**NASSCO / NSRP ASE Project**

# Demonstration of Enhanced Filtration for Treatment of Shipyard Storm Water

(Agreement No. 20000925)

## DELIVERABLE 1

## DESIGN REPORT

**July 2000**

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# Design Report
# Demonstration of Enhanced Filtration for Treatment of Shipyard Stormwater
# San Diego, California

STORMWATER MANAGEMENT

**Prepared for**
**National Shipbuilding Research Program**

**July 2000**
**J-7374**

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# DESIGN REPORT
# DEMONSTRATION OF ENHANCED FILTRATION FOR TREATMENT OF SHIPYARD STORMWATER

## 1.0 INTRODUCTION

National Steel and Shipbuilding Company (NASSCO), supported by Hart Crowser, Inc. and Stormwater Management, Inc., is conducting the National Shipbuilding Research Program (NSRP)-sponsored Demonstration of Enhanced Filtration for Treatment of Shipyard Stormwater Project at its San Diego shipyard. This Design Report presents the rationale, system description, and implementation plan for the Demonstration Project.

### *1.1 Project Purpose and Objectives*

Shipyards face increasing regulation of stormwater discharges as citizens and environmental groups pressure the USEPA and the states to implement provisions of the Clean Water Act. Shipyards are among the first industries to be targeted by the states for heavier regulation because of their high-profile waterfront locations and their necessary use of toxic antifouling compounds in hull coatings. The traditional "best management practices" — protocols to reduce pollution and effectively manage waste materials — that shipyards have long relied on will not be sufficient to comply with ever more stringent regulatory constraints on stormwater discharges. The main alternative to stormwater filtration – full-scale collection and diversion to the sanitary sewer – is far more costly and imposes additional burdens on municipal infrastructure. In response, NASSCO, in partnership with the NSRP, is studying a relatively low-cost but effective stormwater filtration technology to minimize the cost of environmental compliance at U.S. shipyards and strengthen the public's view of shipyards as environmental stewards.

In 1997, Hart Crowser, working on behalf of a consortium of Puget Sound (Washington) shipyards, conducted a laboratory-scale study of stormwater filtration (Hart Crowser, 1997). The study showed that filtration, when enhanced through the use of an adsorbent organic medium such as compost, can remove up to 94 percent of dissolved copper and zinc (toxic pollutants of concern at shipyards) and is a cost-effective treatment alternative. Although long-term performance of the system remained a question, a follow-on study at Penn State University confirmed that enhanced filtration is an alternative worthy of demonstration testing (Burgos, 1997). The NASSCO/Hart Crowser/Stormwater Management demonstration project will complete the testing cycle by documenting the performance of enhanced filtration in a full-scale, real-world shipyard application. The objectives of the project will be to provide a comparative analysis of three enhanced filtration options in a shipyard setting and to develop critical performance and cost data for the industry.

### *1.2 Site Description*

NASSCO is the largest new construction shipyard on the West Coast. Although the company's roots date to 1905, NASSCO has been building large ships for commercial customers and the U.S. Navy since 1959. NASSCO's shipyard facilities are capable of building commercial cargo ships and tankers and Navy auxiliary ships up to 1,000 feet in length and servicing or repairing any vessel sailing on the West Coast of the United States. The shipyard encompasses 79 acres of land and 47 acres of water. The shipyard is located on San Diego Bay. A vicinity map and site plan of the shipyard is shown on Drawing G-1. Tables, figures, and drawings referenced in this report are presented in numerical order at the end of the main text.

The stormwater treatment system will treat runoff from the SW-3 area and the Berth 9/10 pier. These locations are described in Section 2.

### *1.3 Regulatory Requirements*

Presently, regulation of stormwater at shipyards is in various stages of development around the country. Some yards have no specific discharge limitations and only the most basic monitoring requirements, whereas other yards have technology-based limits for conventional pollutants (such as oil & grease, and total suspended solids). A few yards have discharge limits for copper, zinc, and/or other metals. Metals limits are usually water quality-based limits intended to protect the quality of the receiving water body. With the growing emphasis on the development of Total Maximum Daily Loads (TMDLs) for regulating water-quality limited watersheds, discharge limits for metals will become more common at shipyards.

NASSCO's NPDES permit, as well as those for other shipyards and Naval facilities in San Diego, is structured to regulate the quality of stormwater using toxicity limits rather than chemical concentrations or loads. It is thought that effluent toxicity tests are a more direct measure of potential impacts to aquatic life because metals are present in a variety of forms and complexes that greatly affect the toxicity of the discharge water. NASSCO's permit limitation for stormwater is extremely stringent, and specifies essentially *no acute toxicity at the end of the pipe*. The permit includes the following specific requirements:

- Stormwater discharges shall produce greater than 70 percent survival of laboratory test species, 90 percent of the time, in acute effluent bioassay tests; and

- Stormwater discharges shall produce greater than 90 percent survival of laboratory test species, 50 percent of the time, in acute effluent bioassay tests.

- The discharge of the first flush [defined as the first 0.25 inch of rainfall] of stormwater from high risk areas shall be terminated (diverted to sanitary sewer), or

- An alternative which achieves a reduction in the discharge of pollutants to San Diego Bay equivalent to that resulting from compliance with the previous requirement for termination of the first flush (0.25-inch) shall be implemented.

Thus, the regulatory goals of the present study are to bring NASSCO into compliance with its strict stormwater toxicity limitations, and to demonstrate a lower cost technology that provides an alternative to diverting the first 0.25 inch of rainfall to the sanitary sewer.

## 1.4 Scope of Work

This project involves the design, installation, operation, and testing of an enhanced stormwater filtration system at the NASSCO Shipyard in San Diego. The objective of this project is to demonstrate a low-cost, innovative stormwater treatment technology in a full-scale shipyard application. The following tasks will be conducted:

- Task 1—Design and Permitting
- Task 2—Procurement and Installation
- Task 3—Operation and Monitoring
- Task 4—Data Analysis and Engineering Report
- Task 5—Meetings, Presentations, and Final Report

### 1.4.1 Task 1—Design and Permitting

Prepare a Design Report (this document), containing the rational for selecting process options, design details for the test units, and a operations and monitoring plan, will be prepared and submitted to a group of Technical Advisors (Figure 1). The Technical Advisors will review and comment prior to initiation of Task 2. Subtasks of Task 1 include:

**Task 1.1 Assemble Project Team.** Assemble the project team, conduct a detailed project overview, and initiate task assignments.

**Task 1.2 Conduct Drainage Survey.** Conduct a survey of drainage area SW-3 to identify drainage boundaries, available hydraulic head, and existing pipe diameter and length.

**Task 1.3 Perform Hydrologic Analyses.** Perform a hydrologic analysis of stormwater runoff in drainage area SW-3. The hydrologic analysis will identify design storms, peak hourly and average daily flows, and total storm volumes. (Summarized in Section 2 of this report.)

**Task 1.4 Contaminant Assessment.** Review and synthesize existing stormwater chemistry and toxicity data at the shipyard, focusing on drainage areas SW-3 and the Berth 9/10 Pier, to define influent/effluent requirements for the enhanced stormwater filtration system test units. (Summarized in Section 3 of this report).

**Task 1.5 Technology Assessment.** Review and synthesize available information on technologies used for removing solids and dissolved metals from stormwater and select process options for the test system. (Summarized in Section 4 of this report).

**Task 1.6 Design Filtration Test Units.** Based on review of the above site-specific information, select the test location and complete design of the filtration test units. (Summarized in Section 5 of this report).

**Task 1.7 Prepare Design Report.** Document the results of the design phase in a Design Report. Prepare a draft and final version of the Design Report.

**Task 1.8 Obtain Construction Permits.** Prior to construction, procure local permits for installation of the test units.

### ***1.4.2 Task 2—Procurement/Installation***

Stormwater flow from drainage areas SW-3 and the Berth 9/10 Pier will be split and treated through three different treatment trains. Each treatment train will consist of a solids removal unit process and a dissolved metals removal unit process in series. Subtasks of Task 2 include:

**Task 2.1 Procure Materials for Test Units.** Equipment and materials for the filtration test units will be procured following approval of the Design Report.

**Task 2.2 Install Test Units.** An approved, licensed contractor will conduct installation of the filtration system.

**Task 2.3 Prepare Installation Report.** An installation completion report will be prepared and submitted to NSRP to document completion of Task 2.

### *1.4.3 Task 3—Operation and Monitoring*

The test filtration system will be operated and monitored for two wet seasons. An operations and monitoring plan for the project is presented in Section 6. Subtasks of Task 3 include:

**Task 3.1 System Start-up.** Start-up operations of the test filtration system will be conducted. Start-up activities will include observation of proper operation of pump and hydraulic control elements using plant water prior to the first storm event.

**Task 3.2 System Operation.** The test filtration system will be operated during two rainy seasons. The filtration vaults will have no moving parts and as such will have relatively simple operational requirements.

**Task 3.3 System Monitoring.** The test filtration system will be monitored during two rainy seasons. We expect to monitor at least three storm events during each rainy season.

### *1.4.4 Task 4—Data Analysis and Engineering Report*

Following the first year of system operation and monitoring, an Engineering Report will be prepared and submitted to the Technical Advisors for review and comment. The Engineering Report will present the effectiveness of the filtration systems (percent pollutant reduction), recommended full-scale design parameters, operation and maintenance requirements, and confirmed system costs. Subtasks of Task 4 include:

**Task 4.1 Analysis of Test Results.** Hart Crowser will conduct a comparative analysis for the stormwater monitoring data collected during the test.

**Task 4.2 Engineering Report.** The results of testing will be evaluated and documented by Hart Crowser in the Engineering Report. A draft and final version of the Engineering Report will be prepared.

### *1.4.5 Task 5—Meetings, Presentations, and Final Report*

As part of industry implementation, project progress, results, and recommendations will be presented at two SP-1 Panel meetings of the NSRP and a Final Report will be submitted to the NSRP.

A schedule is presented in Section 8.

## *1.5 Project Organization*

The project organization chart is shown on Figure 1. Project roles and responsibilities for NASSCO and its subcontractors are as described below. Contact information for the key project participants is presented in Table 1.

**NASSCO** is the primary shipyard sponsor, responsible for overall project coordination and progress reporting to the NSRP. NASSCO is coordinating several subcontractors, including engineering consultants, equipment vendors, earthwork and piping contractors, and analytical laboratories. NASSCO is also providing field labor for collection of stormwater samples. **Hart Crowser** is the project engineering firm responsible for evaluation and selection of the process options for testing, final design of the filtration test units, analysis of chemical and biological testing results, reporting, and presentation of technical results at industry meetings. **Stormwater Management, Inc**. is providing equipment as well as engineering assistance during design, installation, and maintenance of the filtration test units. Chemical testing of stormwater samples will be performed by **Analytical Chemists, Inc.** and effluent bioassay testing of stormwater samples will be performed by **Ogden Environmental**.

An **Expert Advisory Panel** is providing review and consultation during all phases of the project—Gary Minton, Ph.D., stormwater engineer with Resource Planning Associates in Seattle; Jean Nichols, Ph.D., biologist/toxicologist with JNE Associates in San Diego; James Lenhart, P.E., stormwater technology developer with Stormwater Management Inc. of Portland, Oregon; and Todd Thornburg, Ph.D., stormwater hydrologist with Hart Crowser, Inc.

# 2.0 HYDROLOGIC ANALYSIS

This section presents a description of hydrologic analysis of the project site at the NASSCO shipyard, specific to the drainage areas for outfall SW-3 and Berths 9/10 where the prototype filtration vaults will be installed. The hydrologic design criteria developed in this section are used in Section 5 to size and configure the treatment system.

## 2.1 Description of Drainage Area and Hydrologic Conditions

Hirsch and Company of San Diego completed a survey of the SW-3 drainage area on May 24-26, 2000. From the topographic data generated as part of the survey, the SW-3 drainage area was delineated, and the location and elevation of existing conveyance systems were identified.

The SW-3 study area, encompassing 9.25 acres, is shown on Drawing C-1. The area is used generally for machining and parts storage. Buildings in the area include a machine shop and metal production building. There are also a number of flat concrete "tables" which are fabrication areas for large sections of vessels. The surface is generally impervious with fairly flat slopes.

The study area can be divided into four drainage subareas that each discharge to a central catch basin. Runoff flows overland or collects in drainage trenches and ditches. It was assumed that all building areas contributed runoff to the treatment system, and any runoff originating outside of SW-3 was ignored. With the exception of the northern most subarea, the drainage areas are bounded by ways, rail lines, and water edge curbs.

Rainfall statistics for San Diego show an average of 18 storms per year with an average duration of about 12 hours and average depth of 0.5 inch. Thus an average annual rainfall of 9 inches is expected at the NASSCO shipyard. The coastal rainfall is generally lower than other areas of San Diego County because, in this area, rainfall tends to increase as storms move inland.

The Berth 9/10 Pier is located north of the SW-3 area. PDS Engineering conducted the hydrologic analysis of the Berth 9/10 Pier under a separate contract. Runoff from the Berth 9/10 Pier will be collected, pumped to a storage tank, and metered to the treatment system at a peak flow rate of 90 gallons per minute.

## 2.2 Methodology for Determining the Design Storm

The permit requires toxicity reduction 90 percent of the time. It was assumed that a system could be designed to meet this criteria in two ways. The design could be based on capturing and treating at least 90 percent of the runoff volume (Percent Capture by Volume), or it could be based on capturing runoff on at least 90 percent of the rain days (Percent Capture by Time). These methods were used to determine threshold precipitation values that represented 90, 95, and 98 percent capture. The Santa Barbara Urban Hydrograph Method (SBUH) was used to calculate a peak flow rate for each of the threshold precipitation values. The design peak flow rate was chosen from the hydrograph that corresponds to the threshold precipitation value that satisfied the capture requirement.

**Percent Capture.** Estimates of threshold precipitation, percent capture, and runoff rate are shown in Table 2. Calculations are shown in Appendix A. Threshold precipitation values representing 90, 95, and 98 percent capture of the recorded rainfall for the San Diego International Airport were determined (NOAA, 2000). To calculate percent capture by volume it was assumed that, for each day, all rainfall up to a given threshold value would be captured. The total captured rainfall (which is the sum of the daily captured rainfall) was compared to total rainfall for the period of record. Percent capture by time was calculated as the number of days with rainfall greater than the threshold value divided by the total number of significant (0.1-inch) rainfall events.

### *2.3 Design Storm*

The design flow rate was calculated as the SBUH 15-minute peak discharge for the design storm event. Hydrographs were generated for each subarea and summed to obtain the overall hydrograph. The design peak flow is 4.28 cubic feet per second, which corresponds to a storm with 1.17 inches of rainfall in a 24-hour period and 95 percent capture by volume. This design storm met the percent capture criteria with respect to both volume and time. It also incorporates some over design to make up for uncertainties related to the hydrologic model since we have no site data with which to calibrate the model.

The calculated peak is likely conservative for a few reasons. First, the model used assumed that the peak flow for all four subareas occurred at the same time. However, it is likely that the peaks will not coincide, which would result in a lower peak discharge. Also, the south subarea appears to be sloped such that runoff would collect at the southern edge of the property. From the site map, there does not appear to be a means of conveying this water back to the central catch basin. The treatment system is designed to accommodate flow from the south subarea if in the event it is captured in the future.

## 3.0 CONTAMINANT ASSESSMENT

This section presents a summary of stormwater quality at the NASSCO shipyard, both site-wide and also specific to the drainage areas for outfall SW-3 and Berths 9/10 where the prototype filtration vaults will be installed. NASSCO's stormwater quality will also be compared to ambient urban runoff in the City of San Diego, as well as EPA water quality criteria.

### *3.1 NASSCO Stormwater Quality*

NASSCO has been collecting comprehensive stormwater data over the last three winter wet seasons since its current NPDES permit was issued in October 1997. NASSCO typically collects stormwater samples during two storm events each year, from eight private drainages, four pier structures, and thirteen private laterals that tie into a municipal storm drain crossing the site. In total, NASSCO has collected and analyzed over 100 samples of stormwater during the last three years. Fifty-six of these samples were also analyzed for acute toxicity.

Summary statistics for NASSCO's stormwater are presented in Table 3. This table includes site-wide stormwater quality data, as well as stormwater quality specific to drainage SW-3 and Berths 9/10 (study area).

**Chemical Concentrations.** A comparison of concentrations in the study area with the shipyard as a whole shows that *the study area is reasonably representative of the shipyard.* With the exception of tributyltin (TBT), average concentrations in the study area are within a factor of two compared to the average concentrations site-wide. Moreover, the average concentrations in SW-3, which accounts for the majority of the runoff that will be treated, are all equal to or greater than the 50th percentile value for the site, with the exception of zinc which is just below the 50th percentile. Therefore, roughly half the site would be considered a lower risk for water quality impacts. Note that the arithmetic averages presented in the table are typically between the 50th and 75th percentiles, because a few anomalous spikes in concentration can significantly drive up the average.

**Effluent Toxicity.** As per NASSCO's NPDES permit, stormwater discharges are regulated on the basis of effluent toxicity, not chemical concentration or mass load. Effluent toxicity is measured in terms of "percent survival" of a laboratory test species cultured in stormwater over the course of a 96-hour acute toxicity test. Specifically, NASSCO's stormwater must exhibit 70 percent survival 90 percent of the time, and 90 percent survival 50 percent of the time in such tests.

NASSCO's stormwater falls short of this standard, not surprising since urban runoff from most municipalities cannot meet such a stringent criterion (see Section 3.4, below). Site-wide, NASSCO's effluent toxicity tests average about 40 percent survival. The SW-3 drainage is slightly better at 56 percent survival, and the drainage from Berths 9/10 is better still at 78 percent survival. However, these basin-specific statistics are based on small data sets that inherently contain a higher degree of uncertainty. To curtail this toxicity and comply with NASSCO's permit limitations, the chemical constituents causing the toxicity must be identified so that filtration technology can be tailored to effect their removal, as discussed in the following section.

### 3.2 Comparison with EPA Water Quality Criteria

Unlike some shipyards, NASSCO's NPDES permit does not contain specific limitations for chemical concentrations in stormwater. However, NASSCO's stormwater quality is compared below with EPA Water Quality Criteria (WQC) to determine which chemicals are likely responsible for the observed toxicity. EPA's WQC for metals are published in EPA (1999). The metals criteria have been converted to a "total metal" basis using the conversion factors presented in this document. Only a draft criterion is available for tributyltin (TBT) (EPA, 1997). The criteria presented in Table 2 are *acute* WQC. During NASSCO's appeal of its permit, the California State Water Quality Control Board determined that *chronic* criteria were not applicable to stormwater discharges, because such discharges are short-lived and variable.

NASSCO's "Average Water Quality Exceedence" is presented in Table 3 for the shipyard metals of concern (including TBT). The "Average Water Quality Exceedence" is the ratio of the average site-wide concentration divided by the respective WQC. On average, copper is 84 times higher than its WQC, and zinc is 25 times higher. Nickel is a lesser concern at the shipyard, averaging 3.5 times its WQC. Lead and TBT are actually below their respective criteria, on average, although isolated samples will spike above the criteria, as indicated by the maximum values for these contaminants. Thus, *copper and zinc, and particularly copper, are the likely cause of the observed toxicity at the shipyard.*

### 3.3 Threshold of Toxicity in Shipyard Stormwater

EPA's WQC are based largely on laboratory studies of toxicity in which the test waters are spiked with toxic metals in a form that is readily assimilated by the test organisms. In contrast, shipyard metals have a much lower bioavailability because they are bound up and sequestered in sandblast grit and paint chips. It is therefore expected that toxic effects will not be observed until the metals in shipyard runoff are present at concentrations significantly higher than their WQC.

The threshold of toxicity can be roughly estimated by analyzing the "cause and effect" relationship between copper concentrations and percent survival in acute toxicity tests. Percent survival decreases as the copper concentration increases. Although stormwater data contain a high degree of variability, the available data suggest that copper concentrations of about 0.03 to 0.05 mg/L would result in 70 percent survival in toxicity tests, as required by NASSCO's permit. This corresponds to approximately *90 percent reduction in influent copper concentrations to meet permit requirements.* Additional bioassay data collected during this study should allow us to refine the estimated toxic threshold concentrations for copper and zinc.

### 3.4 Comparison of Shipyard Stormwater with Ambient Urban Runoff

Copper and zinc are routinely detected in urban runoff from all metropolitan areas, moreover, these metals are routinely present at concentrations above their respective WQC. Two sources of urban runoff data are available. NASSCO has been collecting samples of municipal stormwater upgradient of the facility because a portion of NASSCO's runoff commingles with municipal stormwater that enters the shipyard at 28th Street and crosses the facility ("Harbor Drive Urban Runoff"). In addition, four years of stormwater monitoring data were compiled from City of San Diego NPDES monitoring reports ("City of San Diego Urban Runoff").

It is clear from these statistical summaries that urban runoff in San Diego routinely exceeds WQC for copper and zinc. For example, average and 90th percentile copper concentrations in the City of San Diego are 0.04 and 0.09 mg/L, respectively, compared to a WQC of 0.006 mg/L. Average and 90th percentile zinc concentrations are 0.23 and 0.55 mg/L, respectively, compared to a WQC of 0.095 mg/L. The quality of urban runoff should be considered in evaluating the effectiveness of stormwater treatment at shipyards and the relative contributions of metals loading to the bay.

## 4.0 TECHNOLOGY ASSESSMENT

In this section, available technologies for treatment of NASSCO shipyard stormwater are identified and screened based on potential effectiveness and technical feasibility. The scope of this pilot study will investigate filtration of stormwater. Therefore, infiltration, discharges to the sanitary sewer, reuse as process water, or other non-treatment methods of managing stormwater are not considered. Because previous laboratory studies showed that filtration performance was highly dependent on suspended solids (Hart Crowser, 1997), first available solids removal technologies are evaluated for TSS removal performance as pre-treatment. Then, various filter media are evaluated for dissolved copper and zinc removal.

The criteria used to screen the stormwater treatment technologies are defined as follows:

- **Effectiveness.** Eliminate technologies that lack demonstrated ability to remove the target contaminants from stormwater. In the event a technology has the capacity to remove both solids and metals, its overall effectiveness will be considered; and

- **Technical Feasibility.** Eliminate technologies that cannot be installed because of site constraints or are undemonstrated or difficult to implement.

## 4.1 Technology Background

Constituents of concern in shipyard stormwater include copper, zinc, lead, total suspended solids (TSS), and oil and grease (O&G). The metals—copper and zinc—are especially problematic from a treatability standpoint. Treatment options to address metals in stormwater discharges are typically expensive and require significant space. The demonstrated technology for removing metals from industrial waste streams is chemical precipitation followed by sedimentation; however, this is not a practical option for shipyard stormwater because of its large volume and relatively low but variable concentrations. An alternative treatment technology—implementable and economical—is needed to remove metals from shipyard stormwater.

Filtration is of interest for the treatment of stormwater runoff because filters are effective during intermittent flows, and because they can be readily implemented in below-ground, gravity-flow configurations. Sand filtration has been shown to be effective for treating runoff from urban and commercial areas. However, shipyard stormwater differs significantly from urban and commercial runoff because of potentially higher concentrations of copper and zinc and the large but variable fraction of dissolved metals. Recently, organic-based (enhanced) filtration media have become available that are more effective than sand in removing dissolved metals. Enhanced filtration media have been produced from leaf compost, peat, and other humic substances. Only limited stormwater treatment testing has been conducted using the enhanced filtration media to date. Most of this testing has involved small catchments in urban or commercial areas.

In 1997, Hart Crowser was hired by a group of shipyards in the Puget Sound region of Washington State to conduct a bench-scale treatability study of enhanced filtration of stormwater. The study involved stormwater from two active shipyards and involved use of three different organic-based filtration media. Results of the study contained in the final report dated May 7, 1997, showed that the media were able to remove up to 97 and 94 percent of the dissolved copper and zinc, respectively, but that long-term performance was strongly dependent on solids loading. The conclusion of the study was that enhanced filtration was a cost-effective alternative for treatment of shipyard stormwater. The main data gap from the study involved the long-term performance of the system under dynamic hydraulic, solids, and chemical loading. The proposed demonstration project would address this data gap and document the performance of enhanced filtration in a full-scale, long-term, shipyard application.

A subsequent study conducted by Dr. Burgos at Penn State evaluated the feasibility of using porous adsorbents to remove dissolved heavy metals from shipyard stormwater. Batch testing was conducted to measure adsorbent capacity, sorption kinetics, and contaminant breakthrough characteristics of copper and nickel using two microporous, carbonaceous adsorbents. Results of the study completed in December 1997 confirmed that enhanced filtration of stormwater is a viable alternative worthy of demonstration testing.

Stormwater Management, Inc. has been designing, installing, and monitoring enhanced stormwater filtration systems since 1991. Based on the performance of earlier prototype systems, installed in transportation corridor and commercial applications, they have applied research and development efforts to optimize system design and filter configuration. In pollutant removal tests conducted at the University of Alabama at Birmingham, the compost media marketed by Stormwater Management was one of the most effective media in removing copper (Water Environment Federation Conf., October 1997). Stormwater Management has continued to collect performance data for enhanced filtration systems and is undoubtedly the U.S. leader in the field.

## *4.2 Identification and Screening of Solids Removal Technologies for Pre-treatment*

When treating stormwater for metals, it is regularly recommended that pre-treatment be provided. This helps extend the life of the filter by minimizing the particulates that reach them and it helps protect the filters from unexpected flushes of solids. There are a number of available technologies for solids removal. General technology categories are discussed below.

### *4.2.1 Identification of Technologies*

**Standard Settling Units** include detention ponds and wet vaults. They provide detention and storage to allow solids to settle out.

**Biotreatment Units.** Biotreatment of stormwater utilizes the filtering capacity of plants and root zones to remove solids from stormwater. It can include bioswales, artificial wetlands, and proprietary products. One example, called

StormTreat, allows the stormwater to flow through a vegetated gravel layer, which acts much like a compact artificial wetland.

**Enhanced Settling Devices** are proprietary devices that improve settling conditions and usually require less space than a standard vault. The units can generally be categorized as either wet vaults with improved hydraulic conditions, swirl concentrators, or tangential screening units. Improved wet vaults use baffles and weirs to minimize resuspension of sediment. Swirl concentrators utilize the improved settling conditions of swirling water to increase settling and decrease resuspension of particles. A tangential screening unit utilizes swirl technology and screening. The incoming water swirls around the center of the unit and then filters out through a screen.

**Catch Basin Inserts** are simple units that can be installed in existing catch basins to provide additional storage capacity or improved settling conditions.

**Filtration Media.** Filtration is an effective method for solids removal. Specific types of filter media reviewed include fabric, perlite, and CSF (compost filter media). The type of filter fabric reviewed was a pleated polyester fabric that has weave openings between 30 and 70 μm. The fabric can be washed and reused. Perlite is a naturally occurring volcanic ash with many small channels and pores. This multicellular structure provides a high surface area for adhesion of oil and grease. Suspended solids tend to become trapped in the pores. The CSF compost media consists of pellets of composted leaves. Similar to the perlite, its multicellular structure tends to trap suspended solids. The compost material has also been shown to have a high capacity for adsorbing organic materials.

### 4.2.2 Screening of Technologies

Results of the initial screening are shown in Table 4. Standard settling units, biotreatment units, catch basin inserts, and sand filtration were eliminated based on technical feasibility concerns. Many of the swirl regulators and physical separators were eliminated because of insufficient performance data. The technologies retained for detailed analysis included the filtration media and most of the enhanced settling units.

Table 5 shows the detailed screening of technologies for solids removal pre-treatment. The perlite, filter fabric, and compost media were selected for use in the pilot study based on media performance and technical feasibility. Findings for specific technologies are described below.

**Enhanced Settling Devices.** Based on available data, enhanced settling does not appear to effectively remove solids at low TSS concentrations (<50 mg/L). While data for some of the devices showed performance that was similar to the performance of filter media, these devices are generally intended for gross solids removal. In addition, they also lacked the single vault implementability or additional metals removal advantages that filter media provide.

Three of the five units reviewed in the detailed screening had usable data. The Continuous Deflective Separation (CDS) unit, a tangential screening device, has been independently tested. It performed well, removing 70 to 84 percent of incoming solids. However, the results may not be applicable to this site because the influent concentrations were much higher than those expected at NASSCO.

Results from a field test on the Stormceptor, an improved wet vault unit, suggested potentially good performance at low TSS concentrations. This, however, was based on only two grab samples. Overall efficiency for that study was good, but the average influent concentration for all samples was 200 mg/L. Another study showed good removal but at a very low loading rate (less than 0.1 $gpm/ft^2$).

The Vortechs Separator, a swirl separator, had a field study that reported a net removal efficiency of 84 percent with average influent concentration of 63 mg/L. Based on consultation with Gary Minton, a stormwater expert, it was decided, as noted earlier, that enhanced settling devices are generally intended for use on sites with much higher TSS concentrations.

**Filtration Media for Solids Removal.** The filter fabric and the compost media were selected for the pre-treatment units in the field study. They were selected based on several factors.

The filter fabric was selected because (1) test data suggest effective removal of solids, (2) it is easily implemented because it can be installed in the CSF cartridge, and (3) it was recommended by the manufacturer over the perlite. The filter fabric normally has a high maintenance cost associated with it because the fabric clogs much more quickly than the perlite. However, with the low TSS concentration, this is not expected to be a significant problem.

Coarse CSF media was selected because it can provide some limited protection but at the same time it provides an extra metals removal step. The available data show marginal performance for TSS removal, but with the low concentrations of TSS, the added metals removal step should make up for any loss of treatment life in the second compost stage.

Perlite was not selected based on manufacturer's recommendation and may not be as easily implemented as the filter fabric. However, the available information suggested that perlite can effectively remove TSS even at low influent concentrations, as expected at the NASSCO site. Because there are data supporting its effectiveness, perlite will be retained as an option for the second year of testing in the event that unforeseen problems arise with the filter fabric.

## 4.3 Identification and Screening of Filtration Media for Metals Removal

Enhanced filtration media (those media performing better than sand) were identified and screened to select the most appropriate candidate filtration media for field-scale testing, based on removal of the shipyard constituents of concern (copper, lead, zinc, and TSS). Identification and screening are summarized in Table 6.

### 4.3.1 Identification of Technologies

**CSF Compost Media.** As described previously the CSF compost media consists of pellets of composted leaves. The multicellular structure provides not only the pore spaces to trap particulate metals, but also a great deal of surface area for removal of dissolved metals through ion exchange. The ion exchange occurs because of humic substances that are produced during the composting process. The media is not regenerable and requires disposal after metals breakthrough. The media has been demonstrated in the treatment of highway and parking lot stormwater runoff.

**ATA Aqua-Fix Media.** A humic-based material produced in a proprietary process to stabilize the material. The media is regenerable with an acid wash to remove sorbed metals. The media has been demonstrated in acid mine drainage water, oil production wastewater, and in laboratory research.

**MultiSorb 100 Media.** A material prepared by processing peat. The media is regenerable with an acid wash to remove sorbed metals. The media has been demonstrated in acid mine drainage water and in laboratory research.

**Zeolite.** A mineral with an extremely high surface area that is mined for use as a cation exchange and anion adsorption medium. A laboratory test showed the media to have roughly half the copper removal capacity of the CSF media (Water Environment Federation Conf., October 1997).

### 4.3.2 Screening of Technologies

The identification and screening of potentially applicable filtration media are summarized in Table 6.

**CSF Compost Media.** The CSF compost media was selected because of the preponderance of evidence showing its ability to remove metals. The reports and studies listed show copper removals ranging from approximately 50 percent to greater than 80 percent and zinc removals ranging, generally from 40 to 86 percent, with one study showing only 20 percent removal. Most of the test data reported were with influent concentrations less than those expected at the NASSCO site.

Table 7 shows results of the short-term testing using coarse and fine CSF material to treat stormwater (Hart Crowser, 1997). Concentrations of solids and metals in the Marco Shipyard (Seattle) stormwater were very similar to concentrations measured at NASSCO. Additionally, the column tests were performed using a loading rate that is similar to what is expected for this system. These tests clearly showed (1) both gradations of CSF media are very effective at removal of zinc, and (2) effective removal of copper is possible, but is sensitive to media grain size. When utilizing these materials in the pilot test, it will be very important to provide fine-grained CSF for copper removal.

**ATA Aqua-Fix Media** was screened out based on results of the Hart Crowser AKART study performed in 1997 (Hart Crowser, 1997). Although the Aqua-Fix media was effective at removing metals and even had a higher saturation capacity than the other media types, it reduced the pH in the stormwater, causing any remaining particulate metals to become more soluble. Therefore, it was eliminated because it has the potential to increase toxicity by making the metals more bioavailable.

**MultiSorb 100 Media** was screened out based on feasibility concerns. Although the Multisorb 100 media effectively removed metals, it is still in the early phases of development. It is not readily available nor is it available as part of a system that can be installed, operated, and maintained as simply as the Storm Filter cartridge system.

**Zeolite** was also eliminated because of a lack of performance data. However, it should not be completely ruled out. Zeolite is being developed as a possible metals filter. A particular advantage of the zeolite as compared to the CSF is related to the cost of producing finer grade media. Because zeolite is crushed and sieved instead of rolled and sieved, a finer gradation can be achieved much more economically. As the column tests showed, media gradation is very important to treatment effectiveness. Because this media is currently being developed, zeolite will be retained as an option for the second year of testing.

# 5.0 FILTRATION SYSTEM DESCRIPTION

## *5.1 System Location*

The optimum location of the Filtration System is off-line with the current 30-inch-diameter corrugated metal pipe (CMP) storm drain, downstream from the existing catchbasin (Drawing C-2). This location will allow stormwater from drainage area SW-3 and pumped stormwater from the Berth 9/10 Pier to be treated. Off-line placement with the existing storm drain will minimize trenching for pipe placement, and minimize head losses resulting from increased pipe lengths and connections.

## *5.2 Design Criteria*

Design criteria for the Filtration System are shown in Table 8 and Drawing G-2.

## *5.3 System Description*

To assess the effectiveness of various treatment configurations, the Filtration System will consist of three separate treatment trains installed in parallel. A flow schematic of the system is presented on Drawing G-2. The system layout and profile are shown on Drawings C-2 and C-3, respectively.

Stormwater will enter the high-flow bypass manhole by gravity flow (drainage area SW-3) and by pumping (Berth 9/10 Pier). The high-flow bypass manhole is shown on Drawing C-5. An adjustable weir in the high-flow bypass manhole will allow use to respond to changes in hydraulic performance and ensure that we are able to capture the design storm. Flow rates exceeding the design storm maximum flow will bypass the system through the existing 30-inch-diameter outfall.

From the high-flow bypass manhole, the total captured flow will be routed to a 3-way flow splitter manhole, where the flow will be split, with one-third of the flow entering each treatment train by gravity flow. The 3-way flow splitter manhole is shown on Drawing C-6. Each outlet from the splitter manhole will be equipped with an identical orifice, to ensure an exact flow split and equal hydraulic loading to each of the treatment trains. The orifices will be adjustable, allowing us to respond to changes in hydraulic performance and balance the flows to the treatment trains. The inlet the 3-way flow splitter manhole will be equipped with a velocity-depth, continuous-reading flow meter. Flow monitoring at this location will allow us to measure the real-time hydrograph as it enters the treatment vaults, and provide us with a basis for compositing our stormwater samples for the first flush of the storm (see Section 6.0).

The heart of the Filtration System will be the three treatment trains. Each treatment train will consist of pre-cast concrete vaults containing StormFilter cartridges filled with various filtration media. A schematic of the treatment train vault configuration is shown on Drawing C-7. The vaults within each train will be piped to act as parallel units, with stormwater passing through a single cartridge filter prior to exiting the system.

Treatment Train No. 1 will operate at the standard hydraulic loading of 15 gallons per minute per cartridge and contain a single media in each cartridge. Treatment Train Nos. 2 and 3 will operate at a reduced hydraulic loading of 7.5 gallons per minute per cartridge and contain dual media in each cartridge. This approach will result in uniform residence times through each media and provide a range of treatment effectiveness and cost.

A description of each treatment train is as follows:

- Treatment Train No. 1 will consist of two pre-cast concrete vaults containing a total of 45 cartridge filters. Each cartridge will contain a relatively coarse gradation of compost media. The objective will be to measure the amount of solids and dissolved metal removal in a single uniform media.

- Treatment Train No. 2 will consist of three pre-cast concrete vaults containing a total of 90 filter cartridges. Each cartridge will be packed radially with filter fabric and fine compost media. By passing through a single cartridge, stormwater will first contact the filter fabric for solids removal, followed by contact with the relatively fine compost media for metals removal. The filter fabric was selected over Perlite for solids removal in this treatment train based on performance and cost considerations.

- Treatment Train No. 3 will consist of three pre-cast concrete vaults containing a total of 90 filter cartridges. Each cartridge will be packed radially with coarse and fine compost media. By passing through a single cartridge, stormwater will first contact coarse compost media for solids removal, followed by contact with the relatively fine compost media for metals removal.

Figure 2 presents a schematic of the StormFilter cartridge unit. The patented siphon design increases the flow potential and distribution of pollutants across the filter media, increasing the effectiveness and useful life of the filter cartridge. Sample ports will be located throughout the system (Drawing G-2), allowing collection of stormwater samples prior to treatment and following treatment by each treatment train.

The head losses across the treatment trains require that treated stormwater be pumped to the existing SW-3 outfall location. Treated stormwater will gravity flow from the treatment train outlets to a pump station and be discharged to the existing outfall by a force main pump system. Design of the force main system considers the effects of tidal influence at the site.

## 6.0 OPERATION AND MONITORING PLAN

The stormwater filtration test units will be operated and monitored for two rainy seasons. Water samples and flow measurements will be collected during storm events to evaluate the comparative effectiveness of the different process options. Three storm events will be sampled during each of the rainy seasons.

### *6.1 System Start-up*

Following completion of system installation, start-up operations of the filtration test units and the pump station will be conducted. Start-up activities will include observation of proper operation of pump and hydraulic control elements using plant water prior to the first storm event.

To prevent the discharge of fines and tannins into the bay, the filters will be washed at the factory and during start-up. During start-up, each treatment train will be flushed with plant water until the effluent runs clean. During washing, the effluent will be collected and pumped to the sanitary sewer for disposal.

### *6.2 System Operation*

NASSCO will operate the filtration treatment system during two rainy seasons. The filtration units will have no moving parts and as such will have relatively simple operational requirements.

The following operation and maintenance activities will be conducted:

- The pump station and flow metering controls and indicators will be inspected within 8 hours following the start of any storm event;
- The bypass and flow-splitter manholes will be inspected monthly and sediments will be removed after 6 inches of sediment accumulation;
- The pump station sump will be inspected and sediments will be removed after 6 inches of sediment accumulation; and

- Filtration media capacity will be monitored and media will be replaced if needed. Media will be monitored for both hydraulic and chemical removal capacity. Hydraulic capacity is limited by solids accumulation and will be monitored by observing increased head loss. Chemical capacity is limited by metal accumulation and will be monitored by comparing influent and effluent data, collected as described below. We do not anticipate that the media will need to be replaced during the first year of operation.

Following the first year of operation, system performance will be evaluated as described in Section 7.0. Based on this analysis, flow rate and/or media modification may be implemented.

## 6.3 System Monitoring

### 6.3.1 Stormwater Quality Monitoring

Stormwater sampling will be conducted during three storm events per rainy season. We will monitor additional storm events up to a total of 10 if additional measurable events occur. Stormwater samples will be collected at two times during each monitored storm event:

- During the initial portion of the storm (first flush); and
- During the last portion of the storm (waning storm).

Stormwater samples will be collected at four locations:

- An influent sample just before the three way split; and
- Three effluent samples, one from each of the treatment lines.

The stormwater samples will be composite samples as described in the following section. The sampling locations are shown on Drawing G-2. Sample identification numbers and specific analyses are shown in Table 9.

Water samples will be collected and submitted for the following chemical analyses:

- Total and dissolved metals (copper, lead, and zinc);
- Total suspended solids (TSS);
- Oil and grease; and
- pH.

Effluent water samples from the first flush sampling of each storm will also be submitted for bioassay testing. The toxicity analysis will consist of 96-hour acute toxicity testing of *Mysidopsos bahia* (a marine shrimp), using a five-concentration, 0.5-geometric dilution series.

Influent samples from the first flush of each storm will also be submitted for iron and aluminum testing. Iron and aluminum compete with copper, lead, and zinc for cation exchange sites on the compost.

The analytical methods and sample requirements are listed in Table 10.

### Sampling Procedures

Water samples will be collected at 15-minute intervals during the first four hours of the storm. After the storm, the hydrograph will be examined and two composite samples will be created for each sampling location. One composite sample will be generated from samples collected during the rising part of the hydrograph, to represent the first flush conditions. The second composite sample will be generated from samples collected during the falling part of the hydrograph, to represent the waning storm conditions. The following method will be used to collect water samples with a peristaltic pump.

1. Make field notes as necessary on the Water Sampling Form throughout the sampling procedure to ensure thorough and accurate recordkeeping.
2. Attach the silicone and polyethylene tubing to the peristaltic pump. Attach an inline 0.45 μm filter to the effluent end of the tubing. Attach the tubing to a stainless steel pole with zip ties (for influent sample) or sampling port (for effluent samples).
3. For the influent sample, lower the peristaltic pump into the flow splitter manhole.
4. Connect the electrodes for the peristaltic pump to the battery.
5. Allow approximately 50 ml of sample to flush through the filter before collecting a sample.
6. Fill the dissolved metals sample bottles.
7. Remove the 0.45 μm filter and fill the oil and grease and TSS sample bottles.
8. At effluent sampling locations (samples S#-EF-T#-F#) during the first flush sampling fill bioassay jars.
9. Ensure that sample labels are completely filled out and affixed to the sample bottles.
10. Clean the exterior of all sample bottles and store them in a cooled ice chest.
11. Ensure that the Water Sampling Form is completed.
12. Proceed to next sampling location.

In general, the sampling procedures will conform to the current sampling protocols used by NASSCO for NPDES monitoring.

### Sample Labeling

All sample bottles will be labeled at the time of sampling clearly identifying the project name, sampler's initial, sample location identification, analysis to be performed, date, and time.

### Sample Custody

**Definition of Custody.** After sampling, samples will be maintained in custody until formally transferred to the laboratory. For purposes of this work, custody will be defined as follows:

- In plain view of the field representative;
- Inside a cooler which is in plain view of the field representative; or
- Inside any locked space such as a cooler, locker, car, or truck to which the field representative has the only immediately available key(s).

**Custody Records.** A chain of custody record will be initiated at the time of sampling for each sample collected. This record will be signed by the field representative and others who subsequently hold custody of the sample. A copy of the chain of custody with all the appropriate signatures will be returned to the project manager.

### ***6.3.2 Flow Monitoring***

Flow and water depth data will be downloaded from the data logger during all storm events. First flush and waning storm flow analysis will be made. Flow rate and water depth monitoring will be performed with a velocity-depth flow meter installed in the inlet pipe to the flow splitter manhole.

### ***6.3.3 Solids Removal Monitoring***

In addition to monitoring the influent and effluent TSS, we will also measure the mass of solids removed by the Filtration System. The following procedure will be followed:

Estimate Sediment within the Filters

- Weigh a sampling of 4 filter cartridges from each vault after shipping but prior to installation.

- Weigh the same filter cartridges at the end of their service period.
- Take a vertical sample from each filter cartridge and analyze the water content in each sample.
- Subtract the water weight from each filter cartridge.
- Subtract the original weight of each filter cartridge from the final dry weight to estimate the sediment load.

Estimate Sediment on the Floor of the Vaults

- Map the sediment depth in each vault at 9 locations.
- Estimate the volume of sediment in each vault by multiplying the average sediment depth by the vault area.
- Collect a vertical sediment sample from each vault.
- Analyze the water content in each sample.
- Calculate the unit mass of sediment and determine the mass of sediment in each vault.

The sediment load from the cartridges will be added to the sediment load from the corresponding vaults to estimate the total sediment load removed. Particle size distribution will be measured for two sediment samples.

## 7.0 DATA INTERPRETATION AND REPORTING

The results of the study will be directly transferable to other shipyards across the country. The primary vehicles for technology transfer will include:

- Publication of results in the Engineering Report, focused on generic and exportable design parameters that can be tailored to individual yards;
- Presentation of results at SP-1 Panel meetings; and
- Ongoing site visit opportunities at NASSCO to observe the prototype units in operation.

### *7.1 Engineering Report*

Hart Crowser will conduct a comparative analysis for the stormwater monitoring data collected during the test. The objectives of the analysis will be to:

- Provide a descriptive and statistical comparison of the alternative treatment trains;
- Select a preferred treatment scheme based on the comparison; and
- Assess the feasibility and practicability of full-scale stormwater filtration at the NASSCO shipyard.

The results of testing will be evaluated and documented by Hart Crowser in the Engineering Report, which will be submitted to NSRP for review and approval.

The report will include:

- Summary of performance data for treatment test units, including percent pollutant reductions;
- Summary of performance comparison of filtration designs;
- Recommended design parameters for industry implementation;
- Unit costs for filtration vault installation, normalized to drainage size;
- Recommended operation and maintenance procedures; and
- Comparison of effluent quality with toxicity and water quality requirements.

Treatment performance will be compared using the contaminant mass loading and removal for each of the treatment trains. Mass loadings will be calculated using flow-weighted concentrations. Summary statistics will also be presented, including mean and geometric mean values.

The Engineering Report will provide generic design parameters that will allow the industry to customize the size and composition of the filtration units to match specific shipyard characteristics in terms of the size of drainage areas, flow volumes, and storm intensities. Shipyards will be able to use the data to estimate the cost of full-scale implementation of stormwater filtration, and based on measures of pollutant reduction, to predict the degree to which filtration will bring the shipyard into compliance with local discharge regulations. Submission of a technical paper to a peer-reviewed engineering journal will also be pursued.

Based on the results of the comparative performance analysis, a preferred filtration system will be selected for application in the shipyard industry. A generic Operation and Maintenance Plan will be developed for this system that will serve as a template for site-specific shipyard manuals that can be used by shipyard workers. The manual will specify stormwater sampling procedures, filter change-out rates, performance control limits, and other details as necessary to ensure that the filters are performing optimally, and not interfering with shipyard operations (i.e., to prevent clogging and flooding).

## *7.2 Presentations at Environmental Panel SP-1 Meetings of the NSRP*

Barry Kellems and Todd Thornburg of Hart Crowser will attend two meetings of the Environmental Panel SP-1 of the NSRP. Presentations to the NSRP meetings will be concurrent with project deliverables, and will likely include presentation of the technology review and prototype design; results of chemical and biological monitoring of treated stormwater; and comparative analysis of treatment technologies and effectiveness.

### *7.3 Ongoing Site Visit Opportunities at NASSCO*

With appropriate notification, NASSCO will provide opportunities for visitors to observe the filtration units in operation in the field. These visits will be arranged with Ron Miller, the Program Manager at NASSCO, on an as-needed basis.

## 8.0 SCHEDULE

The schedule for completing the Demonstration of Enhanced Filtration for Treatment of Shipyard Stormwater Project is shown on Figure 3 - Project Schedule. Figure 3 shows the duration, and starts and finish dates, for each of the five tasks contained in the Scope of Work (Section 1.4).

## 9.0 REFERENCES


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# TABLES

**Table 1 - Project Team Members**
**Demonstration of Enhanced Filtration for Treatment of Shipyard Storm Water**

| Project Role | Name | Address | Phone/Fax/E-mail |
|---|---|---|---|
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| Subcontractor-HC<br>Project Manager | Barry L. Kellems, P.E.<br>Senior Associate Engineer | Hart Crowser, Inc.<br>1910 Fairview Avenue East<br>Seattle, WA 98102-3699 | Phone: 206/324-9530<br>Fax: 206/328-5581<br>E-mail: blk@hartcrowser.com |
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| Laboratory | David Elgas | Analytical Chemists, Inc.<br>7535 Convoy Court<br>San Diego, CA 92111 | Phone: 619/560-4916 |
| Laboratory | Marilyn Schwartz | Ogden Environmental.<br>5510 Morehouse Drive<br>San Diego, CA 92121 | Phone: 858/458-9044 ext. 300 |

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**Table 2 - Alternative Design Storms**

| Storm | | Rainfall | Capture in Percent | | SBUH Peak Flow | |
|---|---|---|---|---|---|---|
| Frequency[1] | Duration | in Inches | by volume | by time | 15 min. in cfs | Avg Hour in cfs |
| 0.4 | 24 hour | 0.89 | 90.1 | 88.4 | 3.22 | 2.20 |
| 0.8 | 24 hour | 1.17 | 95.0 | 94.0 | 4.28 | 2.92 |

Notes:

1. Frequency was calculated from San Diego International Airport precipitation data.
2. Peak runoff includes the south subarea, which, with current site conditions, may not drain to our treatment system. Its contribution was calculated assuming a collection system would be installed from the south corner of the subarea to our treatment system.
3. The calculated peak runoff is conservative due to modeling constraints. The SBUH modeling program used in this analysis assumes all peaks, regardless of concentration time, will occur at the same time. The concentration times for the subareas varied enough to suggest that the hydrograph peaks may not coincide.
4. The estimated peak flow listed is for SW-3 only. It does not include runoff from the Berth 9/10 pier.

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## Table 3 - Influent Chemical Characteristics

| | O&G mg/L | TPH mg/L | TSS mg/L | Cu mg/L | Pb mg/L | Ni mg/L | Zn mg/L | TBT ug/L | Acute Toxicity % Surviv. |
|---|---|---|---|---|---|---|---|---|---|
| ***EPA Water Quality Criteria*** | | | | | | | | | |
| | N/A | N/A | N/A | 0.006 | 0.221 | 0.075 | 0.095 | 0.370 | N/A |
| ***NASSCO Average Water Quality Exceedence*** | | | | | | | | | |
| | | | | 84.4 | 0.5 | 3.5 | 25.3 | 0.5 | |
| ***NASSCO Site Wide Stormwater*** | | | | | | | | | |
| average | 7 | 1.5 | 41 | 0.49 | 0.11 | 0.26 | 2.40 | 0.171 | 39 |
| minimum | 1 | 0.5 | 1 | 0.03 | 0.00 | 0.01 | 0.26 | 0.005 | 0 |
| maximum | 57 | 22.0 | 552 | 2.20 | 0.92 | 1.00 | 9.90 | 7.260 | 95 |
| 10th %ile | 3 | 0.5 | 5 | 0.11 | 0.02 | 0.02 | 0.72 | 0.010 | 0 |
| 25th %ile | 5 | 0.5 | 7 | 0.19 | 0.10 | 0.05 | 0.93 | 0.017 | 3 |
| 50th %ile | 5 | 0.7 | 15 | 0.32 | 0.10 | 0.22 | 1.60 | 0.043 | 40 |
| 75th %ile | 7 | 1.8 | 44 | 0.65 | 0.10 | 0.36 | 3.58 | 0.110 | 70 |
| 90th %ile | 16 | 3.7 | 82 | 1.00 | 0.14 | 0.66 | 5.74 | 0.235 | 80 |
| ***SW-3 Drainage*** | | | | | | | | | |
| average | 8 | 1.6 | 26 | 0.34 | 0.09 | 0.28 | 1.45 | 0.061 | 56 |
| minimum | 2 | 0.5 | 5 | 0.16 | 0.02 | 0.02 | 0.79 | 0.017 | 35 |
| maximum | 22 | 6.2 | 49 | 0.76 | 0.17 | 0.57 | 3.30 | 0.110 | 68 |
| ***Berths 9/10 Drainage*** | | | | | | | | | |
| average | 4 | 1.4 | 24 | 0.54 | 0.06 | 0.31 | 0.98 | 0.034 | 78 |
| minimum | 2 | 0.5 | 7 | 0.19 | 0.01 | 0.01 | 0.26 | 0.009 | 75 |
| maximum | 5 | 4.2 | 46 | 1.39 | 0.10 | 0.74 | 2.31 | 0.076 | 80 |
| ***Harbor Drive Urban Runoff*** | | | | | | | | | |
| average | 5 | 0.5 | 48 | 0.11 | 0.07 | 0.10 | 0.32 | 0.007 | 90 |
| minimum | 3 | 0.5 | 5 | 0.05 | 0.03 | 0.01 | 0.07 | 0.005 | 80 |
| maximum | 5 | 0.5 | 101 | 0.17 | 0.10 | 0.20 | 0.65 | 0.010 | 100 |
| ***City of San Diego Urban Runoff*** | | | | | | | | | |
| average | 4 | 0.5 | 280 | 0.04 | 0.04 | N/C | 0.23 | N/M | N/M |
| 90th %ile | 12 | 0.5 | 580 | 0.09 | 0.09 | N/C | 0.55 | N/M | N/M |

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**Table 4 - Solids Removal Technologies-Preliminary Screening** 



| Technology | Description | Screening Results | Comments |
|---|---|---|---|
| **Standard Settling Units** | | | |
| Detention Ponds, Wet Vaults | Lowers runoff velocities and allows settling of particulate pollutants. | Eliminated | Not applicable due to site constraints. Cannot be installed subsurface. |
| **Biotreatment Units** | | | |
| Bioswales, Filter Strips, Artificial Wetlands | Bioswales or grass filter strips lower runoff velocity and act as a filter to trap particulate pollutants. | Eliminated | Not applicable due to site constraints. Cannot be installed subsurface. |
| StormTreat System | Compact artificial wetland. Stormwater filtered through vegetated gravel unit. | Eliminated | Not applicable due to site constraints. Cannot be installed subsurface. |
| **Enhanced Settling Devices** | | | |
| BaySaver Separation System | Wet vault with improved hydraulic conditions. | Eliminated | Limited Information |
| Stormceptor System | Wet vault with improved hydraulic conditions. | Retained for detailed analysis | Laboratory data available |
| Downstream Defender | Flow through swirl concentrator. | Retained for detailed analysis | Laboratory data available |
| V2B1 Structural Treatment System | Swirl concentrator | Retained for detailed analysis | Laboratory data available |
| Vortechs Stormwater Treatment System | Swirl concentrator | Retained for detailed analysis | Laboratory data available |
| CDS | Combination swirl concentrator and tangential screening | Retained for detailed analysis | Laboratory and field data available |
| CrystalStream Oil/Grit Separator | Simple Separator | Eliminated | Limited Information |
| High Velocity Stormwater Interceptor | Unidentified | Eliminated | Limited information |
| AquaShield Filtration System | Unidentified | Eliminated | Limited Information |

7374/DesignReport.xls - Table 4

## Table 4 - Solids Removal Technologies-Preliminary Screening



| Technology | Description | Screening Results | Comments |
|---|---|---|---|
| **Catch Basin Inserts** | | | |
| Ultra-Urban Filter | Catch basin insert primarily for oil and grease removal, secondarily sediment removal. | Eliminated | Not applicable due to site constraints. There is only one catch basin on site |
| Gullywasher Brand Products | Catch basin insert radial flow cartridge filters | Eliminated | |
| Hydro-Kleen Filtration System | Catch basin insert | Eliminated | |
| StreamGuard Products | Temporary catch basin insert for spill control/ construction activities | Eliminated | |
| The SNOUT | Downturned elbow with vent to eliminate siphoning. | Eliminated | |
| **Filtration Media for Solids Removal** | | | |
| Perlite | Radial flow Cartridge with filter media | Retained for detailed analysis | Laboratory and field data available |
| Pleated Fabric with Perlite | Radial flow Cartridge with filter media | Retained for detailed analysis | Laboratory and field data available |
| Compost Media | Radial flow Cartridge with filter media | Retained for detailed analysis | Laboratory and field data available |
| Sand Filtration | Wet vault with sand layer and underdrain system | Eliminated | Not considered feasible due to excessive maintenance requirements. |

7374/DesignReport.xls - Table 4

**Table 5 - Solids Removal Technologies-Detailed Screening**

| | Description | PERFORMANCE | | | | | Effectiveness | Feasibility | Comments | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Removal | Runoff in cfs | Loading Rate in $gpm/ft^2$ | Data Source | Influent Conc. in mg/L | | | | |
| **Enhanced Settling Devices** | | | | | | | | | | |
| Stormceptor System | Wet Vault with improved hydraulic conditions. | 98% | 0.007 | 0.04 to 0.1 | Field[1] | 47-400 | Unproven effectiveness at low TSS. | Medium: Subsurface installation of unit similar to standard manhole | | Eliminated. Unproven effectiveness at low TSS. |
| | | 80% | 0.5 cfs | 8 | Field[2] | 50-300 | | | | |
| Downstream Defender | Swirl concentrator | 83% >150 mm; 75% overall | 4.73 | 75 | Lab[3] | 300 | Limited Test Data Available | Medium: Subsurface installation of unit similar to standard manhole | Cost estimated from reported range. These units are reportedly used extensively by the United Sewerage Agency in Portland, OR. | Eliminated due to limited testing |
| V2B1 Structural Treatment System | Swirl concentrator | 70%silt; 95% sand | Not Reported | 20 | Lab[4] | Not Reported | Limited Test Data Available | Medium: Subsurface installation requires precision joining of adjacent units | Cost estimated from reported range. Approved for installation by: State of Connecticut; Naval Warfare College, NETC, Newport, RI; Naval Air Station, Norfolk, VA | Eliminated due to limited testing |
| CDS | Combination swirl concentrator and tangential screening | 100% > 140 mm | 3 | 48 | Lab[5] | NR | | Medium: Subsurface installation of unit similar to standard manhole | Removal based on lab data showing 100% removal of particles 50% of screen opening. This unit has a 280 mm screen | Eliminated. Unproven effectiveness at low TSS. |
| | | Cumulative 70%-84% | 0.3-0.6 | | Lab[6] | 500-1000 | Good removal at high TSS | | Study by Professor Scott Wells, Portland State[1] | |
| Vortechs Stormwater Treatment System | Swirl concentrator | 84% | 2.7 | 20 | Field[7] | 4 - 3440 (average 60) | | Medium: Subsurface installation requires precision joining of adjacent units | Field Tested by Vortechnics at Delorme Publishing Co., Yarmouth, ME | Eliminated. Unproven effectiveness at low TSS. |

**Table 5 - Solids Removal Technologies-Detailed Screening**

| | Description | PERFORMANCE | | | | | Effectiveness | Feasibility | Comments | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Removal | Runoff in cfs | Loading Rate in gpm/ft$^2$ | Data Source | Influent Conc. in mg/L | | | | |
| **Filtration Media for Solids Removal**[10] | | | | | | | | | | |
| **Perlite** | Media Filter Cartridge | 64% - 70% | Not Reported | 2.7 | Field[8] | 47 | Good Removal at low TSS concentrations | Medium: Filter cartridge facilitates maintenance | Results based on two, time composite samples. Samples from a 200-acre commercial area. | Chosen because of performance and quantity of applicable data |
| | | 79% | Not Reported | 2.7 | Field[8] | 708 | | | Results based on one, time composite sample. Samples from a 1- acre parking lot. | |
| **Pleated Fabric with Perlite** | Media Filter Cartridge | 96% | Not Reported | 2.7 | Field[9] | 708 | Good removal at high TSS | High: Installed within filter media cartridge. Separate Vault not required | One field study at a 1-acre lot, based on six samples. Filter fabric can be installed within a CSF cartridge | Chosen because of fair performance and high feasibility |
| **Compost Media** | Media Filter Cartridge | 10%-53% | Not Reported | 2.7 | Field[8] | 21-56 | Fair to Poor removal at low TSS concentrations | Medium: Filter cartridge facilitates maintenance | Results based on a flow weighted, a time composite, and a grab sample froma 200-acre commercial area. | Chosen because of abililty to remove TSS and metals |
| | | 28% | Not Reported | 2.7 | Field[8] | 76 | | | Results based on one time composite samples. Samples from road runoff. | |
| | | 79%-82% | Not Reported | 2.7 | Field[8] | 308 | Good removal at higher TSS concentrations | | Results based on one time composite samples. Samples from a 5- acre parking lot. | |

Notes:

1. CSR Hydro Conduit, 1997.
2. CSR Hydro Conduit, (Undated).
3. H.I.L. Technologies, 1998.
4. As reported by Environment 21.
5. As reported by CDS Technologies.
6. Schwartz and Wells, 1999.
7. As reported by Vortechnics, Inc.
8. Stormwater Management, Inc., 2000.
9. Stormwater Management, Inc., 1998a.
10. Loading based on 15 gpm/ cartridge

## Table 6 - Identification and Screeing of Potentially Applicable Filtration Media

Sheet 1 of 2

| | | Performance | | | | | Evaluation | | |
|---|---|---|---|---|---|---|---|---|---|
| Media | Description | Hydraulic Loading in gpm/ft$^2$ | Contaminant | % Removal | Lab or Field Data | Influent Conc. in mg/L | Effectiveness | Technical Feasibility | Screening Result |
| CSF Compost Media | Leaf compost granules | 2.7 | Copper total | 50% | Lab[1] | 0.37 | Good removal of dissolved metals. | Prefilter recommended. | Retained for pilot-scale testing |
| | | | Zinc total | 84% | Lab[1] | 3.6 | | | |
| | | 2 to 5 | Copper total | 100% | Field[2] | 0.014 | | | |
| | | | Zinc total | 20% | Field[2] | 0.2 | | | |
| | | 2 to 2.5 | Copper | first flush 75%, flow-paced 47% | Lab[3] | first flush 0.038, flow-paced 0.026 | | | |
| | | | Zinc | first flush 86%, flow-paced 78% | Lab[3] | first flush 0.256, flow-paced 0.177 | | | |
| | | | Copper and Zinc | >80% | Lab[4] | Not Listed | | | |
| | | | Copper | 58% | Lab[5] | 0.009 - 0.040 | | | |
| | | | Zinc | 85% | Lab[5] | 0.070 - 0.321 | | | |
| | | | Copper | 54% | Field[6] | 0.004 - 0.017 | | | |
| | | | Zinc | 37% | Field[6] | 0.029 - 0.41 | | | |
| ATA Aqua-Fix media | Proprietary peat granules | 2 to 5 | Copper total | 54% | Lab[1] | 0.37 | Good removal of dissolved metals, however, the media tended to lower pH which increased solubility of particulate metals | Prefilter recommended. Material is very expensive. | Eliminated due to cost and solubility issues |
| | | | Zinc total | 85% | Lab[1] | 3.6 | | | |
| MultiSorb 100 Media | Proprietary peat granules | 1 to 4 | Copper total | 76% | Lab[1] | 0.37 | Good removal of dissolved metals. | Limited availability and implementability. Plant was not operating as of last year. Material only available in bulk. | Eliminated due to lack of implementability |
| | | | Zinc total | 94% | Lab[1] | 3.6 | | | |

7374/DesignReport.xls - Table 6

**Table 6 - Identification and Screeing of Potentially Applicable Filtration Media**



| | | Performance | | | | | Evaluation | | |
|---|---|---|---|---|---|---|---|---|---|
| **Media** | **Description** | **Hydraulic Loading in gpm/ft$^2$** | **Contaminant** | **% Removal** | **Lab or Field Data** | **Influent Conc. in mg/L** | **Effectiveness** | **Technical Feasibility** | **Screening Result** |
| Zeolites | Mineral with ion exchange sites | | | No available performance data | | | No available performance data | Prefilter recommended. Standard gradation approximately twice the cost of CSF, but finer gradation potentially more economical[7] | Eliminate due to cost and lack of data |

1. Hart Crowser, 1997.
2. Stormwater Management, 1998b.
3. Stormwater Management, (undated).
4. Clark et al., 1997.
5. Tenney, S., (Undated).
6. Stormwater Management, 1998c.
7. As reported by Stormwater Management

**Table 7 - Summary of 1997 Bench-Scale Test Criteria and Results**

| Test | Media Sieve Size | Screen Size in Inches | Unrestricted Flow: Flow Rate in gpm/SF | Unrestricted Flow: Flow Rate in gpm/CF | Controlled Flow: Average Flow Rate in gpm/SF | Controlled Flow: Average Flow Rate in gpm/CF | Removal Rate in Percent: Copper | Removal Rate in Percent: Lead | Removal Rate in Percent: Zinc | Removal Rate in Percent: TSS |
|---|---|---|---|---|---|---|---|---|---|---|
| Short-Term High Loading* | #7 to #13 | 0.11 to 0.06 | 17 | 9 | 3.3 | 1.7 | 50 | 28 | 83 | 44 |
| Short-Term Low Loading* | #7 to #13 | 0.11 to 0.06 | 13 | 7 | 2.4 | 1.2 | 49 | 23 | 85 | 38 |
| Long-Term 500 EBV** | #14 to #30 | 0.055 to 0.023 | 14 | 14 | 2 | 2 | 97 | 82 | 94 | NM |
| Long-Term 900 EBV** | #14 to #30 | 0.055 to 0.023 | 14 | 14 | 2 | 2 | 97 | 95 | 71 | NM |

* Short-term results based on treatment of Marco Shipyard (Seattle) stormwater, average of three effluent samples.

** Long-term results based on treatment of synthetic stormwater containing no suspended solid.

Grab samples collected following treatment of 500 and 900 empty bed volumes (EBV).

NM = Not Measured

7374/DesignReport.xls - Table 7

**Table 8 - Filtration System Design Criteria**

## DESIGN FLOW

| | |
|---|---|
| Drainage Areas | SW-3 and Berth 9/10 Pier |
| SW-3 Peak Flow | 1,900 gallons per minute (4.3 cubic feet per second) |
| Berth 9/10 Pier Peak Flow | 100 gallons per minute (0.2 cubic foot per second) |
| Total Peak Flow | 2,000 gallons per minute (4.5 cubic feet per second) |
| SW-3 Runoff Capture | 95 percent |
| Nominal Design Storm Return Period | 1 year |
| Nominal Peak Flow Averaging Period | 15 minutes |

## INFLUENT CHARACTERISTICS

| | | |
|---|---|---|
| Total Suspended Solids - | Average | 25 mg/L |
| | Peak | 49 mg/L |
| Oil and Grease - | Average | 7.2 mg/L |
| | Peak | 22 mg/L |
| Total Copper - | Average | 370 ug/L |
| | Peak | 760 ug/L |
| Total Zinc - | Average | 1,500 ug/L |
| | Peak | 3,300 ug/L |

## EFFLUENT REQUIREMENTS

| | | |
|---|---|---|
| Total Copper - | Percent Removal | 90 percent |
| | Average Concentration | 37 ug/L |
| Total Zinc - | Percent Removal | 80 percent |
| | Average Concentration | 300 ug/L |

## EXISTING ELEVATIONS IN FEET

| Terminal Catch Basin (TCB) | NAVD 88 | MLLW |
|---|---|---|
| Rim | 7.85 | 7.20 |
| Discharge Invert | 4.80 | 4.15 |

| | | |
|---|---|---|
| Outfall | | |
| Discharge Invert | 3.76 | 3.11 |
| Mean Higher High Water (MHHW) | 6.38 | 5.73 |
| Mean Lower Low Water (MLLW) | 0.65 | 0.0 |

**AVAILABLE STATIC HEAD IN FEET**

| | |
|---|---|
| Available Static Head (TCB Rim/TCB Discharge) | 3.05 |
| Available Static Head (TCB Rim/Discharge Invert) | 4.09 |
| Available Static Head (TCB Rim/MHHW) | 1.47 |
| Available Static Head (TCB Rim/MLLW) | 7.2 |

**SPLITTER MANHOLE**

| | |
|---|---|
| Number | 1 |
| Split Ratio | 3:1 |
| Peak Influent Flow | 2,000 gallons per minute |
| Peak Effluent Flow | 675 gallons per minute (1.5 cubic feet per second) |

**TREATMENT TRAIN NO. 1**

| | |
|---|---|
| Peak Flow | 675 gallons per minute (1.5 cubic feet per second) |
| Treatment Technology | Storm Filter Pre-Cast Treatment Vault |
| Metal Removal Filtration Media | Coarse Compost |
| Nominal Grain Size | 0.2- to 0.4-inch |
| Filtration Rate | 15 gallons per minute/unit |
| Driving Head | 2.3 feet |
| Total No. Of Filter Units | 45 |
| No. of Vaults | 2 |
| Vault 1A/1B Size | 8 feet x 16 feet |
| Vault 1A No. Of Filter Units | 30 |
| Vault 1B No. Of Filter Units | 15 |

**TREATMENT TRAIN NO. 2**

| | |
|---|---|
| Peak Flow | 675 gallons per minute (1.5 cubic feet per second) |
| Treatment Technology | Composite Storm Filter Pre-Cast Treatment Vault |

**Table 8 - Filtration System Design Criteria**

| | |
|---|---|
| Solids Removal Method | Pleated Fabric |
| Nominal Opening Size | 70 micron |
| Metals Removal Filtration Media | Fine Compost |
| Nominal Grain Size | 0.06- to 0.4-inch |
| Filtration Rate | 7.5 gallons per minute/unit |
| Driving Head | 2.3 feet |
| Total No. Of Filter Units | 90 |
| No. of Vaults | 3 |
| Vault 2A/2B/2C Size | 8 feet x 16 feet |
| Vault 2A/2B/2C No. Of Filter Units | 30 |
| **TREATMENT TRAIN NO. 3** | |
| Peak Flow | 675 gallons per minute (1.5 cubic feet per second) |
| Treatment Technology | Composite Storm Filter Pre-Cast Treatment Vault |
| Solids Removal Filtration Media | Coarse Compost |
| Nominal Grain Size | 0.2- to 0.4-inch |
| Metals Removal Filtration Media | Fine Compost |
| Nominal Grain Size | 0.06- to 0.4-inch |
| Filtration Rate | 7.5 gallons per minute/unit |
| Driving Head | 2.3 feet |
| Total No. Of Filter Units | 90 |
| No. of Vaults | 3 |
| Vault 3A/3B/3C Size | 8 feet x 16 feet |
| Vault 3A/3B/3C No. Of Filter Units | 30 |
| EFFLUENT PUMP STATION | |
| Ground Surface Elevation (NAVD 88) | 9.9 feet |
| Peak Flow | 2,000 gallons per minute (4.5 cubic feet per second) |
| TDH | 12 to 15 feet |
| Discharge Location | Existing 30-inch CMP |
| No. of Pumps | 1 |
| Pump Horsepower | 20 |
| RPM | 900 |
| Phase | 3 |
| Power | 460 volt |

F:\docs\jobs\7374\DesignCriteria.doc

## Table 9 - Sample Identification and Analysis

| Sample ID | Total metals | Dissolved metals | Oil and grease | TSS | Bioassay | Aluminum and iron | pH |
|---|---|---|---|---|---|---|---|
| S1-IN-F | 1 | 1 | 1 | 1 | | 1 | 1 |
| S1-EF-T1-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S1-EF-T2-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S1-EF-T3-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S1-IN-W | 1 | 1 | 1 | 1 | | | 1 |
| S1-EF-T1-W | 1 | 1 | 1 | 1 | | | 1 |
| S1-EF-T2-W | 1 | 1 | 1 | 1 | | | 1 |
| S1-EF-T3-W | 1 | 1 | 1 | 1 | | | 1 |
| | | | | | | | |
| S2-IN-F | 1 | 1 | 1 | 1 | | 1 | 1 |
| S2-EF-T1-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S2-EF-T2-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S2-EF-T3-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S2-IN-W | 1 | 1 | 1 | 1 | | | 1 |
| S2-EF-T1-W | 1 | 1 | 1 | 1 | | | 1 |
| S2-EF-T2-W | 1 | 1 | 1 | 1 | | | 1 |
| S2-EF-T3-W | 1 | 1 | 1 | 1 | | | 1 |
| | | | | | | | |
| S3-IN-F | 1 | 1 | 1 | 1 | | 1 | 1 |
| S3-EF-T1-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S3-EF-T2-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S3-EF-T3-F | 1 | 1 | 1 | 1 | 1 | | 1 |
| S3-IN-W | 1 | 1 | 1 | 1 | | | 1 |
| S3-EF-T1-W | 1 | 1 | 1 | 1 | | | 1 |
| S3-EF-T2-W | 1 | 1 | 1 | 1 | | | 1 |
| S3-EF-T3-W | 1 | 1 | 1 | 1 | | | 1 |
| Total number samples | 24 | 24 | 24 | 24 | 9 | 3 | 24 |

Sample Key:
S# - storm event
IN - influent
EF - effluent
T# - treatment train number
F - First flush sample
W - waning storm sample

7374/DesignReport.xls - table9

**Table 10 - Analytical Methods and Sample Requirements**

| Analyte | Method | Volume | Container | Holding Time |
|---|---|---|---|---|
| Acute Toxicity | EPA/600/4-90/027F<br>August 1993 | 1 gallon | PolyPropylene | 36 hours; keep at 4°C |
| | | | | |
| Copper | EPA 6020 by ICP/MS | 250mL* | Poly | Nitric preserved - 6 mos. |
| Lead | EPA 6020 by ICP/MS | 250mL* | Poly | Nitric preserved - 6 mos. |
| Zinc | EPA 6020 by ICP/MS | 250mL* | Poly | Nitric preserved - 6 mos. |
| Iron | EPA 6020 by ICP/MS | 250mL* | Poly | Nitric preserved - 6 mos. |
| Aluminum | EPA 6020 by ICP/MS | 250mL* | Poly | Nitric preserved - 6 mos. |
| | | | | |
| Oil & Grease | EPA 413.1 | 500 mL | Amber glass | Sulfuric acid pres. - 28d |
| TSS | EPA 160.2 | 250 mL** | Poly | 7 days; no preservative |
| PH | EPA 150.1 | 250 mL** | Poly | asap/≤24 hrs max.<br>no preservative - keep at 4°C |

*A single 250mL sample is sufficient volume for both dissolved and total concentrations of all metals requested.

**A single 250mL poly bottle is sufficient for both TSS and pH.

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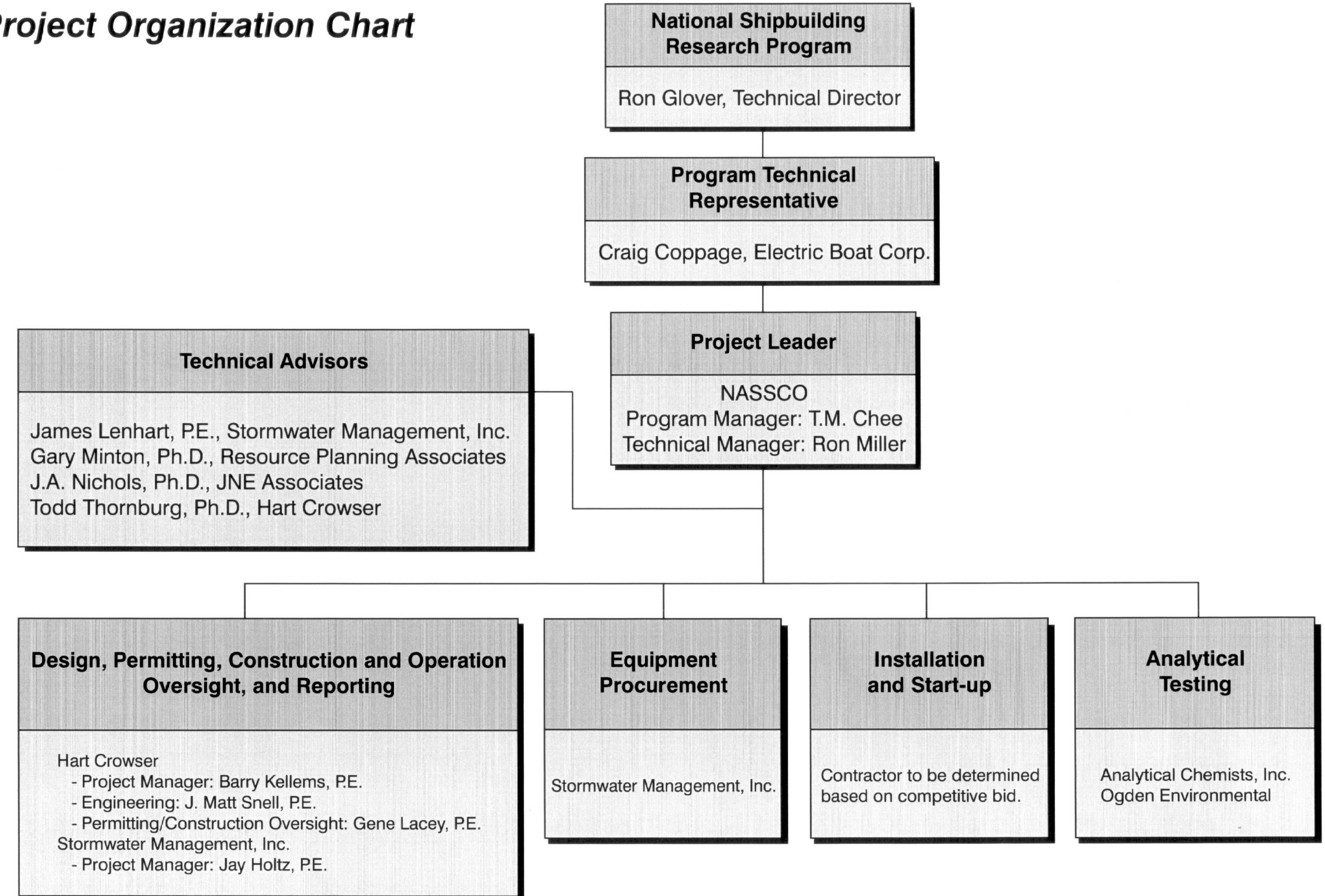
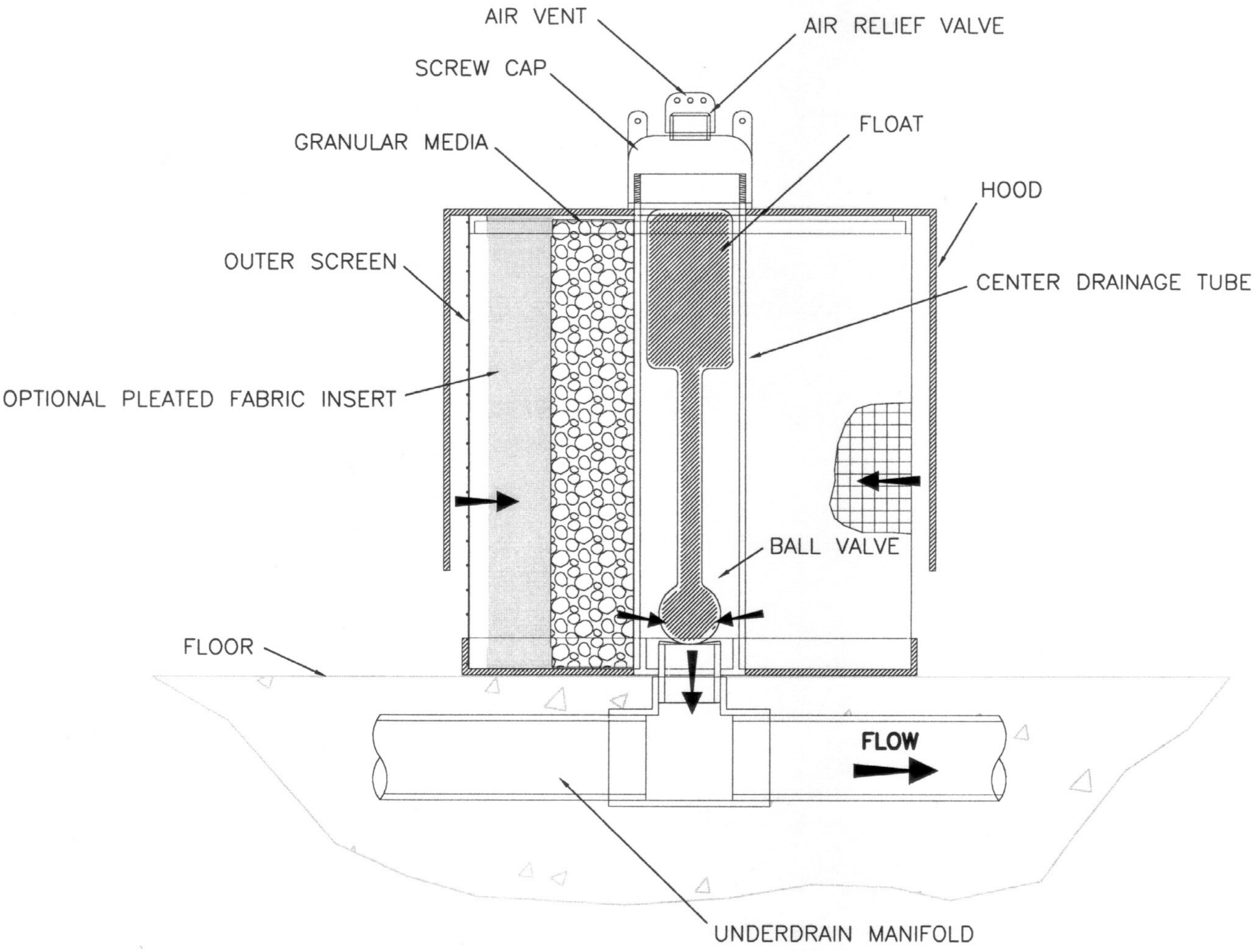
# FIGURES

# Project Organization Chart




HARTCROWSER
J-7374 6/00
Figure 1

CVD 6/20/00 737400B.cdr




STORMWATER MANAGEMENT

2035 N.E. COLUMBIA BLVD. : PORTLAND, OR 97211
(503) 240-3393 : FAX: 240-9553

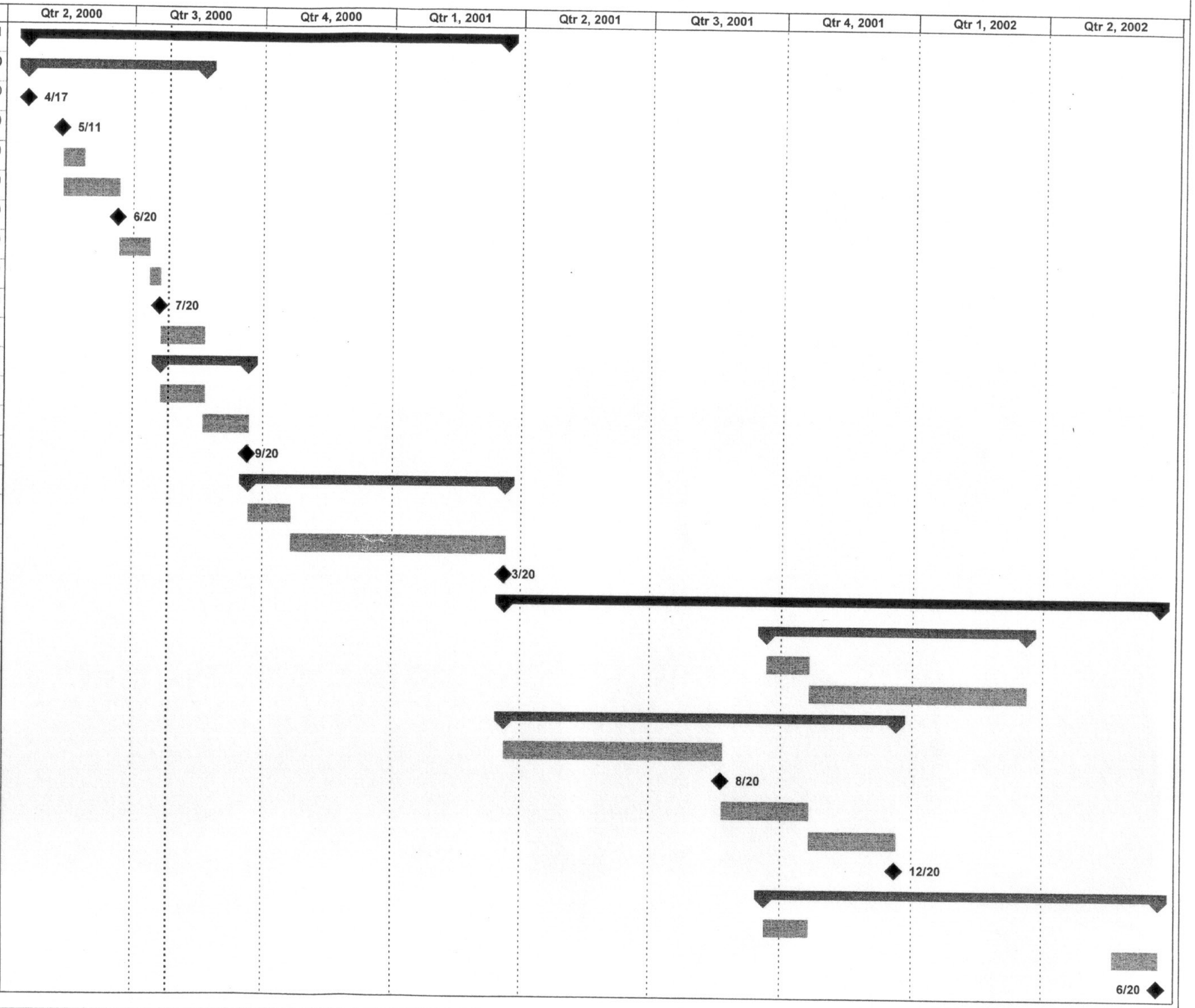
FIGURE 2

| SELF-CLEANING FILTER CARTRIDGE | SCALE | DATE | DESIGN | DRAWN | CHECKED |
|---|---|---|---|---|---|
| 73740005.DWG | N.T.S. | 6/15/00 | JHL | DMW | JFH |

# DRAWINGS

Figure 3 - Project Schedule
Demonstration of Enhanced Filtration for Treatment of Shipyard Storm Water

| Task Name | Start | Finish |
|---|---|---|
| **Phase I - Design, Construct, Operate During First Year** | **Mon 4/17/00** | **Tue 3/20/01** |
| **Task 1 - Design and Permitting** | **Mon 4/17/00** | **Sun 8/20/00** |
| Contract Award | Mon 4/17/00 | Mon 4/17/00 |
| Project Kick-Off Meeting | Thu 5/11/00 | Thu 5/11/00 |
| Conduct Drainage Survey | Fri 5/12/00 | Fri 5/26/00 |
| Prepare Draft Design Report | Fri 5/12/00 | Tue 6/20/00 |
| Submit Draft Design Report | Tue 6/20/00 | Tue 6/20/00 |
| Review Draft Design Report | Wed 6/21/00 | Wed 7/12/00 |
| Prepare Final Design Report | Thu 7/13/00 | Thu 7/20/00 |
| Submit Final Design Report | Thu 7/20/00 | Thu 7/20/00 |
| Obtain Construction Permits | Fri 7/21/00 | Sun 8/20/00 |
| **Task 2 - Procurement and Installation** | **Fri 7/21/00** | **Wed 9/20/00** |
| Procure Equipment and Materials | Fri 7/21/00 | Sun 8/20/00 |
| Install Test Units | Sun 8/20/00 | Wed 9/20/00 |
| Submit Installation Completion Report | Wed 9/20/00 | Wed 9/20/00 |
| **Task 3 - Operation and Monitoring (1st Year )** | **Thu 9/21/00** | **Tue 3/20/01** |
| System Startup | Thu 9/21/00 | Fri 10/20/00 |
| 1st Year Operation and Monitoring | Sat 10/21/00 | Tue 3/20/01 |
| Submit 1st Year Interim Report | Tue 3/20/01 | Tue 3/20/01 |
| **Phase II - Operate During 2nd Year and Report** | **Wed 3/21/01** | **Thu 6/20/02** |
| **Task 3 - Operation and Monitoring (2nd Year )** | **Fri 9/21/01** | **Wed 3/20/02** |
| System Startup | Fri 9/21/01 | Sat 10/20/01 |
| 2nd Year Operation and Monitoring | Sun 10/21/01 | Wed 3/20/02 |
| **Task 4 - Comparative Analysis/Reporting** | **Wed 3/21/01** | **Thu 12/20/01** |
| Prepare Engineering Report | Wed 3/21/01 | Mon 8/20/01 |
| Submit Draft Engineering Report | Mon 8/20/01 | Mon 8/20/01 |
| Review Draft Engineering Report | Tue 8/21/01 | Sat 10/20/01 |
| Revise Draft Engineering Report | Sun 10/21/01 | Thu 12/20/01 |
| Submit Engineering Report | Thu 12/20/01 | Thu 12/20/01 |
| **Task 5 -Meetings, Presentations, and Final Report** | **Thu 9/20/01** | **Thu 6/20/02** |
| Attend 1st NSRP Meeting | Thu 9/20/01 | Sat 10/20/01 |
| Attend 2nd NSRP Meeting | Mon 5/20/02 | Thu 6/20/02 |
| Submit Final Report | Thu 6/20/02 | Thu 6/20/02 |



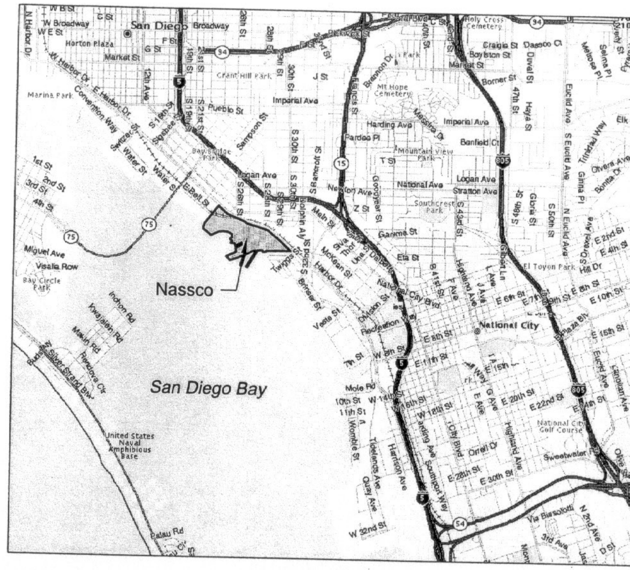

Project: 7374-00
Date: Wed 7/26/00

Subtask | Milestone | Summary | Rolled Up Task

# ENHANCED FILTRATION OF STORM WATER

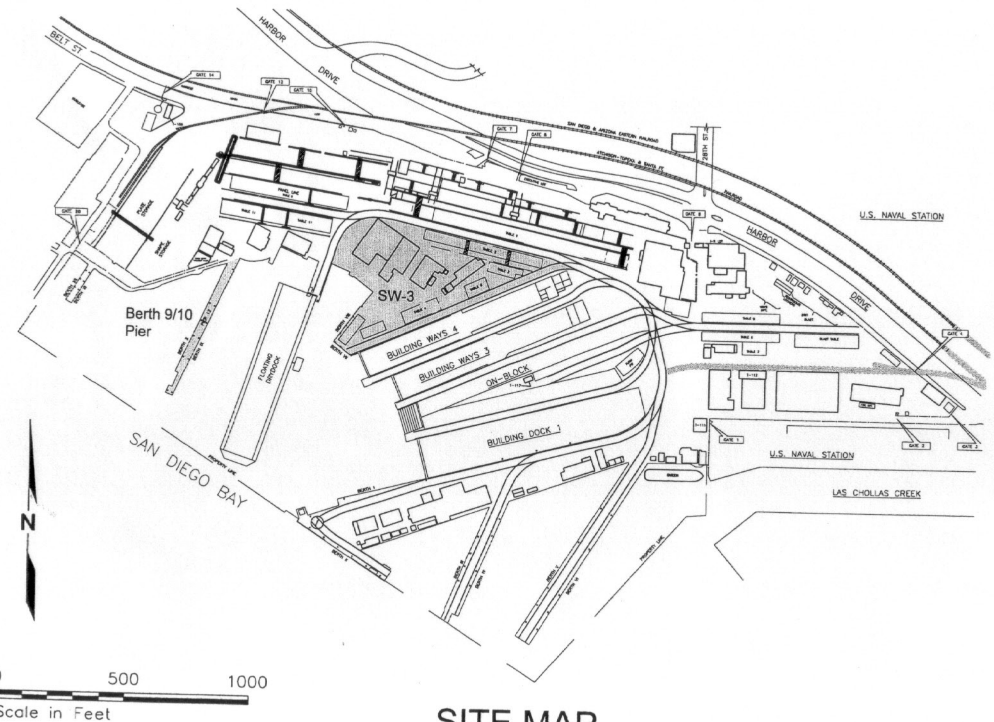
## National Steel and Shipbuilding Company

Post Office Box 85278
Harbor Drive and 28th St.
San Diego, CA 92186-5278




## VICINITY MAP

NOT TO SCALE




## SITE MAP

## DRAWING INDEX



PRELIMINARY - NOT FOR CONSTRUCTION


HARTCROWSER
1910 FAIRVIEW AVENUE EAST
SEATTLE, WASHINGTON 98102
TEL. 206-324-95230 FAX 206-328-5581


COVER SHEET

DRAWING FILE NAME: 73740007.DWG
PROJECT NO. J-7374
SCALE: AS SHOWN

DESIGNED BY: ECL CHECKED BY: BLK CHECK DATE: 7/27/00
DRAWN BY: bts APPROVED BY: APPR. DATE:
DATE | BY | REVISION | CK'D | APPR.

SHEET 1 of
DWG NO. G-1

PLOT DATE: 7/27/00
LAST EDIT: bts

SCOPE OF WORK

THE SCOPE OF WORK WILL CONSIST OF INSTALLATION OF A STORMWATER FILTRATION SYSTEM AT THE NASSCO SHIPYARD. STORMWATER FLOW FROM DRAINAGE AREAS SW-3 AND THE BERTH 9/10 PIER WILL BE SPLIT USING A FLOW SPLITTER MANHOLE AND TREATED THROUGH A FILTRATION SYSTEM CONSISTING OF THREE DIFFERENT TREATMENT TRAINS. THE FILTRATION SYSTEM WILL BE AN OFF-LINE FACILITY LOCATED AT THE DOWNSTREAM END OF THE EXISTING SW-3 OUTFALL. NASSCO WILL PROVIDE STORMWATER FLOW FROM THE BERTH 9/10 PIER TO THE HIGH-FLOW BYPASS MANHOLE. THE TREATMENT TRAINS WILL CONSIST OF CONCRETE VAULTS CONTAINING CARTRIDGE FILTERS FILLED WITH VARIOUS FILTRATION MEDIA. TREATED EFFLUENT FROM THE TREATMENT VAULTS WILL PASS THROUGH A SINGLE SAMPLING VAULT AND THEN INTO AN EFFLUENT PUMP STATION MANHOLE, WHERE STORMWATER WILL BE PUMPED BACK TO THE EXISTING 30-INCH CMP FOR DISCHARGE TO SAN DIEGO BAY.

HE CONTRACTOR SHALL INSTALL THE SYSTEM DESCRIBED ON THESE DRAWINGS, INCLUDING:
- HIGH-FLOW BYPASS MANHOLE;
- 3-WAY FLOW SPLITTER MANHOLE;
- FILTRATION SYSTEM;
- SAMPLING VAULT;
- EFFLUENT PUMP STATION MH; AND
- PUMP CONTROL PANEL

HE CONTRACTOR SHALL PROCURE AND INSTALL THE DISCHARGE PUMP, PIPING, FLOW METER AND PROBE, VALVES, ND OTHER APPURTENANCES NEEDED TO MAKE A COMPLETE AND WORKABLE SYSTEM.

ASSCO SHALL PROCURE THE MANHOLES, VAULTS, CARTRIDGE FILTERS, AND FILTRATION MEDIA UNDER A SEPARATE ONTRACT AND PROVIDE SUCH TO THE CONTRACTOR AT THE WORK SITE.

ESIGN CRITERIA

ESIGN FLOW

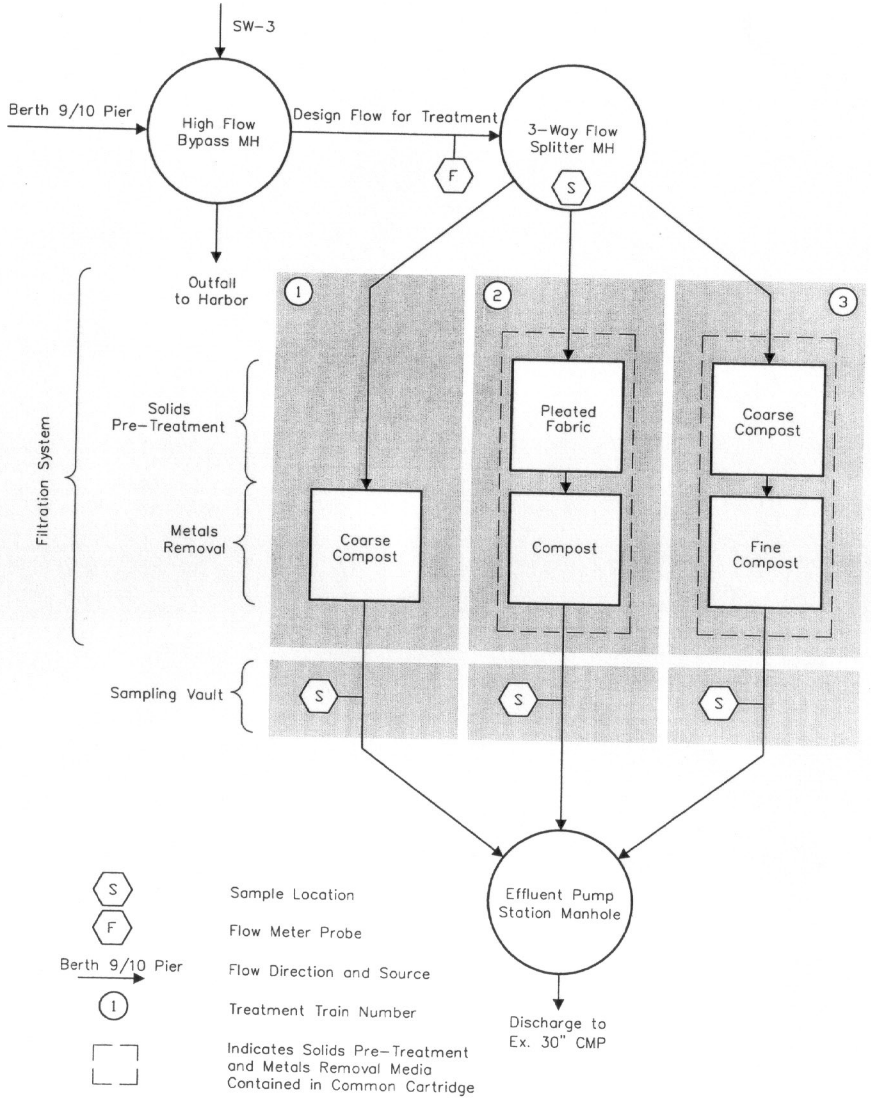
| | |
|---|---|
| RAINAGE AREAS | SW-3 AND BERTH 9/10 PIER |
| W-3 PEAK FLOW | 1,900 GALLONS PER MINUTE (4.3 CUBIC FEET PER SECOND) |
| ERTH 9/10 PIER PEAK FLOW | 100 GALLONS PER MINUTE (0.2 CUBIC FOOT PER SECOND) |
| OTAL PEAK FLOW | 2,000 GALLONS PER MINUTE (4.5 CUBIC FEET PER SECOND) |
| W-3 RUNOFF CAPTURE | 95 PERCENT |
| OMINAL DESIGN STORM RETURN PERIOD | 1 YEAR |
| OMINAL PEAK FLOW AVERAGING PERIOD | 15 MINUTES |

FLUENT CHARACTERISTICS

| | | |
|---|---|---|
| TAL SUSPENDED SOLIDS – | AVERAGE | 25 mg/L |
| | PEAK | 49 mg/L |
| . AND GREASE – | AVERAGE | 7.2 mg/L |
| | PEAK | 22 mg/L |
| TAL COPPER – | AVERAGE | 370 ug/L |
| | PEAK | 760 ug/L |
| TAL ZINC – | AVERAGE | 1,500 ug/L |
| | PEAK | 3,300 ug/L |

FLUENT REQUIREMENTS

| | | |
|---|---|---|
| TAL COPPER – | PERCENT REMOVAL | 90 PERCENT |
| | AVERAGE CONCENTRATION | 37 ug/L |
| TAL ZINC – | PERCENT REMOVAL | 80 PERCENT |
| | AVERAGE CONCENTRATION | 300 ug/L |




FLOW SCHEMATIC

NOT TO SCALE

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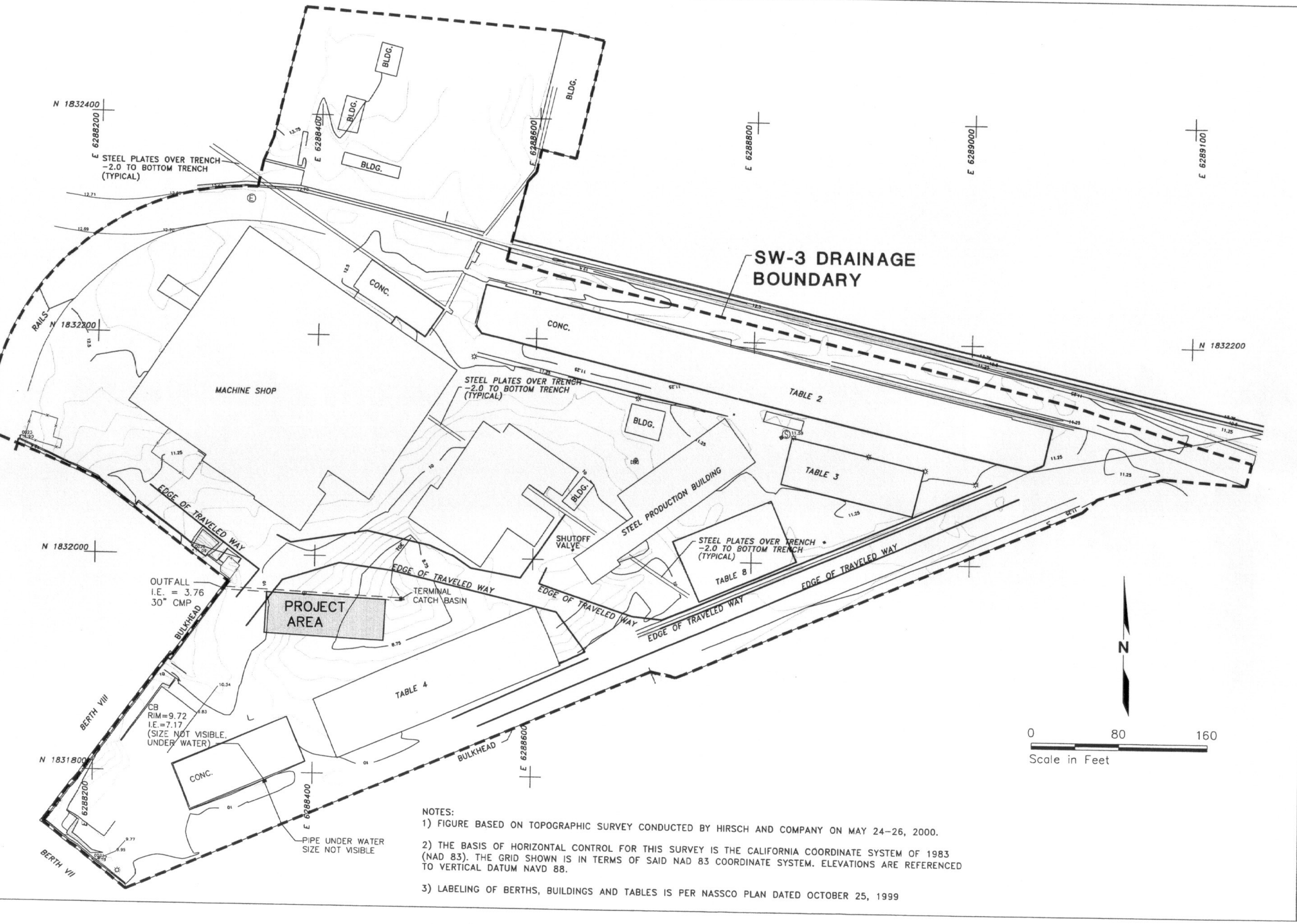
SCOPE OF WORK/FLOW SCHEMATIC

SCALE: AS SHOWN | PROJECT NO. J-7374 | DRAWING FILE NAME: 73740008.DWG

DESIGNED BY: ECL CHECKED BY: BLK CHECK DATE: 7/27/00
DRAWN BY: bls APPROVED BY: APPR. DATE:
DATE | BY | REVISION | CK'D | APPR.

SHEET 2 of
DWG NO. G-2

PLOT DATE: 7/27/00
LAST EDIT: bls




NOTES:
1) FIGURE BASED ON TOPOGRAPHIC SURVEY CONDUCTED BY HIRSCH AND COMPANY ON MAY 24–26, 2000.

2) THE BASIS OF HORIZONTAL CONTROL FOR THIS SURVEY IS THE CALIFORNIA COORDINATE SYSTEM OF 1983 (NAD 83). THE GRID SHOWN IS IN TERMS OF SAID NAD 83 COORDINATE SYSTEM. ELEVATIONS ARE REFERENCED TO VERTICAL DATUM NAVD 88.

3) LABELING OF BERTHS, BUILDINGS AND TABLES IS PER NASSCO PLAN DATED OCTOBER 25, 1999

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SW-3 SITE PLAN

| SCALE: | PROJECT NO. | DRAWING FILE NAME: |
|---|---|---|
| AS SHOWN | J-7374 | 73740009.DWG |

DESIGNED BY: ECL CHECKED BY: BLK CHECK DATE: 7/27/00
DRAWN BY: bts APPROVED BY: APPR. DATE:

| DATE | BY | REVISION | CK'D | APPR. |
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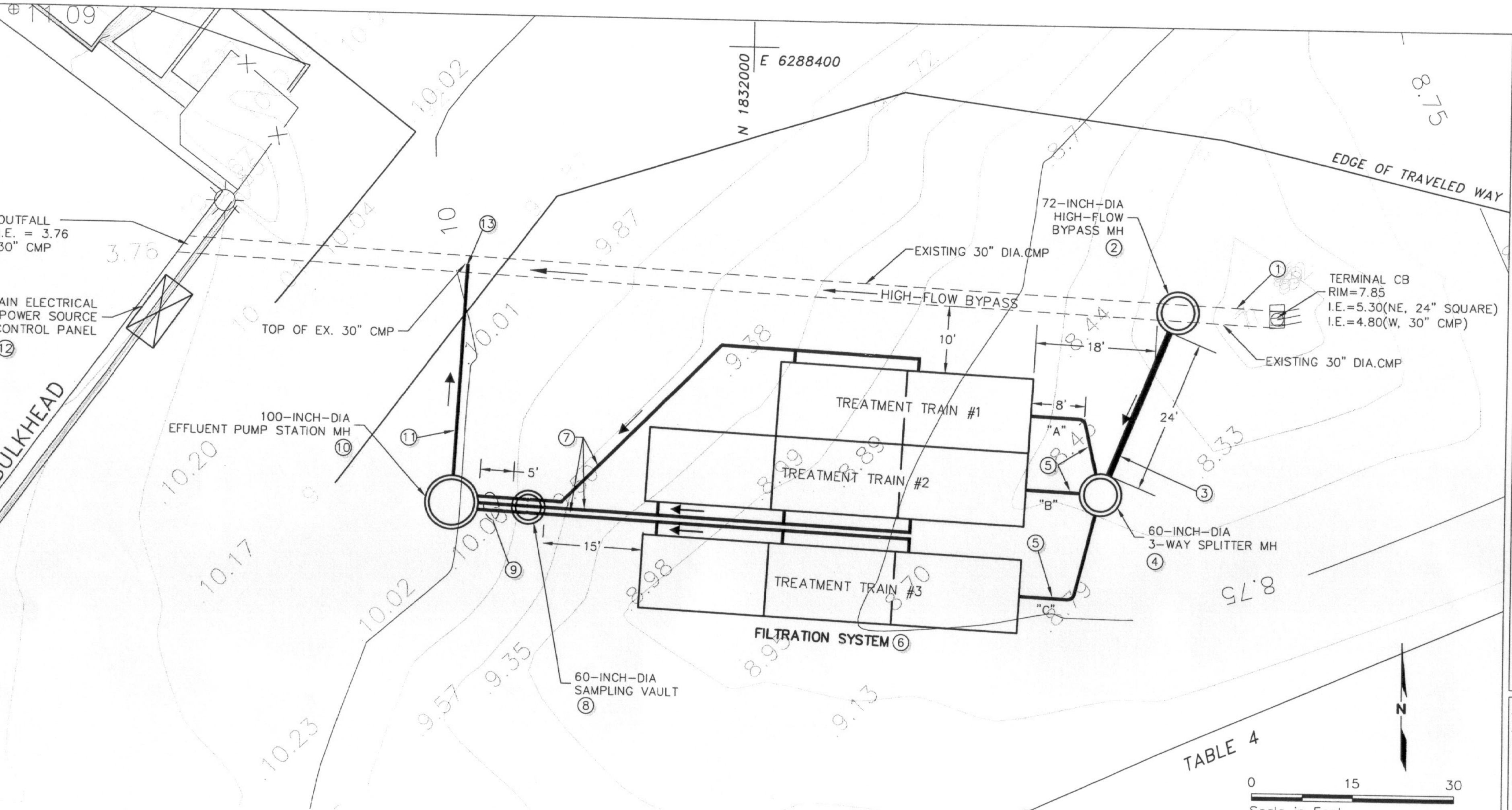
SHEET 3 of
DWG NO. C-1

PLOT DATE: 7/27/00
LAST EDIT: bts




## CONSTRUCTION NOTES

1. REMOVE 8 FEET OF EXISTING 30" CMP OUTFALL LINE (STARTING APPROXIMATELY 10 FEET WEST OF EXISTING TERMINAL CATCH BASIN)
2. INSTALL HIGH-FLOW BYPASS MANHOLE (SEE DWG C-5) AND INTERCONNECT INFLUENT AND EFFLUENT 30" CMP OUTFALL LINE
3. INSTALL ONE (1)-12-INCH-DIAMETER HDPE, SCH. 80 PIPE DISCHARGING FROM THE HIGH-FLOW BYPASS MANHOLE TO THE 3-WAY FLOW SPLITTER MANHOLE. (SEE DETAIL 1, DWG C-4)
4. INSTALL 3-WAY FLOW SPLITTER MANHOLE (SEE DWG C-6). INSTALL ONE VELOCITY-DEPTH FLOW METER WITH INSERTED SUBMERGED PROBE (SEE DWG E-1) INTO THE INLET PIPE TO THE 3-WAY FLOW SPLITTER MANHOLE.
5. INSTALL THREE (3) - 8-INCH-DIAMETER HDPE, SCH. 80 PIPES DISCHARGING FROM THE 3-WAY FLOW SPLITTER MANHOLE TO EACH FILTRATION SYSTEM TREATMENT TRAIN (#1, #2, AND #3) INFLUENT WITH 8-INCH ELBOWS (A-17'; B-8'; C-22') (SEE DETAIL 1, DWG C-4).
6. INSTALL EACH TREATMENT TRAIN SYSTEM; #1-TWO PRE-CAST CONCRETE STORMFILTER VAULTS AND #2/#3 - THREE PRE-CAST CONCRETE STORMFILTER VAULTS WITH BASE ANTI-FLOATATION BASE FOUNDATION SLAB (SEE DWG C-7).
7. INSTALL THREE (3) - 8-INCH DIAMETER HDPE, SCH. 80 PIPES DISCHARGING FROM THE SIDE OUTLETS FROM EACH STORMFILTER VAULT (SEE DETAIL 1, DWG C-4).
8. INSTALL PRE-CAST CONCRETE SAMPLING VAULT (SEE DETAIL 2, DWG C-4) APPROXIMATELY 15 FEET WEST OF FILTRATION SYSTEM WITH BASE FOUNDATION SLAB; INSTALL 3 SAMPLE TAPS, 1 PER 8-INCH-DIA PIPE.
9. INTERCONNECT THREE 8-INCH HDPE SCH. 80 DISCHARGE PIPES FROM FILTRATION SYSTEM THROUGH SAMPLING VAULT TO PUMP STATION. (SEE DETAIL 1, DWG C-4)
10. INSTALL PRE-CAST CONCRETE PUMP STATION (SEE DETAIL 3, DWG C-4) WITH WET-PIT, NON-CLOG, SELF-PRIMING, SUBMERSIBLE CENTRIFUGAL PUMP, PLUG AND CHECK VALVES AND CONTROLS, APPROXIMATELY 20 FEET WEST OF FILTRATION SYSTEM; INTERCONNECT THREE 8-INCH HDPE; SCH. 80 INFLUENT PIPES FROM SAMPLING VAULT.
11. INSTALL 8-INCH-DIAMETER HDPE, SCH. 80 FORCE MAIN FROM CENTRIFUGAL PUMP OUTLET TO PUMP STATION DISCHARGE OUTLET (SEE DETAIL 1, DWG C-4) AND INTERCONNECT INTO TOP OF EXISTING 30" CMP OUTFALL LINE, APPROXIMATELY 45 FEET EAST OF FINAL OUTFALL TO HARBOR
12. INSTALL 460 VOLT ELECTRICAL INTERCONNECTIONS FROM MAIN POWER SOURCE AT BULKHEAD, 45 FEET WEST OF PUMP STATION, TO PUMP STATION WITH OPERATIONAL CONTROLS/INSTRUMENTATION CABLES; INSTALL PUMP CONTROL PANEL IN NEMA 4 ABOVE-GROUND ENCLOSURE AT MAIN POWER SOURCE FOR DISCHARGE PUMP OPERATIONS (SEE DETAIL 1, DWG E-1).
13. INSTALL 8-INCH-DIA HDPE FORCEMAIN INTO TOP OF EX. 30" CMP.
14. VERIFY OPERATION OF THE PUMP CONTROL PANEL, AND DEMONSTRATE ALL SYSTEM FUNCTIONS TO THE SATISFACTION OF NASSCO ON COMPLETION OF ALL WORK.
15. FURNISH A COMPLETE SET OF AS-BUILT MARKUP DRAWINGS TO DOCUMENT ALL ABOVE-GROUND AND SUBSURFACE FACILITIES AND PIPING CONNECTIONS INSTALLED UNDER THIS CONTRACT.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# FACILITY SITE PLAN

DRAWING FILE NAME: 73740010.DWG
PROJECT NO. J-7374
SCALE: AS SHOWN

| DESIGNED BY: ECL | CHECKED BY: BLK | CHECK DATE: 7/27/00 |
|---|---|---|
| DRAWN BY: bts | APPROVED BY: | APPR. DATE: |

| DATE | BY | REVISION | CK'D | APPR. |
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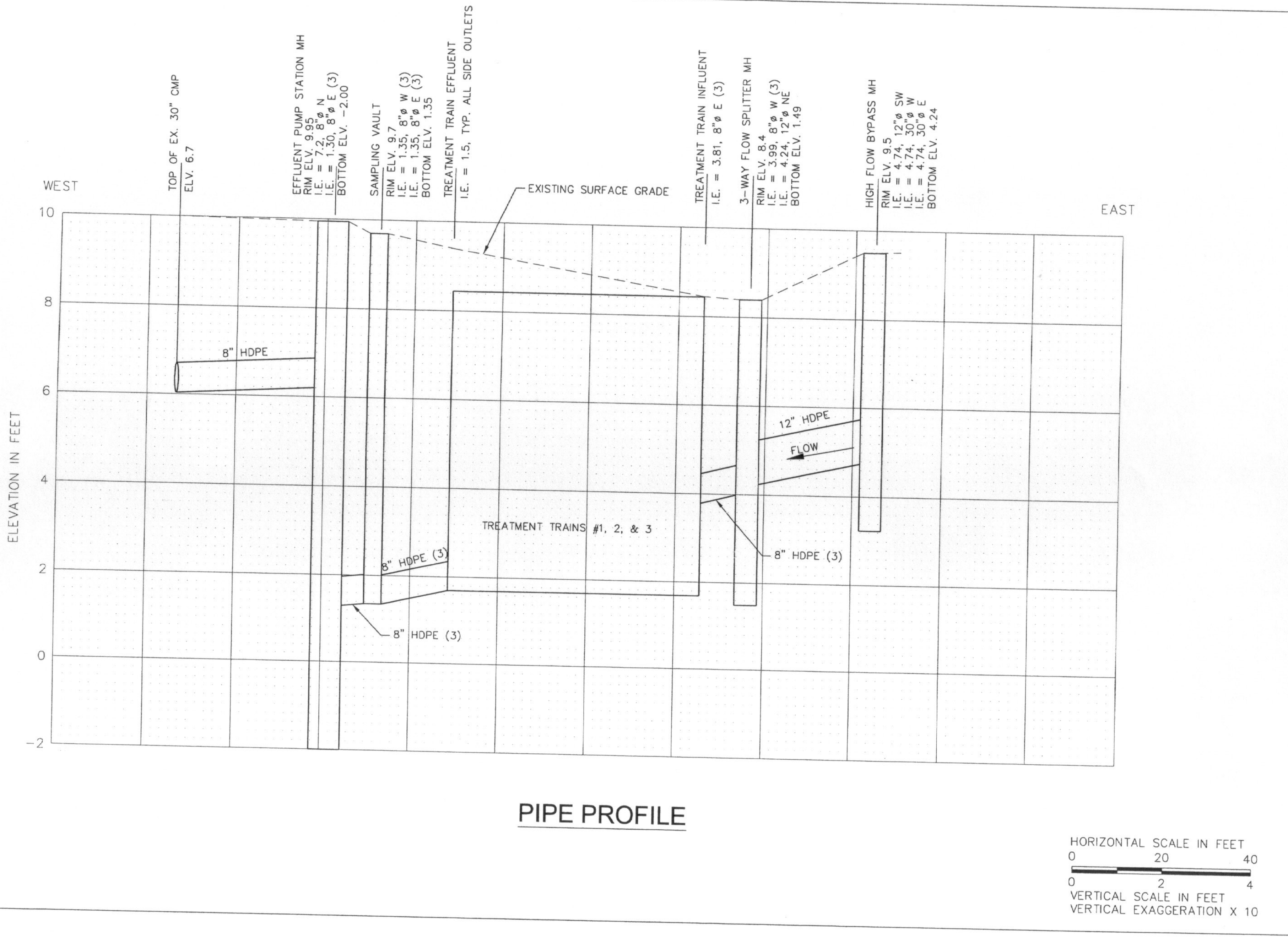
SHEET 4 of
DWG NO. C-2

PLOT DATE: 7/18/00
LAST EDIT: bts




# PIPE PROFILE

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PIPE PROFILE

SCALE: AS SHOWN | PROJECT NO. J-7374 | DRAWING FILE NAME: 73740015.DWG

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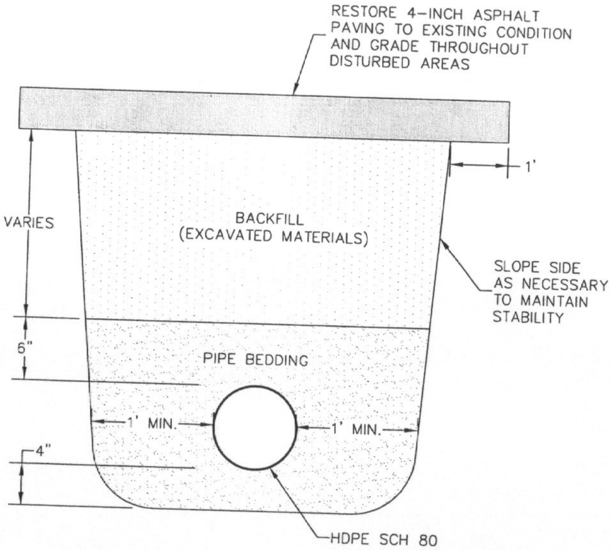
SHEET 5 of
DWG NO. C-3

PLOT DATE: 7/27/00
LAST EDIT: bts




## DETAIL 1: STORM SEWER TRENCH (TYP.)

NOT TO SCALE

NOTES:

1. FOR MULTIPLE PIPES IN SINGLE TRENCH (EAST OF EFFLUENT PUMP STATION MH), PROVIDE 1-FOOT SEPARATION BETWEEN PIPES, OUTSIDE WALLS.

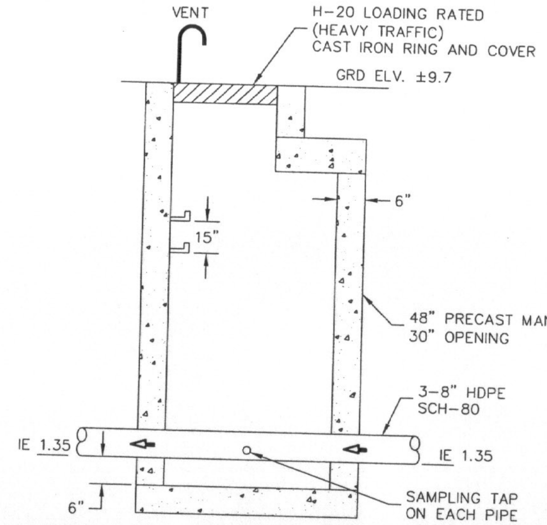
2. PIPE BEDDING

BEDDING SHALL BE OF THE TYPE AND THICKNESS SHOWN. BEDDING SHALL BE CLEAN, SAND-GRAVEL MIXTURE FREE FROM ORGANIC MATTER AND CONFORMING TO THE FOLLOWING GRADATION WHEN TESTED IN ACCORDANCE WITH ASTM D 422.

| US STANDARD SIEVE SIZE | PERCENT PASSING |
|---|---|
| 1-INCH | 100 |
| NO. 4 | 25-80 |
| NO. 200 | 0-10 |

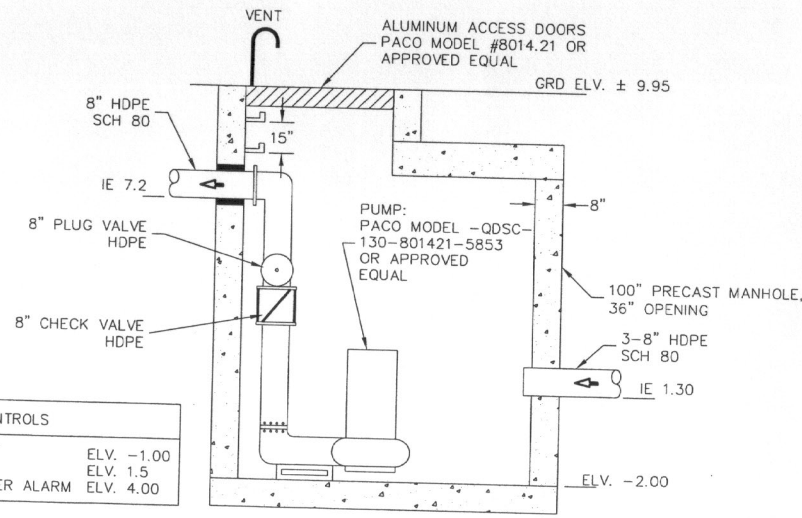
3. BACKFILLING AND COMPACTION

BACKFILL MATERIAL SHALL CONSIST OF EXCAVATED MATERIAL. BACKFILL SHALL BE PLACED IN LAYERS NOT EXCEEDING 6 INCHES LOOSE THICKNESS FOR COMPACTION BY HAND-OPERATED MACHINE COMPACTORS, AND 8 INCHES LOOSE THICKNESS FOR OTHER THAN HAND-OPERATED MACHINES, UNLESS OTHERWISE SPECIFIED. EACH LAYER SHALL BE COMPACTED TO AT LEAST 95 PERCENT MAXIMUM DENSITY FOR COHESIONLESS SOILS AND 90 PERCENT MAXIMUM DENSITY FOR COHESIVE SOILS, UNLESS OTHERWISE SPECIFIED.




## DETAIL 2: SAMPLING VAULT

NOT TO SCALE




| PUMP CONTROLS | |
|---|---|
| PUMP OFF | ELV. -1.00 |
| PUMP ON | ELV. 1.5 |
| HIGH WATER ALARM | ELV. 4.00 |

## DETAIL 3: EFFLUENT PUMP STATION MH

NOT TO SCALE

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CIVIL DETAILS

DRAWING FILE NAME: 73740012.DWG
PROJECT NO. J-7374
SCALE: AS SHOWN

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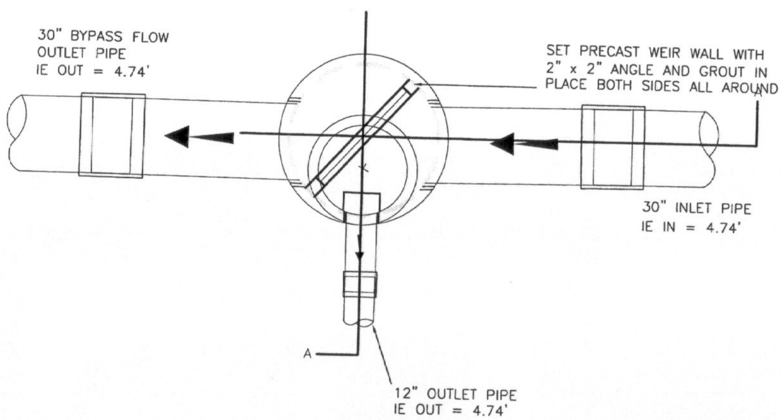
SHEET 6 of
DWG NO. C-4

PLOT DATE: 7/27/00
LAST EDIT: bls



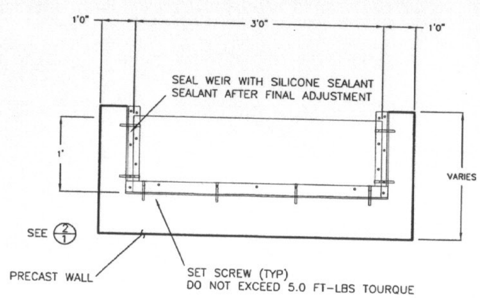

THE STORMGATE™ – PLAN VIEW
SCALE: N.T.S
1/1

## BASIC OPERATIONS MAINTENANCE GUIDELINES

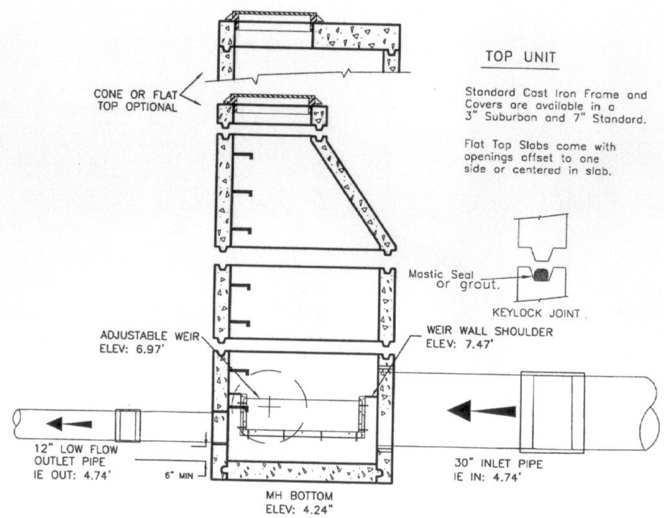
A.) MINIMUM ANNUAL MAINTENANCE INCLUDES INSPECTION OF COMPONENTS AND REMOVAL OF SEDIMENTS.
B.) INSPECT SYSTEM CONDITION IN THE EVENT OF A 5 YEAR STORM OR GREATER.
NOTE: FOLLOW ALL LOCAL, STATE, & FEDERAL SAFETY GUIDELINES.

## GENERAL NOTES:

1.) PRE-CAST CONCRETE MANHOLE CONSTRUCTED IN ACCORDANCE WITH ASTM C478.
2.) FLEXIBLE COUPLINGS TO BE SET 18" OUTSIDE FACE OF WALL. FERNCO OR ENGINEER APPROVED.
3.) PRECASTER IS RESPONSIBLE FOR PRODUCING MANHOLES IN ACCORDANCE WITH LOCAL CITY/COUNTY SPECIFICATIONS.
4.) ENGINEER TO SUBMIT PLANS AND COMPLETED STORMGATE DATA BLOCK TO STORMWATER MANAGMENT FOR PRODUCT DESIGN VERIFICATION.




THE STORMGATE™ WEIR DETAIL
SCALE: N.T.S
2/1




THE STORMGATE™ – SECTION VIEW
SCALE: N.T.S
A–A/1

STORMWATER™ MANAGEMENT
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(503) 240-3393 · FAX: 240-9553

# HIGH FLOW BYPASS MH DETAIL
## NASSCO PROJECT

| SCALE: | PROJECT NO. | DRAWING FILE NAME: |
|---|---|---|
| AS SHOWN | 2254 | 73740016.DWG |

| DESIGNED BY: JFH | CHECKED BY: | CHECK DATE: |
|---|---|---|
| DRAWN BY: JFH | APPROVED BY: | APPR. DATE: |

| DATE | BY | REVISION | CK'D | APPR. |
|---|---|---|---|---|

SHEET
DWG NO.
C–5

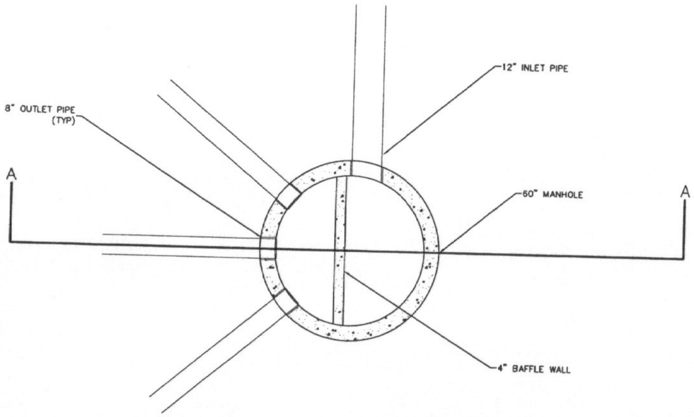
PLOT DATE: 7/27/00
LAST EDIT: JFH

## BASIC OPERATIONS MAINTENANCE GUIDELINES

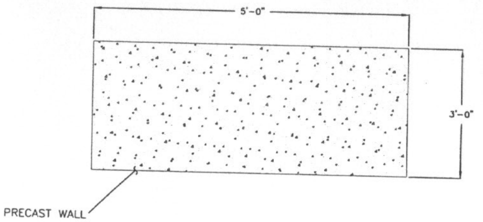
A.) MINIMUM ANNUAL MAINTENANCE INCLUDES INSPECTION OF COMPONENTS AND REMOVAL OF SEDIMENTS.
B.) INSPECT SYSTEM CONDITION IN THE EVENT OF A 5 YEAR STORM OR GREATER.
NOTE: FOLLOW ALL LOCAL, STATE, & FEDERAL SAFETY GUIDELINES.

## GENERAL NOTES:

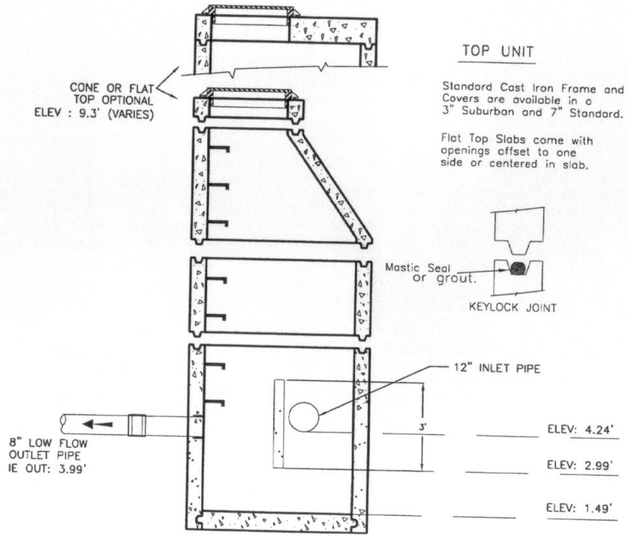
1.) PRE-CAST CONCRETE MANHOLE CONSTRUCTED IN ACCORDANCE WITH ASTM C478.
2.) FLEXIBLE COUPLINGS TO BE SET 18" OUTSIDE FACE OF WALL. FERNCO OR ENGINEER APPROVED.
3.) PRECASTER IS RESPONSIBLE FOR PRODUCING MANHOLES IN ACCORDANCE WITH LOCAL CITY/COUNTY SPECIFICATIONS.
4.) ENGINEER TO SUBMIT PLANS AND COMPLETED STORMGATE DATA BLOCK TO STORMWATER MANAGMENT FOR PRODUCT DESIGN VERIFICATION.




TRIPLE SPLIT MH – PLAN VIEW (1/1)
SCALE: N.T.S




BAFFLE WALL DETAIL (2/1)
SCALE: N.T.S




TRIPLE SPLIT MH – SECTION VIEW (A–A/1)
SCALE: N.T.S

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**3-WAY FLOW SPLITTER MH DETAIL**
**NASSCO PROJECT**

| SCALE: | PROJECT NO. | DRAWING FILE NAME: |
|---|---|---|
| AS SHOWN | 2254 | 73740017.DWG |

| DESIGNED BY: JFH | CHECKED BY: | CHECK DATE: |
|---|---|---|
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| DATE | BY | REVISION | CK'D | APPR. |
|---|---|---|---|---|
| | | | | |

SHEET
DWG NO. C–6

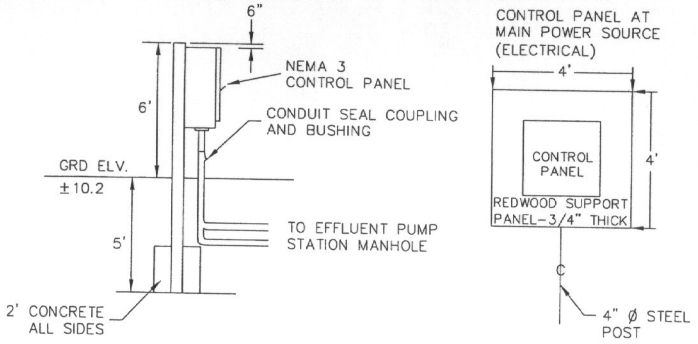
PLOT DATE: 7/27/00
LAST EDIT: JFH

# TO BE COMPLETED BY ELECTRICAL ENGINEER

FLOW METER EQUIPMENT LIST

TYPE: AMERICAN SIGMA VELOCITY-DEPTH METER

| DESCRIPTION | PART # | QUANTITY |
|---|---|---|
| 910 AV FLOW METER | 4900 | 1 |
| PROBE, SUBMERGE DEPTH/VEL W/CONN 0-10 FT. | 88000 | 1 |
| CABLE, SUB PRESS, AV | 3564 | 1 |
| RING, MOUNTING, 10 IN. DIA. DEPTH SENSOR | 1363 | 10 |
| CLIP, MOUNTING, AV FOR AV PROBE | 3263 | 1 |
| BATTERY, EVEREADY ALKALINE LANTERN | 3667 | 6 |
| INSERTION TOOL | 9574 | 1 |




## DETAIL 1: CONTROL PANEL AT MAIN POWER SOURCE

NOT TO SCALE

| | | | | | | |
|---|---|---|---|---|---|---|
| SHEET 10 of | DESIGNED BY: ECL | CHECKED BY: BLK | CHECK DATE: 7/27/00 | ELECTRICAL | | HARTCROWSER |
| DWG NO. E-1 | DRAWN BY: bts | APPROVED BY: | APPR. DATE: | SCALE: AS SHOWN | PROJECT NO. J-7374 | DRAWING FILE NAME: 73740014.DWG |
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PLOT DATE: 7/27/00

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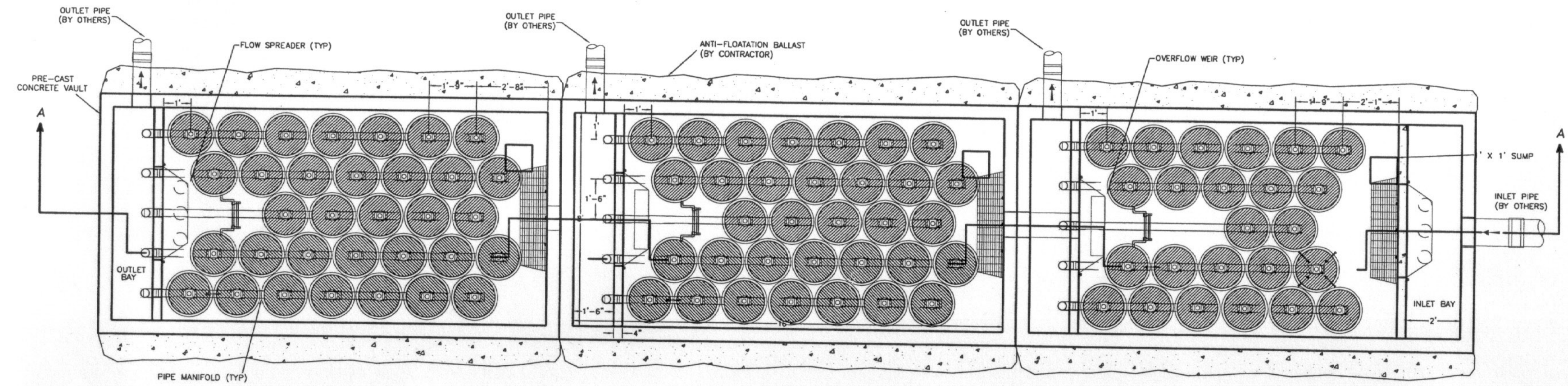
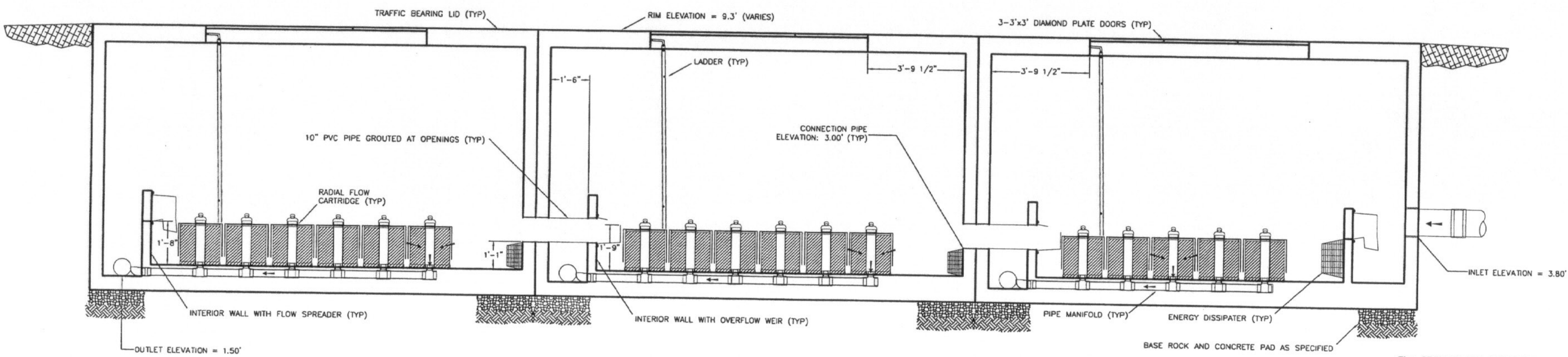
## GENERAL NOTES:

1.) STORMFILTER BY STORMWATER MANAGEMENT, PORTLAND, OREGON (503-240-3393).
2.) ALL STORMFILTERS REQUIRE REGULAR MAINTENANCE. REFER TO OPERATION AND MAINTENANCE MANUAL FOR DETAILS.
3.) PRECAST CONCRETE VAULT CONSTRUCTED IN ACCORDANCE WITH ASTM C858.
4.) EXTERNAL PIPING AND COUPLINGS PROVIDED BY OTHERS.
5.) FLEXIBLE COUPLINGS TO BE SET 18" OUTSIDE FACE OF WALL. FERNCO OR ENGINEER APPROVED.
6.) SEE PRECAST STORMFILTER DATA SHEET FOR VAULT DIMENSIONS, ELEVATIONS AND NUMBER OF CARTRIDGES.
7.) ANTI-FLOATATION BALLAST TO BE SET ALONG ENTIRE LENGTH OF BOTH SIDES OF FILTER AS SHOWN. SEE PRECAST FILTER DATA BLOCK FOR BALLAST WIDTH AND HEIGHT DIMENSIONS.




8'x16'/8'x16'/8'x16' PRECAST STORMFILTERS™ – PLAN VIEW
SCALE: N.T.S.
1/1




8'x16'/8'x16'/8'x16' PRECAST STORMFILTERS™ – SECTION VIEW
SCALE: N.T.S.
A-A/1

The STORMWATER MANAGEMENT *StormFilter*™
U.S. PATENT No. 5,322,629, No. 5,624,576, AND OTHER U.S. AND FOREIGN PATENTS PENDING

| SHEET | DESIGNED BY: JFH | CHECKED BY: | CHECK DATE: |
|---|---|---|---|
| DWG NO. C-7 | DRAWN BY: JFH | APPROVED BY: | APPR. DATE: |

| DATE | BY | REVISION | CK'D | APPR. |
|---|---|---|---|---|
| | | | | |

**STORMFILTER PLAN AND SECTION**
**8'x16'/8'x16'/8'x16' PRECAST STORMFILTER**
**NASSCO PROJECT**

| SCALE: | PROJECT NO. | DRAWING FILE NAME: |
|---|---|---|
| AS SHOWN | 2254 | 73740013.DWG |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LAST EDIT: JFH
PLOT DATE: 7/27/00

# APPENDIX A
# HYDROLOGIC ANALYSIS

Contents of Appendix A

**Stormwater Collection and Treatment System Threshold Precipitation Values** **J-7374**

| Storm Frequency[1] | Storm Duration | Rainfall (inches) | Capture %by volume | Capture % by time | SBUH Peak Flow (cfs) |
|---|---|---|---|---|---|
| 0.4 | 24 hour | 0.89 | 90.1% | 88.4% | 3.22 |
| 0.8 | 24 hour | 1.17 | 95.0% | 94.0% | 4.28 |
| 2.0 | 24 hour | 1.54 | 98.0% | 97.6% | 5.66 |
| 2 yr(NOAA) | 24 hour | 1.62 | | | 6.47 |

Notes:
1. For the first three storms, frequency was calculated from precipitation data. For the last storm, frequency and precipitation are as shown on the NOAA precipitation maps. It is the value that was used initially to estimate the size of the treatment system.

**HARTCROWSER** Calculations

Page 1 of 3

Job No. 7374

Project NASSCO

Date 5/25/00

Calculations for Determining Design Storm Event

Made by RGJ

Discussion w/ Shane Cherry concerning approach to convert regulatory requirements into design flow rates

Regulatory Requirements state that the following 2 conditions must be met:

① System must treat first flush (defined as first 1/4")

② System must abide by the following Toxicity requirements

a) survival must exceed 90% atleast 50% of the time

b) survival must exceed 70% atleast 90% of the time

Interpretation: If we design a system that treats all flow 90% of the time, we can provide treatment to meet toxicity requirements for that volume of water.

∴ Determine the design rainfall event (inches) for which atleast 90% of the rain is captured. Use that precipitation value with the Santa Barbara method to estimate a peak flow rate for which the system will be designed.

Qualifiers ⟹ There are a few important qualifiers to be considered with this approach.

① It is assumed that % capture by volume ≈ % capture by event. The relationship between these two depends on storm type. Both should be calculated and compared.

② The approach assumes that the synthetic Type I curves used by the SBUH method are representative of the worst case distribution. Someone at NOAA or who lives in San Diego should be consulted about the type of rain that can be expected.

Calculations

HARTCROWSER



Job No. 7374

Project NASSCO

Date 5/25/00

Calculations for Determine Design Storm Event

Made by RGJ

Qualifiers (cont.)

(3) Since the capture % is based on a threshold rain depth, all rainfall above that threshold is assumed to bypass the system. However, this is not exactly the case. A system sized for a certain storm will capture a percentage of larger storms because part of the excess volume will reach the system at a flow rate less than the design flow rate.

Design Storm Methodology:

1- Based on available rainfall data, determine the threshold rainfall amount that corresponds to 90%, 95%, and 98% capture by volume.

- Daily precipitation was obtained from NOAA for its San Diego Lindbergh Field station (Int'l Airport). The data cover a 73 year period from 1/1927 to 2/2000

- The monthly precipitation in excess of the threshold precip value (inches) was tabulated and summed for the entire record. This exceedence was compared against the total rainfall for the period of record. Threshold values were iterated until three values were obtained that correspond to 90%, 95%, and 98% capture.

- A return period was assigned to each precipitation value by comparing the exceedence events with the time period covered by the record.

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Calculations

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2- Using SBUH calculate peak flows associated with the rainfall determined in step 1

3- Check qualifiers

1- All days with more precipitation than the threshold value were counted. This count was compared to the total number of days having greater than 0.1 inch rainfall. This value was chosen to represent the lower limit of a 'significant' rainfall event. The percent capture based on event was derived from these values. When compared to percent capture by volume it suggests that the two are approximately inter-changeable.

2- The SCS TR-55 document was reviewed. It states that the synthetic curves used are intended to represent the rainfall distribution in a given area that would result in the highest peak runoff. It is therefore legitimate to assume that the SBUH method will generate a worst case peak flow since it is based on SCS TR-55.

3- Hydrographs corresponding to the 95% and 98% capture precipitation values were superimposed. It was determined that the runoff rate of the larger storm would exceed the peak flow of the smaller storm for 10 min. A system sized to capture the peak of the smaller storm would capture 90% of the larger storm. This suggests our method to be very conservative

5

**TREATMENT OF EXCESS RUNOFF VOLUME DURING LARGER STORMS** **J-7374**

Comparison of the 0.8- year and the 2-year event

| PEAKS | 4.281 | 5.663 | Excess | Excess | Excess |
|---|---|---|---|---|---|
| Time (hrs) | 0.8 yr Runoff (cfs) | 2 yr Runoff (cfs) | Total Volume ft3 | Bypass Rate cfs | Bypass Volume ft3 |
| 0.25 | 0.08 | 0.10 | 20.7 | 0 | 0 |
| 0.5 | 0.16 | 0.21 | 46.8 | 0 | 0 |
| 0.75 | 0.18 | 0.24 | 53.1 | 0 | 0 |
| 1 | 0.19 | 0.25 | 56.7 | 0 | 0 |
| 1.25 | 0.19 | 0.26 | 56.7 | 0 | 0 |
| 1.5 | 0.19 | 0.26 | 56.7 | 0 | 0 |
| 1.75 | 0.20 | 0.26 | 56.7 | 0 | 0 |
| 2 | 0.20 | 0.26 | 56.7 | 0 | 0 |
| 2.25 | 0.20 | 0.27 | 60.3 | 0 | 0 |
| 2.5 | 0.21 | 0.28 | 63 | 0 | 0 |
| 2.75 | 0.22 | 0.29 | 62.1 | 0 | 0 |
| 3 | 0.22 | 0.29 | 63 | 0 | 0 |
| 3.25 | 0.22 | 0.29 | 63 | 0 | 0 |
| 3.5 | 0.22 | 0.29 | 63 | 0 | 0 |
| 3.75 | 0.23 | 0.30 | 66.6 | 0 | 0 |
| 4 | 0.24 | 0.31 | 70.2 | 0 | 0 |
| 4.25 | 0.24 | 0.32 | 70.2 | 0 | 0 |
| 4.5 | 0.24 | 0.32 | 69.3 | 0 | 0 |
| 4.75 | 0.25 | 0.33 | 72 | 0 | 0 |
| 5 | 0.26 | 0.34 | 74.7 | 0 | 0 |
| 5.25 | 0.27 | 0.36 | 77.4 | 0 | 0 |
| 5.5 | 0.28 | 0.37 | 81.9 | 0 | 0 |
| 5.75 | 0.29 | 0.39 | 86.4 | 0 | 0 |
| 6 | 0.30 | 0.40 | 89.1 | 0 | 0 |
| 6.25 | 0.30 | 0.40 | 90 | 0 | 0 |
| 6.5 | 0.30 | 0.40 | 89.1 | 0 | 0 |
| 6.75 | 0.32 | 0.43 | 93.6 | 0 | 0 |
| 7 | 0.34 | 0.45 | 100.8 | 0 | 0 |
| 7.25 | 0.36 | 0.48 | 107.1 | 0 | 0 |
| 7.5 | 0.39 | 0.51 | 111.6 | 0 | 0 |
| 7.75 | 0.41 | 0.54 | 118.8 | 0 | 0 |
| 8 | 0.43 | 0.57 | 126 | 0 | 0 |
| 8.25 | 0.48 | 0.64 | 140.4 | 0 | 0 |
| 8.5 | 0.53 | 0.70 | 155.7 | 0 | 0 |
| 8.75 | 0.63 | 0.84 | 184.5 | 0 | 0 |
| 9 | 0.74 | 0.98 | 216.9 | 0 | 0 |
| 9.25 | 0.88 | 1.17 | 258.3 | 0 | 0 |
| 9.5 | 1.03 | 1.37 | 301.5 | 0 | 0 |
| 9.75 | 2.59 | 3.42 | 749.7 | 0 | 0 |
| 10 | 4.28 | 5.66 | 1243.8 | 1.382 | 1243.8 |
| 10.25 | 3.11 | 4.13 | 919.8 | 0 | 0 |
| 10.5 | 1.69 | 2.26 | 505.8 | 0 | 0 |
| 10.75 | 1.30 | 1.72 | 381.6 | 0 | 0 |
| 11 | 0.97 | 1.29 | 286.2 | 0 | 0 |
| 11.25 | 0.82 | 1.09 | 240.3 | 0 | 0 |
| 11.5 | 0.69 | 0.91 | 200.7 | 0 | 0 |
| 11.75 | 0.65 | 0.86 | 189 | 0 | 0 |
| 12 | 0.62 | 0.82 | 180 | 0 | 0 |
| 12.25 | 0.56 | 0.75 | 165.6 | 0 | 0 |
| 12.5 | 0.51 | 0.68 | 149.4 | 0 | 0 |
| 12.75 | 0.49 | 0.65 | 144.9 | 0 | 0 |
| 13 | 0.48 | 0.64 | 140.4 | 0 | 0 |

Additional volume treated
90%

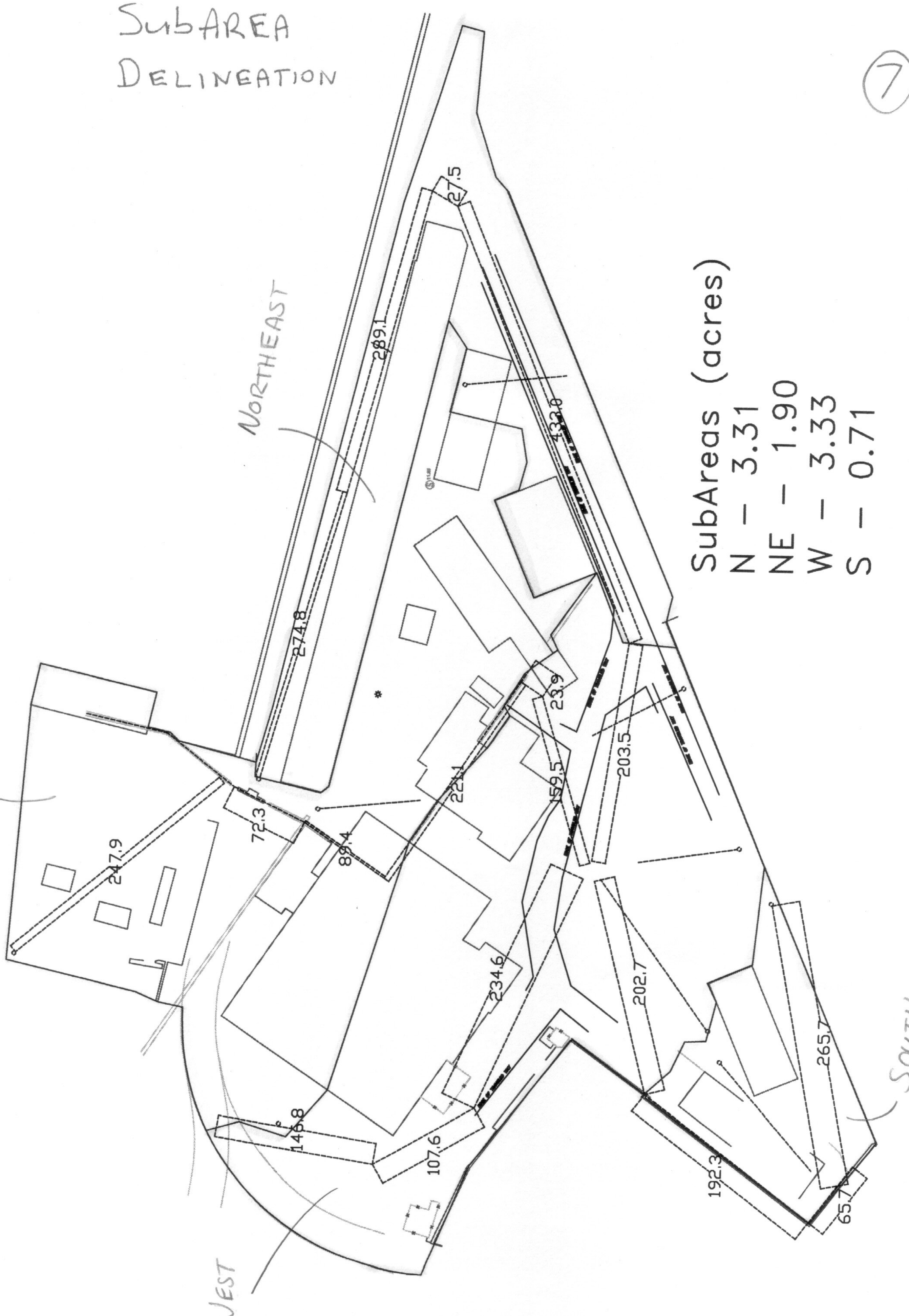
A system designed for the peak of the 1-yr storm will treat this percentage of the excess volume of water discharged during a 2-year storm.

(6)

| Time (hrs) | 0.8 yr Runoff (cfs) | 2 yr Runoff (cfs) | Total Volume ft3 | Bypass Rate cfs | Bypass Volume ft3 |
|---|---|---|---|---|---|
| 13.25 | 0.47 | 0.62 | 136.8 | 0 | 0 |
| 13.5 | 0.46 | 0.61 | 134.1 | 0 | 0 |
| 13.75 | 0.44 | 0.58 | 128.7 | 0 | 0 |
| 14 | 0.42 | 0.55 | 121.5 | 0 | 0 |
| 14.25 | 0.39 | 0.52 | 116.1 | 0 | 0 |
| 14.5 | 0.37 | 0.50 | 110.7 | 0 | 0 |
| 14.75 | 0.36 | 0.48 | 105.3 | 0 | 0 |
| 15 | 0.35 | 0.46 | 102.6 | 0 | 0 |
| 15.25 | 0.35 | 0.46 | 100.8 | 0 | 0 |
| 15.5 | 0.35 | 0.46 | 99.9 | 0 | 0 |
| 15.75 | 0.33 | 0.43 | 95.4 | 0 | 0 |
| 16 | 0.31 | 0.41 | 90.9 | 0 | 0 |
| 16.25 | 0.31 | 0.40 | 89.1 | 0 | 0 |
| 16.5 | 0.30 | 0.40 | 89.1 | 0 | 0 |
| 16.75 | 0.29 | 0.39 | 85.5 | 0 | 0 |
| 17 | 0.28 | 0.38 | 83.7 | 0 | 0 |
| 17.25 | 0.28 | 0.38 | 82.8 | 0 | 0 |
| 17.5 | 0.28 | 0.37 | 82.8 | 0 | 0 |
| 17.75 | 0.27 | 0.36 | 80.1 | 0 | 0 |
| 18 | 0.26 | 0.35 | 77.4 | 0 | 0 |
| 18.25 | 0.25 | 0.33 | 73.8 | 0 | 0 |
| 18.5 | 0.24 | 0.32 | 70.2 | 0 | 0 |
| 18.75 | 0.25 | 0.33 | 72.9 | 0 | 0 |
| 19 | 0.26 | 0.34 | 74.7 | 0 | 0 |
| 19.25 | 0.25 | 0.33 | 74.7 | 0 | 0 |
| 19.5 | 0.24 | 0.32 | 71.1 | 0 | 0 |
| 19.75 | 0.23 | 0.30 | 65.7 | 0 | 0 |
| 20 | 0.22 | 0.29 | 63 | 0 | 0 |
| 20.25 | 0.22 | 0.29 | 63 | 0 | 0 |
| 20.5 | 0.22 | 0.29 | 62.1 | 0 | 0 |
| 20.75 | 0.22 | 0.29 | 62.1 | 0 | 0 |
| 21 | 0.22 | 0.29 | 62.1 | 0 | 0 |
| 21.25 | 0.21 | 0.27 | 60.3 | 0 | 0 |
| 21.5 | 0.20 | 0.26 | 57.6 | 0 | 0 |
| 21.75 | 0.21 | 0.27 | 60.3 | 0 | 0 |
| 22 | 0.21 | 0.28 | 63 | 0 | 0 |
| 22.25 | 0.21 | 0.27 | 60.3 | 0 | 0 |
| 22.5 | 0.20 | 0.26 | 58.5 | 0 | 0 |
| 22.75 | 0.20 | 0.26 | 57.6 | 0 | 0 |
| 23 | 0.20 | 0.26 | 56.7 | 0 | 0 |
| 23.25 | 0.20 | 0.26 | 56.7 | 0 | 0 |
| 23.5 | 0.20 | 0.26 | 56.7 | 0 | 0 |
| 23.75 | 0.19 | 0.25 | 54.9 | 0 | 0 |
| 24 | 0.17 | 0.23 | 53.1 | 0 | 0 |
| TOTALS ($ft^3$) | | | 12652 | | 1244 |
| Percent of Total | | | | | 10% |

SubAREA
DELINEATION

7



# COMPOSITE HYDROGRAPH FOR SW-3 DRAINAGE AREA



(8)

| | Composite Storm - 0.89 inch rainfall | | | | | Composite Storm - 1.17 inch rainfall | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time (hrs) | SW-3N Runoff (cfs) | SW-3NE Runoff (cfs) | SW-3W Runoff (cfs) | SW-3S Runoff (cfs) | Summation Total cfs | SW-3N Runoff (cfs) | SW-3NE Runoff (cfs) | SW-3W Runoff (cfs) | SW-3S Runoff (cfs) | Summation Total cfs |
| 0.25 | 0.021 | 0.007 | 0.024 | 0.004 | 0.056 | 0.029 | 0.01 | 0.032 | 0.005 | 0.076 |
| 0.5 | 0.045 | 0.018 | 0.047 | 0.009 | 0.119 | 0.059 | 0.024 | 0.063 | 0.012 | 0.158 |
| 0.75 | 0.049 | 0.024 | 0.05 | 0.01 | 0.133 | 0.065 | 0.031 | 0.066 | 0.014 | 0.176 |
| 1 | 0.052 | 0.027 | 0.053 | 0.011 | 0.143 | 0.069 | 0.036 | 0.07 | 0.015 | 0.19 |
| 1.25 | 0.052 | 0.029 | 0.053 | 0.011 | 0.145 | 0.07 | 0.038 | 0.07 | 0.015 | 0.193 |
| 1.5 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.039 | 0.07 | 0.015 | 0.194 |
| 1.75 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.04 | 0.07 | 0.015 | 0.195 |
| 2 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.04 | 0.07 | 0.015 | 0.195 |
| 2.25 | 0.055 | 0.031 | 0.056 | 0.012 | 0.154 | 0.073 | 0.041 | 0.074 | 0.016 | 0.204 |
| 2.5 | 0.058 | 0.032 | 0.059 | 0.012 | 0.161 | 0.077 | 0.043 | 0.078 | 0.016 | 0.214 |
| 2.75 | 0.058 | 0.033 | 0.059 | 0.012 | 0.162 | 0.078 | 0.044 | 0.078 | 0.017 | 0.217 |
| 3 | 0.058 | 0.033 | 0.059 | 0.013 | 0.163 | 0.078 | 0.044 | 0.078 | 0.017 | 0.217 |
| 3.25 | 0.058 | 0.033 | 0.059 | 0.013 | 0.163 | 0.078 | 0.044 | 0.078 | 0.017 | 0.217 |
| 3.5 | 0.058 | 0.033 | 0.059 | 0.013 | 0.163 | 0.078 | 0.044 | 0.078 | 0.017 | 0.217 |
| 3.75 | 0.061 | 0.034 | 0.062 | 0.013 | 0.17 | 0.081 | 0.046 | 0.082 | 0.017 | 0.226 |
| 4 | 0.064 | 0.036 | 0.065 | 0.014 | 0.179 | 0.085 | 0.047 | 0.086 | 0.018 | 0.236 |
| 4.25 | 0.064 | 0.036 | 0.065 | 0.014 | 0.179 | 0.085 | 0.048 | 0.086 | 0.018 | 0.237 |
| 4.5 | 0.064 | 0.037 | 0.065 | 0.014 | 0.18 | 0.085 | 0.049 | 0.086 | 0.018 | 0.238 |
| 4.75 | 0.067 | 0.038 | 0.068 | 0.014 | 0.187 | 0.089 | 0.05 | 0.09 | 0.019 | 0.248 |
| 5 | 0.07 | 0.039 | 0.07 | 0.015 | 0.194 | 0.093 | 0.052 | 0.094 | 0.02 | 0.259 |
| 5.25 | 0.073 | 0.041 | 0.073 | 0.016 | 0.203 | 0.097 | 0.054 | 0.098 | 0.021 | 0.27 |
| 5.5 | 0.076 | 0.042 | 0.076 | 0.016 | 0.21 | 0.1 | 0.056 | 0.102 | 0.021 | 0.279 |
| 5.75 | 0.078 | 0.044 | 0.079 | 0.017 | 0.218 | 0.104 | 0.058 | 0.105 | 0.022 | 0.289 |
| 6 | 0.081 | 0.045 | 0.082 | 0.017 | 0.225 | 0.108 | 0.06 | 0.109 | 0.023 | 0.3 |
| 6.25 | 0.082 | 0.046 | 0.082 | 0.017 | 0.227 | 0.109 | 0.061 | 0.109 | 0.023 | 0.302 |
| 6.5 | 0.082 | 0.047 | 0.082 | 0.018 | 0.229 | 0.109 | 0.062 | 0.109 | 0.023 | 0.303 |
| 6.75 | 0.087 | 0.049 | 0.088 | 0.019 | 0.243 | 0.116 | 0.065 | 0.117 | 0.025 | 0.323 |
| 7 | 0.093 | 0.051 | 0.094 | 0.02 | 0.258 | 0.123 | 0.068 | 0.125 | 0.026 | 0.342 |
| 7.25 | 0.099 | 0.054 | 0.1 | 0.021 | 0.274 | 0.131 | 0.072 | 0.133 | 0.028 | 0.364 |
| 7.5 | 0.104 | 0.058 | 0.106 | 0.022 | 0.29 | 0.139 | 0.077 | 0.141 | 0.03 | 0.387 |
| 7.75 | 0.11 | 0.061 | 0.112 | 0.023 | 0.306 | 0.147 | 0.081 | 0.148 | 0.031 | 0.407 |
| 8 | 0.116 | 0.064 | 0.117 | 0.025 | 0.322 | 0.154 | 0.085 | 0.156 | 0.033 | 0.428 |
| 8.25 | 0.13 | 0.07 | 0.132 | 0.028 | 0.36 | 0.173 | 0.093 | 0.176 | 0.037 | 0.479 |
| 8.5 | 0.145 | 0.078 | 0.147 | 0.031 | 0.401 | 0.192 | 0.103 | 0.195 | 0.041 | 0.531 |
| 8.75 | 0.173 | 0.09 | 0.177 | 0.036 | 0.476 | 0.229 | 0.12 | 0.235 | 0.048 | 0.632 |
| 9 | 0.202 | 0.105 | 0.206 | 0.042 | 0.555 | 0.268 | 0.139 | 0.274 | 0.056 | 0.737 |
| 9.25 | 0.241 | 0.124 | 0.247 | 0.051 | 0.663 | 0.321 | 0.165 | 0.329 | 0.067 | 0.882 |
| 9.5 | 0.282 | 0.146 | 0.288 | 0.059 | 0.775 | 0.375 | 0.194 | 0.384 | 0.079 | 1.032 |
| 9.75 | 0.723 | 0.305 | 0.777 | 0.145 | 1.95 | 0.961 | 0.405 | 1.033 | 0.192 | 2.591 PEAK |
| 10 | 1.195 | 0.526 | 1.255 | 0.244 | 3.22 | 1.589 | 0.699 | 1.669 | 0.324 | 4.281 HOUR |
| 10.25 | 0.847 | 0.495 | 0.811 | 0.187 | 2.34 2.20 | 1.126 | 0.658 | 1.078 | 0.249 | 3.111 2.92 |
| 10.5 | 0.432 | 0.349 | 0.389 | 0.103 | 1.273 | 0.575 | 0.464 | 0.517 | 0.137 | 1.693 |
| 10.75 | 0.327 | 0.258 | 0.318 | 0.074 | 0.977 | 0.435 | 0.343 | 0.423 | 0.099 | 1.3 |
| 11 | 0.246 | 0.192 | 0.239 | 0.055 | 0.732 | 0.327 | 0.256 | 0.317 | 0.074 | 0.974 |
| 11.25 | 0.21 | 0.152 | 0.208 | 0.046 | 0.616 | 0.279 | 0.202 | 0.276 | 0.062 | 0.819 |
| 11.5 | 0.178 | 0.124 | 0.175 | 0.039 | 0.516 | 0.236 | 0.165 | 0.233 | 0.052 | 0.686 |
| 11.75 | 0.17 | 0.109 | 0.17 | 0.037 | 0.486 | 0.226 | 0.145 | 0.226 | 0.049 | 0.646 |
| 12 | 0.164 | 0.101 | 0.164 | 0.035 | 0.464 | 0.218 | 0.134 | 0.218 | 0.047 | 0.617 |
| 12.25 | 0.15 | 0.092 | 0.149 | 0.033 | 0.424 | 0.199 | 0.123 | 0.198 | 0.043 | 0.563 |
| 12.5 | 0.135 | 0.084 | 0.135 | 0.029 | 0.383 | 0.18 | 0.112 | 0.179 | 0.039 | 0.51 |
| 12.75 | 0.132 | 0.079 | 0.132 | 0.028 | 0.371 | 0.175 | 0.105 | 0.175 | 0.038 | 0.493 |
| 13 | 0.129 | 0.076 | 0.129 | 0.028 | 0.362 | 0.171 | 0.101 | 0.172 | 0.037 | 0.481 |

# COMPOSITE HYDROGRAPH FOR SW-3 DRAINAGE AREA



(9)

| Time (hrs) | SW-3N Runoff (cfs) | SW-3NE Runoff (cfs) | SW-3W Runoff (cfs) | SW-3S Runoff (cfs) | Summation Total cfs | SW-3N Runoff (cfs) | SW-3NE Runoff (cfs) | SW-3W Runoff (cfs) | SW-3S Runoff (cfs) | Summation Total cfs |
|---|---|---|---|---|---|---|---|---|---|---|
| 13.25 | 0.126 | 0.074 | 0.126 | 0.027 | 0.353 | 0.167 | 0.098 | 0.168 | 0.036 | 0.469 |
| 13.5 | 0.123 | 0.072 | 0.123 | 0.026 | 0.344 | 0.163 | 0.096 | 0.164 | 0.035 | 0.458 |
| 13.75 | 0.117 | 0.069 | 0.117 | 0.025 | 0.328 | 0.156 | 0.092 | 0.156 | 0.034 | 0.438 |
| 14 | 0.111 | 0.066 | 0.111 | 0.024 | 0.312 | 0.148 | 0.088 | 0.148 | 0.032 | 0.416 |
| 14.25 | 0.105 | 0.063 | 0.105 | 0.023 | 0.296 | 0.14 | 0.084 | 0.14 | 0.03 | 0.394 |
| 14.5 | 0.1 | 0.06 | 0.1 | 0.022 | 0.282 | 0.132 | 0.079 | 0.132 | 0.029 | 0.372 |
| 14.75 | 0.097 | 0.057 | 0.097 | 0.021 | 0.272 | 0.128 | 0.076 | 0.129 | 0.028 | 0.361 |
| 15 | 0.094 | 0.055 | 0.094 | 0.02 | 0.263 | 0.124 | 0.073 | 0.125 | 0.027 | 0.349 |
| 15.25 | 0.093 | 0.054 | 0.094 | 0.02 | 0.261 | 0.124 | 0.072 | 0.125 | 0.027 | 0.348 |
| 15.5 | 0.093 | 0.054 | 0.094 | 0.02 | 0.261 | 0.124 | 0.072 | 0.125 | 0.027 | 0.348 |
| 15.75 | 0.088 | 0.052 | 0.088 | 0.019 | 0.247 | 0.117 | 0.069 | 0.117 | 0.025 | 0.328 |
| 16 | 0.082 | 0.049 | 0.082 | 0.018 | 0.231 | 0.109 | 0.065 | 0.109 | 0.024 | 0.307 |
| 16.25 | 0.082 | 0.048 | 0.082 | 0.018 | 0.23 | 0.109 | 0.064 | 0.109 | 0.023 | 0.305 |
| 16.5 | 0.082 | 0.047 | 0.082 | 0.018 | 0.229 | 0.109 | 0.063 | 0.109 | 0.023 | 0.304 |
| 16.75 | 0.079 | 0.046 | 0.079 | 0.017 | 0.221 | 0.105 | 0.061 | 0.105 | 0.023 | 0.294 |
| 17 | 0.076 | 0.045 | 0.076 | 0.016 | 0.213 | 0.101 | 0.059 | 0.101 | 0.022 | 0.283 |
| 17.25 | 0.076 | 0.044 | 0.076 | 0.016 | 0.212 | 0.101 | 0.059 | 0.101 | 0.022 | 0.283 |
| 17.5 | 0.076 | 0.044 | 0.076 | 0.016 | 0.212 | 0.101 | 0.058 | 0.101 | 0.022 | 0.282 |
| 17.75 | 0.073 | 0.043 | 0.073 | 0.016 | 0.205 | 0.097 | 0.057 | 0.097 | 0.021 | 0.272 |
| 18 | 0.07 | 0.041 | 0.07 | 0.015 | 0.196 | 0.093 | 0.055 | 0.094 | 0.02 | 0.262 |
| 18.25 | 0.067 | 0.04 | 0.067 | 0.015 | 0.189 | 0.09 | 0.053 | 0.09 | 0.019 | 0.252 |
| 18.5 | 0.064 | 0.038 | 0.064 | 0.014 | 0.18 | 0.086 | 0.051 | 0.086 | 0.018 | 0.241 |
| 18.75 | 0.067 | 0.038 | 0.068 | 0.014 | 0.187 | 0.089 | 0.051 | 0.09 | 0.019 | 0.249 |
| 19 | 0.07 | 0.039 | 0.07 | 0.015 | 0.194 | 0.093 | 0.052 | 0.094 | 0.02 | 0.259 |
| 19.25 | 0.067 | 0.039 | 0.067 | 0.014 | 0.187 | 0.089 | 0.052 | 0.09 | 0.019 | 0.25 |
| 19.5 | 0.064 | 0.038 | 0.064 | 0.014 | 0.18 | 0.086 | 0.05 | 0.086 | 0.018 | 0.24 |
| 19.75 | 0.061 | 0.036 | 0.062 | 0.013 | 0.172 | 0.082 | 0.048 | 0.082 | 0.018 | 0.23 |
| 20 | 0.059 | 0.035 | 0.059 | 0.013 | 0.166 | 0.078 | 0.046 | 0.078 | 0.017 | 0.219 |
| 20.25 | 0.058 | 0.034 | 0.059 | 0.013 | 0.164 | 0.078 | 0.045 | 0.078 | 0.017 | 0.218 |
| 20.5 | 0.058 | 0.034 | 0.059 | 0.013 | 0.164 | 0.078 | 0.045 | 0.078 | 0.017 | 0.218 |
| 20.75 | 0.058 | 0.034 | 0.059 | 0.013 | 0.164 | 0.078 | 0.045 | 0.078 | 0.017 | 0.218 |
| 21 | 0.058 | 0.034 | 0.059 | 0.013 | 0.164 | 0.078 | 0.045 | 0.078 | 0.017 | 0.218 |
| 21.25 | 0.056 | 0.033 | 0.056 | 0.012 | 0.157 | 0.074 | 0.043 | 0.074 | 0.016 | 0.207 |
| 21.5 | 0.053 | 0.031 | 0.053 | 0.011 | 0.148 | 0.07 | 0.042 | 0.07 | 0.015 | 0.197 |
| 21.75 | 0.055 | 0.032 | 0.056 | 0.012 | 0.155 | 0.073 | 0.042 | 0.074 | 0.016 | 0.205 |
| 22 | 0.058 | 0.033 | 0.059 | 0.012 | 0.162 | 0.077 | 0.043 | 0.078 | 0.016 | 0.214 |
| 22.25 | 0.056 | 0.032 | 0.056 | 0.012 | 0.156 | 0.074 | 0.043 | 0.074 | 0.016 | 0.207 |
| 22.5 | 0.053 | 0.031 | 0.053 | 0.011 | 0.148 | 0.07 | 0.041 | 0.07 | 0.015 | 0.196 |
| 22.75 | 0.053 | 0.031 | 0.053 | 0.011 | 0.148 | 0.07 | 0.041 | 0.07 | 0.015 | 0.196 |
| 23 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.04 | 0.07 | 0.015 | 0.195 |
| 23.25 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.04 | 0.07 | 0.015 | 0.195 |
| 23.5 | 0.052 | 0.03 | 0.053 | 0.011 | 0.146 | 0.07 | 0.04 | 0.07 | 0.015 | 0.195 |
| 23.75 | 0.05 | 0.029 | 0.05 | 0.011 | 0.14 | 0.066 | 0.039 | 0.066 | 0.014 | 0.185 |
| 24 | 0.047 | 0.028 | 0.047 | 0.01 | 0.132 | 0.062 | 0.037 | 0.062 | 0.013 | 0.174 |
| Peaks | | | | | | | | | | |
| 15 min | 1.195 | 0.526 | 1.255 | 0.244 | 3.22 cfs | 1.589 | 0.699 | 1.669 | 0.324 | 4.281 cfs |
| | 537 | 236 | 563 | 110 | 1446 gpm | 713 | 314 | 749 | 145 | 1922 gpm |
| avg hr | 0.80 | 0.42 | 0.81 | 0.17 | 2.20 cfs | 1.06 | 0.56 | 1.07 | 0.23 | 2.92 cfs |
| | 359 | 188 | 363 | 76 | 986 gpm | 477 | 250 | 482 | 101 | 1311 gpm |

TIME OF CONCENTRATION SUMMARY

| Sub Area | Flow Type | | Flow Path Lengths ft | slope | Time hr | min | |
|---|---|---|---|---|---|---|---|
| North Sub Area | | | | | | | |
| Area | overland | | | | | | |
| 144247 ft2 | | sheet flow | 247.9 | 0.0052 | 0.0991 | 5.95 | |
| 3.31 (acres) | channelized | | 72.3 | | | | |
| | | | 89.4 | | | | |
| | | | 221.1 | | | | |
| | | | 23.9 | | | | |
| | | | 159.5 | | | | |
| | | trench | 566.2 | 0.0133 | 0.0481 | 2.886 | |
| | | | | | **0.15** | **9.0** | **Tc** |
| NEastern Sub Area | | | | | | | |
| 82728 ft2 | overland | | | | | | |
| 1.90 (acres) | | sheet flow | 275 | 0.0045 | 0.111 | 6.66 | |
| | channelized | | 289.1 | | | | |
| | | | 27.5 | | | | |
| | | | 433 | | | | |
| | | ditch | 749.6 | 0.0026 | 0.1942 | 11.65 | |
| | overland | | | | | | |
| | | shallow concentrated | 203.5 | 0.0106 | 0.0283 | 1.70 | |
| | | | | | **0.33** | **19.8** | **Tc** |
| West Sub Area | | | | | | | |
| 144927 ft2 | overland | | 146.8 | | | | |
| 3.33 (acres) | | | 107.6 | | | | |
| | | | 234.6 | 0.0082 | | | |
| | | | 489 | | | | |
| | | sheet flow | 300 | | 0.0986 | 5.92 | |
| | | shallow concentrated | 189 | 0.014 | 0.0229 | 1.37 | |
| | | | | | **0.12** | **7.2** | **Tc** |
| South Sub Area | | | | | | | |
| 30945 ft2 | overland | | | | | | |
| 0.71 (acres) | | sheet flow | 266 | 0.0027 | 0.127 | 7.62 | |
| | channelized | | 192.3 | | | | |
| | | | 202.7 | | | | |
| | | ditch | 395 | 0.01 | 0.0595 | 3.57 | |
| | | | | | **0.18** | **10.8** | **Tc** |

Calc Parameters

P2
1.62 inches
n
0.011
Total Area
402848 ft2
9.25 acre

Note:
1. tends to flow away from catch basin. Approx. relief: 10 - 8.5 = 1.5 feet. Since very small area at elevation 8.5, the South drainage area has storage for 1.5/2 = 0.75 feet or 9 inches of rain. It is not likely this area will contribute without drainage improvement.

Check Mannings Eqn in cross section of channelized flow areas to estimate the flow geometry

$Q=(1.49/n)*A*R^{2/3}*S^{1/2}$

| | Estimated Flow | Flow Depth | Side Slope | Bottom Width | Area | P | R | So | $n^1$ | Qcalc | Diff | Velocity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cfs | ft | | ft | ft2 | ft | ft | | | cfs | | fps |
| Trench | 1.6 | 0.15 | 0 | 3 | 0.45 | 3.30 | 0.14 | 0.01 | 0.013 | 1.5 | 0 | 3.33 |
| NE ditch | 0.7 | 0.08 | 10 | 7 | 0.64 | 8.63 | 0.07 | 0.003 | 0.013 | 0.7 | 0 | 1.10 |
| S ditch | 0.3 | 0.07 | 0 | 3 | 0.22 | 3.15 | 0.07 | 0.01 | 0.013 | 0.4 | 0 | 1.94 |

Notes:

1. Estimate of Manning's 'n':

For trench and ditches, assumed similar to concrete culvert with bends, connections, debris: n=0.013

From page 111 V.T.Chow Open Channel Hydraulics

2 Values for area and wetted perimeter (P) used in TR-55 worksheets to determine travel time through conveyance.

11

TR-55 WORKSHEET 3 Time of Concentration or Travel Time

Project : NASSCO
Location: North Segment

By : RGJ
Checked:

Date : 6/14/00
Date :

(12)

Circle One: Present Developed
Circle One: Tc Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Inlcude a map, schematic, or description of flow segments.

SHEET FLOW (Applicable to Tc only)

| | | | Segment ID | |
|---|---|---|---|---|
| 1. Surface Description (table 3-1) | | | | |
| 2. Manning's roughness coeff.,n (table 3-1) | | | .011 | 0. |
| 3. Flow Length, L (total L <= 300 ft) | ft | | 248 | |
| 4. Two-yr 24-hr rainfall, P2 | in | | 1.62 | 0. |
| 5. Land slope ,s | ft/ft | | 0.0054 | 0. |
| 6. Tt = 0.007(nL)^.8/P2^.5 s^.4 | hr | Compute Tt | 0.0991 | 0. |
| | | | | 0.0991 |

SHALLOW CONCENTRATED FLOW

| | | | Segment ID | |
|---|---|---|---|---|
| 7. Surface Description (paved or unpaved) | | | | |
| 8. Flow Length, L | ft | | | |
| 9. Watercourse Slope, s | ft/ft | | 0. | 0. |
| 10. Average Velocity, v (from figure) | ft/s | | 0. | 0. |
| 11. Tt = L/(3600V) | hr | Compute Tt | 0. | 0. |
| | | | | 0. |

CHANNEL FLOW

| | | | Segment ID | |
|---|---|---|---|---|
| 12. Cross Sectional Flow Area, | ft^2 | | 0.4 | 0. |
| 13. Wetted Perimeter, Pw | ft | | 3.3 | . |
| 14. Hydraulic Radius r = a/Pw | ft | | .1 | . |
| 15. Channel Slope, s | ft/ft | | 0.013 | 0. |
| 16. Manning's roughness coeff.,n | | | .013 | 0. |
| 17. V=1.49 r^2/3 s^1/2 / n | ft/s | Compute V | 3.46 | 0. |
| 18. Flow Length, L | ft | | 566 | |
| 19. Tt = L/(3600V) | hr | Compute Tt | 0.0454 | 0. |
| | | | | 0.0454 |

20. Watershed or subarea Tc or Tt .add Tc in steps 6,11, and 19 hr 0.144

TR-55 WORKSHEET 3 Time of Concentration or Travel Time

Project : NASSCO
Location: NE Segment

By : RGJ
Checked:

Date : 6/14/00
Date :

(13)

Circle One: Present Developed ____________
Circle One: Tc Tt through subarea ____________

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Inlcude a map, schematic, or description of flow segments.

| SHEET FLOW (Applicable to Tc only) | Segment ID | | |
|---|---|---|---|
| 1. Surface Description (table 3-1) .............. | | | |
| 2. Manning's roughness coeff.,n (table 3-1)...... | | .011 | 0. |
| 3. Flow Length, L (total L <= 300 ft) .......... | ft | 275 | |
| 4. Two-yr 24-hr rainfall, P2 ................... | in | 1.62 | 0. |
| 5. Land slope ,s ............................... | ft/ft | 0.005 | 0. |
| 6. Tt = 0.007(nL)^.8/P2^.5 s^.4 Compute Tt.... | hr | 0.111 | 0. |
| | | | 0.111 |

| SHALLOW CONCENTRATED FLOW | Segment ID | | |
|---|---|---|---|
| 7. Surface Description (paved or unpaved) ....... | | | |
| 8. Flow Length, L ............................. | ft | 204 | |
| 9. Watercourse Slope, s ....................... | ft/ft | 0.01 | 0. |
| 10. Average Velocity, v (from figure) ........... | ft/s | 2. | 0. |
| 11. Tt = L/(3600V) Compute Tt.... | hr | 0.0283 | 0. |
| | | | 0.0283 |

| CHANNEL FLOW | Segment ID | | |
|---|---|---|---|
| 12. Cross Sectional Flow Area, ................. | ft^2 | 0.6 | 0. |
| 13. Wetted Perimeter, Pw ........................ | ft | 8.6 | . |
| 14. Hydraulic Radius r = a/Pw .................... | ft | .1 | . |
| 15. Channel Slope, s ............................ | ft/ft | 0.003 | 0. |
| 16. Manning's roughness coeff.,n ............... | | .013 | 0. |
| 17. V=1.49 r^2/3 s^1/2 / n Compute V .......... | ft/s | 1.11 | 0. |
| 18. Flow Length, L ............................. | ft | 750 | |
| 19. Tt = L/(3600V) Compute Tt.... | hr | 0.1879 | 0. |
| | | | 0.1879 |

20. Watershed or subarea Tc or Tt .add Tc in steps 6,11, and 19 hr 0.327

TR-55 WORKSHEET 3 Time of Concentration or Travel Time



Project : NASSCO
Location: W of Machine Shop

By : RGJ
Checked:

Date : 6/14/00
Date :

Circle One: Present Developed ______________________
Circle One: Tc Tt through subarea ______________________

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Inlcude a map, schematic, or description of flow segments.

| SHEET FLOW (Applicable to Tc only) | | Segment ID | |
|---|---|---|---|
| 1. Surface Description (table 3-1) .............. | | | |
| 2. Manning's roughness coeff.,n (table 3-1)...... | | .011 | 0. |
| 3. Flow Length, L (total L <= 300 ft) .......... | ft | 300 | |
| 4. Two-yr 24-hr rainfall, P2 .................. | in | 1.62 | 0. |
| 5. Land slope ,s ............................... | ft/ft | 0.008 | 0. |
| 6. Tt = 0.007(nL)^.8/P2^.5 s^.4 Compute Tt.... | hr | 0.0986 | 0. |
| | | | 0.0986 |

| SHALLOW CONCENTRATED FLOW | | Segment ID | |
|---|---|---|---|
| 7. Surface Description (paved or unpaved) ....... | | | |
| 8. Flow Length, L .............................. | ft | 165 | |
| 9. Watercourse Slope, s ........................ | ft/ft | 0.016 | 0. |
| 10. Average Velocity, v (from figure) ............ | ft/s | 2. | 0. |
| 11. Tt = L/(3600V) Compute Tt.... | hr | 0.0229 | 0. |
| | | | 0.0229 |

| CHANNEL FLOW | | Segment ID | |
|---|---|---|---|
| 12. Cross Sectional Flow Area, .................. | ft^2 | 0. | 0. |
| 13. Wetted Perimeter, Pw ....................... | ft | . | . |
| 14. Hydraulic Radius r = a/Pw .................. | ft | . | . |
| 15. Channel Slope, s ........................... | ft/ft | 0. | 0. |
| 16. Manning's roughness coeff.,n ............... | | .005 | 0. |
| 17. V=1.49 r^2/3 s^1/2 / n Compute V .......... | ft/s | 8.14 | 0. |
| 18. Flow Length, L ............................. | ft | | |
| 19. Tt = L/(3600V) Compute Tt.... | hr | 0. | 0. |
| | | | 0. |

20. Watershed or subarea Tc or Tt .add Tc in steps 6,11, and 19 hr 0.121

TR-55 WORKSHEET 3 Time of Concentration or Travel Time

(15)

Project : NASSCO
Location: South Segment

By : RGJ
Checked:

Date : 614/00
Date :

Circle One: Present Developed ____________________
Circle One: Tc Tt through subarea ____________________

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Inlcude a map, schematic, or description of flow segments.

| SHEET FLOW (Applicable to Tc only) | Segment ID | | |
|---|---|---|---|
| 1. Surface Description (table 3-1) .............. | | | |
| 2. Manning's roughness coeff.,n (table 3-1)...... | | .011 | 0. |
| 3. Flow Length, L (total L <= 300 ft) .......... | ft | 253 | |
| 4. Two-yr 24-hr rainfall, P2 .................. | in | 1.62 | 0. |
| 5. Land slope ,s ............................. | ft/ft | 0.003 | 0. |
| 6. Tt = 0.007(nL)^.8/P2^.5 s^.4 Compute Tt.... | hr | 0.1274 | 0. |
| | | | 0.1274 |

| SHALLOW CONCENTRATED FLOW | Segment ID | | |
|---|---|---|---|
| 7. Surface Description (paved or unpaved) ....... | | | |
| 8. Flow Length, L ............................ | ft | | |
| 9. Watercourse Slope, s ...................... | ft/ft | 0. | 0. |
| 10. Average Velocity, v (from figure) ............ | ft/s | 0. | 0. |
| 11. Tt = L/(3600V) Compute Tt.... | hr | 0. | 0. |
| | | | 0. |

| CHANNEL FLOW | Segment ID | | |
|---|---|---|---|
| 12. Cross Sectional Flow Area, .................. | ft^2 | 0.2 | 0. |
| 13. Wetted Perimeter, Pw ........................ | ft | 3.2 | . |
| 14. Hydraulic Radius r = a/Pw .................. | ft | .1 | . |
| 15. Channel Slope, s ........................... | ft/ft | 0.01 | 0. |
| 16. Manning's roughness coeff.,n ............... | | .013 | 0. |
| 17. V=1.49 r^2/3 s^1/2 / n Compute V .......... | ft/s | 1.94 | 0. |
| 18. Flow Length, L ............................ | ft | 395 | |
| 19. Tt = L/(3600V) Compute Tt.... | hr | 0.0564 | 0. |
| | | | 0.0564 |

20. Watershed or subarea Tc or Tt .add Tc in steps 6,11, and 19 hr 0.184

# APPENDIX B
# REVIEW CONFERENCE FOR DRAFT DESIGN REPORT

## MEMORANDUM

**DATE:** July 20, 2000

**TO:** NASSCO Stormwater Filtration Team

**FROM:** Barry Kellems

**RE:** Review Conference for Draft Design Report
J-7374

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Based on comments received on the Draft Design Report dated June 20, 2000, a review meeting was held on July 12, 2000. Attending the review meeting by teleconference were:

| | | |
|---|---|---|
| James Lenhart, P.E. | Stormwater Management | Technical Advisor |
| Gary Minton, Ph.D. | Resource Planning Assoc. | Technical Advisor |
| Jean Nichols, Ph.D. | JNE & Assoc. | Technical Advisor |
| Todd Thornburg, Ph.D. | Hart Crowser | Technical Advisor |
| Barry Kellems, P.E. | Hart Crowser | Project Manager |
| Gene Lacey, P.E. | Hart Crowser | Project Engineer |
| Randy Johnson | Hart Crowser | Hydrologic Engineer |
| Jay Holtz, P.E. | Stormwater Management | Project Manager |

Barry Kellems facilitated the review meeting, which lasted from 9 am to 11:30 am. The following comments on the Draft Design Report were received from Gary Minton (GM), Jean Nichols (JN), Todd Thornburg (TT) and Jim Lenhart (JL). Also included below is the resolution of each comment based on the review meeting

### Comments from Todd Thornburg

TT1. My primary comment is that I would like to see an alternative retained in which treatment is sequential, i.e. a first stage perlite filter followed by a second stage compost filter. This could be directly compared with the single-cartridge perlite-compost layered mixture. A basic comparison of treatment in parallel versus treatment in series seems to be needed. Placing two media in a single cartridge seems like a new and innovative approach, but should we dedicate all three treatment trains to these more complex cartridge designs?

I'd like to see us get some basic performance data on traditional single-media cartridges before we get too fancy.

Response: Comment Accepted - Significant discussion concerning process configuration (see comments TT2, TT3, GM 15 and GM 16). Train No. 1 will contain a single media operating at 15 gpm per cartridge and Train No 2 and No. 3 will contain dual media in series (in a single composite filter cartridge) operating at 7.5 gpm. This was deemed suitable. The text in Section 5 was edited to describe our rationale.

TT2. The vaults are presently set up to treat flow in parallel. How readily can they be adapted to treat flow in sequence if sequential treatment turns out to be more effective? I am wondering how flexible these configurations are.

Response: Comment Accepted - The system as designed will contain flexibility to vary hydraulic loading in the future, and simulate parallel versus series treatment. No Revision Required (NRR).

TT3. Does pleated fabric take up cartridge space? Looks to me like it does. If so, why not dedicate that treatment train to simple one-stage compost treatment, given the relatively low TSS at NASSCO. Again, I would recommend simplicity, at least during the first year of testing. We need some baseline information before we can evaluate whether more complex cartridge designs are necessary or effective.

Response: Comment Accepted - The pleated fabric takes up 40% of the diameter. Discussed pros and cons of pleated fabric versus perlite and the need for solids pretreatment given the low TSS at Nassco. The consensus regarding treatment train unit processes within a single cartridge was:

| | |
|---|---|
| Train No. 1 | Coarse Compost |
| Train No. 2 | Fabric/Fine Compost |
| Train No. 3 | Coarse Compost/Fine Compost |

TT4. I don't see a vault height dimension on Figure 7.

Response: Comment Accepted - Dimensions will be added.

TT5. P. 18, first bullet. It may not always be possible to anticipate a storm event. Therefore, how can we be assured that we will be able to check controls and indicators within a specified period of time prior to a storm event?

Response: Comment Accepted - Inspect within 8 hours following the start of any storm event.

TT6. I suggest collected Total Metals as well as dissolved, at least for the first flush sample. Presently, we are only scoped to collect dissolved. However, all other shipyards in the country are only collecting total metals, so that is their only basis of comparison with NASSCO.

Response: Comment Accepted - Total metals added.

TT7. The most common current usage that I have seen in peer-reviewed journals and agencies is "stormwater" (one word). It seems to me that Hart Crowser's (GTB's) insistence on "storm water" (two words) is antiquated. Let's ask Gary Minton's opinion. I have been using "stormwater" in all my reports.

Response: Comment Accepted - We will use stormwater.

**Comments from Jean Nichols**

JN1. My comments are mostly editorial. The main substantive comment concerns Section 3.4 Comparison of Shipyard Stormwater with Ambient Urban Runoff. I strongly recommend deleting the last sentence. Treating the stormwater to levels below the ambient urban runoff will decrease the total input to the bay. That is a good thing. Admittedly, cost-effectiveness for the shipyard is questionable. However, as worded in the report the issue becomes a very large red flag to the local environmental community. With time ambient urban runoff, levels will probably decrease. If this project uses current levels as criteria, it will be leaving the door open for future problems.

Response: Comment Accepted - Edited

JN2. I believe the way to approach the problem is to consider the cost of maximum possible treatment and cost of treating to meet ambient urban runoff levels during the demonstration. If the incremental cost of treating shipyard runoff is "manageable" NASSCO would have an excellent argument to the Regional Board and City that the City is responsible to reducing the runoff levels before stormwater enters the NASSCO property.

Response: Comment Accepted - NRR

JN3. I am not an engineer, so can not provided detailed comments about the design. I like the approach. I do have some concerns about the monitoring plan. I have not done a serious study of storm patterns around the bay. However, my general impression is that continuous rain for four hours is unusual. (Inland probably receives longer rainfall periods.) Sampling may need to be done on a fifteen-minute interval to obtain more than two samples.

Response: Comment Accepted – Section 6.3.1.1 edited to change sampling frequency to 15-minute intervals.

JN4. Following are specific editorial suggestions.

Section 1.2 Site Description, second paragraph, and first line: insert "the "before SW-3

Section 1.3 Regulatory Requirements,
1st paragraph, and 1st line: delete "the"; also, should there be some mention that shipyard regulations vary by state (the impression I get is regulations vary by individual shipyard because of the shipyard rather than because of location).

2nd paragraph: should specifies essentially be changed to essentially specifies? (I think it reads better when switched.); After "end of the pipe: insert "The permit includes the following specific requirements:"; delete "In addition, NASSCO's permit requires:"

Section 1.4 Scope of Work This section has a future tense problem.

1st paragraph delete will involve, insert involves: delete will be, insert is
Task 1 Change first paragraph to: Prepare a Design Report (this document), containing the rational for selecting process options, design details for the test units, and an operations and monitoring plan for the NSRP Program Technical representative (PTR). The PTR will review and comment prior to Task 2 initiation. Subtasks of Task 1 include:

Section 2.1 Drainage Area Description

2nd paragraph 2nd line: change storage of parts to parts storage; 3rd paragraph, 2nd line, change which to that

Section 2.3 Methodology

1st paragraph last sentence: change to "checked to ensure it met first flush requirements."

2nd paragraph 1st sentence: change to Threshold precipitation values representing 90%, 95%, and 98% capture of the total rainfall were determined.

Section 3.1

1st paragraph; 5th line: change to storm drain crossing the site.
6th line: delete well, change water over the last years to water during the last three years

3rd paragraph 8th line delete in other words, insert therefore

last paragraph 1st line; delete far, last line delete that

Page 12; first paragraph delete "will be" and "that"

Page 13 1st paragraph change which lack to lacking. Next line delete that
2nd paragraph change which to that

Section 4.1 2nd paragraph 8th line change which to that

Section 4.2

1st paragraph, last line: one or more commas are needed. I'm not sure if this is 3 different items or a combination of two and a second item.

2nd paragraph change screening of solids to solids screening

Response: Comment Accepted – Edited as requested.

**Comments from Gary Minton**

Overall an excellent report that clearly lays out the project at hand. Here are some comments.

GM 1. It would be helpful whenever referring to a table or a figure to put the page number for said table or figure in parens after each reference, since all of the tables and figures are in the back of the report.

Response: Formatting not changed.

GM 2. Page 3: I really don't understand explanation of the effluent requirements starting with "In addition, NASSCO's permit requires: .....".
What is meant by "terminated"???? some explanation would be helpful. How do you terminate a storm flow? The second bullet also makes no sense to me. What is meant by "previous requirement"?

Response: Comment Accepted - discussed meaning of terms, NRR

GM 3. Page 7, 2.2 Design Storm: I would delete the first 2 sentences of the first paragraph. "Storms .... Type 1" is not correct and is misleading. Type 1 is just a statistical construct that is not directly related to any given real storm in any particular city (within the Type 1 area). The second sentence is also not necessarily valid given the large variation in stormwater statistics around the country.

Response: Comment Accepted - Edited as requested

GM 4. Page 7, 2.2 Design Storm: Second paragraph... the statement "providing 33% safety factor" is not readily obvious to the reader. It would be helpful to explain how this was derived, using the numbers from Table 2. A "0.4-year" storm may not be readily understandable by many readers of this report.
Should put it in lay terms.

Response: Comment Accepted - Edited as requested

GM 5. Page 7, 2.2 Design Storm: It seems that in fact you are providing more than a 33% safety factor given that the average flow through each cartridge (225 cartridges) at the peak flow of 4.28 cfs will be only 0.019 cfs/cartridge, when the recommended flow rate is 0.033 cfs/cartridge. I understand the rationale behind the low flow rate of 0.019 cfs/cartridge. However, this rationale is not explained in the text.

Response: Safety factor clarified.

GM 6. Page 7, 2.2 Design Storm: the conclusions of this analysis are placed at the bottom of page 7, but then we go into "Methodology" . Seems like the discussion of the design storm, which is the outcome of the methodology, ought to follow Section 2.3.

Response: Comment Accepted - Edited as requested

GM 7. Page 8, 2.3 Methodology: Methodology to do what? It would be clearer if the said "Methodology to determine the design storm", and then place Section 2.2 after 2.3.

Response: Comment Accepted – Edited as requested

GM 8. Page 8, 2.3.1, threshold precipitation: I am not sure I understand just what the threshold precipitation represents. Looking at Table 2, for the rainfall depth of 0.89", you capture 90.1%. But is the volume of all storms equal to or less than 0.89"/24 hours? If so, you are not including the volume from the 0.89" of each of the larger storms. If you included this you would exceed the 90% volume requirement by a considerable margin, and you would also exceed the 90% time requirement. This would allow you to reduce the number of cartridges.

Response: Resolved approach, we will not reduce number of cartridges - NRR

GM 9. Page 9, Section 2.3.2: paragraph 3: I am really not understanding what is happening with SBUH. I think we need to walk through this at the meeting on July 12. Seems like this is resulting a very conservative estimate of the peak, to which is added 33% safety factor, to which is added a low flow rate through the filters (0.019 cfs/cartridge). We may have a facility that has about twice as many cartridges as is necessary. At the meeting on the 12th, lets review again the work that was done in the previous report (the lab column work) and what this work tells us concerning the relationship between media thickness and the needed reduction of metals.

Response: Resolved approach, we will not reduce number of cartridges - NRR

GM 10. Page 10, 3.1, paragraph 3: You use means to make comparisons. While this will not likely change any conclusions, you should be using geometric means not means. Why? Many years of stormwater testing has demonstrated that concentrations of untreated stormwater follow a log-normal distribution. You make reference to this reality with the statement "a few anomalous spikes ... can significantly drive up the average". You can see this in Table 3. Note that for TSS the mean is 41 but the 50th percentile is only 15. Using geometric means is relevant when considering the relationship between the sortion capacity of a media and influent concentrations, which relates to the determination of the maintenance cycle.

Response: Comment Accepted - NRR for Section 3. However, Section 7 will be edited to state "Treatment performance will be compared using the contaminant mass loading and removal for each of the treatment trains. Mass loadings will be calculated using flow-weighted concentrations. Summary statistics will also be presented, including mean and geometric mean values."

GM 11. Page 11: Section 3.2, first paragraph, line 3: Suggest you change the "will be compared" to "is compared below"

Response: Comment Accepted – Edited as requested

GM 12. Page 11: Section 3.3: A graph of some sort is needed to demonstrate the claim that "about 0.03 to 0.05 mg/L would ....". I assume some sort of correlation was determined between copper concentration and survival? This finding is very important so I think a graph more clearly substantiating the claim that is made is warranted. Also, did you do any correlation analysis between survival and the storm depth, or between survival and maximum hourly intensity of each storm? This might tell us something.

Response: Resolved approach - NRR

GM 13. Page 15: hydraulic separators: This discussion is really rather irrelevant. This systems should be eliminated for the simply reason that they do not remove dissolved pollutants. End of discussion.

Response: Resolved approach, we are screening for solids pretreatment - NRR

GM 14. Page 16, paragraph 2: Zeolite may be twice as expensive. However, what is its sorption capacity in comparison to leaf compost? And what is its performance capability: i.e. rate of metals removal. Yes, zeolite may be more expensive but this is a relatively small (less than 50%) of the cost of the maintenance. Hence, if the maintenance cycle can be extended for zeolite in comparison to compost, zeolite may be the better media.

Response: Zeolite will not be tested in the field at this time due to lack of data with shipyard stormwater and increased cost concerns – NRR.

GM 15. Page 17: There is no explanation of how you go from 4.28 cfsto 225 cartridges, and why you have 45 in one and 90 in the other two. I understand the following logic: the cartridges in Train 1 are almost 100% fine compost. Hence, the flow through this train will be at the normal rate of 15 gpm/cartridge. However, the cartridges in Trains 2 and 3 have only ½ of the fine compost, therefore the flow rate will be 7.5 gpm/cartridge. But is the lower flow rate supportable by the earlier lab tests with the columns? I dont know if I have the logic correct, but whatever it is it should be explained.

Response: Comment Accepted – See Comment TT1. The text in Section 5 edited to better describe rationale.

GM 16. Page 17: media schemes: in light of the very low TSS in the influent, I think we ought to rethink the media schemes with Stormwater Management input of course. I am not sure that I see the logic of the perlite and course compost schemes, given the low TSS.

Response: Although the mean TSS based on limited sampling in SW-3 is relatively low with respect to industry standards, there is still the potential for elevated concentrations at times during continuous operation. Therefore, we will eliminate solids pretreatment from Train No. 1 but retain it on Train No. 2 and No. 3. The final unit processes are listed under Comment TT3. Jim did a quick calculation to show that the cartridges should last a year based on solids loading.

GM 17. Page 17: number of cartridges. See Comment #8.

Response: NRR

GM 18. Page 18, Section 6.0: Only 3 storms per season, total of 6 storms? Two points. If you are only going to do six storms, why do it over two rainy seasons? It would be better to just get it done in the first wet season. Secondly, it is a shame you are only going to do six storms, given the expense in installing the system. Six storms is just not enough, particularly since I think you will want to modify the flow rates through each of the trains to ascertain the effluent of flow rate on performance. The shipyard does two events per year. Could they somehow integrate their two efforts into yours, thereby increasing the number of sampled events to 10? If we reduce the size of the filter system, thereby reducing its costs (as per the comments above), can the savings be used to sample more storms? In truth, you should be sampling every storm that comes through the filter. Why? To properly determine the maintenance cycle, you need to know the total loading that goes through and the incremental loading that is removed by the filtration system. We can discuss this more on the 12th. I am very concerned about the validity of this project if only six storms are sampled. Its seems "penny-wise but pound foolish".

Response: Comment Accepted – Rainfall on the waterfront in San Diego is less than observed further inland. Nassco has trouble monitoring their two NPDES-required storm events some years due to the lack of rainfall. Therefore, the text edited to say that the expected number of storm storms events to be monitored is three. However, we will monitor additional events up to a total of 10 if additional measurable events occur.

GM 19. Page 18, monitoring plan: The plan should also include cleaning of the diversion manhole and the filter vaults... i.e. removal of sediment and weighing of the sediment, to see what is removed by these components of the treatment system. I also would like us to chat with Stormwater Management about the efficacy of weighing the cartridges before and after the experimental period to ascertain how much sediment is removed by the cartridges. This is useful information.

Response: Comment Accepted – Provision added to estimate solids accumulation.

GM 20. Page 19, Section 6.3: I dont know about California but in many (most?) states the standard for each metal is a function of the hardness. Hence, hardness should also be determined. Also pH. Duplicate samples? I think I understand why you want to do this. However, my experience is that it is unwarranted. I did a study for the Port of Seattle where we collected triplicate samples from nine outfalls over a period of about two years. There was no difference between the triplicate samples. The results were also consistently the same.

Response: Comment Accepted. Hardness is only a factor in freshwater criteria, not marine. However, pH is a permit required criteria and will be added to the analyte list. Duplicate sampling will not be conducted.

GM 21. I think the idea of separately sampling for the first flush and the post flush periods is great. However, with storm durations of 12 hours the "rising hydrograph" may be rather illusive. I suppose simply arbitrarily stating that 4 hours constitutes first flush is okay. Visual inspection of individual samples before compositing may also be useful.

Response - NRR

GM 22. Page 19: Section 6.3: I assume that you will be using automatic samplers? If so, you should be using the 24 bottle setup, taking a sample every 30 minutes, and then composting based on flow. Where will you get the flow information? This protocol should be explained. But if you are using automatic samplers, how to take samples for oil/grease. This must be done by hand. But if you are doing everything by hand, how do you make certain that you will be out there before the storm begins. I suggest we chat about this on the 12th.

Response: Comment Accepted - Automatic samplers will not be used to avoid the significant monthly costs associated with them. An influent flow meter will be added to ensure that we collect accurate hydrograph data with which to composite samples during first flush and waning storm intervals.

GM 23. Page 20: Item #2: I thought that acid-washed tygon tubing was to be used, rather than polyethylene, when sampling for metals. Tygon tubing should be used in the automatic samplers as well?

Response: Comment Accepted – The monitoring protocol will be based on Nassco's current stormwater monitoring procedure.

GM 24. Page 20: Nothing is said regarding "clean metal" techniques. Should we not be following "clean metal" techniques: i.e. clean hands/dirty hands, use of non-talc gloves, etc?

Response: Comment Accepted – The monitoring protocol will be based on Nassco's current stormwater monitoring procedure.

GM 25. Page 20: Procedures to calibrate flow through each train?

Response: The use of orifices will preclude calibrating the flows-NRR

GM 26. Figure 6: Are the effluent samples obtained before or after any bypass rejoins the flow stream. Or do all bypasses occur at the splitter manhole and therefore there will be no bypasses through each train?

Response: Bypasses occur at the splitter manhole. Effluent samples are obtained before the bypass rejoins the flow stream.

**Comments from Jim Lenhart**

JL 1. Cover - Please replace Stormwater Management Inc (SMI) with new logo
Response: Comment Accepted

JL 2. Can we obtain a copy of the Penn State Report?
Response: We will send you a copy.

JL 3. Task 4 – Data Analysis and Engineering Report - Following the first year of operation it would be of value to assess the filter performance and consider changing either flow rates or media specification. Stormwater Management is continuously researching new media. Of late we have begun looking into media for higher levels of copper removal.

Response: Comment Accepted – Text edited accordingly.

JL 4. Section 1.5 Project Organization - NASSCO is providing the labor for sample collection. This is a key element of the project and sampling techniques can make significant differences in results. The StormFilter has a complex method of operation relative to a sampling protocol. We recommend the following:

- The sampling team have a thorough understanding of the hydraulic operation of the filters
- During sampling a technician should be present to observe the sampling conditions. Many times field observations can explain spurious results.
- The field data collection staff work with Stormwater Management R&D staff to evaluate the sampling methodology and early data interpretation.

Response: Comment Accepted

JL 5. Section 2.1 - Drainage Area Description - I do not understand Paragraph 4. – Just need a clarification on what is being treated.

Response: NRR

JL 6. Section 2.3.1 – Threshold Precipitation - A total of 73 years of daily precipitation data were used to establish the 90% capture rate. We would recommend using the normal rainfall data, which is usually calculated from the previous 10 years of data. This helps by eliminating smoothing of long term trends.

Response: Comment Accepted – The analysis was based on the previous 10 years of data.

JL 7. Section 3.4 – Comparison of Shipyard Stormwater with Ambient Urban Runoff - Stormwater Management has collected many influent and effluent samples from various types of land use. With reference to metals removal, it is clear that removal rates can greatly vary. Clearly, water chemistry has an influence on removal rates of dissolved metals. The oxidation state, concentration, competition with other metals, degree of saturation of exchange sites all impact the removal of a specific metal. Of particular interest to SMI is the association of metals with colloid suspensions. Removal of colloids by filtration is ineffective while the charge of the metal is satisfied by attachment to the colloid and becomes unavailable for cation exchange. The combination of the two factors can defeat the mechanisms used by the StormFilter for metals removal. We suggest that some artificial samples of stormwater be collected from the site. These samples are then sent to SMI, so we can perform a few bench scale tests to both characterize the water and try a few different flow rates, media sizes, and media types for copper and zinc removal. This would allow for a bracketing of combinations to increase the probability of success in the field.

Response: We feel that the 1997 column test results support field-scale testing at this time and that additional lab-scale testing would not be cost-effective. However, in the event that performance during the initial storm event falls short of expectations, additional lab testing may be conducted at that time.

JL 8. Section 6.1 Start Up - Most of the filter media being used will contain some residual fine particles and color. The compost media for example will initially discharge some fines and a brown color caused by tannins. For the purposes of sampling and data collection, the systems should be run until clear prior to the sampling period.

Response: Comment Accepted – Text edited to require pre-washing of media at the factory and at the site prior to allowing stormwater to enter the vaults.

JL 9. Section 6.2 System Operation - After the first year of operation, we recommend that a few of the cartridges be examined for the degree of occlusion, etc.

Response: Comment Accepted

JL 10. Section 6.3.1 Storm Water Quality Monitoring - We recommend that Total Metals analysis be performed as well. This helps with the understanding of how the metals are partitioned in the water column and helps maintain a check on dissolved metals, (i.e. Do dissolved metals exceed total metals.) We recommend a periodic check of iron and aluminum as high concentrations can saturate exchange sites which would be available for zinc and copper removal.

Response: Comment Accepted – Total and dissolved metals will be tested on all samples and iron and aluminum will be tested on all influent samples.

JL 11. Section 6.3.2 – See Comment number 4

Response: Comment Accepted – Text edited accordingly.

**Other Comments During Meeting**

1. We discussed the results of the 1997 column tests and how they compare to the current design criteria. Barry presented a table showing the design criteria and performance of the compost media treating Marco stormwater. The table will be included in the final design report. The following two observations were made from the comparison:

- Hydraulic loading was similar in the column test.
- Grain size was smaller in the column test

Based on these results, Barry asked Jim if we could use a finer grain size for the field test. Jim is checking supplies but said that the stormfilter design would need to be modified to hold media smaller than No. 10 sieve size.

2. According to Stormwater Management, a concrete slab will be needed below the treatment vaults to provide a foundation and prevent differential settlement. Jay will provide details concerning vault loaded weight and tie down configuration to Gene.

3. Stormwater Management is concerned regarding resuspension of solids in the single flow-splitter manhole and suggested that two manholes be provided. One for bypass and one for flow splitting. The double splitter approach was selected.