# PRELIMINARY WATER QUALITY MANAGEMENT PLAN (PWQMP)

**Project Name:**

**STARFISH**
**LOTS 1 TO 7 AND LOT A – TENTATIVE TRACT NO. 19115**
**9779 Starfish Avenue**
**Fountain Valley, CA 92708**
**APN 167-232-01**

Prepared for:

STARFISH FV VENTURE, LLC
2961 W. MacArthur Blvd., Suite 210
Santa Ana, CA 92704
(714) 791-3771

Prepared by:

DMS Consultants, Inc.
Engineer: Surender Dewan, P.E. Registration No.: 34559
12371 Lewis Street, Suite 203
Garden Grove, CA 92840
(714) 740-8840

Date Prepared: July 21, 2020

| PROJECT OWNER'S CERTIFICATION | | | |
|---|---|---|---|
| Permit/Application No. | | Grading Permit No. | TBD |
| Tract No. | 19115<br>Lots 1 to 7 & Lot A | Building Permit No. | TBD |
| CUP, SUP, and/or APN (Specify Lot Numbers if Portions of Tract) | | | APN 167-232-01 |

This Preliminary Water Quality Management Plan (PWQMP) has been prepared for STARFISH FV VENTURE, LLC by DMS CONSULTANTS, INC. The WQMP is intended to comply with the requirements of the local NPDES Stormwater Program requiring the preparation of the plan.

The undersigned, while it owns the subject property, is responsible for the implementation of the provisions of this plan and will ensure that this plan is amended as appropriate to reflect up-to-date conditions on the site consistent with the current Orange County Drainage Area Management Plan (DAMP) and the intent of the non-point source NPDES Permit for Waste Discharge Requirements for the County of Orange, Orange County Flood Control District and the incorporated Cities of Orange County within the Santa Ana Region. Once the undersigned transfers its interest in the property, its successors-in-interest shall bear the aforementioned responsibility to implement and amend the WQMP. An appropriate number of approved and signed copies of this document shall be available on the subject site in perpetuity.

| OWNER: | | | |
|---|---|---|---|
| Name/Title | David Nguyen | | |
| Company | Starfish FV Venture, LLC | | |
| Address | 2961 W. MacArthur Blvd., Suite 210<br>Santa Ana, CA 92704 | | |
| Email | david@keystonedcs.com | | |
| Telephone # | (714) 791-3771 | | |
| I understand my responsibility to implement the provisions of this WQMP including the ongoing operation and maintenance of the best management practices (BMPs) described herein. | | | |
| Signature | [signature] | Date | 07-21-2020 |

| PREPARER (ENGINEER): | | | |
|---|---|---|---|
| Title | President | PE Registration # | 34559 Exp. 9/30/21 |
| Company | DMS Consultants, Inc. | | |
| Address | 12371 Lewis Street, Suite 203<br>Garden Grove, California 92840 | | |
| Email | Surender@DMSConsultantsInc.com | | |
| Telephone # | (714) 740-8840 | | |
| I hereby certify that this Water Quality Management Plan is in compliance with, and meets the requirements set forth in Order No. R8-2009-0030/NPDES No. CAS618030, of the Santa Ana Regional Water Quality Control Board. | | | |
| Preparer Signature | [signature] | Date | 7/21/20 |
| Place Stamp Here | REGISTERED PROFESSIONAL ENGINEER<br>SURENDER M. DEWAN<br>No. 34559<br>Exp. ______<br>CIVIL<br>STATE OF CALIFORNIA | | |

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# SECTION I DISCRETIONARY PERMITS AND WATER QUALITY CONDITIONS

| PROJECT INFORMATION | | | |
|---|---|---|---|
| Permit/Application No. | | Grading or Building Permit No. (If applicable) | TBD |
| Address of Project Site (or Tract Map and Lot Number if no address) and APN | Lots 1 to 7 & Lot A - Tract 19115<br>9779 Starfish Avenue<br>Fountain Valley, CA<br>APN 167-232-01 | | |
| **WATER QUALITY CONDITIONS** | | | |
| Water Quality Conditions of Approval or Issuance applied to this project | This is a Preliminary Water Quality Management Plan. At this time, no Conditions of Approval or Water Quality Conditions have been issued. Conditions of Approval will be provided for Final WQMP approval. | | |
| **WATERSHED-BASED PLAN CONDITIONS** | | | |
| Provide applicable conditions from watershed - based plans including WIHMPs and TMDLS. | Not applicable | | |

# SECTION II PROJECT DESCRIPTION

## II.1 Project Description

The proposed Lots 1 to 7 and Lot A of Tentative Tract 19115 encompasses 1.02 acres in the City of Fountain Valley. The site is bounded by existing residential properties to the north and west, by vacant land on the east, and by Starfish Avenue on the south.

| DESCRIPTION OF PROPOSED PROJECT | | | | |
|---|---|---|---|---|
| Development Category (Verbatim from WQMP): | Development Category 1 - New development projects that create 10,000 square feet or more of impervious surface. This category includes commercial, industrial, residential housing subdivisions, mixed-use, and public projects on private or public property that falls under the planning and building authority or the Permittees. | | | |
| Project Area (ft$^2$): | 44,255 ft$^2$ / 1.02 acres | | | |
| Number of Dwelling Units: | 7 single family homes | | | |
| SIC Code: | Not applicable | | | |
| Narrative Project Description: | The project consists of construction of seven (7) single family homes varying in sizes from 2408 SF to 3204 SF and Lot sizes varies from 4552 SF to 5989 SF, private street, open space, and private garage spaces. Each residential unit will include a two car garage. The breakdown of the site conditions is as follows:<br><br>Building coverage: 12,832 SF<br>Parking spaces: 38<br>Garage spaces: 14<br>Guest spaces: 24<br>Open space: 24,907 SF<br><br>The proposed landscaping consists of drought tolerant material, some of which will be native as required by the City of Fountain Valley. | | | |
| | Pervious Area (acres or sq ft) | Pervious Area Percentage | Impervious Area (acres or sq ft) | Impervious Area Percentage |
| Pre-Project Conditions: | 0.80 acres | 79% | 0.22 acres | 21% |
| Post-Project Conditions: | 0.58 acres | 57% | 0.44 acres | 43% |
| Drainage Patterns/Connections: | A Geotechnical Report and Infiltration Study conducted by Geoboden, Inc., dated April 10, 2020, Geoboden, Inc., indicates an infiltration rate of 1.40 inches/hour which is more than the minimum permissible of 0.30 inches/hour. A copy of this report is included in Attachment E. | | | |

| | |
|---|---|
| Drainage Patterns/Connections: | **EXISTING CONDITIONS**<br>The proposed project is located along the northerly curb of Starfish Avenue, west of Mt. Henry Street. The overall site slopes towards Starfish Avenue. The approximate elevations of the site vary from 32.0 to 28.0 feet above mean sea level (msl). Currently the site is vacant land. Single family homes are located to the east and Huntington Valley Baptist Church to the west of the project. Under existing conditions the project drains to Starfish Avenue.<br><br>**PROPOSED CONDITIONS**<br>To capture, store, and infiltrate storm water (low flow) runoff will be directed to Eco-Stone permeable pavers underlaid with open graded gravel in drive areas. Overflow (high flow) from the area will be directed via a parkway drain to Starfish Avenue. |

## II.2 POTENTIAL STORMWATER POLLUTANTS

The table below, derived from Table 2 of the Countrywide Model WQMP Technical Guidance Document (May 2011), summarizes the categories of land use or project features of concern and the general pollutant categories associated with them.

| POLLUTANTS OF CONCERN | | | |
|---|---|---|---|
| Pollutant | E = Expected to be of concern<br>N = Not Expected to be of concern | | Additional Information and Comments |
| Suspended-Solid/ Sediment | **E** | | Existing landscaping areas and disturbed earth surfaces. |
| Nutrients | **E** | | Fertilizers, sediment and trash/debris. |
| Heavy Metals | **E** | | Vehicles and automotive fluids as well as various construction materials. |
| Pathogens (Bacteria/Virus) | **E** | | Pets, food wastes and landscaping/sediment areas. |
| Pesticides | **E** | | Landscaping and household sources. |
| Oil and Grease | **E** | | Parked vehicles. |
| Toxic Organic Compounds | **E** | | Public street. |
| Trash and Debris | **E** | | Common litter and trash. |

## II.3 HYDROLOGIC CONDITIONS OF CONCERN

The purpose of this section is to identify any hydrologic conditions of concerns (HCOC) with respect to downstream flooding, erosion potential of natural channels downstream, impacts of increased flows on natural habitat, etc.

In the North Orange County permit area, HCOCs are considered to exist if any streams located downstream from the project are determined to be potentially susceptible to hydromodification impacts and either of the following conditions exists:

- Post-development runoff volume for the 2-yr, 24-hr storm exceeds the pre-development runoff volume for the 2-yr, 24-hr storm by more than 5 percent

*or*

- Time of concentration (Tc) of post-development runoff for the 2-yr, 24-hr storm exceeds the time of concentration of the pre-development conditions for the 2-yr, 24-hr storm by more than 5 percent.

If these conditions do not exist or streams are not potentially susceptible to hydromodification impacts, an HCOC does not exist and hydromodification does not need to be considered further. In the North Orange County permit area, downstream channels are considered not susceptible to hydromodification, and therefore do not have potential for a HCOC, if all downstream conveyance channels that will receive runoff from the project are engineered, hardened, and regularly maintained to ensure design flow capacity, and no sensitive habitat areas will be affected.

Is the proposed project potentially susceptible to hydromodification impacts?

☐ Yes ☒ No (show map)

The project is not susceptible to hydromodification impacts because all downstream receiving waters, namely the Talbert Watershed is considered stabilized. See map provided in Attachment A.

## II.4 POST DEVELOPMENT DRAINAGE CHARACTERISTICS

To capture, store, and infiltrate storm water (low flow) runoff will be directed to Eco-Stone permeable pavers underlaid with open graded gravel in drive areas.

Overflow (high flow) from the area will be directed via a parkway drain to Starfish Avenue

## II.5 PROPERTY OWNERSHIP/MANAGEMENT

A Home Owners Association (HOA) will be formed upon project completion. The HOA will be responsible for inspecting and maintaining all onsite and offsite BMPs prescribed for Tentative Tract No. 19115. Until an HOA is formally established, Starfish FV Venture, LLC shall assume all BMP maintenance and inspection responsibilities for the proposed project. Inspection and maintenance activities are outlined in Section V of this WQMP.

# SECTION III SITE DESCRIPTION

## III.1 PHYSICAL SETTING

| | |
|---|---|
| Planning Area/ Community Name: | Lots 1 to 7 & Lot A - Tract 19115<br>Villa Serena |
| Location/Address: | 9779 Starfish Avenue, Fountain Valley, CA |
| Land Use: | Residential |
| Zoning: | GH |
| Acreage: | 1.02 acres |
| Predominant Soil Type: | Sandy clay |

## III.2 SITE CHARACTERISTICS

| | |
|---|---|
| Precipitation Zone: | 0.70 inches |
| Topography: | The overall site is relatively flat. The approximate elevations of the site vary from 28.0 to 32.0 feet above mean sea level (msl). |
| Drainage Patterns/Connections: | The site surface drains to Starfish Avenue and then on to Talbert Channel and ultimately to the Pacific Ocean. |
| Soil Type, Geology, and Infiltration Properties: | According to the infiltration study constraint maps, Section XVI-2 of the T.G.D., the project is located in hydrological soil Group B. A Geotechnical Study conducted on the project site indicates the soil to be silty sand to sandy silt. An infiltration study conducted for the project indicates an infiltration rate of 1.40 inches/hour. |
| Hydrogeologic (Groundwater) Conditions: | The project is not located in plume protection boundary nor is identified as natural pollution source area, contaminated site or within 250 feet of a contaminated site. Groundwater was not encountered. Review of available maps prepared by the State of California indicates that the historic high groundwater level is as shallow as 10 feet. |
| Geotechnical Conditions: (relevant to infiltration) | There are no contamination sires or groundwater protection plumes within the project vicinity. There are no concerns with the use of infiltration BMPs on-site. |
| Off-Site Drainage: | The project does not receive offsite run-on from adjacent properties. |
| Utility and Infrastructure Information: | There are no existing subsurface utilities that will impact the location of LID BMPs on-site. |

## III.3 WATERSHED DESCRIPTION

| | |
|---|---|
| Receiving Waters: | Talbert Channel and Santa Ana River Watershed |
| 303(d) Listed Impairments: | None listed |
| Applicable TMDLs: | None |
| Pollutants of Concern for the Project: | Expected pollutants from parking lot development include sediment, nutrients, pathogens, pesticides, oil and grease, and trash. |
| Environmentally Sensitive Areas and Areas of Special Biological Significant: | There are no ESAs or ASBS within the project's vicinity. |

# SECTION IV BEST MANAGEMENT PRACTICES (BMPS)

## IV. 1 PROJECT PERFORMANCE CRITERIA

Is there an approved WIHMP or equilvalent for the project area that includes more stringent LID feasibility criteria or if there are opportunities identified for implementing LID on regional or sub-regional basis?

☐ Yes ☒ No

| PROJECT PERFORMANCE CRITERIA | |
|---|---|
| Hydromodification Control Performance Criteria: (Model WQMP Section 7.II.4.2.2) | For proposed projects within the North County permit area that may have an HCOC, each Priority Project proponent must determine the impact of the proposed development on the downstream hydrologic characteristics. The evaluation of potential impacts is based on the following for a two-year frequency storm event:<br>▪ Increases in runoff volume;<br>▪ Deceases in infiltration;<br>▪ Changes in time of concentration;<br>▪ Potential for increase in post development downstream erosion; and<br>▪ Potential for adverse downstream impacts on physical structure, aquatic and riparian habitat.<br><br>A project does not have an HCOC if either of the following conditions is met:<br>▪ The volumes and time of concentration of stormwater runoff for the post-development conditions do not significantly exceed those of the predevelopment condition for a two-year frequency storm event (a difference of five percent or less is considered insignificant).<br>▪ The site infiltrates at least the runoff from a two-year storm event.<br><br>If a hydrologic condition of concern (HCOC) exists, priority projects shall implement onsite or regional hydromodification controls such that:<br>▪ Post-development runoff volume for the two-year frequency storm does not exceed that of the predevelopment condition by more than five percent, and<br>▪ Time of concentration of post-development runoff for the two-year storm event is not less than that for the predevelopment condition by more than five percent.<br><br>Where the Project WQMP documents that excess runoff volume from the two-year event cannot feasibly be retained and where in-stream controls cannot be used to otherwise mitigate HCOCs, the project shall implement on-site or regional hydromodification controls |

| | |
|---|---|
| | to:<br>▪ Retain the excess volume from the two-year runoff event to the MEP, and<br>▪ Implement on-site or regional hydromodification controls such that the post-development runoff two-year peak flow is no greater than 110 percent of the pre-development runoff two-year peak flow rate. |
| LID Performance Criteria: (Model WQMP Section 7.II-2.4.3) | Infiltrate, harvest and use, evapotranspire, or biotreat/biofilter, the 85$^{th}$ percentile 24-hour storm event (Design Capture Volume). LID BMPs must be designed to retain, on-site, (infiltrate, harvest and use, or evaportranspire) storm water runoff up to 80 percent average annual capture efficiency. |
| Treatment Control BMP Performance Criteria: | If it not feasible to meet LID performance criteria through retention and/or biotreatment provided on-site or a sub-regional scale, then treatment control BMPs shall be provided on-site or offsite prior to discharge to waters of the US. Sizing of treatment control BMPs shall be based on either the unmet volume after claiming applicable water quality credits, if appropriate. |
| LID Design Storm Capture Volume for Project: | See BMP calculations in Attachment A. |

## IV.2 SITE DESIGN AND DRAINAGE

The following section describes the site design BMPs used in this project and the methods used to incorporate them. Careful consideration of site design is a critical first step in storm water pollution prevention from new developments and redevelopments.

<u>Minimize Impervious Area</u>

Impervious area will be minimized with the site's design. Surface infiltration BMPs will be incorporated as part of the project, rather than placing impervious surfaces over areas for infiltration.

<u>Preserve Existing Drainage Patterns</u>

Existing drainage patterns will be preserved as indicated. The site will drain similarly to existing conditions.

<u>Disconnect Impervious Areas</u>

Buildings will drain to landscaping. Impervious surfaces will ultimately drain to permeable pavers.

<u>Landscape Design</u>

Drought tolerant plants have been utilized in the project's landscape design. The landscape plan has been submitted to the City, under separate review and approval.

<u>Drainage Management Areas</u>

The project site drainage will be delineated into one (1) Drainage Management Areas (DMAs).

| DRAINAGE MANAGEMENT AREAS | | | | | | |
|---|---|---|---|---|---|---|
| DMA | Drainage Area (acres) | DCV ($ft^3$) | Proposed LID BMP | BMP ID | Volume Provided ($ft^3$) | Latitude and Longitude |
| Area A | 1.02 | 2320 | Permeable Pavers | INF-6 | 2950 | Lat: 33.7097859<br>Long: -117.958221 |

## IV.3 LID BMP SELECTION AND PROJECT CONFORMANCE ANALYSIS

Low Impact Development (LID) BMPs are required to reduce pollutants in storm water runoff. LID BMPs are engineered facilities that are designed to retain or biotreat runoff on the project site.

### IV.3.1 Hydrologic Source Controls

Hydrologic source controls (HSCs) can be considered to be an integration of site design practices and LID BMPs.

Hydrologic Source Controls (HSCs) were not selected for the project.

| HYDROLOGIC SOURCE CONTROLS | | |
|---|---|---|
| ID | Name | Included? |
| HSC-1 | Localized on-lot infiltration | ☐ |
| HSC-2 | Impervious area dispersion (e.g. roof top disconnection) | ☐ |
| HSC-3 | Street trees (canopy interception) | ☐ |
| HSC-4 | Residential rain barrels (not actively managed) | ☐ |
| HSC-5 | Green roofs/Brown roofs | ☐ |
| HSC-6 | Blue roofs | ☐ |
| HSC-7 | Impervious area reduction (e.g. permeable pavers, site design) | ☐ |

### IV.3.2 Infiltration BMPs

Infiltration BMPs are LID BMPs that capture, store and infiltrate storm water runoff. These BMPs are engineered to retain a specified volume of water on-site and have no discharge until the volume is exceeded. Examples of infiltration BMPs include infiltration trenches, bioretention without underdrains, drywells, permeable pavement, and underground infiltration galleries.

| INFILTRATION | | |
|---|---|---|
| ID | Name | Included? |
| INF-3 | Bioretention wthout underdrains | ☐ |
| INF-4 | Rain gardens | ☐ |
| | Porous landscaping | ☐ |
| | Infiltration planters | ☐ |
| | Retention swales | ☐ |
| INF-2 | Infiltration trenches (off-site) | ☐ |
| INF-1 | Infiltration basins | ☐ |
| INF-5 | Drywells | ☐ |
| INF-7 | Subsurface infiltration galleries | ☐ |
| | Hydrodynamic separator | ☐ |
| -- | French drains | ☐ |
| INF-6 | Permeable asphalt | ☐ |
| | Permeable concrete | ☐ |
| | Permeable concrete pavers | ☒ |
| | Other: | ☐ |

All LIDs are located in common areas. Retention swales and infiltration basins were considered but not found feasible. Permeable pavers were used to accomplish infiltration.

Based on the design infiltration rate, infiltration BMPs were designed using the procedure specified in the T.G.D. The table below summarizes the results for proposed infiltration BMPs including pretreatment BMPs.

| INFILTRATION BMP SIZING SUMMARY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **DMA** | **Drainage Area (acres)** | **DCV ($ft^3$)** | **Proposed LID BMP** | **BMP Effective Depth (ft)** | **BMP Footprint Needed ($ft^2$)** | **BMP Footprint Provided ($ft^2$)** | **Storage Provided ($ft^3$)** | **Drawdown Time (hrs)** | **Latitude and Longitude** |
| Area A | 1.02 | 1218 | Permeable Pavers | 1.5 | 2320 | 2950 | 1548 | 20.80 | Lat: 33.709759<br>Long: -117.958221 |

### IV.3.3 Evapotranspiration, Rainwater Harvesting BMPs

Evapotranspiration BMPs are a class of retention BMPs that discharges stored volume predominately to ET, though some infiltration may occur. ET includes both evaporation and transpiration, and ET BMPs may incorporate one or more of these processes. BMPs must be designed to achieve the maximum feasible ET, where required to demonstrate that the maximum amount of water has been retained on-site. Since ET is not the sole process in these BMPs, specific design and sizing criteria have not been developed for ET-based BMPs.

Evapotranspiration and Harvest and Reuse BMPs were not selected for the project since infiltration requirements have been met.

| EVAPOTRANSPIRATION | | |
|---|---|---|
| ID | Name | Included? |
| -- | All HSCs; *See Section IV.3.1* | ☐ |
| -- | Surface-based infiltration BMPs | ☐ |
| -- | Biotreatment BMPs | ☐ |
| -- | Other: | ☐ |

| HARVEST & REUSE / RAINWATER HARVESTING | | |
|---|---|---|
| ID | Name | Included? |
| HU-1 | Above-ground cisterns and basins | ☐ |
| HU-2 | Underground detention | ☐ |
| -- | Other: | ☐ |

### IV.3.4 Biotreatment BMPs

Biotreatment BMPs are a class of structural LID BMPs that treat suspended solids and dissolved pollutants in storm water using mechanisms characteristic of biologically active systems. These BMPs are considered treat and release facilities and include treatment mechanisms that employ soil microbes and plants. Additional benefits of these BMPs may include aesthetic enjoyment, recreational use, wildlife habitat and reduction in storm water volume.

Biotreatment BMPs have not been selected for the project since infiltration requirements have been met.

| BIOTREATMENT | | |
|---|---|---|
| ID | Name | Included? |
| BIO-1 | Bioretention with underdrains | ☐ |
| | Stormwater planter boxes with underdrains | ☐ |
| | Rain gardens with underdrains | ☐ |

| | | |
|---|---|---|
| BIO-5 | Constructed wetlands | ☐ |
| BIO-2 | Vegetated swales | ☐ |
| BIO-3 | Vegetated filter strips | ☐ |
| BIO-7 | Proprietary vegetated biotreatment systems | ☐ |
| BIO-4 | Wet extended detention basin | ☐ |
| BIO-6 | Dry extended detention basins | ☐ |
| | Other: | ☐ |

### IV.3.5 Hydromodification Control BMPs

There are no HCOCs for the project.

| HYDROMODIFICATION CONTROLS | |
|---|---|
| BMP Name | BMP Description |
| Not applicable | |

### IV.3.6 Regional/Sub-Regional LID BMPs

Not applicable to the project.

### IV.3.7 Treatment Control BMPs

Treatment control BMPs can only be considered if the project conformance analysis indicates that it is not feasible to retain the full design capture volume with LID BMPs.

Treatment Control BMPs have not been selected for the project since infiltration requirements have been met.

| TREATMENT CONTROL BMPs | | |
|---|---|---|
| ID | Name | Included? |
| TRT-1 | Sand filters | ☐ |
| TRT-2 | Cartridge media filter | ☐ |
| PRE-1 | Hydrodynamic separation device | ☐ |
| PRE-2 | Catch basin insert | ☐ |
| -- | Other: | ☐ |

### IV.3.8 Non-Structural Source Control BMPs

The table below indicates all Non-Structural Source Control BMPs to be utilized in the project. For those designated as not applicable, a brief explanation why is provided.

| Non-Structural Source Control BMPs | | | | |
|---|---|---|---|---|
| ID | Name | Included | Not Applicable | If not applicable, state brief reason |
| N1 | Education for Property Owners, Tenants and Occupants | ☒ | ☐ | |
| N2 | Activity Restrictions | ☒ | ☐ | |
| N3 | Common Area Landscape Management | ☒ | ☐ | |
| N4 | BMP Maintenance | ☒ | ☐ | |
| N5 | Title 22 CCR Compliance (How development will comply) | ☐ | ☒ | No hazardous materials |
| N6 | Local Industrial Permit Compliance | ☐ | ☒ | Residential development |
| N7 | Spill Contingency Plan | ☐ | ☒ | Residential development |
| N8 | Underground Storage Tank Compliance | ☐ | ☒ | None proposed on project |
| N9 | Hazardous Materials Disclosure Compliance | ☐ | ☒ | No hazardous materials |
| N10 | Uniform Fire Code Implementation | ☐ | ☒ | No hazardous materials |
| N11 | Common Area Litter Control | ☒ | ☐ | |
| N12 | Employee Training | ☒ | ☐ | |
| N13 | Housekeeping of Loading Docks | ☐ | ☒ | None proposed on project |
| N14 | Common Area Catch Basin Inspection | ☒ | ☐ | No hazardous materials |
| N15 | Street Sweeping Private Streets and Parking Lots | ☒ | ☐ | |
| N16 | Retail Gasoline Outlets | ☐ | ☒ | None proposed on project |

N1. Education for Property Owners, Tenants, and Occupants

Proper education of onsite occupants will help to reduce all potential and anticipated pollutants from the site. Practical information shall be provided by the property owner to homeowners and employees to reduce pollutants from reaching the storm drain system.

N2. Activity Restrictions

Activity restrictions can be developed to restrict activities that have the potential to create adverse impacts on water quality. Activities include but are not limited to: the handling and disposal of contaminants, trash management and litter control, irrigation and landscaping practices, vehicle and equipment cleaning, and fertilizer applications.

N3. Common Area Landscape Management

All maintenance shall be consistent with City of Fountain Valley guidelines. Proper landscape maintenance practices will help to reduce or eliminate pollution from pesticides, nutrients, trash/debris, and sediments.

N4. BMP Maintenance

In accordance with City LIP and OC DAMP, Starfish FV Venture, LLC and/or HOA will be responsible for the implementation of all applicable non-structural BMPs, as well as scheduling inspections and maintenance of all applicable structural BMP facilities through its landscape contractor and any other necessary maintenance contractors for the project site. Responsibility shall be consistent with the BMP Inspection and Maintenance Responsibilities Matrix provided in Section V of this WQMP, with documented records of inspections and maintenance activities completed.

N11. Common Area Litter Control

Regular litter control for the project shall be performed including trash pick-up on a weekly basis, and sweeping of littered common areas, as performed by the maintenance crew. The HOA will take note of trash disposal violations by homeowners and enforce CC&Rs appropriately.

N12. Employee Training

Employees of Starfish FV Venture, LLC and/or HOA as well as any contractors of the aforementioned entity will require training to ensure that employees are aware of activities that may result in pollutants reaching the storm drain. Training shall be conducted on an annual basis to ensure proper maintenance activities and daily activities are occurring. Educational materials to be used may be found at the Orange County Public Works website at http://www.ocwatersheds.com.

N14. Common Area Catch Basin Inspection

Proper maintenance of the onsite catch basins will help to reduce the amount of trash/debris and silt/sediment in runoff. The onsite catch basins shall be inspected and cleared of any trash or debris in or around the opening prior to the rainy season (by October $1^{st}$). Thereafter, inspections will be conducted every four months.

N15. Street Sweeping Private Streets and Parking Lots

The project's private street shall be swept, at a minimum, prior to the start of the traditional rainy season and at least once every three months.

### V.3.9 Structural Source Control BMPs

The table below indicates all Structural Source Control BMPs to be utilized in the project,

| Structural Source Control BMPs | | | | |
|---|---|---|---|---|
| ID | Name | Included | Not Applicable | If not applicable, state brief reason |
| S1 | Provide storm drain system stenciling and signage | ☒ | ☐ | |
| S2 | Design and construct outdoor material storage areas to reduce pollution introduction | ☐ | ☒ | No outdoor material storage areas. |
| S3 | Design and construct trash and waste storage areas to reduce pollution introduction | ☐ | ☒ | No designated common trash area proposed. |
| S4 | Use efficient irrigation systems & landscape design, water conservation, smart controllers, and source control | ☒ | ☐ | |
| S5 | Protect slopes and channels and provide energy dissipation | ☐ | ☒ | Not applicable. No large slopes (hillside landscaping) proposed. |
| S6 | Dock areas | ☐ | ☒ | None proposed. |
| S7 | Maintenance bays | ☐ | ☒ | None proposed. |
| S8 | Vehicle wash areas | ☐ | ☒ | None proposed. |
| S9 | Outdoor processing areas | ☐ | ☒ | None proposed. |
| S10 | Equipment wash areas | ☐ | ☒ | None proposed. |
| S11 | Fueling areas | ☐ | ☒ | None proposed. |
| S12 | Hillside landscaping | ☐ | ☒ | None proposed. |
| S13 | Wash water control for food preparation areas | ☐ | ☒ | None proposed. |
| S14 | Community car wash racks | ☐ | ☒ | None proposed. |

S1. Provide Storm Drain Stenciling and Drainage

Storm drain stencils or signage prohibiting dumping and discharge of materials ("No Dumping – Drains to Ocean") shall be provided adjacent to the project's proposed inlets. The stencils shall be inspected and re-stenciled as needed to maintain legibility.

S4. Use Efficient Irrigation Systems and Landscape Design, Water Conservation, Smart Controllers, and Source Control

Installing and maintaining efficient irrigation systems designed to minimize water by eliminating overspray to hardscape areas, and setting irrigation timing and cycle lengths in accordance with water demands, given time of year, weather, and day and night temperatures. Where feasible, includes incorporation of native tolerant species for landscaping, protection of slopes and efficient irrigation.

## IV.4 ALTERNATIVE COMPLIANCE PLAN

### IV.4.1 Water Quality Credits

Not applicable. No water quality credits apply since infiltration requirements have been met.

### IV.4.2 Alternative Compliance Plan Information

Not applicable. An alternative compliance plan is not necessary since infiltration requirements have been met.

# SECTION V INSPECTION/MAINTENANCE RESPONSIBILITY FOR BMPs

It has been determined that Starfish FV Venture, LLC shall assume all BMP inspection and maintenance responsibilities for the Lots 1 to 7 and Lot A – Tentative Tract No. 19115, until an HOA is formally established.

| | |
|---|---|
| Contact Name: | David Nguyen |
| Title: | |
| Company: | Starfish FV Venture, LLC |
| Address: | 2961 W. MacArthur Blvd., Suite 210<br>Santa Ana, CA 92704 |
| Telephone #: | (714) 791-3771 |
| Email: | david@keystonedcs.com |

The Owner/HOA shall verify BMP implementation and ongoing maintenance through inspection, self-certification, survey, or other equally effective measure. The certification shall verify that, at a minimum, the inspection and maintenance of all structural BMPs including inspection and performance of any required maintenance in the late summer/ early fall, prior to the start of the rainy season. A form that may be used to record implementation, maintenance and inspection of BMPs is included in Attachment C.

The City of Fountain Valley may conduct verifications to assure that implementation and appropriate maintenance of structural and non-structural BMPs described within this WQMP is taking place at the project site. The owner shall retain operations, inspections and maintenance records of the BMPs and they will be made available to the City or County upon request. All records must be maintained for at least five (5) years after the recorded inspection date for the lifetime of the project.

Long term funding for operations and maintenance of BMPs will be generated through HOA fees. CC&Rs specifying BMP maintenance requirements of the HOA and annual HOA BMP Inspection and Maintenance budget will be finalized and submitted to the City for final review.

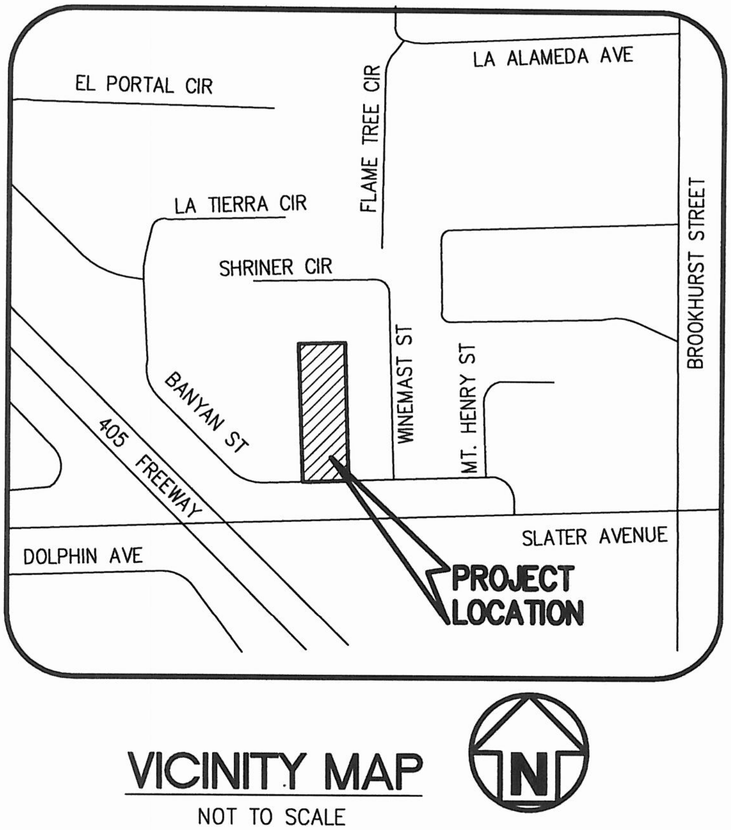
| BMP INSPECTION & MAINTENANCE RESPONSIBILITY MATRIX | | | | |
|---|---|---|---|---|
| BMP | | Inspection/ Maintenance Activities Required | Minimum Frequency | Responsible Party |
| **INFILTRATION BMPs** | | | | |
| INF-6 | Permeable Pavers | Inspect periodically for ponding or areas with reduced levels of infiltration. Vacuum wash the area to maintain effectiveness. | Monthly, and after every major storm | Owner / HOA |
| **Non-Structural Source Control BMPs** | | | | |
| N1 | Education for Property Owners, Tenants and Occupants | Educational materials will be provided to home owners upon occupancy. (See Attachment B) | Annually | Owner / HOA |
| N2 | Activity Restrictions | Activity and use restrictions will be developed and enforced by the Owner/HOA through CC&Rs. | Ongoing | Owner / HOA |
| N3 | Common Area Landscape Management | Maintenance shall be consistent with City requirements, plus fertilizer and/or pesticide usage shall be consistent with the OC DAMP. Maintenance includes mowing, weeding, and debris removal on a weekly basis. Trimming, replanting and replacement of mulch shall be performed on an as-needed basis. Trimmings, clippings, and other waste shall be properly disposed of off-site in accordance with local regulations. Materials temporary stockpiled during maintenance activities shall be placed away from water courses and drain inlets. | Monthly | Owner / HOA |
| N4 | BMP Maintenance | Maintenance of BMPs implemented at the project site shall be performed at the frequency prescribed in this WQMP. Records of inspections and BMP maintenance shall be maintained by the Owner/HOA and documented with the WQMP, and shall be available for review upon request. | Ongoing | Owner / HOA |
| N11 | Common Area Litter Control | Litter patrol. Violations investigation, reporting and other litter control activities shall be performed in conjunction with maintenance activities. Litter collection and removal shall be performed on a weekly basis. | Weekly | Owner / HOA |
| N12 | Employee Training | The HOA shall educate all new employees/managers on storm water pollution prevention, particularly good housekeeping practices, prior to the start of the rainy season (October 1st). | Annually | Owner / HOA |

| BMP INSPECTION & MAINTENANCE RESPONSIBILITY MATRIX | | | | |
|---|---|---|---|---|
| **BMP** | | **Inspection/ Maintenance Activities Required** | **Minimum Frequency** | **Responsible Party** |
| N14 | Common Area Catch Basin Inspection | Catch basin inlets, area drains, swales, curb-and-gutter systems and other drainage systems shall be inspected after each storm event and, when debris is present, cleaned prior to the storm season by October 1st each year. | Annually | Owner / HOA |
| N15 | Street Sweeping Private Streets and Parking Lots | Streets must be swept at minimum prior to the start of the rainy season (October 1st). Streets shall be swept as-needed. | Quarterly and as-needed | Owner / HOA |
| **STRUCTURAL SOURCE CONTROL BMPs** | | | | |
| S1 | Provide Storm Drain System Stenciling and Signage | Storm drain stencils shall be inspected for legibility, at minimum, once prior to the storm season, no later than October 1st each year. Those determined to be illegible will re-stenciled as soon as possible. | Annually | Owner / HOA |
| S4 | Use Efficient Irrigation Systems & Landscape Design | In conjunction with routine maintenance activities, verify that landscape design continues to function properly by adjusting properly to eliminate overspray to hardscape areas, and to verify that irrigation timing and cycle lengths are adjusted in accordance with water demands, day or night time temperatures based on system specifications and local climate patterns. | Monthly | Owner / HOA |

# SECTION VI BMP EXHIBIT (SITE PLAN)

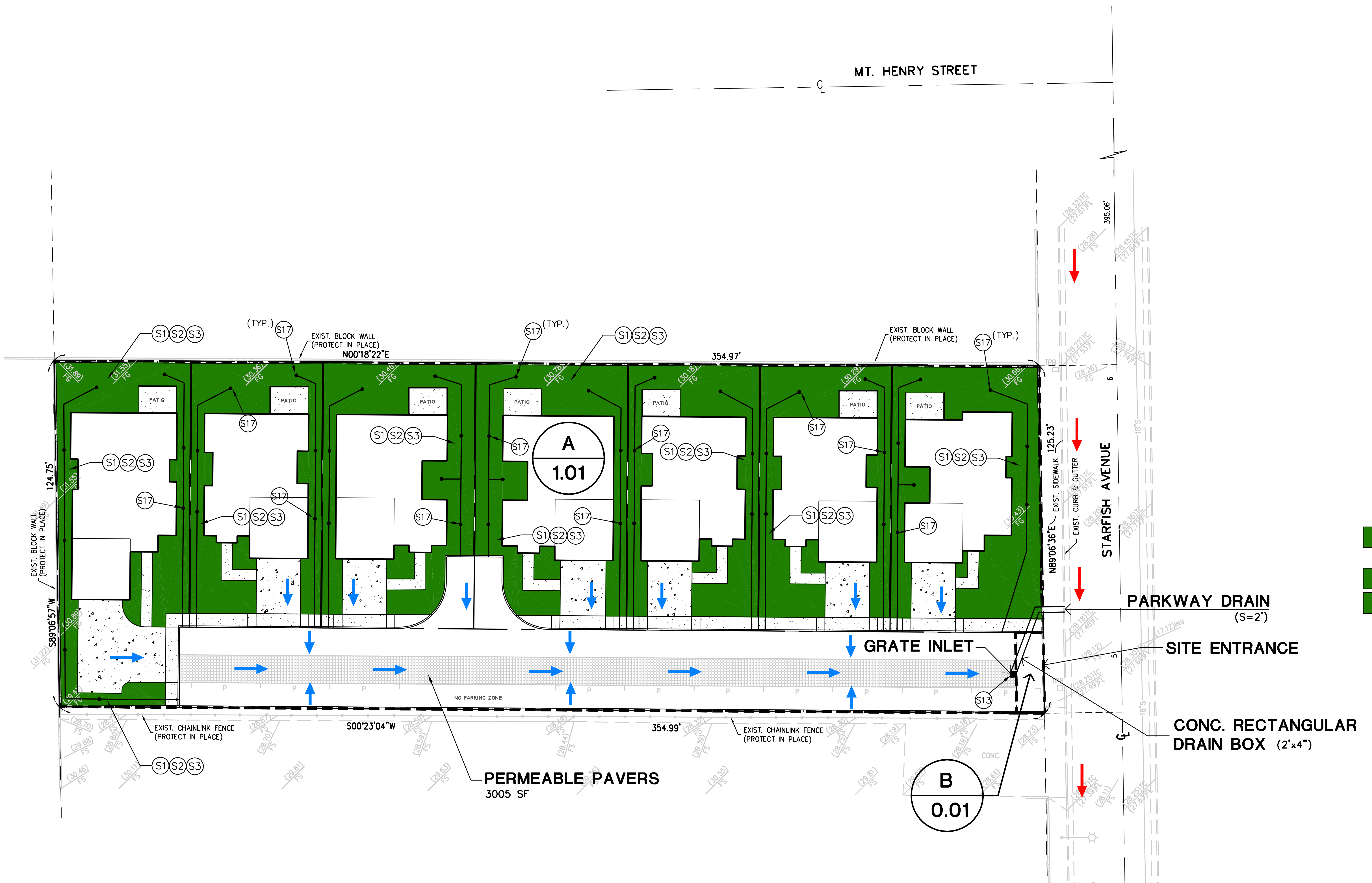
## VI.1 BMP EXHIBIT (SITE PLAN)

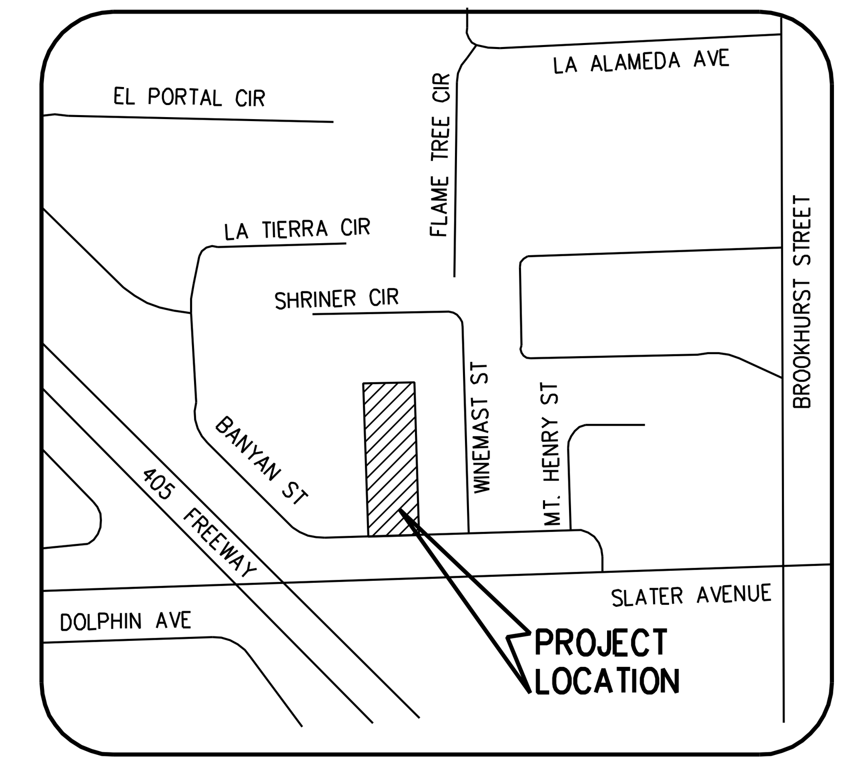
- Vicinity Map
- WQMP Exhibit
- Precise Grading Plan




VICINITY MAP

NOT TO SCALE

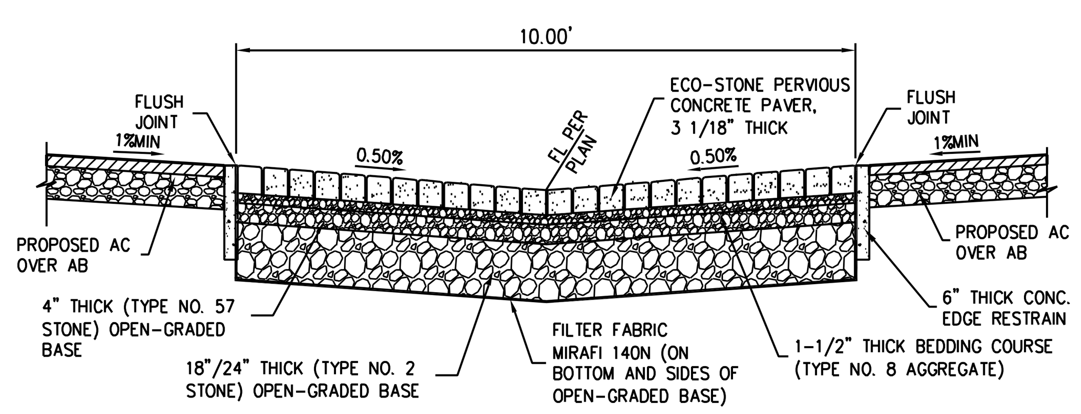


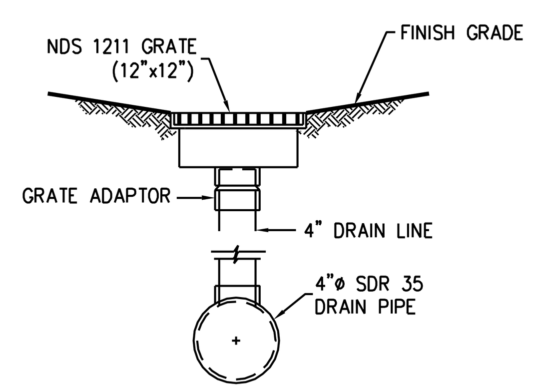

**VICINITY MAP**
NOT TO SCALE

**LEGEND**

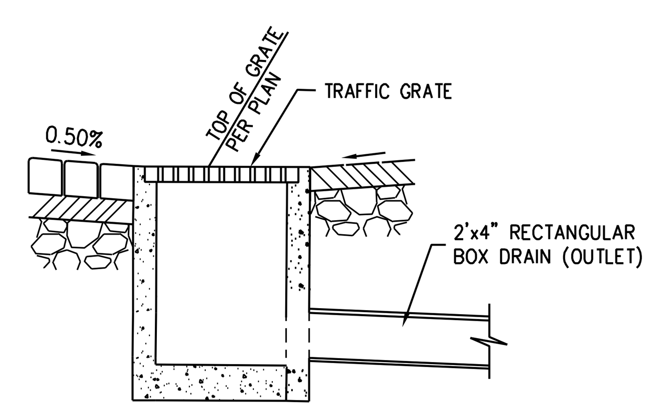
- S1 — FILTRATION: SURFACE RUNOFF SHALL BE DIRECTED TO LANDSCAPE AREAS WHEREVER PRACTICAL
- S2 — COMMON AREA EFFICIENT IRRIGATION
- S3 — COMMON AREA RUNOFF–MINIMIZING LANDSCAPE DESIGN
- S17 — YARD DRAIN INLETS
- S13 — CATCH BASIN STENCILING "NO DUMPING, DRAINS TO OCEAN"
- PERMEABLE POROUS CONC. PAVERS
- NAP — NOT A PART
- DIRECTION OF ONSITE SURFACE FLOW
- DIRECTION OF OFFSITE SURFACE FLOW
- BMP AREA LIMITS
- X / X.XX — BMP AREA DESIGNATION / AREA IN ACRES



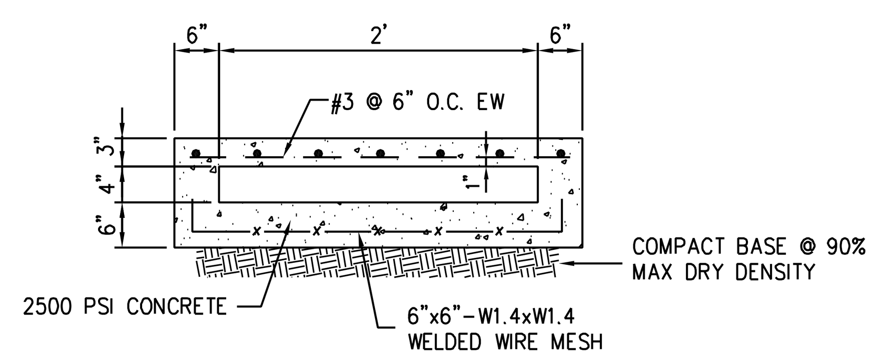

**ECO-STONE PERMEABLE PAVERS DETAIL**
NTS




**DRAIN INLET DETAIL**
NTS




**GRATE INLET DETAIL**
N.T.S.
(BROOKS DRAIN BOX NO. 2424)
LOCATED IN PRIVATE DRIVE




**RECTANGULAR DRAIN BOX**
NTS

SCALE: 1"=20'

PREPARED UNDER THE SUPERVISION OF
SURENDER M. DEWAN
REGISTERED PROFESSIONAL ENGINEER SURENDER M. DEWAN NO. 34559 CIVIL STATE OF CALIFORNIA

ENGINEER
DMS CONSULTANTS, INC.
CIVIL ENGINEERS
12371 Lewis St. #203 Garden Grove CA. 92840 P. 714-740-8840 F. 714-740-8842

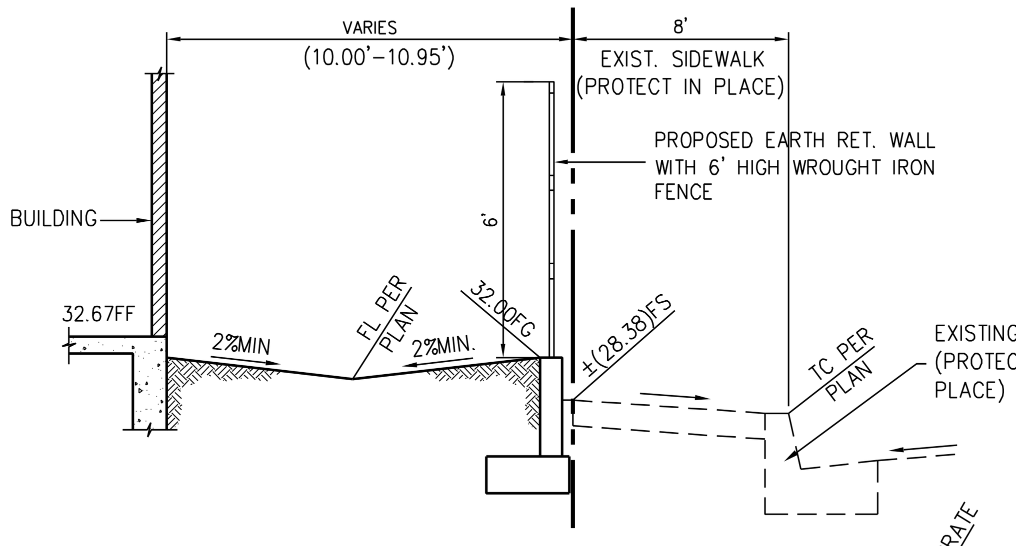
OWNER/DEVELOPER:
STARFISH FV VENTURE, LLC

CITY OF FOUNTAIN VALLEY
WQMP PLOT PLAN
TENTATIVE TRACT NO. 19115
9779 STARFISH AVENUE, FOUNTAIN VALLEY, CA 92708
DATE : 07/22/2020
SHEET 1 OF 1

# TENTATIVE TRACT NO. 19115

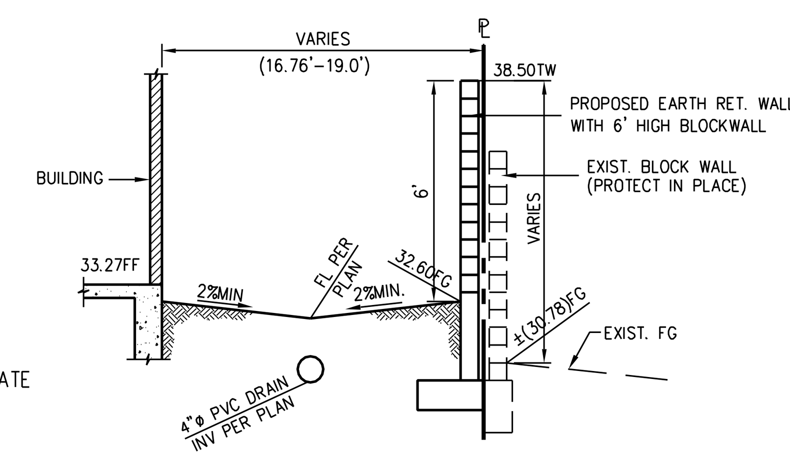
IN THE CITY OF FOUNTAIN VALLEY, COUNTY OF ORANGE, STATE OF CALIFORNIA

9779 STARFISH AVENUE, FOUNTAIN VALLEY, CA



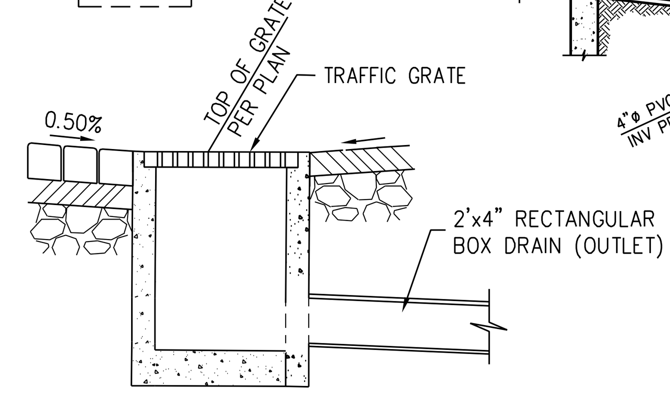
**SECTION A-A**

NTS



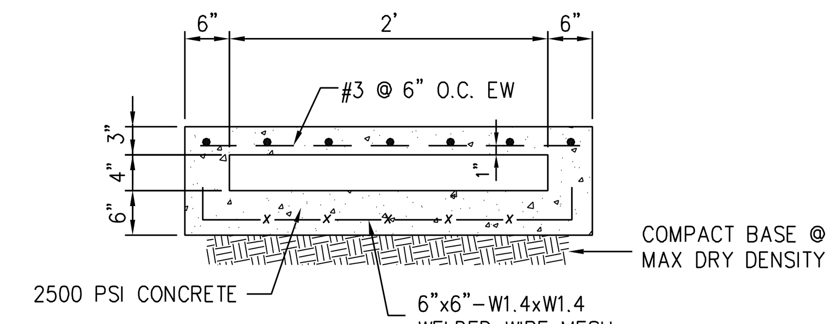
**SECTION B-B**

NTS



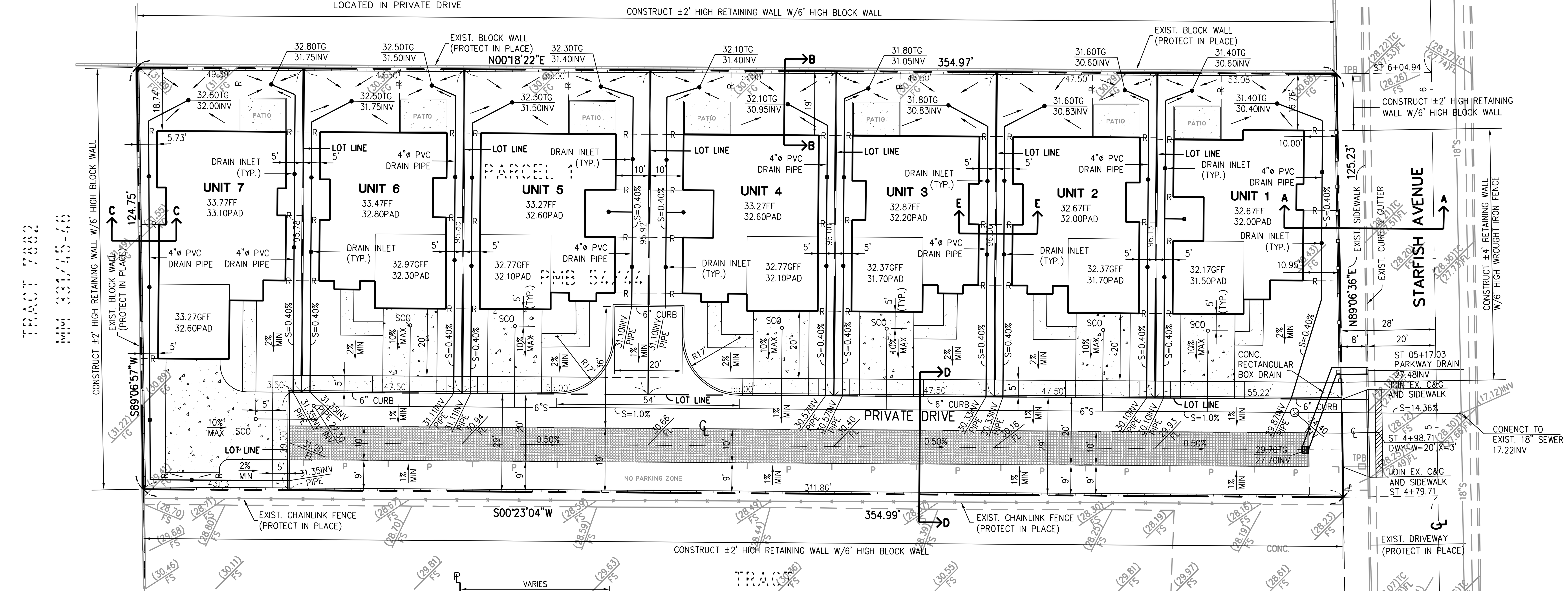
**GRATE INLET DETAIL**

N.T.S.
(BROOKS DRAIN BOX NO. 2424)
LOCATED IN PRIVATE DRIVE



**RECTANGULAR CHANNEL**

NTS




## FLOOD ZONE:

FLOOD ZONE: X (AREA WITH REDUCED FLOOD RISK DUE TO LEVEE)
FLOOD MAP NO.: 06059C0254J
DATED: DECEMBER 3, 2009
COMMUNITY NAME: CITY OF FOUNTAIN VALLEY
COMMUNITY PANEL NO.: 060218

## ZONING:

R-1 (SINGLE FAMILY RESIDENTIAL)

| LOT AREA TABLE | |
|---|---|
| LOT 1 | 5,207 SF |
| LOT 2 | 4,565 SF |
| LOT 3 | 4,562 SF |
| LOT 4 | 5,278 SF |
| LOT 5 | 5,275 SF |
| LOT 6 | 4,552 SF |
| LOT 7 | 5,887 SF |
| LOT "A" | 9,034 SF |

## PREPARED FOR:

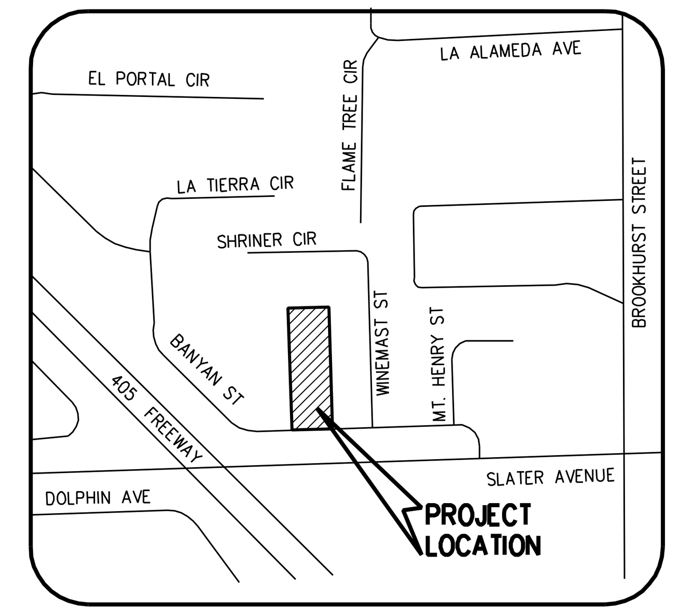
STARFISH FV VENTURE, LLC.

## SOILS ENGINEER:

GEOBODEN INC.
GEOTECHNICAL CONSULTANTS
5 HODGENVILLE, IRVINE, CA 92620
TEL: 949-872-9565

## SITE ADDRESS:

9779 STARFISH AVENUE
FOUNTAIN VALLEY, CA 92708




**VICINITY MAP**

NOT TO SCALE

## LEGAL DESCRIPTION

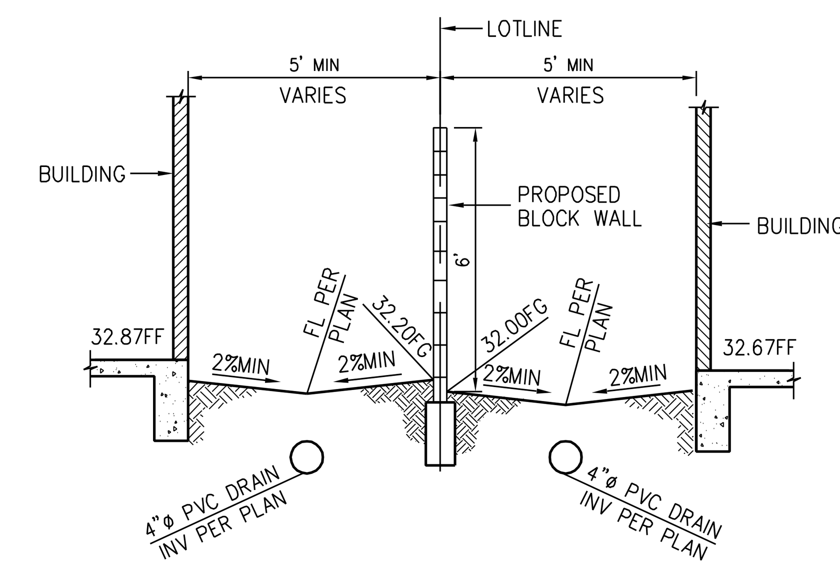
THE LAND REFERRED TO HEREIN BELOW IS SITUATED IN THE CITY OF FOUNTAIN VALLEY, IN THE CITY OF FOUNTAIN VALLEY, COUNTY OF ORANGE, STATE OF CALIFORNIA, AND IS DESCRIBED AS FOLLOWS:
THAT PORTION OF THE SOUTH 18 ACRES OF THE SOUTHEAST QUARTER OF THE NORTHEAST QUARTER OF SECTION 30, TOWNSHIP 5 SOUTH, RANGE 10 WEST, IN THE RANCHO LAS BOLSAS, IN THE CITY OF FOUNTAIN VALLEY, COUNTY OF ORANGE, STATE OF CALIFORNIA, AS PER MAP FILED IN BOOK 51, PAGE 12 OF MISCELLANEOUS MAPS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHEAST CORNER OF THE LAND DESCRIBED IN THE DEED TO FELLOWSHIP OF BAPTIST FOR HOME MISSIONS RECORDED DECEMBER 12, 1966, IN BOOK 8124, PAGE 873, OF OFFICIAL RECORDS OF SAID COUNTY; THENCE, ALONG THE EAST LINE OF SAID DEED, NORTH 0°38' 06" WEST 354.78 FEET TO THE NORTHEAST CORNER OF SAID DEED; THENCE ALONG THE EASTERLY PROLONGATION OF THE NORTHERLY LINE OF SAID DEED, NORTH 88°10' 28" EAST, 124.78 FEET; THENCE SOUTH 0°37' 30" EAST, 354.78 FEET TO AN INTERSECTION WITH A LINE THAT BEARS NORTH 88°10' 28" EAST FROM SAID POINT OF BEGINNING; THENCE SOUTH 88°10' 28" WEST, 124.72 FEET TO THE POINT OF BEGINNING.

EXCEPTING THEREFROM ALL OIL, GAS, MINERALS, AND OTHER HYDROCARBON SUBSTANCES LYING BELOW A DEPTH OF 500 FEET, TO TAKE, MARKET, MINE, EXPLORE OR DRILL FOR SAME, AS RESERVED IN THAT GRANT DEED FROM DONALD J. HARPER, A MARRIED MAN, TO CLASSIC DEVELOPMENT CORPORATION, A CALIFORNIA CORPORATION, DATED JUNE 26, 1973.

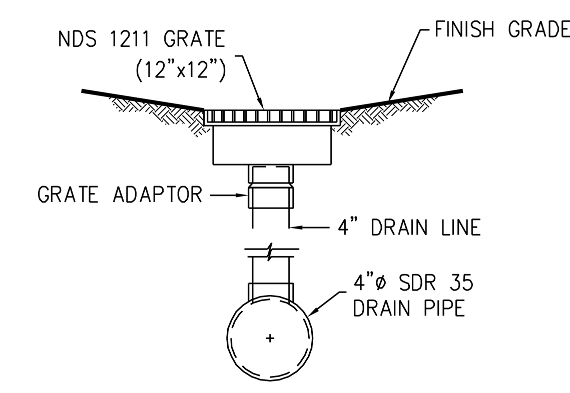
ALSO SHOWN AS:
PARCEL 1, IN THE CITY OF FOUNTAIN VALLEY, COUNTY OF ORANGE, STATE OF CALIFORNIA, AS SHOWN ON PARCEL MAP FILED IN BOOK 54, PAGE 44 OF PARCEL MAPS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY.

ASSESSOR'S PARCEL MAP NO. 167-232-01



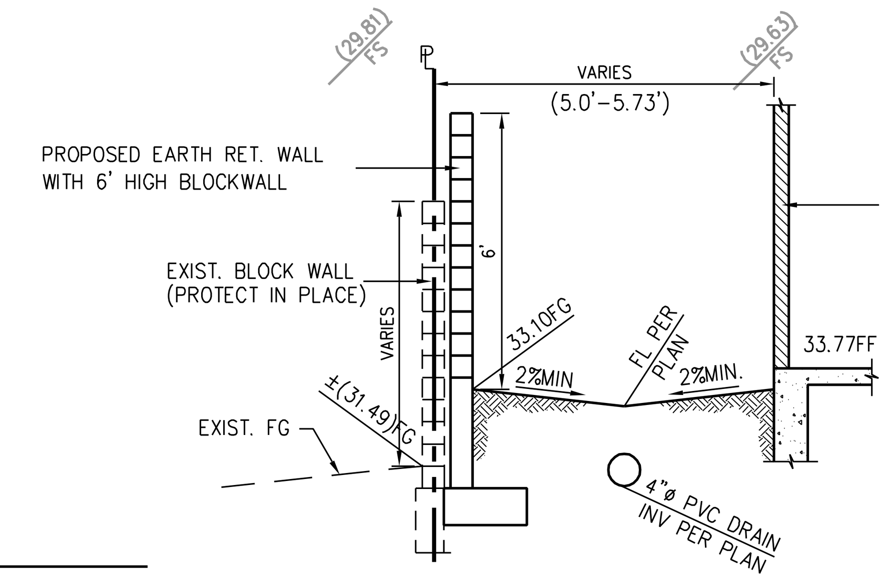
**SECTION E-E**

NTS



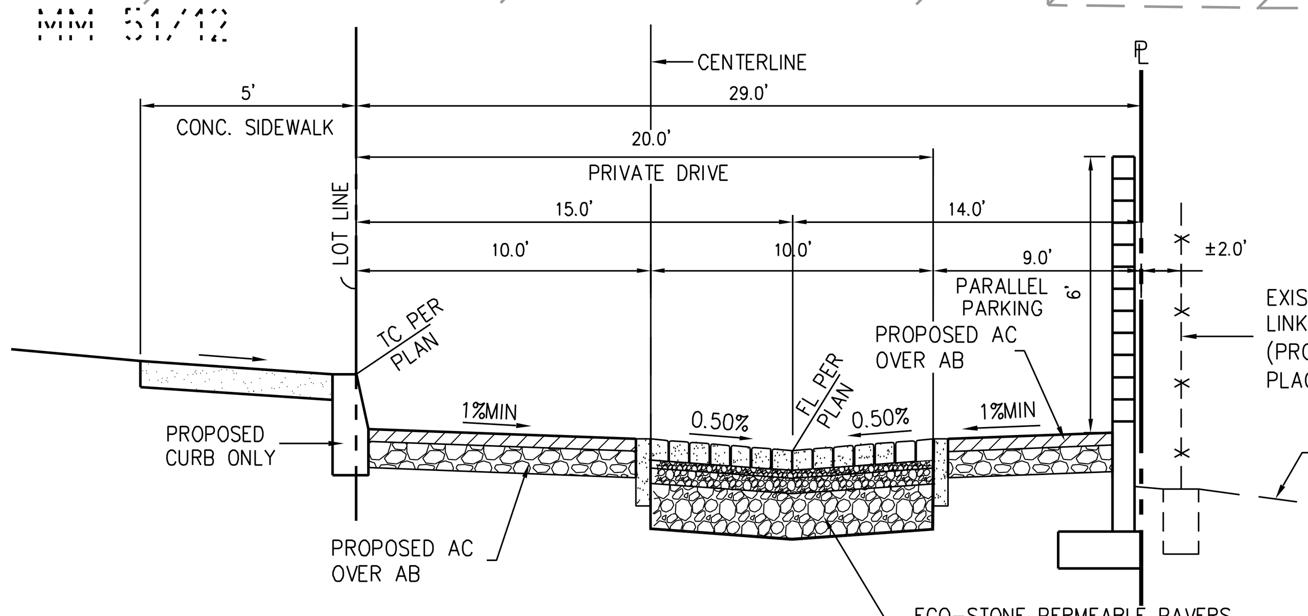
**DRAIN INLET DETAIL**

NTS



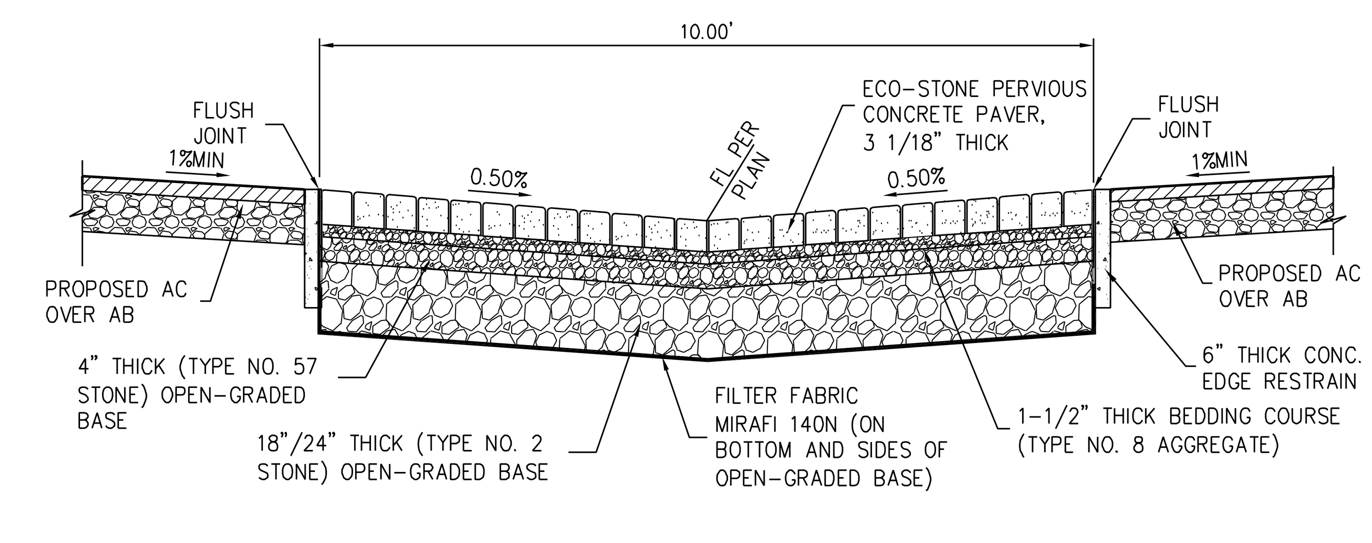
**SECTION C-C**

NTS



**SECTION D-D**

PRIVATE DRIVE
NTS



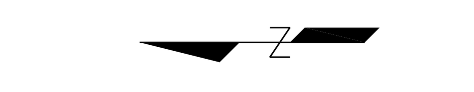
**ECO-STONE PERMEABLE PAVERS DETAIL**

NTS

## PROJECT DESCRIPTION

ZONING
PROPOSED: R-1(SINGLE FAMILY RESIDENTIAL)
TYPE OF CONSTRUCTION: TYPE V-B, 2 STORY BUILDING, SPRINKLERS
BUILDING CODES: 2016 CBC, CMC, CPC, CEC, CFC, CRC
2016 GBC CALIFORNIA GREEN BUILDING STD CODE
2016 CALIFORNIA ENERGY CODE
CITY OF SANTA ANA ORDINANCE
LOT SIZE: 44,358 SF (1.02 Acres)
UNIT TYPE & MIX
UNIT 4&5: TYPE A
GROSS AREA: 2845 SF
2-CAR GARAGE AREA: 455 SF
UNIT 2,3&6: TYPE B
GROSS AREA: 2408 SF
2-CAR GARAGE AREA: 455 SF
UNIT 1: TYPE C1
GROSS AREA: 2792 SF
2-CAR GARAGE AREA: 455 SF
UNIT 7: TYPE C2
GROSS AREA: 3210 SF
2-CAR GARAGE AREA: 455 SF

SPRINKLED: Y (FIRE SPRINKLER PER SEPARATE PERMIT IN ACCORDANCE WITH CRC R313.3 OR NFPA 13D)
DENSITY: 6.86 DU/ACRES
PARKING SUMMARY
NO. OF PARKING SPACES: 38
LANDSCAPE AREA: 16,026 SF (36.20%)
BUILDING COVERAGE: 12,838 SF (29.00%)
IMPERVIOUS AREA: 19,348 SF



GRAPHIC SCALE
( IN FEET )
1 inch = 20 ft.

## BENCH MARK :

FV-57-70 ELEVATION : 29.945 (2010)
FD 3 3/4" OCS ALUMINUM BENCHMARK DISK STAMPED "FV-57-70". SET IN THE NW CORNER OF A 5FTx5.5FT CONC. CB. MONUMENT IS LOCATED IN THE NE CORNER OF THE INTERSECTION OF BROOKHURST ST. & SLATER AVE., 46 FT EASTERLY OF THE CENTERLINE OF THE MEDIAN ALONG BROOKHURST ST. AND 84.5 FT NORTHERLY OF THE PROLONGATION OF THE NORTH CURB ALONG SLATER AVE. MONUMENT IS SET LEVEL WITH THE SIDEWALK.

APN: 167-232-01

**CONCEPT GRADING PLAN**

PREPARED BY:
DMS CONSULTANTS, INC.
CIVIL ENGINEERS
04/18/2020
SURENDER M. DEWAN RCE 34559 EXP. 9/30/19

REGISTERED PROFESSIONAL ENGINEER
SURENDER M. DEWAN
NO. 34559
Exp. 9/30/21
CIVIL
STATE OF CALIFORNIA

TENTATIVE TRACT NO. 19115
7 UNIT RESIDENTIAL DEVELOPMENT
9779 STARFISH AVENUE
FOUNTAIN VALLEY, CA 92708

DATE: 04/18/2020

SHEET 1 OF 1

# SECTION VII EDUCATIONAL MATERIALS

The educational materials that may be used for the proposed project are included in Attachment B of this WQMP and are listed below.

| EDUCATION MATERIALS | | | |
|---|---|---|---|
| **Residential Material** http://www.ocwatersheds.com | **Check If Applicable** | **Business Material** http://www.ocwatersheds.com | **Check If Applicable** |
| The Ocean Begins at Your Front Door | ☒ | Tips for the Automotive Industry | ☐ |
| Tips for Car Wash Fund-raisers | ☐ | Tips for Using Concrete and Mortar | ☐ |
| Tips for the Home Mechanic | ☐ | Tips for the Food Service Industry | ☐ |
| Homeowners Guide for Sustainable Water Use | ☐ | Proper Maintenance Practices for Your Business | ☐ |
| Household Tips | ☒ | **Other Material** | **Check If Attached** |
| Proper Disposal of Household Hazardous Waste | ☒ | | |
| Recycle at Your Local Used Oil Collection Center (North County) | ☐ | INF-6 Permeable Pavers (See Attachment C) | ☒ |
| Recycle at Your Local Used Oil Collection Center (Central County) | ☐ | | ☐ |
| Recycle at Your Local Used Oil Collection Center (South County) | ☐ | | ☐ |
| Tips for Maintaining a Septic Tank System | ☐ | | ☐ |
| Responsible Pest Control | ☒ | | ☐ |
| Sewer Spill | ☐ | | ☐ |
| Tips for the Home Improvement Projects | ☐ | | ☐ |
| Tips for Horse Care | ☐ | | ☐ |
| Tips for Landscaping and Gardening | ☒ | | ☐ |
| Tips for Pet Care | ☒ | | ☐ |
| Tips for Pool Maintenance | ☐ | | ☐ |
| Tips for Residential Pool, Landscape and Hardscape Drains | ☐ | | ☐ |
| Tips for Projects Using Paint | ☐ | | ☐ |

## ATTACHMENTS

# Attachment A

## TGD Worksheets, BMP Calculations, and Details

**Table 2.7: Infiltration BMP Feasibility Worksheet**

| | *Infeasibility Criteria* | *Yes* | *No* |
|---|---|---|---|
| 1 | **Would Infiltration BMPs pose significant risk for groundwater related concerns?** Refer to Appendix VII (Worksheet I) for guidance on groundwater-related infiltration feasibility criteria. | | X |
| Provide basis:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability. | | | |
| 2 | Would Infiltration BMPs **pose significant risk of increasing risk of geotechnical hazards that cannot be mitigated to an acceptable level**? (Yes if the answer to any of the following questions is yes, as established by a geotechnical expert):<br>• The BMP can only be located less than 50 feet away from slopes steeper than 15 percent<br>• The BMP can only be located less than eight feet from building foundations or an alternative setback.<br>• A study prepared by a geotechnical professional or an available watershed study substantiates that stormwater infiltration would potentially result in significantly increased risks of geotechnical hazards that cannot be mitigated to an acceptable level. | | X |
| Provide basis:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability. | | | |
| 3 | Would infiltration of the DCV from drainage area **violate downstream water rights**? | | X |
| Provide basis:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability. | | | |

**Table 2.7: Infiltration BMP Feasibility Worksheet (continued)**

<table>
<tr><th></th><th>Partial Infeasibility Criteria</th><th>Yes</th><th>No</th></tr>
<tr><td>4</td><td>Is proposed infiltration facility located on HSG D soils or the site geotechnical investigation identifies presence of soil characteristics which support categorization as D soils?</td><td></td><td>X</td></tr>
<tr><td colspan="4">Provide basis:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.</td></tr>
<tr><td>5</td><td>Is measured infiltration rate below proposed facility less than 0.3 inches per hour? This calculation shall be based on the methods described in Appendix VII.</td><td></td><td>X</td></tr>
<tr><td colspan="4">Provide basis:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.</td></tr>
<tr><td>6</td><td>Would reduction of over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?</td><td></td><td>X</td></tr>
<tr><td colspan="4">Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.</td></tr>
<tr><td>7</td><td>Would an increase in infiltration over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?</td><td></td><td>X</td></tr>
<tr><td colspan="4">Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.</td></tr>
</table>

**Table 2.7: Infiltration BMP Feasibility Worksheet (continued)**

| Infiltration Screening Results (check box corresponding to result): | | |
|---|---|---|
| 8 | Is there substantial evidence that infiltration from the project would result in a significant increase in I&I to the sanitary sewer that cannot be sufficiently mitigated? (See Appendix XVII)<br><br>Provide narrative discussion and supporting evidence:<br><br>Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability. | **NO** |
| 9 | If any answer from row 1-3 is yes: infiltration of any volume is **not feasible** within the DMA or equivalent.<br><br>Provide basis:<br><br>Summarize findings of infeasibility screening | **NO** |
| 10 | If any answer from row 4-8 is yes, infiltration is **permissible but is not presumed to be feasible for the entire DCV.** Criteria for designing biotreatment BMPs to achieve the maximum feasible infiltration and ET shall apply.<br><br>Provide basis:<br><br>Summarize findings of infeasibility screening | **NO** |
| 11 | If all answers to rows 1 through 10 are no, infiltration of the full DCV is potentially feasible, BMPs must be designed to infiltrate the full DCV to the maximum extent practicable. | **YES** |

## AREA "A" Permeable Pavement

Worksheet B: Simple Design Capture Volume Sizing Method

| | | | | |
|---|---|---|---|---|
| ***Step 1: Determine the design capture storm depth used for calculating volume*** | | | | |
| 1 | Enter design capture storm depth from Figure III.1, *d* (inches) | d= | 0.70 | inches |
| 2 | Enter the effect of provided HSCs, $d_{HSC}$ (inches) (Worksheet A) | $d_{HSC}$= | | inches |
| 3 | Calculate the remainder of the design capture storm depth, $d_{remainder}$ (inches) (Line 1 – Line 2) | $d_{remainder}$= | 0.70 | inches |
| ***Step 2: Calculate the DCV*** | | | | |
| 1 | Enter Project area tributary to BMP (s), *A* (acres) | A= | 1.02 | acres |
| 2 | Enter Project Imperviousness, *imp* (unitless) | imp= | 0.43 | |
| 3 | Calculate runoff coefficient, $C= (0.75 \times imp) + 0.15$ | C= | 0.47 | |
| 4 | Calculate runoff volume, $V_{design}= (C \times d_{remainder} \times A \times 43560 \times (1/12))$ | $V_{design}$= | 1218.15 | cu-ft |
| ***Step 3: Design BMPs to ensure full retention of the DCV*** | | | | |
| **Step 3a: Determine design infiltration rate** | | | | |
| 1 | Enter measured infiltration rate, $K_{observed}$ [1] (in/hr) (Appendix VII) | $K_{observed}$= | 1.40 | In/hr |
| 2 | Enter combined safety factor from Worksheet H, $S_{total}$ (unitless) | $S_{total}$= | 2 | |
| 3 | Calculate design infiltration rate, $K_{design} = K_{observed} / S_{total}$ | $K_{design}$= | 0.70 | In/hr |
| **Step 3b: Determine minimum BMP footprint** | | | | |
| 4 | Enter drawdown time, *T* (max 48 hours) | T= | 48 | Hours |
| 5 | Calculate max retention depth that can be drawn down within the drawdown time (feet), $D_{max} = K_{design} \times T \times (1/12)$ | $D_{max}$= | 2.80 | feet |
| 6 | Calculate minimum area required for BMP (sq-ft), $A_{min} = V_{design} / d_{max}$ | $A_{min}$= | 435.17 | sq-ft |

***Step 4: Determine the aggregate reservoir depth.***

$d_{48} \geq (n_R \times d_R)$

Where: $d_{48} = 4.00$ feet

$n_R = 0.35$

$d_R = 1.50$ feet

$4.00 \geq (0.35 \times 1.50)$

***Step 5: Calculate required infiltrating area.***

$A = DCV / (n_R \times d_R)$

$A = 1218 / (0.35 \times 1.50) = 2320$ ft$^2$

Area provided = 2950 ft$^2$ > 2320 ft$^2$

## Worksheet H: Factor of Safety and Design Infiltration Rate Worksheet

| Factor Category | | Factor Description | Assigned Weight (w) | Factor Value (v) | Product (p) p = w x v |
|---|---|---|---|---|---|
| A | Suitability Assessment | Soil assessment methods | 0.25 | 1 | 0.25 |
| | | Predominant soil texture | 0.25 | 1 | 0.25 |
| | | Site soil variability | 0.25 | 1 | 0.25 |
| | | Depth to groundwater / impervious layer | 0.25 | 1 | 0.25 |
| | | Suitability Assessment Safety Factor, $S_A = \Sigma p$ | | | 1.00 |
| B | Design | Tributary area size | 0.25 | 1 | 0.25 |
| | | Level of pretreatment/ expected sediment loads | 0.25 | 3 | 0.75 |
| | | Redundancy | 0.25 | 3 | 0.75 |
| | | Compaction during construction | 0.25 | 3 | 0.25 |
| | | Design Safety Factor, $S_B = \Sigma p$ | | | 2.0 |

| | |
|---|---|
| Combined Safety Factor, $S_{total} = S_A \times S_B$ | 2.0 |
| Observed Infiltration Rate, inch/hr, $K_{observed}$ (corrected for test-specific bias)[1] | 1.40 inches/hour |
| Design Infiltration Rate, in/hr, $K_{design} = K_{observed} / S_{total}$ | 0.70 inches/hour |

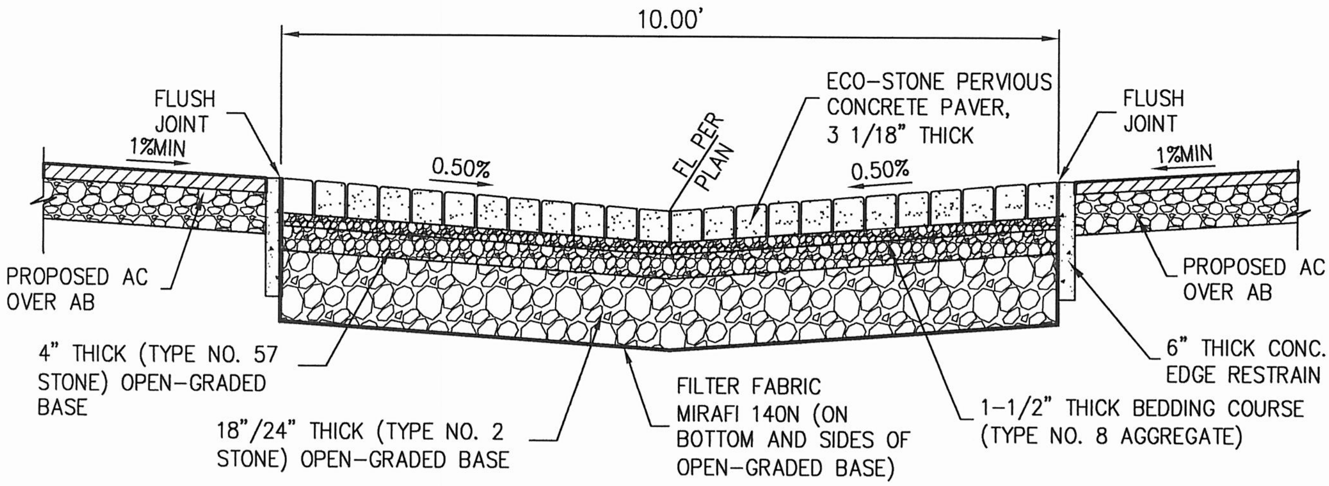
**Supporting Data**

Briefly describe infiltration test and provide reference to test forms:

See Attachment E of the WQMP.

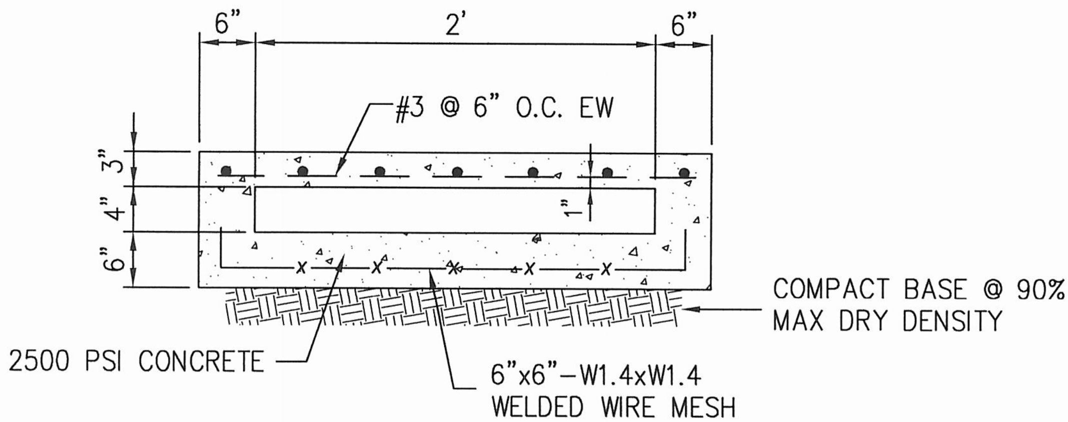
**Note:** The minimum combined adjustment factor shall not be less than 2.0 and the maximum combined adjustment factor shall not exceed 9.0.

1 - $K_{observed}$ is the vertical infiltration measured in the field, before applying a factor of safety. If field testing measures a rate that is different than the vertical infiltration rate (for example, three-dimensional borehole percolation rate), then this rate must be adjusted by an acceptable method (for example, Porchet method) to yield the field estimate of vertical infiltration rate, $K_{observed}$



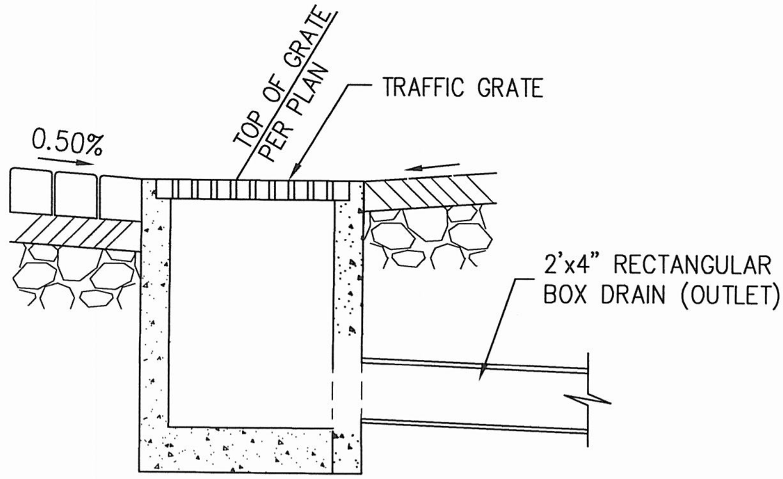

## ECO-STONE PERMEABLE PAVERS DETAIL

NTS




## RECTANGULAR DRAIN BOX

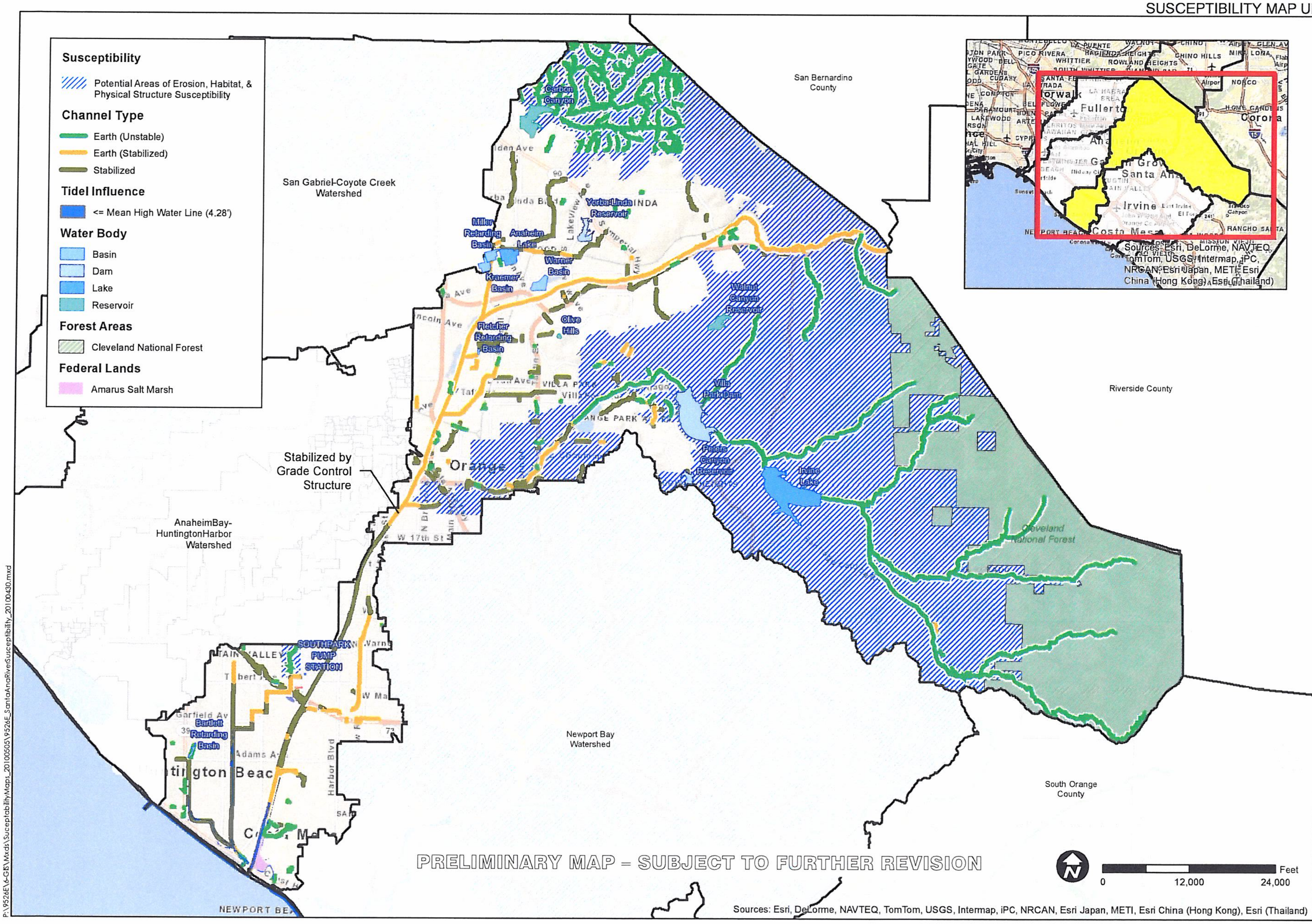
NTS




## GRATE INLET DETAIL

N.T.S.
(BROOKS DRAIN BOX NO. 2424)
LOCATED IN PRIVATE DRIVE

SUSCEPTIBILITY MAP UPDATE (DEC 2012)

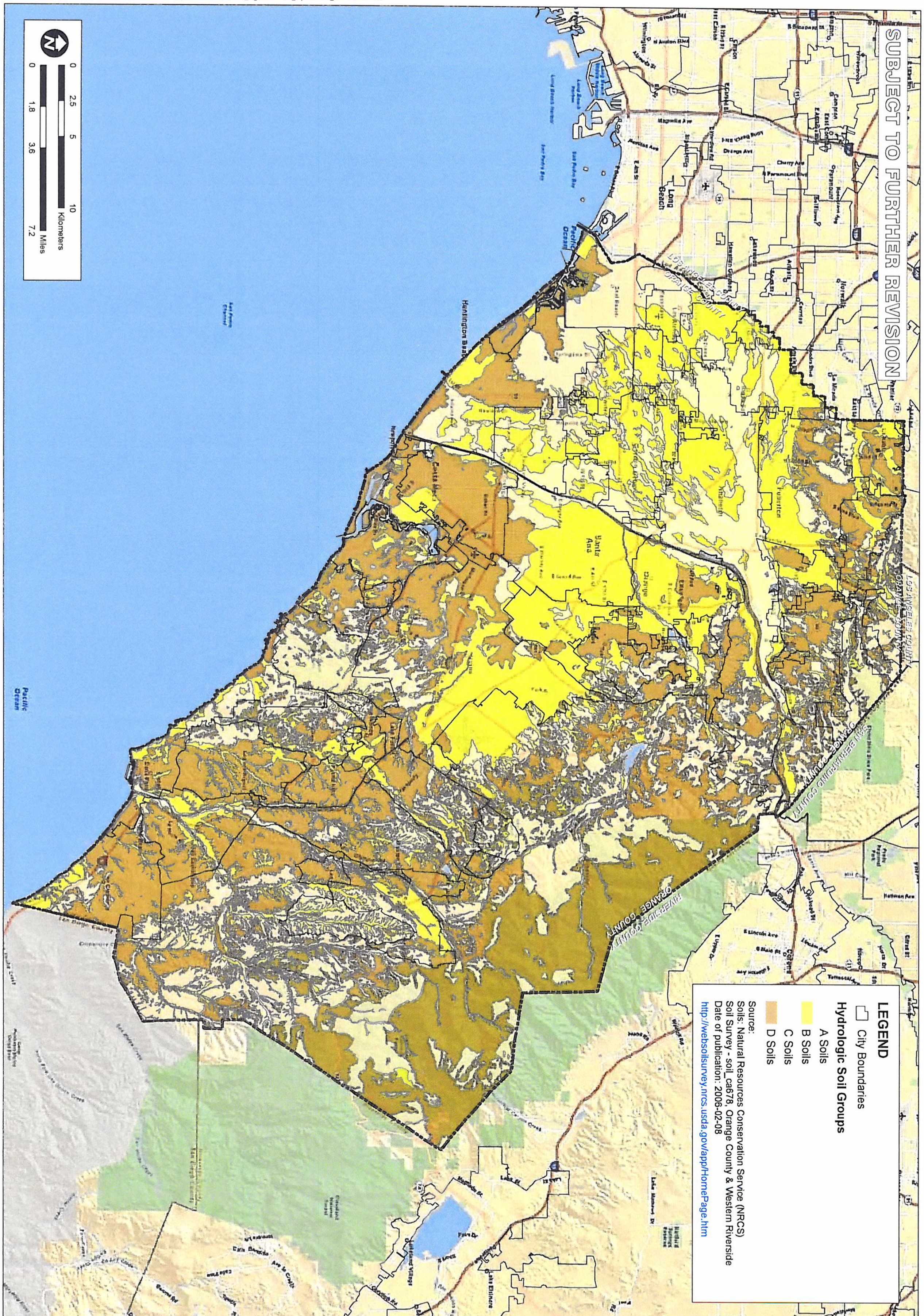



| | |
|---|---|
| TITLE | SUSCEPTIBILITY ANALYIS SANTA ANA RIVER |
| JOB | ORANGE COUNTY WATERSHED MASTER PLANNING |
| | ORANGE CO. CA |
| SCALE | 1" = 12000' |
| DESIGNED | TH |
| DRAWING | TH |
| CHECKED | BMP |
| DATE | 04/30/10 |
| JOB NO. | 9526-E |

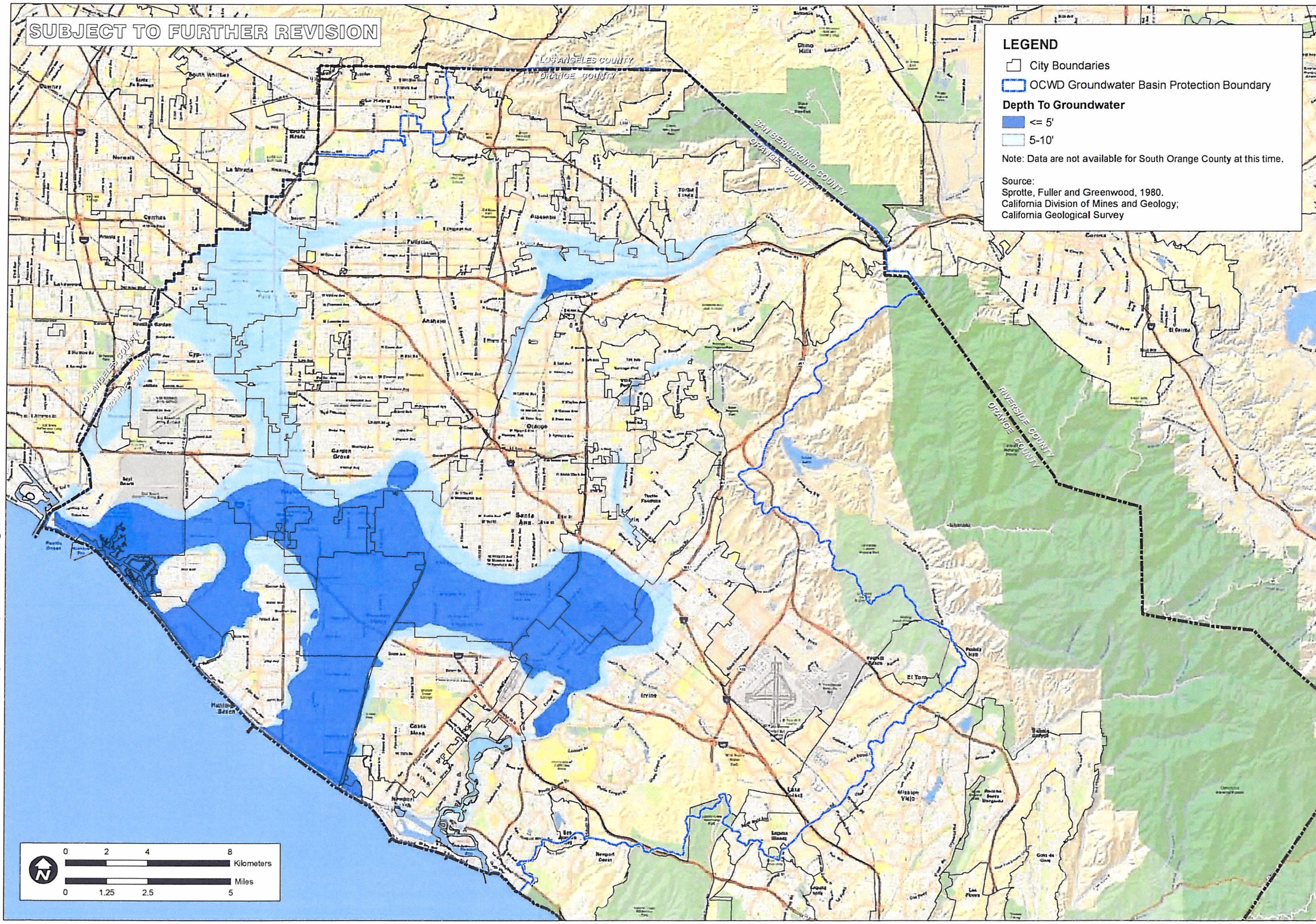
PACE
Advanced Water Engineering

FIGURE 3

P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-2a_HydroSoils_20110215.mxd




| | | | |
|---|---|---|---|
| FIGURE XVI-2a | PACE Advanced Water Engineering | SCALE 1" = 1.8 miles; DESIGNED TH; DRAWING TH; CHECKED BMP; DATE 02/09/11; JOB NO. 9526-E | JOB: ORANGE COUNTY INFILTRATION STUDY — ORANGE CO. CA |
| | | | TITLE: NRCS HYDROLOGIC SOILS GROUPS |

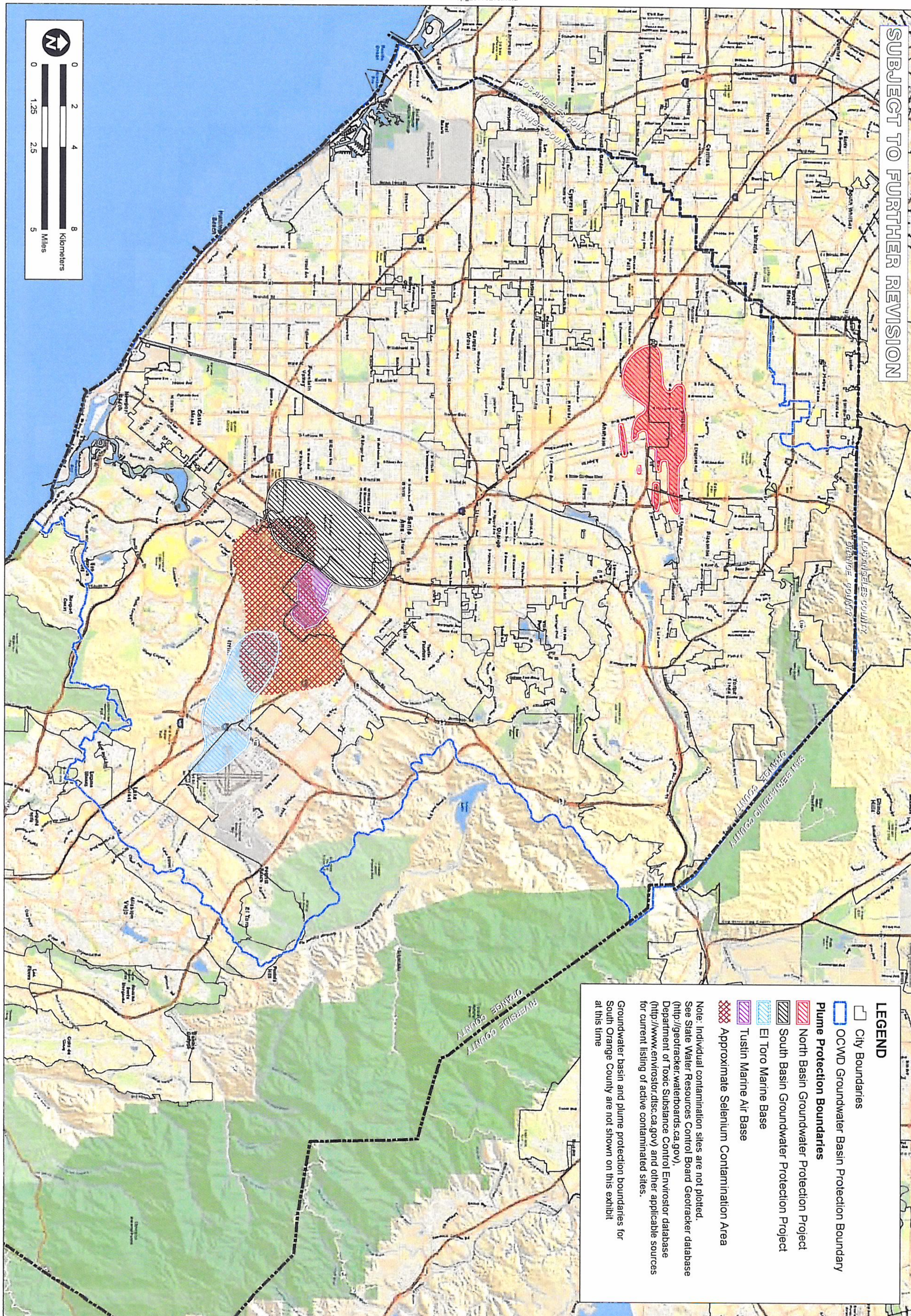



| | |
|---|---|
| TITLE | NORTH ORANGE COUNTY MAPPED SHALLOW GROUNDWATER |
| JOB | ORANGE COUNTY INFILTRATION STUDY |
| | ORANGE CO. CA |
| SCALE | 1" = 1.25 miles |
| DESIGNED | TH |
| DRAWING | TH |
| CHECKED | BMP |
| DATE | 02/09/11 |
| JOB NO. | 9526-E |

PACE
Advanced Water Engineering

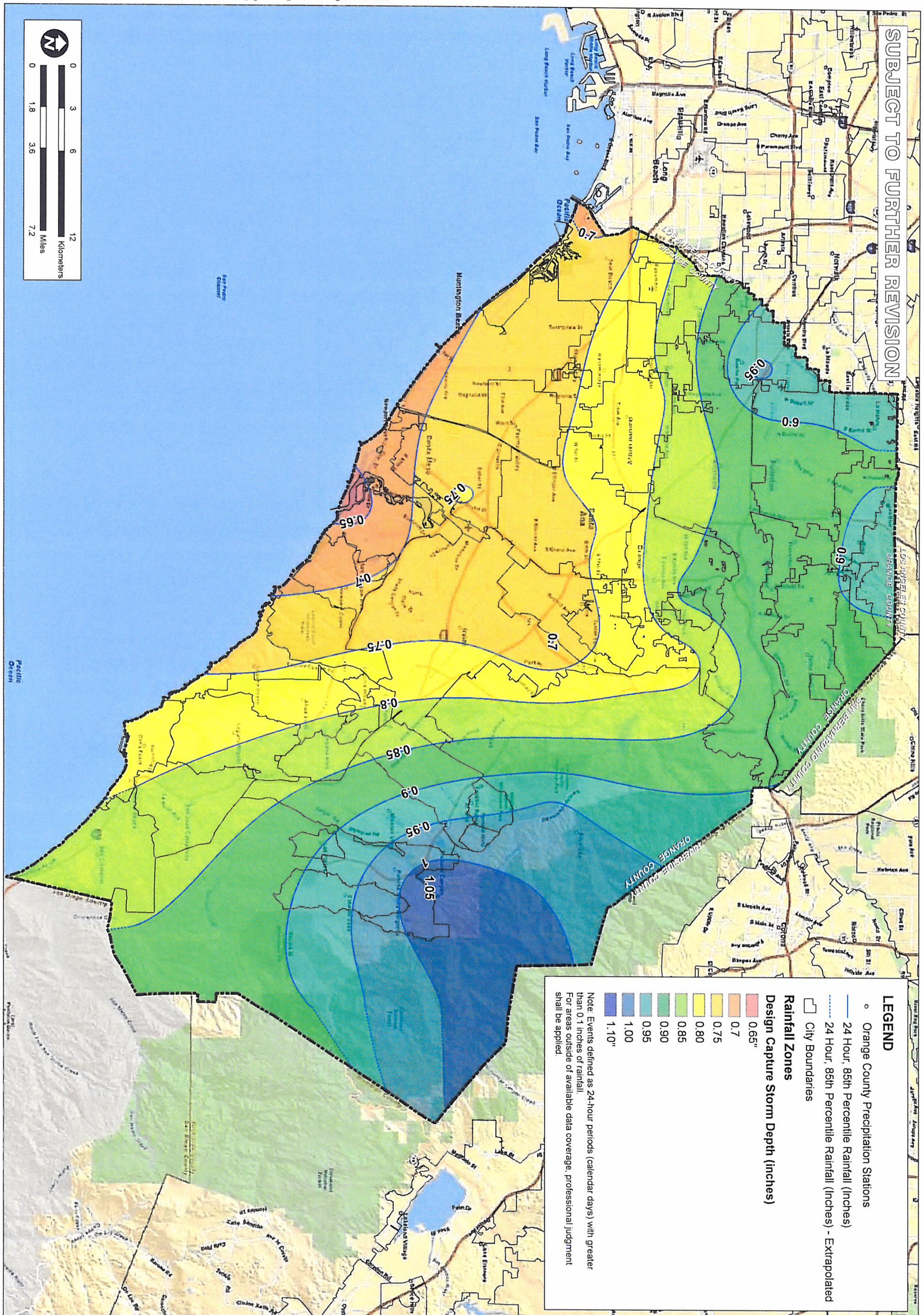
FIGURE
XVI-2e

P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-2f_NorthOCGroundwaterProtectionAreasStreetMap_20110215.mxd




| FIGURE | | SCALE 1" = 1.25 miles | JOB | TITLE |
|---|---|---|---|---|
| XVI-2f | PACE Advanced Water Engineering | DESIGNED TH<br>DRAWING TH<br>CHECKED BMP<br>DATE 04/22/10<br>JOB NO. 9526-E | ORANGE COUNTY INFILTRATION STUDY<br>ORANGE CO. CA | NORTH ORANGE COUNTY GROUNDWATER PROTECTION AREAS |

P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-1_RainfallZones_20110215.mxd




| FIGURE | | SCALE 1" = 1.8 miles | JOB | TITLE |
|---|---|---|---|---|
| XVI-1 | PACE Advanced Water Engineering | DESIGNED TH<br>DRAWING TH<br>CHECKED BMP<br>DATE 04/22/10<br>JOB NO. 9526-E | ORANGE COUNTY TECHNICAL GUIDANCE DOCUMENT<br>ORANGE CO. CA | RAINFALL ZONES |

# Attachment B

## Educational Materials

The Ocean Begins at Your Front Door

Household Tips

Proper Disposal of Household Hazardous Waste

Responsible Pest Control

Tips for Landscaping and Gardening

Tips for Pet Care

# Attachment C

## Operation and Maintenance Plan and Supplements

Eco-Stone Permeable Pavers
INF-6 Permeable Pavement

# Operations and Maintenance (O&M) Plan

## For

## Lots 1 to 7 and Lot A – Tentative Tract No. 19115

## 9779 Starfish Avenue, Fountain Valley, CA

## APN 167-232-01

| BMP Applicable? Yes/No | BMP Name and BMP Implementation, Maintenance, and Inspection Procedures | Implementation, Maintenance, and Inspection Frequency and Schedule | Person or Entity with Operation & Maintenance Responsibility |
|---|---|---|---|
| **Non-Structural Source Control BMPs** | | | |
| Yes | **N1. Education for Property Owners, Tenants and Occupants**<br>Education materials will be provided to homeowners at close of escrow by developer and thereafter on an annual basis by the HOA. | Annually | Owner / HOA |
| Yes | **N2. Activity Restrictions**<br>The Owner will prescribe activity restrictions to protect surface waters quality, through a Covenant, Conditions and Restrictions (CC&R) agreement, or other equally effective measure, for the property. Upon takeover of the site responsibilities by the HOA, the HOA shall be responsible for ensuring residents compliance. | Ongoing | Owner / HOA |
| Yes | **N3. Common Area Landscape Management**<br>Maintenance shall be consistent with City requirements, plus fertilizer and/or pesticide usages shall be consistent with County guidelines for use of fertilizers and pesticides. Maintenance includes mowing, weeding, and debris removal on a weekly basis. Trimming, replanting and replacement of mulch shall be performed on an as-needed basis. Trimmings, clippings, and other waste shall be properly disposed of off-site in accordance with local regulations. Materials temporarily stockpiled during maintenance shall be placed away from water courses and drain inlets. | Monthly | Owner / HOA |
| Yes | **N4. BMP Maintenance**<br>Maintenance of BMPs implemented at the project site shall be performed at the frequency as per manufacturer specifications. | Ongoing | Owner / HOA |
| No | **N5. Title 22 CCR Compliance**<br>Not applicable to residential project. | | |
| No | **N7. Spill Contingency Plan**<br>Not applicable to residential project. | | |

| BMP Applicable? Yes/No | BMP Name and BMP Implementation, Maintenance, and Inspection Procedures | Implementation, Maintenance, and Inspection Frequency and Schedule | Person or Entity with Operation & Maintenance Responsibility |
|---|---|---|---|
| No | **N8. Underground Storage Tank Compliance**<br>Not applicable. None onsite. | | |
| No | **N9. Hazardous Materials Disclosure Compliance**<br>Not applicable to residential project. | | |
| No | **N10. Uniform Fire Code Implementation**<br>Not applicable to residential project. | | |
| Yes | **N11. Common Area Litter Control**<br>Litter patrol, violations investigation, reporting and other litter control activities shall be performed in conjunction with landscape maintenance activities. | Ongoing patrols. Weekly (minimum) pick up and removal. | Owner / HOA |
| Yes | **N12. Employee Training**<br>Train employees, contractors and subcontractors of CCF on the potential impacts of their actions on water quality. Provide training on proper material use and storage and proper clean up and disposal methods. | Annually and as needed. | Owner / HOA |
| No | **N13. Housekeeping of Loading Docks**<br>Not applicable. No loading docks onsite. | | |
| Yes | **N14. Common Area Catch Basin Inspection**<br>Catch basin inlets, area drains, swales, curb-and-gutter systems and other drainage systems shall be inspected prior to October 1st of each year and after large storm events. If necessary, drains shall be cleaned prior to any succeeding rain events. | Annually | Owner / HOA |
| Yes | **N15. Street Sweeping Private Streets and Parking Lots**<br>Streets must be swept at minimum, prior to the start of the rainy season (October 1st). Streets shall also be swept as needed. | Quarterly and as needed. | Owner / HOA |
| No | **N.17 Retail Gasoline Outlets**<br>Not applicable to residential project. | | |

| Structural Source Control BMPs | | | |
|---|---|---|---|
| Yes | **S1. Provide Storm Drain System Stenciling and Signage**<br>Storm drain stencils shall be inspected for legibility, at minimum, once prior to the storm season, no later than October 1st each year. Those determined to be illegible will be re-stenciled as soon as possible. | Annually | Owner / HOA |
| No | **S2. Design and Construct Outdoor Material Storage Areas to Reduce Pollutant Introduction**<br>Not applicable. No outdoor storage of hazardous materials onsite. | | |
| No | **S3. Design and Construct Trash and Waste Storage Areas to Reduce Pollutant Introduction**<br>Not applicable. None proposed. | | |
| No | **S4. Use Efficient Irrigation Systems & Landscape Design**<br>In conjunction with routine maintenance activities, verify that landscape design continues to function properly by adjusting properly to eliminate overspray to hardscape area, and to verify that irrigation timing and cycle lengths are adjusted in accordance with water demands, given time of year, weather, day or night time temperatures based on system specifications and local climate pattern. | Monthly | Owner / HOA |
| No | **S5. Protect Slopes and Channels and Provide Energy Dissipation**<br>Not applicable. Site is flat. | | |
| No | **S6. Loading Docks**<br>Not applicable. No loading docks onsite. | | |
| No | **S7. Maintenance Bays**<br>Not applicable. No maintenance bays onsite. | | |
| No | **S8. Vehicle Wash Areas**<br>Not applicable. No vehicle wash areas onsite. | | |
| No | **S9. Outdoor Processing Areas**<br>Not applicable. No outdoor processing onsite. | | |
| No | **S10. Equipment Wash Areas**<br>Not applicable. No equipment wash areas onsite. | | |

| | | | |
|---|---|---|---|
| No | **S11. Fueling Areas**<br>Not applicable. No fueling areas onsite. | | |
| No | **S12. Site Design and Landscape Planning (Hillside Landscaping)**<br>Not applicable. Project is not a hillside development. | | |
| No | **S13. Wash Water Controls for Food Preparation Areas**<br>Not applicable. No restaurant facilities onsite. | | |
| No | **S14. Community Car Wash Racks**<br>Not applicable. No community car wash areas onsite. | | |
| **Treatment Control BMPs** | | | |
| Yes | **LID BMP # 1**<br>Permeable Concrete Pavers | Twice a year inspect for ponding or areas with reduced levels of infiltration. In accordance with manufacturer's recommendations. Vacuum type street cleaning equipment should be used for removing sediment from the openings. Surface should be dry when cleaning. | Owner / HOA |

## Required Permits

No additional permits are necessary for the operation and maintenance of the proposed BMPs.

## Forms to Record BMP Implementation, Maintenance, and Inspection

The form that will be used to record implementation, maintenance, and inspection of BMPs is attached.

## Funding

The owner is aware of the maintenance responsibilities of the proposed BMPs. All records must be maintained for at least five (5) years and must be made available for review upon request.

## RECORD OF BMP IMPLEMENTATION, MAINTENANCE, AND INSPECTION

**Today's Date:** ______________________________

**Name of Person Performing Activity (Printed):** ______________________________

**Signature:** ______________________________

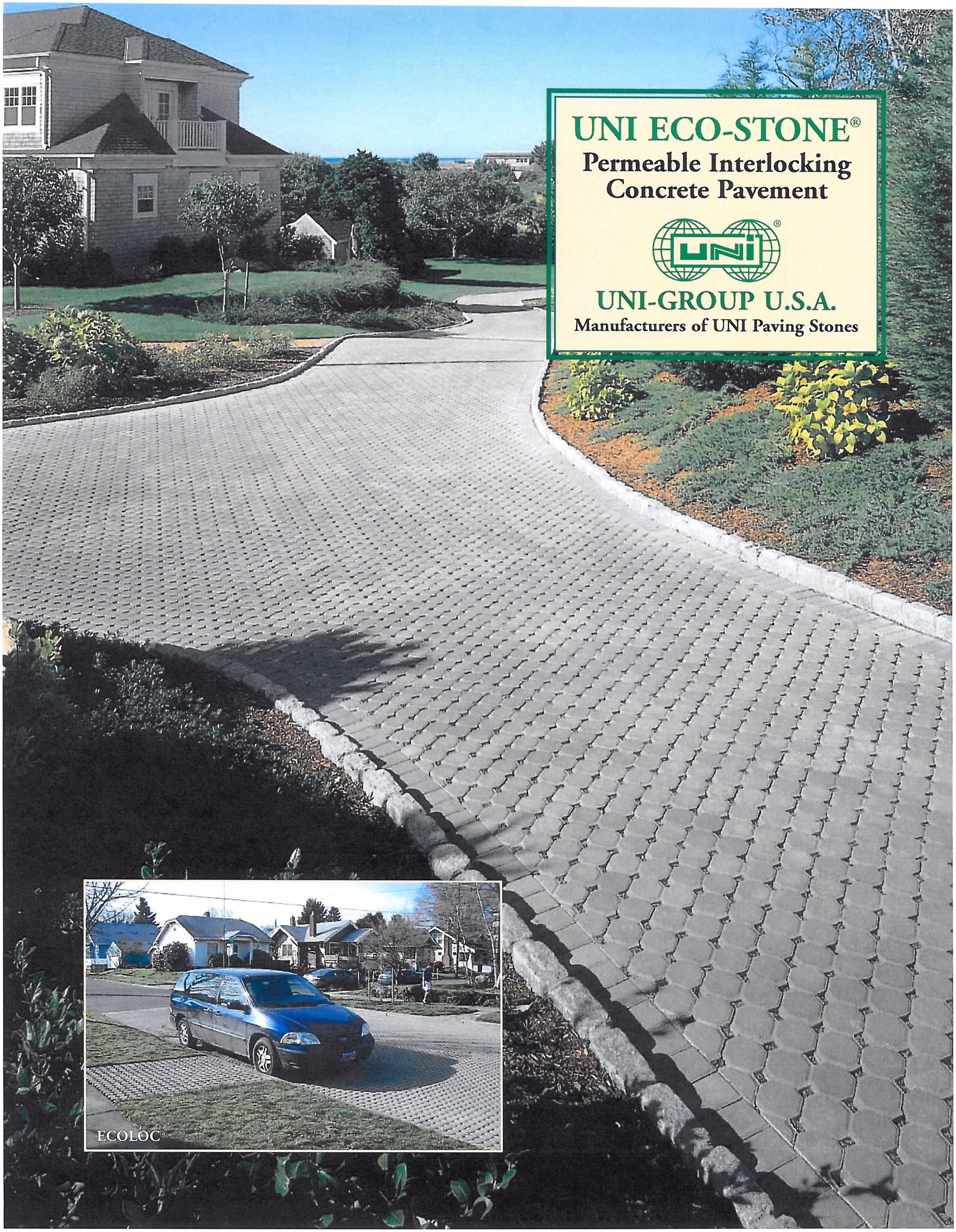
| BMP Name (As Shown in O&M Plan) | Brief Description of Implementation, Maintenance, and Inspection Activity Performed |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

# UNI ECO-STONE®

## Permeable Interlocking Concrete Pavement

UNI-GROUP U.S.A.

Manufacturers of UNI Paving Stones



ECOLOC®

## DEVELOPMENT, IMPERVIOUS COVER AND IMPACTS OF STORMWATER RUNOFF

With ever-increasing levels of development, natural, open land is rapidly being replaced with impervious surfaces such as asphalt roadways, parking lots, and buildings. As a result, the management of increased levels of stormwater runoff and its impact on the environment has become a major issue for all levels of government throughout the country. Numerous studies indicate that stormwater runoff is the primary source of pollutants found in surface waters and contains a toxic combination of oils, pesticides, metals, nutrients, and sediments. Additionally, research has shown that once a watershed reaches just 10% impervious cover, water resources are negatively impacted.

*Stormwater Inlet Drain - Lake Park, FL*

In the early 1990s, the United States Environmental Protection Agency (EPA) established the National Pollutant Discharge Elimination System (NPDES) stormwater regulations to comply with the requirements of the Clean Water Act. Compliance with federal, state, and local stormwater programs involves the use of "best management practices" (BMPs) to manage and control stormwater runoff. Effective management of stormwater runoff offers a number of benefits, including improved quality of surface waters, protection of wetland and aquatic ecosystems, conservation of water resources, and flood mitigation. The EPA recommends approaches that integrate control of stormwater and protection of natural systems.

In 1999 and 2001, the International City/County Managers Association (ICMA) and EPA released the framework for "Smart Growth" policies that communities around the country could adopt to meet environmental, community, and economic goals. Simultaneously, organizations such as the Low Impact Development Center and the Center for Watershed Protection began advocating low impact development (LID) as a way to preserve and protect the nation's water resources. They promote comprehensive land planning and engineering design, watershed planning and restoration, and stormwater management approaches that protect water resources and attempt to maintain pre-existing hydrologic site conditions. Their goal is to achieve superior environmental protection, while still allowing for development.

The EPA began working with these organizations in 2006 to promote the use of LID and Smart Growth as a way to manage stormwater runoff. The goal is to protect water resources at the regional level by encouraging states and municipalities to implement policies that consider both growth and conservation simultaneously. These approaches are quickly gaining favor across the country and are being incorporated into local development regulations to help meet stormwater runoff requirements and provide more livable, sustainable communities for residents. One of the

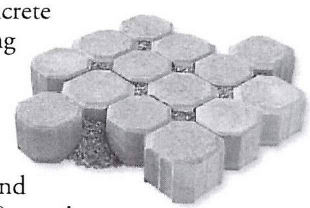
*Private Residence - Narragansett, RI*

primary goals of LID design is to reduce runoff volume by infiltrating rainwater on site and to find beneficial uses for the water as opposed to utilizing storm drains. LID objectives include the reduction of impervious cover, preservation of natural landscape features, and the maximization of infiltration opportunities. Infiltration helps recharge groundwater, reduces urban heat island effects, and reduces downstream erosion and flooding. This allows development to occur with much less environmental impact.

In addition, "green building" programs are gaining in popularity. The Leadership in Energy and Environmental Design (LEED®) green building assessment system, developed by the U.S. Green Building Council, has been adopted by a number of cities and states that now require municipal buildings to meet LEED® certification standards. Also, the National Association of Home Builders (NAHB) has released a comprehensive guide on green building that promotes mixed-use developments, cluster housing, green technologies and materials, and alternative stormwater approaches.

## UNI ECO-STONE®...THE SOLUTION TO STORMWATER RUNOFF PROBLEMS

Permeable interlocking concrete pavements (PICPs) are becoming increasingly popular as more cities and states are faced with meeting stormwater runoff regulations, increased impervious cover restrictions, and the adoption of LID or LEED® practices.



*UNI Eco-Stone®*

Eco-Stone® is a permeable interlocking concrete pavement system that mitigates stormwater runoff through infiltration. This allows for reduction of volume and peak flows, improved water quality, filtering of pollutants, mitigation of downstream flooding, and recharge of groundwater. Eco-Stone® is a true interlocking paver that offers the structural support, durability, and beauty of traditional concrete pavers, combined with the environmental benefit of permeability. The permeability is achieved through the drainage openings created by its notched design. Measurements of a typical UNI Eco-Stone® paver and physical characteristics are shown in Figure 1.

**Physical Characteristics**

| | | | |
|---|---|---|---|
| Height/Thickness | 3 1/8" | = | 80mm |
| Width | 4 1/2" | = | 115mm |
| Length | 9" | = | 230mm |
| Pavers per sq ft | | = | 3.55 |
| Percentage of drainage void area per sq ft | | = | 12.18% |

**Composition and Manufacture**

Minimum compressive strength - 8000psi
Maximum water absorption - 5%
Meets or exceeds ASTM C-936
and freeze-thaw testing per
section 8 of ASTM C-67.

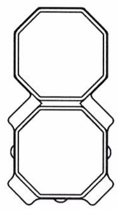


*Figure 1*

The drainage openings in an Eco-Stone® permeable pavement are created when the pavers are installed (Figure 2). This is what distinguishes Eco-Stone® permeable pavers from traditional interlocking concrete pavers. The drainage openings are filled with a clean, hard crushed aggregate that is highly permeable, allowing for rapid infiltration of stormwater (Figure 3).

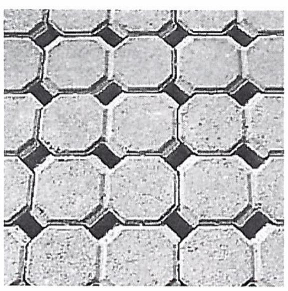


*Figure 2*

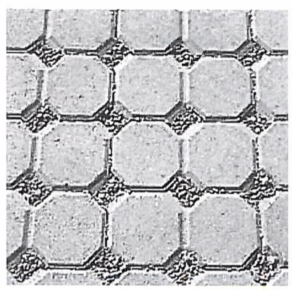


*Figure 3*

## ECO-STONE® PERMEABLE PAVEMENT AS AN EPA BEST MANAGEMENT PRACTICE

The EPA encourages "system building" to allow for the use of appropriate site-specific practices that will achieve the minimum measures under Phase II of NPDES. Governing authorities must develop and implement strategies that include a combination of structural and/or non-structural BMPs appropriate for their communities. Structural practices include storage practices, filtration practices, and infiltration practices that capture runoff and rely on infiltration through a porous medium for pollutant reduction. Infiltration BMPs include detention ponds, green roofs, bioswales, infiltration trenches, and permeable pavements. Non-structural practices are preventative actions that involve management and source controls. Many states and municipalities have incorporated the EPA regulations into their stormwater design and BMP manuals as they attempt to deal with stormwater runoff, increased impervious cover, and over-taxed drainage and sewer systems.

PICPs are considered structural BMPs under infiltration practices. From an engineering viewpoint, permeable pavements are infiltration trenches with paving on top that supports pedestrian and vehicular traffic. By combining infiltration and retention, Eco-Stone® permeable interlocking concrete pavement offers numerous benefits over other types of structural systems. Permeable pavements also work well in conjunction with other recommended BMP practices such as swales, bioretention areas, and rain gardens.

*Rainwater Runoff Model - Minnehaha Creek Watershed District, MN*

## ECO-STONE® PERMEABLE PAVEMENT AND LID, LEED AND GREEN BUILDING

According to the Natural Resources Defense Council, LID has emerged as an attractive approach to controlling stormwater pollution and protecting watersheds. With reduction of impervious surfaces a major tenant of LID, permeable and porous pavements, such as Eco-Stone®, are listed as one of the ten most common LID practices. The use of site-scale technologies, such as PICPs that control runoff close to the source, closely mirror the natural process of rainwater falling onto undeveloped areas and infiltrating into the earth. With many areas of the country experiencing water shortages and increasing water pollution, LID and Smart Growth approaches will not only help alleviate these problems, but also create cities that are more energy efficient, environmentally sustainable, and cost effective.

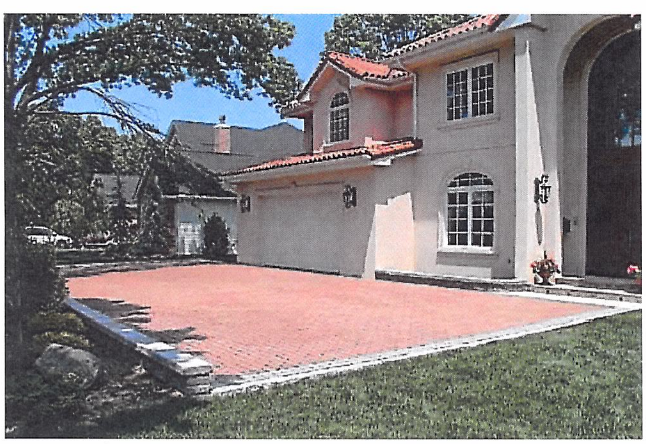
*McKinney Green Building, McKinney, TX - LEED® Platinum Certified*

*Sherwood Island State Park - Westport, CT*

The LEED® green building assessment system has become increasingly popular with the North American design community since its inception in 1998. This voluntary building system for rating new and existing commercial, institutional, and high-rise residential buildings, evaluates environmental performance from a "whole building" perspective over the project's life cycle. New green design standards are being considered for neighborhood design and residential homes as well. The minimum number of points or credits for a project to be LEED® certified is 26, though silver (33-38 points), gold (39-51 points), and platinum (52-69 points) ratings also are available.

UNI Eco-Stone® permeable pavements may qualify for up to 14 points under the Sustainable Sites (SS), Material and Resources (MR), and Innovation and Design Process (ID) credits. While traditional concrete pavers also may qualify under some of the credits, PICP can earn LEED® points via Sustainable Sites stormwater management credits by meeting water quality and runoff treatment criteria.

For years, most home builders and developers were wary of green building practices. However, with impervious cover restrictions and the increasing costs of energy now beginning to impact residential projects, the NAHB is encouraging the use of "green" products in single and multi-family developments. Eco-Stone® permeable pavement offers an attractive solution to impervious cover restrictions.



*Private Residence - Long Island, NY*

## ECO-STONE® AND MUNICIPAL STORM-WATER MANAGEMENT OBJECTIVES

Municipal regulations for managing stormwater runoff vary across the country. Water quality and/or quantity may be regulated, with criteria for reducing water pollutants such as nitrogen, phosphorous, nitrates, metals, and sediment. Many municipalities now restrict the amount of impervious surfaces for virtually all types of construction, including private residences. Thousands of municipalities have created stormwater utilities to fund the increasing costs of managing stormwater. These fees vary, but are usually based on runoff volumes and impervious cover.

*Lafayette Road Office Park - North Hampton, NH*

Regional authorities, counties, and municipalities use a number of design goals for managing stormwater runoff:

- Limit impervious cover to reduce stormwater runoff and pollutants from developments
- Capture the entire stormwater volume so there is zero discharge from the drainage area
- Capture and treat stormwater runoff to remove a stated percentage of pollutants
- Capture and treat a fixed volume of runoff, typically 0.75-1.5 in. (18-40 mm), which usually contains the highest level of pollutants
- Maintain runoff volumes generated by development at or near pre-development levels
- Maintain groundwater recharge rates to sustain stream flows and ecosystems and recharge aquifers

Eco-Stone® permeable interlocking concrete pavements may offer solutions for attaining all of these goals. PICP can reduce runoff volumes and flows and recharge groundwater. It also can filter pollutants with removal rates of up to 95% total suspended solids, 70% total phosphorous, 51% total nitrogen, and 99% zinc. Reduction of runoff also may offer property owners reductions in stormwater utility fees.

## FEATURES AND BENEFITS OF THE UNI ECO-STONE® PAVEMENT SYSTEM

Eco-Stone® is an attractive pavement that can be used for residential, commercial, institutional, and recreational pedestrian and vehicular applications. It can be used for parking lots, driveways, overflow parking, emergency lanes, boat ramps, walkways, low-speed roadways, and storage facilities. *Permeable or porous pavements should not be used for any site classified as a* ***stormwater hotspot*** (anywhere there is a risk of stormwater contaminating groundwater). This includes fueling and maintenance stations, areas where hazardous materials or chemicals are stored, or land uses that drain pesticides/fertilizers onto permeable pavements.

UNI Eco-Stone® permeable pavements are a site-scale infiltration technology that is ideal for meeting the EPA's NPDES regulations, LID and Smart Growth objectives, LEED® certification, municipal and regional impervious cover restrictions, and green building requirements.

- Can be designed to accommodate a wide variety of stormwater management objectives
- Runoff reductions of up to 100% depending on project design parameters
- Maximizes groundwater recharge and/or storage
- Reduces nonpoint source pollutants in stormwater, thereby mitigating impact on surrounding surface waters, and may lessen or eliminate downstream flooding and streambank erosion
- Allows better land-use planning and more efficient use of available land for greater economic value, especially in high-density, urban areas
- May decrease project costs by reducing or eliminating drainage and retention/detention systems
- May reduce cost of compliance with stormwater regulatory requirements and lower utility fees
- May reduce heat island effect and thermal loading on surrounding surface waters

*Glen Brook Green, Jordan Cove Watershed - Waterford, CT*

Examples of pollutant removal and infiltration rates for Eco-Stone® are shown in Tables 1 and 2. This data is from the Jordan Cove Urban Watershed Project 2003 Annual Report by the University of Connecticut, who conducted monitoring on this EPA Section 319 National Monitoring Project. It should be noted that these infiltration results were achieved using a dense-graded base. Even higher infiltration rates would be expected with open-graded bases.

| Test and Year | Asphalt | Eco-Stone® in./hr (cm/hr) | Crushed Stone in./hr (cm/hr) |
|---|---|---|---|
| Single Ring Infiltrometer test 2002 | 0 | 7.7 (19.6) | 7.3 (18.5) |
| Single Ring Infiltrometer test 2003 | 0 | 6 (15.3) | 5 (12.7) |
| Flowing Infiltration test 2003 | 0 | 8.1 (20.7) | 2.4 (6) |

Table 1. *Average infiltration rates from asphalt, Eco-Stone® and crushed stone Jordan Cove Urban Watershed Project*

| Variable | Asphalt | | Eco-Stone Pavement | | Crushed Stone | |
|---|---|---|---|---|---|---|
| Runoff depth, mm | 1.8 | a | 0.5 | b | 0.04 | c |
| Total suspended solids, mg/l | 47.8 | a | 15.8 | b | 33.7 | a |
| Nitrate nitrogen, mg/l | 0.6 | a | 0.2 | b | 0.3 | ab |
| Ammonia nitrogen, mg/l | 0.18 | a | 0.05 | b | 0.11 | a |
| Total Kjeldahl nitrogen, mg/l | 8.0 | a | 0.7 | b | 1.6 | ab |
| Total phosphorous, mg/l | 0.244 | a | 0.162 | b | 0.155 | b |
| Copper, ug/l | 18 | a | 6 | b | 16 | a |
| Lead, ug/l | 6 | a | 2 | b | 3 | b |
| Zinc, ug/l | 87 | a | 25 | b | 57 | ab |

Table 2. *Mean weekly pollutant concentration in stormwater runoff from asphalt, Eco-Stone® and crushed stone driveways*
*Note: Within each variable, means followed by the same letter are not significantly different at* $\alpha = 0.05$

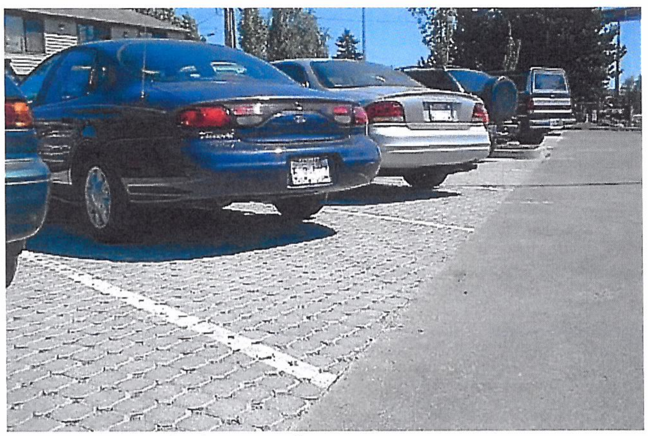
## ECO-STONE® DESIGN AND GENERAL CONSTRUCTION GUIDELINES

UNI-GROUP U.S.A. offers design professionals a variety of tools for designing Eco-Stone® permeable pavements. Research on Eco-Stone® has been conducted at major universities such as Texas A&M, University of Washington, and Guelph University, and ongoing pollution monitoring is being conducted at EPA Section 319 National Monitoring Program sites Jordan Cove Urban Watershed Project in Connecticut and Morton Arboretum in Illinois. We offer design manuals, case studies, and Lockpave® Pro structural interlocking pavement design software, with PC-SWMM PP™ for hydraulic design of Eco-Stone® permeable pavements. Eco-Stone® is featured in the book *Porous Pavements* by Bruce Ferguson, a national authority on stormwater infiltration. And, as members of the Interlocking Concrete Pavement Institute, we can offer additional design and reference information, such as ICPI's *Permeable Interlocking Concrete Pavements* manual, Tech Specs™ and CAD files.

It is recommended that a qualified civil engineer with knowledge in hydrology and hydraulics be consulted for applications using permeable interlocking concrete pavement to ensure desired results. Information provided is intended for use by professional designers and is not a substitute for engineering skill or judgement. It is not intended to replace the services of experienced, professional engineers.

## Design Options - Full, Partial and No Exfiltration

Eco-Stone® pavements can be designed with full, partial, or no exfiltration into the soil subgrade. Optimal installation is infiltration through the base aggregate, with complete exfiltration into a permeable subgrade. This allows for not only runoff and pollutant reduction, but also groundwater recharge. For full exfiltration under vehicular loads, the minimum soil infiltration rate is typically 0.52 in./hr (3.7 x $10^{-6}$ m/sec). Where soil conditions limit the amount of infiltration and only partial exfiltration can be achieved, some of the water may need to be drained by perforated pipe. Where soils have extremely low or no permeability, or conditions such as high water tables, poor soil strength, or over aquifers where there isn't sufficient depth of the soil to filter pollutants, no exfiltration should occur. An impermeable liner is often used and perforated pipe is installed to drain all stored water to an outfall pipe. This design still allows for infiltration of stormwater and some filtering of pollutants and slows peak rates and volumes, so it still can be beneficial for managing stormwater. For extreme rainfall events, any overflows can be controlled via perimeter drainage to bio-retention areas, grassed swales or storm sewer inlets.



*Ash Avenue Park and Ride - Marysville, WA*

## Infiltration Rate Design

Permeable interlocking concrete pavements are typically designed to infiltrate frequent, short duration storms, which make up 75-85% of rainstorms in North America. It also may be possible to manage runoff volumes from larger storms through engineering design and the use of complementary BMPs, such as bio-retention areas and swales.

One of the most common misconceptions when designing or approving PICP is the assumption that the amount or percentage of open surface area of the pavement is equal to the percentage of perviousness. For example, a designer or municipal agency might incorrectly assume that a 15% open area is only 15% pervious. The permeability and amount of infiltration are dependent on the infiltration rates of the aggregates used for the joint and drainage openings, the bedding layer, and the base and subbase (if used). Compared to soils, the materials used in Eco-Stone® permeable pavements have very high infiltration rates – from 500 in./hr (over $10^{-3}$ m/sec) to over 2000 in./hr (over $10^{-3}$ to $10^{-2}$ m/sec). This is much more pervious than existing site soils.

*Private Residence - Minneapolis, MN*

Though initial infiltration rates are very high, it is important to consider *lifetime* design infiltration of the entire pavement cross-section, including the soil subgrade when designing PICPs. Based on research conducted to date, a conservative design rate of 3 in./hr (2.1 x $10^{-5}$ m/sec) can be used as the basis for the design surface infiltration rate over a 20-year pavement life.

A number of design methods may be used for sizing of the open-graded base (see references). For designers who use Natural Resources Conservation Service (NRCS) curve numbers in determining runoff calculations, the curve number for PICP can be estimated at 40, assuming a life-time design infiltration rate of 3 in./hr (75mm/hr) with an initial abstraction of 0.2 (applies to NRCS group A soils). Other design professionals may use coefficient of runoff (C) for peak runoff calculations. For the design life of permeable interlocking concrete pavement, C can be estimated with the following formula: C = I – Design infiltration rate, in./hr ÷ I, where I = design rainfall intensity in inches per hour.

## Construction Materials and General Installation

It is preferable that site soils not be compacted if structural strength is suitable, as compaction reduces infiltration rates. Low CBR soils (<4%) may require compaction and/or stabilization for vehicular traffic applications. Drains also would typically be required for low CBR soils. If soils must be compacted, the reduced infiltration rates should be factored into the design. Permeable and porous pavements should not exceed 5% slope for maximum infiltration.

*Goodbys Marina - Jacksonville, FL*

Permeable interlocking concrete pavements are typically built over open-graded aggregate bases consisting of washed, hard, crushed stone, though a variety of aggregate materials, including dense-graded, may be used depending on project parameters. Typically, stone materials should have less than 1% fines passing the No. 200 sieve.

Current industry recommendations include a subbase of open-graded aggregate (typically ASTM No. 2 or equivalent) at a minimum thickness of 6 in. (150mm) for pedestrian applications and 8 in. (200mm) for vehicular applications. This makes it easier for contractors to install the base materials. A base layer of open-graded aggregate (typically ASTM No. 57 or equivalent) is installed over the subbase. This helps meet filter criteria between the layers. The recommended thickness for this layer is 4 in. (100mm). It may be possible, however, to use a single material for the base and subbase depending on project design parameters and contractor experience. Open-graded materials described here typically have a water storage void space between the aggregates of between 30-40%, which maximizes storage of infiltrated stormwater.

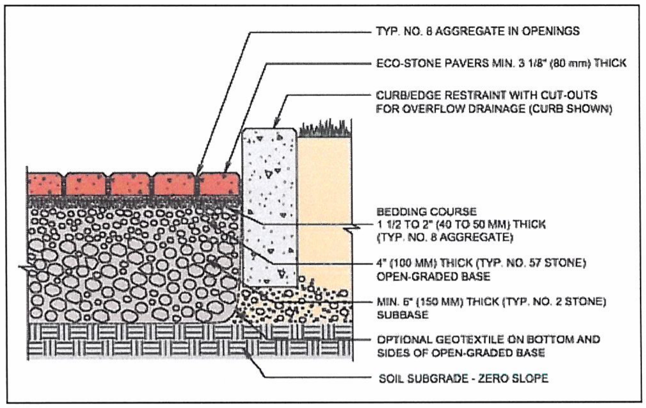
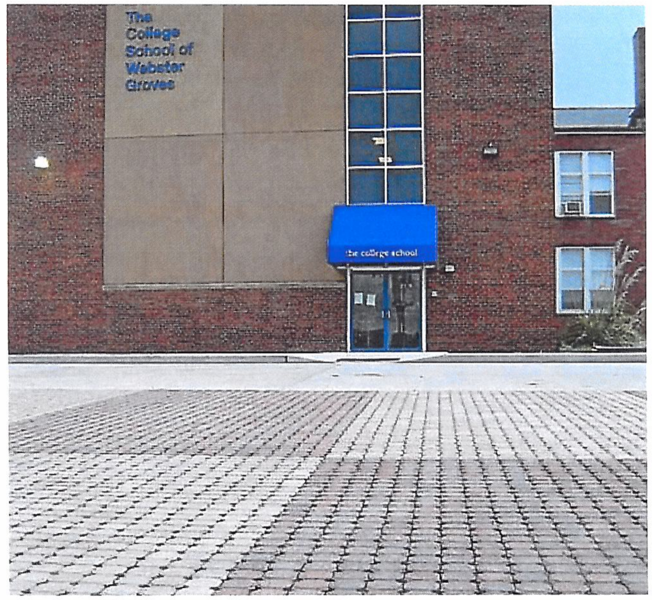



*Figure 4 - Typical Cross-Section of an Eco-Stone® Permeable Pavement Full Exfiltration*

For the bedding layer, material equivalent to ASTM No. 8 stone is recommended. This same material is used to fill the drainage openings and joints. If desired, material equivalent to No. 9, 10 or 89 stone also may be used to fill the smaller joints between the pavers. Bedding and jointing sand used in the construction of traditional interlocking concrete pavements should not be used for PICP.

*Private Residence - Danvers, MA*




*The College School of Webster Groves - St. Louis, MO*

UNI Eco-Stone® can be mechanically installed and trafficked immediately after final compaction, unlike other types of porous pavements. It has been used successfully for many years throughout North America and can withstand repeated freeze/thaw in northern climates due to adequate space for ice to expand within the open-graded base. PICP can be snow plowed, and because water does not stand on the surface, it may reduce ice slipping hazards. Winter sanding is not recommended on PICPs. Permeable interlocking concrete pavement conforms to current ADA requirements that surfaces be firm, stable, and slip resistant. If the openings in the surface are not desirable, solid pavers can be installed in areas used by disabled persons.

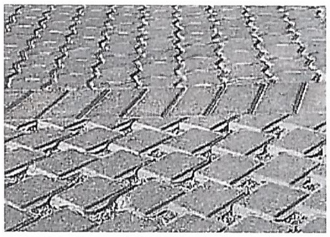
## Maintenance

All permeable pavements require periodic cleaning to maintain infiltration, and care must be taken to keep sediment off the pavement during and after construction. Studies and field experience have shown that vacuum-type street cleaning equipment is most effective for removing sediment from the openings to regenerate infiltration. Vacuum settings may require adjustment to prevent the uptake of aggregate in the pavement openings and joints. The surface should be dry when cleaning. Replenishment of joint and opening aggregate can be done, if needed, at the time of cleaning. The frequency of cleaning is dependent on traffic levels. It is generally recommended to vacuum the pavement surface at least once or twice a year, though some low-use pavements may not need cleaning as often. As street cleaning is a BMP under EPA guidelines, this also satisfies other criteria in a comprehensive stormwater management program.

If properly constructed and maintained, PICP should provide a service life of 20 to 25 years. Like our traditional interlocking concrete pavers, Eco-Stone® may be taken up and reinstated if underground repairs are needed. If at the end of its design life the pavement no longer infiltrates the required amount of stormwater runoff, PICP is the only type of permeable pavement that can be taken up, the base materials removed and replaced, and the pavers reinstalled.

## UNI ECOLOC® HEAVY-DUTY PERMEABLE INTERLOCKING CONCRETE PAVEMENT

Ecoloc® features all the same attributes and features of our Eco-Stone® permeable paver with the added benefit of supporting industrial loads. It can be used together with our industrial traditional interlocking paver, UNI-Anchorlock® to provide design professionals with the option of combining solid pavement areas with permeable areas.



*Ecoloc® with UNI-Anchorlock®*

Like Eco-Stone®, Ecoloc® features funnel-shaped openings that facilitate the infiltration of stormwater runoff. Physical characteristics are described in Figure 5.

**Physical Characteristics**

| | | |
|---|---|---|
| Height/Thickness | 3 1/8" | = 80mm |
| Width | 8 7/8" | = 225mm |
| Length | 8 7/8" | = 225mm |
| Pavers per sq ft | | = 2.41 |
| Percentage of drainage void area per sq ft | | = 12.18% |

**Composition and Manufacture**

Minimum compressive strength - 8000psi
Maximum water absorption - 5%
Meets or exceeds ASTM C-936 and freeze-thaw testing per section 8 of ASTM C-67.

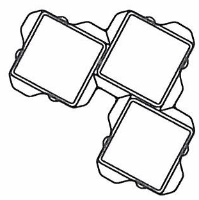
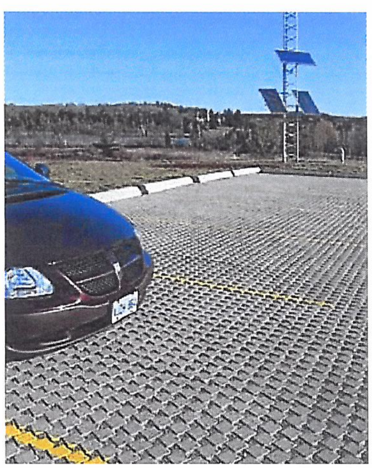


*Figure 5*

Ecoloc® can be mechanically installed and is ideal for larger-scale projects such as parking lots, roadways, storage and depot areas, and ports. Over 173,000 sf of Ecoloc® was used for an EPA Section 319 National Monitoring Permit Project at Morton Arboretum in Illinois. It also is in use at a test site located at Howland Hook Terminal at the Port of New York/New Jersey that is subjected to heavy, containerized loads, port forklifts and cargo carriers. Another 30,000 sf of Ecoloc® was installed at the East Gwillimbury Go Commuter Train Station parking lot in Newmarket, Ontario.



*Seneca College - Toronto, Ontario*

*Morton Arboretum - DuPage County, IL*

In addition, Ecoloc® is undergoing an evaluation at Seneca College in Ontario for the Toronto and Region Conservation Authority to study permeable interlocking concrete pavement performance in cold climates conditions.

Please check with your local UNI® manufacturer for availability of Ecoloc® in your area. Please visit our website www.uni-groupusa.org for updated information, design references and research, a list of manufacturers, and more.

*East Gwillimbury Go Commuter Train Station - Newmarket, Ontario*

### REFERENCES & RESOURCES


- *Annual Report - Jordan Cove Urban Watershed Section 319 National Monitoring Program Project*, University of Connecticut, 2003
- *UNI Eco-Stone® Design Guide and Research Summary*
- *Lockpave® Pro structural design software with PC-SWMM™ PP hydraulic design software*
- *Porous Pavements* - Bruce K. Ferguson, CRC Press, 2005
- *Permeable Interlocking Concrete Pavements* - Interlocking Concrete Pavement Institute, 2006



*A special thank you to the Interlocking Concrete Pavement Institute for use of some project photos.*

*Front cover photos: Eco-Stone® - Private Residence Cape Cod, MA and Ecoloc® - Westmoreland Street Project - Portland, OR*





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INF-6: Permeable Pavement (concrete, asphalt, and pavers)

*Also known as:*
- *Pervious pavement*
- *Porous concrete*
- *Pavers*
- *Permeable asphalt*

Permeable Pavement
*Source: Geosyntec Consultants*

Permeable pavements contain small voids that allow water to pass through to a gravel base. They come in a variety of forms; they may be a modular paving system (concrete pavers, grass-pave, or gravel-pave) or poured in place pavement (porous concrete, permeable asphalt). All permeable pavements treat stormwater and remove sediments and metals to some degree within the pavement pore space and gravel base. While conventional pavement result in increased rates and volumes of surface runoff, properly constructed and maintained porous pavements, allow stormwater to percolate through the pavement and enter the soil below. This facilitates groundwater recharge while providing the structural and functional features needed for the roadway, parking lot, or sidewalk. The paving surface, subgrade, and installation requirements of permeable pavements are more complex than those for conventional asphalt or concrete surfaces. For porous pavements to function properly over an expected life span of 15 to 20 years, they must be properly sited and carefully designed and installed, as well as periodically maintained. Failure to protect paved areas from construction-related sediment loads can result in their premature clogging and failure.

### *Feasibility Screening Considerations*

- Permeable pavement shall pass infiltration infeasibility screening to be considered for use.
- Permeable pavements pose a potential risk of groundwater contamination; they may not provide significant attenuation of stormwater pollutants if underlying soils have high permeability.

### *Opportunity Criteria*

- Permeable pavement areas can be applied to individual lot driveways, walkways, parking lots, low-traffic roads, high-traffic (with low speeds) roads/lots, golf cart paths, within road right-of-ways, and in parks and along open space edges. Impervious surfaces draining to the BMP are limited to surfaces immediately adjacent to the permeable pavement, rooftop runoff, and other nearby surfaces that do not contain significant sediment loads.
- Soils are adequate for infiltration or can be amended to provide an adequate infiltration rate.
- Infiltration is into native soil, or depth of engineered fill is ≤ 5 feet from the bottom of the facility to native material and infiltration into fill is approved by a geotechnical professional.

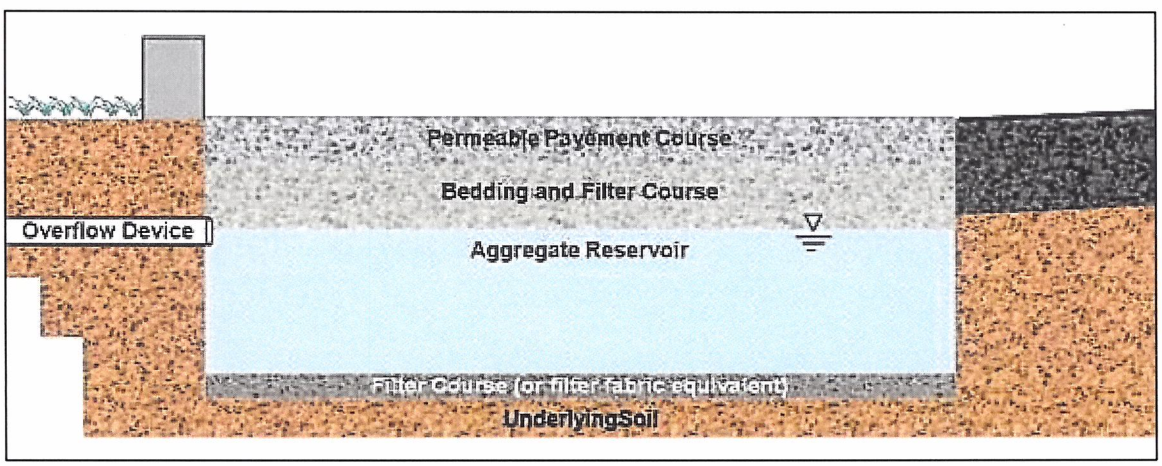
### *OC-Specific Design Criteria and Considerations*

☐ Placement of BMPs should observe geotechnical recommendations with respect to geological hazards (e.g. landslides, liquefaction zones, erosion, etc.) and set-backs (e.g., foundations, utilities, roadways, etc)

☐ Minimum separation to mounded seasonally high groundwater of 5 feet shall be observed.

- ☐ A biotreatment BMP should be provided for all runoff from off-site sources that are not directly adjacent to the permeable pavement, with the exception of rooftops.
- ☐ Permeable pavement should not be used for drainage areas with high sediment production potential (e.g., landscape areas) unless preceded by full treatment control with a BMP effective for sediment removal
- ☐ All aggregate used to construct permeable pavement shall be thoroughly washed before being delivered to the construction site.
- ☐ The top or wearing layer course (permeable pavement course) should consist of asphalt or concrete with greater than normal percentage of voids, or paving stones.
- ☐ A layer of washed fine aggregate (e.g., No. 8) just under the permeable pavement course may be installed to provide a level surface for installing the permeable pavement and also acts as a filter to trap particles and help prevent the reservoir layer from clogging. This layer can also act as interstitial media between pavers.
- ☐ Below this layer, the bedding and filter course course should be 1.5 to 3 inches deep and may be underlain by choking stone to prevent the smaller sized aggregate from migrating into the large aggregate base layer.
- ☐ The bedding, filter, and choke stone layers, as applicable, are referred to collectively as the bedding and filter course.
- ☐ The aggregate reservoir layer should be designed to function as a support layer as well as a reservoir layer the reservoir layer should be washed, open-graded No. 57 aggregate without any fine sands.
- ☐ The type of pedestrian traffic should be considered when determining which type of permeable pavement to use in particular locations (e.g., pavers may not be a good option for locations where people wearing high heels will be walking).
- ☐ An overflow device is required in the form of perimeter control or overflow pipes. This should generally be set at an elevation to prevent ponding of water into the bedding and filter course.

**Figure XIV.1: Schematic Diagram of Permeable Pavement without Underdrains**



## *Simple Sizing Method for Permeable Pavement*

Permeable pavement that manages only direct rainfall and runoff from adjacent impermeable surfaces less than 50 percent the size of the permeable pavement are are not required to conduct sizing calculations. These areas are assumed to be self-retaining for the purpose of drainage planning.For permeable pavement with larger tributary area ratios, sizing calculations must be performed.

If the Simple Design Capture Volume Sizing Method described in **Appendix** III.3.1 is used to size permeable pavement, the user calculates the DCV, designs the geometry required to draw down the DCV in 48 hours, then determines the area that is needed for the BMP. The area of the porous pavement itself as well as the area of the tributary areas should be considered in calculating the DCV. The sizing steps are as follows:

### Step 1: Determine Permeable Pavement DCV

Calculate the DCV using the Simple Design Capture Volume Sizing Method described in **Appendix** III.3.1.

### Step 2: Determine the 48-hour Effective Depth

The depth of water that can be drawn down in 48 hours can be calculated using the following equation:

$$d_{48} = K_{DESIGN} \times 48 \text{ hours} \times 1 \text{ ft}/12 \text{ inches}$$

Where:

$d_{48}$ = pavement effective 48-hour drawdown depth, ft

$K_{DESIGN}$ = basin design infiltration rate, in/hr (See Appendix VII)

This is the maximum effective depth of water storage in the aggregate reservoir to achieve drawdown in 48 hours.

### Step 3: Determine the Aggregate Reservoir Depth

The depth of water stored in the gravel reservoir should be equal or less than $d_{48}$. Determine the reservoir depth such that:

$$d_{48} \geq (n_R \times d_R)$$

Where:

$d_{48}$ = trench effective 48-hour depth, ft (from Step 2)

$n_R$ = porosity of aggregate reservoir fill; 0.35 may be assumed where other information is not available

$d_R$ = depth of trench fill, ft

### Step 4: Calculate the Required Infiltrating Area

The required infiltrating area can be calculated using the following equation:

$$A = DCV / (n_R \times d_R)$$

Where:

$A$ = required footprint area, sq-ft

DCV = design capture volume, cu-ft (see Step 1)

$n_R$ = porosity of trench fill; 0.35 may be assumed where other information is not available

$d_R$ = depth of trench fill, ft

This area is equal to the required pavement area.

The ratio total tributary area (including the porous pavement) to the area of the porous pavement should not exceed 4:1.

### *Capture Efficiency Method for Permeable Pavement*

If BMP geometry has already been defined and deviates from the 48 hour drawdown time, the designer can use the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix** III.3.2) to determine the fraction of the DCV that must be provided to manage 80 percent of average annual runoff volume. This method accounts for drawdown time different than 48 hours.

#### *Option 1: Pavement Geometry is Predefined*

**Step 1: Determine the Drawdown Time Associated with the Selected Pavement Geometry**

$DD = ((n_R \times d_R) / K_{DESIGN}) \times 12$ in/ft

Where:

$DD$ = time to completely drain pavement, hours

$n_R$ = porosity of reservoir fill; 0.35 may be assumed where other information is not available

$d_R$ = depth of reservoir, ft

$K_{DESIGN}$ = basin design infiltration rate, in/hr (See Appendix VII)

**Step 2: Determine the Required Adjusted DCV for this Drawdown Time**

Use the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix** III.3.2) to calculate the draw-down adjusted DCV that the basin must hold to achieve 80 percent capture of average annual stormwater runoff volume based on the pavement drawdown time calculated above.

**Step 3: Determine the Pavement Infiltrating Area Needed**

The required infiltrating area can be calculated using the following equation:

$A = DCV / (n_R \times d_R)$

Where:

$A$ = required footprint area, sq-ft

$DCV$ = design capture volume, cu-ft (see Step 1)

$n_R$ = porosity of reservoir fill; 0.35 may be assumed where other information is not available

$d_R$ = depth of reservoir, ft

If the area required is greater than the selected pavement area, adjust reservoir depth and recalculate required area until the required area is achieved.

### *Configuration for Use in a Treatment Train*

- Permeable pavement may be preceded in a treatment train by HSCs in the drainage area, which would reduce the runoff volume to be infiltrated by the permeable pavement
- Permeable pavement areas can be designed to be self-retaining to lessen the pollutant and volume load on downstream BMPs.

### *Additional References for Design Guidance*

- SMC LID Manual (pp 84): http://www.lowimpactdevelopment.org/guest75/pub/All_Projects/SoCal_LID_Manual/SoCalLID_Manual_FINAL_040910.pdf

- Los Angeles Unified School District (LAUSD) Stormwater Technical Manual, Chapter 5: http://www.laschools.org/employee/design/fs-studies-and-reports/download/white_paper_report_material/Storm_Water_Technical_Manual_2009-opt-red.pdf?version_id=76975850
- City of Portland Stormwater Management Manual (Pervious Pavement, page 2-40) http://www.portlandonline.com/bes/index.cfm?c=47954&a=202883

  San Diego County LID Handbook Appendix 4 (Factsheets 8, 9 & 10): http://www.sdcounty.ca.gov/dplu/docs/LID-Appendices.pdf

  City of Santa Barbara Storm Water BMP Guidance Manual, Chapter 6: http://www.santabarbaraca.gov/NR/rdonlyres/91D1FA75-C185-491E-A882-49EE17789DF8/0/Manual_071008_Final.pdf

  County of Los Angeles Low Impact Development Standards Manual, Chapter 5: http://dpw.lacounty.gov/wmd/LA_County_LID_Manual.pdf

# Attachment D

## WQMP Notice of Transfer of Responsibility

***To be included in Final WQMP***

# Attachment E

## Infiltration Report and Soils Report

1357

GEOBODEN, INC.
Geotechnical Consultants

April 10, 2020

Attention: Mr. David Nguyen

**Subject:** **Percolation Testing for**
**Storm Water Retention**
**Proposed Residential Development**
**9779 Starfish Avenue**
**Fountain Valley, California**

This letter presents the results of our geotechnical investigation for the storm water infiltration rate for design of infiltration system at the subject site. The scope of this work consisted of percolation testing on the subject site in order to determine the infiltration potential of the surface soils. The percolation rates determined should be useful in assessing storm water retention needs. It is our understanding that on-site storm water retention will be required. We anticipate that the storm water system will be installed at an approximate depth of 5 feet below the finished surface to be installed on native soils. This report presents the results of our study, discussion of our findings, and provides percolation rates for the subject system.

## PURPOSE AND SCOPE OF SERVICES

The purpose of this study was to determine the general percolation rates and physical characteristics of the onsite soils in order to provide design parameters for the proposed onsite infiltration system. Services provided for this study consisted of the following:

- Review of available information;
- Site exploration consisting of the excavation and logging of two test holes;
- Percolation testing in the borings (P-1 and P-2);
- Compilation of this report, which presents the results of our study and provides percolation rates for the design of an onsite infiltration system.

## SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The subject property is located at 9779 Starfish Avenue in the city of Westminster, California. The site is fairly level throughout and near the elevation of the adjacent properties and roadways.

The proposed development will include residential buildings. Further information regarding proposed development and test holes locations is shown on Figure 1, Plot Plan.

## FIELD INVESTIGATION

Our field investigation consisted of excavating three exploratory test holes used as percolation borings. Hollow stem auger drill rig was utilized to excavate the exploratory test holes to the maximum depth explored depth (5 feet bgs). An engineer logged and observed the test holes excavations. Soil classification was based on visual observation. The approximate locations of the exploratory and percolation test holes are shown on Figure 1 (Plot Plan). Logs of the exploratory borings are presented in Appendix A.

## SUBSURFACE SOILS CONDITIONS

### SOIL PROFILE

The subsurface conditions encountered in our borings consisted of sandy clay and sandy silt to the maximum depth explored (5 feet bgs). A more detailed description of these materials is provided in the exploratory boring logs included in the enclosed Appendix A. Soils encountered were classified according to the Unified Soil Classification System (USCS).

### GROUNDWATER

Groundwater was not encountered within our exploratory borings. Review of the available maps prepared by the State of California indicates that the historic high groundwater level is as shallow as 10 feet bgs (CDMG, 1998).

## PERCOLATION TESTING AND PROCEDURE

Percolation testing was performed in general accordance with Technical Guidance Development prepared by Santa Ana Regional Water Quality Control Board. The purpose of this testing was to assess the general percolation rates of the onsite soils for the design of an onsite infiltration system.

The continuous pre-soak test procedure was utilized for testing. A 2-inch diameter, 0.02 slotted PVC pipe was placed in the borehole and the annulus was filled with gravel to approximately 1 foot above the slotted interval. Water was allowed to presoak in each test hole prior to obtaining test readings. Following the presoak period, the drop in water level in each hole was monitored every 10 to 30 minutes to determine the appropriate method for testing. Test holes were refilled following each reading or when the water depth was below 6 inches. Test times ranged from 240 minutes. The drop in water level was recorded to the nearest 1/10$^{th}$ inch to produce conservative water level readings.

## SUMMARY OF INFILTRATION TEST RESULTS

We used borehole-type method, the percolation rate obtained converted to a reasonable estimate of the infiltration rate using the Porchet Method (aka Inverse Borehole Method). The conversion equation used in our calculations is:

$$It = \Delta H\ (60r)/(\ \Delta t(r + 2Havg)$$

"Ho" is the initial height of water at the selected time interval.
"Hf" is the final height of water at the selected time interval.
"ΔH" is the change in height over the time interval.
"Havg" is the average head height over the time interval.
"It" is the tested infiltration rate

It should be noted that the infiltration rates determined are ultimate rates based upon field test results. An appropriate safety factor should be applied to account for subsoil inconsistencies and potential silting of the percolating soils. The safety factor should be determined with consideration to other factors in the storm water retention system design (particularly storm water volume estimates) and the safety factors associated with those design components.

Infiltration tests results are summarized below:

| Test Hole No. | Rate (IN/HOUR) |
|---|---|
| 1 | 1.51 |
| 2 | 1.44 |

It should be noted that the infiltartion rates determined are ultimate rates based upon field test results. An appropriate safety factor should be applied to account for subsoil inconsistencies and potential silting of the percolating soils. The safety factor should be determined with consideration to other factors in the storm water retention system design (particularly storm water volume estimates) and the safety factors associated with those design components.

## ON-SITE STORM WATER DISPOSAL

To dispose of storm water on-site, there has to be a suitable area underlain by a layer of sufficient thickness and permeability to accept the storm water. The layer should also be located below the floor slab level of nearby structures so that subdrain systems for the structures do not intercept the storm water and be above the historic high ground water level.

The Storm water Manager's Resource Center (SMRC) web site (http://www.stormwatercenter.net/) sponsored by the Environmental Protection Agency (EPA) includes guidelines for disposal of storm water. The SMRC includes guidelines for disposal of storm water with respect to setback of structures. It is included in the SMRC that infiltration facilities should be setback 5 feet down-gradient from structures. In order to avoid potential adversely impacting any existing structures, we recommend that any infiltration system be kept a horizontal distance of at least 5 feet from the edge of any buildings, property line, or adjacent pavements. On-site disposal of storm water by infiltration is therefore considered to be feasible for this project.

## LIMITATIONS

The findings and recommendations of this report were prepared in accordance with generally accepted professional engineering and engineering geologic principals and practice within our opinion at this time in Southern California. Our conclusions and recommendations are based on the results of the field investigations, combined with an interpolation of subsurface conditions between and beyond exploration locations.

As the project evolves; our continued consultation and construction monitoring should be considered. Geotechnical International should review plans and specifications to ensure the recommendations presented herein have been appropriately interpreted, and that the design assumptions used in this study are valid. Where significant design changes occur, Geotechnical International may be required to augment or modify these recommendations. Subsurface conditions may differ in some locations from those encountered in the explorations and may require additional analyses and/or modified recommendations. This report was written for Client, and design team members, and only for the proposed development described herein. We are not responsible for technical interpretations made by others, or exploratory information that has not been described or documented in this report. Specific questions or interpretations concerning our findings and conclusions may require written clarification.

We appreciate the opportunity to provide service to you on this project. If you have questions regarding this letter or the data included, please contact the undersigned.

Sincerely,
GEOBODEN, INC.

Cyrus Radvar,
Principal Engineer, G.E. 2742

Attachments:

Figure 1 – Plot Plan
Appendix A – Test Borings Logs

## REFERENCES

Department of Conservation, Division of Mines and Geology. 1997. "Seismic Hazard Zone Report for the Anaheim and Newport Beach 7.5-Minute Quadrangles, Orange County, California, Seismic Hazard Zone Report 03.

Technical Guidance Document - For SARWQCB Consideration, March 22, 2011.

# GEOBODEN, INC.

# BORING NUMBER P-1



**CLIENT** Mr. David Nguyen
**PROJECT NAME** Proposed Infiltration System - Residential Development
**PROJECT NUMBER** Starfish-2-01
**PROJECT LOCATION** 9779 Starfish Avenue, Fountain Valley
**DATE STARTED** 4/6/20 **COMPLETED** 4/6/20
**GROUND ELEVATION** **HOLE SIZE** 8 inches
**DRILLING CONTRACTOR** Geoboden, Inc.
**GROUND WATER LEVELS:**
**DRILLING METHOD** HSA
**AT TIME OF DRILLING** ---
**LOGGED BY** C.R. **CHECKED BY**
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | SANDY CLAY (CL): olive brown, moist [FILL] | | | | | | | | | | |
| 2.5 | | | | | | | | | | | | |
| | | SANDY CLAY (CL): light olive, moist [NATIVE] | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | |

Bottom of borehole at 5 feet below ground surface. Ground water was not encountered. Boring was backfilled with cuttings.
Bottom of borehole at 5.0 feet.

## GEOBODEN, INC.

## BORING NUMBER P-2



CLIENT Mr. David Nguyen

PROJECT NUMBER Starfish-2-01

DATE STARTED 4/6/20 COMPLETED 4/6/20

DRILLING CONTRACTOR Geoboden, Inc.

DRILLING METHOD HSA

LOGGED BY C.R. CHECKED BY

NOTES

PROJECT NAME Proposed Infiltration System - Residential Development

PROJECT LOCATION 9779 Starfish Avenue, Fountain Valley

GROUND ELEVATION HOLE SIZE 8 inches

GROUND WATER LEVELS:

AT TIME OF DRILLING ---

AT END OF DRILLING ---

AFTER DRILLING ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | SANDY CLAY (CL): dark brown, moist [FILL] | | | | | | | | | | |
| 2.5 | | | | | | | | | | | | |
| | | SANDY CLAY (CL): olive brown, moist [NATIVE] | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | |

Bottom of borehole at 5 feet below ground surface. Ground water was not encountered. Boring was backfilled with cuttings.

Bottom of borehole at 5.0 feet.

## Boring Percolation Testing Field Log P-1

**Project No.:** Starfish-1-01
**Project Name:** Proposed Storm Water Retention
**Project Location:** 9779 Starfish Avenue, Fountain Valley
**Earth Description:** Alluvium
**Tested by:** SR
**Liquid Description:** Clear Clean Water

**Date:** 04/06/20 - 04/06/20

**Boring/Test Number:** P-1
**Diameter of Boring, inches:** 8
**Diameter of Casing, inches:** 2
**Depth of Boring, feet:** 5
**Depth to Invert of BMP, feet:**
**Depth to Groundwater, feet:** NE
**Depth to Initial Water Depth, ($d_1$) feet:** 3.00
**Water Remaining in Boring (Y/N):** N

**Start Time for Pre-Soak:** 4/6/20 7:03
**Start Time for Standard:** 4/6/20 8:05
**Standard Time Interval Between Readings,** 10 mins.

| Reading Number | Time Start/End (hh:mm) | Elapsed Time Δtime (min) | Water Depth (feet)[1] | Water Drop, Δd (feet) | Water Drop, Δd (inch) | Percolation Rate (in/hr) | Initial Height of Water (ft) | Initial Height of Water (in) | Final Height of Water (ft) | Final Height of Water (in) | Change in Height of Water, ΔH (inch) | Average Head Height of Water over Interval | Infiltration Rate (in/hr) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8:13<br>8:23 | 10 | 3.00<br>4.45 | 1.45 | 17.4 | 104.4 | 2.0 | 24.0 | 0.6 | 6.6 | 17.4 | 15.3 | 12.07 | Refilled to initial water depth every 10 minutes |
| 2 | 8:23<br>8:33 | 10 | 3.00<br>4.30 | 1.30 | 15.6 | 93.6 | 2.0 | 24.0 | 0.7 | 8.4 | 15.6 | 16.2 | 10.29 | |
| 3 | 8:33<br>8:43 | 10 | 3.00<br>4.30 | 1.30 | 15.6 | 93.6 | 2.0 | 24.0 | 0.7 | 8.4 | 15.6 | 16.2 | 10.29 | |
| 4 | 8:43<br>8:53 | 10 | 3.00<br>4.10 | 1.10 | 13.2 | 79.2 | 2.0 | 24.0 | 0.9 | 10.8 | 13.2 | 17.4 | 8.16 | |
| 5 | 8:53<br>9:03 | 10 | 3.00<br>3.91 | 0.91 | 10.9 | 65.5 | 2.0 | 24.0 | 1.1 | 13.1 | 10.9 | 18.5 | 6.38 | |
| 6 | 9:03<br>9:13 | 10 | 3.00<br>3.82 | 0.82 | 9.8 | 59.0 | 2.0 | 24.0 | 1.2 | 14.2 | 9.8 | 19.1 | 5.60 | |
| 7 | 9:13<br>9:23 | 10 | 3.00<br>3.73 | 0.73 | 8.8 | 52.6 | 2.0 | 24.0 | 1.3 | 15.2 | 8.8 | 19.6 | 4.86 | |
| 8 | 9:23<br>9:33 | 10 | 3.00<br>3.65 | 0.65 | 7.8 | 46.8 | 2.0 | 24.0 | 1.4 | 16.2 | 7.8 | 20.1 | 4.24 | |
| 9 | 9:33<br>9:43 | 10 | 3.00<br>3.50 | 0.50 | 6.0 | 36.0 | 2.0 | 24.0 | 1.5 | 18.0 | 6.0 | 21.0 | 3.13 | |
| 10 | 9:43<br>9:53 | 10 | 3.00<br>3.32 | 0.32 | 3.8 | 23.0 | 2.0 | 24.0 | 1.7 | 20.2 | 3.8 | 22.1 | 1.91 | |
| 11 | 9:53<br>10:03 | 10 | 3.00<br>3.32 | 0.32 | 3.8 | 23.0 | 2.0 | 24.0 | 1.7 | 20.2 | 3.8 | 22.1 | 1.91 | |
| 12 | 10:03<br>10:13 | 10 | 3.00<br>3.32 | 0.32 | 3.8 | 23.0 | 2.0 | 24.0 | 1.7 | 20.2 | 3.8 | 22.1 | 1.91 | Final Reading used to caluclate the infiltration rate. |

[1] Water depth below ground surface

**Infiltration Rate:** 1.51 **in/hr**

## Boring Percolation Testing Field Log P-2

**Project No.:** Starfish-1-01
**Project Name:** Proposed Storm Water Retention
**Project Location:** 9779 Starfish Avenue, Fountain Valley
**Earth Description:** Alluvium
**Tested by:** SR
**Liquid Description:** Clear Clean Water

**Date:** 07/02/18 - 07/02/18

**Boring/Test Number:** P-2
**Diameter of Boring, inches:** 8
**Diameter of Casing, inches:** 2
**Depth of Boring, feet:** 5
**Depth to Invert of BMP, feet:**
**Depth to Groundwater, feet:** NE
**Depth to Initial Water Depth, ($d_1$) feet:** 3.00
**Water Remaining in Boring (Y/N):** N

**Start Time for Pre-Soak:** 12/14/17 7:03
**Start Time for Standard:** 12/14/17 8:05
**Standard Time Interval Between Readings,** 10 mins.

| Reading Number | Time Start/End (hh:mm) | Elapsed Time Δtime (min) | Water Depth (feet)[1] | Water Drop, Δd (feet) | Water Drop, Δd (inch) | Percolation Rate (in/hr) | Initial Height of Water (ft) | Initial Height of Water (in) | Final Height of Water (ft) | Final Height of Water (in) | Change in Height of Water, ΔH (inch) | Average Head Height of Water over Interval | Infiltration Rate (in/hr) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8:20<br>8:30 | 10 | 3.00<br>4.35 | 1.35 | 16.2 | 97.2 | 2.0 | 24.0 | 0.7 | 7.8 | 16.2 | 15.9 | 10.86 | Refilled to initial water depth every 10 minutes |
| 2 | 8:30<br>8:40 | 10 | 3.00<br>4.25 | 1.25 | 15.0 | 90.0 | 2.0 | 24.0 | 0.8 | 9.0 | 15.0 | 16.5 | 9.73 | |
| 3 | 8:40<br>8:50 | 10 | 3.00<br>4.10 | 1.10 | 13.2 | 79.2 | 2.0 | 24.0 | 0.9 | 10.8 | 13.2 | 17.4 | 8.16 | |
| 4 | 8:50<br>9:00 | 10 | 3.00<br>3.87 | 0.87 | 10.4 | 62.6 | 2.0 | 24.0 | 1.1 | 13.6 | 10.4 | 18.8 | 6.03 | |
| 5 | 9:00<br>9:10 | 10 | 3.00<br>3.78 | 0.78 | 9.4 | 56.2 | 2.0 | 24.0 | 1.2 | 14.6 | 9.4 | 19.3 | 5.27 | |
| 6 | 9:10<br>9:20 | 10 | 3.00<br>3.64 | 0.64 | 7.7 | 46.1 | 2.0 | 24.0 | 1.4 | 16.3 | 7.7 | 20.2 | 4.16 | |
| 7 | 9:20<br>9:30 | 10 | 3.00<br>3.52 | 0.52 | 6.2 | 37.4 | 2.0 | 24.0 | 1.5 | 17.8 | 6.2 | 20.9 | 3.27 | |
| 8 | 9:30<br>9:40 | 10 | 3.00<br>3.49 | 0.49 | 5.9 | 35.3 | 2.0 | 24.0 | 1.5 | 18.1 | 5.9 | 21.1 | 3.06 | |
| 9 | 9:40<br>9:50 | 10 | 3.00<br>3.42 | 0.42 | 5.0 | 30.2 | 2.0 | 24.0 | 1.6 | 19.0 | 5.0 | 21.5 | 2.58 | |
| 10 | 9:50<br>10:00 | 10 | 3.00<br>3.31 | 0.31 | 3.7 | 22.3 | 2.0 | 24.0 | 1.7 | 20.3 | 3.7 | 22.1 | 1.85 | |
| 11 | 10:00<br>10:10 | 10 | 3.00<br>3.31 | 0.31 | 3.7 | 22.3 | 2.0 | 24.0 | 1.7 | 20.3 | 3.7 | 22.1 | 1.85 | |
| 12 | 10:10<br>10:20 | 10 | 3.00<br>3.31 | 0.31 | 3.7 | 22.3 | 2.0 | 24.0 | 1.7 | 20.3 | 3.7 | 22.1 | 1.85 | Final Reading used to caluclate the infiltration rate. |

[1] Water depth below ground surface

**Infiltration Rate:** 1.44 **in/hr**

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# GEOTECHNICAL INVESTIGATION REPORT
# PROPOSED RESIDENTIAL DEVELOPMENT
# 9779 STARFISH AVENUE

Fountain Valley, California

*Prepared for:*
**MR. DAVID NGUYEN**

*Prepared by:*
**GEOBODEN INC.**
Irvine, CA 92620

April 10, 2020

Project No. Starfish-1-01

**GEOBODEN INC.**

# GEOTECHNICAL INVESTIGATION REPORT
# PROPOSE RESIDENTIAL DEVELOPMENT
# 9779 STARFISH AVENUE
# FOUNTAIN VALLEY, CALIFORNIA

**MR. DAVID NGUYEN**

*Prepared by:*

**GEOBODEN INC.**
5 Hodgenville
Irvine, California 92620

April 10, 2020

J.N. Starfish-1-01

GEOBODEN, INC.
Geotechnical Consultants

April 10, 2020

Project No. Starfish-1-01

Attention: Mr. David Nguyen

**Subject: Geotechnical Investigation Report**
**Proposed Residential Development**
**9779 Starfish Avenue**
**Fountain Valley, California**

GeoBoden, Inc. is pleased to provide you with this report on our geotechnical investigation report for the proposed Residential Development on the subject site.

This report presents the results of our field investigation, laboratory testing and our engineering judgment, opinions, conclusions and recommendations pertaining to the proposed Residential Development.

Should you have any questions regarding the contents of this report, or should you require additional information, please contact us at (949) 872-9565.

Respectfully submitted,
**GEOBODEN, INC.**

Cyrus Radvar,
Principal Engineer, G.E. 2742

REGISTERED PROFESSIONAL ENGINEER
SHAHROKH E. RADVAR
2742
GEOTECHNICAL
STATE OF CALIFORNIA

Copies: 2/Addressee

5 Hodgenville | Irvine, CA 92620 | Off 949-872-9565 | Fax 949-743-2935

# GEOTECHNICAL INVESTIGATION REPORT

***PROPOSED RESIDENTIAL DEVELOPMENT***
***9779 Starfish Avenue***
***FOUNTAIN VALLEY, CALIFORNIA***

## TABLE OF CONTENTS

## FIGURES



## APPENDIXES

# GEOTECHNICAL INVESTIGATION REPORT
# PROPOSED RESIDENTIAL DEVELOPMENT
# 9779 STARFISH AVENUE
FOUNTAIN VALLEY, California

## 1.0 INTRODUCTION

This report presents the results of our geotechnical study performed by GeoBoden, Inc. (GeoBoden) for the proposed Residential Development on the subject site. The general location of the project is shown on Figure 1, "Site Vicinity Map".

The purposes of this study were to determine the geotechnical properties of subsurface soil conditions, to evaluate their in-place characteristics, evaluate site seismicity, and to provide geotechnical recommendations with respect to design and construction of the proposed improvements.

The scope of the authorized investigation included performing a site reconnaissance, conducting field exploration and laboratory testing programs, performing engineering analyses, and preparing this Geotechnical Investigation Report. Evaluation of environmental issues or the potential presence of hazardous materials was not within the scope of services provided.

## 2.0 SITE LOCATION AND DESCRIPTION

The subject site is located at 9779 Starfish Avenue in Fountain Valley, California and is currently occupied by existing building. The site is enclosed by existing residential properties to the north and west, by a vacant land on the east, and by Starfish on the south.

The proposed residential development will include new construction residential homes. The new buildings will be two-story wood-frame construction with slabs on-grade.

## 3.0 GEOTECHNICAL INVESTIGATION

Our geotechnical investigation included a field exploration program and a laboratory testing programs. These programs were performed in accordance with our scope of services. The field exploration and laboratory testing programs are described below.

## 3.1 FIELD EXPLORATION PROGRAM

The field exploration program was performed and involved drilling of one hollow-stem auger boring to depth of 51.5 feet below existing ground surface. Soil materials encountered were visually classified and logged in accordance with the Unified Soil Classification System. The approximate location of the boring is shown on Figure 2.

Log of subsurface conditions encountered in the boring was prepared in the field by an engineer. Soil samples consisting of relatively undisturbed brass ring samples and Standard Penetration Tests (SPT) samples were collected at approximately 2 and 5-foot depth intervals and were returned to the laboratory for testing. One bulk sample was collected at depths of 1 to 5 feet below ground surface (bgs). The SPTs were performed at selected depth in accordance with ASTM D-1586. Final boring log was prepared from the field log and is presented in Appendix A.

## 3.2 LABORATORY TESTING

Selected samples collected during drilling activities were tested in the laboratory to assist in evaluating controlling engineering properties of subsurface materials at the site. Physical tests performed included moisture and density determination, No. 200 Wash, Atterberg limits, Expansion, direct shear, and corrosion. The results of the laboratory testing are presented in Appendix B.

## 4.0 DISCUSSION OF FINDINGS

The following discussion of findings for the site is based on the results of the field exploration and laboratory testing programs.

## 4.1 SITE AND SUBSURFACE CONDITIONS

Generally, the near surface soil conditions encountered in our boring consisted of sandy clay. Deeper soils were predominately sandy clay, clay and interlayer of silty sand.

Fill material was encountered within our exploratory boring to maximum depth of approximately 3 feet below the existing ground surface. Fill materials consisted of sandy clay. Native materials were observed beneath the fill within our exploratory boring. These materials were observed to be stiff to very stiff. For more detailed descriptions of the subsurface materials refer to the boring logs in Appendix A.

## 4.2 GROUNDWATER CONDITIONS

Groundwater was encountered within our exploratory boring B-1 at an approximate depth of 10 feet bgs. Based on information from the California Geological Survey (California Division of Mines and Geology, 1997), the historic high ground water level in the site vicinity is at a depth of approximately 5 feet beneath the existing ground surface.

Fluctuations of the groundwater level, localized zones of perched water, and soil moisture content should be anticipated during and following the rainy season. Irrigation of landscaped areas on or adjacent to the site can also cause a fluctuation of soil moisture content and local groundwater levels.

## 4.3 SOIL ENGINEERING PROPERTIES

Physical tests were performed on the relatively undisturbed samples to characterize the engineering properties of the native soils. Moisture content and dry unit weight determinations were performed on the samples to evaluate the in-situ unit weights of the different materials. Moisture content and dry unit weight results are shown on the boring logs in Appendix A.

## 5.0 STRONG GROUND MOTION POTENTIAL

The project site is located in a seismically active area typical of Southern California and likely to be subjected to a strong ground shaking due to earthquakes on nearby faults.

The site is not within an Earthquake Fault Zone. Based on our review of published and unpublished geotechnical maps and literature pertaining to the site, the San Joaquin Hills Fault and Newport Inglewood fault zone (S. Los Angeles Basin section-southern) are located 3.43 and 4.25 kilometers of the site with anticipated maximum moment magnitudes (Mw) of 7 and 7.2, respectively.

## 5.1 CBC DESIGN PARAMETERS

To accommodate effects of ground shaking produced by regional seismic events, seismic design can, at the discretion of the designing Structural Engineer, be performed in accordance with the 2019 edition of the California Building Code (CBC). Table below, 2019 CBC Seismic Parameters, lists (next) seismic design parameters based on the 2019 CBC methodology, which is based on ASCE/SEI 7-16:

| 2019 CBC Seismic Design Parameters | Value |
|---|---|
| Site Latitude (decimal degrees) | 33.7096 |
| Site Longitude (decimal degrees) | -117.9584 |
| Site Class Definition | D |
| Mapped Spectral Response Acceleration at 0.2s Period, $S_s$ | 1.358 |
| Mapped Spectral Response Acceleration at 1s Period, $S_1$ | 0.489 |
| Short Period Site Coefficient at 0.2s Period, $F_a$ | 1.2 |
| Long Period Site Coefficient at 1s Period, $F_v$ | 1.811 |
| Adjusted Spectral Response Acceleration at 0.2s Period, $S_{MS}$ | 1.630 |
| Adjusted Spectral Response Acceleration at 1s Period, $S_{M1}$ | 0.886 |
| Design Spectral Response Acceleration at 0.2s Period, $S_{DS}$ | 1.087 |
| Design Spectral Response Acceleration at 1s Period, $S_{D1}$ | 0.591 |

## 6.0 LIQUEFACTION POTENTIAL

For liquefaction to occur, all of three key ingredients are required: liquefaction-susceptible soils, groundwater within a depth of 50 feet or less, and strong earthquake shaking. Soils susceptible to liquefaction are generally saturated loose to medium dense sands and non-plastic silt deposits below the water table.

We have used the risked based peak acceleration PGAM = 0.703g in our liquefaction analysis for the subject site. The predominant modal earthquake magnitude 6.89 used in our liquefaction analysis is based on the results of PSHA Deaggregation (https://earthquake.usgs.gov/hazards/interactive). The SPT consists of driving a standard sampler, as described in the ASTM 1586 Standard Method, using a 140 pound hammer falling 30 inches. An Automatic Trip Hammer was used to drive samplers 18 inches into the soil. For an automatic hammer, the energy ratio value of 1.27 was used in our analysis. SPT hammer was raised 30 inches utilizing an Automatic Trip Hammer. A correction factor of 1.0 for borehole correction was used in our revised liquefaction evaluation. The screening criteria of

Bray and Sancio (2006) were used to determine if fine-grained soils within boring B-1 is susceptible to liquefaction. To determine if soils are susceptible to liquefaction, the Plasticity Index (PI) and in-situ moisture content were determined. For screening analysis purposes, all soil samples above and below the groundwater table were soaked and saturated, and then tested for moisture content. Bray and Sancio (2006) found loose soils with a PI < 12 and moisture content> 85% of the liquid limit are susceptible to liquefaction. For PI greater than 12 and moisture content less than 85 percent of liquid limit, clayey soils are not susceptible to liquefaction. Based on the results of Atterberg limits testing, clayey soils are not susceptible to liquefaction. Computer program LiquefyPro developed by CivilTech Software was used for evaluation of liquefaction at the site. The program is based on the most recent publications of NCEER Workshop and SP117a Implementation. The results of our liquefaction analyses are attached. In order to estimate the amount of post-earthquake settlement, methods proposed by Tokimatsu and Seed (1987) were used for the settlement calculations.

Based on our analysis and under the current site conditions, the maximum total liquefaction-induced ground settlements at the site is 0.65 inches. Differential settlement of 0.43 or less is anticipated over a span of 40 feet. It is our opinion that potential for liquefaction at the site will not adversely impact the foundation performance of the new Residential Development provided recommendations in this report are incorporated in the design.

## 7.0 DESIGN RECOMMENDATIONS

Based upon the results of our investigation, the proposed residential development is considered geotechnically feasible provided the recommendations presented herein are incorporated into the design and construction. If changes in the design of the structure are made or variations or changed conditions are encountered during construction, GeoBoden should be contacted to evaluate their effects on these recommendations. The following geotechnical engineering recommendations for the proposed Residential Development are based on observations from the field investigation program and the physical test results.

### 7.1 EARTHWORK

All earthworks, including excavation, backfill and preparation of subgrade, should be performed in accordance with the geotechnical recommendations presented in this report and applicable portions of the grading code of local regulatory agencies. All earthwork should be performed under the observation and testing of a qualified geotechnical engineer.

## 7.2 SITE AND FOUNDATION PREPARATION

All site preparation should be observed by experienced personnel reporting to the project Geotechnical Engineer. Our field monitoring services are an essential continuation of our prior studies to confirm and correlate the findings and our prior recommendations with the actual subsurface conditions exposed during construction, and to confirm that suitable fill soils are placed and properly compacted.

Earthwork is expected to consist of subgrade preparation for construction of shallow continuous footings for the proposed Residential Development. We recommend the upper 4 feet of existing soils be removed and recompacted. The compacted fill should be extended laterally at least 5 feet beyond the footprints of the proposed buildings footprints.

Excavations below the final grade level should be properly backfilled using lean concrete or approved fill material compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM Test Method D1557. The backfill and any additional fill should be placed in loose lifts less than 8 inches thick, moisture conditioned to a few percent above optimum content, and compacted to 90 percent. Fill materials should be free of construction debris, roots, organic matter, rubble, contaminated soils, and any other unsuitable or deleterious material as determined by the Geotechnical Engineer. The on-site soils are suitable for use as compacted fill, provided the soil is free of any deleterious substance. All import fill material should be approved by the Geotechnical Engineer prior to importing to the site for use as compacted fill.

Excavation activities should not disturb adjacent structures or undermine any adjacent footings. Existing utilities should be removed and adequately capped at the project boundary line or salvaged/rerouted as designed.

It is our opinion that the construction of the proposed residential buildings and the completed site grading will not negatively impact the project site or the adjacent properties. The graded site and proposed development will not be subject to landslides, slippage or settlements provided that the recommendations included in this report are incorporated into design of the proposed residential development.

## 7.3 FILL PLACEMENT AND COMPACTION REQUIREMENTS

Material for engineered fill should be select free of organic material, debris, and other deleterious substances, and should not contain fragments greater than 3 inches in maximum dimension. On-site excavated soils that meet these requirements may be used to backfill the excavated Residential Development area.

All fill should be placed in 6-inch-thick maximum lifts, watered or air dried as necessary to achieve a few percent above optimum conditions, and then compacted in place to a maximum relative compaction of 90 percent. The laboratory maximum dry density and optimum moisture content for each change in soil type should be determined in accordance with Test Method ASTM D 1557. A representative of the project consultant should be present on-site during grading operations to verify proper placement and compaction of all fill, as well as to verify compliance with the other geotechnical recommendations presented herein.

Imported soils, if any, should consist of clean materials exhibiting a VERY LOW expansion potential (Expansion Index less than 20). Soils to be imported should be approved by the project geotechnical consultant prior to importation.

## 7.4 GEOTECHNICAL OBSERVATIONS

Exposed bottom surfaces in each removal area should be observed and approved by the project geotechnical consultant prior to placing fill. No fill should be placed without prior approval from the geotechnical consultant.

The project geotechnical consultant should be present on site during grading operations to verify proper placement and compaction of fill, as well as to verify compliance with the recommendations presented herein.

## 7.5 POST-GRADING CONSIDERATIONS

Positive drainage devices such as concrete flatwork, graded swales, and area drains should be provided around the new construction to collect and direct all water to a suitable discharge area.

Neither rain nor excess irrigation water should be allowed to collect or pond against buildings foundations.

## 7.6 UTILITY TRENCH BACKFIL

All utility trench backfill should be compacted to a minimum relative compaction of 90 percent. Trench backfill materials should be placed in lifts no greater than approximately 6 inches in thickness, watered or air-dried as necessary to achieve a few percent above optimum conditions, and then mechanically compacted in place to a minimum relative compaction of 90 percent. A representative of the project geotechnical consultant should probe and test the backfills to verify adequate compaction.

As an alternative for shallow trenches where pipe or utility lines may be damaged by mechanical compaction equipment, such as under buildings floor slabs, imported clean sand exhibiting a sand equivalent (SE) value of 30 or greater may be utilized. The sand backfill materials should be watered to achieve a few percent above optimum conditions and then tamped into place. No specific relative compaction will be required; however, observation, probing, and if deemed necessary, testing should be performed by a representative of the project geotechnical consultant to verify an adequate degree of compaction and that the backfill will not be subject to settlement.

Where utility trenches enter the footprint of the buildings, they should be backfilled through their entire depths with on-site fill materials, sand-cement slurry, or concrete rather than with any sand or gravel shading. This "Plug" of less- or non-permeable materials will mitigate the potential for water to migrate through the backfilled trenches from outside of the buildings to the areas beneath the foundations and floor slabs.

## 7.7 SHALLOW FOUNDATIONS

Following the site and foundation preparation recommended above, foundation for load bearing walls and interior columns if any may be designed as discussed below.

### 7.7.1 Bearing Capacity and Settlement

Load bearing walls and interior columns may be supported on continuous spread footings and isolated spread footings, respectively, and should bear entirely upon properly engineered fill or competent native soils. Continuous and isolated footings should have a minimum width of 14 inches and 18 inches, respectively. All footings should be embedded a minimum depth of 24 inches measured from the lowest adjacent finish grade. Continuous and isolated footings placed on such materials may be designed using an allowable (net) bearing capacity of 2,000 pounds per square foot (psf). Allowable increases of 200 psf for each additional 1 foot in width and 200 psf for each additional 6 inches in depth may be utilized, if desired. The maximum allowable bearing pressure should be 2,500 psf. The maximum bearing value applies to combined dead and sustained live loads. The allowable bearing pressure may be increased by one-third when considering transient live loads, including seismic and wind forces.

Based on the allowable bearing value recommended above, total settlement of the shallow footings are anticipated to be less than one inch, provided foundation preparations conform to the recommendations described in this report. Differential settlement is anticipated to be approximately half the total settlement for similarly loaded footings spaced up to approximately 30 feet apart.

### 7.7.2 Lateral Load Resistance

Lateral load resistance for the spread footings will be developed by passive soil pressure against sides of footings below grade and by friction acting at the base of the concrete footings bearing on compacted fill. An allowable passive pressure of 250 psf per foot of depth may be used for design purposes. An allowable coefficient of friction 0.30 may be used for dead and sustained live load forces to compute the frictional resistance of the footings constructed directly on compacted fill. Safety factors of 2.0 and 1.5 have been incorporated in development of allowable passive and frictional resistance values, respectively. Under seismic and wind loading conditions, the passive pressure and frictional resistance may be increased by one-third.

### 7.7.3 Footing Reinforcement

Reinforcement for footings should be designed by the structural engineer based on the anticipated loading conditions. Footings for lightly loaded wood-frame structures that are supported in low expansive soils should have No. 4 bars, two top and two bottom.

## 7.8 CONCRETE SLAB ON-GRADE

Concrete slabs will be placed on undisturbed natural soils or properly compacted fill as outlined in Section 7.2. Moisture content of subgrade soils should be maintained a few percent above the optimum moisture content. This moisture content should penetrate to a depth of approximately 18 inches into the subgrade.

At the time of the concrete pour, subgrade soils should be firm and relatively unyielding. Any disturbed soils should be excavated and then replaced and compacted to a minimum of 90 percent relative compaction.

Expansion index test was performed on a collected bulk sample. The expansion test data is attached for reference. The potential for expansion is low. The foundation may be designed per Section 1808.6 of the 2016 CBC (WRI/CRSI or PTI methods) by project structural engineer for expansive soil conditions and the intended use. Since the buildings will be constructed on level buildings pads, and in consideration of the estimated unconfined compressive strength of the onsite soils, it is recommended that the weighted plasticity index, as provided herein, be multiplied by a factor of 1.2 in order to determine the value of the effective plasticity index (per Figure 9 of the WRI publication). In summary, it is recommended that an effective plasticity index of 30 be utilized by the project structural engineer to design slabs on-ground with an interior grade beam system in accordance with the WRI publication. The expansion index of imported soils should be tested by geotechnical consultant to verify that the expansion index is not greater than 20 (low). We understand that post-tension slab is currently not proposed for construction. The structural engineer should determine the minimum slab thickness and reinforcing depending upon the expansive soil condition intended use. Slabs placed on low expansive soils should be at least 4 inches thick and have minimum reinforcement of No. 4 bars placed at mid-height of the slabs and spaced 18 inches on centers, in both directions. The structural engineer may require thicker slabs with more reinforcement depending on the anticipated slab loading conditions.

Per CALGreen Code, a 4-inch thick base of ½ -inch or larger clean aggregate shall be provided with a vapor retarder in direct contact with concrete and a concrete mix design which will address bleeding, shrinkage and curling shall be used. Alternatively, concrete floor slabs should be underlain with a moisture vapor retarder consisting of a polyvinyl chloride membrane such as 10-mil Visqueen, or equivalent. All laps within the membrane should be sealed, and at least 2 inches of clean sand should be placed over the membrane to promote uniform curing of the concrete. To reduce the potential for punctures, the membrane should be placed on a pad surface that has been graded smooth without any sharp protrusions. If a smooth surface can not be achieved by grading, consideration should be given to placing a 1-inch thick leveling coarse of sand across the pad surface prior to placement of the membrane.

## 7.9 SOLUBLE SULFATES AND SOIL CORROSIVITY

Minimum resistivity test on one near surface bulk sample from the site indicated that on-site soils are corrosive when in contact with ferrous materials. The preliminary chemical test results are included in Appendix B. Typical recommendations for mitigation of the corrosive potential of the soil in contact with buildings materials are the following:

- Below grade ferrous metals should be given a high quality protective coating, such as an 18 mil plastic tape, extruded polyethylene, coal tar enamel, or Portland cement mortar.

- Below grade ferrous metals should be electrically insulated (isolated) from above grade ferrous metals and other dissimilar metals, by means of dielectric fittings in utilities and exposed metal structures breaking grade.

- Steel and wire reinforcement within concrete in contact with the site soils should have at least two inches of concrete cover.

It is also recommended that additional sampling and analysis be conducted during the final stages of site grading to provide a complete assessment of soil corrosivity. GeoBoden does not practice corrosion engineering. Therefore, we recommend that on-site soils be tested and analyzed near or at the completion of precise grading by a qualified corrosion engineer to evaluate the general corrosion potential of the on-site soils and any impact on the proposed construction.

Corrosion test results also indicate that the surficial soils at the site have negligible sulfate attack potential on concrete. No special sulfate-resistant cement will be necessary for concrete placed in contact with the on-site soils.

## 8.0 EXTERIOR CONCRETE FLATWORK

### 8.1 THICKNESS AND JOINT SPACING

Concrete sidewalks should be at least 4 inches thick and provided with construction joints or expansion joints every 10 feet or less. Concrete subslabs to be covered with decorative pavers should also be at least 4 inches thick and provided with construction joints or expansion joints every 10 feet or less. Concrete driveway slabs should be at least 6 inches thick and provided with construction joints or expansion joints every 10 feet or less.

### 8.2 REINFORCEMENT

Consideration should be given to reinforcing all concrete patio-type slabs, driveways and sidewalks greater than 5 feet in width with No. 4 bars spaced 18 inches on centers, both ways. The reinforcement should be positioned near the middle of the slabs by means of concrete chairs or brick.

### 8.3 SUBGRADE PREPARATION

The subgrade soils below concrete flatwork areas should first be compacted to a minimum relative compaction of 90 percent and then thoroughly moistened to achieve a moisture content that is a few percent above optimum moisture content. Pre-wetting of the soils will promote uniform curing of the concrete and minimize the development of shrinkage cracks. A representative of the project geotechnical consultant should observe and verify the density and moisture content of the soils, and the depth of moisture penetration prior to pouring concrete.

## 9.0 CONSTRUCTION CONSIDERATIONS

Based on our field exploration program, earthwork can be performed with conventional construction equipment.

## 9.1 TEMPORARY DEWATERING

Groundwater was encountered within our exploratory boring at 10 feet. Based on the anticipated excavation depths, it is unlikely that dewatering will be required during construction.

## 9.2 CONSTRUCTION SLOPES

The temporary excavation side walls may be cut vertically to a maximum height of 3 feet. Surcharge loads should be kept away from the top of temporary excavations a horizontal distance equal to at least one-half the depth of excavation. Surface drainage should be controlled along the top of temporary excavations to preclude wetting of the soils and erosion of the excavation faces.

## 9.3 POST INVESTIGATION SERVICES

Final project plans and specifications should be reviewed prior to construction to confirm that the full intent of the recommendations presented herein have been applied to design and construction. Following review of plans and specifications, observation should be performed by the geotechnical engineer during construction to document that foundation elements are founded on/or penetrate onto the recommended soils, and that suitable backfill soils are placed upon competent materials and properly compacted at the recommended moisture content.

## 10.0 CLOSURE

The conclusions, recommendations, and opinions presented herein are: (1) based upon our evaluation and interpretation of the limited data obtained from our field and laboratory programs; (2) based upon an interpolation of soil conditions between and beyond the borings; (3) are subject to confirmation of the actual conditions encountered during construction; and, (4) are based upon the assumption that sufficient observation and testing will be provided during construction.

If parties other than GeoBoden are engaged to provide construction geotechnical services, they must be notified that they will be required to assume complete responsibility for the geotechnical phase of the project by concurring with the findings and recommendations in this report or providing alternate recommendations.

If pertinent changes are made in the project plans or conditions are encountered during construction that appear to be different than indicated by this report, please contact this office. Significant variations may necessitate a re-evaluation of the recommendations presented in this report.

## 11.0 REFERENCES

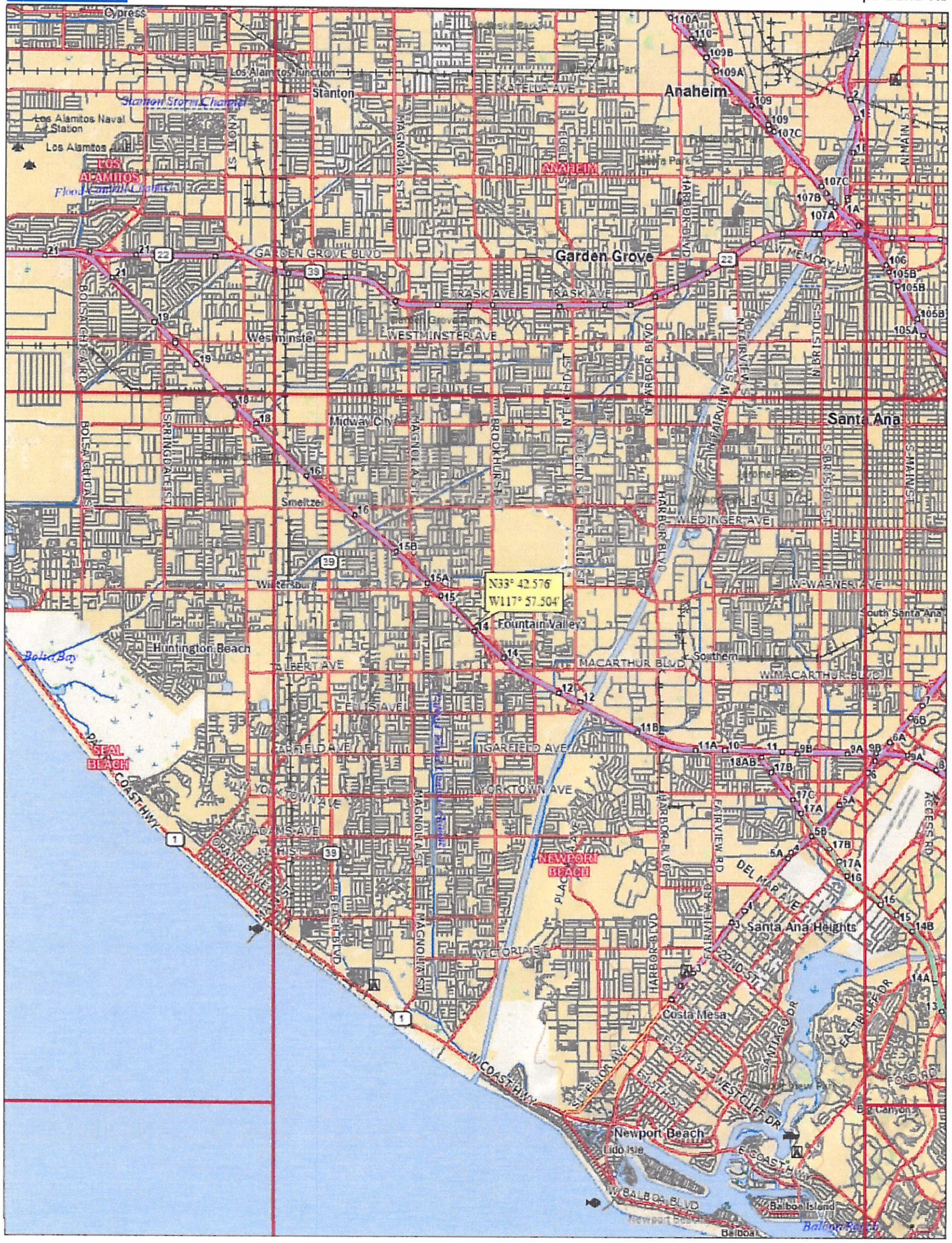
California Building Code, 2019 Volume 2.

Department of Conservation, Division of Mines and Geology. 1997. "Seismic Hazard Zone Report for the Anaheim and Newport Beach 7.5-Minute Quadrangles, Orange County, California, Seismic Hazard Zone Report 03.

# FIGURES

DeLORME

DeLorme Topo USA® 7.0

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Data Zoom 11-0

| GEOBODEN INC. Geotechnical Consultants | SITE VICINITY MAP<br>Proposed Residential Development<br>9779 Starfish Avenue<br>Fountain Valley, California | Figure By S.R. | Project No. Starfish-1-01 |
|---|---|---|---|
| | | Map No. XX | Figure No. 1 |
| | | Date 04-10-20 | |

# APPENDIX A
# BORING LOGS

# APPENDIX A
# SUBSURFACE EXPLORATION PROGRAM

***PROPOSED RESIDENTIAL DEVELOPMENT***
***9779 Starfish Avenue***
***FOUNTAIN VALLEY, CALIFORNIA***

Prior to drilling, the proposed boring was located in the field by measuring from existing site features.

A total of one exploratory boring (B-1) was drilled using a hollow-stem auger drill rig equipped with 8-inch outside diameter (O.D.) augers. GeoBoden of Irvine, California performed the drilling. The boring location is shown on Figure 2.

Depth-discrete soil samples were collected at selected intervals from the exploratory boring using a 2 ½ -inch inside diameter (I.D.) modified California Split-barrel sampler fitted with 12 brass ring of 2 ½ inches in O.D. and 1-inch in height and one brass liner (2 ½ -inch O.D. by 6 inches long) above the brass rings. The sampler was lowered to the bottom of the borehole and driven 18 inches into the soil with a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler the lower 12 inches is shown on the blow count column of the boring logs.

After removing the sampler from the borehole, the sampler was opened and the brass rings and liner containing the soil were removed and observed for soil classification. Brass rings containing the soil were sealed in plastic canisters to preserve the natural moisture content of the soil. Soil samples collected from exploratory boring were labeled, and submitted to the laboratory for physical testing.

Standard Penetration Tests (SPTs) were also performed at alternative depths in Boring. The SPT consists of driving a standard sampler, as described in the ASTM 1586 Standard Method, using a 140-pound hammer falling 30 inches. The number of blows required to drive the SPT sampler the lower 12 inches of the sampling interval is recorded on the blow count column of the boring logs.

The soil classifications and descriptions on field logs were performed using the Unified Soil Classification System as described by the American Society for Testing and Materials (ASTM) D 2488-90, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)." The final boring logs were prepared from the field logs and are presented in this Appendix.

At the completion of the sampling and logging, the exploratory boring was backfilled with the drilled cuttings.

# GEOBODEN, INC.

## BORING NUMBER B-1



**CLIENT** Mr. David Nguyen

**PROJECT NAME** Proposed Residential Development

**PROJECT NUMBER** Starfish-1-01

**PROJECT LOCATION** 9779 Starfish Avenue, Fountain Valley

**DATE STARTED** 4/6/20 **COMPLETED** 4/6/20

**GROUND ELEVATION** ______ **HOLE SIZE** 8 inches

**DRILLING CONTRACTOR** Geoboden, Inc.

**GROUND WATER LEVELS:**

**DRILLING METHOD** HSA

∇ **AT TIME OF DRILLING** 10.00 ft

**LOGGED BY** C.R. **CHECKED BY** ______

**AT END OF DRILLING** ---

**NOTES** ______

**AFTER DRILLING** ---

| DEPTH (ft) | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | SANDY CLAY (CL): olive brown, moist [FILL] | | | | | | | | | | |
| | SANDY CLAY (CL): light olive, moist [NATIVE] | | | | | | | | | | |
| 5 | | MC R-1 | | 16 | | 105 | 21 | 46 | 21 | 25 | 67 |
| 10 | ∇ | SS S-2 | | 9 | | | 25 | | | | 69 |
| 15 | | SS S-3 | | 11 | | | 28 | | | | |
| 20 | | SS S-4 | | 13 | | | 30 | 44 | 23 | 21 | 69 |
| | SILTY SAND (SM): dark olive gray, moist, fine sand | | | | | | | | | | |
| 25 | | SS S-5 | | 14 | | | 29 | | | | 26 |
| | SANDY CLAY (CL): light greenish gray, moist, fine sand | | | | | | | | | | |
| 30 | | SS S-6 | | 12 | | | 32 | 45 | 26 | 19 | 70 |
| | CLAY (CL): light olive, moist, fine sand | | | | | | | | | | |
| 35 | | | | | | | | | | | |

*(Continued Next Page)*

# GEOBODEN, INC.

## BORING NUMBER B-1



**CLIENT** Mr. David Nguyen

**PROJECT NAME** Proposed Residential Development

**PROJECT NUMBER** Starfish-1-01

**PROJECT LOCATION** 9779 Starfish Avenue, Fountain Valley

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | | CLAY (CL): light olive, moist, fine sand *(continued)* | SS S-7 | | 14 | | | 36 | 47 | 25 | 22 | 93 |
| 40 | | | SS S-8 | | 15 | | | | | | | |
| | | light olive brown, moist | | | | | | | | | | |
| 45 | | | SS S-9 | | 19 | | | | | | | 91 |
| | | SANDY CLAY (CL): light greenish gray, moist | | | | | | | | | | |
| 50 | | | SS S-10 | | 21 | | | | | | | |

Bottom of borehole at 51.5 feet below ground surface. Ground water was encountered at 10 feet below the existing grade. Boring was backfilled with cuttings.

Bottom of borehole at 51.5 feet.

# APPENDIX B
# LABORATORY TESTING

## APPENDIX B
## LABORATORY TESTING

***PROPOSED RESIDENTIAL DEVELOPMENT***
***9779 Starfish Avenue***
***MIDWAY, CALIFORNIA***

Laboratory tests were performed on selected samples to assess the engineering properties and physical characteristics of soils at the site. The following tests were performed:

- moisture content and dry density
- No. 200 Wash
- Atterberg limits
- expansion
- direct shear
- corrosion potential

Test results are summarized on laboratory data sheets or presented in tabular form in this appendix.

**Moisture Density Tests**

The field moisture contents, as a percentage of the dry weight of the soils, were determined by weighing samples before and after oven drying. The dry density, in pounds per cubic foot, was also determined fir all relatively undisturbed ring samples collected. These analyses were performed in accordance with ASTM D 2937. The results of these determinations are shown on the boring log in Appendix A.

**No. 200 Wash Sieve**

A quantitative determination of the percentage of soil finer than 0.075 mm was performed on selected soil sample by washing the soil through the No. 200 sieve. Test procedures were performed in accordance with ASTM Method D1140. The results of the test is shown on the boring log.

**Atterberg Limits**

Liquid limit, plastic limit, and plasticity index were determined for selected soil samples in accordance with ASTM D 4318. The soil sample was air-dried and passed through a No. 40

sieve and moisturized. The liquid and plastic limit tests were performed on the fraction passing the No. 40 sieve. Results of the Atterberg limits tests are shown in this Appendix.

**Expansion Potential**

Expansion index test was performed on a representative bulk sample of the on-site soils in accordance with ASTM D4829. The result of expansion test is summarized in Table B-1.

**TABLE B-1 (Expansion Index Test Data)**

| **Boring Designation** | **Depth (ft)** | Expansion Index (EI) |
|---|---|---|
| B-1 | 0-3 | 23 |

**Direct Shear**

Direct shear tests were performed on undisturbed samples of on-site soils. A different normal stress was applied vertically to each soil sample ring which was then sheared in a horizontal direction. The resulting shear strength for the corresponding normal stress was measured at a maximum constant rate of strain of 0.005 inches per minute. The direct shear results are shown graphically on a laboratory data sheet included in this appendix.

**Corrosion Potential**

Corrosion was tested on the selected soil sample in the near surface to determine the corrosivity of the site soil to steel and concrete. The soil samples were tested for soluble sulfate (Caltrans 417), soluble chloride (Caltrans 422), and pH and minimum resistivity (Caltrans 643). The results of corrosion tests are summarized in Table B-1.

**TABLE B-1 (Corrosion Test Results)**

| **Boring No.** | **Depth (ft)** | **Chloride Content (Calif. 422) ppm** | **Sulfate Content (Calif. 417) % by Weight** | **pH (Calif. 643)** | **Resistivity (Calif. 643) Ohm*cm** |
|---|---|---|---|---|---|
| B-1 | 0-5 | 126 | 0.0197 | 7.7 | 1,069 |

# GEOBODEN, INC.

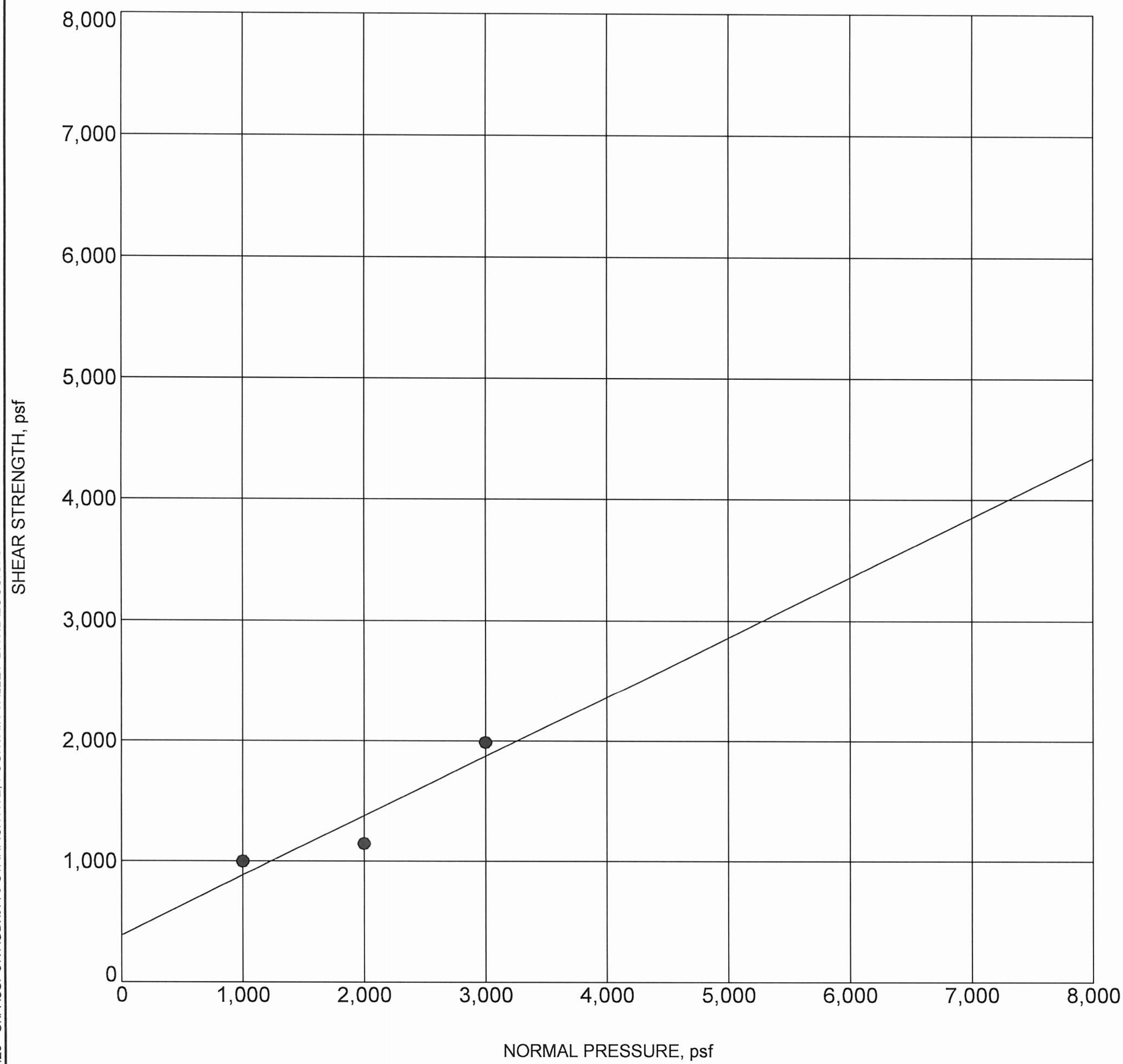
# DIRECT SHEAR TEST

**CLIENT** Mr. David Nguyen

**PROJECT NAME** Proposed Residential Development

**PROJECT NUMBER** Starfish-1-01

**PROJECT LOCATION** 9779 Starfish Avenue, Fountain Valley




| | Specimen Identification | | Classification | $\gamma_d$ | MC% | c | ϕ |
|---|---|---|---|---|---|---|---|
| ● | **B-1** | **5.0** | **SANDY LEAN CLAY(CL)** | **105** | **21** | **387.7** | **26** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**GEOBODEN, INC.**

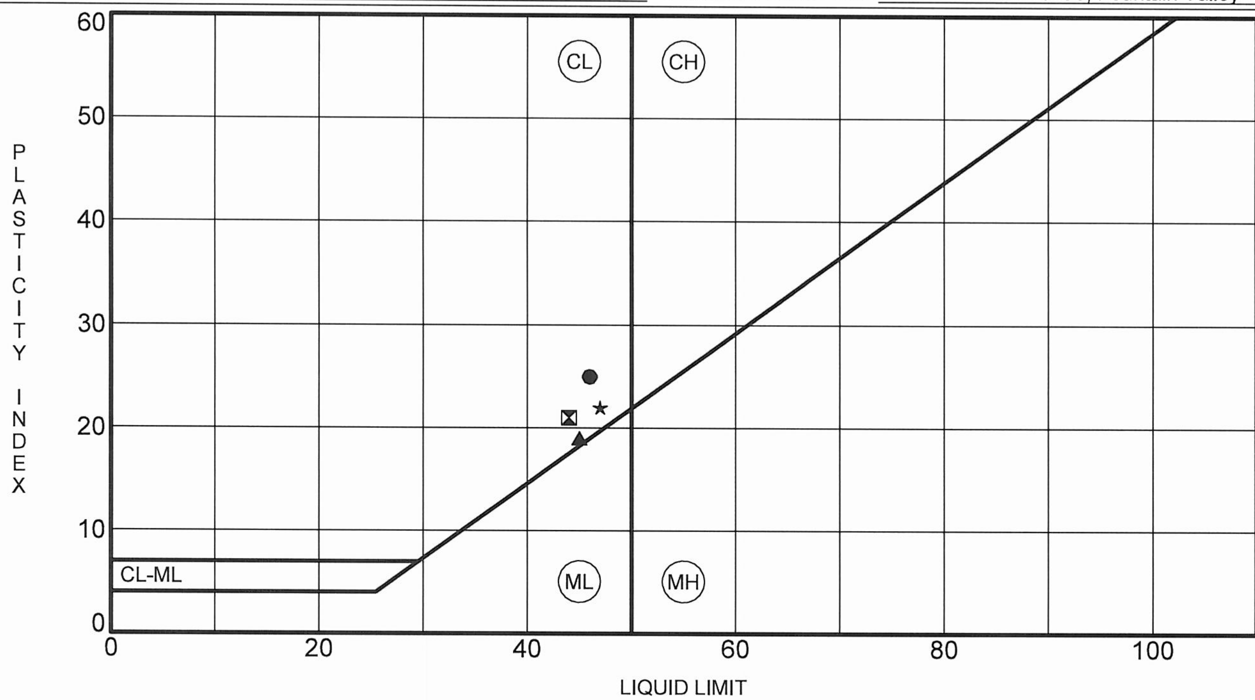
# ATTERBERG LIMITS' RESULTS

**CLIENT** Mr. David Nguyen

**PROJECT NUMBER** Starfish-1-01

**PROJECT NAME** Proposed Residential Development

**PROJECT LOCATION** 9779 Starfish Avenue, Fountain Valley




| | Specimen Identification | | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | B-1 | 5.0 | 46 | 21 | 25 | 67 | SANDY LEAN CLAY(CL) |
| ⊠ | B-1 | 20.0 | 44 | 23 | 21 | 69 | SANDY LEAN CLAY(CL) |
| ▲ | B-1 | 30.0 | 45 | 26 | 19 | 70 | SANDY LEAN CLAY(CL) |
| ★ | B-1 | 35.0 | 47 | 25 | 22 | 93 | LEAN CLAY(CL) |

ATTERBERG LIMITS - GINT STD US LAB.GDT - 4/10/20 09:20 - C:\PASSPORT\GB\9779 STARFISH AVE, FOUNTAIN VALLEY-DAVID\LOGS.GPJ

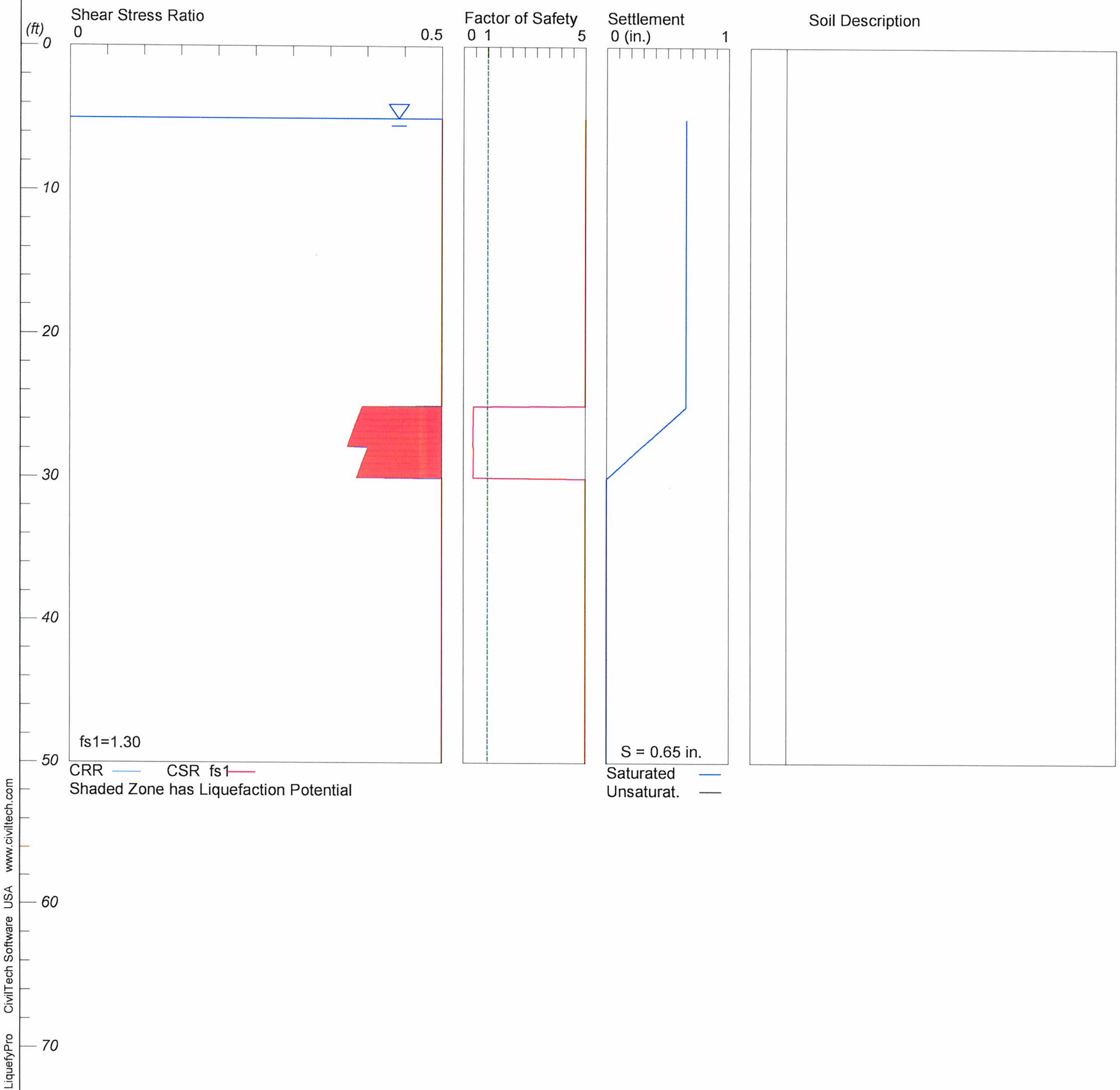
# APPENDIX C
# LIQUEFACTION ANALYSIS

# LIQUEFACTION SETTLEMENT ANALYSIS

## Proposed Residential Development

***Hole No.=B-1*** ***Water Depth=5 ft***

***Magnitude=6.89***
***Acceleration=0.703g***



*******************************************************************************************************

LIQUEFACTION ANALYSIS CALCULATION DETAILS



*******************************************************************************************************

Font: Courier New, Regular, Size 8 is recommended for this report.
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Input File Name: C:\Passport\GBI\9779 Starfish Ave, Fountain Valley-David\B-1.liq
Title:  Proposed Residential Development
Subtitle:  9779 Starfish Avenue, Fountain Valley, CA

Input Data:

Surface Elev.=
Hole No.=B-1
Depth of Hole=50.00 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 10.00 ft
Max. Acceleration=0.7 g
Earthquake Magnitude=6.89
No-Liquefiable Soils:   CL, OL are Non-Liq. Soil
1. SPT or BPT Calculation.
2. Settlement Analysis Method: Tokimatsu/Seed
3. Fines Correction for Liquefaction: Idriss/Seed
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
6. Hammer Energy Ratio,   Ce = 1.27
7. Borehole Diameter,   Cb= 1
8. Sampling Method,   Cs= 1.2
9. User request factor of safety (apply to CSR) ,   User= 1.3
   Plot one CSR curve (fs1=User)
10. Average two input data between two Depths: No
* Recommended Options

In-Situ Test Data:

| Depth ft | SPT | Gamma pcf | Fines % |
|---|---|---|---|
| 5.00 | 10.00 | 124.00 | NoLiq |
| 10.00 | 9.00 | 124.00 | NoLiq |
| 15.00 | 11.00 | 124.00 | NoLiq |
| 20.00 | 13.00 | 124.00 | NoLiq |
| 25.00 | 14.00 | 124.00 | 26.00 |
| 30.00 | 12.00 | 124.00 | NoLiq |
| 35.00 | 14.00 | 124.00 | NoLiq |
| 40.00 | 15.00 | 124.00 | NoLiq |
| 45.00 | 19.00 | 124.00 | NoLiq |
| 50.00 | 21.00 | 124.00 | NoLiq |

Output Results:

Calculation segment, dz=0.050 ft
User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.70g

CSR Calculation:

| Depth ft | gamma pcf | sigma atm | gamma' pcf | sigma' atm | rd | mZ g | a(z) g | CSR | x fs1 | =CSRfs |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.00 | 61.60 | 0.293 | 61.60 | 0.293 | 0.99 | 0.000 | 0.703 | 0.45 | 1.30 | 0.59 |
| 10.00 | 124.00 | 0.586 | 61.60 | 0.439 | 0.98 | 0.000 | 0.703 | 0.60 | 1.30 | 0.78 |
| 15.00 | 124.00 | 0.879 | 61.60 | 0.584 | 0.97 | 0.000 | 0.703 | 0.66 | 1.30 | 0.86 |
| 20.00 | 124.00 | 1.172 | 61.60 | 0.730 | 0.95 | 0.000 | 0.703 | 0.70 | 1.30 | 0.91 |
| 25.00 | 124.00 | 1.465 | 61.60 | 0.875 | 0.94 | 0.000 | 0.703 | 0.72 | 1.30 | 0.94 |
| 30.00 | 124.00 | 1.758 | 61.60 | 1.021 | 0.93 | 0.000 | 0.703 | 0.73 | 1.30 | 0.95 |
| 35.00 | 124.00 | 2.051 | 61.60 | 1.166 | 0.89 | 0.000 | 0.703 | 0.71 | 1.30 | 0.93 |
| 40.00 | 124.00 | 2.344 | 61.60 | 1.312 | 0.85 | 0.000 | 0.703 | 0.69 | 1.30 | 0.90 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 45.00 | 124.00 | 2.637 | 61.60 | 1.457 | 0.81 | 0.000 | 0.703 | 0.67 | 1.30 | 0.87 |
| 50.00 | 124.00 | 2.930 | 61.60 | 1.603 | 0.77 | 0.000 | 0.703 | 0.64 | 1.30 | 0.83 |

CSR is based on water table at 5.00 during earthquake

CRR Calculation from SPT or BPT data:

| Depth ft | SPT | Cebs | Cr | sigma' atm | Cn | (N1)60 | Fines % | d(N1)60 | (N1)60f | CRR7.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.00 | 10.00 | 1.52 | 0.75 | 0.293 | 1.70 | 19.43 | NoLiq | 8.89 | 28.32 | 0.35 |
| 10.00 | 9.00 | 1.52 | 0.85 | 0.586 | 1.31 | 15.23 | NoLiq | 8.05 | 23.28 | 0.26 |
| 15.00 | 11.00 | 1.52 | 0.95 | 0.731 | 1.17 | 18.62 | NoLiq | 8.72 | 27.34 | 0.33 |
| 20.00 | 11.00 | 1.52 | 0.95 | 0.877 | 1.07 | 17.01 | NoLiq | 8.40 | 25.41 | 0.29 |
| 25.00 | 13.00 | 1.52 | 0.95 | 1.023 | 0.99 | 18.61 | NoLiq | 8.72 | 27.33 | 0.33 |
| 30.00 | 14.00 | 1.52 | 1.00 | 1.168 | 0.93 | 19.74 | 26.00 | 6.81 | 26.55 | 0.31 |
| 35.00 | 12.00 | 1.52 | 1.00 | 1.314 | 0.87 | 15.96 | NoLiq | 8.19 | 24.15 | 0.27 |
| 40.00 | 14.00 | 1.52 | 1.00 | 1.459 | 0.83 | 17.66 | NoLiq | 8.53 | 26.20 | 0.30 |
| 45.00 | 15.00 | 1.52 | 1.00 | 1.605 | 0.79 | 18.05 | NoLiq | 8.61 | 26.65 | 0.31 |
| 50.00 | 19.00 | 1.52 | 1.00 | 1.750 | 0.76 | 21.89 | NoLiq | 9.38 | 31.26 | 0.50 |

CRR is based on water table at 10.00 during In-Situ Testing

Factor of Safety, - Earthquake Magnitude= 6.89:

| Depth ft | sigC' atm | CRR7.5 | x Ksig | =CRRv | x MSF | =CRRm | CSRfs | F.S.=CRRm/CSRfs |
|---|---|---|---|---|---|---|---|---|
| 5.00 | 0.19 | 0.35 | 1.00 | 0.35 | 1.24 | 2.00 | 0.59 | 5.00 ^ |
| 10.00 | 0.38 | 0.26 | 1.00 | 0.26 | 1.24 | 2.00 | 0.78 | 5.00 ^ |
| 15.00 | 0.48 | 0.33 | 1.00 | 0.33 | 1.24 | 2.00 | 0.86 | 5.00 ^ |
| 20.00 | 0.57 | 0.29 | 1.00 | 0.29 | 1.24 | 2.00 | 0.91 | 5.00 ^ |
| 25.00 | 0.66 | 0.33 | 1.00 | 0.33 | 1.24 | 2.00 | 0.94 | 5.00 ^ |
| 30.00 | 0.76 | 0.31 | 1.00 | 0.31 | 1.24 | 0.39 | 0.95 | 0.41 * |
| 35.00 | 0.85 | 0.27 | 1.00 | 0.27 | 1.24 | 2.00 | 0.93 | 5.00 ^ |
| 40.00 | 0.95 | 0.30 | 1.00 | 0.30 | 1.24 | 2.00 | 0.90 | 5.00 ^ |
| 45.00 | 1.04 | 0.31 | 1.00 | 0.31 | 1.24 | 2.00 | 0.87 | 5.00 ^ |
| 50.00 | 1.14 | 0.50 | 0.98 | 0.49 | 1.24 | 2.00 | 0.83 | 5.00 ^ |

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:
Fines Correction for Settlement Analysis:

| Depth ft | Ic | qc/N60 | qc1 atm | (N1)60 | Fines % | d(N1)60 | (N1)60s |
|---|---|---|---|---|---|---|---|
| 5.00 | - | - | - | 28.32 | NoLiq | 0.00 | 28.32 |
| 10.00 | - | - | - | 23.28 | NoLiq | 0.00 | 23.28 |
| 15.00 | - | - | - | 27.34 | NoLiq | 0.00 | 27.34 |
| 20.00 | - | - | - | 25.41 | NoLiq | 0.00 | 25.41 |
| 25.00 | - | - | - | 27.33 | NoLiq | 0.00 | 27.33 |
| 30.00 | - | - | - | 26.55 | 26.00 | 0.00 | 26.55 |
| 35.00 | - | - | - | 24.15 | NoLiq | 0.00 | 24.15 |
| 40.00 | - | - | - | 26.20 | NoLiq | 0.00 | 26.20 |
| 45.00 | - | - | - | 26.65 | NoLiq | 0.00 | 26.65 |
| 50.00 | - | - | - | 31.26 | NoLiq | 0.00 | 31.26 |

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:
Settlement Analysis Method: Tokimatsu/Seed

| Depth ft | CSRsf | / MSF* | =CSRm | F.S. | Fines % | (N1)60s | Dr % | ec % | dsz in. | dsp in. | S in. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49.95 | 0.83 | 1.00 | 0.83 | 5.00 | NoLiq | 31.28 | 93.01 | 0.587 | 0.0E0 | 0.000 | 0.000 |
| 45.00 | 0.87 | 1.00 | 0.87 | 5.00 | NoLiq | 26.65 | 82.96 | 1.086 | 0.0E0 | 0.000 | 0.000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40.00 | 0.90 | 1.00 | 0.90 | 5.00 | NoLiq | 26.20 | 82.04 | 1.115 | 0.0E0 | 0.000 | 0.000 |
| 35.00 | 0.93 | 1.00 | 0.93 | 5.00 | NoLiq | 24.15 | 78.10 | 1.243 | 0.0E0 | 0.000 | 0.000 |
| 30.00 | 0.95 | 1.00 | 0.95 | 0.41 | 26.00 | 26.55 | 82.74 | 1.093 | 6.6E-3 | 0.007 | 0.007 |
| 25.00 | 0.94 | 1.00 | 0.94 | 5.00 | NoLiq | 27.33 | 84.33 | 1.044 | 0.0E0 | 0.647 | 0.653 |
| 20.00 | 0.91 | 1.00 | 0.91 | 5.00 | NoLiq | 25.41 | 80.50 | 1.164 | 0.0E0 | 0.000 | 0.653 |
| 15.00 | 0.86 | 1.00 | 0.86 | 5.00 | NoLiq | 27.34 | 84.35 | 1.043 | 0.0E0 | 0.000 | 0.653 |
| 10.00 | 0.78 | 1.00 | 0.78 | 5.00 | NoLiq | 23.28 | 76.48 | 1.297 | 0.0E0 | 0.000 | 0.653 |
| 5.00 | 0.59 | 1.00 | 0.59 | 5.00 | NoLiq | 28.32 | 86.38 | 0.964 | 0.0E0 | 0.000 | 0.653 |

Settlement of Saturated Sands=0.653 in.
qc1 and (N1)60 is after fines correction in liquefaction analysis
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

| Depth ft | sigma' atm | sigC' atm | (N1)60s | CSRsf | Gmax atm | g*Ge/Gm | g_eff | ec7.5 % | Cec | ec % | dsz in. | dsp in. | S in. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.00 | 0.29 | 1.14 | 0.00 | 0.59 | 0.00 | 0.0E0 | 0.0000 | 0.0000 | 0.00 | 0.9639 | 0.00E0 | 0.000 | 0.000 |

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=0.653 in.
Differential Settlement=0.327 to 0.431 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)

| | |
|---|---|
| SPT | Field data from Standard Penetration Test (SPT) |
| BPT | Field data from Becker Penetration Test (BPT) |
| qc | Field data from Cone Penetration Test (CPT) [atm (tsf)] |
| fs | Friction from CPT testing [atm (tsf)] |
| Rf | Ratio of fs/qc (%) |
| gamma | Total unit weight of soil |
| gamma' | Effective unit weight of soil |
| Fines | Fines content [%] |
| D50 | Mean grain size |
| Dr | Relative Density |
| sigma | Total vertical stress [atm] |
| sigma' | Effective vertical stress [atm] |
| sigC' | Effective confining pressure [atm] |
| rd | Acceleration reduction coefficient by Seed |
| a_max. | Peak Ground Acceleration (PGA) in ground surface |
| mZ | Linear acceleration reduction coefficient X depth |
| a_min. | Minimum acceleration under linear reduction, mZ |
| CRRv | CRR after overburden stress correction, CRRv=CRR7.5 * Ksig |
| CRR7.5 | Cyclic resistance ratio (M=7.5) |
| Ksig | Overburden stress correction factor for CRR7.5 |
| CRRm | After magnitude scaling correction CRRm=CRRv * MSF |
| MSF | Magnitude scaling factor from M=7.5 to user input M |
| CSR | Cyclic stress ratio induced by earthquake |
| CSRfs | CSRfs=CSR*fs1 (Default fs1=1) |
| fs1 | First CSR curve in graphic defined in #9 of Advanced page |
| fs2 | 2nd CSR curve in graphic defined in #9 of Advanced page |
| F.S. | Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf |
| Cebs | Energy Ratio, Borehole Dia., and Sampling Method Corrections |
| Cr | Rod Length Corrections |
| Cn | Overburden Pressure Correction |
| (N1)60 | SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs |

| | |
|---|---|
| d(N1)60 | Fines correction of SPT |
| (N1)60f | (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60 |
| Cq | Overburden stress correction factor |
| qc1 | CPT after Overburden stress correction |
| dqc1 | Fines correction of CPT |
| qc1f | CPT after Fines and Overburden correction, qc1f=qc1 + dqc1 |
| qc1n | CPT after normalization in Robertson's method |
| Kc | Fine correction factor in Robertson's Method |
| qc1f | CPT after Fines correction in Robertson's Method |
| Ic | Soil type index in Suzuki's and Robertson's Methods |
| (N1)60s | (N1)60 after settlement fines corrections |
| CSRm | After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF* |
| CSRfs | Cyclic stress ratio induced by earthquake with user inputed fs |
| MSF* | Scaling factor from CSR, MSF*=1, based on Item 2 of Page C. |
| ec | Volumetric strain for saturated sands |
| dz | Calculation segment, dz=0.050 ft |
| dsz | Settlement in each segment, dz |
| dp | User defined print interval |
| dsp | Settlement in each print interval, dp |
| Gmax | Shear Modulus at low strain |
| g_eff | gamma_eff, Effective shear Strain |
| g*Ge/Gm | gamma_eff * G_eff/G_max, Strain-modulus ratio |
| ec7.5 | Volumetric Strain for magnitude=7.5 |
| Cec | Magnitude correction factor for any magnitude |
| ec | Volumetric strain for unsaturated sands, ec=Cec * ec7.5 |
| NoLiq | No-Liquefy Soils |

References:


1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.

SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.

2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.

3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.


Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

# Attachment F

## Conditions of Approval

***To be included in Final WQMP***