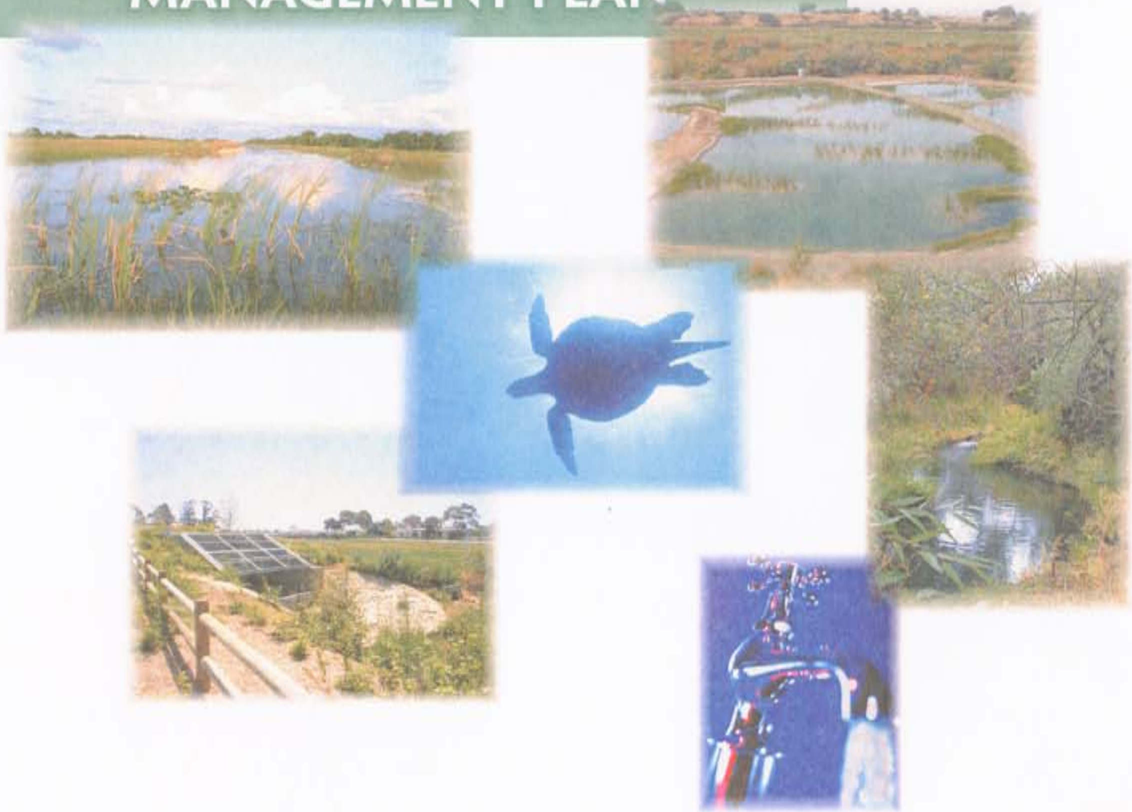
Appendix H: Drainage and Water Quality Information

H.1 - PRELIMINARY WATER QUALITY MANAGEMENT PLAN

PRELIMINARY WATER QUALITY MANAGEMENT PLAN



Project Site:
MARINA PARK
Newport Beach, CA

Prepared for:
CITY OF NEWPORT BEACH
PUBLIC WORKS DEPARTMENT
3300 Newport Blvd.
Newport Beach, CA 92663

Project Manager:
Trevor Dodson, P.E.

Date Prepared: October 17, 2008
JN: 1001.01.01

Prepared by:
FUSCOE ENGINEERING
16795 Von Karman Avenue, Suite 100
Irvine, CA 92606
(949) 474-1960
www.fuscoe.com

PRELIMINARY
WATER QUALITY MANAGEMENT PLAN
(PWQMP)

MARINA PARK

CUP NO. TBD
DESIGN REVIEW NO. TBD

Located at Balboa Boulevard between
18th Street and 16th Street of the Balboa Peninsula
in the
City of Newport Beach
County of Orange, California

Prepared for:

CITY OF NEWPORT BEACH, PUBLIC WORKS DEPARTMENT
3300 Newport Blvd.
Newport Beach, CA 92663
949.644.3309

Prepared by:

FUSCOE ENGINEERING, INC.
16795 Von Karman Ave, Suite 100
Irvine, CA 92606
949.474.1960

Date Prepared: October 17, 2008

OWNER'S CERTIFICATION

WATER QUALITY MANAGEMENT PLAN (WQMP)

City of Newport Beach Design Review No. ________

This Water Quality Management Plan has been prepared for the City of Newport Beach by Fuscoe Engineering, Inc. This WQMP is intended to comply with the requirements of the County of Orange, Planning and Development Services Division (PDSD), Site Development Permit/Application Number TBD, Condition Number(s) TBD, requiring the preparation of a project-specific Water Quality Management Plan (WQMP).

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 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 under the jurisdiction of the Santa Ana Regional Water Quality Control Board. A copy of this WQMP will be maintained at the project site or project office.

This WQMP will be reviewed with the facility operator, facility supervisors, employees, tenants, maintenance and service contractors, or any other party having responsibility for implementing portions of this WQMP. At least one copy of the approved and certified copy of this WQMP shall be available on the subject property in perpetuity. Once the undersigned transfers its interest in the property, its successors-in-interest shall bear the aforementioned responsibility to implement and amend this WQMP.

______________________ Signature	______________________ Title
______________________ Name	______________________ Company

____
Address

______________________ Phone	______________________ Date

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APPENDICES

BMP TABLES

LOCATION MAP, SITE PLANS AND BMP DETAILS (INCLUDED IN SECTION 6.0)

INTRODUCTION

This Preliminary Water Quality Management Plan (PWQMP) has been prepared to provide specifications for the post-construction management of storm water runoff from the proposed project, Marina Park. Improperly managed runoff can be a significant source of water pollution causing impacts to aquatic habitat, wildlife, and water-dependent beneficial uses. The implementation of this plan ensures that such impacts are reduced to the Maximum Extent Practicable (MEP).

This PWQMP covers the post-construction operations on Marina Park in the City of Newport Beach, California (see Vicinity Map in Section 6.0). It has been developed as required under State Water Resources Control Board (SWRCB) Municipal NPDES Storm Water Permit for the County of Orange and the Incorporated Cities of Orange County, and in accordance with good engineering practices. This PWQMP describes this facility and its operations, identifies potential sources of storm water pollution at the facility, and recommends appropriate Best Management Practices (BMPs) or pollution control measures to reduce the discharge of pollutants in storm water runoff.

PROJECT CATEGORIES

In accordance with the OC DAMP and Countywide Model WQMP, a project is considered a "Priority Project" if it meets any of the following criteria:

CHECK IF APPLICABLE	PRIORITY PROJECT CATEGORY
	1. Residential development of 10 units or more
	2. Commercial and industrial development greater than 100,000 square feet including parking area
	3. Automotive repair shops (SIC codes 5013, 5014, 5541, 7532-7534, and 7536-7539)
	4. Restaurants where the land area of development is 5,000 square feet or more including parking area (SIC code 5812)
	5. *For San Diego Region:* Hillside development greater than 5,000 square feet *For Santa Ana Region*: Hillside developments on 10,000 square feet or more, which are located on areas with known erosive soil conditions or where natural slope is twenty-five percent or more
✓	6. Impervious surface of 2,500 square feet or more located within, directly adjacent to (within 200 feet), or discharging directly to receiving waters within Environmentally Sensitive Areas
	7. Parking Lots 5,000 square feet or more, or with 15 parking spaces or more, and potentially exposed to urban storm water runoff.
	8. *For San Diego Region:* Streets, roads, highways, and freeways which would create a new paved surface that is 5,000 square feet or greater
✓	9. *For Santa Ana Region:* All Significant Redevelopment projects, where Significant Redevelopment is defined as the addition of 5,000 or more square feet of impervious surface on an already developed site.

The proposed Marina Park Project meets **Categories 6 & 9**, and therefore, is considered a "Priority Project" in accordance with the OC DAMP.

1.0 DISCRETIONARY PERMIT(S) & WATER QUALITY CONDITIONS

The proposed project, designated Project/Application Number TBD by the City of Newport Beach, located in Tract Number TBD, is a subdivision of Parcel Map Number TBD in the City of Newport Beach, State of California, Office of the County Recorder, Orange County.

1.1 DISCRETIONARY PERMITS

To be determined.

1.2 RESOLUTIONS

To be determined.

1.3 CONDITIONS OF APPROVAL

Pending. To be provided in the Final WQMP.

2.0 PROJECT DESCRIPTION

2.1 FACILITY DESCRIPTION

The proposed Marina Park project site encompasses approximately 7-acres located in the City of Newport Beach, CA. The project site is bounded by Balboa Boulevard to the south, 18th Street to the west, 16th Street to the east, and the Lower Newport Bay to the north. A Vicinity Map is provided in Section 6.0.

Under existing conditions, the project site consists of a mobile home park with 57 units, a community center, Girl Scout House, four tennis courts, and a small playground. Adjacent land uses include residential developments to the west and south, American Legion Post 291 to the east, and a small commercial building and SCE substation to the southeast.

The proposed project will include the removal of the existing facilities for the construction of a recreational park and sailing center. A new Girl Scout House will be constructed in the western portion of the site. Also proposed for the western portion of the site are open lawn and play areas, picnic areas, water play zone, beach access and a playground. Within the central portion of the site, a Community Center and Sailing Center are proposed. New boat slips and a visiting vessel marina will be constructed adjacent to the Sailing Center. Parking lots will be provided adjacent to the relocated Girl Scout House and south of the Community Center and Sailing Center buildings. Lastly, two tennis courts will be relocated adjacent to the American Legion facility that will remain under proposed conditions.

2.2 PROJECT FEATURES

PARKING FACILITIES

Parking will be provided throughout the project site in the form of three surface lots. The western parking lot will have 24 regular spaces with 2 handicap spaces, and will serve the Girl Scout House and adjacent park facilities. The Central parking lot will have 97 spaces with 5 handicap spaces, and the East Lot will have 26 spaces. Both the Center Lot and the East Lot will serve the Community/Sailing Center complex. When the Project is complete, a total of 154 parking spaces will be provided. Portions of the parking lots will be constructed with permeable concrete pavers, as discussed further in Section 4.3.

LANDSCAPED AREAS

The project site will include landscaping in the form of open turf play areas, shade trees, palm trees, parking lot islands, and adjacent to the proposed buildings. Under proposed conditions, the majority of the site acres will be landscaped. Further details on proposed landscaping will be provided in the Final WQMP.

DRAINAGE AND RUNOFF ALTERATIONS

Prior to construction, approximately 90% of the site is impervious and the runoff coefficient is 0.83. After completion, the entire site will be approximately 50% impervious and the runoff coefficient will be 0.53.[1] These statistics are summarized in the figure below.

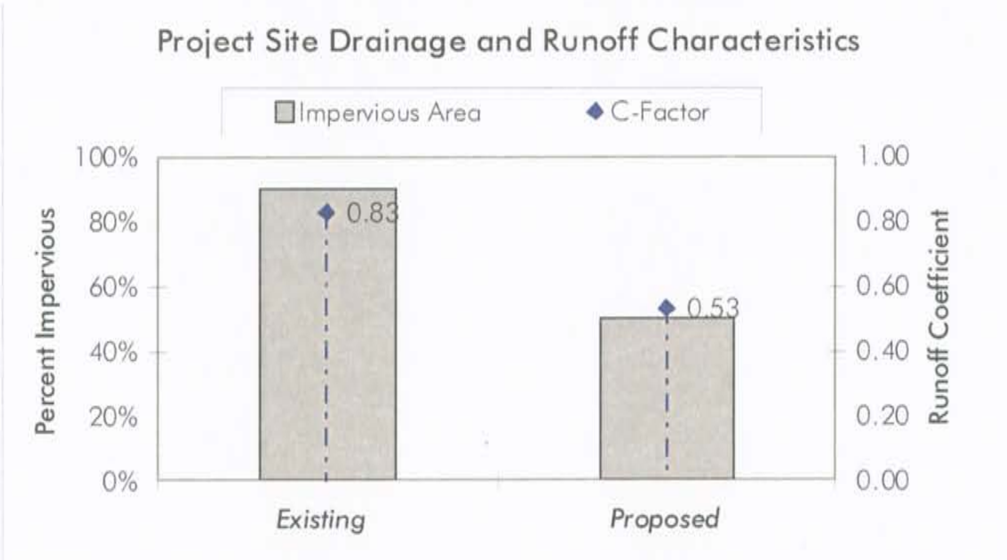

Chart 1. Changes in site drainage and the coefficient of runoff as a result of the proposed improvements.

ANTICIPATED AND POTENTIAL POLLUTANTS

As a result of the proposed project's alteration of existing conditions, the project site may create new pollutant sources, and in turn, change the makeup of pollutant constituents generated by Marina Park's operations. But because storm water runoff pollution is diffuse in nature, the composition, level, and cumulative effects of specific pollutants generated by the project cannot be appropriately quantified. Based on the proposed land uses for Marina Park, however, this project PWQMP can predict the anticipated and potential pollutants generally associated with the project's post-construction operations. With this information in hand, this will allow the project WQMP to appropriately assign BMPs to effectively mitigate storm water pollution prior to the runoff discharging off-site.

The table below, derived from the Countywide Model WQMP, summarizes the categories of land use or project features of concern and the general pollutant categories associated with them. The types of project features listed below that are proposed for Marina Park are: Commercial/Industrial Development, Restaurants, and Parking Lots. As a result, anticipated pollutants include: Bacteria/Virus, Heavy Metals, Organic Compounds, Trash & Debris, Oxygen Demanding Substances, and Oil & Grease. In addition, potential pollutants include: Nutrients, Pesticides, and Sediments.

[1] Runoff coefficients derived from Table A-1 of Attachment A of the Orange County Local WQMP (August 13, 2003).

GENERAL POLLUTANT CATEGORIES									
Priority Project Categories and/or Project Features	BACTERIA/ VIRUS	HEAVY METALS	NUTRIENTS	PESTICIDES	ORGANIC COMPOUNDS	SEDIMENTS	TRASH & DEBRIS	OXYGEN DEMANDING SUBSTANCES	OIL & GREASE
Commercial/Industrial Development	P(3)	P	P(1)	P(1)	P(5)	P(1)	X	P(1)	X
Restaurants	X						X	X	X
Parking Lots	P (6)	X	P (1)	P (1)	X (4)	P (1)	X	P (1)	X

Notes:
X = Anticipated
P = Potential
(1) A potential pollutant if landscaping or open area exist on-site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.
(6) Analyses of pavement runoff routinely exhibit bacterial indicators.

Source: County of Orange Flood Control District, *2003 Drainage Area Master Plan, Table 7-1.3*, July 1, 2003.

OWNERSHIP OF SITE

The table provided below describes the ownership of all land space within the project site once the construction of the project has been completed.

SITE FEATURE	OWNER
Public Streets	City of Newport Beach
Private Streets	Not applicable.
Landscaped Areas	City of Newport Beach
Open Space	City of Newport Beach
Easements	City of Newport Beach
Parks	City of Newport Beach
Buildings	City of Newport Beach

The City of Newport Beach will be responsible for inspecting and maintaining all BMPs prescribed for Marina Park. Further details on maintenance and responsibilities are provided in Section 5.0 of this PWQMP.

2.3 SPECIFIC INDUSTRIAL / COMMERCIAL DETAILS

The Marina Park project will include 3 buildings with various uses. All of the buildings, and their planned uses, described in the proposed project plan will be addressed in the following table.

BUILDING SUMMARY			
BUILDING NAME	**USE**	**SIZE**	**FEATURES**
Girl Scout House	Girl Scout program uses	~4,800	Classrooms, administrative rooms
Community Center	Classrooms for sailing programs and other city programs	~11,100 ft^2	Classrooms, administrative rooms, banquet room/large classroom.
Sailing Center	Meeting areas, café, and storage spaces	~10,200 ft^2	Storage for sailing program boats & equipment, restrooms, locker room, meeting room, reception area, restaurant on 2nd level.
Playground	Children's play area	~8,800 ft^2	Rubberized play surface, bridge and pier, seating areas, shade structures, restrooms, lighthouse icon w/ viewing deck
Visiting Vessel Marina	On-water storage for various types of boats	~72,500 ft^2	28 slips 48' in length with full hookups, one additional side tie, 200' long dock, concrete floating docks
Off-Site Restroom Improvement	Restroom	Pending – to be provided in Final WQMP	Restroom facility

Materials to be stored on-site include boating and other equipment for sailing programs, as well as for other city programs and uses. With the exception of boats in the marina area, all equipment will be stored indoors within the community center/sailing complex buildings. Activities that may be conducted outdoors include functions associated with sailing programs such as swim lessons and other instructional activities, in addition to recreational activities within the park and play areas. Further details on the proposed activities and materials stored will be provided in the Final WQMP.

New developments and significant redevelopments generally incorporate certain site features that may potentially impact storm water runoff quality if proper site design is not considered. These features include, but are not limited to, trash enclosures, loading docks, maintenance bays, vehicle or equipment wash areas, outdoor processing areas, fueling areas, food preparation areas, and community car wash areas. The following table provides a breakdown of specific features proposed for the project site.

SITE FEATURES SUMMARY		
SITE FEATURE	PROPOSED?	POLLUTANTS OF CONCERN
Trash Enclosures	Yes	Trash and debris, bacteria
Loading Docks	No	Organic compounds, trash and debris, oil and grease, heavy metals, wash water
Maintenance Bays	No	Trash and debris, oil and grease, heavy metals
Fueling Areas	No	Oil and grease, heavy metals, organic compounds
Equipment / Vehicle Wash Areas	No	Trash, sediment, oil and grease, washing compounds (soap)
Food Preparation Areas	Yes	Oil and grease, bacteria/virus
Outdoor Processing Areas	No	Trash and debris, heavy metals, oil and grease
Community Car Wash Racks	No	Trash, sediment, oil and grease, washing compounds (soap)

Further details on the number, design and location of these features will be documented in the Final WQMP.

In the event site features are added to the proposed Project that are not identified in the Final WQMP, these features will be designed in accordance with the Orange County Drainage Area Management Plan (OC DAMP, 2003) requirements and City LIP and verified during the precise grade plan check review process.

3.0 SITE DESCRIPTION

3.1 WATERSHED

The project site is located within the Newport Bay watershed. The Newport Bay Watershed covers 13.2 square miles along the coast of central Orange County. It includes portions of Costa Mesa and Newport Beach. The East Costa Mesa, Santa Isabel, and other smaller channels drain into Newport Bay.

Specifically, runoff from the project drains into the Lower Newport Bay.

303(d) LISTED WATER QUALITY LIMITED SEGMENTS

Based on the 2006 section 303(d) list of Water Quality Limited Segments published by the Santa Ana Regional Water Quality Control Board, the Lower Newport Bay is listed as impaired for chlordane, copper, DDT, PCBs, and sediment toxicity.

TMDLs

Once a water body has been listed as impaired, a Total Maximum Daily Load (TMDL) for the constituent of concern (pollutant) must be developed for that water body. A TMDL is an estimate of the daily load of pollutants that a water body may receive from point sources, non-point sources, and natural background conditions (including an appropriate margin of safety), without exceeding its water quality standard. Those facilities and activities that are discharging into the water body, collectively, must not exceed the TMDL.

Several TMDLs have been developed jointly for the San Diego Creek Watershed and the Newport Bay, including nutrients, pathogens and pesticides. In addition, TMDLs for organochlorine compounds and metals are currently in development by the RWQCB.

HYDROLOGIC CONCERNS

The purpose of this section is to identify any hydrologic conditions of concern with respect to downstream flooding, erosion potential of natural channels downstream, impacts of increased flows on natural habitat, etc. Hydrologic conditions of concern are typically directed to those developments that discharge directly into receiving water bodies (natural drainage courses or partially improved channels).

The site is fully developed under existing conditions, and the Project will not increase impervious surfaces as compared to existing conditions. In addition, Runoff from the project site discharges into an existing underground MS4 at Balboa Boulevard, as under existing conditions. Runoff ultimately discharges to the lower Newport Bay, which is subject to tidal action. Therefore, hydrology conditions will not change as a result of the Project, and there are no hydrologic conditions of concern.

3.2 SITE LOCATION

PLANNING AREA/ COMMUNITY NAME	Marina Park
GENERAL LOCATION	Bayside of Balboa Boulevard between 18th Street and 16th Street on the Balboa Peninsula in the City of Newport Beach.
ADDRESS	To be determined
PROJECT SIZE	~7 acres

SOIL CHARACTERISTICS

A geotechnical study was performed for the project site in September 2001 and was revised in December 2003. Based on the investigation, soils on the project site generally consist of sand, with some silt in the top two feet. Due to the proximity to the Lower Newport Bay, groundwater was encountered at a depth of 8 feet below ground surface, and is subject to tidal fluctuation.[2]

EXISTING DRAINAGE CONDITIONS

Under existing conditions, runoff from the eastern portion of the site is conveyed via existing storm drain lines to the storm drain line at Balboa Boulevard that ultimately discharges into the Lower Newport Bay at 15th Street. Runoff from the western portion of the site is conveyed via existing storm drain lines to the storm drain line at Balboa Boulevard that ultimately discharges to the Lower Newport Bay at 18th Street.

PROPOSED DRAINAGE CONDITIONS

Under proposed conditions, runoff will flow in similar patterns to existing conditions, and continue to drain to the two storm drain lines at Balboa Boulevard. The existing lines within the project site will be removed. Low-flow and first-flush runoff on-site will generally sheet flow to the proposed treatment control BMPs, including porous pavement and landscaped biocells (see Section 4.3 for further details). Higher flows will continue to flow to the existing storm drain lines at Balboa Boulevard.

LAND USE AND ZONING

The project site is zoned as PC-51 Planned Community.

[2] Abstract Consulting Group. Geotechnical Investigation, North Side of Balboa Blvd. to the Bay Between 15th & 18th Street, Newport Beach, California. September 5, 2001. revised and updated December 16, 2003.

3.3 EXISTING WATER QUALITY ISSUES

The proposed project is located within the lower Newport Bay. Since the Lower Newport Bay is listed as impaired on the 303(d) list of impaired water bodies, it is designated as an Environmentally Sensitive Area (ESA) according to the OC DAMP.

Under existing conditions, the project site is fully developed. There are no pre-existing water quality issues identified for the site, nor has there been any indication of past soil contamination since this area's development. If such problems are discovered at any stage o the project's improvements, this condition will be evaluated and mitigated.

4.0 BEST MANAGEMENT PRACTICES

The WQMP shall identify Best Management Practices (BMPs) that will be used on-site to control predictable pollutant runoff, and shall identify, at a minimum, the measures specified in the Countywide Water Quality Management Plan (WQMP) and NPDES Drainage Area Management Plan (DAMP), the assignment of long-term maintenance responsibilities (specifying the developer, parcel owner, maintenance association, lessee, etc.) and the locations of all structural BMPs.

Projects designated as Priority Projects are required to incorporate and implement site design, source control, and treatment control BMPs, unless not applicable due to the project characteristics. Site design BMPs help minimize the introduction or generation of potential pollutants from a facility's operations. Source control BMPs are operational practices that reduce potential pollutants at the source, and include both structural and routine non-structural practices. Treatment control BMPs remove pollutants of concern from storm water runoff and must be located and designed appropriately so as to infiltrate, filter, and/or treat the required runoff volume or flow prior to discharging into receiving waters. Selection of treatment control BMPs is based on the pollutants of concern of the project site (identified under Section 2.2) and the BMP's ability to effectively mitigate those pollutants, in consideration of site conditions and constraints. Further details on the Project's selected treatment control BMPs (Porous Pavement and Landscaped Biocells) are provided in Section 4.3.

4.1 SITE DESIGN BMPs

The following table 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.

SITE DESIGN CONCEPT 1: MINIMIZE STORM WATER RUNOFF, MINIMIZE PROJECT'S IMPERVIOUS FOOTPRINT, AND CONSERVE NATURAL AREAS			
DESIGN CONSIDERED: SPECIFIC BMP	YES	NO	DESCRIPTION
Maximize permeable area.	☒	☐	The Project will result in a reduction in impervious surfaces as compared to existing conditions. In addition, permeable pavers are proposed to further maximize permeable area.
Conserve natural areas.	☐	☒	The project site is fully developed under existing conditions. No natural areas will be preserved.
Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.	☒	☐	Portions of the proposed parking lots will be constructed with permeable pavers.
Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised[1]. Incorporate landscaped buffer areas between sidewalks and streets.	☒	☐	Drive aisles will be constructed to minimum widths necessary in accordance with local requirements.
Reduce widths of street where off-street parking is available[2].	☐	☒	Street widths will not be reduced under the project.

SITE DESIGN CONCEPT 1: MINIMIZE STORM WATER RUNOFF, MINIMIZE PROJECT'S IMPERVIOUS FOOTPRINT, AND CONSERVE NATURAL AREAS			
DESIGN CONSIDERED: SPECIFIC BMP	**YES**	**NO**	**DESCRIPTION**
Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought-tolerant trees and large shrubs.	☐	☒	Currently, the project site is developed, and there are no natural areas to conserve.
Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design.	☒	☐	Decorative concrete will be minimized in landscape design.
Use of natural drainage systems.	☐	☒	No natural drainage systems are proposed for the site. However, landscaped biocells and permeable pavers are proposed to provide treatment of storm water runoff.
Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration[3].	☐	☒	No gravel filtration pits are proposed. However, permeable pavers are proposed to provide treatment of storm water runoff.
Construct on-site ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas.	☒	☐	Landscaped biocells and permeable pavers are proposed to provide treatment of storm water runoff.
Other comparable site design options that are equally effective.	☐	☐	None.

1. Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.
2. However, street widths must still comply with life safety requirements for fire and emergency vehicle access.
3. However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff. Infiltration areas may be subject to regulation as Class V injection wells and may require a report to the US EPA.

SITE DESIGN CONCEPT 2: MINIMIZE DIRECTLY CONNECTED IMPERVIOUS AREAS			
DESIGN CONSIDERED: SPECIFIC BMP	**YES**	**NO**	**DESCRIPTION**
Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain.	☒	☐	Rooftops will drain to landscaped areas and proposed bioswales.
Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping.	☒	☐	Sidewalks will drain towards adjacent landscaped areas.
Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales.	☒	☐	One bioswales is proposed, collecting runoff from the proposed Community/Sailing Center complex. In addition, landscaped biocells and permeable pavers are proposed to provide treatment of storm water runoff. Existing underground storm drain piping will be removed.
USE ONE OR MORE OF THE FOLLOWING:			
Rural Swale System: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings.	☐	☒	No streets are proposed on-site.

SITE DESIGN CONCEPT 2: MINIMIZE DIRECTLY CONNECTED IMPERVIOUS AREAS			
DESIGN CONSIDERED: SPECIFIC BMP	YES	NO	DESCRIPTION
Urban curb/swale system: street slopes to curb; periodic swale inlets drain to vegetated swale/ biofilter.	☒	☐	No streets are proposed on-site. However, a vegetated bioswales is proposed, collecting runoff from the new Community/Sailing Center complex.
Dual drainage system: first flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems.	☐	☒	No streets are proposed on-site.
Other comparable design concepts that are equally effective.	☒	☐	Landscaped biocells, a vegetated bioswale, and permeable pavers are proposed to provide treatment of storm water runoff.
USE ONE OR MORE OF THE FOLLOWING FOR THE DESIGN OF DRIVEWAYS AND PRIVATE RESIDENTIAL PARKING AREAS:			
Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system.	☐	☒	Not applicable – non-residential development.
Uncovered temporary or guest parking on private residential lots may be: paved with a permeable surface; or, designed to drain into landscaping prior to discharging to the municipal storm drain system.	☐	☒	Not applicable – non-residential development.
Other comparable design concepts that are equally effective.	☐	☒	None.
USE ONE OR MORE OF THE FOLLOWING FOR THE DESIGN OF PARKING AREAS:			
Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.	☒	☐	Landscaped biocells are proposed for portions of the parking areas.
Overflow parking (parking stalls provided in excess of the minimum parking requirements) may be constructed with permeable paving.	☒	☐	Portions of the parking lots will be constructed with permeable pavers.
Other comparable design concepts that are equally effective.	☐	☒	None.

4.2 SOURCE CONTROL BMPs

The table below indicates all BMPs to be incorporated in the project. For those designated as not applicable (N/A), a brief explanation why is provided.

INCORPORATED ROUTINE NON-STRUCTURAL BMP:		YES	N/A	DESCRIPTION
N1	HOMEOWNER/ TENANT EDUCATION	☐	☒	No homes or residential units are planned for the project site.
N2	ACTIVITY RESTRICTIONS	☒	☐	The City of Newport Beach shall develop activity restrictions that include those that have the potential to create adverse impacts on water quality. Activities include, but are no limited to: handling and disposal of contaminants, fertilizer and pesticide application restrictions, litter control and pick-up, and vehicle or equipment repair and maintenance.
N3	COMMON AREA LANDSCAPE MANAGEMENT	☒	☐	Landscape management for the project site will be conducted by the City of Newport Beach, and will maintain the grounds and landscape areas in accordance with acceptable practices for irrigation, fertilizer, and pesticide use and integrated pesticide management techniques.
N4	BMP MAINTENANCE	☒	☐	The City of Newport Beach will be responsible for the implementation and maintenance of each applicable non-structural BMP, as well as scheduling inspections and maintenance of all applicable structural BMP facilities through its staff, landscape contractor, and/or any other necessary maintenance contractors. Details on BMP Maintenance are provided in Section 5.0 of this WQMP.
N5	TITLE 22 CCR COMPLIANCE	☐	☒	Not applicable. No hazardous waste on project site.
N6	LOCAL WATER QUALITY PERMIT COMPLIANCE	☐	☒	The City of Newport Beach does not issue water quality permits.
N7	SPILL CONTINGENCY PLAN	☐	☒	Not applicable. The site will not require a spill contingency plan.
N8	UNDERGROUND STORAGE TANK COMPLIANCE	☐	☒	No underground storage tanks are proposed for the project site.

INCORPORATED ROUTINE NON-STRUCTURAL BMP:		YES	N/A	DESCRIPTION
N9	HAZ-MAT DISCLOSURE COMPLIANCE	☐	☒	Hazardous materials will not be stored on the project site.
N10	UNIFORM FIRE CODE IMPLEMENTATION	☐	☒	Not applicable.
N11	COMMON AREA LITTER CONTROL	☒	☐	The City of Newport Beach shall be required to implement trash management and litter control procedures aimed at reducing pollution of discharge. This includes providing an appropriate number of trash receptacles, performing trash pickup in common areas, noting improper disposal materials by the public and reporting such violations to the City for investigation.
N12	EMPLOYEE TRAINING	☒	☐	All employees and any contractors of the owner will require training to ensure that employees are aware of maintenance activities that may result in pollutants reaching the storm drain.
N13	HOUSEKEEPING OF LOADING DOCKS	☐	☒	No loading docks are proposed for the site.
N14	CATCH BASIN INSPECTION	☒	☐	All on-site catch basins, grate inlets, and drainage facilities shall be inspected and cleaned when necessary, prior to the rainy season, no later than October 1st, each year.
N15	STREET SWEEPING PRIVATE STREETS AND PARKING LOTS	☒	☐	Private drive aisles and parking lots within the project site will be swept on a quarterly basis at a minimum.
N17[3]	RETAIL GASOLINE OUTLETS	☐	☒	No retail gasoline outlets are proposed for the site.

INCORPORATED ROUTINE STRUCTURAL BMP:	YES	N/A	DESCRIPTION
STORM DRAIN STENCILING AND SIGNAGE	☒	☐	The phrase "NO DUMPING! DRAINS TO OCEAN", or an equally effective phrase, will be stenciled on all catch basins within the project site to alert the public to the destination of pollutants discharged into storm water. Stencils shall be in place by completion of construction.

[3] There is no BMP with the designation N16.

INCORPORATED ROUTINE STRUCTURAL BMP:	YES	N/A	DESCRIPTION
PROPER OUTDOOR HAZARDOUS MATERIAL STORAGE DESIGN	☐	☒	No outdoor hazardous material storage areas are proposed.
PROPER TRASH STORAGE DESIGN	☒	☐	All trash and waste shall be stored in containers that have lids or tarps to minimize direct precipitation into the containers. Storage areas shall be paved, covered, and either be sloped or include a barrier to keep drainage out of the storm drain. The City of Newport Beach shall ensure trash is stored properly and does not come into contact with runoff.
EFFICIENT IRRIGATION SYSTEMS AND LANDSCAPE DESIGN	☒	☐	The Owner shall be responsible for the installation and maintenance of all common landscape areas utilizing similar planting materials with similar water requirements to reduce excess irrigation runoff. The City of Newport Beach shall be responsible for implementing all efficient irrigation systems for common area landscaping including but not limited to provisions for water sensors and programmable irrigation cycles. The irrigation systems shall be in conformance with water use efficiency guidelines.
PROTECT SLOPES AND CHANNELS	☐	☒	No slopes or channels on the project site. however, bulkheads or revetment will be constructed within the marina to protect from boat wakes.
SPECIFIC LAND USE/ PROJECT TYPE BMPs			
LOADING DOCK AREAS	☐	☒	No loading dock areas are proposed.
MAINTENANCE BAYS	☐	☒	No maintenance bays are proposed.
EQUIPMENT WASH AREAS	☐	☒	No equipment wash areas are proposed.
VEHICLE WASH AREAS	☐	☒	No vehicle wash areas are proposed.
OUTDOOR PROCESSING AREAS	☐	☒	No outdoor processing areas are proposed.
FUELING AREAS	☐	☒	No fueling areas are proposed.
HILLSIDE LANDSCAPING	☐	☒	No hillside landscaping is proposed.

INCORPORATED ROUTINE STRUCTURAL BMP:	YES	N/A	DESCRIPTION
WASH WATER CONTROLS FOR FOOD PREPARATIONS AREAS	☒	☐	Food preparation facilities shall meet all health and safety, building and safety and any other applicable regulations, codes requirements.
COMMUNITY CAR WASH RACKS	☐	☒	No community car wash racks are proposed.

The routine structural and non-structural BMPs have been selected in the above tables to address the anticipated and potential pollutants generated by the project site's land uses. The implementation of these BMPs is designed to reduce the pollutants associated with the land uses discussed in Section 2.3 and shown in the table below. With the implementation of these routine source control BMPs, the Project area will effectively minimize its potential to generate pollutants that may potentially cause water quality impacts to the downstream receiving water body (Lower Newport Bay).

SOURCE CONTROL BMP	TARGET POLLUTANTS
ACTIVITY RESTRICTIONS AND TENANT EDUCATION	Heavy metals, oil & grease, bacteria, nutrients
COMMON AREA LANDSCAPE MANAGEMENT	Nutrients, pesticides, sediments, oxygen demanding substances
COMMON AREA LITTER CONTROL AND TRASH STORAGE AREAS	Trash and debris, organics
EMPLOYEE TRAINING	Heavy metals, trash and debris, oil and grease, oxygen demanding substances.
CATCH BASIN INSPECTION	Sediment, particulates, heavy metals, trash and debris
STREET SWEEPING	All pollutants, particularly trash and debris
STORM DRAIN SIGNAGE	All pollutants, particularly trash and debris
EFFICIENT IRRIGATION AND LANDSCAPE DESIGN	Nutrients, pesticides, sediments, oxygen demanding substances
FOOD PREPARATION AREAS	Trash and debris, oil and grease, bacteria

4.3 TREATMENT CONTROL BMPs

The following table describes the treatment control BMPs that will be incorporated into this project. The treatment BMPs in this table are included in the project design to mitigate any pollutants of concern that were identified in the water quality planning process. The table also describes why a BMP was not chosen for the project. If necessary, details describing the design of the BMPs will be provided below.

INCORPORATED TREATMENT CONTROL BMP:	YES	NO	IF NO, DESCRIBE WHY
VEGETATED (GRASS) STRIPS	☐	☒	Ineffective for the Project's pollutants of concern.
VEGETATED (GRASS) SWALES	☒	☐	One bioswale is proposed, collecting and pre-treating runoff from the new Community/Sailing Center complex. Further details are provided on the following pages.
PROPRIETARY CONTROL MEASURES	☐	☒	Ineffective for the Project's pollutants of concern.
DRY DETENTION BASIN	☐	☒	Insufficient space for large-scale BMPs.
WET DETENTION BASIN	☐	☒	Insufficient space for large-scale BMPs.
CONSTRUCTED WETLAND	☐	☒	Insufficient space for large-scale BMPs.
BIORETENTION	☒	☐	Bioretention ("biocells") will be utilized to treat runoff from the park areas of the project. Further details are provided on the following pages.
DETENTION BASIN/SAND FILTER	☐	☒	Insufficient space for large-scale BMPs.
POROUS PAVEMENT DETENTION	☒	☐	Portions of the parking lots will be paved with permeable concrete pavers. Further details are provided on the following pages.
POROUS LANDSCAPE DETENTION	☐	☒	Other treatment BMP chosen.
INFILTRATION BASIN	☐	☒	Insufficient space for large-scale BMPs.
INFILTRATION TRENCH	☐	☒	Other treatment BMP chosen.
MEDIA FILTER	☐	☒	Ineffective for the Project's pollutants of concern.

The table below lists the general pollutant removal efficiencies for Treatment Control BMP Categories (from the Orange County Model WQMP).

TREATMENT CONTROL BMP SELECTION MATRIX								
	SEDIMENT/ TURBIDITY	NUTRIENTS	ORGANIC COMPOUNDS	TRASH & DEBRIS	OXYGEN DEMANDING SUBSTANCES	BACTERIA & VIRUSES	OIL AND GREASE	PESTICIDES
Biofilters / Vegetated Swales	H/M	L	U	L	L	U	H/M	U
Detention Basins[1]	M	M	U	M	M	U	M	U
Infiltration Basins[2]	H/M	H/M	U	U	H/M	H/M	U	U
Wet Ponds / Wetlands[3]	H/M	H/M	U	U	H/M	U	U	U
Sand Filter/ Filtration[4]	H/M	L/M	H/M	H/M	H/M	H/M	H/M	U
Water Quality Inlets	L	L	L	M	L	L	M	L
Hydrodynamic Separators[5]	H/M*	L	L	H/M	L	L	L/M	L

Notes:
L: Low removal efficiency
M: Medium removal efficiency
H: High removal efficiency
U: Unknown removal efficiency
* L for turbidity

1 Includes extended/dry detention basins with 36-48-hour drawdown time
2 Includes infiltration basins, infiltration trenches, and porous pavements
3 Includes permanent pool wet ponds and constructed wetlands
4 Includes media filters
5 Also known as hydrodynamic devices, baffle boxes, swirl concentrators, or cyclone separators

Source: Excerpted, with minor revision, from the Orange County Model Water Quality Management Plan. September 26, 2003.

TREATMENT CONTROL #1: POROUS PAVEMENT

Permeable pavement, such as permeable pavers, grass pavers, porous concrete, and porous asphalt, provides a surface suitable for light-loads and parking areas in which water can drain through pore spaces to an underlying rock reservoir (approximately 1-3 feet deep) underneath. The sub-surface base allows for physical and microbial filtering processes to take place thereby removing pollutants such as particulates, organics, hydrocarbons and total suspended sediments, including attached heavy metals.

Porous concrete pavers are proposed for the parking stalls within the three parking lots. The porous pavement areas will consist of layers of permeable concrete pavers, geotechnical fabric, clean non-compacted aggregate base, and a perforated underdrain system designed to carry high flows directly to the MS4. The rock reservoir underneath the porous surface allows storm water runoff to be temporarily stored before discharging into storm drain. The porous pavement sections proposed for the project will have an average rock reservoir depth of 8 inches; however, depths may be increased to 1-2 feet if needed to achieve the minimum required treatment design volumes for each drainage area. Typical cross sections and details are provided in Section 6.0. further details and final design of the porous pavement will be provided in the Final WQMP.

TREATMENT CONTROL #2: VEGETATED SWALE ("BIOSWALE")

Vegetated swales (also known as bioswales) are treatment BMPs that provide filtration through a grassed or vegetated bottom and the vegetation provides a mechanism for retarding surface runoff and filtering flows to drop sediments, fines, debris, and organics. Swales also provide treatment of runoff within the upper soil zone where biological and chemical reactions occur to absorb pollutants entering from the top soil. Due to the slow velocity of runoff through the swale, fine particulates can settle in the bottom of the channel and the runoff will infiltrate into the soil profile where the vegetation will uptake nutrients (e.g. nitrogen and phosphorous), microbial contaminants, oil and grease, and pesticides.

The bioswale will provide pretreatment and additional infiltration opportunities for storm water runoff from the proposed Community/Sailing Center complex prior to reaching the landscaped biocells for further treatment. As a result, the swale is considered a pretreatment and conveyance mechanism and therefore, sizing information is not included in this WQMP. Sizing of the landscaped biocells is discussed further in the following sub-section.

TREATMENT CONTROL #3: BIORETENTION ("LANDSCAPED BIOCELLS")

Landscaped biocells are features that can be utilized within the landscaping areas to capture, treat and infiltrate runoff. Landscaped biocells can also be placed within the landscaped islands in the parking lots and drive aisles to provide treatment of runoff from the adjacent areas. Landscaped biocells, also known as bioretention zones, are small, vegetated depressions to promote infiltration and filtration of storm water runoff. They combine shrubs, grasses, and flowering perennials in depressions that allow water to pool and filter through a minimum of 18 inches of soil where vegetation will uptake nutrients (e.g. nitrogen and phosphorous), microbial contaminants, oil and grease, and pesticides, and sediments and fine particulates can settle out.[4] Treated runoff is infiltrated into the sub-soils below. An underdrain provides drainage of flows under high flow conditions. Refer to Section 6.0 for locations of the proposed biocells for storm water treatment.

TREATMENT BMP SIZING CALCULATIONS

In accordance to the Countywide Model WQMP, the treatment BMPs will be sized to treat the maximum the volume of runoff produced from a 24-hour 85th percentile storm event, as determined from the local historical rainfall record. This is termed the Stormwater Quality Design Volume. The Stormwater Quality Design Volume (SQDV), is thus determined by the following equation:

$$SQDV = C * I * A_{TOTAL}$$

Where:

	C	=	coefficient of runoff (see Appendix 1)
	I	=	0.7 inches
	A_{TOTAL}	=	total area to be treated

The calculations are provided in the table below. Detailed calculations are provided in Appendix 1.

[4] LFR Inc. and Dan Cloak Environmental Consulting. Contra Costa Clean Water Program Infiltration Site Characterization Criteria and Guidance Study, Milestone Report #3. April 1, 2005.

SQDV[1] SUMMARY			
Area Name	% Impervious	Drainage Area (acres)	SQDV (ft^3)
West Parking Lot	100%	0.23	519.9
Central Parking Lot	100%	0.78	1,792.3
East Parking Lot	100%	0.34	788.9
Tennis Courts	100%	0.44	1,073.2
Remainder of Site	50%	4.54	6,076.0

(1) Calculations are based on Per Orange County Drainage Area Management Plan (DAMP), Table A-1, Exhibit 7.11 – Attachment A.

Based on the treatment requirements set forth in the Orange County DAMP, the treatment BMPs must be sized to treat a combined total volume of 10,250 ft^3 of storm water runoff. Correspondingly, the table below indicates that the treatment BMP for the proposed project is sized to treat over 22,800 ft^3 of runoff.

SUMMARY OF TREATMENT BMP SIZING				
Area Name	BMP Type	Minimum Area Needed[1]	Estimated Area Provided[2]	Treatment Capacity
West Parking Lot	Porous Pavement	2,174.9 ft^2	1,617 ft^2	433 ft^3
West Parking Lot	Biocell	192.2 ft^2	550 ft^2	1,484 ft^3
Central Parking Lot	Porous Pavement	7,498.3 ft^2	14,046 ft^2	3,764 ft^3
East Parking Lot	Porous Pavement	3,300.4 ft^2	3,810 ft^2	1021 ft^3
Tennis Courts	Biocells	394.6 ft^2	677 ft^2	1,821 ft^3
Remainder of Site	Biocells	2,233.8 ft^2	5,312 ft^2	14,329 ft^3

1 Assumes reservoir depth below porous pavement at 8" with 40% porosity. For biocells, refer to Appendix 1 for approximate dimensions used and detailed calculations.
2 Areas are approximate for conceptual design/Preliminary WQMP purposes. Details will be provided in Final WQMP.

Please note that the areas shown on the table above and in the Exhibits in Section 6.0 are estimated to show the Project's overall BMP concept for this Preliminary WQMP. Further design details and specific sizing of the porous pavement and biocells will be provided in the Final WQMP upon final design.

Maintenance requirements and frequencies for the landscaped biocells and porous pavement is discussed in Section 5.0 (BMP Inspection & Maintenance) of this report.

5.0 BMP INSPECTION & MAINTENANCE (O&M PLAN)

It has been determined that the City of Newport Beach shall assume all BMP inspection and maintenance responsibilities for the Marina Park Project.

CONTACT NAME	To be provided in the Final WQMP
TITLE	
COMPANY	City of Newport Beach
ADDRESS	3300 Newport Boulevard Newport Beach, CA 92663
PHONE	949.644.3309

Should the maintenance responsibility be transferred at any time during the operational life of Marina Park, such as when an HOA or POA is formed for a project, a formal notice of transfer shall be submitted to the City of Newport Beach at the time responsibility of the property subject to this WQMP is transferred. The transfer of responsibility shall be incorporated into this WQMP as an amendment.

ANNUAL CERTIFICATION OF BMP MAINTENANCE

The City of Newport Beach 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. The form that will be used to record implementation, maintenance, and inspection of BMPs is included in Appendix 6.

The City of Newport Beach may conduct verifications to assure that implementation and appropriate maintenance of structural and non-structural BMPs prescribed within this WQMP is taking place at the project site. The City shall retain operations, inspections and maintenance records of these 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 BMP MAINTENANCE

Long-term funding for BMP maintenance shall be provided by the City of Newport Beach.

ACCESS EASEMENT FOR CITY/COUNTY INSPECTION

If a private entity retains or assumes responsibility for operation and maintenance of structural BMPs, the City shall be able access for inspection through a formal agreement.

5.1 MAINTENANCE OF SOURCE CONTROLS

The post development BMP maintenance responsibility and frequency matrices provided in this section detail the specific party to perform the inspection and maintenance of each BMP for Marina Park and details the maintenance and inspection activities to be performed, and the frequency with which each shall be performed.

NON-STRUCTURAL BMPs		RESPONSIBLE PARTY	MINIMUM MAINTENANCE FREQUENCY
N2	ACTIVITY RESTRICTIONS	City of Newport Beach	The City of Newport Beach will prescribe activity restrictions to protect surface water quality, through lease terms or other equally effective measure, for the property. Minimum Frequency: ONGOING
N3	COMMON AREA LANDSCAPE MANAGEMENT	City of Newport Beach	Maintenance shall be consistent with City requirements, plus fertilizer and/or pesticide usage shall be consistent with County Management Guidelines for Use of Fertilizers (OC DAMP). Typical maintenance includes mowing, trimming, replanting, and debris removal. Minimum Frequency: MONTHLY
N4	BMP MAINTENANCE	City of Newport Beach	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 City of Newport Beach. Minimum Frequency: ONGOING
N11	COMMON AREA LITTER CONTROL	City of Newport Beach	Litter patrol, violations investigation, reporting and other litter control activities shall be performed in conjunction with maintenance activities. Minimum Frequency: WEEKLY

NON-STRUCTURAL BMPs		RESPONSIBLE PARTY	MINIMUM MAINTENANCE FREQUENCY
N12	EMPLOYEE TRAINING	City of Newport Beach	The Owner shall educate all new employees/ managers on storm water pollution prevention, particularly good housekeeping practices, prior to the start of the rainy season (October 1). Refresher courses shall be conducted on an as needed basis. Minimum Frequency: ANNUALLY
N14	CATCH BASIN INSPECTION	City of Newport Beach	Catch basin inlets shall be inspected and, if necessary, cleaned prior to the storm season by October 1st each year. Minimum Frequency: ANNUALLY
N15	STREET SWEEPING PRIVATE STREETS AND PARKING LOTS	City of Newport Beach	Parking lots must be swept at least quarterly (every 3 months), including prior to the start of the rainy season (October 1st). Minimum Frequency: QUARTERLY

STRUCTURAL BMPs	RESPONSIBLE PARTY	MINIMUM MAINTENANCE FREQUENCY
STORM DRAIN STENCILING AND SIGNAGE	City of Newport Beach	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. Minimum Frequency: ANNUALLY
PROPER TRASH STORAGE DESIGN	City of Newport Beach	Sweep trash area at least once per week and before October 1st each year. Maintain area clean of trash and debris at all times. Minimum Frequency: WEEKLY

STRUCTURAL BMPs	RESPONSIBLE PARTY	MINIMUM MAINTENANCE FREQUENCY
EFFICIENT IRRIGATION SYSTEMS AND LANDSCAPE DESIGN	City of Newport Beach	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, given time of year, weather, and day or night time temperatures. Minimum Frequency: MONTHLY
WASH WATER CONTROLS FOR FOOD PREPARATIONS AREAS	City of Newport Beach	Food preparation areas will be inspected as determined by the City of Newport Beach on a regular basis to ensure proper waste disposal and water usage procedures. Minimum Frequency: ANNUALLY

Any waste generated from maintenance activities will be disposed of properly. Wash water and other waste from maintenance activities is not to be discharged or disposed of into the storm drain system. Clippings from landscape maintenance (i.e. prunings) will be collected and disposed of properly off-site, and will not be washed into the streets, local area drains/conveyances, or catch basin inlets.

5.2 MAINTENANCE OF TREATMENT CONTROLS

The post development BMP maintenance responsibility and frequency matrix provided in this section detail the specific party to perform the inspection and maintenance of each BMP for Marina Park and details the maintenance and inspection activities to be performed, and the frequency with which each shall be performed.

TREATMENT BMPs	RESPONSIBLE PARTY	MINIMUM MAINTENANCE FREQUENCY
POROUS PAVEMENT DETENTION	City of Newport Beach	Pavement should be swept/vacuumed quarterly at a minimum to remove accumulated sediment and debris. Minimum Frequency: QUARTERLY
VEGETATED BIOSWALE	City of Newport Beach	Bioswale should be inspected post-construction after seeding and after first major storm event for damages. Afterwards, inspection/ maintenance should occur semi-annually, at the beginning and end of rainy season, for erosion or visible damage or debris. Inspection and maintenance of clogging and sand/soil bed should occur on an annual basis. Minimum Frequency: SEMI-ANNUALLY
LANDSCAPED BIOCELLS	City of Newport Beach	Biocells should be inspected post-construction after seeding and after first major storm event for damages. Afterwards, inspection/ maintenance should occur semi-annually, at the beginning and end of rainy season, for erosion or visible damage or debris. Inspection and maintenance of clogging and sand/soil bed should occur on an annual basis. Minimum Frequency: SEMI-ANNUALLY

TREATMENT CONTROL #1: POROUS PAVEMENT

Keep pavement clean and free from debris and sediment. Minor maintenance should be conducted 3 to 4 times per year and consists of vacuum cleaning surface using a commercially available sweeper at the following times – before and after the wet season, and (optionally) once during the wet season. If routine cleaning does not restore infiltration rates, then more invasive maintenance should occur as needed but no more than every 15-20 years, which may involve the following: Reconstruction of part of or entire pervious surface, lifting area and inspection of internal material, and replacement of surface materials, geotextiles, or sub-surface layers.

TREATMENT CONTROL #2: VEGETATED BIOSWALE

Proper maintenance for the operation of swales should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary.

Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover.

TREATMENT CONTROL #3: LANDSCAPED BIOCELLS

In the first year, biocells may require vigilant weeding. The need for weeding will decrease as plants become established. Therefore, monthly weeding shall be conducted during the first year of establishment. After the first year, weeding shall be conducted on an as needed basis but no less than 4 times per year. At least once per year in the spring, the biocell will be inspected for standing dead plant debris. Any observed plant debris will need to be removed, and replanting will occur with the approved plant palette options when necessary. The biocell shall be inspected for sediment trapped in the biocell, at least once in late summer or early fall, prior to the start of the rainy season (October 1) and cleaned out as necessary. Shrubs shall be pruned as necessary to keep a neat appearance.

Additional BMP maintenance information is provided in Section 6.0.

6.0 PLOT PLAN AND BMP DETAILS

The exhibits provided in this section are to illustrate the post construction BMPs prescribed within this WQMP. Drainage flow information of the proposed project, such as general surface flow lines, concrete or other surface drainage conveyances, and storm drain facilities are also depicted. All structural source control and treatment control BMPs are shown as well.

PLOT PLANS

- Vicinity Map
- Water Quality Management Plan Exhibit

BMP DETAILS

- Porous Concrete Pavers
- Bioretention ("Biocells")
- Vegetated Swale ("Bioswale")

VICINITY MAP

(Not to Scale)

FUSCOE ENGINEERING
16795 Von Karman, Suite 100
Irvine, California 92606
tel 949.474.1960 • fax 949.474.5315
www.fuscoe.com

NO.	DATE	DESCRIPTION OF REVISIONS	APPROVED

PRELIMINARY GRADING/DRAINAGE & WATER QUALITY
MARINA PARK
Schematic Design
CITY OF NEWPORT BEACH
PUBLIC WORKS DEPARTMENT
C1.01
OCTOBER 6, 2008

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Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).

- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

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be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

References and Sources of Additional Information

Coffman, L.S., R. Goo and R. Frederick, 1999: Low impact development: an innovative alternative approach to stormwater management. Proceedings of the 26th Annual Water Resources Planning and Management Conference ASCE, June 6-9, Tempe, Arizona.

Davis, A.P., Shokouhian, M., Sharma, H. and Minami, C., "Laboratory Study of Biological Retention (Bioretention) for Urban Stormwater Management," *Water Environ. Res.*, 73(1), 5-14 (2001).

Davis, A.P., Shokouhian, M., Sharma, H., Minami, C., and Winogradoff, D. "Water Quality Improvement through Bioretention: Lead, Copper, and Zinc," *Water Environ. Res.*, accepted for publication, August 2002.

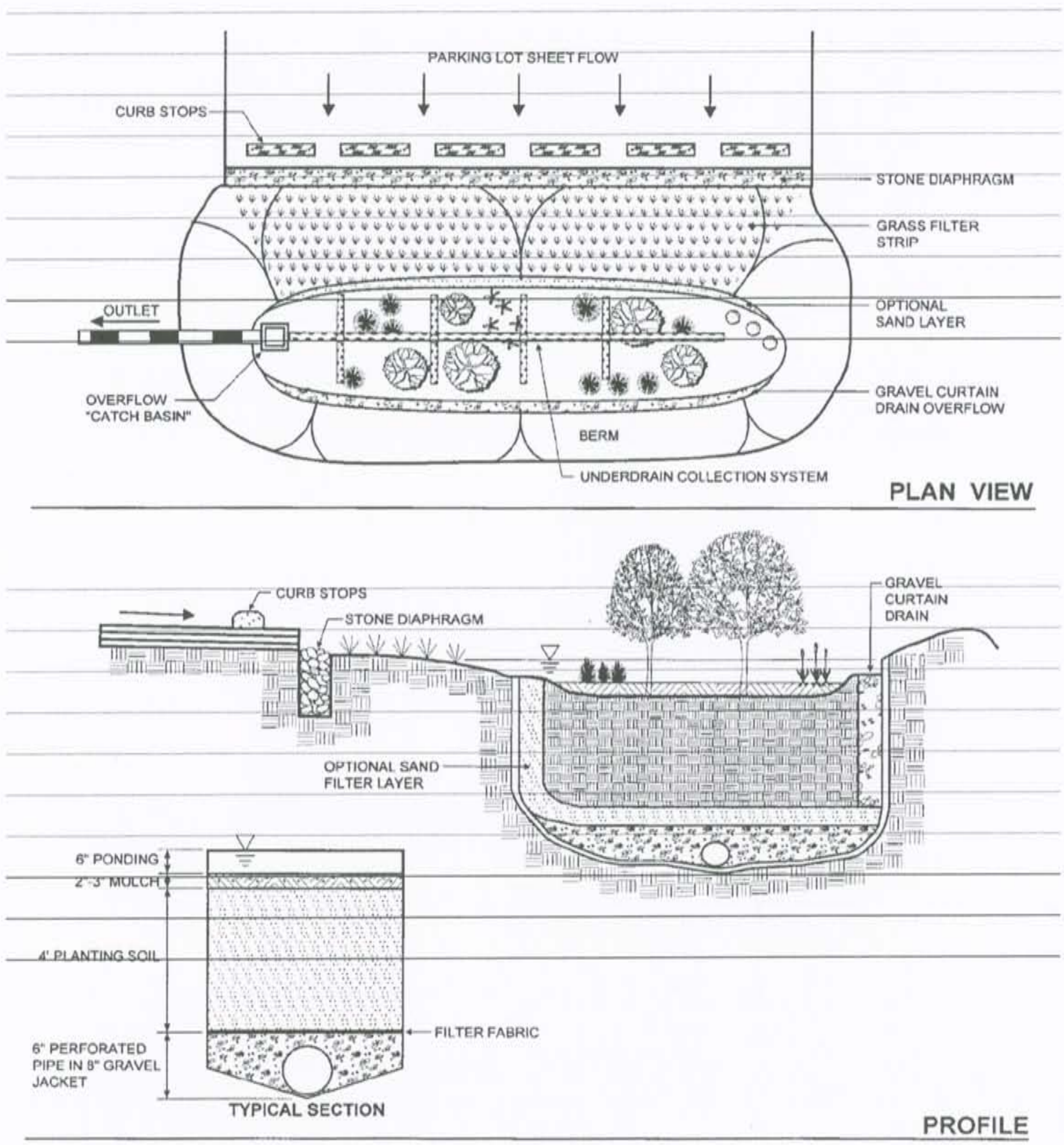
Kim, H., Seagren, E.A., and Davis, A.P., "Engineered Bioretention for Removal of Nitrate from Stormwater Runoff," *WEFTEC 2000 Conference Proceedings on CDROM Research Symposium, Nitrogen Removal*, Session 19, Anaheim CA, October 2000.

Hsieh, C.-h. and Davis, A.P. "Engineering Bioretention for Treatment of Urban Stormwater Runoff," *Watersheds 2002, Proceedings on CDROM Research Symposium*, Session 15, Ft. Lauderdale, FL, Feb. 2002.

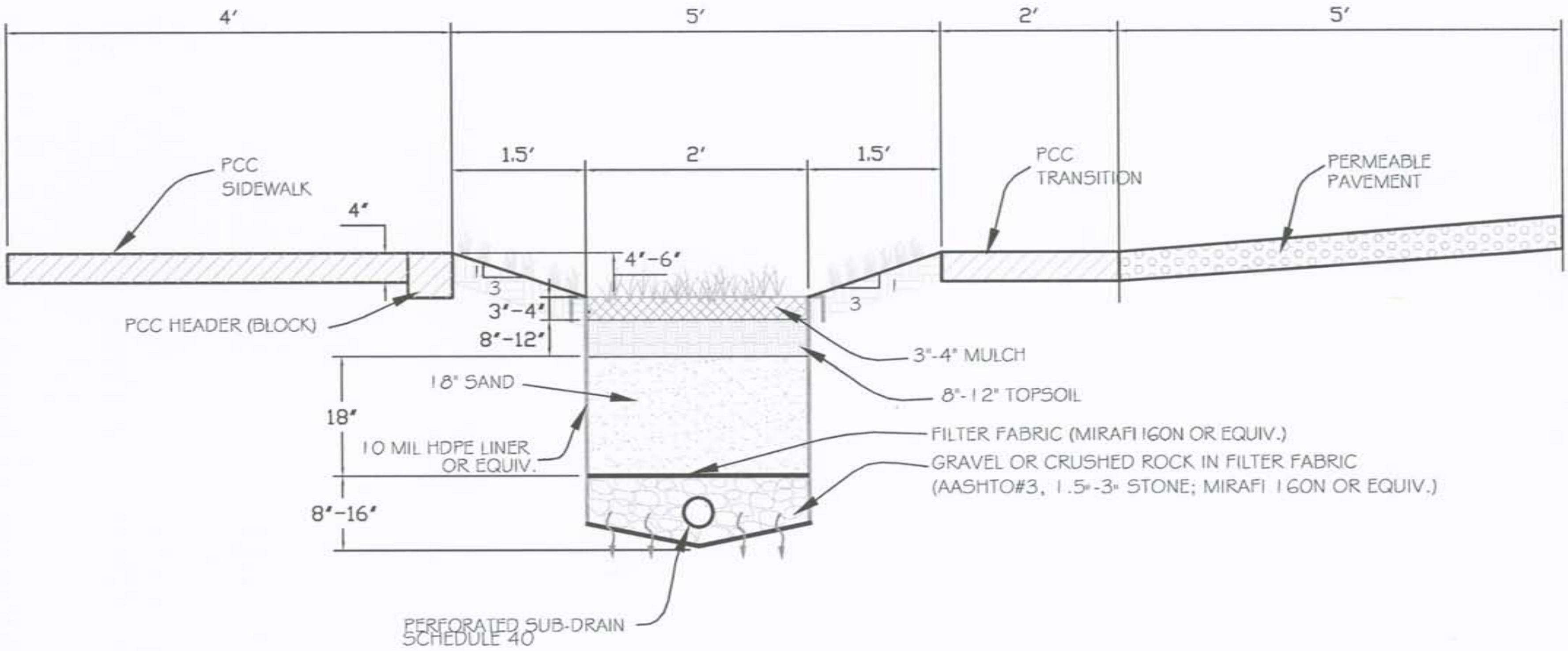
Prince George's County Department of Environmental Resources (PGDER), 1993. Design Manual for Use of *Bioretention in Stormwater Management*. Division of Environmental Management, Watershed Protection Branch. Landover, MD.

U.S. EPA Office of Water, 1999. Stormwater Technology Fact Sheet: Bioretention. EPA 832-F-99-012.

Weinstein, N. Davis, A.P. and Veeramachaneni, R. "Low Impact Development (LID) Stormwater Management Approach for the Control of Diffuse Pollution from Urban Roadways," *5th International Conference Diffuse/Nonpoint Pollution and Watershed Management Proceedings*, C.S. Melching and Emre Alp, Eds. 2001 International Water Association



Schematic of a Bioretention Facility (MDE, 2000)



Example Landscape Biocell Detail

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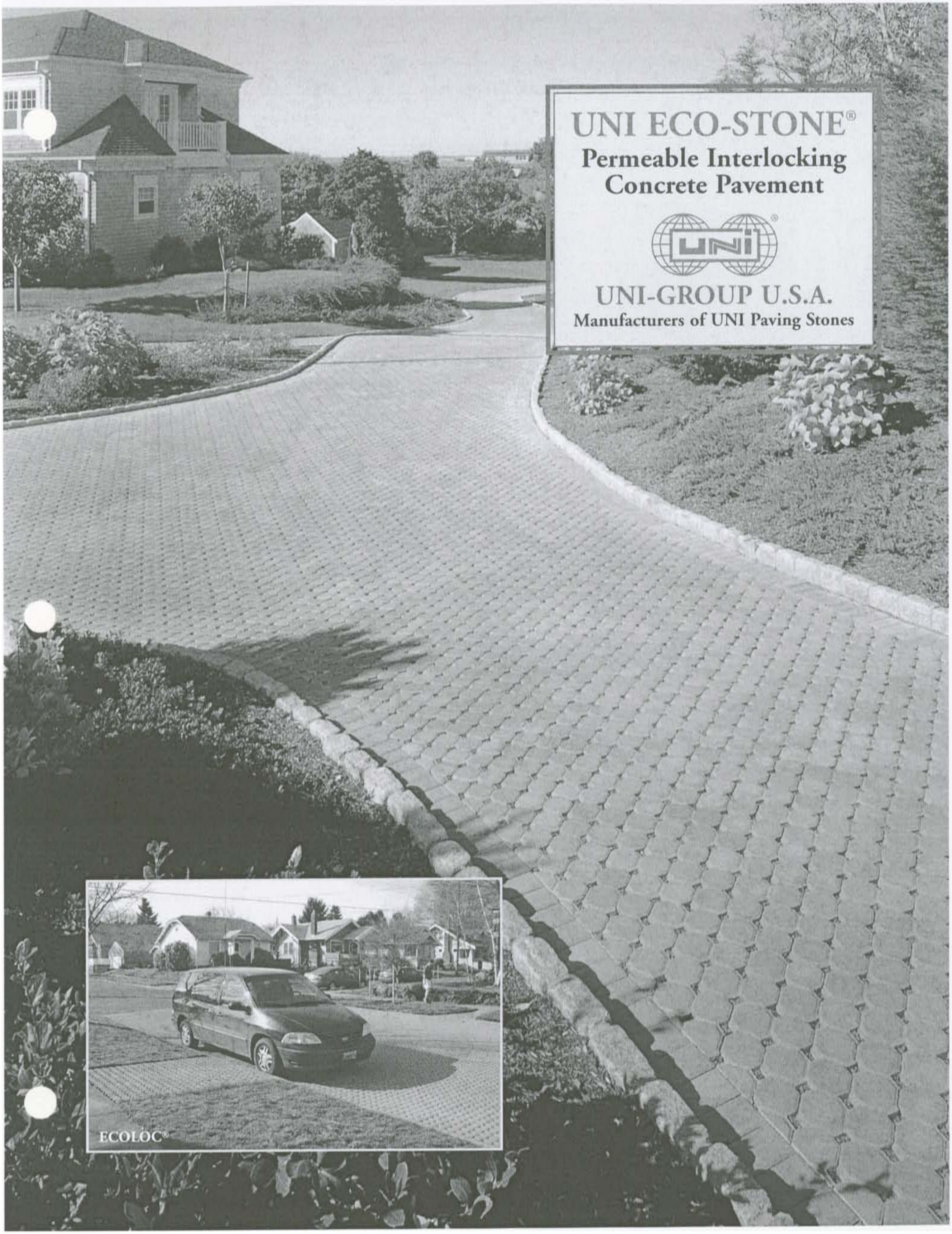
UNI ECO-STONE®

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

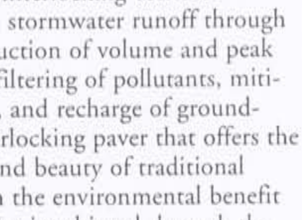

Private Residence - Narragansett, RI

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.

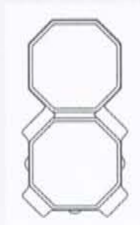


Figure 1

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.

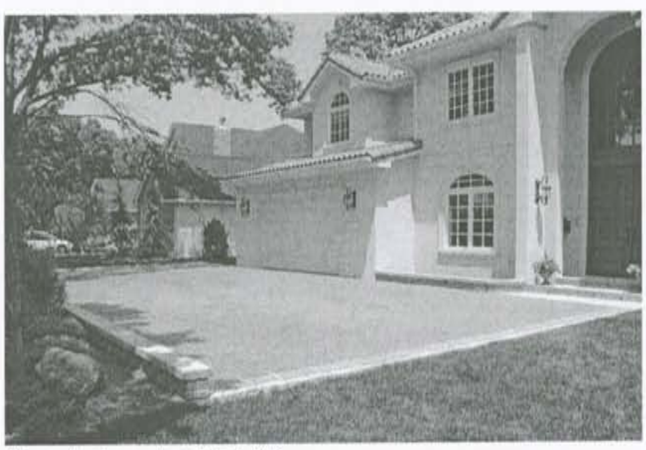
McKinney Green Building, McKinney, TX - LEED® Platinum Certified

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.

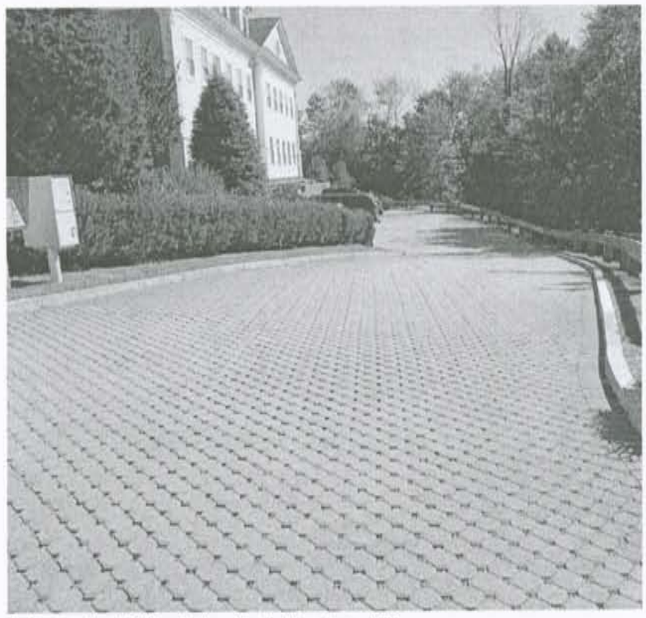
For years, most home builders and developers were wary of green building practices. However, with impervious cover restrictions and the increasing costs of energy now beginning to impact residential projects, the NAHB is encouraging the use of "green" products in single and multi-family developments. 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 α =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.

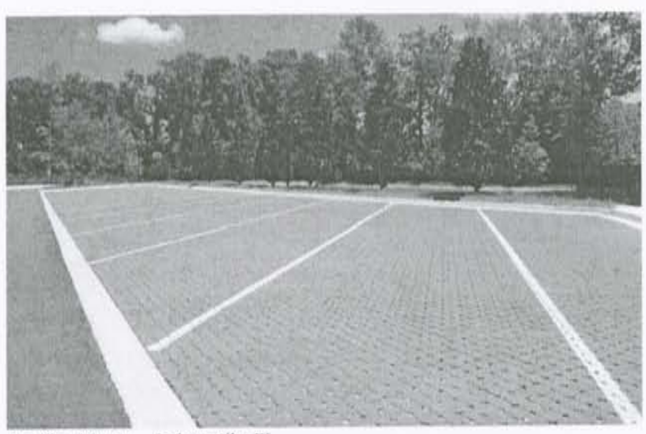
Private Residence - Minneapolis, MN

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: $C = I - \text{Design infiltration rate, in./hr} \div I$, 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.

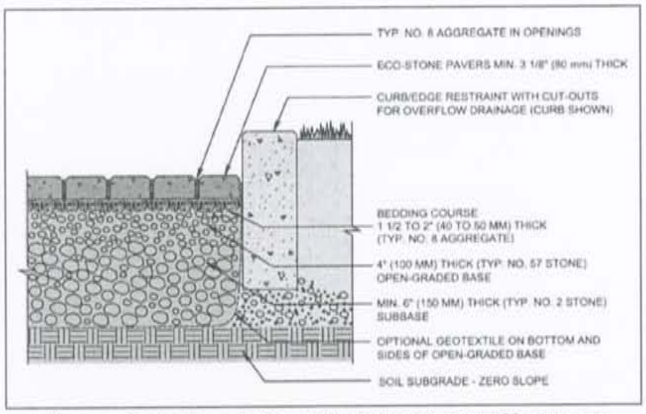


Figure 4 - Typical Cross-Section of an Eco-Stone® Permeable Pavement Full Exfiltration

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

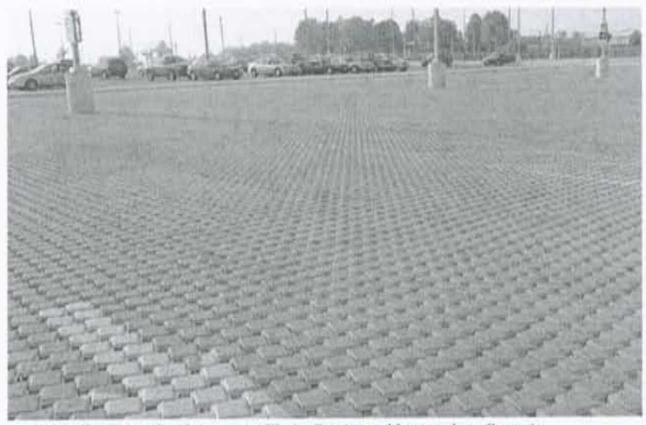
Ecoloc® can be mechanically installed and is ideal for larger-scale projects such as parking lots, roadways, storage and depot areas, and ports. Over 173,000 sf of Ecoloc® was used for an EPA Section 319 National Monitoring Permit Project at Morton Arboretum in Illinois. It also is in use at a test site 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

UNI-GROUP U.S.A. - National Headquarters Office
4362 Northlake Blvd. • Suite 204 • Palm Beach Gardens, FL 33410
(561) 626-4666 • FAX (561) 627-6403 • 1-800-872-1864
www.uni-groupusa.org • E-mail: info@uni-groupusa.org

UNI-GROUP U.S.A.

Permeable Interlocking Pavement Cross-Sections

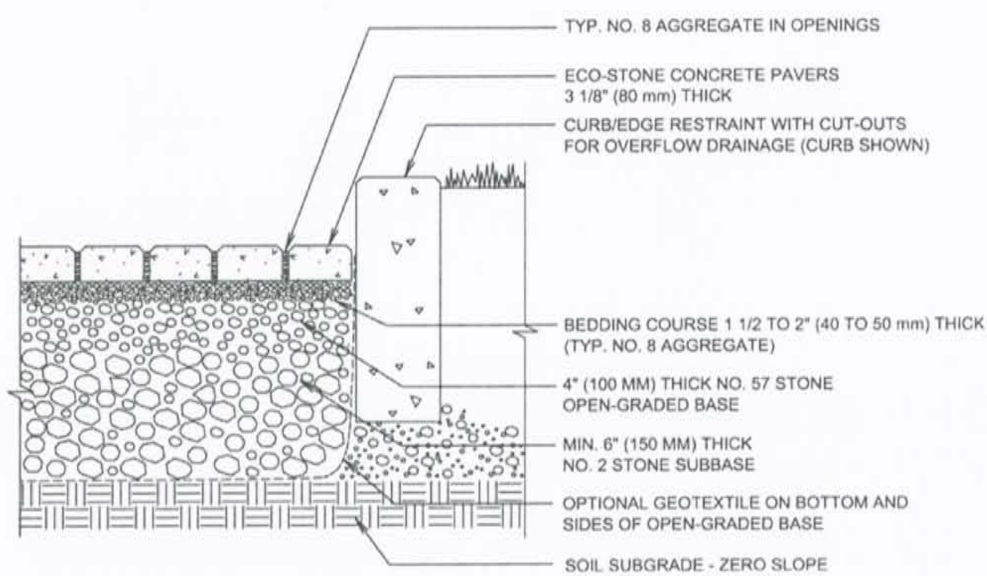
These cross-sections are provided as a guide for the design of permeable interlocking concrete pavements. Actual design of the pavement will vary according to local regulations and standards, climate, available construction materials, design methods, soil conditions, and traffic loads. A qualified architect, landscape architect, and/or engineer should be consulted in permeable concrete paver applications to ensure desired results.

Other design options, such as draining to a deeper permeable layer, or collection and treatment of stormwater runoff are possible. Consult an engineer experienced in hydrology and hydraulics for these types of applications.

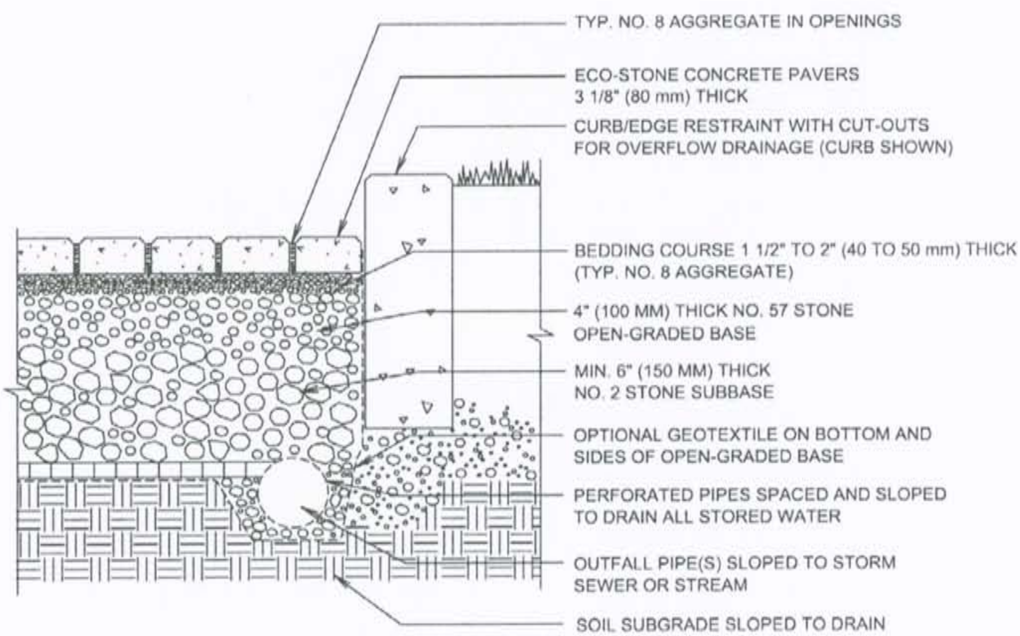
If you would like to receive cross-sections as DWG files for CAD, please request these through our web site. Contact your UNI® Manufacturer or visit our web site for more information.

UNI ECO-STONE CROSS-SECTIONS

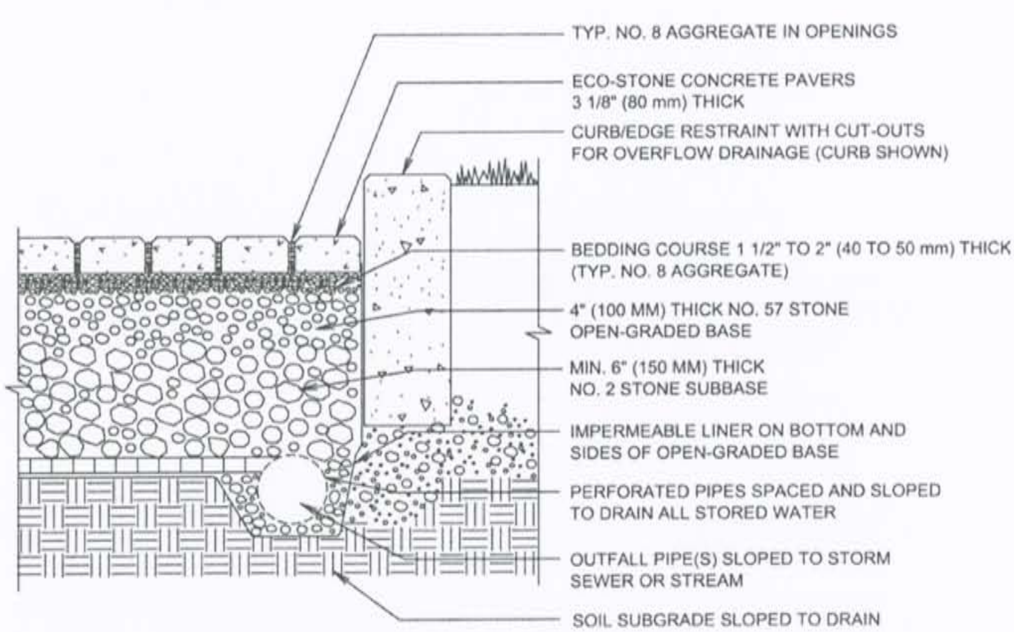
FULL EXFILTRATION



PARTIAL EXFILTRATION



NO EXFILTRATION



References: ICPI Zaphers

Vegetated Swale TC-30

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data							
	Removal Efficiencies (% Removal)						
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width): 1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	Swale Size (Depth and Top Width): 3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	Comment
Lawn Mowing	\$0.85 / 1,000 ft²/ mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft²/ year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd²	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	--

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

References and Sources of Additional Information

Barrett, Michael E., Walsh, Patrick M., Malina, Joseph F., Jr., Charbeneau, Randall J, 1998, "Performance of vegetative controls for treating highway runoff," *ASCE Journal of Environmental Engineering*, Vol. 124, No. 11, pp. 1121-1128.

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region*. Prepared for the Chesapeake Research Consortium, Edgewater, MD, by the Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection (CWP). 1996. *Design of Stormwater Filtering Systems.* Prepared for the Chesapeake Research Consortium, Solomons, MD, and USEPA Region V, Chicago, IL, by the Center for Watershed Protection, Ellicott City, MD.

Colwell, Shanti R., Horner, Richard R., and Booth, Derek B., 2000. *Characterization of Performance Predictors and Evaluation of Mowing Practices in Biofiltration Swales*. Report to King County Land And Water Resources Division and others by Center for Urban Water Resources Management, Department of Civil and Environmental Engineering, University of Washington, Seattle, WA

Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. *Retention, Detention and Overland Flow for Pollutant Removal From Highway Stormwater Runoff. Vol. 1.* FHWA/RD 89/202. Federal Highway Administration, Washington, DC.

Goldberg. 1993. *Dayton Avenue Swale Biofiltration Study*. Seattle Engineering Department, Seattle, WA.

Harper, H. 1988. *Effects of Stormwater Management Systems on Groundwater Quality*. Prepared for Florida Department of Environmental Regulation, Tallahassee, FL, by Environmental Research and Design, Inc., Orlando, FL.

Kercher, W.C., J.C. Landon, and R. Massarelli. 1983. Grassy swales prove cost-effective for water pollution control. *Public Works*, 16: 53–55.

Koon, J. 1995. *Evaluation of Water Quality Ponds and Swales in the Issaquah/East Lake Sammamish Basins*. King County Surface Water Management, Seattle, WA, and Washington Department of Ecology, Olympia, WA.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.Oakland, P.H. 1983. An evaluation of stormwater pollutant removal through grassed swale treatment. In *Proceedings of the International Symposium of Urban Hydrology, Hydraulics and Sediment Control, Lexington, KY*. pp. 173–182.

Occoquan Watershed Monitoring Laboratory. 1983. Final Report: *Metropolitan Washington Urban Runoff Project*. Prepared for the Metropolitan Washington Council of Governments, Washington, DC, by the Occoquan Watershed Monitoring Laboratory, Manassas, VA.

Pitt, R., and J. McLean. 1986. *Toronto Area Watershed Management Strategy Study: Humber River Pilot Watershed Project*. Ontario Ministry of Environment, Toronto, ON.

Schueler, T. 1997. Comparative Pollutant Removal Capability of Urban BMPs: A reanalysis. *Watershed Protection Techniques* 2(2):379–383.

Seattle Metro and Washington Department of Ecology. 1992. *Biofiltration Swale Performance: Recommendations and Design Considerations*. Publication No. 657. Water Pollution Control Department, Seattle, WA.

Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Technical report no. 31. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

U.S. EPA, 1999, Stormwater Fact Sheet: Vegetated Swales, Report # 832-F-99-006 http://www.epa.gov/owm/mtb/vegswale.pdf, Office of Water, Washington DC.

Wang, T., D. Spyridakis, B. Mar, and R. Horner. 1981. *Transport, Deposition and Control of Heavy Metals in Highway Runoff*. FHWA-WA-RD-39-10. University of Washington, Department of Civil Engineering, Seattle, WA.

Washington State Department of Transportation, 1995, *Highway Runoff Manual*, Washington State Department of Transportation, Olympia, Washington.

Welborn, C., and J. Veenhuis. 1987. *Effects of Runoff Controls on the Quantity and Quality of Urban Runoff in Two Locations in Austin, TX*. USGS Water Resources Investigations Report No. 87-4004. U.S. Geological Survey, Reston, VA.

Yousef, Y., M. Wanielista, H. Harper, D. Pearce, and R. Tolbert. 1985. *Best Management Practices: Removal of Highway Contaminants By Roadside Swales*. University of Central Florida and Florida Department of Transportation, Orlando, FL.

Yu, S., S. Barnes, and V. Gerde. 1993. *Testing of Best Management Practices for Controlling Highway Runoff*. FHWA/VA-93-R16. Virginia Transportation Research Council, Charlottesville, VA.

Information Resources

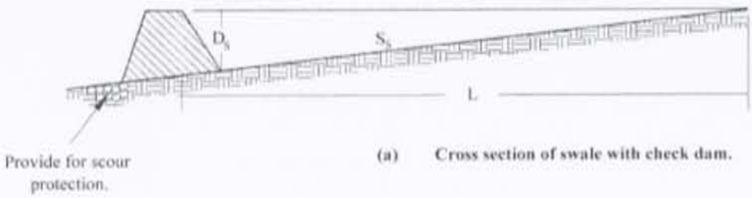
Maryland Department of the Environment (MDE). 2000. *Maryland Stormwater Design Manual*. www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2001.

Reeves, E. 1994. Performance and Condition of Biofilters in the Pacific Northwest. *Watershed Protection Techniques* 1(3):117–119.

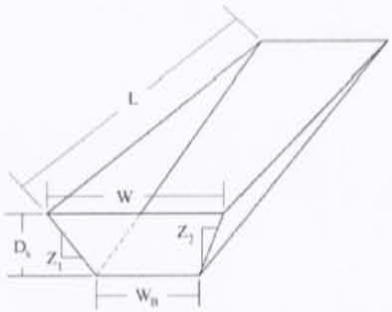
Seattle Metro and Washington Department of Ecology. 1992. *Biofiltration Swale Performance.* Recommendations and Design Considerations. Publication No. 657. Seattle Metro and Washington Department of Ecology, Olympia, WA.

USEPA 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water. Washington, DC.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* Prepared for U.S. Environmental Protection Agency, Office of Water. Washington, DC, by the Watershed Management Institute, Ingleside, MD.



(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:

L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

7.0 PUBLIC EDUCATION

The educational materials included in this WQMP are provided to inform people involved in future uses, activities, or ownership of the site about the potential pitfalls associated with careless storm water management. "The Ocean Begins at Your Front Door" provides users with information about storm water that is/ will be generated on site, what happens when water enters a storm drain, and its ultimate fate, discharging into the ocean. Also included are activities guidelines, such as "Tips for Landscape & Gardening", to educate anyone who is or will be associated with activities that have a potential to impact storm water runoff quality. These guidelines generally provide a menu of BMPs to effectively reduce the generation of storm water runoff pollutants from a variety of activities.

The educational materials to be used for the proposed project will be included in Appendix 3 of the Final WQMP and are listed below.

BROCHURES

- The Ocean Begins at Your Front Door
- Tips for Landscape & Gardening
- Waste Oil Collection Centers Central OC
- Keeping Pest Control Products Out of Creeks, Rivers and the Ocean
- Tips for Pet Care
- Sewage Spill Reference Guide
- Help Prevent Ocean Pollution: Proper Disposal of Household Hazardous Materials
- Help Prevent Ocean Pollution: A Guide for Food Service Facilities
- Help Prevent Ocean Pollution: Proper Maintenance Practices for Your Business

BMP FACT SHEETS

- SD-10 Site Design & Landscape Planning
- SD-11 Roof Runoff Controls
- SD-12 Efficient Irrigation
- SD-13 Storm Drain Signage
- SD-20 Pervious Pavements
- SD-32 Trash Storage Areas
- SC-10 Non-Stormwater Discharges
- SC-11 Spill Prevention, Control & Cleanup
- SC-34 Waste Handling & Disposal
- SC-41 Building & Grounds Maintenance
- SC-43 Parking/Storage Area Maintenance
- SC-50 Over Water Activities
- SC-71 Plaza and Sidewalk Cleaning
- SC-73 Landscape Maintenance
- SC-74 Drainage System Maintenance

8.0 APPENDICES

Appendix 1	*Runoff Coefficient References*
Appendix 2	*Notice of Transfer of Responsibility*
Appendix 3	*Public Education Materials (to be provided in Final WQMP)*
Appendix 4	*Post-Construction BMP Fact Sheets (to be provided in Final WQMP)*
Appendix 5	*Final Resolutions / Conditions of Approval (to be provided in Final WQMP)*
Appendix 6	*Record of BMP Implementation, Maintenance, and Inspection*

APPENDIX 1

RUNOFF COEFFICIENT REFERENCES

APPENDIX 1

PROJECT REPORT

Date: October 8, 2008

Project: Marina Park, Newport Beach

Re: Stormwater Quality Design Volume (SQDV) for volume-based BMPs

Job: 1001.01.01

Stormwater Quality Design Volume (SQDV) Calculation

(Orange County Drainage Area Management Plan (DAMP), Exhibit 7.11 – Model Water Quality Management Plan, September 26, 2003)

Calculate the stormwater quality design volume for the site (or each sub-drainage area that will discharge to a separate BMP) produced by a 24-hour, 85th percentile storm event using the following equation:

SQDV = C * I * A * (*unit conversion*)

Where:

C = runoff coefficient obtained from Table A-1
I = rainfall intensity (see map on following page)
A = area of the site treated by the BMP, in acres

Vegetated Biocell Sizing

(Source: Los Angeles Regional Water Quality Control Board (RWQCB). Example Standard Urban Storm Water Management Plan [SUSMP]; Appendix A: Water Quality Volume Calculations. Website: http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/general/sams_club/Appendix%20A.pdf)

Calculate the volume of water treated by each biocell based on the depths and properties of the various layers of the biocell:

$V_{BC} = V_P + V_{MGS} + V_{SO} + V_1$

Where:

V_{BC} = volume treated by biocell in ft^3 (must be equal to or greater than SQDV)
V_P = volume ponded in biocell in ft^3
V_{MGS} = volume stored in mulch, gravel, and topsoil in ft^3
V_1 = volume infiltrated in ft^3

The volumes in the equation above can be determined by the following sequence of equations:

Volume Ponded in Biocell (V_P):

$V_P = [(A_T + A_B) * P] / 2$

Where:

A_T = area of top of biocell, in square feet
A_B = area of bottom of biocell, in square feet
P = ponding depth, in feet

Volume in Mulch, Topsoil and Gravel Layer (V_{MGS})

$V_{MGS} = A_T * [(M*\eta_M) + (G*\eta_G) + (S*\eta_S)]$

Where:

A_T = area of top of biocell, in square feet
M = depth of mulch, in feet
η_M = porosity of mulch, in percent void space
G = depth of gravel layer, in feet
η_G = porosity of gravel layer, in percent void space
S = depth of topsoil
η_S = porosity of top soil, in percent void space

Velocity of Water in Amended Soil Layer (v_i)

$V_i = F_P / [12 * \eta_{SO} * (1-w)]$

Where:

F_P = infiltration capacity of the amended soil, or hydraulic conductivity (in inches per hour)
η_{SO} =
w = soil water content before rain event, in percent of voids assumed saturated

Duration of Infiltration During 24 hr Storm Event (T)

$T = 24 - (S_O / v_i)$

Where:

S_O = depth of amended soil layer, in feet

Volume Infiltrated (V_1)

$V_1 = T * A_T * [F_P / (12 * SF)]$

Where:

SF = safety factor for infiltration capacity. Assumed to be 1 if overflow drain is provided.

Porous Pavement Sizing

For sizing of porous pavement, the treated runoff volume is stored in the void space between the stones of the reservoir course below the pavement, similar to an infiltration trench.

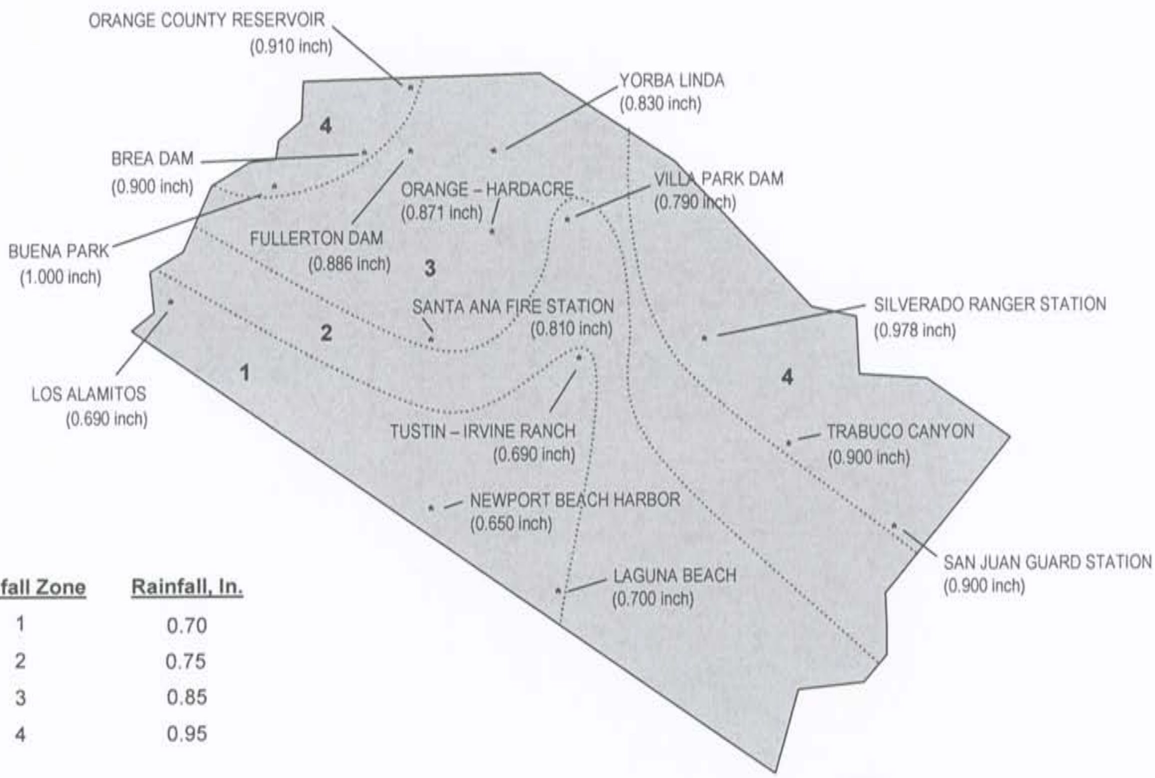
Minimum Surface Area of Pavement Needed to treat SQDV

(SQDV / Porosity) * coarse depth = surface area of pavement required

Where:

SQDV = volume of runoff to be treated
Porosity = typically 35% to 40% for gravel
Depth = typically 8 to 12 inches

RUNOFF COEFFICIENT REFERENCES



Rainfall Zone	Rainfall, In.
1	0.70
2	0.75
3	0.85
4	0.95

Figure A-1
Orange County California
Precipitation Stations
24-hour, 85th percentile rainfall

Table A-1

C Values Based on Impervious/Pervious Area Ratios

% Impervious	% Pervious	C
0	100	0.15
5	95	0.19
10	90	0.23
15	85	0.26
20	80	0.30
25	75	0.34
30	70	0.38
35	65	0.41
40	60	0.45
45	55	0.49
50	50	0.53
55	45	0.56
60	40	0.60
65	35	0.64
70	30	0.68
75	25	0.71
80	20	0.75
85	15	0.79
90	10	0.83
95	5	0.86
100	0	0.90

Storm Water Quality Design Volume Calculations - Orange County

10.08.08

SQDV = C * I * A * (Conversion)

C = Runoff Coefficient
I = Rainfall Intensity
conversion = (1/12)

depth = volume / area
I = volume / C * A * conversion

POROUS PAVEMENT

#	Drainage Area	% impervious	Runoff Coefficient	Rainfall Intensity (in)	Drainage Area (ft^2)	Conversion Factor	Treatment Required (ft^3)	Ratio for Porous Pavement (8")	Minimum Area Required (ft^2)
1	West Parking Lot	100%	0.90	0.7	9,886	0.0833	**519.9**	0.22	**2,174.9**
2	Center Parking Lot	100%	0.90	0.7	34,083	0.0833	**1,792.3**	0.22	**7,498.3**
3	East Parking Lot	100%	0.90	0.7	15,002	0.0833	**788.9**	0.22	**3,300.4**

BIOCELL PLANTERS

#	Drainage Area	% impervious	Runoff Coefficient	Rainfall Intensity (in)	Drainage Area (ft^2)	Conversion Factor	Treatment Required (ft^3)	Ratio for Biocell Planter (2' depth)	Minimum Area Required (ft^2)
1	West Parking Lot	100	0.9	0.7	9,886	0.0833	**519.0**	2.7	**192.2**
4	Tennis Courts	100%	0.90	0.7	20,408	0.0833	**1,073.2**	2.7	**397.5**
5	Remainder of Site	50%	0.53	0.7	197,835	0.0833	**6,076.0**	2.7	**2,250.4**

Biocell Water Quality Volume Calculations

10.08.08

Symbol	Parameter	Example Biocell Design Parameters			
		Tennis Courts 135x5	West Parking 110x5	East Parking	All
A_T	Top Area (ft^2)	675	550	857	5312
A_B	Bottom Area (ft^2)	264	214	334	2071
P	Ponding Depth (ft)	0.5	0.5	0.5	0.5
M	Mulch Depth (Ft)	0	0	0	0
η_M	Mulch Porosity (%)	0.4	0.4	0.4	0.4
G	Gravel Depth (ft)	0.5	0.5	0.5	0.5
η_G	Gravel Porosity (%)	0.4	0.4	0.4	0.4
S	Planting Soil Depth (ft)	0.5	0.5	0.5	0.5
η_S	Planting Soil Porosity (%)	0.3	0.3	0.3	0.3
S_o	Sand Filter Depth (ft)	1	1	1	1
η_{So}	Sand Filter Porosity (%)	0.3	0.3	0.3	0.3
T	Total Depth Below Surface (ft)	2	2	2	2
w	Soil Water Content (%)	0.5	0.5	0.5	0.5
F_P	Infiltration Capacity (in/hr)	1	1	1	1
SF	Safety Factor for Infiltration	1	1	1	1
v_i	Infiltration Velocity (ft/hr)	0.56	0.56	0.56	0.56
T	Time Infiltration Occurs (hr)	22.2	22.2	22.2	22.2
V_P	Ponding Volume (ft^3)	235	191	298	1,846
V_{MGS}	Volume in Gravel/Sand/Mulch (ft^3)	236	193	300	1,859
V_{So}	Volume in Sand Filter (ft^3)	101	83	129	797
V_I	Volume Infiltrated (ft^3)	1,249	1,018	1,585	9,827
V_{BC}	**Total Volume Treated (ft^3)**	**1,821**	**1,484**	**2,312**	**14,329**

Ratio Surface Area to Volume	2.70	2.70	2.70	2.70

APPENDIX 2

NOTICE OF TRANSFER OF RESPONSIBILITY

NOTICE OF TRANSFER OF RESPONSIBILITY

WATER QUALITY MANAGEMENT PLAN

Marina Park
Newport Beach, CA

Submission of this Notice Of Transfer of Responsibility constitutes notice to the City of Newport Beach that responsibility for the Water Quality Management Plan ("WQMP") for the subject property identified below, and implementation of that plan, is being transferred from the Previous Owner (and his/her agent) of the site (or a portion thereof) to the New Owner, as further described below.

I. Previous Owner/ Previous Responsible Party Information

Company/ Individual Name:		Contact Person:	
Street Address:		Title:	
City:	State:	ZIP:	Phone:

II. Information about Site Transferred

Name of Project (if applicable):	
Title of WQMP Applicable to site:	
Street Address of Site (if applicable):	
Planning Area (PA) and/ or Tract Number(s) for Site:	Lot Numbers (if Site is a portion of a tract):
Date WQMP Prepared (and revised if applicable):	

III. New Owner/ New Responsible Party Information

Company/ Individual Name:		Contact Person:	
Street Address:		Title:	
City:	State:	ZIP:	Phone:

IV. Ownership Transfer Information

General Description of Site Transferred to New Owner:	General Description of Portion of Project/ Parcel Subject to WQMP Retained by Owner (if any):

Lot/ Tract Numbers of Site Transferred to New Owner:
Remaining Lot/ Tract Numbers Subject to WQMP Still Held by Owner (if any):
Date of Ownership Transfer:

Note: When the Previous Owner is transferring a Site that is a portion of a larger project/ parcel addressed by the WQMP, as opposed to the entire project/parcel addressed by the WQMP, the General Description of the Site transferred and the remainder of the project/ parcel no transferred shall be set forth as maps attached to this notice. These maps shall show those portions of a project/ parcel addressed by the WQMP that are transferred to the New Owner (the Transferred Site), those portions retained by the Previous Owner, and those portions previously transferred by Previous Owner. Those portions retained by Previous Owner shall be labeled as "Previously Transferred".

V. Purpose of Notice of Transfer

The purposes of this Notice of Transfer of Responsibility are: 1) to track transfer of responsibility for implementation and amendment of the WQMP when property to which the WQMP is transferred from the Previous Owner to the New Owner, and 2) to facilitate notification to a transferee of property subject to a WQMP that such New Order is now the Responsible Party of record for the WQMP for those portions of the site that it owns.

VI. Certifications

A. Previous Owner

I certify under penalty of law that I am no longer the owner of the Transferred Site as described in Section II above. I have provided the New Owner with a copy of the WQMP applicable to the Transferred Site that the New Owner is acquiring from the Previous Owner.

Printed Name of Previous Owner Representative:	Title:
Signature of Previous Owner Representative:	Date:

B. New Owner

I certify under penalty of law that I am the owner of the Transferred Site, as described in Section II above, that I have been provided a copy of the WQMP, and that I have informed myself and understand the New Owner's responsibilities related to the WQMP, its implementation, and Best Management Practices associated with it. I understand that by signing this notice, the New Owner is accepting all ongoing responsibilities for implementation and amendment of the WQMP for the Transferred Site, which the New Owner has acquired from the Previous Owner.

Printed Name of New Owner Representative:	Title:
Signature:	Date:

APPENDIX 3

PUBLIC EDUCATION MATERIALS

(Pending, to be provided in the Final WQMP)

APPENDIX 4

POST-CONSTRUCTION BMP FACT SHEETS

(Pending, to be provided in the Final WQMP)

APPENDIX 5

FINAL RESOLUTIONS / CONDITIONS OF APPROVAL

(Pending, to be provided in the Final WQMP)

APPENDIX 6

RECORD OF BMP IMPLEMENTATION, MAINTENANCE, AND INSPECTION

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

H.2 - CITY OF NEWPORT BEACH MARINA PARK COASTAL ENGINEERING STUDY

CITY OF NEWPORT BEACH
Marina Park Coastal Engineering Study

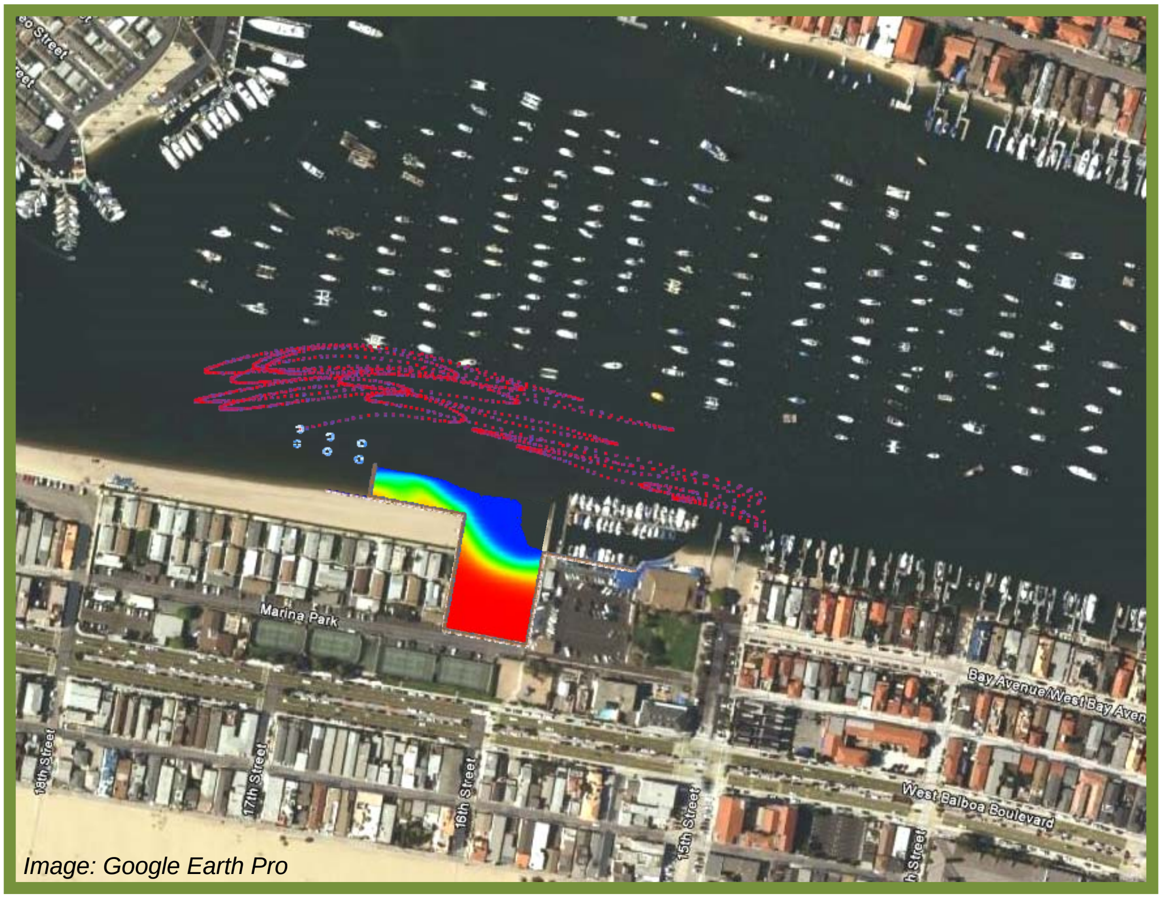


Image: Google Earth Pro

Prepared for
URS|Cash & Associates

Prepared by
Everest International Consultants, Inc.

October 2008

CITY OF NEWPORT BEACH

MARINA PARK COASTAL ENGINEERING STUDY

Final Report

Prepared for:

URS|CASH & ASSOCIATES
P.O. Box 2715
Huntington Beach, CA 92647-0715

Contact: Randy Mason

Prepared by:

Everest International Consultants, Inc.
444 West Ocean Boulevard, Suite 1104
Long Beach, CA 90802

Contact: Ying-Keung Poon

October 2008

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1. INTRODUCTION

The Marina Park Master Plan is a proposed project to improve the physical and visual access to Newport Bay by providing new and expanded park and beach facilities, recreational boating facilities, and a new Community Center. The proposed Marina Park is a nine-acre site located on the Bay side of Newport Peninsula north of Balboa Boulevard between 18^{th} and 15^{th} Street in Newport Beach, California. Figure 1 shows the location of the proposed park in Newport Bay, as well as some pictures of the existing facilities in the vicinity of the project location.

As described in the master plan, amenities of the proposed Marina Park include picnic tables, restroom, showers, play areas, tennis courts, benches, Girl Scout House, public beach and water access, parking, short-term visiting vessel marina, public dock and Sailing Center, and improved boat launch areas. Figure 2 shows an architectural rendering of the proposed Marina Park Master Plan.

Everest International Consultants, Inc. (Everest) was contacted by Mr. Randy Mason of the URS|Cash Associates to conduct a coastal engineering study to analyze the wave loadings on the docks within the proposed marina, as well as the water quality and sedimentation issues. The Scope of Work for the coastal engineering study includes:

1. Conduct a site visit to observe existing conditions.
2. Obtain and review prior data/information related to the project.
3. Perform wind wave and ship wake analyses and corresponding wave loading calculations for the docks, boats, and piles within the proposed marina basin.
4. Perform hydrodynamic and water quality modeling to evaluate potential water quality issues within the proposed marina basin and make recommendation on ways to improve water quality.
5. Review existing sedimentation issues at the project site and potential sedimentation issues at the proposed marina basin.
6. Prepare a summary report to summarize the purpose, methods and results for this coastal engineering study.

The results of the wave and wave loading analyses are presented in Section 2 of this report. Sections 3 and 4 summarize the approach and results for the water quality and sedimentation analyses, respectively. A summary of the findings of this study is provided in Section 5.

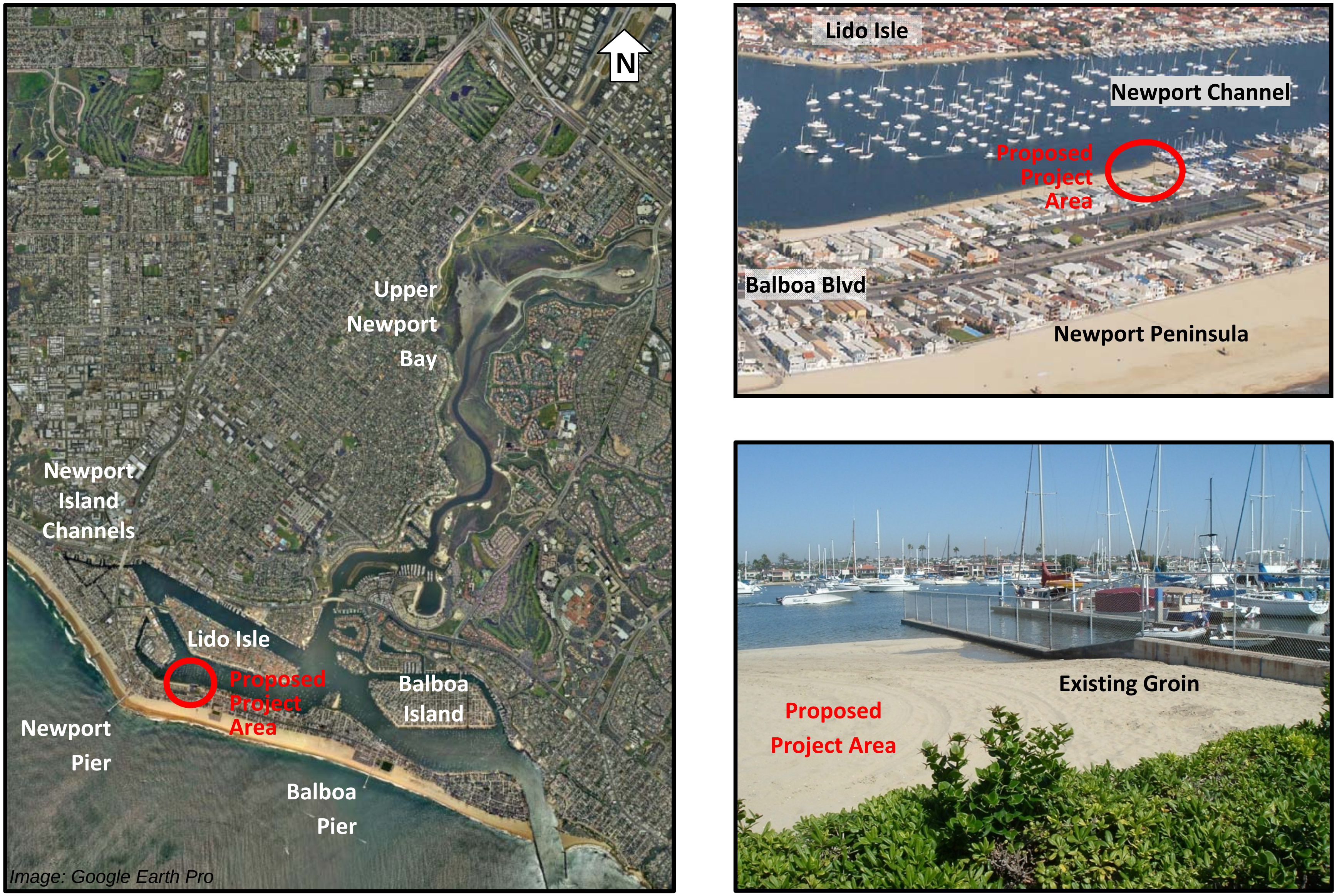


Figure 1. Existing and Proposed Project Site

Figure 2. Proposed Marina Park Master Plan

2. WAVE LOADING ANALYSES

2.1 OVERVIEW

The purpose of the wave loading analyses is to estimate the horizontal wave induced forces and moments (where applicable) on the boats, docks, and piles of the proposed Marina Park. A wave analysis was first conducted to estimate the wind wave and ship wake conditions at the proposed marina. The wind wave analyses utilized local wind data compiled from Balboa Pier to estimate the operational wind conditions while long term wind data compiled from John Wayne Airport were used to estimate the extreme wind conditions. Ship waves were estimated based on typical boats and operating conditions at the project location. Wave loadings on boats, docks and piles due to the larger of the wind waves and ship waves were then calculated using different methods and tide elevations.

2.2 WAVE ANALYSIS

Marina Park is well sheltered by land and far away from the Newport Harbor entrance so no significant ocean swell is expected to penetrate to this location. Hence, the design wave conditions for the proposed marina are governed by local wind waves or ship wakes generated by passing ships.

Wind Waves

Analysis of wind waves starts with understanding the local wind patterns. Wind data are available from the nearby Balboa Pier for July, 2004 through April, 2008 (MesoWest 2008) and were used to develop the operational wave conditions at the site. A longer wind record is needed for the development of the extreme wind conditions for determining the design wave loadings. Nearby John Wayne Airport has 46 years of wind data ending in May, 2008 (WeatherUnderground 2008), which were used for establishing the extreme wind conditions. Figure 3 shows the location of these two wind data sources relative to the project site.

Figure 4 shows the operational wind rose developed based on the wind data from Balboa Pier. It shows that the majority of the winds come from the southwest quadrant with speeds of less than 10 knots. However, higher winds usually come from the north-northeast. As illustrated in the insert of Figure 4, for winds greater than 15 knots, approximately 45% come from the north-northeast with 5% exceeding 22 knots. Since at Marina Park, the operational winds come from land and blow offshore (to the northeast), the operational wind waves at Marina Park would be created inside the marina basin and on the order of only a few inches in height.

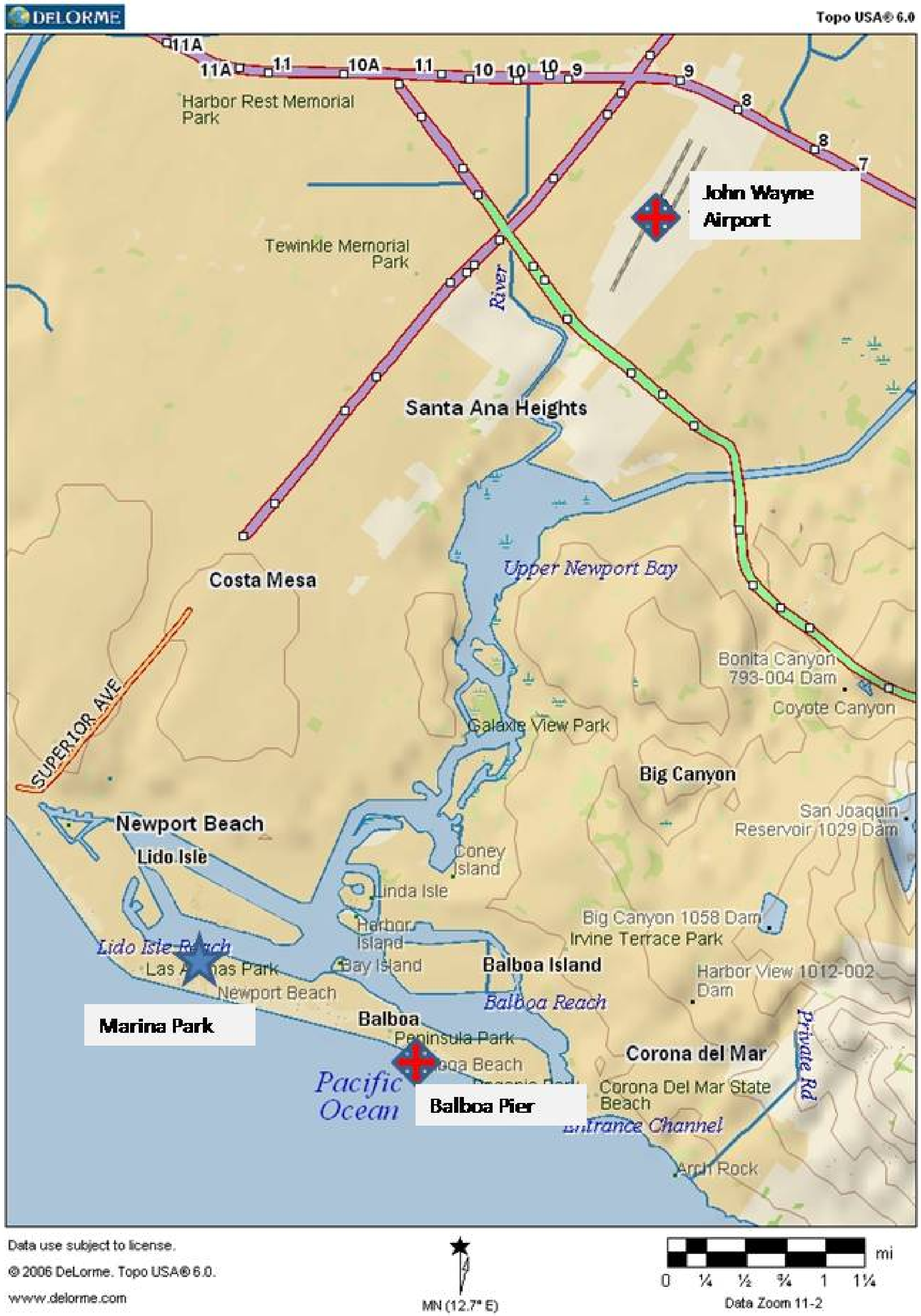


Figure 3. Wind Data Sources Including Balboa Pier and John Wayne Airport

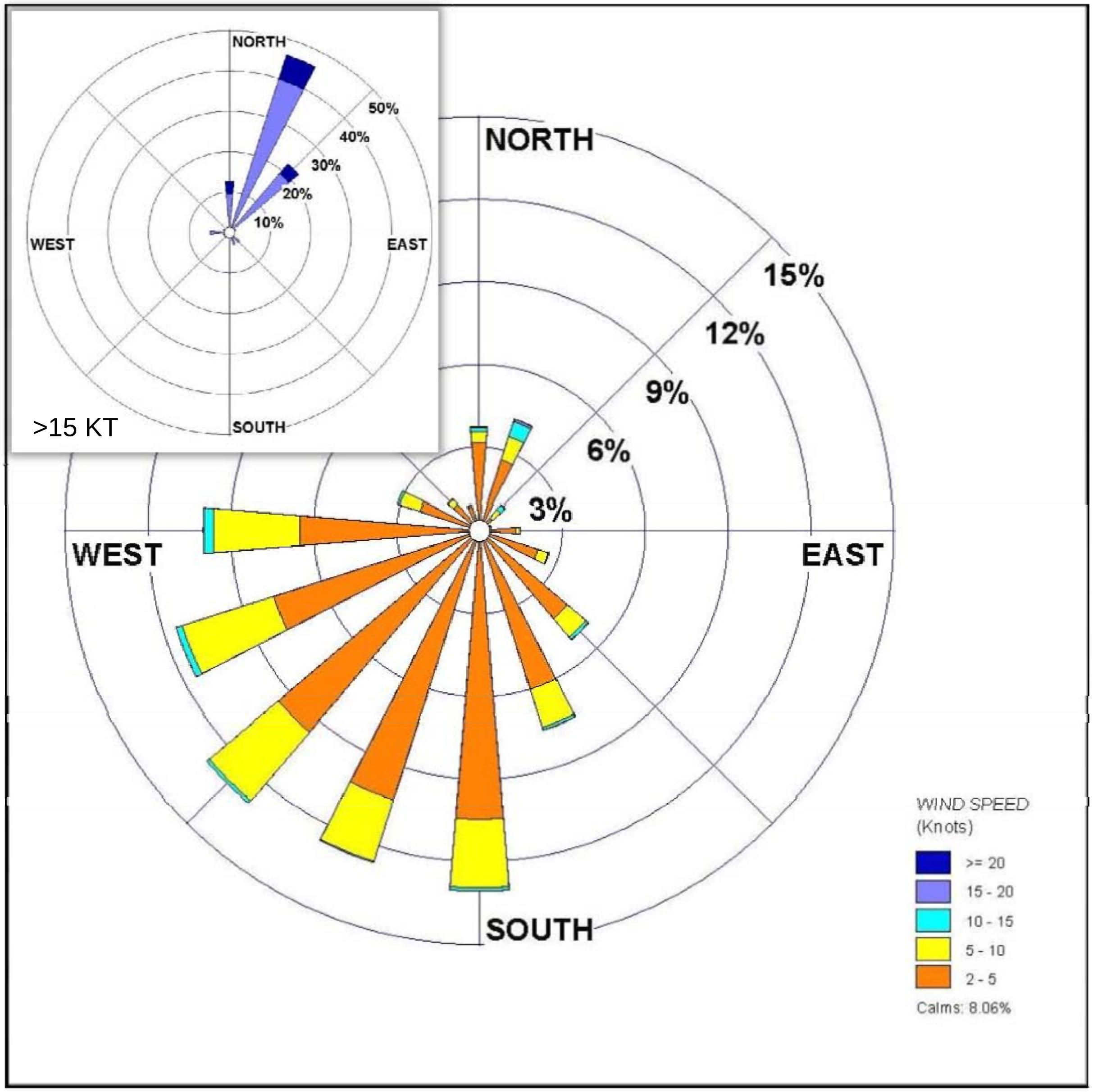


Figure 4. Wind Rose for Balboa Pier: Operational Winds and Winds Greater than 15 Knots (insert)

An extremal analysis was performed based on the 46-year data record collected at John Wayne Airport. The results are summarized in Table 1 below. The return period is defined as the average time interval between successive occurrences of an event being equaled or exceeded. For example, a wind speed with a 100-year return period can be expected to be exceeded, on average, once every 100 years.

Table 1. Extreme Wind Speeds at John Wayne Airport

Return Period (yr)	2-Minute Wind Speed (knot)
2	31.7
5	42.4
10	50.5
25	61.2
50	69.3
100	77.4

A common, conservative approach to estimate the extreme wind waves is to apply the fastest wind over the longest fetch leading to the project site, with the necessary adjustment of the wind duration appropriate for the fetch distance. The extreme wind wave heights at Marina Park were estimated with this approach and the results are summarized in Table 2. In the table, H_{mo} is the energy based significant wave height and T_p is the peak wave period.

Table 2. Extreme Wind Waves at Marina Park

Return Period (yr)	H_{mo} (ft)	T_p (sec)
50	2.1	2.7
100	2.4	2.8

Ship Wakes

Ship wakes are vessel generated waves which propagate away from the sailing line of the vessel. Figure 5 shows a picture of ship wakes generated by a recreational boat. The probable ship wake at Marina Park would be governed by the types and dimensions of ships likely to pass by the docks; as well as how fast they are traveling and their distance from the docks. Hence, a range of vessel types and sizes were used in estimating ship wakes at Marina Park. The dimensions of the vessels were estimated from aerial photographs of

Newport Harbor. The speed limit in Newport Harbor is 5 miles per hour (4.4 knot), but for this analysis it was assumed that, at times, some vessels may exceed the legal limit. Table 3 summarizes the vessel properties and conditions, calculation methods, and resulting wave conditions at Marina Park. The table shows the maximum wave height, H_{max}, and the associated wave period, T, at Marina Park.

Figure 5. Ship Wake from a Recreational Boat

Table 3. Ship Wake Input, Calculation Method, and Resulted Wave Conditions

SCENARIO DESCRIPTION	BOAT LENGTH (FT)	SPEED (KNOT)	METHOD	H_{MAX} (FT)	T (SEC)
Sportboat - planning	20	20	Bhowmik	0.3	n/a
Sportboat - subcritical	20	8	Kriebel	1.9	2.4
Superyacht - posted speed limit	120	4.4	Kriebel	0.1	1.2
Superyacht - speeding	120	8	Kriebel	1.7	2.4
Superyacht - speeding, deep water	120	8	Kriebel	0.9	2.2
Superyacht - posted speed limit	120	4.4	Gates Herbich	0.8	1.2
Superyacht - speeding	120	8	Gates Herbich	1.8	2.4
Superyacht - speeding, deep water	120	8	Gates Herbich	1.8	2.2

n/a - no wave period can be calculated for planning boats.

As shown in Table 3, even with the largest boats in Newport Harbor exceeding the posted speed limit, the resulting wave heights and periods at Marina Park are still smaller than those of the extreme wind waves shown in Table 2. Hence, wind waves are the controlling wave conditions in calculating the wave loading at the docks and piles in Marina Park.

2.3 WAVE LOADING

The purpose of the wave loading analyses was to estimate the horizontal wave induced forces and moments (where applicable) on the docks, boats and piles at the proposed Marina Park basin. Each structure (boat, dock, or pile) requires a different calculation method and hence is discussed separately below.

As mentioned earlier, extreme wind waves are higher than ship wakes and hence would be used in calculating the wave loadings. For rigid structures it is common to use a design wave height equal to the highest 1% of the waves, which is calculated as 1.67 times the significant wave height. The marina basin depth was assumed to be -12 feet, MLLW (Mason 2008), and wave loadings are evaluated for two tide elevations - Mean Higher High Water (MHHW) and the Mean Lower Low Water (MLLW).

Docks

Wave forces on the vertical side of a dock were estimated using three different methods. The wave forces estimated based on each of the three methods are of the same order but slightly different. As expected, all the three methods show that the wave forces increase with the design wave heights (i.e. wave force is higher for the 100-year condition compared to the 50-year condition). However, the methods are not consistent in the effect of tide elevations on the wave forces. One method shows that the wave force is slightly higher for MHHW tide compared with MLLW tide, while another method shows the opposite. Each of these methods has different assumptions so one method is no better than the others. Instead of simply picking the largest wave force for each return period as a recommended conservative design wave force for each tide elevation, one recommended design wave force is estimated as the combined average of the top results irrespective of tide elevation, i.e. there is only one recommended design wave force for each return period. The recommended wave force per unit length of dock for the 50 and 100-year wind wave is shown in Table 4.

Table 4. Wave Forces on Docks

RETURN PERIOD (YR)	WAVE FORCE PER UNIT LENGTH OF DOCK (LB/FT)
50	217
100	241

An example application of this force is provided. For a 40-ft long section of dock, the 100-year, maximum horizontal wave force would be 9,640 lbs (40 ft x 241 lb/ft). This force should be applied at the elevation of the dock connection to the pile for calculating the moment on the pile.

Boats

Horizontal wave forces on vertical sides of the boats were calculated assuming the boat draft was 6 feet with 4 feet of freeboard running the entire length of the boat. Table 5 summarizes the resulting wave forces in pounds per linear foot (lb/ft) of boat face parallel to the wave crest.

Table 5. Wave Forces on Boats

RETURN PERIOD	WATER LEVEL	WAVE FORCE PER UNIT LENGTH OF BOAT (LB/FT)
50-Year	MLLW	508
	MHHW	487
100-Year	MLLW	608
	MHHW	558

An example application of this force is provided. For a 40-ft long boat, the 100-Year, maximum horizontal wave force during a MLLW tide would be 24,320 lbs (40 ft x 608 lb/ft).

The forces on boats are not necessarily additive to forces on docks since there is a phase difference between wave impacts on the two. This concept about the wave phase differences is illustrated in Figure 6. As the 100-year wave passes the boat and dock, while the wave is at its crest at the dock (exerting maximum horizontal force), the wave motion is down on the channel side of the boat (exerting minimum horizontal force).

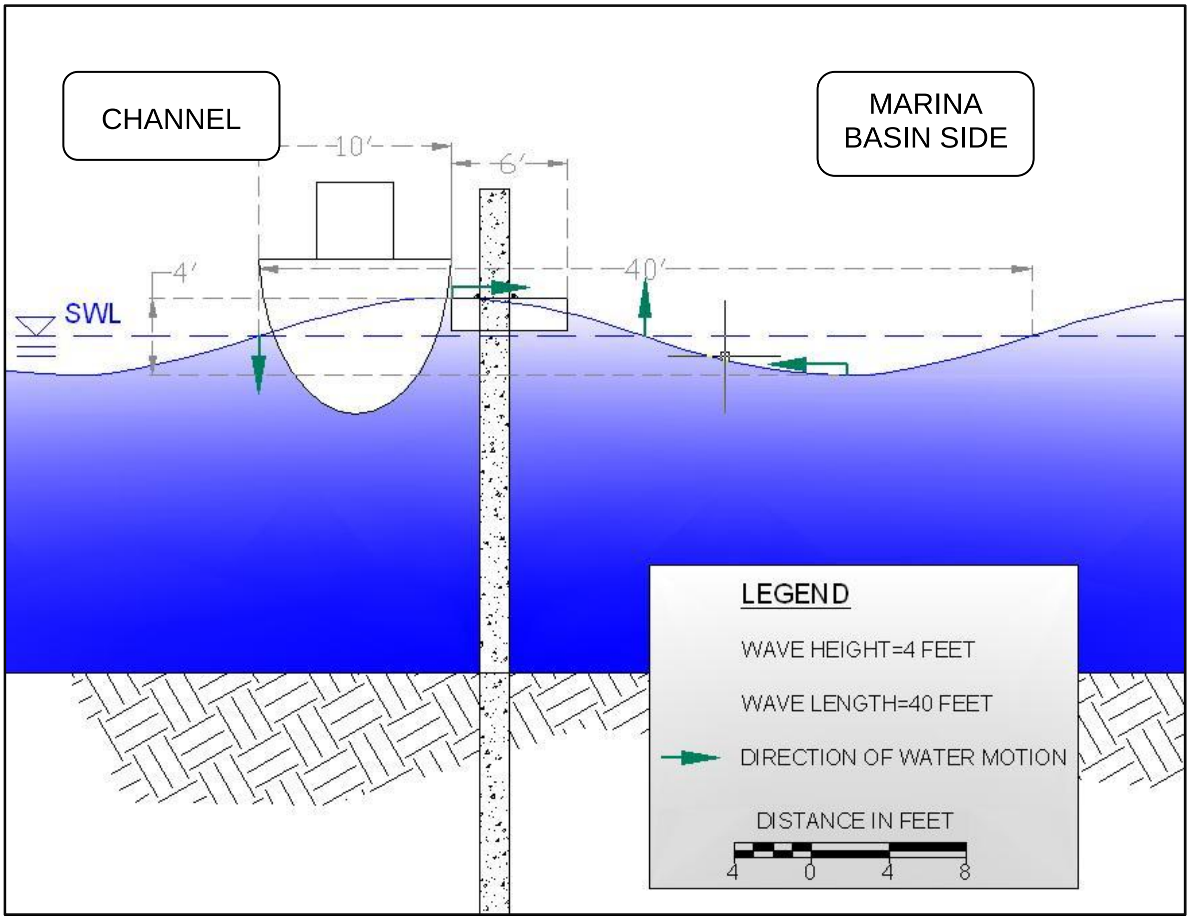
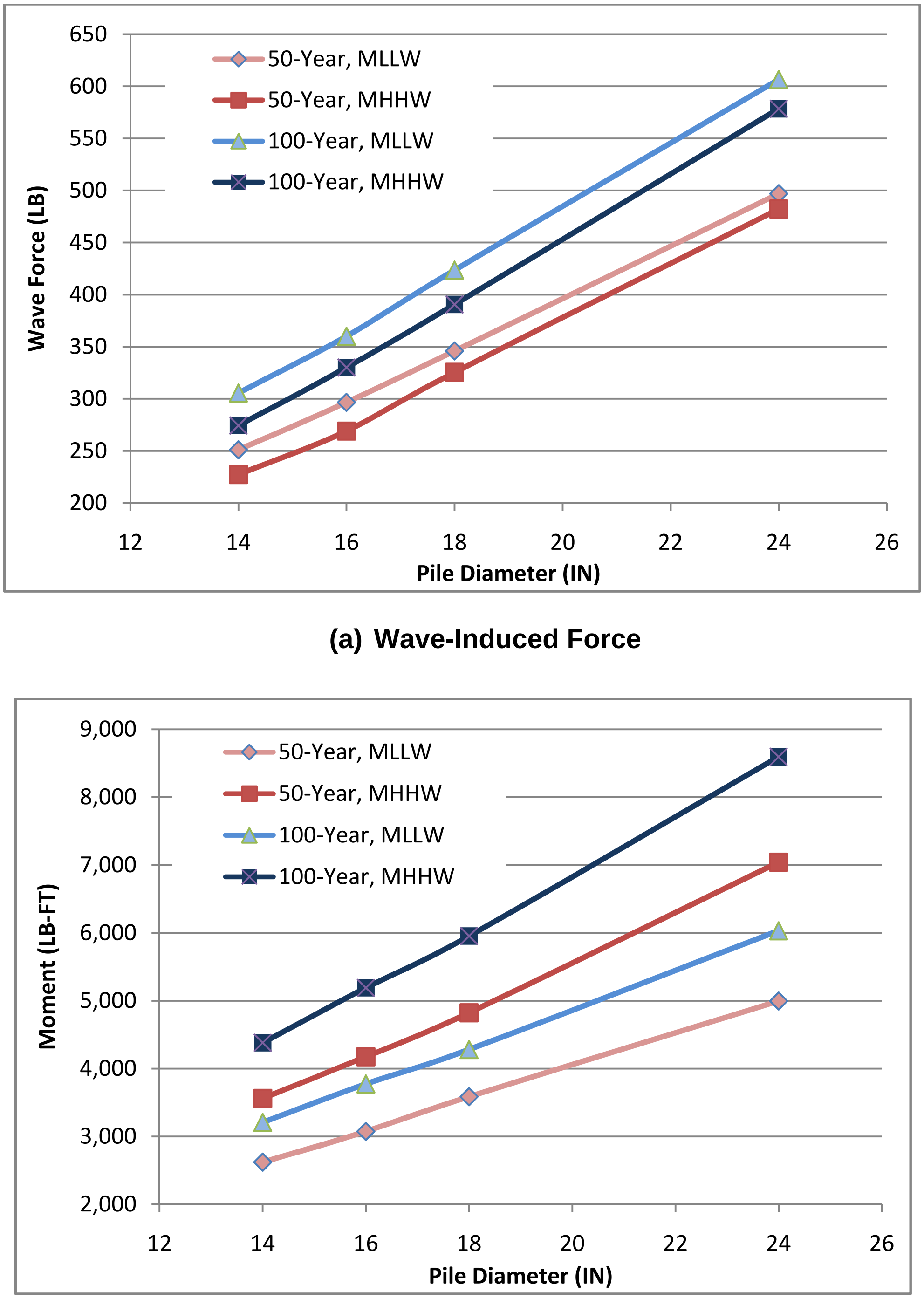


Figure 6. Phase Lag in a Cross Section of Wave Passing a Docked Boat

Piles

Nonlinear wave theory was used to calculate wave forces and moments with forces given in pounds per exposed pile above the un-scoured mud line. Figure 7 shows the wave forces and wave moments calculated for concrete piles with diameters ranging from 14 to 24 inches. Forces are the maximum possible combination of inertial and drag forces for a single vertical pile.

The wave forces and moments were calculated for a range of pile diameters so that the marina engineer can choose the most appropriate results for their purposes. The marina engineer has indicated that 16-inch diameter piles may be preferred on the most exposed docks closest to the channel (Mason 2008). The wave forces and moments on 16-inch diameter piles can be easily read from Figure 7 and the results are summarized in Table 6.



(a) Wave-Induced Force

(b) Wave-Induced Moments

Figure 7. Wave-Induced Forces and Moments on Piles

Table 6. Wave Forces and Moments on 16” Pile

Return Period (Yr)	Water Level	Wave Force on 16” Pile (lb)	Moment on 16” Pile (lb-ft)
50	MLLW	297	3,073
	MHHW	269	4,174
100	MLLW	360	3,753
	MHHW	330	5,239

3. WATER QUALITY ANALYSES

3.1 OVERVIEW

Water quality within the proposed marina basin depends on the tidal flushing capabilities or how fast “old” water in the basin is mixed with “new” water from the bay. Poor circulation and flushing can create stagnant water where pollutants could build up to undesirable levels and impact recreational or biological resources.

Water quality analyses were conducted to estimate the potential impact of the proposed marina on water quality in the immediate vicinity of the proposed marina basin and adjacent waterway. The impact of the proposed marina basin on water quality was evaluated based on the U.S. Environmental Protection Agency (EPA) guidelines for marina flushing management measures (EPA 1993). These EPA guidelines were specified to minimize nonpoint source pollution in coastal waters. Although there is no specific guideline for marina basins in Southern California, EPA guidelines for southeastern and northwestern United States suggest adequate tidal flushing to maintain water quality requires flushing reductions (the amount of a conservative substance that is flushed from the basin) ranging from 70% to 90% over a 24-hour period. In other words, the average concentration of a conservative pollutant within the marina should be reduced by 70% to 90% within 24 hours due to tidal flushing.

A hydrodynamic and water quality model was used for this study to evaluate the tidal flushing capabilities of the proposed marina basin. The model was used to simulate the reduction of a hypothetical conservative pollutant within the basin due to tidal flushing. The predicted flushing reduction was compared to the EPA guidelines,

3.2 WATER QUALITY MODELING

The two-dimensional (2D) hydrodynamic model RMA2 was used to simulate tidal elevations and circulation (currents) within Newport Bay. The tidal circulation results from RMA2 were then used to drive the water quality model RMA4 to simulate the dispersion of a conservative pollutant representing the flushing capability of the proposed marina basin.

The flushing analysis was conducted for two cases as follows:

- Case 1 – Proposed Marina Park with Existing Groin
- Case 2 – Proposed Marina Park without Existing Groin

The numerical model grids for Case 1 and 2 are shown in Figures 8 and 9, respectively. Both figures show the overall grid of Newport Bay as well as a close-up of the proposed

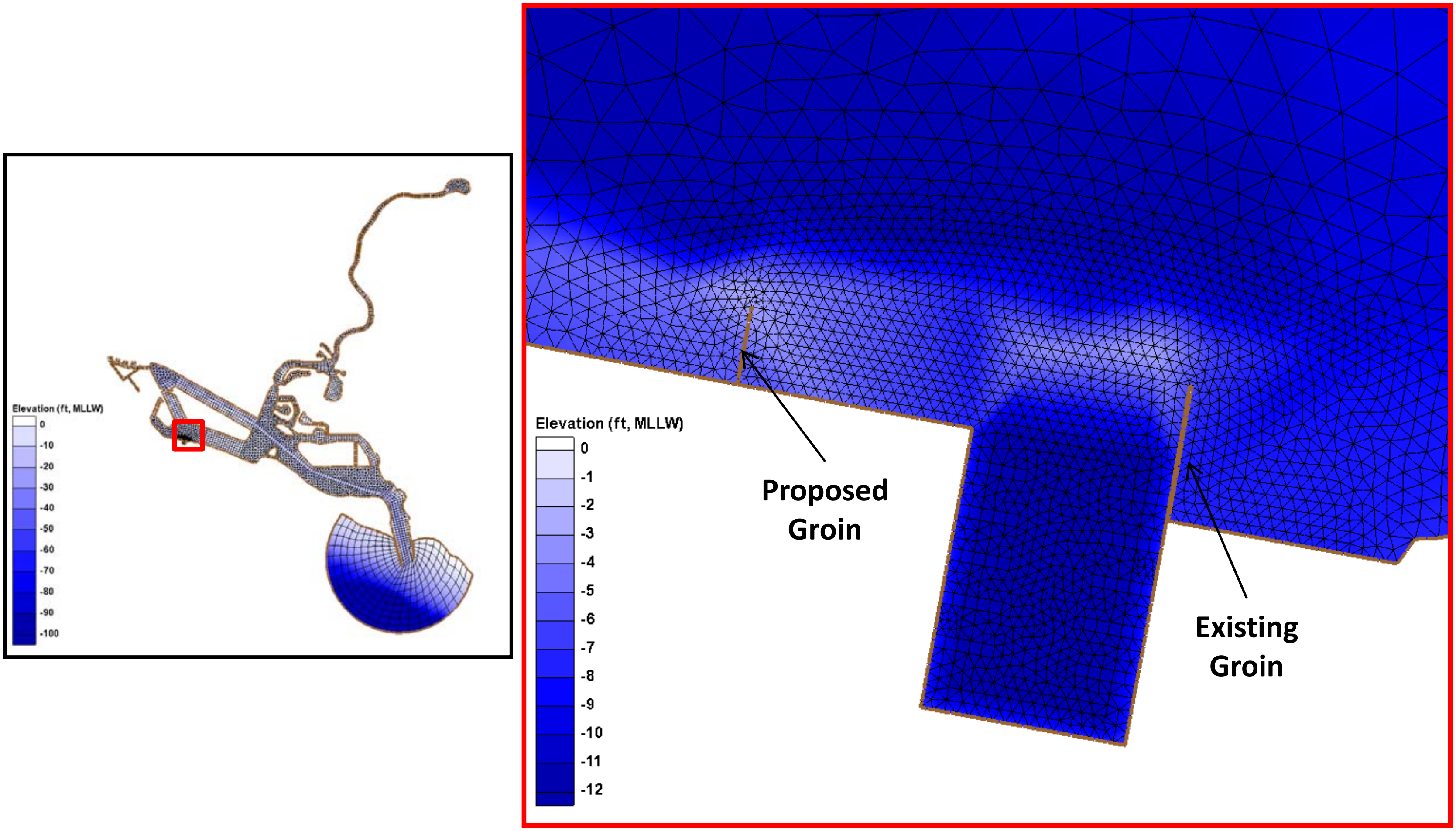


Figure 8. Numerical Model Grid for Case 1

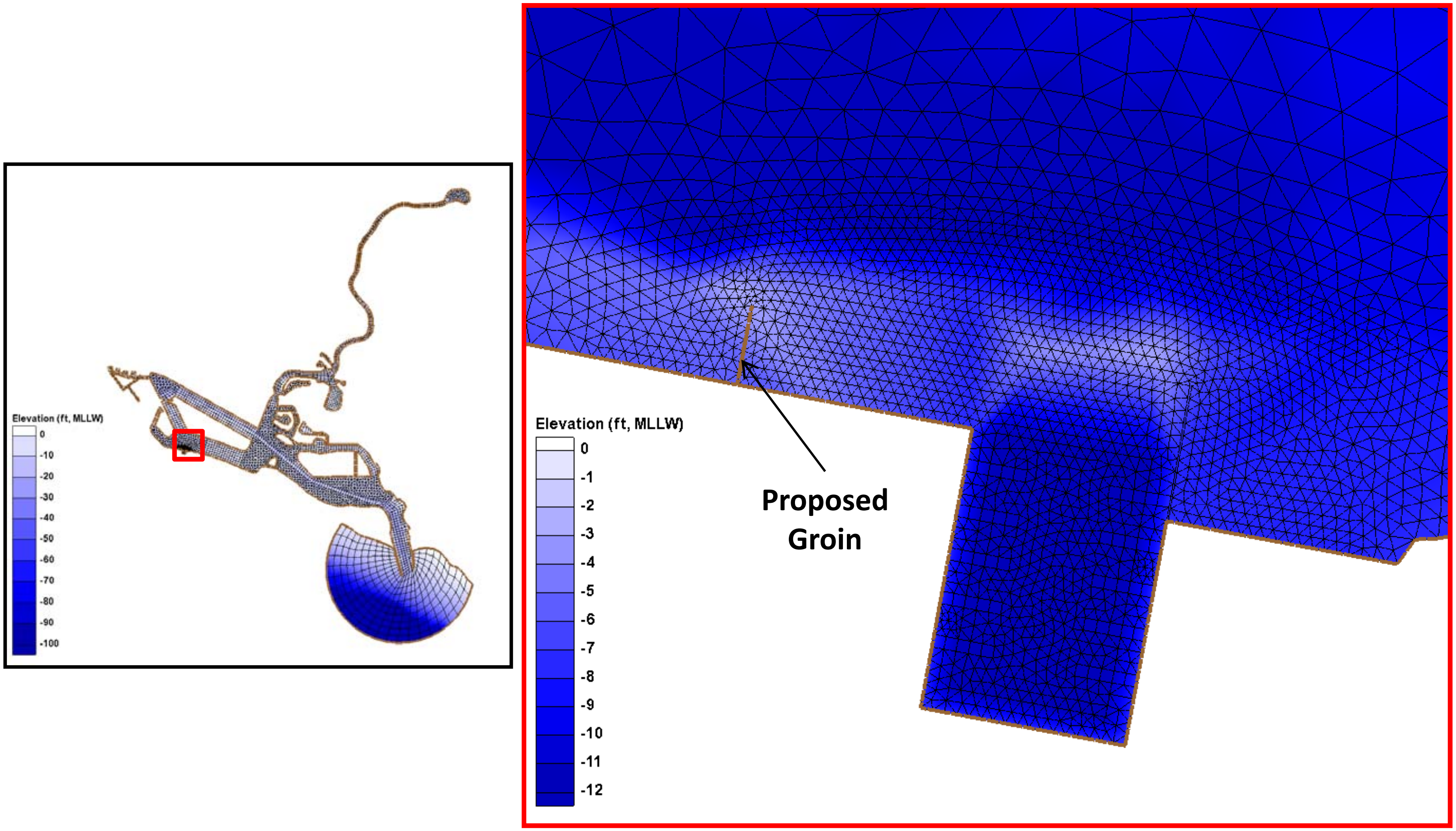


Figure 9. Numerical Model Grid for Case 2

project area where the grid has a higher resolution. Bathymetry data used in setting up the model grids were based on a composite of several data sources including: Upper Newport Bay survey data conducted by USACE in 2003, Lower Newport Bay survey data conducted by USACE in 2006, City of Newport Beach 1976 dredging plan for Newport Island Channels, proposed marina basin design depths, and National Oceanic and Atmospheric Administration (NOAA) navigation chart for Newport Bay.

Tide conditions used to determine the tidal circulation using RMA2 were based on the mean tide range for Newport Bay as shown in Figure 10. These tidal datums are from the NOAA Newport Bay Entrance (Station 9410580) bench marks for the 1983 – 2001 tidal epoch. The mean diurnal tide range represents the long-term average tidal conditions near the proposed project site. The tidal flushing simulation using RMA4 started with an initial unit concentration of a conservative pollutant tracer within the proposed marina basin. For comparison purposes between Cases 1 and 2, the initial concentration was placed between the proposed and existing groins.

The initial concentration and resulting flushing reductions for Case 1 and Case 2 are shown in Figure 11. An initial unit concentration (shown in red) of a conservative pollutant was placed between the proposed and existing groins. The flushing reductions are shown as a spatial distribution of the percent reduction of the initial concentration after one tidal cycle (24-hours). For the color scale, red indicates no reduction in concentration, while dark blue indicates 100% reduction in concentration. Based on the EPA guideline (70% to 90% flushing reduction) the blue colors indicate areas with adequate flushing while red to green areas indicate poor tidal flushing.

The flushing reduction for Case 1 with both the proposed and existing groins in place show that there is adequate tidal flushing at less than about one-quarter of the way into the basin while there is minimum flushing reduction (shown in red) farther into the basin. Poor tidal flushing conditions exist in the majority of the basin as well as portions on the east side of the proposed groin. Overall, the flushing reductions for Case 1 show an average reduction throughout the marina basin of 43% over 24-hours.

Removal of the existing groin under Case 2 improves the tidal flushing as higher flushing reductions are seen within the basin and east of the proposed groin. However, the average flushing reduction for Case 2 is only 48% over 24-hours, which does not meet the EPA guideline.

Flushing reductions within the proposed marina basin can be improved by using mechanical devices to enhance the movement and mixing of water within the basin. The use of mechanical devices to improve water circulation has been evaluated in the past for different areas in Newport Bay with poor circulation. The mechanical devices that have been evaluated include the use of mechanical pumps, and propeller-type devices (e.g. In-Streem,

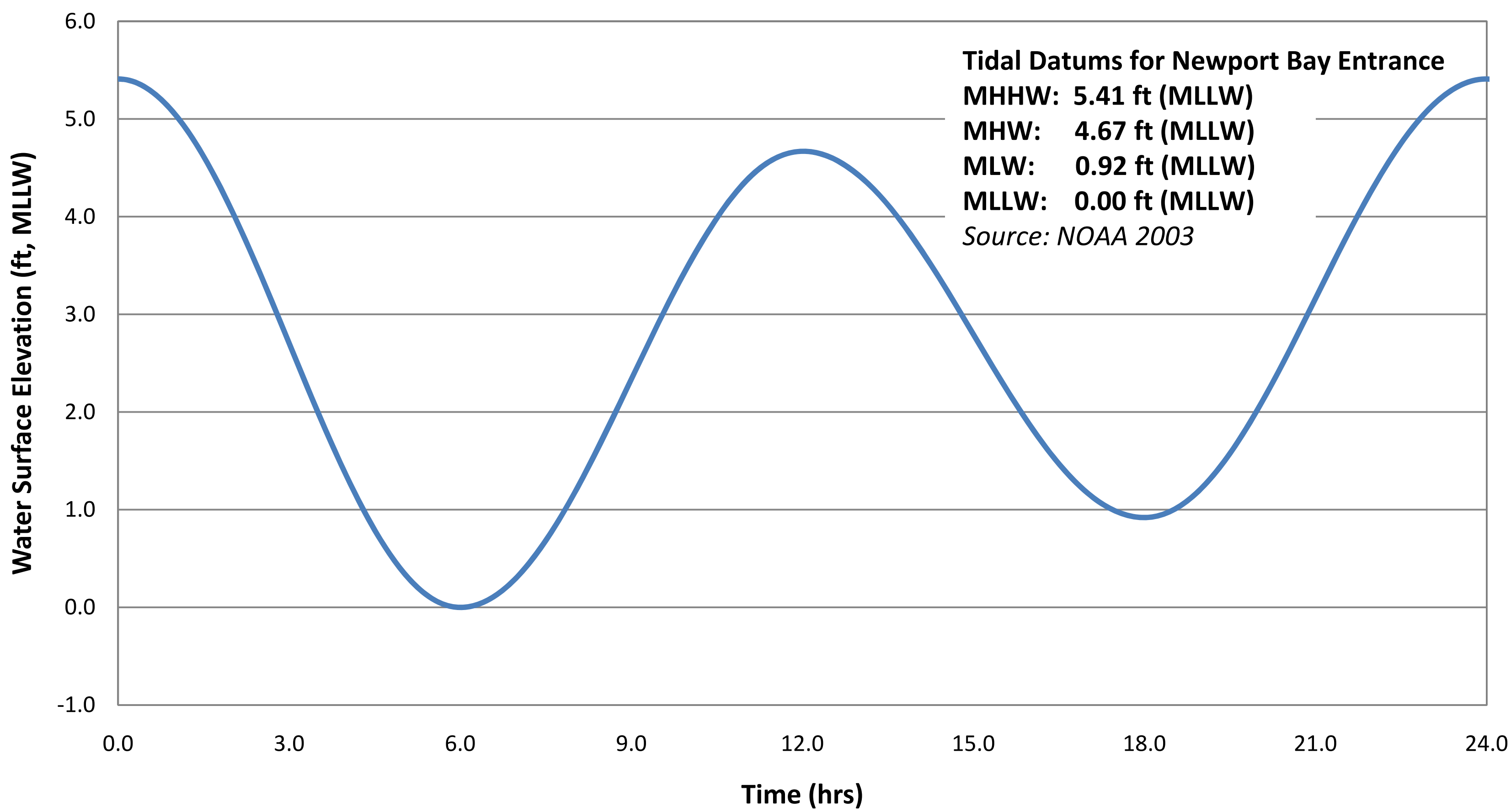


Figure 10. Mean Tide Conditions

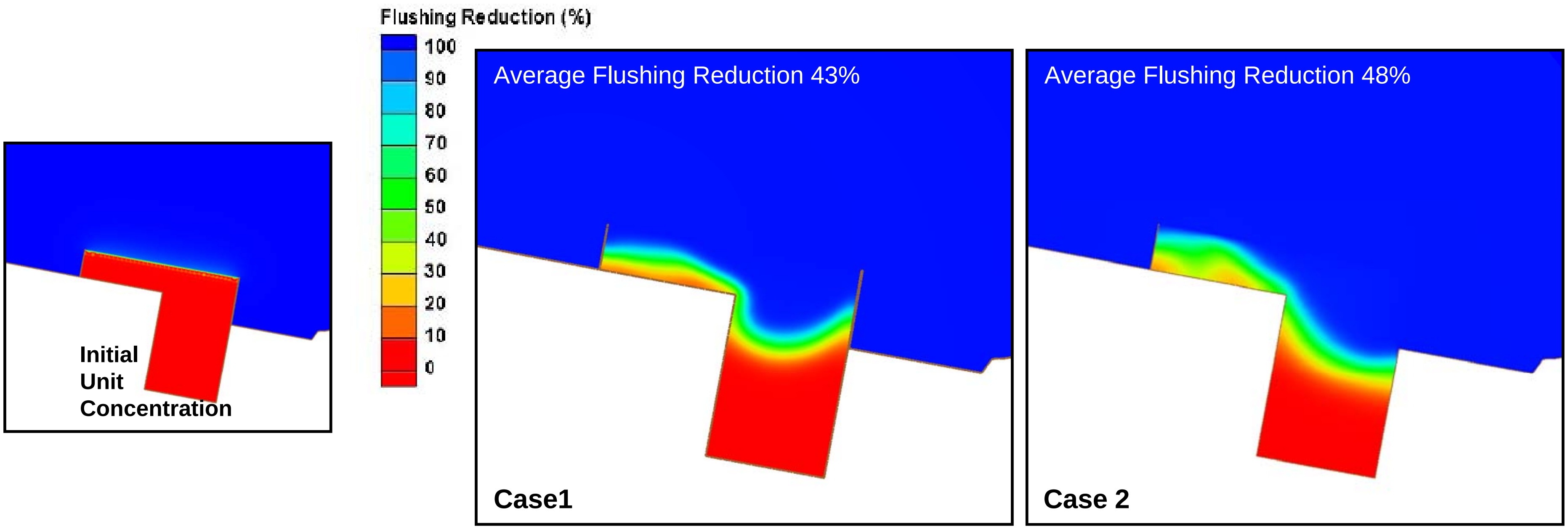


Figure 11. Flushing Reduction for Cases 1 and 2

and Oloids). Both the In-Streem and Oloid have been tested in Newport Bay and were demonstrated to be very effective in enhancing water circulation in areas with poor tidal flushing.

Additional flushing analyses were conducted with the use of four Oloids placed inside the marina basin to illustrate the potential improvement in tidal flushing that can be achieved at Marina Park. The placement of the Oloids for this example and the resulting flushing reduction is shown in Figure 12. As shown in the figure, the four Oloids were positioned at the ends of the floating docks in a clockwise direction within the basin. The spatial distribution of the flushing reduction shows a dramatic improvement in tidal flushing within the basin. The average flushing reductions in 24 hours reach 80% and 89% for Case 1 and Case 2, respectively. The circulation enhancement example shows that it is feasible to mitigate poor tidal flushing of the proposed marina basin by using mechanical flow enhancement devices such that the EPA guidelines for adequate flushing can be met. The Oloids were chosen just for demonstration so other mechanical devices could be used to achieve similar improvement. Implementation of mechanical flow enhancement devices would require further evaluation for the optimal numbers and placement locations within the basin.

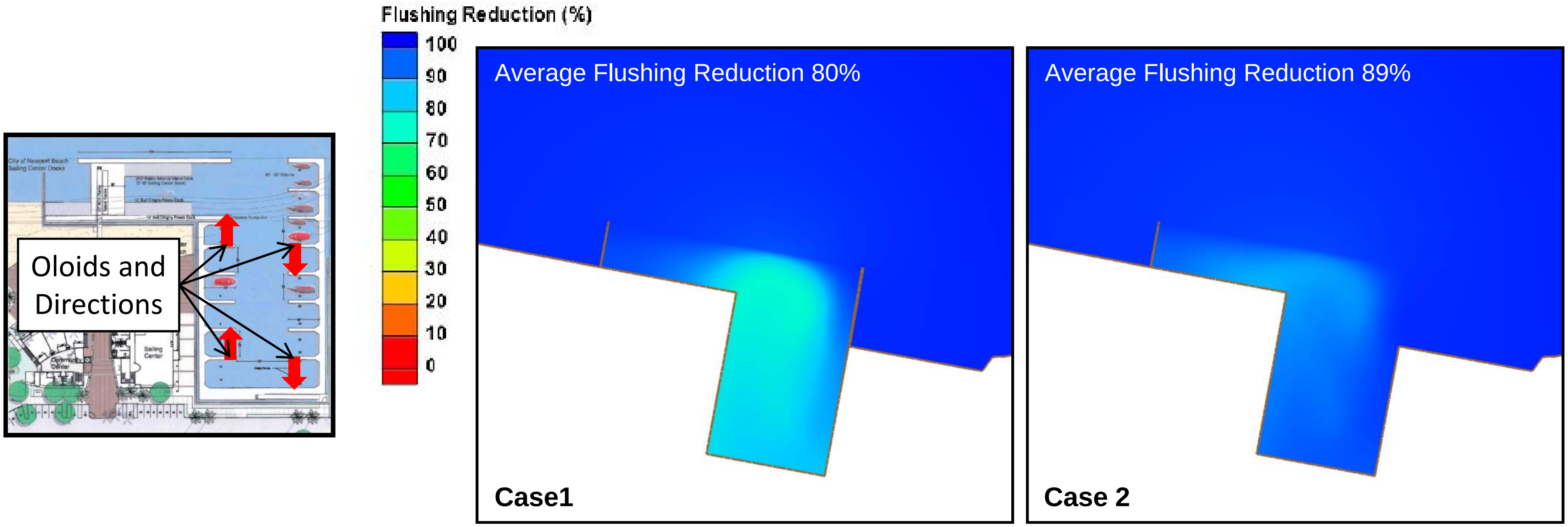


Figure 12. Flushing Reduction with Mechanical Circulation Enhancement

4. SEDIMENTATION ANALYSES

4.1 OVERVIEW

The Marina Park marina basin has a proposed groin to keep sediment moving along the existing beach area (west of the proposed groin) from migrating into the proposed marina basin. This proposed groin is the same length as an existing groin for the American Legion Post 291 marina just east of the proposed marina basin. Since the proposed groin is expected to provide similar protection for the proposed marina as the existing groin for the American Legion marina, the sedimentation conditions at the American Legion marina were first reviewed to provide an estimate of the potential sedimentation condition for the proposed marina. In addition, the hydrodynamic model described in the last section was used to establish the potential trajectory of sediment movement. This analysis was used to determine whether suspended sediment located on the west side of the proposed groin would be transported by tidal currents into the proposed marina basin.

4.2 SEDIMENT DEPOSITION AT EXISTING MARINA

The existing marina adjacent to the proposed Marina Park is called American Legion Post 291. It was originally constructed between 1958 and 1959. The marina was last dredged in 1986 and 1988 when a total of 365 cubic yards of sediment were removed from near the west and east groins (Miller, 2008). Since this last dredging there has been some shoaling throughout the marina, with a special area of concern being at the guest dock, near the existing groin. Most boats docked at the guest dock, shown in the left photo of Figure 13 currently become grounded at low tides. At other locations in the marina, deep keel sailboats also become grounded at low tides (Geensen, 2008).

Based on observations during site visits and pictures of the area (Figure 13), the existing groin serves the function of stopping most sediment transport but does not completely block sediment transport into the existing marina basin. While there is insufficient data to estimate sedimentation rates, it is safe to say that there is a long-term sedimentation problem in the existing marina basin. Since the proposed groin is expected to perform similar to the existing groin, there is a potential that some sedimentation, especially immediately east and adjacent of the groin, will occur over time.

Figure 13. Marina Neighboring Proposed Marina Park Location: American Legion Post 291

4.3 PARTICLE TRACKING ANALYSIS

A particle tracking analysis was conducted to evaluate if sediments from the beach area west of the proposed groin were mobilized/suspended (e.g. by boat activities), whether these suspended sediments would have the potential of impacting the proposed and existing marinas. The particle tracking analysis utilizes the RMA2 simulated tidal circulation results based on mean tide conditions (Section 3) to track the movement of the suspended sediments (clays and sands) released at six locations west of the proposed groin. Particle tracking simulations was conducted for the two marina layouts discussed earlier - Case 1 (with both proposed and existing groins in place) and Case 2 (with only the proposed groin in place).

Since the movement of the particles will depend on when the sediments were mobilized (e.g. during high or low tide), particle tracking simulations were conducted with the sediments released at different times (release times) of the tidal cycle – MHHW, peak ebb tide, and MLLW. Particle tracking results for the clay-sized particles for Case 1 are shown in Figures 14 to 16 for release times at MHHW, peak ebb tide, and MLLW, respectively. In each figure, each of the six panels shows the particle trajectory released at one of the six released locations for a one-week simulation period. The settling velocity of clay particles is very small and the particles remain in suspension throughout the one week simulation. As shown in the figures, sediment transport for clay-sized particles for all three release times shows the east-to-west movement reflecting the tidal oscillation, eastward during the ebb tide and westward during the flood tide, with the net sediment transport to the east. The clay particle tracking results indicate the groins are pretty effective in preventing the suspended sediments from migrating into both the proposed and existing marina basins.

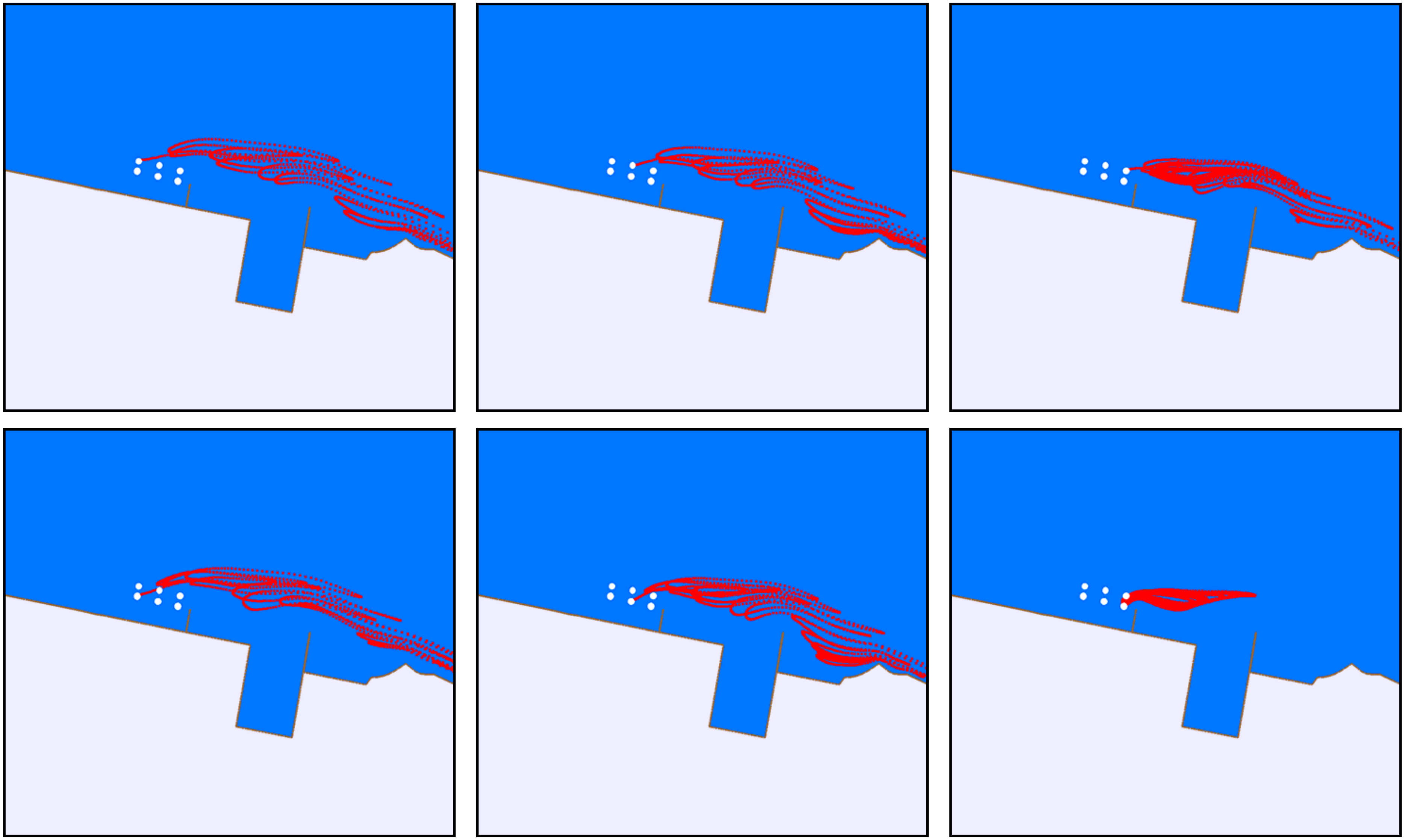


Figure 14. Case 1: Particle Tracking for Clay Particle Release at MHHW

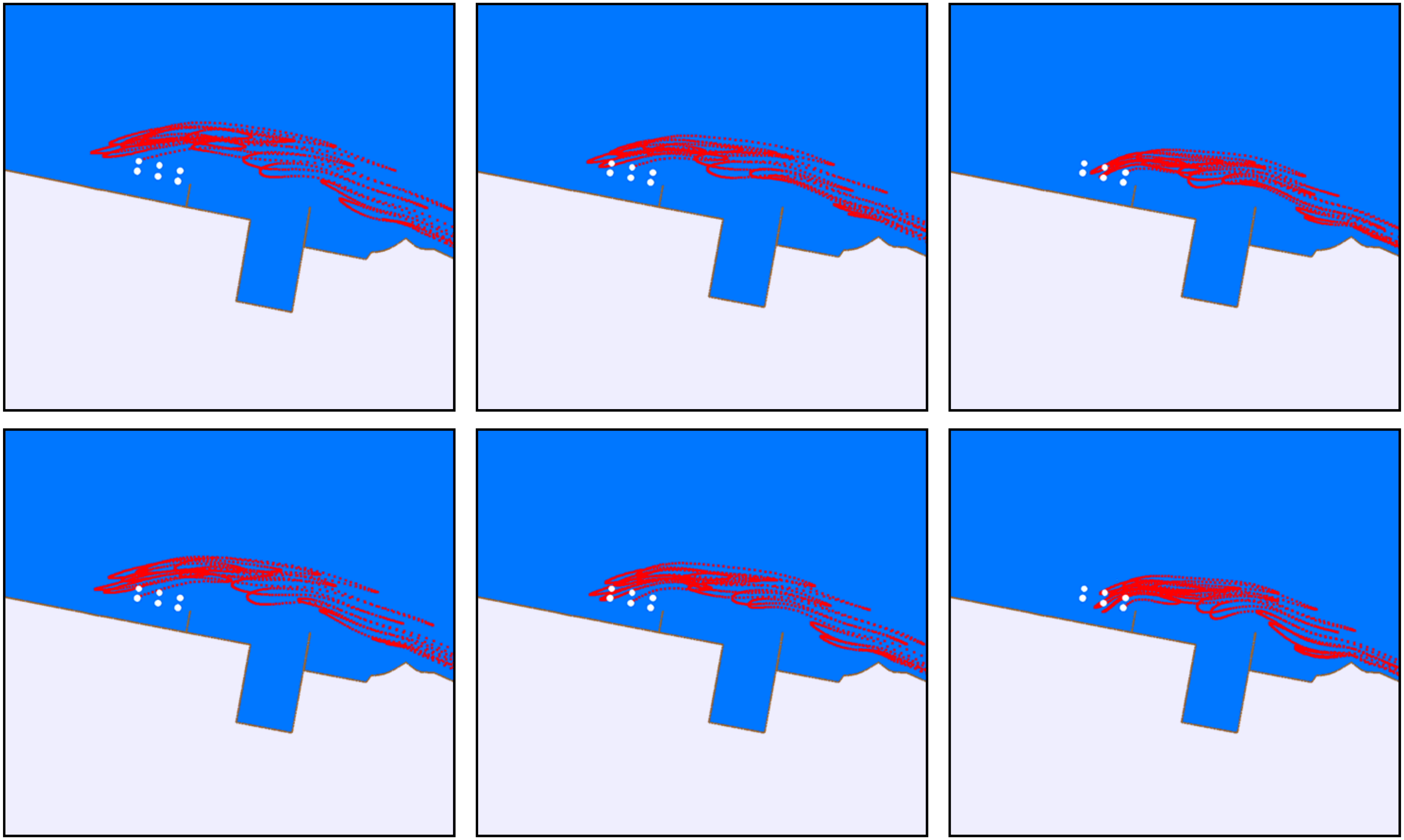


Figure 15. Case 1: Particle Tracking for Clay Particle Release at Peak Ebb

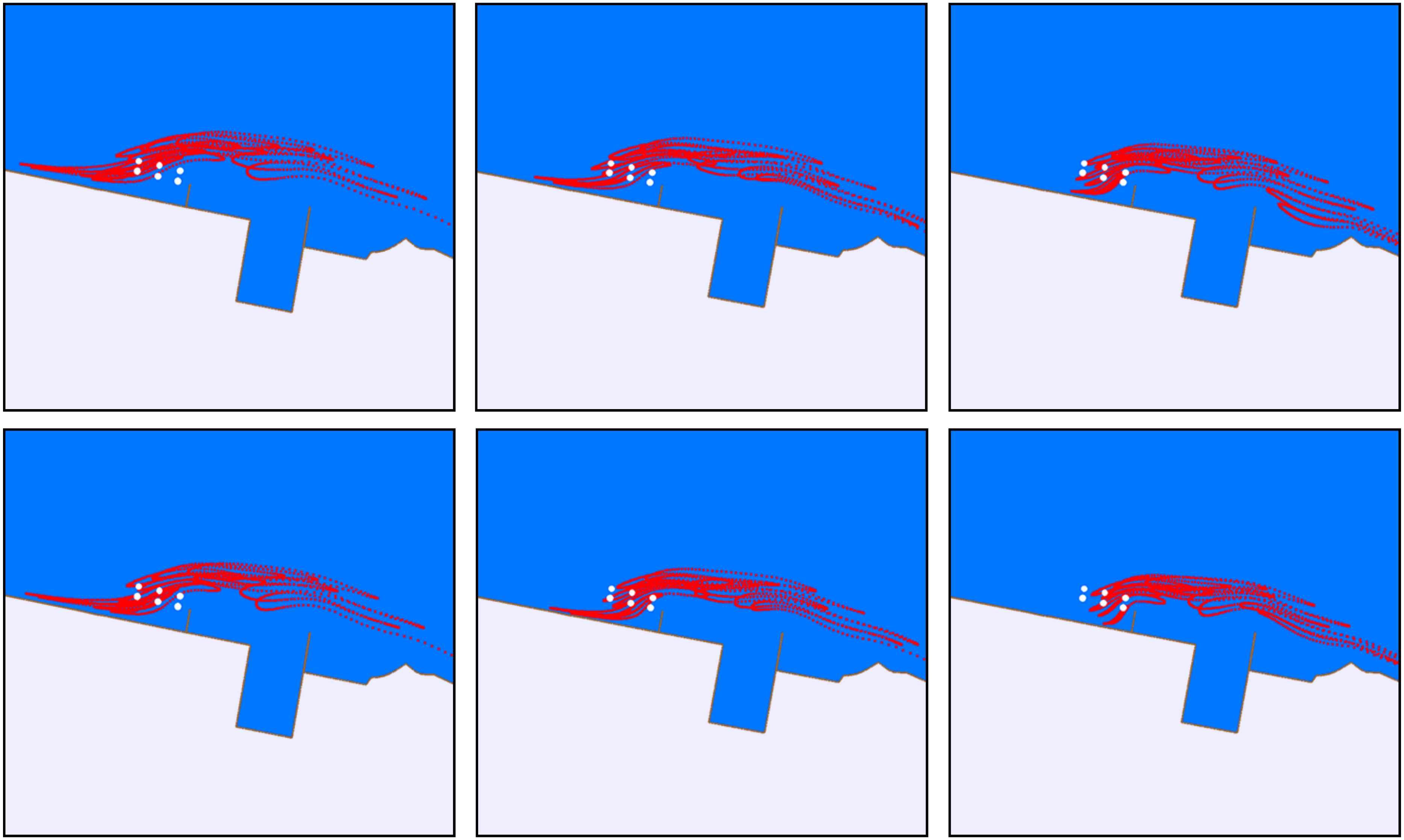


Figure 16. Case 1: Particle Tracking for Clay Particle Release at MLLW

The particle tracking results for sand particles are shown in Figure 17. In the figure, each panel shows the results for all six release locations at MHHW, peak ebb tide, and MLLW. The sand particles settled within an hour after release so the sand settled within a short distance from the release location. Particles between clay and sand would be expected to follow and settle somewhere along the paths for the clay particles.

Particle tracking results for the clay particles for Case 2 are shown in Figures 18 to 20. The results show that the proposed groin would be effective in preventing the clay particles from migrating into the proposed marina basin. However, with the removal of the existing groin, some of the clay particles would migrate into the existing marina basin. For sand particles which settle in less than an hour, the particle tracking results as shown in Figure 21 are almost identical as the results for Case 1. The sand particles settled within a short distance from the release locations.

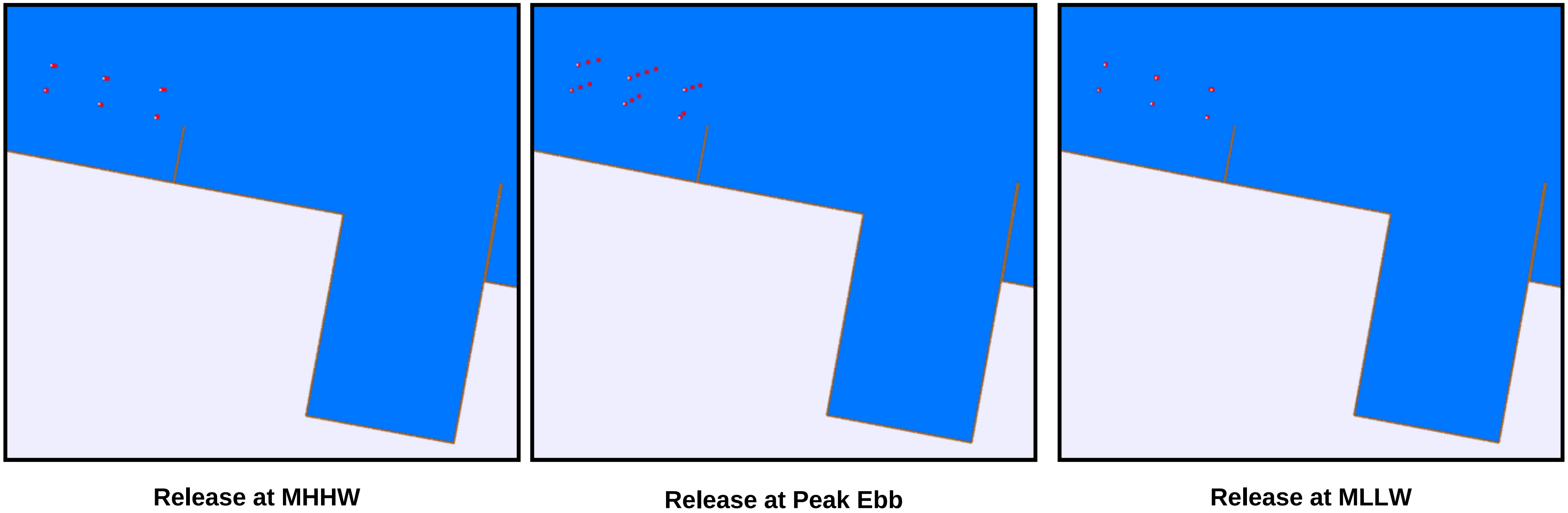


Figure 17. Case 1: Particle Tracking for Sand Particles

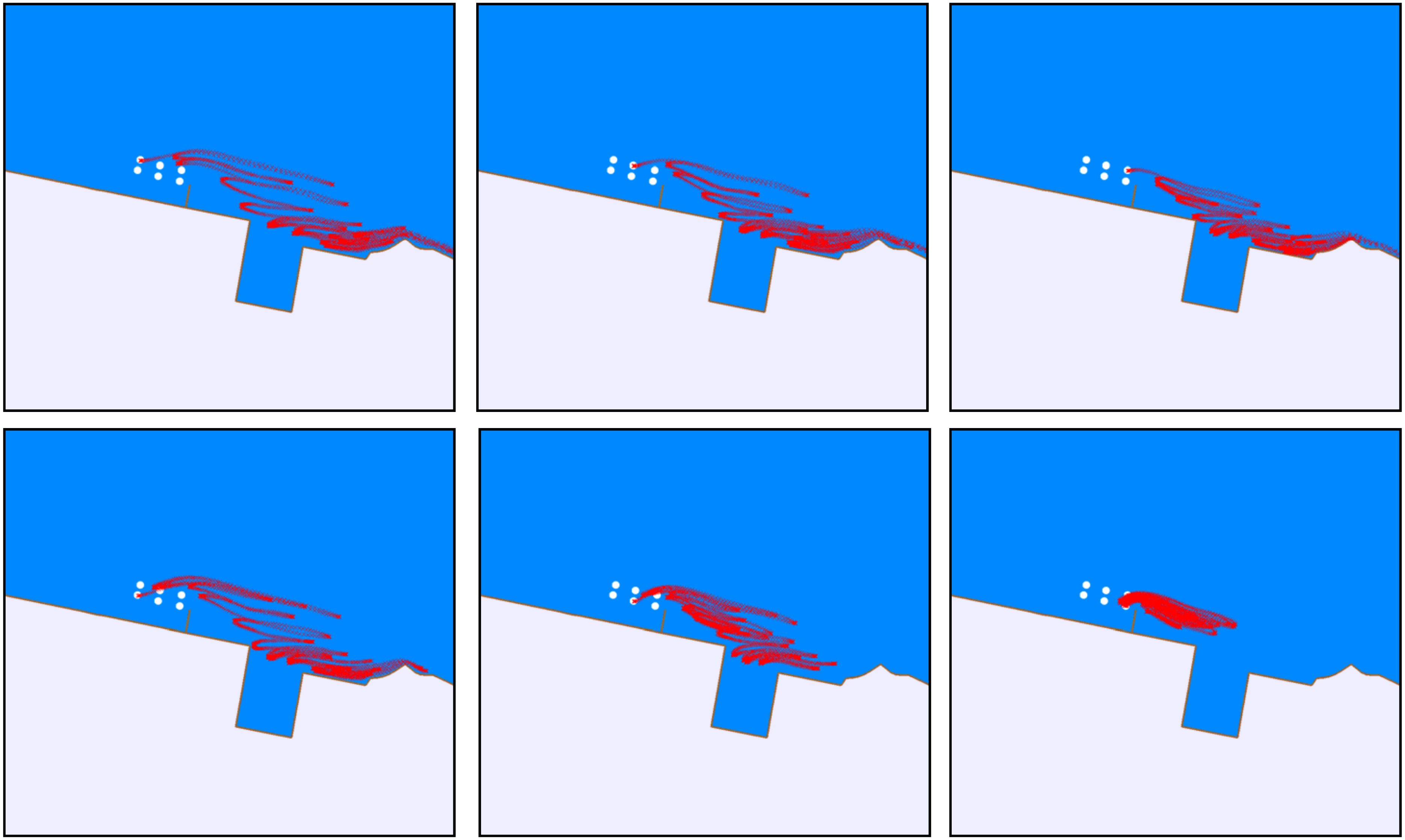


Figure 18. Case 2: Particle Tracking for Clay Particle Release at MHHW

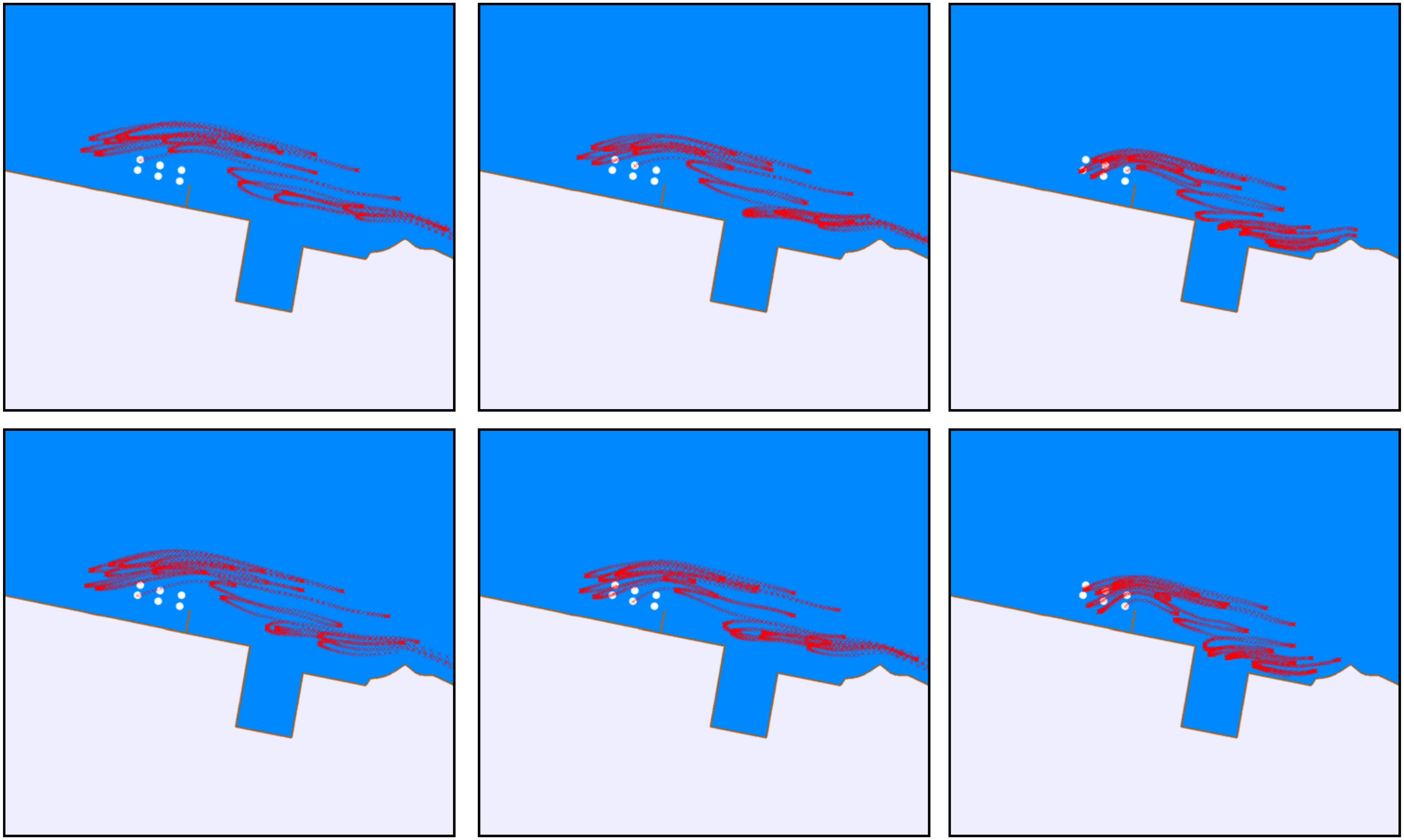


Figure 19. Case 2: Particle Tracking for Clay Particle Release at Peak Ebb

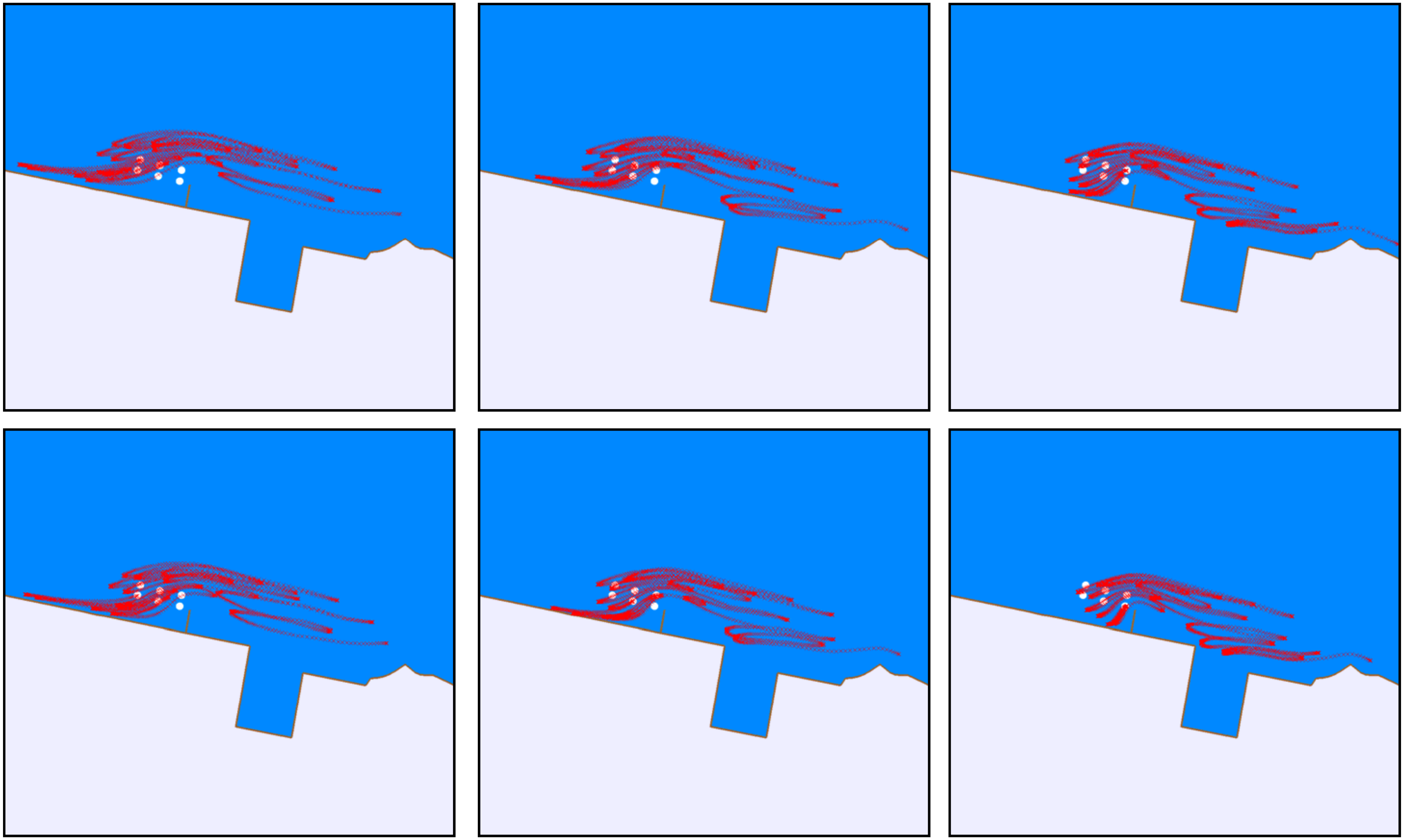


Figure 20. Case 2: Particle Tracking for Clay Particle Release at MLLW

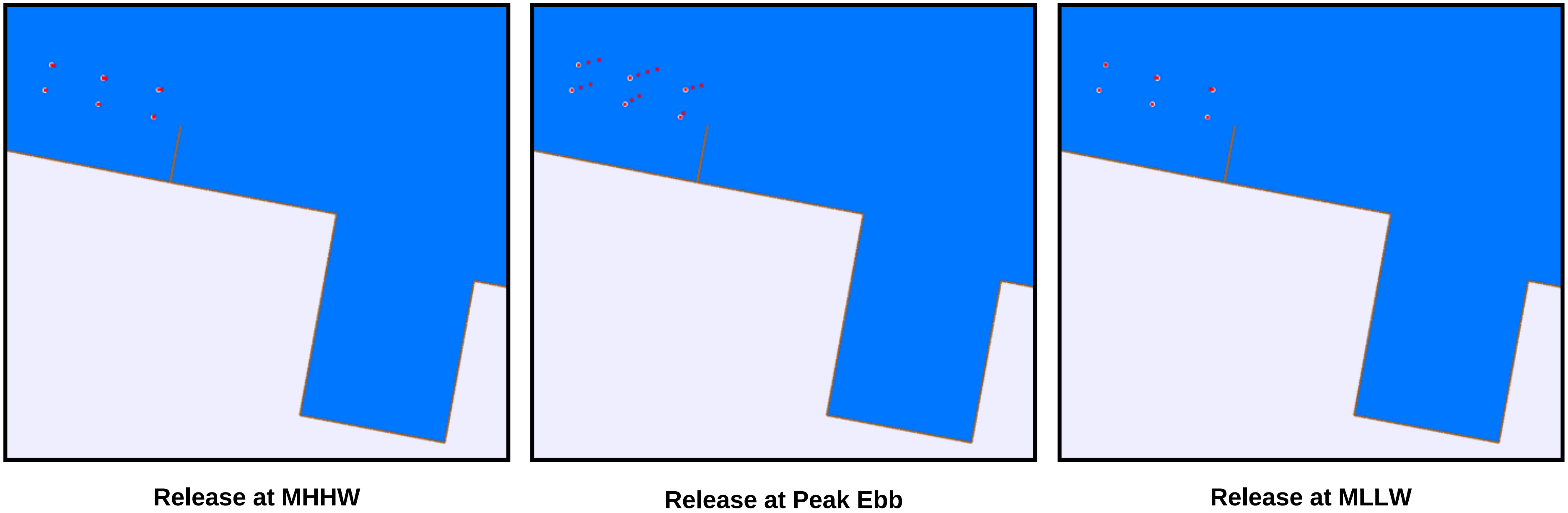


Figure 21. Case 2: Particle Tracking for Sand Particles

5. SUMMARY OF FINDINGS

This report presents the methods and findings of a coastal engineering study conducted for the proposed Marina Park boat basin in Newport Beach. The coastal engineering study evaluates the wind and ship waves at the marina basin and the corresponding wave loading on boats, docks and piles, as well as the potential water quality and sedimentation conditions of the marina basin.

5.1 WAVE LOADINGS

Operational wind winds at the basin were found to produce very small waves at the basin because most of the time, winds would be blowing across land before reaching the basin. Wind data at the nearby John Wayne Airport was analyzed to produce the extreme wind wave conditions (e.g. the 50- and 100-year return period winds) at the site. Ship waves generated by typical vessels passing the site were also analyzed and found to be smaller than the extreme wind waves. Hence, the wave loadings on the docks, boats, and piles were calculated based on the calculated extreme wind waves at the basin. Table 7 below provides a brief summary of the wave loadings at the proposed marina basin.

Table 7. Summary of Wave Forces

RETURN PERIOD (YR)	WATER LEVEL	WAVE FORCE ON DOCK (LB/FT)	WAVE FORCE ON BOAT (LB/FT)	WAVE FORCE ON 16" PILE (LB)	MOMENT ON 16" PILE (LB-FT)
50	MLLW	217	508	297	3,073
	MHHW		487	269	4,174
100	MLLW	214	608	360	3,753
	MHHW		558	330	5,239

5.2 WATER QUALITY

The water quality analyses evaluated the tidal flushing capabilities of the proposed marina basin with two different layouts - Case 1 (with both the proposed and existing groins) and Case 2 (with only the proposed groin). The results indicate that tidal flushing for both cases are rather poor and the flushing capabilities are well below the EPA guidelines which suggest adequate tidal flushing to maintain water quality of marina basins requires flushing reductions (the amount of a conservative substance that is flushed from the basin) ranging from 70% to 90% over a 24-hour period. Even though removing the existing groin (Case 2) provides slight improvement in tidal flushing over Case 1, the improvement is not enough to provide good water quality for the proposed marina basin.

It is recommended to use mechanical devices to improve tidal flushing of the proposed marina basin. As an example, addition water quality modeling was conducted to illustrate the improvement of tidal flushing that can be achieved with the use four Oloids. Figure 22 compares the flushing reductions with and without the use of Oloids for both Case 1 and Case 2. As illustrated in the figure, the use of four Oloids can substantially improve flushing for both cases and meet the EPA guideline for marina basin.

This circulation enhancement example shows that it is feasible to mitigate poor flushing of the proposed marina basin by using mechanical flow enhancement devices. The Oloids were chosen just for demonstration and other mechanical devices can also be used to achieve similar improvements. Implementation of mechanical flow enhancement devices would require further evaluation for the optimal numbers and placement locations within the basin.

5.3 SEDIMENTATION ANALYSES

Observations of existing sediment deposition conditions indicate a slow, but long-term sedimentation problem in the neighboring marina basin (American Legion Post 291). Since the proposed groin is expected to provide similar protection as the existing groin for the American Legion marina, similar long-term sedimentation is likely to happen at the proposed marina basin. The particle tracking analysis results are consistent with these observations showing there is a net sediment transport to the east along Newport Channel, bringing sediment from the beach west of the groin towards the entrance of the marina basin. In addition, the particle tracking results shows the proposed groin is effective in preventing fine sediments from migrating into the proposed marina, but the existing groin would still be important in preventing some fine sediment from migrating into the existing marina even with the proposed groin in place.

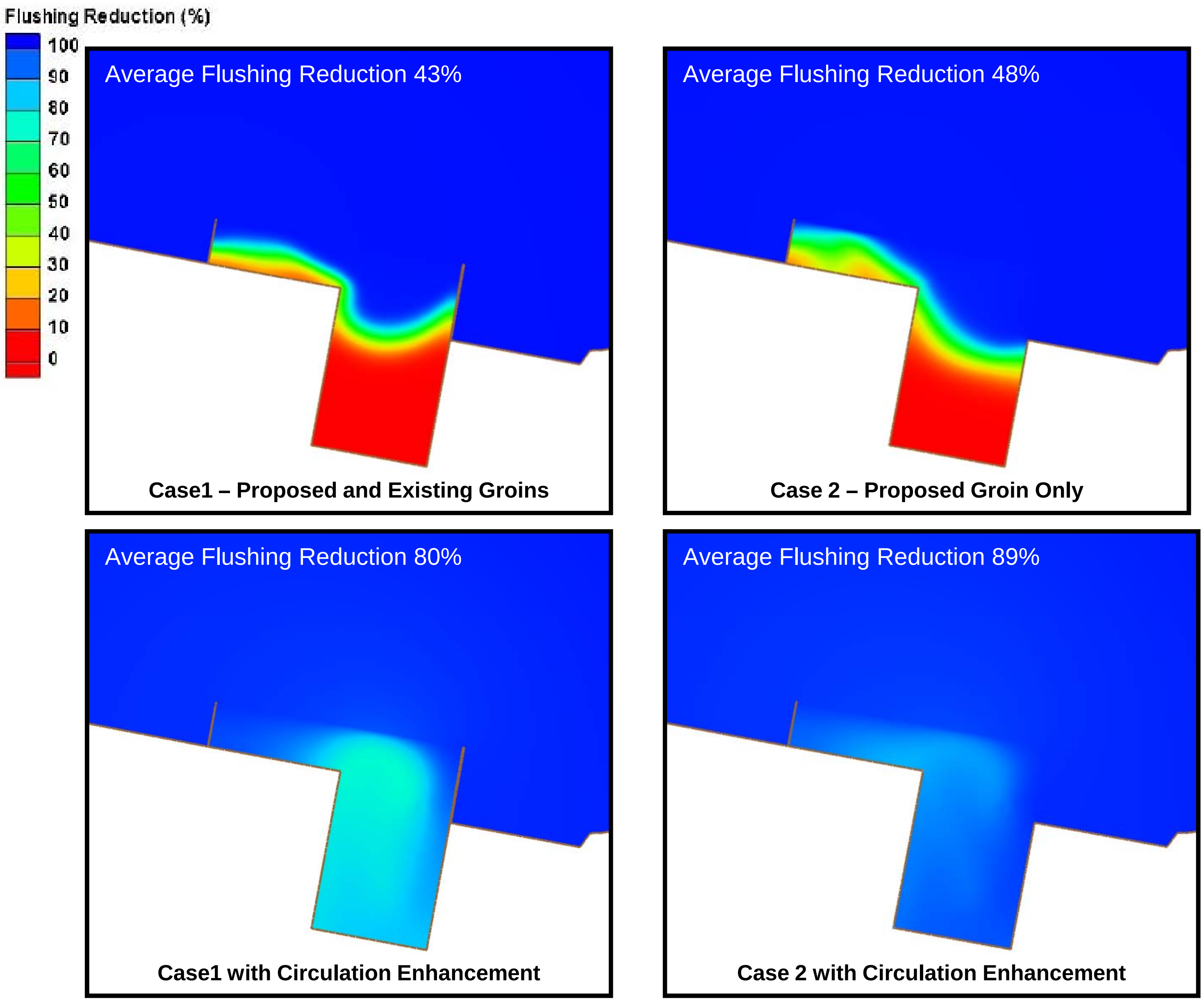


Figure 22. Comparison of Flushing Reductions

5.4 PROPOSED AND EXISTING GROINS

The Marina Park marina basin has a proposed groin to keep sediment moving along the existing beach area (west of the proposed groin) from migrating into the proposed marina basin. This proposed groin has the same length as an existing groin for the American Legion Post 291 marina just east of the proposed marina. The results of the sedimentation analysis indicate that the proposed groin would serve the purpose of preventing most of the sediment from the beach to migrate into the new marina basin. In addition, the sedimentation analysis results also indicate that the proposed groin would likely to prevent most of the sediments from migrating into the existing American Legion Post 291 marina. On the other hand, the water quality modeling results indicate that removing the existing groin could only slightly improve water circulation (hence water quality) of the proposed marina. Hence, from the standpoints of sedimentation and water quality, there is no compelling reason for either keeping or removing the existing groin.

6. REFERENCES

EPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. U.S. Environmental Protection Agency. EPA 840-B-92-002. January 1993.

Geensen, Ray. 2008. Telephone conversation June 4, 2008. Dock Master, American Legion Post 291, Newport Harbor. http://www.al291.com

Mason, Randy. 2008. URS|Cash & Associates. E-mail May 6, 2008.

Mesowest. 2008. Station H0498 Balboa Pier, University of Utah Mountain Meteorology Group. http://www.met.utah.edu/

Miller, Chris. 2008. City of Newport Beach Harbor Resources Division. E-mail 6/13/08.

NOAA. 2003. Published Bench Mark Sheet for 9410580 Newport Beach, Newport Bay Entrance. National Oceanic and Atmospheric Administration.

National Ocean Service. 2003. *Newport Beach, Newport Bay Entrance, CA, Station ID 9410580, Bench Mark Data Sheets*. Department of Commerce, National Oceanic and Atmospheric Administration. http://tidesandcurrents.noaa.gov/. April 21, 2003.

Weather Underground. 2008. History for John Wayne Airport, Santa Ana, CA, KSNA, http://www.wunderground.com/history/airport/KSNA/