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Technical Memorandum

DATE: February 22, 2009

TO: Mr. Dave Marshall, B.Sc., A.Sc.T
Director of Engineering Services
The Corporation of the District of Oak Bay
2167 Oak Bay Avenue
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FROM: Robert Warren, P.Eng.

RE: **UPLANDS SEWERAGE SYSTEM MODELLING**
Rutland and Humber Catchments
Our File 547-012 – 300

1. INTRODUCTION

KWL submitted a revised technical memo on the above captioned issue on February 13, 2008. Since this time it has come to light that cost sharing for the proposed $1.2 Billion CRD treatment plants will be based on annual sewer flow rates from each municipality.

Since so much of the flow into the ECI is rain and groundwater significant savings in capital charges to CRD for a separation scheme that limits inflow and infiltration (I&I) are possible.

At the request of the Oak Bay Engineering Department KWL has investigated 3 new sewer options including traditional gravity, centralized vacuum systems, and a decentralized pumped low pressure system. We have appended this information and discussion thereof to the end of the February report leaving in the information regarding a new storm drain option. As well we have edited some of the original text.

It should be noted that this assignment is preliminary in scope and is intended for comparison purposes. The comparisons betweens systems provide guidance on which is the most favourable to council, however the cost estimates are preliminary and are not intended for accurate budgeting.

2. NEW STORM DRAIN SYSTEM

The District of Oak Bay (Oak Bay) has reviewed a variety of options in order to comply with the Provincial Municipal Sewage Regulations (MSR) and the Capital Regional District's (CRD) Liquid Waste Management Plan (LWMP) for the Uplands area. In order to comply with these commitments, a combined sewer separation program must be undertaken to lower inflow and infiltration (I&I) rates in the existing Upland's combined sanitary sewer system. These I&I rates are to be lowered so that no combined sewer overflows (CSOs) occur at frequencies lower than a 5-year return period. The current 90 l/s injection rate for each catchment are extremely high when compared to generally accepted I and I targets. The high end of generally accepted North American I and I targets yield less than 1/3 of this flow for the Rutland and Humber catchments. These expectations are not related to the current LWMP and the MSR. There is no formal request by the CRD for lower rates.

During significant flows in the East Coast Interceptor, the pumping rates for the Rutland and Humber pump stations are limited to 1 pump each (about 90 L/s). Therefore, in order to comply with the LWMP and MSR, the I&I rate must be reduced, so that an overflow does not occur during the 5-year storm event. The I&I rate must be reduced to 90 L/s minus the peak sanitary flow.

The Humber and Rutland catchments have been studied many times previously, in particular as part of many reports prepared for the CRD regarding the East Coast Interceptor (ECI). Several of the key reports include the following:

- 1987 ECI Design Memorandum[1]
- Investigation of Alternatives to Combined Sewer Separation in the Rutland Drainage Basin[2].
- Assessment of ECI Pressure Siphon Capacity and Arbutus Peak Flow Storage Tank[3]

A key point to be noted from the 1987 ECI Design Memorandum is that the "preferred plan" for the Humber and Rutland Pump Stations was to capture the first flush of storm events. Therefore, it appears that the intention of these pump stations was to allow overflows during storm events. Apparently this was deemed acceptable as long as the early portion of the flow, which contains the greatest concentration of environmentally deleterious substances, was pumped to the ECI. The ECI Design Memorandum report also discussed that it is not practical to eliminate overflows for the 1-year return period (mean annual event) for Oak Bay without separating the sewer system. The current requirement according to the LWMP and MSR is for no overflows during the 5-year event.

[1] East Coast Interceptor Design Memorandum, Kerr Wood Leidal Associates, 1987
[2] Investigation of Alternatives to Combined Sewer Separation in the Rutland Drainage Basin, Kerr Wood Leidal Associates, June 1995
[3] Assessment of ECI Pressure Siphon Capacity and Arbutus Peak Flow Storage Tank, Kerr Wood Leidal Associates, September 2004

In the Rutland Separation Alternatives Report a number of options were developed for the Rutland Catchment. These options were developed to meet the following criteria:

- Eliminate all CSOs in the summertime;
- Remove all floatables and materials of obvious sewage origin;
- Reduce the total number of treated CSOs per year to 4 or less; and,
- Provide treatment for all CSOs less than the 5-year storm.

The "preferred plan" developed to meet this criteria included the construction of one to three storage/treatment tanks (total volume of 500 m^3 to 1500 m^3) and a fine screening facility. The criteria above was not accepted by the Ministry of Environment as the Ministry required all combined sewers to be separated. Therefore, this option was not developed further.

The Assessment of ECI Pressure Siphon Capacity and Arbutus Peak Flow Storage Tank technical memorandum reviewed the capacity of the pressure siphon portion of the ECI and developed future design flows and upgrading programs through the year 2045. One option in the technical memorandum assumed that the combined sewers in the Upland areas would be separated and that the maximum flows from Humber and Rutland pump stations would be reduced to 22 L/s and 30 L/s in a 5-year storm event, respectively. However, Oak Bay has decided to set the I&I reduction target at 90 L/s minus the peak sanitary flow, as described above.

Recently, Associated Engineering (AE) was commissioned to investigate options to meet the above commitments. The AE report entitled *Uplands Subdivision Combined Sewerage System, Compliance with Core Area Liquid Waste Management Plan and Municipal Sewage Regulation, April 2005* presented 4 options. Although the report did not recommend a preferred option, Oak Bay staff have preliminarily determined that a program of new storm sewer construction is the most logical.

The purpose of this study is to confirm the proposed CSO reduction strategy selected by Oak Bay staff, and investigate the extent of new storm sewers to meet the above target.

2.1 DEVELOPMENT OF A COMPUTER MODEL

The modelling for the combined sewer was completed using the hydrodynamic software package *XP-SWMM*. Oak Bay provided KWL with mapping information from their geographic information system and aerial photos for development of modelling parameters. The study area is illustrated on Figure 1.

The models were setup for the Rutland and Humber catchments using physical parameters obtained from the GIS database (i.e. tributary area, slope, percent impervious, etc.). Actual flow and rain data was obtained from the CRD for the winter of 2001/2002, and imported into the model. The rainfall information was provided from the CRD's rainfall station located at the Penrhyn Pump Station. The Penrhyn Pump Station is located immediately north of the study area in the District of Saanich. The flows are measured at the inlets to the Rutland and Humber pump stations by the CRD with weir structures.

The models were then calibrated by reducing the directly connected impervious area until the predicted flow signals matched the actual flows recorded. It was assumed that all of the municipal roads were connected to the combined sewer system. In order to calibrate the model, the area of building roof tops was adjusted. This calibration resulted in the following conclusion: 30% of the roof tops in the Rutland catchment and 89% of the building roof tops in the Humber catchment are directly tied to the combined sewer system. The surprisingly low connection rate in the Rutland catchment may be attributable to the more permeable soil conditions in the area. If rain water can easily infiltrate into the ground, homeowners are less likely to connect roof leaders.

Figures 2 and 3 illustrate the calibration results comparing measured flows and predicted flows at the Rutland and Humber pump stations. The results are considered very good as the two lines are nearly identical. This indicates that the model can now accurately predict the impact of various storm events and can predict the frequency of future CSOs once a new storm sewer is constructed.

2.2 DETERMINATION OF DESIGN FLOWS

Based on the LWMP and MSR commitments outlined above, a 5-year storm was run through these models to determine the current design I&I rate. The 5-year storm pattern selected was the SCS Type 1a 24-hour storm. The resulting peak flow rates resulting from this storm are 442 L/s (520,000 L/ha/day) and 539 L/s (860,000 L/ha/day) for the Rutland and Humber catchments, respectively. In other words, assuming a new storm sewer is not constructed, the Humber and Rutland Pump and all of the downstream East Coast Interceptor would need to be upgraded to accommodate these flows. Hydrographs showing the results over 24-hours along with the allowable I&I rates are illustrated on Figure 4. The allowable I&I rates were calculated based on the existing pumping capacities of the Humber and Rutland pump stations (i.e. 90 L/s minus the peak sanitary flow). Since the allowable I and I rate is significantly below the design 5 year peak flows, combined sewer overflows from storms much smaller than the 5-year event will occur.

2.3 CALCULATION OF REQUIRED LENGTHS FOR NEW STORM SEWER CONSTRUCTION

The calculated storm sewer lengths required to meet the LWMP and MSR criteria are 5,630 m and 5,150 m for the Rutland and Humber catchments respectively. The total length of storm drains[4] to service the entire Rutland and Humber catchments are 7000 m and 6500 m, respectively. The construction of all these mains will not reduce the I&I to the required level unless separate stormwater connections for the houses currently on combined services are also undertaken. This is appropriate considering Oak Bay has a municipal policy requiring the separation of storm and sanitary service laterals for all new and reconstructed homes in the Uplands subdivision. It should also be noted that as pipes deteriorate over time it is likely that even more pipe will need to be replaced to achieve the targets in the LWMP and MSR.

In order to estimate the rate that homes will be connected to the new storm drain, some assumptions must be made. These assumptions are as follows:

- On average 100 m of storm drain will be installed per year in each catchment. This is based on spending $100,000 per year in each catchment at a cost of $1,000 per metre of main line storm drain including 150 mm service laterals to just outside of the roadways, connection of the existing catch basins and asphalt resurfacing of the entire road width (2006 construction dollars). The budget amount of $100,000 per catchment was provided by Oak Bay staff.
- In 50 years, all houses, next to a storm main, in the Uplands area will have separate storm and sanitary service connections as a result of house reconstruction or new construction.

The CRD have promoted much lower flows for injection into the ECI and these are not achievable with a new storm drain system even if the entire catchment is separated. The existing sewer system will allow too much I & I to enter the system without significant replacement or trenchless repair methods that would likely include work on both municipal and private property.

2.4 STORMWATER QUALITY

A separated sewer system will also result in flows to the outfalls which currently do not occur. Stormwater will be discharged to the ocean more frequently. We have discussed this matter with the Department of Fisheries and Oceans (DFO), the Ministry of Environment (MoE) and the CRD's Environmental Services division. In discussions with the DFO it is our understanding that a permit from them will not be required because the existing outfalls can be used for the stormwater discharge. The MoE has a policy to prevent deleterious substances from being discharged. In discussions with the MoE, it is our understanding that because the catchments do not involve industrial activities, the MoE would not get involved in this project. Rather, the MoE would leave it up to the local or regional government to establish policies to prevent discharges of deleterious substances. In discussions with the CRD Environmental Services division, it is our understanding that the CRD has focused on source controls to prevent stormwater pollution. In reviewing the CRD's Code of Practice for Streets and Roads, catch basins alone will provide an adequate level of stormwater treatment. Furthermore, the CRD stated that there are only a few instances where stormwater treatment units have been added to an

[4] Uplands Subdivision Combined Sewerage System, Compliance with Core Area Liquid Waste Management Plan and Municipal Sewage Regulation, Associated Engineering, April 2005.

existing system in the capital region and these have only been for discharges to the Inner Harbour.

In the future more stringent requirements could be adopted and at that time treatment options will be assessed. Technologies such as curbside rain gardens that treat road runoff would provide an effective removal mechanism for common road runoff pollutants.

2.5 IMPLEMENTATION SCHEDULE

Based on the construction of 100 m of new storm mains per year per catchment it would take in excess of 50 years to reach the LWMP and MSR targets. It is likely that most if not all of the existing houses, that have roof drains connected to the sewer, will have constructed separate storm water services or disconnected from the sewer by this time. Design of the storm sewers will start in 2009 with construction starting in 2010.

2.6 ADDITIONAL ISSUES

The above analysis is contingent on the connection of houses to the new storm drain. The current municipal policy requires the separation of storm and sanitary service laterals for all new and reconstructed homes. As well the Public Sewer Bylaw states that homeowners separate their storm and sewer laterals within one year of the commissioning for the new storm system.

3. SANITARY SEWER OPTIONS

The construction of a new sewer system instead of a new storm drain system was not previously considered because the system would need to be constructed in a matter of a few years versus the more that 50 years calculated for a new storm drain system. This is because the existing system would continue to be a combined system injecting into the ECI until the very last house connection is switched over to separated services. Any system that contained sewage would need to go into the ECI and could not be discharged into the waters of Oak Bay. The combined system would be connected to the storm system and therefore overflows would continue at the current rate and no environmental benefit would accrue until the entire system was functional. This approach brings with it a need to find large levels of funding.

There are however compelling reasons to investigate a new sanitary sewer system as there are potentially large capital and maintenance savings available when compared to a new storm drain system. These savings can be realized both as capital cost savings to build the system as well as a reduction in the charges that CRD is planning to levy on all users of the planned treatment plants.

Three alternatives to a new storm drain system have been considered in this report as follows:

1. Traditional gravity system
2. Centralized vacuum system
3. low pressure system (LPS)

An estimate of the capital costs to the municipality and to the homeowners for each alternative and for the previously proposed gravity system is included in this report. The benefits and detriments of each are also outlined on this table. The following discussion describes the operation of each system.

3.1 TRADITIONAL GRAVITY SYSTEM

This system is a network of 200 mm diameter municipal mains running parallel to the existing combined system. The depths of these sewers vary but are typically 1 to 3 meters deep and require 1.5 to 2.0 m wide trenches, and 1.2 m diameter manholes. Each house would need to disconnect their sewer system from their combined service and run a new 100 mm service from the lowest fixture or pipe (often in the basement) to the municipal right of way. There would be no mechanical parts to this system except for the existing Humber and Rutland pump stations.

3.2 CENTRALIZED VACUUM SYSTEM

A vacuum sewer system consists of three major components: the services, the collection piping and the vacuum station. The system uses the differential pressure between atmospheric pressure and a partial vacuum maintained in the sewer network by the rotary vane vacuum pumps at the vacuum station. This differential pressure allows a central vacuum station to collect the wastewater from individual homes, depending on terrain and the local situation. Vacuum sewers take advantage of available natural slope in the terrain and are most economical in flat sandy soils with high ground water.

The system requires normally-closed vacuum/gravity interface valves that are installed inside the collection chambers. Any sewage flows by means of gravity into each house's collection sump. After a certain fill level inside this sump is reached, the interface valve will open. The impulse to open the valve is usually transferred by a pneumatically (pneumatic pressure created by fill level) controlled controller unit. No electricity is needed to open or close the valve. While the valve is open, the resulting differential pressure between atmosphere and vacuum becomes the driving force and transports the wastewater towards the vacuum station. Beside these collection chambers, no other manholes, neither for changes in direction, nor for inspection or connection of branch lines, are necessary. High flow rates keep the system free of any blockages or sedimentation. The sumps are located in the municipal right of way and it is most economical to have two houses share one sump. The municipality maintains the sumps and valves and the homeowner has a service line identical to that in a traditional gravity system.

In order to ensure reliable transport, the vacuum sewer line is laid in a saw-tooth (length-) profile. The whole vacuum sewers are filled with air at a pressure of -0.4 to -0.6 bar. The most important aspect for a reliable operation is the air-to-liquid ratio. When a system is well designed, the sewers contain only very small amounts of sewage.

Depending on system size, communities using vacuum sewers may employ a full or part-time operation and maintenance employee or staff. The pumps at the pumping station need to be checked and gauge readings need to be taken daily. Vacuum systems also require a working emergency generator at the pumping station, which also should be checked periodically. Division valves that connect different parts of the sewer lines need to be checked at least twice a year, and the pneumatic vacuum valves at each connection should be checked annually. According to manufacturer recommendations, the vacuum valves and parts of the valve pit may need to be rebuilt or replaced every five to 10 years.

3.3 LOW PRESSURE SYSTEM (LPS)

A low pressure system uses small diameter forcemains installed relatively shallow and following the ground surface profile. Sewage from individual dwellings is discharged to the pressure sewer forcemain with grinder pumps installed in the low pressure pumping stations for individual homes. A check valve on the service line prevents backflow and a redundant check valve is included at the pumping unit. Isolating valves and cleanouts are required throughout the sewer system to facilitate maintenance. Air release valves are required at high points in the system.

Because the system is pressurized both the depths of the municipal lines and the individual homeowner services are minimized saving excavation and backfill costs and minimizing disruption. Unlike the gravity storm drain or gravity sewer systems all of the municipal lines would be located in the roadway and not in narrow rear lot easements. There is also the option to install services through trenchless methods and this along with avoiding the narrow easements would significantly reduce the impact on homeowners' gardens.

Individual pump stations are buried in the ground with fiberglass covers that are roughly 1.0 m in diameter. A 220 volt circuit is typically run from the homes electrical panel on a 30 amp breaker such that any electrical breaks are contained in the exterior pump station panel. The costs to run the pump are estimated at around $0.30/day. During a power outage the system does not function but the typical storage times are estimated at 8 hours and the pump station may be purchased with a larger wet well that extends this storage time. The likely cost to install a pump, electrical hookup, and forcemain to the property line is $7,000. Trenchless forcemains would increase this cost and a larger wet well that would extend the storage time in the event of a blackout would be another $500.

It is likely that the available pressure in the system could inject directly to the ECI and that the Rutland and Humber Pump Stations could be decommissioned with the use of this system thereby saving maintenance costs to the municipality.

4. CRD TREATMENT PLANTS

The current estimated costs for the CRD wastewater treatment plants is $1.2 Billion and the CRD has indicated that these will be apportioned by municipality based on their annual average flow rates. The high presence of inflow and infiltration (I&I) in the older municipalities increases their share dramatically. The combined system for Uplands has an even more dramatic effect on this share. The annual flow currently injected into the ECI at the Rutland and Humber pump stations represents an $8.9 million share of the overall costs. Of this $5.1 million is I and I. Since the Federal and Provincial governments are planning to each fund 1/3 of the treatment plants the extra costs to Oak Bay for this 'extra' water is expected to be $1.7million. Further to this the extra running and maintenance costs apportioned to the excess flow has been calculated at a NPV of $2.5M. This means that Oak Bay could pay a premium of $1.7 + $2.5 = $4.2 million for the sewage treatment plants. The Federal and Provincial governments would pay an extra $1.7 million each on top of this.

5. COMPARISONS

The originally proposed new storm drain system is compared with the three new sanitary sewer options in the attached table. Capital costs to build the systems, the portion to be paid by the District, the CRD treatment plant costs, the overall cost to Oak Bay, and the Homeowner costs are compared along with a list of advantages and disadvantages for each.

6. RECOMMENDATIONS AND CLOSING REMARKS

The decision on which alternative to pursue will require that the following questions be answered by the District:

1. Does a 50 + year construction schedule for a storm drain system comply with the LWMP and the MSR?
2. Will a partially combined system (as proposed in the storm drain system) be acceptable to the Province?
3. Are the high flow rates acceptable to the CRD/Province/ECI?

6.1 NEW STORM DRAIN SYSTEM

If these answers lead the District to follow a Storm Drain alternative then the following is recommended:

- 5,600 metres of new storm drain system be installed in the Rutland catchment to remove approximately 80% of the existing roadways from the existing combined sewer system.
- 5,150 metres of new storm drain system be installed in the Humber catchment to remove approximately 79% of the existing roadways from the existing combined sewer system.
- The storm drain systems should be designed at sufficient depth and with sufficient capacity so that the new storm drain service laterals can be connected.
- All new building permits to include the provision that roof, area drains, and foundation drains be disconnected from the sewer connection.

The estimated total cost of this project based on 2006 levels is approximately $10,750,000. Our comparative analysis estimated a higher number than this but is a class D estimate and is accurate for comparison purposes. Based on a total funding level of $200,000 per year, it is estimated that it will take in excess of 54 years to construct the new storm sewer system.

The lengths of storm drains presented above will eliminate overflows at the Humber and Rutland Pump Stations during the 5-year storm event for 1 pump in operation at each station. However, there will still be significant portions of each catchment that does not have a storm drain system. As a result the I&I rates will not be reduced to the levels as indicated in the Assessment of ECI Pressure Siphon Capacity and Arbutus Peak Flow Storage Tank study, which assumed for a completely separated system.

6.2 NEW SEWER SYSTEM

The comparison of all three alternatives clearly shows that the Low Pressure (LPS) system is the most economical overall. All of the sewer options will need to be fully operational before any environmental benefits are realized and this will likely require that they are built within a short time frame of a few years. The overall costs to the municipality for the LPS system is expected to be 1/2 of what a new storm drain system would be. Disruption to public and private property will be minimized and it is likely that the Rutland and Humber pump stations could be decommissioned. The cost savings to Oak Bay have not been added to this report for this decommissioning.

The following steps are recommended to pursue this option further:

- Funding sources be identified to fund a LPS system. The cost savings to the District are significant (the project would cost roughly ½ of the storm drain system). The project will also stop the overflow of sewage into the waters of Oak Bay and as such may meet the provincial water quality objectives for funding.
- A detailed preliminary design be undertaken to properly estimate the costs of the LPS system in order to properly budget for funding.

We trust this submission meets your requirements for this project. However, if further information or clarification is required please contact the undersigned.

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RW/rw

STATEMENT OF LIMITATIONS

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