787-14

Rosario Resort Redevelopment
TPN 160621001

Stormwater Site Plan (SSP)

3231 Olga Road
Orcas Island, WA

October 2015

Rosario Signal LLC
c/o Nels Strandberg
PO Box 319
Anacortes, WA 98221

EXPIRES:

HART PACIFIC ENGINEERING
PO Box 3287, Friday Harbor, WA 98250 Ph. 360-378-7048
PO Box 124, Eastsound, WA 98245 Ph. 360-376-3996

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P.O. Box 3287, Friday Harbor, WA 98250 Ph. 360-378-7048
P.O. Box 124, Eastsound, WA 98245 Ph. 360-376-3996

Stormwater Site Plan
Rosario Resort Expansion

The Stormwater Site Plan presented in this report conforms to the requirements of the Washington State Dept. of Ecology's *Stormwater Management Manual for the Puget Sound Basin*, (SWMM February 2005). The plan includes a description of existing and proposed land use conditions, an analysis of downstream impacts due to development, and a drainage plan for the subject property. The structure of this report is based on the required elements for Stormwater Site Plans that are outlined in SWMM Volume I, Chapter 3, page 3-1.

The Unified Development Code for San Juan County (UDC), which outlines the storm drainage standards for the County, incorporates the *Stormwater Management Manual for the Puget Sound Basin*, (Washington State Dept. of Ecology, Feb, 1992) by reference in Section 6.7. The successor manuals to this manual were published in August 2001 and February 2005 (SWMM) and are now authorized for use in the county. The SWMM was used to determine standards for the design and implementation of best management practices (BMPs) for stormwater control and treatment at this site.

According to San Juan County Community Development and Planning Department policy 09-002 issued 11/18/2009 the thresholds for determining which minimum requirements apply to the project will be based on the additions of impervious surfaces and the area of land disturbed *in the previous 2 years together with the proposed development*. Existing impervious surfaces and land disturbed at an earlier date will not be added to the proposed to determine which requirements apply.

The plans presented herein have been based on proposed development plans provided by the property owner and are shown on the accompanying drawings. This plan is being submitted for approval. If final development of the property differs in any significant way from the scheme presented here, the drainage plan should be reevaluated by a qualified professional and revised accordingly.

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1. Project Overview

The general vicinity of the property is shown on Figure 1. The property consists of approximately 14.9 acre of property located on the east side of Orcas Island about 5 miles east of the Eastsound Village. Access is off the end of Rosario County Road. An aerial photograph from the Assessor's website showing the existing condition and the topography of the site is shown on Figure 2. Please refer to the Proposed Development Plan prepared by GCH consultants, below. Under the proposed plan 8 existing buildings will be demolished and replaced with 19 single unit Hotel Cottages, 7 four-plex units, an eight-plex building, 2 Cliffhouse Ct. Houses, Rosario Mansion improvemnts, Mansion Pool and Terrace, 12 Marina Village Cottages, 3 Marina Village West Condo buildings, a new Marina Village Cabana building with outdoor pool, a grocery / office, Marina Village East Condos building, 3 Bowman Bluff units, a fish ladder and a lighthouse. The Marina improvements are not included in the scope of this Stormwater Plan. The plan layout is shown in more detail in Development Plan Figures 3.1, 3.2, 3.3 and 3.4 below. Parking areas will be provided for the buildings as well as cart pathways to serve the Rosario Resort property. A tabulation of impervious surfaces and converted areas created under this project is provided in the table below. The areas listed for each unit include roofs, decks, walkways and all impervious surfaces associated with the planned unit development.

The project will include an estimated 1' to 4' cuts to create each building site, and imported gravel will be need for structural fills, utility work and road building. We have done a preliminary estimate of the earthwork for this project and expect a total of 5500 cy of stripping and haul away, 11000 cy of onsite cuts and fills and 18000 cy of imported gravels. The local gravel pit will be the source for haul-away and imported gravels. The first phase of the project is currently planned for construction in 2016 through 2018. Existing contours have been provided for the building sites, and preliminary finish grades established for buildings and roads, but a formal grading plan with proposed contours has not be prepared at this time. The clearing limits provide maximum limits of grading work.

A summary of impervious surfaces and converted areas created under this project is provided in the table below.

Table 1 – New and Converted Surfaces After Development

Converted Surface	All Basins
Gravel road and parking areas (PGIS)	60011 sf
Roof Areas†	92080 sf
Decks, patios, and sidewalks	58833 sf
Total Impervious Surface	210924 sf
Total clearing and grading area – max. limits	8.79 AC
Forest converted to lawn & landscaping (PGPS)	30000 sf

† Horizontal projection

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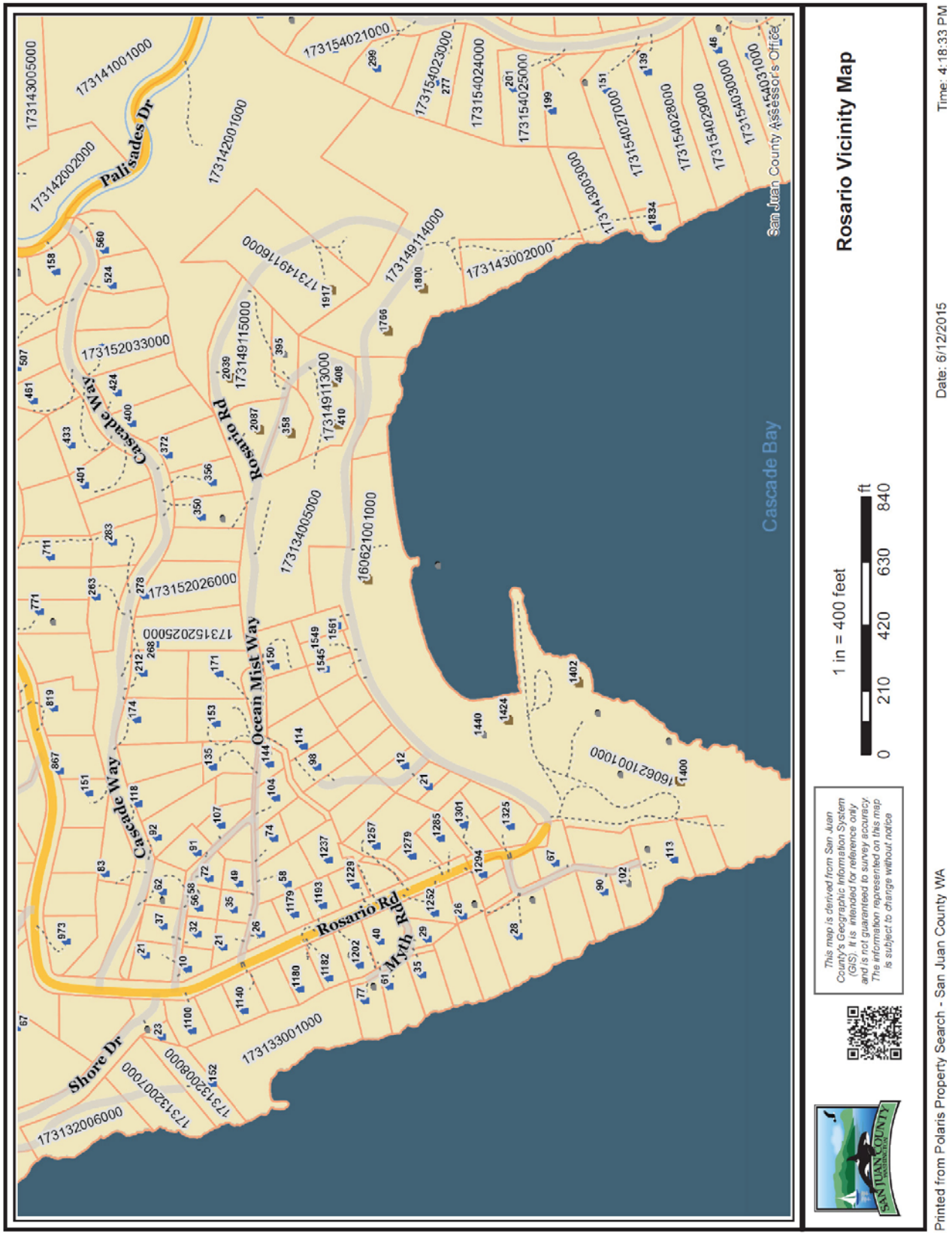

Figure 1 – Vicinity Map, 1400 Rosario Rd.

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Figure 2.3 Existing Conditions

2. Existing Conditions Summary

The existing condition of the property is shown on Figure 2.1, 2.2 and 2.3. The site includes five major drainage basins which flow into directly into Cascade Bay. The site has been developed as a residence and then a resort over the last 100 years. Much of the site has been previously disturbed and cleared to provide open lawn and parking areas. Much of the site parking would be reduced and / or relocated as part of the renovation. The site is generally rocky with shallow soils, but some deeper soils are expected in the Bow Tie Pond area. An Archaeological Assessment report was completed for the site by Cascadia Archaeology dated 10/30/14 that indicates that there appears to be intact as well as disturbed cultural deposits present at the site, and makes recommendations in order to manage the excavation work to minimize possible impacts.

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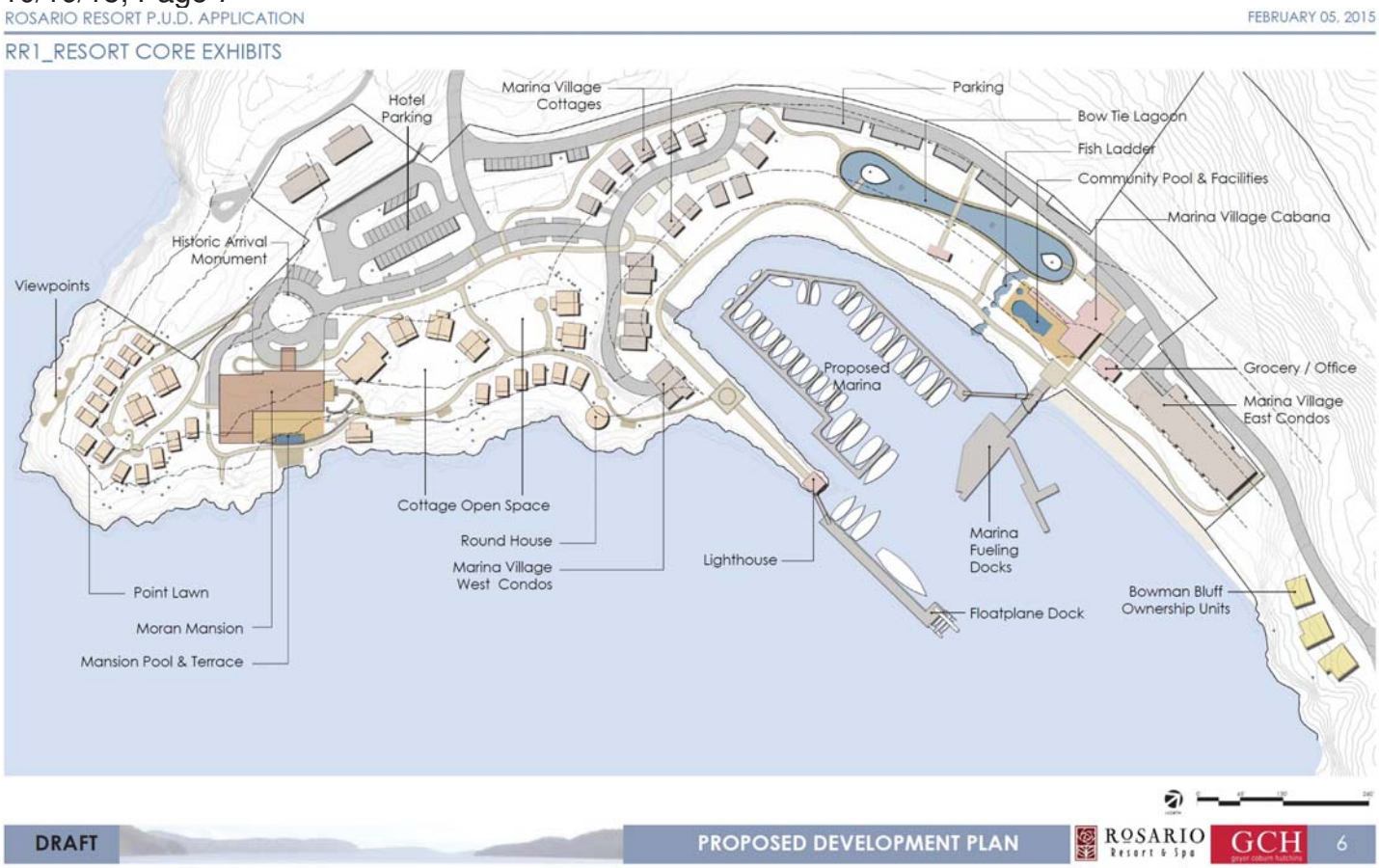

GCH – Development Plan (insert 11x17)

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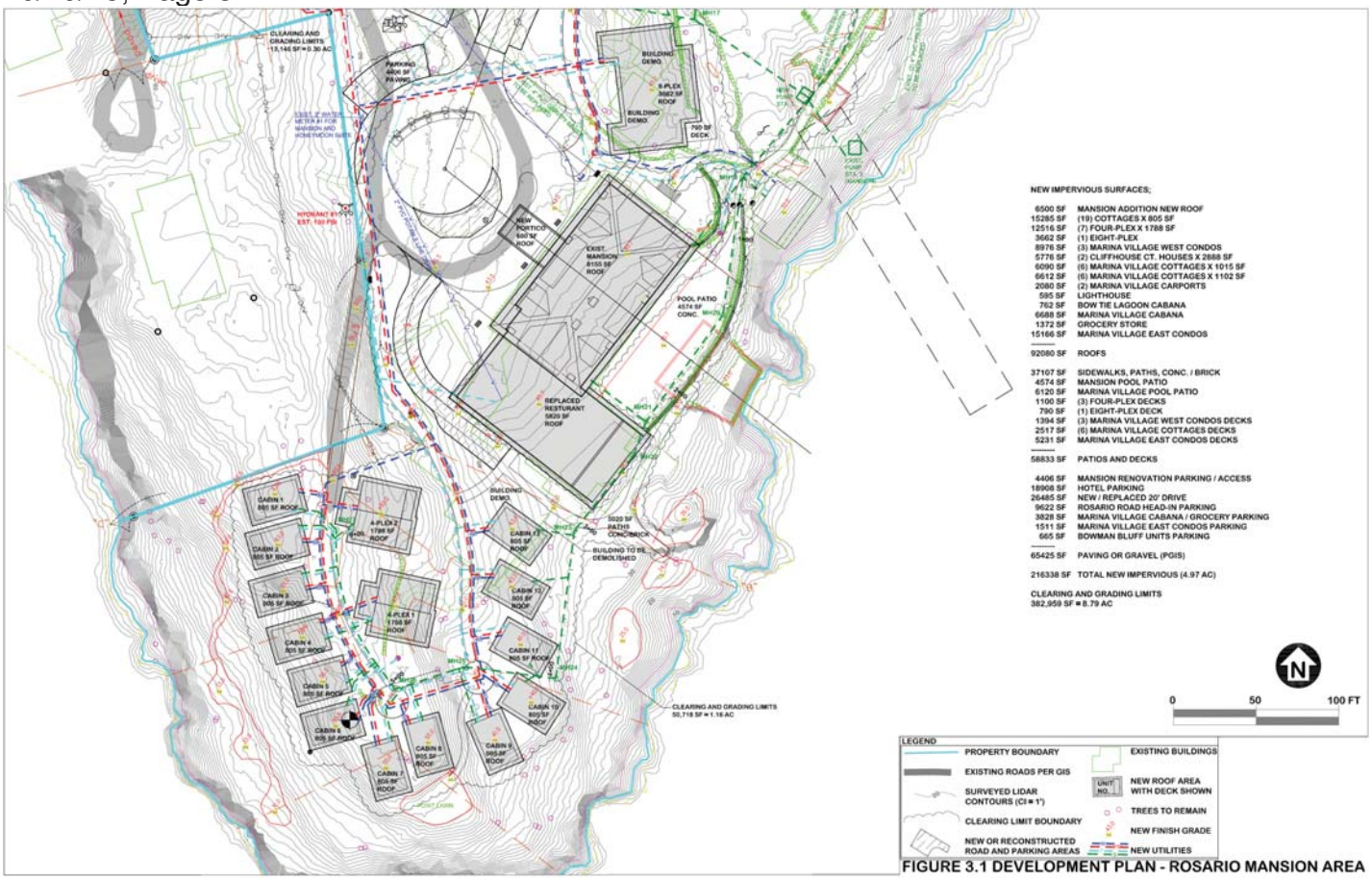

Figure 3.1 – Development Plan (insert 11x17)

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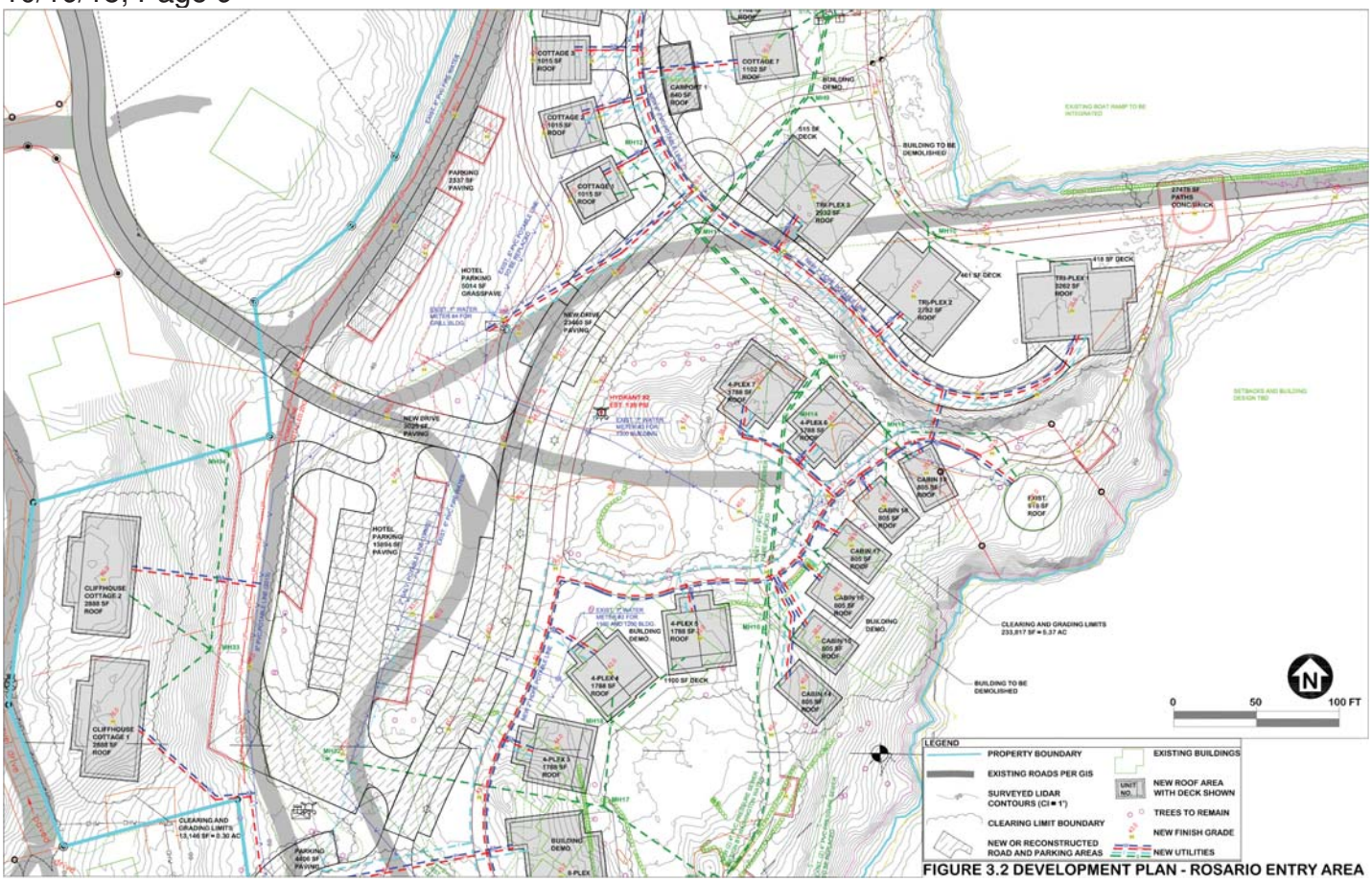

Figure 3.2 – Development Plan (insert 11x17)

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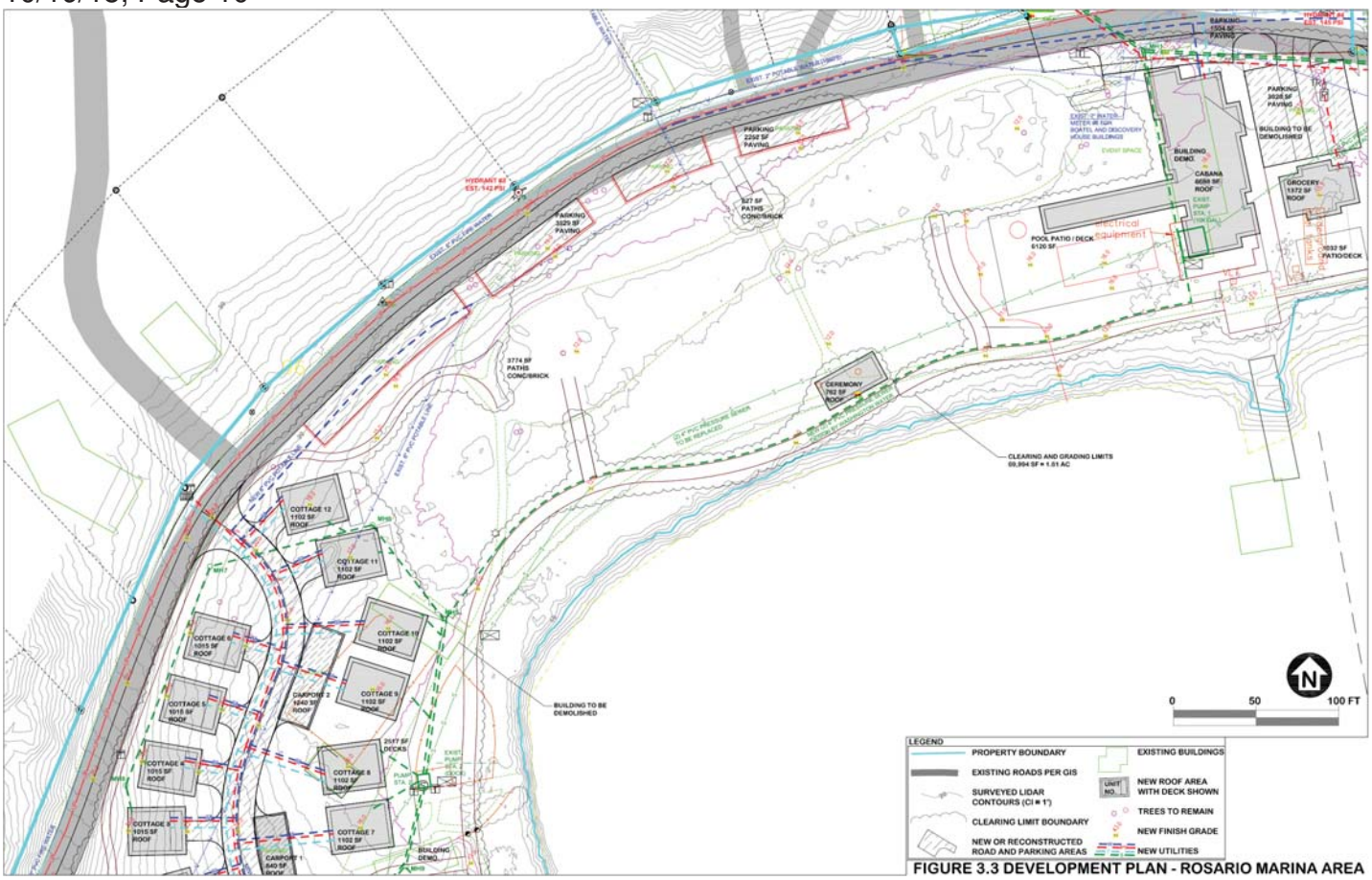

Figure 3.3 – Development Plan (insert 11x17)

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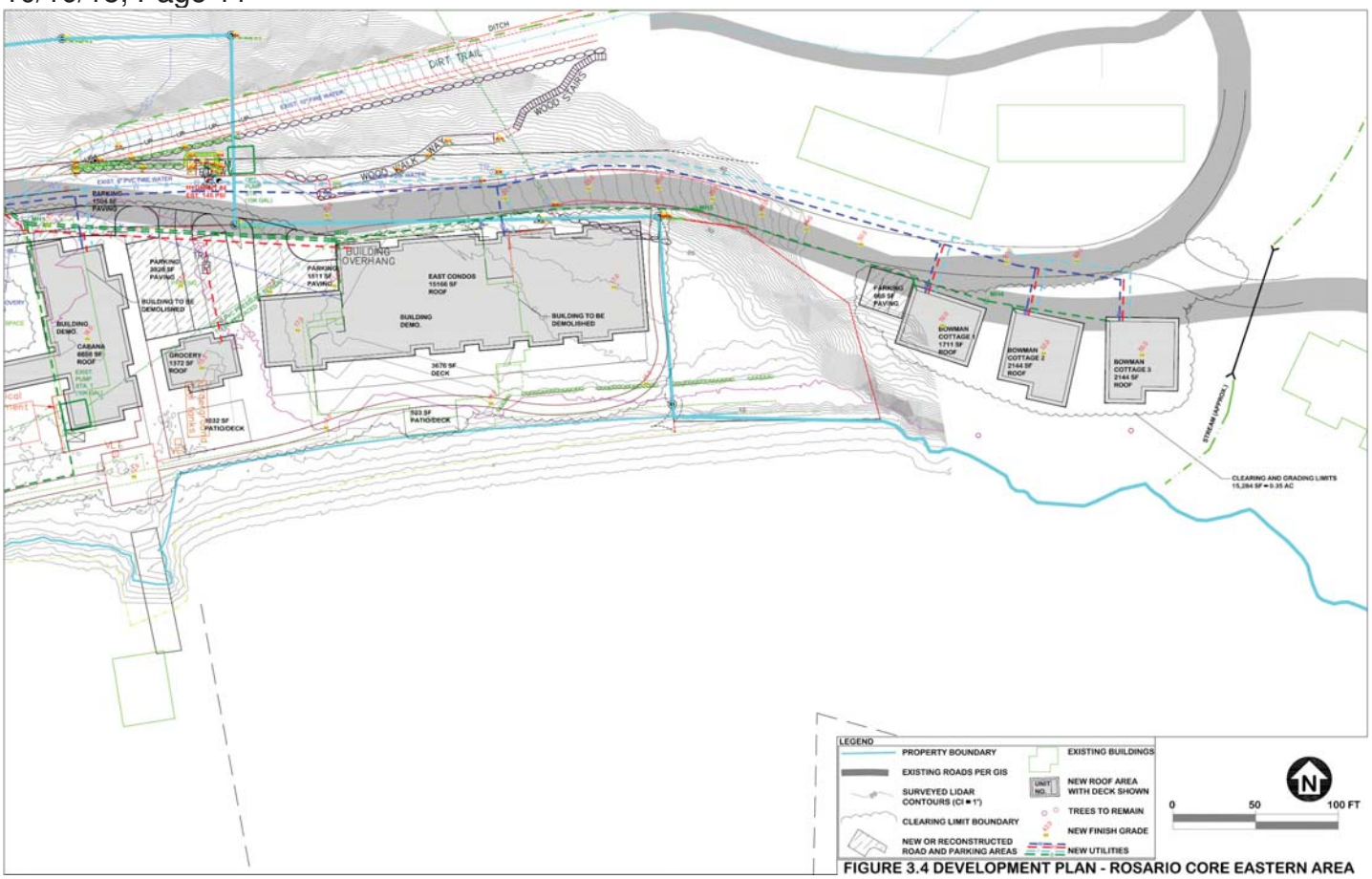

FIGURE 3.4 DEVELOPMENT PLAN - ROSARIO CORE EASTERN AREA

Figure 3.4 – Development Plan (insert 11x17)

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Site Soil Characteristics

Figure 4 presents a map of the soil types in the vicinity of the project site. The soils covering the property are classified by the SCS Soils Survey of San Juan County as Rock Land and Pickett Rock Outcrop soils. The types mapped by the SCS for the property include PrD (Pickett Rock Outcrop, 0 to 30% slopes) and PrE (Pickett Rock Outcrop, 30 to 70% slopes). According to the SCS the Pickett series soils belong to hydrologic group C. This soil is generally not well suited for infiltration and does exhibit a high rate of runoff and potential for erosion due to thin soil layers over rock.

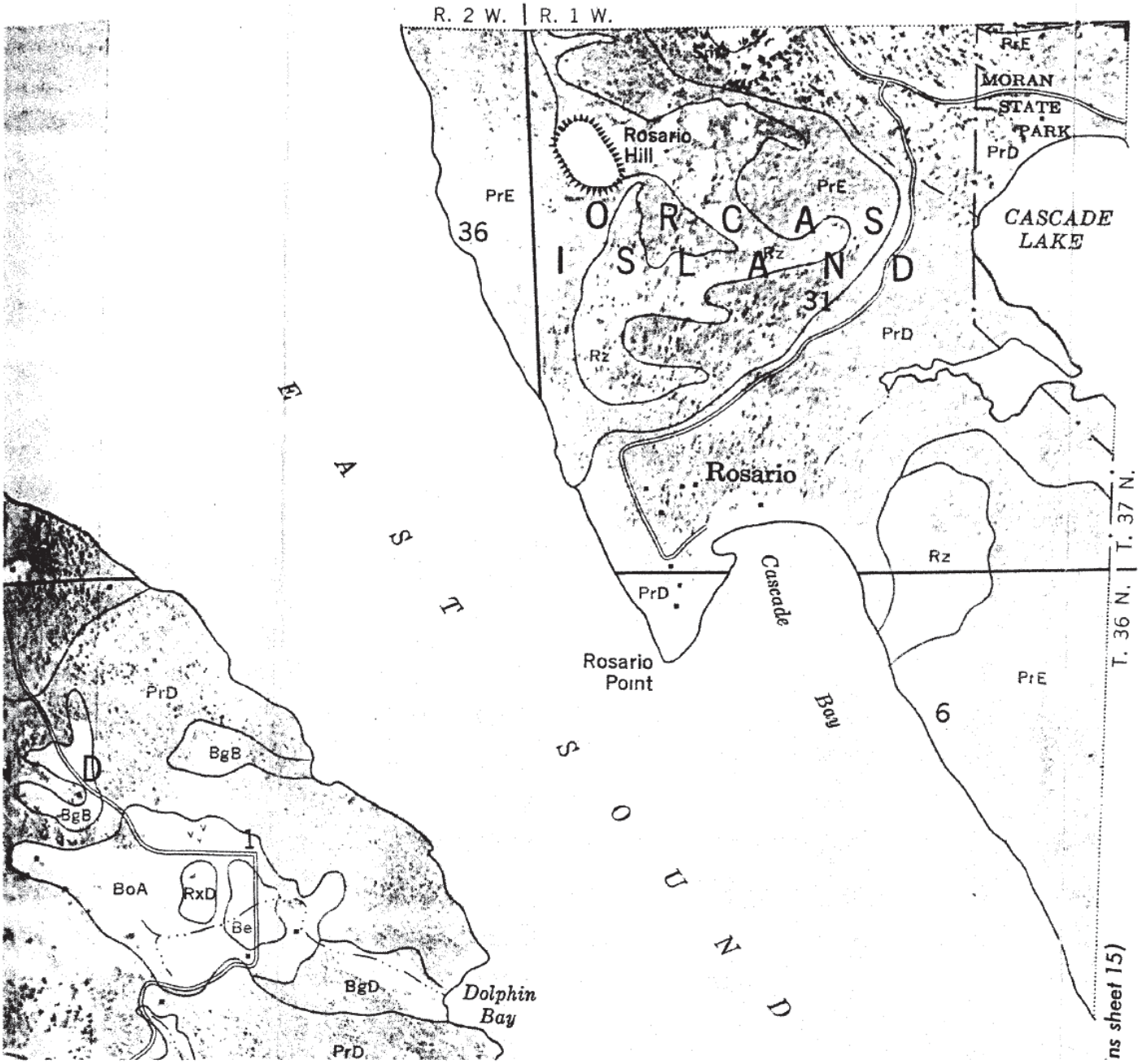

Figure 4 – Soils Map

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3. Offsite Analysis Report

Figure 5 provides a drainage basin map for the project area. The map which is based on the USGS 7.5 minute series shows the general stormwater drainage routes in the vicinity of the site, contour interval is 5'. As shown in the Proposed Development Figures 3.1 to 3.4, surface runoff from the property includes multiple discharge points located in several basins. Each of these basins can be considered to represent a separate threshold discharge area since each provides a different flowpath from the development site which does not join within ¼ mile of the site with any other prior to discharge into the receiving waters of the state (per the SWMM definition for separate threshold discharge areas). The upstream and downstream flowpaths are characterized below;

Basin R1:

Refer to Figure 5 for the boundary of Basin R1 which is estimated at 1.2 acres. Flow from this basin is limited to the Rosario Mansion roof and a small upstream area from the west. The flows are collected in catch basins near the entrance to the Mansion and flows are combined along the north side of the building and piped to the sea via an existing 6" outfall pipe in a well vegetated area with rocks below.

Basin R1 Rosario Mansion 6" outfall, looking east.

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Basin R2:

Refer to Figure 5 for the boundary of Basin R2 which is estimated at 3.9 acres. Flow from this basin is mostly on Rosario property and includes three residences to the west. Upper sheet flows concentrate as they flow to the east following the road that leads out to the jetty. A low area is under the Cascade Bay Grill and small catch basins appear to direct flow to a 6" outlet pipe which was observed to be flowing significantly in my April 2015 site visit, with no signs of erosion along the shoreline.

Existing outfall for Basin R2 into the marina, thought to be 6" dia., located under building in line with photo, with outlet in rock area.

Basin R3:

Refer to Figure 5 for the boundary of Basin R3 which is estimated at 5.9 acres. Flows from Rosario County Road and about 5 residences flow to the east and cross Rosario Private Road where the flow sheets across the grass area leading down to the Community Pool. There does not appear to be a concentrated outfall and the flows likely infiltrate into the soils near the marina. As this area is developed we plan to collect the runoff and direct it into a new combined outfall for basin R3 and R2, in order to avoid possible flooding in the low areas.

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Basin R4:

Refer to Figure 5 for the boundary of Basin R4 which is estimated at 37.1 acres. Flows from this basin originate at the centerline of Rosario County Road and include mostly built-out residential area. Both Cascade Way and Grove Street gravel plat roads have shown erosion and potholing problems which can be a source of sediment coming through the site. The flow crosses Rosario Private Road with a recently installed 6" PVC culvert pipe. Also, water flows over the road in the area north of the Bowtie Pond which experiences seasonal minor flooding. New catch basins are proposed to help collect these surface flows and direct them into the pond. The pond outlet is 6" dia. and discharges along the rocky shoreline. The flow capacity of the Rosario Private Road culvert has not been evaluated as part of this study, but it likely should be increased to handle upstream flows. Conversion of the pond to a fish hatchery is proposed along with a fish ladder which can be designed to properly handle the basin flows. A 6" dia. bypass pipe with flow splitting device is also installed entering into the north east corner of the pond that allows bypass flows from Cascade Lake from the hydropower plant outflow which normally outflows in the 24" concrete box culvert at the bottom of Basin R5.

6" culvert under Rosario Private Road, looking north.

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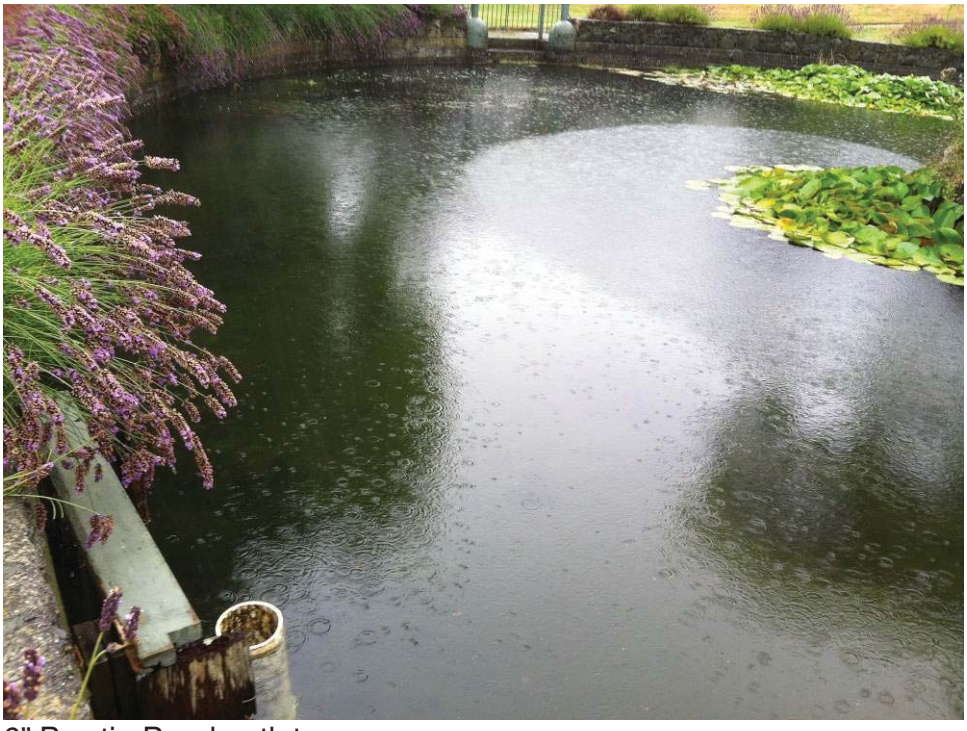
Minor area flooding near Bowtie Pond



6” Bowtie Pond outlet

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Basin R5:

Refer to Figure 5 for the boundary of Basin R5 which is estimated at 41.5 acres. This basin begins at Tomihi Road and includes a residential area above and below Rosario road. Refer to Figure 5. Flow from the upper area is intercepted by Rosario County Road crossing with a 12" culvert then flows south in ditches through private properties down to the vicinity of the hydro-power plant at Rosario, near the north end of the Boatel Building, where it is collected into the catch basin that flows out in the 24" concrete box culvert. There is some ponding and minor flooding in the parking area for the Rosario Beach House Building. Another culvert is located under a portion of the Beach House which is 12" diameter and discharges over the concrete seawall. We plan to abandon the Beach House culvert when the building is replaced by the new East Condo Building and send the flows to the 24" concrete box culvert.

12" culvert under the Beach House, to be abandoned, looking north.

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24” concrete box culvert outlet to Basin R5, looking south at the pier.

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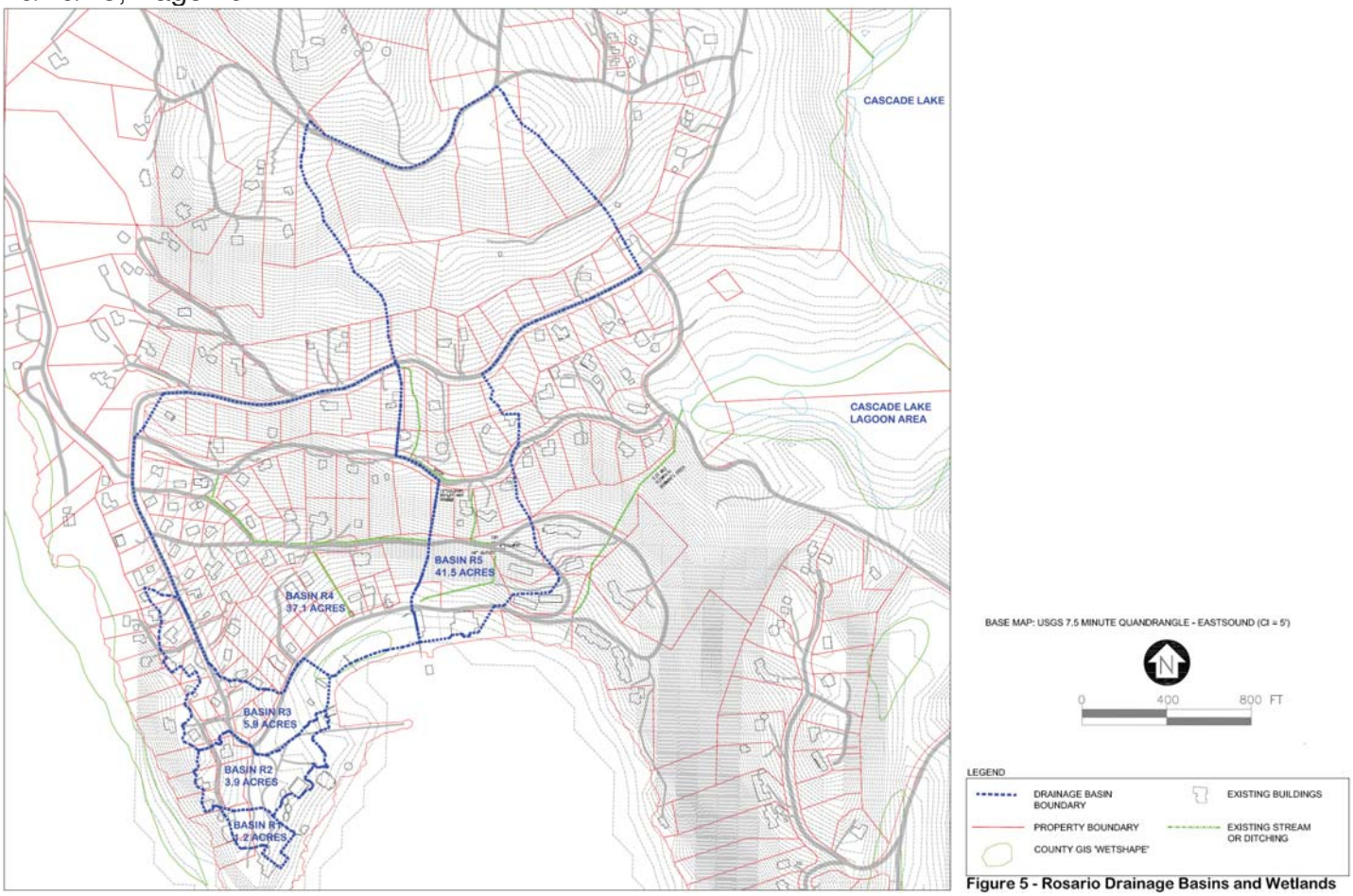

Figure 5 - Rosario Drainage Basins and Wetlands

Figure 5 – Basins and Wetlands (insert 11x17)

4. Applicable Minimum Requirements

The 2005 Dept. of Ecology Stormwater Management Manual (SWMM) sets out the minimum stormwater documentation and design requirements for all new development and redevelopment projects depending on the size of the project. The minimum requirement thresholds for this project are as follows:

1. Projects proposing less than 2000 square feet of new plus replaced impervious surface must meet SWMM requirement #2.
2. Projects proposing more than 2000 sf but less than 5000 sf or have land disturbing activity of 7000 sf or greater are required to meet SWMM requirements #1 through #5.
3. Projects proposing 5000 sf or more of new impervious surface, converts ¾ acres, or more, of native vegetation to lawn or landscaped areas, or converts 2.5 acres, or more, of native vegetation to pasture are required to meet SWMM requirements #1 through #10.

The development planned for this property is shown in Figure 3. The total area converted to landscaping and impervious surfaces for this project are tallied in Table 1. The plan for this property includes 210,924 sf of new or replaced impervious surface. The level of development planned for this site falls into the threshold limits specified under category 3 above. Therefore, the development must comply with SWMM requirements #1 through #10. The SWMM requirements for this site are evaluated and summarized below.

Minimum Requirement #1: Preparation of Stormwater Site Plans

This drainage plan shall satisfy the requirement for a stormwater site plan. This report is intended to satisfy that requirement and has been prepared in accordance with Chapter 3 of the SWMM.

Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP)

This is a requirement for implementing erosion and sediment control measures during construction. Hart Pacific Engineering has yet to prepare a SWPPP for this project, since this is expected to be constructed in phases. We expect a SWPPP will be prepared and submitted for approval for each building phase.

Minimum Requirement #3: Source Control of Pollution

This is a requirement to provide controls to prevent stormwater from coming into contact with pollutants. This site development includes the construction of residential units, and gravel drive and parking areas, which do not require source control.

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

This is a requirement to maintain historical natural drainage patterns for the site, if possible. No new channels to divert stormwater runoff are proposed for this site, except to avoid flooding or the construction of buildings. The dispersion BMPs proposed for this development will help to minimize erosion and flow capacity impacts.

Minimum Requirement # 5: On-site Stormwater Management

This is a requirement to employ appropriate permanent on-site stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible. Appropriate BMPs will be used for this project. See Figure 6 and Item 5 below for a description of the elements of the Permanent Stormwater Control Plan for this project.

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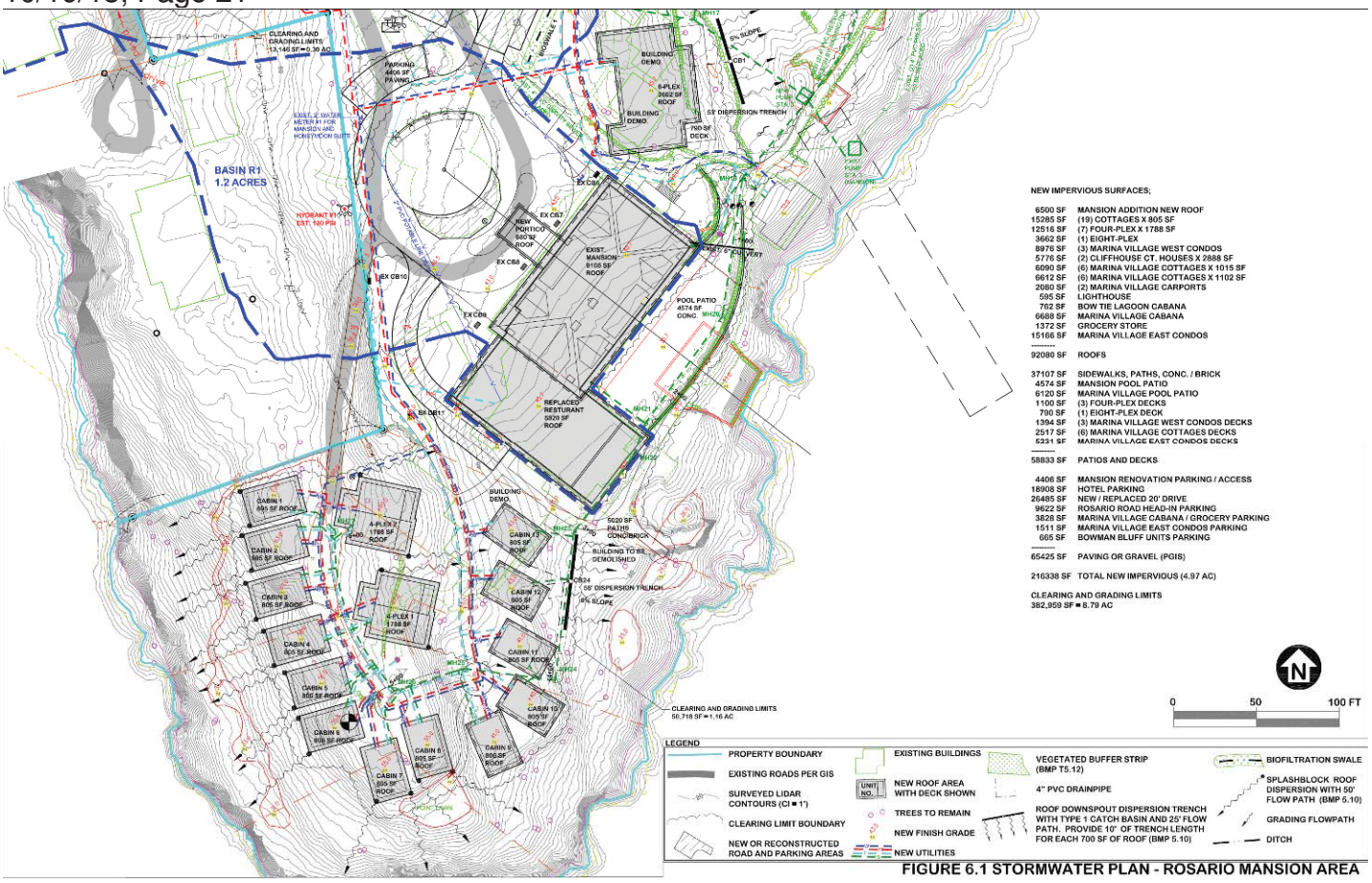

Figure 6.1 – Stormwater Plan (insert 11x17)

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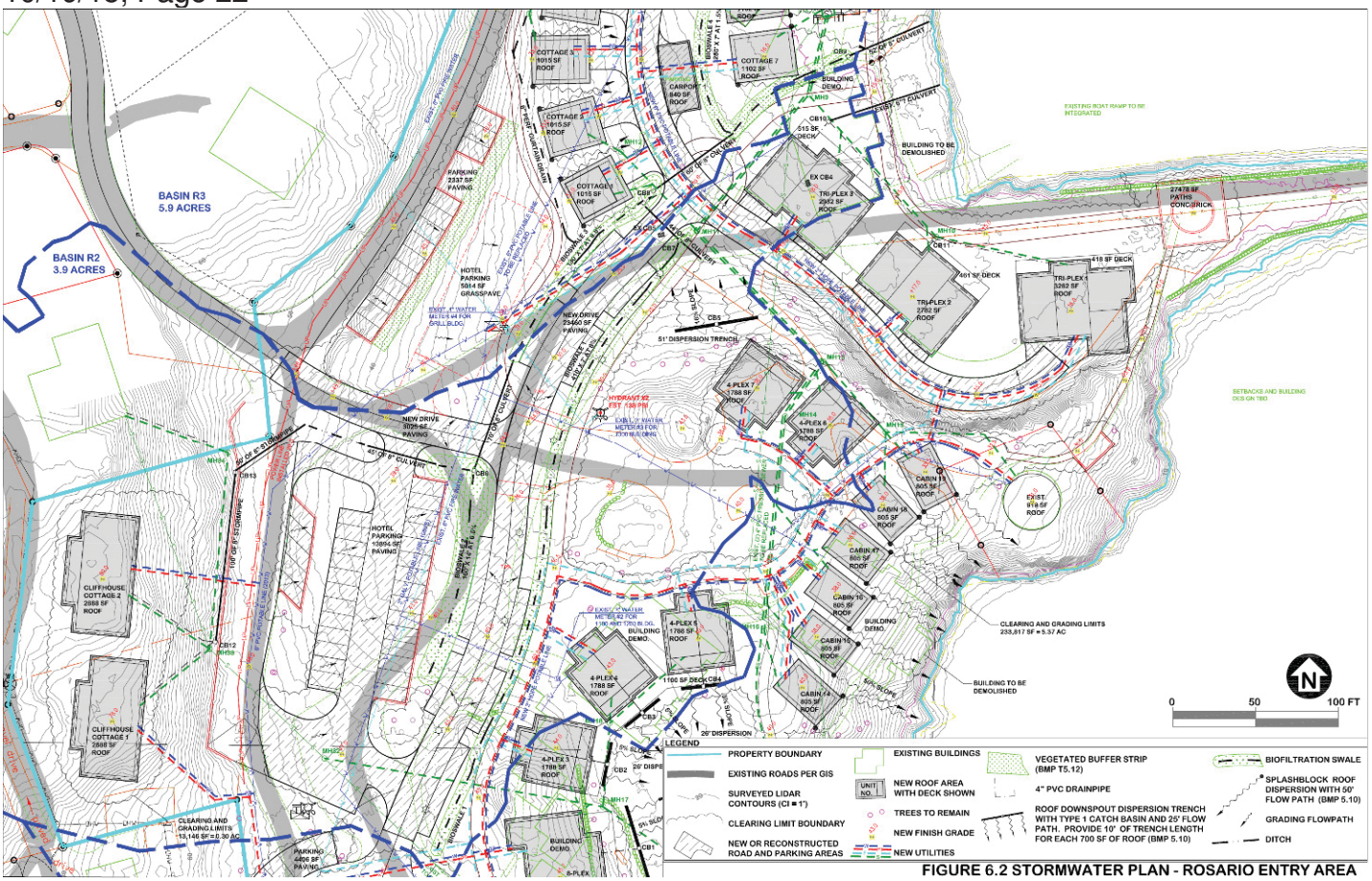

FIGURE 6.2 STORMWATER PLAN - ROSARIO ENTRY AREA

Figure 6.2 – Stormwater Plan (insert 11x17)

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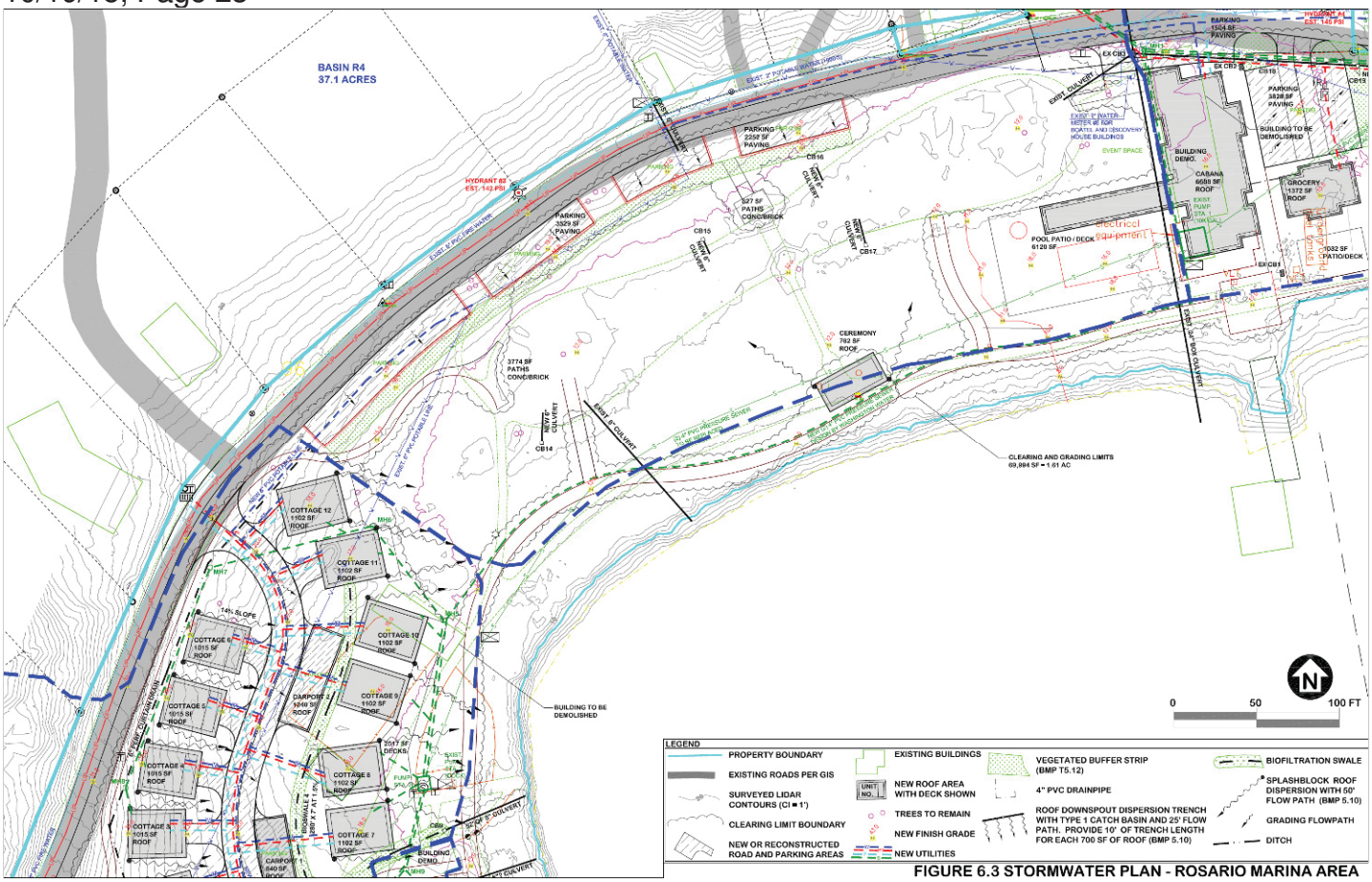

Figure 6.3 – Stormwater Plan (insert 11x17)

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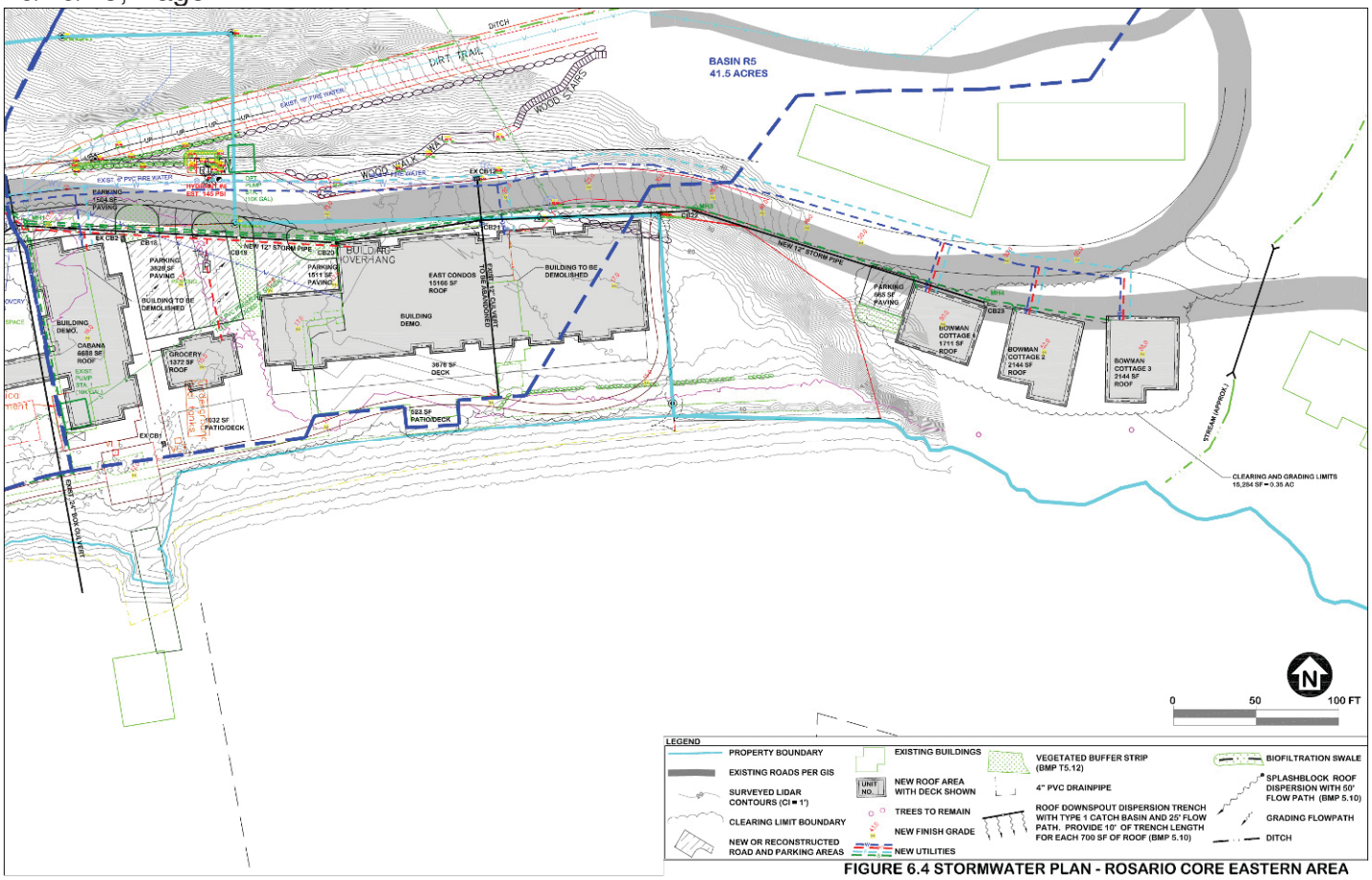

FIGURE 6.4 STORMWATER PLAN - ROSARIO CORE EASTERN AREA

Figure 6.4 – Stormwater Plan (insert 11x17)

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Minimum Requirement # 6: Runoff Treatment

This requirement applies to:

- Projects in which the total of effective, pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or

- Projects in which the total of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre (32,670 sf) or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.

The thresholds limits for requiring treatment and detention facilities are based on the pollution-generating impervious surfaces in each basin. A tabulation of converted surfaces created within each of the basins is provided in Table 2 below.

Table 2 - New or Replaced PGPS and PGIS by Basin

Converted Surface (approx.)	Basin R1	Basin R2 and Basin R3
Gravel roads and parking areas (PGIS)	4,406 sf	40,094 sf
Forest converted to lawn & landscaping (PGPS)	5,000 sf	15,000 sf

† Horizontal projection

Table 2 - New or Replaced PGPS and PGIS by Basin

Converted Surface (approx.)	Basin R4	Basin R5
Gravel roads and parking areas (PGIS)	5,781 sf	6,843 sf
Forest converted to lawn & landscaping (PGPS)	5,000 sf	5,000 sf

† Horizontal projection

Runoff treatment will be required for combined Basins R2 and R3, Basin R4, and Basin R5 since the PGIS resulting from the planned development is above the 5,000 sf threshold limit in each of these basins. Treatment should not be required in Basin R1.

Basin R1: 4,406 sf new or replaces PGIS is proposed so stormwater treatment is not required. T5.11 Sheet Flow dispersion and T5.12 Concentrated flow Dispersion best management practices shall be utilized in the development of the driveway and parking areas. The attached descriptions define the limitations and applicability of each BMP.

Basin R2 and R3: 40,094 sf new or replaced PGIS is proposed so stormwater treatment is required. Biofiltration swales are proposed for treatment of the combined Basins R2 and R3. The biofiltration swales have been preliminarily sized and area as follows;

Bioswale 1; 410' x 7' at 8%, Bioswale 2; 160' x 14' at 6.5%, Bioswale 3; 130' x 7' at 8.8%, Bioswale 4; 280' x 7' at 1.5% as shown in the Stormwater Site Plan Figures 6.1, and 6.2. Final biofiltration swale calculations will be prepared and submitted to the County for review at a later date, along with the construction drawings to confirm that they will meet the design requirements. At the end of each biofiltration swale, a small bioretention cell (Rain Garden) is proposed with a 1' ponded depth to allow for additional infiltration and treatment.

Basin R4: 5,781 sf new or replaced PGIS is proposed so stormwater treatment is required. Filter strips along the parking areas are proposed to treat the runoff. See attached standard filter strip details and limitations. The grading of the head-in parking should be directly toward the filter strips. Based on Figure 9.9 of BMP T9.50 the filter strip should be 10' wide and extend along the downhill side of the parking areas as shown in the stormwater plan.

Basin R5: 6,843 sf new or replaced PGIS is proposed so stormwater treatment is required. Filter strips along the parking areas are proposed to treat the runoff. See attached standard filterstrip details and limitations. The grading of the head-in parking should be directly toward the filter strips. Based on Figure 9.9 of BMP T9.50 the filter strip should be 10' – 15' wide and extend along the downhill side of the parking areas as shown in the stormwater plan.

Runoff treatment due to pollution generating pervious surfaces (PGPS) should also not be necessary in any basin since the PGPS created by all of the basins is less than the ¾ acres allowed by the PGPS threshold limit, 30,000 sf of landscape is proposed.

Minimum Requirement #7: Flow Control

This is a requirement to reduce the impacts of increased storm water runoff from new impervious surfaces and land cover conversions to a fresh water. This requirement applies to:

- Projects in which the total of effective impervious surfaces is 10,000 square feet or more in a threshold discharge area, or
- Projects that convert ¾ acres (32,670 sf) or more of native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site, or
- Projects that through a combination of effective impervious surfaces and converted pervious surfaces, cause a 0.1 cubic feet per second (cfs) increase in the 100-year flow frequency from a threshold discharge area as estimated using the Western-Washington Hydrology Model or other approved model.

The level of development planned for this site is more than the 10,000 sf effective impervious surface limitation described above but since it flows to a receiving water and

does not impact a freshwater resource downstream of the site the flow control requirements should not apply to this site.

Minimum Requirement #8: Wetlands Protection

This requirement is for the protection of wetlands where stormwater is discharged to them either directly or indirectly. The county GIS data base shows a wetland (" wet shapes") in the vicinity of the man-made Bow Tie Pond on Figure 5. A wetlands review was done by Scott Rozenbaum of Rozewood Environmental and determined that the Bowtie Pond area is not a regulated wetland.

Minimum Requirement #9: Basin/Watershed Planning

This is a requirement for the implementation of more stringent pollution controls in basins, which have adopted Basin/Watershed Plans. However, at this time there are no known special requirements for development or for stormwater treatment or control within this watershed. Minimum Requirement #9 should not apply to this project.

Minimum Requirement #10: Operation and Maintenance

Minimum requirement #10 does apply to basins where permanent stormwater treatment facilities are proposed to be constructed. Refer to the attached Maintenance Standards for Drainage Facilities for biofiltration swales and dispersion trenches. Owners shall ensure that development restrictions and covenants include requirements for drainage maintenance per the attached Standards. We have not prepared a formal Operations and Maintenance manual at this time but could do so if the County feels it is needed for this project.

The ongoing maintenance of the drainage facilities, ie ditches, culverts, catch basins and biofiltration swale shall be the responsibility of the owners.

5. Permanent Stormwater Control Plan

A drainage plan has been developed which includes filter strips, biofiltration swales, bioretention cells (Rain Gardens) and dispersion best management practices to the greatest extent feasible.

A drainage plan has been developed for this site to address the above-referenced requirements. This plan employs on-site stormwater management BMPs for mitigation of runoff impacts. A description of the proposed drainage plan is provided below and the location of the BMPs is shown on Figure 6.1, 6.2, 6.3, and 6.4.

DESCRIPTION OF PROPOSED NEW DRAINAGE FACILITIES

Basic Biofiltration Swale (BMP T9.10): Biofiltration swales are proposed to treat the runoff from the road and parking areas for Basin R2 and R3. There are four biofiltration swales noted in the plan, and the final design and engineered construction drawings for these will be completed for San Juan County review and approval before construction, but have the following preliminary sizes; Bioswale 1; 410' x 7' at 8%, Bioswale 2; 160' x 14' at 6.5%, Bioswale 3; 130' x 7' at 8.8%, Bioswale 4; 280' x 7' at 1.5%.

BMP T9.40 Basic Filter Strip and BMP T9.50 Narrow Area Filter Strip: This treatment BMP is for the runoff from the driveway and parking areas in Basins R2, R3, R4 and R5 which exceeds 5000 sf. The attached descriptions define the limitations and applicability of each BMP.

Roof Downspout Dispersion (BMP T5.10): Dispersion trenches have been sized for most of the new and existing roofs (10' per 700 sf roof). The location of these BMPs are shown on Figures 6.1, 6.2, 6.3 and 6.4. A photo of the flowpath area for each dispersion trench is also shown below. The downspouts will need to be piped to the dispersion location shown on the plan. Care should be taken to ensure that the catch basin rims are set at least 6" below the bottom of footings or crawlspace to avoid possible back flooding of these areas from downspout flows. Splash blocks are planned at the discharge outlets of all downspouts for most of the Hotel Cottages and Marina Village Cottages and will be limited to no more than 700 sf of roof area per splashblock. BMP T5.10 requires this geotechnical review for flowpath slopes steeper than 20%. The site has been walked and reviewed with Dan Sorenson of Geotest Inc. and each dispersion trench steeper than 20% was discussed and documented. Due to geotechnical slope stability concerns, the three Bowman Bluff units and two Cliffhouse Ct. houses are planned to be piped to other areas. See attached geotechnical letter.

Parking Area Flow Dispersion (BMP T5.12): Runoff control for some of the parking areas will be accomplished by sheet flow dispersion (BMP T5.12). The parking area surfaces will be graded to provide a minimum cross slope of 2 to 5 percent toward the vegetated buffers. Due to the topography of the site, vegetated buffers lie on the down slope side of the parking areas. The required vegetated buffers are shown in hatching on Stormwater Site Plan Figures 6.1, 6.2, 6.3 and 6.4.

Constructed slopes: All cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. The maximum side slope shall be 2H:1V for this project and all side slopes shall be stabilized as specified in the attached SWPPP – see Elements 3, 4, and 5.

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Vegetated flowpath area for the 8-Plex Building dispersion trench, at CB 1.

Vegetated flowpath area for 4-Plex 3 Building dispersion trench, at CB 2.

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Vegetated flowpath area for the 4-Plex 4 Building dispersion trench, at CB 3.

Vegetated flowpath area for the 4-Plex 5 Building dispersion trench, at CB 4.

Rosario Resort Expansion SSP
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Vegetated flowpath area for the 4-Plex 6,7 Buildings dispersion trench, at CB 5.

Vegetated flowpath area for Cabins 9-13 dispersion trench, at CB 24.

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Vegetated flowpath area for Cabins 1-8 downspout dispersion area.

Vegetated flowpath area for Cabins 14-19 downspout dispersion area.

6. Construction Stormwater Pollution Prevention Plan (SWPPP)

The SWPPP and not been prepared yet, but will be prepared and submitted for review and approval by San Juan County along with the permit submittal package for each building phase.

7. Other Permits

A NPDES permit will be required for this project if 1 acre or more is disturbed during the preparation of the roads, driveways and building areas. This project is planned to be done in phases. The total planned clearing and grading limit is 8.79 acres. If warranted it will be submitted separately.

8. Operations and Maintenance Manual

An O & M Manual is attached for the appropriate stormwater facilities included in this plan.

9. Bond Quantities Worksheet

There are no bonds for this project. At this time San Juan County does not require a bond for construction.

Prepared by:
Gregg Bronn, PE

Attachments:
- 2005 SWMM BMPs
  - BMP T9.10 Basic Biofiltration Swale, pp 9-2 to 9-4
  - BMP T9.50 Narrow area Filter Strip, pp 9-25 to 9-28
  - T5.10 Downspout Dispersion, pp 5-3 to 5-8.
  - T5.12 Sheet Flow Dispersion, pp 5-11 to 5-12
- O & M Manual – drainage maintenance standards, Vol. V, pp 4-30 – pp 4-42
- Geotechnical Review Letter - August 2015

2005 SWMM BMP T9.10 Basic Biofiltration Swale
pp 9-2 to 9-4

9.4 Best Management Practices

This Chapter presents the following Biofiltration Treatment BMPs:

BMP T9.10 – Basic Biofiltration Swale
BMP T9.20 - Wet Biofiltration Swale
BMP T9.30 – Continuous Inflow Biofiltration Swale
BMP T9.40 – Basic Filter Strip & Compost-Amended Filter Strip
BMP T9.50 – Narrow Area Filter Strip

BMP T9.10 Basic Biofiltration Swale

Description:

Biofiltration swales are typically shaped as a trapezoid or a parabola as shown in Figure 9.1.

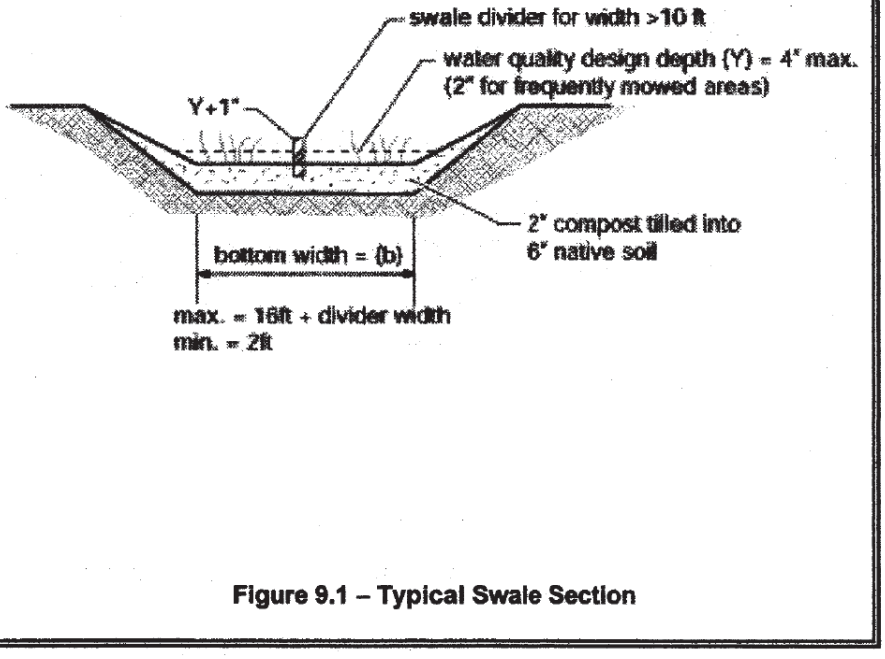

Figure 9.1 – Typical Swale Section

Limitations:

Data suggest that the performance of biofiltration swales is highly variable from storm to storm. It is therefore recommended that treatment methods providing more consistent performance, such as sand filters and wet ponds, be considered first. Swales downstream of devices of equal or greater effectiveness can convey runoff but should not be expected to offer a treatment benefit. (Horner, 2000)

Design Criteria:

- *Design criteria are specified in Table 9.1.* A 9 minute hydraulic residence time is used at a multiple of the peak 15 minute Water Quality Design Flow Rate (Q) representing 91% runoff volume as determined by the Western Washington Hydrology Model (WWHM). (See Volume I)
- Check the hydraulic capacity/stability for inflows greater than design flows. Bypass high flows, or control release rates into the biofilter, if necessary.
- Install level spreaders (min. 1-inch gravel) at the head and every 50 feet in swales of ≥4 feet width. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofilter as needed.
- Use energy dissipators (riprap) for increased downslopes.

Guidance for Bypassing Off-line Facilities:

Most biofiltration swales are currently designed to be on-line facilities. However, an off-line design is possible. Swales designed in an off-line mode should not engage a bypass until the flow rate exceeds a value determined by multiplying Q, the off-line water quality design flow rate predicted by the WWHM, by the ratio determined in Figure 9.5b. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures. Ecology's intent is to maintain recent biofiltration sizing recommendations (9 minutes detention at the peak design flow rate estimated by SBUH for a 6-month, 24-hour storm with a Type 1A rainfall distribution) until more definitive information is collected concerning bioswale performance. The only advantage of designing a swale to be off-line is that the stability check, which may make the swale larger, is not necessary.

Sizing Procedure for Biofiltration Swales

This guide provides biofilter swale design procedures in full detail, along with examples.

Preliminary Steps (P)

P-1 Determine the Water Quality design flow rate (Q) in 15-minute time-steps using the WWHM. Use the correct flow rate, off-line or on-line, for your design situation.

P-2 Establish the longitudinal slope of the proposed biofilter.

P-3 Select a vegetation cover suitable for the site. Refer to Tables 9.2, 9.3, and 9.4 (in text) to select vegetation for western Washington.

Design Calculations for Biofiltration Swale

There are a number of ways of applying the design procedure introduced by Chow (Chow, 1959). These variations depend on the order in which steps are performed, what constants are established at the beginning of the process and which ones are calculated, and what values are assigned to the variables selected initially.

The procedure recommended here is an adaptation appropriate for biofiltration applications of the type being installed in the Puget Sound region. This procedure reverses Chow's order, designing first for capacity and then for stability. The capacity analysis emphasizes the promotion of biofiltration, rather than transporting flow with the greatest possible hydraulic efficiency. Therefore, it is based on criteria that promote sedimentation, filtration, and other pollutant removal mechanisms. Because these criteria include a lower maximum velocity than permitted for stability, the biofilter dimensions usually do not have to be modified after a stability check.

Design Steps (D):

D-1. Select the type of vegetation, and design depth of flow (based on frequency of mowing and type of vegetation). (Table 9.1)

D-2. Select a value of Manning's n (Table 9.1 with footnote #3).

Table 9.1 – Sizing Criteria

Design parameter	BMP T 9.10-Biofiltration swale	BMP T 9.40-Filter strip
Longitudinal Slope	0.015 - 0.025[1]	0.01 - 0.15
Maximum velocity	1 ft / sec (@ K multiplied by the WQ design flow rate ; for stability, 3 ft/sec max.	0.5 ft / sec
Maximum water depth[2]	2"- if mowed frequently; 4" if mowed infrequently	1-inch max.
Manning coefficient (22)	(0.2 – 0.3)[3](0.24 if mowed infrequently)	0.35 (0.45 if compost-amended, and mowed to maintain grass height ≤ 4")
Bed width (bottom)	(2 - 10 ft)[4]	---
Freeboard height	0.5 ft	---
Minimum hydraulic residence time at Water Quality Design Flow Rate	9 minutes (18 minutes for continuous inflow) (See Volume I, Appendix B)	9 minutes
Minimum length	100 ft	Sufficient to achieve hydraulic residence time in the filter strip
Maximum sideslope	3 H : 1 V 4H:1V preferred	Inlet edge ≥ 1" lower than contributing paved area
Max. tributary drainage flowpath	---	150 feet
Max. longitudinal slope of contributing area	---	0.05 (steeper than 0.05 need upslope flow spreading and energy dissipation)
Max. lateral slope of contributing area	---	0.02 (at the edge of the strip inlet)

2005 SWMM BMP T9.40 Basic Filter Strip and T9.50 Narrow Filter Strip pp 9-25 to 9-28

BMP T9.40 Basic Filter Strip

Description:

A basic filter strip is flat with no side slopes (Figure 9.9). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

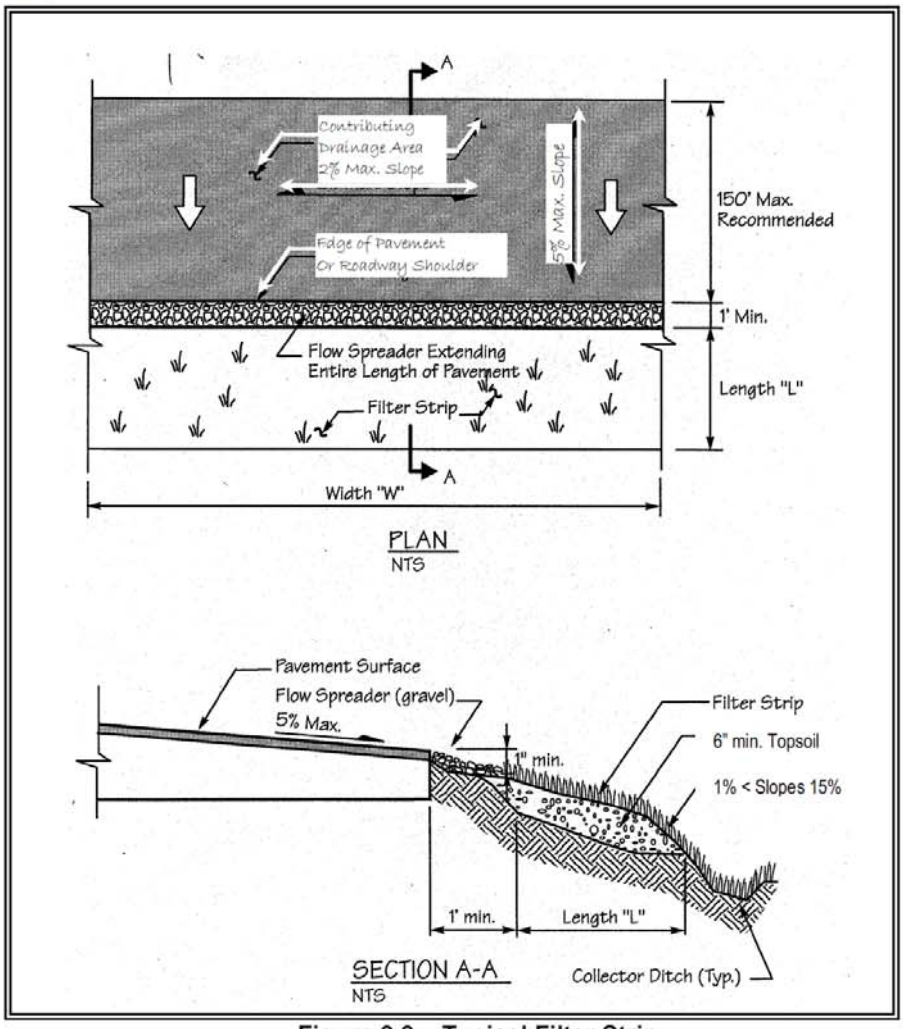

Figure 9.9 – Typical Filter Strip

Applications/Limitations:

The basic filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways. Where a filter strip area is compost-amended to a minimum of 10% organic content in accordance with BMP T5.13; with hydroseeded grass maintained at 95% density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs), the filter strip serves as an Enhanced Treatment option.

Design Criteria for Filter strips:

- Use the Design Criteria specified in Table 9.1
- Filter strips should only receive sheet flow.
- Use curb cuts ≥ 12-inch wide and 1-inch above the filter strip inlet.

Calculate the design flow depth using Manning's equation as follows:

$$KQ = (1.49A\ R^{0.67}\ s^{0.5})/n$$

Substituting for AR:

$$KQ = (1.49Ty^{1.67}\ s^{0.5})/n$$

Where:

$Ty = A_{rectangle,\ ft}^{2}$
$y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)
Q = peak Water Quality design flow rate based on WWHM, ft^3/sec (See Appendix I-B, Volume I)
K = The ratio determined by using Figure 9.5a
n = Manning's roughness coefficient
s = Longitudinal slope of filter strip parallel to direction of flow
T = Width of filter strip perpendicular to the direction of flow, ft.
A = Filter strip inlet cross-sectional flow area (rectangular), ft^2
R = hydraulic radius, ft.

Rearranging for y:

$$y = [KQn/1.49Ts^{0.5}]^{0.6}$$

y must not exceed 1 inch

Note: As in swale design an adjustment factor of K accounts for the differential between the WWHM Water Quality design flow rate and the SBUH design flow

Calculate the design flow velocity V, ft./sec., through the filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft./sec

Calculate required length, ft., of the filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$L = tV = 540V$

BMP T9.50 Narrow Area Filter Strip

Description:

This section describes a filter strip design[1] for impervious areas with flowpaths of 30 feet or less that can drain along their widest dimension to grassy areas.

Applications/Limitations:

A narrow area filter strip could be used at roadways with limited right-of-way, or for narrow parking strips, the narrow strip. If space is available to use the basic filter strip design, that design should be used in preference to the narrow filter strip.

The treatment objectives, applications and limitations, design criteria, materials specifications, and construction and maintenance requirements set forth in the basic filter strip design apply to narrow filter strip applications.

Design Criteria:

Design criteria for narrow area filter strips are the *same as specified for basic filter strips*. The sizing of a narrow area filter strip is based on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).

Step 1: Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining sheet flow to the strip. Normally this is the same as the width of the paved area, but if the site is sloped, the flow path may be longer than the width of the impervious area.

Step 2: Calculate the longitudinal slope of the filter strip (along the direction of unconcentrated flow), averaged over the total width of the filter strip. The minimum sizing slope is 2 percent. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum allowable filter strip slope is 20 percent. If the slope exceeds 20 percent, the filter strip must be stepped down the slope so that the treatment areas between drop sections do not have a longitudinal slope greater than 20 percent. Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. Vertical drops along the slope must not exceed 12 inches in height. If this is not possible, a different treatment facility must be selected.

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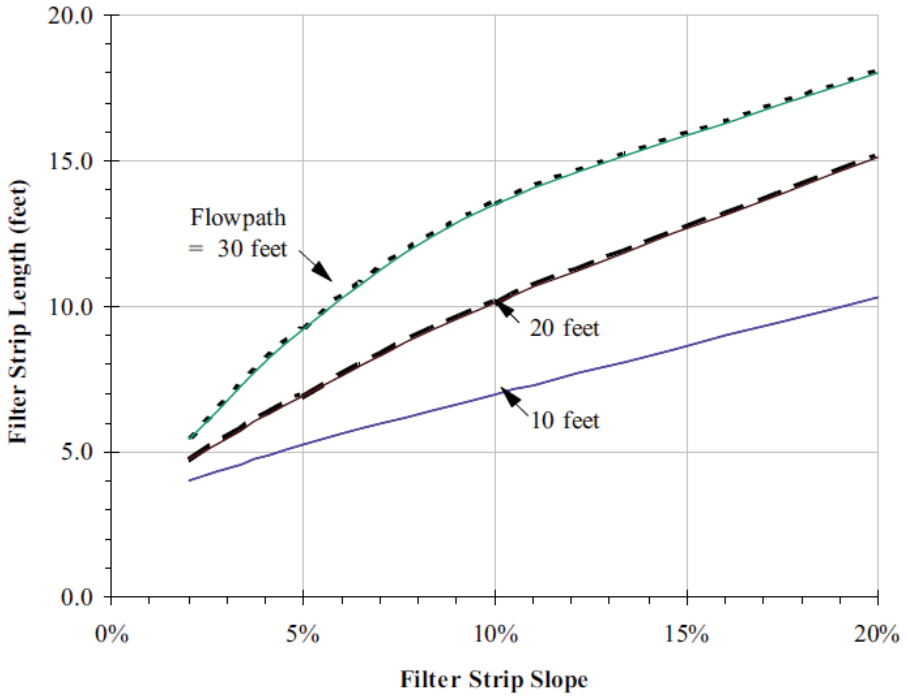
[1] This narrow area filter strip design method is included here because technical limitations exist in the basic design method which result in filter strips that are proportionately longer as the contributing drainage becomes narrower (a result that is counter-intuitive). Research by several parties is underway to evaluate filter strip design parameters. This research may lead to more stringent design requirements that would supersede the design criteria presented here.

Step 3: Select the appropriate filter strip length for the flowpath length and filter strip longitudinal slope (Steps 1 and 2 above) from the graph in Figure 9.10. The filter strip must be designed to provide this minimum length *L* along the entire stretch of pavement draining into it.

To use the graph: Find the length of the flowpath on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design longitudinal slope of the filter strip (x-axis) is directly below. Read the filter strip length on the y-axis which corresponds to the intersection point.



Note: minimum allowable filter strip length is 4 feet

Figure 9.10 – Filter Strip Lengths for Narrow Right-of-Way

2005 SWMM BMP T5.10 Downspout Dispersion
pp 5-3 to 5-8, Figure 5.1, 5.2, and 5.3

5.3.1 Dispersion and Soil Quality BMPs (Required for Manual Equivalency)

The following BMPs pertain to dispersion and soil quality applications.

BMP T5.10 Downspout Dispersion

Purpose and Definition

Downspout dispersion BMPs are splashblocks or gravel-filled trenches that serve to spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits.

Applications and Limitations

- Downspout dispersion is required on all subdivision single family lots which meet one of the following criteria:
  1. Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Volume III, Chapter 3.
  2. Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration as determined in Volume III, Chapter 3 and where the design criteria below can be met.
- All other projects required to apply Roof Downspout BMPs must provide downspout dispersion if downspout infiltration is not feasible or applicable as determined in Volume III, Chapter 3, and if the design criteria below can be met.

Flow Credit for Roof Downspout Dispersion

If roof runoff is dispersed according to the requirements of this section on single-family lots greater than 22,000 square feet, and the *vegetative flow*path[•] is 50 feet or larger through undisturbed native landscape or lawn/landscape area that meets BMP T5.13, the designer may click on the "Credits" button in the WWHM and enter the percent of roof area that is being dispersed.

General Design Guidelines

- Dispersion trenches designed as shown in the Figures 5.1 and 5.2 shall be used for all downspout dispersion applications except where

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• *Vegetative flow path* is measured from the downspout or dispersion system discharge point to the downstream property line, stream, wetland, or other impervious surface.

splashblocks are allowed below. See Figure 5.3 for a typical splashblock.

- Splashblocks may be used for downspouts discharging to a vegetated flowpath at least 50 feet in length as measured from the downspout to the downstream property line, structure, sensitive steep slope, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flowpath lengths. The vegetated flowpath must be covered with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.
- If the vegetated flowpath (measured as defined above) is less than 25 feet on a subdivision single-family lot, a perforated stub-out connection may be used in lieu of downspout dispersion (See Volume III, Chapter 3). A perforated stub-out may also be used where implementation of downspout dispersion might cause erosion or flooding problems, either on site or on adjacent lots. This provision might be appropriate, for example, for lots constructed on steep hills where downspout discharge could be cumulative and might pose a potential hazard for lower lying lots, or where dispersed flows could create problems for adjacent offsite lots. This provision does not apply to situations where lots are flat and onsite downspout dispersal would result in saturated yards.

  Note: For all other types of projects, the use of a perforated stub-out in lieu of downspout dispersion shall be as determined by the Local Plan Approval Authority.

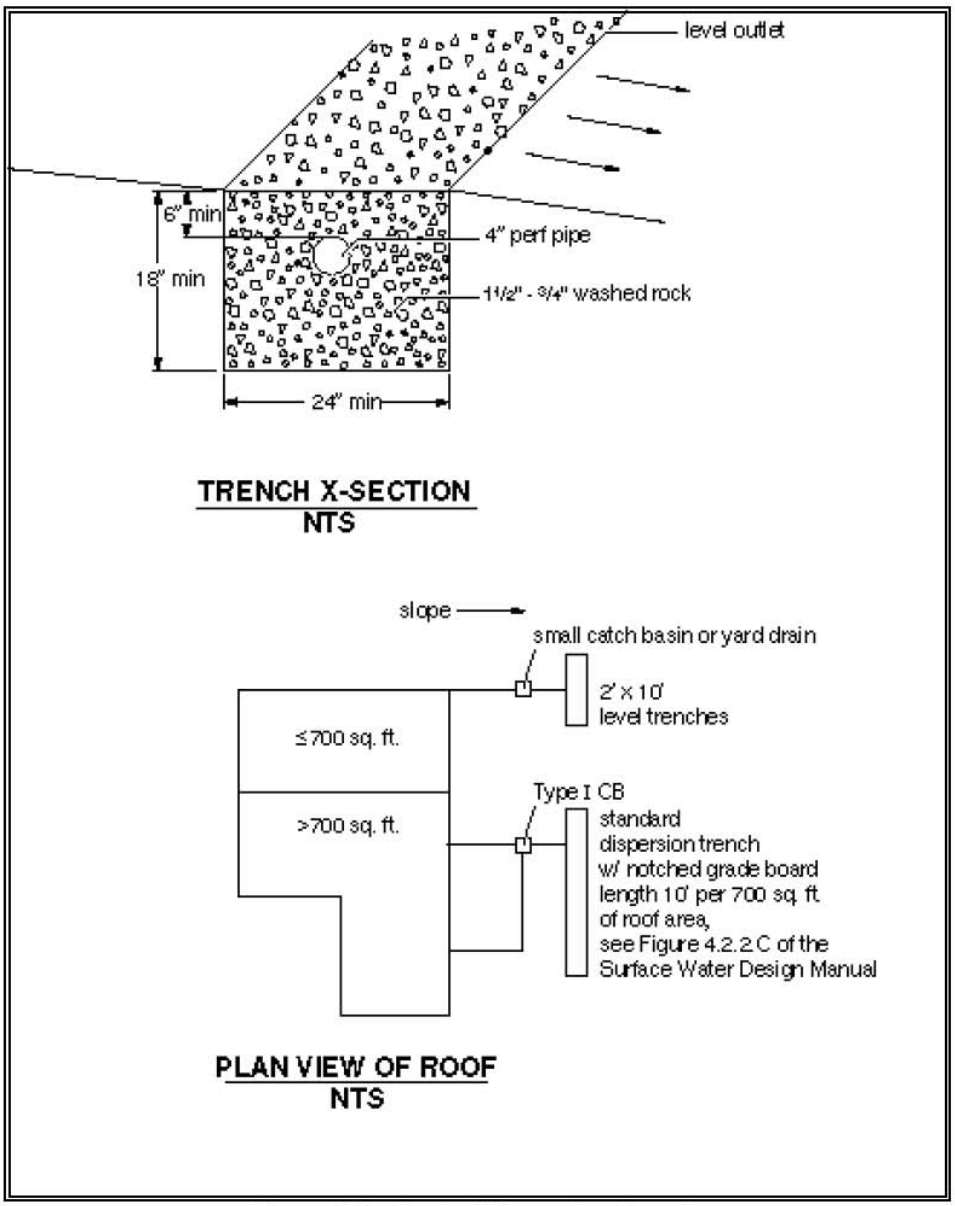

Figure 5.1 – Typical Dispersion Trench

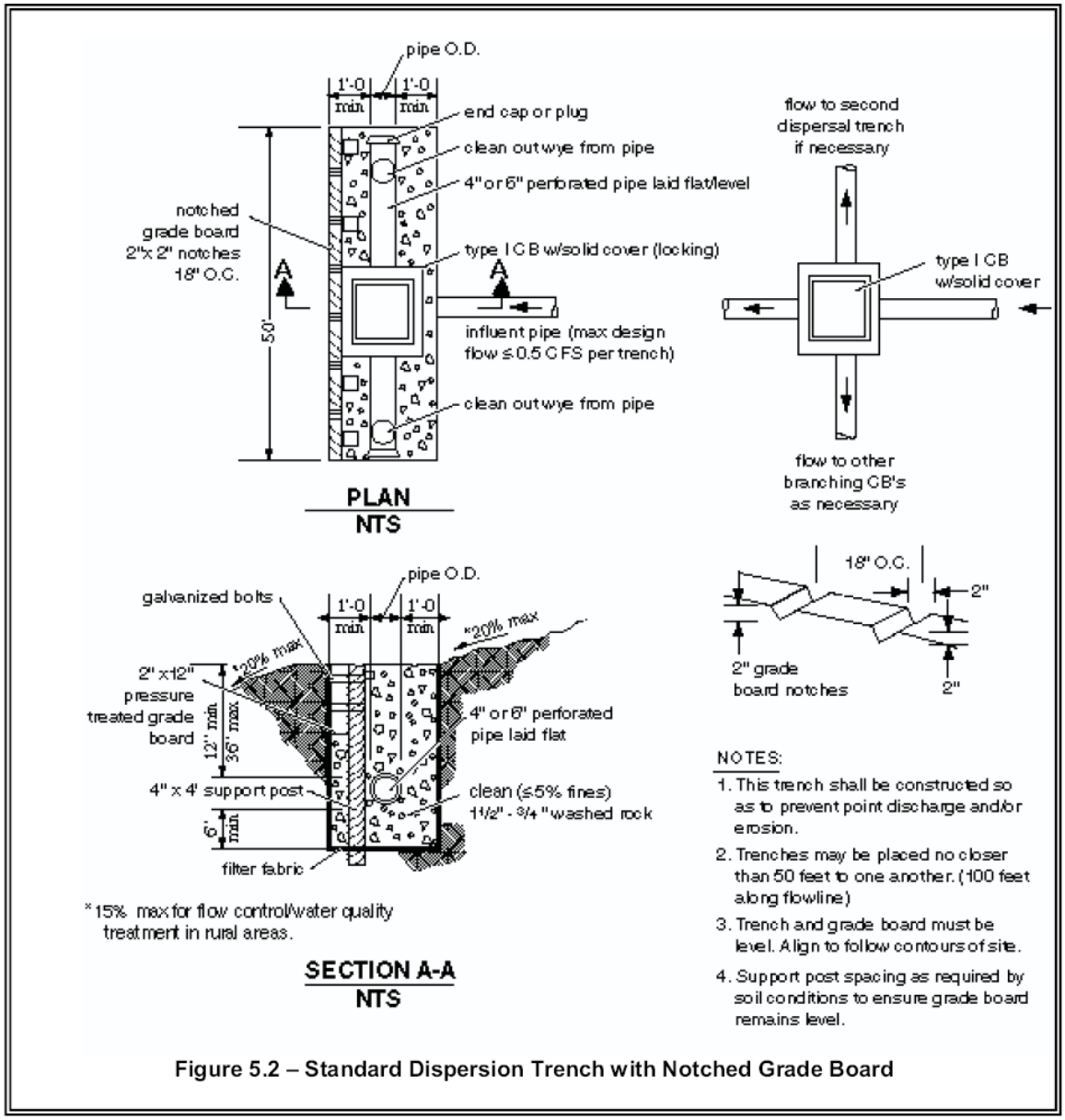

Figure 5.2 – Standard Dispersion Trench with Notched Grade Board

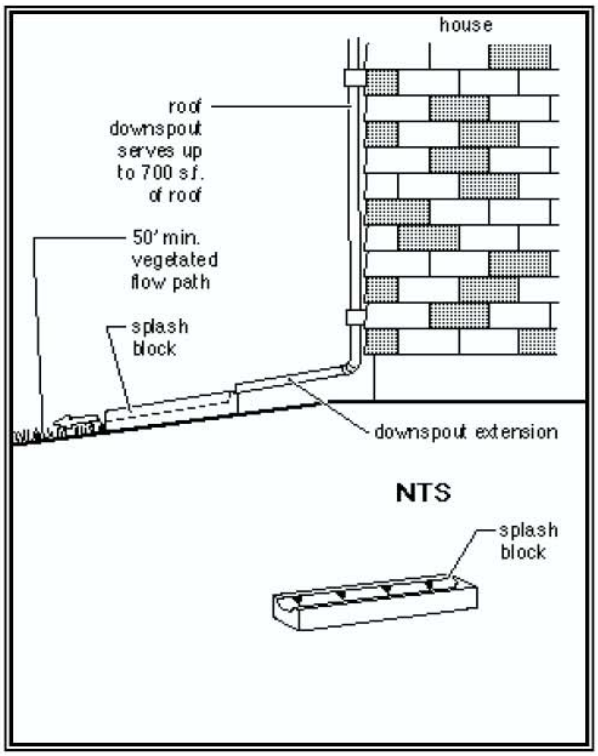

Figure 5.3 – Typical Downspout Splashblock Dispersion

Additional Design Criteria for Dispersion Trenches

- A vegetated flowpath of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any steep slope. Sensitive area buffers may count towards flowpath lengths.
- Trenches serving up to 700 square feet of roof area may be simple 10-foot-long by 2-foot wide gravel filled trenches as shown on Figure 5-1. For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in Figure 5-2 may be used as approved by the Local Plan Approval Authority. The total length of this design must provide at least 10 feet of trench per 700 square feet of roof area and not exceed 50 feet.
- A setback of at least 5 feet must be maintained between any edge of the trench and any structure or property line.
- No erosion or flooding of downstream properties may result.

- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and jurisdiction approval.
- For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by the jurisdiction's permit review staff if site topography will clearly prohibit flows from intersecting the drainfield.

Additional Design Criteria for Splashblocks

In general, if the ground is sloped away from the foundation, and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

The following conditions must be met to use splashblocks:

- A vegetated flowpath of at least 50 feet must be maintained between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- A maximum of 700 square feet of roof area may drain to each splashblock.
- A splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each downspout discharge point.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. Splashblocks may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.
- For sites with septic systems, the discharge point must be downslope of the primary and reserve drainfield areas. This requirement can be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.

2005 SWMM BMP T5.12 Sheet Flow Dispersion
pp 5-11 to 5-12, Figure 5.5

BMP T5.12 Sheet Flow Dispersion

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

Applications and Limitations

Flat or moderately sloping (<15% slope) impervious surfaces such as driveways, sport courts, patios, and roofs without gutters; sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture; or any situation where concentration of flows can be avoided.

Design Guidelines

- See Figure 5.5 for details for driveways.
- A 2-foot-wide transition zone to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the Local Plan Approval Authority.
- A vegetated buffer width of 10 feet of vegetation must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each addition 20 feet of width or fraction thereof.
- A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture). Slopes within the 25-foot minimum flowpath through vegetation should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.
- No erosion or flooding of downstream properties may result.
- Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.
- For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.

Flow Credits

- Where BMPT5.12 is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the" landscaped area" field.

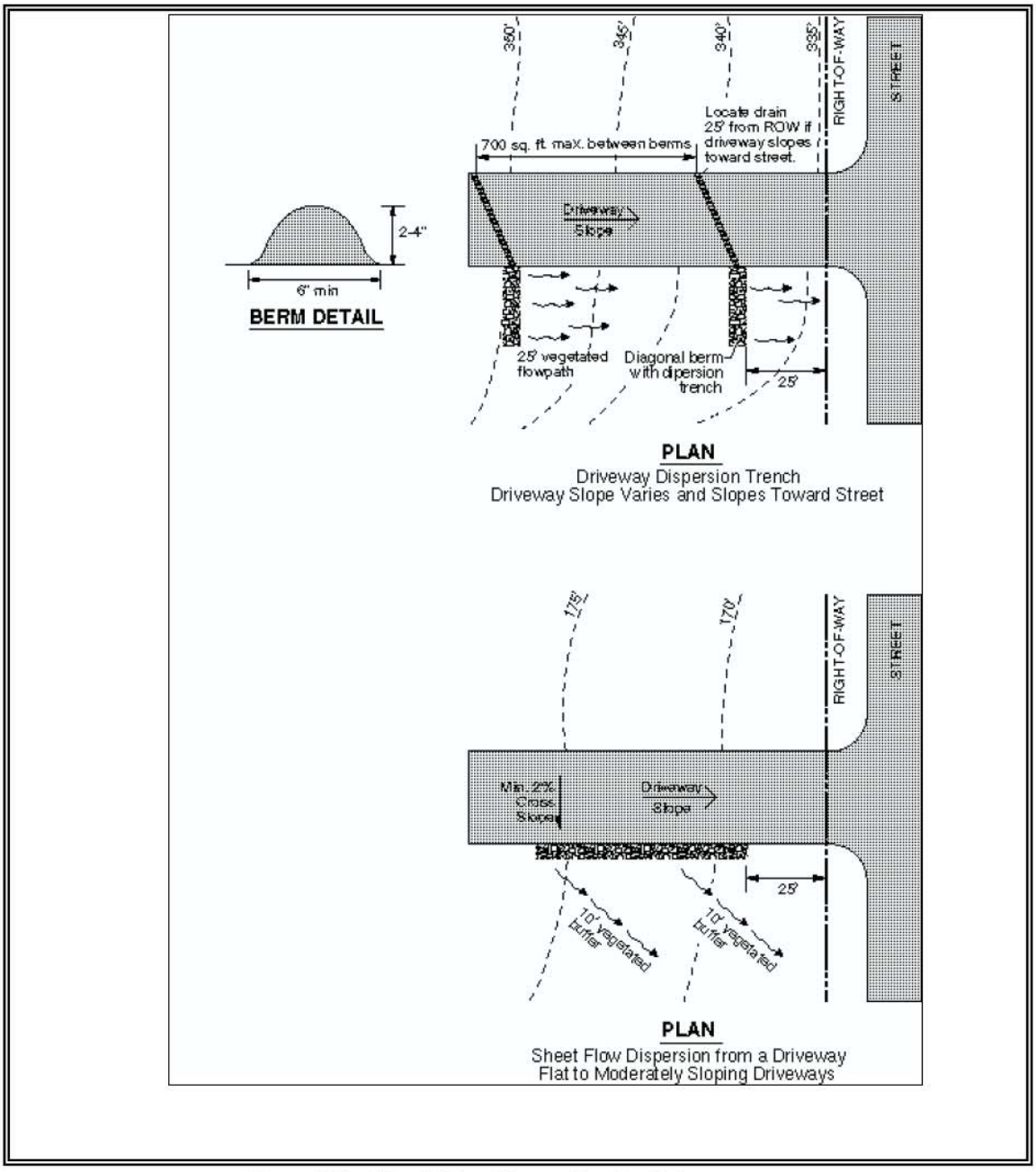

Figure 5.5 – Sheet Flow Dispersion for Driveways

O & M Manual
2005 SWMM BMP Operation and Maintenance Standards
pp 4-30 to 4-42 Volume 5

4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table 4.5 – Maintenance Standards

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	~~No contaminants or pollutants present.~~
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 7 – Energy Dissipaters

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 8 – Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

No. 9 – Wet Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation	Sediment depth exceeds 2-inches in 10% of the swale treatment area.	Remove sediment deposits in treatment area.
	Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
	Trash and Debris Accumulation	See "Detention Ponds" (No. 1).	Remove trash and debris from wet swale.
	Erosion/Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.

No. 10 – Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

No. 11 – Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

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