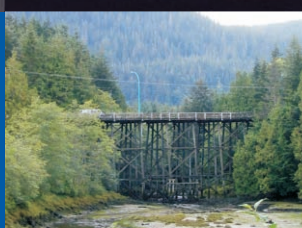
S U M M A R Y   R E P O R T

City of Prince Rupert

Stage 1 - Liquid Waste Management Plan

JANUARY 2009



Associated Engineering

Executive Summary

1 INTRODUCTION

The City of Prince Rupert's (City) sewerage system dates back to the early 1900s. The sewerage system within the urban area is divided into ten sewerage areas, each with a piped discharge into Prince Rupert Harbour. Of these ten areas, six are combined sewers and four are separated sanitary and storm sewers. The majority of the wastewater is currently discharged untreated.

The City has an existing Wastewater Discharge Permit, PE-5577, issued by the Ministry of Water, Land and Air Protection (now the Ministry of Environment, MOE) that covers all of the discharge points. This permit was updated in 2000. One of the requirements of the updated Permit was the development of a wastewater system upgrading plan by the City. This Plan was completed and submitted to the MOE in May 2004. The recommendations of the Plan were that the City undertakes a Liquid Waste Management Plan (LWMP) to address the complex issues involved in wastewater management decisions over the coming decades.

The development of a LWMP is an interactive process that requires consensus building with the stakeholder groups. The LWMP process is undertaken in three stages. Stage 1 involves identifying the existing wastewater management systems and the available options for managing liquid waste. Stage 2 further evaluates the management options developed in Stage 1. Stage 3 uses the information developed in Stages 1 and 2 to produce the strategic direction.

The LWMP will include all of the liquid waste management issues within the boundaries of the City of Prince Rupert, with the exception of the following:

- Industrial operations that operate under a separate Provincial Waste Management Permit.
- The City of Prince Rupert solid waste landfill and leachate management system (covered under an approved Solid Waste Management Plan).

So far, the City has been working on Stage 1 of the LWMP.

2 STAGE 1 – REQUIREMENTS

Stage 1 of the LWMP involves the following key components:

- Establishing and working with a Technical Advisory Committee (TAC) to obtain technical and regulatory input in the LWMP.
- Establishing and involving the public through a Local Advisory Committees (LAC) and public information meetings and open houses.
- Addressing ideas received from the public information meetings.
- Determine future development and population growth.
- Confirming the type(s) and number of wastewater treatment facilities currently in place.
- Outlining possible wastewater treatment and disposal methods.

The City has already completed significant background work for the Stage 1 LWMP. This work includes the "Comprehensive Monitoring Program – Impacts of Wastewater Discharge on Prince Rupert's Harbour, (Associated Engineering, 2003) and City of Prince Rupert Sewage System Upgrading Plan (Associated Engineering, May 2004). These two documents provide a firm basis for initiating the Stage 1 LWMP preparation.

Stage 1 LWMP for the City consisted of the following major tasks:

- Wastewater Management Issues
- Existing and Projected Community Development
- Source control
- CSO and Wet Weather Flow Management
- Development of Wastewater Management Options
- Public Involvement
- Final Report for Stage 1 LWMP

3 STAGE 1 – SUMMARY

Stage 1 of the three-stage LWMP process for the City focuses on identifying the existing wastewater management systems and the available options for managing liquid waste that will be considered in greater detail in Stage 2. Based on the major tasks for this Stage 1 study, five discussion papers were written and presented to the LWMP PAC and TAC. A short summary of each of the discussion papers developed for Stage 1 of the LWMP are presented below.

3.1 Wastewater Management Issues

Wastewater treatment is a multi-stage process that improves that quality of wastewater prior to discharge to the receiving environment. In this discussion paper, the wastewater management issues for the City were discussed. Currently, only the sewage from one area in the core urban area sewer system of the City, Area I, receives limited wastewater treatment. Sewage from the other collection areas serving the core urban area is discharged to the aquatic receiving environment without any treatment. The City's combined sewer systems, i.e., sewers that collect both sanitary sewage and stormwater flow, can reach flow capacity during wet weather.

In addition to the potential public health concerns and environmental impacts from these wastewater discharges, the financial aspects of the liquid waste management, i.e., capital and operating cost estimates as well as present worth and/or net present value analysis, will be significant to the decision making process. Based on available information, there are potential indirect or direct public health concerns and environmental impacts as a result of these wastewater discharges to the receiving environment.

3.2 Community Development

Development and population are dynamic parameters dependent on each other and on the economic condition of the City and the region. In this discussion paper, urban and rural residential, industrial and commercial developments and populations over the 20 year and 40 year planning period were discussed. Historically, Prince Rupert has been a fairly transient city due to seasonal work opportunities. Like many small northern British Columbia communities, a limited number of employers provide employment to many residents. As a result, the population is greatly impacted by the economic conditions of the industries and businesses operating in Prince Rupert. However, at present, times are changing and new prospective investment opportunities are on the horizon, such as the recent government investment in the City's northern transportation infrastructure, which has stimulated new development and business opportunities with the City. The City of Prince Rupert LWMP will use the projected population values established in this discussion paper to effectively manage liquid waste over the 20 and 40 year planning period.

3.3 Source Control

Source control, like the name implies, controls the discharge of highly toxic or nuisance pollutants at the source. In this discussion paper, options for source control and reductions of municipal and industrial wastewater volume and toxicity were investigated. Since the City does not have a wastewater treatment facility, chemicals that are currently put down the drain and enter the sewer system, enter the ocean untreated. In the future, these chemicals can harm the treatment process.

Source control can be a combination of activities carried out by municipal governments to inspect, monitor, enforce, and educate the general public, industries, and businesses that discharge liquid waste into their wastewater collection systems. Source control programs use a combination of source reduction, regulation, and promotion of pollution prevention strategies. Together, these provide an effective means of reducing contaminant levels entering the sewer system by preventing them from entering the waste stream in the first place.

A successful source control program requires a public education program aimed at informing both the public and private sectors about responsible use of the City's sewer system, which includes proper disposal of waste chemicals, e.g., not dumping antifreeze, metal plating waste, used motor oil, or restaurant oils and greases down sewer drains. The extent of a source control program for the City is yet to be determined and will depend on the quality and quantity of wastewater discharged by both the domestic and non-domestic (commercial and industrial) sectors.

3.4 Wet Weather Flow Management

Managing the wet weather flows is one of the most significant issues that the City of Prince Rupert needs to deal with as part of their overall wastewater management plan. In this discussion paper, the management of wastewater flows to Prince Rupert Harbour, particularly flows during wet weather conditions, were addressed. During wet weather conditions, extra flows generated from the storm event enters the sewer system. In the storm events where sewer pipes are essentially full, additional inflow will cause the pipe to "surcharge" resulting in the overflow of manholes or the backup of wastewater into homes through the sewer service connection.

When future wastewater treatment facilities are constructed for the City, it will not be cost-effective to route the entire wet weather flow through the full treatment works. As a result, the LWMP must include a wet weather flow management strategy to handle the surplus wet weather flow. The management approach for the City could involve a combination of source controls, collection system controls, storage facilities, and treatment technologies.

3.5 Wastewater Management Options

As part of the LWMP, and considering the existing and future legislative requirements, the City needs to think about the level of wastewater treatment required to protect the harbour and the merits of going to secondary treatment, either in

the near term or the long-term. In this discussion paper, secondary wastewater treatment options, conveyance of wastewater to treatment facilities, the number of wastewater facilities, i.e., centralized treatment compared to decentralized treatment, and the general locations of the treatment facilities for the City were outlined. This discussion paper looked at the fraction of wastewater that should be treated through secondary treatment as well as the approach to deal with the remainder of the flows.
This approach is based on BC's Municipal Sewage Regulation requirements and consists of treating two times average dry weather flow (ADWF) through the secondary treatment system. Flows above two times ADWF and up to four times ADWF would be bypassed and treated through wet weather flow treatment facilities. These flows will be treated to primary level. In this approach any flows above 4 X ADWF would be low strength and considered combined sewer overflows (CSO). CSOs will be discharged to the ocean through short outfalls after preliminary treatment such as screening.

One of the questions that need to be answered in Stage 2 LWMP is: should all flows be conveyed to the treatment facility(ies) and then partitioned at the treated as discussed above, or should only 4 X ADWF be conveyed for treatment with flows above 4 X ADWF (i.e. the CSOs) treated locally and then discharged?

If centralized treatment were selected, this approach could consist of one central facility, likely in the vicinity of Hays Creek, near the harbour front. If decentralized treatment were selected, this approach could consist of three separate facilities, potentially located in the vicinity of Morse Creek, Hays Creek, and Richie Point, near the harbour front. The decentralized approach has less pumping requirements for wastewater conveyance than for a centralized treatment facility, i.e., a minimum of two less pump stations. As part of the LWMP process, a residual management process should also be developed to deal with the solids resulting from any of the treatment technologies considered for the City.

3.6 Resource Recovery

In light of increasing public awareness and political attention with respect to limited resources, improvements in energy efficiency, and reductions in greenhouse gases (GHGs), there has been an increasing interest in wastewater as a resource. There are four categories of resource utilization or integration opportunities for wastewater, which could each be considered within the LWMP framework: energy from organic solids, wastewater heat energy, water reuse, and nutrient recovery. These options have been discussed.

3.7 Public and Agency Consultation

During the Stage 1 LWMP planning process, two meetings were held with the Technical and Local Advisory Committees (TAC and LAC) to present discussion papers and to receive comments and direction from committee members. The first meeting with the TAC and LAC was held on October 29, 2007 at the City's Council Chambers. At this meeting, Discussion Papers on Wastewater Management Issues, Community Development, and Source Control were presented. The second meeting with the TAC and LAC was held on April 30, 2008 at the City's Council Chambers. At this meeting discussion papers on Wet Weather Flow Management and Wastewater Management Options were presented. The minutes of both Technical and Local Committee meetings are provided in Appendix F.

The public meeting for the Stage 1 LWMP report was held in September 2008 in Prince Rupert. Details regarding this meeting are provided in Section 7.

3.8 Next Steps

Following approval of the LWMP Stage 1 final report, Stage 2 of the LWMP will involve further examination of waste management options and their associated costs. LWMP Stage 2 will involve completion of the following steps:

- Confirm the Stage 2 Study objectives based on the findings of the approved Stage 1 Final Report;
- Complete LWMP Stage 2 study;
- Prepare LWMP Stage 2 draft report;
- Integrate comments from LAC and TAC on LWMP Stage 2 draft report;
- Release the second draft of LWMP Stage 2 report for public review;
- Prepare LWMP Stage 2 final report; and
- Obtain approval of the LWMP Stage 2 final report by the MOE Regional Environmental Protection Manager.

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1 Introduction

1.1 BACKGROUND

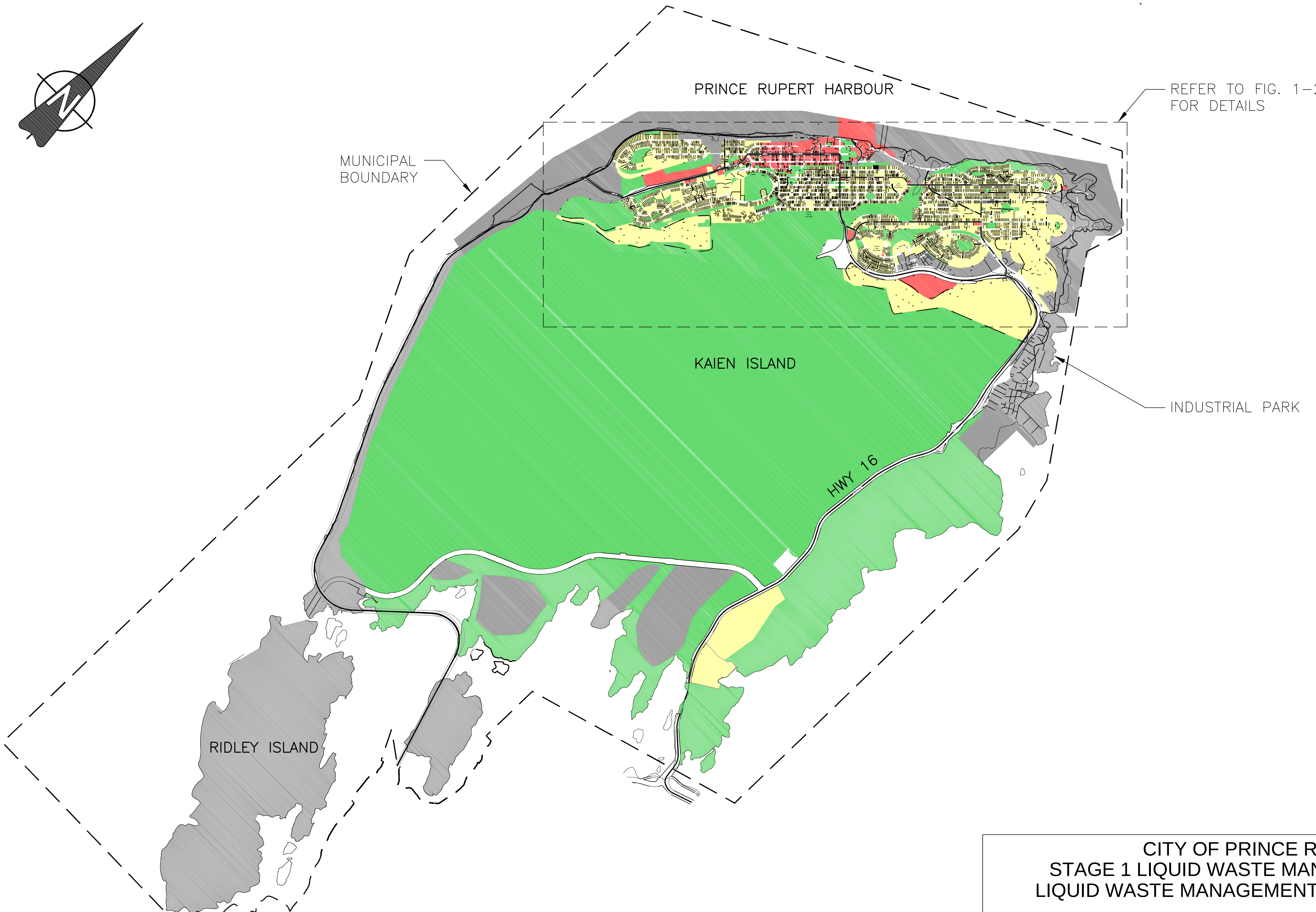
For well over a century, the City has served as a regional hub for the resource and transportation sectors. Mountains, islands, and water surround the City of Prince Rupert (City), located just north of the Skeena River in northern British Columbia. The municipal limits of Prince Rupert include Kaien, Ridley, and Watson Islands. Kaien Island is primarily limited to urban development use, whereas, both Ridley and Watson Islands are limited to industrial use. The urban development in the northwest portion of Kaien Island includes residential, commercial, industrial, and recreational land use. The remainder of Kaien Island is primarily undeveloped with the exception of the industrial areas at Miller Bay and along the east coast. The population estimate for the City from the 2006 Census is approximately 12,815 persons (Statistics Canada, 2007). This is approximately a 12.5 percent decline from the 2001 Census - a direct result of the economic slow down of the forestry, fishing, and mining industries.

The City's sewerage system dates back to the early 1900s when sewers were first constructed to service the original town centre. In the older areas, the construction of the sewers started before World War I. The original sewerage system was designed and constructed as a combined sanitary and storm water collection system. Approximately 50 percent of the City's sewer system was constructed prior to World War II. In 1959 and 1960, a major infrastructure program was undertaken to replace and extend many trunk and lateral sewers.

The City's sewerage system consists of ten sewerage sub-catchments in the Core Area, each with a separate outfall discharging to the Prince Rupert Harbour. Four of the catchments are serviced by separated sanitary and storm sewer systems. Combined sewers service the remaining six catchments. The 11th catchment, sewer area M, which is not included in the Core Area, services a small area east of the Core Area that primarily uses individual septic tank systems at each dwelling, connected into a common sewer that discharges into Fern Passage. Of the total sewered area, combined sewers serve approximately 21 percent of the Core Area. Combined sewers provide service to approximately 26 percent of the population (Associated Engineering, 2003). Although the collection systems are primarily gravity flow, there are nine pump stations in the City's sanitary sewer system that operate in catchments A, B, I, and L. The sewerage areas for the City's sanitary system are presented in Figures 1-1 and 1-2.

Prior to the Pollution Control Act, introduced by the Province in 1967, there was very little environmental regulation governing treatment and disposal of wastewater. In the late 1970's, the Prince Rupert sewerage system consisted of twelve individual sub-catchment areas, all discharging directly into Prince Rupert harbour without treatment. At the present time, only Area I in the core urban area sewerage system receives preliminary wastewater treatment through the use of comminutors, which are units that grind up sewage solids prior to discharge. Sewage from the other collection areas serving the core urban area is discharged directly to Prince Rupert Harbour without treatment.

The City is currently undertaking the development of a Liquid Waste Management Plan (LWMP)



CITY OF PRINCE RUPERT
STAGE 1 LIQUID WASTE MANAGEMENT PLAN
LIQUID WASTE MANAGEMENT PLAN BOUNDARY

FIGURE 1-1

SOURCE: CITY OF PRINCE RUPERT COMMUNITY PLAN

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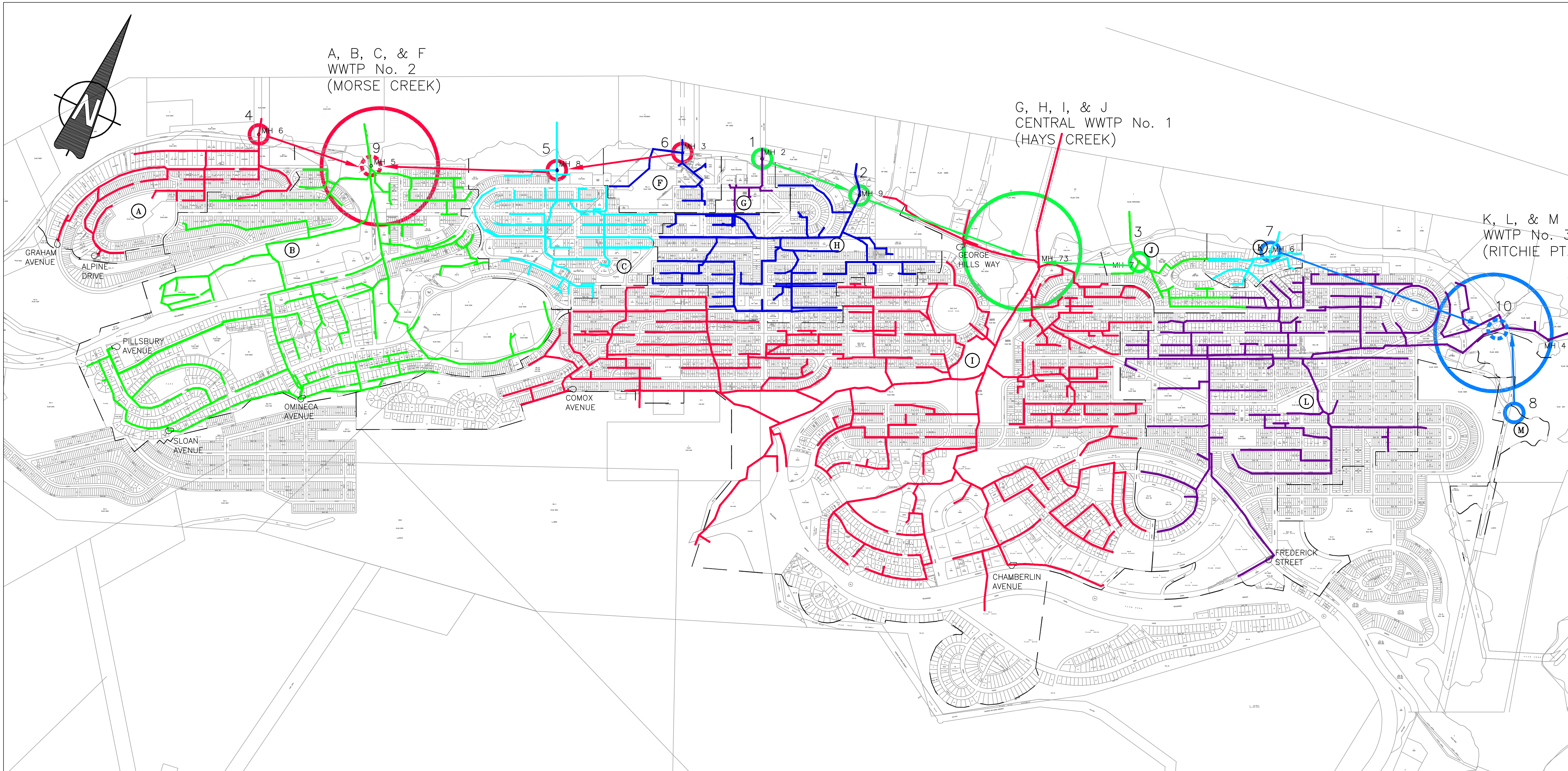

LEGEND

POTENTIAL PUMP STATION

FORCEMAIN

CITY OF PRINCE RUPERT
STAGE 1 LIQUID WASTE MANAGEMENT PLAN
WASTEWATER TREATMENT AND CONVEYANCE OPTIONS

FIGURE 1-2

N.T.S.

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under the Provincial Waste Management Act to help ensure the long-term protection of both human health and the environment. Liquid wastes consist of, but are not limited to the following: municipal sewage, storm water runoff, combined sewer overflows, and industrial or commercial wastes discharged to municipal sewers.

The development of a LWMP is an interactive process that requires consensus building with stakeholder groups. The LWMP provides a strategy for managing liquid wastes, i.e., wastewater, for the 20 and 40-year planning periods and is undertaken in three stages. Stage 1 involves identifying the existing liquid waste management systems and the available options for managing liquid wastes. Stage 2 evaluates the management options developed in Stage 1. Stage 3 uses the information developed in Stages 1 and 2 to produce the plan.

1.2 THE LWMP

Prince Rupert's LWMP will include all of the liquid waste management issues within the City boundary, with the exception of industrial operations that operate under a separate Provincial Waste Management Permit. This would include the former Skeena Cellulose pulp mill, major fish processing industries along the harbour, and the City solid waste landfill and leachate management system. The latter are covered under an approved Solid Waste Management Plan. While the LWMP will not deal with existing industrial permit holders directly, the overall role in wastewater management will be considered in the LWMP. Wastewater systems, covered under a separate Permit, such as the City's Industrial Park and the BC and Alaska Ferry Terminals will be included in the plan. As with the core area discharges, it is expected that the Permits for these discharges would ultimately be replaced with Operational Certificates under the approved LWMP.

Table 1-1 lists the currently active industrial liquid waste discharge permits within the City of Prince Rupert.

Table 1-1
List of Prince Rupert Industrial Municipal Liquid Waste Permits
(Source: British Columbia Ministry of Environment, Dec. 2008)

Discharge Permit Holder	Permit No.
Rivtow Marine Inc.	PE-2603
British Columbia Ferry Corporation	PE-2615
City of Prince Rupert - Industrial Park	PE-4299
Prince Rupert Grain Ltd.	PE-6279
British Columbia Ferry Corporation	PE-8221
City of Prince Rupert - Alaska Ferry Terminal	PE-11412
Prince Rupert Port Authority	PE-18350

1.3 STAGE 1 OBJECTIVES

Development of the Stage 1 LWMP involved the following key objectives:

- Establishing and working with a Technical Advisory Committee to obtain technical and regulatory input in the LWMP.
- Establishing and involving the public through a Local Advisory Committees and public information meetings and open houses.
- Addressing ideas received from the public information meetings.
- Determining future development and population growth.
- Confirming the type(s) and number of wastewater treatment facilities currently in place.
- Outlining possible wastewater treatment and disposal methods.

The City has already completed significant background work for the Stage 1 LWMP. This work includes the "Comprehensive Monitoring Program – Impacts of Wastewater Discharge on Prince Rupert's Harbour" (Associated Engineering, 2003) and "City of Prince Rupert Wastewater System Upgrading Plan" (Associated Engineering, 2004). These two documents provide a firm basis for initiating the Stage 1 LWMP preparation.

In general, the Stage 1 LWMP consists of the following major tasks:

- Determining the Local Wastewater Management Issues
- Examining Existing and Projected Community Development
- Investigating Source Control
- Investigating CSO and Wet Weather Flow Management
- Investigating Effluent and Biosolids Reuse
- Investigating Effluent Disposal
- Development of Wastewater Management Options
- Providing a Venue for Public Involvement
- Preparation of Final Report for Stage 1 LWMP

For this project, after discussions with the advisory committees, and considering the climatic and economical aspects of effluent reuse, it was decided that effluent reuse would not be considered further. Discussion related to biosolids reuse and effluent disposal as part of the Stage 1 LWMP for the City, were carried out as part of the wastewater management options.

As part of the City's Stage 1 LWMP process, five discussion papers were prepared by the City's engineering consultant and circulated to the LWMP Technical and Local Advisory Committees (TAC and LAC) for review and comments. Summaries of the discussion papers are provided below, with complete discussion papers appended to this summary report (Appendices A through E).

1.4 ACKNOWLEDGEMENTS

This report has been prepared by Associated Engineering for the City of Prince of Rupert. We would like to thank City of Prince Rupert's staff for their support during preparation of the Stage 1 LWMP. The City of Prince Rupert and Associated Engineering would like to thank members of Technical and Local Advisory Committees for their participation in the meetings and their input.

2 Wastewater Management Issues

Wastewater treatment is a multi-stage process to restore wastewater before it re-enters a body of water, is applied to the land, or is reused. Wastewater treatment involves the use of unit processes to separate, modify, remove, and destroy objectionable, hazardous, and pathogenic substances carried by wastewater in solution or suspension in order to render the water fit and safe for intended uses or disposal. Generally, the impurities, contaminants, and solids removed from all wastewater treatment processes must ultimately be collected, handled, and disposed of safely, without damage to humans or the environment. Currently, only the sewage from Area I in the core area sewerage system receives limited wastewater treatment. Sewage from the other collection areas serving the core urban area is discharged without any treatment.

The City has five separate comminutor stations on the various “branches” of the Area I sewer system. Communitors are units that grind up sewage solids prior to discharge. This type of preliminary treatment process was used worldwide for marine discharges prior to the 1980s. It has since fallen out of favour and is typically no longer used as a stand-alone process. Preliminary treatment now is more likely to mean fine screening to remove screenable solids, typically larger than 6 mm in size. In addition to preliminary treatment, current wastewater standards require primary and secondary treatment, as well as disinfection prior to discharge.

There are two significant impacts on the harbour caused by the current discharge of wastewater and storm water. These are the impact of pathogenic organisms, as measured by fecal coliform concentrations, and the impact of metals and trace organic contaminants in the sediments near the outfall discharge points. The current levels of fecal coliforms preclude the possibility of water contact recreation activities along the City’s waterfront. As a result of the nature of the waterfront and climatic factors, activity has been limited and therefore, this is not likely a significant factor in long-term planning. At more remote areas of the inlet, it is likely that fecal coliform values would be well below levels that would result in a beach closure. The more significant impact of the pathogenic organism input is on shellfish harvesting. While much of the harbour has been closed to shellfish harvesting for decades, there is recent interest in the possibility of re-opening remote areas. With the current level of wastewater treatment, or in some areas the lack thereof, the re-opening of any areas for shellfish harvesting is unlikely in the short term. Treatment specifically targeting a reduction in pathogenic organisms would be required prior to this occurring in the future.

Wet weather flow is a concern because untreated wastewater overflows can be a significant source of water pollution due to the type of pollutants discharged. Problems with untreated wastewater flows typically occur during wet weather events, when capacity in the sewer and or treatment plant is exceeded. This is of particular concern for combined sewer systems, such as those used by the City, which collects and transports sanitary sewage and stormwater runoff in a single-pipe system. If total wastewater and stormwater flow exceeds the capacity of the combined sewer system, a proportion of wastewater flow must be discharged untreated, by design, directly to the receiving water body. This is referred to as a combined sewer overflow (CSO) event. CSOs are composed of untreated domestic, commercial, and industrial waste and wastewater, as well as stormwater runoff. In the City's case, these flows are not termed "CSO" because all flows, at all times, are discharged directly to the receiving water body with little to no treatment. However, the City's potential impact is quite similar to that of a CSO event – just at a much larger extent due to the frequency and duration of the discharge.

Exposure to viruses, bacteria, pathogens and other related pollutants or toxics from wastewater effluents is an obvious public health concern. Recreation users exposed to contaminants in wastewater may be vulnerable to gastroenteritis, respiratory infections, eye or ear infections, skin rashes, hepatitis and other diseases, with children, the elderly, and people with suppressed immune systems being especially vulnerable. In addition to public health concerns, wastewater pollutants from both domestic and non-domestic sources can lead to increased turbidity and toxins and reduced oxygen levels in the water, which can also adversely affect wildlife and aquatic habitat.

In addition to the protection of public health and the environment, the financial aspects of liquid waste management are important and will be significant to the decision making process. Financial aspects include capital and operating cost estimates, and present worth and/or net present value analysis. As management options are developed, some general elements that will need to be considered are the cost of the options to the province, local government, and taxpayer. Equally important are when and how the options will be funded if they are selected for implementation. These financial elements will be investigated in a future discussion paper, once the liquid waste management options are developed.

Discussion Paper No. 1-1 (provided in Appendix A) explores wastewater management issues. Based on the information provided in the discussion paper, there appear to be some valid concerns about the potential for the discharge of untreated wastewater to Prince Rupert Harbour to adversely impact the environment and human health, either directly or indirectly.

3 Community Development

Development and population are dynamic parameters dependent on each other and on the economic condition of the City and the region. Development due to increased opportunities will affect land use. Increased employment opportunities will increase the demand for housing. This in turn will increase the need for urban and residential and commercial and industrial development. Recent government investment in the City's northern transportation infrastructure has stimulated new development and business opportunities. The tourism industry in Prince Rupert is steadily growing and providing local businesses with new opportunities. The Prince Rupert cruise ship terminal opened in 2004, bringing in thousands of new tourists and tourist dollars into the city (Prince Rupert Port Authority, 2005).

The City has outlined three potential areas for residential development within, or adjacent to, the already developed urban area of the city including Fairview, Oldfield Slopes, and portions of Seal Cove (City of Prince Rupert, 2008). Fairview is approximately 30 ha, Oldfield Slopes is approximately 60 ha, and Seal Cove is approximately 62 ha in gross area. Priorities for residential development were recommended for Oldfield Slopes (Royop shopping centre site) and Seal Cove (City of Prince Rupert, 2008). The potential residential development of the Fairview, Oldfield Slopes, and Seal Cove areas is variable since it is influenced by accessibility, slope stability, and sun exposure (City of Prince Rupert, 2008).

Historically, Prince Rupert has been a fairly transient city due to seasonal work opportunities. Like many small northern British Columbia communities, a limited number of employers provide employment to many residents. As a result, the population is greatly impacted by the economic conditions of the industries and businesses operating in Prince Rupert. When employment opportunities cease to exist, residents are forced to move. Over the time period from 1961 to 2001, the average rate of growth has been less than 0.5 percent.

According to the 2001 Census, the population of Prince Rupert was 14,643 (Statistics Canada, 2002). The 2001 population decreased by 12.4 percent compared to the 1996 Census population of 16,714 (Statistics Canada, 2002). The reader should note the 2006 Census results were not released in time to be included in this discussion paper; however, the census data were released in 2007 for a population of 12,815 persons (Statistics Canada, 2007). Based on the 2001 Census, the population density of Prince Rupert was 267 persons per square kilometre. Almost one third of the population was between the prime working ages of 25 and 44, with the median age of the population being 34.8 years. Based on the 2006 Census, the population density of Prince Rupert is 233 persons per square kilometre. Similar to the 2001 Census, almost one third of the population is between the prime working ages of 25 and 44. On the other hand, the median age of the population increased slightly from 34.8 years in 2001 to being 38.5 years in 2006.

Using the 2006 Statistics Canada Census population value of 12,815, the future population of Prince Rupert was projected using 1 percent, 1.5 percent, and 2 percent growth for the LWMP planning years 2028 and 2048. The projected population for Prince Rupert for LWMP planning years 2028 and 2048 are presented in Table 3-1.

Table 3-1
Projected Populations for Planning Years 2028 and 2048

Growth (%)	Population – 2028	Population - 2048
1	15,951	19,463
1.5	17,782	23,949
2	19,812	29,439

According to City of Prince Rupert (1994), the target population is projected to be 25,000, even though the City of Prince Rupert acknowledges that not enough land is available to accommodate the projected residential land demand for 25,000, at normal densities. At 1 percent and 1.5 percent growth, this target population would not be reached by 2048. At 2 percent growth, this target population would be reached in year 2040.

Discussion Paper No. 1-2 (provided in Appendix B) investigates projections of urban and rural residential, industrial, and commercial development and populations over the planning period of 20 and 40 years. Community development and population are important in the development of the City's LWMP so that public health and safety may be protected.

4 Source Control

Due to an increasing demand to improve effluent discharge and protect the environment, most local governments are relying on bylaws to assist in controlling the materials discharged into their wastewater collection and treatment systems. Source control implementation and enforcement is typically in accordance with federal, provincial, or local municipal bylaws. The need for a source control program for the City is yet to be determined and will depend on the quality and quantity of wastewater discharged by both the domestic and non-domestic (commercial and industrial) sectors. The drafting of a local bylaw, should one be required, must not exceed the City's authority. Upon determining the legal authority, the City may then enact and enforce a bylaw for source control. The drafting of the bylaw requires the City to make some important decisions regarding the following:

.1 The City's policy regarding the identification of pre-treatment requirements (if any) to be imposed, or potentially imposed on industrial or commercial users (ICUs).
.2 Whether or not requirements identified in (.1) are to be self-implementing or will require some identifiable triggering action.
.3 The degree of specificity to be included in the bylaw.
.4 The degree of enforcement that the City wishes to provide.

To implement a source control bylaw, it is imperative that the City develops an enforcement response plan that is consistent, appropriate, and fair in addressing non-compliance. In order to evaluate compliance during reporting periods, it is recommended that detailed procedures on how to evaluate discharger self-monitoring data and City inspection and sampling data be included in the response plan.

The implementation and enforcement of a source control bylaw will require the City to carry out adequate fiscal planning in order to develop and maintain a budget that reflects current and future source control bylaw activities. Many local governments have obtained initial funding through municipal bonds and surplus or reserve revenues. However, the main source of funding for the implementation of the bylaw and initial start up may be collected from the regulated industrial/commercial facilities. Initial start up costs can be recovered through user surcharges, and/or fees based on municipal taxes.

Source control programs provide an effective means of reducing contaminant levels entering the sewer system by preventing them from entering the waste stream in the first place. Source control programs collectively use a combination of source reduction, regulation, and promotion of pollution prevention strategies to achieve this goal. A successful source control program requires a public education program aimed at informing both the public and private sectors about responsible use of the City's sewer system, which includes proper disposal of waste chemicals, i.e., not dumping antifreeze, used motor oil, metal plating waste, or restaurant oil and greases down sewer drains.

As part of the LWMP planning objectives, options for source control and reductions of municipal and industrial wastewater volume and toxicity were investigated in Discussion Paper 1-3 (provided in Appendix C). Source control, like the name implies, controls the discharge of highly toxic or nuisance pollutants at the source. Source control can be a combination of activities carried out by municipal governments to inspect, monitor, enforce, and educate the general public, industries, and businesses that discharge liquid waste into their wastewater collection systems.

5 Wet Weather Flow Management

During wet weather conditions, flow generated from the storm event enters the sewer system. These extraneous flows are termed rainfall-dependent inflow and infiltration. "Inflow" is rainwater that enters the sewer system from sources such as yard and patio drains, roof gutter downspouts, and storm drains. Inflow is greatest during heavy rainfall. "Infiltration" refers to groundwater (water found below the ground surface) that enters sewer pipes through cracks, pipe joints, and other system leaks.

As part of the City's comprehensive monitoring program, the existing capacity of the sewerage system was modelled, using computer software, for various wet weather conditions (Associated Engineering, 2003). The term "at capacity" essentially means that the sewer pipe is full; thereby additional inflow into the sewer will cause the pipe to "surcharge", resulting in the overflow of manholes or the backup of wastewater into homes through the sewer service connection. The computer modeling indicated that the sewer system is at or over capacity in about 20 locations under a rainfall event that occurs once per year. Some of these sections may reach capacity under a less severe rainfall event. In the more extreme 5-year return storm event, about 30 locations are at or over capacity.

At the present time, the ratio of wet weather flow to average dry weather flow (ADWF) in the sewerage system (the system of sewer pipes and pump stations conveying the wastewater) can exceed ten to one in some sub-catchments. Typical ratios are in the 2 x ADWF to 4 X ADWF range. While this is not a critical factor now, when future wastewater treatment facilities are constructed, it will not be cost-effective to route the entire wet weather flow through the full treatment works. This requires that the LWMP develop a wet weather flow management strategy to handle the surplus wet weather flow. This would typically involve either temporary storage of the surplus flow and eventual routing to the plant, or separate combined and sanitary wastewater treatment and discharge. Current overflow control and elimination practices involve the following broad categories:

- Source controls
- Collection system controls
- Storage facilities
- Treatment technologies

The type of control mechanisms used depends heavily on the characteristics of the sewer system, problems experienced by the sewer system, resources available, water quality goals and requirements, and site-specific conditions. Further discussion regarding this issue is provided in Section 6.

Source control, as discussed previously in Section 4, controls the discharge of highly toxic or nuisance pollutants at the source. Collection system controls optimize the flow through the combined sewer by reducing or diverting flows or by increasing infrastructure capacity. Storage controls provide flow equalization by storing wet weather flows when flows exceed collection system capacity. The stored flows are released in a controlled manner once capacity becomes available. Treatment controls provide treatment of the wet weather flows with the objectives of reducing the pollutant load prior to discharge and minimizing the environmental impact.

Managing the wet weather flows is one of the most significant issues that the City of Prince Rupert needs to deal with as part of their overall wastewater management. There will be more than one solution required for the City's wet weather flow management issue. Any management policy will likely include a combination of the options presented in this section.

The management of wastewater flow to Prince Rupert Harbour, particularly flows during wet weather periods, is an issue that is addressed in Discussion Paper 1-4 (provided in Appendix D). The flow issue is complicated by the presence of combined sewers and by old, separated sewers that allow infiltration and inflow to enter the sewer pipe containing the sanitary wastewater flow.

6 Wastewater Management Options

As part of the LWMP, and considering the existing and future Provincial and/or Federal legislative requirements, the City needs to think about the level of wastewater treatment required to protect the harbour and the merits of going to secondary treatment, either in the near term or the long-term.

Wastewater treatment can consist of relatively simple systems to very advanced systems. The type of treatment system used is based on several key design parameters, which include the following:

- Level of treatment required by the regulatory agency
- The parameters of concern in the influent wastewater
- The quality of the receiving body of water and its capacity to assimilate discharges
- The facility operator's experience, qualifications, and level of comfort
- Available site capacity
- Treatment system practicality and robustness

6.1 TREATMENT APPROACHES AND OPTIONS

This section looks specifically at the fraction of wastewater that should be treated through secondary treatment as well as the approach to deal with the remainder of the flows.

This approach is based on BC's Municipal Sewage Regulation requirements and consists of treating two times average dry weather flow (ADWF) through the secondary treatment system.

Flows above two times ADWF and up to four times ADWF would be bypassed and treated through wet weather flow treatment facilities. These flows will be treated to primary standards. In this approach any flows above 4 X ADWF would be low strength and considered combined sewer overflows (CSO). CSOs will be discharged to the ocean through short outfalls after preliminary treatment such as screening.

The ADWF is the average non-storm flow over 24-hours during the dry months of the year (typically May through beginning of September and more specifically July to August). It is composed of both the average sanitary flow, and the average dry weather inflow/infiltration. This approach, only treating two times the ADWF to the secondary level, is based on the premise of providing the City with a cost effective treatment scheme which would maximize the use and efficiency of capital investment, minimize expenditures on facility and related equipment that would be used infrequently, and at the same time provide the required level of environmental protection.

One of the questions that need to be answered in Stage 2 LWMP is: should all flows be conveyed to the treatment facility(ies) and then partitioned at the treated as discussed above, or should only 4 X ADWF be conveyed for treatment with flows above 4 X ADWF (i.e. the CSOs) treated locally and then discharged? Such questions can only be answered after conceptual designs and preliminary costing have been prepared in Stage 2 of the LWMP.

There are several potential options for the number and general location of wastewater treatment facilities that may be considered by the City. In the past, the approach was to convey the collected wastewater to a single, large treatment facility. This is commonly referred to as “centralized” treatment. More recently, the concept of “decentralized” treatment has developed. Decentralized treatment basically refers to the treatment of wastewater using several “local” treatment facilities. Decentralized treatment may be driven by a number of factors. One such factor may be the inability to locate a large centralized plant due to lack of a large enough suitable site.

The City’s LWMP needs to take into account both the economics of the on-shore wastewater treatment works and the environmental impacts of the effluent outfalls. The impact of discharging the treated effluent at one location (centralized treatment) versus discharges at several locations (decentralized treatment) needs to be evaluated. Currently the City does not own any properties on the waterfront that are readily available to site the required treatment facilities.

6.2 WASTEWATER CONVEYANCE

Conveyance of the wastewater to the treatment facility(ies) should be considered as part of the overall LWMP. Basically, wastewater needs to be collected upstream of the existing outfalls and conveyed to the treatment facility(ies) by means of trunk sewers and pump stations. Naturally any conveyance system design should attempt to take advantage of a gravity sewer system as much as possible and minimize the number of pump stations and the volume of pumped wastewater. The potential maximum number of pump stations required to convey the wastewater to the treatment facilities are presented in Figure 1-1. If one central facility at Hays Creek is selected, potentially the number of pump stations would increase by two. In addition to wastewater conveyance, pump stations located immediately upstream of the treatment facility would also assist with flow equalization at the respective treatment facility. Each pump station will have a certain holding capacity within their wet well and incoming sewers. This capacity, along with process regulations, would help maintain a more stable and constant flow to the facility, which in turn will assist in maintaining the treatment performance.

If a central treatment facility is selected, the flows from the various pump stations, gravity sewers, and force mains could be consolidated so that wastewater is directed to one wastewater treatment facility. Consolidation of the collection system could occur by constructing a major trunk sewer interceptor system along the waterfront that would direct the wastewater from all ten existing catchment areas to the centralized treatment facility. Almost 40% of the City’s total wastewater flow is discharged through Outfall I (Hays Creek area), which is the City’s deepest outfall. A potential location for a single facility would be near the harbour front, in the vicinity of Hays Creek. Assuming there is adequate outfall capacity available, treated effluent would then be discharged through the existing outfall. Alternatively, a larger outfall could be installed. If this option were selected, there would certainly be requirements for the installation of new pump stations and gravity sewers to convey the wastewater along the City’s waterfront to the treatment facility. Conveyance using gravity alone would not be possible due to the relatively flat topography of the area.

If three separate decentralized treatment facilities are selected, the flows from the various pump stations, gravity sewers, and force mains could be merged so that wastewater is directed to one of three wastewater treatment facilities. These facilities would likely be located near the harbour front in the vicinity of Morse Creek, Hays Creek, and Ritchie Point, as presented in Figure 1-1. These locations have been selected because they correspond with the areas generating the largest sanitary flows and therefore, it is more economical to pump wastewater from the smaller areas to the larger areas, rather than vice versa. Wastewater from Areas A, B, C, and F would be conveyed to the Morse Creek Wastewater Treatment Facility. Wastewater from Areas G, H, I, and J would be conveyed to the Hays Creek Wastewater Treatment Facility. Wastewater from Areas K, L, and M would be conveyed to the Ritchie Point Wastewater Treatment Facility. Treated effluent would be discharged from the respective treatment facilities to the harbour through long, deep outfalls. This option would potentially require pumping wastewater along the City's shore to convey the flows to the respective treatment facilities; however, the pumping requirements will be lower than those for a central treatment facility (e.g. as a minimum there would be two less pump stations required).

The former pulp mill at Port Edward, located at a relatively short distance (about 15 km) outside the City is another potential location for a wastewater treatment facility. From a technical perspective, the Port Edwards site is a possible location considering that the existing tankage at the former pulp mill could potentially be converted to a secondary wastewater treatment process. For this option, the entire City's wastewater should first be carried to a central location (most likely the location proposed for a central treatment facility, i.e. the Hays Creek area) and then pumped to the Port Edward facility via a major pump station. Economically, the cost to pump the raw wastewater to the facility using a pump station and force main could be quite extensive. In addition to this, the costs of acquiring the existing facilities and refurbishing the existing tanks and aeration system would need to be considered. This option nonetheless remains as a potentially technically viable option.

Developing the wastewater management options is part of the "liquid" waste management process. In addition, a residual management plan should also be developed at the later stages and parallel to this process to deal with the solids resulting from any of the technologies described in this discussion paper. Resulting solids include biosolids, i.e., digested sludge, screenings, and solids resulting from mechanical separation processes. Due to space constraints at the wastewater treatment facility sites, solids would most likely have to be dealt with off site, at a different and ideally, central facility. This approach would include trucking the solids from the wastewater treatment facilities to another location.

6.3 RESOURCE RECOVERY

In light of increasing public awareness and political attention with respect to limited resources, improvements in energy efficiency, and reductions in greenhouse gases (GHGs), there has been an increasing interest in wastewater as a resource. There are four categories of resource utilization or integration opportunities for wastewater, which could each be considered within the LWMP framework: energy from organic solids, wastewater heat energy, water reuse, and nutrient recovery.

Biogas

Energy from organic solids is considered to be a clean energy technology and results from the anaerobic digestion of the solids and the production of a methane-rich biogas that can be used to generate on-site electrical power and heat. This biogas has been recognized as having a high value as a fuel, particularly in terms of greenhouse gas management. Technological improvements in this area have been aimed at improving the processes to refine the biogas to a quality that is suitable for use in vehicles or as an addition to a natural gas grid. Biogas generation can be potentially enhanced through the addition of other organic wastes, such as food wastes collected through municipal source-separated organics programs.

Heat Recovery

Wastewater heat energy takes advantage of the typical average temperature of wastewater, which is approximately 15ºC. Heat exchange and heat pump systems are an advancing technology that is becoming increasingly cost effective at extracting heat from wastewater effluent prior to reuse or discharge. The recovered heat would potentially be used as a supplemental heat source in a centralized community heating system.

Water Reuse

Water reuse refers to the use of treated effluent for irrigation, industrial purposes, augmentation of flow in watercourses, and non-potable urban applications, such as toilet flushing. Treated effluent suitable for reuse could be supplied from either a local/regional treatment plant or from a small-scale wastewater treatment plant located internally within the same building or complex. This type of system often incorporates rainwater capture and aims to reduce the overall potable water use in the complex, as well as reducing the amount of wastewater sent off-site for treatment.

Considering the locale and the climate in Prince Rupert, water reuse may prove not to be feasible. In the future, when the City adds a new water treatment facility, the unit value of the treated water may provide impetus for water reuse. Nevertheless, it will be reviewed as part of the resource recovery options within the LWMP framework.

Nutrient Recovery

With respect to nutrient recovery, traditional wastewater objectives have included the reduction of phosphorus and nitrogen concentrations in the treated effluent prior to discharge. More recently there has been a move towards the utilization of evolving technologies to recover these nutrients for their resource potential. For example, ammonia and phosphorus can be extracted from anaerobic digester liquids as struvite and magnesium ammonium phosphate

Centralized versus Decentralized Treatment

Wastewater management can incorporate considerations for resource recovery as well as overall urban water planning. Conventional urban planning uses a centralized wastewater management system that collects all flows at a single, large treatment facility, followed by disposal of the effluent to a nearby surface water body, such as a river or ocean.

Some resource recovery technologies, such as energy recovery from organic solids, have advantages at a larger scale, others, such as heat recovery or water reuse are better achieved on a local, decentralized, basis. Implementing a hybrid of the two concepts would provide a distributed approach to wastewater management. For example, decentralized plants that provide local heat recovery or water reuse can be developed in the sewerage area, with a centralized system focused on wet weather flow management and energy recovery from the organic solids. Increasing opportunity for this type of distributed concept is made feasible by technological advances in wastewater treatment, such as membrane-based separation technology, which provide an increase in treatment performance and a smaller equipment footprint.

The option of three proposed treatment facilities would be in line with a distributed approach. The City could transport the organic solids to the larger treatment facility at Hays Creek area. All three facilities will be evaluated with respect to resource recovery options.

Discussion Paper 1-5 (provided in Appendix E) covers the potential wastewater management options. This discussion includes options for secondary treatment of the wastewater, options for the number and general location of wastewater treatment facilities, conveyance of wastewater to the treatment facilities, and options for dealing with solids and sludge generated from wastewater treatment activities.

7 Public and Agency Consultation

7.1 TECHNICAL AND LOCAL ADVISORY COMMITTEE MEETINGS

During the Stage 1 LWMP planning process, two meetings have been held with the Technical and Local Advisory Committees to present discussion papers and to receive comments and direction from committee members.

The first meeting with the Technical and Local Advisory Committees was held on October 29, 2007 at the City's Council Chambers. Discussion Papers 1-1 Wastewater Management Issues, 1-2 Community Development, and 1-3 Source Control were presented. The minutes of this meeting are provided in Appendix F.

The second meeting with the Technical and Local Advisory Committees was held on April 30, 2008 at the City's Council Chambers. Discussion Papers 1-4 Wet Weather Flow Management and 1-5 Wastewater Management Options were presented. The minutes of this meeting are provided in Appendix F.

The third meeting with the Technical and Local Advisory Committees was held on September 9, 2008 at the City's Council Chambers. Public meeting summary, final report completion requirements and next steps were discussed during this meeting. The minutes of this meeting are provided in Appendix F.

7.2 PUBLIC COMMUNICATION

A public communication meeting and open house was held on September 9, 2008, between 4:30 pm and 7:00 pm in the City's Council Chambers. Advertisements had been placed in the local newspaper and on the City's web site. The meeting was announced on the cable television broadcast of the Council on the prior evening.

The initial part of the meeting was an open house format followed by the second part of the meeting that included a presentation by the consultant team. The presentation was formatted to allow questions and dialog with the members of the public.

Thirteen members of the public attended the meeting. A staff member from the Daily News also attended the meeting and interviewed the consultant team. A newspaper article on the LWMP progress was published.

A copy of the slide presentation and summary report along with the handout and questionnaire is appended in Appendix F. The discussion with the public covered a wide range of issues in the presentation. There was also general support for the direction of the LWMP into Stage 2.

The public information meeting was considered successful. This coupled, with the posting of material on the City's LWMP web page (www.princerupert.ca under City plans and projects) and the cable television coverage of the discussion at Council meetings, has led to a reasonable degree of communication with the public in Stage 1.

8 Next Steps

Following approval of the LWMP Stage 1 final report, Stage 2 of the LWMP will involve further examination of waste management options and their associated costs. LWMP Stage 2 will involve completion of the following steps:

- Confirm the Stage 2 Study objectives based on the findings of the approved Stage 1 Final Report;
- Complete LWMP Stage 2 Study;
- Prepare LWMP Stage 2 draft report;
- Integrate comments from LAC and TAC on LWMP Stage 2 draft report;
- Release the second draft of LWMP Stage 2 report for public review;
- Prepare LWMP Stage 2 final report; and
- Obtain approval of the LWMP Stage 2 final report by the MOE Regional Environmental Protection Manager.

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A Appendix A - DP 1-1 - Wastewater Management Issues

DISCUSSION PAPER NO. 1-1

City of Prince Rupert
Liquid Waste Management Plan – Stage 1

Wastewater Management Issues

Issued:	March 12, 2007
Previous Issue:	None

1 Objectives

The focus of this Stage 1 LWMP discussion paper is to identify wastewater management issues pertaining to the City of Prince Rupert by:

- Reviewing the operation and performance of the municipal wastewater and stormwater systems,
- Reviewing the environmental and public health impacts of wastewater discharge,
- Reviewing the effects of existing and future industrial development on the wastewater system, and
- Reviewing the issues related to wet weather flow management.

2 Background

The City of Prince Rupert's (City) sewerage system dates back to the early 1900s when sewers were first constructed to service the original town centre. In the older areas, the construction of the sewers started before World War I. The original sewerage system was designed and constructed as a combined sanitary and storm water collection system. Approximately 50 percent of the City's sewer system was constructed prior to World War II. In 1959 and 1960, a major infrastructure program was undertaken to replace and extend many trunk and lateral sewers.

Prior to the Pollution Control Act, introduced by the Province in 1967, there was very little environmental regulation governing treatment and disposal of wastewater. In the late 1970's, the Prince Rupert sewerage system consisted of twelve individual sub-catchment areas, all discharging directly into Prince Rupert harbour without treatment. At the present time only Area I in the core urban area sewerage system receives preliminary wastewater treatment through the use of comminutors, which are units that grind up sewage solids prior to discharge. Sewage from the other collection areas serving the core urban area is discharged directly to Prince Rupert Harbour without treatment.

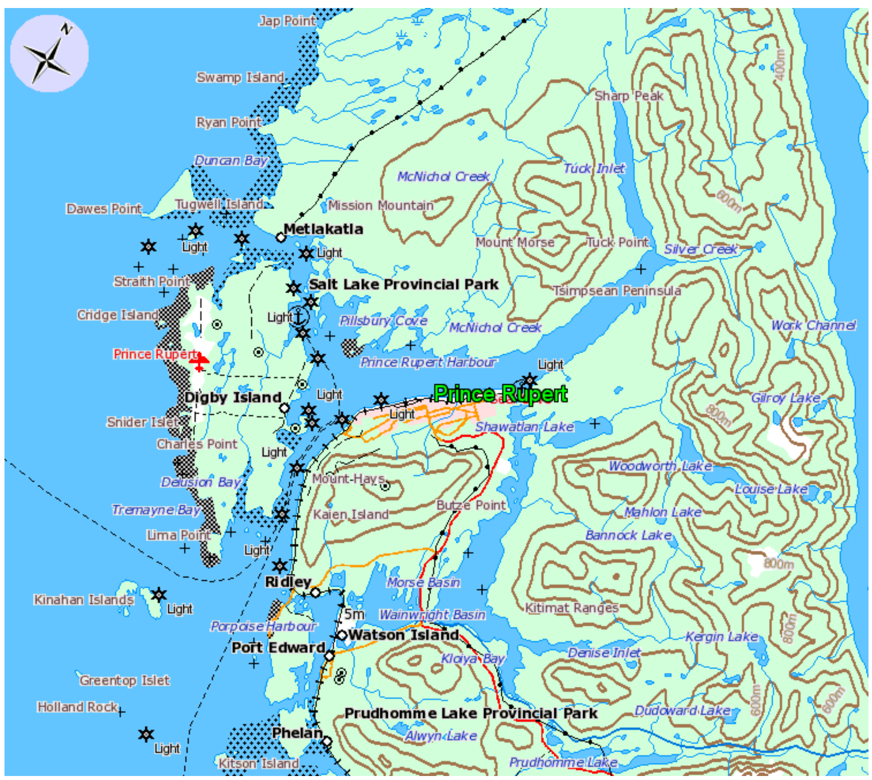
2.1 The City and Community

Mountains, islands, and water surround Prince Rupert, located just north of the Skeena River in northern British Columbia. Charles Hays, a railway executive who founded the town in 1906, intended Prince Rupert to become a leading seaport for trade between North America and Asia.

However, when the Grand Trunk Pacific Railway was completed in 1914, the railway-building era was slowing down and Canada was moving into economic recession. To compensate for the economic slowdown, Prince Rupert's Cow Bay became a centre for fishing activities. The fishing industry diversified Prince Rupert and over the next 75 years served as a valuable resource and economic base for the community.

The municipal limits of Prince Rupert include Kaien, Ridley, and Watson Islands are shown on Figure 2-1. Kaien Island is primarily limited to urban development use; whereas, both Ridley and Watson Islands are limited to industrial use. The urban development in the northwest portion of Kaien Island includes residential, commercial, industrial, and recreational land use. The remainder of Kaien Island is primarily undeveloped with the exception of the industrial areas at Miller Bay and along the east coast.

Figure 2-1
Municipal Limits of Prince Rupert



The population estimate for the City of Prince Rupert from the 2001 Census is 14,643 (Statistics Canada). This is approximately a 12 percent decline from the 1996 Census - a direct result of the economic slow down of the forestry, fishing, and mining industries.

Prince Rupert's educational resources span the range from nursery schools to workplace training. There are 14 elementary schools, two secondary schools, one alternate school, a First Nations

Education Centre, North Coast Community Skills Centre, Northwest Community College, and a branch campus of the University of Northern British Columbia.

2.2 Economy

Booming trade with Asia has overwhelmed many of the main ports in North America, forcing shipping lines to look for new harbours. As a result, new investment opportunities, such as the Prince Rupert Harbour container port, are emerging. This, in turn, has stimulated other business sectors. Highway and rail links to the remote coastal community are also being upgraded.

For well over a century, the City has served as a regional hub for the resource and transportation sectors. Due to the various modes of transportation available, tourism is a major contributor to the City's economy, bringing between 300,000 to 500,000 travelers a year. Local entrepreneurs have turned the historic Cow Bay area into a centre for shopping, dining and sightseeing for the tourism industry. Most tourists stop in Prince Rupert en route to other destinations. The City’s current goal is to have visitors extend their length of stay. Recently, the tourism industry has been promoting native heritage and archaeology, ecotourism, wilderness attractions, and fishing. Several businesses are also exploring new rail and road tours, some with cruise connections.

The fishing industry has led Prince Rupert's economy for decades. The Skeena Cellulose pulp mill on Watson Island, when it was in operation until 2001, had a workforce of approximately 800 people. Prince Rupert's port is also a leading player in economic development with opportunities for cruise ship berthing facilities, sulphur and container cargo terminals for commodities such as coal and grains, a pig-iron production plant, and an aluminum smelter.

2.3 Prince Rupert Harbour

2.3.1 Description

Prince Rupert Harbour is the body of water bounded by the City’s waterfront on Kaien Island from the southeast, Digby Island and Venn Passage from the west, confluence of the Fern Passage from the northwest, and waters off Casey Point on Kaien Island from the south. A plan of the harbour is shown in Figure 2-2.

Figure 2-2
Prince Rupert Harbour

Prince Rupert Harbour is accessible through three water passages: Venn Passage, Fern Passage, and Chatham Sound. The primary navigational passage is the channel between Digby and Kaien Islands. The harbour is also accessible through the Venn Passage between the north end of Digby Island and Tsimshian Peninsula. This waterway is only suitable for small boats due to its narrow section and shallow profile (Associated Engineering, 2004).

The harbour has been the scene of industrial activity for over a century. As with other industrial harbours around the world, historic activities have shaped the development of the shoreline. In addition, activities such as bilge dumping, log sort, and storage debris and waste disposal have led to an impact on the bottom sediments (Associated Engineering, 2002).

2.3.2 Physical Oceanography

Prince Rupert Harbour opens directly to Chatham Sound and as a result, is influenced by the Sound's oceanography (Institute of Ocean Sciences, 1993). Digby Island, to the west, shelters the harbour from Chatham Sound. Water depths in mid-harbour generally vary between 40 to 60 m. The movement of tides, the circulation of water, and the stratification of the ocean are all important factors affecting the dilution and dispersion of the City's wastewater discharge to Prince Rupert Harbour (Associated Engineering, 2004).

The tides cycle at Prince Rupert Harbour are predominantly mixed, semi-diurnal (DFO, 1991). There are typically two high and two low tides per day. The largest tidal range in the harbour is 7.7 m, with the average tidal range of 4.9 m (Institute of Ocean Sciences, 1993). This large tidal fluctuation creates considerable flushing action in the harbour where millions of cubic metres of tidal water move in and out of the harbour daily (Associated Engineering, 1977). In addition, the bottom water of the Harbour has a net movement away from the City's shoreline and exhibits a significant mixing capability.

There are two primary sources of fresh water into Chatham Sound: the Skeena and Nass Rivers. The Skeena River discharges into Chatham Sound, just south of Prince Rupert. The Nass River discharges from the north through the Portland Inlet. The spring runoff generated by snowmelt from the Skeena River and the landmasses surrounding the harbour discharge large quantities of freshwater into the harbour. This freshwater, overlying the dense ocean water causes stratification that can extend 20 m or more below the water surface (Associated Engineering, 1977).

2.4 Stage 1 Liquid Waste Management Plan

The City of Prince Rupert is currently undertaking the development of a Liquid Waste Management Plan (LWMP) to help ensure the long-term protection of both human health and the environment. The LWMP provides a strategy for managing liquid wastes, i.e., wastewater, for the 20 and 40-year planning periods. The LWMP will essentially serve as the "road map" for community development and wastewater management decisions for the City.

"Wastewater" does not just pertain to domestic sewage. Wastewater is essentially all the water used in homes and businesses that goes down drains and into the sewer system. This includes water from baths, showers, sinks, dishwashers, washing machines, toilets, and commercial, institutional, and industrial activities. In combined municipal sewage systems, such as the City of Prince Rupert's, water from storm drains is also accounted for because much of it enters the same municipal sewer system.

Stage 1 of the three-stage LWMP process will focus on identifying the problems and developing a list of potential solutions that should be considered in greater detail in Stage 2 of the LWMP process.

3 Municipal Wastewater and Storm Water Systems

3.1 Existing Systems

The City of Prince Rupert sewerage system, a system of buried pipelines used for conveying sewage and other wastewater for disposal, is unique amongst British Columbia communities. There are ten sewerage sub-catchments in the core area, each with a separate outfall discharging to the Prince Rupert Harbour. Some areas have combined sewer systems, which convey both domestic wastewater and stormwater in the same pipe. Some areas have separate sewer systems for the domestic wastewater and the stormwater. Both the combined and separated sewer systems have a high degree of inflow and infiltration.

“Inflow” is rainwater that enters the sewer system from sources such as yard and patio drains, roof gutter downspouts, uncapped cleanouts, pond or pool overflow drains, footing drains, cross-connections with storm drains, and even holes in manhole covers. Inflow is greatest during heavy rainfall.

“Infiltration” refers to groundwater (water found below the ground surface) that enters sewer pipes through cracks, pipe joints, and other system leaks. Since most sewer lines do not flow full (under pressure), groundwater "infiltrating" into the sewer line is actually more of a problem than sewage leaking out of the line. Storm events can raise groundwater levels and increase infiltration of groundwater into sewer pipes. The highest infiltration flows are observed during or right after heavy rain.

Preliminary treatment is the first step in wastewater treatment. The goal of preliminary treatment is to screen out, grind up, or separate debris from the wastewater. Preliminary treatment via comminution (the grinding up of sewage solids) exists on only one of the discharges (Outfall I). There is no treatment of any form at any of the other nine discharge locations in the Core Area (excludes the eleventh sewer area, Sewer Area M, a small area east of the core area which uses primarily individual septic tank systems at each dwelling, connected into a common sewer that discharges into Fern Passage).

The City has an existing Wastewater Discharge Permit, PE-5577, issued by the Ministry of Water, Land and Air Protection (which is now called the Ministry of Environment) that includes all of the eleven discharge points. This Permit was updated in 2000.

3.2 Catchment Areas

The City’s sewerage system currently consists of separate catchment areas, each being defined by natural drainage boundaries. Four of the catchments in the core area are serviced by separated sanitary and storm sewer systems, with six of the catchments serviced by combined sewers. The eleventh catchment, sewer area M, services a small area east of the core area that primarily uses individual septic tank systems at each dwelling, connected into a common sewer that discharges into Fern Passage.

Besides Sewer Area M, each of the ten other sewerage areas has a dedicated marine outfall which discharges wastewater into the Prince Rupert Harbour. The complete sewer networks for all ten catchments are illustrated in Figure 3-1. Details of the catchment areas are presented in Table 3-1.

Table 3-1
Catchment Areas

Sewer Area	System Type	Area Served (ha)	Total Length of Sewer (m)
A	Combined	27	3,850
B	Sanitary	116	16,440
C	Combined	37	5,900
F	Sanitary	12	830
G	Combined	5	480
H	Combined	40	7,720
I	Sanitary	241	31,660
J	Combined	11	1,570
K	Combined	6	1,180
L	Sanitary	116	14,240
TOTALS		**611**	**83,870**

The City's Industrial Park, southeast of the City core area, is served by a separate wastewater collection, treatment, and disposal system. This system employs a secondary treatment plant and marine discharge into Fern Passage under a separate discharge permit. The BC Ferry and Alaska Ferry terminals, to the west of the core urban area, are each served by a septic tank and marine outfall into the harbour. They each have their own discharge permit.

Since the collection systems are primarily gravity flow, there are nine pump stations in the City's sanitary sewer system. They operate in catchments A, B, I, and L. The pump station characteristics are provided in Table 3-2.

Table 3-2
Pump Station Characteristics

Name	Sewer Area	No. of Pumps	Pump Capacity (L/s)[1]
Alpine Drive	A	2	4.0
Graham Avenue	A	2	15.0
Pillsbury Avenue	B	2	47.0
Sloan Avenue	B	2	12.6
Omineca Avenue	B	2	10.9
Comox Avenue	I	2	7.6
George Hills Way	I	2	0.9
Chamberlin Avenue	I	2	7.9
Frederick Street	L	2	15.0

Notes: [1] Pump capacity for one pump only.

3.3 System Condition

The typical service life of sewer pipes is in the range of 40 to 80 years, depending upon the quality of materials, construction, and the local environment. Pumping stations and treatment plants have a serviceable life of about 40 years, assuming proper maintenance is carried out. Much of the City's sewerage system is in the mid to late stages of its "service" life. Rehabilitation over the last 30 years has been limited due to budget constraints. In general, the overall condition could be described as "average to poor".

In 2000, the City embarked on a four-stage multi-year sewer rehabilitation project to upgrade the sewers in the Moresby sewer area (Area B), one of the areas suffering from the most severe deterioration. The City has recently embarked on the development of a 10-Year Capital Plan that will identify a systematic sewer rehabilitation / replacement program. Based on current financial capacity, it is likely that the needs for rehabilitation will be greater than the funding capability. Development of a sustainable basis for maintaining the integrity and investment in the sewerage system will be a critical part of the LWMP development process.

3.4 Wastewater Disposal

The City of Prince Rupert's wastewater is discharged into the harbour via ten outfalls. These outfalls vary in size, length, and depth depending on catchment area, sewer type, and topography. Table 3-2 summarizes the diameter, length, and depth of discharge of each outfall.

Table 3-2
Outfall Characteristics

Outfall	Diameter (mm)	Length (m)	Depth of Discharge Below Lower Low Water Level (m)
A	600	60	18
B	450	71	6
C	1200	58	15
F	200	50	15
G	375	37	11
H	1200	58	22
I	750	316	64
J	300	120	22
K	300	41	22
L	450	103	8

Outfall I is the largest of the sanitary sewage outfalls and was one of three long deep outfalls originally planned in the 1970s. This outfall is a 750 mm diameter pipe that extends approximately 316 m offshore. It is equipped with a 19 m long diffuser section, lying at a depth of 64 m below lower low water. Approximately 40 percent of the City's total average dry weather wastewater flow is discharged to the harbour through this outfall.

4 Wastewater Flows

Wastewater flow to the harbour and particularly the management of the flows during wet weather periods is an issue that requires further attention during the LWMP process. The flow issue is complicated by the presence of combined sewers and by old, separated sewers that allow rainfall and groundwater to enter the pipe containing the sanitary wastewater flow. The differences between the dry weather and the wet weather flow situation are described below.

4.1 Dry Weather Flows

The dry weather sewage flow consists of sanitary flow and groundwater infiltration during the driest part of the year. Statistically, this would be August. However, because of the influence of tourism, it could be argued that September would be a more representative month. Sanitary flow is the wastewater discharged from residential, commercial, institutional, and industrial properties to the sewer system. In the comprehensive monitoring plan (Associated Engineering, 2002), the base sanitary flow was estimated at approximately 350 L/person/day. This is a typical value determined from studies in other sewerage systems.

In addition to the base sanitary flow; additional "clean" water will enter the sewers during "dry" weather conditions. This is typically groundwater infiltration that enters the pipe through cracks in the manholes or pipe barrel or through foundation drains at the dwellings. If the groundwater table is well above the sewer pipe, infiltration could be substantial. When the flow is averaged over an extended "dry weather" period, it is termed the average dry weather flow (ADWF). The concepts of dry weather flows are similar for both sanitary and combined sewers. The ADWF is typically higher in a combined sewer, as the base groundwater infiltration is typically higher.

4.2 Wet Weather Flows

During wet weather conditions, i.e. most of the period November through January, additional flow generated from the storm event enters the sewer system. These extraneous flows are termed rainfall-dependent inflow and infiltration. This is a combination of rainfall-induced infiltration and storm water inflow.

Rainfall-dependent inflow and infiltration is flow seeping into defective pipes occurring during and immediately after rainfall events. Typically, the groundwater table rises as the ground gets saturated from the storm event, thereby, increasing groundwater infiltration. In a sanitary sewer, stormwater inflow is water that enters a sewer system from such sources as cross-connections, directly connected roof leaders, and manhole covers during rainfall events.

A combined sewer, of course, is designed to handle the stormwater, so street catch basins and stormwater connections from private property are directly connected to the combined sewer in the street. The peak wet weather flow (PWWF) is determined by the severity of the rainfall event. In a well-constructed and maintained sanitary sewer, the ratio of the PWWF to the ADWF is about two to three. In Prince Rupert, the ratio can be much higher due to the age and condition of the sewers. In a combined sewer, designed to accommodate the stormwater flow, this ratio can be ten or more.

4.3 System Capacity

As part of the comprehensive monitoring program, the existing capacity of the sewerage system was modelled, using computer software, for various wet weather conditions (Associated Engineering, 2002). These wet weather conditions are defined as "return" storms. They included the one, two, and five-year return period design storm events. For example, a one-year return storm is a precipitation event that happens every year.

The computer modelling indicated that the sewer system is at or over capacity in about 20 locations under a rainfall event that occurs once per year. Some of these sections may reach capacity under a less severe rainfall event. In the more extreme 5-year return storm event, about 30 locations are at or over capacity. The term “at capacity” essentially means that the sewer pipe is full. Additional inflow will cause the pipe to “surcharge” resulting in the overflow of manholes or the backup of sewage into homes, through the sewer service connection.

5 Issues

5.1 Environmental

Municipal wastewater effluent represents one of the largest threats to the quality of Canadian waters (Canadian Council of Ministers of the Environment). It is made up of both sanitary sewage and stormwater and can contain grit, debris, suspended solids, disease-causing pathogens, decaying organic wastes, nutrients, and about 200 identified chemicals. Municipal wastewater can result in increased nutrient levels, often leading to algal blooms; depleted dissolved oxygen, sometimes resulting in fish kills; destruction of aquatic habitats with sedimentation, debris, and increased water flow; and acute and chronic toxicity to aquatic life from chemical contaminants, as well as bioaccumulation and biomagnification of chemicals in the food chain.

The environmental impacts of sewage and storm discharges to Prince Rupert Harbour were investigated and reported in the 2002 study by Associated Engineering titled, The Comprehensive Monitoring Program – Impacts of Wastewater Discharges on Prince Rupert Harbour. The settlement of wastewater solids near the Outfall I diffuser is occurring, as evidenced by the high carbon to nitrogen ratio and elevated fecal coliform concentrations in the sediments. Copper and PAH concentrations are also elevated in those sediment. Although not measured, it is likely a similar situation exists near the other nine outfall discharge points.

Wastewater loading to the receiving environment can be defined by a number of parameters including BOD, nutrients or fecal coliform. In marine situations, where the initial dilution is relatively high, BOD and nutrient concentrations rapidly decrease to near background levels. They are thus not particularly useful in demonstrating the impacts on the environment. Fecal coliform concentrations in non-disinfected discharges, on the other hand, are high and serve as an excellent parameter to visualize the impact of dilution and dispersion. As definitive standards for water contact recreation and shellfish harvesting exist, the level of impact can be readily assessed by comparison of the modelling results with the standards. As a result, fecal coliform concentrations were used in the 2002 oceanographic modelling as a measure of wastewater loading.

Fecal coliform concentrations exceeding 700 MPN/100 mL are predicted in mid-channel. Concentrations of about 200 MPN/100 mL are expected in the Venn Passage. These predicted and expected concentration are very close, or greater than the Municipal Sewage Regulation fecal coliform requirements of 200 per 100 mL for recreation use and much greater than the 14 per 100 mL for shellfish areas. The effluent plume from the deep diffuser on Outfall I is trapped at depths of between 40 and 55 m below the surface throughout the year. The principal dispersion pathway is confined to the central portion of Prince Rupert Harbour, and follows the ebb and flood current trajectories. The plume essentially oscillates up and down the inlet on the tide and is slowly diffused into the surrounding receiving water. Flushing is a relatively slow process at these depths and the residence time for effluent is at least several days long (Associated Engineering, 2002). The situation in Prince Rupert Harbour is similar to other industrial harbours receiving wastewater flows.

5.1.1 Water Quality in the Harbour

There are two significant impacts on the harbour caused by the current discharge of wastewater and storm water. These are the impact of pathogenic organisms, as measured by fecal coliform concentrations, and the impact of metals and trace organic contaminants in the sediments near the outfall discharge points.

The current levels of fecal coliforms preclude the possibility of water contact recreation activities along the City's waterfront. As a result of the nature of the waterfront and climatic factors, activity has been limited and therefore, this is not likely a significant factor in long-term planning. At more remote areas of the inlet, it is likely that fecal coliform values would be well below levels that would result in a beach closure.

The more significant impact of the pathogenic organism input is on shellfish harvesting. While much of the harbour has been closed to shellfish harvesting for decades, there is recent interest in the possibility of re-opening remote areas. With the current level of wastewater treatment, or in some areas the lack thereof, the re-opening of any areas for shellfish harvesting in unlikely. Treatment specifically targeting a reduction in pathogenic organisms would be required prior to this occurring in the future.

The sediment sampling near Outfall I has indicated that some metals and trace organics levels are slightly elevated compared to the Interim Sediment Quality Guidelines used by the Province to determine the degree of sediment contamination and to the Probable Effects Level (PEL), developed by the US Environmental Protection Agency and used by Federal agencies (Associated Engineering, 2002). Although no sampling has been carried out near the other outfalls, a similar situation likely exists. While the discharge of untreated wastewater certainly has contributed to the elevated results, the fact that Prince Rupert Harbour has been the scene of significant industrial activity for over 100 years has likely also contributed to the current level of contamination. The situation in Prince Rupert Harbour is similar to many other industrial harbours receiving wastewater flows. The accumulation of metals and trace organics near a diffuser is typical, as witnessed by the monitoring programs carried out by the Greater Vancouver Regional District and the Capital Regional District on their outfalls (Associated Engineering, 2004).

5.1.2 Treatment Standards

Wastewater management planning, carried out 25 years ago, called for the consolidation of the dry weather wastewater discharges into three, deeper outfalls. During wet weather flows, combined sewer overflows (CSOs) would occur on an intermittent basis through some of the existing shorter outfalls. Comminution, or the grinding up of sewage solids, was proposed for the dry weather discharges. No treatment was proposed for the CSOs. One of the deep outfalls, Outfall I, was constructed in the early 1980s. None of the other work ever proceeded.

Since the original planning work, there have been a number of changes in the scientific understanding of the marine environment, in regulatory thinking, and in technology. Comminution, or the grinding up of sewage solids prior to discharge, is no longer considered an acceptable practice worldwide. At present, there are four regulations that govern the treatment and discharge of wastewater in British Columbia. These include:

- BC Waste Management Act and its attendant 1999 Municipal Sewage Regulation (MSR),
- BC Liquid Waste Management Plan (LWMP) Process,
- BC Health Act and its attendant Sewerage System Regulation, and
- Federal Fisheries Act.

The BC MSR applies to all wastewater flows above 22.7 m^3/day and to any discharges to surface waters, regardless of flow not covered under a LWMP. The level of treatment that is required under the MSR varies but for most situations, the minimum level of treatment would be secondary treatment, i.e. the effluent is never to exceed 45 mg/L biochemical oxygen demand (BOD) or 45 mg/L total suspended solids (TSS). In some cases, such as the places like Kelowna and Penticton, tertiary treatment, e.g. less than 10 mg/L BOD, and less than 10 mg/L TSS, and/or phosphorus removal is required in order to protect the water quality of Okanagan Lake and prevent algal blooms. The Ministry of Environment administers the MSR.

Under the BC LWMP process, any treatment plants that are planned and developed under the LWMP would operate under “operational certificates” or “OC’s” issued by and administered by the Ministry of Environment. Based on the results of the LWMP, the OC requires that the treatment plant provide a certain level of treatment, e.g. secondary treatment, and have an effluent that is consistently better than stated effluent quality requirements. In many cases, these effluent quality requirements are the same as those in the MSR. One main difference between the MSR and the LWMP OC approach is under an approved LWMP, borrowing money to build a treatment plant specified as part of the

LWMP does not require that there be a referendum. Under the MSR approach, unless a referendum is held and approved, any borrowing bylaw would potentially be subjected to a counter petition and, ultimately, a vote. Under the LWMP, no such votes are required on the basis that the public provided input during the development of the LWMP. In the context of this LWMP study area, the City is allowed to develop a plan to meet the required treatment standards and in doing so, can use a phased approach in implementing the treatment processes required to achieve the treatment standards.

The BC Health Act Sewerage System Regulation applies to flows less than 22.7 m^3/day (5000 Imperial gallons/day) going to ground disposal. The Ministry of Health administers this regulation. Typically, this applies to small on-site septic systems.

The Federal Fisheries Act seeks to protect fish from the addition of "deleterious substances", i.e. "any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water" (Fisheries Act, Chapter F-14, 34.(1)). The Federal department, Oceans Canada (FOC) (also know as "DFO") administers this Act. With typical wastewaters, the Fisheries Act applies primarily to the issue of effluent ammonia toxicity. The Fisheries Act requires that any undiluted wastewater treatment effluent that is discharged to surface water (fresh water or marine) be non-toxic as defined by a bioassay test involving rainbow trout.

Based on the above information, it is clear that treatment facilities with flows of more than 22.7 m^3/day fall under the jurisdiction of the Ministry of Environment. Furthermore, any community treatment facilities developed under an approved LWMP would have an OC issued and administered by the Ministry of Environment.

5.1.3 Wastewater Treatment

Wastewater treatment is a multi-stage process to restore wastewater before it re-enters a body of water, is applied to the land, or is reused. Wastewater treatment involves the use of unit processes to separate, modify, remove, and destroy objectionable, hazardous, and pathogenic substances carried by wastewater in solution or suspension in order to render the water fit and safe for intended uses or disposal. Generally, the impurities, contaminants, and solids removed from all wastewater treatment processes must ultimately be collected, handled, and disposed of safely, without damage to humans or the environment.

A measure of the strength of the wastewater is 5 – day biochemical oxygen demand, or BOD_5. The BOD_5 measures the amount of oxygen microrganisms require in five days to break down organics in the wastewater. Untreated municipal wastewater has a BOD_5 ranging from 100 mg/L to 300 mg/L. Pathogens or disease-causing organisms are present in wastewater. Coliform bacteria are used as an indicator of disease-causing organisms. Wastewater also contains nutrients (such as ammonia and phosphorus), minerals, and metals.

The goal of wastewater treatment is to reduce or remove organic matter, solids, nutrients, disease-causing organisms and other pollutants from wastewater to a level that will cause no impacts. Each receiving body of water has a limit to the amount of pollutants it can receive without degradation. Therefore, each wastewater treatment plant must hold a permit listing the allowable levels of BOD_5, suspended solids, coliform bacteria, and other pollutants.

Currently, in the City of Prince Rupert, only the sewage from Area I in the core area sewerage system receives limited wastewater treatment. Sewage from the other collection areas serving the core urban area is discharged without any treatment. The City of Prince Rupert has five separate preliminary wastewater treatment facilities (WWTFs) on the various “branches” of the Area I sewer system. The preliminary WWTFs are equipped with comminutors. This type of preliminary treatment process was used world wide for marine discharges prior to the 1980s. It has since fallen out of favour and is typically no longer used as a stand-alone process. Preliminary treatment now is more likely to mean fine screening to remove screenable solids, typically larger than 6 mm in size. In addition to preliminary treatment, current wastewater standards require primary and secondary treatment, as well as disinfection prior to discharge.

The following sections will describe primary and secondary treatment, as well as disinfection methods, in more detail.

Primary Treatment

Primary treatment is the second step in wastewater treatment. Primary treatment involves the removal of floating solids and suspended solids, both fine and coarse, by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD_5, and the total suspended solids (TSS) of the incoming wastewater is reduced before discharge. The goal of primary treatment is to reduce oils, grease, fats, sand, grit, and coarse (settleable) solids.

Sand and grit are removed in a sand or grit channel where the velocity of the incoming wastewater is carefully controlled to allow sand, grit, and stones to settle but still maintain the majority of the organic material within the flow. Sand, grit, and stones need to be removed early in the process to avoid damage to pumps and other equipment in the remaining treatment stages.

Many WWTFs have a sedimentation stage where the wastewater is allowed to pass slowly through large tanks, commonly referred to as "primary clarifiers" or "primary sedimentation tanks". The tanks are large enough that heavier solids can settle and floating material, such as congealed oils and grease and plastics can rise to the surface and be skimmed off. The settled solids are drawn off the bottom. Both receive further treatment as sludge. The clarified wastewater flows on to the next stage of wastewater treatment. In some cases, there is no further treatment, e.g. the GVRD's Iona Island and Lions Gate WWTFs.

The main purpose of the primary treatment stage is to produce a generally homogeneous liquid capable of being better treated biologically using secondary treatment with few problems and a sludge that can be separately treated or processed.

Secondary Treatment

Secondary treatment is a biological treatment process to remove dissolved and colloidal organic matter from wastewater. In all secondary treatment methods, bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain carbon molecules, etc.) and bind much of the less soluble fractions into floc particles and settleable cell mass.

These approaches are discussed below. The final step in the secondary treatment stage is to settle out the biological floc and cell mass in the secondary clarifier and produce wastewater effluent containing very low levels of organic material and suspended matter.

Disinfection

Disinfection focuses on killing disease-causing organisms in the wastewater. The disinfection of wastewater provides a degree of protection from contact with pathogenic organisms including those causing cholera, polio, typhoid, hepatitis and a number of other bacterial, viral and parasitic diseases. Disinfection is a process where a significant percentage of pathogenic organisms are killed or controlled. Since individual pathogenic organisms can be difficult to detect in a large volume of wastewater, disinfection efficiency is most often measured using "indicator organisms" that coexist in high quantities where pathogens are present. The most common indicator organism for wastewater evaluation is fecal coliform. Typical targets for fecal coliforms in wastewater effluents are less than 200 per 100 mL (the swimming contact standard) and 14 per 100 mL in shellfish areas (Municipal Sewage Regulation, 1999).

Disinfection of wastewater has played a large part in the reduction of waterborne diseases. There are a number of chemicals and processes that will disinfect wastewater, but none are universally applicable. Chlorination/dechlorination, ozonation, and ultraviolet (UV) light are the most widely used disinfection technologies.

5.1.4 Wet Weather Flow Management

Wet weather flow is a concern because untreated wastewater flows can be a major source of water pollution due to the type of pollutants discharged. For many communities, problems with untreated wastewater flows typically occur during wet weather events, when capacity in the sewer and or treatment plant is exceeded, and therefore a certain percentage of wastewater flow must be bypassed untreated. In a combined sewer system, this is referred to as a combined sewer overflow. Combined sewer overflows are composed of untreated domestic, commercial, and industrial waste and wastewater, as well as storm water runoff. A combined sewer system, such as those used by the City of Prince Rupert collects and transports sanitary sewage and stormwater runoff in a single-pipe system. A CSO event occurs when the total wastewater and storm water flow exceeds the capacity of the combined sewer system, and, by design, excess flows bypass the treatment plant and are discharged directly to the receiving water body. In the City's case, these flows are not termed "CSO" because all flows, at all times, are discharged directly to the receiving water body with little to no treatment. However, the City's impact is quite similar to that of a CSO event – just at a much larger extent due to the frequency and duration of the discharge.

CSO is of concern because it may contain pollutants, which may potentially impact the physical, chemical and biological characteristics of the water body. In some cases, they can cause havoc to aquatic habitats through increased concentrations of suspended solids, nutrients, heavy metals, pathogens, floating matter, oils, and oxygen demanding compounds. CSOs contain varying concentrations of pollutants depending on the characteristics of the sewer system, weather conditions, and the service population. The water quality in CSOs may also vary from event to event and also, within a given event (Moore, Valente, and Sullivan, 2004).

Generally, water quality standards are exceeded in water bodies downstream of CSO outfalls resulting in reduced water quality, beach closures, shellfish bed closures, contamination of drinking water supplies, and other environmental and human health problems (Moore et al., 2004 and Andoh, 2004). Due to the current regulations requiring CSO monitoring and controls, substantial data on CSO water quality is available. According to Moore et al. (2004), "average bacteria concentrations in CSOs are several thousand times higher than water quality standards, and receiving water bodies often lack sufficient dilution or assimilative capacity." Table 5-1 characterizes the water quality of CSOs to stormwater, untreated domestic wastewater, and secondary treated wastewater (Andoh, 2004).

Table 5-1
Water Quality Characteristics of Typical CSOs (Andoh, 2004)

Contaminant Source	BOD_5 (mg/L)	TSS (mg/L)	Total N (mg/L)	Total P (mg/L)	Fecal Coliforms (cts/100 mL)
Untreated Domestic Wastewater	100 - 400	100 - 300	20 - 85	4 - 15	10^7 - 10^9
CSO	25 - 100	150 - 400	3 - 24	1 - 10	10^5 - 10^7
Stormwater	10 - 250	67 - 101	0.4 – 1.0	0.7 – 1.7	10^3 - 10^7
Secondary Treated Wastewater	<5 - 30	<5 - 30	15 – 25	<1 - 5	<200

As indicated by the data in Table 5-1, the water quality of CSOs is quite similar to untreated domestic wastewater. The concentration of total nitrogen in CSOs is lower, possibly due to dilution effects from rainfall runoff. The concentration of total suspended solids (TSS) is higher, probably due to the re-suspension of sediments and other solids materials deposited in the sewers during dry weather, low flow conditions.

Current CSO control and elimination practices involve the following broad categories:

- Collection system controls
- Storage facilities
- Treatment technologies

The type of control mechanisms depends heavily on the characteristics of the sewer system, problems experienced by the sewer system, resources available, water quality goals and requirements, and site-specific conditions.

Collection system controls optimize the flow through the combined sewer by reducing or diverting flows or by increasing infrastructure capacity. Storage controls provide flow equalization by storing wet weather flows when flows exceed collection system capacity. The stored flows are then released for downstream treatment once capacity becomes available. Treatment controls provide treatment of the wet weather flows with the objectives of reducing the pollutant load prior to discharge and minimizing the environmental impact. Physical or physico-chemical treatment processes can potentially improve CSO discharges.

Given the reality of the existing combined sewer system, long-term planning by the City may entail both sewer separation as well as management of surplus wet weather flows. The final strategy may likely include some level of CSO treatment, and system storage to reduce the number of CSO events.

5.2 Community

5.2.1 Potential Environmental and Public Health Impacts of Discharge

The last 100 years have brought significant environmental advances. At the beginning of the 20th century, water and wastewater were treated by one principle, "the solution to pollution is dilution." But as population density increased, so did the spread of infectious disease. Only by the use of science and technology have threats to public health been identified and addressed. Wastewater effluent discharge limits also continue to evolve.

Since untreated wastewater contains microbial pathogens, suspended solids, toxics, nutrients, trash, and pollutants that deplete dissolved oxygen, discharges can contribute to beach closures, shellfish bed closures, limited fishing and other recreational activities, contamination of drinking water supplies, contamination of food supplies (consumption of contaminated fish and shellfish) and other environmental and public health concerns.

Exposure to viruses, bacteria, pathogens and other related pollutants or toxics is an obvious public health concern. Recreation users exposed to wastewater contaminants are vulnerable to gastroenteritis, respiratory infections, eye or ear infections, skin rashes, hepatitis and other diseases. Children, the elderly, and people with suppressed immune systems are especially vulnerable.

Wastewater pollutants, which lead to increased turbidity and toxins, and reduced oxygen levels in the water, also can adversely affect wildlife and aquatic habitat.

5.2.2 Effects of Existing and Future Industrial Development on the Wastewater System

Wastewater from non-domestic sources, such as industrial developments, may contain high concentrations of toxic and hazardous chemicals and/or nuisance compounds, which may not be adequately treated by municipal WWTFs, and, as a result, may cause impairment to the marine environment. Due to an increasing demand to improve effluent discharge and protect the environment, local governments are relying on ordinances to assist in controlling the materials discharged into their collection and treatment systems. Source control bylaw implementation and enforcement is typically in accordance with federal, state, provincial, county, shire, or local municipal laws and ordinances. Source control, like the name implies, controls the discharge of highly toxic or nuisance pollutants at the source. Source control can be a combination of activities carried out by municipal governments to inspect, monitor, enforce, and educate industries and businesses that discharge liquid waste into their wastewater collection systems.

Local ordinances are used by local governments to regulate a variety of rules and regulations. Ordinances can be used to enact specific local laws, or specific requirements that can be enforced at the local level. Local ordinances should meet the needs of the local community. The topic of source control, including options, will be investigated in a future discussion paper.

5.3 Financial

The financial aspects of liquid waste management are important and will be significant to the decision making process. Financial aspects include capital and operating cost estimates, and present worth and/or net present value analysis. As management options are developed, some general elements that will need to be considered are the cost of the options to the province, local government, and taxpayer. Equally important are when and how the options will be funded if they are selected for implementation. These financial elements will be investigated in a future discussion paper, once liquid waste management options are developed.

6 Summary

Discussion Paper No. 1-1 has explored wastewater management issues. Based on the information provided in this discussion paper, there appear to be some valid concerns about the potential for the discharge of untreated wastewater to adversely impact the environment and human health, either directly or indirectly. Discussion Paper No. 1-2 will begin to investigate existing and projected community development.

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B Appendix B - DP 1-2 - Community Development

DISCUSSION PAPER NO. 1-2

City of Prince Rupert
Liquid Waste Management Plan – Stage 1

Community Development

Issued:	March 12, 2007
Previous Issue:	None

1 Introduction

The City of Prince Rupert is developing a Liquid Waste Management Plan (LWMP) to manage the City's wastewater over the long term. Discussion Paper No. 1-1 documented the most likely wastewater management issues that will need to be addressed in the LWMP. One of these issues is future wastewater flows. This discussion paper will investigate projections of urban and rural residential, industrial, and commercial development and populations over the planning period of 20 and 40 years. Community development and population are important in the development of the Prince Rupert LWMP so that public health and safety may be protected.

2 Development

Covering a land area of almost 55 square kilometres (Statistics Canada, 2001), the City of Prince Rupert is the largest municipality and business centre in the Skeena Queen Charlotte Regional District (Prince Rupert Economic Development Commission). Prince Rupert's history is based on coastal life, the ocean and fisheries resources. Prince Rupert serves as the land, air, and water transportation hub of British Columbia's north coast, and is home to approximately 15,300 people (Statistics Canada, 2001). Economically, Prince Rupert currently relies on the fishing industry, port, commerce, and tourism.

The City of Prince Rupert is a key supplier of goods and services, recreation and culture, and financial and government services for the region. The demand for goods and services, and general development within the region impacts Prince Rupert by stimulating business activity, tourism, employment, and population. Subsequently, such changes have the potential to create new demands for homes, offices, and community facilities as well as for municipal services such as water and sewer. Both development and population are dynamic parameters dependent on each other and on the economic condition of Prince Rupert and the region. Development due to increased opportunities in Prince Rupert will affect land use. Increased employment opportunities will increase the demand for housing. This in turn will increase the need for urban and residential and commercial and industrial development. In the past, many communities the size of Prince Rupert have had residents move to larger cities to pursue post-secondary education. However, a new regional college opened in 2004, offering locals an alternative to moving out of town to upgrade their academic and/or trade skills.

2.1 Industrial and Commercial

Since 1910, planners and economic forecasters have envisioned the development of Prince Rupert's port as the mechanism that would allow the City of Prince Rupert to grow and achieve prosperity. However, during the past decade, Prince Rupert has experienced a series of economic disasters. Local pulp mills and sawmills have closed, the salmon fishery has declined, a fish-processing plant has burned down, and coal shipments through the port dropped off. To make matters worse, in 2001, the Skeena Cellulose Pulp Mill which directly employed about 800 people in the Prince Rupert area, and as many as 12 times that number of jobs in the region that indirectly depended on the mill, shut down (Hunter, 1998). During this economic tragedy, numerous residents were forced to leave town, leaving many homes for sale. The real estate market consequently collapsed, banks foreclosed on many homes, and some retailers had no choice but to cut back or close up.

Recent government investment in Prince Rupert's northern transportation infrastructure has stimulated new development and business opportunities. Highway and rail links to Prince Rupert have been upgraded and a major container port is underway. The container port has triggered other major development projects and as a result, has created a renewed interest and employment in Prince Rupert. The container port facility will have a substantial impact on employment levels in the region and throughout northern B.C., creating nearly 500 direct and indirect jobs through a significant multiplier effect (Prince Rupert Port Authority, 2004).

Major industries in Prince Rupert include:

- Deep sea port and terminals
- Commercial fishing
- Fish processing
- Logging
- Lumber processing
- Cargo storage and transport
- Tourism

Ridley Island, which is limited to industrial use only, is home to Prince Rupert Grain Ltd. (grain storage and handling terminal) and Ridley Terminals Inc. (coal storage and handling terminal). Considerable land is available for industrial and port-related development. In 2004, Associated Engineering prepared a feasibility study for the Prince Rupert Economic Development Commission, which looked into developing Ridley Island into a Seafood Industrial Park and the special infrastructure requirements of seafood industry tenants, particularly with respect to wastewater treatment (Associated Engineering, 2004). At present, industrial development opportunities are still available.

The tourism industry in Prince Rupert is steadily growing and providing local businesses with new opportunities. The Prince Rupert cruise ship terminal opened in 2004, bringing in thousands of tourists and tourist dollars (Prince Rupert Port Authority, 2005). Tourists are attracted to Prince Rupert for its sport fishing, insights into First Nations culture and history, the Historic Museum of Northern British Columbia that resides in the award-winning Chatham Village Longhouse, and guided tours of Laxspa'aws (Pike Island). Laxspa'aws, which is located approximately 15 km from Prince Rupert, has five significant Tsimshian archaeological sites, including village sites that date back 1,800 years. The Tsimshian were the first inhabitants of the Prince Rupert area. According to the Prince Rupert Port Authority (2005), the cruise ship "shore excursion program created jobs in a wide variety of industries…. [including] tour and fishing guides, pilots, rail operations, and entertainers…longshoremen, retail operators, marine operations, shipping agents, security services, and ship and vessel pilots." The increase in cruise ship traffic and the expansion into containerization create two very significant opportunities for Prince Rupert. These initiatives represent a shift from commodity export to tourism and import.

According to the Prince Rupert Economic Development Corporation (2005), the following investment projects, shown in Table 1, are planned for 2006 to 2011. These projects have the potential to create both short-term and long-term employment opportunities, increasing the stability and desirability of living and working in Prince Rupert.

Table 1
Investment Projects Planned for 2006 to 2011

Project	Description	Time Line	Investment
Phase 1 Container Terminal	Intermodal facility, shipping 500,000 containers annually	2006 – 2007	$145,000,000
Phase 2 Container Terminal	2,000,000 containers annually	2007 – 2010	$500,000,000
Ridley Terminals	Wood pellet and sulphur shipping	2007 –2008	$11,000,000
Westpack, LNG Terminal	Liquid natural gas terminal	2010	$350,000,000
Royop, Shopping Complex	25 acre shopping complex	2007	$30,000,000
Gaming Centre	Gaming, entertainment, conference centre, condos and marina	2006 – 2007	$13,000,000
Katabatic Power, Wind Farm	14 wind turbines on Mount Hays	2008	$50,000,000
Canada Safeway	Store renovations, Starbucks	2006	Multi-million
Sun Wave Forest Products	Pulp mill / industrial park	2006 – 2010	-

2.2 Urban and Residential

Urban and residential development is directly related to the economic well being of Prince Rupert. As reported in Section 2.1, the past decade presented economic difficulty for many industries that provide employment to Prince Rupert and neighbouring residents. Due to the loss of jobs, many residents were forced to find employment in other locations. This prevented large-scale urban and residential development from occurring.

With recent industrial and commercial development, new employment opportunities have developed. Homes that were previously vacant have already been or soon will be occupied through rental or purchase. As a result, more residential lots will be required. According to the City of Prince Rupert Official Community Plan (OCP), residential policies preserving present residential areas and the provision of sufficient serviced lots to accommodate future growth are in place. Based on the City of Prince Rupert General Development, Growth and Land Use – A Background Report for the Prince Rupert OCP (1994), the projected number of additional households in Prince Rupert in the year 2005, at 1%, 1.5% and 2% annual growth, are 887, 1,375, and 1,896, respectively.

The prime areas for residential development within, or adjacent to, the already developed urban area or the city are considered to be Areas A and B on Kaien Island (City of Prince Rupert, 1994). Area A is approximately 92 ha in gross area and Area B is approximately 76 ha in gross area (City of Prince Rupert, 1994). The total land area of Areas A and B does not reflect the potential density of development on this property. Physical features such as ravines, slopes or stream and land required for roads, parks, schools and commercial developments is included in the total land area, even though it may not be available for building lots. The actual amount of land suitable for future development in Prince Rupert represents about 37 ha in Area A and 30 ha in Area B (City of Prince Rupert, 1994).

As cited in City of Prince Rupert (1994), the Demographic Background Report details that the community (over 80% of the OCP survey respondents) has expressed a desire to see the population of Prince Rupert grow to at least 25,000. For the target Prince Rupert population of 25,000, there is not enough land available in these areas to accommodate the projected residential land demand, at any density (City of Prince Rupert, 1994). Since Prince Rupert's supply of residential land is a very finite resource, continued urban and residential development requires effective planning and management.

3 Populations

3.1 Historic Population Growth

Historically, Prince Rupert has been a fairly transient city due to seasonal work opportunities. Many people come to Prince Rupert for a few months of employment and then leave. Like many small northern British Columbia communities, a few employers provide employment to many Prince

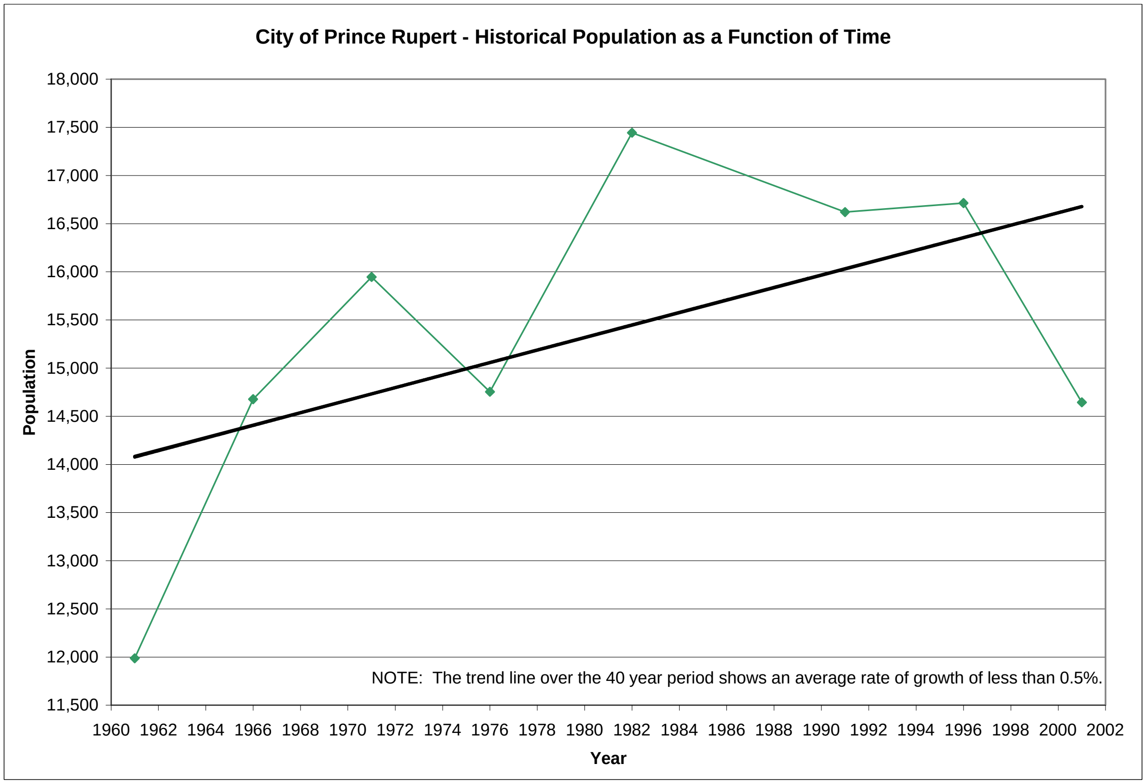
Rupert residents. As a result, the population of Prince Rupert is greatly impacted by the economic conditions of the industries and businesses operating in Prince Rupert. Business closures and layoffs leave scores of residents without work, without a source of income, and without other employment prospects. When employment opportunities cease to exist, residents are forced to move. As shown by the population values provided in Table 2 and shown in Figure 1, over the past few decades the population of Prince Rupert has increased and decreased, reflecting changes to Prince Rupert's economy. Over the time period from 1961 to 2001, the average rate of growth has been less than 0.5 percent.

Table 2
Historic Population Values

Year	Population
1961	11,987*
1966	14,677*
1971	15,947*
1976	14,754*
1982	17,444**
1991	16,620***
1996	16,714***
2001	14,645***
2006	Not available (waiting for Census data)

Notes:
* Value taken from the City of Prince Rupert's *Official Community Plan*.
** Value taken from *General Development, Growth and Land Use – A Background Report for the Prince Rupert Official Community Plan*.
*** Value taken from Statistics Canada.

Figure 1
Historical Population as a Function of Time



According to the 2001 Census, the population of Prince Rupert is 14,643 (Statistics Canada). The 2001 population decreased by 12.4 percent compared to the 1996 Census population of 16,714 (Statistics Canada). The reader should note the 2006 Census results were not released in time to be included in this discussion paper.

Based on the 2001 Census, the population density of Prince Rupert is 267 persons per square kilometre. Table 3 provides a breakdown of the age and gender characteristics of the Prince Rupert population (Statistics Canada). Almost one third of the population is between the prime working ages of 25 and 44, with the median age of the population being 34.8.

Table 3
Age and Gender of Prince Rupert Population at the 2001 Census

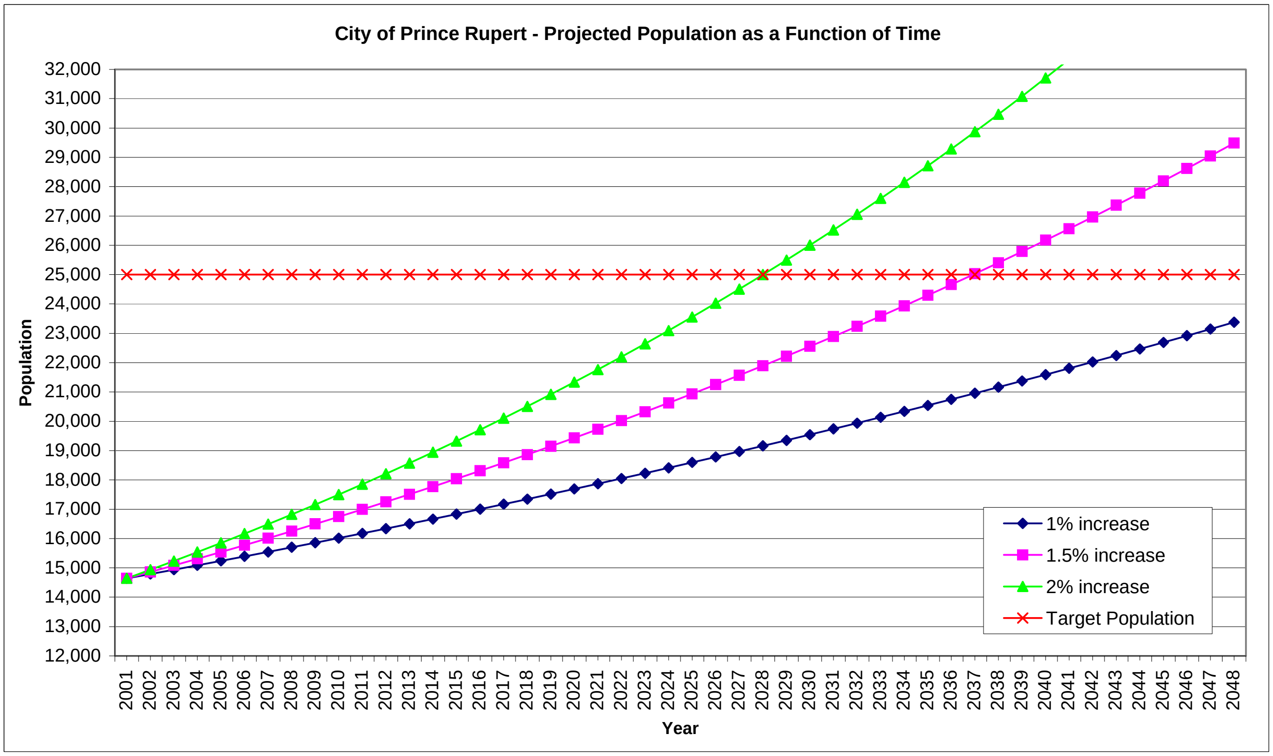
Age Characteristics of the Population	City of Prince Rupert		
	Total	Male	Female
Total – All persons	14,645	7,415	7,225
Age 0 - 4	1,005	520	485
Age 5 -14	2,415	1,240	1,180
Age 15 - 19	1,145	575	575
Age 20 - 24	850	415	435
Age 25 - 44	4,475	2,215	2,265
Age 45 - 54	2,270	1,205	1,060
Age 55 - 64	1,270	695	580
Age 65 - 74	710	360	350
Age 75 - 84	365	150	205
Age 85 and over	135	35	95
Median age of the population	34.8	35.2	34.2
% of the population ages 15 and over	76.6	76.3	77.0

3.2 Projected

The future population of Prince Rupert depends on the current population, current level of economic stability, and potential future economic development opportunities. As described in Section 2.1, many large projects are planned to occur from 2006 to 2011. These large projects will impact Prince Rupert through the creation of new employment opportunities, which have the potential to stimulate population growth.

Using the 2001 Statistics Canada Census population value of 14,643, the future population of Prince Rupert was projected using 1 percent, 1.5 percent, and 2 percent growth and is shown in Figure 2.

Figure 2
Projected Future Population Growth



According to City of Prince Rupert (1994), the target population is projected to be 25,000, even though the City of Prince Rupert acknowledges that not enough land is available to accommodate the projected residential land demand for 25,000, at normal densities. At 1 percent growth, this target population is never reached. At 1.5 percent growth, this target population is reached in year 2037. At 2 percent growth, this target population is reached in year 2029.

The projected populations for the LWMP planning years 2028 and 2048 were determined and are provided in Table 4. At 1 percent growth, the City of Prince Rupert reaches a population of 19,159 by 2028 and 23,377 by 2048. At 1.5 percent growth, the City of Prince Rupert reaches a population of 21,891 by 2028 and 29,484 by 2048. At 2 percent growth, the City of Prince Rupert reaches a population of 24,997 by 2028 and 37,145 by 2048.

Table 4
Projected Populations for Planning Years 2028 and 2048

Growth (%)	Population – 2028	Population - 2048
1	19,159	23,377
1.5	21,891	29,484
2	24,997	37,145

4 Summary

Urban and rural residential, industrial and commercial developments and populations over the 20 and 40 year LWMP planning period were discussed. Prince Rupert has experienced some very tough economic times, causing a decrease in population. However, at present, times are changing and new prospective investment opportunities are in the horizon. Based on the 2001 Census results, population values were projected using 1 percent, 1.5 percent and 2 percent growth. The City of Prince Rupert LWMP will use the projected population values established in this discussion paper to develop strategies to effectively manage liquid waste over the 20 and 40-year planning period.

5 References

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C Appendix C - DP 1-3 - Source Control

DISCUSSION PAPER NO. 1-3

City of Prince Rupert
Liquid Waste Management Plan

Source Control

Issued:	March 22, 2007
Previous Issue:	None

1 Introduction

1.1 Objective

A Liquid Waste Management Plan (LWMP) for the City of Prince Rupert (City) is being developed. As part of the LWMP planning objectives, options for source control and reductions of municipal and industrial wastewater volume and toxicity need to be investigated. The following documents the results of these investigations.

1.2 Background

Source control, like the name implies, controls the discharge of highly toxic or nuisance pollutants at the source. For many municipalities, the main objectives of developing and implementing source control bylaws include the following:

- To protect the receiving environment, i.e. river, lake or ocean,
- To protect sewerage facilities against harmful effects related to the presence of contaminants in wastewater,
- To ensure the health and safety of staff and the general public is not put at risk due to the presence of contaminants in wastewater,
- To protect the quality of wastewater sludges to allow the full range of options for its beneficial use,
- To protect treatment plants against upset due to inhibition of treatment processes by high contaminant loadings,
- To ensure fair and balanced use of the sewerage facilities through education,
- To provide means for regulation, enforcement and the application of the user-pay principle, and
- To promote responsible pollution prevention practices.

Source control can be a combination of activities carried out by municipal governments to inspect, monitor, enforce, and educate the general public, industries, and businesses that discharge liquid waste into their wastewater collection systems.

1.3 Need for Source Control

Wastewater from domestic and non-domestic sources can potentially contain high concentrations of toxic and hazardous chemicals and/or nuisance compounds, which may not be adequately treated by conventional municipal wastewater treatment facilities (WWTFs), and therefore, may cause impairment to the marine environment. Examples of domestic contaminants that find there way into the City's sewer system include used motor oil, left-over paint, and pharmaceuticals and personal care products. In addition to domestic sources, there may also be non-domestic sources, considering there are several small and large commercial businesses and industries that operate in the City. Amongst them are a commercial laboratory, a photo development centre, several restaurants, fish processing plants, and timber companies. Examples of non-domestic contaminants include oils and greases from restaurants, highly corrosive and toxic chemicals from manufacturing and processing facilities, and metals from plating industries.

Due to an increasing demand to improve effluent discharge and protect the environment, most local governments are relying on bylaws to assist in controlling the materials discharged into their collection and treatment systems. Source control implementation and enforcement is typically in accordance with federal, provincial, or local municipal bylaws. The need for a source control program for the City is yet to be determined and will depend on the quality and quantity of wastewater discharged by the both the domestic and non-domestic (commercial and industrial) sectors.

1.4 Approach

Local bylaws are used by local governments to regulate a variety of rules and regulations. Bylaws can be used to enact specific local laws, or specific requirements that can be enforced at the local level. Local bylaws should meet the needs of the local community.

The drafting of a local bylaw, should one be required, must not exceed the City's authority. Upon determining the legal authority, the City may then enact and enforce a bylaw for source control. The drafting of the bylaw requires the City to make some important decisions regarding the following:

.1 The City's policy regarding the identification of pre-treatment requirements (if any) to be imposed, or potentially imposed on industrial or commercial users (ICUs).
.2 Whether or not requirements identified in (.1) are to be self-implementing or will require some identifiable triggering action.
.3 The degree of specificity to be included in the bylaw.
.4 The degree of enforcement that the City wishes to provide.

The above items pertain to non-domestic (ICUs) sources of wastewater because they typically discharge larger volumes of wastewater than domestic sources. The following sections contain reviews of the abovementioned decision items.

2 Source Control Bylaw Elements

2.1 Authorization to Discharge

The inclusion of pre-treatment requirements can provide the City with greater control of ICU wastewater discharge activities, which in turn can facilitate other related source control implementation activities. Through the drafting of the bylaw, the City has the authority to require ICUs to initiate specified pre-treatment activities at all times, or in specific situations. Such activities can include mandating the discharger to increase the frequency of self-monitoring and sampling. After decisions regarding pre-treatment requirements are made, the City must decide how each of the requirements will be implemented and enforced.

2.1.1 Self-Implementing or Trigger Action?

A self-implementing bylaw is one that would directly impose a requirement on an ICU. The ICU would have to comply with the requirements outlined in the bylaw, regardless of whether their discharge permit included the requirements set out in the bylaw. The advantage of a self-implementing bylaw is that it applies to all users, not just large ICUs that hold discharge permits.

A trigger action bylaw is a bylaw that identifies the requirements that should be included in a discharge permit issued to an ICU. If requirements listed in the source control bylaw, e.g. pH and biochemical oxygen demand (BOD), are not included in the user discharge permit, the ICU is excused from complying with those unlisted requirements. Under a trigger action bylaw, a requirement can also be triggered by an action carried out by the City. An example of this is the bylaw or user discharge permit could require the ICU to develop a spill prevention plan on written notice from the City.

2.1.2 Degree of Specificity

In drafting a source control bylaw, the degree of specificity refers to whether the bylaw will be very specific, i.e. numerical standards, or more broad based, i.e. narrative, “public nuisance” standards. The advantage of using numerical standards rather than narrative “public nuisance” standards is that numerical standards are easier to enforce. For example, in response to restaurant discharges of oils and greases, a narrative standard would state “minimize the discharge of pollutants that may clog the sewer system”, whereas a numerical standard would state “discharge to contain less than 100 mg/L of oils and greases (of animal/vegetable origin)”. If numerical standards were used in the City’s source control bylaw, sampling results, or a self-monitoring report from an ICU could be used to determine if the discharger has exceeded the established numerical standards. Determining and proving whether or not a discharger has exceeded a narrative public nuisance standard can be more difficult due to interpretation of what type and quantity of discharge actually constitutes to being a “public nuisance”.

2.2 Discharge Limits

A source control bylaw can prohibit and/or establish limits on the type and concentration of pollutant discharged into the collection system. In situations where specific pollutant limits are not stated, are too vague, or do not exist, the City may decide to include in the source control bylaw a prohibition of any specific pollutant that has the ability to pass through the treatment plant untreated, and or interferes with the normal operation or performance of the treatment plant. This is assuming a treatment plant will be built in the future to treat the City's wastewater.

Specific prohibitions may include reference to, but are not limited to the following:

- Pollutants that are capable of interfering with biological processes and/or treatment operations.
- Pollutants that create a fire or explosion risk.
- Pollutants that are corrosive.
- Solid or highly viscous pollutants.
- Petroleum oil, non-biodegradable oil, etc.
- Non-mineral oils and greases.
- Any discharges with temperatures greater than 40°C.
- Pollutants that can produce toxic gases, vapours, and fumes.

2.3 Monitoring of Discharges

Monitoring of discharges from the ICU can take place using a variety of methods, namely the following:

- Scheduled sampling - Notice is given to the ICU, prior to the control authority conducting sampling.
- Unscheduled sampling - No notice is given to the ICU, prior to the control authority conducting sampling.
- Demand or investigative sampling - Intensive sampling effort that is initiated by the control authority in response to a known or suspected violation by the ICU.
- Self-monitoring sampling - Involves the ICU taking responsibility for conducting sampling and for submitting sample analysis data to the control authority at pre-determined times, e.g., monthly.

Typically, many municipalities rely on self-monitoring because it provides the control authority with water quality data to monitor compliance, while reducing the municipalities monitoring costs. Using a self-monitoring approach, the City can require ICUs to conduct wastewater sampling and analysis. The required sampling and analysis may be scheduled, unscheduled, or a combination of both. After the results are obtained, the discharger submits results to the City for review by authorized personnel. This form of monitoring ideally places compliance responsibility on users, and still provides the City with water quality data. Self-monitoring can be included in the source control bylaw to assist City staff in enforcing the bylaw without over-extending City personnel and resources. When self-monitoring is mandated by a local government, many ICUs choose to contract the sampling out to a private firm. If the City decides to implement self-monitoring, it is advisable to also enact compliance tracking, as defined below.

Compliance tracking is conducted by control authority staff and involves inspecting ICU self-monitoring reports for completeness. Compliance tracking ensures that the ICU has submitted all the data requested by the City in a timely manner. In addition, compliance tracking determines whether the submitted data is within the user discharge permit limit, or if it violates the permit and the source control bylaw. Violations of the permit and/or source control bylaw require the City to take enforcement action against the discharger.

2.4 Enforcement

To implement a source control bylaw, it is imperative that the City develops an enforcement response plan that is consistent, appropriate and fair in addressing non-compliance. The enforcement response plan should clearly specify the person(s) responsible for enforcing the bylaw, the responsibilities and duties given to this person(s), and action procedures to handle any non-compliance events. In order to evaluate compliance during reporting periods, it is recommended that detailed procedures on how to evaluate discharger self-monitoring data and City inspection and sampling data be included in the response plan.

The following are important items the City needs to address in its enforcement plan:

- How the City will investigate non-compliance?
- Who will be responsible for investigating non-compliance? Enforcement personnel should be properly trained in the review procedures and should have experience in conducting inspections and monitoring ICU discharges.
- Indicate the procedures that all ICUs will follow to implement a self-monitoring program, complete with sampling protocol, preservation, transportation, and analytical requirements. All of these items are necessary to ensure that the results obtained are legally defensible.
- The types of escalated enforcement actions the City will implement in response to the various types of user violations? The actions should provide for increasing formal levels of penalty against the discharger in response to increasing levels of non-compliance.
- What time periods within which actions will be initiated and how they will be followed up?
- Whether or not the City will conduct periodic inspections and/or sampling visits to industrial/commercial discharge facilities? If so, will the visits be scheduled or unannounced? How often will periodic inspections and/or visits be made?
- Whether or not the City will request ICUs to submit self-monitoring reports? If so, the desired submission frequency?
- It is advisable to develop standardized forms for ICUs to document compliance/non-compliance data in an organized manner. This will allow for the collected data to be used as evidence if enforcement actions need to be taken.

Prior to initiating an enforcement response, the City must evaluate the severity of discharger non-compliance. To what degree does the discharger's non-compliance activity exceed the applicable discharge limitations or other prohibitions specified in the discharger's permit or in the local bylaw? The City should consider non-numerical criteria such as impact to the collection system, treatment plant, environment, duration of non-compliance, and discharger compliance history. The City should decide whether or not the discharger is negligent in keeping and or maintaining accurate self-monitoring reports, which may indicate instances of non-compliance.

2.5 Public Education Programs

An effective source control program requires public involvement in the form of education and participation. Public education and pollution prevention strategies are emphasized as primary mechanisms in achieving a cleaner, safer environment. The better the public understands what can and cannot enter the collection system, the more successful the source control program will be.

Many municipalities have developed educational outreach programs to convey general information about what source control is to their domestic and ICU sectors. They have also included viable strategies for source reduction (discussed further in Section 2.6). Educational outreach programs have consisted of developing and distributing informational pamphlets, working with schools and community groups, and participating at local events by having educational booths set up to publicize source control.

To assist in the implementation of a source control bylaw, some communities have established committees composed of local industry representatives, members of the public, and local government representatives. The main objective in establishing such a committee is to work as a team promoting source control, which in turn will contribute to a healthy living environment. Through regularly scheduled meetings, the source control committee can exchange ideas and information regarding testing, existing laws, proposed laws, and the overall direction and progress of the source control program.

2.6 Source Reduction

Reducing the amount of water used and, thereby, the amount of wastewater generated can have a significant impact on reducing overall wastewater flows in some situations. Installing low volume faucets and showerheads and low flush or dual flush toilets in homes and businesses can help reduce the amount of wastewater generated. Front loading washing machines and water efficient dishwashers also reduce water consumption. Reducing the amount of domestic wastewater produced is just one part of the equation. Industrial and commercial facilities, which are responsible for discharging large quantities of non-domestic wastewater, comprise another part of the equation.

In the past, when "dilution was the solution" not much thought was given to segregating different types of non-domestic wastewater (process, storm, organic contaminated, inorganic contaminated, etc.). In those cases, all non-domestic wastewater was treated the same way. Now it is standard practice to segregate similar wastewater sources and carry out treatment or pre-treatment on these separated sources. However, segregation and at source treatment or pre-treatment can be capital cost and/or space prohibitive, limiting the application of these concepts.

Source reduction, which entails not creating wastewater in the first place or separating it out as it is being made using internal (within the process) and external (outside the process) recycle, is the improved method. However, recycling non-domestic wastewater streams has limitations, which may include the buildup of pollutant concentrations, which in turn can contribute to problems such product quality impairment. Problems in the sewer and/or treatment systems can also arise such as corrosion, scaling, and deposition.

There are two general methods of source reduction that can be used in an ICU pollution prevention program: product changes and process changes. Product changes are changes in the composition or use of the intermediate or end products that are performed by the manufacturer with the purpose of reducing waste from manufacture, use, or ultimate disposal of the products. Process changes are manufacturing modifications that impact how the product is produced. Process changes include: input material changes, technology changes and improved operating practices. Typically, improved operating practices can be implemented more quickly and at less expense than input material and technology changes.

2.7 Cost Recovery

The implementation and enforcement of a source control bylaw will require the City to carry out adequate fiscal planning in order to develop and maintain a budget that reflects current and future source control bylaw activities. Typically, fiscal planning needs to include the following components:

- Labour charges, which may include personnel wages, salaries, benefits, etc.
- Support services, which may include the use of engineers, laboratories, legal services, technical services, administrative services, telephone, utilities, etc.
- Materials and supplies, which may include office and safety supplies, fuel, replacement parts for equipment, etc.
- Equipment, which may include vehicles, monitoring equipment (portable sampler, flow meter, pH meter etc), computers, printers, office furniture, etc.

Many local governments have obtained initial funding through municipal bonds and surplus or reserve revenues. However, the main source of funding for the implementation of the bylaw and initial start up may be collected from the regulated industrial/commercial facilities. Initial start up costs can be recovered through user surcharges, and/or fees based on municipal taxes. Fees are based on the cost of monitoring an ICU and comparing it to the sum of all monitoring costs. However, in order to maintain fairness, generally “high-impact” users should pay a proportionally larger share of the costs than “low-impact” users.

3 Example Source Control Bylaws

In regions that have a source control bylaw in place, the bylaw serves as the main regulatory instrument for source control in wastewater collection systems and applies to any discharge of waste into a sewer that is connected to a wastewater treatment facility. To provide the City with actual examples of functioning source control bylaws, brief descriptions of source control bylaws from the Greater Vancouver Regional District and Capital Regional District are provided.

3.1 Greater Vancouver Regional District

The Greater Vancouver Regional District (GVRD) is comprised of four separate legal entities, with the Greater Vancouver Sewerage and Drainage District (GVS&DD) Board overseeing the Sewer Use Bylaw. In June 1990, the GVS&DD Board adopted Sewer Use Bylaw No. 164. Bylaw No. 164 established a system for regulating non-domestic discharges to the sanitary sewer system (GVRD, 1990).

Waste discharge permits are required for discharges or potential discharges to the sewer that are either a high volume discharge (discharge volume that exceeds 10 m^3/day or 300 m^3/month), or a restricted waste discharge (as defined in Schedule "B" of the Bylaw). Waste discharge permits are regulatory documents issued to industries and businesses under the Bylaw that outline requirements for wastewater treatment such as wastewater volume, effluent quality, and monitoring and reporting. The discharge of stormwater, uncontaminated water (i.e. cooling water), and groundwater also require a waste discharge permit. An applicant for a waste discharge permit must complete and submit a waste discharge permit application. After reviewing the application, the GVS&DD will take one of the following actions:

- Issue a discharge permit for the discharge.
- Inform the discharger that the discharge is subject to regulation under a mandatory Code of Practice and therefore, a permit is not required.
- Inform the discharger that neither a permit nor compliance with the Code of Practice is required.

A Code of Practice is a regulatory document containing mandatory sanitary sewer discharge standards for specific industrial, institutional or commercial sectors. Currently, the GVS&DD has only one Code of Practice, which pertains to the Food Service sector. All companies operating in the Food Service Sector must abide the mandatory Code of Practice for Wastewater Management at Food Sector Establishments, and therefore, do not require a Waste Discharge Permit.

The GVRD has an education and awareness program, SmartSteps, designed to help businesses save money and become more competitive by increasing the efficiency of energy, water, and materials use. SmartSteps does not specifically target the GVRD's source control program. It is a business tool for overall sustainability.

The GVS&DD has an enforcement policy to ensure non-domestic discharges to the sewer are being managed to meet the conditions outlined in the waste discharge permit. The discharger is responsible for submitting monitoring reports to the GVS&DD. The GVS&DD will assess compliance by reviewing the monitoring reports, reviewing results of independent sampling conducted by the GVS&DD, and site inspections. Non-compliance of the discharge permit results in enforcement actions such as monetary fines. Infractions that do not pose an immediate threat are stepped through an enforcement action sequence, which informs the discharger of the seriousness and consequences of the offence and requests immediate corrective action. More serious infractions such as the discharge of prohibited substances are dealt with under the authority of the British Columbia Waste Management Act.

3.2 Capital Regional District

The Capital Regional District (CRD) serves thirteen municipal governments including the City of Victoria. In contrast to the GVRD, which has both primary and secondary treatment plants, the CRD only has preliminary screening for treating its wastewater. The CRD's Regional Source Control program is a pollution prevention initiative aimed at reducing the amount of contaminants that industry, businesses, institutions, and households discharge into the CRD's sanitary sewer systems and, hence, into the ocean. The program has been active region wide since the adoption of the CRD's Sewer Use Bylaw No. 2922 in August 1994 (CRD, 1994). This bylaw serves as the main regulatory instrument for source control in collection systems and applies to any discharge of waste into a sewer that is connected to a wastewater facility operated by the CRD.

Similar to the GVS&DD Bylaw, the CRD's Bylaw issues waste discharge permits to industries, businesses or other operations that discharge significant non-domestic wastewater flows (greater than 10 m^3/day) or wastewater containing high loads of specified chemical contaminants into the sanitary sewer. The CRD also issues Letters of Authorization. Authorizations issued by the CRD are normally issued without expiry dates and have no sampling or reporting requirements. However, for verification purposes, CRD staff conducts periodic inspections.

Compared to the GVS&DD's single Code of Practice, the CRD Bylaw No. 2922 is more extensive and contains eleven Codes of Practice. The CRD's Codes of Practice outline mandatory sewer discharge standards for the following sectors:

- Food Services Operations
- Photographic Imaging Operations
- Dry Cleaning Operations
- Dental Operations
- Automotive Repair Operations
- Vehicle Wash Operations
- Printing Operations
- Carpet Cleaning
- Recreation Facilities
- Laboratories
- Fermentation Operations (breweries and wineries)

The CRD's Environmental Education Division undertakes a range of education and outreach activities which include the development and production of guidebooks, brochures and information sheets for Code of Practice sectors, newspaper articles and advertisements, presentations and workshops for specific business sectors, information booths and displays at trade shows, and development and production of video clips for release on a local community television station.

Permit holders are required to sample and analyze their wastes, record flows, and report to the CRD on a regular basis, as specified in their permit. CRD source control staff performs regular inspections and audit monitoring to confirm permit compliance. A comprehensive monitoring program is conducted by the CRD to verify permit compliance and confirm that the self-monitoring data being submitted by permitted facilities are representative of their discharges. This compliance monitoring includes collection and analysis of random samples from each permitted site two times per year.

The CRD has adopted a stepwise, cooperative approach to enforcing the bylaw. This enforcement policy classifies offences, outlines enforcement steps and includes use of cooperative measures, such as increased communication, education and monitoring to resolve issues of non-compliance. When cooperative efforts to achieve compliance using the enforcement policy fail, CRD bylaw enforcement officers under the CRD Ticket Information Authorization Bylaw may issue warnings or tickets.

Cost recovery is in the form of the following: Application Fee, Permit Administration Fees, Discharge Fee, Sampling and Analysis Charges, and Code of Practice Fee.

4 Implementation

If the City decides to move forward with a source control program, the following key decision items will need to be addressed by the City:

- Confirm the City's legal authority to enact and enforce a source control bylaw.
- Develop the City's policy regarding the identification of pre-treatment requirements (if any) to be imposed, or potentially imposed on ICUs.
- Determine whether or not pre-treatment requirements are to be self-implementing or will require some identifiable trigger action.
- Select the degree of specificity to be included in the bylaw, i.e. numerical standards versus narrative "public nuisance" standards.
- Establish prohibited pollutants and concentration limits for allowable pollutants.
- Determine the method and frequency of monitoring discharges.
- Determine the method of enforcement and enforcement response plan.
- Identify the number of City staff required to implement and enforce the source control program.

- Establish the City's fiscal requirements, available budget, funding, and cost recovery strategies.
- Implement a public education program, including a source reduction component, to be developed along side the source control program.

In addressing the abovementioned items, the City will need to consider its corporate mandate and how it relates to the need for, and development of, a source control program. To be effective, the City's social, environmental, and economic commitments must be directly integrated into the overall goals and objectives of the source control program.

5 Summary

One of the major challenges in treating wastewater is removing things that do not belong in it. Harsh chemicals, solvents, pesticides, paint, grease, and antifreeze — anything that goes down a drain, will end up in the wastewater collection and treatment system. For the City, which does not have a WWTF, chemicals that are put down the drain and enter the sewer system will eventually enter the ocean untreated. Many flammable, corrosive, reactive, or toxic chemicals get discharged to the sewer system and can corrode pipes, cause fires and explosions, or otherwise harm people and the environment. Grease can build up in sewers and create blockages, which lead to overflows into businesses and homes. By controlling pollutants at the source, the City can do a better job of managing its wastewater and protecting public health and the environment in a cost-effective manner. Source control programs provide an effective means of reducing contaminant levels entering the sewer system by preventing them from entering the waste stream in the first place. Source control programs collectively use a combination of source reduction, regulation, and promotion of pollution prevention strategies to achieve this goal. A successful source control program requires a public education program aimed at informing both the public and private sectors about responsible use of the City's sewer system, which includes proper disposal of waste chemicals, i.e., not dumping antifreeze or used oil down sewer drains.

6 References

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D Appendix D - DP 1-4 - Wet Weather Flow Management

DISCUSSION PAPER NO. 1-4

City of Prince Rupert
Liquid Waste Management Plan – Stage 1

Wet Weather Flow Management

Issued:	March 25, 2008
Previous Issue:	None

1 Introduction

1.1 Background and Objectives

The City of Prince Rupert is currently undertaking the development of a Liquid Waste Management Plan (LWMP) to ensure the long-term protection of both human health and the environment. The LWMP provides a strategy for managing wastewater. Wastewater is essentially all the water used in homes, institutions and businesses that goes down drains and into the sewer system. This wastewater is called sanitary or municipal wastewater.

The City of Prince Rupert currently has both combined and separated sewer systems. A sewer is a system of buried pipelines used for fluid conveyance. Separate sewers are sewers designed to carry sanitary waste in one pipe system and storm water runoff in a different pipe system. Combined sewers are sewers designed to carry both sanitary wastewater and storm water together in the same pipe system. Existing wastewater management in the City does not include wastewater treatment; therefore, all wastewater and storm water is currently discharge directly to the receiving water body.

The management of wastewater flow to Prince Rupert Harbour, particularly flows during wet weather periods, is an issue that requires further attention and will be addressed in this discussion paper. The flow issue is complicated by the presence of combined sewers and by old, separated sewers that allow rainfall and groundwater to enter the sewer pipe containing the sanitary wastewater flow.

1.2 Wet Weather Flows

During wet weather conditions, extra flow generated from the storm event enters the sewer system. These extraneous flows are termed rainfall-dependent inflow and infiltration. This is a combination of rainfall-induced infiltration and storm water inflow. "Inflow" is rainwater that enters the sewer system from sources such as yard and patio drains, roof gutter downspouts, uncapped cleanouts, pond or pool overflow drains, footing drains, cross-connections with storm drains, and even holes in manhole covers. Inflow is greatest during heavy rainfall. "Infiltration" refers to groundwater (water found below the ground surface) that enters sewer pipes through cracks, pipe joints, and other system leaks. Since most sewers do not flow full (under pressure), groundwater "infiltrating" into the sewer pipe is actually more of a problem than wastewater leaking out of the pipe. Wet weather events can raise groundwater levels and increase infiltration of groundwater into sewer pipes. The highest infiltration flows are observed during or right after heavy rain.

Rainfall-dependent inflow and infiltration is flow seeping into defective pipes occurring during and immediately after rainfall events. In the City of Prince Rupert's case, considering the wet climate, this is of particular interest. Typically, the groundwater table rises as the ground gets saturated from the storm event, thereby, increasing groundwater infiltration. Inflow and infiltration, generally referred to as I&I, can be a large contributor to wastewater flows, especially during wet weather events.

When the sanitary flow is averaged over an extended "dry weather" period, it is termed the average dry weather flow or ADWF. The peak wet weather flow (PWWF) is determined by the severity of the rainfall event. In a well-constructed and maintained sanitary sewer system, the ratio of the peak PWWF to the ADWF is about two to three. In the Prince Rupert situation, the ratio can be much higher do to the age and condition of the sewers. A combined sewer is originally designed to handle the stormwater, so street catch basins and stormwater connections from private property are directly connected to the combined sewer in the street. In a combined sewer, designed to accommodate the stormwater flow, the PWWF to ADWF ratio can be ten or more.

Combined sewer overflow (CSO) and sanitary sewer overflow (SSO) are terms commonly used in communities that have an active treatment system. The overflows refer to the amount of flow that cannot be handled by the system (i.e. the sewer system including the pump stations and/or the wastewater treatment facilities) and is directly discharged to the environment. When the City builds their wastewater treatment facility(ies) the CSOs and SSOs would be the flows that cannot be handled by the system. It should be noted that SSO's are not allowed by legislation.

2 Regulatory and Administrative Framework

There are three main jurisdictions that currently impact and/or control the treatment of wastewater in British Columbia. These include:

- The BC Waste Management Act and its attendant 1999 Municipal Wastewater Regulations (MSR)
- The BC Liquid Waste Management Plan (LMWP) Process
- The BC Health Act and its attendant Sewerage System Regulations

Sections 2.1 to 2.3 provide a brief overview of the current regulatory administrative framework governing municipal wastewater. Section 2.4 provides information pertaining to a proposed Federal Government strategy for the harmonized management of municipal wastewater effluent. This strategy is currently in the developmental stages; however, if enacted, it will impact the management of wastewater in the City.

2.1 Municipal Wastewater Regulations

The BC Ministry of Environment administers the MSR. In the context of this LMWP study area, the MSR would apply to any treatment systems that discharge to surface waters, or to any treatment systems, including septic systems, discharging more than 22.7 m^3/day to ground. All new treatment facilities would now fall under the MSR. The level of treatment that is required under the MSR varies but for most situations, the minimum level of treatment would be secondary treatment, i.e. the effluent is never to exceed 45 mg/L biochemical oxygen demand (BOD) or 45 mg/L total suspended solids (TSS). Based on the regulatory framework within the Province of British Columbia the City must act in accordance with the requirements of the MSR.

Combined sewers are addressed under Schedule 1, clause 14 of the MSR. According to the MSR, Clause 14, combined sewer systems are not permitted to be constructed or expanded. Emergency repairs to existing combined sewer systems are permitted, however, wherever possible, the feasibility of sewer separation should be considered.

2.2 Liquid Waste Management Plan

Under the BC LWMP process, any treatment plants that are planned and developed under the LMWP would operate under "operational certificates" or "OCs" which are similar to, but more flexible than, the previous permit system. These OCs are issued by and administered by the Ministry of Environment. For the most part an OC issued under a completed and approved LWMP is essentially the same as a permit under the previous BC system. Based on the results of the LWMP, the OC requires that the treatment plant provide a certain level of treatment, e.g. secondary treatment, and have an effluent that is consistently better than stated effluent quality requirements. In many cases, these effluent quality requirements are the same as those in the MSR.

2.3 Sewerage System Regulations

Sewerage system is another name for wastewater system. The BC Sewerage System Regulations, administered by the BC Ministry of Health, apply to flows less than 22.7 m^3/day going to ground disposal. The Sewerage System Regulation applies to the construction and maintenance of the following:

(a) a holding tank,
(b) a sewerage system that serves a single family residence or a duplex,
(c) a sewerage system or combination of sewerage systems with a combined design daily domestic wastewater flow of less than 22,700 litres that serves structures on a single parcel, and
(d) a combination of sewerage systems with a combined design daily domestic wastewater flow of less than 22,700 litres that serves structures on one or more parcels or strata lots or on a shared interest.

Although this pertains to small, on-site septic systems, it could also apply to mechanical-biological treatment facilities discharging to ground.

2.4 Canada-Wide Strategy for the Management of Municipal Wastewater Effluent

In the near future, the Federal Government of Canada may enact a Canada-wide strategy for the management of municipal wastewater effluent. Currently, the Canadian Councils of Ministers of the Environment (CCME) has established a Development Committee to develop the strategy. The Canada-wide strategy for municipal wastewater effluent will be developed and implemented on the basis of the following three cornerstones:

- Harmonization of the regulatory framework across all Provinces and Territories
- Coordinated science and research
- Environmental risk management model

The overall goal of the strategy is to have an effective, efficient, and harmonized management approach for municipal wastewater effluent. The strategy will examine all requirements for municipal wastewater effluent at the municipal, provincial, territorial, and federal levels, and recommend an approach to wastewater management that is fair, consistent, and predictable. Such a strategy will ensure that the roles and responsibilities of all levels of government are clear.

One of the likely outcomes of this strategy is a minimum requirement of secondary treatment for all discharges. Priorities will be placed on communities that have less than secondary treatment like Victoria, BC, St. John's, NL, and Prince Rupert.

3 Existing Sewerage System

3.1 Overview of System

The City of Prince Rupert sewerage system consists of ten sewerage sub-catchments in the Core Area, each with a separate outfall discharging to the Prince Rupert Harbour. Four of the catchments are serviced by separated sanitary and storm sewer systems. Combined sewers service the remaining six catchments. The 11th catchment, sewer area M which is not included in the Core Area, services a small area east of the Core Area that primarily uses individual septic tank systems at each dwelling, connected into a common sewer that discharges into Fern Passage. The complete sewer networks for all ten catchments are illustrated in Figure 3. Details of the catchment areas are presented in Table 3-1.

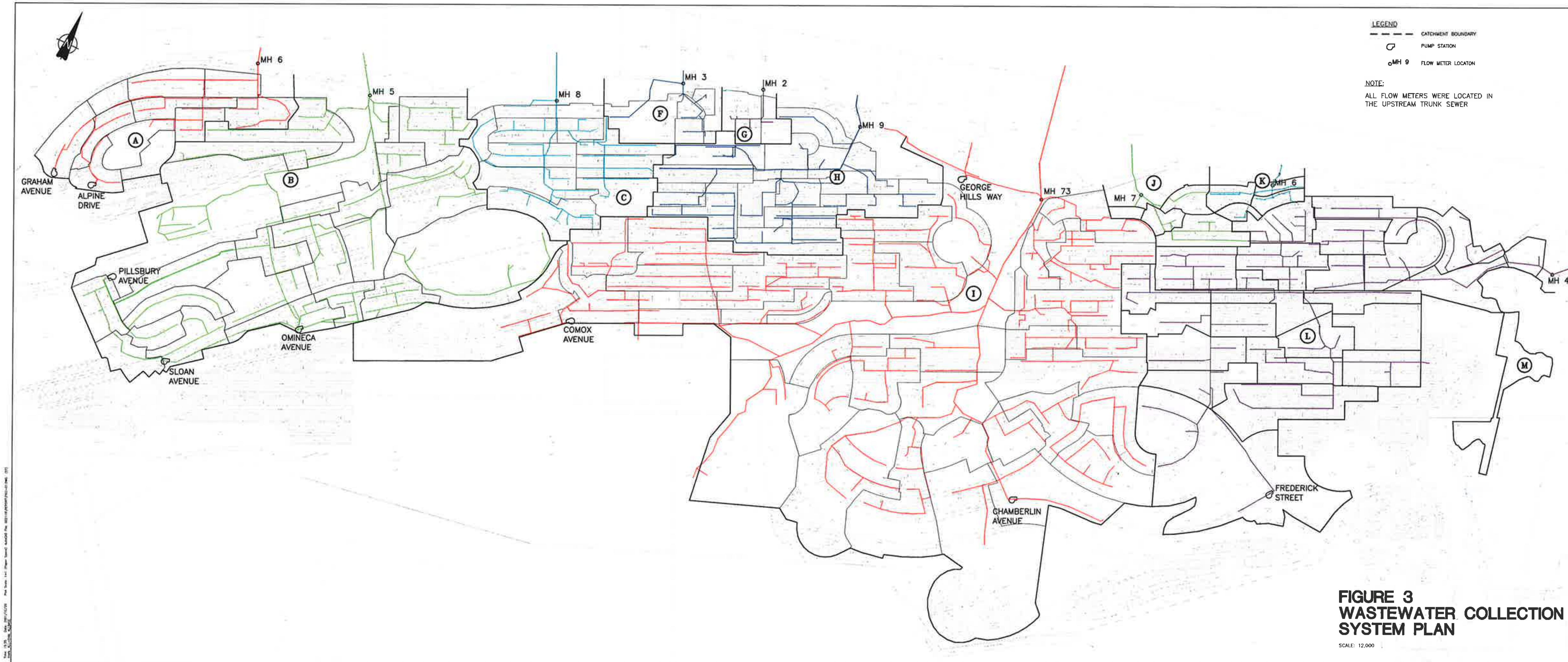


FIGURE 3
WASTEWATER COLLECTION SYSTEM PLAN

SCALE: 12,000

Table 3-1
Catchment Areas

Sewer Area	System Type	Area Served (ha)	Total Length of Sewer (m)
A	Combined	27	3,850
B	Sanitary	116	16,440
C	Combined	37	5,900
F	Sanitary	12	830
G	Combined	5	480
H	Combined	40	7,720
I	Sanitary	241	31,660
J	Combined	11	1,570
K	Combined	6	1,180
L	Sanitary	116	14,240
TOTALS		**611**	**83,870**

Of the total sewered area, combined sewers serve approximately 21 percent of the Core Area. Combined sewers provide service to approximately 26 percent of the population (Associated Engineering, 2003).

Although the collection systems are primarily gravity flow, there are nine pump stations in the City's sanitary sewer system. They operate in catchments A, B, I, and L.

The typical service life of sewer pipes is in the range of 40 to 80 years, depending upon the quality of materials, construction, and the local environment. Pump stations and treatment plants have a serviceable life of about 40 years, assuming proper maintenance is carried out. Much of the City's sewerage system is in the mid to late stages of its "service" life. Rehabilitation over the last 30 years has been limited due to budget constraints. In general, the overall condition could be described as "average to poor".

In 2000, the City embarked on a four-stage multi-year sewer rehabilitation project to upgrade the sewers in the Moresby sewer area (Area B), one of the areas suffering from the most severe deterioration. The City has recently embarked on the development of a Ten-Year Capital Plan that will identify a systematic sewer rehabilitation / replacement program. Based on current financial capacity, it is likely that the needs for rehabilitation will be greater than the funding capability. Development of a sustainable basis for maintaining the integrity and investment in the sewerage system will be a critical part of the LWMP development process.

3.2 Historic System Overflows

As part of the comprehensive monitoring program, the existing capacity of the sewerage system was modelled, using computer software, for various wet weather conditions (Associated Engineering, 2003). These wet weather conditions are defined as “return” storms. They included the one, two, and five-year return period design storm events. For example, a one-year return storm is a precipitation event that happens every year.

The computer modeling indicated that the sewer system is at or over capacity in about 20 locations under a rainfall event that occurs once per year. Some of these sections may reach capacity under a less severe rainfall event. In the more extreme 5-year return storm event, about 30 locations are at or over capacity. The term “at capacity” essentially means that the sewer pipe is full. Additional inflow will cause the pipe to “surcharge” resulting in the overflow of manholes or the backup of wastewater into homes, through the sewer service connection. These results are based on computer modeling. The City is using the findings as an indication of likely problem sewer sections during wet periods. Field observations are carried out during high flow events and the observations are recorded. This will allow the City to determine priorities in terms of sewer system upgrading.

At the present time, the ratio of wet weather flow to dry weather flow in the sewerage system (the system of sewer pipes and pump stations conveying the wastewater) can exceed ten in some sub-catchments. While this is not a critical factor now, when future wastewater treatment facilities are constructed, it will not be cost-effective to route the entire wet weather flow through the full treatment works. This requires that the LWMP develop a wet weather flow management strategy to handle the surplus wet weather flow. This would typically involve either temporary storage of the surplus flow, and eventual routing to the plant, or separate combined and sanitary wastewater treatment and discharge.

4 Overflow Reduction Strategies

Current overflow control and elimination practices involve the following broad categories:

- Source controls
- Collection system controls
- Storage facilities
- Treatment technologies

The type of control mechanisms depends heavily on the characteristics of the sewer system, problems experienced by the sewer system, resources available, water quality goals and requirements, and site-specific conditions.

Collection system controls, optimize the flow through the combined sewer by reducing or diverting flows or by increasing infrastructure capacity. Storage controls provide flow equalization by storing wet weather flows when flows exceed collection system capacity. The stored flows are released once capacity becomes available. Treatment controls provide treatment of the wet weather flows with the objectives of reducing the pollutant load prior to discharge and minimizing the environmental impact. Physical or physico-chemical treatment processes can potentially improve the quality of overflow discharges.

Given the reality of the existing combined sewer system, and the age of separated system, long-term planning by the City may entail sewer separation, sewer system rehabilitation, as well as management of surplus wet weather flows. The final strategy may likely include some level of sewer overflow treatment, and system storage to reduce the number of overflow events.

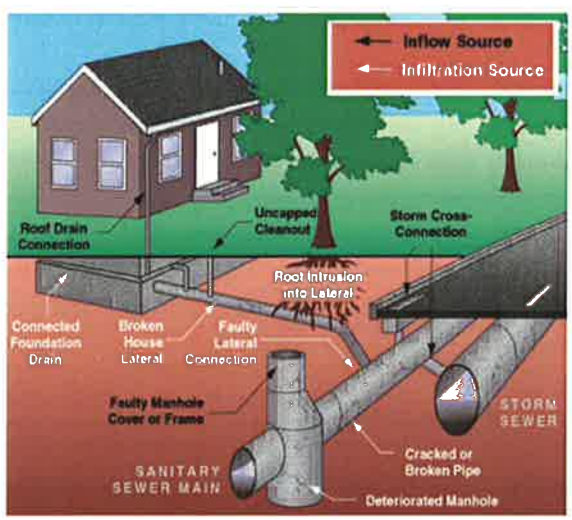
4.1 I&I Reduction

Overview of Inflow and Infiltration

As mentioned in Section 1.2 above, Inflow and Infiltration (I&I) refers to rainwater and/or groundwater that enters the sewer system and represents additional flows above the base sanitary wastewater flows.

Figure 4-1 provides a schematic of a topical sewer system to assist with understanding the terminology.

Figure 4-1
Infiltration and Inflow Sources



Generally, infiltration flow is more constant and has a lower volume than inflow. Infiltration is difficult and expensive to control since problems with infiltration can be difficult to isolate and represent a general deterioration in the sewer system. Controlling infiltration may have less effect on overflow volumes due to its relatively small magnitude.

The benefits of I&I reduction, specially when there is a treatment facility downstream, include reduced operating costs over the long term, deferred capital expenditures, and reduced environmental impacts. Overall operating costs are dominated by day-to-day operating conditions (i.e. overall average flows). Significant reductions in operating costs will be realized over the long-term when I&I are reduced. Reductions in extraneous flow are equivalent to an increase in the capacity of the system. This means that as the City's population grows, the City's sewer system is able to meet this demand without addition to the pipes or pipe diameter. Significant capital expenditures to upgrade the system can be deferred or avoided. Capacity that is not needed to convey and treat wet weather flows can be utilized for sanitary wastewater flows.

Source Controls

Source controls affect the amount and type of runoff that is permitted to enter the collection system. Source controls focus on reducing the volume, flow, and or pollutant load entering the collection system. Some possible source controls that may be implemented by the City are listed below:

- *Porous pavements* – help reduce runoff by allowing storm water to drain through the pavement to the soil.
- *Street sweeping* – helps prevent the accumulation of dirt, debris, pollutants, which may wash off streets and into the sewer system during a storm event.
- *Fertilizer and pesticide control* – where applicable, proper handling and application help ensure that chemicals are not a major source of pollution.
- *Commercial/industrial runoff control* – can contribute to grit, oils, grease, and other pollutants. The installation and regular maintenance of oil and grease separators in catch basins are area drains can help control runoff. Pre-treatment of industrial waste can also assist in reducing the pollutant load.
- *Soil erosion control* – properly vegetated and/or stabilized soils are less susceptible to erosion and as a result will not be washed into the sewer system during wet weather events.

Rehabilitate Manholes and Lines

A rehabilitation program for the City's sanitary sewer collection system can involve the repair of leaking sewer pipes and manholes. This provides positive benefits in terms of I&I reductions. Significant lengths of the sewer system must be rehabilitated to effectively remove infiltration and the effort often must include house laterals.

The rehabilitation can range anywhere from localized leaning (flushing, jetting, balling, drag scraping, pigs/kites/bags, air scouring), to localized repair (chemical stabilization, joint sealing, resin injection, patch repair, robotic repair, rerounding/lining), to complete replacement of the lines that are in poor conditions. Appendix A summarizes the results of a literature review on the rehabilitation options which was carried out by Associated Engineering as part of a wastewater rehabilitation study for the City.

Replace Manholes and Lines

A replacement program (using bursting, splitting, ramming, directional drilling, microtunnelling, open cut), for the City's sanitary sewer collection system can involve the replacement of leaking, non-repairable sewer pipes and manholes.

4.2 Separation of Sewers

Sewer separation involves converting a combined sewer system into separate storm water and sanitary wastewater collection systems. Sewer separation is a means of eliminating overflows and preventing sanitary wastewater from entering the receiving waters during wet weather periods. Sewer separation is normally carried out in combination with other means of overflow reduction such as the ones discussed earlier in this paper. In the City of Prince Rupert almost 20% of the sewer system is combined. Sewer separation can have considerable effect on controlling the overflows.

In general, conventional wastewater collection systems consist of gravity sewers to transport wastewater from homes or other sources of wastewater via gravity flow through buried piping systems to a central treatment facility. Gravity sewers have no power requirements because they rely on the slope of the land and gravity forces to convey wastewater through the network of sewer pipes. The application of gravity sewers is feasible in densely populated areas. In low-density areas, where lot sizes are large and homes are spaced widely apart, a gravity sewer system may not be practical and/or cost-effective.

The cost of implementing gravity sewers increases substantially when deep excavations in hilly or flat terrain are required. Material costs are proportionally related to pipe diameter sizes. Trenching is also a major cost item, regardless of the size of the pipes. Additionally, the installation and/or operation and maintenance of manholes, wastewater pump stations and other appurtenances also add to the cost of the gravity sewer system.

In the City's case, for the combined serviced areas, the existing combined sewer, provided it is still in good working condition, could be used to convey storm water runoff. A new separate gravity sewer would be designed and installed to convey sanitary wastewater flow. Since the cost of sewer system separation is readily associated with pipe size and excavation, it is preferable to design a new sewer system for sanitary wastewater flow instead of storm water flow. Pipes used to convey sanitary wastewater flows are considerably smaller in diameter and, therefore, have a lower cost than pipes used for storm water flow.

If the existing combined sewer is not in good condition and requires complete replacement, it may be best to replace the existing combined sewer system with a new sanitary sewer and a new storm sewer. There are several economic and non-economic benefits to this approach. Regardless of whether one new sewer system or two new sewer systems are installed, excavation, trenching, pavement resurfacing, etc. will be required. Installing both sewers at the same time can result in overall cost savings. Additionally, by integrating the installation of two new sewers, non-economic factors such as disturbance to the neighbourhood and environment, construction noise, and general inconvenience to residents will only be experienced once.

4.3 Overflow Storage

The Role of Overflow Storage as a Wastewater Management Tool

Even in communities with a long history of wastewater treatment, overflow storage can be an effective wet weather management tool to control the extreme flows before they reach the treatment facilities. As discussed before, the City of Prince Rupert's sewerage system consists of both combined and separate sanitary sewer systems. Although to different degrees, both combined and separate sewer systems will be impacted by precipitation events. Overflow storage provides flow equalization by storing wet weather flows when flows exceed collection and treatment system's capacity.

When the peak flows subside and capacity becomes available, the stored flows are released to the collection system where they can either go through the treatment facility or undergo some level of treatment before discharge. These controls include measures such as in-line storage (i.e., large diameter pipes) and off-line storage (i.e., storage tanks).

In-line Storage – Large Diameter Sewers

In-line storage using large diameter sewers or a series of box culverts constructed in place of the existing sanitary sewers provides a reliable, low maintenance solution to overflow problems. The in-line storage option attenuates inflows into pump stations, and involves wastewater flowing continually through storage tanks rather than being diverted off-line.

Off-line Storage - Large Tanks

Different arrangements of off-line storage tanks are also utilized to handle large volumes of flow during maximum flow periods, while releasing stored flows back to the system during relatively lower flow periods.

Off-line Storage – Satellite Tanks

Alternatively, a series of smaller satellite tanks can be designed to store the excess flows. The satellite tanks would be spread throughout the area and would separately control the excess upstream flows. Stored flows would be released back to the sewer system once capacity was available.

4.4 Wastewater Overflow Treatment Options

In-line Screens and Vortex Separators

The objective of treating wet weather flows is to reduce the pollutant load prior to wastewater overflow discharge and minimizing the environmental impacts. Physical or physicochemical treatment processes can potentially control wastewater overflow discharges. Due to the high concentration of solids, screening is one of the principal technologies used to address wastewater overflow control challenges. However, screens do not remove the particulate solids fraction that has the associated pollutant loads. The larger the solids are, the easier they are physically removed from the wastewater.

One of the in-line treatment systems that have been proven to be effective for wastewater overflow treatment is the vortex type separator. The vortex separator can contain the smaller flows and treat the large flows during storm events. Vortex separation provides both flow regulation and settleable solids removal for the control of wastewater overflows. The performance of vortex devices depends on the settling velocity distribution of the particles in the wastewater. Appendix B includes some additional information from one of the suppliers of Vortex separators.

Vortex separation devices are a class of physical treatment technology that use cylindrical chambers to induce rotational forces to separate settleable solids and associated pollutants. The vortex action concentrates solids into an underflow stream or underflow sump, thereby removing the solids and associated pollutants from the effluent stream. Vortex separation devices have essentially no moving parts and rely on the inertial forces induced by the flow-path to collect and remove the concentrated pollutants. In some cases, the design of the device allows for the capture of floatable material.

Studies indicate vortex solids separators are effective at removing gritty materials, heavy particulates, and floatables from wastewater flow, but ineffective in removing materials with poor settleabilities.

In the City's case, physical treatment of the overflows will, of course, be more meaningful when the wastewater treatment facilities are in place. However, these systems can be considered as an interim measure while the more advanced treatment system is in being added.

Ultraviolet Irradiation Disinfection

Disinfection using ultraviolet irradiation can follow physical treatments such as vortex separation. Disinfection is a process used to kill most disease-causing organisms (Metcalf and Eddy, 1991). Disinfection mainly consists of chlorination based systems or ultraviolet (UV) irradiation. UV disinfection is a physical disinfection process, which uses electromagnetic radiation at wavelengths ranging from 100 to 400 nanometers. Some UV systems are submerged in water and some are placed above the water level. Only submerged UV systems are used for wastewater overflow disinfection applications.

In submerged UV systems, overflow flows through a channel. The UV modules, which consist of UV lamps mounted on racks, are lowered into the flow channel. Each lamp is inserted into a transparent glass tube and sealed, thereby eliminating exposure to water. The size of the UV module used in the disinfection system varies according to the level of disinfection required and is based on the influent flow rate and water quality. This dependency is very important for treatment of low quality water such as wastewater overflow.

The water quality of the overflows can vary significantly on a short-term and seasonal basis. Understanding influent water quality parameters, in particular their variability is very important for the proper design of a disinfection system. UV disinfection of overflows has been found to be a function of total suspended solids concentration and light transmittance as well as contact time and UV intensity.

Suspended solids concentration, particle size distribution, presence of UV-absorbing compounds, and initial concentration of micro-organisms significantly influence UV performance. Therefore, to make UV more effective for overflow application, some level of physical treatment, such as vortex separation, should precede the disinfection process.

The disinfection of overflows should also be considered as part of the bigger picture, i.e. the overall City's wastewater treatment and disinfection.

5 Summary

Managing the wet weather flows is one of the most significant issues that the City of Prince Rupert should deal with as part of their overall wastewater management. Currently, even though steps are being taken to deal with wet weather flows issues, it has not been very critical since the there are no particular wastewater treatment systems in place, except for some sporadic grinding stations. Now that the City is moving towards a more comprehensive wastewater management system, the significance of the wet weather flow increases.

This Discussion Paper provided a general overview of the wet weather flows and the resulting issues. It also provided a summary of the options that can be implemented to control and manage the wet weather flows.

There will not be a single solution for the City's wet weather flow management issue. Any management policy will likely include a combination of the options presented in this discussion paper. In subsequent stages of the LWMP, the City has to look at these options more specifically and in combination with the rest of the wastewater management system.

6 References

Comprehensive Monitoring Program, Final Report, Associated Engineering, March 2003.

APPENDIX A – SEWER REHABILITATION TECHNIQUES (A LITERATURE REVIEW)

A1 Introduction

As part of the Hays Creek Sewer (HCS) Rehabilitation Options Study for the City of Prince Rupert, Associated Engineering previously conducted a literature review in order to identify all potential rehabilitation techniques which may be considered for inclusion in the subsequent options evaluation phase of the study. This literature review identifies available rehabilitation options and briefly describes the equipment and systems associated with each technique. These options, although originally prepared for HCS study, can be applied to other sewerage systems in the City.

The options for trenchless rehabilitation will be split into the following categories for convenience:

- Cleaning
- Localized Repair
- Lining Techniques
- Replacement and New Installation Techniques.

In addition to trenchless techniques, the following options will be addressed:

- Direct Replacement
- Twin Mains/Pumping
- Open Cut Trenching.

A summary of each technique is given below.

A2 Cleaning

One option for the rehabilitation of the HCS is to combine improving the hydraulic condition of the pipe with localised structural repairs to the pipe. The internal condition of the HCS is not known but it is likely that cleaning is required.

There are various different methods of cleaning available, the selection of which will depend on the method of rehabilitation selected. In this section we give brief summaries of the available cleaning technologies.

A2.1 Flushing

Sewer flushing is generally used to wash sediments to a strategic location for the purpose of increasing hydraulic performance and occasionally to mitigate the risk of pollution events.

Flushing involves rapidly introducing an unsteady source of water either manually or through automated valve control. An assessment of the internal condition of the HCS may prove that flushing would provide significant gains.

A2.2 High Pressure Water Jetting

In high pressure water jetting, a mobile compressor unit is used in combination with a range of hoses and nozzles to squirt high-pressure water or a solution of nutrients, stimulants, penetrants and surfactants into the sewer main. The solution loosens and liquefies heavy grease deposits and promotes rapid bio-degradation.

A2.3 Balling

Balling is a hydraulic cleaning method in which the pressure of a water head creates high velocity water flow around an inflated rubber cleaning ball. The ball has an outside spiral thread and swivel connection that causes it to spin, resulting in a scrubbing action along the pipe. Balling removes settled grit and grease deposits in pipes up to 600 mm in diameter.

A2.3 Drag Scraping

Drag scraping involves the use of spring steel scraper blades winched back and forth through the pipe to remove encrustations. This method can be used on a wide range of pipe diameters from 75 m to 1000 mm.

A2.4 Pigs, Kites and Bags

Kites and bags are similar to balls in that a rigid rim around the devices causes scouring of the pipe wall. Water pressure is used to move the kite or bag along inside the pipe; a line attached to the device provides restraint.

Pigging differs from kites and bags in that restraint is not provided. The pig moves along with a build up of water pressure behind it. Pigging is used for large sanitary sewer installations.

A2.5 Air Scouring

Air scouring is significantly cheaper than pigging, generally about a third of the price. Air scouring involves draining down a section of pipe and injecting slugs of water mixed with compressed air into the pipe. The air creates a vortex effect in the water which scours the pipe wall, removing sediment and accumulated solids.

A3 Localized Repair Techniques

Repair systems are used to address localized structural defects within a pipeline. In general, stabilization techniques will address a localized problem, such as infiltration, without adding to the structural integrity of the pipeline.

A3.1 Chemical Stabilization

The trunk sewer and laterals can be treated at the same time through the isolation of a section of pipe and the addition of an environmentally safe chemical solution (usually sodium silicate). The chemical is allowed to permeate the cracks in the pipe and is then pumped out quickly. A second solution is then pumped into the main which reacts with the residue of the first solution. A waterproof membrane is formed and the second solution is pumped out, the pipe is then cleaned to remove any residual chemicals. Figure A3-1 illustrates the application of chemical stabilization.

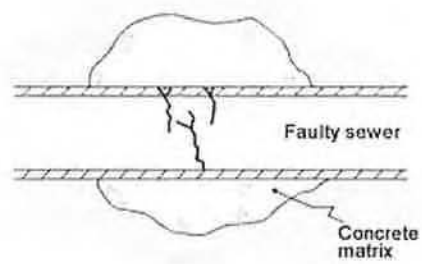


Figure A3-1
Chemical Stabilization

A3.2 Joint Sealing & Testing

Joint sealing and testing combines the functions of leak detection and grout injection and is widely used in gravity pipelines. The viability of the system for the HCS rehabilitation will depend on the number of defects and access constraints.

A packer with inflatable end elements is positioned across a pipe joint and pressurized to isolate the joint. Air or water pressure is then applied to the centre section of the packer and the rate of pressure loss through the joint is measured. If the loss exceeds a specified limit, a sealing resin compound is injected into the joint through the packer and the joint is re-tested.

Polyurethane grouts are hydrophobic and react with the water solution injected through the packer, resulting in a waterproof seal and enhancing structural stability. The repair head is flexible enough to negotiate bends in the sewer and the repair material is also relatively flexible to allow small amounts of pipe movement.

A3.3 Resin Injection Systems

Resin injection systems repair pipes locally, by injection of a resin formulation into defects that subsequently cures to prevent leakage and further deterioration. Resin injection systems, normally using an epoxy resin or mortar, stabilize and re-bond the existing pipe structure in addition to sealing against ex-filtration and infiltration. Recent developments in this technology may enable its application to more serious defects than have traditionally been repaired, such as holes and circular fractures. Resin injection can provide an even, relatively thick lining, giving some stiffness and potentially some structural support. Although the technology does not provide a full structural repair, it will stabilize an installation by preventing the creation or enlargement of voids in the pipe surround or by reinstating the ground support.

Resin injection is used where infiltration/ex-filtration problems have been identified, but it is not normally considered where the repair may come into contact with water. Additional protection may be required in the case of the HCS.

Resin injection involves winching an inflatable packer into position so that it is centered on the defect. The isolated defect is repaired by the injection of a rapid-setting epoxy resin into the crack, fracture or hole in the pipe wall. The packer is left in position until the resin has cured and is then deflated and removed. A thin internal collar of resin usually remains after the packer has been withdrawn.

A3.4 Patch Repair Systems

Figure A3-2 Patch Repair

Patch repair techniques involve impregnating a fabric with a suitable resin and positioned in place within the sewer around an inflatable packer. The packer filled with water, steam or air under pressure, presses the patch against the existing sewer wall while the resin cures. The packer is flexible enough to negotiate small bends and in some systems sewer flow can continue during the repair. Figure A3-2 illustrates the application of a patch repair. Both thermal-cure and ambient-cure systems are available. Resins are usually polyester (ambient temperatures) or epoxy (thermal cure). Patch repairs are short versions of cured-in-place liners, using polyester needle-felt on its own or in combination with glass fibre.

After curing, the packer is deflated and removed. The repaired pipe is then re-inspected by closed circuit television (CCTV), and any lateral connections are re-opened using the same techniques available for full-length liners.

A3.5 Robotic Repair Systems

Robotic repair systems for gravity pipelines consist of grinding and filler robots. Grinder robots remove encrustation and intrusions, and also mill out cracks to provide a good surface and key for the repair materials. The filler robot then applies an epoxy mortar into the slot formed by the grinder and trowels off the material to a smooth finish. Diameters up to 800 mm can be repaired. Figure A3-3 illustrates the robotic repair procedure.

The hydraulic-driven grinding head of the robotic system can be fitted with various shapes of cutter to cope with most pipe materials. Cutters are usually cooled by a water spray issuing from the central hub, providing a coolant and lubricant for the operation. Intruding laterals, grout deposits and hard encrustation can also be removed.

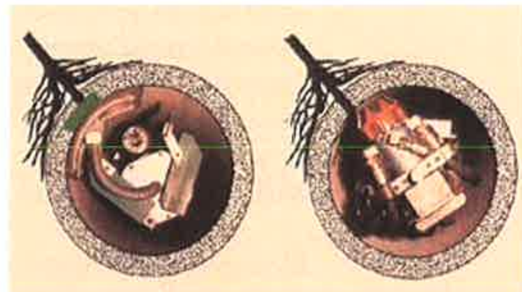


Figure A3-3 Robotic Repair

A CCTV camera attached to the grinding head monitors the operation of the self-propelled robots. Defective lateral connections can be repaired by sealing the connections to the main pipe with epoxy resin to form a flush finish. Some filler robots can inject expandable foam into voids to stop infiltration.
Robotic repair systems are versatile, but need a consistent program of work to be economically viable.

A3.6 Re-rounding

Re-rounding is used to reshape a deformed pipe prior to patch repair or relining. An expander unit re-rounds the pipe and installs a metal or plastic clip, which holds the pipe fragments in position until a patch or liner is installed. The expander system is inflated with hydraulic pressure or, alternatively, a hydraulic mole forces steel 'petals' outwards with hydraulic rams. CCTV control is used to position the expander, and the clip is then expanded with sufficient pressure to re-round the pipe. Figure A3-4 illustrates a typical re-rounding tool.

Figure A3-4 Re-rounder

A4 Lining Techniques

Coating and sheet liners are used to provide corrosion protection, eliminate or control infiltration and inflow and to prevent release of sewerage. Many of the materials used in lining techniques can provide a high level of structural renovation. There is a huge range of materials and techniques available, as such virtually any pipe can be renovated with lining techniques.

Factors which will effect the practicality of lining systems for the rehabilitation of the HCS are the provision of anchorage systems and the ability of the lining material to bond to the host pipe material, as such, preparation of the creek bed for anchorage and preparation of the host pipe will be critical to the viability of the following lining systems.

A4.1 Cement Mortar Lining Systems

Cement mortar lining is a centrifugally applied continuous lining of dense Portland cement mortar with a smooth and uniform finish. The lining provides internal corrosion and abrasion protection. Figure A4-1 illustrates the various components of the cement mortar system.

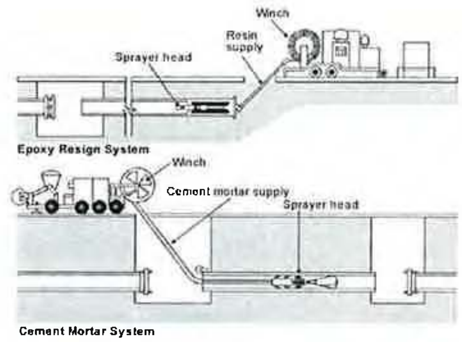


Figure A4-1
Cement Mortar Lining Components

A4.2 Spray or Brush Lining Systems

Spray or brush lining systems are methods of lining pipes with a thin layer of coal tar epoxy resin, polyester, silicon, urethane or vinylester. This layer is typically 1 mm thick and is sprayed or brushed onto the surface of a cleaned main. There may be some potential for these techniques to be used to reinforce the structural capabilities of the host main. Figure A4-2 illustrates a spray lining head tool.

Figure A4-2
Epoxy Lining Spray Head

A4.3 Cured-in-place Pipe Lining

Cured-in-place pipe lining (CIPP) requires no excavation, resulting in minimal site disturbance and low environmental impact and can renovate deteriorated pipes up to 1200 mm. CIPP can also be used to carry out patch repairs where there is only localised host-pipe damage.

The CIPP process involves installing a flexible resin-impregnated felt liner in the existing host-pipe under a head of water. Once in place the material forms a lining against the original pipe; the lining is then cured with hot water.

Once cured, the liner is a stand-alone structural pipe, designed to take the loads imposed by soil, water table and surface applied loads. Liners can be specifically designed to meet requirements of the host pipe.

A4.4 Sliplining

Sliplining techniques involve the insertion of continuous or discreet lengths of pipe within a host main. This is generally a low cost technique which has the disadvantage of reduction of hydraulic capacity. Figure A4-3 illustrates the various components of the sliplining system.

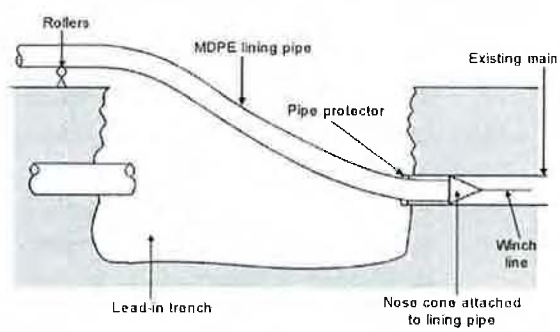


Figure A4-3
Sliplining Components

Swage and Die Draw Lining

Swage and die draw lining is a close-fit thermoplastic pipe lining system which involves stretching a liner pipe by pulling it through one or more dies to produce a temporary reduction in diameter. This enables the liner pipe to enter the host pipe and then expand to give a tight fit against the wall of the host. Figure A4-4 illustrates the various components of the swage and die draw lining system.

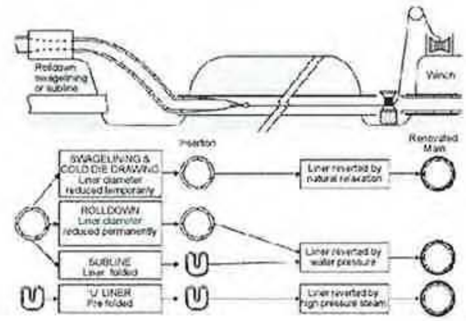


Figure A4-4
Swage and Die Draw Lining Components

Deformed Pipe Lining

Deformed pipe lining can be split into the following categories:

Compact Pipe - In this system polyethylene (PE) pipe is factory-extruded in a "C" shape and coiled onto a drum. This shape creates a clearance for the installation of the PE pipe into the host pipe. The folded pipe is then pressurized with steam which expands the liner to form a close fit within the host pipe, sealing leakage and preventing corrosion. Compact pipe may not be suitable for the larger portions of the HCS.

Subline - The subline system involves the folding of thin walled PE into a U shape to enable installation within an existing pipe. The shape is held by a series of bands which create a clearance for the installation of the PE pipe into the host pipe. The folded pipe is then pressurized, snapping the bands and allowing the liner to revert back to its original shape to form a close fit within the host pipe. Sublining is suitable for larger trunk mains. Figure A4-5 shows the replacement liner used in the subline system.

Figure A4-5
Deformed Pipe

Subcoil

In the subcoil system PE pipe is factory folded into a "U" shape, which is held by a continuous sleeve. The product is then coiled onto a drum. The folding creates a reduction in diameter which gives clearance for the installation of the liner into the host. The folded pipe is then cold pressurized which snaps the sleeve allowing the liner to revert back to its original shape to form a close fit within the host pipe. Subcoil may not be suitable for the larger portions of the HCS.

Thermopipe

Thermopipe is a circular woven, high tensile polyester reinforced polyethylene lining system. Supplied as a factory folded 'C' shaped liner, thermopipe is semi-rigid when cool. Once pulled into the pipe, inflated, and heated, it becomes flexible and expands. This achieves a close fit to the host pipe providing structural lining. It should be noted that thermopipe is ideally suited for the renovation of pressurized piping systems.

Spiral Wound Lining

In this system a plastic strip is spirally or helically wound to form a continuous lining. This is held in place initially by the expansion of the helix. A grout layer may be injected between the liner and the host pipe wall. Figure A4-6 illustrates the main components of the system.

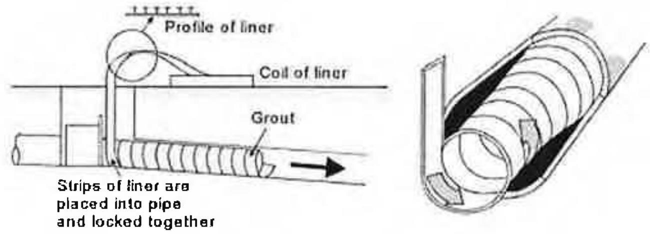


Figure A4-6
Spiral Wound Lining

A5 Replacement and New Installation Techniques

There are clear advantages in using the existing sewer line as a host for a new pipe, such as minimal disruption to the creek bed, the option to leave lateral connections in their existing positions, and maintaining the known hydraulic performance of pipe profiles.

In this section we describe methods which may be used for on-line replacement of the existing sewer main. Replacement and new installation techniques have been split into in-situ replacement and replacement techniques.

A5.1 In-situ Replacement Techniques

In-site replacement is replacement of sewer lines along the original alignment.

Pipe Bursting

Pipe bursting may be used for the in-line replacement of a fracturable host main. Pipe bursting has the advantage of providing an increased diameter main by expanding the host main. Figure A5-1 illustrates the pipe bursting procedure.

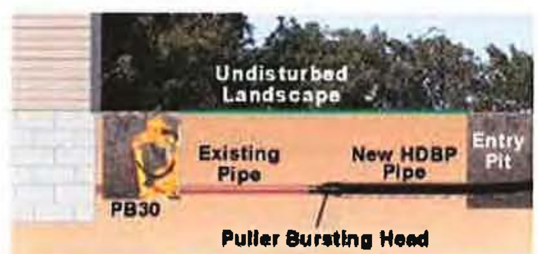


Figure A5-1
Pipe Bursting

A conical expanding device, which may be pneumatic, hydraulic or static, is introduced into the defective pipeline, shattering the pipe and drawing in the new line behind it. The practicality of pipe bursting for the rehabilitation of the HCS will depend on the provision of access for winching equipment, pipe and other materials. The three methods of pipe bursting are described below.

Hydraulic Bursting

Hydraulic bursting uses a hydraulically actuated bursting head and is ideal for manhole to manhole installations such the HCS. The system utilizes a hydraulic rod winch coupled to a diesel power pack. Winch rods are fed into the service to be replaced, then a cracking head is attached to the rods and the new pipe is pulled into the pipe. As the cracking head is pulled into the pipe, it splits the old service and simultaneously provides an annulus for the new pipe to be installed into.

Pneumatic Bursting

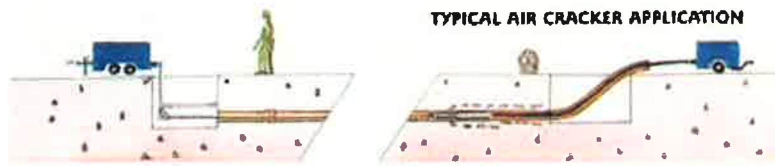


Figure A5-2
Pneumatic Bursting System

Pneumatic bursting utilizes an air powered percussive hammer head that is well suited to steel pipe installations. A constant tension, variable speed winch is used to drag the cracker through the host pipe. Figure A5-2 illustrates the main components of the pneumatic bursting system.

Static Bursting

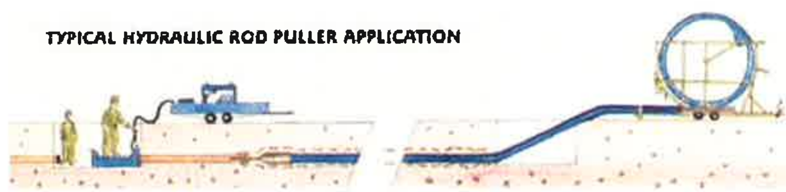


Figure A5-3
Static Bursting System

A hydraulically powered bursting unit consisting of an expander and roller cutting blades is winched through the host main utilizing a rod system. The cutting blades fracture the host main and the new pipe is pulled through as with the other bursting methods. Static bursting may be well suited to the HCS as the cutting blades prevent tearing of the host main. Figure A5-3 illustrates the main components of the pneumatic bursting system.

Pipe Splitting

Pipe splitting is similar in technique to pipe bursting but is specifically used in non-fragmental pipe applications such as steel. The technique is generally the same but instead of utilizing conical burst head and blade formats the systems use specialist splitting heads designed to cut through the pipe wall and joints, expanding the existing pipe into the surrounding ground. Figures A5-4 and A5-5 show the main components of the Pipe Splitting System.

Figure A5-4
Pipe Splitting Bursting Head

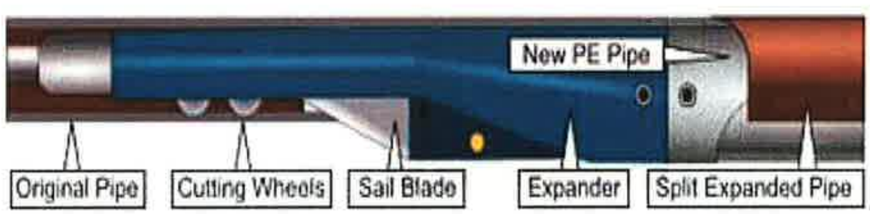


Figure A5-5
Pipe Splitting Equipment

Pipe Eating

Predominantly used on concrete sewer installations, this system allows for size for size replacement and upsizing. Pipe eating is an on-line, microtunnel replacement technique. The existing defective pipeline is crushed (or eaten), by the tunnelling machine and removed through the new pipeline. Lateral connections must be disconnected in advance and may be replaced by rider sewers or reconnected by angled drilling. It should be noted that pipe eating is not suitable for steel installations and as such would have to be used in parallel with an alternative rehabilitation method for the steel portion of the HCS. Figure A5-6 shows the main components of a typical pipe eating rig.

Figure A5 -6
Pipe Eating Equipment

A5.2 Replacement Techniques

Replacement techniques involve the construction of a new pipeline in a new location or in the existing pipe location, as described in the following four techniques.

Pipe Ramming

Pipe ramming is a technique utilizing a pneumatic hammer to drive steel casings through the ground from one pit to another. Pipes up to and over 2 m diameter and exceeding 70 m in length have been rammed. Figure A5-7 shows a pipe ramming operation.

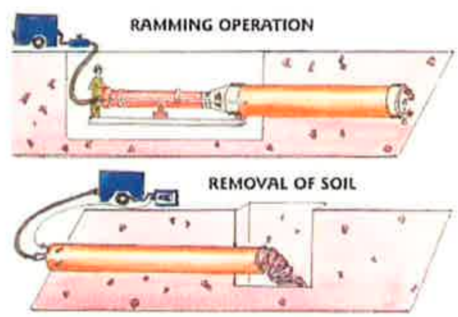


Figure A5-7
Pipe Ramming

The rammer and first casing length are connected directly or via ram cones, they are then positioned on a tracing or 'H' beam in the launch pit. Using adjustable cradles or air bags, the assembly is aligned and levelled on target. The air supply is partly applied to start the rammer and slowly increased as the first casing enters the ground. Full power is applied when the skin friction on the casing is sufficient to overcome the backstroke of the piston. As each casing length is inserted in to the ground, the rammer is removed and the next casing welded in place, the rammer is then replaced and restarted.

On completion of the ram, the soil in the casing can be removed by one of several methods: pressurization and blow-out, pressure jetting or mini excavator.

Access limitations and varying ground conditions may render pipe ramming impractical for the majority of the HCS.

Horizontal Boring
Horizontal boring consists of the mechanical construction of miniature tunnels in which vertical but not horizontal direction can be altered during the tunnelling process. Excavation down to the depth of the new pipeline may be required. Horizontal boring can be categorized in either the auger or the slurry methods.

Auger Method - Auger boring involves jacking a casing from an entrance pit while simultaneously removing the spoil with a continuous flight of augers. The auger is driven by a power source in the entrance pit which transmits power to the cutting head. As the auger proceeds, pieces are added until it reaches the exit pit. The auger is then removed and the pipeline or cable is put into place. Typical diameters range from 100 to 2100 mm, with driving lengths up to 180 m. Figure A5-8 illustrates the main components of an auger boring system.

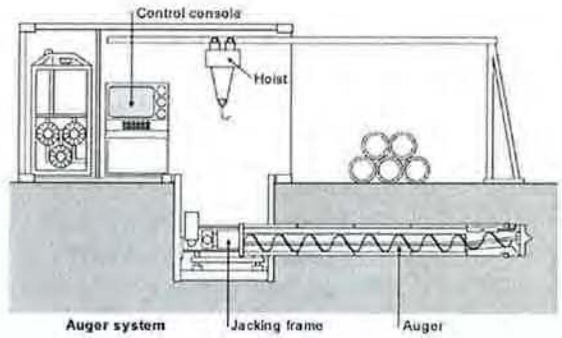


Figure A5-8
Auger Boring

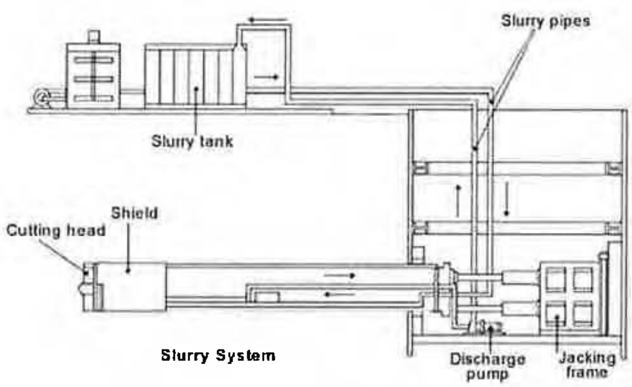


Figure A5-9
Slurry Boring

Slurry Method - Drill bits and drill tubing are used instead of the cutting heads and augers as with the Auger method. A slurry mixture is used to keep the drill bit clean and assist in the spoil removal. Cutting is carried out mechanically and the pipeline is inserted upon removal of the drill tubing. Figure A5-9 illustrates the main components of a slurry boring system.

Microtunnelling
Microtunnelling is a general term to describe remotely controlled mechanical tunnelling systems where the spoil is removed from the cutting head within the new pipeline, which is advanced by pipe jacking.

Microtunnelling machines have now been developed to work from drive shafts in a wide variety of ground conditions. The specific type of equipment required for a microtunnelling scheme is dependant on ground conditions and as such a thorough ground investigation will be required.

Excavations are required for drive and reception shafts, spoil may be removed from the face by an auger running through the newly installed pipeline to a skip in the base of the drive shaft. Alternatively, water or bentonite may be used to convert the soil into slurry at the cutting face. The slurry is then pumped to the surface where the solids are separated before disposal. Both systems provide face support by mechanical earth pressure balance. Slurry pressure at the face can also be used to combat external ground water. Drive and reception shafts can be located where manholes are required in the finished scheme.

Microtunnelling causes minimal surface disruption and is generally seen as an environmentally sound method of installation, the system is also relatively accurate which is beneficial in the installation of gravity sewers where maintaining a pre-designed gradient is critical.

Horizontal Directional Drilling (Guided Boring)
Horizontal directional drilling (HDD), or guided boring, is ideal for the installation of various underground conduits without excavation or trenching. Horizontal directional drilling causes minimal environmental disruption can be applied to diverse rock and soil conditions. Directional underground drilling is used for road, landscape and river crossings.

Figure A5-10
Horizontal Drilling Rig

The system uses a removable drill head (matched to soil conditions by the operator) and a series of drill stems to push and rotate the head. Once the pilot bore is completed, a reamer/backreamer is attached to the drill stem string and pulled back, this enlarges the bore wall to accommodate the pipe that is subsequently pulled into place.

The equipment required for HDD is relatively big and heavy; this again may prove to be the critical factor in the selection of a method for the rehabilitation of the HCS. Figure A5-10 shows a horizontal drilling rig.

A6 Summary

This literature review was originally prepared to present a brief description of the basic elements of the options which exist for the rehabilitation of the HCS. The options could be applied to other sewerage systems within the City's boundary. The intent was to provide the LWMP Advisory Committees with an overview of the characteristics of each rehabilitation system.

A7 Acknowledgements

Figures reproduced with kind permission of the UK Society for Trenchless Technology and Subterra.

A8 References

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- Sewer System Infrastructure Analysis and Rehabilitation, EPA Handbook, Cincinnati, OH, 1991
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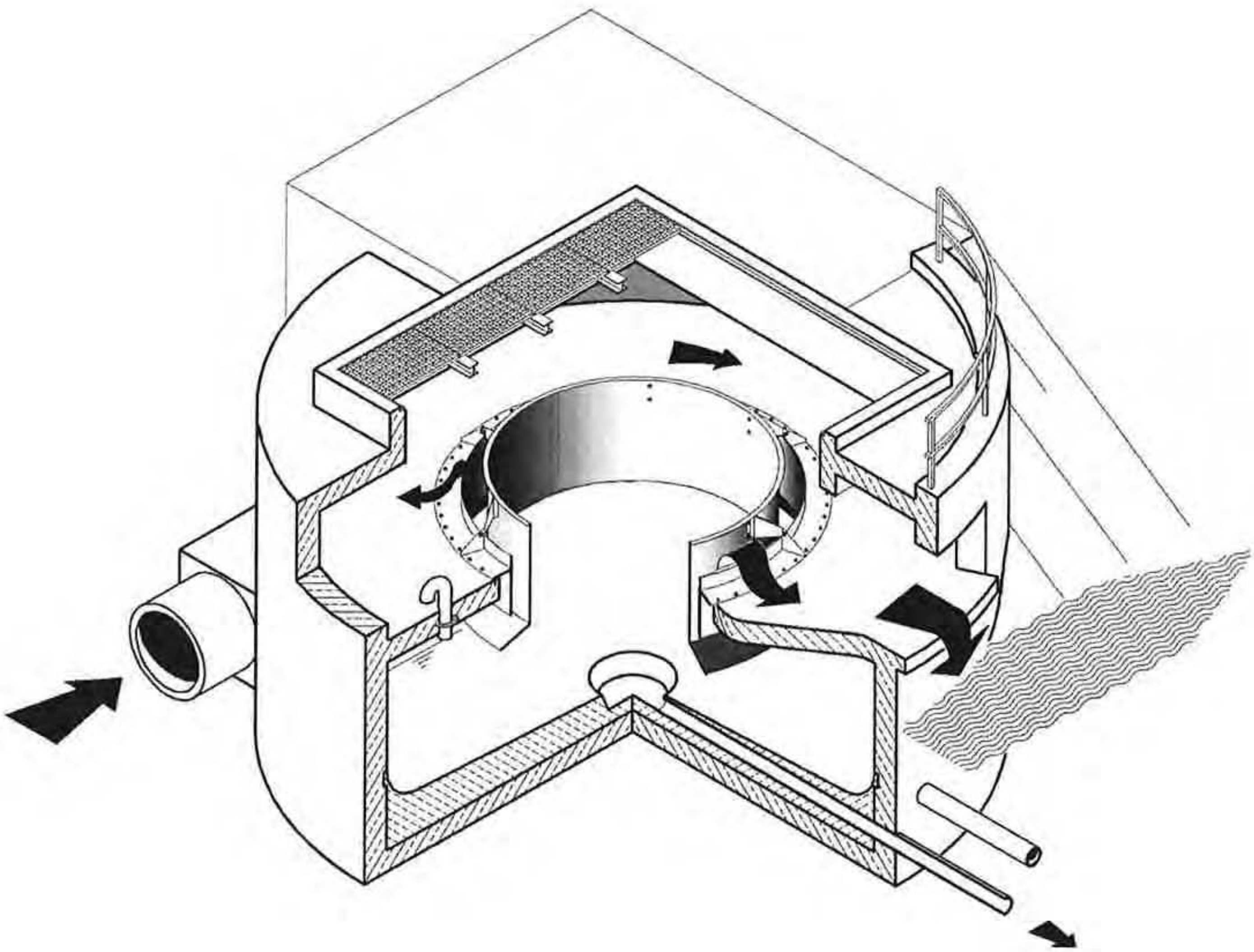
- North American Society for Trenchless Technology (http://www.nastt.org)
- International Society for Trenchless Technology (http://wwwistt.com)
- UK Society for Trenchless Technology (http://www.ukstt.org.uk)
- IDS Water (http://www.idswater.com)

APPENDIX B - VORTEX SEPARATOR

CSO/STORMWATER MANAGEMENT

®Hydrovex®
*Fluid*Sep Vortex Separator



John Meunier

HYDROVEX® *FLUID*SEP VORTEX SEPARATOR

INTRODUCTION

The **HYDROVEX® *Fluid*Sep** Vortex Separator is a tool in the treatment of CSO and Stormwater. The treatment relies on the properties of the controlled vortex to eliminate settleable suspended solids, as well as floatables carried by the incoming water.

Since 1985, UFT, the German leader in CSO and Stormwater equipment development, has developed the **HYDROVEX® *Fluid*Sep**. UFT and its owner, Dr. Hans Brombach, have specialized since the late '70s in induced vortex equipment design. Following the various laboratory and field developments, UFT has created a new concept of vortex separator, the **HYDROVEX® *Fluid*Sep** that presents better performances than those already existing.

UFT started the first **HYDROVEX® *Fluid* Sep** units in the summer of 1987 in the City of Tengen near Schaffhausen in Germany. The units are still operating successfully. A special research program that ended in the summer of 1990 supplied evidence of the superior efficiency of the **HYDROVEX® *Fluid*Sep**. The program was based on the qualitative evaluation of sampling campaigns performed at the installation.

HYDROVEX® *Fluid*Sep is currently in full operation in Germany, France and the United States of America.

GENERALITIES

Regulators and retention tanks are the most common CSO pollution control structures. If the combined sewer regulator allows important flows to pass without treatment to the outfall, the retention tank acts differently: it offers the advantage of storing the polluted water. In the case of transit type tanks, it can clarify the water before discharging it. The drawback is that these tanks are always very expensive and represent a massive capital investment.

For storm drainage, the stormwater is evacuated by the shortest path directly to the receiving body of water without any treatment. Under these conditions, important pollutant quantities, resulting from the washing of the impervious surfaces (mainly streets, parking lots and roof drainage) are directly sent to the environment.

The **HYDROVEX® *Fluid*Sep** Vortex Separator offers, both in Combined Sewers and in Stormwater Drainage, an effective solution to protect the receiving bodies of water. The technology is particularly interesting when applied in combined sewer rehabilitation or extension. The Vortex Separator is also very effective as a stormwater treatment.

OPERATION

The operation of the **HYDROVEX® *Fluid*Sep** Vortex Separator described here is based on an In-line installation in a Combined Sewer System. The Dry Weather Flow that gets to the unit passes by freely on the sloped bottom towards the central cone of evacuation and then through a flow regulator.

During a storm event, the incoming flow becomes bigger than the regulated outflow. This will effectively start the filling of the vortex separator. A lot of minor events can be fully intercepted and contained inside the vortex separator volume without actual overflow.

For more intense or more durable storm events, the **HYDROVEX® *Fluid*Sep** Vortex Separator start overflowing through its central annular overflow weir. This weir is made of two plunging cylindrical treatment baffles providing a double crown arrangement. The overflow water is evacuated through the ring-shaped opening formed by these two treatment baffles. The overflow is fixed in the circular opening of the top cover of the vortex separator structure. The overflowed water falls from the weir on the upper chamber of the separator and is then evacuated, either towards an additional treatment system or directly to the outfall. Due to its tangential inlet port, the incoming water brings the mass of retained water into a rotational movement inside the tank.

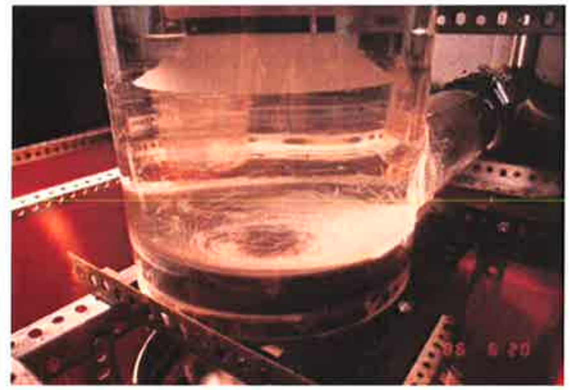
This rotational movement induces the ideal conditions for the creation of a vortex separation in the tank.

The resulting flow pattern is non-turbulent and very favorable to the separation of suspended solids. These particles can readily settle and are furthermore pulled by the centrifugal currents towards the wall of the separator. Once the particles are caught on the limit layer along the walls, they fall to the structure bottom and are finally brought to the unit's evacuation cone. From there, they are carried out with the underflow water through the regulator. The double crown baffle arrangement, plunging into the central section of the chamber, helps to ease secondary currents and increase the limit surface area. The overflow water is clarified.

When the **HYDROVEX®** ***Fluid*****Sep** Vortex Separator is filled, an air pocket is formed under the unit's cover, imprisoned by the baffle partition arrangement. The floatables entering the separator will be caught there and will simply circulate around until the unit progressively gets back to dry time flow conditions. The lower surface of the cover always remains free of water, due to the captured air pocket.

If the flow conditions allow it, the vortex separator lower cone can be fitted with an underflow drain. This drain can help separate the coarse elements from the separator. It can also help flush out entrapped material. The opening of the drain allows the draining of the cone to a stocking area located below the device. The sludge drained from the unit must be removed periodically after natural dehydration.

Bench Test for HYDROVEX® FluidSep Vortex Separator



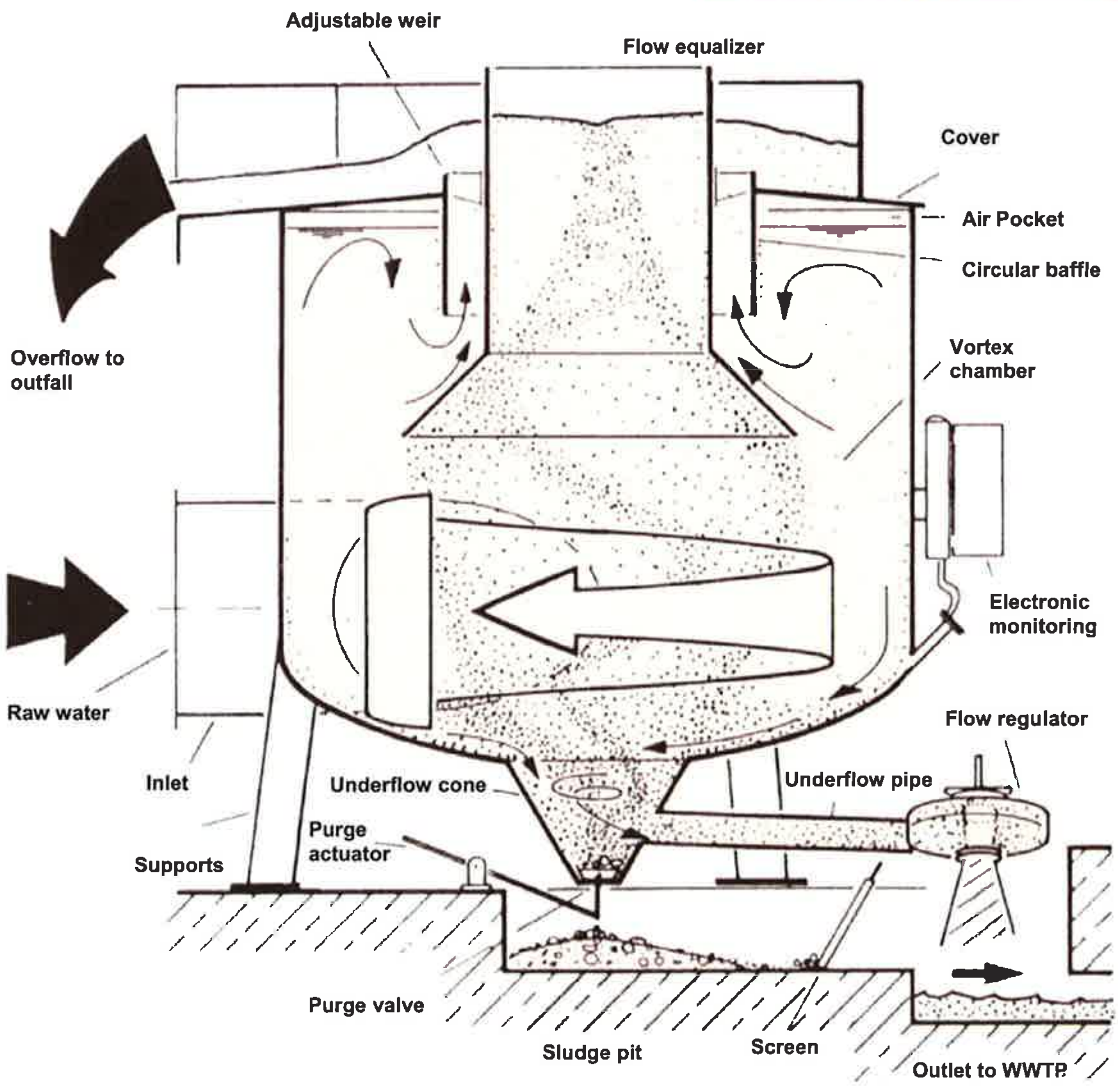


Figure 1: Cross section of a Hydrovex® FluidSep Vortex Separator in full operation

APPLICATIONS

The **HYDROVEX®** ***Fluid*****Sep** Vortex Separator has numerous possible applications, either in the storm drainage lines, in the combined sewer system or at the wastewater treatment plant. If required, many **HYDROVEX®** ***Fluid*****Sep** units can be operated in parallel. Also, the **HYDROVEX®** ***Fluid*****Sep** can be implanted off-line from the main sewer system. In the case of poor flow conditions, the **HYDROVEX®** ***Fluid*****Sep** can even be pump fed.

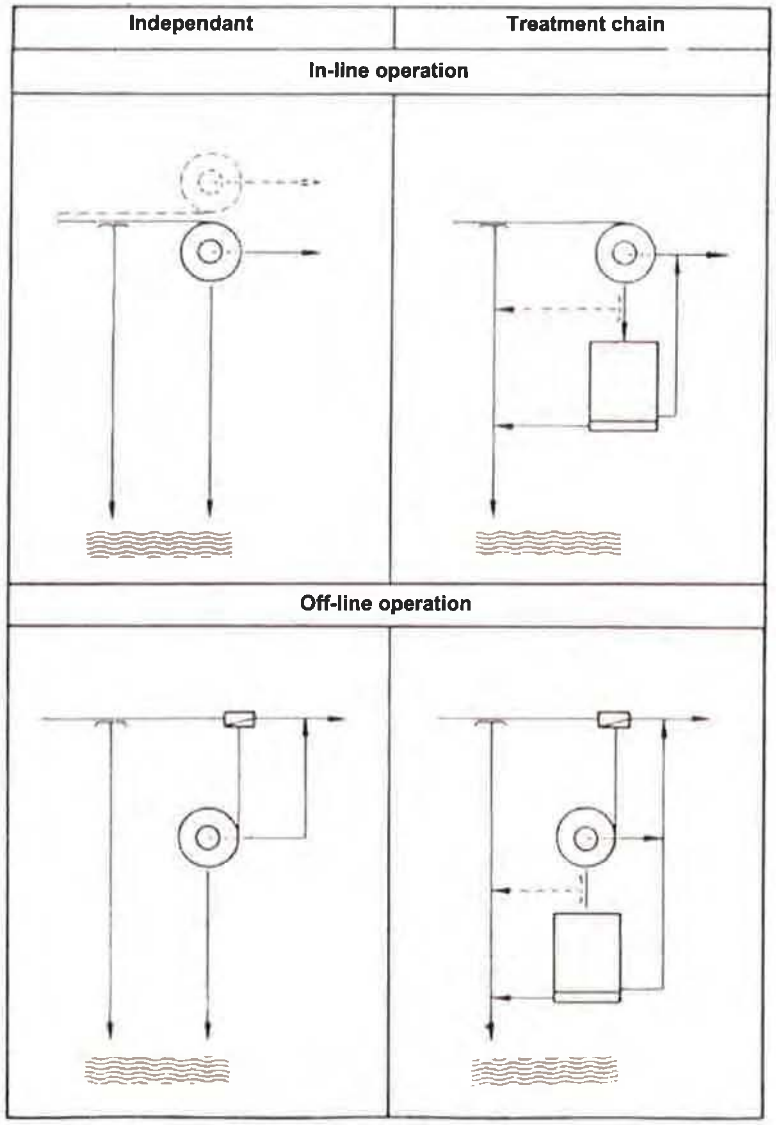


Figure 2: Various configurations of HYDROVEX® FluidSep vortex separators

COMBINED SEWER APPLICATION

The **HYDROVEX®** ***Fluid*****Sep** Vortex Separator can be used as a main CSO treatment, in replacement of a conventional overflow weir arrangement. The overflow frequency will be automatically reduced, simply based on the important retention volume offered by the vortex separator's structure. In overflow conditions, the unit will offer a treatment level equivalent to a headwork. An important fraction of the suspended solids and floatables will be retained and sent to the Wastewater Treatment Plant.

The use of the **HYDROVEX®** ***Fluid*****Sep** Vortex Separator, in combination with a transit type clarifier tank, is very effective. The vortex separator will be used as a preliminary treatment whereas the transit type clarifier tank will operate both as a retention tank and a polishing treatment. Low intensity events will be accounted for by the vortex separator alone. For bigger events, the overflow water, already treated in the vortex unit, will receive up to primary clarifier degree treatment in the transit type clarifier tank. Both units are performing far better together than in their stand-alone version. The problems related to resuspending settled materials and cleaning of the retention/treatment structure is greatly reduced.

STORMWATER APPLICATION

The **HYDROVEX® *Fluid*Sep** Vortex Separator can treat stormwater from street, roads, parking lots, roof drains, truck loading pads and industrial parks. The bigger part of settleable suspended solids can be trapped inside the unit rather than being freely sent to the environment. However, only an in-line arrangement can be used for this type of application. In storm drains, the solid load essentially includes mineral elements. These can either be sent to the sanitary sewer line or pumped out into a grit classifier for eventual disposal. This last solution is particularly adapted to areas where there are conditions with high grit, sand and salt content.

WASTEWATER TREATMENT PLANT APPLICATION

The **Hydrovex® *Fluid*Sep** Vortex Separator can be installed in the Wastewater treatment plant as an additional headwork component. It allows extra polishing of the grit chamber outflow.

DIMENSIONING

The fundamental data required to select and size a **HYDROVEX® *Fluid*Sep** Vortex Separator is the local hydraulic conditions and peak flow value Q_{max}. With these limit conditions, we can determine the size and the hydraulic efficiency of the separator.

The **HYDROVEX® *Fluid*Sep** should never be too small to maintain the retention volume function of the structure. Conversely, oversizing the unit will increase the construction expenses uselessly. If necessary, it is possible to design several vortex separators in parallel.

To determine the efficiency of the **HYDROVEX® *Fluid*Sep** Vortex Separator, it is recommended that a formal characterization campaign be carried out. This will help to identify the real characteristics of the effluent by identifying the composition of polluting materials to separate. When such data is not available, we can use the numerous sedimentation curves available in our group.

The additional equipment necessary to properly operate a **HYDROVEX® *Fluid*Sep** Vortex Separator is variable. Normally, it is limited to a flow regulator installed at the underflow exit of the structure. We recommend the installation of flow and level monitoring devices to insure the follow up of the unit and the frequency of activation of the structure.

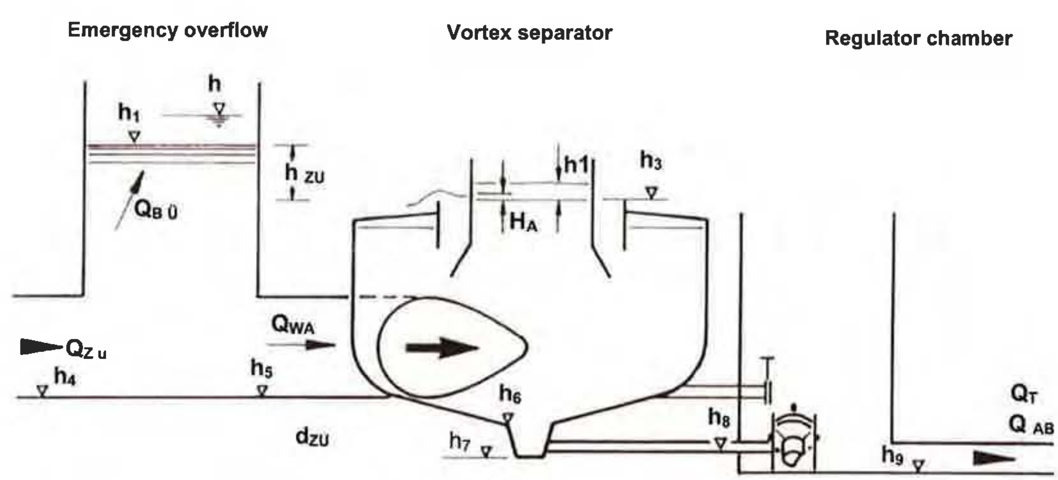


***Figure 3:** Side section of a simple vortex separator installation. In-line arrangements with free flow conditions.*

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