EXECUTIVE SUMMARY

INTRODUCTION

It is widely accepted in the scientific community that climate is changing. Climate data is used to design infrastructure and, under climate change, historical climate data as the basis of design may not be appropriate.

In 2008, Metro Vancouver and Engineers Canada cooperated in the Vancouver Sewerage Area (VSA) vulnerability assessment. The VSA study was one of seven original pilot study applications of an assessment protocol developed by Engineers Canada for use with all types of infrastructure across Canada. That study focussed on an area that is largely combined (i.e. sanitary sewage and stormwater conveyed in the same pipe) and currently undergoing significant change through an ongoing program of sewer separation (i.e. separating stormwater and sanitary sewage into different pipes). The Fraser Sewerage Area (FSA) study is a logical extension of the work done in the VSA study and it provides Metro Vancouver with new findings relevant to separated sanitary sewer systems.

The FSA is approximately 36,700 ha in size and it serves about one million people in 13 municipalities within Metro Vancouver[1]. Both separated and combined sewer systems within the area are tributary to the Annacis Island Waste Water Treatment Plant (AIWWTP), which provides secondary treatment and is the largest of five Metro Vancouver wastewater treatment plants.

Years 2020 and 2050 were selected for analysis of climate change effects. Much of the FSA infrastructure dates to the 1960s or earlier. 2020 represents an early design life boundary for the oldest piping and appurtenances. A key operational target is Metro Vancouver's commitment, outlined in the 2002 Liquid Waste Management Plan (LWMP), to eliminate combined sewer overflows (CSOs) in the FSA by 2075. Since the single largest impact of climate change on the FSA was known to be increased rainfall (and therefore wastewater flow), a 2050 assessment of climate change is timely for Metro Vancouver's sewer separation planning.

Addressing climate change requires two complementary actions: mitigation and adaptation. Minimizing the region's contribution to global climate change is one of the primary goals of the current Air Quality Management Plan. And, through a new Energy Planning Program, Metro Vancouver is also actively pursuing opportunities to recover energy within its own operations, often with related benefits of overall reduction in greenhouse gas (GHG) emissions. The degree to which a municipality is able to address the impacts of climate change is often referred to as its adaptive capacity.

[1] The total serviced area tributary to the Annacis Island Wastewater Treatment Plant (AIWWTP) is approximately 36,700 ha. There is an additional area of approximately 9 sq.km, also within the legal boundary of the FSA, that is serviced by a different wastewater treatment plant known as the Northwest Langley Wastewater Treatment Plant (NWLWWTP). The NWLWWTP is not included in the scope of this study. For the purposes of this study, the FSA area refers to that area tributary to AIWWTP.

CLIMATE CHANGE

According to the Intergovernmental Panel on Climate Change (a global scientific body established by the World Meteorological Organization and the United Nations Environment Program), the warming that has been experienced over the last half century is likely without precedent in at least the past 1,300 years. For the purposes of this project, climate change modelling was performed by Ouranos (a Quebec-based climatology research consortium) using the Canadian Regional Climate Model to quantify expected changes to various climate factors.

In general, all precipitation indices suggest that there will be an increase in total rainfall amount, and in both the frequency and magnitude of rainfall events. In addition, modelling projects consistently increasing temperature trends at both the 2020 and 2050 horizons, implying that snowfall will decrease.

Global sea level rise estimated by Ouranos is 0.14 m by the 2050s and 0.26 m by the 2080s. The most recent report from the IPCC has a range in predicted sea level rise by 2100 of between 0.2 m and 0.6 m.

Monthly average minimum and maximum temperatures are predicted to increase by 1.4°C to 2.8°C by the 2050s.

A summary of climate events is outlined below.

Summary of Climate Events

Climate Event	Expected Change
Intense Rain	Increase in 1-day maximum rainfall: 17% by 2050s (Ouranos) [1]
Total Annual / Seasonal Rain	Increase in total annual precipitation: 14% by 2050s (Ouranos, addendum)
Sea Level Elevation	Increase in global sea level elevation[2]: 0.26 m by 2080s (Ouranos) to 1.6 m by 2100 (Rohling et al, 2007)
Storm Surge	Not quantified. Likely to increase[3].
Floods	Not quantified. Likely to increase.
Temperature (monthly average high)	Increases in monthly average maximum temperature: 1.4°C to 2.8°C by 2050s (Ouranos).
Drought	Modelling is inconclusive in trend. Average maximum length of dry spell may increase by 0.25 days by 2050s (Ouranos).
Wind (extremes, gusts)	Not quantified. Likely to increase.

Notes:
1. Estimate is based on total precipitation, which is assumed to be approximately equivalent to rainfall in the FSA.
2. Does not include local effects such as subsidence and atmospheric effects.
3. Storm surge is a significant contributor to extreme high water events and therefore lack of quantitative data is a critical information gap.

According to Ouranos, climate scenarios are difficult to produce for certain highly localized events (wind gusts, tornadoes, and thunderstorms) or events where processes are complex and depend on a number of factors (hurricanes, ice storms). Therefore, quantitative predictions of wind speed were not provided.

As described in more detail in Section 2, there are a number of uncertainties and assumptions involved in the climate projections listed above and these reflect only limited range of possible future scenarios for GHG emissions.

In addition, regional climate is affected by large-scale oscillations in climate known as:

- El Niño/Southern Oscillation (ENSO); and
- Pacific Decadal Oscillation (PDO).

ENSO is a well-known phenomenon characterized by an east-west shifting pattern in tropical sea surface temperatures. The time scale of the shifts is relatively short: cycles last from 2 to 7 years. Generally, El Niño winters are associated with decreased precipitation in southwestern British Columbia, with the reverse trend occurring during La Niña events.

The PDO operates over the entire Pacific basin on a decadal timescale. Phases generally persist for about 20 years to 35 years. The PDO last shifted to a predominantly positive (warm) phase in 1976. For coastal B.C., the warm phase generally results in thinner snowpacks due to higher temperatures and generally a greater percentage of precipitation in the form of rain. It is now generally believed that, as of 2008, the PDO has shifted to a predominantly negative (cool) phase, which is associated with generally cooler temperatures and increased precipitation.

FRASER SEWERAGE AREA (FSA)

The FSA is largely a separated sewerage area; however, in New Westminster and in the City of Burnaby parts of the municipal systems have sewers that convey combined sanitary and stormwater flow. Together, the combined sewer areas make up 1,440 ha, which represents about 4% of the FSA.

During dry weather, all flows from the FSA are conveyed to the AIWWTP before discharge of treated effluent to the Fraser River. The exception is when, due to operational issues, power outage, or capacity exceedance during wet weather, flow is discharged to either land or water as a sanitary sewer overflow (SSO) or a combined sewer overflow (CSO).

At the AIWWTP, Metro Vancouver provides secondary treatment for flows up to two times average dry weather flow (ADWF), or 960 MLD.

DESIGN AND PLANNING CONSIDERATIONS

Metro LWMP outlines the region's strategy for managing liquid waste, including:

- setting a desired level of service;
- identifying areas that fall short of target performance; and

- evaluating options to improve system operation.

Under the LWMP, Basic Service capacity is the minimum desired level of service for conveyance capacity and is the basis for determining when upgraded facilities are required to accommodate sewerage area growth. Basic Service Criteria include allowance for peak dry weather flow (PDWF) plus 11,200 litres per hectare per day (L/ha/d) inflow and infiltration (I&I).

Under climate change constraints, materials with a high embedded carbon footprint are less desirable and may become less available. There may also be an opportunity to consider alternative energy sources for pump and plant operations from sewer stream resource recovery.

One approach to maximizing resource recovery is distributed wastewater management, which involves the spatial distribution of treatment facilities. A distributed management approach offers a number of advantages, including some that improve adaptive capacity. First, it reduces the upgrading requirements on downstream facilities as capacity is returned to them by intercepting flow upstream. Second, additional opportunities for water reuse and wastewater-derived heat energy are created over a wider geographic area. Finally, by reducing flow in the downstream reaches of the system the frequency and volumes of existing wet weather overflows can be greatly reduced if not eliminated. Further study is recommended to explore resource recovery and distributed wastewater management opportunities.

INFRASTRUCTURE ASSESSMENT

An important part of the Protocol is a qualitative assessment in which professional judgment and experience are used to determine the likely effect of individual climate events on individual components of the infrastructure.

Combined Sewers

It is certain that increased rainfall intensities and volumes will lead to increased flows in the combined sewers in the absence of other mitigating system changes (e.g. increased efforts at green infrastructure). The effect will be reduced capacity to convey sanitary flow to the AIWWTP; as a result, CSOs will be more frequent and discharge greater volumes.

Separated Sewers

Even in a completely separated storm sewer and sanitary sewer system, rainwater enters sanitary sewer mains through I&I. Sanitary mains are designed to convey some I&I; currently the LWMP allows for a maximum of 11,200 L/ha/d for storms with less than a five year return period. It is certain that increased rainfall intensities and volumes will lead to increased I&I, however, it is noted that as a result of spatial variation in rainfall intensity, a 5-year event will produce very different rainfall volumes across Metro Vancouver.

Further work is recommended to determine how this (or other variables such as soil type or grade) relates to a specific I&I target (e.g. 11,200 L/ha/day). Geographic or rainfall related targets may be more equitable amongst member municipalities.

Pump Stations

As mentioned above, increased rainfall is certain to increase I&I and thereby increase flows at pump stations. Exceeding station capacity could result in overflows locally or upstream. In both the combined and separated areas excess flow is discharged at outfalls and designated overflows to prevent overflows at a more sensitive location.

Annacis Island Wastewater Treatment Plant

Hydraulic constraints within the FSA collection system physically "shelter" the AIWWTP from the excess amount of wet-weather wastewater flow resulting from I&I or combined sewers. Therefore, even though climate change may result in an increase in the magnitude and frequency of intense rainfall events and thus increase the potential to generate wet-weather flows, higher peak flow rates are not expected to be received at the AIWWTP. Nevertheless, more frequent and/or more intense, or longer duration of individual wet-weather events could impact the treatment process in other ways. For example, primary clarification performance may be reduced during wet-weather flow events, which could result in more days per year with increased organic mass loading to the secondary treatment process units.

In addition, increased frequency of such events would reduce process redundancy "windows" (e.g. treatment units taken out of service for maintenance). This situation could leave the AIWWTP with greater exposure to operational challenges. The AIWWTP is scheduled for significant growth upgrading (Stage V) in the coming years.

Other Vulnerability Factors

Sewer Separation. In the VSA study, Metro Vancouver staff pointed out that the reduction in sewer flow from sewer separation will, in general, be vastly greater than the increase due to climate-based rainfall effects. In the FSA, sewer separation will significantly decrease inflow into the collection system, but only in localized areas and specific sections of mains.

Long Range Plans. Construction projects that are part of long range plans will improve system operations, presumably increasing the ability to manage SSOs and CSOs. It is expected that the Eastern Township of Langley will soon be connected to the FSA, increasing flow.

Infrastructure Replacement. Replacement of aging infrastructure decreases the risk of system blockages and provides the opportunity to install larger mains or separate systems.

Green Infrastructure. Increasing efforts at building green infrastructure may be used to increase resiliency in adapting to climate change. Metro Vancouver has completed significant efforts studying and promoting green infrastructure over the past number of years, with the overarching goal of net sustainability benefits at a watershed scale.

Inflow & Infiltration Reduction and Age Based Rate Decay. Sanitary sewer loads can decrease with inflow & infiltration reduction programs (at the municipal or regional level), but generally increase due to material deterioration over time.

Population Growth. Population growth will increase sanitary sewer loading over the entire study period. Metro Vancouver is developing a Growth Management Strategy, which envisions population growth of approximately 1 million people (to 2.75 million) from 1996 to 2021.

Land Use. Planned densification may increase total impervious area, leading to more runoff and sewer loading.

Water Conservation. Water conservation programs reduce indoor water use, decreasing sanitary loading.

Seismic Events. Landslides or ground shifting caused by seismic events break or degrade sewer main integrity. Earthquake activity is not thought to be climate change related, however landslide frequency is directly related to saturated soil conditions and heavy rainfall.

CONCLUSIONS

In general, it is noted that the FSA is fortunately situated with respect to climate change effects relative to other locations in Canada. Vancouver does not typically experience extreme or catastrophic weather events such as ice storms, drought, or extreme cold.

The climate factors identified as threats to infrastructure vulnerability will be evidenced as gradual changes. However, often the extremes, even if uncommon, have a far greater impact on public perception of risk. Under climate change scenarios, these events may occur more frequently.

In fact, the greatest pressure to initiate adaptive action comes not from climate change but from timing of planned infrastructure improvement plans such as the AIWWTP Stage V upgrades and combined sewer separation program. So while climate change effects may reveal vulnerabilities, Metro Vancouver is in an ideal position to proactively mitigate and adapt to these challenges as part of regular infrastructure upgrading cycles.

The key priorities with respect to climate change adaptation in the collection system centre on increased rainfall and the associated potential increase in sewer flow, both under combined and separate sewer configurations. Increasing I&I rates as a result of climate change related rainfall increase and as a result of aging infrastructure will worsen capacity limitations. Further study is warranted to determine the best approach to I&I management.

Hazard mapping is a tool that could be used to integrate water resources information with important sites requiring protection. Much of the information compiled for a sewerage management plan could be used for vulnerability assessments for other types of infrastructure.

Metro Vancouver would therefore have a valuable tool for implementing integrated resource management and creating links between its various plans.

The vulnerabilities judged to be of the highest priority at the treatment plant are those associated with the dyke elevations at Annacis Island and the AIWWTP site itself because of rises in the tidally-influenced Fraser River. These effects will be exaggerated when increases in the river level coincide with storm surge. Additional study is recommended to develop more detailed information in the context of these potential vulnerabilities.