swales. Deliberate and thorough communication will improve the quality of installed LID features and will also raise contractor awareness during future projects.

4.4.1.2 Demonstration Project: Scripps Proton Therapy Center

RIORITY DEVELOPMENT PROJECT

Location
Scripps Proton Therapy Center, Summers Ridge Road, San Diego

Highlighted IMPs
Bioretention
Bioretention Swales

Impervious Area Treated
4.5 acres

IMP Footprint[1]
0.85 acres
(water quality + HMP)

Other LID Features
Permeable Pavement
(Plastic Grid Pavers)

Construction Date
October 2012

Design Engineer
Rick Engineering

[1]*See Design Criteria*

4.4.1.2.1 Site Background and Proposed Development

Scripps health, Scripps Clinic Medical Group, and Advanced Particle Therapy are constructing a 102,000-square-foot facility for advanced radiation therapy treatment. The Scripps Proton Therapy Center (SPTC) will have capacity to treat 2,400 patients annually and will house a cyclotron particle accelerator for proton beam generation. To meet SUSMP requirements in a cost-effective manner, LID IMPs were incorporated throughout the site.

The facility is located off of Summers Ridge Road in the Fenton Carroll Canyon Technology Center of San Diego's Mira Mesa community, as shown in Figure 4-27.

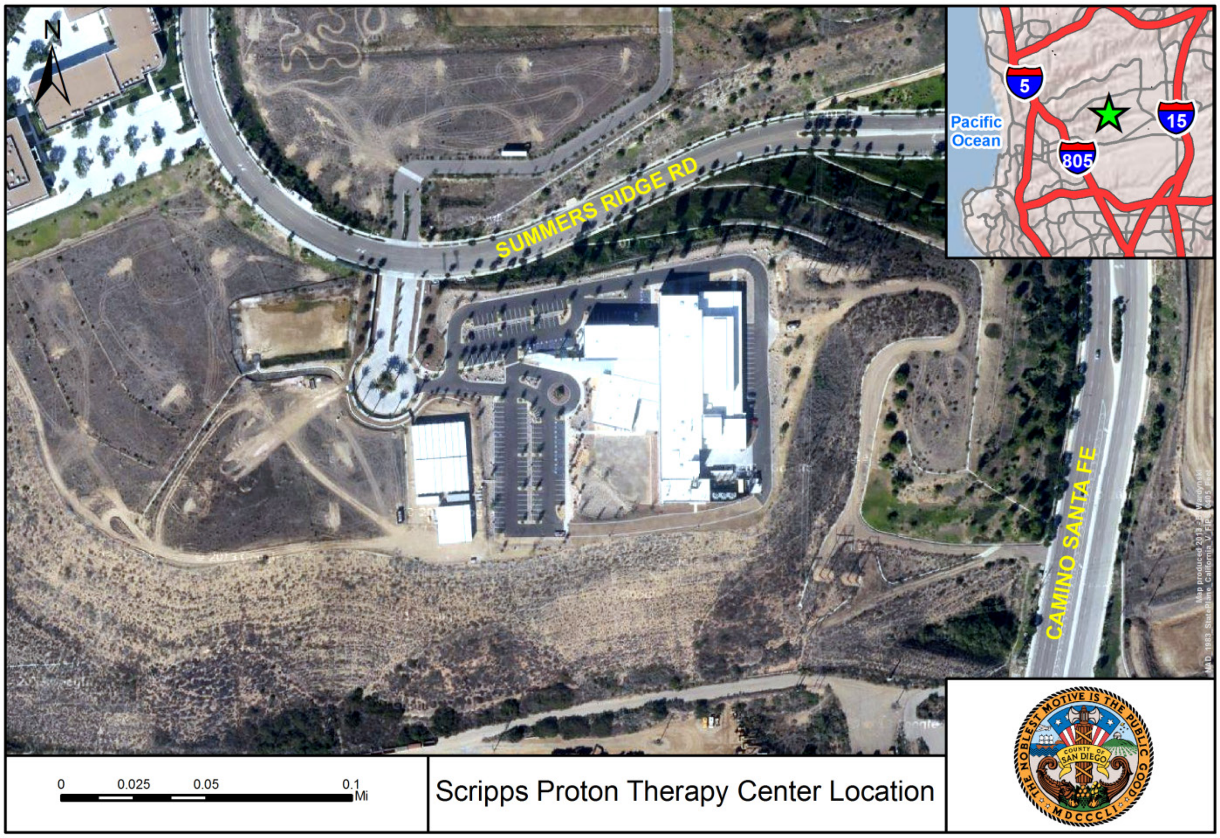

Figure 4-27. Aerial view of Scripps Proton Therapy Center (photo credit Google 2013).

4.4.1.2.2 Design Criteria

The WQTR identified the following anticipated or potential pollutants from the project site:

Anticipated

- Heavy metals
- Trash and Debris
- Oil and Grease

Potential

- Sediment
- Organic compounds
- Oxygen demanding substances
- Pesticides

Because runoff from the project site ultimately drains to the Los Penasquitos Lagoon, sediment was considered the primary pollutant of concern.

Hydromodification criteria did not apply to this project because the project extent was less than the 50-acre threshold in the 2008 Storm Water Standards Manual. For demonstration purposes, the IMPs in this example project have been enhanced to demonstrate the sizing requirements to meet both the water quality and hydromodification control of the $0.1Q_2$ flow threshold as required by the SUSMP.

4.4.1.2.3 LID Site Planning Practices

The following site planning practices should be considered during all projects:

- Conserve natural areas, soils, and vegetation
- Minimize disturbances to natural drainages
- Minimize and disconnect impervious surfaces
- Minimize soil compaction
- Drain runoff from impervious surface to pervious surfaces

The SPTC was constructed in a technology park complex that was mass graded prior to the onset of site design, so conservation of natural areas, soils, vegetation, and natural drainages were not feasible LID design goals for this project. Had this project been new development, the site could be designed to minimize impacts to native hydrologic conditions by clustering development, retaining natural features throughout the site, and minimizing roadway widths. The site was designed to minimize directly-connected impervious surfaces, and, wherever practicable, runoff flows to pervious surfaces incorporated in parking lot medians, perimeters, and in landscaped areas. Soil compaction was minimized during construction to the extent practicable to allow infiltration in self-treating areas, although underlying soils precluded infiltrating practices.

4.4.1.2.4 IMP Selection

The primary pollutant of concern for the project site was sediment, so bioretention with underdrains was selected as the IMP to meet SUSMP criteria. Bioretention was selected due to high sediment removal performance and the flexibility to incorporate throughout the site to treat runoff near its source (per LID principles). Underlying soils were classified as Hydrologic Soil Group D so underdrains were included to ensure adequate drainage. Some facilities would require impermeable liners due to proximity to steep slopes—these IMPs should be sized as flow-through planters because they would not allow incidental infiltration.

4.4.1.2.5 IMP Design

Once IMPs were selected to meet the SUSMP criteria, the design steps shown in Table 4-5 could be employed to incorporate bioretention and bioretention swales into the site design. Photos of the site are shown in Figure 4-28 through Figure 4-31.

Table 4-5. Bioretention and bioretention swales design step process

Design step		Design component/ consideration	General specification
1	**IMP Siting**	Layout and site incorporation	Based on available space and maintenance access, bioretention was incorporated into landscaped areas, along the parking lot perimeter, and parking medians throughout the site.
2	**Determine IMP Function and Configuration**	Impermeable liner	Where required per geotechnical specifications, a geomembrane liner was installed for slope and infrastructure protection (facilities with impermeable liners should be designed as flow-through planters).

Design step		Design component/ consideration	General specification
		Underdrain (required if subsoil infiltration rate is less than 0.5 in/hr [HSG C & D])	Schedule 40 PVC pipe with perforations (slots or holes) every 6 inches. The 4-inch diameter lateral pipes should join a 6-inch collector pipe, which conveys drainage to the downstream storm network. Provide cleanout ports/observation wells for each underdrain pipe. The underdrain should be elevated 12” above the subgrade, consistent with hydromodification design assumptions.
		Lateral hydraulic restriction barriers	Impermeable geomembrane was used to restrict lateral flows to adjacent subgrades, foundations, or utilities.
3	**Determine IMP Sizing Approach**	Flow-based (common SUSMP methodology)	Refer to SUSMP (County of San Diego 2012) chapters 2 and 4 for appropriate sizing factors to determine surface area, ponding depth, and media depth. For the purpose of this example, IMPs on this site were sized to meet water quality and hydromodification requirements using a sizing factor of 0.16. Flow from the contributing drainage area would require detention such that discharge does not exceed the $0.1Q_2$ flow threshold.
4	**Size the System**	Temporary ponding depth	10 inches per hydromodification design assumptions
		Soil media depth	1.5 feet per SUSMP
		Slope and grade control	Check dams were used to maintain maximum 2.5% bed slope. Install a 4-inch deep layer of ASTM No. 57 stone (underlain by filter fabric) extending 2 feet downslope from the check dam to prevent erosion.
		Surface area(volume-based water quality)	Sized using the flow-based method per SUSMP requirements.
5	**Specify Soil Media**	Composition and texture	Per SUSMP, specified loamy sand with minimum long-term percolation rate of 5 in/hr.
		Permeability	
		Chemical composition	
		Drainage layer	
6	**Design Inlet and Pretreatment**	Inlet	Runoff enters by diffuse flow from parking lot or through curb cuts along driving lanes
		Pretreatment	Gravel pads provided at inlets for energy dissipation and pretreatment
7	**Select and Design Overflow/Bypass Method**	Outlet configuration	<u>Online</u>: All runoff is routed through system—install an elevated overflow structure or weir at the elevation of maximum ponding.
		Hydromodification control	If necessary, additional aggregate storage could be specified to provide hydromodification control where the surface area is not available for design of IMPs using the sizing factors. Alternative designs would require verification by modeling.
8	**Select Mulch and Vegetation**	Mulch	Hardwood mulch, gravel, and cobble were used
		Vegetation	Drought tolerant, native plants
9	**Design for Multi-Use Benefits**	Additional benefits	Attractive xeriscaped landscaping design, irrigated with reclaimed water

Figure 4-28. Bioretention swales with raised outlet structures capture, convey, and filter parking lot runoff through a soil media layer.

Figure 4-29. Roads and parking lots are graded towards bioretention areas that treat runoff near its source.

Figure 4-30. Curb cuts accept gutter flow from driving lanes into bioretention swales.

Figure 4-31. Bioretention areas with raised outlet structures are distributed throughout the site to transform traditional landscaped areas into stormwater IMPs.

4.4.1.2.6 Design Details

The following sheets provide example plans, profiles, and cross sections of the IMPs installed at the SPTC.

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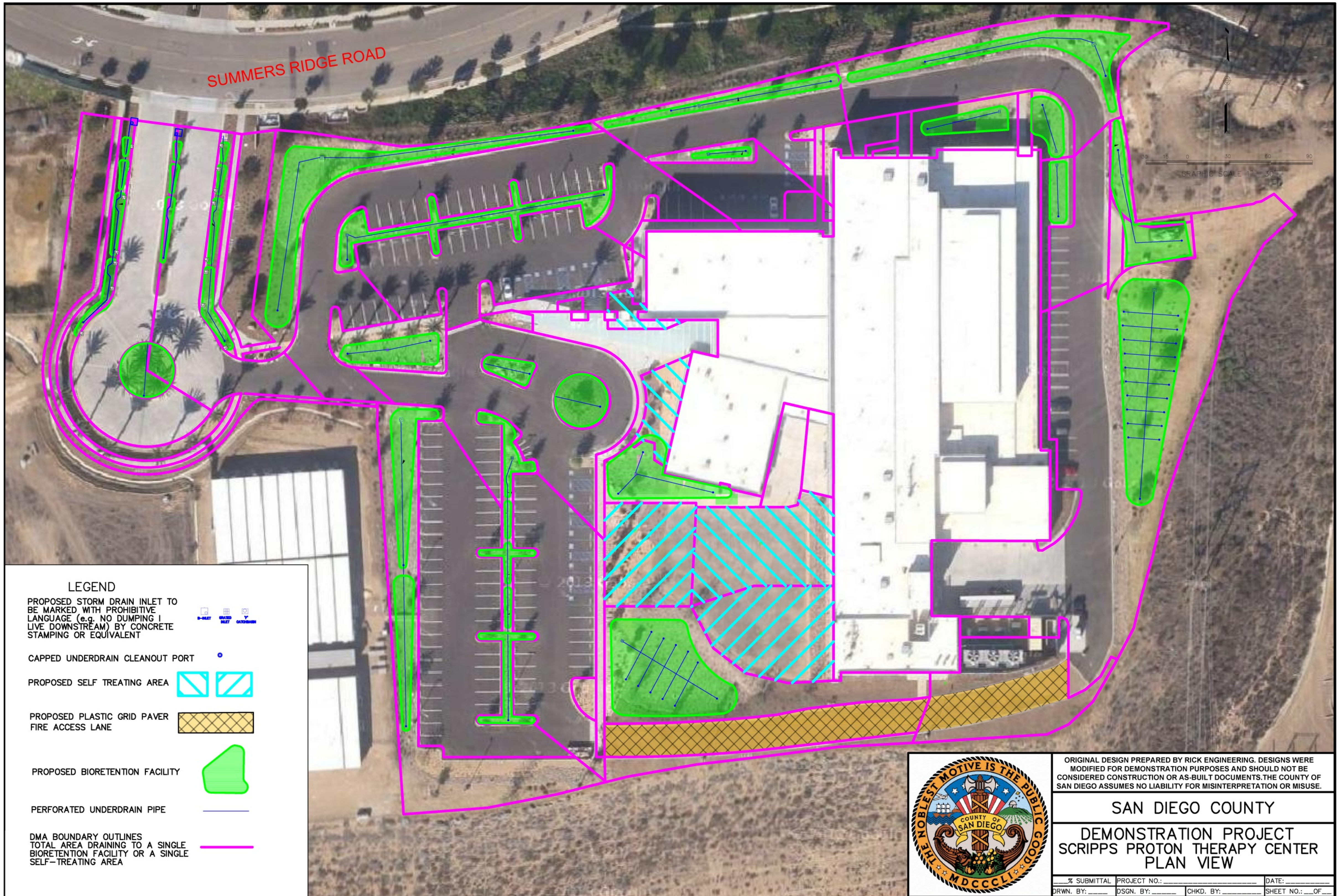

SUMMERS RIDGE ROAD
LEGEND
PROPOSED STORM DRAIN INLET TO BE MARKED WITH PROHIBITIVE LANGUAGE (e.g. NO DUMPING I LIVE DOWNSTREAM) BY CONCRETE STAMPING OR EQUIVALENT
CAPPED UNDERDRAIN CLEANOUT PORT
PROPOSED SELF TREATING AREA
PROPOSED PLASTIC GRID PAVER FIRE ACCESS LANE
PROPOSED BIORETENTION FACILITY
PERFORATED UNDERDRAIN PIPE
DMA BOUNDARY OUTLINES TOTAL AREA DRAINING TO A SINGLE BIORETENTION FACILITY OR A SINGLE SELF-TREATING AREA
ORIGINAL DESIGN PREPARED BY RICK ENGINEERING. DESIGNS WERE MODIFIED FOR DEMONSTRATION PURPOSES AND SHOULD NOT BE CONSIDERED CONSTRUCTION OR AS-BUILT DOCUMENTS.THE COUNTY OF SAN DIEGO ASSUMES NO LIABILITY FOR MISINTERPRETATION OR MISUSE.
SAN DIEGO COUNTY
DEMONSTRATION PROJECT
SCRIPPS PROTON THERAPY CENTER
PLAN VIEW
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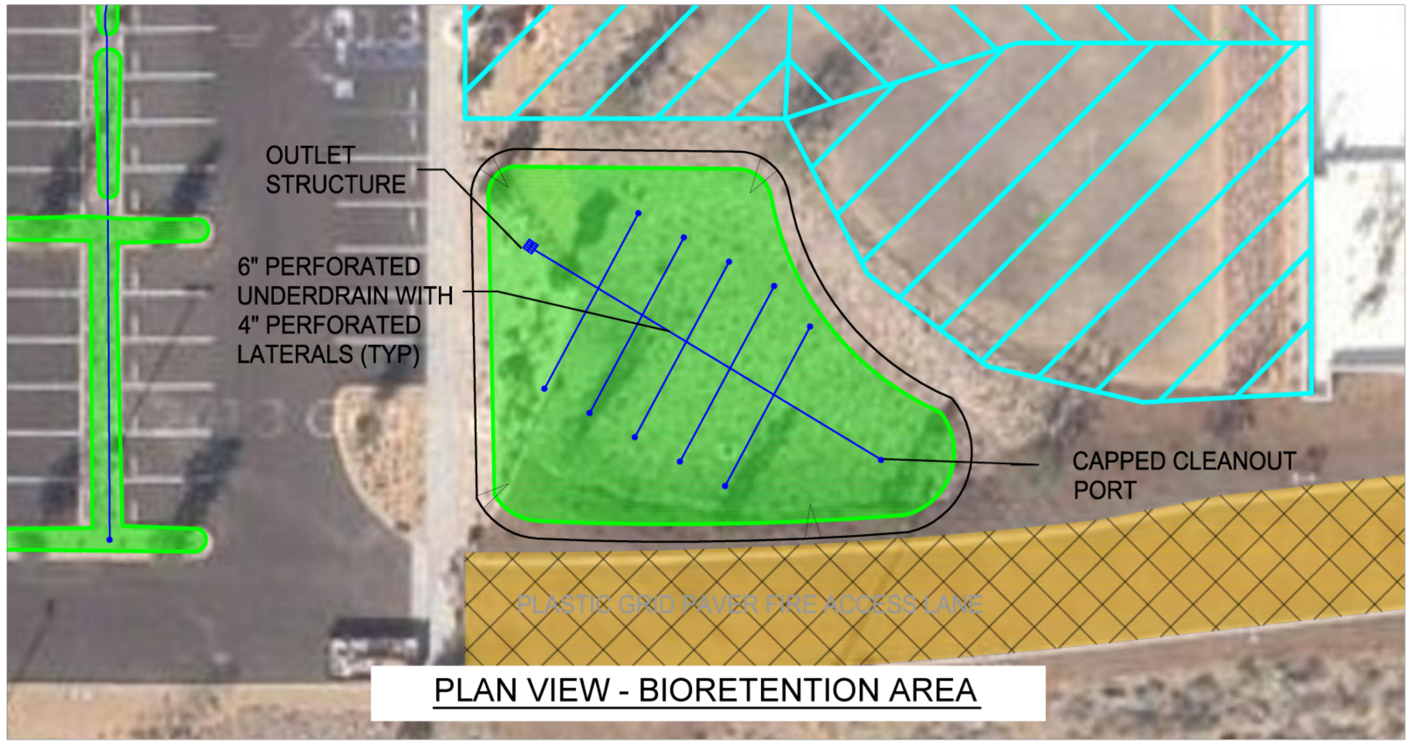


PLAN VIEW - BIORETENTION AREA

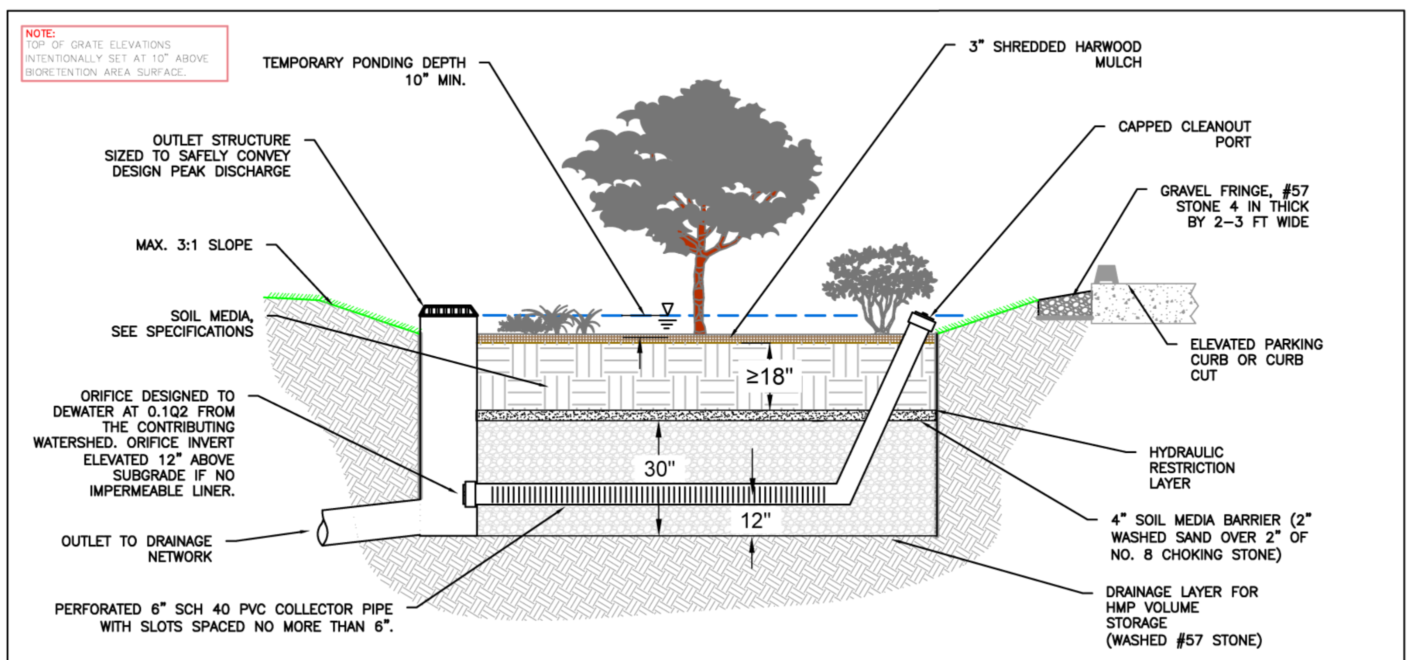
SOIL MEDIA SPECIFICATIONS

18" DEPTH OF LOAMY SAND WITH MINIMUM LONG–TERM PERCOLATION RATES OF 5 IN./HR.

VEGETATION SPECIFICATIONS

FOR BIORETENTION TO FUNCTION PROPERLY AS STORMWATER TREATMENT AND BLEND INTO THE LANDSCAPING, VEGETATION SELECTION IS CRUCIAL. APPROPRIATE VEGETATION WILL HAVE THE FOLLOWING CHARACTERISTICS:

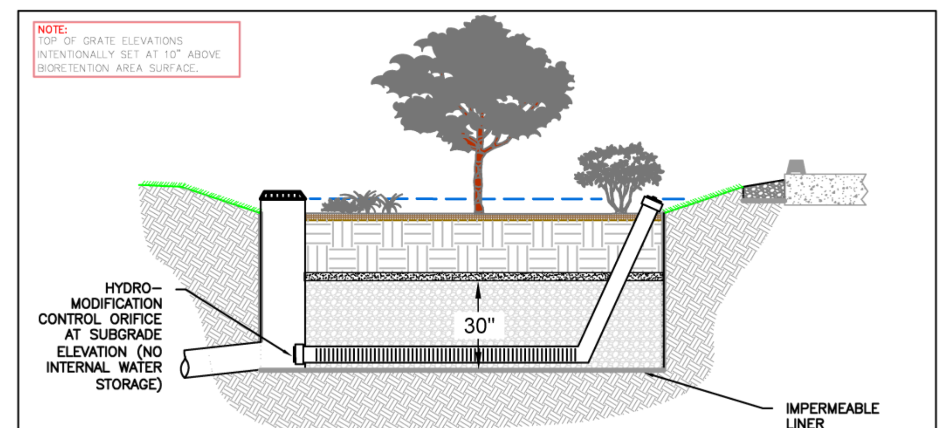
1. PLANT MATERIALS MUST BE TOLERANT OF SUMMER DROUGHT, PONDING FLUCTUATIONS, AND SATURATED SOIL CONDITIONS FOR 10 TO 48 HOURS.
2. IT IS RECOMMENDED THAT A MINIMUM OF THREE TREE, THREE SHRUBS, AND THREE HERBACEOUS GROUNDCOVER SPECIES BE INCORPORATED TO PROTECT AGAINST FACILITY FAILURE FROM DISEASE AND INSECT INFESTATIONS OF A SINGLE SPECIES. PLANT ROOTING DEPTHS MUST NOT DAMAGE THE UNDERDRAIN, IF PRESENT. SLOTTED OR PERFORATED UNDERDRAIN PIPE MUST BE MORE THAN 5 FEET FROM TREE LOCATIONS (IF SPACE ALLOWS).
3. NATIVE PLANT SPECIES OR HARDY CULTIVARS THAT ARE NOT INVASIVE AND DO NOT REQUIRE CHEMICAL INPUTS ARE RECOMMENDED TO BE USED TO THE MAXIMUM EXTENT PRACTICABLE.
4. SHADE TREES SHOULD BE FREE OF BRANCHES BELOW 1/3 THEIR TOTAL HEIGHT.



UNLINED BIORETENTION AREA PROFILE (TYP.)

THIS DETAIL SHOULD BE APPLIED WHEN GEOTECHNICAL SPECIFICATIONS ALLOW INCIDENTAL INFILTRATION. IF INFILTRATION IS PROHIBITED, DESIGN AS FULLY–LINED SYSTEM (FLOW–THROUGH PLANTER). ALL NOTES APPLY TO FULLY–LINED SYSTEMS UNLESS OTHERWISE NOTED.

NTS



FULLY LINED BIORETENION PROFILE

THIS DETAIL SHOULD BE APPLIED WHEN GEOTECHNICAL SPECIFICATIONS PROHIBIT INFILTRATION (SUCH AS NEAR STEEP SLOPES AND SENSITIVE INFRASTRUCTURE). THE FACILITY SHOULD BE SIZED AS A FLOW–THROUGH PLANTER AND SHOULD CONTAIN NO INTERNAL WATER STORAGE.

ORIGINAL DESIGN PREPARED BY RICK ENGINEERING. DESIGNS WERE MODIFIED FOR DEMONSTRATION PURPOSES AND SHOULD NOT BE CONSIDERED CONSTRUCTION OR AS-BUILT DOCUMENTS.THE COUNTY OF SAN DIEGO ASSUMES NO LIABILITY FOR MISINTERPRETATION OR MISUSE.

SAN DIEGO COUNTY

DEMONSTRATION PROJECT
SCRIPPS PROTON THERAPY CENTER
BIORETENTION DETAILS

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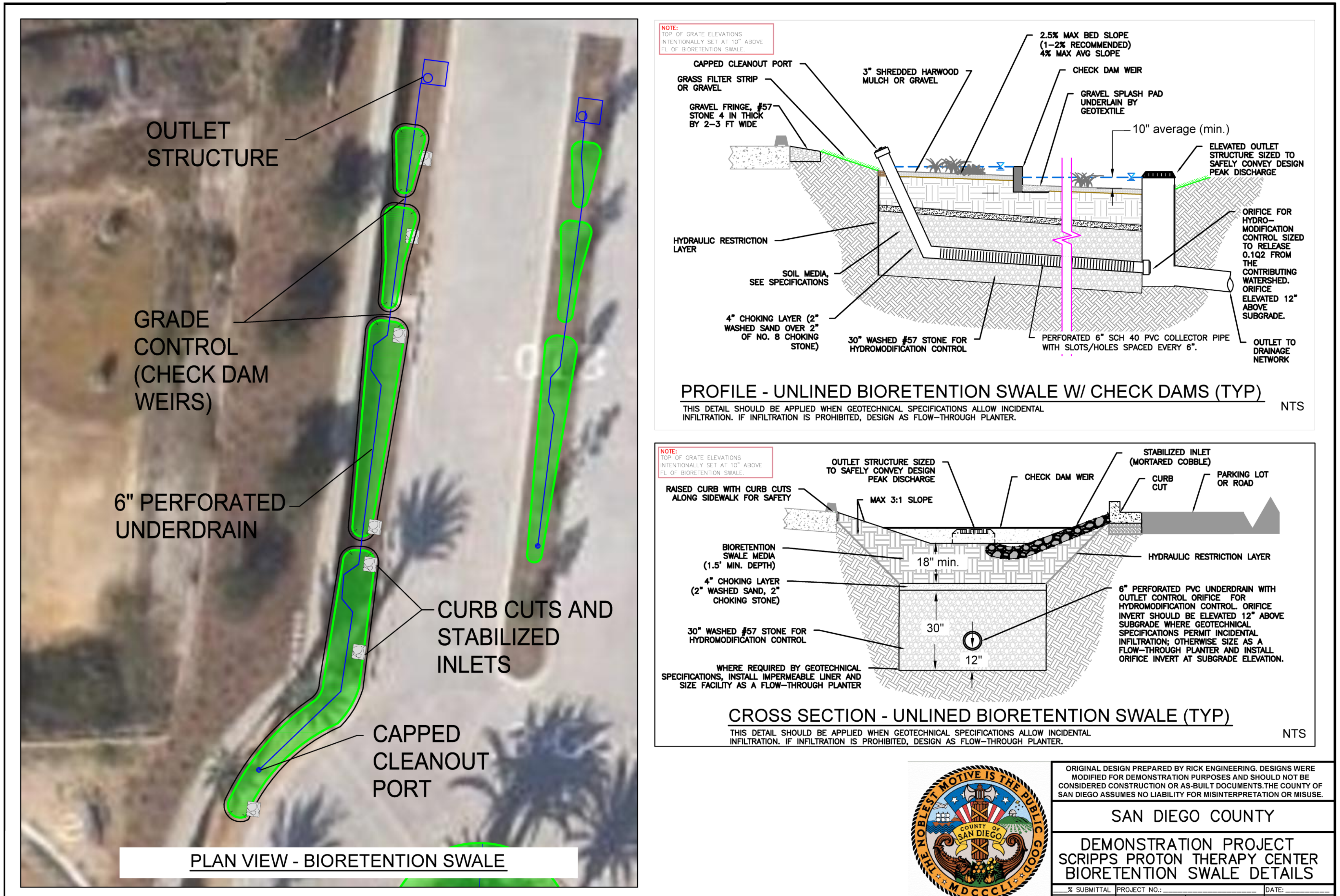
DRWN. BY: ____	DSGN. BY: ____	CHKD. BY: ____	SHEET NO.: ___OF___


OUTLET STRUCTURE
GRADE CONTROL (CHECK DAM WEIRS)
6" PERFORATED UNDERDRAIN
CURB CUTS AND STABILIZED INLETS
CAPPED CLEANOUT PORT
PLAN VIEW - BIORETENTION SWALE
NOTE: TOP OF GRATE ELEVATIONS INTENTIONALLY SET AT 10" ABOVE FL OF BIORETENTION SWALE.
CAPPED CLEANOUT PORT
GRASS FILTER STRIP OR GRAVEL
GRAVEL FRINGE, #57 STONE 4 IN THICK BY 2-3 FT WIDE
3" SHREDDED HARWOOD MULCH OR GRAVEL
2.5% MAX BED SLOPE (1-2% RECOMMENDED) 4% MAX AVG SLOPE
CHECK DAM WEIR
GRAVEL SPLASH PAD UNDERLAIN BY GEOTEXTILE
10" average (min.)
ELEVATED OUTLET STRUCTURE SIZED TO SAFELY CONVEY DESIGN PEAK DISCHARGE
HYDRAULIC RESTRICTION LAYER
SOIL MEDIA, SEE SPECIFICATIONS
ORIFICE FOR HYDRO-MODIFICATION CONTROL SIZED TO RELEASE 0.1Q2 FROM THE CONTRIBUTING WATERSHED. ORIFICE ELEVATED 12" ABOVE SUBGRADE.
4" CHOKING LAYER (2" WASHED SAND OVER 2" OF NO. 8 CHOKING STONE)
30" WASHED #57 STONE FOR HYDROMODIFICATION CONTROL
PERFORATED 6" SCH 40 PVC COLLECTOR PIPE WITH SLOTS/HOLES SPACED EVERY 6".
OUTLET TO DRAINAGE NETWORK
PROFILE - UNLINED BIORETENTION SWALE W/ CHECK DAMS (TYP)
NTS
THIS DETAIL SHOULD BE APPLIED WHEN GEOTECHNICAL SPECIFICATIONS ALLOW INCIDENTAL INFILTRATION. IF INFILTRATION IS PROHIBITED, DESIGN AS FLOW-THROUGH PLANTER.
NOTE: TOP OF GRATE ELEVATIONS INTENTIONALLY SET AT 10" ABOVE FL OF BIORETENTION SWALE.
OUTLET STRUCTURE SIZED TO SAFELY CONVEY DESIGN PEAK DISCHARGE
CHECK DAM WEIR
STABILIZED INLET (MORTARED COBBLE)
CURB CUT
PARKING LOT OR ROAD
RAISED CURB WITH CURB CUTS ALONG SIDEWALK FOR SAFETY
MAX 3:1 SLOPE
BIORETENTION SWALE MEDIA (1.5' MIN. DEPTH)
18" min.
HYDRAULIC RESTRICTION LAYER
4" CHOKING LAYER (2" WASHED SAND, 2" CHOKING STONE)
6" PERFORATED PVC UNDERDRAIN WITH OUTLET CONTROL ORIFICE FOR HYDROMODIFICATION CONTROL. ORIFICE INVERT SHOULD BE ELEVATED 12" ABOVE SUBGRADE WHERE GEOTECHNICAL SPECIFICATIONS PERMIT INCIDENTAL INFILTRATION; OTHERWISE SIZE AS A FLOW-THROUGH PLANTER AND INSTALL ORIFICE INVERT AT SUBGRADE ELEVATION.
30" WASHED #57 STONE FOR HYDROMODIFICATION CONTROL
30"
12"
WHERE REQUIRED BY GEOTECHNICAL SPECIFICATIONS, INSTALL IMPERMEABLE LINER AND SIZE FACILITY AS A FLOW-THROUGH PLANTER
CROSS SECTION - UNLINED BIORETENTION SWALE (TYP)
NTS
THIS DETAIL SHOULD BE APPLIED WHEN GEOTECHNICAL SPECIFICATIONS ALLOW INCIDENTAL INFILTRATION. IF INFILTRATION IS PROHIBITED, DESIGN AS FLOW-THROUGH PLANTER.
THE NOBLEST MOTIVE IS THE PUBLIC GOOD
COUNTY OF SAN DIEGO
MDCCCLI
ORIGINAL DESIGN PREPARED BY RICK ENGINEERING. DESIGNS WERE MODIFIED FOR DEMONSTRATION PURPOSES AND SHOULD NOT BE CONSIDERED CONSTRUCTION OR AS-BUILT DOCUMENTS.THE COUNTY OF SAN DIEGO ASSUMES NO LIABILITY FOR MISINTERPRETATION OR MISUSE.
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4.4.1.2.7 Implementation Considerations

Construction technique and sequencing are critical to bioretention and bioretention swale performance. Failure of improperly constructed systems can be easily avoided by effectively communicating with the contractor and by inspecting the system during key steps. In addition to the general construction considerations provided in chapter 4, emphasizing the following points will help ensure successful installation of bioretention and bioretention swales.

- Minimize and mitigate compaction by scarifying subsoil surface
- Inspect soil media before placement
- Verify that average ponding depth is provided (a note was provided in the construction plans indicating that outlet structures are intended to be elevated above the bed of the bioretention area or bioretention swale).

Bioretention areas and bioretention swales require regular plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. Table 4-6. provides a detailed list of maintenance activities.

Table 4-6. Inspection and maintenance tasks

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Catchment inspection	Weekly or biweekly with routine property maintenance	Excessive sediment, trash, or debris accumulation on the surface of bioretention.	Permanently stabilize any exposed soil and remove any accumulated sediment. Adjacent pervious areas might need to be re-graded.
Inlet inspection	Weekly or biweekly with routine property maintenance	Internal erosion or excessive sediment, trash, and debris accumulation	Check for sediment accumulation to ensure that flow into the bioretention is as designed. Remove any accumulated sediment.
Trash and leaf litter removal	Weekly or biweekly with routine property maintenance	Accumulation of litter and leafy debris within bioretention area	Litter and leaves should be removed to reduce the risk of outlet clogging, reduce nutrient inputs to the bioretention area, and to improve facility aesthetics.
Pruning	1 to 2 times per year	Overgrown vegetation that interferes with access, lines of sight, or safety	Nutrients in runoff often cause bioretention vegetation to flourish.
Mowing	2 to 12 times per year	Overgrown vegetation that interferes with access, lines of sight, or safety	Frequency depends on location and desired aesthetic appeal.
Mulch removal and replacement	1 time every 2 to 3 years	2/3 of mulch has decomposed	Mulch accumulation reduces available surface water storage volume. Removal of decomposed mulch also increases surface infiltration rate of fill soil. Remove decomposed fraction and top off with fresh mulch to a total depth of 3 inches

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Temporary watering	1 time every 2 to 3 days for first 1 to 2 months, sporadically after established	Until established and during severe droughts	Watering after the initial year might be required.
Fertilization	1 time initially	Upon planting	One-time spot fertilization for first year vegetation.
Remove and replace dead plants	1 time per year	Dead plants	Within the first year, 10% of plants can die. Survival rates increase with time.
Outlet inspection	Once after first rain of the season, then monthly during the rainy season	Erosion at outlet	Remove any accumulated mulch or sediment. Ensure IMP maintains a drain down time of less than 96 hours.
Miscellaneous upkeep	12 times per year	Tasks include trash collection, plant health, spot weeding, removing invasive species, and removing mulch from the overflow device.	

4.4.1.2.8 Lessons Learned

The cobble lining applied to the bed of the bioretention areas at this site was primarily installed for an aesthetic surface condition. While cobbling in some areas, particularly around inlets, may be beneficial, extensive cobbling should be avoided because it must be removed by hand for maintenance. A gravel or mulch surface cover may provide a more easily maintained bioretention bed that can be mechanically maintained by backhoe or shovel.

Providing the required soil media infiltration rates was challenging at this site due to over-compaction of bioretention areas. To avoid laborious removal and replacement of soil media, it is important that material is minimally compacted upon installation.

4.5 References

Brown, R.A., and W.F. Hunt. 2011. Impacts of media depth on effluent water quality and hydrologic performance of under-sized bioretention cells. *Journal of Irrigation and Drainage Engineering,* 137(3):132–143.

ASTM (American Society for Testing and Materials). 2009. *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer*. ASTM D 3385. American Society for Testing and Materials, West Conshohocken, PA.

Caltrans (California Department of Transportation). 2003. *Construction Site Best Management Practices (BMPs) Manual*. http://www.dot.ca.gov/hq/construc/stormwater/CSBMPM_303_Final.pdf.

CASQA (California Stormwater Quality Association). 2011. *Construction BMP Handbook*. https://www.casqa.org/store/products/tabid/154/p-167-construction-handbookportal-initial-subscription.aspx.

County of San Diego. 2012. *County of San Diego SUSMP: Standard Urban Stormwater Mitigation Plan Requirements for Development Applications*. http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmppdf/susmp_manual_2012.pdf.

FHW (Federal Highway Administration). 2002. *Storm Water Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring.* Federal Highway Administration, Washington, DC. Accessed June 5, 2013. http://environment.fhwa.dot.gov/ecosystems/ultraurb/index.asp.

Hinman, C. 2005. *Low Impact Development Technical Guidance Manual for Puget Sound*. http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf.

Luell, S.K., W.F. Hunt, and R.J. Winston. 2011. Evaluation of Undersized Bioretention Stormwater Control Measures for Treatment of Highway Bridge Deck Runoff. *Water Science & Technology,* 137(9): 790-799.

Tyner, J.S., W.C. Wright, and P.A. Dobbs. 2009. Increasing exfiltration from pervious concrete and temperature monitoring. *Journal of Environmental Management,* 90:2636-2641.

USEPA (U.S. Environmental Protection Agency). 1999. Stormwater Technology Fact Sheet: Bioretention. EPA 832-F-99-012. U.S. Environmental Protection Agency, Office of Water, Washington, DC. http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_biortn.pdf.

USEPA. 2000. Low Impact Development: A Literature Review. EPA-841-B-00-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC. http://www.lowimpactdevelopment.org/pubs/LID_litreview.pdf.

USEPA. 2011. *Evaluation of Urban Soils: Suitability for Green Infrastructure or Urban Agriculture*. EPA Publication No. 905R1103. http://water.epa.gov/infrastructure/greeninfrastructure/upload/Evaluation-of-Urban-Soils.pdf.

USEPA (U.S. Environmental Protection Agency). 2012. Urban Stormwater BMP Performance Monitoring. U.S. Environmental Protection Agency, Office of Water, Washington, DC. http://water.epa.gov/scitech/wastetech/guide/stormwater/monitor.cfm.

Wardynski, B.J. and W.F. Hunt. 2012. Are Bioretention Cells Being Installed per Design Standards in North Carolina? A Field Assessment. *Journal of Environmental Engineering*, 138(12): 1210-1217.