (based on data used for Figure 1) below 2 m geodetic elevation compared with daily high tide being between 1 m and 2 m geodetic.

SLR could impact agricultural lands in a range of ways including:

- increasing demand on flood protection infrastructure and drainage infrastructure during storm events, demands such as pumping;
- increasing saltwater intrusion of groundwater further inland;
- altering soil chemistry from saltwater intrusion; and,
- rising groundwater levels, causing greater saturation of rooting zones.

As sea levels rise, higher tides and groundwater levels in Richmond's ALR are expected to cause shallower rooting zones that are saturated longer, thereby reducing root growth, crop yield, and plant resilience (BC Ministry of Agriculture, 1997). Increased saturation times in the rooting zone could also be caused by increased water levels in the city's drainage system from higher tides and runoff taking longer to drain due to the expected increase in rainfall intensity and volumes. In some cases, low lying areas and areas near drainage outlets may not drain at all resulting in bog-like conditions.

These impacts due to climate change risk the food security for all everyone that receives food grown in Richmond. To reduce the risks associated with climate change and maintain or increase the food security, actions need to be taken in Richmond to further reduce agricultural flood risk and slowdown or stop the saltwater intrusion.

2.3 Flood Management

Richmond relies on flood management to protect land uses in urban and rural areas across Lulu Island. As seen in Figure 1, almost all of Richmond is within the floodplain, with the natural elevation ranging between 0 m and 3.5 m and the majority of land being between 0.5 m and 2.5 m elevation. Without flood management infrastructure, most lands in Richmond would experience flood events annually from high Fraser River levels (especially during freshet), increased precipitation and storm surge and even daily flooding from tidal cycles.

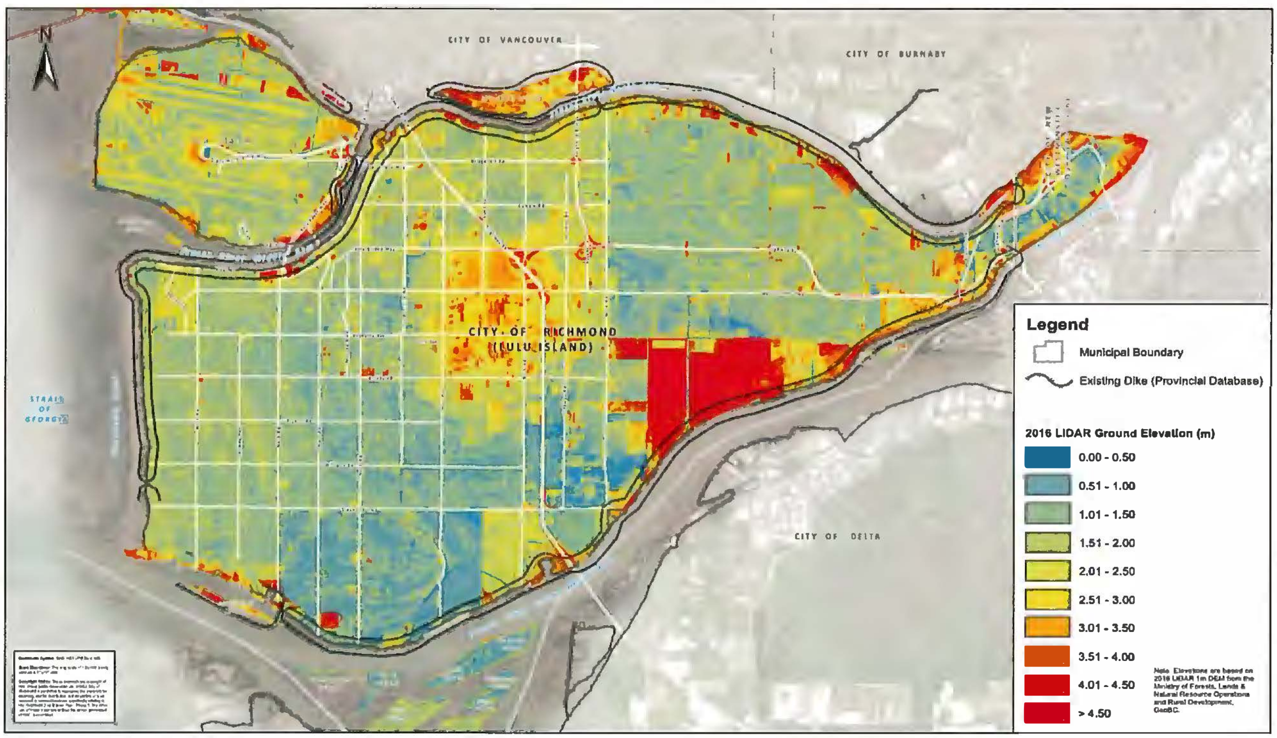

Figure 1: Ground Elevation Range in Richmond

The practice of flood management in Richmond dates back to the 1800's starting with activities by local farmers constructing rudimentary diking systems to keep their lands from flooding multiple times a year. Since then, large flood events in 1894 and 1948 led to the widespread installation of diking around the perimeter of Lulu Island which has reduced flood risks enough to allow urban, rural, and agricultural development to occur.

To further reduce flood risk, Richmond established a Drainage and Diking Utility in 2002, adopted Flood Construction Levels (FCL) that set the minimum elevation for development in the floodplain, and developed flood protection management strategies in order to mitigate flood risk. The established Drainage and Diking Utility, currently generates over $13 million annually which goes to maintaining and upgrading Richmond's flood protection infrastructure. Upgrades and improvements to the flood protection infrastructure is based on the guiding framework developed in The Flood Protection Management Strategies (FPMS), with the latest adopted strategy was developed by KWL in 2019. The 2019 FPMS reviews and updates the 2008 FPMS by providing a better understanding of flood risk in Richmond and recommending new flood management strategies for flood hazards under current and future climate change conditions. The FPMS continually seeks to mitigate flood risks by guiding urban and rural development and city planning and enforcing the adaptation to climate change (City of Richmond, 2019).

The 2019 FPMS recommends widespread land raising for flood protection in agricultural areas in accordance with the regulatory framework outlined by the ALC. Land raising is expected to be an effective way of offsetting subsidence and flooding by raising land above the estimated flood level. Though there are no well-documented examples of agricultural land raising for the purpose of flood management in other jurisdictions, studies like this one have been completed that recommend a similar process.

3. Lulu Island

Land can be raised through natural processes or through human engineering (e.g., importing soils). Prior to diking, Lulu Island was subject to periodic river flooding and storm surge events that caused sediment to accumulate and raise land naturally over time. However, diking for flood protection cut off this natural sediment deposition, leading to gradual land subsidence (sinking) across Lulu Island. As sea levels rise and the land subsides, agricultural land on Lulu Island is getting lower relative to surrounding river and sea levels.

3.1 Historical Geomorphology

To raise land effectively in Richmond and Lulu Island it is important to understand the natural process that formed Fraser River delta and Lulu Island. With this understanding in mind, best management practices can be better established in agricultural land raising that will maintain or enhance agricultural lands.

The Fraser River Delta was formed by a combination of deglaciation of the region and the rapid westward extension of the Fraser River east of the City of New Westminster. Clauge (1983) estimates that about 10,000 years ago, the Fraser River began to empty into the Strait of Georgia and, as the sea dropped below its present level relative to the land over many years, and glacier melt carried sediments down towards the Strait and a delta was formed south and west from the point of discharge. The westward movement of the delta continued after sea level stabilized at about – 12 m elevation after 8,000 years before present (BP) (Clauge *et. al.,* 1991). Approximately 4,000 – 5,000 years ago, when the sea levels were approximately 1 m or 2 m below their present position, a large area of the delta emerged and bogs began to form. Since then, the Fraser River Delta grew westward under a regime of relatively stable sea levels (Clague, Luternauer, & Hebda, 1983).

In recent centuries, sediment deposition and accretion on Lulu Island has been from the Fraser River water levels rising above Lulu Island's exposed land; most of which is sand discharged during annual freshet (Milliman, 1980). Throughout the remainder of the year, the river carries mainly silt and clay with much lower flow and sediment concentrations. At lower Fraser River flows, sediments are still deposited at the westward edge of Lulu Island due to annual tidal cycles that influence the transport of sediment by reducing the transport capacity of the Fraser River and 'pushing' the westwards flow eastwards towards Lulu Island (Ages and Woollard, 1976).

3.2 Impacts of Diking

The installation of dikes in Richmond began in the 1800s and has eliminated the natural sediment deposition processes, causing land subsidence to be the dominant process. The elimination of Fraser River flooding across the delta (Lulu Island) has eliminated the recruitment of nutrient-rich soil. If left undisturbed, the annual cycles of sediment deposition that formed the Fraser River Delta and Lulu Island would have continued and cause the land elevation on Lulu Island to reach a quasi-stable equilibrium (i.e., there would not be a long term trend of land subsidence or rising when compared to sea level).

Subsidence

Historically, subsidence of land in Richmond has been attributed to tectonic processes and crustal deformation. In recent years, it has been observed that subsidence is likely due to the slow, natural consolidation (compacting) of thick Holocene sediments (Ertolahti, 2014). Most delta environments experience the effect of subsidence, but the rate of subsidence is offset by sediment accretion from their respective river. Sediment settlement has contributed to Lulu Island subsiding at an average rate of 1 – 2 mm per year, with small pockets subsiding at rates up to 3.5 mm per year. Figure 2 below shows the rate of uplift in the lower mainland from annual surface comparisons. Subsidence due to the settlement of sediments combined with SLR means that, on average, Lulu Island is estimated to drop approximately 12mm per year relative to sea level (annual subsidence + SLR); with exceptions in areas where there is positive uplift seen in Figure 2.

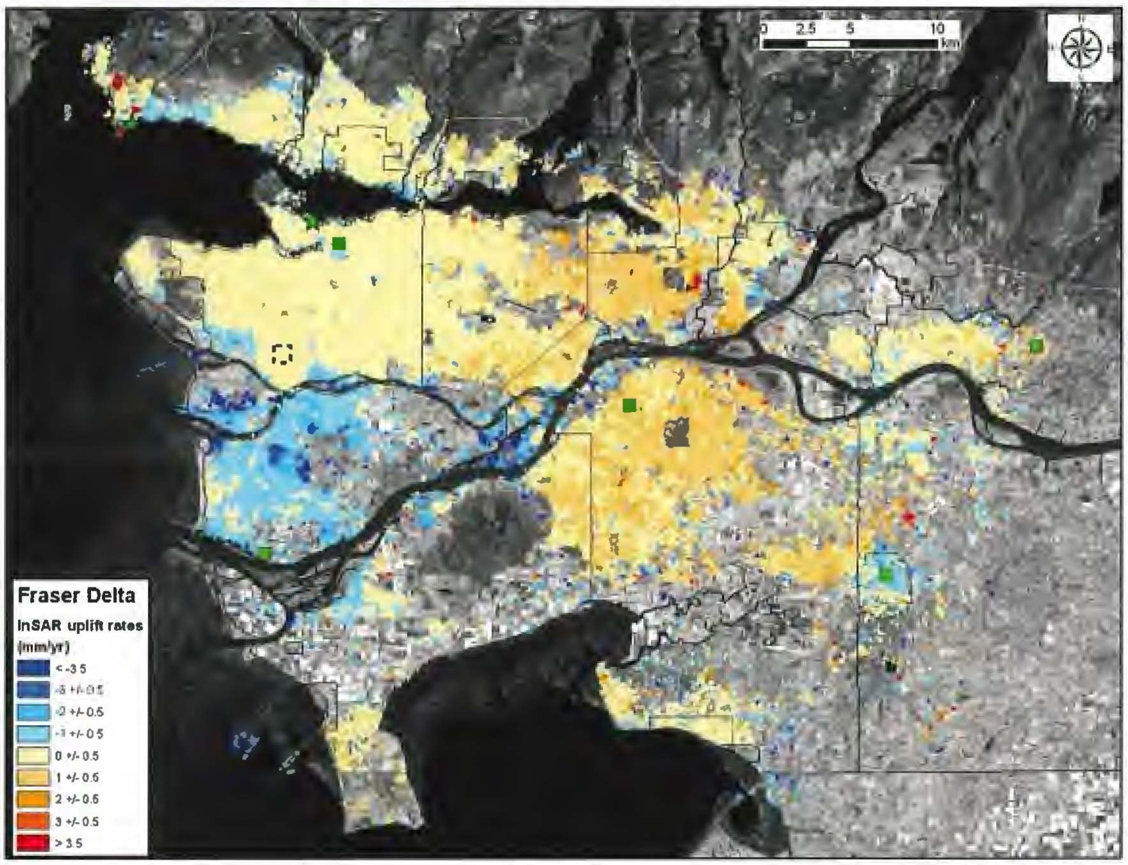

Figure 2: CTM-InSAR Uplift Rates from Surface Movement Analysis (Lambert *et. al.*, 2008)

Nutrients

Diking in Richmond has also been found to affect the soils on Lulu Island. Without annual replenishment of sediments that supply nutrients, soils slowly lose nutrients with annual crop yield. With nutrient replenishment cut off in Richmond, agricultural practices return nutrients to the soils. These practices include but are not limited to the planting of nitrogen fixing crops, though nitrogen fixing crops are not common in Richmond so, more commonly, fertilizers are applied to return nutrients to the soils and increase crop yield. Unfortunately there are risks associated with the application of fertilizer, with regards to this study as stated by a Madrone report in 2020, the high-water tables in Richmond make the application of fertilizers problematic due to the potential for groundwater contamination.

3.3 Theoretical Development without Diking

Before development, Lulu Island was mainly comprised of wet prairie, bog, and marsh (Davis & Rose, 2004). It is now a mix of urban, industrial, and agricultural land, surrounded by dikes and crossed by numerous transportation and infrastructure networks. Dikes prevent regular flooding from the river and ocean and have allowed development and traditional agriculture practices to ensue.

According to Williams and Roberts (1988) there was approximately an average of 0.12 mm to 0.40 mm of accretion in the Fraser River delta annually with larger magnitude flood events (>1 in 5 year return period event) transporting more sediments (Attard, Venditti & Church, 2014), resulting in event-based accretion in excess of the annual range. Without diking, the island would, on average, be higher than it is currently. If it was assumed that diking cut off the accretion of sediments in the late 1800's, it could be also be assumed that some areas could be as much as 12-50 mm higher than today; though, these assumptions would not account for a possibility of a non-linear annual accretion patterns. It is most likely that without diking, the potential sediment accretion experienced in the floodplain would vary vertically and horizontally, with lower areas closer to the ocean experiencing greater rates of accretion than higher elevation areas inland.

When Williams and Roberts (1988) concluded their research, they were both under the impression that the sediment discharge rate of the Fraser River was sufficient to allow accretion of Lulu Island to keep pace with the rate of sea-level rise and to maintain westward expansion throughout the period of rising sea level. However, this estimate was made in the early 1990's. Recent research has estimated the rate of SLR to be larger than it was in the early 1990's. This means that SLR could still have exceeded natural sediment accretion even if dikes had not been installed. Regardless of SLR, if left unhindered, Lulu Island would be expected to have varying degrees of ground elevations higher than the elevations seen to today, with most of the island covered in bog and marsh land, possibly intersected with Fraser River distributary channels.

3.4 Current Land Raising Practices

Land raising within the ALR can be achieved by adding soil to land barren of agricultural activity or by uprooting an existing crop, raising the land with agriculturally viable soil, and replanting with a new crop on top of the raised land.

Richmond

Currently, property owners who wish to import soil to raise a property in the ALR must submit a soil deposit application to the City and provide either a 'Soil Use for the Placement of Fill Application' or, a 'Notice-of-Intent' application to the ALC. A 'Soil Use for the Placement of Fill Application' requires Council approval prior to the ALC reviewing and deciding on said application.

Applications to import soil to raise lands in the ALR undergo a thorough review by staff. Should provincial legislation require it, applications also are assessed by Council. City requirements include, but are not limited to, the following:

- Report provided by a QP (property and soil quality assessments);
- Farm Plan provided by a QP;
- Drainage Plan/Assessment provided by a QP;
- Geotechnical report prepared by a geotechnical engineer;
- Topographic survey provided by a registered land surveyor;
- Erosion and Sediment Control Plan; and
- BC ENV site profile.

Should a permit to import soil be issued by the City, permit conditions include, but are not limited to, the following:

- Source site investigation/sign-off by a QP;
    - Addresses source soil type to ensure it meets the agrologist's recommendations and City/ALC approval requirements and invasive species review/assessment;
- Soil deposit site monitoring during soil deposit operations;
- Soil deposit site monitoring reports (typically every 3,000 cubic metres); and
- Requirements to adhere to the recommendations within all other reports provided by the applicant (i.e. Geotechnical report, Drainage Plan, Farm Plan, etc.).

ALC Regulations (Soil Placement / Removal)

An application must also adhere to Section 20 (3) of the Agricultural Land Commission Act (S.B.C. 2002) regarding the placement and removal of fill which states:

(1) A person must not remove soil from, or place fill on agricultural land unless one of the following applies:

a. the removal or placement is permitted under section 25 or 45 and the removal or placement is done in accordance with the permission;

b. the removal or placement is permitted under the regulations and the removal or placement is done in accordance with the regulations;

c. the person

i. is an owner of the agricultural land, or has a right of entry, granted under an enactment, to the agricultural land,

ii. first submits to the chief executive officer the prescribed fee and notice of the person's intent, in the form and manner required by the chief executive officer, and

iii. receives approval under subsection (2) (b) and removes the soil or places the fill in accordance with the approval, or is a person to whom subsection (4) applies.

The above excerpt from the ALC act refers to the conditions required for permitted removal or fill, in accordance with 'regulations'. Regarding the process of the placement of fill and its quality there are two sets of regulations that need to be adhered to, the first is the ALC Policy L-23 regarding fill that states:

Soil and Fill Use applications for fill placement under Section 20.3 of the Agricultural Land Commission Act (the "ALCA") may be approved where it can be demonstrated to the satisfaction of the Agricultural Land Commission (the "Commission") that:

a. Fill placement will aid the farm/farming activity;

b. Fill placement will not reduce the agricultural capability of the land, degrade soils, or limit the range of crops that can be grown on the subject property compared to the current crop suitability of the land;

c. Applicants are able to demonstrate that fill placement is the only means available to address implementation of standard agricultural best practices;

d. Fill placement will aid in the rehabilitation of agricultural lands severely impacted by past fill activities or other activities that have degraded agricultural land whether permitted or not permitted;

e. Fill placement will not foul, obstruct, or impede the flow of any waterway;

f. If fill is required for drainage improvements, the proposed fill height does not exceed more than 0.5 metres above the maximum height of the water table (as confirmed by a Qualified Registered Professional) which is equivalent to a Class 1 excess water limitation;

g. The final finished grade of the subject property compliments adjacent landforms and provides for a smooth transition between the land contours and drainage channels on adjacent lands and the reclaimed area; and

h. Fill placement activities should not extend beyond two years. Extensions will not be granted beyond the expiry date indicated in a Commission decision letter.

The second is the City of Richmond's regulations from the *Soil Removal and Fill Deposit Regulation* Bylaw No. 8094 which states:

Permitted Material Includes:

a. Any material that is listed in the Guidelines for Farm Practices Involving Fill, or that is used as specified in the Guidelines for Farm Practices Involving Fill;

b. Any material not specified in (a) that is certified in writing, as a standard farm practice, by a Professional Agrologist in a form acceptable to the Manager; and

c. And material that is authorized for deposit as fill at a specified location by the Commission pursuant to Section 20 (3) of the Agricultural Land Commission Act, as amended.

To adhere to all the regulations regarding fill stated above, if all imported soils cannot meet the quality required for the rooting zone as recommended by a QP, the professional can consider preserving the existing rooting zone material and using imported material as the base (below the rooting zone) and place the native material back on top of the placed base.

Other Jurisdictions

Research into land raising practices and policies revealed Richmond's situation is unique within the lower mainland, due to the majority of Richmond being so close to sea level. There are many examples of studies in jurisdictions that recommend land raising as a flood mitigation, but there were limited examples of municipalities situated on deltas that have employed land raising as a means of flood management. Most other lower mainland jurisdictions do not consider widespread land raising as a means of flood mitigation because most of their municipal land is high enough that the current high tide and SLR can be effectively mitigated in other ways. Although their soil bylaws include similar requirements to Richmond's, they identify imported soil quality and raising groundwater tables as issues that need to be addressed before soil importation can proceed.

One example of a jurisdiction that incorporated agricultural land raising into its flood management strategy is in the Netherlands. Their '*Poldar*' system (Hoogheemraadschap van Rijnland, 2009), among many other measures, promotes the active agricultural land be raised above the expected water level in the drainage system. It is important to note that the *Poldar* system is quite unique as most of the agricultural area in the Netherlands is below sea level, and like in Richmond, their main flood management system is an elaborate network of dikes. Jurisdictions in the Netherlands actively employ land raising in agricultural area out of necessity with success (Hoogheemraadschap van Rijnland, 2009).

4. Potential Impacts of Land Raising Practices on Agriculture

Land raising for flood management should be done in a way that maximizes benefits and reduces negative impacts on agricultural lands. Land raising can be an effective way to mitigate the effect of climate change and improve agricultural viability. This section summarizes the main challenges and potential benefits that land rising can have on agricultural land.

4.1 Irrigation & Groundwater

In Richmond and on Lulu Island there is a dynamic groundwater table that goes up and down with the tide and the Fraser River water levels. At high tide and during freshet months the groundwater table raises to its highest levels. In some places, groundwater can reach ground level, which is problematic for growing the majority of crops seen in Richmond (B.C. Ministry of Agriculture, 1997).

Saltwater intrusion is also detrimental to crops specific to the ALR in Richmond and is associated with high tides. Saltwater intrusion is a process where water from a saline waterbody seeps into the fresh groundwater reaching inland. In Richmond's case, saline water comes from the sea as well as from a saltwater wedge that travels up the Fraser River and lies below the outflowing freshwater of the river (Thomson, 1981). This intrusion causes saline groundwater to periodically rise into the rooting zone in lands adjacent to the sea or salt wedge. Once the groundwater recedes, it can leave behind salt precipitate which can greatly affect the viability of some crops, particularly those sensitive to soil salinity. In Richmond, crops that would be sensitive to salinity include berry crops like strawberries, raspberries, and blueberries (Province of Manitoba, 2020).

Without land raising, higher water levels (due to SLR and subsidence) outside the perimeter dikes is expected to result in greater seepage through the foundation of the dikes resulting in a higher groundwater table and an increase in groundwater salinity (Atlantic Climate Adaptation Solutions Association, 2011).

Benefits of Land Raising

- Keeps the growing medium out of the water table by offsetting subsidence and rising groundwater table due to SLR.
- Reduces the effect of increased salinity in the unsaturated zone and rooting zone in agricultural lands adjacent to the sea or salt wedge.
- Increases the number of growing days annually by reducing the period when the groundwater table reaches into the rooting zone during freshet. Freshet can cause high groundwater levels for weeks. If the land is raised enough such that the rooting zone is higher than the freshet groundwater level during high Fraser River flows, the rooting zone will not experience weeks of total saturation.
- Facilitates drainage by increasing the unsaturated zone in turn increasing the volume of rainfall that can be infiltrated. Infiltrated water flows slower through the ground than overland which reduces peak runoff rates in drainage ditches. Additionally, increasing land elevation around drainage ditches could increase ditch conveyance capacity and increasing storage potential as well as reduce the risk of drainage-based flooding.

Challenges of Land Raising

- Affecting groundwater flow patterns on adjacent land (City of Richmond & Richmond Farmers Institute, 2003 & Ritter, J., 2016). Raising land in one area can, depending on the hydraulic conductivity of the imported soils and grading, affect lower adjacent land. Soils with lower conductivity on the raised land could cause groundwater to flow into adjacent lands.
- Increased irrigation requirements, due to an increased unsaturated zone and a deeper groundwater table causing a drier rooting zone. Especially in summer months, more irrigation could be required after land raising has been undertaken because of groundwater providing less moisture to the larger unsaturated zone.

4.2 Soil Quality & Crop Viability

One of the major challenges of land raising is obtaining quality soil that is suitable for maintaining crop health, viability, and longevity. Currently, Richmond has an established agricultural region that supports mostly berry, grass and various vegetable crops. Soils that make up the native material in Richmond currently support these crops and importing soils that will continue to support these crops is essential to crop viability. Imported soils will likely have a different distribution of sand, silt, gravels, and organics than native material so it is essential to use best practices to bring in quality soils and preserving as much native material as possible.

Benefits of Land Raising

- Through best practices like re-using native topsoil, importing high-quality soils, etc., the land raising process can maintain the current quality of existing soils or re-established soils. By raising land, it would maintain an unsaturated rooting zone that is required for agriculture. Soil that is consistently saturated or within the groundwater table for an extended time would reduce its agricultural value.
- Reduces saltwater intrusion by allowing the groundwater table elevation to increase. Having more available storage area for infiltrated rainfall and runoff, will effectively add to the existing groundwater and the groundwater table elevation will increase. A higher groundwater table would increase the hydraulic head (height of groundwater above sea level) which would reduce the movement landward of saline groundwater from the ocean. To reduce saltwater intrusion, it would be important to raise the land enough such that the freshwater table on the land can rise and apply more force against the opposing saline groundwater intrusion force (Atlantic Climate Adaptation Solutions Association, 2011).
- Enhance quality of existing soils. A parcel of land capability recognized by the 'Land Capability Classification for Agriculture in BC' could be enhanced by establishing an unsaturated zone higher than the groundwater table, conducive to agriculture.

Challenges of Land Raising

- Maintaining soil quality as it is known that, due to its many origins, soil is variable in terms of its particle size distribution and organic composition. Any imported soils need to make up a profile in the unsaturated zone and rooting zone that is ideal for agriculture in Richmond and/or specifically ideal for desired crops within individual land parcels.
- Mitigation of introducing invasive species. Importing clean soil is essential to crop viability, invasive species have the potential to severely reduce crop viability within the land being raised and adjacent lands where imported invasive species could spread.
- Land rehabilitation. Rehabilitation efforts will likely need to be undertaken if the imported soils do not have the same soil profile and soil characteristics as in the existing land that is being raised, or if there is a disturbance to the existing soil profile through re-grading. It has been observed that after native soils have been disturbed or imported soils with different soil profile have been placed it can reduce crop viability initially due imported soils unestablished soil profile that is conducive for the crop being planted or the area it was placed. Rehabilitation through the addition of nutrients, or organics or some years of established crops would eventually develop a productive soil profile that is capable of supporting crop yields experienced before the disturbance (Ministry of Agriculture and Rural Affairs Ontario, 2016 & Miner G.L., *et. al.,* 2020).

5. Conclusions and Recommendations

The findings from this study suggest that land raising in Richmond's ALR lands could have the following benefits if performed in accordance with Richmond's Soil Removal and Fill Deposit Regulation Bylaw No. 8094, soil deposit application checklist, ALC Act and the ALR Regulation and corresponding ALC policies. The potential benefits of land raising are:

- Offsetting subsidence and sediment replenishment that would naturally occur without the dikes;
- Mitigating the effects of SLR by:
    a. Reducing the saltwater intrusion effect,
    b. Reducing flood risk, and
    c. Maintaining or increasing the unsaturated zone;
- Reducing flood risk from high river flows, ocean storm surge events and stormwater drainage by having more land elevations higher than the estimated flood water levels;
- Reinforcing existing flood protection when land is raised adjacent to diking;
- Increasing number of growing days for crops;
- Facilitating drainage; and
- Improving agricultural viability on lands that currently experience high groundwater tables.

The most prominent challenges identified with agricultural land raising are:

- Changing drainage patterns and groundwater movement around raised land and affecting the existing drainage patterns on neighbouring properties at a lower elevation;
- Obtaining quality soils that are satisfactory for agriculture in Richmond;
- Mitigating the potential introduction of invasive species.

General Recommendations

In general, it is recommended that Richmond consider the following actions when raising lands in agricultural areas:

- City staff and Council maintain the current soil deposit application requirements and internal staff review process in order to mitigate the above-mentioned challenges in raising agricultural lands.
- Maintain continued best practices, with respect to all soil deposit applications requiring supporting documents provided by QP's i.e. professional reliance model with review by relevant City staff
- City staff ensure that the existing *Soil Removal and Fill Deposit Regulation Bylaw No. 8094* remain relevant given recent changes to the ALC Act and the ALR Regulations
- If deemed acceptable by a QP, dredged materials from the Fraser River could be used as inexpensive agricultural soil and would come from the historical source of material on Lulu Island.
- City planning processes could facilitate the widespread raising of land so individual parcels of land are not raised without adjacent lands being raised as well; reducing drainage impacts on neighbouring properties at a lower elevation.

- Create/maintain an open dialogue with the ALC, Ministry of Agriculture and any other provincial or federal ministries regarding the challenges of ensuring Richmond farmland remains viable given the changing climate and likely impacts due to rising sea levels

Agricultural land raising can be a flood management strategy and a response to the enacted climate emergency that improves existing infrastructure, reduces flood risk, and benefits agricultural practices in areas with high groundwater tables. If undertaken with the best practices mentioned above, it is considered to be an effective response to the climate emergency that mitigates the effect of SLR, restores the quasi-stable natural process which kept Richmond's' agricultural lands above sea level prior to the construction of dikes, protects raised lands from Fraser River flooding and maintain or improve agricultural viability in the lowest-lying areas of Richmond thus increasing food security in the region.

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