MEMORANDUM

Date:	August 3, 2012
To:	Jenni Chancey, District of Squamish
Cc:	Peter Gigliotti; Catherine Simpson, Urban Systems Ltd.
From:	Ehren Lee; Urban Systems Ltd.
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Subject:	Technical Memo #4 – Urban Runoff

This technical memo describes urban runoff issues and priorities as it relates to the District of Squamish's Liquid Waste Management Plan (LWMP). Three local information sources were consulted to create this document:

I. 2008 Official Community Plan
II. Public Works Asset Management Plan (2011)
III. Interviews with District of Squamish Operations Team

The aim of this document is to summarize issues and priorities for urban runoff through review and evaluation of existing information.

Incorporating urban runoff issues into LWMP's is not new. Over the last decade, local governments in BC have experienced strong encouragement from the Ministry of Environment to elevate storm water quality and urban runoff management. As such, liquid waste management plans have become a priority mechanism to address urban runoff and stormwater quality issues. Taking this one step further, a key outcome for this memorandum is to view the pollutant loading effects of urban runoff and connect these issues back to a LWMP.

Sections of the memorandum will be further discussed during Stage 1 committee meetings scheduled for summer 2012.

1. Storm Water System Overview

The storm water system is made up of 31km of storm water mains, multiple lift stations for major rainfall events, 420 catchbasins, and 72km of drainage ditches. These are rough figures only because it is estimated that less than half of the drainage infrastructure has been properly inventoried and mapped. Creating the inventory for all stormwater assets is required to develop a baseline for infrastructure planning. Any strategies arising from the LWMP should be supported by a complete drainage inventory.

There are 5 primary rivers in the District of Squamish: Cheakamus, Cheekeye, Squamish, Mamquam, and Stawamus. The dyking and flood protection infrastructure associated with these rivers also make up a large portion of the District's stormwater assets. In the last 5 years, investments into drainage infrastructure have centered on the major flood protection system.

Fishery Resources: Although documentation is limited, it is widely known in the District that fish habitat and fishery resources exist in abundance throughout Squamish. A strong community desire to preserve and enhance these resources is consistent with local environmental values.

Area Overview: To allow for comparisons throughout the LWMP, the District of Squamish was divided into four storm water quality regions. The areas are illustrated on Figure 1, the first enclosed figure. These areas were selected to help characterize the water quality impacts from developed and undeveloped lands over the planning horizon (20 year).

1.1 Scope of Influence

While there is much overlap between storm water quality and quantity (flows), it is important to establish a lens for liquid waste management that centers on urban runoff. An effective LWMP will elevate the profile of urban runoff and the pollutant loading that arises from storm water flows. This will be the first priority, while the secondary priority is to provide ideas for integrating urban runoff with drainage planning and hydrological processes.

This strategic direction lends itself to the Integrated Stormwater Management Plan framework in that the health of the receiving water bodies remains paramount.

2. URBAN RUNOFF BACKGROUND

2.1 Storm Water Quality

Source control and managing pollution where it originates is at the core of liquid waste management planning. This section describes the sources of pollutants in urban runoff so that problem solving can be focused on actual sites and specific parameters.

The number of potential organic and inorganic substances found in stormwater runoff may be surprising to many. In essence, just about anything that finds its way onto urban surfaces — particularly impervious surfaces such as roads, parking lots, and buildings — can be washed off those surfaces by rain and snowmelt. This is called “non-point source” (NPS) pollution because the sources tend to be highly dispersed across the landscape. In some cases, NPS pollution is washed directly into watercourses, such as any one of the 5 major rivers, or anywhere within the 72 km of ditching in the District.

Table 1 provides a list of some major NPS pollutant sources and the pollutants they commonly generate. While many of these pollutants can be acutely toxic at higher concentrations, stormwater runoff is not typically considered toxic. Rather, the accumulated effect of pollutant wash off into watercourses over time can yield unacceptable chronic toxicity or bioaccumulation in aquatic life. In the absence of contrary evidence, it should be assumed that many, if not all, the pollutants listed are present in Squamish’s runoff.

Poorly managed runoff can contaminate groundwater aquifers. Salt management programs are used to limit chloride contamination of groundwater from stormwater runoff. In addition, locations where untreated runoff can infiltrate into the aquifers without benefit of contact with organic soils can carry dissolved pollutants such as phosphorus, trace metals, and pesticides into those aquifers.

Many pollutants found in stormwater runoff are to some degree hydrophobic; in other words, they are associated with sediments that can, in turn, be settled or filtered. This suggests that, once entrained in runoff, a primary treatment strategy can focus on removing total suspended solids (TSS). That said, it is preferable to keep pollutants out of runoff in the first place, through source controls, street cleaning, and other best management practices (BMPs).

Table 1: Typical Non-Point Source Urban Pollutants and Their Sources

Source	Major Pollutants
Atmospheric deposition	From urban and rural areas. Fine particles, phosphorus, ammonia, nitrate, metals, pesticides, petroleum products, and toxic organics
Litter and leaf fall	Residential and commercial debris such as plastics, paper, cans and food discarded to roadway and parking lots. Biochemical oxygen demand (total BOD_5), nitrogen, phosphorus, humic organics, and metals.
Residential and roadside landscape maintenance	Bacteria, phosphorus and nitrogen, pesticides and herbicides, and dissolved organics from soil amendments.
Transportation vehicles	Fuels, brake drum and tire wear, body rust. Fine particles, metals in particular, zinc, copper, cadmium, lead, and chromium, and petroleum products such as oil and grease and poly-aromatic hydrocarbons (PAH).
Pavement and pavement maintenance	Temperature modification, petroleum derivatives from asphalt, materials from abraded or degraded pavement.
Pavement deicing	Chlorides, sulfates, organics from acetate deicers, coarse sediments, and cyanide.
Building exteriors	Galvanized metals, chipped and eroded paints, corrosion of surfaces accelerated by acid rain, metals, and roofing grit.
Commercial businesses	Parked vehicles; improperly disposed refuse such as discarded food, used cooking oil and grease, and packaging materials; internal drains improperly connected to the storm system; metals, total BOD_5, bacteria, phosphorus, nitrogen, oil, and grease.
Residential activities	Landscaping, pest control, moss control, vehicle maintenance, painting, wood preservation, pesticides and herbicides, phosphorus, nitrogen, petroleum products, zinc, and bacteria.
Site development	High pH from fresh concrete surfaces, petroleum products from fresh asphalt and spills, organics and particles from landscaping materials, eroded sediment and associated constituents such as phosphorus, pollutants associated with improperly disposed construction materials (e.g., fresh concrete and paints), and cement from preparation of exposed aggregate concrete.
Public infrastructure	Metals from galvanized stormwater drain systems, metals and petroleum products from maintenance shops, and bacteria, nitrogen, phosphorus, and organics from exfiltrating or overflowing sanitary sewers.

Source: Table 2.3, in G. Minton, *Stormwater Treatment: Biological, Chemical and Engineering Principles, Second Edition*, 2005

To assess the pollutant loads associated with stormwater runoff in Squamish, a screening-level tool developed by the Center for Watershed Protection was used. The tool[1], or method, requires minimal input, all of which was readily available for this Stage 1 preliminary assessment:

- Drainage catchment areas
- Impervious cover
- Annual average rainfall
- Pollutant concentrations.

Squamish was divided into four storm water quality areas. Impervious cover was assumed for each of the following basic land-use categories:

- Single Family Residential
- Multi Family Residential
- Industrial
- Commercial
- Institutional
- Open Space (park)
- Unclassified (areas within the DOS with no Zoning or OCP designation)

If areas were already classified into these categories in the Zoning and OCP, then their designations were carried forward. If they did not match one of these categories, they were reclassified to the most appropriate designation in the list above.

For this analysis, impervious coverages were assumed based on the conventional rational method C-values, except that Open Space was assigned a much lower percentage (five per cent, because the classification relates to predominantly green, undeveloped spaces in environmental areas). Pollutant concentrations are median Event Mean Concentrations (EMCs), based on data collated by researchers in the U.S. and found to be quite typical across the continent[2]. The method was applied to existing conditions (e.g., current zoning) and the OCP land uses to assess 'current' and 'future' conditions. Without stormwater management efforts, as the city continues to develop, pollutant loadings can only increase. The estimated *annual* loads generated for several typical NPS pollutants are:

- Total Suspended Solids – 2,625,000 kg
- Chemical Oxygen Demand – 2,994,000 kg
- Total Nitrogen – 55,809 kg
- Faecal Coliforms – 3,740 x 10^{12} colonies
- Total Lead – 765 kg.

Presenting urban runoff pollutants in total loadings (kg) for the entire community demonstrates the significance of it for liquid waste management planning.

[1] Schueller, Tom, *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's*, for Metropolitan Council of Governments, Washington, D.C., 1987

[2] Pitt, R.E., A. Maestre and R. Morquecho, "The National Stormwater Quality Database (NSQD, version 1.1)," 2004; the EMCs developed in this database update the values provided in the Center for Watershed Protection's original method, which were based on work done in the 1970's.

Further, presenting the total mass loadings by catchment helps to identify key areas of concern for urban runoff. Table 2 lists the mass loadings per NPS pollutant by catchment.

	TSS (kg)	% of Total	COD (kg)	% of Total	Nitrogen (kg)	% of Total	Fecal Coliform (colonies x 10^{12})		Lead	% of Total
Catchment 1 *Area: 3,135 ha*	498,571	19%	533,768	18%	12,138	22%	740	20%	131	17%
Catchment 2 *Area: 3,328 ha*	668,333	25%	702,932	23%	12,138	22%	1,072	29%	161	21%
Catchment 3 *Area: 4,210 ha*	1,207,581	46%	1,472,291	49%	26,317	47%	1,610	43%	394	52%
Catchment 4 *Area: 1,489 ha*	250,719	10%	284,849	10%	5,216	9%	319	9%	78	10%
Total	2,625,203	100%	2,993,840	100%	55,809	100%	3,740	100%	765	100%

A key observation from this table is the relative contributions from Catchment 3. This is a result of high commercial and industrial areas.

The impact of pollutant loadings in urban runoff can also be shown in kg/ha, or, the *rate* of runoff depending on the land use. Employing a rate-based approach to urban runoff pollution provides multiple benefits:

- Focusing programs toward specific sites for greater effect, thereby realizing a better return on investments
- Informing land use decisions by assessing the changes to pollutant concentrations pre- and post-development
- Creating metrics for pollutant reductions

Table 4 lists the pollutant loading rates for several typical NPS pollutants.

Land Use Code	TSS (kg/ha)	COD (kg/ha)	Nitrogen (kg/ha)	Fecal Coliform (colonies x 10^{12})	Lead (kg/ha)
Single family Residential	1,541	1,730	28.93	2.64	0.38
Multi-Family Residential	1,151	1,291	21.60	1.97	0.28
Industrial	2,949	4,214	77.25	3.03	1.26
Commercial	13,216	2,811	51.54	2.02	0.84
Institutional	1,626	1,825	30.52	2.78	0.40
Open Space (Parks)	397	345	6.30	0.59	0.08
Unclassified	397	345	6.30	0.59	0.08

A key observation from this information is the relative pollutant loading that comes from commercial and industrial land uses. Therefore, increasing the total area of commercial and industrial land uses will also increase the rate and total loadings of these NPS pollutants in local waterways.[3]

This need not deter communities from promoting densification and economic development however it does serve to elevate the importance of urban runoff management in core areas.

Using Preliminary Analysis to Guide Future Work

This analysis should be considered preliminary and provisional, indicative of potential NPS runoff pollution generated within the city, but certainly not definitive. In general, the analysis provides reasonable estimates of pollutant export from urban development activities, though several caveats apply. The method does not account for specific local soil conditions, ice management activities (e.g., sand application), street sweeping and other pollutant removal or capture activities, nor runoff from ice melt. Further, it does not account for physical, chemical, or biological changes that may occur to pollutants over time, both prior to wash off and within a stream or lake environment. More sophisticated modeling will be needed to analyze the complex conditions within the city as the detailed basis for developing a non-point source pollution management plan.

At this time, no estimate has been made of the pollutants contributed by upper watershed areas outside the District. The open space category used in this analysis is not suitable for rural or non-urban areas. It is expected that a significant amount of sediment is washed from the upper watershed, likely in amounts exceeding that generated within the city. On the other hand, in the absence of knowledge of specific pollutant-generating activities outside the city, it is prudent to assume that the presence of trace metals, bacteria, exotic chemicals, and other pollutants in stormwater runoff equals or exceeds that of the uplands.

Growth and Future Capacity

Of the additional 17,000 people expected in the next 20 years, approximately 75% of the growth will be located in South Squamish, or largely within Catchment 3. Table 3 outlines the projected changes in land use from current to existing based on the OCP buildout.

[3] Also, communities tend to compare NPS loadings to other watersheds to compare their order of impact with other communities. However for Squamish, the amount of growth projected over the next 20 years is significant enough to compare two slightly different communities. Comparing Squamish 2012 and Squamish 2032 will be beneficial to the LWMP.

Land Use Change	Change in Land Use %
Single family Residential	-33%
Multi-Family Residential	-10%
Industrial	-20%
Commercial	67%
Institutional	27%
Open Space (Parks)	-2%
Unclassified	204%

Generally, the output of the land use plan in the OCP will increase the amount of commercial and institutional spaces where as residential development area decreases. Initially, the reduction in residential land use would be misleading given the population increase that is expected. However, residential growth will likely occur via infill and more intensive residential developments, thereby reducing sprawl. From an urban runoff perspective, the level of impervious surface is going to increase (significantly in some core areas) and the pollutant loadings per hectare will increase accordingly.

Lastly, construction activities increase mass loadings for key parameters and pollutant rates per hectare. Therefore, it is both the type of land use and the activities required to develop the land that both contribute to issues of urban runoff and water pollution.

3. Storm Water Investments

District expenditures over the last 5 years for storm water primarily relate to dyking and drainage maintenance to maintain flood protection systems. The importance of these systems cannot be overstated. However, the investment trend appears to underfund water quality improvements.

Based on the District's financial projections, annual spending on storm water ranges from $387,000/year to $484,000/year from 2009 to 2015. The amount of spending on renewal (replacement due to condition deterioration) for drainage infrastructure is not specifically known. Updating the drainage inventory (including GIS mapping) for asset renewal programs and for completing stormwater master plans will be critical the success of implementing the LWMP (because drainage and stormwater quality are tied).

Further, viewing storm water and urban runoff as liquid wastes that require pollution management will require a shift in investments in order to reduce the impacts of NPS pollutants on local rivers and creeks. For example, it is expected that dyking and drainage investments will depend on the reliability and depreciation of flood infrastructure, whereas the investments in urban runoff and pollution control will be based on goals for protecting stream health.

Lastly, stormwater utilities are gaining popularity in BC following years of relative success in the United States. The opportunity to pay for urban runoff and stormwater quality projects from user fees has many benefits. These ideas can be explored later in the project.

4. PRELIMINARY PRIORITIES

Looking forward to creating an urban runoff management strategy, several key issues stand out:

4.1 Issue Definitions

a) Fish and fishery resources are prevalent all throughout the District in various rivers and streams. The sensitivity of habitat and biological conditions is not known. It will be important to determine specific locations of fish habitat sensitivity so the LWMP can develop goals for pollutant reductions to enhance ecological systems.

b) The scope of growth will increase the total mass (kg) and the rate (kg/ha) of NPS pollutants being discharged into local waterways. Development and construction will increase the NPS pollutant loadings and these practices will require varying techniques to reduce the impacts.

c) Industrial and commercial land uses contribute significant NPS pollutant loadings for existing and future conditions.

d) Percentages of impervious surface will increase significantly in core areas resulting in higher storm water flow rates.

e) Storm water investments do not address water quality issues therefore revenues (e.g. rates and taxes) may not be well aligned to fund urban runoff improvements.

f) Baseline information for drainage infrastructure, riparian issues, wetlands, stream health and ecosystems must be improved to allow for cost-effective strategies that can be implemented and monitored.

g) Education programs will improve NPS source controls for all properties including residences.

Each of these issues will be explored in further detail throughout the LWMP.

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