Ripple Effect: Planning a Regenerative Hub for the Southeast False Creek Flats

Angles on Green Buildings
The Learning City Institute, December 2005

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TABLE OF CONTENTS

INTRODUCTION

Research Design Team

The *Ripple Effect* proposal is a joint research project completed for the Angles on Green Buildings course held during the Fall 2005 at The Learning City Institute, Great Northern Way Campus. Research contributions for this proposal include a collaboration of expertise in industrial design, urban planning, and chemical and civil engineering from the following team members:

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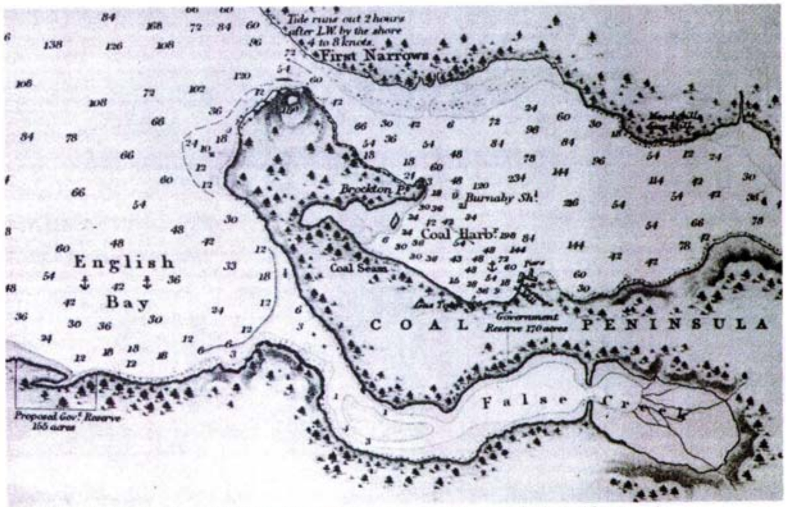
Mandate

Ripple Effect: planning a regenerative hub for the Southeast False Creek Flats, originated from a research project envisioned by Bryn Davidson, Principal/ Designer, Rao-D Cityworks Architecture and Planning. The purpose of this project is to explore Eco-Urban Infrastructure for the Great Northern Way Lands with the following research objectives:

- identify key stakeholders & interests
- establish integrated design framework
- justify focus area
- identify constraints
- illustrate trade-offs of Centralized vs. Decentralized infrastructures
- present development concept & components
- provide cost-benefits analysis & market research
- explain risk management and maintenance
- recommend further research topics

CONTEXT



Reproduction of original survey conducted by Captain George H. Richards, on the HMS Plumper in which False Creek first appeared. Originally published in 1860. (Burkinshaw, 1984, p.5)

figure 1

False Creek Flats Historic Landscape

The Great Northern Way Campus (GNWC) is located within the Southeast False Creek Flats. Historically, the area existed as tidal mudflats and housed an active marine and fresh water ecosystem, abundant creeks and wildlife such as salmon, sturgeon, perch, waterfowl, deer and elk on which the local Coast Salish people subsisted (Burkinshaw, 1984, pp. 4-7). Prominent tributaries, including Brewery, China and Still creeks, drained into the Flats basin to feed False Creek.

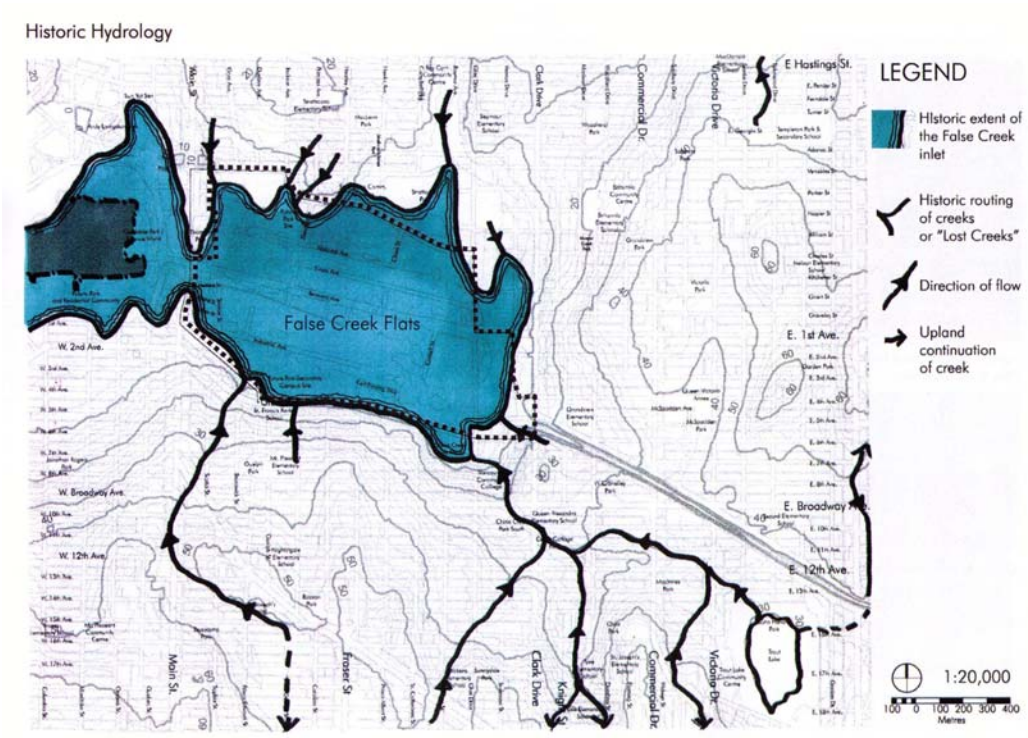


figure 2

During the early 1900's Brewery Creek supplied fresh water to a growing industry in Burrard Inlet and essentially catalyzed the development of the south shore of False Creek (Burkinshaw, 1984, 20). As pressures increased for more developable land, major creeks were diverted underground and significant filling 'reclaimed' the Flats for industrial and rail use. The overland flow changed dramatically with the introduction of an extensive network of storm and combined sewers (Russell, 2004, 34) which continue to transport storm and waste water through the Flats and into False Creek beneath Science World. In essence, the Flats were transformed from "a natural wildlife ecosystem with healthy thriving streams, industrial area" (Russell, 2004, 7).

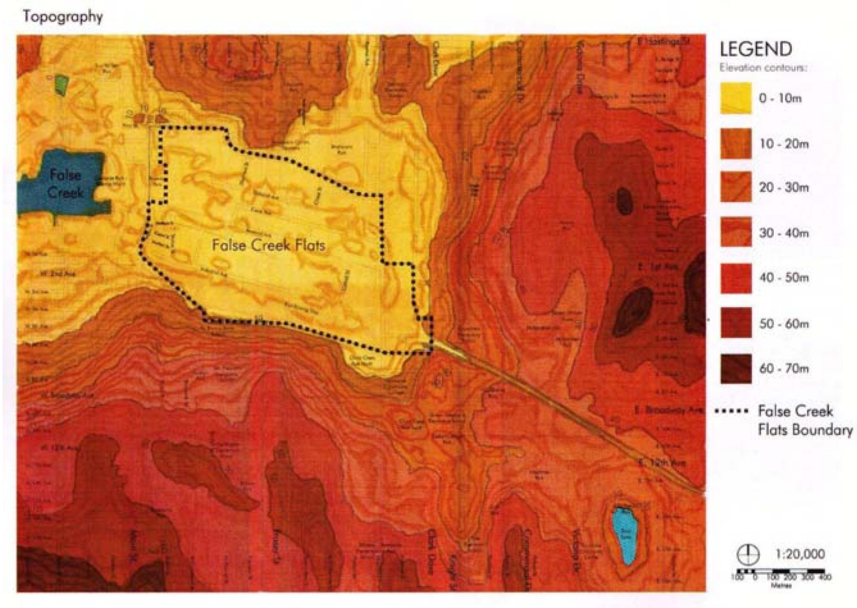


figure 3

The exact soil composition of the Flats is unknown without an extensive survey. In general, the soils consist of tidal flats and fill material from the Grandview Cut and Mt. Pleasant re-grading (Burkinshaw, 1984, p.33). This combination of densely compacted soils and organic material typically exhibits poor drainage characteristics and low infiltration rates (Marsh, 1998, 414).

Despite significant hydrologic change the Flats remain in a valley surrounded by ridges. Significant elevation gains from the Flats offer relatively unobstructed and world class views, to the upland areas, of the North Shore Mountains, Downtown Vancouver and False Creek.

The Flats Today

figure 4

Today, the GNWC is strategically located within the Southeast False Creek Energy Precinct, an area envisioned to become a hub of sustainable development showcasing community scale energy conservation alternatives, green building and smart growth (City of Vancouver, "Proposed Energy Precinct, 2005). Within the Flats, it also serves as a 'gateway' to downtown Vancouver and is highly visible from the Skytrain to tourists and passersby. The site is surrounded by active light industry, rail, commercial, live-work studios, apartments, offices, and educational facilities such as the Vancouver Community College. Proximity to these land uses makes the GNWC an ideal location for creating synergies with adjacent neighborhoods including Mount Pleasant, Southeast False Creek, Grandview Woodlands, Strathcona/City Gate and the Downtown Eastside.

Great Northern Way Campus

The existing buildings on campus are currently used for teaching and research activities by four partnering institutions, and co-owners, UBC, SFU, BCIT and ECI, as well as a few commercial tenants. These activities finance the operating costs of the campus in advance of GNWC establishing its own academic program, anticipated to serve 4,000 full-time students by 2020 (Clayman, 2005).

Photo credit: Bruce P. Clayman

figure 5

The site is zoned CD-1 (402), By-law No. 8131, and permits a mix of uses such as light industry, institutional, live-work (250 units maximum), recreational/cultural, service and office use. A large portion of the 7.6 hectare site was donated by Finning International in 2001 after many years of heavy industrial use both above and below ground. It is important to note, however, that no underground storage tanks were sited on the westernmost portion of the site (our study area).

Other than the existing tenants and students using the GNWC, there is little attraction for the general public. A lack of amenities and the steep grades leading down into the site render the campus inviting and disconnected from the surrounding neighborhood. There is incredible potential to re-integrate this campus into the community with a unique identity as a place of learning and interaction, however, until this happens the site remains largely underutilized.

STAKEHOLDER INTERESTS

In addition to the GNWC Board of Directors there are several interest groups to consider and involve in the re-development of the GNWC including:

Institutional tenants

- British Columbia Institute of Technology
- University of British Columbia
- Simon Fraser University
- Emily Carr Institute
- proposed Centre for Interactive Research and Sustainability (CIRS)

Regional and Municipal Planning Groups

- GVRD
- Translink
- City of Vancouver
-

Adjacent Land Owners

- Burlington Northern South Fraser (BNSF)
- Canadian National Railway (CN)
-

Non-Profit organizations

- Better Environmentally Sound Transportation (BEST)
- Business Improvements Associations and other community groups within Mount Pleasant, South East False Creek, Grandview Woodlands, Strathcona/City Gate, Downtown Eastside
- Rao-D Cityworks Architecture & Planning

A literature review and consultation with representatives from many of these interest groups has revealed divergent agendas and priorities that will greatly impact the re-development potential of GNWC. The possibility of a new Rapid Transit line and station and additional North-South connections between Great Northern Way and Industrial Road would shape the future development pattern and potential building envelopes.

For this reason, we recommend that the GNWC Board establish strategic alliances to implement a comprehensive plan that achieves the highest and best use of the site and offers environmental, social and economic benefits to the greater community and region. Extensive public consultation has been conducted by the City throughout the planning process for the False Creek Flats. Common themes arising from this consultation include:

Environmental

- remediate contaminated sites
- improve water quality
- improve air quality
- mitigate storm water overflow/flooding
- reduce noise pollution
- implement regenerative and LEED building practices

Social

- enhance community identity and conviviality
- increase opportunities for public amenities (cultural and recreational)
- create green ways for pedestrian/cycling connections
- promote trans-disciplinary education on sustainability
- utilize an integrated design planning process
- develop a long term planning horizon
- improve safety and traffic calming
- develop a mobility node as a gateway to the City

Economic

- generate revenue
- increase property values
- protect view corridors
- maintain and strengthen local industries
- encourage local employment
- increase opportunities for tourism
- preserve a vibrant rail economy
-

Source: Adapted from the City of Vancouver's, "False Creek Flats Planning: Community Group Meetings - Summary Report," June 2005. Retrieved from web site (December 2005) http://vancouver.ca/commsvcs/currentplanning/fcflats/pdf/public/cgm_appb.pdf

OBJECTIVES OF AN INTEGRATED SYSTEM

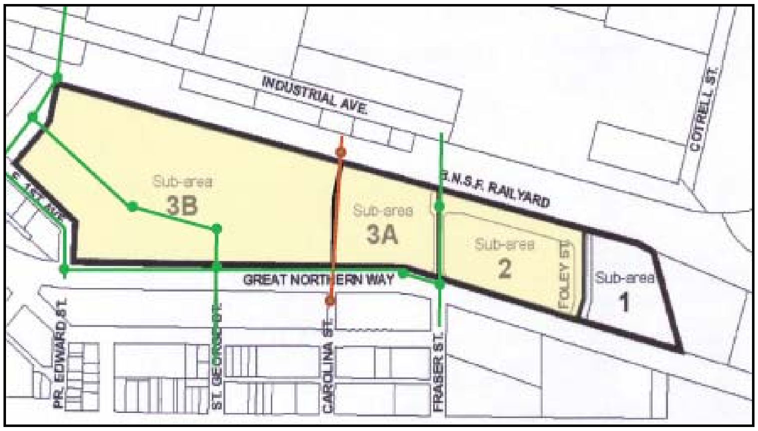
The following *Cradle to Cradle* objectives for regenerative design provided the framework to design and evaluate the *Ripple Effect* concept based on a triple bottom line that optimizes the environmental, social and economic benefits:

1. waste = food
2. increase biodiversity
3. share health and wealth
4. use current solar income

These objectives are discussed in detail in the Centralized vs. Decentralized Infrastructures section.

FOCUS AREA AND RATIONALE

The focus of our study includes the western portion of the GNWC identified as Sub-Area 3-B in the CD-1 (402) Zoning By-law No. 8131 (Figure 6). The zoning permits are variety of uses in this area including a maximum of 250 live-work studios.



Source: Adapted from City of Vancouver Zoning & Development By-law No. 8131, CD-1 (402) figure 6

For this reason, we chose this area of vacant land working around existing buildings in operation to propose a mixed-use development that will generate revenue for, and anchor, the re-development of GNWC. Our rationale concurs with a recent study undertaken for the GNWC Board of Directors identifying the west end of the site as playing a key role in developing an appropriate financial model for the development and operation of the campus (Clayman, 2005).

The study area is located near historic watercourses thereby promoting the natural history of the site. It is also located in close proximity to existing storm and sanitary sewers thereby capitalizing on these infrastructures to provide convenient redundancies in the system. Furthermore, the opportunity exists to partner with Rao-D Cityworks Architecture & Planning to extend St. Georges 'creek,' envisioned from daylighting sections of St. Georges Street storm sewer, figure 2 into the GNWC in order to strengthen ties to the community and benefit from the volume of water flow (figure 7).

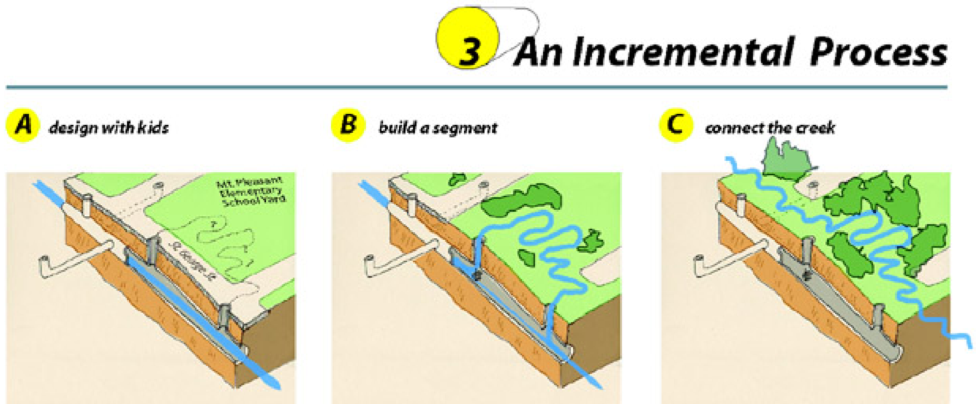


Figure 7, Source: St-Georges 'creek' project, Rao-D Cityworks Architecture & Planning

CONSTRAINTS

Some of the constraints to implementing an integrated system as we propose include:

Environmental

- fluctuating water volumes
- need for geotechnical and environmental assessments
- water quality requirements

Social / Political

- overlapping legislation for land use, storm water and wastewater use
- divergent interests among stakeholders
- lack of vision for the Flats

Economic

- physical constraints to development potential (existing roads, rail)
- cost/benefit trade-offs
- potential liabilities

These constraints will be discussed in detail throughout the remainder of this report.

CENTRALIZED VS DE-CENTRALIZED INFRASTRUCTURES

In order to compare centralized sanitary and stormwater infrastructure to decentralized sanitary and stormwater infrastructure, the previously described integrated framework is employed. Specific goals are developed and used as a basis for comparison between the use of constructed wetland and the use of a standard storm sewer connection. The goals are also used to compare the use of a solar aquatics treatment system and the use of existing sanitary sewer and water treatment facilities. Technology selection will be based on the ability to achieve the desired goals of the framework objectives. A summary of each comparison is included is included in Appendix 1.

Goals for Transforming Waste into Food

In attempting to apply the concept of transforming (regenerating) waste into food, it is important to determine what opportunities exist for producing any beneficial products from wastes, or the removal of wastes, contained in stormwater runoff and sanitary discharge.

Currently, the GVRD Sustainable Region Initiative suggests that taking steps to conserve water today will ensure that the Greater Vancouver remains a livable region in the years to come[1]. The residential sector accounts for approximately 54% of total water consumption in Vancouver[2], approximately 60% of which is consumed in indoor activities and the remaining 40% of which is used for outdoor activities[3] (including landscape irrigation). As such, a beneficial product that can be attained from the collection and treatment of stormwater and sanitary discharge is the potential to reduce water consumption relating to indoor and outdoor water use.

The Air Quality Management Plan for Greater Vancouver includes principles such as using processes in ways that minimize pollution and waste at the source in order to improve air quality[4]. In accordance with these plans, using waste and water from the stormwater and sanitary discharge to improve air quality is an additional beneficial product if the opportunity exists.

Urban runoff contains rain water mixed with nutrients such as nitrogen, phosphorous, metals such as copper, lead, and zinc, and other compounds such

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[1] "Use Water Wisely Brochure". Prepared by the GVRD. As accessed at the following website: http://www.gvrd.bc.ca/water/pdfs/UseWaterWisely.pdf

[2] Clift, S. (September 28, 2004) "Drinking Water Conservation Measures and Water Metering Initiatives for the City of Vancouver". City of Vancouver - Administrative Report. Accessed at the following website: http://www.city.vancouver.bc.ca/ctyclerk/cclerk/20041021/cs2.htm

[3] As accessed from the City of Vancouver web site as follows: http://www.city.vancouver.bc.ca/engsvcs/watersewers/water/conservation/outdoor.htm

[4] (September 2005) "Air Quality Management Plan for Greater Vancouver", as accessed at the following website: http://www.gvrd.bc.ca/air/pdfs/AQMPSeptember2005.pdf

as hydrocarbons. Sanitary discharge from households consists primarily of human waste, food scraps, oil, cleaning products, pharmaceuticals, and other chemicals. In managing these waste streams which contain so many components, the opportunity exists to use the ingredients to produce a beneficial product, instead of just re-locating the waste.

Incorporating these ideas into the objective of transforming waste into food results in the following goals:

- Transform waste from into a usable product;
- Increase potential for water to be re-circulated for indoor use;
- Increase potential for water to be used for outdoor use; and
- Increase potential to improve air quality.

Wetland vs. Storm Sewer (Waste = Food)

Constructed wetlands used for stormwater management achieve the goals associated with transforming waste into food, as follows:

- Plant life takes up carbon, nutrients and other trace elements and incorporates them into plant tissue[5];
- Microbial activity transforms organic and inorganic substances into innocuous substances[5];
- Water quality improvement capability and storage capacity facilitate water reuse and recycling[5] (i.e., toilet flushing and irrigation); and
- Plant growth through photosynthesis consumes atmospheric carbon dioxide and produces oxygen.

Historically, centralized stormwater collection and drainage systems were designed to safely and efficiently collect and dispose of stormwater runoff with little regard for impacts to the environment[6]. Storm water collection has been managed through the use of combined sanitary/stormwater sewers. As part of the GVRD's liquid waste management plan (LWMP), no new combined sewers will be constructed in the GVRD[7]. Additionally, the cities of Vancouver, Burnaby and New Westminster have implemented a combined sewer separation program, which is proceeding at a rate of approximately 1% of system

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[5] "Natural Wetlands and Urban Stormwater: Potential Impacts and Management", U.S. Environmental Protection Agency Office of Wetlands, Oceans and Watersheds. Wetland Division. Washington D.C. (February, 1993)

[6] GVRD Policy and Planning Department (October 1999) "Liquid Waste Management Plan Stage 2 – Stormwater Management Plan". Prepared for Stormwater Management Technical Advisory Task Group. http://www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/lwmp_storm_mgmtplan/vol6.pdf

[7] GVRD "Liquid Waste Management Plan" February 2001. As accessed at the following website: http://www.gvrd.bc.ca/sewerage/lwmp_feb2001/lwmp_plan_feb2001.pdf

replacement/separation per year, with expected completion in 2050[7]. Although this will reduce sewer overflow, a separate storm sewer will still not utilize or transform the stormwater or it's ingredients to usable products. As such, centralized infrastructure does not achieve the desired goals of transforming waste into food.

Solar Aquatics vs. Sanitary Sewer and Centralized Treatment (Waste = Food)

Solar aquatics are engineered technologies which replicate natural purification processes by including bacteria, algae, plants and aquatic animals in the treatment process[8]. The outputs of the solar aquatic facility include treated water and the production of plants. As the facility would be located onsite, potential for reuse of treated water is feasible. The solar aquatic facility meets all goals associated with transforming waste into food as the plants produced will also utilize carbon dioxide during photosynthesis.

In terms of centralized sanitary water treatment, the potential exists to transform waste into food through the production of methane (natural gas), which is a by product of the processing of treatment sludge. The methane is then used to produce heat and energy used in the operation of the treatment plant. Additionally, GVRD wastewater treatment plants produce approximately 70,000 tonnes of biosolids every year, which are recycled as fertilizers[9]. Although the water treatment plants transform the waste into food, some of the waste is not suitable for reuse because of industrial contaminants and must be sent to the landfill.

It does not seem practical to reuse the treated sanitary sewer water from a centralized system back at the site that it was generated due to the pumping requirements associated with the distribution, along with the additional pipe network that this would require. In this regard, the production of plants resulting from the production of fertilizer gives this option credit in improving air quality, however, as stated previously, some waste is not suitable for reuse and must be sent to the landfill.

One additional note is that it seems that it would be logistically easier to manage what goes into the sanitary system in a small community of approximately 625[10] people in a small area than it would be to try to manage a system for hundreds of thousands of people, spread out over an entire city.

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8 "Healthy Hi Rise -A Guide To Innovation in the Design and Construction of High-Rise Residential Buildings" – Prepared by the Canada Mortgage and Housing Corporation. As accessed at the following website: http://www.cmhc-schl.gc.ca/en/imquaf/himu/upload/Chapter%2D6%2DGreen%2DInfrastructure%2Epdf

9 GVRD Brochure "What Happens When I Flush". Accessed at the following website http://www.gvrd.bc.ca/sewerage/pdf/WhenIFlushBrochure.pdf

10 This number is calculated based on 250 units, with an average 2.5 people per unit

Goals for Increasing Biodiversity

Biodiversity is the variety of plants, animals and microorganisms and the terrestrial, aquatic and marine ecosystems that they are a part of[11]. As such, the goals associated with increasing biodiversity include:

- Promote plant growth
- Increase wildlife habitat for area

Wetland vs. Storm Sewer (Biodiversity)

The utilization of a constructed wetland and natural landscaping is favored over centralized storm sewer infrastructure for management of stormwater as wetlands by their very nature; provide food, cover, shelter and breeding habitat for a wide diversity of plants and animals[12]. A centralized storm sewer transports the water from one location to another. The water is either treated in a wastewater treatment plant in combined sewer applications prior to ocean discharge, or else is discharged directly into the ocean. This linear processing of wastewater does not promote wildlife habitat or biodiversity.

Solar Aquatics vs. Sanitary Sewer and Centralized Treatment (Biodiversity)

As stated previously, solar aquatics facilities produce plants, thus meeting one goal of the objective. Secondly, if treated discharge is used onsite for irrigation or non-potable indoor use, then water is being removed from the municipal system and is not being discharged into the ocean. As the solar aquatics facility is located onsite, this will reduce the volume of rainwater infiltration into the influent waste stream. Furthermore, in the event that the solar aquatics facility has to discharge into the ocean, it will be discharging treated water. Centralized infrastructure is not given credit for the goal of increasing habitat area because of the untreated discharge of up to approximately 22 billion litres of combined sewer overflows each year[13] into the ocean. The GVRD's LWMP will reduce this volume through the combined sewer separation; however, the separation will not be completed until 2050. Furthermore, as the sewage is pumped to the treatment facility, infiltration of rain water into the distribution pipe is inevitable

[11] http://www.gvrd.bc.ca/growth/biodiversity.htm

[12] Douglas College Institute of Urban Ecology "Conserving Biodiversity in Greater Vancouver: Fact Sheet #1 – Wetland Ecosystems". Produced for the Environmental Stewardship Division, Ministry of Water, Land and Air Protection – Lower Mainland, Surrey. Accessed from the following website: http://www.gvrd.bc.ca/growth/biodiversity/BioD_Factsheet1_wetland.pdf

[13] A Sierra Legal Defence Fund Report (2004) "The National Sewage Report Card – Grading the Sewage Treatment of 22 Canadian Cities". Page 51. Accessed at the following website http://www.sierralegal.org/reports/sewage_report_card_III.pdf

and will always result in the treatment of excess water volumes during rain events. Partial credit is given for the production of plant life associated with the production of fertilizer in the wastewater treatment process.

Goals for Current Using Solar Income

In order to meet this objective, the technology must primarily use solar energy as its primary energy source. This will minimize the requirement of additional energy requirements derived from other forms of energy generation.

Wetland vs. Storm Sewer (Solar Income)

Wetlands operate primarily on solar energy. Solar energy is utilized by plants during photosynthesis. Furthermore, water flow through the wetland is driven by gravity drainage, which does not require the input of additional energy inputs. The addition of energy is required in the first few years of development of the wetland in the form of maintenance, however, over time, the wetland requires an annual inspection frequency[14].

Sewer conveyance of stormwater requires the input of energy for pumping[15]. Furthermore, energy is required for treatment in the combined sewer system. As such, the storm system does not receive credit for using solar energy.

Solar Aquatics vs. Sanitary Sewer and Centralized Treatment (Solar Income)

In regards to using solar energy, both the solar aquatics facility and the centralized sanitary system require the inputs of external energy other than solar. Both systems, however, receive partial credit. The solar aquatics facility uses solar energy during photosynthesis in water treatment and for heat during warmer months. However, the input of additional energy is required for pumping requirements and heat generation in the winter months. As stated previously, wastewater treatment and conveyance requires the input of energy (not solar). However, partial credit is given as the case is made that a portion of the methane generated from the digestion of sludge can be attributed to solar income. These comparisons demonstrate the value of incorporating both a constructed wetland and solar aquatic facility at GNWC as part of an integrated system that relies on eco-urban infrastructure and not on conventional practice.

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[14] United States Environmental Protection Agency (1999) "Storm Water Technology Fact Sheet – Storm Water Wetland". Office of Water, Washington, D.C. EPA 832-F-99-025

[15] Cool Vancouver Task Force (2003) " A Discussion Paper on Greenhouse Gas Reduction Planning for the City of Vancouver" Page 76. Accessed from the following website: http://66.102.7.104/search?q=cache:OKMacQbWRz4J:vancouver.ca/ctyclerk/cclerk/20030624/rr1.pdf+cool+vancouver+task+force+water+pumping&hl=en

Goals for Sharing Health and Wealth

In order to receive financing for development, developers can pre-sell units in their proposed development prior to construction. In terms of generating economic wealth, the developer will ensure that there is a market base for the product that they are selling and will seek to minimize upfront capital costs. Landowners may not be qualified to assume legal responsibility for ensuring that public utilities are maintained. As such, the desire to minimize stakeholder liability is asserted. The following goals are associated with achieving the 'share health and wealth' objective:

- Minimize upfront capital costs
- Ensure there is a market for development
- Minimize landowner liability
- Ensure human health is maintained while wastewater is managed
- Enhance community identity
- Increase property value

Wetland vs. Existing Storm Sewer (Sharing Health and Wealth)

Up front capital costs associated with the proposed constructed wetland and associated water efficient landscaping are approximated as follows:

- Wetland construction - $1,000,000[16]
- Forested buffer construction - $250,000[17]
- Cost for infiltration trench in forested buffer area - $50,000[18]
- Permeable path construction - $20,000[19]
- Flow form cost of approximately $10,000 (this cost has been assumed)

This yields a total upfront cost of approximately $1,330,000 for the proposed constructed wetland and associated water efficient landscaping.
The cost for a conventional parkland landscape development to cover the same area as the proposed wetland and associated water efficient landscaping is

[16] Costs approximated from a wetland area of approximately 2,800 m^2, and a cost ranging from approximately $350/$m^2$ to $450/$m^2$. Cost provided by John Grindon of Brinkman and Associates Reforestation Ltd.
[17] Cost approximated from a forested buffer area of approximately 10,000 m^2, and a cost of approximately $25/$m^2$. Cost provided by John Grindon of Brinkman and Associates Reforestation Ltd.
[18] Cost based on a trench area of approximately 500 m^2 and a unit cost of approximately $100/$m^2$. Cost attained from: CH2MHILL (2002) "Interim Report on Effectiveness of Stormwater Source Control". Prepared for the Greater Vancouver Sewerage and Drainage District, page 26.
[19] Cost approximated from a permeable path area of approximately 1,000 m^2, and costing for permeable pavement of approximately $20/$m^2$. Cost attained from: CH2MHILL (2002) "Interim Report on Effectiveness of Stormwater Source Control". Prepared for the Greater Vancouver Sewerage and Drainage District, page 26.

approximately $1,280,000[20]. Additionally, more urban sites, which include hardscapes and potential water features, will cost considerably more[21].

In addition to these upfront costs, studies have shown that maintenance costs associated with natural landscaping can yield a savings of approximately $4,000 per acre over a 10 year period, when compared to turf grass approaches[22]. Based on the information presented, both the wetland and conventional centralized approaches receive credit in the category of minimizing up front costs.

In 2004, the Canadian Mortgage and Housing Corporation (CMHC) conducted a survey in order to attain more information regarding market demand for "Healthy Housing." Results of the survey indicated that water-efficient landscaping to help conserve water and reduce maintenance and recycling of rainwater for landscape irrigation and to reduce sewer loading would encourage purchase decisions 89% and 87% of respondents, respectively[23]. This suggests that a market exists for the de-centralized approach to stormwater management. Current stormwater infrastructure is managed by local governments. A de-centralized approach shifts the liability associated with the infrastructure from the local government to the landowner/residents. As such, a centralized approach achieves the goal of minimizing landowner liability, a de-centralized approach does not.

Solar Aquatics vs. Sanitary Sewer and Centralized Treatment (Sharing Health and Wealth)

The up front capital cost of a solar aquatic facility to treat the anticipated water volume of sanitary wastewater from the proposed development is approximately $650,000[24]. As a risk management approach, the solar aquatic facility will be connected to the existing sanitary sewer in the event of malfunction or maintenance. As such, a centralized approach which utilizes existing sanitary sewer infrastructure is favored for developers and homebuyers in terms of reducing upfront capital costs.

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[20] Cost based on an area of approximately 12,800 m^2 and a unit cost of approximately $100/$m^2$. Costs provided by Randy Sharpe of Sharpe & Diamond Landscape Architecture & Planning.
[21] Information provided by Randy Sharpe of Sharpe & Diamond Landscape Architecture & Planning.
[22] Conservation Research Institute (2005) "Changing Cost Perspectives: An analysis of Conservation Development". Page iii – as accessed at the following website: http://www.nipc.org/environment/sustainable/conservationdesign/cost_analysis/Cost%20Analysis%20Report.pdf
[23] CMHC (2004) "Research Highlight - Univercity: Assessing Consumer Demand for Sustainable Development" Socio-economic Series – 04-022.
[24] Cost based on 94 m^3 of sanitary discharge per day. Cost provided by Kimron Rink of ECO-TEK Ecological Technologies Inc.

In the GVRD, the average household pays approximately $280 annually for the management, collection and treatment of wastewater[25]. Annual operating costs of the solar aquatics facility are approximately $30,000; however, the potential exists for annual revenue of approximately $20,000, resulting in an annual cost of $40 per household[26].

As stated in the previous section, market demand exists for homes with features which reduce loading on sewers. Results from the same study indicate that respondents are willing to pay from 2.5% to 6.5% above market value for "Healthy Housing"[23]. As the average new condominium cost in Vancouver is approximately $320,000[27], and the development size is approximately 250 units, the increased household cost resulting from the purchase of a solar aquatic facility would be less than 1% above market. This suggests that the required market demand exists for the use of a solar aquatic facility to treat sanitary waste.

Another aspect of achieving the shared health and wealth objective is the opportunity to enhance the community and cultural identity of the GNWC within the existing urban fabric. It is well known that peoples' identification of a *neighborhood*, its location, its boundaries and its characteristics, enables them to experience a sense of community in that neighborhood (Holahan et al. as quoted in McAndrew, 1993, 222). Unfortunately, while GNWC is surrounded by well defined neighborhoods, it is not well integrated into the community fabric. On the contrary, the area lacks its own unique character and detracts from the community with its unkempt and poorly lit streets, its lack of refuge for pedestrians and cyclists, and its fast moving traffic. Together these characteristics make for "a rather inhospitable environment that lacks a sense of place, a sense of arrival, [and] a sense of unique history" (Russell, 2004, 6).

Formatting? The introduction of natural and artistic landscapes will enhance the community design and attract attention from surrounding neighborhoods. Elements such as the proposed pedestrian-oriented plaza and marketplace, central open space, and interpretive forest and wetland will celebrate both the cultural identity (e.g. showcasing artisans) and natural history of the site (e.g. teaching about historic watercourses, like Brewery Creek, which used to run though the site). As a result, meaning will be restored to the site by promoting a sense of community and unique local identity through human interaction, recreation and education at GNWC.

[25] http://www.gvrd.bc.ca/sewerage/pdf/WhenIFlushBrochure.pdf
[26] Based on 250 households in the development. Cost and potential revenue from plant sales is provided by Kimron Rink of ECO-TEK Ecological Technologies Inc.
[27] http://www.cmhc-schl.gc.ca/mktinfo/store/files/opims/Regions/British%20Columbia/Vancouver/Housing%20Market%20Outlook/2005/64363_2005_B02.pdf

figure 8

Imagine walking along the Central Valley Greenway on a wet Vancouver afternoon and experiencing a variety of landscapes as you follow the artistic flow forms, listen to the running water, smell the fresh herbs, and decide to grab a warm cup of coffee while browsing the artisan creations. The resulting cumulative effect of these experiences will leave a lasting impression of Vancouver and its landscape (Russell, 2004, 58).

figure 9

In addition, these improvements will likely encourage new and re-development and increased property values both for GNWC and potentially for adjacent lands which will gain even better views and opportunities to use the recreational amenities and services at GNWC.

Recommendations

Based on their greater ability to achieve the desired goals of the framework objectives, the use of a solar aquatics facility for sanitary water treatment and the use of a constructed wetland for stormwater management are recommended for implementation in the development plan for 555 Great Northern Way.

Risk Management

In order to reduce perceived risks associated with the implementation of a constructed wetland and solar aquatic facility, one strategy set forth in this plan is to connect the systems to the existing infrastructure in the event of system failure or required maintenance. This will ensure that residents will be provided with the service of sanitary wastewater and stormwater collection.

To address the difficulties that arise in terms of ownership, maintenance and liability associated with de-centralized infrastructure, one solution provided by the CMHC is the creation of a small, community-based utility that can manage all aspects of the infrastructure[Error! Bookmark not defined.]. Additionally, at the Great Northern Way location, a relationship could be formed with the academic institutions, the community groups and the local governments. These relationships can provide educational benefits for all stakeholders in terms of wetland and solar aquatics performance in achieving desired water quality. Additionally, local governments can benefit from a partnership of this nature in terms of system assessment as a pilot test for potential implementation at other locations.

An additional strategy that could be implemented to ensure that the solar aquatics facility effluent quality is maintained is that a document could be drafted in which all the residents of the development would sign and agree to use eco-friendly products. Along with ensuring that the solar aquatics facility produces a quality effluent water stream, the plants produced would not contain any potential toxins.

A risk associated with the use of a constructed wetland, is the potential for drought in summer months, which can result in the death of wetland plants, and the potential reduction in wetland performance. One risk management strategy is the use of indigenous, drought tolerant plant species which are adapted to our seasonal temperature fluctuations. This will work for some sections of the wetland, however, deeper sections of the wetland, which do not utilize drought tolerant species, will require another source of water. One potential solution to this is through the use of the solar aquatic effluent. During drought periods, effluent from the solar aquatic facility could be directed to these areas to provide water.

Another risk associated with the use of a wetland is the presence of deeper zones (2 m water depth). This poses a risk in terms of the potential for someone to fall into the water. A potential risk management strategy would be through the use of more dense, taller plant species to minimize access to these water sources particularly for children. Thorny shrubs such as the nootka rose bush seem to be very efficient for this purpose. As access will be required for maintenance, signage should be posted to promote safety at all access locations. In addition to this, community engagement and education will be crucial to the successful implementation of this risk management strategy.

Review of Previous Remedial Works

In 1995, six UST nests and approximately 350 m^3 of hydrocarbon contaminated soils were removed[28]. An additional 210 m^3 of soil containing metals concentration greater then contaminated sites regulation soil standards for commercial land use[28]. On May 17, 2000, a certificate of compliance (CofC) was issued for the Great Northern Way Campus. Schedule B of the certificate states that it is recommended that a qualified environmental consultant be available to identify, characterize, and appropriately manage any soil and/or groundwater materials of suspect environmental quality which may be encountered during any future subsurface work at the site[29]. Additionally, Schedule B also states that fill exceeding commercial land use for copper, lead, and/or zinc were identified in isolated locations, however, the soil was classified as meeting commercial standards. It is assumed that any development conducted at this location will do so in compliance with the certificate and thus, costs for remediation are not included in this document.

The information provided in the CofC affects the development of this site as follows:

- A soil specialist should be consulted prior to any subsurface work;
- Potential for development of residential units on the ground floor may be limited as residential land use soil standards are typically more stringent

[28] McCammon, A (November 24, 1999) "Approval In Principle". Issued for lands located at 555 and 577 Great Northern Way, Vancouver, B.C.
[29] McCammon, A.W (May 17, 2000) "Certificate of Compliance". Issued for the lands located at 555 and 577 Great Northern Way, Vancouver, B.C.

than commercial land use standards (an environmental consultant should be involved in decision making regarding this aspect);

- The potential for infiltration may be limited due to the potential mobilization of metals existing in the soil. As such, the wetland design would likely require lining in areas of concern. This may shift the design from infiltration in the buffer zone to the potential re-use of water in other applications such as toilet flushing;
- A phased development strategy may be required in conjunction with site remediation. One possible remedial approach to explore would be the potential for use of phytoremediation technology. There may be potential for plants grown in the solar aquatics facility to be used for this purpose, however, more detailed investigation is required.

The use of phytoremediation which uses vegetation to "pull out heavy metals and toxic substances involves seeding a site with carefully selected plants, allowing them to naturally metabolize organic contaminants contained in the soil" (Lam, p.25). Afterward, the biomass can then be incinerated as biofuel and the metals can be retrieved for reuse.

figure 10

Regional Capital Plans

As stated previously, the GVRD is undergoing a combined sewer separation program. Capital plans have allocated approximately $16,150,000 per year and approximately $3,000,000 per year in Vancouver and Burnaby, respectively, until scheduled completion in 2050[7]. On a small scale, the proposed solar aquatics facility and constructed wetland are directly in sequence with the LWMP's vision of making Greater Vancouver "a place where human activities enhance rather than degrade the natural environment, where the quality of the built environment approaches that of the natural setting"[7]. In addition, the district of North Vancouver's community infrastructure plans include the objective to implement pilot or demonstration projects that test the feasibility of new approaches or technologies[30]. As the proposed de-centralized system in orders of magnitude may help the GVRD attain its vision, and may present cost savings, a demonstration project to further assess system performance, costs and applicability to other location could prove beneficial to Greater Vancouver.

COMPONENTS OF AN INTEGRATED SYSTEM

We recommend including the following components to create an integrated system of eco-urban infrastructure at GNWC.

Eco-urban infrastructure, or *natural* infrastructure relying on trees, watercourses, soils, etc. is the naturally occurring physical foundation of our planet (Fink, 2002, 396). The idea is to mimic natural processes, in this case the original watershed basin for False Creek.

In a constructed wetland, water collects and is stored and in filtered in depressions in the landscape through the soil and plants before it enters the water table and storm sewer. Not only are engineered wetlands emerging as a technology to manage and treat contaminated stormwater runoff in urban environments, (France, 2002, 11) but they also serve to provide wildlife habitat, recreational amenity (e.g. trails and greenways) and educational venues.

figure 11

30 http://www.cnv.org/c/DATA/2/107/~CHAPTER%2011%20COMMUNITY%20INFRASTRUCTURE.PDF

There are two main types of constructed wetlands: the subsurface flow (SF) constructed wetland and the free water surface (FWS) wetland. As water flow through the SF wetland occurs below the top of the aggregate media (rock or gravel bed) and the peak flow of storms would be very high, the use of a SF wetland would result in a very high cost for the amount of gravel to contain peak storms[31]. As such, a FWS wetland is typically selected for stormwater treatment. The type of FWS wetland chosen for this site is a pond/wetland system. The pond/wetland consists of the following components:

- Wet pond – traps sediments and reduces runoff velocities;
- Shallow and High Marsh – water filtration and potential for infiltration;
- Semi wet zones – water filtration and extra capacity during storm events; and
- Micropool – additional settling prior to discharge.

A pond/wetland should be designed for 24-hour detention of the 1-year storm and should encompass an area of approximately 1% of the drainage area[31]. The drainage area used for design is bounded by 555 Great Northern Way, Prince Edward Street, Broadway and Fraser street. The total estimated drainage area is approximately 27 hectares. As such, a minimum area used for design is 0.27 hectares (2,700m^2). Based on precipitation data provided by Environment Canada[32], the maximum expected daily volume of water from the drainage area is estimated to be 1,400m^3, during annual storm events. Please refer to Appendix 2 for calculations regarding wetland design.

The primary purpose of the constructed wetland is to maximize on site filtration of storm water through natural landscapes, bioswales and other permeable surfaces. Storm water is filtered using a selected plant list (Appendix 2) and can be reused on site, as we propose, for irrigation and other uses. In doing so, this minimizes the overland flow and discharge to the sewer, and ultimately a treatment facility, while removing run off contaminants from the water.

Another advantage of using the constructed wetland is the ability to modify the design to handle water volumes as they evolve over time (e.g. as GNWC expands) and to incorporate various interesting architectural styles within a flexible spatial footprint.

[31] United States Environmental Protection Agency (1999) "Storm Water Technology Fact Sheet – Storm Water Wetland". Office of Water, Washington, D.C. EPA 832-F-99-025

[32] http://www.climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?Province=ALL&StationName=vancouver&SearchType=BeginsWith&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=882&

In addition, the reclamation of rainwater provides opportunities to enhance landscapes and buildings with creative water features and use the water to heat, cool, irrigate, flush toilets and for washing purposes (Russell, 2004, 22).

Living Buffer

After being purified through several ponds, the wetland will be directed through a swale surrounded by a forested corridor for irrigation purposes. Ultimately this swale leads to a final holding pond which has a security overflow to the stormsewer. Considering that the buffer could grow over 500 trees, and that a "mature cypress tree absorb up to 880 gallons of water a day"(33), this becomes a desirable mitigation strategy which would alleviate the pressure on municipal infrastructures.

Additionally, the area along this northern boundary of GNWC will provide a Living Buffer to protect the site and its inhabitants from the noise and the dust of the adjacent railway systems. Furthermore, as the trees mature, this strategy might enable the building to avoid the need to use a mechanically ventilated cooling system. Sub-canopy species may be planted to encourage the symbiotic relationships of a maturing ecosystem (Benyus, 2002, 258), as well as provide food, herbs and plants for ethnobotanical research and educational purposes. (Pojar, 1994, 154).

figure 12

Along with atmospheric contaminants, the adjacent railway system leaches high concentrations of pesticides and creosote which are lethal to the surrounding biota. Chemical cocktails of diuron, which is toxic to vertebrate and invertebrate organisms, and glyphosates, which are lethal to all vegetation and particularly harmful to marine ecosystems, must be removed (Dionne, Noël, O'Melinn, Purewal, Tynan, 2005, 7).

33"Trees, the oldest new thing in stormwater treatment", Stormwater. http://www.forester.net/sw_0203_trees.html

figure 13

To prevent future contamination leaching into GNWC, a mutually beneficial solution could be sought in partnership with the neighboring Burlington Northern Santa Fe (BNSF) Rail Corporation. For example, in lieu of monthly pesticides applications, the use of indigenous sedums mats (Figure 13) would eliminate the need for pesticides and be virtually maintenance free. These densely vegetated mats prevent the growth of weeds, and invasive species as they are compact and propagate rapidly. These crassulaceaes are drought resistant, grow on shallow substrates and their maximum height is of 25 centimeters, which is compatible with railway requirements. Additionally, these mats would reduce dust as well as absorb noise pollution.

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Solar Aquatic Facility

Another key component of the integrated system is the proposed solar aquatic facility. Used to treat wastewater from the live-work studios, this component offers a flexible design that can be adapted to the volumes of its occupants.

figure 14

The size of a facility suitable for this project was calculated from the maximum allowable density of occupancy of the live-work units according to the city by-laws and the footprint of the building would be of 200 square meters (detailed calculations in appendix 3).

The process of filtration is performed by aquatic organisms which use the root systems of plants as their infrastructures. Various stages of filtration are required for the purification of wastewater as such:

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- Metabolism of complex organics
- Nitrification and nutrient reduction
- Clarification and solid removal
- Denitrification and pathogen removal

Conveniently, the “waste” products from this process may all be reused onsite;

- the water may be recycled in the units for toilet flushing
- the sludge may be converted into growing medium for the landscaping of sub-zone 1, 2 and 3A.
- the support vegetation produced may be of pre-selected indigenous species for the incremental landscaping of sub-zone 1, 2 and 3A.

Once these sites are fully vegetated, we could extend the Ripple Effect to adjacent neighborhoods which could generate revenue as well as a positive perception from the surrounding community.

Connectivity

The introduction of a constructed wetland and solar aquatic facility will fit within a framework of flow forms, footpaths, bridges and plazas. The flow forms provide an interesting architectural feature that functions to oxygenate and cleanse the storm water as it moves through the wetland system. Likewise, permeable paths will enhance the natural landscape and provide additional filtration opportunities.

The paths, bridges and plazas will promote pedestrian connectivity, social interaction and respite throughout the GNWC. In addition, these connections will tie in well with the proposed Central Valley Greenway (Figure 15) which will increase pedestrian and cyclist traffic along Great Northern Way.

Access and circulation will also be essential for entrepreneurs and artisans to attract business from the surrounding community into their studios. We propose a main plaza and marketplace at the ground level of the mixed use development to showcase the studios and offer services for users of GNW and the proposed Centre for Interactive Research on Sustainability (CIRS). We envision, a pedestrian-friendly marketplace, a “Granville Island without cars” to become a new focal point in the community with many opportunities to demonstrate the environmental, social and economic benefits of using eco-urban infrastructure in an integrated system.

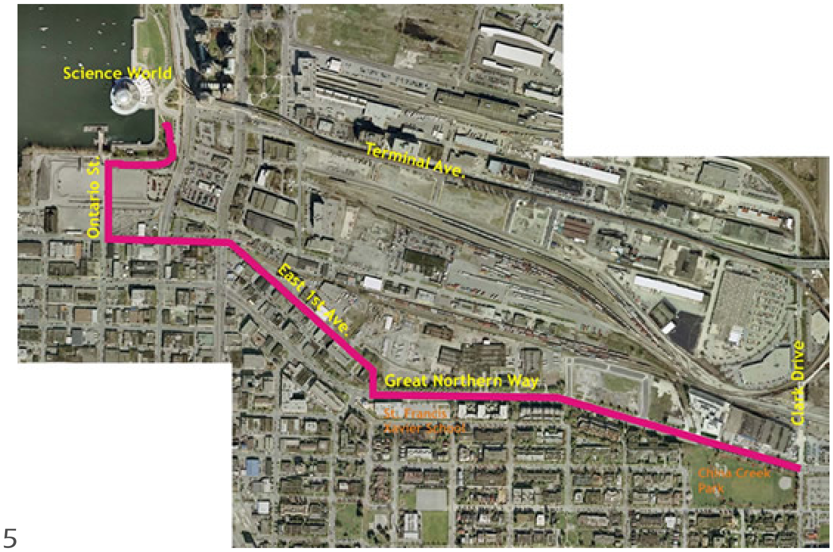

figure 15
Source: Photo taken from
http://vancouver.ca/engsvcs/streets/greenways/city/cvg_sections.htm

Recommended Design

Together these elements meet the criteria of a Cradle to Cradle approach and offer triple bottom line benefits (environmental, social and economic) not only to this hub of sustainable research and practice at GNWC, but extending out into the surrounding communities with innovative ties and modeling decentralized systems that can be applied throughout the Great Vancouver Region. In essence, it is these ties or spheres of influence that will generate the *Ripple Effect*.

(please consult PDF presentation).

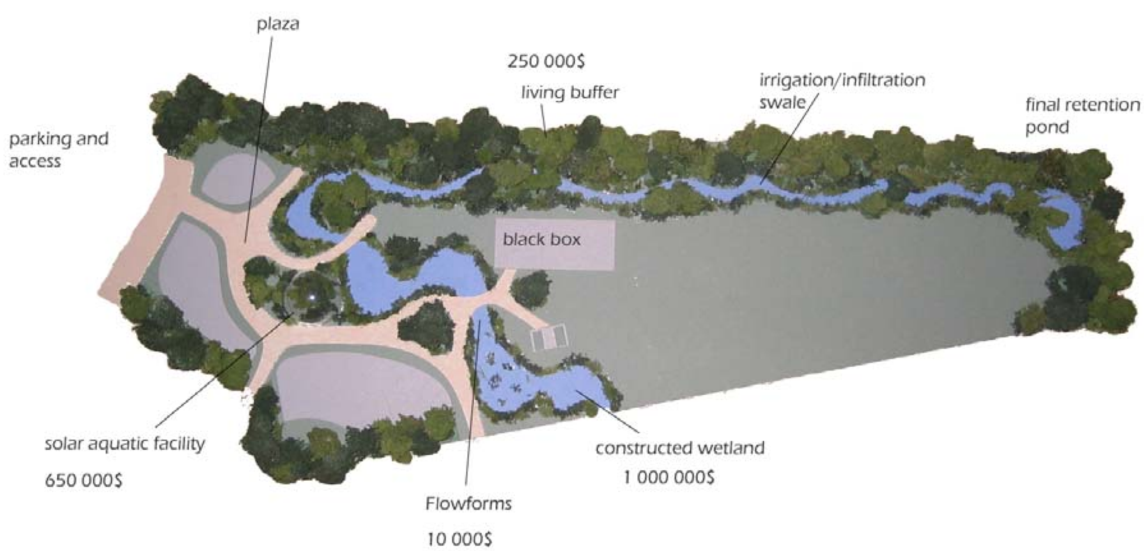

figure 16

POLICY FRAMEWORK & CURRENT PLANNING INITIATIVES

As part of our mandate we investigated the current plans, policies and bylaws that would impact the development of a *Ripple Effect*, and how this development ties into current sustainability initiatives.

Legislation at the federal, provincial, regional and municipal levels interplay to govern land use, sewage treatment and storm water management at the GNWC. Those of key interest include:

- GVRD Liquid Waste Management Plan (LWMP)
- Greater Vancouver Sewerage and Drainage District – Sewer Use Bylaw No. 164
- City of Vancouver LWMP
- Sewer and Watercourse Bylaw
- City of Vancouver Zoning By-law No. 8131, CD-1 (402), 555 Great Northern Way (density and height restrictions)

Within this framework, the City of Vancouver has conducted numerous planning reviews over the past ten years to determine a long term vision for the Flats. Rail studies have confirmed the need to retain the Canadian National (CN) rail network to serve expanding port activities in Burrard Inlet (City of Vancouver, July 8, 2004, p.3). However, it is anticipated the BNSF line, bordering GNWC on the north, will cease to operate in the near future allowing the area north of the tracks to be developed (personal communication, City Planning, November, 23, 2005). Parkland has already been retained by the City in anticipation of this development. Moreover, this development will provide additional opportunities for the GNWC to establish a prosperous hub of activity that serves, and is well integrated into, the surrounding neighborhoods.

It is also important to note that such development will require improved north-south connections between Great Northern Way and Industrial Avenue. The current concept in the Great Northern Way Lands Public Realm Plan (2002) shows the extension of three streets running through GNWC, including Thornton Street which runs directly through the area we recommend be used for a pedestrian friendly, mixed-used development complete with an uninterrupted amenity space and marketplace. Alternatively, we strongly recommend access continue north from Carolina Street, or, it may also continue north from the access we propose off E. 1st Avenue which will run north along the west property line. In keeping with this strategy, the GNWC will attain its own vision of promoting the 'liveable city' and a sustainable urban environment.

We recommend the GNWC Board work closely with the City during the next plan review for the Flats, scheduled for January 2006, to determine the best location for these connections that will maximize both the development potential and liveability of the GNWC and community.

On a broader level, the City of Vancouver has expressed a growing concern and commitment towards issues of sustainability such as:

1. Improving water quality
2. Creating unique recreational spaces
3. Protecting, enhancing and restoring stream habitat and riparian areas
4. Minimizing impervious surfaces particularly within drainage basins
5. Adopting an Integrated Approach to land use planning, operations and maintenance

Source: adapted from Russell, 2004, p.83

In particular, many of the pilot programs that have been implemented relate to urban stormwater management. The following table summarizes just a few of these programs and how they resolved storm water issues through unconventional storm water management.

Program	Goals
Green Barrel and Roof Leader Disconnection Pilot Program (1995)	• reduce volume of storm water entering sewer system • lower wastewater treatment costs • lower combined sewer overflows and flooding potential • delay costly infrastructure upgrades
Stream Day-lighting	• open water channels in lieu of installing costly storm sewers • educational tool for stream and environmental stewardship • symbol of City's natural history • aesthetic community amenity • enhance natural environment
False Creek Flats – Grass Swales along National Ave. and Thornton St. (City of Vancouver, October 21, 2003)	• filter pollutants from road runoff • groundwater recharge • improved streetscape

Southeast False Creek Official Development Plan & Green Buildings Policy	• store, convey and treat storm water runoff from public streets and private lots (e.g. using swales, wetlands, storm water channels and green roofs) • LEED standard storm water management requirements

Source: Russell, 2004, p.82-83

While these programs emphasize storm water management, our preliminary discussions with the City and GVRD suggest that, given a feasible alternative to discharging grey water into the sewer system, an alternative plan to treat and re-use grey water on site at GNWC could be supported. Thus, the *Ripple Effect* concept reflects the interests of GNWC, to become a hub of innovation in Urban Sustainability, and the interests of the City and the GVRD, to create a vibrant community in the Flats with better stewardship of storm and waste water.

CONCLUSION

As discussed in this report, the proposed integrated system of eco-urban infrastructure demonstrates a decentralized system that maintains and strengthens GNWC's connection to the surrounding community environmentally, socially and economically as illustrated through the *Ripple Effect.* The GNWC stands to gain the following benefits from using this decentralized system in place of conventional infrastructure:

Environmental

- increase biodiversity
- become a hub of grey and storm water treatment within the Sustainability Precinct
- reclaim treated storm and grey water for irrigation, green roofs and toilet flushing
- adapt wetland and solar aquatic facilities incrementally as GNWC develops
- create habitat for flora and fauna
- ensure higher quality of water introduced into the wetland

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Social

- enhance community identity
- improve aesthetics/view of site with interesting urban landscapes
- increase opportunities for recreation and social interaction
- create a more attractive/humane environment for public and private users
- address other community concerns identified in False Creek Flats Planning Process (e.g. strengthen local business, reduce noise and air pollution,

create safe and meaningful places, daylight creeks/incorporate water features, create greenway connections and more recreational facilities)

- build internal social cohesion in community (e.g. co-op for eco-detergents)
- strengthen alliances with stakeholders in the Flats visioning process
- provide unique educational opportunities (interpretive wetland and forest) for CIRS and schools in the surrounding communities
- attract world caliber experts and knowledge

Economic

- increase property values
- explore potential synergies with local designers, builders and suppliers to construct the wetland and solar aquatic facilities
- reduce water consumption and reduce costs of future water metering
- propagate plants to landscape the campus as it develops
- continue plant production as enterprise to generate revenue as a supplier to local businesses and City Parks

Not only is the *Ripple Effect* concept effective and feasible but, more importantly, it takes the first step towards a unified vision for GNWC and this area of the Flats, a vision that acknowledges constraints and capitalizes on current resources. It is the desire of our research design team that this information be used by the GNWC Board of Directors and other stakeholders as a guiding tool towards planning a well-informed, well-designed and innovative re-development strategy for this piece of the Vancouver urban fabric. We consider this proposal very timely in the midst of much attention of sustainable development practices. Clearly, this is an opportunity for GNWC to serve as an example (pilot project) for the implementation of decentralized infrastructures in other sites throughout the City. We recognize these infrastructures may be implemented using varying degrees of decentralization, depending on site constraints and resources. Yet, the global effect is an incessant wave of 'sustainability' influence, the *Ripple Effect*, that will extend in all directions well beyond the Great Northern Way Campus and Southeast False Creek Sustainability Precinct transforming the status quo wherever it goes.

FUTURE RESEARCH INITIATIVES

Some of the areas we would recommend further research be conducted to extend the Cradle to Cradle design in the environmental, social, and economic conditions of the Great Northern Way site and surrounding communities include:

- micro hydroelectric opportunities
- solar water recycling
- sewer thermal heating
- composting toilets
- potential for urban agriculture
- symbiotic relationships with local businesses and industries
- opportunities to create local employment
- life cycle analysis of wetland and solar aquatic facilities
- reduced parking requirements with improved transit/mobility networks

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Stantec Engineering
City of Vancouver
Department of Fisheries and Ocean
Department of Engineering, UBC
Ministry of water, Land and Air Protection
The Learning City

APPENDIX 1 Storm Water & Sanitary Matrices

Objective	WASTE = FOOD				INCREASE BIODIVERSITY		USE CURRENT SOLAR INCOME
Goals	Transform Waste into a Usable Product	Increase Potential for Treated Water to be Re-Circulated for use in Building or for Sale	Increase Potential for Treated Water to be used for on-site Irrigation	Improve Air Quality	Promote Plant Life	Increase Wildlife Habitat Area	Uses Solar Energy
Storm Water Technologies							
Storm Sewer Connection Only	No	No	No	No	No	No	No
Constructed Wetland (Including Conneciton to Existing Storm Sewer for Overflow Conditions)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Objective	SHARE HEALTH AND WEALTH					
Goals	Minimize Up Front Capital Cost	Ensure there is a Market Demand	Enhance Property Value	Manage Storm Water	Minimize Onsite Liability for Land Owners	Enhance Community Identity
Storm Water Technologies						
Storm Sewer Connection Only	Yes	Yes	No	Yes	Yes	No
Constructed Wetland (Including Conneciton to Existing Storm Sewer for Overflow Conditions)	Yes	Yes	Yes	Yes	No	Yes

Objective	WASTE = FOOD				INCREASE BIODIVERSITY		USE CURRENT SOLAR INCOME
Goals	Transform Waste into a Usable Product	Increase Potential for Treated Water to be Re-Circulated for use in Building or for Sale	Increase Potential for Treated Water to be used for on-site Irrigation	Improve Air Quality	Promote Plant Life	Reduce Contaminant Discharge to Ocean During Sewer Overflow (i.e., Save Fish)	Use Solar Power
Sanitary Technology							
Sanitary Sewer Connection	Partial Credit methane, fertilizer,	No	No	Partial Credit fertilizer,	Partial Credit fertilizer	No	Partial Credit Potential Case for CoGen
Solar Aquatics Treatment Facility (Including Connection to Sanitary Sewer In the event of a malfunction or maintenance)	Yes	Yes	Yes	Yes	Yes	Yes	Partial Credit Uses solar energy for photosynthesis

Objective	SHARE HEALTH AND WEALTH					
Goals	Minimize Up Front Capital Cost	Ensure there is a Market Demand	Enhance Property Value	Ensure Human Health is Maintained While Ensuring Waste is Managed	Minimize Onsite Liability for Land Owners	Enhance Community Identity
Sanitary Technology						
Sanitary Sewer Connection	Yes	Yes	No	Yes	Yes	No
Solar Aquatics Treatment Facility (Including Connection to Existing Sanitary Sewer In the event of a malfunction or maintenance)	No	Yes	Yes	Yes	No	Yes

APPENDIX 2 Wetland Calculations and Plant List

Wetland Design Calculations

1. Determine Water Volume in 24 period from Drainage Area

Use Rationale Equation

$Q = 0.00278*C*I*A$ http://www.ct.gov/dot/lib/dot/documents/ddrainage/6.9.pdf

where: Q = maximum rate of runoff, m3/s (ft3/s)

C = runoff coefficient representing a ratio of runoff to rainfall

I = average rainfall intensity for a duration equal to the time of concentration, for a selected return period, mm/h (in/h)

A = drainage area tributary to the design location, ha (acres)

For adjacent Lands

C = 0.7 http://www.ct.gov/dot/lib/dot/documents/ddrainage/6.9.pdf

I = 0.5 mm/h (Based on weather data from Vancouver City Hall - December Average(183.3 mm in 14.1 days))

A= 21.4 ha

Therefore

Q(adjacent) = 0.02081247 m^3/s **899 m^3/day**

For GNW Campus

Use High C because the site is mostly paved

C= 0.9 http://www.ct.gov/dot/lib/dot/documents/ddrainage/6.9.pdf

A = 5.28 ha

Therefore - Q (GNW) = 0.009 m^3/s **399.49 m3/day**

Expected Volume from Solar Aquatics facility = **94 m^3/day**

Therefore, total Volume (Qtotal) = 1,400m^3/day

2. Determine Wetland Area

Wetland area = 1% of Drainage area (United States Environmental Protection Agency (1999) "Storm Water Technology Fact Sheet – Storm Water Wetland". Office of Water, Washington, D.C. EPA 832-F-99-025)

Therefore, Drainage area minimum = approximately 2,600 m2

3. Calculate Area of Wetland Components

According to USEPA, (United States Environmental Protection Agency (1999) "Storm Water Technology Fact Sheet – Storm Water Wetland". Office of Water, Washington, D.C. EPA 832-F-99-025)

Pond/Wetland Components have the following percentage of area and depth Range

Component	% of wetland surface Area	Depth Range (m)	
Micropool	5%	2	3
Deep Water 1	40%	0.5	2
Low Marsh	25%	0.17	0.50
High Marsh	25%	0.15	0.15
Semi Wet	5%	0.00	0.61

Wetland Design Calculations

Therefore, according to USEPA critera, the following component dimensions are used.

Component	Area	Depth	Volume
	(m^2)	(m)	(m^3)
Micropool	140	2	280
Deep Water 1	839	0.5	419
Deep Water 2	280	1.25	350
Low Marsh	699	0.35	245
High Marsh	699	0.15	107
Semi Wet	140	0	0
Total	2797		1400

Plant List

A list of candidate plants suitable for stormwater control in our region may be consulted at:

www.gvrd.**bc**.ca/sewerage/ pdf/Storm_Source_Control_PartVII.pdf

Appendix 3 Calculations for the solar aquatic facility

Maximum allowable density: 250 units

2.5 people per unit

150 liters average daily flow from each person
= 1.8 m2/ m3 sewage

therefore: 250 units x 2.5 people/unit x .15 m3/person x 2.0 m2/m3
= 187.50 m2 building footprint.

The building's dimensions could be 7.5 x 25m = 187.50

building/installation cost: $600,000-700,000

maintenance costs: $30,000 per year or $120/year per unit.

Energy requirement for pumping and heating: 100,000 KWH/year

Average daily flow: 94 m3/day

potential revenue: reclaimed water sales= $10,000/year
plant sales= $20,000/year plant sales

APPENDIX 4 Suppliers/Consultants

Constructed Wetland

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