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Technical Memorandum

DATE: January 29, 2021

TO: Jen Moller, P.Eng., Manager of Land Development Engineering, District of West Vancouver

FROM: Laurel Morgan, P.Eng.
Chris Johnston, P.Eng.

RE: **DISTRICT OF WEST VANCOUVER**
Non-Single-Family Lot Redevelopment Rainwater Management Guidelines
Our File 409.091-300

1. Introduction

1.1 Purpose

The purpose of this memorandum is to provide the District of West Vancouver (District) with:

- methodology in assessing the impacts from redevelopment of a non-single-family lot;
- design criteria for redevelopment of a non-single-family-residential lot; and
- design guidance for permit application.

This information is intended to be used as a guide to facilitate submission and evaluation of stormwater management plans for redevelopment of all lots that zoning land use other than single family residential. A professional engineer specializing in stormwater management will be required to seal all calculations and drawings for each application.

1.2 Limitations

This guide is for non-single-family-residential redevelopment including multi-family, industrial, commercial, and institutional land uses. For redevelopment of single-family lots, refer to the *Single-Family Lot Redevelopment Rainwater Management Guidelines*.

This guide applies to a majority of the existing non-single-family lots in West Vancouver where redevelopment is proposed. However, in areas of geotechnical concern (i.e. lots next to ravines or geotechnically significant slopes, etc.), a professional geotechnical engineer should be engaged by the applicant to review the applicability of surface and sub-surface infiltration. Areas of geotechnical concern may include, but are not limited to:

- lots close or adjacent to ravines;
- lots with geotechnically significant slopes or where the surface grade will be modified or controlled by retaining walls that require design by a professional geotechnical engineer;
- lots with surficial or near-surface bedrock; and
- lots with defined or potential geohazards such as unstable fills or slopes.

The decision to engage a professional geotechnical engineer should be made by the Civil Engineer of Record for the site servicing plans. Even in areas of geotechnical concern and where a geotechnical engineer determines that infiltration is not advisable, detention tanks should be used to provide the required level of flow control.

In areas where an Integrated Stormwater Management Plan (ISMP) has been completed, the ISMP will define the on-lot stormwater management criteria if the ISMP criteria is more stringent than this guideline. This guideline will be a minimum standard for the District.

2. Stormwater Management Requirements

The basic requirements of these guidelines are listed as follows:

1. Prior to carrying out any development and/or redevelopment, [the applicant] must submit a stormwater management plan for the site and must obtain the District's written approval of the plan.
2. For any development and/or redevelopment, the stormwater management system must be installed according to the plan and may be inspected by the District prior to approval of permit.
3. The site stormwater management plan should include:
   - A site plan showing the following:
     - overall site showing property boundaries, lot dimensions and area;
     - location of the District's storm sewer connection;
     - **existing** development including all buildings, patios, walkways, decks, driveways, and other impervious surfaces as well as gardens, lawn areas, and undisturbed forest areas. Areas must be labeled and their footprint area must be calculated in square metres. Existing surfaces should be shown by dashed lines;
     - **proposed** development including all buildings, patios, walkways, decks, driveways, and other impervious surfaces as well as gardens, lawn areas, and undisturbed forest areas. Areas must be labeled and their footprint area must be calculated and noted in square metres;
     - Storage volume required as described in Section 4 complete with dimensions and calculation for storage volume and orifice;
     - proposed drainage facilities including locations of roof leaders, splash pads, storage tanks, rock pits, overflow locations, lawn basins, etc.
     - upslope interception ditches (if applicable) to protect property from surface runoff potentially draining onto site from upslope (Note: interceptor ditches can't be used to intercept groundwater or interflow);
   - Area calculation (square metres) showing the proposed change in connected impervious area.
   - Calculation of volume (cubic metres) and rate of runoff (cubic metres / second) from the **existing** site (excluding natural forested areas).
   - Calculation of volume and rate of runoff from the **proposed** development on the site (excluding natural forested areas).
   - Calculation of storage volume required as shown in Section 4 complete with orifice dimensions and calculation.

- Description, drawing, and sizing of the stormwater source controls to be used including any tanks, infiltration systems, rain gardens, and permeable pavements.
- If an infiltration facility is proposed for the site, supporting documentation must be submitted including:
  - Infiltration testing in the vicinity of the proposed facility and at the bottom depth of the proposed facility to determine the design infiltration rate used to size the infiltration facility.
  - Confirmation by a qualified geotechnical engineer that the proposed infiltration is appropriate and safe for the site based on the available information if there are any areas of geotechnical concern (see section 1.2).
- A description of the applicable Operations and Maintenance (O&M) requirements for the stormwater management system in accordance with the District's Development Bylaw.
- The submission must include drawings, calculation notes, graphs, and digital spreadsheets, as needed to document the sizing and design of the proposed on-lot stormwater management facilities. The submission shall be sealed by a Profession Engineer registered in B.C. and specializing in stormwater management.

3. Stormwater Management Criteria – Non-Single-Family Redevelopment

There are three design criteria required under these guidelines to adequately address the development and redevelopment of non-single-family lots:

- Detention Storage for Rate Control,
- Volumetric Capture, and
- Water Quality treatment.

Both rate control and volumetric capture criteria are needed because they serve separate goals for stormwater management for the District. Detention storage provides rate control for the protection of downstream infrastructure. Volumetric capture retains a portion of the rainfall onsite by infiltrating it into the ground (or storing and releasing it at very low baseflow-equivalent rates) and provides a reduction in the total flow discharged for protection of fisheries values in the receiving creeks.

Detention storage applies to the NEW impervious surfaces proposed in the redevelopment plan, i.e. the incremental increase in impervious cover for the proposed development vs. the existing developed condition. **Should no new surfaces be planned, no detention storage will be required.**

Volumetric capture applies to ALL surfaces on the redeveloped site. Water quality treatment applies to ALL vehicle-accessible ground impervious areas, such as driveways, parking lots and interior roads.

3.1 Detention Storage Criteria

For redevelopment of non-single-family residential lots, there shall be no net increase in the rate of rainwater runoff from existing conditions. Under no circumstances shall the runoff exceed existing conditions unless approved by the District. Existing conditions are defined as the state of the land prior to any alterations proposed or undertaken as part of a permit application. Existing conditions include mature forest cover, grass/gardens, and impervious and semi-impervious areas.

Redevelopment of a site shall include design to handle any runoff increase above existing conditions during the 10-year, 5-year, and 2-year return period storm events on-site. Only the natural, forested areas can be excluded from the runoff calculations in both the existing and proposed development calculations.

All sites shall have one or more storage facilities to assist in attenuating rainwater runoff flows for the 10-year, 5-year, and 2-year return period events to their pre-development flow rates under six design storm durations ranging from 1-hour to 24-hours. Methodology in sizing of a tank is provided in Section 4 of this document.

Exception: In an area where an ISMP shows that there is downstream storm pipe capacity for future developed conditions including climate change, AND the downstream outfall is to the ocean rather than to a creek, the District may choose to waive the requirement for on-site detention.

3.2 Volume Capture Criteria

In addition to the detention storage, a volumetric capture is required for each site. This criterion is required to mitigate against increasing erosion in creeks and watercourses caused by increasing impervious surfaces. It also minimizes the damage to the aquatic environment and improves water quality along the beaches of the District.

Development or re-development of a site shall include the necessary measures to infiltrate or re-use the target amount of rainfall that falls on the site in a storm event of up to 24 hours duration. Note: If the design engineer prefers to use a continuous simulation water balance methodology, the target can also be expressed as capturing 75% of the average annual rainfall amount.

The volume capture criterion shall be applied to all surfaces, not just the new impervious surfaces. Redevelopment of a site shall include the necessary measures to infiltrate or re-use the captured runoff, assuming dry conditions:

- Below El. 100 m
  - the first 35 mm of rainfall falling on im*pervious* surfaces; and
  - the first 50 mm of rainfall falling on *pervious* surfaces.
- Between El. 100 m and 400 m
  - the first 50 mm of rainfall falling on im*pervious* surfaces; and
  - the first 72 mm of rainfall falling on *pervious* surfaces.

Exceptions for volumetric capture:

1. Geotechnical Concerns: In areas of geotechnical concern (see section 1.2, above), a professional geotechnical engineer should be engaged by the applicant to review the applicability of infiltration measures. In these areas, the detention storage requirements may be increased to accommodate a slow release of the capture volume to the storm system. The capture volume may be released at a rate-of-discharge that is equal to the infiltration rate of the native soil times the lot area (see Section 5.1: Slow Release Capture Alternative)
2. Roof Leaders: Currently, the District has a mandatory roof leader connection policy where all roof leaders must be connected to the municipal storm drainage system. Consequently, any increase in roof area must be offset by a decrease in the surface level impervious areas, the use of infiltration / re-use measures, or increased storage and slow-release of runoff.

Section 5 outlines the acceptable analysis measures for volumetric capture.

3.3 Water Quality Criteria

The water quality target is as follows:

- treat the first 35 mm of rain in 24 hours from all vehicle-accessible impervious surfaces. The treatment requirement is 80 % removal of all particles down to 50 microns. The removal should be calculated on the basis of a 24-hour storm event rather than on an annual basis.

If the volumetric capture target for such surfaces is met via infiltration through soil, then the water quality target will also be met at the same time.

For any areas where the water quality target will not be met by infiltration of the capture target volume, the professional engineer must provide a separate treatment method for the runoff from vehicle-accessible impervious surfaces. For small areas, this could be settling through an inlet sump, or for larger areas this could be a structural separator unit.

4. Volume Sizing for Detention Storage

Volume analysis shall be performed using a version of the Rational Method as described in this document. All calculations shall be performed and sealed by the Professional Engineer. Selection of runoff coefficients for each surface must be clearly identified.

Alternatively, the stormwater professional may choose to model the stormwater runoff from the development using suitable hydrologic/hydraulic modelling software.

4.1 Rational Method Style Calculation

The volume of runoff for any given time step on smaller properties can be calculated using the formula:

Runoff Volume (cubic metres) = C * R /1000 * A **Equation 1**

Where

C = Runoff Coefficient (Table 1 below)
R = Rainfall amount over a time interval (mm)
A = Area (sq. m)

Note that Equation 1 uses rainfall amount in mm, not rainfall intensity.

The runoff coefficients are provided below.

Note: These coefficients differ slightly from those used for the traditional “Rational Method” calculation as they are used to calculate a volume rather than a peak instantaneous flow rate.

Table 1: Runoff Coefficient (C)

Surface	10 Year Runoff Coefficient
Driveway	0.95
Roof	1.0
Patio / Deck / Walkway / Artificial Turf[1] Areas	0.95
Lawn (existing development)	0.65
Proposed Lawn (400 mm Topsoil)	0.3
Proposed Gardens (400+ mm Topsoil)	0.3
Pervious Paving	0.5
Natural Woodlands/Mature Forest	0.2

Selection of runoff coefficients for each surface must be clearly identified.

Multiple surfaces can be added together by performing the above equation for each surface then adding the flows together to represent the entire lot area (including undeveloped areas).

By applying the above Rational Method Style formula (Equation 1) for each rainfall time step, a runoff hydrograph can be created for both the existing development scenario and the redeveloped scenario.

Note: the above equation and coefficients should only be used for sites less than 2,500 sq.m in size. The rational method will overestimate runoff volume on larger sites. For larger sites, the Professional Engineer should use a model that will calculate the runoff using a hydrograph method and state all assumptions for the model for the District's review.

4.2 Rainfall and Elevation Correction

Rainfall amounts for the runoff calculations are provided in Table 2. These depths are derived from a rainfall Intensity-Duration-Frequency (IDF) curve for Metro Vancouver's District of West Vancouver Municipal Hall (VW14) rain gauge. Table 2 is valid for site elevations less than 100 m geodetic elevation within the District of West Vancouver.

Table 2 lists rainfall amounts for design storms ranging from 1-hour to 6-hours.

For higher elevations, an elevation correction factor shall be applied to adjust the rainfall depth to reflect actual conditions. For non-single-family residential lots located at elevations ranging from 100 m to 400 m, a factor of 1.45 shall be applied to the rainfall depths. For higher elevations ranging from 401 m to 950 m, a factor of 1.9 shall be applied to the rainfall depths. This is defined in the target amounts shown for volume capture in section 3.2.

[1] If the subgrade is unduly compacted, there is an impervious liner, or there is a hard surface below the artificial turf, then the area must be treated as an impervious patio area rather than as a permeable area. Artificial turf may be used in a similar manner to pervious paving if and only if it is installed with the same care and consideration to ensure that the subgrade below the installation is permeable and allows natural levels of infiltration into the subgrade soil.

4.3 Determination of Detention Storage Volume Required

The Rational Style Method described above, or a suitable hydrologic/hydraulic model, shall be used to calculate the storage volume required to detain excess runoff from the proposed development or redevelopment. Excess runoff is defined as the additional peak flow that would be flowing from the site in development or redevelopment conditions that exceeds the peak flow from the site under existing conditions.

To use a detention spreadsheet method, the spreadsheet should calculate the amount of runoff leaving the site in both existing conditions and proposed redevelopment conditions and take the difference between the two conditions. Only the natural, forested areas can be excluded from the runoff calculations in both the existing and proposed development calculations. The calculations will be performed using a time step approach whereby the flow leaving the site is calculated in 5-minute time steps.

Note: This methodology is NOT the "Modified Rational Method" found in textbooks and other guidance and the "Modified Rational Method" is not acceptable as a substitute for sizing the required detention storage volume.

The calculation approach requires the following steps to be carried out:

- Calculate the volume released in each 5-minute time step by using Equation 1 to calculate runoff volume for the rainfall amounts provided in Table 2.
  - This calculation should be done for the 6-hour storm duration for the existing development scenario, which is the target release rate for the site.
  - This calculation should be done for each of the storm durations in Table 2 from the 1-hour to the 6-hour for the proposed development scenario.
- Size an orifice and detention tank volume that limits the release rate in each of the 4 storm durations in the proposed development condition to no more than the 6-hour peak runoff rate in the existing development condition.
  - The calculated orifice flow should be within 10% of the target release rate for the site.
  - The orifice size should be determined by matching the flow through the orifice to the target existing development release rate when the water level is at the maximum head (H_{max}) in the storage unit.
  - The release rate of the 10-year, 6-hour storm can not exceed 31.8 L/s/ha under any circumstances.
  - To determine tank sizing, a spreadsheet should be used to calculate the water level in the tank during the storm event. Five minute time intervals corresponding to the rainfall time series should be used to calculate the water level in the tank.
  - An iterative process should be used to determine the optimum tank size by assuming a tank footprint and height and calculating the maximum water level, and then doing the calculation again using the calculated tank sizing until the process does not generate a different tank size.
  - The maximum tank size calculated for the 1-hour, 2-hour, 4-hour, or 6-hour event shall be the design tank size for the proposed development.
- If runoff from parts of the lot cannot be directed to the detention storage tank, it is acceptable to include a bypass flow for this amount in the calculation of a release rate, providing:

  - The combined orifice flow from the storage tank and bypass flow from the remainder of the site cannot exceed the 6-hour existing development discharge flow for the site.
- To size the detention for multiple return periods, the sizing process should be repeated for the 5-year and 2-year events in addition to the 10-year event. The final detention size required will be the largest of the volumes determined for the three return periods.
  - Control of the 6-month event will be met by volumetric capture and sizing for detention for the 6-month event is not required.

In other words, the release rate from the storage tank through the orifice will be lower than the target release rate from the site.

This approach as outlined above will provide the tank and orifice size.

Detention is sized by this method for the incremental increase in impervious area on the site, however, the calculations for existing development and post-development conditions will be performed on the entire site (excluding only forested area that will remain unchanged) NOT the incremental difference in impervious area.

Figure 1 provides an example of what the results of this calculation process should look like for the 1-hour storm.

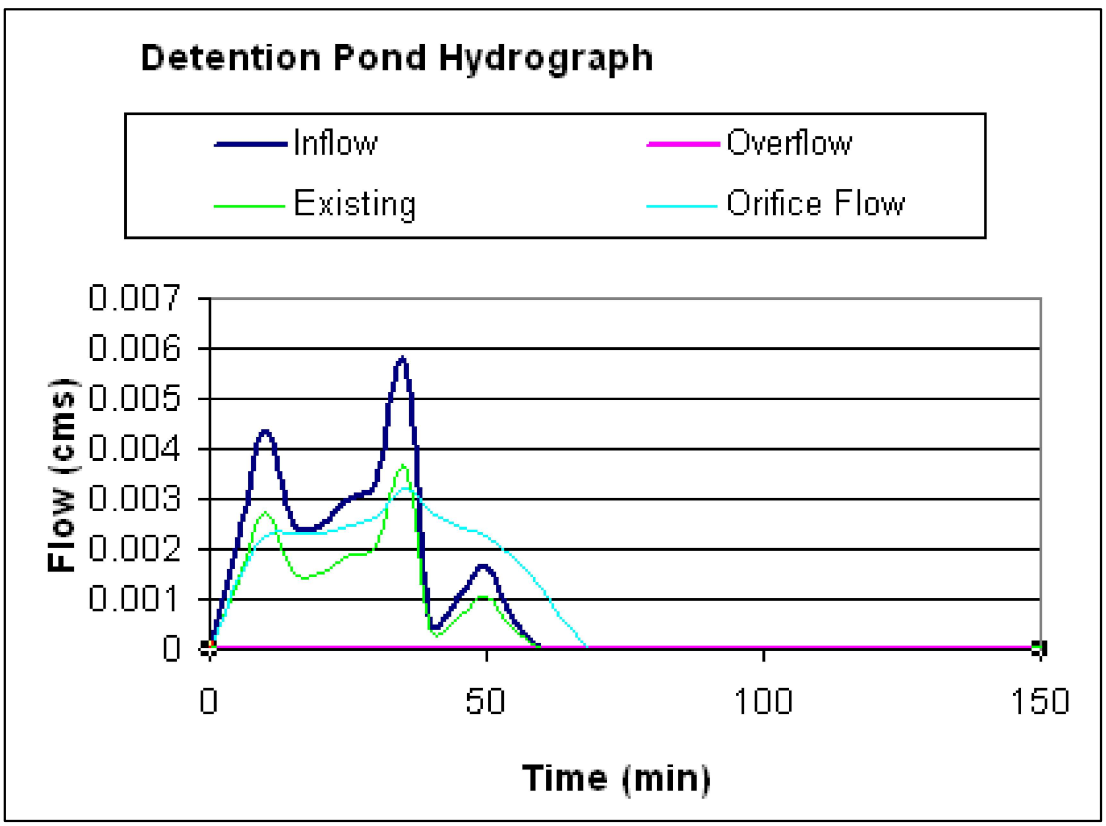

Figure 1: Example of detention pond hydrograph for 10-yr 1-hr storm

The Design Engineer must ensure all rainwater intercepted on site drains into the storage facility.

The storage facility will have an overflow outlet connected to the District's storm sewer or drainage system. The maximum hydraulic grade line (HGL) of the storage facility will be noted on the drawings along with the minimum building elevation. The minimum building elevation must be above the maximum HGL of the storage facility or there must be a backflow prevention device installed above the storage facility.

4.4 Orifice Outlet to Control Storage Release Rate

The Professional Engineer shall ensure that outlet flow from the storage facility is controlled to not exceed the allowable release rate (31.8 L/s/ha) by designing and sizing an orifice outlet to control outflows from the detention storage. The orifice shall be designed to be protected so as to avoid plugging by floatables and other materials. An access hatch shall be provided to maintain the orifice.

The release rate for the detention storage can be calculated using the standard orifice equation as follows:

$$\text{Release Rate } Q\ (m^3/s) = 0.6 \times \text{Orifice Area } (m^2) \times (19.62 \times H\ (m))^{0.5}$$ **Equation 2**

Where:

H = the height of water above the orifice centreline

The minimum size of an orifice will be 10 mm for the detention tank. Actual orifice size will be determined by an iterative process using the above calculations.

The easiest way to perform the above set of calculations is within a spreadsheet. As noted above, the calculation to size the orifice should assume the maximum head/water level in the tank. If a model is used to calculate the site runoff, the model may be used to size the orifice outlet for the storage volume.

In order to provide detention for all three design storm events, 10-year, 5-year and 2-year, the orifice sizing calculations should be performed for all three design storms. Multiple orifices, a compound orifice, or a non-circular shape outlet may been needed to create the desired outflow rates for the different design storm events using a combined storage volume.

The orifice shall be designed to be protected in such a way as to avoid plugging by floatables and other materials, e.g. by a wire basket that covers and holds debris away from the orifice. An access hatch shall be provided to clean out any debris and check and maintain the orifice.

4.5 Storage Facilities

The Professional Engineer shall select one or more storage facility (i.e., tank) that can detain stormwater on-site and limit runoff flows to not exceed existing conditions, using the methodologies described above.

The Professional Engineer must ensure all stormwater captured on site drains into the storage facility, or that bypass flows are accounted for in the sizing of the orifice and detention storage tank.

The storage facility will have an overflow outlet connected to the District's storm sewer or drainage system. The maximum hydraulic grade line (HGL) of the storage facility will be noted on the drawings along with the minimum building elevation. The minimum building elevation must be above the maximum HGL of the storage facility in order for the system to provide drainage by gravity only.

4.6 Pumping for Downslope Lots

For lots located downslope from the road and below the municipal storm drainage service line to which the lot will be connected, the proposed development will typically require a pump to lift the water up to the road and storm drainage service. If the grades allow, it is preferred to locate the pump upstream of the detention storage tank so that the tank drains by gravity to the municipal storm drainage service line and regulates the flow from the lot.

If it is not possible to achieve gravity drainage from the detention storage tank to the municipal storm service, then the pump may be located downstream of the stormwater detention tank, in a separate sump. The pump will have a higher rate of flow than the tank orifice outlet; it will cycle on and off and only be able to pump the volume of flow that is released from the detention storage tank.

4.7 Perimeter Drains

The sizing for the detention storage facility does not incorporate flow from the foundation perimeter drains. Perimeter drains shall not be connected to the storage facility. The surface collection system shall not be connected to the building footing drain system upstream of the storage facility as this could cause backflow into the perimeter drain system from the surface collection system. Flows from perimeter drains should be connected to the lot’s storm service line downstream of the storage facility.

5. Analysis and Methods to Meet Volumetric Capture Criteria

This section provides the background information available to guide the design of the measures required to meet the volumetric capture criteria. The designer is also referred to the supporting documentation: Metro Vancouver Stormwater Source Control Guidelines 2012. Together, these documents form the requirements for achieving the volumetric capture criteria.

The following capture measures are available: Pervious Paving, Infiltration System, Rain Gardens, Green Roofs, and Rainwater Harvesting (aka Purple Pipe system). The Stormwater Source Control Guidelines 2012 provides specifications, design details, and sizing criteria for Pervious Paving, Infiltration Trench and Soakaway Infiltration Swale System, and Rain Gardens. Requirements for Green Roofs will rely on specifications from system manufacturers and designers. Purple pipe systems must be designed in accordance with the BC Building Code and other applicable standards.

No surface runoff shall be allowed to flow on to neighbouring properties. All surface runoff must be intercepted. As well, all trenches, rock pits, and other underground conduits must be appropriately sealed to prevent uncontrolled groundwater or interflow from leaving the subject property at rates greater than pre-developed rates. This can be accomplished through the use of low-permeability trench dams.

Slow-Release Capture Alternative

In areas where infiltration facilities such as infiltration trenches and rain gardens are not allowed due to geotechnical concerns, the volumetric capture criterion may be met via storage of the capture volume in a tank and release at a baseflow-equivalent rate of 0.25 L/s/ha. This release rate will be lower than the release rate for the detention storage and a separate orifice will be required. If a single tank is used for detention and for slow-release of the capture volume, the slow-release capture volume must be stored below the detention volume (i.e., below the elevation of the detention volume orifice). This means that the slow-release orifice will also be constructed below the detention volume orifice.

5.1 Absorbent Landscape

All cleared and landscaped areas not covered with hard surfaces shall have a minimum of 400 mm of topsoil and will be terraced as much as possible to maintain vegetated areas of 2% slope or flatter.

Topsoil may be an existing growing medium that was removed during construction, stockpiled, and replaced on the site, or it may be imported topsoil. Where topsoil is imported, it must be shown to meet appropriate landscape standards for organic content (see MMCD "Properties for growing medium"), and the other requirements contained in the "Absorbent Landscape" section of the *Stormwater Source Control Guidelines 2012*. Existing and imported topsoil must have a minimum of 3.5 mm/hr infiltration rate.

Where disconnected impervious surfaces are directed to absorbent landscaping, the ratio of impervious surface area to absorbent landscaping area may not exceed 2 (i.e., a maximum ratio of 2:1).

5.2 Forest Areas

The Design Engineer shall make every effort to limit the reduction of forest cover as much as possible. Tree canopies of mature, existing forest trees are valuable for rainwater management on any site. For the purposes of this guideline, it is assumed that natural forested areas meet the volumetric capture target and no further action is required.

Forested areas cannot be used as treatment measures for runoff from impervious areas.

5.3 Driveways and Patios

If the existing driveway will remain intact and will not be modified in any way, no new measures are required. However, if the driveway surface is increased or the surface is re-constructed, the volumetric capture criterion will apply to the increased impervious area. Volumetric capture methods for driveways could include:

1. Re-direction of runoff to adjacent absorbent landscaping consistent with the requirements for absorbent landscaping, above,
2. Construction of the driveway using pervious paving techniques, such as permeable pavers, permeable concrete, or permeable asphalt,
3. Capture of runoff and direction of flow to a sump for settling and cleanout of sediment and debris followed by an infiltration trench, or
4. Where infiltration is not allowed due to the presence of near-surface bedrock or geotechnical hazard, the driveway runoff may be collected and directed to a sump for settling of sediment and then discharge to a slow-release tank.

Note that the above options are listed in order of preference for water quality treatment of driveway runoff to remove pollutants prior to the runoff entering either an infiltration system or the municipal storm drainage system.

Patios, walkways, and other on-lot impervious surfaces should be sloped to drain to adjacent absorbent landscape areas wherever possible. For large patio areas, a rain garden could be used to provide storage and infiltration of runoff from a patio in a smaller footprint area than absorbent landscaping. If the runoff from patio and walkway areas cannot be directed to adjacent landscaping or a rain garden, then options 2 through 4 listed above for driveways may be used.

5.4 Roof Leaders

Currently, the District requires that all roof leaders must be directly connected to the municipal storm sewer system. This means that the roof leaders must be directly tied to the proposed storage tank and roof runoff cannot be distributed at the surface to be infiltrated into the ground. In order to meet the volume capture target, any increase in roof area must be offset by the reduction or disconnection of ground surface impervious area or the use of the "slow-release capture alternative".

5.5 Parking Lots

Runoff from surface parking areas should be directed to treatment systems. This may take the form of:

- Underground structural treatment units or
- Treatment rain gardens with or without infiltration

Parking areas may be constructed of permeable paving as an alternative, however the property owner must commit to maintaining the permeable paving to retain its permeable capacity.

Runoff from the incremental increase in impervious area must also be captured.

5.6 Infiltration Systems

Direct connection of any ground level impervious surfaces to infiltration trenches (rock pits) and rain gardens is prohibited. Water entering an infiltration trench or rain garden from ground level impervious surfaces must first flow overland through pervious vegetation (minimum travel length 4.0 m).

Infiltration trenches and rain gardens shall be designed with the following features:

- A minimum 600 mm diameter sump c/w 500 mm (minimum) sediment trap and floatables protection must be installed upstream of the infiltration trench. Floatables protection shall be accomplished using a 150 mm diameter tee on the outlet connection.
- A perforated drain shall be installed at the top of the rock layer below the growing medium and must be connected directly to the storage facility;
- The base of the rock layer cannot be more than 2 m below the ground surface;
- Appropriate filter fabric shall be used on the top of the infiltration trench to prevent migration of fines from the topsoil layer (growing medium) to voids in the rock material; and,
- Infiltration testing of native sub-surface soil conditions should be carried out in the area of the proposed infiltration trench. **Under no circumstances will an infiltration trench or rain garden be designed to exfiltrate more than 3.5 mm/hr.** Infiltration trenches and rain gardens must be constructed in native material and cannot be bisected by utility trenches or highly permeable soils. In cases where this cannot be avoided, trench dams comprised of low permeability material can be used to prevent the trench from exfiltration at rates greater than 3.5 mm/hour.

In some cases, blasting of the bedrock may be required to allow for the construction of the storage layer. Raising the ground elevation with imported fill is also acceptable provided that the fill material does not allow the infiltration to exceed 3.5 mm/hr. This will require a lower permeability fill material.

6. Greenfield Development Considerations

There are limited areas of the District where greenfield development is occurring or planned to occur. In these areas, the application of stormwater management will differ from the re-development situation.

In particular, in areas served by flow diversions intended to protect the receiving creeks from increased flows due to development, the detention storage requirement does not apply. This assumes that the diversion is diverting flows from the storm sewer network before the increased flows enter and impact the creeks.

Even where there are diversions to mitigate the increase in flow, volumetric capture must be applied to the development lots and to the same level as specified in Section 3.2.

Water quality improvement must be applied for all on-lot vehicle-accessible surfaces such as driveways and surface parking lots.

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Attachments: Table 2

Statement of Limitations

Table 2: Rainfall Amounts

Time (minutes)	10-yr 1-hr Rain (mm)	10-yr 2-hr Rain (mm)	10-yr 4-hr Rain (mm)	10-yr 6-hr Rain (mm)
0	0.00	0.00	0.00	0.00
5	1.53	0.00	0.00	0.00
10	3.06	1.11	0.00	0.00
15	1.72	1.11	0.00	0.00
20	1.72	2.21	0.72	0.00
25	2.10	2.21	0.72	0.00
30	2.29	1.24	0.72	0.50
35	4.01	1.24	0.72	0.50
40	0.38	1.24	1.44	0.50
45	0.76	1.24	1.44	0.50
50	1.15	1.52	1.44	0.50
55	0.38	1.52	1.44	0.50
60	0.00	1.66	0.81	0.58
65	0.00	1.66	0.81	0.58
70		2.90	0.81	0.58
75		2.90	0.81	0.58
80		0.28	0.81	0.58
85		0.28	0.81	0.58
90		0.55	0.81	0.83
95		0.55	0.81	0.83
100		0.83	0.99	0.83
105		0.83	0.99	0.83
110		0.28	0.99	0.83
115		0.28	0.99	0.83
120		0.00	1.08	0.41
125			1.08	0.41
130			1.08	0.41
135			1.08	0.41
140			1.89	0.41
145			1.89	0.41
150			1.89	0.58
155			1.89	0.58
160			0.18	0.58
165			0.18	0.58
170			0.18	0.58
175			0.18	0.58
180			0.36	1.16
185			0.36	1.16
190			0.36	1.16
195			0.36	1.16
200			0.54	1.16
205			0.54	1.16

Time (minutes)	10-yr 1-hr Rain (mm)	10-yr 2-hr Rain (mm)	10-yr 4-hr Rain (mm)	10-yr 6-hr Rain (mm)
210			0.54	0.74
215			0.54	0.74
220			0.18	0.74
225			0.18	0.74
230			0.18	0.74
235			0.18	0.74
240			0.00	0.83
245				0.83
250				0.83
255				0.83
260				0.83
265				0.83
270				0.74
275				0.74
280				0.74
285				0.74
290				0.74
295				0.74
300				0.74
305				0.74
310				0.74
315				0.74
320				0.74
325				0.74
330				0.58
335				0.58
340				0.58
345				0.58
350				0.58
355				0.58
360				0.58
365				0.58
370				0.58
375				0.58
380				0.58
385				0.58
390				0.00