Corporate Report

NO: R269

COUNCIL DATE: DECEMBER 18, 2006

REGULAR COUNCIL

TO:	**Mayor & Council**	DATE:	**December 12, 2006**
FROM:	**General Manager, Engineering**	FILE:	**4802-709**
SUBJECT:	**East Clayton Sustainable Drainage Strategies - Report on Monitoring and Next Steps**		

RECOMMENDATION

The Engineering Department recommends that Council:

1. Receive this report for information; and

2. Authorize staff to develop City wide low impact drainage standards, review these standards with stakeholders, and then report further to Council on the matter.

PURPOSE OF REPORT

The purpose of this report is to apprise Council of:

- The results of storm water monitoring undertaken in the first phases of the East Clayton Neighbourhood;
- The opportunities, constraints and limitations of low impact drainage standards within the City; and
- Staff recommendations for development of standards for use throughout the City.

BACKGROUND

In December 1998, the City of Surrey initiated the East Clayton Neighbourhood Concept Plan. City Council approved the Sustainability Principles of the Plan in November 1999. The NCP was approved by Council in March 2003, following an extensive multi-stakeholder process.

The targeted benefits of this sustainable community include:

- Sound storm water management;

- Reduced local vehicle trips;
- Protection of the natural environment;
- Enhanced livability and quality of life for East Clayton residents;
- Safer, walkable neighbourhoods in stronger, healthier and complete communities;
- Possible lower servicing costs in the long run;
- Energy savings; and
- Leadership in promoting sustainable development.

In the longer term, the neighbourhood is to provide a framework from which to base new development plans in Surrey, the Lower Mainland of BC and perhaps Canada. This project represents the first time sustainability principles had been used in British Columbia as the basis for developing a new “green field” urban community.

Situated upland of the Agricultural Land Reserve, the East Clayton area drains into two of the region's most significant water courses (the Serpentine and the Nicomekl Rivers). The East Clayton Neighbourhood Concept Plan (NCP) is based upon the approved General Land Use Plan for Clayton (approved in 1999). The land use and development concept identified in the NCP conform to seven principles for sustainable development. These principles were endorsed by Surrey City Council, and have guided the development of East Clayton in ways that support local and regional sustainability objectives. The NCP supports a variety of land uses to maximize affordability, sociability, walkability, and availability of commercial services within easy walking distance. Envisioned as a complete, mixed-use community, East Clayton is designed to promote social cohesion, local economic opportunities, and environmental stewardship while providing equitable access to housing and jobs and reducing dependence on the automobile. The seven principles of sustainability that formed the basis of the NCP are outlined in Appendix 1.

The project has brought local, provincial, national and international recognition to the City of Surrey. The NCP received a number of Awards including more recently the 2006 Federation of Canadian Municipalities – CH2M Hill Sustainable Community Award for excellence and innovation in municipal service delivery with advanced sustainable community development.

With respect to storm water management the goal of preserving the natural drainage system by attempting to mimic natural runoff response was the leading edge of low impact development strategies.

A Canada-BC infrastructure grant was provided to the City to help implement these systems on a pilot basis and develop a multi-year testing program to support new Drainage Performance Standards based on the goals of the NCP. The City started a monitoring and analysis program to quantify the benefits of the sustainability measures implemented in the East Clayton NCP. The monitoring and evaluation provides information on the benefits of the original Best Management Practices (BMP) included in the NCP. The objective is to determine the relative value of each type of BMP and evaluate potential opportunities for implementation through out the City.

DISCUSSION

Monitoring results

The specific NCP drainage objectives under **Principle #7** are summarized as:

1. Reduce runoff volumes by infiltrating rainwater into the ground (target amount was 0.5 to 1.0 mm/hr for all rain events).
2. Control runoff rates to pre development levels.

The following is a summary of the study findings for the combined Best Management Practices effectiveness to reach the proceeding goals.

Single Family Sites

- Enhanced topsoil provided significant benefits in reducing total runoff volume;
- Exfiltration Rock pits in these tight soils (clay based) provided some benefit; however, they are more costly than other methods currently available such as community detention pond.

Multi-Family Sites

- Exfiltration Rock pits provided marginal benefits in the reduction of peak flows; and
- Due to their nature, multi-family sites will require more refined strategies that must be developed as an integral part of their site design.

Roadways

- Roadways in both Single Family and Multi-Family sites are a significant contributor to runoff; and
- The mitigation measures for road surfaces impacts have not been monitored at this phase of the program.

Implementation Issues

The East Clayton NCP specified runoff performance targets in an effort to be less prescriptive and to allow individual developments and their designers to implement innovative solutions that could complement their proposed building schemes and landscaping. In some cases this approach worked well and innovative solutions were designed and constructed. In others, the solutions required substantial re-work by City staff and final installations were not meeting the objectives of the plans.

Currently, land development projects within the City of Surrey are designed and constructed based on our Design Guideline Manual. This manual is prescriptive, well used, and has shown its value over time. A number of designers and developers that have worked in East Clayton to date have specifically asked that prescriptive Best Management Practices design be adopted. This would allow for more certainty in developing designs and help streamline the approval process.

Environmental Agency Expectations

Low Impact Developments standards have progressively become the expectation of environmental groups, senior environmental agencies (e.g., Fisheries and Oceans Canada, Ministry of Environment of BC), and in some cases the general public. Recent projects in south Surrey (Grandview Corners, Morgan Heights NCP) are prime examples of projects in which traditional servicing options were not favored by the City or approved by Department of Fisheries and Oceans due to anticipated impacts to downstream watercourses. In these cases, the proponents were able to develop solutions that met the 'no impact' requirement but only with substantial design effort and a lengthy approval process.

Implementation Costs

The issue of implementation costs associated with storm water Low Impact Development and BMPs was brought to Council's attention when the East Clayton NCP was endorsed. As the design and implementation details are being refined the costs have been reducing significantly. At the time, the development industry indicated that the 'rock pit' exfiltration systems lead to an increase in cost of approximately $5,000 per single family home. The increased cost of thicker enhanced topsoil ranged from $1,000 to $2,000 per lot, depending on the material handling constraints of the specific sites. These costs were confirmed during the implementation stage. Best Management Practices on streets did not lead to an increase in cost compared to our traditional standards.

Developers involved in the first phases of East Clayton have indicated that substantial cost reductions can be achieved by modifying the BMPs that take advantage of granular pipe bedding specified in our standard design guidelines. The developers have also indicated that better use of on street systems can further reduce costs. Other substantial reductions in costs were noticed as contractors became more familiar with the designs and were also able to optimize the staging of construction.

Best Management Practices currently being proposed in the Morgan Heights NCP (Grandview Heights NCP #1) are anticipated to cost approximately $1,000 to $2,000 per lot. The proposed systems include on-site landscaping details and some on-street BMPs. If more substantial under-ground exfiltration galleries are required they are expected to cost approximately $3,000 per lot.

At this point in time, a significant problem in implementing Low Impact Development practices in a cost effective manner is the lack of consistency in design and installation procedures. It is hoped that by developing standard details and construction methods that overall costs would be reduced even further.

City Wide Standards

The specification of Low Impact Development strategies has become a mainstay of new and re-developments within the Lower Mainland in recent years. The objectives of these strategies vary, as do their costs, based on site specific issues. City of Surrey staff must continue to investigate the most viable solutions to be implemented in the City. A standardized set of Low Impact Development designs will help meet this objective.

Details for the implementation of the following measures will be developed as part of the development guidelines:

- Enhanced Topsoil depth consisting of growing medium installation and verification.
- Individual exfiltration pit design and layout and installation procedures.
- Roadway mitigation measure investigation and evaluation.

The design details will be refined based on the information gathered to date. The drainage design guidelines will be updated to include construction and implementation details. Implementation of the revised guidelines will start with internal reviews with City staff. The revised guidelines will be discussed with stakeholder groups, then brought back to Council for consideration on whether to be applied to all new development.

CONCLUSION

Surrey is a leader in the implementation of low impact developments on a neighbourhood scale. The strategies pioneered at the neighbourhood level in East Clayton have increased the knowledge base of low impact developments but more importantly have shown that the strategies are valid and can be implemented in different areas such as Highway 99 Corridor and Campbell Heights. This in turn has increased the expectation of senior agencies with respect to the implementation of low impact approaches on a broader basis.

Significant opportunities exist to improve the design and implementation of the BMPs to reduce costs and to improve the effectiveness in meeting the desired targets. The monitoring indicates that combining Best Management Practices (BMPs) of disconnected rainwater leaders, enhanced topsoil (i.e., additional thickness) and infiltration pits can reduce the increase in runoff volumes and peaks by approximately 50%, compared to conventional development. Adding in features to control and infiltrate more of the road drainage will improve this amount, potentially up to 60 or 70%. The most cost effective BMPs are disconnected rainwater leaders and enhanced topsoil.

The monitoring results have also shown that the details in the actual construction of the Best Management Practices is of key importance to ensure the system operates as intended and does not increase the risk of system failure downstream. Standardized designs and construction monitoring are needed to help developers streamline the approval process and provide a higher level of certainty with respect to runoff targets.

Sustainable drainage strategies have already been used in areas beyond East Clayton; namely, Campbell Heights and the Highway 99 Corridor. The City will now consult with the development industry and the regulatory agencies on the implications of expanding sustainable drainage development standards to other areas of Surrey, and report back to Council.

Paul Ham, P.Eng.
General Manager, Engineering

VL/RD/DOH:kd2:rdd

APPENDIX 1

Seven Principle of Sustainability
For East Clayton NCP

The following seven principles of sustainability formed the basis of the East Clayton NCP development:

Principle No. 1 *Increase density to conserve energy by the design of compact walkable neighbourhoods to encourage pedestrian activities where basic services (e.g. schools, parks, transit, shops, etc.) are within a 5 to 6 minute walking distance from their homes.*

Principle No. 2 *Different dwelling types (a mix of housing types, a broad range of densities from single family homes to apartment buildings) in the same neighbourhood and even on the same street.*

Principle No. 3 *Communities designed for people: therefore all dwellings present a friendly face to the street to promote social interaction.*

Principle No. 4 *Car storage and services handled in lanes at the rears of dwelling.*

Principle No. 5 *Interconnected street network to insure that every trip, whether on foot, bike, or by car, is via the shortest possible route to disperse traffic congestion; and public transit to connect East Clayton with the surrounding region.*

Principle No. 6 *Narrow streets shaded by rows of trees to save costs and to provide greener and friendlier environment.*

Principle No. 7 *Preservation of the natural environment and promotion of natural drainage systems where storm water is held on the surface and permitted to seep naturally into the ground.*

Monitoring results of the East Clayton BMPs

Results of the three year monitoring program are summarized below.

Monitoring Methodology

To date, two important Best Management Practices have been monitored:

- Enhanced topsoil; and
- Exfiltration rock pits.

The Monitoring program consisted of 4 high accuracy flow logging stations, one complete weather station and a groundwater level monitoring program at the location of the BMPs. The monitoring period ran for a period of three years.

Two of the flow loggers were installed downstream of development areas with only enhanced topsoil. One site was a single family development and the other a multi family development. The second two flow loggers were installed downstream of similar land use developments with but with the enhanced topsoil and exfiltration rock pits. (See Site plan for locations).

Comparing the flow logger data between developments with and without the additional BMPs provides information on the effectiveness of the measures. Reduced flows observed in the flow loggers in areas with exfiltration rock pits confirms that the pits have the desired effect of reducing area runoff.

Measurements of local groundwater levels inside the exfiltration rock pits and adjacent to the rock pits provides information on the behavior of the rock pits over time. The local monitoring is used to verify the long term soil exfiltration rates. The objective of this monitoring is to determine if the soils surrounding the rock pits loose their ability to absorb water over the long term. In addition, the groundwater monitoring provides information on the migration of water towards servicing trenches and how these contribute to the area drainage characteristics.

Collecting climate information provides data on rainfall, temperature and evaporation. The local weather station ensures that the data represents the conditions at the monitored sites. Variability in the weather from season to season and annually requires that the monitoring and analysis be conducted over several years to reduce the effects of these variations on the monitoring program conclusions.

All the data was collected and reviewed on a monthly basis. Flow data and weather information was recorded at 5 minute intervals.

As the data was collected it was incorporated into an area hydrologic computer model. The model provides a means to analyze the individual components of the watershed. The model included information about the individual lots such as roof area, driveways, lawns and roadways. In this manner the impact of the roads and the roofs can be isolated from the lawn and BMPs. The model developed in the East Clayton NCP provides a calibrated tool that can be used to quantify the performance of selected BMPs and to compare them to the desired targets as set out in the original NCP document.

All the data was reviewed on an annual basis to observe trends as they developed. The model results were compared to forested conditions and other typical servicing conditions typical of the lower mainland in order to asses the overall benefits of the implemented BMPs.

Study Results

Single Family Volume Control

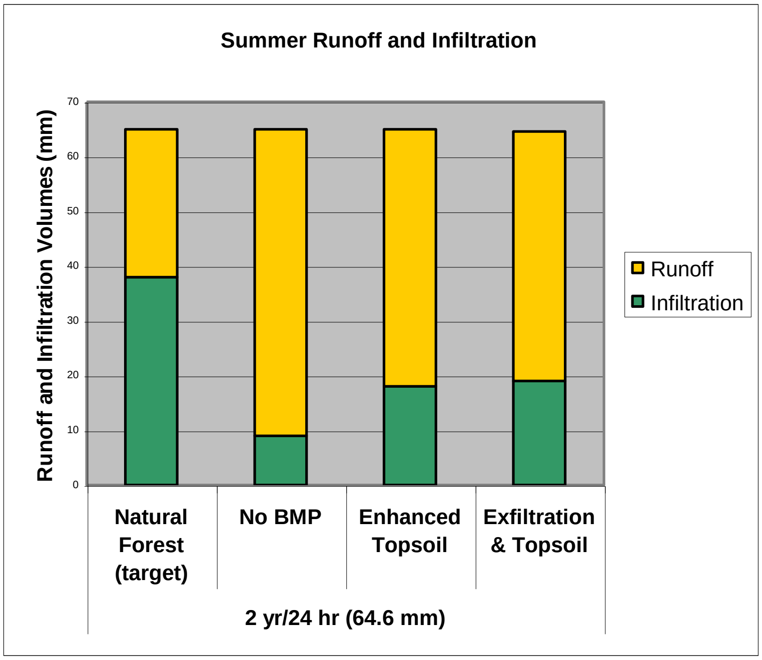
The study confirms that the two important BMP's monitored to date in East Clayton contribute to the reduction of runoff from development.

Runoff from the City's standard design events was estimated using the site's calibrated model. The following table summarizes the results for the single family lots not including the road contribution:

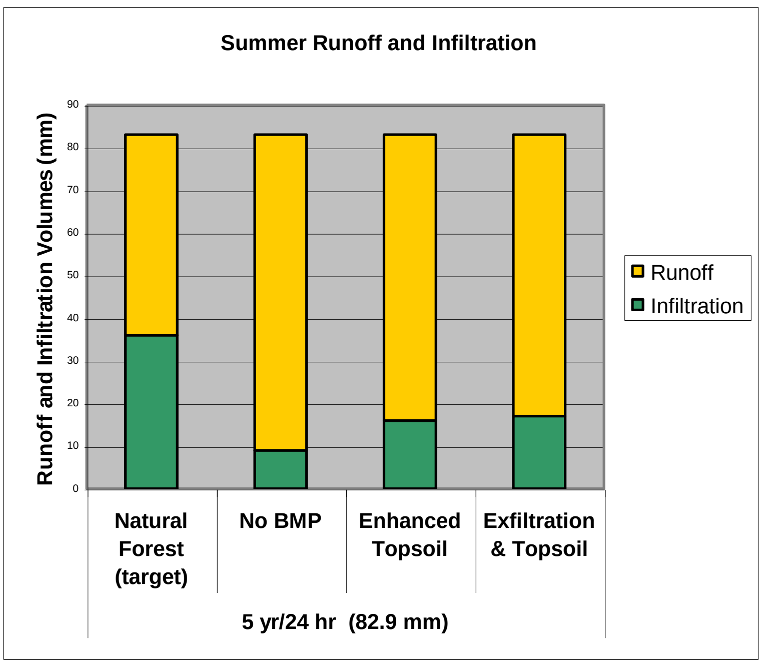
The infiltration (or capture) target for East Clayton is 0.5 to 1 mm/hr over the entire development. To meet the target, development lots should infiltrate 3 to 6 mm of rainfall for a 6 hour event and 12 to 24 mm of rainfall for a 24 hour event. Tables 1 and 2 list the runoff and infiltration amounts for the monitored single family lots, excluding the roadway contributions. Figure 1 through 4 also show reductions graphically.

Table 1 Dry Weather Runoff and Infiltration

Summer Event Runoff And Infiltration Rates						
Rain Event (depth of rain)	**2 yr/24 hr (64.6 mm)**		**5 yr/24 hr (82.9 mm)**		**5 yr/6hr (37.3 mm)**	
	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)
Natural Forest (target)	27	38	47	36	4	34
Connected roof leaders no topsoil	56	9	74	9	29	9
Disconnected roof leaders enhanced topsoil	47	18	67	16	22	16
Disconnected roof leaders and exfiltration pits	45.6	19	66	17	21	17



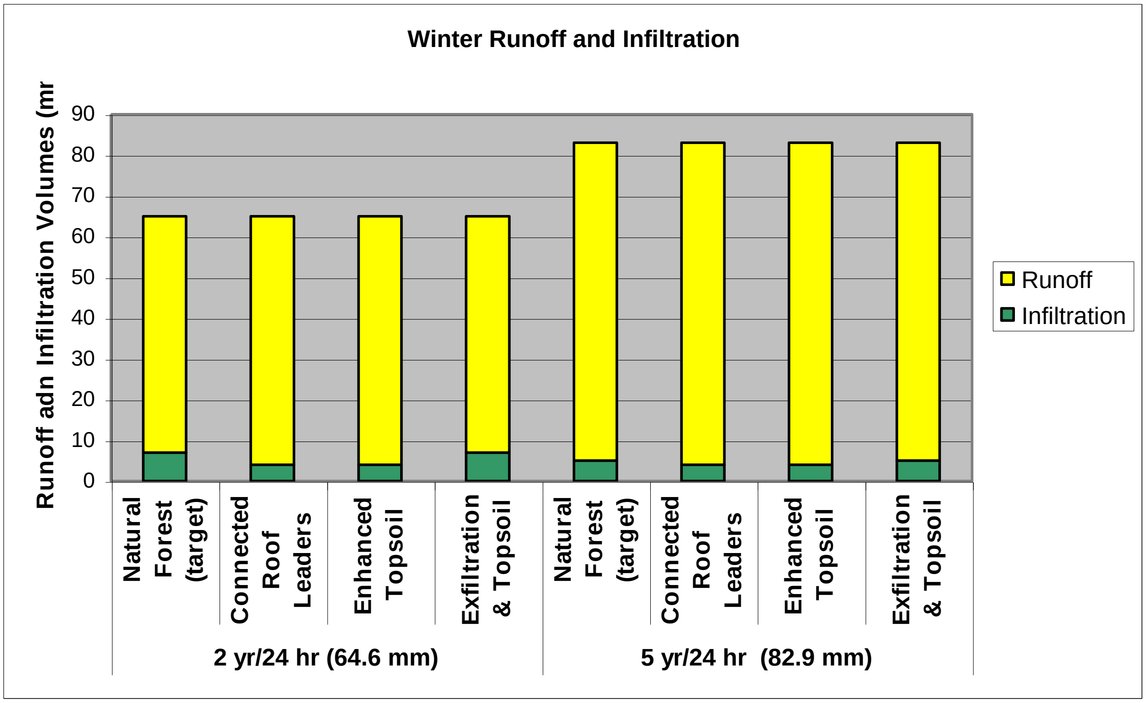
Summer Runoff and Infiltration
Runoff and Infiltration Volumes (mm)
70
60
50
40
30
20
10
0
Runoff
Infiltration
Natural Forest (target)
No BMP
Enhanced Topsoil
Exfiltration & Topsoil
2 yr/24 hr (64.6 mm)

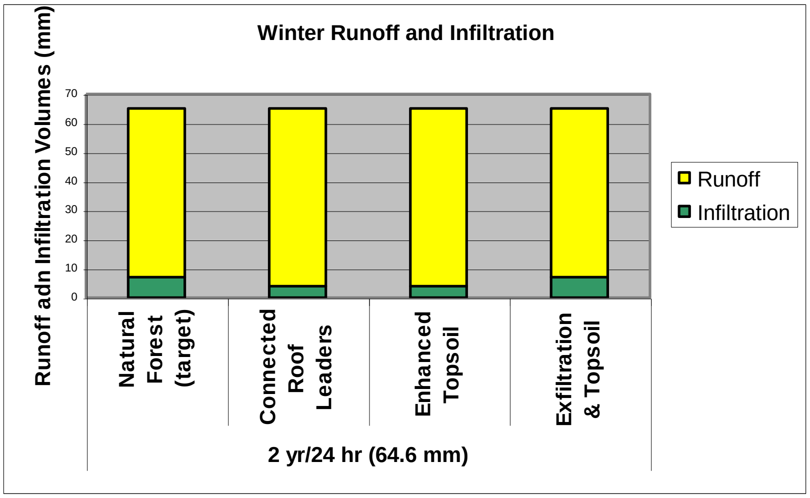


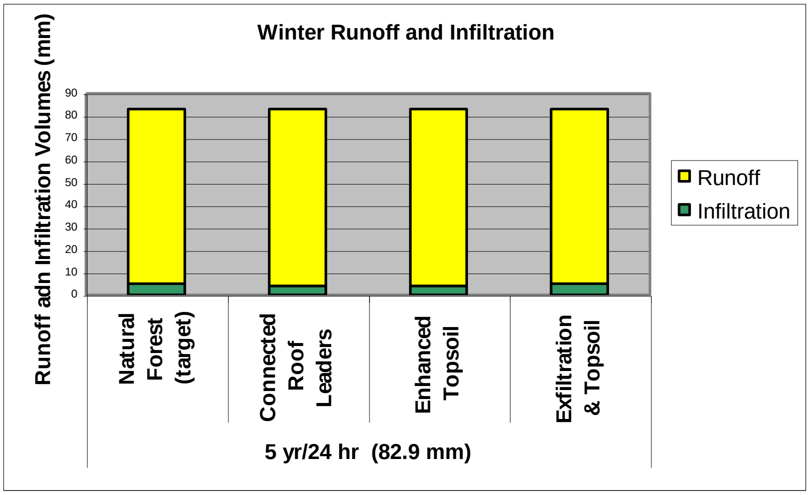
Summer Runoff and Infiltration
Runoff and Infiltration Volumes (mm)
90
80
70
60
50
40
30
20
10
0
Runoff
Infiltration
Natural Forest (target)
No BMP
Enhanced Topsoil
Exfiltration & Topsoil
5 yr/24 hr (82.9 mm)

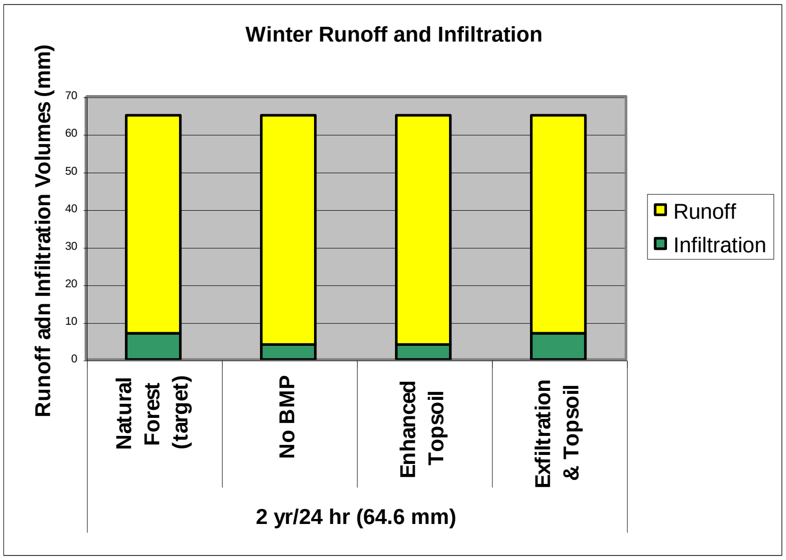
Table 2 Wet Weather Runoff and Infiltration

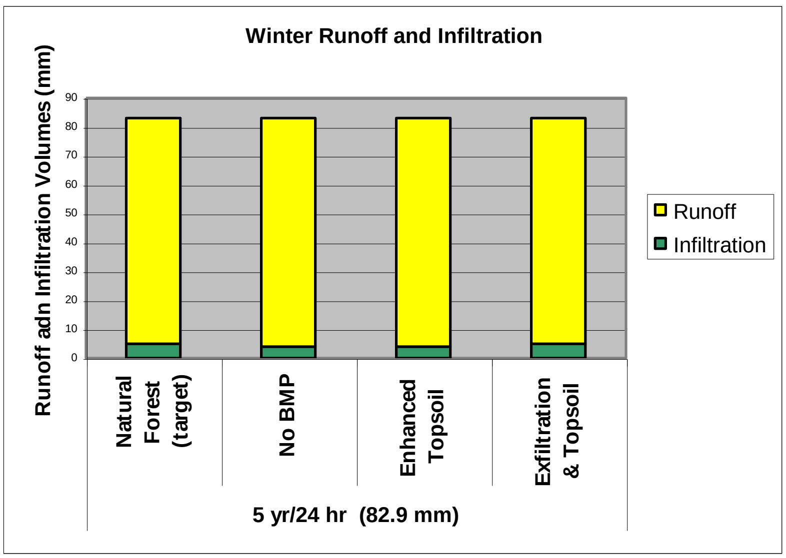
Winter Event Runoff And Infiltration Rates						
Rain Event (depth of rain)	**2 yr/24 hr (64.6 mm)**		**5 yr/24 hr (82.9 mm)**		**5 yr/6hr (37.3 mm)**	
	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)
Natural Forest (target)	58	7	78	5	34	4
Connected roof leaders no topsoil	61	4	79	4	34	4
Disconnected roof leaders enhanced topsoil	61	4	79	4	34	4
Disconnected roof leaders and exfiltration pits	58	7	78	5	34	4


Winter Runoff and Infiltration
Runoff adn Infiltration Volumes (mr
90
80
70
60
50
40
30
20
10
0
Natural Forest (target)
Connected Roof Leaders
Enhanced Topsoil
Exfiltration & Topsoil
Natural Forest (target)
Connected Roof Leaders
Enhanced Topsoil
Exfiltration & Topsoil
2 yr/24 hr (64.6 mm)
5 yr/24 hr (82.9 mm)
Runoff
Infiltration


Winter Runoff and Infiltration
Runoff adn Infiltration Volumes (mm)
70
60
50
40
30
20
10
0
Natural Forest (target)
Connected Roof Leaders
Enhanced Topsoil
Exfiltration & Topsoil
2 yr/24 hr (64.6 mm)
Runoff
Infiltration


Winter Runoff and Infiltration
Runoff adn Infiltration Volumes (mm)
90
80
70
60
50
40
30
20
10
0
Natural Forest (target)
Connected Roof Leaders
Enhanced Topsoil
Exfiltration & Topsoil
5 yr/24 hr (82.9 mm)
Runoff
Infiltration





The infiltration rate (or capture) is highly dependent on the rainfall event. Under dry conditions the system can meet the lower range of the specified target but under wet conditions it falls short of the targets. Dry weather events could be typical of summer where lawns are relatively dry before a rain event while winter conditions can result in saturated soils prior to a rain event. The saturated soils have a lower capacity to absorb water.

The intent of the BMPs is to reduce runoff from developed areas to levels similar to forested areas throughout the year. Single event results above, provide insight into the systems operation, long term simulation results provide a broader context for assessment of impacts. The following table summarizes the benefits of BMPs with respect to long-term total runoff: A typical year produces a total rainfall of approximately 1,144 mm Table 3 shows the total annual runoff for the different BMP's when compared to a forested condition.

Table 3 Total Rainfall and Runoff Over One Year

Total Runoff Per Year		
Condition	**Runoff Depth (mm)**	**Runoff Coefficient**
Natural Forest (target)	771	67%
Developed with Connected roof leaders	989	86%
Disconnected roof leaders and enhanced topsoil	892	78%
Disconnected roof leaders and exfiltration pits	876	77%

Full implementation of the two BMPs provided approximately over half (52%) of the targeted volume reduction (44% from the disconnected roof leaders and an additional 8% from the exfiltration pits).

Single Family Peak Runoff Rate Control

The rock pits provide a significant benefit in reducing the peak runoff to pre-development rates. The monitoring confirms that disconnected roof leaders, enhanced topsoil and exfiltration rock pits, controlled the runoff rates to pre development rates for 80% of all rainfall events. Under the critical 1 in 5 year design event the system provided 29% of the peak reduction required to meet pre-development levels. The detention provided by the exfiltration rock pits is the main contributor in reducing peak flow rates; the thicker top soil did not provide attenuation benefit under severe conditions. This means that the exfiltration system provides an opportunity to reduce community detention volume requirements. A reduction in pond volumes shifts the land requirements for detention, from larger community areas to the individual lots. This can reduce offsite costs by transferring the costs to each individual lot. The benefits associated with implementation of small detention units needs to be balanced with the maintenance and long term performance requirements of the on-lot systems.

Multi Family Volume and Peak Runoff Rate Control

The multi family site results were not as encouraging as runoff rates with infiltration structures stayed at 95% as opposed to the targeted 67% (compared to forested sites). Under the critical 1 in 5 year design event the system provided 20% of the peak reduction required to meet pre-development levels. Multi family sites typically have less landscaping and pervious surfaces. Relying on disconnected roof leaders and additional topsoil in Multi family sites is not effective. To compensate for the lack of pervious areas, additional exfiltration rock pits should be incorporated into Multi Family sites that do not wish to provide landscape areas. Significant additional effort is required to reach the target rates for Multi family sites.

Roadways

Roadways and paved areas are a major contributor to runoff volume, contributing 12% volume increases in single family areas and an estimated 47% contribution in multi family sites. This is the expected contribution as roads are approximately 10% of the total impervious area of typical single family development. Multi family sites have been increasing the percentage of driveway surfaces in a development in efforts to increase density.

Although the BMPs implemented in the first phase of the NCP have made a positive measurable contribution towards achieving the sustainability objectives of the NCP, additional measures are needed. Enhanced topsoil depth provided the greatest increase in performance. Areas to focus on are the runoff from roadways and from impervious areas in multi family developments.

Infiltration BMPs

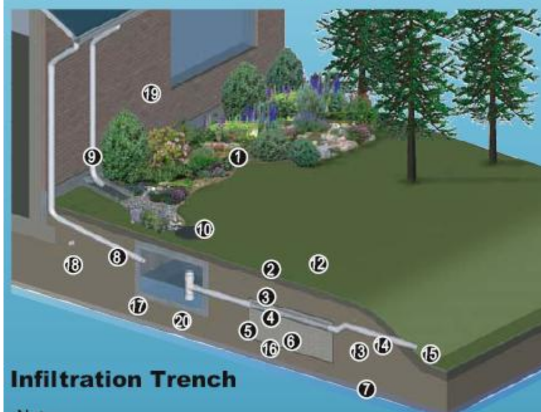
An **Infiltration Trench** System includes an inlet pipe or water source, catch basin sump, perforated distribution pipe, infiltration trench and overflow to the storm drainage system.

A Soakaway Manhole (Sump, or Dry Well) System includes an inlet pipe, a sedimentation manhole, and one or more infiltration shafts with connecting pipes. Use of Infiltration Shaft will be limited by hydro-geotechnical conditions in much of GVRD.

Limitations of Infiltration Trench or Soakaway Manholes:

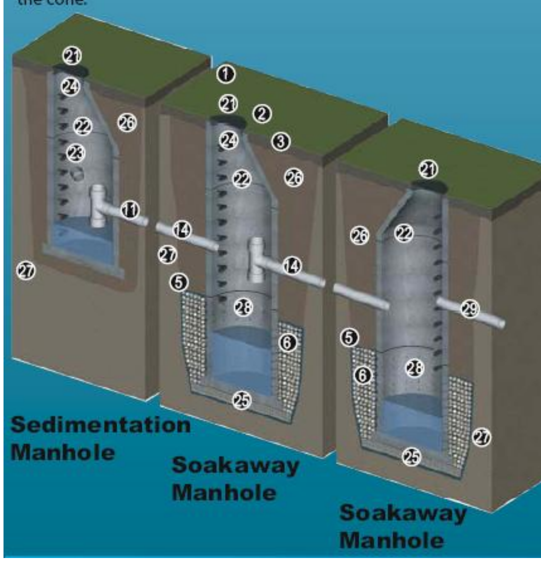
a) To avoid groundwater pollution, do not direct un-treated polluted runoff to Infiltration Trench or Shaft:
- Direct clean runoff (roof, non-automobile paving) to Infiltration Trench or Shaft.
- For polluted runoff (roads > 1000 vehicles / day, parking areas, other pollution sources), provide upstream source control for pollutant reduction prior to release to Infiltration Trench or Shaft.

b) Use infiltration trench or shaft only in areas with footing drains.



Notes:

All precast sections shall conform to the requirements of ASTM C 478.
Provide a min. of 150mm of 25mm or 19mm clean crushed rock under all pipes.
Invert shall be level and smooth.
Soakaway Manhole barrel shall not be perforated within 1200mm of the cone.



1. Grass or Other Planting
2. Finish Grade
3. Growing Medium Backfill
4. 100mm Dia PVC DR28 Perforated Pipe
5. Light Non-woven Polyester Geotextile c/w Min. 400mm Laps
6. 50mm Drain Rock or Rock of Equal Porosity
7. Maximum Groundwater Elevation
8. Non-polluted Drainage From Building or Terrace
9. Alternate Surface Route - With Splash Pad and Vegetated Swale to CB
10. CB Lid / Access Hatch for Cleanout, Inspection and Inflow / Overflow from Sump
11. Solid Pipe c/w Inlet Tee
12. Observation Well (Optional)
13. Provide pipe elbows to have outlet pipe invert at top of infiltration pipe
14. PVC Solid Pipe
15. Discharge to Storm Drainage System. Ensure Drainage Does Not Impact Neighbouring Uses. Direct Discharge to Road Right-of-way if Necessary
16. Infiltration Trench with Level Bottom
17. Catch Basin
18. Building Footing Drain (Not Connected to Infiltration Facility)
19. Building
20. 50mm Dia Drain Hole
21. Standard Manhole Frame and Cover
22. Seal Joints with Cement Grout or Approved Mastic
23. Street Inlet Connection
24. Ladder Rung
25. 25mm Crush Gravel or Drain Rock Base
26. Native Soil Back Fill
27. Undisturbed Ground
28. 1200mm Perforated Barrel (Langley Concrete or Equal)
29. Overflow to storm drainage system.