4.4.1 Demonstration Project Case Studies

The following demonstration projects are provided to supplement the content of the Handbook by illustrating various considerations of LID and IMP design for meeting County SUSMP requirements. These case studies are for demonstration purposes only, thus the design material was abridged for simplicity. The following format should not be considered a comprehensive report that will satisfy local SUSMP submittal requirements. Some project components were modified from the original design to demonstrate specific concepts from the Handbook.

4.4.1.1 Demonstration Project: San Diego International Airport – Terminal 2 Parking Lot

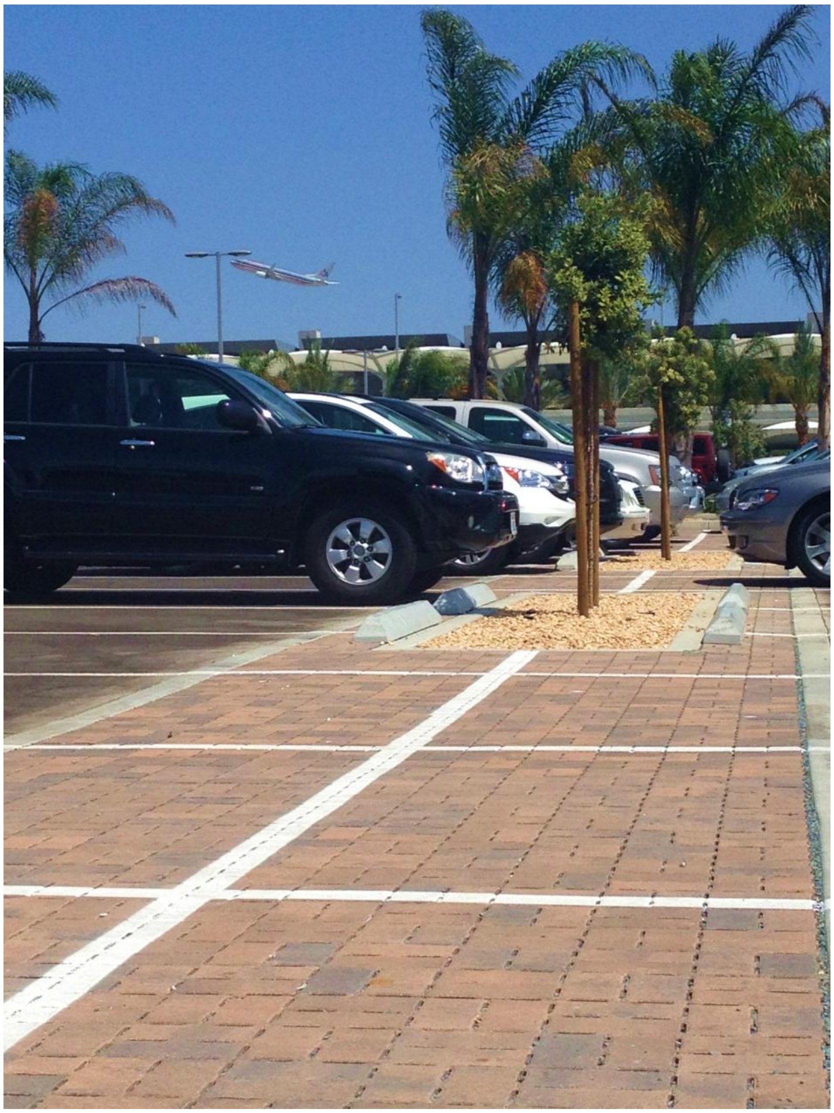


Figure 4-20. Permeable pavement in the Terminal 2 parking lot.

PRIORITY DEVELOPMENT PROJECT

Location
San Diego International Airport, North Harbor Drive, San Diego

Highlighted IMPs
Rock Infiltration Swales
Permeable Pavement

Impervious Area Treated by Highlighted IMPs
9.7 acres

IMP Footprint
3.7 acres

Other IMPs On-site
Swales

Media Filters

Construction Date
2012

Design Engineer
URS Corporation

4.4.1.1.1 Site Background and Proposed Development

The San Diego International Airport recently expanded and improved its facilities. Improvements included a dual-level roadway for passenger departures and arrivals, increased capacity for overnight aircraft parking, 10 new gates, and enhanced indoor facilities. As a component of the expansion, the Terminal 2 short-term parking lot was retrofit with IMPs for stormwater management.

The parking lot is located between Terminal 2 and North Harbor Drive, as shown in Figure 4-21

Figure 4-21. Terminal 2 short-term parking site location.

4.4.1.1.2 Design Criteria

Runoff from the Airport outfalls to San Diego Bay near Harbor Island, which is impaired for metals (copper) and organics (PCBs) according to USEPA's 303(d) list. Due to elevated levels of copper in the vicinity of the Airport outfall, heavy metals were considered the primary pollutant of concern for the priority development project. Secondary pollutants of concern were sediment, nutrients, organic compounds, trash and debris, oxygen demanding substances, oil and grease, bacteria and viruses, and pesticides.

A detailed drainage report was prepared for the site and the 0.55-inch, 24-hour rain event was identified as the 85th-percentile water quality design storm. Because runoff from the site ultimately discharges directly to San Diego Bay, no hydromodification criteria were warranted.

4.4.1.1.3 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 Terminal 2 parking lot was a retrofit and was built on fill material, so conservation of natural areas, soils, vegetation, and natural drainages were challenging LID design goals for this project. Nevertheless, designers made efforts where practicable to protect existing vegetation, provide vegetated swales to disconnect impervious surfaces, minimize impervious surfaces, drain rooftops to landscaped areas, and provide native, drought-tolerant vegetation. Had this project been new development, additional self-treating or self-retaining landscaped areas could be incorporated into islands, medians, and the perimeter of the site to reduce stormwater runoff. Soil compaction was minimized during construction to the maximum extent practicable to limit any impacts to the infiltration rate of the subsoils.

4.4.1.1.4 IMP Selection

Primary treatment control for the Terminal 2 parking lot was provided by manufactured high-flow filters, but the designer chose to incorporate LID as a method to reduce the required treatment volume (and, subsequently, the required high-flow filter size). To reduce runoff volume from the parking lot, permeable pavement was incorporated throughout the site as self-retaining areas. Each permeable pavement was sized to capture and infiltrate the volume of runoff from its respective drainage area associated with the 85th percentile storm event. Similarly, rock infiltration swales were incorporated into parkway along the transit center with the goal of reducing runoff to the high-flow filters by capturing and infiltrating runoff.

4.4.1.1.5 IMP Design

Once IMPs were selected to meet the SUSMP criteria, the design steps presented in Table 4-1 and Table 4-2 could be employed to incorporate rock infiltration swales and permeable pavement into the site design. Photos are shown in Figure 4-22, Figure 4-23, Figure 4-24, Figure 4-25, and Figure 4-26.

Table 4-1. Rock infiltration swale design steps

Design step		Design component/ consideration	General specification
1	**IMP Siting**	Layout and site incorporation	Based on available space, maintenance access, and existing storm drains, rock infiltration swales were incorporated into the landscaped areas along the transit center roadways adjacent to the Terminal 2 short-term lot.
2	**Determine IMP Function and Configuration**	No underdrain	Subsoil infiltration rates allowed full infiltration. Underdrains and impermeable liners were not necessary. Subgrade compaction was minimized.
		Lateral hydraulic restriction barriers	Geotextile was used along the perimeter of the excavation to minimize migration of native soils into amended soils.
3	**Determine IMP Sizing Approach**	Flow-based (common SUSMP methodology)	Used volume-based method below.
		Volume-based (water quality methodology)	Each rock infiltration swale was sized to capture in the soil media void space the runoff volume associated with the 85th percentile storm.
4	**Size the System**	Temporary ponding depth	2 inches of surface ponding was provided to encourage infiltration into the amended soil media
		Soil media depth	1.5 feet of soil media was provided
		Surface Area (Volume-based water quality)	The surface area required to store treatment volume within the soil media depth was determined by dividing the required treatment volume by the effective media depth (product of the media depth and porosity)
5	**Specify Soil Media**	Composition and texture	Sandy loam
		Permeability	5 in/hr per SUSMP, although site-specific volume-based sizing method indicated that a minimum design infiltration rate of 3.6 in/hr would be appropriate to minimize the risk of infiltration failure
6	**Design Inlet and Pretreatment**	Inlet	Provided curb cuts to intercept gutter flow
		Pretreatment	Cobble-lined inlet provides pretreatment and energy dissipation
7	**Select and Design Overflow/Bypass Method**	Outlet configuration	Online: All runoff is routed through system—an elevated overflow structure was installed at the elevation of maximum ponding.
		Hydromodification control	Not necessary – drains to San Diego Bay. (If required, provide additional storage in subsurface aggregate layer and size an appropriate nonclogging orifice or weir to dewater detention volume.)
8	**Select Surface Material**	Cobble or gravel	Surface was stabilized with gravel or decorative cobble.
9	**Design for Multi-Use Benefits**	Additional benefits	Drought-tolerant vegetation was included along the banks of the IMP to improve aesthetics.


Figure 4-22. Curb cut and cobble energy dissipation at inlet to rock infiltration swale.

Figure 4-23. Cobble and gravel stabilize the surface of the rock infiltration swale and prevent scour of underlying soil media. The outlet structure in the foreground is elevated 2" above the bed of the rock infiltration swale to ensure that the design storm flow is retained and filtered through the media.

Table 4-2. Permeable pavement design steps

Design step		Design component/ consideration	General specification
1	**Determine IMP Treatment Volume**	Runoff calculations	Per SUSMP (County of San Diego 2012), the volume of the 24-hour 85th percentile storm is required for the water quality treatment method (County of San Diego 2012 SUSMP, Chapter 2)
2	**IMP Siting**	Layout and site incorporation	Based on available space, permeable pavement was incorporated into parking stalls and along the perimeter of the parking lot.
3	**Select Permeable Pavement Surface Course**	Surface course type	Permeable interlocking concrete pavers (PICP) were selected for practicality and aesthetics.
4	**Determine IMP Function and Configuration**	No underdrain	Subsoil infiltration rates allowed full infiltration. Underdrains and impermeable liners were not necessary. Subgrade compaction was minimized.
		Lateral hydraulic restriction barriers	Geomembranes were used to restrict lateral flows to adjacent subgrades, foundations, or utilities.
		Subgrade slope and geotextile	Subgrade slope should be 0.5% or flatter. Baffles should be used to ensure water quality volume is retained. Geotextile should be used along perimeter of cut to prevent soil from entering the aggregate voids.
5	**Design the Profile**	Surface area and reservoir depth	Water quality volume should be fully stored within the aggregate base layers below the surface course. Base layer should be washed ASTM No. 57 stone (washed ASTM No. 2 may be used as a subbase layer for additional storage).
		Structural Design	A pavement structural analysis should be completed by a qualified and licensed professional.
6	**Design for Overlow/Bypass**	Large storm routing	<u>Modular/Paver-type systems (PICP)</u>: internal overflow is generally recommended to prevent upflow and transport of bedding course-this site allowed surface overflow because slopes were gradual and flow was dispersed over a large area.
7	**Edge Restraints and Transitions**	Transition strip	A concrete transition strip was provided around the perimeter of PICP to contain pavers and delineate permeable surfaces.
8	**Design Signage**	Signage regulations	Signage should indicate prohibited activities that cause premature clogging and alert pedestrians and maintenance staff that the surface is intended to be permeable.
9	**Design for Multi-Use Benefits**	Additional benefits	Attractive patterns and colors were installed.

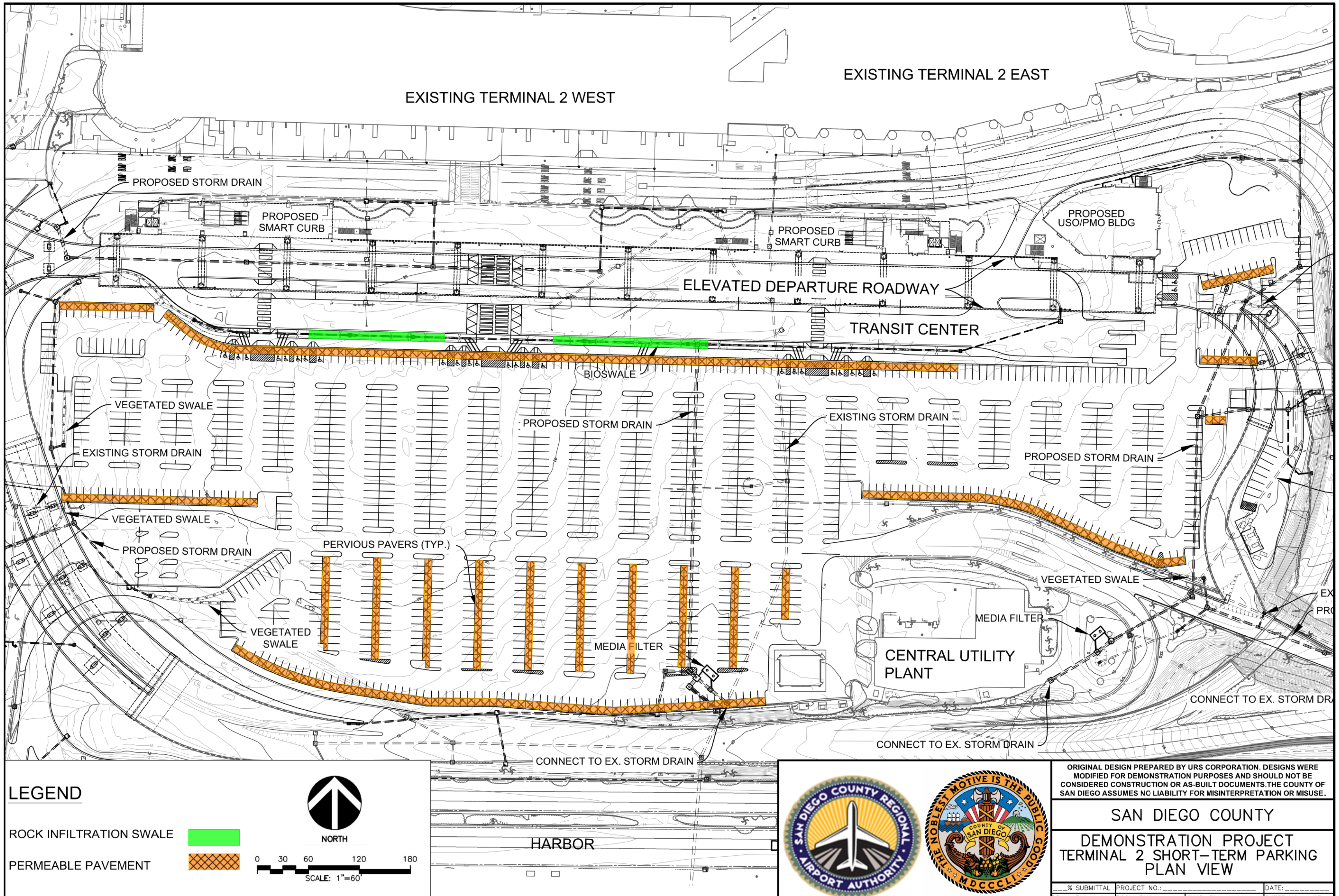
Figure 4-24. A concrete transition strip was used to delineate the permeable surface and provide edge restraints for the pavers.

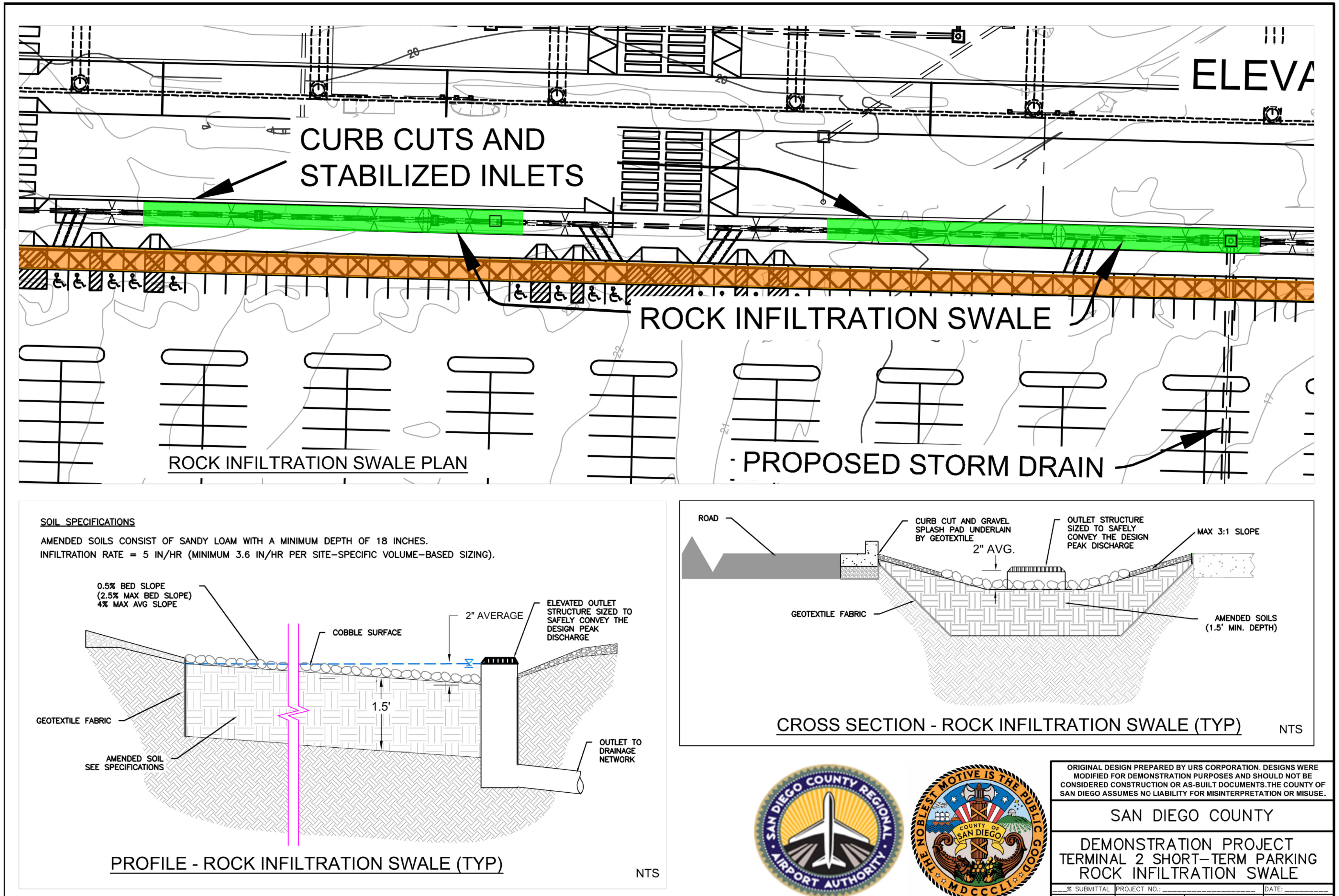
Figure 4-25. PICP was chosen as the surface course for this application. Bedding and joint fill material consists of washed ASTM No. 8.

Figure 4-26. Surface overflow was provided for larger storm routing. Generally, internal bypass is effective for PICP applications to prevent upwelling and transport of the bedding course materials, but gradual slopes and diffuse flows deemed internal bypass unnecessary for this site.

4.4.1.1.6 Design Details

The following sheets provide example plans, profiles, and cross sections of the IMPs installed at the Terminal 2 short-term parking lot.


EXISTING TERMINAL 2 WEST
EXISTING TERMINAL 2 EAST
PROPOSED STORM DRAIN
PROPOSED SMART CURB
PROPOSED SMART CURB
PROPOSED USO/PMO BLDG
ELEVATED DEPARTURE ROADWAY
TRANSIT CENTER
BIOSWALE
VEGETATED SWALE
EXISTING STORM DRAIN
PROPOSED STORM DRAIN
EXISTING STORM DRAIN
PROPOSED STORM DRAIN
VEGETATED SWALE
PROPOSED STORM DRAIN
PERVIOUS PAVERS (TYP.)
VEGETATED SWALE
VEGETATED SWALE
MEDIA FILTER
MEDIA FILTER
CENTRAL UTILITY PLANT
CONNECT TO EX. STORM DRAIN
CONNECT TO EX. STORM DRAIN
CONNECT TO EX. STORM DRAIN
HARBOR
LEGEND
ROCK INFILTRATION SWALE
PERMEABLE PAVEMENT
NORTH
0 30 60 120 180
SCALE: 1"=60'
SAN DIEGO COUNTY REGIONAL AIRPORT AUTHORITY
THE NOBLEST MOTIVE IS THE PUBLIC GOOD
COUNTY OF SAN DIEGO
MDCCCLI
ORIGINAL DESIGN PREPARED BY URS CORPORATION. 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
TERMINAL 2 SHORT-TERM PARKING
PLAN VIEW



ELEVA
CURB CUTS AND
STABILIZED INLETS
ROCK INFILTRATION SWALE
ROCK INFILTRATION SWALE PLAN
PROPOSED STORM DRAIN
SOIL SPECIFICATIONS
AMENDED SOILS CONSIST OF SANDY LOAM WITH A MINIMUM DEPTH OF 18 INCHES.
INFILTRATION RATE = 5 IN/HR (MINIMUM 3.6 IN/HR PER SITE-SPECIFIC VOLUME-BASED SIZING).
0.5% BED SLOPE
(2.5% MAX BED SLOPE)
4% MAX AVG SLOPE
COBBLE SURFACE
2" AVERAGE
ELEVATED OUTLET STRUCTURE SIZED TO SAFELY CONVEY THE DESIGN PEAK DISCHARGE
1.5'
GEOTEXTILE FABRIC
AMENDED SOIL SEE SPECIFICATIONS
OUTLET TO DRAINAGE NETWORK
PROFILE - ROCK INFILTRATION SWALE (TYP)
NTS
ROAD
CURB CUT AND GRAVEL SPLASH PAD UNDERLAIN BY GEOTEXTILE
2" AVG.
OUTLET STRUCTURE SIZED TO SAFELY CONVEY THE DESIGN PEAK DISCHARGE
MAX 3:1 SLOPE
GEOTEXTILE FABRIC
AMENDED SOILS (1.5' MIN. DEPTH)
CROSS SECTION - ROCK INFILTRATION SWALE (TYP)
NTS
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SAN DIEGO COUNTY
DEMONSTRATION PROJECT
TERMINAL 2 SHORT-TERM PARKING
ROCK INFILTRATION SWALE
___% SUBMITTAL PROJECT NO.:________ DATE:________
DRWN. BY:____ DSGN. BY:____ CHKD. BY:____ SHEET NO.:__OF__
SAN DIEGO COUNTY REGIONAL AIRPORT AUTHORITY
THE NOBLEST MOTIVE IS THE PUBLIC GOOD
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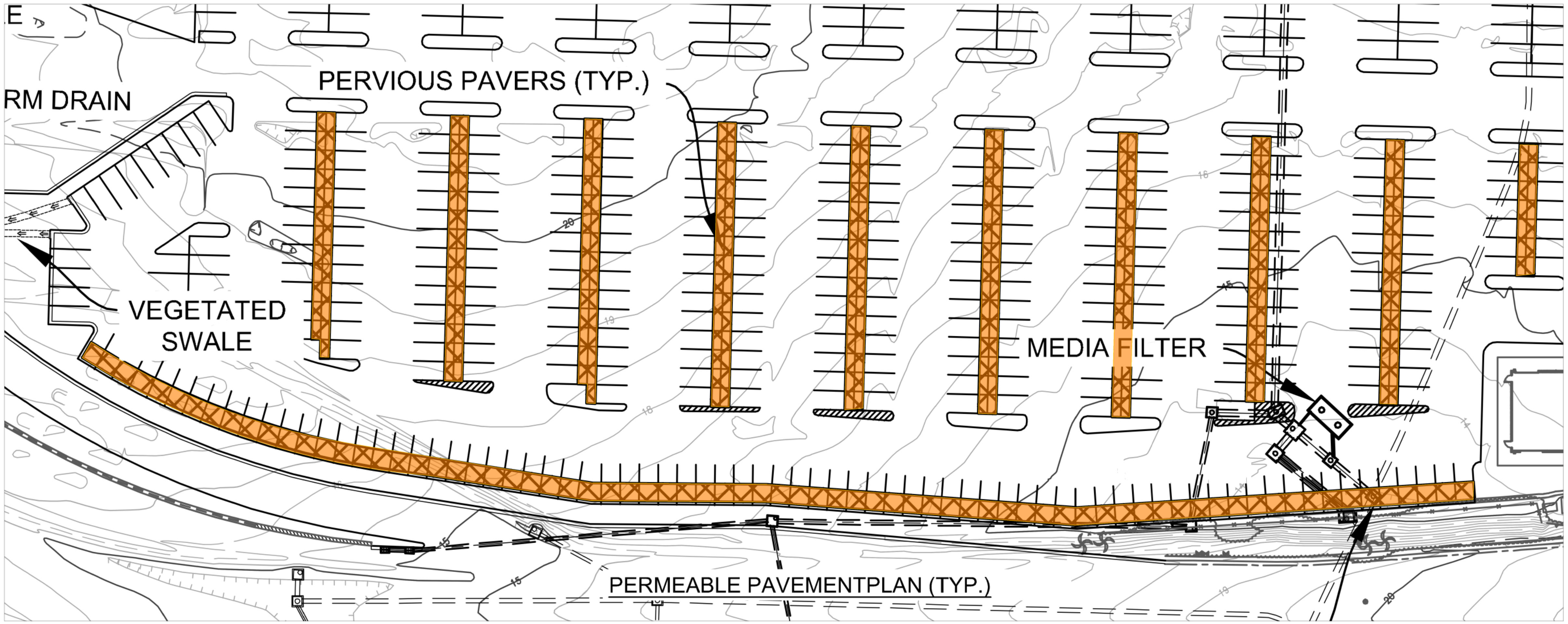

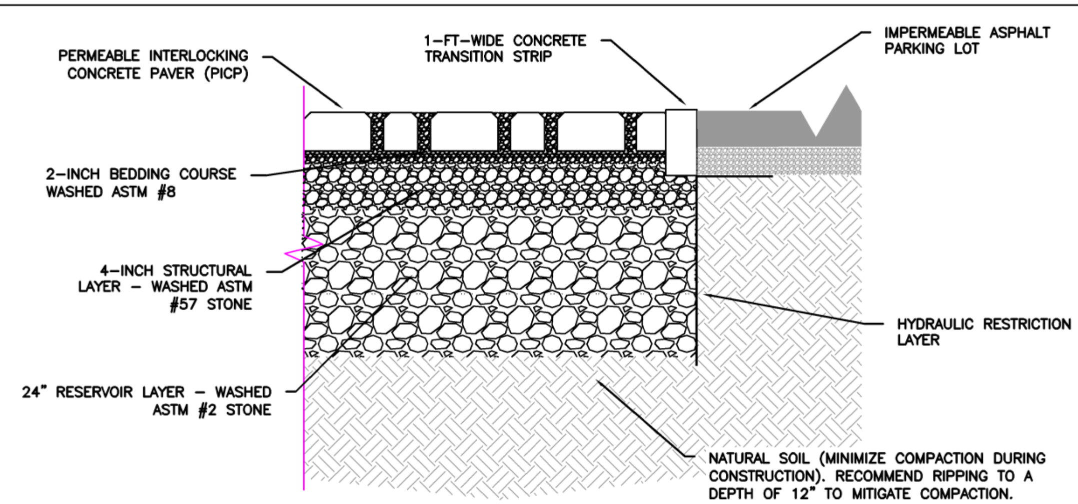

PERMEABLE PAVEMENT PROFILE (TYP.)

NTS

<u>PERMEABLE INTERLOCKING CONCRETE PAVERS</u>

TYPE: ASTM C936, HYDRAULICALLY PRESSED CONCRETE OF 8,000 PSI MINIMUM, 28 DAY COMPRESSIVE STENGTH.

SIZE: 5X10X3 INCH

STYLE: INTERLOCKING

<u>CRUSHED STONE FILLER, BEDDING, BASE, AND SUBBASE:</u>

CRUSHED STONE WITH 90% FRACTURED FACES, LA ABRASION < 40 PER ASTM C131, MINIMUM CBR OF 80% PER ASTM d1883

DO NOT USE ROUNDED RIVER GRAVEL

ALL STONE MATERIAL SHALL BE WASHED WITH LESS THAN 1% PASSING THE NO. 200 SIEVE

JOINT/OPENING FILLER, BEDDING, BASE, AND SUBBASE SHALL CONFORM TO ASTM D448 GRADATION.

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SAN DIEGO COUNTY

DEMONSTRATION PROJECT
TERMINAL 2 SHORT-TERM PARKING
PERMEABLE PAVEMENT DETAILS

___% SUBMITTAL	PROJECT NO.: ________		DATE: ________
DRWN. BY: ____	DSGN. BY: ____	CHKD. BY: ____	SHEET NO.: __OF__

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4.4.1.1.7 Implementation Considerations

Construction technique and sequencing are critical to IMP 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 rock infiltration swales and permeable pavement:

- Inspect soil media before placement
- Inspect aggregate upon delivery to ensure thorough washing was performed
- Verify that average ponding depth is provided in rock infiltration swale
- Inspect subgrade elevations and grading
- Test subgrade infiltration rate
- Minimize and mitigate subsoil compaction by scarifying subsoil surface
- Inspect surface course placement and curing

Following construction, maintenance is necessary to prolong the performance of rock infiltration swales and permeable pavements. Table 4-3 and Table 4-4 provide detailed lists of maintenance activities for the IMPs.

Table 4-3. Rock infiltration swale 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.
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, spot weeding, removing invasive species, and removing debris from the overflow device.	

Table 4-4. Operation and maintenance tasks for permeable pavement

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Catchment inspection	Weekly or biweekly during routine property maintenance	Sediment accumulation on adjacent impervious surfaces or in voids/joints of permeable pavement	Stabilize any exposed soil and remove any accumulated sediment. Adjacent pervious areas might need to be graded to drain away from the pavement.
Miscellaneous upkeep	Weekly or biweekly during routine property maintenance	Trash, leaves, weeds, or other debris accumulated on permeable pavement surface	Immediately remove debris to prevent migration into permeable pavement voids. Identify source of debris and remedy problem to avoid future deposition.
Preventative vacuum/regenerative air street sweeping	Twice a year in higher sediment areas	N/A	Pavement should be swept with a vacuum power or regenerative air street sweeper at least twice per year to maintain infiltration rates.
Replace fill materials	As needed	For paver systems, whenever void space between joints becomes apparent or after vacuum sweeping	Replace bedding fill material to keep fill level with the paver surface.
Restorative vacuum/regenerative air street sweeping	As needed	Surface infiltration test indicates poor performance or water is ponding on pavement surface during rainfall	Pavement should be swept with a vacuum power or regenerative air street sweeper to restore infiltration rates.

4.4.1.1.8 Lessons Learned

Design and construction of LID features can often present new and unexpected challenges. During design of the Terminal 2 short-term parking lot IMPs it became evident that, due to topographical constraints and drainage patterns, locations of available land for LID do not always coincide with areas to which runoff flows. This challenge often arises during LID design and must be overcome with creative solutions that do not always conform to engineering paradigms. The airport IMPs demonstrate such innovative design by intercepting diffuse flow along the entire parking lot perimeter using a narrow band of permeable pavement (instead of converting the entire parking stall to permeable pavement per typical designs).

Sourcing and furnishing the specified materials was another challenge encountered during construction. It was difficult to find a quarry or supplier that provided washed ASTM No. 2 and No. 8 aggregates matching the design specifications. Material substitutions can occasionally be made but it is critical that any substituted material conforms to the original design intent, does not negatively impact the water quality performance of the IMP, and protects the public safety, health, and welfare. The proper washed crushed aggregate was eventually sourced and the permeable pavers were successfully installed.

Construction oversight and open communication with the contractor was also deemed an important component to the success of the project. Explaining the intent and purpose of specific water quality features to the contractor was critical to ensure compaction was minimized and to ensure that IMPs were constructed to retain and infiltrate water instead of freely draining to the storm drains. This was particularly important in retrofit scenarios, such as where existing concrete channels were converted to